2019年5月26日(日)

[E] ポスター発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_3

[P-PS04] 火星と火星圏の科学

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

[PPS04-P01] ハレアカラT60望遠鏡可視分光器による火星電離圏のO_2^+発光の観測

*鈴木 駿久[1]、鍵谷 将人[1]、坂野井 健[1] (1.東北大学理学研究科，惑星プラズマ・大気研究センター)

[PPS04-P02] Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

*大浦 愛菜[1]、笠羽 康正[1]、熊本 篤志[1]、野口 里奈[2]、臼井 寛裕[2]、石山 謙[2]、植村 千尋[3] (1.東北大学、2.宇宙科学研究所、3.総合研究大学院大学)

[PPS04-P03] Detecting surface changes on Mars using principle component analysis of repeat imagery

*Reid Parsons[1]、Hideaki Miyamoto[1] (1.University of Tokyo)

[PPS04-P04] Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

*今村 翔子[1,2]、関根 康人[2]、黒川 宏之[2] (1.東京大学、2.東京工業大学 地球生命研究所)

[PPS04-P05] 火星パヴォニス山に記録された氷床の周期的成長

*神崎 友裕[1]、Reid Parsons[1,2]、逸見 良道[1]、宮本 英昭[1] (1.東京大学、2.フィッチバーグ州立大学)

[PPS04-P06] Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

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

[PPS04-P07] Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

*松原 侑哉[1]、福地 裕範[1]、小川 佳子[1]、林 洋平[2] (1.公立大学法人会津大学、2.国立天文台)

[PPS04-P08] **Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal**

*Brian Hamilton Day[1]、Emily Law[2] (1.NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center、2.NASA Jet Propulsion Laboratory, California Institute of Technology)

[PPS04-P09] 紫外線Ａ・Ｃよる鉄カンラン石からの鉄溶出量の増加

*小森 信男[1] (1.東京学芸大学大学院連合学校教育学研究科)

[PPS04-P10] Small-scale ridges newly identified on the equatorial region of the Phobos nearside

*逸見 良道[1]、菊地 紘[1]、宮本 英昭[1] (1.東京大学)

[PPS04-P11] 火星探査機搭載を目指した超小型ミュオグラフィー装置の開発

*上吉原 弘明[1]、二宮 哲郎[1]、吉原 有里[1]、島添 健次[1]、高橋 浩之[1]、田中 宏幸[1]、宮本 英昭[1] (1.東京大学)

[E] ポスター発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_4

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[E] ポスター発表 | 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

10:45 ~ 12:15 | ポスター会場 幕張メッセ国際展示場 8ホール_2

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

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

[PEM14-P01] **The Daytime and Nighttime Mapped Whistler Plasmapause Observed by DEMETER**

*ChaoYen Chen[1,2]、Tiger J. Y. Liu[1,2,3] (1.Institute of Space Science, National Central University, Taiwan、2.Center for Astronautical Physics and Engineering, National Central University, Taiwan 、3.Center for Space and Remote Sensing Research, National Central University, Taiwan)

[PEM14-P02] Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

*Chi-Kuang Chao[1]、Yi-Wun Chen[1] (1.Graduate Institute of Space Science, National Central University)

[PEM14-P03] The First Result on Ionospheric Space Weather of FORMOSAT-5/AIP Ion Density

*FU-YUAN CHANG[1]、JANN-YENQ Liu[1]、Chi-Kuang Chao[1] (1.National Central University)

[PEM14-P04] **The global total electron content reconstruction in the local time frame**

*Tsung-Che Tsai[1,2]、Hau-Kun Jhuang[3]、Lou-Chuang Lee[3,4,5]、Yi-Ying Ho[4] (1.National Center for High-Performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan、2.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan.、3.Department of Geoscience, National Taiwan University, Taipei, Taiwan.、4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan.、5.Institute of Space Science, National Central University, Jhongli, Taiwan.)

[PEM14-P05] Research on impacts of power line harmonic radiation on ionospheric parameters

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

[PEM14-P06] **Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms**

*Oksana Mandrikova[1]、Yurii Polozov[1]、Bogdana Mandrikova[1,2] (1.Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences、2.Saint Petersburg Electrotechnical University "LETI")

[PEM14-P07] King Tidal Effects on the ionosphere during the period of 2000 to 2017

*TsungYu Wu[1]、JANN-YENQ Liu[1] (1.Institute of Space Science, NCU, Taiwan)

[PEM14-P08] SuperDARN near range echoes and higher resolution measurement - recent improvement and future

*行松 彰[1,2] (1.国立極地研究所、2.総合研究大学院大学)

[PEM14-P09] **The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps**

*Hau-Kun Jhuang[1]、Tsung-Che Tsai[2,3]、Lou-Chuang Lee[1,4,5]、Yi-Ying Ho[4] (1.Department of Geosciences, National Taiwan University, Taipei, Taiwan、2.National Center for High-performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan、3.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan、4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan、5.Institute of Space Science, National Central University, Jhongli, Taiwan)

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17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_5

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

15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_5

[P-CG21] 宇宙・惑星探査の将来計画と関連する機器開発の展望

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

[PCG21-P01] 編隊飛行による地球電磁気圏・熱圏探査衛星計画「FACTORS」搭載可視・紫外イメージャーによる微細オーロラと大気光観測

*坂野井 健[1]、平原 聖文[2]、津田 卓雄[3]、浅村 和史[4]、三好 由純[2]、渡邉 智彦[5]、西山 尚典[6]、大山 伸一郎[2,7]、斎藤 義文[4]、細川 敬祐[3]、小嶋 浩嗣[8]、北村 成寿[9]、小川 泰信[5]、山内 正敏[10]、松岡 彩子[4]、八木 直志[1]、吹澤 瑞貴[1]、石澤 元気[11] (1.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、2.名古屋大学宇宙地球環境研究所、3.電気通信大学情報理工学研究科、4.宇宙航空研究開発機構宇宙科学研究所、5.名古屋大学大学院理学研究科、6. 国立極地研究所、7. フィンランドオウル大学、8.京都大学生存圏研究所、9.東京大学大学院理学研究科、10.スウェーデン宇宙物理学研究所、11.東北大学大学院理学研究科)

[PCG21-P02] 機械学習を用いたフラッシュオーロラの時空間解析

*源田 斗輝[1]、井上 拓海[1]、尾崎 光紀[1]、八木谷 聡[1]、今村 幸祐[1]、塩川 和夫[2]、三好 由純[2]、大山 伸一郎[2]、片岡 龍峰[3]、海老原 祐輔[4]、細川 敬祐[5] (1.金沢大学、2.名古屋大学、3.極地研究所、4.京都大学、5.電気通信大学)

[PCG21-P03] 信号処理によるPc1地磁気脈動地上観測のパルス性雑音除去

*駒瀬 文弥[1]、井上 智寛[1]、尾崎 光紀[1]、八木谷 聡[1]、塩川 和夫[2]、能勢 正仁[2]、長妻 努[3] (1.金沢大学、2.名古屋大学、3.情報通信研究機構)

[PCG21-P04] Application of magneto-impedance sensor to geomagnetic field measurements

*能勢 正仁[1]、野村 麗子[2]、浅村 和史[3]、青山 均[4]、河野 剛健[4]、松岡 彩子[3]、北村 健太郎[5]、小山 幸伸[6]、松本 晴久[7]、平原 聖文[1] (1.名古屋大学宇宙地球環境研究所、2.国立天文台、3.宇宙航空研究開発機構 宇宙科学研究所、4.愛知製鋼株式会社、5.徳山工業高等専門学校、6.大分工業高等専門学校、7.宇宙航空研究開発機構 研究開発部門)

[PCG21-P05] Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

*北村 健太郎[1]、今井 一雅[2]、高田 拓[2]、篠原 学[3]、若林 誠[4]、高専 スペース連携 (1.徳山工業高等専門学校、2.高知工業高等専門学校、3.鹿児島工業高等専門学校、4.新居浜工業高等専門学校)

[PCG21-P06] Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

*徳永 祐也[1]、尾崎 光紀[1]、石坂 圭吾[2]、小嶋 浩嗣[3]、八木谷 聡[1]、頭師 孝拓[3] (1.金沢大学、2.富山県立大学、3.京都大学)

[PCG21-P07] 超小型探査機に搭載する極端紫外撮像装置に用いる電気回路部の放射線耐性の評価

*勝瀬 陸[1]、吉岡 和夫[1]、桑原 正輝[2]、疋田 伶奈[1]、荒尾 昇吾[1]、吉川 一朗[1] (1.東京大学、2.宇宙航空研究開発機構　宇宙科学研究所)

[PCG21-P08] A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

*西村 晟八[1]、吉川 一朗[1]、吉岡 和夫[1]、荒尾 昇吾[1]、張 天旭[1] (1.東京大学)

[PCG21-P09] ３次元電位分布計算による「みお」搭載MIAのトップハット分析器特性の非対称性の解釈

*三宅 亙[1]、斎藤 義文[2]、横田 勝一郎[3] (1.東海大学工学部、2.宇宙科学研究所、3.大阪大学)

[PCG21-P10] 小型衛星用衝撃試験機の建造及びMCPの機械耐性評価

*福場 惇哉[1] (1.東京大学大学院)

[PCG21-P11] Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

*武井 智美[1]、平原 聖文[1] (1.名古屋大学宇宙地球環境研究所)

[PCG21-P12] Microsatellite Development and Education of Space Science and Technology at Kanazawa University

*井町 智彦[1]、八木谷 聡[1]、米徳 大輔[1]、笠原 禎也[1]、澤野 達哉[1]、有元 誠[1]、後藤 由貴[1]、尾崎 光紀[1]、藤本 龍一[1] (1.金沢大学)

[PCG21-P13] Attitude Control System for Kanazawa-SAT3 Microsatellite

中嶋 拓也[1]、安田 有希[1]、瀬川 浩史[1]、*井町 智彦[1]、八木谷 聡[1]、笠原 禎也[1]、米徳 大輔[1]、澤野 達哉[1]、有元 誠[1] (1.金沢大学)

[PCG21-P14] Communications System and Antennas for Kanazawa-SAT3 Microsatellite

源 輝也[1]、稲 航洋[1]、河越 幸平[1]、*井町 智彦[1]、八木谷 聡[1]、後藤 由貴[1]、米徳 大輔[1]、笠原 禎也[1]、澤野 達哉[1]、有元 誠[1] (1.金沢大学)

[PCG21-P15] 6Uクラス超小型深宇宙探査機EQUULEUSに搭載する多層断熱材一体型ダスト計測器CLOTHの開発

*平井 隆之[1]、矢野 創[2]、實川 律子[3]、石岡 英悟[3]、中野 晴貴[3]、新井 和吉[3]、長谷川 直[2] (1.千葉工業大学・惑星探査研究センター、2.宇宙航空研究開発機構・宇宙科学研究所、3.法政大学・理工学部)

[PCG21-P16] DESTINY$^+$搭載小惑星追尾機構の開発：概念設計およびBBMを用いた性能試験

*洪 鵬[1]、石橋 高[1]、佐藤 峻介[2]、竹村 和俊[3]、藤原 航太郎[4]、町井 佳菜子[5]、豊田 裕之[2]、西山 和孝[2]、大槻 真嗣[2]、奥平 修[1]、高島 健[2] (1.千葉工業大学惑星探査研究センター、2.宇宙航空研究開発機構 宇宙科学研究所、3.早稲田大学 基幹理工学研究科 機械科学専攻、4.北海道大学 工学院 機械宇宙工学専攻、5.電気通信大学 情報理工学部 知能機械工学科)

[PCG21-P17] 火星衛星探査計画における望遠カメラ(TENGOO)性能評価装置の開発

*加藤 博基[1]、亀田 真吾[1]、塩谷 圭吾[2]、長田 直也[1] (1.立教大学、2.宇宙航空研究開発機構)

[PCG21-P18] ソーラー電力セイルOKEANOSのクルージングフェーズにおける観測計画

*岩田 隆浩[1]、松浦 周二[2]、津村 耕司[3]、矢野 創[1]、平井 隆之[4]、松岡 彩子[1]、米徳 大輔[5]、三原 建弘[6]、岡田 達明[1]、森 治[1]、中条 俊大[1] (1.宇宙航空研究開発機構　宇宙科学研究所、2.関西学院大学、3.東北大学、4.千葉工業大学、5.金沢大学、6.理化学研究所)

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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_8

[P-CG21] 宇宙・惑星探査の将来計画と関連する機器開発の展望

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

[PCG21-P01] 編隊飛行による地球電磁気圏・熱圏探査衛星計画「FACTORS」搭載可視・紫外イメージャーによる微細オーロラと大気光観測

*坂野井 健[1]、平原 聖文[2]、津田 卓雄[3]、浅村 和史[4]、三好 由純[2]、渡邉 智彦[5]、西山 尚典[6]、大山 伸一郎[2,7]、斎藤 義文[4]、細川 敬祐[3]、小嶋 浩嗣[8]、北村 成寿[9]、小川 泰信[5]、山内 正敏[10]、松岡 彩子[4]、八木 直志[1]、吹澤 瑞貴[1]、石澤 元気[11] (1.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、2.名古屋大学宇宙地球環境研究所、3.電気通信大学情報理工学研究科、4.宇宙航空研究開発機構宇宙科学研究所、5.名古屋大学大学院理学研究科、6. 国立極地研究所、7. フィンランドオウル大学、8.京都大学生存圏研究所、9.東京大学大学院理学研究科、10.スウェーデン宇宙物理学研究所、11.東北大学大学院理学研究科)

[PCG21-P02] 機械学習を用いたフラッシュオーロラの時空間解析

*源田 斗輝[1]、井上 拓海[1]、尾崎 光紀[1]、八木谷 聡[1]、今村 幸祐[1]、塩川 和夫[2]、三好 由純[2]、大山 伸一郎[2]、片岡 龍峰[3]、海老原 祐輔[4]、細川 敬祐[5] (1.金沢大学、2.名古屋大学、3.極地研究所、4.京都大学、5.電気通信大学)

[PCG21-P03] 信号処理によるPc1地磁気脈動地上観測のパルス性雑音除去

*駒瀬 文弥[1]、井上 智寛[1]、尾崎 光紀[1]、八木谷 聡[1]、塩川 和夫[2]、能勢 正仁[2]、長妻 努[3] (1.金沢大学、2.名古屋大学、3.情報通信研究機構)

[PCG21-P04] Application of magneto-impedance sensor to geomagnetic field measurements

*能勢 正仁[1]、野村 麗子[2]、浅村 和史[3]、青山 均[4]、河野 剛健[4]、松岡 彩子[3]、北村 健太郎[5]、小山 幸伸[6]、松本 晴久[7]、平原 聖文[1] (1.名古屋大学宇宙地球環境研究所、2.国立天文台、3.宇宙航空研究開発機構 宇宙科学研究所、4.愛知製鋼株式会社、5.徳山工業高等専門学校、6.大分工業高等専門学校、7.宇宙航空研究開発機構 研究開発部門)

[PCG21-P05] Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

*北村 健太郎[1]、今井 一雅[2]、高田 拓[2]、篠原 学[3]、若林 誠[4]、高専 スペース連携 (1.徳山工業高等専門学校、2.高知工業高等専門学校、3.鹿児島工業高等専門学校、4.新居浜工業高等専門学校)

[PCG21-P06] Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

*徳永 祐也[1]、尾崎 光紀[1]、石坂 圭吾[2]、小嶋 浩嗣[3]、八木谷 聡[1]、頭師 孝拓[3] (1.金沢大学、2.富山県立大学、3.京都大学)

[PCG21-P07] 超小型探査機に搭載する極端紫外撮像装置に用いる電気回路部の放射線耐性の評価

*勝瀬 陸[1]、吉岡 和夫[1]、桑原 正輝[2]、疋田 伶奈[1]、荒尾 昇吾[1]、吉川 一朗[1] (1.東京大学、2.宇宙航空研究開発機構　宇宙科学研究所)

[PCG21-P08] A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

*西村 晟八[1]、吉川 一朗[1]、吉岡 和夫[1]、荒尾 昇吾[1]、張 天旭[1] (1.東京大学)

[PCG21-P09] ３次元電位分布計算による「みお」搭載MIAのトップハット分析器特性の非対称性の解釈

*三宅 亙[1]、斎藤 義文[2]、横田 勝一郎[3] (1.東海大学工学部、2.宇宙科学研究所、3.大阪大学)

[PCG21-P10] 小型衛星用衝撃試験機の建造及びMCPの機械耐性評価

*福場 惇哉[1] (1.東京大学大学院)

[PCG21-P11] Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

*武井 智美[1]、平原 聖文[1] (1.名古屋大学宇宙地球環境研究所)

[PCG21-P12] Microsatellite Development and Education of Space Science and Technology at Kanazawa University

*井町 智彦[1]、八木谷 聡[1]、米徳 大輔[1]、笠原 禎也[1]、澤野 達哉[1]、有元 誠[1]、後藤 由貴[1]、尾崎 光紀[1]、藤本 龍一[1] (1.金沢大学)

[PCG21-P13] Attitude Control System for Kanazawa-SAT3 Microsatellite

中嶋 拓也[1]、安田 有希[1]、瀬川 浩史[1]、*井町 智彦[1]、八木谷 聡[1]、笠原 禎也[1]、米徳 大輔[1]、澤野 達哉[1]、有元 誠[1] (1.金沢大学)

[PCG21-P14] Communications System and Antennas for Kanazawa-SAT3 Microsatellite

源 輝也[1]、稲 航洋[1]、河越 幸平[1]、*井町 智彦[1]、八木谷 聡[1]、後藤 由貴[1]、米徳 大輔[1]、笠原 禎也[1]、澤野 達哉[1]、有元 誠[1] (1.金沢大学)

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[PCG21-P16] DESTINY$^+$搭載小惑星追尾機構の開発：概念設計およびBBMを用いた性能試験

*洪 鵬[1]、石橋 高[1]、佐藤 峻介[2]、竹村 和俊[3]、藤原 航太郎[4]、町井 佳菜子[5]、豊田 裕之[2]、西山 和孝[2]、大槻 真嗣[2]、奥平 修[1]、高島 健[2] (1.千葉工業大学惑星探査研究センター、2.宇宙航空研究開発機構 宇宙科学研究所、3.早稲田大学 基幹理工学研究科 機械科学専攻、4.北海道大学 工学院 機械宇宙工学専攻、5.電気通信大学 情報理工学部 知能機械工学科)

[PCG21-P17] 火星衛星探査計画における望遠カメラ(TENGOO)性能評価装置の開発

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[PCG21-P18] ソーラー電力セイルOKEANOSのクルージングフェーズにおける観測計画

*岩田 隆浩[1]、松浦 周二[2]、津村 耕司[3]、矢野 創[1]、平井 隆之[4]、松岡 彩子[1]、米徳 大輔[5]、三原 建弘[6]、岡田 達明[1]、森 治[1]、中条 俊大[1] (1.宇宙航空研究開発機構　宇宙科学研究所、2.関西学院大学、3.東北大学、4.千葉工業大学、5.金沢大学、6.理化学研究所)

[E] ポスター発表 | 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 | ポスター会場 幕張メッセ国際展示場 8ホール_7

[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)

[AOS09-P01] 高速水温計データの補正について

*木村 詩乃[1]、後藤 恭敬[2]、李 根淙[1]、安田 一郎[1] (1.東京大学、2.気象庁)

[AOS09-P02] 乱流計搭載深海フロートを用いた乱流混合の観測

*翟 燦[1]、安田 一郎[1]、菊地 将彰[1]、後藤 恭敬[1]、李 根淙[1]、田中 雄大[2]、山木 謙[3]、今村 豊[4] (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、3.鶴見精機、4.青森県産業技術センター水産総合研究所)

[AOS09-P03] Evaluation of the underwater glider flight model using the electromagnetic current sensor

*田中 雄大[1]、長谷川 大介[1]、奥西 武[1]、安田 一郎[2] (1.国立研究開発法人　水産研究・教育機構　東北区水産研究所、2.東京大学大気海洋研究所)

[AOS09-P04] Mixing processes observed by a slocum glider at the Oyashio-TWC front

*長谷川 大介[1]、田中 雄大[1]、奥西 武[1]、安田 一郎[2] (1.国立研究開発法人 水産研究・教育機構　東北区水産研究所、2.東京大学　大気海洋研究所)

[AOS09-P05] 月の18.6年周期振動がエルニーニョ南方振動ENSOに与える影響

*安田 一郎[1] (1.東京大学大気海洋研究所)

[AOS09-P06] 潮汐18.6年周期振動が太平洋十年規模振動(PDO)に及ぼす影響

*濵本 真沙希[1]、安田 一郎[1] (1.東京大学大気海洋研究所)

[AOS09-P07] A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

*阿部 佑美[1]、見延 庄士郎[1,5]、Takamitsu Ito[2]、Curtis Deutsch[3]、Matthew Long[4] (1.北海道大学　理学院、2.ジョージア工科大学、3.ワシントン大学、4.アメリカ大気研究センター、5.北海道大学　理学部)

[AOS09-P08] Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

*増田 周平[1] (1.国立研究開発法人　海洋研究開発機構)

[AOS09-P09] Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

*Hung Wei Chou[1]、Humio Mitsudera[1]、Hatsumi Nishikawa[1]、Kaihe Yamazaki[2] (1.Hokkaido University, Institute of Low Temperature Science、2.Hokkaido University, Graduate School of Environmental Science)

[AOS09-P10] Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

*近藤 能子[1,2]、砂原 雄大[2]、西岡 純[3]、小畑 元[4]、武田 重信[1,2] (1.長崎大学大学院水産・環境科学総合研究科、2.長崎大学水産学部、3.北海道大学低温科学研究所、4.東京大学大気海洋研究所)

[AOS09-P11] Chemical and physical speciation of copper in the subarctic North Pacific

*黄 国宏[1]、小畑 元[1]、金 泰辰[2]、近藤 能子[3]、西岡 純[4] (1.東京大学大気海洋研究所、2.韓国ソウル国立大学、3.長崎大学、4.北海道大学低温科学研究科)

[AOS09-P12] Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

*和賀 久朋[1]、平譯 享[1]、上野 洋路[1] (1.北海道大学)

[AOS09-P13] 黒潮栄養塩ストリームの構造とインパクト

*小松 幸生[1,2]、廣江 豊[3] (1.東京大学大学院新領域創成科学研究科、2.東京大学大気海洋研究所、3.水産研究・教育機構西海区水産研究所)

[AOS09-P14] Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

*Chin-chang Hung[1]、Dewang Li[2]、Wen-Chen Chou[3]、Yung-Yen Shih[1,4]、Guan-Yu Chen[1] (1.Department of Oceanography, National Sun Yat Sen University, Kaohsiung, Taiwan、2.Second Institute of Oceanography, State Oceanic Administration, Hangzhou, PRC、3.Institute of Marine Environmental Chemistry and Ecology, National Taiwan Ocean University, Taiwan、4.Department of Applied Science, R.O.C Naval Academy, Kaohsiung, Taiwan)

[AOS09-P15] Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

*酒井 秋絵[1]、千手 智晴[2]、堤 英輔[2]、松野 健[2]、遠藤 貴洋[2]、安田 一郎[3]、柳本 大吾[3] (1.九州大学大学院総合理工学府大気海洋環境システム学専攻、2.応用力学研究所、3.東京大学大気海洋研究所)

[AOS09-P16] **From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs**

*Siteng Zhu[1]、JING ZHANG[1]、Shota Kambayashi[2]、Takeshi Matsuno[3]、Eisuke Tsutsumi[3]、Shigenobu Takeda[4]、Seiya Nagao[5]、Hiroshi Inoue[5]、Hiroshi Ogawa[6]、Ichiro Yasuda[6] (1.University of Toyama、2.Fukushima university、3.Kyushu university、4.Nagasaki university、5.Kanazawa university、6.The University of Tokyo)

[AOS09-P17] 西部北太平洋亜熱帯観測点KEOにおける時系列観測で明らかとなった貧栄養海域の生物地球化学への低気圧性渦と台風の影響

*本多 牧生[1]、笹井 義一[1]、Siswanto Eko[1]、吉田 聡[2]、相木 秀則[3]、クローニン メグハン[4] (1.海洋研究開発機構、2.京都大学防災研究所、3.名古屋大学、4.米国海洋大気庁太平洋海洋環境研究所)

[AOS09-P18] 本州南方海域のプランクトン群集に対する伊豆海嶺域の島陰効果

*日高 清隆[1]、田所 和明[1]、宮本 洋臣[1]、市川 忠史[1] (1.水産研究・教育機構)

[AOS09-P19] Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

*浦川 昇吾[1]、中野 英之[1]、辻野 博之[1]、坂本 圭[1]、豊田 隆寛[1]、山中 吾郎[1] (1.気象庁気象研究所)

[AOS09-P20] 安定・不安定成層した表層海洋中での圧力－歪み相関のパラメタリゼーション

*牛島 悠介[1]、吉川 裕[1] (1.京都大学大学院理学研究科)

[AOS09-P21] 台風に対する海洋の応答の非対称性についての数値実験

*大倉 大樹[1]、吉川 裕[1] (1.京都大学大学院理学研究科)

[AOS09-P22] Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

*高橋 杏[1]、日比谷 紀之[1]、Alberto Naveira Garabato[2] (1.東京大学大学院理学系研究科 地球惑星科学専攻、2.National Oceanography Centre, University of Southampton)

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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_11

[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)

[AOS09-P01] 高速水温計データの補正について

*木村 詩乃[1]、後藤 恭敬[2]、李 根淙[1]、安田 一郎[1] (1.東京大学、2.気象庁)

[AOS09-P02] 乱流計搭載深海フロートを用いた乱流混合の観測

*翟 燦[1]、安田 一郎[1]、菊地 将彰[1]、後藤 恭敬[1]、李 根淙[1]、田中 雄大[2]、山木 謙[3]、今村 豊[4] (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、3.鶴見精機、4.青森県産業技術センター水産総合研究所)

[AOS09-P03] Evaluation of the underwater glider flight model using the electromagnetic current sensor

*田中 雄大[1]、長谷川 大介[1]、奥西 武[1]、安田 一郎[2] (1.国立研究開発法人　水産研究・教育機構　東北区水産研究所、2.東京大学大気海洋研究所)

[AOS09-P04] Mixing processes observed by a slocum glider at the Oyashio-TWC front

*長谷川 大介[1]、田中 雄大[1]、奥西 武[1]、安田 一郎[2] (1.国立研究開発法人 水産研究・教育機構　東北区水産研究所、2.東京大学　大気海洋研究所)

[AOS09-P05] 月の18.6年周期振動がエルニーニョ南方振動ENSOに与える影響

*安田 一郎[1] (1.東京大学大気海洋研究所)

[AOS09-P06] 潮汐18.6年周期振動が太平洋十年規模振動(PDO)に及ぼす影響

*濵本 真沙希[1]、安田 一郎[1] (1.東京大学大気海洋研究所)

[AOS09-P07] A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

*阿部 佑美[1]、見延 庄士郎[1,5]、Takamitsu Ito[2]、Curtis Deutsch[3]、Matthew Long[4] (1.北海道大学　理学院、2.ジョージア工科大学、3.ワシントン大学、4.アメリカ大気研究センター、5.北海道大学　理学部)

[AOS09-P08] Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

*増田 周平[1] (1.国立研究開発法人　海洋研究開発機構)

[AOS09-P09] Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

*Hung Wei Chou[1]、Humio Mitsudera[1]、Hatsumi Nishikawa[1]、Kaihe Yamazaki[2] (1.Hokkaido University, Institute of Low Temperature Science、2.Hokkaido University, Graduate School of Environmental Science)

[AOS09-P10] Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

*近藤 能子[1,2]、砂原 雄大[2]、西岡 純[3]、小畑 元[4]、武田 重信[1,2] (1.長崎大学大学院水産・環境科学総合研究科、2.長崎大学水産学部、3.北海道大学低温科学研究所、4.東京大学大気海洋研究所)

[AOS09-P11] Chemical and physical speciation of copper in the subarctic North Pacific

*黄 国宏[1]、小畑 元[1]、金 泰辰[2]、近藤 能子[3]、西岡 純[4] (1.東京大学大気海洋研究所、2.韓国ソウル国立大学、3.長崎大学、4.北海道大学低温科学研究科)

[AOS09-P12] Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

*和賀 久朋[1]、平譯 享[1]、上野 洋路[1] (1.北海道大学)

[AOS09-P13] 黒潮栄養塩ストリームの構造とインパクト

*小松 幸生[1,2]、廣江 豊[3] (1.東京大学大学院新領域創成科学研究科、2.東京大学大気海洋研究所、3.水産研究・教育機構西海区水産研究所)

[AOS09-P14] Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

*Chin-chang Hung[1]、Dewang Li[2]、Wen-Chen Chou[3]、Yung-Yen Shih[1,4]、Guan-Yu Chen[1] (1.Department of Oceanography, National Sun Yat Sen University, Kaohsiung, Taiwan、2.Second Institute of Oceanography, State Oceanic Administration, Hangzhou, PRC、3.Institute of Marine Environmental Chemistry and Ecology, National Taiwan Ocean University, Taiwan、4.Department of Applied Science, R.O.C Naval Academy, Kaohsiung, Taiwan)

[AOS09-P15] Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

*酒井 秋絵[1]、千手 智晴[2]、堤 英輔[2]、松野 健[2]、遠藤 貴洋[2]、安田 一郎[3]、柳本 大吾[3] (1.九州大学大学院総合理工学府大気海洋環境システム学専攻、2.応用力学研究所、3.東京大学大気海洋研究所)

[AOS09-P16] **From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs**

*Siteng Zhu[1]、JING ZHANG[1]、Shota Kambayashi[2]、Takeshi Matsuno[3]、Eisuke Tsutsumi[3]、Shigenobu Takeda[4]、Seiya Nagao[5]、Hiroshi Inoue[5]、Hiroshi Ogawa[6]、Ichiro Yasuda[6] (1.University of Toyama、2.Fukushima university、3.Kyushu university、4.Nagasaki university、5.Kanazawa university、6.The University of Tokyo)

[AOS09-P17] 西部北太平洋亜熱帯観測点KEOにおける時系列観測で明らかとなった貧栄養海域の生物地球化学への低気圧性渦と台風の影響

*本多 牧生[1]、笹井 義一[1]、Siswanto Eko[1]、吉田 聡[2]、相木 秀則[3]、クローニン メグハン[4] (1.海洋研究開発機構、2.京都大学防災研究所、3.名古屋大学、4.米国海洋大気庁太平洋海洋環境研究所)

[AOS09-P18] 本州南方海域のプランクトン群集に対する伊豆海嶺域の島陰効果

*日高 清隆[1]、田所 和明[1]、宮本 洋臣[1]、市川 忠史[1] (1.水産研究・教育機構)

[AOS09-P19] Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

*浦川 昇吾[1]、中野 英之[1]、辻野 博之[1]、坂本 圭[1]、豊田 隆寛[1]、山中 吾郎[1] (1.気象庁気象研究所)

[AOS09-P20] 安定・不安定成層した表層海洋中での圧力－歪み相関のパラメタリゼーション

*牛島 悠介[1]、吉川 裕[1] (1.京都大学大学院理学研究科)

[AOS09-P21] 台風に対する海洋の応答の非対称性についての数値実験

*大倉 大樹[1]、吉川 裕[1] (1.京都大学大学院理学研究科)

[AOS09-P22] Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

*高橋 杏[1]、日比谷 紀之[1]、Alberto Naveira Garabato[2] (1.東京大学大学院理学系研究科 地球惑星科学専攻、2.National Oceanography Centre, University of Southampton)

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

15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_8

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

コンビーナ:Yuei-An Liou(National Central University)

[HGG01-P01] **Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck**

*Yan-Jyun Lin[1]、Shen Yu Hsiao[1]、REN-JHIH YANG[1]、Zhen-Yu Wu[1] (1.National Chung Hsing University)

[HGG01-P02] **The environmental impact of mountaineering in the Mt. Manaslu region**

*下嶋 聖[1] (1.東京農業大学)

[HGG01-P03] Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

*Kim-Anh Nguyen[1]、Yuei-An Liou[1] (1.Center for Space and Remote Sensing Research, National Central University)

[HGG01-P04] Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

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

[HGG01-P05] Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

*Joko Widodo[1]、Josaphat Tetuko Sri Sumantyo[1]、Daniele Perissin[2]、Katsunoshin Nishi[1]、Pakhrur Rozi[1] (1.JMRSL - Josaphat Microwave Remote Sensing Laboratory Center for Environmental Remote Sensing Graduate School of Advanced Integration Science Chiba University、2.Sarproz, Razer Limited, Hongkong)

[HGG01-P06] Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

*Peberlin Parulian Sitompul[1]、Josaphat Tetuko Sri Sumantyo[2] (1.Chiba University, and Indonesia National Institute of Aeronautic and Space、2.Center for Environmental Remote Sensing, Chiba University)

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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_14

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

コンビーナ:Yuei-An Liou(National Central University)

[HGG01-P01] **Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck**

*Yan-Jyun Lin[1]、Shen Yu Hsiao[1]、REN-JHIH YANG[1]、Zhen-Yu Wu[1] (1.National Chung Hsing University)

[HGG01-P02] **The environmental impact of mountaineering in the Mt. Manaslu region**

*下嶋 聖[1] (1.東京農業大学)

[HGG01-P03] Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

*Kim-Anh Nguyen[1]、Yuei-An Liou[1] (1.Center for Space and Remote Sensing Research, National Central University)

[HGG01-P04] Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

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

[HGG01-P05] Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

*Joko Widodo[1]、Josaphat Tetuko Sri Sumantyo[1]、Daniele Perissin[2]、Katsunoshin Nishi[1]、Pakhrur Rozi[1] (1.JMRSL - Josaphat Microwave Remote Sensing Laboratory Center for Environmental Remote Sensing Graduate School of Advanced Integration Science Chiba University、2.Sarproz, Razer Limited, Hongkong)

[HGG01-P06] Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

*Peberlin Parulian Sitompul[1]、Josaphat Tetuko Sri Sumantyo[2] (1.Chiba University, and Indonesia National Institute of Aeronautic and Space、2.Center for Environmental Remote Sensing, Chiba University)

[E] ポスター発表 | セッション記号 H (地球人間圏科学)：H-SC 社会地球科学・社会都市システム

15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_10

[H-SC06] Role of Geosciences for sustainable use of marine and coastal ecosystems in urbanized world.

コンビーナ:Kalpana Chaudhari(Institute For Sustainable Development and Research)

[HSC06-P01] Research on Diffusion Method of Factor in Urban Land Classification

★Invited Papers

*Jun Zhou[1] (1.Tianjin Normal University)

[HSC06-P02] Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

*Zhang Hanqiu[1]、Xiang Qiongying[1]、Shi Jiaying[1]、Zhang Junchi[1]、Mao Yingming[1]、Min Kyung-hun[1]、Chen Ge、Oka Tokiya[1]、 Xie Zijiao[1]、Kashima Minami[1]、Natawiguna I Made、Furuya Katsunori [1] (1.千葉大学大学院園芸学研究科)

[HSC06-P03] Study on Green Tourism Experience —— Cases of Popular Strawberry Farms in Chiba Prefecture

*WU YILIN[1]、Gao Mengying[1]、Sato Kazuhei[1]、Lu Tingyu[1]、Zhang Fumeng[1]、Xing Siqi[1]、Brandt Karolina[1]、Uemura Mai、Furuya Katsunori[1] (1.千葉大学大学院園芸学研究科)

[HSC06-P04] **Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.**

*I Made Pradnyan Natawiguna[1]、Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

[E] ポスター発表 | セッション記号 H (地球人間圏科学)：H-SC 社会地球科学・社会都市システム

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_17

[H-SC06] Role of Geosciences for sustainable use of marine and coastal ecosystems in urbanized world.

コンビーナ:Kalpana Chaudhari(Institute For Sustainable Development and Research)

[HSC06-P01] Research on Diffusion Method of Factor in Urban Land Classification

★Invited Papers

*Jun Zhou[1] (1.Tianjin Normal University)

[HSC06-P02] Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

*Zhang Hanqiu[1]、Xiang Qiongying[1]、Shi Jiaying[1]、Zhang Junchi[1]、Mao Yingming[1]、Min Kyung-hun[1]、Chen Ge、Oka Tokiya[1]、 Xie Zijiao[1]、Kashima Minami[1]、Natawiguna I Made、Furuya Katsunori [1] (1.千葉大学大学院園芸学研究科)

[HSC06-P03] Study on Green Tourism Experience —— Cases of Popular Strawberry Farms in Chiba Prefecture

*WU YILIN[1]、Gao Mengying[1]、Sato Kazuhei[1]、Lu Tingyu[1]、Zhang Fumeng[1]、Xing Siqi[1]、Brandt Karolina[1]、Uemura Mai、Furuya Katsunori[1] (1.千葉大学大学院園芸学研究科)

[HSC06-P04] **Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.**

*I Made Pradnyan Natawiguna[1]、Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

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

15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_11

[H-TT20] Environmental Remote Sensing

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

[HTT20-P01] **Classification of Winter Wheat using high spatial resolution data in North China Plain**

*Chunyang Wang[1,2]、Wei Yang[2]、Xifang Wu[3]、Zhichao Chen[1]、Junjun Lu[1]、Zongze Zhao[1]、Hebing Zhang[1] (1.School of Surveying and Land Information Engineering, Henan Polytechnic University、2.Center for Environmental Remote Sensing, Chiba University、3.Graduate School of Science and Engineering, Chiba University)

[HTT20-P02] Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

*楊 偉[1]、小林 秀樹[2]、近藤 昭彦[1] (1.千葉大学、2.海洋研究開発機構)

[HTT20-P03] ***Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)***

*Sarah Kentsch[1,2]、Larry Maximo Lopez Caceres[1]、Yago Diez[1]、Motohisa Fukuda[1] (1.Yamagata University、2.United Graduate School of Agricultural Sciences)

[HTT20-P04] Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

*はりぷ あいふまる[1]、Bhattarai Richa[1]、LIU Wen[1]、Kondoh Akihiko[1,2] (1.Graduate School of Science and Engineering、2.Center for Environmental Remote Sensing, Chiba University)

[HTT20-P05] Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

*楊 偉[1]、陳 晋[2] (1.千葉大学、2.北京師範大学)

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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_18

[H-TT20] Environmental Remote Sensing

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

[HTT20-P01] **Classification of Winter Wheat using high spatial resolution data in North China Plain**

*Chunyang Wang[1,2]、Wei Yang[2]、Xifang Wu[3]、Zhichao Chen[1]、Junjun Lu[1]、Zongze Zhao[1]、Hebing Zhang[1] (1.School of Surveying and Land Information Engineering, Henan Polytechnic University、2.Center for Environmental Remote Sensing, Chiba University、3.Graduate School of Science and Engineering, Chiba University)

[HTT20-P02] Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

*楊 偉[1]、小林 秀樹[2]、近藤 昭彦[1] (1.千葉大学、2.海洋研究開発機構)

[HTT20-P03] ***Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)***

*Sarah Kentsch[1,2]、Larry Maximo Lopez Caceres[1]、Yago Diez[1]、Motohisa Fukuda[1] (1.Yamagata University、2.United Graduate School of Agricultural Sciences)

[HTT20-P04] Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

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[HTT20-P05] Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

*楊 偉[1]、陳 晋[2] (1.千葉大学、2.北京師範大学)

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

15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_13

[S-SS04] New methods for seismicity characterization

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

[SSS04-P01] **Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress**

*椋平 祐輔[1]、直井 誠[2]、Michael Fehler[3]、森谷 祐一[5]、伊藤 高敏[1]、浅沼 宏[4]、Markus Häring[6] (1.東北大学　流体科学研究所、2.京都大学　防災研究所、3.マサチューセッツ工科大学　地球資源研究所、4.産業技術総合研究所　福島再生可能エネルギー研究所、5.東北大学　工学部、6.Häring GeoProject)

[SSS04-P02] Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1]、Eszter Király-Proag[2]、Pascal Bernard[1]、Stefan Wiemer[2] (1.Institut de Physique du Globe de Paris, France、2.ETH Swiss Federal Institute of Technology Zurich, Switzerland)

[SSS04-P03] **Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers**

*Francesco Grigoli[1]、Simone Cesca[2]、Alessandro Vuan[3]、Filippo Broggini[1]、John Clinton[1]、Stefan Wiemer[1] (1.ETH-Zurich, Switzerland、2.GFZ-Potsdam, Germany、3.OGS-Trieste, Italy)

[SSS04-P04] Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

★Invited Papers

*Hilary Chang[1]、Alison Malcolm[1]、Frédérick Massin[2]、Francesco Grigoli[2] (1.Memorial University of Newfoundland, Earth Sciences, Canada、2. ETH Zurich, Department of Earth Sciences, Zürich, Switzerland)

[SSS04-P05] Earthquake nowcasting: further development and application to Japan

*楠城 一嘉[1]、ランドル ジョン[2]、櫻田 哲生[3] (1.静岡県立大学、2.カルフォルニア大学デービス校、3.櫻田商会)

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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_24

[S-SS04] New methods for seismicity characterization

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

[SSS04-P01] **Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress**

*椋平 祐輔[1]、直井 誠[2]、Michael Fehler[3]、森谷 祐一[5]、伊藤 高敏[1]、浅沼 宏[4]、Markus Häring[6] (1.東北大学　流体科学研究所、2.京都大学　防災研究所、3.マサチューセッツ工科大学　地球資源研究所、4.産業技術総合研究所　福島再生可能エネルギー研究所、5.東北大学　工学部、6.Häring GeoProject)

[SSS04-P02] Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1]、Eszter Király-Proag[2]、Pascal Bernard[1]、Stefan Wiemer[2] (1.Institut de Physique du Globe de Paris, France、2.ETH Swiss Federal Institute of Technology Zurich, Switzerland)

[SSS04-P03] **Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers**

*Francesco Grigoli[1]、Simone Cesca[2]、Alessandro Vuan[3]、Filippo Broggini[1]、John Clinton[1]、Stefan Wiemer[1] (1.ETH-Zurich, Switzerland、2.GFZ-Potsdam, Germany、3.OGS-Trieste, Italy)

[SSS04-P04] Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

★Invited Papers

*Hilary Chang[1]、Alison Malcolm[1]、Frédérick Massin[2]、Francesco Grigoli[2] (1.Memorial University of Newfoundland, Earth Sciences, Canada、2. ETH Zurich, Department of Earth Sciences, Zürich, Switzerland)

[SSS04-P05] Earthquake nowcasting: further development and application to Japan

*楠城 一嘉[1]、ランドル ジョン[2]、櫻田 哲生[3] (1.静岡県立大学、2.カルフォルニア大学デービス校、3.櫻田商会)

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

10:45 ~ 12:15 | ポスター会場 幕張メッセ国際展示場 8ホール_6

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

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

[SSS05-P01] 遠地地震により励起されたharmonicな地震波

*村上 理[1] (1.地震予知総合研究振興会　東濃地震科学研究所)

[SSS05-P02] **Dynamic triggering of microseismicity around Yunnan following the 2004 Sumatra and 2012 Indian Ocean Earthquakes**

*Lu Li[1]、Baoshan Wang[1,4]、Zhigang Peng[2]、Danning Li[3] (1.Institute of Geophysics, CEA、2.Georgia Tech、3.Yunnan Earthquake Agency、4.USTC)

[SSS05-P03] Megathrust-inducing azimuthal seismic anisotropy in local and regional crusts

*Tae-Kyung Hong[1]、Junhyung Lee[1]、Ilgoo Kim[1]、Seongjun Park[1] (1.Department of Earth System Sciences, Yonsei University)

[SSS05-P04] **A Novel Method to Estimate Fracture Permeability: Combining microseismic observational data and reservoir engineering model**

*Meihua Yang[1,2]、Yusuke Mukuhira[2]、Takatoshi Ito[2] (1.State Key Laboratory of Oil and Gas Geology and Exploitation, Chendu University of Technology (China) 、2.Institute of Fluid Science, Tohoku University (Japan))

[SSS05-P05] Doublet Earthquake Triggering for the April 2014 Events in the Solomon Islands

*Calvin Luiramo Qwana[1]、Masatoshi Miyazawa[2]、James Mori[2] (1.Graduate School of Science, Kyoto University、2.DPRI, Kyoto Univ.)

[SSS05-P06] Thermal pressurization in a deep geological repository as a possible mechanism for fault reactivation

*Luca Urpi[1]、Antonio Pio Rinaldi[1]、Jonny Rutqvist[2]、Stefan Wiemer[1] (1.Swiss Seismological Service, ETH Zurich, Switzerland、2.Energy Geosceinces Division, LBNL, USA)

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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_25

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

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

[SSS05-P01] 遠地地震により励起されたharmonicな地震波

*村上 理[1] (1.地震予知総合研究振興会　東濃地震科学研究所)

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

15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_16

[S-IT20] 地球型惑星内部での液体の特性とその役割

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

[SIT20-P01] Melting relations in the Fe-P system at high pressures

*中島 陽一[1,2]、小畑 晴幹[2]、木下 大輔[2]、舘野 繁彦[3]、廣瀬 敬[3,4]、平尾 直久[5]、河口 沙織[5]、大石 泰生[5] (1.熊本大学大学院先導機構、2.熊本大学物理科学講座、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)

[SIT20-P02] Elastic property and structure of pyrope glass at high pressure

*久野 直毅[1]、坂巻 竜也[1]、大橋 智典[1]、舟越 賢一[2]、肥後 祐司[3]、柴崎 裕樹[4]、鈴木 昭夫[1] (1.東北大学大学院理学研究科地学専攻、2.総合科学研究機構　中性子科学センター、3.（財）高輝度光科学研究センター、4.国立研究開発法人　物質・材料研究機構　若手国際研究センター)

[SIT20-P03] The effect of water and redox state on melting at the top of the lower mantle

*中嶋 彩乃[1]、坂巻 竜也[1]、鈴木 昭夫[1] (1.東北大学)

[SIT20-P04] Sound velocity measurements on liquid Fe-P alloy up to 80 GPa

*木下 大輔[1]、中島 陽一[1,2]、桑山 靖弘[2,3]、廣瀬 敬[3]、石川 大介[2,4]、Baron Alfred[2] (1.熊本大学、2.理研 MDL、3.東京大学、4.JASRI)

[SIT20-P05] High-pressure structural investigations for hydrous sodium silicate melts

*大橋 智典[1]、坂巻 竜也[1]、舟越 賢一[2]、村主 樹[1]、市東 力[1]、柴崎 裕樹[3]、鈴木 昭夫[1] (1.東北大学大学院理学系研究科、2.総合科学研究機構　中性子科学センター、3.国立研究開発法人　物質・材料研究機構)

[SIT20-P06] Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure

*岩本 朝希[1]、中島 陽一[1,2]、木下 大輔[1]、桑山 靖弘[2,3]、廣瀬 敬[3]、石川 大介[2,4]、Alfred Baron[2] (1.熊本大学、2.理研 MDL、3.東京大学、4.JASRI)

[SIT20-P07] Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

*坂巻 竜也[1]、河野 義生[2] (1.東北大学大学院　理学研究科、2.愛媛大学　地球深部ダイナミクス研究センター)

[E] ポスター発表 | 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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_28

[S-IT20] 地球型惑星内部での液体の特性とその役割

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

[SIT20-P01] Melting relations in the Fe-P system at high pressures

*中島 陽一[1,2]、小畑 晴幹[2]、木下 大輔[2]、舘野 繁彦[3]、廣瀬 敬[3,4]、平尾 直久[5]、河口 沙織[5]、大石 泰生[5] (1.熊本大学大学院先導機構、2.熊本大学物理科学講座、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)

[SIT20-P02] Elastic property and structure of pyrope glass at high pressure

*久野 直毅[1]、坂巻 竜也[1]、大橋 智典[1]、舟越 賢一[2]、肥後 祐司[3]、柴崎 裕樹[4]、鈴木 昭夫[1] (1.東北大学大学院理学研究科地学専攻、2.総合科学研究機構　中性子科学センター、3.（財）高輝度光科学研究センター、4.国立研究開発法人　物質・材料研究機構　若手国際研究センター)

[SIT20-P03] The effect of water and redox state on melting at the top of the lower mantle

*中嶋 彩乃[1]、坂巻 竜也[1]、鈴木 昭夫[1] (1.東北大学)

[SIT20-P04] Sound velocity measurements on liquid Fe-P alloy up to 80 GPa

*木下 大輔[1]、中島 陽一[1,2]、桑山 靖弘[2,3]、廣瀬 敬[3]、石川 大介[2,4]、Baron Alfred[2] (1.熊本大学、2.理研 MDL、3.東京大学、4.JASRI)

[SIT20-P05] High-pressure structural investigations for hydrous sodium silicate melts

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[SIT20-P06] Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure

*岩本 朝希[1]、中島 陽一[1,2]、木下 大輔[1]、桑山 靖弘[2,3]、廣瀬 敬[3]、石川 大介[2,4]、Alfred Baron[2] (1.熊本大学、2.理研 MDL、3.東京大学、4.JASRI)

[SIT20-P07] Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

*坂巻 竜也[1]、河野 義生[2] (1.東北大学大学院　理学研究科、2.愛媛大学　地球深部ダイナミクス研究センター)

[E] ポスター発表 | 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 | ポスター会場 幕張メッセ国際展示場 8ホール_7

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

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

[SIT23-P01] Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

*Walid Ben Mansour[1]、Guust Nolet[2]、Mario Ruiz[3]、Juan Carlos Afonso[1] (1.Department of Earth and Planetary Sciences, Macquarie University, Sydney (Australia)、2.Geoazur, Université Cote d'Azur, Sophia Antipolis (France)、3.Instituto Geofisco, Escuela Politecnica Nacional, Quito (Ecuador))

[SIT23-P02] **Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets**

*Youyue Zhang[1]、Takashi Yoshino[1]、Akira Yoneda[1]、Masahiro Osako[2] (1.Institute for Planetary Materials, Okayama University、2.Division of Physical Sciences, National Museum of Nature and Science)

[SIT23-P03] **The distribution of Cenozoic conglomerates and its sedimentological constraint on the uplift of the South Tianshan, NW China**

*SUN HAITAO[1] (1.China University of Petroluem-Beijing)

[SIT23-P04] **Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH**

*Ran Wang[1] (1.Institute for Planetary Materials, Okayama University)

[SIT23-P05] Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

*西村 祐香[1]、吉澤 和範[2] (1.北海道大学大学院理学院、2.北海道大学大学院理学研究院)

[SIT23-P06] Mapping multi-mode surface wave phase speeds in North America using mode-branch waveforms decomposed by linear Radon transform

*松澤 仁志[1]、吉澤 和範[2] (1.北海道大学大学院理学院、2.北海道大学大学院理学研究院)

[SIT23-P07] Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_K parameter: Application to the Pacific and Australian regions

奥山 秀弥[1]、*吉澤 和範[1,2]、川勝 均[3]、一瀬 建日[3] (1.北海道大学大学院理学院、2.北海道大学大学院理学研究院、3.東京大学地震研究所)

[SIT23-P08] Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

*谷部 功将[1]、平賀 岳彦[1] (1.東京大学大学院理学系研究科)

[SIT23-P09] Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

*堀内 美咲[3]、杉岡 裕子[3]、大林 政行[1]、末次 大輔[1]、塩原 肇[2]、伊藤 亜妃[1]、石原 靖[1]、田中 聡[1]、一瀬 建日[2]、利根川 貴志[1]、吉光 淳子[1]、小林 拓史[3] (1.国立研究開発法人海洋研究開発機構、2.東京大学地震研究所、3.神戸大学)

[SIT23-P10] Shear wave structure of the upper mantle beneath the Ontong Java Plateau

*一瀬 建日[1]、末次 大輔[2]、塩原 肇[1]、杉岡 裕子[3]、伊藤 亜妃[2]、石原 靖[2]、田中 聡[2]、大林 政行[2]、利根川 貴志[2]、吉光 淳子[2]、小林 拓史[3]、吉澤 和範[4] (1.東京大学地震研究所、2.海洋研究開発機構、3.神戸大学、4.北海道大学大学院理学研究院)

[SIT23-P11] Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

*梅本 幸一郎[1] (1.東京工業大学地球生命研究所)

[SIT23-P12] 幌満かんらん岩から回収されたTiに富む特異的なコランダムの報告

*大澤 拓未[1]、山本 伸次[1] (1.横浜国立大学 理工学部　建築都市環境系学科　地球生態学EP)

[SIT23-P13] Deformation experiments on akimotoite

*Longli Guan[1]、Daisuke Yamazaki[1]、Noriyoshi Tsujino[1] (1.Institute for Planetary Materials, Okayama University, Misasa, Japan)

[SIT23-P14] Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

*芳野 極[1]、Edward Baker[2]、Kyle Duffey[3] (1.岡山大学惑星物質研究所、2.オックスフォード大学、3.プリンストン大学)

[E] ポスター発表 | 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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_29

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

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

[SIT23-P01] Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

*Walid Ben Mansour[1]、Guust Nolet[2]、Mario Ruiz[3]、Juan Carlos Afonso[1] (1.Department of Earth and Planetary Sciences, Macquarie University, Sydney (Australia)、2.Geoazur, Université Cote d'Azur, Sophia Antipolis (France)、3.Instituto Geofisco, Escuela Politecnica Nacional, Quito (Ecuador))

[SIT23-P02] **Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets**

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*SUN HAITAO[1] (1.China University of Petroluem-Beijing)

[SIT23-P04] **Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH**

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[SIT23-P05] Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

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*松澤 仁志[1]、吉澤 和範[2] (1.北海道大学大学院理学院、2.北海道大学大学院理学研究院)

[SIT23-P07] Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_K parameter: Application to the Pacific and Australian regions

奥山 秀弥[1]、*吉澤 和範[1,2]、川勝 均[3]、一瀬 建日[3] (1.北海道大学大学院理学院、2.北海道大学大学院理学研究院、3.東京大学地震研究所)

[SIT23-P08] Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

*谷部 功将[1]、平賀 岳彦[1] (1.東京大学大学院理学系研究科)

[SIT23-P09] Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

*堀内 美咲[3]、杉岡 裕子[3]、大林 政行[1]、末次 大輔[1]、塩原 肇[2]、伊藤 亜妃[1]、石原 靖[1]、田中 聡[1]、一瀬 建日[2]、利根川 貴志[1]、吉光 淳子[1]、小林 拓史[3] (1.国立研究開発法人海洋研究開発機構、2.東京大学地震研究所、3.神戸大学)

[SIT23-P10] Shear wave structure of the upper mantle beneath the Ontong Java Plateau

*一瀬 建日[1]、末次 大輔[2]、塩原 肇[1]、杉岡 裕子[3]、伊藤 亜妃[2]、石原 靖[2]、田中 聡[2]、大林 政行[2]、利根川 貴志[2]、吉光 淳子[2]、小林 拓史[3]、吉澤 和範[4] (1.東京大学地震研究所、2.海洋研究開発機構、3.神戸大学、4.北海道大学大学院理学研究院)

[SIT23-P11] Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

*梅本 幸一郎[1] (1.東京工業大学地球生命研究所)

[SIT23-P12] 幌満かんらん岩から回収されたTiに富む特異的なコランダムの報告

*大澤 拓未[1]、山本 伸次[1] (1.横浜国立大学 理工学部　建築都市環境系学科　地球生態学EP)

[SIT23-P13] Deformation experiments on akimotoite

*Longli Guan[1]、Daisuke Yamazaki[1]、Noriyoshi Tsujino[1] (1.Institute for Planetary Materials, Okayama University, Misasa, Japan)

[SIT23-P14] Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

*芳野 極[1]、Edward Baker[2]、Kyle Duffey[3] (1.岡山大学惑星物質研究所、2.オックスフォード大学、3.プリンストン大学)

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

15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_17

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

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

[SIT24-P01] 水に飽和した花崗岩の三軸試験中での地震波減衰の測定

*片山 郁夫[1]、山田 恵也[1]、財間 寛太[1] (1.広島大学大学院理学研究科地球惑星システム学専攻)

[SIT24-P02] Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

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

[SIT24-P03] 3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

*小西 健介[1]、冨士 延章[2]、Deschamps Frederic[1] (1.台湾中央研究院地球科学研究所、2.パリ地球物理研究所)

[SIT24-P04] **Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies**

*Frederic Deschamps[1]、Kensuke Konishi[1]、Nobuaki Fuji[2]、Laura J Cobden[3] (1.Academia Sinica、2.Institut de Physique du Globe de Paris、3.Utrecht University)

[SIT24-P05] Intrinsic attenuation factor Q of partially molten Fe–S–O system

*Chao Liu[1]、Takashi Yoshino[1] (1.Institute for Planetary Materials, Okayama University)

[SIT24-P06] サーマルクラックの入った花崗岩における間隙水圧の弾性波減衰への影響

*山田 恵也[1]、澤山 和貴[2]、片山 郁夫[1] (1.広島大学、2.九州大学)

[E] ポスター発表 | 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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_30

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

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

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

15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_19

[S-TT42] Recent Advances in Exploration Geophysics 2019

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

[STT42-P01] DISCRIMINATION OF HYDRATE BEARING MARINE SEDIMENTS BY USING FREQUENCY BASED ATTENUATION

*Nisar Ahmed[1]、Mubasher Ahmad[1]、Perveiz Khalid[1] (1.Institute of Geology, University of the Punjab, Lahore 54590, Pakistan)

[STT42-P02] Evaluation of methane hydrate based on attenuation parameter in seismic exploration

*川部 瑞貴[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

[STT42-P03] Estimating the earthquake source mechanism using full waveform inversion

*Jang Iktae[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

[STT42-P04] A quantitative analysis of the passive seismic emission tomography using the lattice Boltzmann method

*酒見 祐一[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学 工学部)

[STT42-P05] 超臨界地熱環境下における人工貯留層の造成による地熱資源開発の実現可能性

*植田 樹[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_32

[S-TT42] Recent Advances in Exploration Geophysics 2019

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

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

15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_22

[B-PT04] Biomineralization and the Geochemistry of Proxies

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

[BPT04-P01] Living (stained) benthic foraminifera in the West-Gironde mud patch (Bay of Biscay, France): An ongoing survey for the European Community.

*Christophe Fontanier[1,2]、Bruno Deflandre[1]、Sylvain Rigaud[3]、Sabine Schmidt[1]、Bastien Lamarque[1]、Pascal Lebleu[1]、Dominique Poirier[1]、Antoine Grémare[1] (1. Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE、2.FORAM Research Group, F-49140 Villevêque, FRANCE、3.Nîmes University, GIS Laboratory, EA 7352 CHROME, F-30035 Nïmes, FRANCE)

[BPT04-P02] Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

*Pauline Duros[1]、Christophe Fontanier[1,2,3]、Briony Mamo[4,5]、Deborah Mille[6]、Olivier Herlory[6] (1.FORAM Research Group, F-49140 Villevêque, FRANCE、2.Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE、3.Angers University, 4 boulevard Lavoisier, F-49000 Angers, FRANCE.、4.School of Biological Sciences, University of Hong Kong, Pokfulam Road Sai Wan, Hong Kong SAR, CHINA. 、5.Department of Biology, Macquarie University, North Ryde, NSW, 2109, AUSTRALIA.、6.CREOCEAN, Agence PACA Corse, 230 Avenue de Rome, Valparc-Bât B, F-83500 La Seyne sur Mer, FRANCE.)

[BPT04-P03] 瀬戸内海表層堆積物中の珪藻遺骸群集組成とバイオマーカー組成の比較

*廣瀬 孝太郎[1]、中村 英人[2]、安藤 卓人[4]、浅岡 聡[3]、沢田 健[5] (1.早稲田大学　大学院創造理工学研究科　地球・環境資源理工学専攻、2.大阪市立大学大学院　理学研究科、3.神戸大学 内海域環境教育研究センター、4.北海道大学　極域研究センター、5.北海道大学　大学院理学研究院　地球惑星科学部門)

[BPT04-P04] Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

*Laurie Marie Charrieau[1]、Helena L. Filipsson[2]、Yukiko Nagai[1]、Sachiko Kawada[1]、Karl Ljung[2]、Emma Kritzberg[3]、Takashi Toyofuku[1,4] (1.Japan Agency for Marine-Earth Science and Technology、2.Department of Geology, Lund University, Sweden、3.Department of Biology, Lund University, Sweden、4.Tokyo University of Marine Science and Technology (TUMSAT), Japan)

[BPT04-P05] Effects on larger benthic foraminiferal shell density under global warming

★Invited Papers

*木下 峻一[1]、黒柳 あずみ[2]、西 弘嗣[2]、佐々木 理[2]、藤田 和彦[3]、鈴木 淳[4]、川幡 穂高[5] (1.東北大学大学院理学研究科、2.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、3.琉球大学理学部物質地球科学科、4.独立行政法人産業技術総合研究所地質情報研究部門、5.東京大学　大気海洋研究所)

[BPT04-P06] Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

*長井 裕季子[1,2]、植松 勝之[3]、豊福 高志[2,4] (1.独立行政法人　国立科学博物館、2.国立研究開発法人　海洋研究開発機構、3.マリンワークジャパン、4.東京海洋大学)

[BPT04-P07] Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

*豊福 高志[1,2]、長井 裕季子[1,3] (1.国立研究開発法人海洋研究開発機構、2.東京海洋大学、3.国立科学博物館)

[BPT04-P08] Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

*高木 悠花[1]、木元 克典[2]、藤木 徹一[2]、守屋 和佳[3]、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.早稲田大学教育学部)

[BPT04-P09] 硬骨海綿の骨格化学組成の古海洋プロキシとしての有用性

*浅海 竜司[1]、成瀬 貫[2]、水山 克[3]、植村 立[3]、新城 竜一[3]、伊勢 優史[4]、藤田 喜久[5]、坂巻 隆史[6] (1.東北大学大学院理学研究科、2.琉球大学熱帯生物圏研究センター、3.琉球大学理学部、4.マレーシア科学大学、5.沖縄県立芸術大学、6.東北大学大学院工学研究科)

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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_36

[B-PT04] Biomineralization and the Geochemistry of Proxies

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

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[BPT04-P02] Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

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[BPT04-P03] 瀬戸内海表層堆積物中の珪藻遺骸群集組成とバイオマーカー組成の比較

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[BPT04-P04] Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

*Laurie Marie Charrieau[1]、Helena L. Filipsson[2]、Yukiko Nagai[1]、Sachiko Kawada[1]、Karl Ljung[2]、Emma Kritzberg[3]、Takashi Toyofuku[1,4] (1.Japan Agency for Marine-Earth Science and Technology、2.Department of Geology, Lund University, Sweden、3.Department of Biology, Lund University, Sweden、4.Tokyo University of Marine Science and Technology (TUMSAT), Japan)

[BPT04-P05] Effects on larger benthic foraminiferal shell density under global warming

★Invited Papers

*木下 峻一[1]、黒柳 あずみ[2]、西 弘嗣[2]、佐々木 理[2]、藤田 和彦[3]、鈴木 淳[4]、川幡 穂高[5] (1.東北大学大学院理学研究科、2.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、3.琉球大学理学部物質地球科学科、4.独立行政法人産業技術総合研究所地質情報研究部門、5.東京大学　大気海洋研究所)

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[BPT04-P08] Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

*高木 悠花[1]、木元 克典[2]、藤木 徹一[2]、守屋 和佳[3]、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.早稲田大学教育学部)

[BPT04-P09] 硬骨海綿の骨格化学組成の古海洋プロキシとしての有用性

*浅海 竜司[1]、成瀬 貫[2]、水山 克[3]、植村 立[3]、新城 竜一[3]、伊勢 優史[4]、藤田 喜久[5]、坂巻 隆史[6] (1.東北大学大学院理学研究科、2.琉球大学熱帯生物圏研究センター、3.琉球大学理学部、4.マレーシア科学大学、5.沖縄県立芸術大学、6.東北大学大学院工学研究科)

[E] ポスター発表 | 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 | ポスター会場 幕張メッセ国際展示場 8ホール_9

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

コンビーナ:Groisman Pavel(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA)、Shamil Maksyutov(National Institute for Environmental Studies)、Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS)、Dmitry A Streletskiy(George Washington University)

[MIS01-P01] Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3]、Maria Dyachenko[3]、Polina Mangura[3]、Alexander Krupenko[3]、*Alexander Olchev[1,2] (1.Faculty of Geography, Lomonosov Moscow State University、2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences、3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P02] Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

*Alexander Olchev[1,2]、Natalia Levashova[3]、Dmitry Lukyanenko[3] (1.Faculty of Geography, Lomonosov Moscow State University 、2.Severtsov Institute of Ecology and Evolution, Russian Academy of Science、3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P03] Satellite-derived Burned Area for Siberia (1979 – 2000)

*Soja Amber[1]、Stocks Brian[2]、Potter Stefano[3]、Rogers Brendan[3]、Cahoon Donald[4]、Jurko Natasha[5]、Conard Susan[6]、deGroot William 'Bill'[5]、Tchebakova Nadezhda[7] (1.National Iinstitute of Aerospace / NASA Langley Research Center、2.B.J. Stocks Wildfire Investigations Ltd.、3.Woods Hole Research Center 、4.Terra Systems Research、5.Canadian Forest Service/Service canadien des forêts、6.George Mason University,Fairfax, VA、7.Sukachev Institute of Forestry, Siberian Branch of the Russian Academy of Sciences)

[MIS01-P04] Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

*Irina Repina[1,2] (1.A.M.Obukhov Institute of Atmospheric Physics RAS、2.Lomonosov Moscow State University)

[MIS01-P05] Recent baric and climatic conditions over East Europe with a focus on Belarus

*Irina Danilovich[1]、Vladimir Loginov[1]、Pavel Groisman[2] (1. Institute for Nature Management National Academy of Science, Minsk, Belarus、2. NC State University at NOAA National Centers for Environmental Information, Asheville, USA)

[MIS01-P06] Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)

★Invited Papers

*Aleksandra Alekseevna Mikheeva[1]、Margarita Syromyatina[1]、Yurii Kurochkin[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

[MIS01-P07] Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia

*Kiunnei Kirillina[1]、Wanglin Yan[1] (1.Graduate School of Media and Governance, Keio University SFC)

[MIS01-P08] 北日本の冬季日降水量の定量評価

*増田 南波[1]、谷田貝 亜紀代[1]、仲江川 敏之[2]、上口 賢治[3] (1.弘前大学大学院理工学研究科、2.気象庁気象研究所、3.気象庁)

[MIS01-P09] Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

*Shamil Maksyutov[1]、Alexandre Fofonov[2]、Denis Davydov[2]、Oleg Krasnov[2]、Tadanobu Nakayama[1]、Mikhail Glagolev[3] (1.National Institute for Environmental Studies、2.V.E. Zuev Institute of Atmospheric Optics、3.M.V. Lomonosov Moscow State University)

[MIS01-P10] Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

*Elena I. Parfenova[1]、Nadezhda M. Tchebakova[1] (1.V.N.Sukachev Institute of Forest SB RAS, FRC SB RAS)

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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_40

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

コンビーナ:Groisman Pavel(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA)、Shamil Maksyutov(National Institute for Environmental Studies)、Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS)、Dmitry A Streletskiy(George Washington University)

[MIS01-P01] Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3]、Maria Dyachenko[3]、Polina Mangura[3]、Alexander Krupenko[3]、*Alexander Olchev[1,2] (1.Faculty of Geography, Lomonosov Moscow State University、2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences、3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P02] Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

*Alexander Olchev[1,2]、Natalia Levashova[3]、Dmitry Lukyanenko[3] (1.Faculty of Geography, Lomonosov Moscow State University 、2.Severtsov Institute of Ecology and Evolution, Russian Academy of Science、3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P03] Satellite-derived Burned Area for Siberia (1979 – 2000)

*Soja Amber[1]、Stocks Brian[2]、Potter Stefano[3]、Rogers Brendan[3]、Cahoon Donald[4]、Jurko Natasha[5]、Conard Susan[6]、deGroot William 'Bill'[5]、Tchebakova Nadezhda[7] (1.National Iinstitute of Aerospace / NASA Langley Research Center、2.B.J. Stocks Wildfire Investigations Ltd.、3.Woods Hole Research Center 、4.Terra Systems Research、5.Canadian Forest Service/Service canadien des forêts、6.George Mason University,Fairfax, VA、7.Sukachev Institute of Forestry, Siberian Branch of the Russian Academy of Sciences)

[MIS01-P04] Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

*Irina Repina[1,2] (1.A.M.Obukhov Institute of Atmospheric Physics RAS、2.Lomonosov Moscow State University)

[MIS01-P05] Recent baric and climatic conditions over East Europe with a focus on Belarus

*Irina Danilovich[1]、Vladimir Loginov[1]、Pavel Groisman[2] (1. Institute for Nature Management National Academy of Science, Minsk, Belarus、2. NC State University at NOAA National Centers for Environmental Information, Asheville, USA)

[MIS01-P06] Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)

★Invited Papers

*Aleksandra Alekseevna Mikheeva[1]、Margarita Syromyatina[1]、Yurii Kurochkin[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

[MIS01-P07] Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia

*Kiunnei Kirillina[1]、Wanglin Yan[1] (1.Graduate School of Media and Governance, Keio University SFC)

[MIS01-P08] 北日本の冬季日降水量の定量評価

*増田 南波[1]、谷田貝 亜紀代[1]、仲江川 敏之[2]、上口 賢治[3] (1.弘前大学大学院理工学研究科、2.気象庁気象研究所、3.気象庁)

[MIS01-P09] Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

*Shamil Maksyutov[1]、Alexandre Fofonov[2]、Denis Davydov[2]、Oleg Krasnov[2]、Tadanobu Nakayama[1]、Mikhail Glagolev[3] (1.National Institute for Environmental Studies、2.V.E. Zuev Institute of Atmospheric Optics、3.M.V. Lomonosov Moscow State University)

[MIS01-P10] Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

*Elena I. Parfenova[1]、Nadezhda M. Tchebakova[1] (1.V.N.Sukachev Institute of Forest SB RAS, FRC SB RAS)

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

13:45 ~ 15:15 | ポスター会場 幕張メッセ国際展示場 8ホール_7

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

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

[MGI31-P01] Open Science, Community Science, and AGU's Thriving Earth Exchange.

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

[MGI31-P02] 研究データ利活用協議会（RDUF)の活動紹介：研究データに関わるオープンサイエンス、データ問題の議論のために

武田 英明[2]、*村山 泰啓[1]、研究データ利活用協議会 事務局[3] (1.国立研究開発法人情報通信研究機構 戦略的プログラムオフィス、2.国立情報学研究所、3.科学技術振興機構)

[MGI31-P03] Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

*今井 弘二[1]、村山 泰啓[1] (1.情報通信研究機構)

[MGI31-P04] Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

*木村 智樹[1]、山崎 敦[2]、吉岡 和夫[3]、村上 豪[2]、土屋 史紀[4]、北 元[2]、垰 千尋[5]、吉川 一朗[3]、熊本 篤志[6]、山内 千里[7] (1.東北大学学際科学フロンティア研究所、2.JAXA宇宙科学研究所、3.東京大学新領域創成科学研究科、4.東北大学惑星プラズマ大気研究センター、5.情報通信研究機構、6.東北大学宇宙地球電磁気学講座、7.みさと天文台)

[MGI31-P05] Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

*阿部 修司[1]、田中 良昌[2]、梅村 宜生[3]、新堀 淳樹[3]、上野 悟[4]、能勢 正仁[3] (1.九州大学 国際宇宙天気科学・教育センター、2.国立極地研究所、3.名古屋大学宇宙地球環境研究所、4.京都大学大学院理学研究科附属天文台)

[MGI31-P06] Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

*磯田 総子[1]、村山 泰啓[1]、今井 弘二[1] (1.国立研究開発法人　情報通信研究機構)

[MGI31-P07] A case example of sharing meteor radio observational data by small laboratory

*小山 幸伸[1]、宮成 祐輔[1] (1.大分工業高等専門学校)

[MGI31-P08] 地球科学における市民参加型オープンサイエンスの推進：流星の超低周波帯における電波放射と異常聴音の観測・データ解析プロジェクト

*渡辺 堯[1] (1.ISC World Data System International Programme Office)

[MGI31-P09] Current status of minting DOIs for research data in JAMSTEC

*福田 和代[1]、川上 創[1]、佐々木 朋樹[1]、堀川 博紀[1]、齋藤 秀亮[1]、齊藤 千鶴[1]、園田 朗[1] (1.国立研究開発法人海洋研究開発機構)

[MGI31-P10] Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

*Chien Hao Chang[1]、Ch Yu Liu[1]、Chun Ta Wei[1] (1.Department of Computer Science and Information Engineering,CCIT)

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

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_43

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

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

[MGI31-P01] Open Science, Community Science, and AGU's Thriving Earth Exchange.

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

[MGI31-P02] 研究データ利活用協議会（RDUF)の活動紹介：研究データに関わるオープンサイエンス、データ問題の議論のために

武田 英明[2]、*村山 泰啓[1]、研究データ利活用協議会 事務局[3] (1.国立研究開発法人情報通信研究機構 戦略的プログラムオフィス、2.国立情報学研究所、3.科学技術振興機構)

[MGI31-P03] Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

*今井 弘二[1]、村山 泰啓[1] (1.情報通信研究機構)

[MGI31-P04] Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

*木村 智樹[1]、山崎 敦[2]、吉岡 和夫[3]、村上 豪[2]、土屋 史紀[4]、北 元[2]、垰 千尋[5]、吉川 一朗[3]、熊本 篤志[6]、山内 千里[7] (1.東北大学学際科学フロンティア研究所、2.JAXA宇宙科学研究所、3.東京大学新領域創成科学研究科、4.東北大学惑星プラズマ大気研究センター、5.情報通信研究機構、6.東北大学宇宙地球電磁気学講座、7.みさと天文台)

[MGI31-P05] Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

*阿部 修司[1]、田中 良昌[2]、梅村 宜生[3]、新堀 淳樹[3]、上野 悟[4]、能勢 正仁[3] (1.九州大学 国際宇宙天気科学・教育センター、2.国立極地研究所、3.名古屋大学宇宙地球環境研究所、4.京都大学大学院理学研究科附属天文台)

[MGI31-P06] Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

*磯田 総子[1]、村山 泰啓[1]、今井 弘二[1] (1.国立研究開発法人　情報通信研究機構)

[MGI31-P07] A case example of sharing meteor radio observational data by small laboratory

*小山 幸伸[1]、宮成 祐輔[1] (1.大分工業高等専門学校)

[MGI31-P08] 地球科学における市民参加型オープンサイエンスの推進：流星の超低周波帯における電波放射と異常聴音の観測・データ解析プロジェクト

*渡辺 堯[1] (1.ISC World Data System International Programme Office)

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*福田 和代[1]、川上 創[1]、佐々木 朋樹[1]、堀川 博紀[1]、齋藤 秀亮[1]、齊藤 千鶴[1]、園田 朗[1] (1.国立研究開発法人海洋研究開発機構)

[MGI31-P10] Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

*Chien Hao Chang[1]、Ch Yu Liu[1]、Chun Ta Wei[1] (1.Department of Computer Science and Information Engineering,CCIT)

[E] ポスター発表 | セッション記号 M (領域外・複数領域)：M-SD 宇宙開発・地球観測

13:45 ~ 15:15 | ポスター会場 幕張メッセ国際展示場 8ホール_8

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

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

[MSD42-P01] A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

*栗原 純一[1]、桒原 聡文[2]、藤田 伸哉[2]、坂本 祐二[2]、高橋 幸弘[1] (1.北海道大学 大学院理学研究院、2.東北大学 大学院工学研究科)

[MSD42-P02] Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

*國森 裕生[1]、竹中 秀樹[1]、桒原 聡文[2]、坂本 祐二[2]、藤田 伸哉[2]、冨尾 蓮花[2]、サカル モロコット[2]、栗原 純一[3] (1.情報通信研究機構、2.東北大学、3.北海道大学)

[MSD42-P03] 東北大地上局および運用システムの10年間の実績

*坂本 祐二[1]、桒原 聡文[1]、藤田 伸哉[1] (1.東北大学)

[MSD42-P04] Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

*Purwadi Purwadi[1,2]、高橋 幸弘[1]、栗原 純一[1]、M. Arif Saifudin[3] (1.Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan、2.Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia、3.Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat, 16310, Indonesia)

[E] ポスター発表 | セッション記号 M (領域外・複数領域)：M-SD 宇宙開発・地球観測

17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_47

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

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

[MSD42-P01] A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

*栗原 純一[1]、桒原 聡文[2]、藤田 伸哉[2]、坂本 祐二[2]、高橋 幸弘[1] (1.北海道大学 大学院理学研究院、2.東北大学 大学院工学研究科)

[MSD42-P02] Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

*國森 裕生[1]、竹中 秀樹[1]、桒原 聡文[2]、坂本 祐二[2]、藤田 伸哉[2]、冨尾 蓮花[2]、サカル モロコット[2]、栗原 純一[3] (1.情報通信研究機構、2.東北大学、3.北海道大学)

[MSD42-P03] 東北大地上局および運用システムの10年間の実績

*坂本 祐二[1]、桒原 聡文[1]、藤田 伸哉[1] (1.東北大学)

[MSD42-P04] Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

*Purwadi Purwadi[1,2]、高橋 幸弘[1]、栗原 純一[1]、M. Arif Saifudin[3] (1.Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan、2.Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia、3.Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat, 16310, Indonesia)

[E] ポスター発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_3

[P-PS04] 火星と火星圏の科学

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

In view of unprecedented advances in our understanding of Mars, primarily due to new and ongoing observations of the planet with a number of spacecraft missions of the US, Europe and Asia, we propose a session on Mars. Mars is an object of intense scrutiny. Currently, eight spacecraft are operating at Mars, with six in orbit (Odyssey, MRO, MAVEN, Mars Express, Mangalyaan and TGO) and two on the surface (MSL-Curiosity and MER-Opportunity), the largest number ever at any given time. In addition, InSight is on track to land on Mars in November 2018, and several spacecraft are in various stages of implementation with launches scheduled for 2020 (Mars 2020, ExoMars 2020, Emirates Mars Mission Hope, Chinese Mars Mission and the Japanese Mars Terahertz Microsatellite), 2022 (ISRO's Mangalyaan 2), and 2024 (JAXA's MMX mission to explore Phobos, Deimos, and Mars). All this is a clear demonstration of public's strong fascination with and commitment to Mars exploration and the resulting scientific bonanza. Synergistic investigations with ongoing and already completed missions along with modeling studies and earth-based observations are gradually revealing the nature of Earth's most closely resembling planet that took on a different evolutionary track than our home planet. Morphology and variable phenomena seen on the surface (RSLs, e.g.) and in the atmosphere (methane) indicate that Mars is possibly currently active. Available data are providing a better understanding of Mars' present geologic and atmospheric state, climate evolution, and habitability. Thus, the scope of this session will be the recent results from a broad spectrum of Mars studies encompassing the interior, surface, atmosphere, plasma environment, and the Mars system including its two satellites. Abstracts on modelling, instrumentation and future mission plans are also encouraged.

[PPS04-P01] ハレアカラT60望遠鏡可視分光器による火星電離圏のO_2^+発光の観測

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[PPS04-P02] Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

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[PPS04-P03] Detecting surface changes on Mars using principle component analysis of repeat imagery

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[PPS04-P04] Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

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[PPS04-P05] 火星パヴォニス山に記録された氷床の周期的成長

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[PPS04-P06] Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

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[PPS04-P07] Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

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[PPS04-P08] **Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal**

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[PPS04-P09] 紫外線Ａ・Ｃよる鉄カンラン石からの鉄溶出量の増加

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[PPS04-P10] Small-scale ridges newly identified on the equatorial region of the Phobos nearside

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[PPS04-P11] 火星探査機搭載を目指した超小型ミュオグラフィー装置の開発

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ハレアカラT60望遠鏡可視分光器による火星電離圏のO_2^+発光の観測
Observation of the O_2^+ first negative band (1,0) emissions in the Mars ionosphere with a visible spectrograph on Haleakala T60

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本研究では，火星の大気散逸機構を探るために火星電離圏のO_2^+の発光の検出を目的として，初めて地上望遠鏡による分光観測を行った．分光観測後に整合的な解析を行い，その結果O_2^+ first negative bands (1NG) (1, 0)の発光を検出することができた．また，それよりO_2^+の発光強度と柱密度を導出した．

現在の火星の大気は地球と比べて希薄である．これは宇宙空間への大気の散逸が関与しており，長年の変化により大気が失われていったためであると考えられている．また，現在の火星はダイナモ運動による両極性磁場を持たず一部に弱い磁場が残っているのみであるため，火星上層大気の宇宙空間への散逸は太陽風の影響を強く受けると考えられる．近年，MAVEN探査機などの様々な観測により火星電離圏のイオン組成や密度が調べられている．火星電離圏ではO_2^+が主なイオンであり，太陽直下点では高度130 kmで密度が最大となる[M. Benna et al., 2015]．このO_2^+が解離性再結合をする結果，脱出速度以上のエネルギーを持った中性酸素が生成され，火星の重力を振り切って宇宙空間に散逸していく．この過程は火星大気散逸の中でも重要な要素である．しかし，人工衛星で中性酸素を直接観測することは困難であるため，観測可能であるプラズマの温度や密度よりモデル計算が行われている．そのため，O_2^+をはじめとするイオンや電子の密度の空間分布や高度分布を知ることは宇宙空間への散逸量を知るために重要である．しかし，数百~数千kmでのイオンの散逸過程を調べるためには人工衛星でのその場観測のみでは不十分であり，撮像による全体像の把握を行うことは重要である．地上からの望遠鏡を用いた分光リモートセンシングにより，O_2^+の発光や温度の空間分布や時間変動を捉えることができれば，太陽風や地殻地場の変動が酸素原子やイオンの散逸過程へ与える影響を知ることが期待できる．

観測は2018年の9月10日から19日の間に，マウイ島ハレアカラ山頂の東北大学60cm望遠鏡(T60)に可視分光器を組み合わせて実施した． O_2^+の発光の中でもO_2^+ 1NG (1, 0)に着目し，550 –570 nmの範囲を波長分解能10,000で分光観測した．分光器のスリット(幅2”×長さ90”)は火星の昼半球のリム付近に火星の自転軸と平行に設置した．1フレームの積分時間は2分とし，1日あたり約60フレームを取得した．観測期間中の総積分時間は450分であった．火星の太陽反射スペクトルを参照するためのスペクトル（火星ディスクのスペクトル）もリム観測の前後で取得した．観測したフレームは，個々に1次解析処理（ダーク減算，フラットフィールド補正，波長・空間歪みの補正）を施した後，全フレームについて積算することでS/Nを向上させた．その後，同様の処理を施した太陽反射スペクトルをリム観測データから差し引き，O_2^+1NG (1, 0)のスペクトルを導出した．次に，観測から導出したO_2^+1NG (1, 0)スペクトルを，モデルスペクトル[K. Henriksen and L. Veseth, 1987]と比較した．この際，スペクトルの短周期波長変動について着目するために，観測から導出したO_2^+1NG (1, 0)スペクトルとモデルスペクトルの両方に波長分解能と整合的なハイパスフィルターを施した．その2つのスペクトルの相関係数を計算した結果，波長ずれ（lag）が0の位置で相関係数は最大となり，その値は0.40であった．ここで，相関をとる波長範囲はモデルスペクトルで発光量が大きく，かつ太陽フラウンホーファーの吸収線による影響が小さい部分を選択した．これらの結果から、本研究で火星リム観測による電離圏のO_2^+の発光を初めて検出したと考えられる。さらに，モデルスペクトルと観測での発光スペクトルで最小二乗法を用いて観測されたスペクトルを最も良く再現する明るさを決定した．その結果，見積もられたO_2^+1NG (1, 0)の発光強度は691 +/- 171 $\times 10^3$ Rayleighsとなった。発光機構として太陽共鳴散乱を仮定すると， O_2^+柱密度は4.4 +/- 1.1$\times 10^{13}$ /cm^{2}となった．これはMaven探査機により観測されたO_2^+の高度分布[M. Benna et al., 2015] をもとに全球一様球対称分布を仮定した場合に期待されるO_2^+柱密度よりも約5-10倍

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大きな値となった．本発表では，O_2^+の発光観測スペクトルとモデルスペクトルを比較し，それより発光量と密度を導出した．また，その結果についての考察を述べる．

キーワード：火星、電離圏、地上望遠鏡
Keywords: Mars, ionosphere, ground-based telescope

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Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

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One of recent discoveries on Mars is the recurring slope lineae (RSL), which are certain features on the surface invoking current icy processes. RSLs are distributed on Mars and these narrow features incrementally lengthen down steep slopes, fade in colder seasons, and recur annually. Candidate and confirmed RSL sites are distributed in four regions, (1) southern mid-latitudes (SML), (2) Valles Marineris (VM), (3) equatorial highlands, and (4) northern Chryse Planitia and southwestern Acidalia Planitia (CAP). The RSLs in (2) VM and (4) CAP are more densely located than other two areas.
This study tries to identify the subsurface structures of the northern mid-latitude RSL in (4) Chryse and Acidalia Planitiae by the public data of Mars shallow radar sounder (SHARAD) onboad the Mars Reconnaissance Orbiter opened on the PDS Geosciences Node. That is because CAP RSLs are densely distributed compared to other regions. CAP RSLs are found on the steep slopes of craters. Their source zones are at or below the elevation of the surrounding plains. We used the Java Mission-planning and Analysis for Remote Sensing (JMARS, https://jmars.asu.edu/) in order to investigate the geological information of the RSL sites and the MRO locations at the SHARAD observed data. We then picked up the location correspond to the RSL sites and generated radargrams from SHARAD data. The observation frequency of SHARAD is 15-25 MHz with the bandwidth of 10 MHz, and the subsurface close to the surface can potentially be resolved with the depth resolution of 15 m in vacuum. Using MOLA data, we generated the virtual radargrams with the surface clutter emulated by the Kirchhoff approximation. Then, we compared both observed radargrams with emulated ones to identify whether there are subsurface reflectors or not.
We surveyed about 12 orbits close to the confirmed RSLs. We could find the hypothetical detection of the subsurface reflector in ‘orbit.00688101’ (Jan 14 2008, N10.0-44.7˚, E313.6-318.3˚) and ‘orbit.00673602’ (Jan 03 2008, N10.1-44.7˚, E312.7-317.4˚). In this abstract, we concentrated the characteristics of the former candidate. In this sample, the closest RSL located at N34.1˚, E317.0˚ and nadir line from the orbit was 13.8 km. Another RSL close to this orbit located N34.8˚, E318.6˚ and nadir line from the orbit was 85.2 km. Apparent elevation of closest RSL was about -3,763 ±10 m. The deepest elevation of the crater was about -4,744 ±10 m and the highest elevation of it was about -3,640 ±10 m. The radargram of this orbit showed that the elevation of surface echo was in the range from -3720 to -3780 m and that of subsurface echo ranged from -3750 to -3800 m. This means that the closest RSL height was almost the same as the depth of subsurface reflector. The subsurface echo located 25 m below the surface, and it had a little bit weak echo strength compared to surface one. If this subsurface echo shows the underground reflection, the subsurface layer will be 180 km wide along the orbit. Although this depth is marginal for the depth resolution of SHARAD, we could not identify such an echo in the emulated radargram.
In the presentation, we will summarize the results of this region including other orbits.

キーワード：火星、RSL、SHARAD

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Keywords: Mars, RSL, SHARAD

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Detecting surface changes on Mars using principle component analysis of repeat imagery

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Change detection is an analytical tool of Remote Sensing in which repeat observations of a particular location can be overlain, subtracted, or ratioed to detect differences between images. High-resolution, repeat imagery on Mars has led to several discoveries of ongoing geologic processes operating at the sub-kilometer scale such as recurring slope lineae (RSL) [1-3], new, small impacts [4], aeolian dune migration [5], sublimation of polar ice [6], and gully formation [7]. Generally, the detection of these changes is done manually by overlaying, and “flipping” between the two images. As planetary remote sensing data sets continue to grow, so does the need for a more efficient means of change detection.

Principle component analysis (PCA) offers an advantageous means for detecting change because it considers the values of all pixels in all the repeat images to extract the most statistically significant variations. These variations are then isolated from one another as a hierarchical set of “principle components” of the image dataset. The user can quickly identify patterns or features of interest which are present in one or more of these components. To illustrate this method, nine HiRISE images [8] collected from Palikir crater on Mars between November 2007 and June 2011 documenting RSL formation will be used.

PCA changes the values of the pixels in each image by plotting the pixel data on a set of axes which capture the maximum variance in the dataset. In our example image set, each pixel in the image stack can be treated as a 9-dimensional vector since there is a value for that pixel in each of the nine images. However, each pixel can be plotted on a new set of axes that capture the most important, or PCs of the image stack.

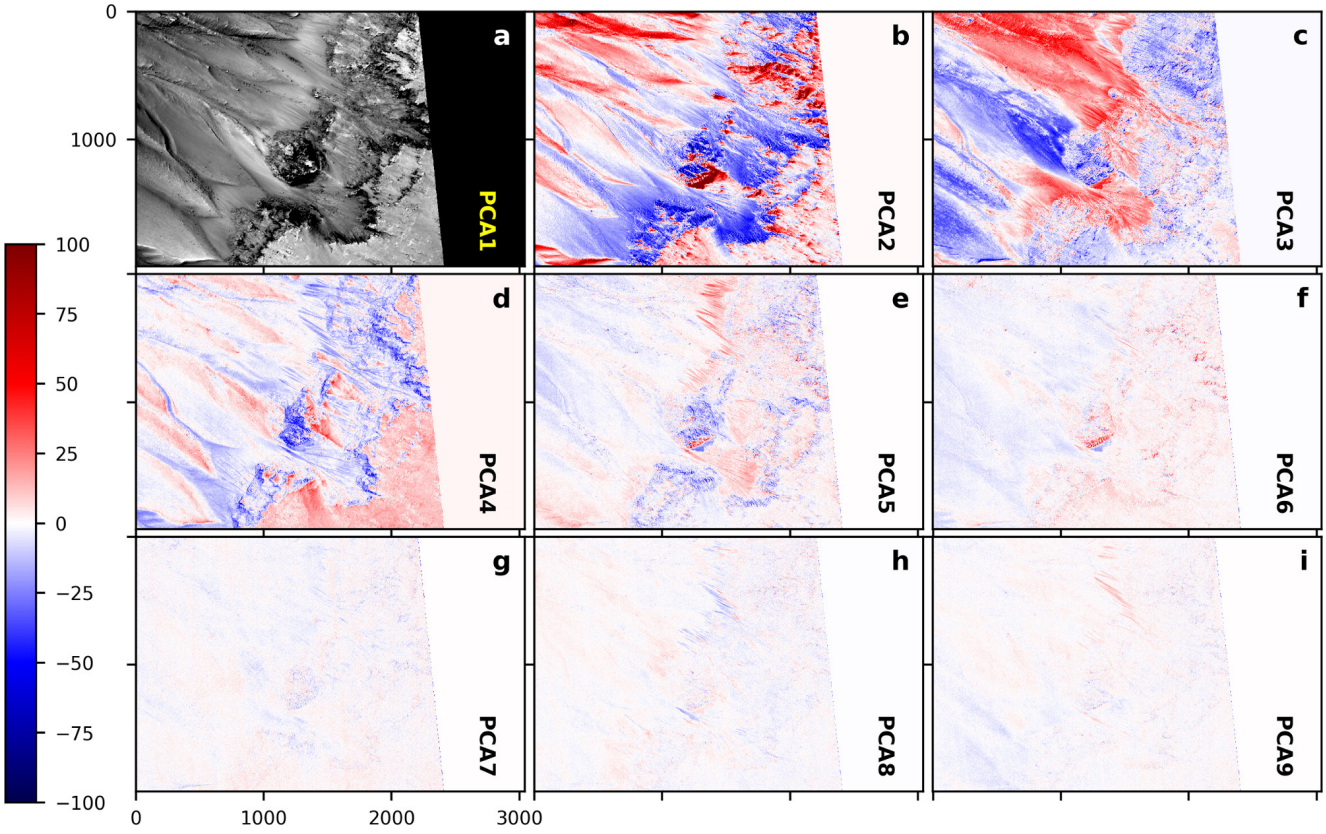
The figure shows the result of the PC transform (performed using ENVI® software) on the stacked time-series. Because most of the variation in the images is captured in the first PC (PCA1), it uses a grayscale color bar spanning 0-255 pixel values. Generally, variations covering a large spatial extent or variations causing a big shift in pixel values will be captured in the lower PCA components. Higher components, on the other hand, will depict smaller amplitude variations occurring in fewer images (or over smaller spatial extents). Thus, components 2 and 3 (panels b and c, respectively) are dominated by variations caused by differences in lighting (sun direction and elevation angle) and possibly dust or frost deposition/erosion. RSL features are identifiable in PCA4 (panel d) as elongated blue “fingers” and become more dominant and appear red in PCA5 (panel e). Subsequent components capture smaller variations caused either by changes in lighting, RSL shape (in PCA 8 and 9), or camera noise.

After identifying the PCs which contain the feature of interest, the feature can be traced back to the original images via an inverting from PC coordinates to image coordinates. Although this step is not completely reliable, it is successful in determining which images contain the most prominent RSL. Eventual combination of this method with machine-learning algorithms may permit a more automated means of detecting interesting surface changes on Mars and other planetary bodies. Note this work was previously published in [9].

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Keywords: Mars, Change, Detection



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Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

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On present-day Mars, pure liquid water is thermodynamically unstable; whereas, high-salinity brine can exist on the surface, at least temporally, due to freezing point depression [1]. Deliquescence and melting of subsurface ice are proposed as being the major processes of formation of liquid brine on Mars [2, 3]. Although liquid brine is suggested to form upon Mars' daily and seasonal changes [2, 3], generation of brine flow has not been confirmed on current Mars. Our previous study suggests that cycles of formation and evaporation of liquid brine can generate characteristic morphological features of downward-elongated flows on steep slopes [4]. This happens because precipitated salts within soil dramatically decrease the porosity and permeability, leading generation of surface flows [4]. Our study also suggests that precipitation of salts reaches up to ~30% in volume within the soil, implying that any detection of such salt may be evidence for the occurrence of brine flow on current Mars [4]. Proposed morphological features formed by current brine activity include recurring slope lineae (RSL) [5, 6]. Although hydrated salts are suggested to exist on RSL at a few locations [6], identification of salt compositions is still challenging. Additionally, there are no reports on detection of hydrated salts at most of the RSL sites across Mars.

In the present study, we investigate the conditions of identification of hydrated salt compositions on RSL using Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboarded on Mars Reconnaissance Orbiter (MRO). We calculate synthesized spectra of mixtures of basaltic soil and various hydrated salts (such as $MgCl_2 \cdot 2H_2O$) with the different mixing ratios using a linear combination method and an addition of random noise with a Gaussian distribution. We evaluate the threshold mixing ratios of salt for the identification of the salt compositions based on the analyses of the synthesized spectra. Our results show that if the mixing ratio of hydrated salt exceeds 20% in volume, O-H bands attributed from hydrated salts can be detected with CRISM. We discuss the observational conditions, such as the observational altitude from the surface, for the identification of salt compositions on RSL in future missions.

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キーワード：火星、CRISM、塩
Keywords: Mars, CRISM, salt

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火星パヴォニス山に記録された氷床の周期的成長
Frequency of ice sheet growth recorded on Mons Pavonis, Mars

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現在の火星において、多量の水氷は極域においてしか観測されていないが、かつて氷体が存在したことを示唆する地形として中緯度帯ではLDA、LVF、CCFが挙げられている（Levy et al., 2014）。また、低緯度帯ではタルシス地域の3つの楯状火山の北西麓に発達する扇状堆積物がそれに相当すると考えられている（例えば、Fastook et al., 2008）。

タルシス三山の扇状堆積物は、山体から西または北西方向に100～500 km程度の範囲の平地に広がる特徴的な地形で、山側から平滑な丘陵であるSmooth Facies、数100 m程度の小丘が密集するKnobby Facies、何本もの線状の隆起地形（以下、モレーン状地形）が平行に発達するRidged Faciesに分類される。特にアルシア山（Kadish et al., 2014）、パヴォニス山（Shean et al., 2005）では扇端に多数のモレーン状地形が見られるが、これらはかつて山麓に発達していた氷床の広がりを示すモレーンであると解釈されてきた。このように、数十kmにわたって氷床の消長を記録すると見られる地形はアルシアおよびパヴォニス山に特徴的である。

これらの氷河性と推定される地形は、かつて火星の地軸傾斜角が十分に大きかった時代に形成されたと考えられている。火星においては、地軸傾斜角は地球のそれと比べて大きく変動しており、過去2千万年のあいだには最大で45˚に達していたと考えられている（Laskar et al., 2004）が、このとき高緯度域での日射量が増大し、極冠が昇華して大気中の水蒸気量が現在よりも多かったことが想定される。モデル計算によると、現在の地軸傾斜角（25.2˚）における火星の表層環境では水の氷は緯度40˚以上でのみ安定して存在できるが、地軸傾斜角が32.3˚を超えると大気中の水蒸気量が十分に多くなり、全球にわたって水の氷が存在できるようになる（Mellon & Jakosky, 1995）。そこで、地軸傾斜角が大きかった時代に中・低緯度域で水氷が堆積したとして「氷期」の存在が提唱されている（Head et al., 2003）。

タルシス三山の山麓における氷床の消長が軌道傾斜角の変動に伴う気候変動を示すものであったとすれば、これらモレーン状地形のそれぞれが1つの古気候サイクルに対応することになる。しかし、その間隔や規模の変動、そして軌道要素の変動との対応関係についてはこれまで検討されてこなかった。そこで本研究では、モレーン状地形の分布を氷床の広がりと関連付けるための基礎検討として、パヴォニス山において扇状堆積物周縁部のDEMデータをCTX画像より作成し、それを用いてそれぞれのモレーン状地形の間隔、断面積を測定したほか、地形断面図を周期解析した。

結果として、モレーン状地形の間隔は数百mから4.5 kmと大きく変動しており、モレーン状地形の分布の疎密が明らかになった。また、モレーンの断面積も1.4×10^4 m^2以下の範囲で大きく変動している。モレーンの分布の疎密および断面積の変動は、氷床の消長を引き起こしたイベントの発生頻度または氷床の拡大・縮小速度の変化を記録していると考えられる。タルシス地域で想定される、氷床の消長に関わる周期的なイベントとしては軌道要素の変化によるグローバルな気候変動と火山活動の盛衰が可能性として挙げられるが、特にグローバルな気候変動によることを示すには、隣接するアルシア山や軌道計算から推定される日射量変動との対比が必要である。そこで、本研究ではパヴォニス山のモレーン状地形の発生頻度を周期解析し、その結果について発表する。

キーワード：火星、火星の気候、タルシス地方、ミランコビッチサイクル
Keywords: Mars, Martian climate, Tharsis region, Milankovich cycle

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Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

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Past trial of direct detection of life on Mars by 1970's Viking mission ended up with a negative conclusion [1]. Whereas, numbers of new finding provided by Mars exploration missions in the last decade indicate that there are good reasons to perform another life detection program. The sensitivity of the gas chromatograph mass spectrometer onboard the Viking mission was not very high, and was not able to detect the microbes 10^6 cells in 1 gram clay [2,3]. Resent observations on Mars have found the evidences of past water activities. MSL Curiosity has found the temporal increase of methane concentration in Martian atmosphere [4]. The presence of reduced sulfur compound such as pyrite in Martian soil was also detected by MSL [5]. Methane and reduced sulfur compound can be the energy source to support the growth of chemoautotrophic microbes [6]. Possible presence of liquid water at Recurring Slope Lineae has been supported by the detection of hydrated salts [7]. The presence of organic compounds of Martian origin has been reported [8]. These evidences tend to support the possible presence of living microbes near the surface of Mars.

Physical and chemical limits for terrestrial life have been major foci in astrobiology [9], and are summarized in ref. [6]. Combining the environmental factors, anywhere in the Martian environment where we can find the three components, water molecules, reducing compounds and oxidative compounds could be an environment where life can be sustained for long periods of time, if other factors such as temperature, pressure, UV and other radiations permit [6]. Among these factors, most of the factors including ionic radiation, can be endured by terrestrial extremophiles. Only UV can kill the most UV-resistant microbes within minutes. However, UV can be shielded by a few centimeters soil layer. These evaluations lead to the conclusion that the Martian soil under a few cm can be the place to support the growth of microbes, if the water activity is higher than 0.6.

For exploring extant life on Mars, we have proposed to search cells from a depth of about 5 - 10 cm below the surface by the Life Detection Microscope (LDM) [6, 10]. LDM has the potential to detect single cells in the resolution of 1 micrometer and could detect less than 10^4 cells in 1 gram clay, which is much higher sensitivity than the instrument onboard Viking. We have developed the solution and combination of fluorescence pigments to detect organic compounds, and to differentiate organic compounds surrounded by membrane, which we think to be the most fundamental features that a cell should possess to constitute life. Our investigation goals are the followings. 1) Identify cell-like structure in which organic compounds are enveloped by membrane, which may represent Martian life. 2) Search for any type of organic compounds in Mars surface samples. The compounds include cells, other biological materials,

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and abiotic polycyclic aromatic hydrocarbon (PAH). 3) High-resolution characterization of regolith and dust particles. The current status of development of LDM will be presented.

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キーワード：蛍光顕微鏡、地球外生命
Keywords: fluorescent microscope, extraterrestrial life

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Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

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The VIS-NIR reflectance spectra observed during latest Mars orbiter missions are of high quality and cover the whole globe. Such data sets are very informative for understanding the materials and their distribution on the surface. Each mineral has unique absorption bands in the spectra. We can identify which minerals are present by comparing the absorption bands of the observed spectra with the known absorption bands in the spectra measured in laboratories. In the case of Mars, we can estimate the type and distribution of hydrous minerals which leads to important clues to understand the water environment.

However, the VIS-NIR spectral data observed on Mars are not well utilized among the community. There are huge volume of accumulated data due to an increasing number of missions and various kinds of instruments with higher accuracy. It is not easy to process huge data and understand the relevance of them visually and intuitively.

We develop a new Mars web-GIS application, "Red Ace", to view and download the Mars observation data, especially the VIS-NIR spectra (image cube data format), easily and intuitively. The Red Ace handles multiple kinds of observation data: the Compact Reconnaissance Imaging Spectrometers for Mars (CRISM) data, the Thermal Emission Imaging System (THEMIS) data and DEM (Digital Elevation Model) data at the same time. Additionally, we use the DEM data from the Mars Orbiter Laser Altimeter (MOLA) to display 3D map of Mars with the Red Ace.

The Red Ace is developed based on CesiumJS that is an open source JavaScript library for 2D/3D maps. The user can choose the dimension of the map. In the Red Ace, the spectral observation points are displayed on the surface image layers. When the user clicks any point on the footprint of the layer, the color of the selected footprint changes and the thumbnail image appears. When the user selects any pixel on the thumbnail image, the Red Ace provides reflectance spectral data and ancillary data as graphs and tables. In response to user operation, multiple kinds of spectral data are displayed on the same window. The Red Ace also provides band- ratio images of THEMIS. The user can download band-ratio images, spectral data and ancillary data as files of PNG, CSV, JSON, XLSX and PVL formats. The user can move the windows displaying thumbnail image and graph freely. In addition, the Red Ace provides the function to control the Mars base map changing the exaggeration of height of the Mars globe. The user can change the order of layers and transparency of layers arbitrarily. The user can also jump to the region of interest directly by setting the coordinates and the zoom level. The user can handle these functions smoothly.

In the case of THEMIS, published data from the mission data archive are not reflectance data but radiance data. Therefore, the Red Ace derives reflectance data from radiance data and ancillary data, in order to compare them with CRISM spectra observed in the same spot.
In this study, considering the portability and extension of the application, the Docker was used for the development environment. Docker is an open source software platform that allow the user to develop applications quickly using containers. JSON format is adopted for data handling to make it easier to add

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new observation data from new observation equipments in the future. In the JSON format, it is unnecessary to associate item order and item meaning. Hence, it has high reusability and freedom. In the Red Ace, by standardizing the structure of JSON format data in advance, it is possible to store and handle diverse data by using the same data structure.

キーワード：火星、分光データ、Web-GIS
Keywords: Mars, Spectral data, Web-GIS

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Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal

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Originally released in June, 2015 as a public outreach tool, Mars Trek is currently being enhanced to support site selection and analysis for upcoming human and robotic missions to Mars. Many new data products are being added, with emphasis on providing detailed information for proposed exploration zones. Data products can be loaded and even combined from many different instruments aboard many different Mars-orbiting spacecraft including Viking, Mars Global Surveyor, Mars Odyssey, Mars Reconnaissance Orbiter, and Mars Express. Users can download data products from Mars Trek and access metadata for each product. Web services and APIs allow other clients to access data from Mars Trek's servers. A standardized interface across the Trek portals provides for advanced 3D visualization and navigation. Standard keyboard gaming controls allow the user to maneuver a first-person visualization of "flying" across the surface of the Mars. User-specified bounding boxes can be used to generate STL and/or OBJ files to create physical models of surface features with 3D printers. A new VR capability allows users to generate their own virtual reality flyovers for any user-defined paths along the Mars' surface.

Mars Trek's power as a tool for education and outreach is exemplified by its being designated as key supporting infrastructure for NASA Science Mission Directorate's STEM Activation Initiative, and its serving of data to a growing community of digital planetariums.

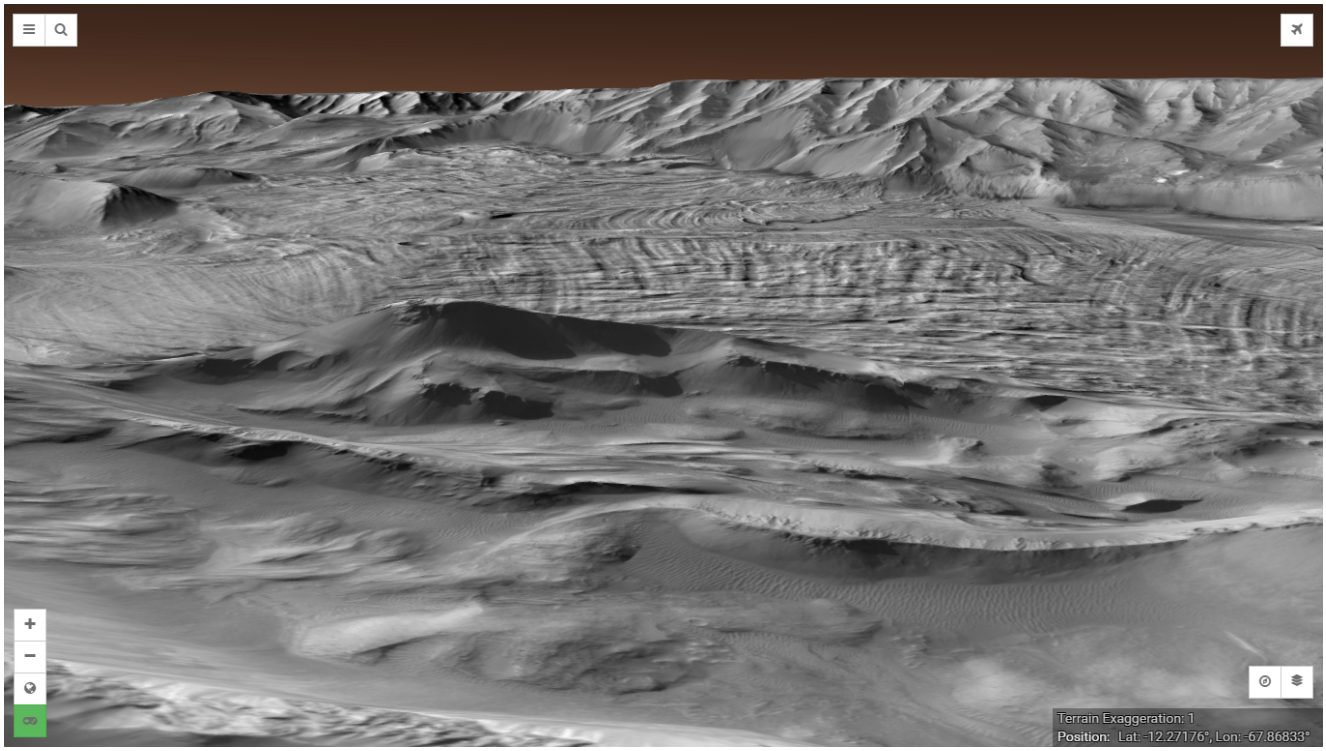
As private industry and space agencies of a growing number of nations plan new missions to Mars, detailed maps and models of Mars' surface and climate will be essential for mission planning. Mars Trek's generalized suite of tools are being designed to meet the needs of this new generation of missions. The portal will also provide an outstanding means of dissemination of data from these missions. Layering and blending many different data products and putting individual products in the context of many others will facilitate mining of information going far beyond what individual products can provide separately. In addition to mission planning and planetary science, Mars Trek will continue supporting the essential task of engaging the public in this great adventure. Mars Trek is developed at NASA's Jet Propulsion Laboratory (JPL) and managed as a project of NASA's Solar System Exploration Research Virtual Institute (SSERVI) at NASA Ames Research Center.

At the request of the Planetary Science Division of NASA's Science Mission Directorate, we are extending the technologies of our existing Trek platforms to create a new portal for Mars' largest moon, Phobos. In this effort, we are working with the International Phobos/Deimos Landing Site Working Group and with JAXA, with JAXA's MMX mission as a primary driver.
Mars Trek is one of the portals in the NASA Solar System Treks Project (SSTP), available at https://trek.nasa.gov. NASA's Solar System Trek online portals provide web-based suites of interactive data visualization and analysis tools to enable mission planners, planetary scientists, students, and the general public to access mapped data products from past and current missions for a growing number of planetary bodies including the Moon, Mars, Vesta, etc. These portals are being used for site selection and analysis by NASA and a number of its international partners, supporting upcoming missions. In addition to demonstrating the capabilities of Mars Trek in this presentation and providing a preview of Phobos Trek,

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we will solicit input from the community for ideas for future enhancements to the portals.

Keywords: Mars



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紫外線Ａ・Ｃよる鉄カンラン石からの鉄溶出量の増加
Increase in Dissolved Iron Concentration from Fayalite by UltravioletA・C Irradiation

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私は「酸素の乏しい火星の表面には酸化鉄が多いのはなぜか」という謎を調査するために、中学校での生徒実験を指導している。Ａ．S. Yen (1999)は,活性酸素種が火星の状況下で鉱物上で生じることを実験で示した。さらに、彼は空気中で鉄の薄膜に紫外線Cを照射放射 して、紫外線照射が 酸化物の生成率を上昇させることを示した。私の実験は、水中の鉄カンラン石に紫外線Cを照射すると鉄イオンの溶脱が促進されることを示したものであり、過去の火星と地球の活性酸素種以外の原因で、酸化鉄が紫外線によって発生する可能性があることを示している。

実験１

私は生徒に塩酸中に入れた鉄カンラン石に紫外線ＡとＣを照射させた。この研究では福島県川俣町産の鉄カンラン石を使用した。この鉄カンラン石は整形されておらず約1gであり、ｐＨ２の塩酸を充填した試験管に入れた。８０時間～１００時間程紫外線を照射後、デジタルパックテストで水溶液中の鉄イオン濃度を確認した。この紫外線Ａを用いた実験は７回行い、紫外線Ｃを用いた実験は３回行った。

紫外線Ａを用いた実験の結果、紫外線を照射しない場合よりも７回中６回照射した場合の方が鉄溶出量が多くなった。紫外線Ｃでの実験結果は３回中３回同じ結果となった。ブラックライトにより発生する紫外線Ａの波長のピークは３６５ｎｍである。殺菌灯により発生する紫外線Ｃの波長のピークは２４５ｎｍである。

実験2

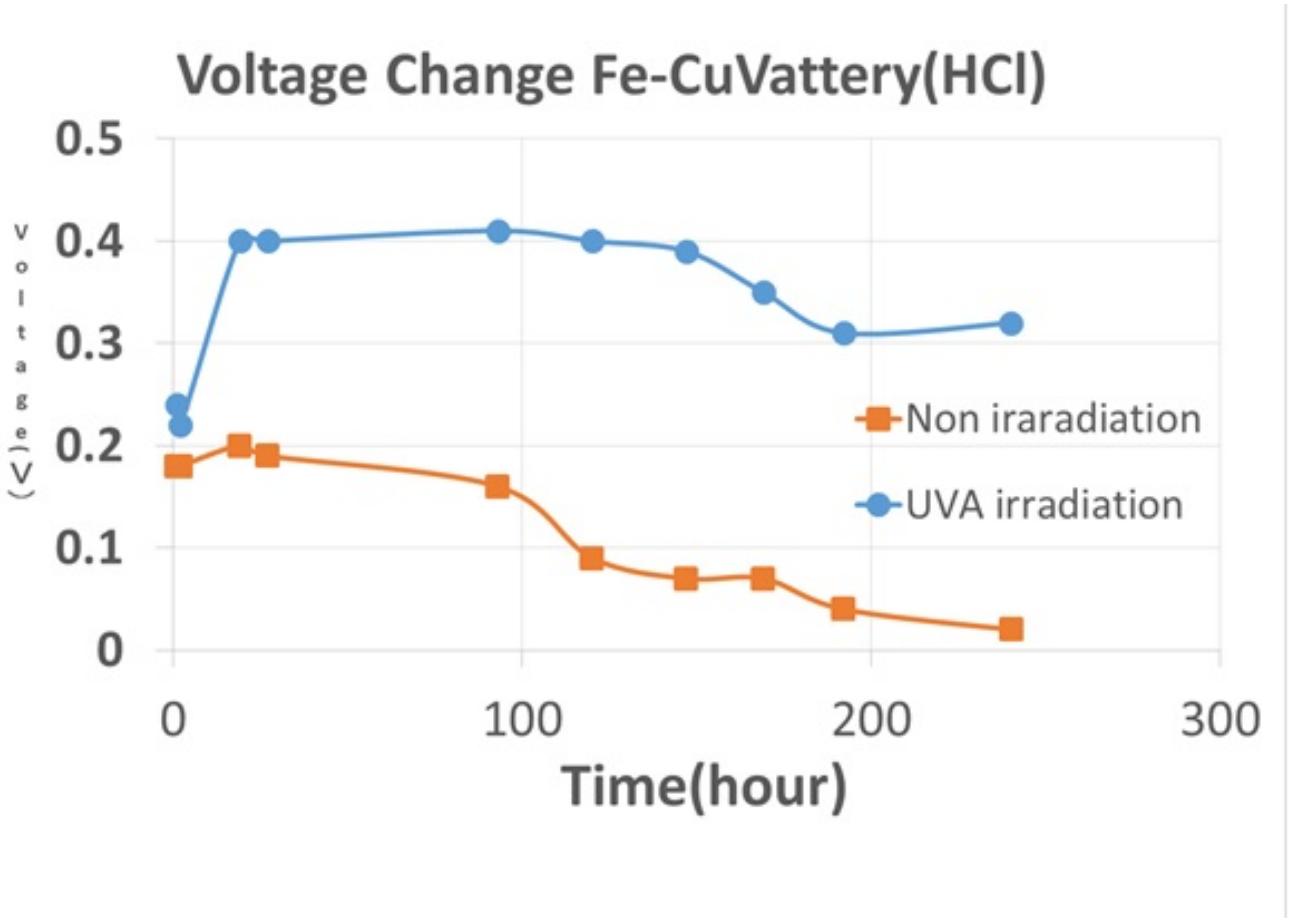
鉄陰極銅陽極を塩酸に入れた電池に紫外線Aを照射させた。そして生徒は電池の発生電圧を測定し、紫外線照射と非照射の電圧を比較した。この紫外線を照射した電池では、電圧は常に0.2V以上であり150時間後に低下することはなかった。もう一方の紫外線を照射されていない電池の電圧は少しずつ低くなり、１５０時間後に電圧は０Ｖに近くなった。この実験は４回行った。すべての場合において、紫外線を照射した電池の電圧は照射していない電池よりも高かった。紫外線のエネルギーにより鉄原子から電子が解離し、鉄イオンが発生するように思われる。

考察

私の実験結果から、紫外線は鉄カンラン石と鉄からの鉄イオンの溶解を促進すると推定する。火星表面にはかつて水が存在していたと考えらており，そこに紫外線が照射されると岩石中の鉄の溶解が促進され，それが酸化鉄の起源の一つとなった可能性がある．

キーワード：紫外線、鉄カンラン石、塩酸、鉄イオン、溶出量増加
Keywords: ultraviolet rays, fayalite , hydrochloric acid, iron, elution increase

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Small-scale ridges newly identified on the equatorial region of the Phobos nearside

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Although the craters and grooves on Phobos are indicative of widespread and abundant surface modification during Phobos' geologic history [Basilevsky et al., 2014], little definitive evidence exists for geologically recent regolith migration other than down-slope mass-wasting [Shi et al., 2016]. Here we report newly found small-scale sinuous ridges identified in Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE [McEwen et al., 2007]) images of the nearside of Phobos. These ridges are spatially focused within the equatorial region (-5° to 20° N). Some of them superpose on craters and grooves, which is consistent with a geologically recent activity. They are ~200 m to ~1 km in length, several 10's m in width, and most of them are roughly parallel to each other and are generally oriented in NE-SW direction. To extract detailed topographic profiles, we constructed a high-resolution (~5-6 m/pixel; almost same as the original image) digital elevation model (DEM) by using shape-from-shading [Alexandrov and Beyer, 2018] in the selected regions of a HiRISE image and a stereo-derived HiRISE DEM (20 m/pixel) [Hemmi and Miyamoto, 2019]. Our preliminary analysis shows these ridges are less than several meters high. Their morphology and topography are unlikely to be formed by impact cratering, extensional stress fields, or mass wasting processes. In this presentation, we provide initial results of geological mapping of the small-scale ridges and discuss their possible origins.

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キーワード：フォボス、HiRISE、数値標高モデル
Keywords: Phobos, HiRISE, Digital Elevation Model

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火星探査機搭載を目指した超小型ミュオグラフィー装置の開発
Development of a compact Muography instrument for future Mars exploration missions

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Muography is a technique that uses cosmic ray muons for visualizing the interior of large-scale structures in much the same way as standard X-ray radiography is used to image the interior of smaller objects. Muography has been successfully applied to explore the internal structure of geological targets on earth. Because exploring the inner structure of the shallow subsurface of celestial bodies is important to understand their origin and evolution, we are planning to operate muography instrument in the extraterrestrial environment, especially on the surface of Mars. Applying muography to planetary explorations has some advantages over conventional internal exploration methods: (1) it is able to observe the absolute linear density of objects; (2) the passive nature of the measurements provides low power consumption; (3) the instrument size is arbitral [1]. However, in order to mount muography instrument on a spacecraft, it is essential to downsize the instrument and investigate the radiation environment on the surface of the celestial body. In this study, we designed and developed a compact muography instrument based on the knowledge of compact gamma ray detectors for nuclear medicine imaging. At the same time, we theoretically estimated the muon production on Mars and evaluated the validity of using muography instrument on Mars.

The detection device of developing muography instrument consists of 64-channel silicon photomultipliers (SiPM), plastic scintillators, dynamic Time-Over-Threshold (dTOT) boards [2], data-acquisition (DAQ) board, and high-voltage power supply units. Incident muons react with the scintillator to emit weak light, and the light is amplified by SiPM attached to the both ends of the scintillator and read out with dTOT boards. The depth of interaction (DOI) in the scintillator is analyzed by measuring the pulse-height ratio of dual-sided readout. The size of the detector is 26.2 mm×26.2 mm×31.4 mm.

We first evaluated DOI resolution of this detector using a point beta-decay source of ^{90}Sr. The result indicates that the DOI resolution (FWHM) is 7.2 mm for the emitted beta rays with a spread of 2.2 mm. Then, we performed a Geant4 [3] simulation to examine the muon angular distribution that would be detected on the ground by this instrument. The result suggests that the structure of the detector makes the observation bias (Fig. 1). There are two solutions that can be considered to solve this problem: (1) developing one more detector and analyzing the coincident signals from dual-sided readout; (2) improving DOI resolution by performing accurate calibration.

We also performed a theoretical estimation to evaluate the muon production on Mars. Although the chemical composition and the density of Martian atmosphere are different from Earth's, the known muon flux in the upper earth atmosphere can be used for estimating the muon rates on Mars [4]. The result shows that the horizontal muon flux is greater than that on Earth (Fig. 2), which means that muography is more suitable for exploration of geological targets on Mars than on Earth.

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In this presentation, we report the development status of the detection device and the concrete result of numerical calculation of radiation environment on Mars.

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キーワード：ミュオグラフィー、ミューオン、内部構造探査、火星探査
Keywords: Muography, Muon, Internal exploration, Mars exploration

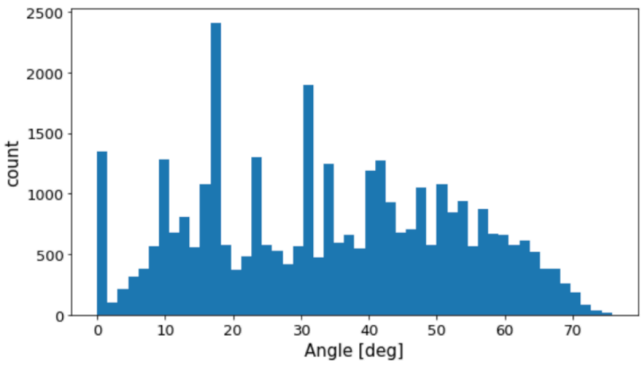


Fig. 1 The simulation result of muon zenith angular distribution that would be detected by developing instrument. The structure of detector makes the observation bias at 0°, 17° and 31°.

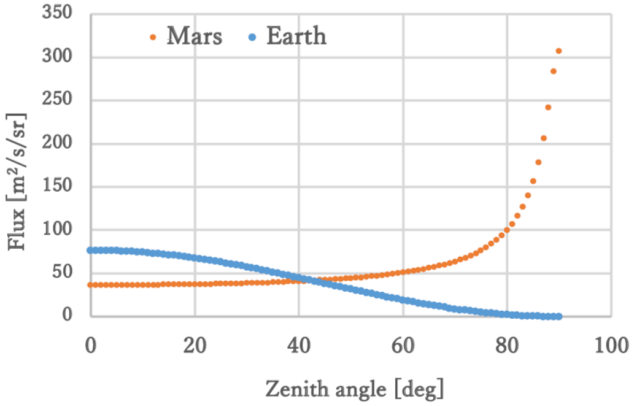


Fig. 2 Zenith angle dependence of muon flux on Mars and Earth. Horizontal muon flux on Mars is greater than that on Earth.

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[E] ポスター発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_4

[P-PS04] 火星と火星圏の科学

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

In view of unprecedented advances in our understanding of Mars, primarily due to new and ongoing observations of the planet with a number of spacecraft missions of the US, Europe and Asia, we propose a session on Mars. Mars is an object of intense scrutiny. Currently, eight spacecraft are operating at Mars, with six in orbit (Odyssey, MRO, MAVEN, Mars Express, Mangalyaan and TGO) and two on the surface (MSL-Curiosity and MER-Opportunity), the largest number ever at any given time. In addition, InSight is on track to land on Mars in November 2018, and several spacecraft are in various stages of implementation with launches scheduled for 2020 (Mars 2020, ExoMars 2020, Emirates Mars Mission Hope, Chinese Mars Mission and the Japanese Mars Terahertz Microsatellite), 2022 (ISRO's Mangalyaan 2), and 2024 (JAXA's MMX mission to explore Phobos, Deimos, and Mars). All this is a clear demonstration of public's strong fascination with and commitment to Mars exploration and the resulting scientific bonanza. Synergistic investigations with ongoing and already completed missions along with modeling studies and earth-based observations are gradually revealing the nature of Earth's most closely resembling planet that took on a different evolutionary track than our home planet. Morphology and variable phenomena seen on the surface (RSLs, e.g.) and in the atmosphere (methane) indicate that Mars is possibly currently active. Available data are providing a better understanding of Mars' present geologic and atmospheric state, climate evolution, and habitability. Thus, the scope of this session will be the recent results from a broad spectrum of Mars studies encompassing the interior, surface, atmosphere, plasma environment, and the Mars system including its two satellites. Abstracts on modelling, instrumentation and future mission plans are also encouraged.

[PPS04-P01] ハレアカラT60望遠鏡可視分光器による火星電離圏のO_2^+発光の観測

*鈴木 駿久[1]、鍵谷 将人[1]、坂野井 健[1] (1.東北大学理学研究科，惑星プラズマ・大気研究センター)

[PPS04-P02] Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

*大浦 愛菜[1]、笠羽 康正[1]、熊本 篤志[1]、野口 里奈[2]、臼井 寛裕[2]、石山 謙[2]、植村 千尋[3] (1.東北大学、2.宇宙科学研究所、3.総合研究大学院大学)

[PPS04-P03] Detecting surface changes on Mars using principle component analysis of repeat imagery

*Reid Parsons[1]、Hideaki Miyamoto[1] (1.University of Tokyo)

[PPS04-P04] Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

*今村 翔子[1,2]、関根 康人[2]、黒川 宏之[2] (1.東京大学、2.東京工業大学 地球生命研究所)

[PPS04-P05] 火星パヴォニス山に記録された氷床の周期的成長

*神崎 友裕[1]、Reid Parsons[1,2]、逸見 良道[1]、宮本 英昭[1] (1.東京大学、2.フィッチバーグ州立大学)

[PPS04-P06] Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

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

[PPS04-P07] Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

*松原 侑哉[1]、福地 裕範[1]、小川 佳子[1]、林 洋平[2] (1.公立大学法人会津大学、2.国立天文台)

[PPS04-P08] **Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal**

*Brian Hamilton Day[1]、Emily Law[2] (1.NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center、2.NASA Jet Propulsion Laboratory, California Institute of Technology)

[PPS04-P09] 紫外線Ａ・Ｃよる鉄カンラン石からの鉄溶出量の増加

*小森 信男[1] (1.東京学芸大学大学院連合学校教育学研究科)

[PPS04-P10] Small-scale ridges newly identified on the equatorial region of the Phobos nearside

*逸見 良道[1]、菊地 紘[1]、宮本 英昭[1] (1.東京大学)

[PPS04-P11] 火星探査機搭載を目指した超小型ミュオグラフィー装置の開発

*上吉原 弘明[1]、二宮 哲郎[1]、吉原 有里[1]、島添 健次[1]、高橋 浩之[1]、田中 宏幸[1]、宮本 英昭[1] (1.東京大学)

ハレアカラT60望遠鏡可視分光器による火星電離圏のO_2^+発光の観測
Observation of the O_2^+ first negative band (1,0) emissions in the Mars ionosphere with a visible spectrograph on Haleakala T60

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*Toshihisa Suzuki[1], Masato Kagitani[1], Takeshi Sakanoi[1]

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本研究では，火星の大気散逸機構を探るために火星電離圏のO_2^+の発光の検出を目的として，初めて地上望遠鏡による分光観測を行った．分光観測後に整合的な解析を行い，その結果O_2^+ first negative bands (1NG) (1, 0)の発光を検出することができた．また，それよりO_2^+の発光強度と柱密度を導出した．

現在の火星の大気は地球と比べて希薄である．これは宇宙空間への大気の散逸が関与しており，長年の変化により大気が失われていったためであると考えられている．また，現在の火星はダイナモ運動による両極性磁場を持たず一部に弱い磁場が残っているのみであるため，火星上層大気の宇宙空間への散逸は太陽風の影響を強く受けると考えられる．近年，MAVEN探査機などの様々な観測により火星電離圏のイオン組成や密度が調べられている．火星電離圏ではO_2^+が主なイオンであり，太陽直下点では高度130 kmで密度が最大となる[M. Benna et al., 2015]．このO_2^+が解離性再結合をする結果，脱出速度以上のエネルギーを持った中性酸素が生成され，火星の重力を振り切って宇宙空間に散逸していく．この過程は火星大気散逸の中でも重要な要素である．しかし，人工衛星で中性酸素を直接観測することは困難であるため，観測可能であるプラズマの温度や密度よりモデル計算が行われている．そのため，O_2^+をはじめとするイオンや電子の密度の空間分布や高度分布を知ることは宇宙空間への散逸量を知るために重要である．しかし，数百~数千kmでのイオンの散逸過程を調べるためには人工衛星でのその場観測のみでは不十分であり，撮像による全体像の把握を行うことは重要である．地上からの望遠鏡を用いた分光リモートセンシングにより，O_2^+の発光や温度の空間分布や時間変動を捉えることができれば，太陽風や地殻地場の変動が酸素原子やイオンの散逸過程へ与える影響を知ることが期待できる．

観測は2018年の9月10日から19日の間に，マウイ島ハレアカラ山頂の東北大学60cm望遠鏡(T60)に可視分光器を組み合わせて実施した． O_2^+の発光の中でもO_2^+ 1NG (1, 0)に着目し，550 –570 nmの範囲を波長分解能10,000で分光観測した．分光器のスリット(幅2”×長さ90”)は火星の昼半球のリム付近に火星の自転軸と平行に設置した．1フレームの積分時間は2分とし，1日あたり約60フレームを取得した．観測期間中の総積分時間は450分であった．火星の太陽反射スペクトルを参照するためのスペクトル（火星ディスクのスペクトル）もリム観測の前後で取得した．観測したフレームは，個々に1次解析処理（ダーク減算，フラットフィールド補正，波長・空間歪みの補正）を施した後，全フレームについて積算することでS/Nを向上させた．その後，同様の処理を施した太陽反射スペクトルをリム観測データから差し引き，O_2^+1NG (1, 0)のスペクトルを導出した．次に，観測から導出したO_2^+1NG (1, 0)スペクトルを，モデルスペクトル[K. Henriksen and L. Veseth, 1987]と比較した．この際，スペクトルの短周期波長変動について着目するために，観測から導出したO_2^+1NG (1, 0)スペクトルとモデルスペクトルの両方に波長分解能と整合的なハイパスフィルターを施した．その2つのスペクトルの相関係数を計算した結果，波長ずれ（lag）が0の位置で相関係数は最大となり，その値は0.40であった．ここで，相関をとる波長範囲はモデルスペクトルで発光量が大きく，かつ太陽フラウンホーファーの吸収線による影響が小さい部分を選択した．これらの結果から、本研究で火星リム観測による電離圏のO_2^+の発光を初めて検出したと考えられる。さらに，モデルスペクトルと観測での発光スペクトルで最小二乗法を用いて観測されたスペクトルを最も良く再現する明るさを決定した．その結果，見積もられたO_2^+1NG (1, 0)の発光強度は691 +/- 171 $\times 10^3$ Rayleighsとなった。発光機構として太陽共鳴散乱を仮定すると， O_2^+柱密度は4.4 +/- 1.1$\times 10^{13}$ /cm^{2}となった．これはMaven探査機により観測されたO_2^+の高度分布[M. Benna et al., 2015] をもとに全球一様球対称分布を仮定した場合に期待されるO_2^+柱密度よりも約5-10倍

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大きな値となった．本発表では，O_2^+の発光観測スペクトルとモデルスペクトルを比較し，それより発光量と密度を導出した．また，その結果についての考察を述べる．

キーワード：火星、電離圏、地上望遠鏡
Keywords: Mars, ionosphere, ground-based telescope

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Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

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One of recent discoveries on Mars is the recurring slope lineae (RSL), which are certain features on the surface invoking current icy processes. RSLs are distributed on Mars and these narrow features incrementally lengthen down steep slopes, fade in colder seasons, and recur annually. Candidate and confirmed RSL sites are distributed in four regions, (1) southern mid-latitudes (SML), (2) Valles Marineris (VM), (3) equatorial highlands, and (4) northern Chryse Planitia and southwestern Acidalia Planitia (CAP). The RSLs in (2) VM and (4) CAP are more densely located than other two areas.
This study tries to identify the subsurface structures of the northern mid-latitude RSL in (4) Chryse and Acidalia Planitiae by the public data of Mars shallow radar sounder (SHARAD) onboad the Mars Reconnaissance Orbiter opened on the PDS Geosciences Node. That is because CAP RSLs are densely distributed compared to other regions. CAP RSLs are found on the steep slopes of craters. Their source zones are at or below the elevation of the surrounding plains. We used the Java Mission-planning and Analysis for Remote Sensing (JMARS, https://jmars.asu.edu/) in order to investigate the geological information of the RSL sites and the MRO locations at the SHARAD observed data. We then picked up the location correspond to the RSL sites and generated radargrams from SHARAD data. The observation frequency of SHARAD is 15-25 MHz with the bandwidth of 10 MHz, and the subsurface close to the surface can potentially be resolved with the depth resolution of 15 m in vacuum. Using MOLA data, we generated the virtual radargrams with the surface clutter emulated by the Kirchhoff approximation. Then, we compared both observed radargrams with emulated ones to identify whether there are subsurface reflectors or not.
We surveyed about 12 orbits close to the confirmed RSLs. We could find the hypothetical detection of the subsurface reflector in ‘orbit.00688101’ (Jan 14 2008, N10.0-44.7˚, E313.6-318.3˚) and ‘orbit.00673602’ (Jan 03 2008, N10.1-44.7˚, E312.7-317.4˚). In this abstract, we concentrated the characteristics of the former candidate. In this sample, the closest RSL located at N34.1˚, E317.0˚ and nadir line from the orbit was 13.8 km. Another RSL close to this orbit located N34.8˚, E318.6˚ and nadir line from the orbit was 85.2 km. Apparent elevation of closest RSL was about -3,763 ±10 m. The deepest elevation of the crater was about -4,744 ±10 m and the highest elevation of it was about -3,640 ±10 m. The radargram of this orbit showed that the elevation of surface echo was in the range from -3720 to -3780 m and that of subsurface echo ranged from -3750 to -3800 m. This means that the closest RSL height was almost the same as the depth of subsurface reflector. The subsurface echo located 25 m below the surface, and it had a little bit weak echo strength compared to surface one. If this subsurface echo shows the underground reflection, the subsurface layer will be 180 km wide along the orbit. Although this depth is marginal for the depth resolution of SHARAD, we could not identify such an echo in the emulated radargram.
In the presentation, we will summarize the results of this region including other orbits.

キーワード：火星、RSL、SHARAD

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Keywords: Mars, RSL, SHARAD

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Detecting surface changes on Mars using principle component analysis of repeat imagery

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Change detection is an analytical tool of Remote Sensing in which repeat observations of a particular location can be overlain, subtracted, or ratioed to detect differences between images. High-resolution, repeat imagery on Mars has led to several discoveries of ongoing geologic processes operating at the sub-kilometer scale such as recurring slope lineae (RSL) [1-3], new, small impacts [4], aeolian dune migration [5], sublimation of polar ice [6], and gully formation [7]. Generally, the detection of these changes is done manually by overlaying, and “flipping” between the two images. As planetary remote sensing data sets continue to grow, so does the need for a more efficient means of change detection.

Principle component analysis (PCA) offers an advantageous means for detecting change because it considers the values of all pixels in all the repeat images to extract the most statistically significant variations. These variations are then isolated from one another as a hierarchical set of “principle components” of the image dataset. The user can quickly identify patterns or features of interest which are present in one or more of these components. To illustrate this method, nine HiRISE images [8] collected from Palikir crater on Mars between November 2007 and June 2011 documenting RSL formation will be used.

PCA changes the values of the pixels in each image by plotting the pixel data on a set of axes which capture the maximum variance in the dataset. In our example image set, each pixel in the image stack can be treated as a 9-dimensional vector since there is a value for that pixel in each of the nine images. However, each pixel can be plotted on a new set of axes that capture the most important, or PCs of the image stack.

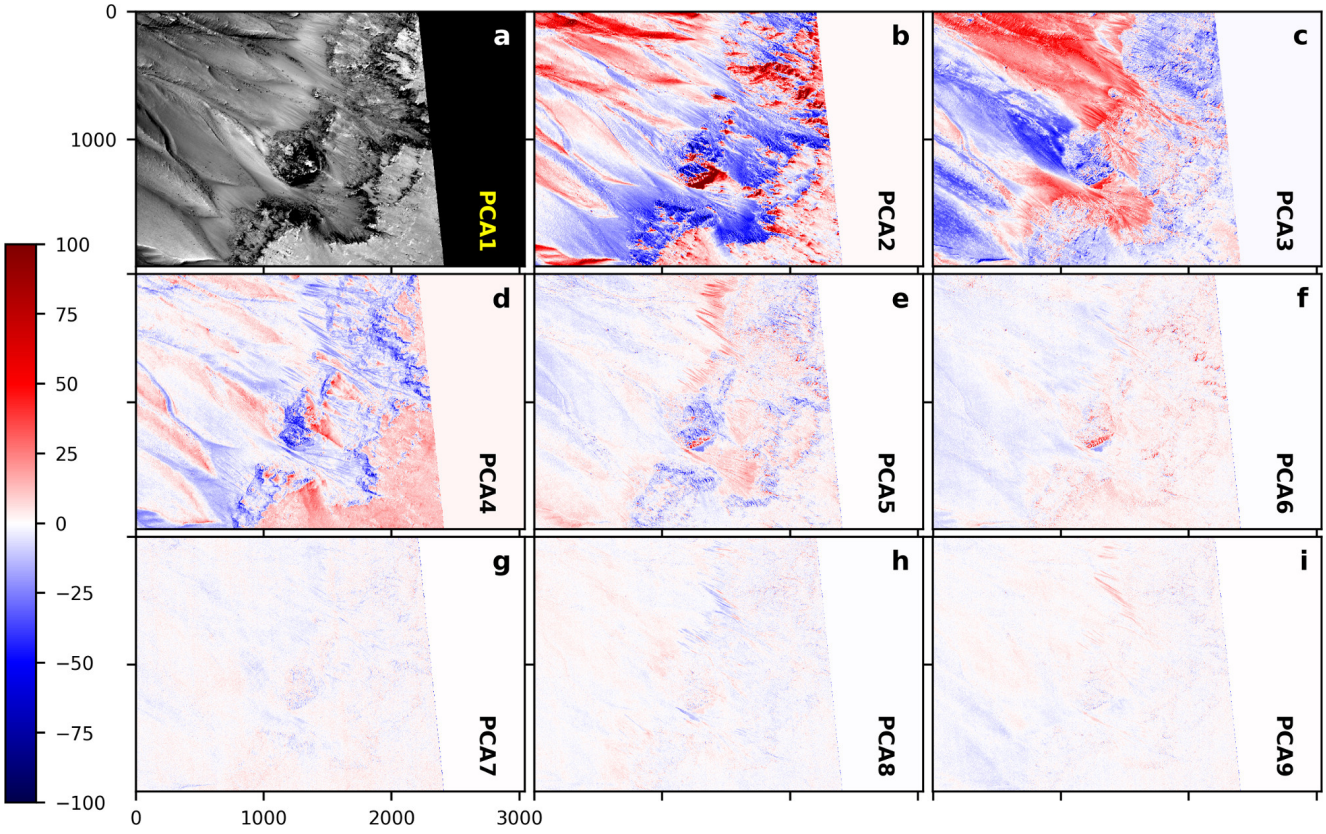
The figure shows the result of the PC transform (performed using ENVI® software) on the stacked time-series. Because most of the variation in the images is captured in the first PC (PCA1), it uses a grayscale color bar spanning 0-255 pixel values. Generally, variations covering a large spatial extent or variations causing a big shift in pixel values will be captured in the lower PCA components. Higher components, on the other hand, will depict smaller amplitude variations occurring in fewer images (or over smaller spatial extents). Thus, components 2 and 3 (panels b and c, respectively) are dominated by variations caused by differences in lighting (sun direction and elevation angle) and possibly dust or frost deposition/erosion. RSL features are identifiable in PCA4 (panel d) as elongated blue “fingers” and become more dominant and appear red in PCA5 (panel e). Subsequent components capture smaller variations caused either by changes in lighting, RSL shape (in PCA 8 and 9), or camera noise.

After identifying the PCs which contain the feature of interest, the feature can be traced back to the original images via an inverting from PC coordinates to image coordinates. Although this step is not completely reliable, it is successful in determining which images contain the most prominent RSL. Eventual combination of this method with machine-learning algorithms may permit a more automated means of detecting interesting surface changes on Mars and other planetary bodies. Note this work was previously published in [9].

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https://www.uahirise.org/dtm/dtm.php?ID=PSP_005943_1380 accessed: 2017-07-03
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Keywords: Mars, Change, Detection



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Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

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On present-day Mars, pure liquid water is thermodynamically unstable; whereas, high-salinity brine can exist on the surface, at least temporally, due to freezing point depression [1]. Deliquescence and melting of subsurface ice are proposed as being the major processes of formation of liquid brine on Mars [2, 3]. Although liquid brine is suggested to form upon Mars' daily and seasonal changes [2, 3], generation of brine flow has not been confirmed on current Mars. Our previous study suggests that cycles of formation and evaporation of liquid brine can generate characteristic morphological features of downward-elongated flows on steep slopes [4]. This happens because precipitated salts within soil dramatically decrease the porosity and permeability, leading generation of surface flows [4]. Our study also suggests that precipitation of salts reaches up to ~30% in volume within the soil, implying that any detection of such salt may be evidence for the occurrence of brine flow on current Mars [4]. Proposed morphological features formed by current brine activity include recurring slope lineae (RSL) [5, 6]. Although hydrated salts are suggested to exist on RSL at a few locations [6], identification of salt compositions is still challenging. Additionally, there are no reports on detection of hydrated salts at most of the RSL sites across Mars.

In the present study, we investigate the conditions of identification of hydrated salt compositions on RSL using Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboarded on Mars Reconnaissance Orbiter (MRO). We calculate synthesized spectra of mixtures of basaltic soil and various hydrated salts (such as $MgCl_2 \cdot 2H_2O$) with the different mixing ratios using a linear combination method and an addition of random noise with a Gaussian distribution. We evaluate the threshold mixing ratios of salt for the identification of the salt compositions based on the analyses of the synthesized spectra. Our results show that if the mixing ratio of hydrated salt exceeds 20% in volume, O-H bands attributed from hydrated salts can be detected with CRISM. We discuss the observational conditions, such as the observational altitude from the surface, for the identification of salt compositions on RSL in future missions.

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キーワード：火星、CRISM、塩
Keywords: Mars, CRISM, salt

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火星パヴォニス山に記録された氷床の周期的成長
Frequency of ice sheet growth recorded on Mons Pavonis, Mars

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現在の火星において、多量の水氷は極域においてしか観測されていないが、かつて氷体が存在したことを示唆する地形として中緯度帯ではLDA、LVF、CCFが挙げられている（Levy et al., 2014）。また、低緯度帯ではタルシス地域の3つの楯状火山の北西麓に発達する扇状堆積物がそれに相当すると考えられている（例えば、Fastook et al., 2008）。

タルシス三山の扇状堆積物は、山体から西または北西方向に100～500 km程度の範囲の平地に広がる特徴的な地形で、山側から平滑な丘陵であるSmooth Facies、数100 m程度の小丘が密集するKnobby Facies、何本もの線状の隆起地形（以下、モレーン状地形）が平行に発達するRidged Faciesに分類される。特にアルシア山（Kadish et al., 2014）、パヴォニス山（Shean et al., 2005）では扇端に多数のモレーン状地形が見られるが、これらはかつて山麓に発達していた氷床の広がりを示すモレーンであると解釈されてきた。このように、数十kmにわたって氷床の消長を記録すると見られる地形はアルシアおよびパヴォニス山に特徴的である。

これらの氷河性と推定される地形は、かつて火星の地軸傾斜角が十分に大きかった時代に形成されたと考えられている。火星においては、地軸傾斜角は地球のそれと比べて大きく変動しており、過去2千万年のあいだには最大で45˚に達していたと考えられている（Laskar et al., 2004）が、このとき高緯度域での日射量が増大し、極冠が昇華して大気中の水蒸気量が現在よりも多かったことが想定される。モデル計算によると、現在の地軸傾斜角（25.2˚）における火星の表層環境では水の氷は緯度40˚以上でのみ安定して存在できるが、地軸傾斜角が32.3˚を超えると大気中の水蒸気量が十分に多くなり、全球にわたって水の氷が存在できるようになる（Mellon & Jakosky, 1995）。そこで、地軸傾斜角が大きかった時代に中・低緯度域で水氷が堆積したとして「氷期」の存在が提唱されている（Head et al., 2003）。

タルシス三山の山麓における氷床の消長が軌道傾斜角の変動に伴う気候変動を示すものであったとすれば、これらモレーン状地形のそれぞれが1つの古気候サイクルに対応することになる。しかし、その間隔や規模の変動、そして軌道要素の変動との対応関係についてはこれまで検討されてこなかった。そこで本研究では、モレーン状地形の分布を氷床の広がりと関連付けるための基礎検討として、パヴォニス山において扇状堆積物周縁部のDEMデータをCTX画像より作成し、それを用いてそれぞれのモレーン状地形の間隔、断面積を測定したほか、地形断面図を周期解析した。

結果として、モレーン状地形の間隔は数百mから4.5 kmと大きく変動しており、モレーン状地形の分布の疎密が明らかになった。また、モレーンの断面積も1.4×10^4 m^2以下の範囲で大きく変動している。モレーンの分布の疎密および断面積の変動は、氷床の消長を引き起こしたイベントの発生頻度または氷床の拡大・縮小速度の変化を記録していると考えられる。タルシス地域で想定される、氷床の消長に関わる周期的なイベントとしては軌道要素の変化によるグローバルな気候変動と火山活動の盛衰が可能性として挙げられるが、特にグローバルな気候変動によることを示すには、隣接するアルシア山や軌道計算から推定される日射量変動との対比が必要である。そこで、本研究ではパヴォニス山のモレーン状地形の発生頻度を周期解析し、その結果について発表する。

キーワード：火星、火星の気候、タルシス地方、ミランコビッチサイクル
Keywords: Mars, Martian climate, Tharsis region, Milankovich cycle

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Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

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Past trial of direct detection of life on Mars by 1970's Viking mission ended up with a negative conclusion [1]. Whereas, numbers of new finding provided by Mars exploration missions in the last decade indicate that there are good reasons to perform another life detection program. The sensitivity of the gas chromatograph mass spectrometer onboard the Viking mission was not very high, and was not able to detect the microbes 10^6 cells in 1 gram clay [2,3]. Resent observations on Mars have found the evidences of past water activities. MSL Curiosity has found the temporal increase of methane concentration in Martian atmosphere [4]. The presence of reduced sulfur compound such as pyrite in Martian soil was also detected by MSL [5]. Methane and reduced sulfur compound can be the energy source to support the growth of chemoautotrophic microbes [6]. Possible presence of liquid water at Recurring Slope Lineae has been supported by the detection of hydrated salts [7]. The presence of organic compounds of Martian origin has been reported [8]. These evidences tend to support the possible presence of living microbes near the surface of Mars.

Physical and chemical limits for terrestrial life have been major foci in astrobiology [9], and are summarized in ref. [6]. Combining the environmental factors, anywhere in the Martian environment where we can find the three components, water molecules, reducing compounds and oxidative compounds could be an environment where life can be sustained for long periods of time, if other factors such as temperature, pressure, UV and other radiations permit [6]. Among these factors, most of the factors including ionic radiation, can be endured by terrestrial extremophiles. Only UV can kill the most UV-resistant microbes within minutes. However, UV can be shielded by a few centimeters soil layer. These evaluations lead to the conclusion that the Martian soil under a few cm can be the place to support the growth of microbes, if the water activity is higher than 0.6.

For exploring extant life on Mars, we have proposed to search cells from a depth of about 5 - 10 cm below the surface by the Life Detection Microscope (LDM) [6, 10]. LDM has the potential to detect single cells in the resolution of 1 micrometer and could detect less than 10^4 cells in 1 gram clay, which is much higher sensitivity than the instrument onboard Viking. We have developed the solution and combination of fluorescence pigments to detect organic compounds, and to differentiate organic compounds surrounded by membrane, which we think to be the most fundamental features that a cell should possess to constitute life. Our investigation goals are the followings. 1) Identify cell-like structure in which organic compounds are enveloped by membrane, which may represent Martian life. 2) Search for any type of organic compounds in Mars surface samples. The compounds include cells, other biological materials,

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and abiotic polycyclic aromatic hydrocarbon (PAH). 3) High-resolution characterization of regolith and dust particles. The current status of development of LDM will be presented.

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キーワード：蛍光顕微鏡、地球外生命
Keywords: fluorescent microscope, extraterrestrial life

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Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

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The VIS-NIR reflectance spectra observed during latest Mars orbiter missions are of high quality and cover the whole globe. Such data sets are very informative for understanding the materials and their distribution on the surface. Each mineral has unique absorption bands in the spectra. We can identify which minerals are present by comparing the absorption bands of the observed spectra with the known absorption bands in the spectra measured in laboratories. In the case of Mars, we can estimate the type and distribution of hydrous minerals which leads to important clues to understand the water environment.

However, the VIS-NIR spectral data observed on Mars are not well utilized among the community. There are huge volume of accumulated data due to an increasing number of missions and various kinds of instruments with higher accuracy. It is not easy to process huge data and understand the relevance of them visually and intuitively.

We develop a new Mars web-GIS application, "Red Ace", to view and download the Mars observation data, especially the VIS-NIR spectra (image cube data format), easily and intuitively. The Red Ace handles multiple kinds of observation data: the Compact Reconnaissance Imaging Spectrometers for Mars (CRISM) data, the Thermal Emission Imaging System (THEMIS) data and DEM (Digital Elevation Model) data at the same time. Additionally, we use the DEM data from the Mars Orbiter Laser Altimeter (MOLA) to display 3D map of Mars with the Red Ace.

The Red Ace is developed based on CesiumJS that is an open source JavaScript library for 2D/3D maps. The user can choose the dimension of the map. In the Red Ace, the spectral observation points are displayed on the surface image layers. When the user clicks any point on the footprint of the layer, the color of the selected footprint changes and the thumbnail image appears. When the user selects any pixel on the thumbnail image, the Red Ace provides reflectance spectral data and ancillary data as graphs and tables. In response to user operation, multiple kinds of spectral data are displayed on the same window. The Red Ace also provides band- ratio images of THEMIS. The user can download band-ratio images, spectral data and ancillary data as files of PNG, CSV, JSON, XLSX and PVL formats. The user can move the windows displaying thumbnail image and graph freely. In addition, the Red Ace provides the function to control the Mars base map changing the exaggeration of height of the Mars globe. The user can change the order of layers and transparency of layers arbitrarily. The user can also jump to the region of interest directly by setting the coordinates and the zoom level. The user can handle these functions smoothly.

In the case of THEMIS, published data from the mission data archive are not reflectance data but radiance data. Therefore, the Red Ace derives reflectance data from radiance data and ancillary data, in order to compare them with CRISM spectra observed in the same spot.
In this study, considering the portability and extension of the application, the Docker was used for the development environment. Docker is an open source software platform that allow the user to develop applications quickly using containers. JSON format is adopted for data handling to make it easier to add

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new observation data from new observation equipments in the future. In the JSON format, it is unnecessary to associate item order and item meaning. Hence, it has high reusability and freedom. In the Red Ace, by standardizing the structure of JSON format data in advance, it is possible to store and handle diverse data by using the same data structure.

キーワード：火星、分光データ、Web-GIS
Keywords: Mars, Spectral data, Web-GIS

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Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal

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Originally released in June, 2015 as a public outreach tool, Mars Trek is currently being enhanced to support site selection and analysis for upcoming human and robotic missions to Mars. Many new data products are being added, with emphasis on providing detailed information for proposed exploration zones. Data products can be loaded and even combined from many different instruments aboard many different Mars-orbiting spacecraft including Viking, Mars Global Surveyor, Mars Odyssey, Mars Reconnaissance Orbiter, and Mars Express. Users can download data products from Mars Trek and access metadata for each product. Web services and APIs allow other clients to access data from Mars Trek's servers. A standardized interface across the Trek portals provides for advanced 3D visualization and navigation. Standard keyboard gaming controls allow the user to maneuver a first-person visualization of "flying" across the surface of the Mars. User-specified bounding boxes can be used to generate STL and/or OBJ files to create physical models of surface features with 3D printers. A new VR capability allows users to generate their own virtual reality flyovers for any user-defined paths along the Mars' surface.

Mars Trek's power as a tool for education and outreach is exemplified by its being designated as key supporting infrastructure for NASA Science Mission Directorate's STEM Activation Initiative, and its serving of data to a growing community of digital planetariums.

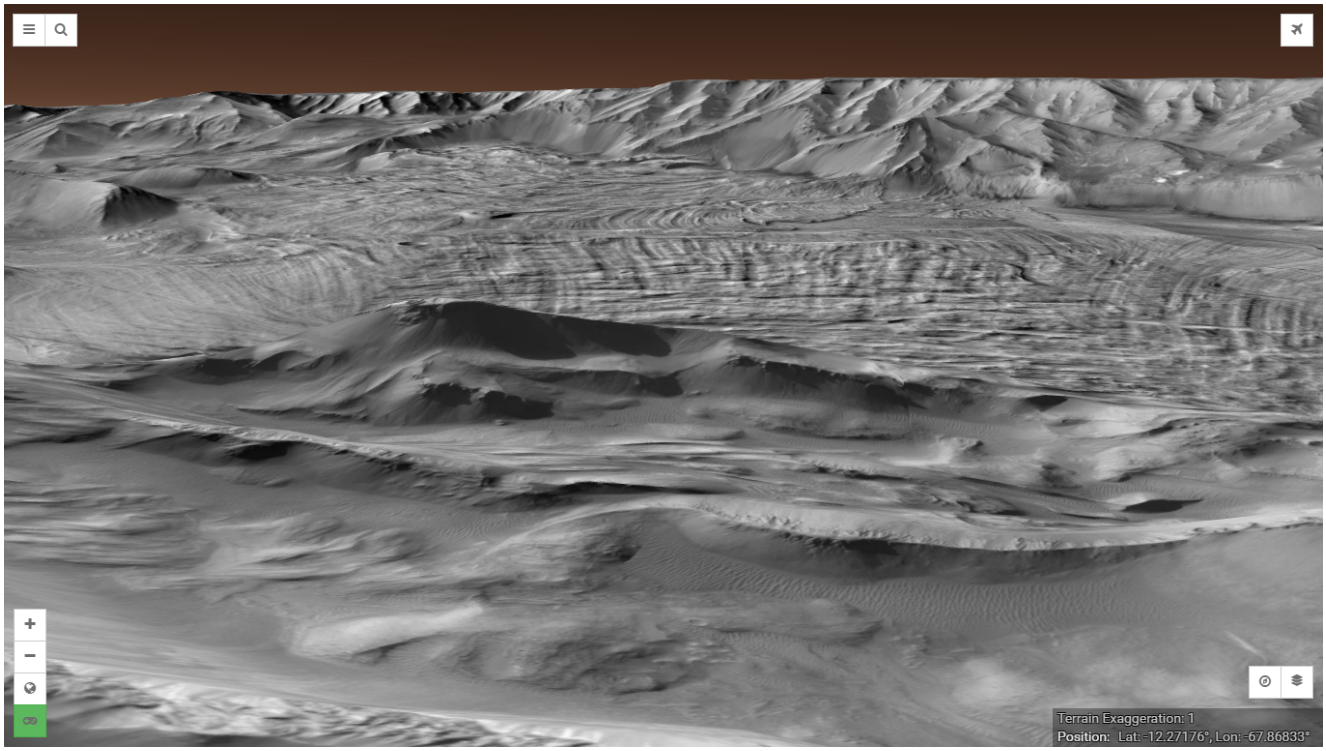
As private industry and space agencies of a growing number of nations plan new missions to Mars, detailed maps and models of Mars' surface and climate will be essential for mission planning. Mars Trek's generalized suite of tools are being designed to meet the needs of this new generation of missions. The portal will also provide an outstanding means of dissemination of data from these missions. Layering and blending many different data products and putting individual products in the context of many others will facilitate mining of information going far beyond what individual products can provide separately. In addition to mission planning and planetary science, Mars Trek will continue supporting the essential task of engaging the public in this great adventure. Mars Trek is developed at NASA's Jet Propulsion Laboratory (JPL) and managed as a project of NASA's Solar System Exploration Research Virtual Institute (SSERVI) at NASA Ames Research Center.

At the request of the Planetary Science Division of NASA's Science Mission Directorate, we are extending the technologies of our existing Trek platforms to create a new portal for Mars' largest moon, Phobos. In this effort, we are working with the International Phobos/Deimos Landing Site Working Group and with JAXA, with JAXA's MMX mission as a primary driver.
Mars Trek is one of the portals in the NASA Solar System Treks Project (SSTP), available at https://trek.nasa.gov. NASA's Solar System Trek online portals provide web-based suites of interactive data visualization and analysis tools to enable mission planners, planetary scientists, students, and the general public to access mapped data products from past and current missions for a growing number of planetary bodies including the Moon, Mars, Vesta, etc. These portals are being used for site selection and analysis by NASA and a number of its international partners, supporting upcoming missions. In addition to demonstrating the capabilities of Mars Trek in this presentation and providing a preview of Phobos Trek,

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we will solicit input from the community for ideas for future enhancements to the portals.

Keywords: Mars



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紫外線Ａ・Ｃよる鉄カンラン石からの鉄溶出量の増加
Increase in Dissolved Iron Concentration from Fayalite by UltravioletA・C Irradiation

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私は「酸素の乏しい火星の表面には酸化鉄が多いのはなぜか」という謎を調査するために、中学校での生徒実験を指導している。Ａ．S. Yen (1999)は,活性酸素種が火星の状況下で鉱物上で生じることを実験で示した。さらに、彼は空気中で鉄の薄膜に紫外線Cを照射放射 して、紫外線照射が 酸化物の生成率を上昇させることを示した。私の実験は、水中の鉄カンラン石に紫外線Cを照射すると鉄イオンの溶脱が促進されることを示したものであり、過去の火星と地球の活性酸素種以外の原因で、酸化鉄が紫外線によって発生する可能性があることを示している。

実験１

私は生徒に塩酸中に入れた鉄カンラン石に紫外線ＡとＣを照射させた。この研究では福島県川俣町産の鉄カンラン石を使用した。この鉄カンラン石は整形されておらず約1gであり、ｐＨ２の塩酸を充填した試験管に入れた。８０時間～１００時間程紫外線を照射後、デジタルパックテストで水溶液中の鉄イオン濃度を確認した。この紫外線Ａを用いた実験は７回行い、紫外線Ｃを用いた実験は３回行った。

紫外線Ａを用いた実験の結果、紫外線を照射しない場合よりも７回中６回照射した場合の方が鉄溶出量が多くなった。紫外線Ｃでの実験結果は３回中３回同じ結果となった。ブラックライトにより発生する紫外線Ａの波長のピークは３６５ｎｍである。殺菌灯により発生する紫外線Ｃの波長のピークは２４５ｎｍである。

実験2

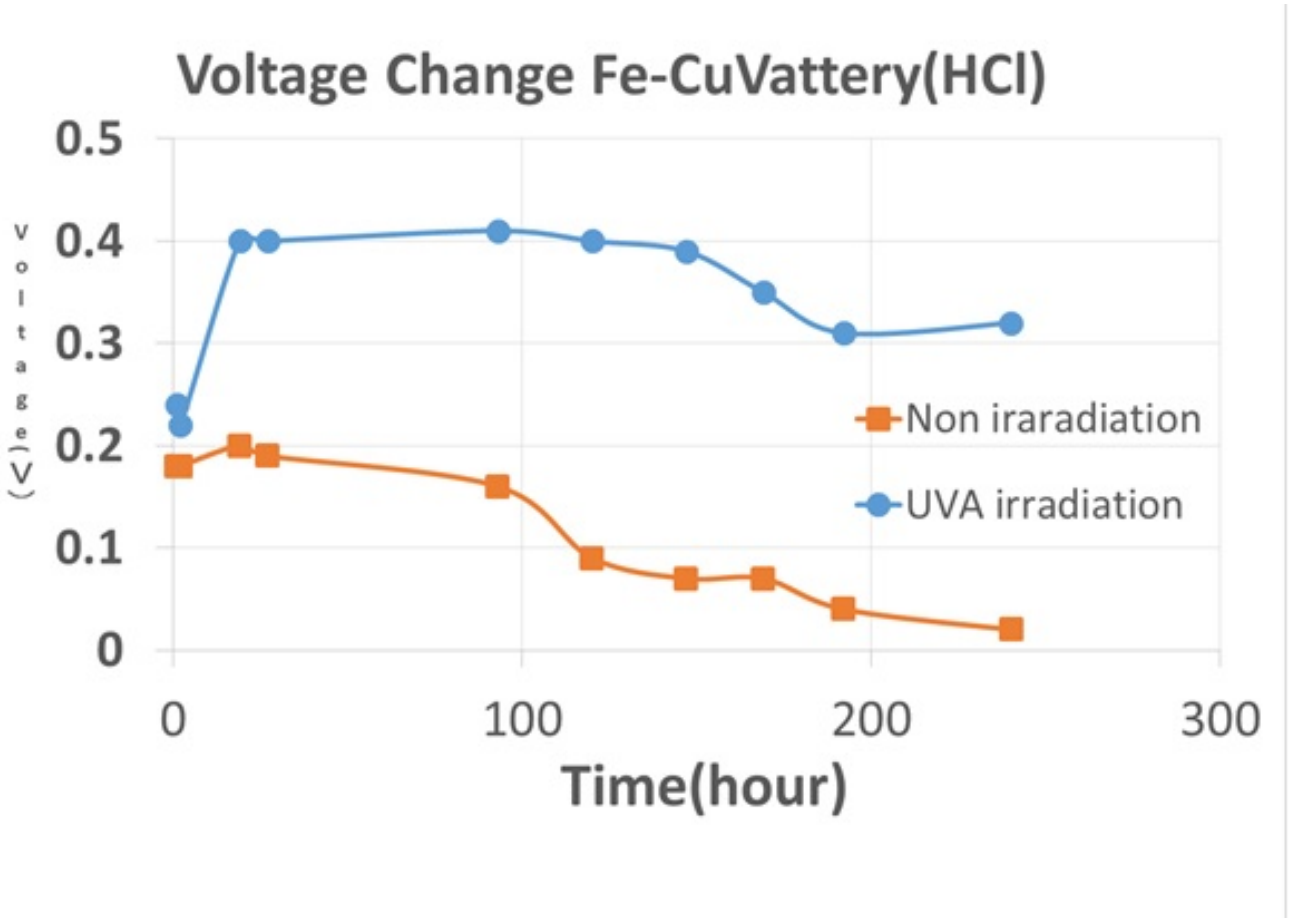
鉄陰極銅陽極を塩酸に入れた電池に紫外線Aを照射させた。そして生徒は電池の発生電圧を測定し、紫外線照射と非照射の電圧を比較した。この紫外線を照射した電池では、電圧は常に0.2V以上であり150時間後に低下することはなかった。もう一方の紫外線を照射されていない電池の電圧は少しずつ低くなり、１５０時間後に電圧は０Ｖに近くなった。この実験は４回行った。すべての場合において、紫外線を照射した電池の電圧は照射していない電池よりも高かった。紫外線のエネルギーにより鉄原子から電子が解離し、鉄イオンが発生するように思われる。

考察

私の実験結果から、紫外線は鉄カンラン石と鉄からの鉄イオンの溶解を促進すると推定する。火星表面にはかつて水が存在していたと考えらており，そこに紫外線が照射されると岩石中の鉄の溶解が促進され，それが酸化鉄の起源の一つとなった可能性がある．

キーワード：紫外線、鉄カンラン石、塩酸、鉄イオン、溶出量増加
Keywords: ultraviolet rays, fayalite , hydrochloric acid, iron, elution increase

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Small-scale ridges newly identified on the equatorial region of the Phobos nearside

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Although the craters and grooves on Phobos are indicative of widespread and abundant surface modification during Phobos' geologic history [Basilevsky et al., 2014], little definitive evidence exists for geologically recent regolith migration other than down-slope mass-wasting [Shi et al., 2016]. Here we report newly found small-scale sinuous ridges identified in Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE [McEwen et al., 2007]) images of the nearside of Phobos. These ridges are spatially focused within the equatorial region (-5° to 20° N). Some of them superpose on craters and grooves, which is consistent with a geologically recent activity. They are ~200 m to ~1 km in length, several 10's m in width, and most of them are roughly parallel to each other and are generally oriented in NE-SW direction. To extract detailed topographic profiles, we constructed a high-resolution (~5-6 m/pixel; almost same as the original image) digital elevation model (DEM) by using shape-from-shading [Alexandrov and Beyer, 2018] in the selected regions of a HiRISE image and a stereo-derived HiRISE DEM (20 m/pixel) [Hemmi and Miyamoto, 2019]. Our preliminary analysis shows these ridges are less than several meters high. Their morphology and topography are unlikely to be formed by impact cratering, extensional stress fields, or mass wasting processes. In this presentation, we provide initial results of geological mapping of the small-scale ridges and discuss their possible origins.

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キーワード：フォボス、HiRISE、数値標高モデル
Keywords: Phobos, HiRISE, Digital Elevation Model

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火星探査機搭載を目指した超小型ミュオグラフィー装置の開発
Development of a compact Muography instrument for future Mars exploration missions

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*Hiroaki Kamiyoshihara[1], Tetsuro Ninomiya[1], Yuri Yoshihara[1], Kenji Shimazoe[1], Hiroyuki Takahashi[1], Hiroyuki Tanaka[1], Hideaki Miyamoto[1]

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Muography is a technique that uses cosmic ray muons for visualizing the interior of large-scale structures in much the same way as standard X-ray radiography is used to image the interior of smaller objects. Muography has been successfully applied to explore the internal structure of geological targets on earth. Because exploring the inner structure of the shallow subsurface of celestial bodies is important to understand their origin and evolution, we are planning to operate muography instrument in the extraterrestrial environment, especially on the surface of Mars. Applying muography to planetary explorations has some advantages over conventional internal exploration methods: (1) it is able to observe the absolute linear density of objects; (2) the passive nature of the measurements provides low power consumption; (3) the instrument size is arbitral [1]. However, in order to mount muography instrument on a spacecraft, it is essential to downsize the instrument and investigate the radiation environment on the surface of the celestial body. In this study, we designed and developed a compact muography instrument based on the knowledge of compact gamma ray detectors for nuclear medicine imaging. At the same time, we theoretically estimated the muon production on Mars and evaluated the validity of using muography instrument on Mars.

The detection device of developing muography instrument consists of 64-channel silicon photomultipliers (SiPM), plastic scintillators, dynamic Time-Over-Threshold (dTOT) boards [2], data-acquisition (DAQ) board, and high-voltage power supply units. Incident muons react with the scintillator to emit weak light, and the light is amplified by SiPM attached to the both ends of the scintillator and read out with dTOT boards. The depth of interaction (DOI) in the scintillator is analyzed by measuring the pulse-height ratio of dual-sided readout. The size of the detector is 26.2 mm×26.2 mm×31.4 mm.

We first evaluated DOI resolution of this detector using a point beta-decay source of ^{90}Sr. The result indicates that the DOI resolution (FWHM) is 7.2 mm for the emitted beta rays with a spread of 2.2 mm. Then, we performed a Geant4 [3] simulation to examine the muon angular distribution that would be detected on the ground by this instrument. The result suggests that the structure of the detector makes the observation bias (Fig. 1). There are two solutions that can be considered to solve this problem: (1) developing one more detector and analyzing the coincident signals from dual-sided readout; (2) improving DOI resolution by performing accurate calibration.

We also performed a theoretical estimation to evaluate the muon production on Mars. Although the chemical composition and the density of Martian atmosphere are different from Earth's, the known muon flux in the upper earth atmosphere can be used for estimating the muon rates on Mars [4]. The result shows that the horizontal muon flux is greater than that on Earth (Fig. 2), which means that muography is more suitable for exploration of geological targets on Mars than on Earth.

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In this presentation, we report the development status of the detection device and the concrete result of numerical calculation of radiation environment on Mars.

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キーワード：ミュオグラフィー、ミューオン、内部構造探査、火星探査
Keywords: Muography, Muon, Internal exploration, Mars exploration

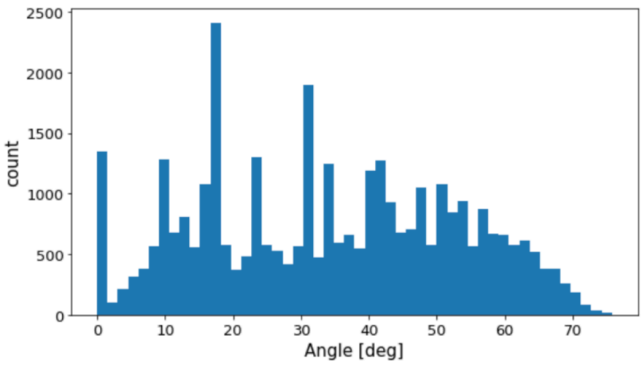


Fig. 1 The simulation result of muon zenith angular distribution that would be detected by developing instrument. The structure of detector makes the observation bias at 0°, 17° and 31°.

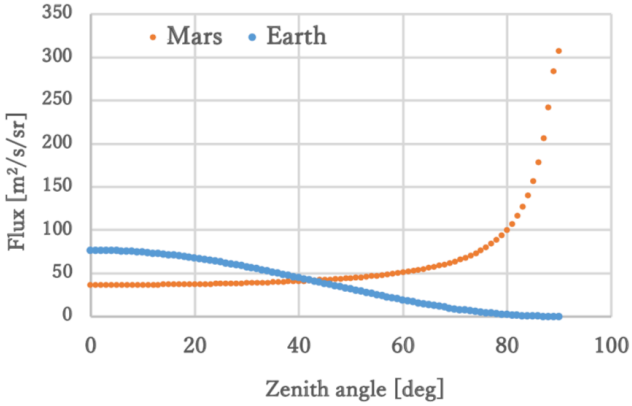


Fig. 2 Zenith angle dependence of muon flux on Mars and Earth. Horizontal muon flux on Mars is greater than that on Earth.

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2019年5月26日(日) 10:45 ~ 12:15 | ポスター会場 幕張メッセ国際展示場 8ホール_2

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

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

Over the past few decades, rapid developments in space technology have advanced the research of ionospheric space weather by increasing a great number of ground- and space-based observations. In the ground segment, the dense ground-based GNSS networks, radars, and airglow instruments have greatly extended the observational coverages. In the space segment, the extraordinary satellite missions with payloads onboard the satellites providing radio occultation soundings of vertical electron density structure and in-situ observations of airglow, temperature, neutral winds, and electron density contribute to the understanding of middle and upper atmospheric dynamics. With the large amount and diversity of datasets, theoretical and empirical models can be validated and implemented for inclusion of new thermosphere and ionosphere phenomena. Furthermore, remarkable breakthrough of data assimilation techniques advances the ionosphere monitoring and forecast. The recent innovations in observations and models reinterpret the studies of ionospheric space weather. The purpose of this session is to solicit studies providing observations, theoretical and empirical modeling and data assimilation on the multiple scales of ionospheric phenomena, from global morphology to small-scale irregularities and traveling ionospheric disturbances. Studies on magnetically quiescent and disturbed conditions will be both addressed.

[PEM14-P01] The Daytime and Nighttime Mapped Whistler Plasmapause Observed by DEMETER

*ChaoYen Chen[1,2]、Tiger J. Y. Liu[1,2,3] (1.Institute of Space Science, National Central University, Taiwan、2.Center for Astronautical Physics and Engineering, National Central University, Taiwan 、3.Center for Space and Remote Sensing Research, National Central University, Taiwan)

[PEM14-P02] Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

*Chi-Kuang Chao[1]、Yi-Wun Chen[1] (1.Graduate Institute of Space Science, National Central University)

[PEM14-P03] The First Result on Ionospheric Space Weather of FORMOSAT-5/AIP Ion Density

*FU-YUAN CHANG[1]、JANN-YENQ Liu[1]、Chi-Kuang Chao[1] (1.National Central University)

[PEM14-P04] The global total electron content reconstruction in the local time frame

*Tsung-Che Tsai[1,2]、Hau-Kun Jhuang[3]、Lou-Chuang Lee[3,4,5]、Yi-Ying Ho[4] (1.National Center for High-Performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan、2.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan.、3.Department of Geoscience, National Taiwan University, Taipei, Taiwan.、4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan.、5.Institute of Space Science, National Central University, Jhongli, Taiwan.)

[PEM14-P05] Research on impacts of power line harmonic radiation on ionospheric parameters

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

[PEM14-P06] Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms

*Oksana Mandrikova[1]、Yurii Polozov[1]、Bogdana Mandrikova[1,2] (1.Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences、2.Saint Petersburg Electrotechnical University "LETI")

[PEM14-P07] King Tidal Effects on the ionosphere during the period of 2000 to 2017

*TsungYu Wu[1]、JANN-YENQ Liu[1] (1.Institute of Space Science, NCU, Taiwan)

[PEM14-P08] SuperDARN near range echoes and higher resolution measurement - recent improvement and future

*行松 彰[1,2] (1.国立極地研究所、2.総合研究大学院大学)

[PEM14-P09] **The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps**

*Hau-Kun Jhuang[1]、Tsung-Che Tsai[2,3]、Lou-Chuang Lee[1,4,5]、Yi-Ying Ho[4] (1.Department of Geosciences, National Taiwan University, Taipei, Taiwan、2.National Center for High-performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan、3.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan、4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan、5.Institute of Space Science, National Central University, Jhongli, Taiwan)

The Daytime and Nighttime Mapped Whistler Plasmapause Observed by DEMETER

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This paper investigates the plasmapause positions in the ionosphere by measurement of the whistler count probed by DEMETER (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions) satellite in the daytime at 1030 LT (local time) and the nighttime at 2230 LT during 2005-2010. The whistler finds the plasmapause position which can be clearly allocated in both daytime and nighttime. We examine the nighttime/daytime plasmapause in various longitudes, solar activities, seasons, and geomagnetic actives. Results show that the daytime plasmapause appears in the equatorward side of the nighttime one. Both the daytime and nighttime plasmapause are sensitive to solar activity, which move equatorward form the low to high solar activity in the study period. The seasonal variation of the plasmapause are rather random and insignificant. During magnetic disturbed condition, the plasmapause tend to move equatorward.

Keywords: Plasmapause position, Whistler, DEMETER satellite

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Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

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1. Graduate Institute of Space Science, National Central University

A FORMOSAT-5 satellite has been launched on25 August 2017 CST into a 98.28° inclination sun-synchronous circular orbit at 720 km altitude along the 1030/2230 local time sectors. The orbital coverage provides a great opportunity to survey terrestrial ionosphere from equatorial to polar region every two days. Advanced Ionospheric Probe (AIP) is a piggyback science payload developed by National Central University for the FORMOSAT-5 satellite to measure ionospheric plasma concentrations, velocities, and temperatures. It is also capable of measuring ionospheric plasma density irregularities at a sample rate up to 8,192 Hz over a wide range of spatial scales. In this presentation/poster, distributions and structures of pre-midnight low-latitude ionospheric plasma density irregularities will be shown from AIP science data collected since winter 2017. Especially, seasonal variations of the distributions will be compared with ROCSAT-1/Ionospheric Plasma and Electrodynamics Instrument dataset (1999-2004) to understand their trends. Meanwhile, high resolution data measured at a BURST rate (8,192 Hz) in some longitudinal sectors with high plasma density irregularity occurrence rates will also be investigated by spectral analysis to understand their characteristics.

Keywords: AIP, FORMOSAT-5, Irregularities

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The First Result on Ionospheric Space Weather of FORMOSAT-5/AIP Ion Density

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1. National Central University

The science payload of Advantage Ionosphere Probe (AIP) onboard FORMOSAT-5 (F5) launched on 24 August 2017 has being operated in a Sun synchronous orbit at 720km altitude with an inclination angle of 98.28 degrees and the revisit period every 2-day. The global distribution of F5/AIP ion density (Ni) in nighttime of 2200LT during November 2017-October 2018 is examined and reported. F5/AIP ion densities show that equatorial plasma depletions frequently appear over South America, Africa, and Asia sectors; four-peaked EIA (non-migrating tide) structures prominently occur in September-March; and plasma depletion bays (PDBs) at low-latitudes in April-August. It is found that prominent locations of the plasma depletions slightly differ from those of equatorial irregularities, while non-migrating tide and PDBs result from different physical mechanisms.

Keywords: topside ionosphere, equatorial plasma depletion bay, plasma drift

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The global total electron content reconstruction in the local time frame

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The total electron content (TEC) data from Global Ionosphere Maps provide a global TEC map in the region between latitude 87.5˚S to 87.5˚N, and longitude 180˚W to 180˚E. The TEC data in geographic coordinates are first transformed into geomagnetic coordinates through Altitude-Adjusted Corrected Geomagnetic Model (AACGM). We then use 2-dimensional (longitude, 180˚W~180˚E and time, 10 days) Fourier transform (FT) of TEC variations along different geomagnetic latitude to obtain all wave modes for the period from November 18, to October 15, 2014. By the summation of all non-migrating tides, migrating tides, and zonal mean, the TEC global map in the local time frame is reconstructed. Again, the AACGM is applied to transform from geomagnetic coordinates back to geographic coordinates. The local time evolution in geographic coordinates of TEC is then produced. The features of TEC peaks in the local time frame are presented.

Keywords: geomagnetic coordinates, Global Ionospheric Maps, Fourier transform, Ionospheric tides

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Research on impacts of power line harmonic radiation on ionospheric parameters

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1. Beihang University

Introduction: Power line harmonic radiation (PLHR) refers to a kind of electromagnetic wave phenomena at harmonic frequencies of 50 or 60 Hz, which are the working frequencies of terrestrial power systems. Since the 1970s, PLHR events have been detected with several magnetically conjugate pairs of receivers and different satellites [1, 2, 3]. With the increase of global power consumption, PLHR has become more serious. Already, many scientific satellites have observed such anthropogenic electromagnetic waves in the ionosphere, and some possible typical impacts of those waves on the ionosphere have been reported [4]. However, reaching a final conclusion as to the impacts has been proven to be a difficult task. To further understand PLHR and its impacts, we utilize the data of three scientific payloads of DEMETER satellite collected with the Langmuir probe (ISL), thermal plasma analyzer (IAP), and energetic particle detector (IDP) to study the variation of ionospheric parameters due to the occurrence of PLHR.

Analytical Methods: DEMETER is a French seismo-electromagnetic microsatellite that was in operation from June 29, 2004 to December 9, 2010. The ISL onboard measured the electron density (N_e), electron temperature (T_e), and ion density (N_i). The IAP measured the density of H^+ (N_{H+}), He^+ (N_{He+}), O^+ (N_{O+}), and ion temperature (T_i). The IDP measured the electron fluxes in the range from 70 keV to 2.5 MeV. The variations of ionospheric parameters are affected by many factors, including latitude, longitude, altitude, daytime or nighttime, season, and solar activity. To minimize these impacts, we proposed an approach that compares the data from the PLHR-orbit and quiet-period orbit ($AE \leqq 50$ nT, AE is an index to evaluate the level of geomagnetic activity).

Among the 133 PLHR events detected by Wu et al. [5] when DEMETER flew over China, one quiet-period orbit, covering most of China's latitudes, was found for each year (2004-2010) according to AE index. In each PLHR-orbit, three-segment dataset were obtained: 30s before, at, and 30s after the occurrence region of PLHR event. By subtracting data of quiet-period orbit with corresponding latitudes from each-segment data of PLHR-orbit, we statistically analyzed the variation trend of ionospheric parameter in each PLHR-orbit due to PLHR.

Results & Discussion: With ISL and IAP data, it was found that both N_e and T_e were at a low level, N_{H+} was at a high level, and N_{O+} was at a low level when PLHR occurred. These results were generally helpful for understanding the formation behaviors of PLHR and were consistent with the theoretical results. From the analysis of IDP data, obvious variations of pitch angles before and after PLHR were occasionally observed to occur, and the variation did not exceed 10°. Its corresponding equatorial pitch-angle may not have fallen into a loss-cone, so the variation tendency of the electron flux did not have a definite connection with the pitch angle. The statistical results indicate that when PLHR occurs, the electron flux in the high-band (>1 MeV) tends to decrease and the decremental magnitude is very large, while the electron flux in the middle-band tends to increase and the incremental magnitude is relatively large.

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Res-Space Phys., 122, 3448-3458.

Keywords: power line harmonic radiation, ionospheric parameters, DEMETER

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Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms

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1. Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2. Saint Petersburg Electrotechnical University "LETI"

Based on the ground station data, the paper makes complex analysis of cosmic ray dynamics and of ionospheric parameters during strong and moderate magnetic storms in 2015-2018. During the investigation, new methods of modeling and data analysis were applied. A neural network model for neutron monitor data classification was presented. This model makes it possible to evaluate galactic cosmic ray flux state and to detect periods of sporadic effect occurrences in automatic mode. By the use of this model, sporadic effects preceding and accompanying strong and moderate magnetic storms were detected. The model showed its efficiency when applied for data on-line analysis and for detection of sporadic effects including those of small amplitude. Ionospheric data were analyzed on the bases of multi-component modeling method and ionospheric parameter analysis [1, 2]. It allowed us to detect ionospheric disturbances of different intensity and to estimate their characteristics. The results of the work confirmed the possibility of ionospheric electron concentration increase effect preceding magnetic storm commencements [3]. Comparison with cosmic ray data showed the correlation of the effects in the ionospehre with anomalous changes in cosmic ray dynamics that was first mentioned in the paper [3].

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Keywords: cosmic rays, ionospheric parameters, data analysis

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King Tidal Effects on the ionosphere during the period of 2000 to 2017

*TsungYu Wu[1], JANN-YENQ Liu[1]

1. Institute of Space Science, NCU, Taiwan

This study examines the spring tide signature of the 14.7-day period in concurrent/co-located measurements of the ionosphere total electron content (TEC) and sea level in an 18-year period of 2000-2017. A discrete Fourier transform is applied to find amplitude and phase of the spring tide in the TEC and sea level. Results show that the spring tide amplitude in the sea level is clear and steady, while that in the ionospheric TEC is rather fluctuated and proportional to the ambient TEC value. The relative amplitude of TEC in the 18-year is a function of the solar local time and become prominent in the daytime of 08:00-19:00. and however that in the nighttime 00:00-06:00 LT becomes prominent in 2002, 2005, 2009, and 2015, when the perihelion and perigee simultaneously occur. On the other hand, the phase of the spring tide signature in the sea level and TEC yield a 3-year period, which is close to the time interval of the above prominent spring tide signature in the nighttime. More detailed discussions and results will be presented.

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SuperDARN near range echoes and higher resolution measurement - recent improvement and future

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1. National Institute of Polar Research, 2. SOKENDAI

SuperDARN (Super Dual Auroral Radar Network) is an international high-frequency radar network originally intended to cover a wide range of polar ionosphere in both hemispheres by its fields-of-view and to monitor global ionospheric plasma convection in high temporal resolution of about 1-2 minitues in quasi real time mainly for space weather research. It can observe not only basic and important ionospheric plasma Doppler velocity and electric field, a variety of geomagnetic waves, ionospheric disturbances and irregularities, but also properties of neutral atmosphere, e.g., traveling ionospheric disturbances (TIDs), mesoepheric echoes like PMSEs and neutral wind around mesopause region. As it is originally designed to measure global large-scale ionospheric plasma parameters, the spatial resolution has been rather coarse, and it was originally difficult to obtain height information of echoes, high temporal resolution less than 1 second, and high spatial resolution of less than 15km in radial direction. Echo height information is very important especially to distinguish those among D, E and F regions as the properties of plasma among them are considerably different and also to obtain precise altitude of meteor echoes around mesopause due to existence of thin layers of neutral wind shear. Recent development in calibrating radar interferometry in SuperDARN community is an important step to improve much the reliability of height information especially in near range echoes and also of region identification for further echoes as well. Combining raw I/Q time series analysis method (Yukimatu and Tsutsumi, GRL, 2002) to be applied to extract underdense meteor echoes precisely, frequency domain interferometry (FDI) and/or over-sampling technique (Tsutsumi et al., 2009) with the appropriate interferometer calibration will improve the reliability and height resolution of the neutral wind measurement possibly leading to global neutral wind observing network around mesopause region with SuperDARN which will contribute to many studies on mesosphere-lower-thermosphere (MLT) or mesoephere-thermosphere-ionosphere (MTI) region dynamics and vertical coupling between ionosphere and neutral upper atmosphere. Another issue possibly critical for some specific studies, e.g., on short period electro-magnetic waves is possibility to achieve higher temporal resolution within a second as well as higher spatial resolution in range direction. (Higher spatial resolution in azimuth direction has been already tried and achieved by some radars using general imaging or spatial domain interferometry (SDI) technique.) There have been some trial against these possibilities with some success depending on the cases of the applied phenomena and the conditions of echoes, but have still been thought to be difficult to be overcome. This presentation will describe the evolution of SuperDARN near range echo measurement after last JpGU meeting, and will also discuss about the reliability of high temporal resolution measurement and the possible method to obtain reliable high temporal resolution data to extend the ability of SuperDARN.

キーワード：SuperDARN、近距離エコー、電磁波、高時間分解能
Keywords: SuperDARN, near range echoes, electromagnetic waves, high temporal resolution

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The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps

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The total electron content (TEC) data from Global Ionosphere Maps (GIM) are used to obtain the wave modes in both UT (universal time) and LT (local time) frames through the Fourier transform. The summation of contributing wave modes at a given local time provides the longitudinal variation of the wave peak structure. The phases of wave modes lead to a constructive or destructive interference of contributing wave modes, which gives different wave peak structure at different local time. The dependence of the wave peak structures on latitudinal, seasonal, and solar activity is studied.

Keywords: Global Ionosphere Maps, Ionospheric tides, Atmosphere Ionosphere coupling

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2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_5

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

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

Over the past few decades, rapid developments in space technology have advanced the research of ionospheric space weather by increasing a great number of ground- and space-based observations. In the ground segment, the dense ground-based GNSS networks, radars, and airglow instruments have greatly extended the observational coverages. In the space segment, the extraordinary satellite missions with payloads onboard the satellites providing radio occultation soundings of vertical electron density structure and in-situ observations of airglow, temperature, neutral winds, and electron density contribute to the understanding of middle and upper atmospheric dynamics. With the large amount and diversity of datasets, theoretical and empirical models can be validated and implemented for inclusion of new thermosphere and ionosphere phenomena. Furthermore, remarkable breakthrough of data assimilation techniques advances the ionosphere monitoring and forecast. The recent innovations in observations and models reinterpret the studies of ionospheric space weather. The purpose of this session is to solicit studies providing observations, theoretical and empirical modeling and data assimilation on the multiple scales of ionospheric phenomena, from global morphology to small-scale irregularities and traveling ionospheric disturbances. Studies on magnetically quiescent and disturbed conditions will be both addressed.

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*ChaoYen Chen[1,2]、Tiger J. Y. Liu[1,2,3] (1.Institute of Space Science, National Central University, Taiwan、2.Center for Astronautical Physics and Engineering, National Central University, Taiwan 、3.Center for Space and Remote Sensing Research, National Central University, Taiwan)

[PEM14-P02] Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

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*FU-YUAN CHANG[1]、JANN-YENQ Liu[1]、Chi-Kuang Chao[1] (1.National Central University)

[PEM14-P04] The global total electron content reconstruction in the local time frame

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[PEM14-P05] Research on impacts of power line harmonic radiation on ionospheric parameters

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

[PEM14-P06] Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms

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[PEM14-P07] King Tidal Effects on the ionosphere during the period of 2000 to 2017

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[PEM14-P08] SuperDARN near range echoes and higher resolution measurement - recent improvement and future

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[PEM14-P09] **The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps**

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The Daytime and Nighttime Mapped Whistler Plasmapause Observed by DEMETER

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This paper investigates the plasmapause positions in the ionosphere by measurement of the whistler count probed by DEMETER (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions) satellite in the daytime at 1030 LT (local time) and the nighttime at 2230 LT during 2005-2010. The whistler finds the plasmapause position which can be clearly allocated in both daytime and nighttime. We examine the nighttime/daytime plasmapause in various longitudes, solar activities, seasons, and geomagnetic actives. Results show that the daytime plasmapause appears in the equatorward side of the nighttime one. Both the daytime and nighttime plasmapause are sensitive to solar activity, which move equatorward form the low to high solar activity in the study period. The seasonal variation of the plasmapause are rather random and insignificant. During magnetic disturbed condition, the plasmapause tend to move equatorward.

Keywords: Plasmapause position, Whistler, DEMETER satellite

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Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

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A FORMOSAT-5 satellite has been launched on25 August 2017 CST into a 98.28° inclination sun-synchronous circular orbit at 720 km altitude along the 1030/2230 local time sectors. The orbital coverage provides a great opportunity to survey terrestrial ionosphere from equatorial to polar region every two days. Advanced Ionospheric Probe (AIP) is a piggyback science payload developed by National Central University for the FORMOSAT-5 satellite to measure ionospheric plasma concentrations, velocities, and temperatures. It is also capable of measuring ionospheric plasma density irregularities at a sample rate up to 8,192 Hz over a wide range of spatial scales. In this presentation/poster, distributions and structures of pre-midnight low-latitude ionospheric plasma density irregularities will be shown from AIP science data collected since winter 2017. Especially, seasonal variations of the distributions will be compared with ROCSAT-1/Ionospheric Plasma and Electrodynamics Instrument dataset (1999-2004) to understand their trends. Meanwhile, high resolution data measured at a BURST rate (8,192 Hz) in some longitudinal sectors with high plasma density irregularity occurrence rates will also be investigated by spectral analysis to understand their characteristics.

Keywords: AIP, FORMOSAT-5, Irregularities

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The First Result on Ionospheric Space Weather of FORMOSAT-5/AIP Ion Density

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The science payload of Advantage Ionosphere Probe (AIP) onboard FORMOSAT-5 (F5) launched on 24 August 2017 has being operated in a Sun synchronous orbit at 720km altitude with an inclination angle of 98.28 degrees and the revisit period every 2-day. The global distribution of F5/AIP ion density (Ni) in nighttime of 2200LT during November 2017-October 2018 is examined and reported. F5/AIP ion densities show that equatorial plasma depletions frequently appear over South America, Africa, and Asia sectors; four-peaked EIA (non-migrating tide) structures prominently occur in September-March; and plasma depletion bays (PDBs) at low-latitudes in April-August. It is found that prominent locations of the plasma depletions slightly differ from those of equatorial irregularities, while non-migrating tide and PDBs result from different physical mechanisms.

Keywords: topside ionosphere, equatorial plasma depletion bay, plasma drift

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The global total electron content reconstruction in the local time frame

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The total electron content (TEC) data from Global Ionosphere Maps provide a global TEC map in the region between latitude 87.5˚S to 87.5˚N, and longitude 180˚W to 180˚E. The TEC data in geographic coordinates are first transformed into geomagnetic coordinates through Altitude-Adjusted Corrected Geomagnetic Model (AACGM). We then use 2-dimensional (longitude, 180˚W~180˚E and time, 10 days) Fourier transform (FT) of TEC variations along different geomagnetic latitude to obtain all wave modes for the period from November 18, to October 15, 2014. By the summation of all non-migrating tides, migrating tides, and zonal mean, the TEC global map in the local time frame is reconstructed. Again, the AACGM is applied to transform from geomagnetic coordinates back to geographic coordinates. The local time evolution in geographic coordinates of TEC is then produced. The features of TEC peaks in the local time frame are presented.

Keywords: geomagnetic coordinates, Global Ionospheric Maps, Fourier transform, Ionospheric tides

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Research on impacts of power line harmonic radiation on ionospheric parameters

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Introduction: Power line harmonic radiation (PLHR) refers to a kind of electromagnetic wave phenomena at harmonic frequencies of 50 or 60 Hz, which are the working frequencies of terrestrial power systems. Since the 1970s, PLHR events have been detected with several magnetically conjugate pairs of receivers and different satellites [1, 2, 3]. With the increase of global power consumption, PLHR has become more serious. Already, many scientific satellites have observed such anthropogenic electromagnetic waves in the ionosphere, and some possible typical impacts of those waves on the ionosphere have been reported [4]. However, reaching a final conclusion as to the impacts has been proven to be a difficult task. To further understand PLHR and its impacts, we utilize the data of three scientific payloads of DEMETER satellite collected with the Langmuir probe (ISL), thermal plasma analyzer (IAP), and energetic particle detector (IDP) to study the variation of ionospheric parameters due to the occurrence of PLHR.

Analytical Methods: DEMETER is a French seismo-electromagnetic microsatellite that was in operation from June 29, 2004 to December 9, 2010. The ISL onboard measured the electron density (N_e), electron temperature (T_e), and ion density (N_i). The IAP measured the density of H^+ (N_{H+}), He^+ (N_{He+}), O^+ (N_{O+}), and ion temperature (T_i). The IDP measured the electron fluxes in the range from 70 keV to 2.5 MeV. The variations of ionospheric parameters are affected by many factors, including latitude, longitude, altitude, daytime or nighttime, season, and solar activity. To minimize these impacts, we proposed an approach that compares the data from the PLHR-orbit and quiet-period orbit ($AE \leqq 50$ nT, AE is an index to evaluate the level of geomagnetic activity).

Among the 133 PLHR events detected by Wu et al. [5] when DEMETER flew over China, one quiet-period orbit, covering most of China's latitudes, was found for each year (2004-2010) according to AE index. In each PLHR-orbit, three-segment dataset were obtained: 30s before, at, and 30s after the occurrence region of PLHR event. By subtracting data of quiet-period orbit with corresponding latitudes from each-segment data of PLHR-orbit, we statistically analyzed the variation trend of ionospheric parameter in each PLHR-orbit due to PLHR.

Results & Discussion: With ISL and IAP data, it was found that both N_e and T_e were at a low level, N_{H+} was at a high level, and N_{O+} was at a low level when PLHR occurred. These results were generally helpful for understanding the formation behaviors of PLHR and were consistent with the theoretical results. From the analysis of IDP data, obvious variations of pitch angles before and after PLHR were occasionally observed to occur, and the variation did not exceed 10°. Its corresponding equatorial pitch-angle may not have fallen into a loss-cone, so the variation tendency of the electron flux did not have a definite connection with the pitch angle. The statistical results indicate that when PLHR occurs, the electron flux in the high-band (>1 MeV) tends to decrease and the decremental magnitude is very large, while the electron flux in the middle-band tends to increase and the incremental magnitude is relatively large.

Reference: [1] R. A. Helliwell, et al. (1975) *J. Geophys. Res-Space Phys.*, 80, 4249-4258. [2] J. P. Matthews, et al. (1981) *Planet. Space Sci.*, 29, 97-106. [3] M. Parrot, et al. (2014) *J. Geophys. Res-Space Phys.*, 119, 5744-5754. [4] M. Parrot, et al. (1996) *Surv. Geophys.*, 17, 67-100. [5] J. Wu, et al. (2017) *J. Geophys.*

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Res-Space Phys., 122, 3448-3458.

Keywords: power line harmonic radiation, ionospheric parameters, DEMETER

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Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms

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Based on the ground station data, the paper makes complex analysis of cosmic ray dynamics and of ionospheric parameters during strong and moderate magnetic storms in 2015-2018. During the investigation, new methods of modeling and data analysis were applied. A neural network model for neutron monitor data classification was presented. This model makes it possible to evaluate galactic cosmic ray flux state and to detect periods of sporadic effect occurrences in automatic mode. By the use of this model, sporadic effects preceding and accompanying strong and moderate magnetic storms were detected. The model showed its efficiency when applied for data on-line analysis and for detection of sporadic effects including those of small amplitude. Ionospheric data were analyzed on the bases of multi-component modeling method and ionospheric parameter analysis [1, 2]. It allowed us to detect ionospheric disturbances of different intensity and to estimate their characteristics. The results of the work confirmed the possibility of ionospheric electron concentration increase effect preceding magnetic storm commencements [3]. Comparison with cosmic ray data showed the correlation of the effects in the ionospehre with anomalous changes in cosmic ray dynamics that was first mentioned in the paper [3].

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Keywords: cosmic rays, ionospheric parameters, data analysis

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King Tidal Effects on the ionosphere during the period of 2000 to 2017

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This study examines the spring tide signature of the 14.7-day period in concurrent/co-located measurements of the ionosphere total electron content (TEC) and sea level in an 18-year period of 2000-2017. A discrete Fourier transform is applied to find amplitude and phase of the spring tide in the TEC and sea level. Results show that the spring tide amplitude in the sea level is clear and steady, while that in the ionospheric TEC is rather fluctuated and proportional to the ambient TEC value. The relative amplitude of TEC in the 18-year is a function of the solar local time and become prominent in the daytime of 08:00-19:00. and however that in the nighttime 00:00-06:00 LT becomes prominent in 2002, 2005, 2009, and 2015, when the perihelion and perigee simultaneously occur. On the other hand, the phase of the spring tide signature in the sea level and TEC yield a 3-year period, which is close to the time interval of the above prominent spring tide signature in the nighttime. More detailed discussions and results will be presented.

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SuperDARN near range echoes and higher resolution measurement - recent improvement and future

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SuperDARN (Super Dual Auroral Radar Network) is an international high-frequency radar network originally intended to cover a wide range of polar ionosphere in both hemispheres by its fields-of-view and to monitor global ionospheric plasma convection in high temporal resolution of about 1-2 minitues in quasi real time mainly for space weather research. It can observe not only basic and important ionospheric plasma Doppler velocity and electric field, a variety of geomagnetic waves, ionospheric disturbances and irregularities, but also properties of neutral atmosphere, e.g., traveling ionospheric disturbances (TIDs), mesoepheric echoes like PMSEs and neutral wind around mesopause region. As it is originally designed to measure global large-scale ionospheric plasma parameters, the spatial resolution has been rather coarse, and it was originally difficult to obtain height information of echoes, high temporal resolution less than 1 second, and high spatial resolution of less than 15km in radial direction. Echo height information is very important especially to distinguish those among D, E and F regions as the properties of plasma among them are considerably different and also to obtain precise altitude of meteor echoes around mesopause due to existence of thin layers of neutral wind shear. Recent development in calibrating radar interferometry in SuperDARN community is an important step to improve much the reliability of height information especially in near range echoes and also of region identification for further echoes as well. Combining raw I/Q time series analysis method (Yukimatu and Tsutsumi, GRL, 2002) to be applied to extract underdense meteor echoes precisely, frequency domain interferometry (FDI) and/or over-sampling technique (Tsutsumi et al., 2009) with the appropriate interferometer calibration will improve the reliability and height resolution of the neutral wind measurement possibly leading to global neutral wind observing network around mesopause region with SuperDARN which will contribute to many studies on mesosphere-lower-thermosphere (MLT) or mesoephere-thermosphere-ionosphere (MTI) region dynamics and vertical coupling between ionosphere and neutral upper atmosphere. Another issue possibly critical for some specific studies, e.g., on short period electro-magnetic waves is possibility to achieve higher temporal resolution within a second as well as higher spatial resolution in range direction. (Higher spatial resolution in azimuth direction has been already tried and achieved by some radars using general imaging or spatial domain interferometry (SDI) technique.) There have been some trial against these possibilities with some success depending on the cases of the applied phenomena and the conditions of echoes, but have still been thought to be difficult to be overcome. This presentation will describe the evolution of SuperDARN near range echo measurement after last JpGU meeting, and will also discuss about the reliability of high temporal resolution measurement and the possible method to obtain reliable high temporal resolution data to extend the ability of SuperDARN.

キーワード：SuperDARN、近距離エコー、電磁波、高時間分解能
Keywords: SuperDARN, near range echoes, electromagnetic waves, high temporal resolution

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The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps

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The total electron content (TEC) data from Global Ionosphere Maps (GIM) are used to obtain the wave modes in both UT (universal time) and LT (local time) frames through the Fourier transform. The summation of contributing wave modes at a given local time provides the longitudinal variation of the wave peak structure. The phases of wave modes lead to a constructive or destructive interference of contributing wave modes, which gives different wave peak structure at different local time. The dependence of the wave peak structures on latitudinal, seasonal, and solar activity is studied.

Keywords: Global Ionosphere Maps, Ionospheric tides, Atmosphere Ionosphere coupling

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2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_5

[P-CG21] 宇宙・惑星探査の将来計画と関連する機器開発の展望

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

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

[PCG21-P01] 編隊飛行による地球電磁気圏・熱圏探査衛星計画「FACTORS」搭載可視・紫外イメージャーによる微細オーロラと大気光観測

*坂野井 健[1]、平原 聖文[2]、津田 卓雄[3]、浅村 和史[4]、三好 由純[2]、渡邉 智彦[5]、西山 尚典[6]、大山 伸一郎[2,7]、斎藤 義文[4]、細川 敬祐[3]、小嶋 浩嗣[8]、北村 成寿[9]、小川 泰信[5]、山内 正敏[10]、松岡 彩子[4]、八木 直志[1]、吹澤 瑞貴[1]、石澤 元気[11] (1.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、2.名古屋大学宇宙地球環境研究所、3.電気通信大学情報理工学研究科、4.宇宙航空研究開発機構宇宙科学研究所、5.名古屋大学大学院理学研究科、6. 国立極地研究所、7.フィンランドオウル大学、8.京都大学生存圏研究所、9.東京大学大学院理学研究科、10.スウェーデン宇宙物理学研究所、11.東北大学大学院理学研究科)

[PCG21-P02] 機械学習を用いたフラッシュオーロラの時空間解析

*源田 斗輝[1]、井上 拓海[1]、尾崎 光紀[1]、八木谷 聡[1]、今村 幸祐[1]、塩川 和夫[2]、三好 由純[2]、大山 伸一郎[2]、片岡 龍峰[3]、海老原 祐輔[4]、細川 敬祐[5] (1.金沢大学、2.名古屋大学、3.極地研究所、4.京都大学、5.電気通信大学)

[PCG21-P03] 信号処理によるPc1地磁気脈動地上観測のパルス性雑音除去

*駒瀬 文弥[1]、井上 智寛[1]、尾崎 光紀[1]、八木谷 聡[1]、塩川 和夫[2]、能勢 正仁[2]、長妻 努[3] (1.金沢大学、2.名古屋大学、3.情報通信研究機構)

[PCG21-P04] Application of magneto-impedance sensor to geomagnetic field measurements

*能勢 正仁[1]、野村 麗子[2]、浅村 和史[3]、青山 均[4]、河野 剛健[4]、松岡 彩子[3]、北村 健太郎[5]、小山 幸伸[6]、松本 晴久[7]、平原 聖文[1] (1.名古屋大学宇宙地球環境研究所、2.国立天文台、3.宇宙航空研究開発機構 宇宙科学研究所、4.愛知製鋼株式会社、5.徳山工業高等専門学校、6.大分工業高等専門学校、7.宇宙航空研究開発機構 研究開発部門)

[PCG21-P05] Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

*北村 健太郎[1]、今井 一雅[2]、高田 拓[2]、篠原 学[3]、若林 誠[4]、高専 スペース連携 (1.徳山工業高等専門学校、2.高知工業高等専門学校、3.鹿児島工業高等専門学校、4.新居浜工業高等専門学校)

[PCG21-P06] Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

*徳永 祐也[1]、尾崎 光紀[1]、石坂 圭吾[2]、小嶋 浩嗣[3]、八木谷 聡[1]、頭師 孝拓[3] (1.金沢大学、2.富山県立大学、3.京都大学)

[PCG21-P07] 超小型探査機に搭載する極端紫外撮像装置に用いる電気回路部の放射線耐性の評価

*勝瀬 陸[1]、吉岡 和夫[1]、桑原 正輝[2]、疋田 伶奈[1]、荒尾 昇吾[1]、吉川 一朗[1] (1.東京大学、2.宇宙航空研究開発機構　宇宙科学研究所)

[PCG21-P08] A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

*西村 晟八[1]、吉川 一朗[1]、吉岡 和夫[1]、荒尾 昇吾[1]、張 天旭[1] (1.東京大学)

[PCG21-P09] ３次元電位分布計算による「みお」搭載MIAのトップハット分析器特性の非対称性の解釈

*三宅 亙[1]、斎藤 義文[2]、横田 勝一郎[3] (1.東海大学工学部、2.宇宙科学研究所、3.大阪大学)

[PCG21-P10] 小型衛星用衝撃試験機の建造及びMCPの機械耐性評価

*福場 惇哉[1] (1.東京大学大学院)

[PCG21-P11] Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

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[PCG21-P12] Microsatellite Development and Education of Space Science and Technology at Kanazawa University

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[PCG21-P13] Attitude Control System for Kanazawa-SAT3 Microsatellite

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[PCG21-P14] Communications System and Antennas for Kanazawa-SAT3 Microsatellite

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[PCG21-P15] 6Uクラス超小型深宇宙探査機EQUULEUSに搭載する多層断熱材一体型ダスト計測器CLOTHの開発

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[PCG21-P16] DESTINY$^+$搭載小惑星追尾機構の開発：概念設計およびBBMを用いた性能試験

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[PCG21-P17] 火星衛星探査計画における望遠カメラ(TENGOO)性能評価装置の開発

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[PCG21-P18] ソーラー電力セイルOKEANOSのクルージングフェーズにおける観測計画

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編隊飛行による地球電磁気圏・熱圏探査衛星計画「FACTORS」搭載可視・紫外イメージャーによる微細オーロラと大気光観測

Visible and ultraviolet imagers for auroral and airglow observations by FACTORS - a future satellite mission for understanding the coupling and transportation processes in the upper atmosphere

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We report science subject, design, development plan and identification of issues to be solved on the visible and ultraviolet imagers for a future satellite mission called FACTORS that aims to understand the coupling processes in the terrestrial magnetosphere/ionosphere/thermosphere and the acceleration and transportation of the space plasma and neutral atmospheric particles. FACTORS stands for Frontiers of Formation, Acceleration, Coupling, and Transport Mechanisms Observed by Outer Space Research System that is proposed as a multi-satellite formation flight mission. This will be a community exploration mission in Japanese apace research after the success of the ERG mission. The working group was approved by ISAS, JAXA this year, and we have started the discussion on detailed science targets, instrumental design, feasibility and so on. We mainly concern on visible and ultraviolet remote imaging of aurora and airglow for this mission. A visible imager (VISAI) on FACTORS will measure small-scale auroral structures at a wavelength of auroral prompt emission line, such as N2 1st PG, with high-time (~0.1s) and high-spatial (~1km) resolutions using a science CMOS or EMCCD. The FOV of 8 x 8 deg covers an area of 400 x 400 km viewed from 3000 km altitude. The high-spatial and high-time resolution imaging data is essential to understand small-scale variations of Alfven aurora, pulsating aurora, etc. Combined with particle and electric/magnetic field data by FACTORS, we will reveal the time and spatial variations of acceleration/scattering process in the complicated magnetosphere-ionosphere coupling system. A far-ultraviolet imager (FUVI) adopts a wide (~40 x 40 deg.) FOV objective mirror system which covers ~2500 x 2500 km area viewed from 3000 km altitude. We plan to adopt a filter wheal in FUV imager to change the wavelength between O 135.6 nm and the N2 LBH band at 140-160 nm. Wide-field multi-wavelength FUV images enable us to examine large-scale auroral dynamics like westward-travelling surge during substorm, omega-bands, and provide us to understand the global thermospheric activity from O/N2 airglow ratio. This year we plan to carry out specific studies for CMOS/EMCCD detectors

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suited for this mission, and perform radiation tests of detectors.
Related to the future FACTORS mission, we are now carrying out the developments of aural cameras for two sounding rocket projects, G-CHASER (Rocksat-XN) and LAMP. The G-CHASER (Rocksat-XN) rocket was successfully launched from Andøya, Norway on January 13, 2019. We installed an auroral camera (AIC) on this rocket to measure N2 1st PG emission with wide-angle FOV lens(96x75 deg), RG-665 filter, and CCD (WAT-910HX). In addition, we are developing two CMOS cameras AIC2 on the LAMP rocket that is scheduled to be launched at Poker Flat Research Range in winter of 2019. AIC2 will be installed on a despun platform to derotate rocket spin. One CMOS camera AIC2-S1 measures N2 1st PG emission with a narrow FOV lens (F-number=0.95, f=17mm, FOV=27x27deg.), and another CMOS camera AIC-S2 measures OI 844.6nm emission with a wide-angle lens (F-number=1.6, f=3.5mm, FOV=120x120deg.). Both cameras adopt the ZWO ASI 180 MM CMOS detector. AIC2-S1 will take fine structure of PsA in the region more than 100 x 100 km area around the magnetic footprint with a few kilo-meter resolution, while AIC2-S2 will obtain an altitude distribution of pulsating aurora in the F-region as well as distribution of PsA in wide-range. The precise imaging and altitude distribution of PsA are obtained with AIC2 at two wavelengths with 10Hz sampling. The imaging data combined with precipitating electron data in the wide energy range enable us to investigate the relativistic electron precipitation called microbursts that is probably caused by chorus waves in the magnetosphere.

キーワード：磁気圏、オーロラ、イメージャー、紫外、可視、電離圏
Keywords: magnetosphere, aurora, imager, ultra violet, visible, ionosphere

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機械学習を用いたフラッシュオーロラの時空間解析
Spatio-temporal analysis of flash aurora using Convolutional Neural Network

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オーロラは宇宙空間に存在する高エネルギー荷電粒子の一部が磁力線に沿って移動し、地球上層大気と衝突することで発光する現象である。つまり、オーロラの地上観測により、間接的に磁気圏に存在している電子の様相を知ることができる。私たちはオーロラの中でも、一秒以下で突発的に発光するフラッシュオーロラに注目している。フラッシュオーロラは、その発光時間の短さから目視による大量のイベント検出が難しく、詳細な解析は行われていない。よって、本研究では、EMCCDカメラで観測されたフラッシュオーロラを機械学習によって自動検出し、時空間変動の統計解析を行った。観測データはガコナ (アメリカ・アラスカ州) に設置されたEMCCDカメラ(サンプリング100 Hz、解像度 256 * 256 ピクセル)を用いた。

本研究で用いた機械学習の手法は、画像認識に特に優れている畳み込みニューラルネットワーク (CNN) である。学習データは、EMCCD画像の南北断面を切り出して時系列に並べたKeogram 画像（解像度2400 * 720 ピクセル、時間幅1 分間）を正方形のブロック（解像度30 * 30 ピクセル、時間幅0.75 秒間）に分割し、目視で分類したものを学習データとして使用した。分類は、脈動オーロラ、フラッシュオーロラ、雑音、オーロラ・雑音共になしの4 種類とした。今回作成した学習ネットワークを使用して、テストデータを分類したところ、その精度は91.2%であった。

作成した学習器によって集めたフラッシュオーロラのイベント (約100イベント) について、代表的な二値化手法である大津の二値化を用いて領域抽出を行なった。フラッシュオーロラの発光継続時間、発光地点、空間サイズ、空間分布について統計解析を行なった。まず、発光継続時間はEMCCDカメラ視野内の磁気緯度、磁気経度に依存しておらず、平均0.21±0.08秒だった。また、観測されたフラッシュオーロラを磁気赤道に投影すると、全イベントのうちの約70 %が地球側に向けて平均0.027 Re大きく拡大していることが確認できた。この結果は、波動の伝搬角や磁気圏におけるロスコーンの空間分布の不均一性が関係していると考えられる。

本発表では私たちが開発したフラッシュオーロラの自動検出法とその時空間解析結果について詳細に報告する予定である。

キーワード：畳み込みニューラルネットワーク、脈動オーロラ、フラッシュオーロラ
Keywords: Convolutional Neural Network, pulsating aurora, flash aurora

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信号処理によるPc1地磁気脈動地上観測のパルス性雑音除去
Study on the pulse noise removal technique for Pc1 geomagnetic pulsations on the ground by signal processing

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磁気圏で発生するプラズマ波動の一種であるElectromagnetic ion cyclotron（EMIC）波動は磁力線に沿って伝搬し、地上においてPc1脈動（0.2～5 Hz）と呼ばれる地磁気の変動として観測される。我々はPc1脈動をカナダのカプスケーシングで地上観測している。地上観測は誘導磁力計を用いて行っており、地磁気の変動を高い時間分解能（64 Hz）で高感度に観測することができる。しかし、強い風などにより観測機器が振動すると、観測波形にパルス性の雑音が含まれてしまう。

本研究では、信号処理技術によって観測波形に含まれるパルス性雑音を除去し、Pc1脈動を抽出する方法について検討を行った。パルス性雑音の特徴として、Pc1脈動よりも広い周波数帯（0.1～10 Hz）にまたがり、Pc1脈動に対して存続時間が短いという点が挙げられる。パルス性雑音除去は、パルス性雑音候補区間の検出、Neural Network（NN）によるパルス性雑音候補区間の分類、およびパルス性雑音区間の波形補間の手順で行う。まず、観測波形の 1 点微分波形の振幅に閾値を設定し、閾値を超えた周辺をパルス性雑音候補区間とした。しかし、この手法ではパルス性雑音以外に高周波に高いエネルギーを持つ区間も検出する。そのため、NNを用いてパルス性雑音候補区間をパルス性雑音区間とそれ以外の区間に分類する。分類のための学習データには、パルス性雑音を強調するためにHPF（High pass filter）を適用した波形を用いた。最後にパルス性雑音区間の波形補間を行う。波形の補間にはエネルギーと位相が必要である。パルス性雑音区間のエネルギーはパルス性雑音区間周辺のエネルギー平均を用いた。位相については、ランダムな位相、観測波形の位相スペクトルを用いた観測位相、非線形最小二乗法による推定位相の３つの位相について検討した。各位相について、チャープ信号に観測波形から抽出したパルス性雑音を印可した波形をテスト信号とするパルス性雑音除去シミュレーションを行い、パルス性雑音除去前後のSNRで評価を行った。その結果、推定位相による向上SNRが22 dBと最も高くなったが、推定にかかる計算時間が膨大であるため用途に応じて使用する位相を変更することが重要であると分かった。以上のパルス性雑音除去手法を用いて実際の観測波形のパルス性雑音除去を行った結果、パルス性雑音を除去し、Pc1脈動を抽出することができた。

本発表では信号処理によるPc1脈動のパルス性雑音除去について詳細に報告する予定である。従来では、観測機器の振動を極力抑える観測環境を吟味、構築する必要があったが、そのコストを削減し、Pc1脈動のより詳細な解析に役立つと考えている。

キーワード：Pc1地磁気脈動、雑音除去、信号処理
Keywords: Pc1 geomagnetic pulsation, Noise removal, Signal processing

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Application of magneto-impedance sensor to geomagnetic field measurements

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Magneto-impedance (MI) effect was discovered about 25 years ago and a micro-size magnetic sensor that utilizes this effect becomes commercially available. We made some modifications to the commercially available MI sensors as they can cover the range of the geomagnetic field. For the period of March 30 to April 27, 2018, we conducted experimental observations of geomagnetic field variations with the MI sensors at Mineyama observation site, which is located about 100 km north-west of Kyoto. Data obtained with the MI sensors were compared with those from the fluxgate magnetometer that has been working at the site. Results showed that the MI sensor recorded geomagnetic variations with amplitudes of ~1 nT that were also detected with the fluxgate magnetometer. This suggests that MI sensors are useful for researches in geomagnetism or space physics, although they are much less expensive than fluxgate magnetometers.

We consider developing two different kinds of systems to measure the geomagnetic field using the MI sensor: a system for ground-based observation and a system for a sounding rocket. In presentation, we will display observation data from the MI sensors and the fluxgate magnetometers at Mineyama and other observatories. Future plans of the system onboard sounding rocket will be also presented and discussed.

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Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

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The ionospheric currents flowing in the dayside ionosphere have been considered as a significant subsequence of Mesosphere-Ionosphere-Magnetosphere coupling. These currents were well detected in the Solar quiet conditions and named Sq currents. In particular, it is well known that the flow pattern of Sq currents shows the north-south hemispheric asymmetry due to the different ionospheric conductivities in the winter and summer hemispheres. This indicates that the asymmetry of the potential must be kept by the energy balance between each hemisphere through the field line.
An InterHemispheric Field Aligned Current (IHFAC) was theoretically predicted by Maeda [1974] and Fukushima [1979, 1991] to interpret the north-south asymmetry in the potential pattern. Several ground magnetic observations and satellite observations suggested an existence of the IHFAC in the noon sector and both the morning and evening terminators. However, the detailed morphology of the IHFAC have not been well understood yet, despite that the direct detection of the IHFAC at Low Earth Orbit (LEO) was reported in the observation by several satellites.
In order to investigate the Sq current system including the IHFAC, the in-situ observation by a CubeSat (2U size satellite emitted from ISS) is proposed in collaboration with 10 national colleges which belong to National Institute of Technology (KOSEN). The fluxgate magnetometer is onboard the CubeSat to observe small perturbations of the magnetic field. After the ejection from the ISS, the CubeSat will gradually glide down to the upper atmosphere due to the strong atmospheric drag and finally burn up in it. The duration of possible observation is estimated for more than 50 days.
The CubeSat can be characterized by the short duration of development (less than 3 years) and low cost (less than 100,000USD). We are considering an actual utilization of this extremely low-cost CubeSat to more realistic science mission. This concept enables us to conduct the multi-satellite in-situ observation in fairly low budget compared to conventional satellite missions.

キーワード：電離層電流、半球間沿磁力線電流、キューブサット
Keywords: Ionospheric Current, Interhemispheric Field Aligned Current, CubeSat

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Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

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We have been measuring electric fields of the plasma waves (a few Hz to several hundred Hz) to understand the magnetospheric dynamics. The spatial resolutions of electric field measurements are not enough because we cannot launch a lot of satellites due to the large size and mass of satellites. Demands of micro satellites like a 1U (10 cubic centimeters) cube satellites are increasing. We need to miniaturize measurement instruments for probing the plasma waves.

This study deals with an electric field instrument in plasma wave observations. We use the electric field instrument for capturing the electric fields detected by wire probe antennas. In this study, the purpose is to miniaturize the electric field instrument with a high radiation tolerance (300 krad) using Application Specific Integrated Circuit (ASIC) technology.

We designed a based amplifier for a new electric field instrument. In the new based amplifier, the equivalent input noise is 50 nV/sqrt(Hz) at 1 kHz, which is 3.9 dB-larger than that of conventional based amplifier (OP-41). The noise performance of new based amplifier is acceptable for capturing the plasma waves. To confirm the radiation tolerance of new based amplifier, we did the radiation tests up to 300 krad using the gamma ray. From the radiation test results, the gain was no change before and after the radiation tests. The output noise was degraded with 5.05 dB at 100 Hz by total ionizing dose effects. However, the based amplifier was not breakdown by the gamma ray. The electric field instrument consisted of new based amplifier could operate with a high radiation tolerance.

We conducted the transient analysis for the new electric field instrument by a circuit simulator (Tanner EDA). In the simulation, rectangular waves of 1 Vpp with 10 Hz input to the new electric field instrument via a sheath impedance (10 MOhms and 100 pF). From the simulation results, the output waveforms of new electric field instrument showed similar output waveforms in comparison with the conventional electric field instrument. The power consumption of new electric field instrument can decrease with approximately 67% than that of the conventional electric field instrument. From the simulation results, we confirmed the basic operations as the electric field instrument for detecting the plasma waves. In the future work, we will need to improve the temperature operating range because the new electric field instrument cannot operate at minus 60 Celsius degrees from the temperature simulation results.

In this presentation, we will present the basic study on electric field instrument for plasma wave observation by ASIC technology in detail.

キーワード：特定用途向け集積回路、電場計測器、プラズマ波動観測
Keywords: ASIC, Electric field instrument, Plasma wave observation

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超小型探査機に搭載する極端紫外撮像装置に用いる電気回路部の放射線耐性の評価

Evaluation of radiation tolerance of electronics parts used for the ultra-small mission

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飛翔体搭載機器に用いられる電子機器は、宇宙空間の放射線に曝されることでノイズの増加、ビット反転、消費電流の増加、などの悪影響を受ける恐れがある。

近年、大学の研究室規模で超小型探査機の開発が実現している。超小型の枠組みでは、民生部品を用いることで開発にかかる費用と時間を大幅に低減することで、短期間でのミッションの実現を可能にしている。しかし、一般の民生部品は放射線耐性を考慮した設計がなされていないため、飛翔体搭載に用いる際には実際の利用環境を再現した試験を通して確認する必要がある。この時、照射するべき総吸収線量は、放射線と物体の物理的な相互作用を考慮したエネルギー収支に関するモンテカルロシミュレーションから求められる。

我々は、2020年に打ち上げ予定の超小型衛星EQUULEUSに搭載される極端紫外撮像機「PHOENIX」を開発している。「PHOENIX」は、地球のプラズマ圏を構成するヘリウム一価イオンが太陽共鳴散乱によって発する極端紫外領域の輝線(波長30.4nm)を月近傍から準定常的に観測することで、プラズマ圏の動的描像と大局的な理解を目指す。この装置に搭載される信号増幅回路部に用いられる半導体素子の放射線耐性を、セシウム137を用いたガンマ線照射装試験を通して評価した。

本発表では、累積放射線量による半導体素子の利得率特性の変化と電気ノイズレベルの変化について評価した結果を述べ、今後の飛翔体ミッションへの応用可能性について議論する。

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A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

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Observation instruments are known to deteriorate under atmospheric condition. Deterioration are mainly caused by reaction with water vapor and oxygen. To prevent this, observation instruments must be maintained under vacuum. The problem is that the conventional vacuum pump are too heavy to carry to the launching site. The need of continuous power supply makes the transport more difficult. Also the vacuum pump must be removed before the launch. These problems are not only making it difficult to maintain observation instruments under vacuum but also causing extra costs. Non-evaporable-getter (NEG) pumps are able to solve these problems. NEG pumps are light weight, compact, oil free, vibration free, and able to operate without energy supply after activation. Considering the utilization of NEG pump for space science missions, we need to quantitatively evaluate the NEG pump to optimize its size, shape, material, and mounting position for each mission. In this study, a method to measure pumping speed of NEG pump for carbon monoxide (as substitute to water vapor and oxygen) was established by using the orifice method. By using this method, it will be able to develop a NEG pump which best applies the case for each mission.

キーワード：非蒸発型ゲッターポンプ、真空ポンプ
Keywords: Non-evaporable-getter pump, vacuum pump

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３次元電位分布計算による「みお」搭載MIAのトップハット分析器特性の非対称性の解釈

Interpretation on slight asymmetry of analyzer characteristics of MIA onboard the Mio by means of a model calculation of 3-D potential distribution

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MIA (Mercury Ion Analyzer) on board Mio employs a top-hat electrostatic analyzer, which has axisymmetric toroidal electrodes and is designed to have no dependence in its characteristics on azimuthal direction of incident ions. However, our ground calibration experiments have revealed that it has a slight dependence. We have tried to explain the dependence by means of three dimensional model calculations. We assumes that all parts of electrode are manufactured precisely. Our results shows that a slight relative rotation (or tilt) of electrodes can lead to a slight dependence on incident azimuthal direction similar to that obtained from the ground experiments.

キーワード：みお、トップハット静電分析器、水星イオン分析器
Keywords: Mio, tophat electrostatic analyzer , MIA

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小型衛星用衝撃試験機の建造及びMCPの機械耐性評価
Construction of impact testing machine for small satellites and evaluation of mechanical resistance of MCPs by the impact test

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近年小型衛星の開発が盛んに行われている。開発段階における環境試験は、小型衛星の信頼性向上に重要な役割を担っている。環境試験では振動や衝撃、熱真空などに対する耐性を確認する必要がある。その中でも衝撃に関する試験は最も実施が困難な試験の一つであり、未だ確実な手法が確立されていない。こうした背景から私たちは小型衛星用の衝撃試験機を建造した。衝撃試験機に求められる性能は大きく二つある。一つは、想定するミッションの衝撃レベルに限りなく近い衝撃を印加することのできるコントロール性である。これは試験対象への過度な衝撃印加を回避するために重要である。二つ目は、狙った衝撃レベルを高い精度で複数回印加することのできる再現性である。再現性が低いと、印加したい衝撃レベルとは異なった意図しない衝撃を印加してしまう可能性があり、試験精度の低下に繋がる。今回建造した衝撃試験機は、印加する衝撃を容易に調整することが可能であり、且つ再現性の高いものを目指し設計した。更にこの衝撃試験機を用いて、光学観測機器に広く用いられるMCP (micro-channel plate)をサンプルとした衝撃試験を実施し、その機械耐性を調べた。ここで用いた衝撃レベルは、2020年にNASAのロケットで打ち上げられるEQUULEUSミッションを想定した衝撃レベルである。今回の発表では、衝撃試験機の詳細及びサンプルを用いた衝撃試験の結果について紹介する。

キーワード：衝撃試験
Keywords: impact test

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Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

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It is well known that the terrestrial and planetary magnetospheres and the interplanetary space are filled with charged particles such as electrons and ions, which are so-called the space plasma, and in-situ observations of the space plasmas have been conducted by using satellites carrying particle instruments, such as the top-hat type electrostatic energy analyzer. Essentially, obtaining three-dimensional velocity distributions of the space plasmas or energy-pitch angle distributions help us understand the dynamics of the space plasmas. Because the top-hat type analyzer is cylindrically symmetric and has a 2π-radian planar field of view, it can independently measure the wide angular and energy distributions of incident particles. Also, three-dimensional velocity or energy-pitch angle distributions can be obtained by utilizing the satellite spin motion.
The top-hat type electrostatic energy analyzers can measure the ions when a negative potential is applied to the inner electrode and the electrons by a positive potential with the outer electrode grounded. Therefore, in the prevailing design of the top-hat type analyzer, the sensor heads separate for the ion and electron observations, respectively. Because of the recent miniaturization of the satellites, the weight and space of the instruments mounted on the small and micro satellites are getting severely restricted. However, if two sensors for electron and ion observations are combined into one sensor head, it is possible to save both weight and space on the small and micro satellites. Therefore, we have been developing double-shell type energy analyzer which can simultaneously measure the ions and the electrons with one sensor head.
We designed the shapes of the collimator and the double-layered dome-shaped electrodes so that the electrons and the ions with appropriate energies pass through the inner gap and the outer gap by applying a negative potential to the central electrode with the inner and outer electrodes grounded, respectively. We made the numerical simulations using SIMION which is a charged particle simulator program and investigated the performance and characteristics as the electrostatic analyzer. Consequently, we confirmed that the electrons and the ions can be analyzed with one sensor head by only applying negative high voltage to the electrodes. So far, we consider the detection unit using Time-Of-Flight velocity spectrometer for the discrimination of the ion species as the part where the ions are detected, and an assembly of micro channel plates is expected for the electron detection. The design of TOF-type mass analysis unit as ion mass analysis unit is one of subjects for future work.

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Microsatellite Development and Education of Space Science and Technology at Kanazawa University

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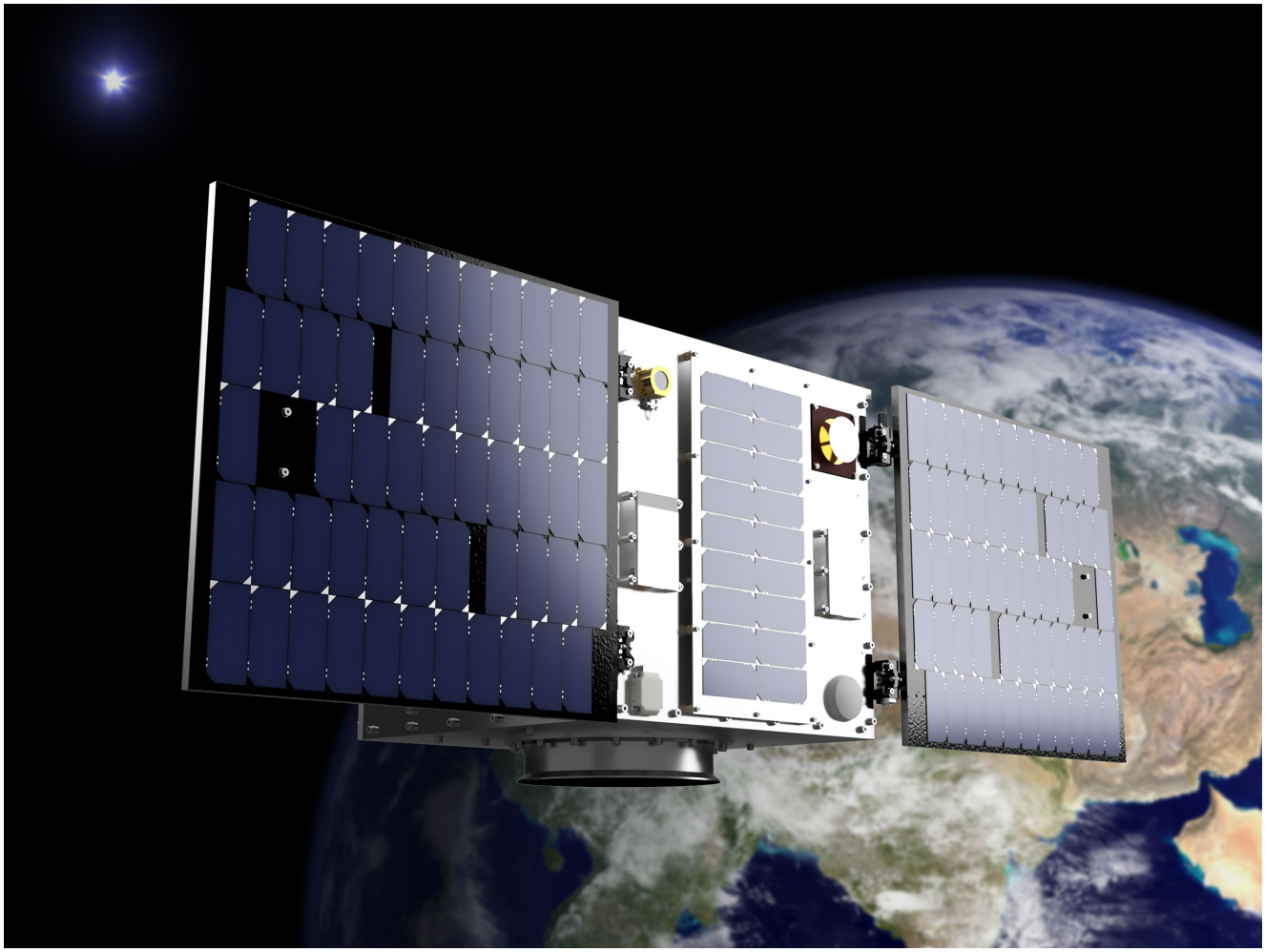
At Kanazawa University, researchers from engineering and science are cooperating to promote the "Kanazawa University Satellite Project (Kanazawa-SAT3: Study and Training in Space Science and Technology for Kanazawa Cube-Satellites)". In this project, a microsatellite is being developed by staff and students of Kanazawa University. It is a scientific satellite which will contribute to the elucidation of the mechanism of gravitational wave generation by identifying the source of gravitational wave by detecting the arrival direction of gamma rays and X rays radiated at the same time when a gravitational waves are generated by collision of astronomical objects The satellite will be inserted into a solar synchronous orbit at about 660 km altitude. It is a microsatellite with a total weight of 50 kg or less, and its size is cubic with a side of 50 cm, and it is designed to be a piggyback on an HII-A rocket.

Also related to this project, a space science and engineering course has been newly established in the Graduate School of Natural Sciences in April 2018. This course is based on the 'satellite development by students', and students are actually involved in the design, fabrication, ground tests, and operation of scientific satellites, aiming to train personnel who are familiar with space science and space engineering, with satellite-development skills.

Ground tests with the thermal and structural model of Kanazawa-SAT3 have been completed , and the unit tests for almost all components are being conducted. Currently, we are completing the design of the flight model. In the presentation, we will report the details of Kanazawa-SAT3 and its development status.

キーワード：超小型衛星、重力波、Kanazawa SAT3
Keywords: Microsatellite, Gravitational wave, Kanazawa SAT3

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Attitude Control System for Kanazawa-SAT3 Microsatellite

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Kanazawa University has been developing a microsatellite. This satellite is equipped with a device to observe celestial bodies emitting gravitational waves with X rays, and aims to elucidate the mechanism of black hole formation by estimating the time of arrival and direction of arrival of gravitational waves.
In this research, the attitude control system is being developed using GAS (Geomagnetic Aspect Sensor) and MTQ (Magnetic Torque). We have constructed the environment for the unit test of RW (Reaction Wheel) also used for attitude control of the satellite.

MTQ is a device that controls the attitude of the satellite by generating a magnetic torque against the geomagnetic field by applying a voltage (an electric current) to a magnetic coil. GAS is a device for detecting the direction of the geomagnetic vector. OBC (On Board Computer) which controls all devices mounted on the satellite receives the geomagnetic field data detected by GAS, and transmits commands to control MTQ. GAS and MTQ cannot be connected to OBC directly, because OBC has just a digital interface, but the output of GAS and the input to MTQ are analog voltages. Therefore, we have developed a control device for on-board equipment using a microcontroller. For the GAS, the voltages are A/D-converted by the microcontroller and transmitted to the OBC. For the MTQ, OBC transmits control commands to the microcontroller, which generates a PWM (Pulse Width Modulation) signal according to the received command that determines the effective voltage to be given to the MTQ. For the system development and operation tests, a PC is used instead of OBC and we carried out experiments of control equipment. For the GAS, we have confirmed the linearity between the analog magnetic field and the corresponding digital values transmitted to the PC. For the MTQ, we have confirmed that the voltage to be given to MTQ were precisely controlled by the duty ratio of the PWM signal output from the microcontroller.

RW is a device to generate a control torque around the rotation axis by accelerating a rotor by a motor and is controlled by transmitting a command from the OBC via an RS-422 serial communication line. The unit test has been carried out by using a PC as a substitute of OBC, but the cable had a influence on the rotation operation of RW. Therefore, we have constructed a system for wirelessly connecting the RW with the PC via a wireless RS-422 communication. Specifically, commands from the PC are wirelessly transmitted to an Arduino microprocessor by a low-power radio module XBee, and the RW is controlled via an RS-422 transceiver. With this system, we demonstrated the basic functions for command and data between the PC and the Arduino via the wireless RS-422 transceiver.

We plan to construct a system that applies appropriate PWM signals to MTQ according to the value detected by GAS. We will also evaluate RW performance by the unit test using the wireless RS-422 communication system.

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キーワード：超小型衛星、姿勢制御システムACS、Kanazawa SAT3
Keywords: Microsatellite, ACS, Kanazawa SAT3

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Communications System and Antennas for Kanazawa-SAT3 Microsatellite

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Teruya Minamoto[1], Koyo Ina[1], Kohei Kawagoshi[1], *Tomohiko Imachi[1], Satoshi Yagitani[1], Yoshitaka Goto[1], Daisuke Yonetoku[1], Yoshiya Kasahara[1], Tatsuya Sawano[1], Makoto Arimoto[1]

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Kanazawa University is developing the first Kanazawa University's microsatellite, named as Kanazawa-SAT3. Kanazawa-SAT3 is planned to be launched within FY2019, and its observation mission is to identify the source of gravitational waves by detecting the occurrence time and arrival direction of the X-rays and gamma rays observed simultaneously with gravity waves from distant astronomical objects.

In this research, we are developing a communications system for Kanazwa-SAT3. Kanazawa-SAT3 has three different communication systems using S band, UHF band and Iridium, and the link design of each of them has generally been completed. We summarize each communication system in detail as the following.

The S-band communication system, will use 2-GHz frequency band. Kanazawa-SAT3 is equipped with two types of antennas: S-band patch antennas and S-beacon antennas. S-band system is a main communication system between the satellite and a ground station, and plays a role of high speed data communication and beacon transmission. On the satellite side, two S-band patch antennas designed for both transmission and reception are mounted on the front and rear panels of the satellite. Two S-beacon antennas for transmission are also mounted on the front and rear panels of the satellite. On the ground side, we will send and receive by the signals using a 2.4-m parabolic dish installed at Kanazawa University.

The UHF communication system will use 400-MHz frequency bands. This system transmits commands from the ground to the satellite and telemetry information from the satellite to the ground. On the satellite side, four inverted-F type antennas we developed are mounted (two for receiving and two for transmitting) on the front and rear panels of the satellite. On the ground side, we will send and receive data by using a Yagi antenna with 14 crossed elements installed at Kanazawa University. We have also constructed an automatic satellite tracking system using the Yagi antenna.

A communication system using the Iridium satellite network uses a frequency band around 1.6 GHz. In this system, communications are performed via Iridium satellite, so that the communication can be established even when our ground station is not visible from the satellite. The data is exchanged between the satellite and the ground by using e-mail. This system can transmit and receive data in almost real time so emergency command and data transmission will be available. On the satellite side, two antennas for both transmission and reception are mounted on the front and rear panels of the satellite. A system has been constructed that exchanges data between a laptop computer simulating an onboard computer (OBC) mounted on a satellite and an iridium satellite.

From now on, for the communication systems using the S band and the UHF band, it is necessary to develop the communication software. For In addition, we need to improve the automatic satellite tracking

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system of Kanazawa-SAT3. For the communication system using Iridium satellite, it is necessary to implement a system on the OBC and conduct a communication experiment.

キーワード：超小型衛星、通信システム、Kanazawa SAT3
Keywords: Microsatellite, Communications System, Kanazawa SAT3

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6Uクラス超小型深宇宙探査機EQUULEUSに搭載する多層断熱材一体型ダスト計測器CLOTHの開発
Development of micrometeoroid impact sensor within a multi-layered insulation (CLOTH) onboard 6U deep-space explorer EQUULEUS

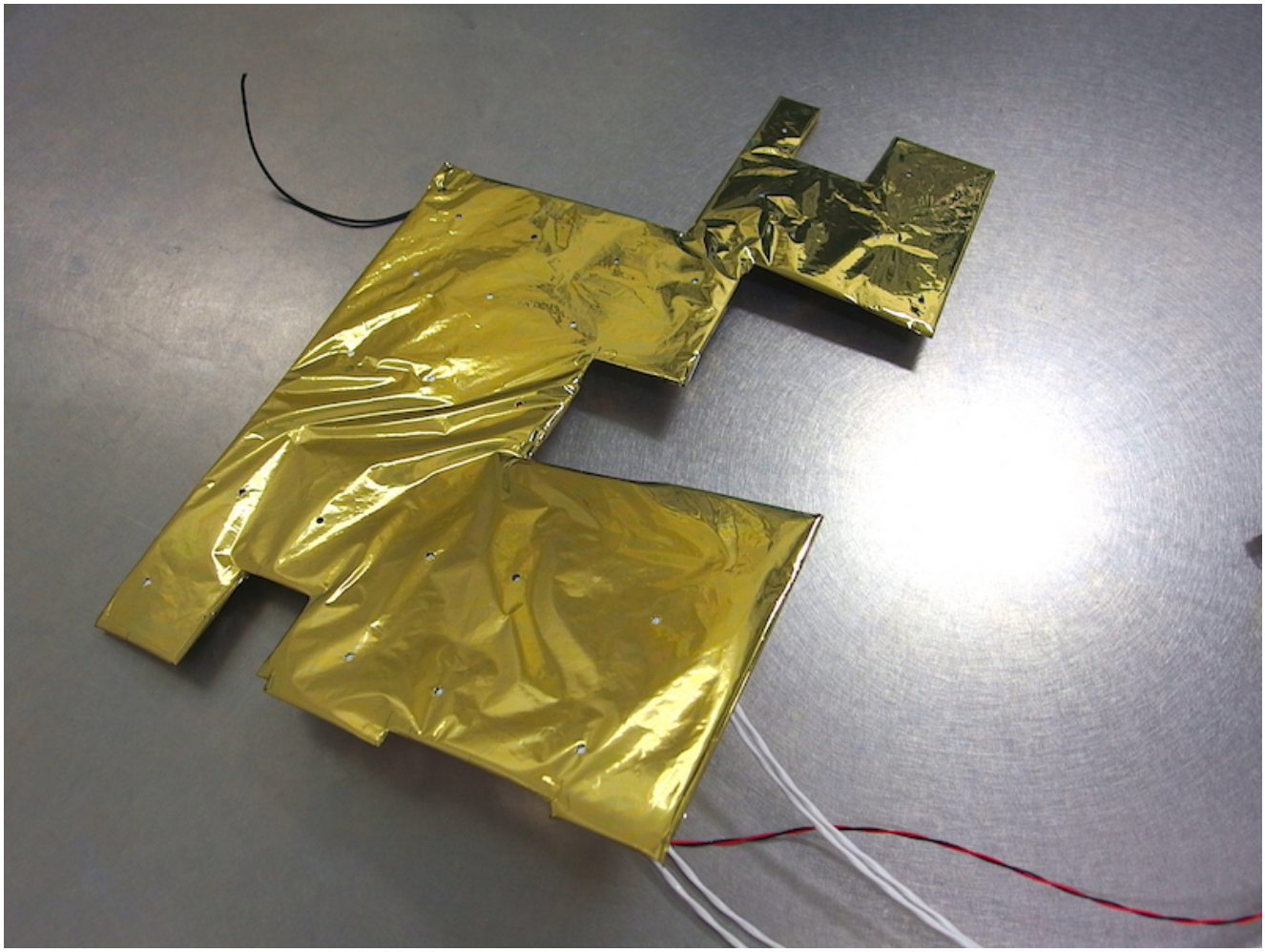
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近年、超小型衛星の利用範囲は地球周回から深宇宙へ広がりを見せている。東京大学とJAXAが開発を主導する超小型新宇宙探査機EQUilibriUm Lunar-Earth point 6U Spacecraft (EQUULEUS)は、米国航空宇宙局（NASA）の新規ロケットSpace Launch System (SLS) の副ペイロードとして打ち上げられる13基の超小型衛星の一つで、地球ー月ラグランジュ点（L2）への航行を通じた太陽ー地球ー月圏での軌道操作技術の実証と、3つの理学ミッションを行う予定である。ジオコロナ観測と月衝突閃光観測に加え、我々はCis-Lunar Object detector within THermal Insulation (CLOTH) を用い、惑星間ダスト観測を行う。CLOTHは、EQUULEUSの表面の一部を覆う多層断熱材 (Multi-Layer Insulation, MLI) と一体化した圧電性フィルムセンサで、MLIの最外層を貫通してくるダストの運動量を推定する。CLOTHの宇宙実証が成功することで、リソースの限られた超小型衛星による深宇宙探査の可能性がより拡大すると期待される。本講演では、衛星そのものに科学観測機能を付与するというCLOTHのコンセプトと、超高速微粒子衝突実験から得られたCLOTHのダスト検出性能について紹介する。

キーワード：圧電性フィルム、ポリフッ化ビニリデン、多層断熱材、超小型衛星、微隕石、超高速衝突
Keywords: Piezoelectric film, PVDF, Thermal insulation, CubeSat, Micrometeoroid, Hypervelocity impact

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DESTINY+搭載小惑星追尾機構の開発：概念設計およびBBMを用いた性能試験

Breadboard model of asteroid tracking system for DESTINY+ mission

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深宇宙探査技術実証機DESTINY+（Demonstration and Experiment of Space Technology for Interplanetary voYage, Phaethon fLyby and dUst Science）はイプシロンロケットによる公募型小型ミッションとして提案され、2023年の打ち上げを目指して現在フェーズA検討が進められている。このミッションではふたご座流星群の母天体と考えられている小惑星（3200）ファエトンを近接フライバイし、地表面の高解像度撮像を行う予定である。探査機には2種類のカメラ、可視光の単色バンドで高解像度撮像を行う望遠カメラTCAP（Telescopic Camera for Phaethon）、と低空間解像度で可視から近赤外のマルチバンド撮像を行うカメラMCAP（Multiband Camera for Phaethon）の搭載が予定されている。探査機で小惑星まで500 kmの位置に最接近し、最接近時およそ40秒前から9秒後までの間にTCAPによって最高空間解像度3.5 m/pxで1秒間隔の撮像を行うことを計画している。カメラの撮像方向は通常は探査機本体の姿勢制御で決められるが、DESTINY+では小惑星ファエトンの特異な軌道のため、相対速度30 –40 km/sという非常に速いフライバイを行う必要があり、探査機本体の姿勢制御だけではTCAPの撮像画像がぶれてしまう。そのため、高速フライバイ中に自律的に小惑星を視野内に収め続け、かつぶれのない高解像度画像を取得するような小惑星追尾機構がTCAPに要求される。そこで私たちはTCAPの追尾機構の概念検討、および追尾機構を適切に駆動するための制御アルゴリズムを検討した。さらに概念検討で得られたデザインを実証するため、追尾機構において中心的な機能を果たす駆動鏡のBBMを試作した。BBMは鏡、ステッピングモータ、減速機およびそれらを制御するFPGA基板から構成される。本発表では小惑星追尾機構の概念検討の結果と、駆動鏡BBMの試作状況および初期性能試験の結果を報告する。

キーワード：DESTINY+、カメラ、フライバイ、追尾機構
Keywords: DESTINY+, camera, flyby, tracking system

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火星衛星探査計画における望遠カメラ(TENGOO)性能評価装置の開発
Development of telescopic camera (TENGOO) performance evaluation device in MMX

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火星にはフォボスとダイモスの二つの衛星が存在する。その起源については捕獲した原始小惑星である説と、火星の巨大衝突事象による破片が集積し形成された説の２つが存在する。この火星衛星の起源を明らかにするために、JAXAはフォボスからサンプルリターンを行う火星衛星探査計画(Martian Moon eXploration)を2024年に検討している。

この計画に搭載される望遠カメラ(Telescopic Nadir imager for Geomorphology, TENGOO)はフォボスの地形を撮像し、平坦な着陸地点や宇宙風化の影響が少ない地点を発見するという目的を持っている。この目的を果たすため、高度20kmでの観測において空間分解能が24cmとなるように、角度解像度が5.8urad/pix、MTF>0.3(ナイキスト周波数)と光学設計が行われた。この光学設計の段階で得られた性能が製造された際にも確保されているか評価する必要がある。従って本研究ではTENGOOの性能評価を行うために、平行光が入射したときの点像関数の広がりを十分な精度で求める。そのため平行光の角度広がりが11.6urad以下の平行光源を作成した。

またこの装置で得られるPSFの半値幅は、TENGOOでは約2x2画素となる。そのためサンプリング間隔が半値幅に対して広くなり、ガウスフィッティングによるPSF推定の誤差が大きくなる。そこで斜線状の光源によってLSFを測定し、複数のPSFを得ることでサンプリング間隔の補完を行った。
本発表では、これらの研究開発の成果を報告する。

キーワード：火星、MMX、camera
Keywords: Mars, MMX, camera

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ソーラー電力セイルOKEANOSのクルージングフェーズにおける観測計画
Observation Plans in the Cruising-Phase of the Solar Power Sail: OKEANOS

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ソーラー電力セイル探査機OKEANOS (Oversize Kite-craft for Exploration and AstroNautics in the Outer Solar system)は、ソーラー電力セイルによる外惑星領域探査を実証することを目的としており、その主要なサイエンスターゲットは木星トロヤ群小惑星の表面および内部の科学探査である。一方で、打上げから木星スイングバイまでのクルージングフェーズは、その空間的・時間的拡がりから、太陽系内の物質・エネルギーの同径方向の分布に関する観測の好機を与える。我々はこのフェーズにおいて、赤外線観測装置EXZIT、ダスト観測装置ALADDIN -2、磁力計MGF、ガンマ線バースト観測装置GAP-2を用いた太陽系ディスク方向の探査を計画している。

可視光・近赤外線で観測される黄道光は、惑星間ダストにより散乱された太陽光であると考えられている。黄道光の2次元分布は、惑星間ダストの3次元構造を反映しているが、小惑星起源と彗星起源の比率が日心距離に応じてどう変化するかは、解明されていない。我々は、EXZITを用いた可視光・近赤外線による黄道光の太陽系動径方向の観測と、ALADDIN-2による惑星間ダストのその場観測を行う。これらを比較することによって、太陽系の固体微粒子の分布や移動の実態を明らかにする。 OKEANOSから得られる観測結果はまた、太陽系のダスト・黄道光が外惑星領域からどのように観測されるかという情報を示し、太陽系外の恒星系観測における指標となることが期待される。

太陽風の温度分布は太陽距離に依存すると考えられるが、その実測値は断熱モデルから予測される値よりも高いことが知られている。このため、プラズマ乱流や磁気再結合などの加熱機構の存在が予測されている。我々はMGF-2によるソーラー電力セイルのスケールでの同時磁場観測を行うことにより、電子スケールでのプラズマ乱流を検出することを検討している。このような観測を、地球軌道から木星軌道にかけて行うことにより、太陽風の加熱機構の解明を目指す。クルージングフェーズの長期間の観測はまた、突発的な太陽風に伴った磁気現象の検出が期待される。また、これらの太陽風ショックに伴うガンマ線の検出可能性も探る。
これらの観測を、はやぶさ、はやぶさ２などの既ミッション、およびOKEANOSのトロヤ群小惑星到着後の探査からの知見と組み合わせることにより、太陽系の内惑星～外惑星領域の物質の分布と移動に関する理解が深められ、生命前駆物質の起源を含め、太陽系の各天体の形成から地球上の生命誕生に至るプロセスが明らかになることが期待される。

キーワード：OKEANOS、黄道光、ダスト、プラズマ、ガンマ線
Keywords: OKEANOS, zodiacal light, dust, plasma, gamma-ray

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

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_8

[P-CG21] 宇宙・惑星探査の将来計画と関連する機器開発の展望

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

[PCG21-P01] 編隊飛行による地球電磁気圏・熱圏探査衛星計画「FACTORS」搭載可視・紫外イメージャーによる微細オーロラと大気光観測

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[PCG21-P02] 機械学習を用いたフラッシュオーロラの時空間解析

*源田 斗輝[1]、井上 拓海[1]、尾崎 光紀[1]、八木谷 聡[1]、今村 幸祐[1]、塩川 和夫[2]、三好 由純[2]、大山 伸一郎[2]、片岡 龍峰[3]、海老原 祐輔[4]、細川 敬祐[5] (1.金沢大学、2.名古屋大学、3.極地研究所、4.京都大学、5.電気通信大学)

[PCG21-P03] 信号処理によるPc1地磁気脈動地上観測のパルス性雑音除去

*駒瀬 文弥[1]、井上 智寛[1]、尾崎 光紀[1]、八木谷 聡[1]、塩川 和夫[2]、能勢 正仁[2]、長妻 努[3] (1.金沢大学、2.名古屋大学、3.情報通信研究機構)

[PCG21-P04] Application of magneto-impedance sensor to geomagnetic field measurements

*能勢 正仁[1]、野村 麗子[2]、浅村 和史[3]、青山 均[4]、河野 剛健[4]、松岡 彩子[3]、北村 健太郎[5]、小山 幸伸[6]、松本 晴久[7]、平原 聖文[1] (1.名古屋大学宇宙地球環境研究所、2.国立天文台、3.宇宙航空研究開発機構 宇宙科学研究所、4.愛知製鋼株式会社、5.徳山工業高等専門学校、6.大分工業高等専門学校、7.宇宙航空研究開発機構 研究開発部門)

[PCG21-P05] Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

*北村 健太郎[1]、今井 一雅[2]、高田 拓[2]、篠原 学[3]、若林 誠[4]、高専 スペース連携 (1.徳山工業高等専門学校、2.高知工業高等専門学校、3.鹿児島工業高等専門学校、4.新居浜工業高等専門学校)

[PCG21-P06] Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

*徳永 祐也[1]、尾崎 光紀[1]、石坂 圭吾[2]、小嶋 浩嗣[3]、八木谷 聡[1]、頭師 孝拓[3] (1.金沢大学、2.富山県立大学、3.京都大学)

[PCG21-P07] 超小型探査機に搭載する極端紫外撮像装置に用いる電気回路部の放射線耐性の評価

*勝瀬 陸[1]、吉岡 和夫[1]、桑原 正輝[2]、疋田 伶奈[1]、荒尾 昇吾[1]、吉川 一朗[1] (1.東京大学、2.宇宙航空研究開発機構　宇宙科学研究所)

[PCG21-P08] A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

*西村 晟八[1]、吉川 一朗[1]、吉岡 和夫[1]、荒尾 昇吾[1]、張 天旭[1] (1.東京大学)

[PCG21-P09] ３次元電位分布計算による「みお」搭載MIAのトップハット分析器特性の非対称性の解釈

*三宅 亙[1]、斎藤 義文[2]、横田 勝一郎[3] (1.東海大学工学部、2.宇宙科学研究所、3.大阪大学)

[PCG21-P10] 小型衛星用衝撃試験機の建造及びMCPの機械耐性評価

*福場 惇哉[1] (1.東京大学大学院)

[PCG21-P11] Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

*武井 智美[1]、平原 聖文[1] (1.名古屋大学宇宙地球環境研究所)

[PCG21-P12] Microsatellite Development and Education of Space Science and Technology at Kanazawa University

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[PCG21-P13] Attitude Control System for Kanazawa-SAT3 Microsatellite

中嶋 拓也[1]、安田 有希[1]、瀬川 浩史[1]、*井町 智彦[1]、八木谷 聡[1]、笠原 禎也[1]、米徳 大輔[1]、澤野 達哉[1]、有元 誠[1] (1.金沢大学)

[PCG21-P14] Communications System and Antennas for Kanazawa-SAT3 Microsatellite

源 輝也[1]、稲 航洋[1]、河越 幸平[1]、*井町 智彦[1]、八木谷 聡[1]、後藤 由貴[1]、米徳 大輔[1]、笠原 禎也[1]、澤野 達哉[1]、有元 誠[1] (1.金沢大学)

[PCG21-P15] 6Uクラス超小型深宇宙探査機EQUULEUSに搭載する多層断熱材一体型ダスト計測器CLOTHの開発

*平井 隆之[1]、矢野 創[2]、實川 律子[3]、石岡 英悟[3]、中野 晴貴[3]、新井 和吉[3]、長谷川 直[2] (1.千葉工業大学・惑星探査研究センター、2.宇宙航空研究開発機構・宇宙科学研究所、3.法政大学・理工学部)

[PCG21-P16] DESTINY$^+$搭載小惑星追尾機構の開発：概念設計およびBBMを用いた性能試験

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[PCG21-P17] 火星衛星探査計画における望遠カメラ(TENGOO)性能評価装置の開発

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[PCG21-P18] ソーラー電力セイルOKEANOSのクルージングフェーズにおける観測計画

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編隊飛行による地球電磁気圏・熱圏探査衛星計画「FACTORS」搭載可視・紫外イメージャーによる微細オーロラと大気光観測

Visible and ultraviolet imagers for auroral and airglow observations by FACTORS - a future satellite mission for understanding the coupling and transportation processes in the upper atmosphere

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We report science subject, design, development plan and identification of issues to be solved on the visible and ultraviolet imagers for a future satellite mission called FACTORS that aims to understand the coupling processes in the terrestrial magnetosphere/ionosphere/thermosphere and the acceleration and transportation of the space plasma and neutral atmospheric particles. FACTORS stands for Frontiers of Formation, Acceleration, Coupling, and Transport Mechanisms Observed by Outer Space Research System that is proposed as a multi-satellite formation flight mission. This will be a community exploration mission in Japanese apace research after the success of the ERG mission. The working group was approved by ISAS, JAXA this year, and we have started the discussion on detailed science targets, instrumental design, feasibility and so on. We mainly concern on visible and ultraviolet remote imaging of aurora and airglow for this mission. A visible imager (VISAI) on FACTORS will measure small-scale auroral structures at a wavelength of auroral prompt emission line, such as N2 1st PG, with high-time (~0.1s) and high-spatial (~1km) resolutions using a science CMOS or EMCCD. The FOV of 8 x 8 deg covers an area of 400 x 400 km viewed from 3000 km altitude. The high-spatial and high-time resolution imaging data is essential to understand small-scale variations of Alfven aurora, pulsating aurora, etc. Combined with particle and electric/magnetic field data by FACTORS, we will reveal the time and spatial variations of acceleration/scattering process in the complicated magnetosphere-ionosphere coupling system. A far-ultraviolet imager (FUVI) adopts a wide (~40 x 40 deg.) FOV objective mirror system which covers ~2500 x 2500 km area viewed from 3000 km altitude. We plan to adopt a filter wheal in FUV imager to change the wavelength between O 135.6 nm and the N2 LBH band at 140-160 nm. Wide-field multi-wavelength FUV images enable us to examine large-scale auroral dynamics like westward-travelling surge during substorm, omega-bands, and provide us to understand the global thermospheric activity from O/N2 airglow ratio. This year we plan to carry out specific studies for CMOS/EMCCD detectors

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suited for this mission, and perform radiation tests of detectors.
Related to the future FACTORS mission, we are now carrying out the developments of aural cameras for two sounding rocket projects, G-CHASER (Rocksat-XN) and LAMP. The G-CHASER (Rocksat-XN) rocket was successfully launched from Andøya, Norway on January 13, 2019. We installed an auroral camera (AIC) on this rocket to measure N2 1st PG emission with wide-angle FOV lens(96x75 deg), RG-665 filter, and CCD (WAT-910HX). In addition, we are developing two CMOS cameras AIC2 on the LAMP rocket that is scheduled to be launched at Poker Flat Research Range in winter of 2019. AIC2 will be installed on a despun platform to derotate rocket spin. One CMOS camera AIC2-S1 measures N2 1st PG emission with a narrow FOV lens (F-number=0.95, f=17mm, FOV=27x27deg.), and another CMOS camera AIC-S2 measures OI 844.6nm emission with a wide-angle lens (F-number=1.6, f=3.5mm, FOV=120x120deg.). Both cameras adopt the ZWO ASI 180 MM CMOS detector. AIC2-S1 will take fine structure of PsA in the region more than 100 x 100 km area around the magnetic footprint with a few kilo-meter resolution, while AIC2-S2 will obtain an altitude distribution of pulsating aurora in the F-region as well as distribution of PsA in wide-range. The precise imaging and altitude distribution of PsA are obtained with AIC2 at two wavelengths with 10Hz sampling. The imaging data combined with precipitating electron data in the wide energy range enable us to investigate the relativistic electron precipitation called microbursts that is probably caused by chorus waves in the magnetosphere.

キーワード：磁気圏、オーロラ、イメージャー、紫外、可視、電離圏
Keywords: magnetosphere, aurora, imager, ultra violet, visible, ionosphere

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機械学習を用いたフラッシュオーロラの時空間解析
Spatio-temporal analysis of flash aurora using Convolutional Neural Network

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オーロラは宇宙空間に存在する高エネルギー荷電粒子の一部が磁力線に沿って移動し、地球上層大気と衝突することで発光する現象である。つまり、オーロラの地上観測により、間接的に磁気圏に存在している電子の様相を知ることができる。私たちはオーロラの中でも、一秒以下で突発的に発光するフラッシュオーロラに注目している。フラッシュオーロラは、その発光時間の短さから目視による大量のイベント検出が難しく、詳細な解析は行われていない。よって、本研究では、EMCCDカメラで観測されたフラッシュオーロラを機械学習によって自動検出し、時空間変動の統計解析を行った。観測データはガコナ (アメリカ・アラスカ州) に設置されたEMCCDカメラ(サンプリング100 Hz、解像度 256 * 256 ピクセル)を用いた。

本研究で用いた機械学習の手法は、画像認識に特に優れている畳み込みニューラルネットワーク (CNN) である。学習データは、EMCCD画像の南北断面を切り出して時系列に並べたKeogram 画像（解像度2400 * 720 ピクセル、時間幅1 分間）を正方形のブロック（解像度30 * 30 ピクセル、時間幅0.75 秒間）に分割し、目視で分類したものを学習データとして使用した。分類は、脈動オーロラ、フラッシュオーロラ、雑音、オーロラ・雑音共になしの4 種類とした。今回作成した学習ネットワークを使用して、テストデータを分類したところ、その精度は91.2%であった。

作成した学習器によって集めたフラッシュオーロラのイベント (約100イベント) について、代表的な二値化手法である大津の二値化を用いて領域抽出を行なった。フラッシュオーロラの発光継続時間、発光地点、空間サイズ、空間分布について統計解析を行なった。まず、発光継続時間はEMCCDカメラ視野内の磁気緯度、磁気経度に依存しておらず、平均0.21±0.08秒だった。また、観測されたフラッシュオーロラを磁気赤道に投影すると、全イベントのうちの約70 %が地球側に向けて平均0.027 Re大きく拡大していることが確認できた。この結果は、波動の伝搬角や磁気圏におけるロスコーンの空間分布の不均一性が関係していると考えられる。

本発表では私たちが開発したフラッシュオーロラの自動検出法とその時空間解析結果について詳細に報告する予定である。

キーワード：畳み込みニューラルネットワーク、脈動オーロラ、フラッシュオーロラ
Keywords: Convolutional Neural Network, pulsating aurora, flash aurora

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信号処理によるPc1地磁気脈動地上観測のパルス性雑音除去
Study on the pulse noise removal technique for Pc1 geomagnetic pulsations on the ground by signal processing

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磁気圏で発生するプラズマ波動の一種であるElectromagnetic ion cyclotron（EMIC）波動は磁力線に沿って伝搬し、地上においてPc1脈動（0.2～5 Hz）と呼ばれる地磁気の変動として観測される。我々はPc1脈動をカナダのカプスケーシングで地上観測している。地上観測は誘導磁力計を用いて行っており、地磁気の変動を高い時間分解能（64 Hz）で高感度に観測することができる。しかし、強い風などにより観測機器が振動すると、観測波形にパルス性の雑音が含まれてしまう。

本研究では、信号処理技術によって観測波形に含まれるパルス性雑音を除去し、Pc1脈動を抽出する方法について検討を行った。パルス性雑音の特徴として、Pc1脈動よりも広い周波数帯（0.1～10 Hz）にまたがり、Pc1脈動に対して存続時間が短いという点が挙げられる。パルス性雑音除去は、パルス性雑音候補区間の検出、Neural Network（NN）によるパルス性雑音候補区間の分類、およびパルス性雑音区間の波形補間の手順で行う。まず、観測波形の 1 点微分波形の振幅に閾値を設定し、閾値を超えた周辺をパルス性雑音候補区間とした。しかし、この手法ではパルス性雑音以外に高周波に高いエネルギーを持つ区間も検出する。そのため、NNを用いてパルス性雑音候補区間をパルス性雑音区間とそれ以外の区間に分類する。分類のための学習データには、パルス性雑音を強調するためにHPF（High pass filter）を適用した波形を用いた。最後にパルス性雑音区間の波形補間を行う。波形の補間にはエネルギーと位相が必要である。パルス性雑音区間のエネルギーはパルス性雑音区間周辺のエネルギー平均を用いた。位相については、ランダムな位相、観測波形の位相スペクトルを用いた観測位相、非線形最小二乗法による推定位相の３つの位相について検討した。各位相について、チャープ信号に観測波形から抽出したパルス性雑音を印可した波形をテスト信号とするパルス性雑音除去シミュレーションを行い、パルス性雑音除去前後のSNRで評価を行った。その結果、推定位相による向上SNRが22 dBと最も高くなったが、推定にかかる計算時間が膨大であるため用途に応じて使用する位相を変更することが重要であると分かった。以上のパルス性雑音除去手法を用いて実際の観測波形のパルス性雑音除去を行った結果、パルス性雑音を除去し、Pc1脈動を抽出することができた。

本発表では信号処理によるPc1脈動のパルス性雑音除去について詳細に報告する予定である。従来では、観測機器の振動を極力抑える観測環境を吟味、構築する必要があったが、そのコストを削減し、Pc1脈動のより詳細な解析に役立つと考えている。

キーワード：Pc1地磁気脈動、雑音除去、信号処理
Keywords: Pc1 geomagnetic pulsation, Noise removal, Signal processing

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Application of magneto-impedance sensor to geomagnetic field measurements

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Magneto-impedance (MI) effect was discovered about 25 years ago and a micro-size magnetic sensor that utilizes this effect becomes commercially available. We made some modifications to the commercially available MI sensors as they can cover the range of the geomagnetic field. For the period of March 30 to April 27, 2018, we conducted experimental observations of geomagnetic field variations with the MI sensors at Mineyama observation site, which is located about 100 km north-west of Kyoto. Data obtained with the MI sensors were compared with those from the fluxgate magnetometer that has been working at the site. Results showed that the MI sensor recorded geomagnetic variations with amplitudes of ~1 nT that were also detected with the fluxgate magnetometer. This suggests that MI sensors are useful for researches in geomagnetism or space physics, although they are much less expensive than fluxgate magnetometers.

We consider developing two different kinds of systems to measure the geomagnetic field using the MI sensor: a system for ground-based observation and a system for a sounding rocket. In presentation, we will display observation data from the MI sensors and the fluxgate magnetometers at Mineyama and other observatories. Future plans of the system onboard sounding rocket will be also presented and discussed.

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Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

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The ionospheric currents flowing in the dayside ionosphere have been considered as a significant subsequence of Mesosphere-Ionosphere-Magnetosphere coupling. These currents were well detected in the Solar quiet conditions and named Sq currents. In particular, it is well known that the flow pattern of Sq currents shows the north-south hemispheric asymmetry due to the different ionospheric conductivities in the winter and summer hemispheres. This indicates that the asymmetry of the potential must be kept by the energy balance between each hemisphere through the field line.
An InterHemispheric Field Aligned Current (IHFAC) was theoretically predicted by Maeda [1974] and Fukushima [1979, 1991] to interpret the north-south asymmetry in the potential pattern. Several ground magnetic observations and satellite observations suggested an existence of the IHFAC in the noon sector and both the morning and evening terminators. However, the detailed morphology of the IHFAC have not been well understood yet, despite that the direct detection of the IHFAC at Low Earth Orbit (LEO) was reported in the observation by several satellites.
In order to investigate the Sq current system including the IHFAC, the in-situ observation by a CubeSat (2U size satellite emitted from ISS) is proposed in collaboration with 10 national colleges which belong to National Institute of Technology (KOSEN). The fluxgate magnetometer is onboard the CubeSat to observe small perturbations of the magnetic field. After the ejection from the ISS, the CubeSat will gradually glide down to the upper atmosphere due to the strong atmospheric drag and finally burn up in it. The duration of possible observation is estimated for more than 50 days.
The CubeSat can be characterized by the short duration of development (less than 3 years) and low cost (less than 100,000USD). We are considering an actual utilization of this extremely low-cost CubeSat to more realistic science mission. This concept enables us to conduct the multi-satellite in-situ observation in fairly low budget compared to conventional satellite missions.

キーワード：電離層電流、半球間沿磁力線電流、キューブサット
Keywords: Ionospheric Current, Interhemispheric Field Aligned Current, CubeSat

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Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

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We have been measuring electric fields of the plasma waves (a few Hz to several hundred Hz) to understand the magnetospheric dynamics. The spatial resolutions of electric field measurements are not enough because we cannot launch a lot of satellites due to the large size and mass of satellites. Demands of micro satellites like a 1U (10 cubic centimeters) cube satellites are increasing. We need to miniaturize measurement instruments for probing the plasma waves.

This study deals with an electric field instrument in plasma wave observations. We use the electric field instrument for capturing the electric fields detected by wire probe antennas. In this study, the purpose is to miniaturize the electric field instrument with a high radiation tolerance (300 krad) using Application Specific Integrated Circuit (ASIC) technology.

We designed a based amplifier for a new electric field instrument. In the new based amplifier, the equivalent input noise is 50 nV/sqrt(Hz) at 1 kHz, which is 3.9 dB-larger than that of conventional based amplifier (OP-41). The noise performance of new based amplifier is acceptable for capturing the plasma waves. To confirm the radiation tolerance of new based amplifier, we did the radiation tests up to 300 krad using the gamma ray. From the radiation test results, the gain was no change before and after the radiation tests. The output noise was degraded with 5.05 dB at 100 Hz by total ionizing dose effects. However, the based amplifier was not breakdown by the gamma ray. The electric field instrument consisted of new based amplifier could operate with a high radiation tolerance.

We conducted the transient analysis for the new electric field instrument by a circuit simulator (Tanner EDA). In the simulation, rectangular waves of 1 Vpp with 10 Hz input to the new electric field instrument via a sheath impedance (10 MOhms and 100 pF). From the simulation results, the output waveforms of new electric field instrument showed similar output waveforms in comparison with the conventional electric field instrument. The power consumption of new electric field instrument can decrease with approximately 67% than that of the conventional electric field instrument. From the simulation results, we confirmed the basic operations as the electric field instrument for detecting the plasma waves. In the future work, we will need to improve the temperature operating range because the new electric field instrument cannot operate at minus 60 Celsius degrees from the temperature simulation results.

In this presentation, we will present the basic study on electric field instrument for plasma wave observation by ASIC technology in detail.

キーワード：特定用途向け集積回路、電場計測器、プラズマ波動観測
Keywords: ASIC, Electric field instrument, Plasma wave observation

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超小型探査機に搭載する極端紫外撮像装置に用いる電気回路部の放射線耐性の評価

Evaluation of radiation tolerance of electronics parts used for the ultra-small mission

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飛翔体搭載機器に用いられる電子機器は、宇宙空間の放射線に曝されることでノイズの増加、ビット反転、消費電流の増加、などの悪影響を受ける恐れがある。

近年、大学の研究室規模で超小型探査機の開発が実現している。超小型の枠組みでは、民生部品を用いることで開発にかかる費用と時間を大幅に低減することで、短期間でのミッションの実現を可能にしている。しかし、一般の民生部品は放射線耐性を考慮した設計がなされていないため、飛翔体搭載に用いる際には実際の利用環境を再現した試験を通して確認する必要がある。この時、照射するべき総吸収線量は、放射線と物体の物理的な相互作用を考慮したエネルギー収支に関するモンテカルロシミュレーションから求められる。

我々は、2020年に打ち上げ予定の超小型衛星EQUULEUSに搭載される極端紫外撮像機「PHOENIX」を開発している。「PHOENIX」は、地球のプラズマ圏を構成するヘリウム一価イオンが太陽共鳴散乱によって発する極端紫外領域の輝線(波長30.4nm)を月近傍から準定常的に観測することで、プラズマ圏の動的描像と大局的な理解を目指す。この装置に搭載される信号増幅回路部に用いられる半導体素子の放射線耐性を、セシウム137を用いたガンマ線照射装試験を通して評価した。

本発表では、累積放射線量による半導体素子の利得率特性の変化と電気ノイズレベルの変化について評価した結果を述べ、今後の飛翔体ミッションへの応用可能性について議論する。

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A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

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Observation instruments are known to deteriorate under atmospheric condition. Deterioration are mainly caused by reaction with water vapor and oxygen. To prevent this, observation instruments must be maintained under vacuum. The problem is that the conventional vacuum pump are too heavy to carry to the launching site. The need of continuous power supply makes the transport more difficult. Also the vacuum pump must be removed before the launch. These problems are not only making it difficult to maintain observation instruments under vacuum but also causing extra costs. Non-evaporable-getter (NEG) pumps are able to solve these problems. NEG pumps are light weight, compact, oil free, vibration free, and able to operate without energy supply after activation. Considering the utilization of NEG pump for space science missions, we need to quantitatively evaluate the NEG pump to optimize its size, shape, material, and mounting position for each mission. In this study, a method to measure pumping speed of NEG pump for carbon monoxide (as substitute to water vapor and oxygen) was established by using the orifice method. By using this method, it will be able to develop a NEG pump which best applies the case for each mission.

キーワード：非蒸発型ゲッターポンプ、真空ポンプ
Keywords: Non-evaporable-getter pump, vacuum pump

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３次元電位分布計算による「みお」搭載MIAのトップハット分析器特性の非対称性の解釈

Interpretation on slight asymmetry of analyzer characteristics of MIA onboard the Mio by means of a model calculation of 3-D potential distribution

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MIA (Mercury Ion Analyzer) on board Mio employs a top-hat electrostatic analyzer, which has axisymmetric toroidal electrodes and is designed to have no dependence in its characteristics on azimuthal direction of incident ions. However, our ground calibration experiments have revealed that it has a slight dependence. We have tried to explain the dependence by means of three dimensional model calculations. We assumes that all parts of electrode are manufactured precisely. Our results shows that a slight relative rotation (or tilt) of electrodes can lead to a slight dependence on incident azimuthal direction similar to that obtained from the ground experiments.

キーワード：みお、トップハット静電分析器、水星イオン分析器
Keywords: Mio, tophat electrostatic analyzer , MIA

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小型衛星用衝撃試験機の建造及びMCPの機械耐性評価
Construction of impact testing machine for small satellites and evaluation of mechanical resistance of MCPs by the impact test

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近年小型衛星の開発が盛んに行われている。開発段階における環境試験は、小型衛星の信頼性向上に重要な役割を担っている。環境試験では振動や衝撃、熱真空などに対する耐性を確認する必要がある。その中でも衝撃に関する試験は最も実施が困難な試験の一つであり、未だ確実な手法が確立されていない。こうした背景から私たちは小型衛星用の衝撃試験機を建造した。衝撃試験機に求められる性能は大きく二つある。一つは、想定するミッションの衝撃レベルに限りなく近い衝撃を印加することのできるコントロール性である。これは試験対象への過度な衝撃印加を回避するために重要である。二つ目は、狙った衝撃レベルを高い精度で複数回印加することのできる再現性である。再現性が低いと、印加したい衝撃レベルとは異なった意図しない衝撃を印加してしまう可能性があり、試験精度の低下に繋がる。今回建造した衝撃試験機は、印加する衝撃を容易に調整することが可能であり、且つ再現性の高いものを目指し設計した。更にこの衝撃試験機を用いて、光学観測機器に広く用いられるMCP (micro-channel plate)をサンプルとした衝撃試験を実施し、その機械耐性を調べた。ここで用いた衝撃レベルは、2020年にNASAのロケットで打ち上げられるEQUULEUSミッションを想定した衝撃レベルである。今回の発表では、衝撃試験機の詳細及びサンプルを用いた衝撃試験の結果について紹介する。

キーワード：衝撃試験
Keywords: impact test

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Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

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It is well known that the terrestrial and planetary magnetospheres and the interplanetary space are filled with charged particles such as electrons and ions, which are so-called the space plasma, and in-situ observations of the space plasmas have been conducted by using satellites carrying particle instruments, such as the top-hat type electrostatic energy analyzer. Essentially, obtaining three-dimensional velocity distributions of the space plasmas or energy-pitch angle distributions help us understand the dynamics of the space plasmas. Because the top-hat type analyzer is cylindrically symmetric and has a 2π-radian planar field of view, it can independently measure the wide angular and energy distributions of incident particles. Also, three-dimensional velocity or energy-pitch angle distributions can be obtained by utilizing the satellite spin motion.
The top-hat type electrostatic energy analyzers can measure the ions when a negative potential is applied to the inner electrode and the electrons by a positive potential with the outer electrode grounded. Therefore, in the prevailing design of the top-hat type analyzer, the sensor heads separate for the ion and electron observations, respectively. Because of the recent miniaturization of the satellites, the weight and space of the instruments mounted on the small and micro satellites are getting severely restricted. However, if two sensors for electron and ion observations are combined into one sensor head, it is possible to save both weight and space on the small and micro satellites. Therefore, we have been developing double-shell type energy analyzer which can simultaneously measure the ions and the electrons with one sensor head.
We designed the shapes of the collimator and the double-layered dome-shaped electrodes so that the electrons and the ions with appropriate energies pass through the inner gap and the outer gap by applying a negative potential to the central electrode with the inner and outer electrodes grounded, respectively. We made the numerical simulations using SIMION which is a charged particle simulator program and investigated the performance and characteristics as the electrostatic analyzer. Consequently, we confirmed that the electrons and the ions can be analyzed with one sensor head by only applying negative high voltage to the electrodes. So far, we consider the detection unit using Time-Of-Flight velocity spectrometer for the discrimination of the ion species as the part where the ions are detected, and an assembly of micro channel plates is expected for the electron detection. The design of TOF-type mass analysis unit as ion mass analysis unit is one of subjects for future work.

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Microsatellite Development and Education of Space Science and Technology at Kanazawa University

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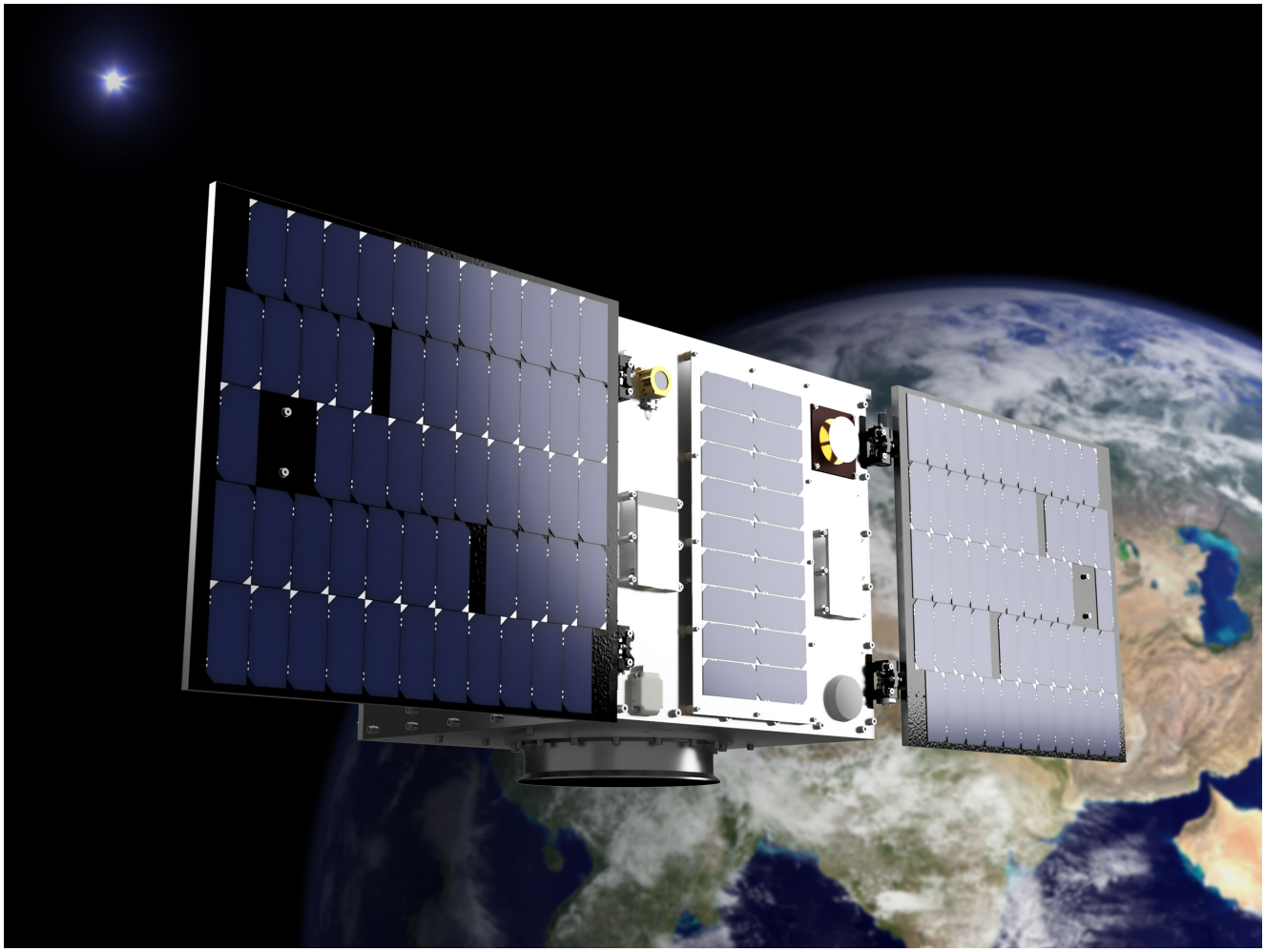
At Kanazawa University, researchers from engineering and science are cooperating to promote the "Kanazawa University Satellite Project (Kanazawa-SAT3: Study and Training in Space Science and Technology for Kanazawa Cube-Satellites)". In this project, a microsatellite is being developed by staff and students of Kanazawa University. It is a scientific satellite which will contribute to the elucidation of the mechanism of gravitational wave generation by identifying the source of gravitational wave by detecting the arrival direction of gamma rays and X rays radiated at the same time when a gravitational waves are generated by collision of astronomical objects The satellite will be inserted into a solar synchronous orbit at about 660 km altitude. It is a microsatellite with a total weight of 50 kg or less, and its size is cubic with a side of 50 cm, and it is designed to be a piggyback on an HII-A rocket.

Also related to this project, a space science and engineering course has been newly established in the Graduate School of Natural Sciences in April 2018. This course is based on the 'satellite development by students', and students are actually involved in the design, fabrication, ground tests, and operation of scientific satellites, aiming to train personnel who are familiar with space science and space engineering, with satellite-development skills.

Ground tests with the thermal and structural model of Kanazawa-SAT3 have been completed , and the unit tests for almost all components are being conducted. Currently, we are completing the design of the flight model. In the presentation, we will report the details of Kanazawa-SAT3 and its development status.

キーワード：超小型衛星、重力波、Kanazawa SAT3
Keywords: Microsatellite, Gravitational wave, Kanazawa SAT3

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Attitude Control System for Kanazawa-SAT3 Microsatellite

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Kanazawa University has been developing a microsatellite. This satellite is equipped with a device to observe celestial bodies emitting gravitational waves with X rays, and aims to elucidate the mechanism of black hole formation by estimating the time of arrival and direction of arrival of gravitational waves.
In this research, the attitude control system is being developed using GAS (Geomagnetic Aspect Sensor) and MTQ (Magnetic Torque). We have constructed the environment for the unit test of RW (Reaction Wheel) also used for attitude control of the satellite.

MTQ is a device that controls the attitude of the satellite by generating a magnetic torque against the geomagnetic field by applying a voltage (an electric current) to a magnetic coil. GAS is a device for detecting the direction of the geomagnetic vector. OBC (On Board Computer) which controls all devices mounted on the satellite receives the geomagnetic field data detected by GAS, and transmits commands to control MTQ. GAS and MTQ cannot be connected to OBC directly, because OBC has just a digital interface, but the output of GAS and the input to MTQ are analog voltages. Therefore, we have developed a control device for on-board equipment using a microcontroller. For the GAS, the voltages are A/D-converted by the microcontroller and transmitted to the OBC. For the MTQ, OBC transmits control commands to the microcontroller, which generates a PWM (Pulse Width Modulation) signal according to the received command that determines the effective voltage to be given to the MTQ. For the system development and operation tests, a PC is used instead of OBC and we carried out experiments of control equipment. For the GAS, we have confirmed the linearity between the analog magnetic field and the corresponding digital values transmitted to the PC. For the MTQ, we have confirmed that the voltage to be given to MTQ were precisely controlled by the duty ratio of the PWM signal output from the microcontroller.

RW is a device to generate a control torque around the rotation axis by accelerating a rotor by a motor and is controlled by transmitting a command from the OBC via an RS-422 serial communication line. The unit test has been carried out by using a PC as a substitute of OBC, but the cable had a influence on the rotation operation of RW. Therefore, we have constructed a system for wirelessly connecting the RW with the PC via a wireless RS-422 communication. Specifically, commands from the PC are wirelessly transmitted to an Arduino microprocessor by a low-power radio module XBee, and the RW is controlled via an RS-422 transceiver. With this system, we demonstrated the basic functions for command and data between the PC and the Arduino via the wireless RS-422 transceiver.

We plan to construct a system that applies appropriate PWM signals to MTQ according to the value detected by GAS. We will also evaluate RW performance by the unit test using the wireless RS-422 communication system.

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キーワード：超小型衛星、姿勢制御システムACS、Kanazawa SAT3
Keywords: Microsatellite, ACS, Kanazawa SAT3

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Communications System and Antennas for Kanazawa-SAT3 Microsatellite

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Teruya Minamoto[1], Koyo Ina[1], Kohei Kawagoshi[1], *Tomohiko Imachi[1], Satoshi Yagitani[1], Yoshitaka Goto[1], Daisuke Yonetoku[1], Yoshiya Kasahara[1], Tatsuya Sawano[1], Makoto Arimoto[1]

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Kanazawa University is developing the first Kanazawa University's microsatellite, named as Kanazawa-SAT3. Kanazawa-SAT3 is planned to be launched within FY2019, and its observation mission is to identify the source of gravitational waves by detecting the occurrence time and arrival direction of the X-rays and gamma rays observed simultaneously with gravity waves from distant astronomical objects.

In this research, we are developing a communications system for Kanazwa-SAT3. Kanazawa-SAT3 has three different communication systems using S band, UHF band and Iridium, and the link design of each of them has generally been completed. We summarize each communication system in detail as the following.

The S-band communication system, will use 2-GHz frequency band. Kanazawa-SAT3 is equipped with two types of antennas: S-band patch antennas and S-beacon antennas. S-band system is a main communication system between the satellite and a ground station, and plays a role of high speed data communication and beacon transmission. On the satellite side, two S-band patch antennas designed for both transmission and reception are mounted on the front and rear panels of the satellite. Two S-beacon antennas for transmission are also mounted on the front and rear panels of the satellite. On the ground side, we will send and receive by the signals using a 2.4-m parabolic dish installed at Kanazawa University.

The UHF communication system will use 400-MHz frequency bands. This system transmits commands from the ground to the satellite and telemetry information from the satellite to the ground. On the satellite side, four inverted-F type antennas we developed are mounted (two for receiving and two for transmitting) on the front and rear panels of the satellite. On the ground side, we will send and receive data by using a Yagi antenna with 14 crossed elements installed at Kanazawa University. We have also constructed an automatic satellite tracking system using the Yagi antenna.

A communication system using the Iridium satellite network uses a frequency band around 1.6 GHz. In this system, communications are performed via Iridium satellite, so that the communication can be established even when our ground station is not visible from the satellite. The data is exchanged between the satellite and the ground by using e-mail. This system can transmit and receive data in almost real time so emergency command and data transmission will be available. On the satellite side, two antennas for both transmission and reception are mounted on the front and rear panels of the satellite. A system has been constructed that exchanges data between a laptop computer simulating an onboard computer (OBC) mounted on a satellite and an iridium satellite.

From now on, for the communication systems using the S band and the UHF band, it is necessary to develop the communication software. For In addition, we need to improve the automatic satellite tracking

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system of Kanazawa-SAT3. For the communication system using Iridium satellite, it is necessary to implement a system on the OBC and conduct a communication experiment.

キーワード：超小型衛星、通信システム、Kanazawa SAT3
Keywords: Microsatellite, Communications System, Kanazawa SAT3

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6Uクラス超小型深宇宙探査機EQUULEUSに搭載する多層断熱材一体型ダスト計測器CLOTHの開発
Development of micrometeoroid impact sensor within a multi-layered insulation (CLOTH) onboard 6U deep-space explorer EQUULEUS

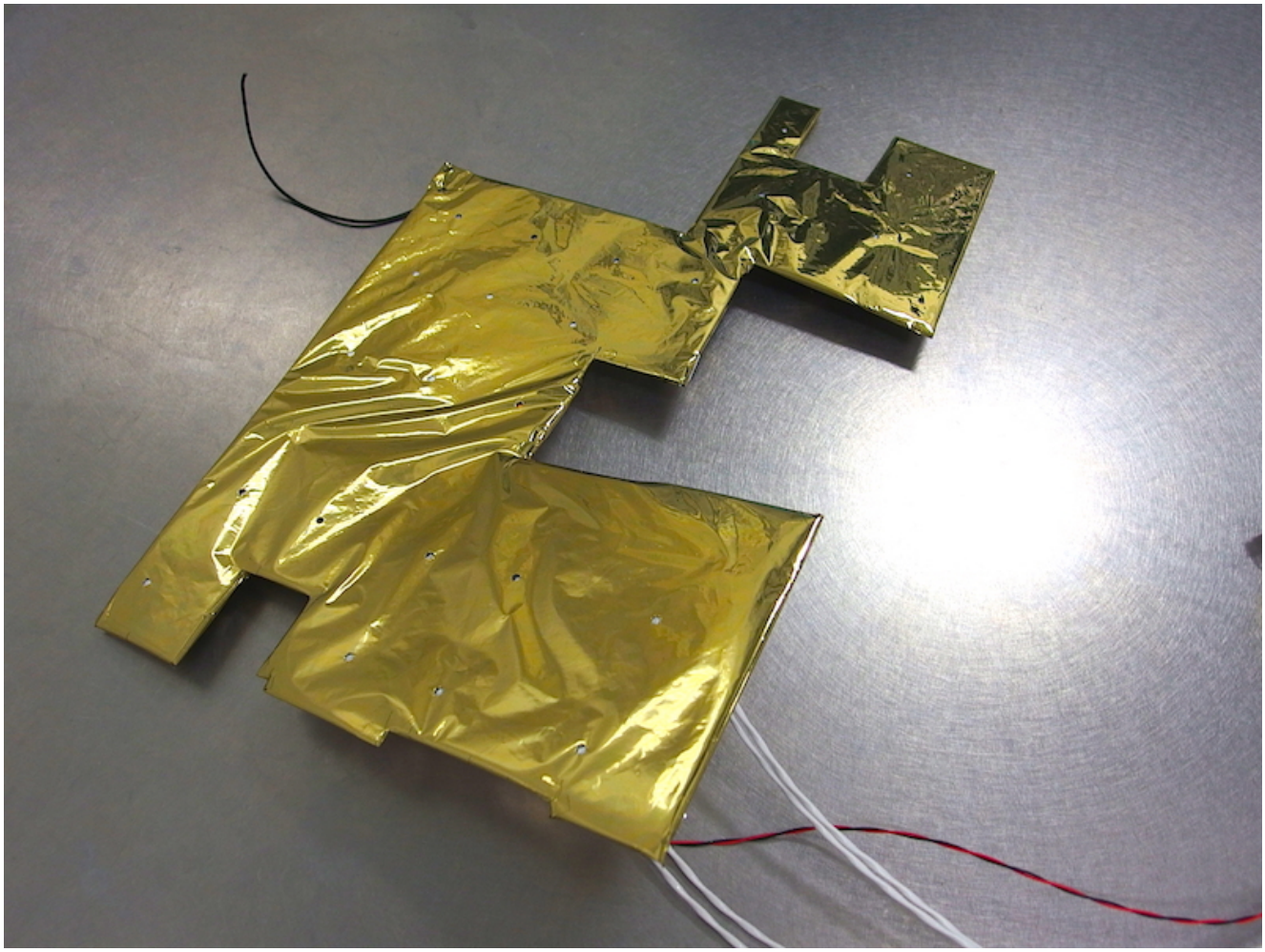
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近年、超小型衛星の利用範囲は地球周回から深宇宙へ広がりを見せている。東京大学とJAXAが開発を主導する超小型新宇宙探査機EQUilibriUm Lunar-Earth point 6U Spacecraft (EQUULEUS)は、米国航空宇宙局（NASA）の新規ロケットSpace Launch System (SLS) の副ペイロードとして打ち上げられる13基の超小型衛星の一つで、地球ー月ラグランジュ点（L2）への航行を通じた太陽ー地球ー月圏での軌道操作技術の実証と、3つの理学ミッションを行う予定である。ジオコロナ観測と月衝突閃光観測に加え、我々はCis-Lunar Object detector within THermal Insulation (CLOTH) を用い、惑星間ダスト観測を行う。CLOTHは、EQUULEUSの表面の一部を覆う多層断熱材 (Multi-Layer Insulation, MLI) と一体化した圧電性フィルムセンサで、MLIの最外層を貫通してくるダストの運動量を推定する。CLOTHの宇宙実証が成功することで、リソースの限られた超小型衛星による深宇宙探査の可能性がより拡大すると期待される。本講演では、衛星そのものに科学観測機能を付与するというCLOTHのコンセプトと、超高速微粒子衝突実験から得られたCLOTHのダスト検出性能について紹介する。

キーワード：圧電性フィルム、ポリフッ化ビニリデン、多層断熱材、超小型衛星、微隕石、超高速衝突
Keywords: Piezoelectric film, PVDF, Thermal insulation, CubeSat, Micrometeoroid, Hypervelocity impact

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DESTINY+搭載小惑星追尾機構の開発：概念設計およびBBMを用いた性能試験

Breadboard model of asteroid tracking system for DESTINY+ mission

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深宇宙探査技術実証機DESTINY+（Demonstration and Experiment of Space Technology for Interplanetary voYage, Phaethon fLyby and dUst Science）はイプシロンロケットによる公募型小型ミッションとして提案され、2023年の打ち上げを目指して現在フェーズA検討が進められている。このミッションではふたご座流星群の母天体と考えられている小惑星（3200）ファエトンを近接フライバイし、地表面の高解像度撮像を行う予定である。探査機には2種類のカメラ、可視光の単色バンドで高解像度撮像を行う望遠カメラTCAP（Telescopic Camera for Phaethon）、と低空間解像度で可視から近赤外のマルチバンド撮像を行うカメラMCAP（Multiband Camera for Phaethon）の搭載が予定されている。探査機で小惑星まで500 kmの位置に最接近し、最接近時およそ40秒前から9秒後までの間にTCAPによって最高空間解像度3.5 m/pxで1秒間隔の撮像を行うことを計画している。カメラの撮像方向は通常は探査機本体の姿勢制御で決められるが、DESTINY+では小惑星ファエトンの特異な軌道のため、相対速度30 –40 km/sという非常に速いフライバイを行う必要があり、探査機本体の姿勢制御だけではTCAPの撮像画像がぶれてしまう。そのため、高速フライバイ中に自律的に小惑星を視野内に収め続け、かつぶれのない高解像度画像を取得するような小惑星追尾機構がTCAPに要求される。そこで私たちはTCAPの追尾機構の概念検討、および追尾機構を適切に駆動するための制御アルゴリズムを検討した。さらに概念検討で得られたデザインを実証するため、追尾機構において中心的な機能を果たす駆動鏡のBBMを試作した。BBMは鏡、ステッピングモータ、減速機およびそれらを制御するFPGA基板から構成される。本発表では小惑星追尾機構の概念検討の結果と、駆動鏡BBMの試作状況および初期性能試験の結果を報告する。

キーワード：DESTINY+、カメラ、フライバイ、追尾機構
Keywords: DESTINY+, camera, flyby, tracking system

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火星衛星探査計画における望遠カメラ(TENGOO)性能評価装置の開発
Development of telescopic camera (TENGOO) performance evaluation device in MMX

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火星にはフォボスとダイモスの二つの衛星が存在する。その起源については捕獲した原始小惑星である説と、火星の巨大衝突事象による破片が集積し形成された説の２つが存在する。この火星衛星の起源を明らかにするために、JAXAはフォボスからサンプルリターンを行う火星衛星探査計画(Martian Moon eXploration)を2024年に検討している。

この計画に搭載される望遠カメラ(Telescopic Nadir imager for Geomorphology, TENGOO)はフォボスの地形を撮像し、平坦な着陸地点や宇宙風化の影響が少ない地点を発見するという目的を持っている。この目的を果たすため、高度20kmでの観測において空間分解能が24cmとなるように、角度解像度が5.8urad/pix、MTF>0.3(ナイキスト周波数)と光学設計が行われた。この光学設計の段階で得られた性能が製造された際にも確保されているか評価する必要がある。従って本研究ではTENGOOの性能評価を行うために、平行光が入射したときの点像関数の広がりを十分な精度で求める。そのため平行光の角度広がりが11.6urad以下の平行光源を作成した。

またこの装置で得られるPSFの半値幅は、TENGOOでは約2x2画素となる。そのためサンプリング間隔が半値幅に対して広くなり、ガウスフィッティングによるPSF推定の誤差が大きくなる。そこで斜線状の光源によってLSFを測定し、複数のPSFを得ることでサンプリング間隔の補完を行った。
本発表では、これらの研究開発の成果を報告する。

キーワード：火星、MMX、camera
Keywords: Mars, MMX, camera

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ソーラー電力セイルOKEANOSのクルージングフェーズにおける観測計画
Observation Plans in the Cruising-Phase of the Solar Power Sail: OKEANOS

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ソーラー電力セイル探査機OKEANOS (Oversize Kite-craft for Exploration and AstroNautics in the Outer Solar system)は、ソーラー電力セイルによる外惑星領域探査を実証することを目的としており、その主要なサイエンスターゲットは木星トロヤ群小惑星の表面および内部の科学探査である。一方で、打上げから木星スイングバイまでのクルージングフェーズは、その空間的・時間的拡がりから、太陽系内の物質・エネルギーの同径方向の分布に関する観測の好機を与える。我々はこのフェーズにおいて、赤外線観測装置EXZIT、ダスト観測装置ALADDIN -2、磁力計MGF、ガンマ線バースト観測装置GAP-2を用いた太陽系ディスク方向の探査を計画している。

可視光・近赤外線で観測される黄道光は、惑星間ダストにより散乱された太陽光であると考えられている。黄道光の2次元分布は、惑星間ダストの3次元構造を反映しているが、小惑星起源と彗星起源の比率が日心距離に応じてどう変化するかは、解明されていない。我々は、EXZITを用いた可視光・近赤外線による黄道光の太陽系動径方向の観測と、ALADDIN-2による惑星間ダストのその場観測を行う。これらを比較することによって、太陽系の固体微粒子の分布や移動の実態を明らかにする。 OKEANOSから得られる観測結果はまた、太陽系のダスト・黄道光が外惑星領域からどのように観測されるかという情報を示し、太陽系外の恒星系観測における指標となることが期待される。

太陽風の温度分布は太陽距離に依存すると考えられるが、その実測値は断熱モデルから予測される値よりも高いことが知られている。このため、プラズマ乱流や磁気再結合などの加熱機構の存在が予測されている。我々はMGF-2によるソーラー電力セイルのスケールでの同時磁場観測を行うことにより、電子スケールでのプラズマ乱流を検出することを検討している。このような観測を、地球軌道から木星軌道にかけて行うことにより、太陽風の加熱機構の解明を目指す。クルージングフェーズの長期間の観測はまた、突発的な太陽風に伴った磁気現象の検出が期待される。また、これらの太陽風ショックに伴うガンマ線の検出可能性も探る。
これらの観測を、はやぶさ、はやぶさ２などの既ミッション、およびOKEANOSのトロヤ群小惑星到着後の探査からの知見と組み合わせることにより、太陽系の内惑星～外惑星領域の物質の分布と移動に関する理解が深められ、生命前駆物質の起源を含め、太陽系の各天体の形成から地球上の生命誕生に至るプロセスが明らかになることが期待される。

キーワード：OKEANOS、黄道光、ダスト、プラズマ、ガンマ線
Keywords: OKEANOS, zodiacal light, dust, plasma, gamma-ray

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

2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_7

[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)

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。

[AOS09-P01] 高速水温計データの補正について

*木村 詩乃[1]、後藤 恭敬[2]、李 根淙[1]、安田 一郎[1] (1.東京大学、2.気象庁)

[AOS09-P02] 乱流計搭載深海フロートを用いた乱流混合の観測

*翟 燦[1]、安田 一郎[1]、菊地 将彰[1]、後藤 恭敬[1]、李 根淙[1]、田中 雄大[2]、山木 謙[3]、今村 豊[4] (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、3.鶴見精機、4.青森県産業技術センター水産総合研究所)

[AOS09-P03] Evaluation of the underwater glider flight model using the electromagnetic current sensor

*田中 雄大[1]、長谷川 大介[1]、奥西 武[1]、安田 一郎[2] (1.国立研究開発法人　水産研究・教育機構　東北区水産研究所、2.東京大学大気海洋研究所)

[AOS09-P04] Mixing processes observed by a slocum glider at the Oyashio-TWC front

*長谷川 大介[1]、田中 雄大[1]、奥西 武[1]、安田 一郎[2] (1.国立研究開発法人 水産研究・教育機構　東北区水産研究所、2.東京大学　大気海洋研究所)

[AOS09-P05] 月の18.6年周期振動がエルニーニョ南方振動ENSOに与える影響

*安田 一郎[1] (1.東京大学大気海洋研究所)

[AOS09-P06] 潮汐18.6年周期振動が太平洋十年規模振動(PDO)に及ぼす影響

*濵本 真沙希[1]、安田 一郎[1] (1.東京大学大気海洋研究所)

[AOS09-P07] A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

*阿部 佑美[1]、見延 庄士郎[1,5]、Takamitsu Ito[2]、Curtis Deutsch[3]、Matthew Long[4] (1.北海道大学　理学院、2.ジョージア工科大学、3.ワシントン大学、4.アメリカ大気研究センター、5.北海道大学　理学部)

[AOS09-P08] Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

*増田 周平[1] (1.国立研究開発法人　海洋研究開発機構)

[AOS09-P09] Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

*Hung Wei Chou[1]、Humio Mitsudera[1]、Hatsumi Nishikawa[1]、Kaihe Yamazaki[2] (1.Hokkaido University, Institute of Low Temperature Science、2.Hokkaido University, Graduate School of Environmental Science)

[AOS09-P10] Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

*近藤 能子[1,2]、砂原 雄大[2]、西岡 純[3]、小畑 元[4]、武田 重信[1,2] (1.長崎大学大学院水産・環境科学総合研究科、2.長崎大学水産学部、3.北海道大学低温科学研究所、4.東京大学大気海洋研究所)

[AOS09-P11] Chemical and physical speciation of copper in the subarctic North Pacific

*黄 国宏[1]、小畑 元[1]、金 泰辰[2]、近藤 能子[3]、西岡 純[4] (1.東京大学大気海洋研究所、2.韓国ソウル国立大学、3.長崎大学、4.北海道大学低温科学研究科)

[AOS09-P12] Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

*和賀 久朋[1]、平譯 享[1]、上野 洋路[1] (1.北海道大学)

[AOS09-P13] 黒潮栄養塩ストリームの構造とインパクト

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[AOS09-P14] Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

*Chin-chang Hung[1]、Dewang Li[2]、Wen-Chen Chou[3]、Yung-Yen Shih[1,4]、Guan-Yu Chen[1] (1.Department of Oceanography, National Sun Yat Sen University, Kaohsiung, Taiwan、2.Second Institute of Oceanography, State Oceanic Administration, Hangzhou, PRC、3.Institute of Marine Environmental Chemistry and Ecology, National Taiwan Ocean University, Taiwan、4.Department of Applied Science, R.O.C Naval Academy, Kaohsiung, Taiwan)

[AOS09-P15] Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

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[AOS09-P16] **From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs**

*Siteng Zhu[1]、JING ZHANG[1]、Shota Kambayashi[2]、Takeshi Matsuno[3]、Eisuke Tsutsumi[3]、Shigenobu Takeda[4]、Seiya Nagao[5]、Hiroshi Inoue[5]、Hiroshi Ogawa[6]、Ichiro Yasuda[6] (1.University of Toyama、2.Fukushima university、3.Kyushu university、4.Nagasaki university、5.Kanazawa university、6.The University of Tokyo)

[AOS09-P17] 西部北太平洋亜熱帯観測点KEOにおける時系列観測で明らかとなった貧栄養海域の生物地球化学への低気圧性渦と台風の影響

*本多 牧生[1]、笹井 義一[1]、Siswanto Eko[1]、吉田 聡[2]、相木 秀則[3]、クローニン メグハン[4] (1.海洋研究開発機構、2.京都大学防災研究所、3.名古屋大学、4.米国海洋大気庁太平洋海洋環境研究所)

[AOS09-P18] 本州南方海域のプランクトン群集に対する伊豆海嶺域の島陰効果

*日高 清隆[1]、田所 和明[1]、宮本 洋臣[1]、市川 忠史[1] (1.水産研究・教育機構)

[AOS09-P19] Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

*浦川 昇吾[1]、中野 英之[1]、辻野 博之[1]、坂本 圭[1]、豊田 隆寛[1]、山中 吾郎[1] (1.気象庁気象研究所)

[AOS09-P20] 安定・不安定成層した表層海洋中での圧力－歪み相関のパラメタリゼーション

*牛島 悠介[1]、吉川 裕[1] (1.京都大学大学院理学研究科)

[AOS09-P21] 台風に対する海洋の応答の非対称性についての数値実験

*大倉 大樹[1]、吉川 裕[1] (1.京都大学大学院理学研究科)

[AOS09-P22] Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

*高橋 杏[1]、日比谷 紀之[1]、Alberto Naveira Garabato[2] (1.東京大学大学院理学系研究科 地球惑星科学専攻、2.National Oceanography Centre, University of Southampton)

高速水温計データの補正について
Correction method of fast-response thermistors data to estimate turbulence intensity

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高速水温計(FP07)は、乱流エネルギー散逸率 ε と水温消散率 χ を測定することができ、海洋内部についてより詳細なデータが得られるため有用である。しかし、時間分解能が低く、強乱流域で過小評価となるため、補正を施す必要がある。本研究では、0.6-0.7m/sで降下する自由落下型乱流計で得られた流速シア微細構造と水温微細構造の同時観測データを用いて、FP07からの ε _Tと、シアープローブからの ε _Sの２つの乱流エネルギー散逸率を比較し、FP07のデータにどのくらいの補正が必要かを見積もった。FP07の時定数を3m 秒で２次極補正または時定数を7m 秒で1次極補正をした場合に、 ε _S =10^{-10}– 10^{-7}W/kgの範囲でファクタ３で補正が可能であることが示された。発表では水温消散率 χ に及ぼす影響や２重拡散の影響についても議論する。

キーワード：鉛直混合、乱流
Keywords: vertical mixing, turbulence

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乱流計搭載深海フロートを用いた乱流混合の観測
Observation of turbulent mixing using a deep float with microstructure sensors

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海洋乱流の自動観測を目指し、乱流センサーを搭載した深海フロート(DeepNINJA)を用いた乱流評価手法を進めている。浮力調節時のモーター作動による振動は流速シア観測への悪影響を及ぼす他、浮上速度の下限値など、流速シア観測の妥当性について、同時に観測した高速水温計との比較で検討した。2016年8月に試験観測を行い、シア及び高速水温計両方の良好なデータが得られる区間を利用して、水温計からのデータを補正し、シアデータが不良な場合を補完するなど、適切にデータを取り除くことで、比較的信頼できるデータを取得できる。この機器を用いた三陸沖冬季の乱流時系列観測を現在行っており、乱流計搭載深海フロートの特徴を明らかにし、三陸沖乱流混合の時間変動について報告する予定である。

キーワード：鉛直混合、深海フロート、エネルギー散逸率
Keywords: vertical mixing , deep float, energy dissipation rate

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Evaluation of the underwater glider flight model using the electromagnetic current sensor

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Turbulence measurement by underwater gliders has become more common in recent years. For the accurate estimation of energy dissipation rates, the accurate measurement of the fall rate and gliding path angle is necessary. The gliding path angle should take the angle of attack (AOA) into account, which is the difference between the gliding path angle and the pitch angle. AOA calculation has been done by using the so-called flight model assuming dynamical force balance in the quasi-steady state. Due to the difficulty in measuring AOA directly, the validity of AOA derived from the flight model and the flight model itself has not been adequately evaluated so far. In this study, we put the electromagnetic current sensor (EM sensor) on the turbulence package to obtain AOA directly and to compare the AOA from EM sensor with that from the flight model. Using the dataset obtained by a Slocum glider in Jul. - Aug. 2017, we found that AOA from the EM sensor during descent and ascent has a mean (standard deviation) of 0.7 (1.2) deg. and -0.7 (1.1) deg., respectively, while AOA from the flight model is 4.9 (0.4) deg. and -4.5 (0.5) deg., respectively. In order to know what cause this difference, we discuss the validity of parameters given in the flight model. It is suggested that a drag coefficient due to parasite drag given in the flight model may be somewhat larger than that calculated using the EM sensor.

キーワード：水中グライダー、フライトモデル、電磁流速計、迎角
Keywords: underwater glider, flight model, electromagnetic current sensor, angle of attack

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Mixing processes observed by a slocum glider at the Oyashio-TWC front

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In order to grasp the detailed mixing processes along the frontal region between the Oyashio and the Tsugaru Warm Current (TWC), we conducted a zigzag survey crossing the front several times from the merging region of the two current systems to the down stream by an underwater glider (Slocum G2 Glider) equipped with a turbulence sensor, from July 24thto August 29thin 2017. The observed frontal structure indicated the subduction and the intrusion processes of the cold and fresh Oyashio water under the warm and salty TWC water, along layer between 26.5 to 26.8 sigma-theta, which resulted the favorable conditions to the salt finger convection at the upper interface along the 26.5 sigma-theta, and the diffusive convection at the lower interface along the 26.8 sigma-theta where the fresh and cold Oyashio water lying above the warm and salty water. The strong turbulence intensity is observed around the intruded layer, and the mean temperature and the salinity in the layer became warmer and saltier with the increase of the distance from the front, which suggested the time evolution of the vertical mixing driven by double diffusive convections between the three different water masses. Though the strongest turbulence intensity was observed around the frontal region, which may suggest the importance of the cabbeling effect as the additional source of the turbulent mixing.

キーワード：二重拡散対流、混合、キャベリング
Keywords: double diffusion, mixing, cabbeling

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月の18.6年周期振動がエルニーニョ南方振動ENSOに与える影響
Impact of the astronomical lunar 18.6-yr tidal cycle on El-Niño and Southern Oscillation

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Even though El-Niño and Southern Oscillation (ENSO) has a tremendous impact on global climate and society, its long-term forecast remains difficult. In this study, we discovered a statistically significant relationship between ENSO timing and the 18.6-year period lunar tidal cycle in the mature-phase (December –February) ENSO time-series during 1867–2015 and extending back to 1706 with proxy data. It was found that El-Niño tended to occur in the 1st, 10th, and 13th years after the maximum diurnal tide in the 18.6-yr cycle, and La-Niña tended to occur in the 3rd, 12th, and 16th years. These tendencies were also confirmed by corresponding sea-surface temperature (SST) and sea-level pressure (SLP) distributions; particularly Pacific SST and SLP spatial patterns in the third La-Niña and the tenth El-Niño year well resemble those of Pacific Decadal Oscillation (PDO). These findings contribute to understanding and forecasting long-term ENSO variability.

キーワード：エルニーニョ南方振動、大気海洋相互作用、潮汐、混合、気候
Keywords: El-Niño and Southern Oscillation, air-sea interaction, tide, mixing, climate

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潮汐18.6年周期振動が太平洋十年規模振動(PDO)に及ぼす影響
The effect of 18.6-year period lunar nodal cycle on Pacific Decadal Oscillation (PDO)

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Pacific Decadal Oscillation (PDO) is the most dominant decadal-inter-decadal ocean-climate variability over the North Pacific; however, the periodicity and cause have not been fully understood. Previous studies suggested that 18.6-year period lunar tidal cycle ($T_{18.6}$) regulate bi-decadal PDO variability through changes in the strength of diapycnal mixing of ocean around the Kuril Islands to result in ocean variability, together with air-sea interactions in the mid-latitude North Pacific and/or equatorial Pacific. In the present study, 297yr-long reconstructed PDO timeseries was re-examined, and 27.9yr (3/2 times 18.6-yr, henceforth, $T_{27.9}$) period variability was significantly detected, and the zero-crossing from minus to plus was found to occur simultaneously with $T_{18.6}$ variability in the interval of 55.4 years (3 times $T_{18.6}$). In the PDO spectrum, a broad multi-decadal 50-80-yr peak (corresponding to 3-5 times $T_{18.6}$, henceforth T_M) was also detected with the zero-crossing synchronized with $T_{18.6}$; this is the extension of previous studies during 1900-2000 back to 1700s on the synchronous changes of bi-decadal and penta-decadal variabilities. These $T_{18.6}$, $T_{27.9}$ and T_M explain 71% of the 10-year low-passed PDO variability. These imply that the 27.9-yr and the multi-decadal variabilities could be related to $T_{18.6}$ tide-induced variability, and may be excited by $T_{18.6}$ tidal forcing, considering that external periodic forcing for delayed oscillator models could excite 3 times period of the external forcing and some non-linear processes may make the half-period variability.

キーワード：潮汐18.6年周期振動、太平洋十年規模振動
Keywords: 18.6-year period lunar nodal cycle, Pacific Decadal Oscillation

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A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

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Recent studies revealed that the ocean deoxygenation has been accelerating since the 1980s over the global oceans (Schmidtko et al. 2017; Ito et al. 2017), and the observed trend in the last half-century appears to be much larger than the model simulations conducted for CMIP5 (Bopp et al. 2013). This discrepancy is an important issue of the ocean deoxygenation researches as highlighted by a review paper published in the last year (Oschlies et al. 2018).

In order to understand better the relations of oxygen variations between CMIP5 models and observations, we compare oxygen concentration simulated by CMIP5 models and gridded oxygen anomaly dataset used by Ito et al. (2017). For the global oceans, the observed oxygen reduction rate for the historical experiment period appears to be within uncertainty of the models, though this result can be sensitive to the choice of the analysis period associated with the rapid recent oxygen reduction. We also closely examined the two basins that are relatively well sampled, i.e., the North Pacific and the North Atlantic. It is found that the observed North Pacific oxygen reduction is much stronger than the simulated ones, but such a strong reduction of observed oxygen does not occur in the North Atlantic. These results suggest that there are substantial spatio-temporal variations of oxygen concentration on decadal timescales and their mechanism in each basin should be explored in future studies.

キーワード：北太平洋、北大西洋
Keywords: North Pacific, North Atlantic

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Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

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Our aim is to synthesize pre-existing ocean data with newly-acquired turbulence data using state-of-art assimilation technique. Available observations of turbulence strength in the ocean, will be “blended” with pre-existing ocean data applying dynamically self-consistent state estimation approach with 4D-VAR adjoint system. We propose some new techniques and schemes to assimilate turbulence data, which tends to include unique features. The obtained state estimation will provide improved description of ocean circulation, its heat and salt transports, and oceanic ecosystem at lower trophic level.

キーワード：OMIX、海洋、混合、データ同化
Keywords: OMIX, ocean , mixing , data assimilation

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Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

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The pattern of exchange flow between the Sea of Okhotsk and Pacific is a system composed by an Okhotsk-ward inflow through Kruzenshtern strait in north and a Pacific-ward outflow through Bussol strait in south. One of major theories for explaining the dynamic of water exchange through Kuril Island Chain is the turbulence induced by tidal vertical mixing. Turbulence is an important physical process in geostrophic boundary layer, and because of the complexity of topographic in Kuril island chain, the breaking of internal tides in island coast area leads to increase the thickness of surface mixing layer and causes tilting of isopycnal layer in vicinity. The tilting of isopycnal layer around islands forms a clockwise flow along the shore by geostrophic adjustment. However, above process is majorly broclinicly, and how can it impact to barotropic component is still unknown.

By setting the tidal force as a controlled variable, results from realistic OGCM model COCO show only the case with tidal forcing can consistent with the exchange flow pattern as historical observation (Fig.1). Besides, the vertical diffusivity values also show the magnitude difference in summer time, which the flow in north strait in non-tidal case is opposite to tidal one (Fig.2). Therefore, we designed four experiments for understanding the impact of tidal diffusive adjustment in summer: 1. install vertical diffusivity value generated by tidal case into non-tidal run; 2. install vertical diffusivity value generated by non-tidal case into tidal run; 3. set the vertical diffusivity value as zero in tidal case and 4. in non-tidal case as well. Further, for preventing the underestimates the depth of the mixing layer in Mellor-Yamada turbulence closure scheme, two more experiments with the larger vertical diffusivity mask are applied in both tidal and non-tidal case. After calculating the fraction of baroclinic and barotropic components in either north strait or southern strait, results show the vertical mixing dose influence the strength of volume transported but not the direction as original tidal and non-tidal case shows. Hence, for further understanding the impact of vertical diffusivity, we start a tidal forcing run with non-tidal initial conditions to detect the relationship between the flow direction and magnitiude of vertical diffusivity values by time developing. But the baroclinic result implies that the vertical mixing might not be the main reason to control the flow direction (Fig.3).

This study also implies the tidal impacts in OGCM is not only the vertical mixing, but other geostrophic fluid dynamics might occur, especially the interaction of topography with tidal waves. Therefore, for reproducing the real ocean phenomena, movement of tidal waves should be considered.

Keywords: OGCM, tidal mixing , Okhotsk, cross-basin exchange system

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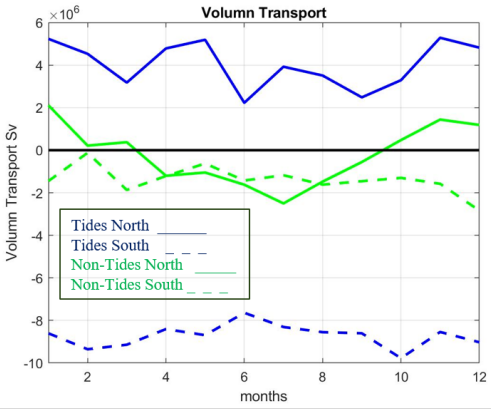


Fig.1: volume transportation in tidal and non-tidal run.
Positive value is Okhotsk-ward and negative value is Pacific-ward flow.

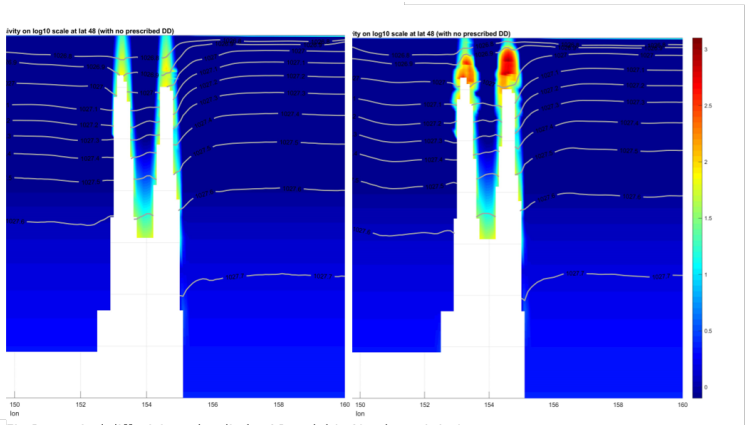


Fig.2: vertical diffusivity value (in log10 scale) in North strait in June, left one is non-tidal run and right is tidal run.

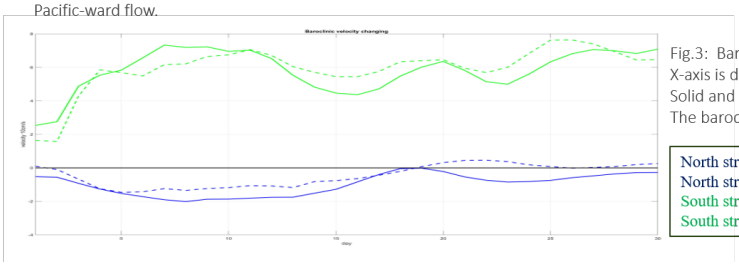


Fig.3: Baroclinic components in the tidal run with non-tidal initial condition.
X-axis is day and y-axis is velocity. Blue line is north strait and green line is south strait.
Solid and dot line are upper and lower isopycal layer, respectively.
The baroclinic velocity is stable after a week running.

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Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

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Iron (Fe) is well known as a key parameter for primary productivity in the ocean. To understand the distributions and biogeochemical cycle of Fe in the ocean, we need to investigate the sources and sinks of Fe. A recent study has demonstrated a concentration gradient of dissolved Fe in the North Pacific Intermediate Water (NPIW) between western and eastern areas (Nishioka and Obata, 2017), suggesting that Fe-rich intermediate water was transported laterally across the western subarctic gyre. Moreover, it has been demonstrated that most dissolved Fe in seawater is complexed with natural organic ligands. Since bioavailability of Fe in seawater depends on its species, the chemical speciation of Fe is needed to evaluate the nutrient status for phytoplankton. However, the distribution of natural organic ligands has not been revealed yet in the subarctic North Pacific. In this study, vertical distributions of organic Fe-binding ligands were investigated in the eastern and western subarctic North Pacific to clarify its impact on Fe cycle. Seawater samples were obtained through the whole water column during GEOTRACES-Japan cruise KH-17-03 using trace metal clean technique to avoid metal contaminations. Filtered seawater samples (<0.2 μm) for organic Fe-binding ligands analysis were collected in acid-washed bottles inside a laminar-flow clean booth, then they were stored at -20°C until just before analysis. The organic Fe-binding ligands' concentration and their conditional stability constants were determined by competitive ligand equilibration-adsorptive cathodic stripping voltammetry (CLE-ACSV) method using salicylaldoxime (Abualhaija and van den Berg, 2014). The concentration and conditional stability constants of organic ligands ranged from 0.7 nM to 5.9 nM and from $10^{10.1}$ M^{-1} to $10^{12.3}$ M^{-1}, respectively. The concentrations of organic ligands exceeded those of dissolved Fe concentration more than 1 nM in all samples except for the surface (10-m) at the Oyashio-Kuroshio transition zone station; consequently >99% of dissolved Fe was estimated to be complexed with these natural organic ligands. At the western station, high concentrations of organic ligands were observed in the intermediate layers (400 –600 m), which hydrographic data (27.2 σ_θ –27.3 σ_θ) were corresponding to the lower NPIW (Yasuda et al., 2004), suggesting that organic Fe-binding ligands might be transported within the lower NPIW.

キーワード：鉄、有機配位子、北太平洋亜寒帯域、GEOTRACES
Keywords: iron, organic ligand, subarctic North Pacific, GEOTRACES

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Chemical and physical speciation of copper in the subarctic North Pacific

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Organic complexation of Cu in seawater plays a major role in controlling the toxicity and bioavailability of Cu for marine microorganism. In this study, we determined the concentrations of Cu and its organic ligands in the soluble and dissolved phases in the subarctic North Pacific. Samples were taken from three stations in the subarctic NorthPacific, CL-2 (western), CL-5 (central) and CL-16 (eastern), during summer 2017.

Concentrations of total dissolved and soluble Cu ranged from 1.28 nM –4.82 nM, and 0.47 nM –2.75 nM, respectively, in the subarctic North Pacific. At both CL-2 and CL-16, soluble Cu accounted for 30% - 100% of total dissolved Cu. The proportion of the soluble Cu fraction was low in surface waters, increased a maximum in the intermediate waters, and decreased slightly in deep waters. Two classes of organic ligands were detected in the surface and intermediate waters of CL-5 and CL-16, and in the intermediate waters of CL-2. In all other depths, only one class of ligand was detected. Concentrations of the stronger ligand (L_1) and weaker ligand (L_2) ranged from 1.02 nM –2.95 nM, and 0.77 nM –8.78 nM, respectively. The distributions of L_1 followed closely that of total dissolved Cu in the surface waters, and no clear trend was observed in the intermediate waters. At CL-2, L_1 mainly existed in the soluble phase, whereas for CL-16, soluble L_1 accounted for 50% - 100% of total dissolved L_1. Concentrations of L_2 were relatively constant throughout the water column but elevated concentrations were detected in the surface waters of CL-5 and in the surface and intermediate waters of CL-16. On the other hand, there were a slight depletion of L_2 in the intermediate waters of CL-2.

キーワード：銅、有機錯体、北太平洋亜寒帯
Keywords: copper, organic ligands, subarctic North Pacific

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Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

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Phytoplankton plays a critical role in a number of key ocean processes. One of the most important functions of phytoplankton is to determine the energy transfer efficiency in marine ecosystems. Although the energy flow from the base of the food web to higher trophic levels depends on both the biomass and size structure of phytoplankton community, phytoplankton size structure is particularly important because energy flow in marine pelagic food webs is largely based on size specific predator-prey relationships. Therefore, spatiotemporal dynamics in size structure of phytoplankton community can trigger changes in the ecosystem’s functioning through trophic cascade effects in the trophic chain. With the development of remote sensing techniques, mesoscale eddies, nearly ubiquitous features of the World Ocean, has been recognizing as important feature for the distribution of phytoplankton not only the direct transport of phytoplankton and eddy trapping, but also the vertical flux of nutrients. Recent studies have examined regional variations in the influence of mesoscale eddies on phytoplankton community. Namely, phytoplankton production is enhanced in cyclonic eddies (CEs) than that of anticyclonic eddies (ACEs) because of upwelling inside the eddy; this view, on the other hand, does not hold for a substantial portion of eddies within oceanic subtropical gyres, the largest ecosystems in the ocean. However, previous efforts have focused mainly on variations in chl*a*, whereas quite a few studies have worked on that in the size structure of phytoplankton community because remote estimations of phytoplankton size structure are newly established techniques during the last decade. Here we improved a chl*a* size distribution (CSD) model which estimates the synoptic size structure of phytoplankton community, to assess the impact of mesoscale eddies on spatiotemporal variations in phytoplankton size structure. Original CSD model was based on the spectral features of the phytoplankton absorption coefficient ($a_{ph}(\lambda)$), which estimation accuracy becomes poor in areas of the low productivity, such as subtropical gyres. To avoid this, we used not only $a_{ph}(\lambda)$ but also chl*a* to improve estimation accuracy of the CSD model. The resulting estimation error of the improved CSD model was the median absolute percent difference of 26.0% between the measured and satellite-matched values, and global distribution of the phytoplankton size structure was reliable even in subtropical gyres. The phytoplankton size structure showed a clear latitudinal variation: larger and smaller assemblages in temperate (>30˚S and >30˚N) and low latitudes (30˚S–30˚N) latitudes, respectively. When comparing the phytoplankton size structure within ACEs and CEs, a larger phytoplankton size structure was found in ACEs especially in low latitudes. This result was consistent with a previous report that ACEs are more productive than CEs in subtropical gyres because of winter mixing. In addition, we found increasing trends ($p < 0.05$) in differences between the phytoplankton size structure within ACEs and CEs in low latitudes for the years 2003–2014, suggesting a growing importance of ACEs for phytoplankton and in turn marine ecosystem. Consequently, this study demonstrates significant advantages of satellite remote sensing for biogeochemical and ecological studies.

キーワード：衛星、中規模渦、植物プランクトン
Keywords: Satellite, Mesoscale eddy, Phytoplankton

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黒潮栄養塩ストリームの構造とインパクト
Structure and impact of the Kuroshio nutrient stream

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Recently the Kuroshio has drawn attention as an important supply route of nutrients in the western North Pacific. However, it is unknown whether nutrient concentrations are enhanced along the jet on isopycnal surfaces, as is the case for the “nutrient stream” along the Gulf Stream. We aim to ascertain the structure of nutrient concentration enhancement along the Kuroshio jet and to estimate the impact of nutrient transport downstream to the Kuroshio-Oyashio interfrontal zone (KOIZ), which is a highly productive region and a major global fishing ground. Recent multiple- transects and retrospective analyses of historic hydrographic data have revealed that the along-jet maximum nitrate concentration appears only in spring on the isopycnal surface $25<\sigma_\theta<26$ in the downstream region of the Kuroshio. The Kuroshio nutrient stream contributes significantly to productivity in the euphotic layer along its downstream trajectory, in conjunction with enhanced vertical turbulence. Analysis of the budget of epipycnal nitrate transport across transects that enclosed the KOIZ suggests that the Kuroshio nutrient stream has a non-negligible potential to significantly impact high productivity in the KOIZ.

キーワード：黒潮栄養塩ストリーム、黒潮親潮移行領域、等密度面輸送
Keywords: Kuroshio nutrient stream, Kuroshio-Oyashio interfrontal zone, epipycnal transport

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Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

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To understand nutrient supply and the biogeochemical response induced by internal waves in the deep basin of the northern South China Sea (NSCS), nitrate, chlorophyll *a* (Chl *a*), particulate organic carbon (POC) fluxes were measured during the passage of large internal waves using drifting sediment traps attached with hydrographic sensors. Results revealed large variations in temperature, nitrate and chlorophyll *a* (Chl *a*) concentrations during and after internal waves, suggesting that cold nutrient-replete waters may be brought to the euphotic zone in the dissipation zone during and after the passage of internal wave packets, resulted in phytoplankton flourished in oligotrophic water. The result reveals that ocean mixing triggered by internal waves in warm water of the NSCS may be important for phytoplankton species composition. Most importantly, POC fluxes (110.9±10.7 mg C m^{-2} d^{-1}) were significantly enhanced after internal waves compared to non-internal wave area (32.6–73.0 mg C m^{-2} d^{-1}) in the NSCS. Such elevated POC fluxes may be induced by downward flourished biogenic particles, particle aggregation or converged particles from mixed layer triggered by internal waves.

Keywords: internal waves, ocean mixing, South China Sea, nutrient dynamics

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Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

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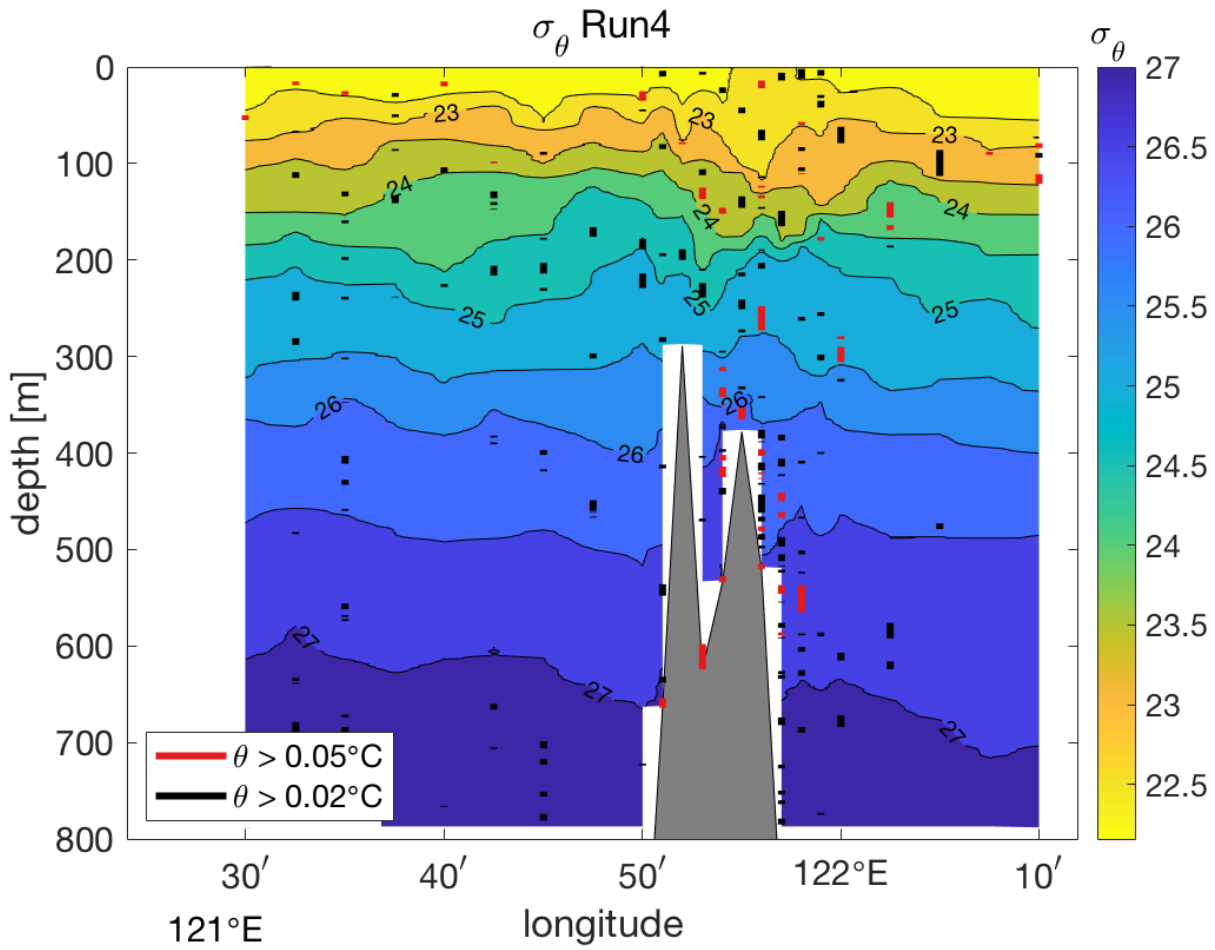
The Luzon Strait has two parallel ridges running from north to south, which is known to create large amplitude internal tides. To investigate the mixing processes accompanied by the internal tides, we carried out repeated observations with XBT, XCTD, CTD, and ADCP in the cruise of R/V Hakuho-maru KH-17-5, Leg-2, in November 2017 as part of the OMIX project. We obtained 6 cross sections around the eastern ridge between 121° 30’ E and 122° 10’ E along the line of 21° N.

The cross sections showed wavy structures of isopycnals over the ridge, with 4-7 km of horizontal scale and about 50 m of vertical scale. Velocity distributions by the shipboard ADCP showed strong vertical shear over the ridge, suggesting high-mode internal waves. Froude number of the high-mode internal waves exceeds unity around two summits of the ridge during the periods of strong tidal flow. This suggests that the high-mode internal waves stay over the ridge.

Many temperature inversions, especially large inversions (θ > 0.05 °C) were formed near the ridge (figure). Therefore, energy dissipation rate and vertical diffusivity assuming the model of Osborn (1980) were estimated by calculating Thorpe scale from the temperature profiles. Relatively large energy dissipation rate and vertical diffusivity were distributed over the ridge from surface to the bottom, as well as unstable regions of Ri < 0.25. These results reflect strong mixing over the ridge due to the high-mode internal waves.

キーワード：内部波、ルソン海峡
Keywords: internal waves, Luzon Strait

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From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs

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More than 95% of the water flowing into the Sea of Japan comes from the Tsushima Strait, and 80% of it is Kuroshio Intimidate Water (KIW), which is rich in nutrients compared with Kuroshio surface Water and Kuroshio Tropical Water. However, there is a lack of direct evidence based on surveys or measurement data. ^{137}Cs in the subtropical mode water (STMW) that originated in the Fukushima Dai-ichi Nuclear Power Plant (FNPP1) accident is an excellent tracer which can be transported from the Kuroshio upstream to the Sea of Japan crossing the shelf edge of the East China Sea (ECS) via the KIW. It is also useful for research on the transport of nutrients from the KIW.

Data and water samples were collected during the Hakuho-Maru KH-17-5 Cruise and the Nagasaki-Maru 464 Cruise in November and July 2017, respectively. Data from the KH-17-5 Cruise was used for the study of the area around the Luzon Strait and those of the Nagasaki-maru 464 Cruise was used for the study of area around the outer shelf region of the East China Sea and the Tsushima Strait. The ^{137}Cs active concentration was analyzed by γ-Ray spectrometry after preconcentration. The turbulence intensity was measured using TurboMAP and VMP2000.

The maximum ^{137}Cs concentration shows the existence of the subtropical mode water (STMW) in the Luzon Strait, the ECS and the Tsushima Strait, respectively, at the similar density (25.2-25.7 kg/m^3), temperature (15-17℃) and salinity (34.60-34.75). Although their depth changes from 400 m in the Luzon Strait to 150 m at the shelf edge of the ECS and 100m in the East Channel of the Tsushima Strait, they can all be identified as the KIW because of the similar density. It is noteworthy that around Luzon Strait, the distribution of ^{137}Cs is influenced by strong vertical mixing. The percentage of nutrients transported to the Sea of Japan by KIW is estimated and this is meaningful to the ecosystem of the Sea of Japan.

Keywords: 137Cs, subtropical mode water, water masses, KIW, nutrients

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西部北太平洋亜熱帯観測点KEOにおける時系列観測で明らかとなった貧栄養海域の生物地球化学への低気圧性渦と台風の影響
Impact of cyclonic eddies and typhoons on biogeochemistry in the oligotrophic ocean based on time-series observation at the western Pacific subtropical station KEO

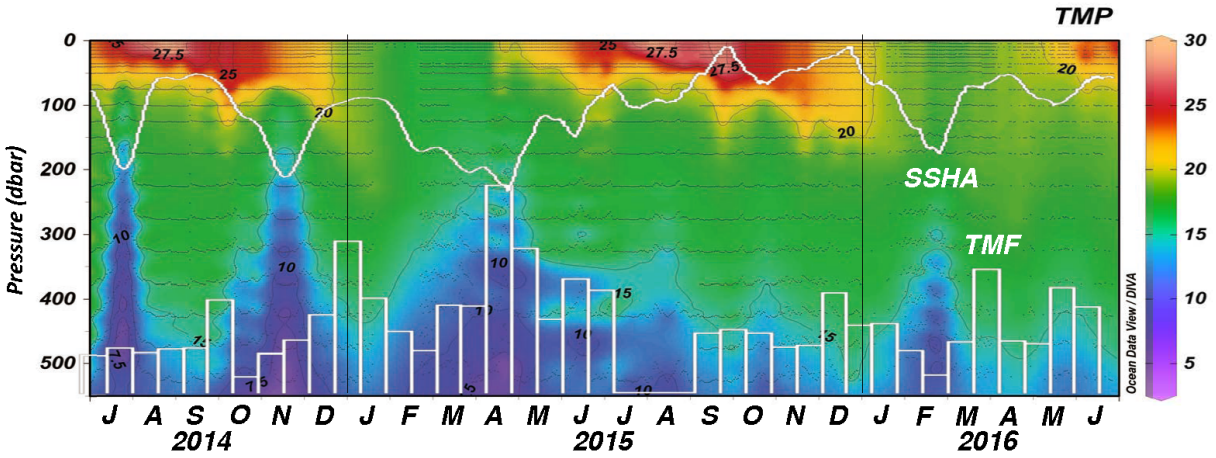
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2014年, NOAA PMELの表層ブイの隣でセジメントトラップ実験を開始した。水深5000mに設置した2年間のセジメントトラップデータから、晩冬（3月）ー晩春（6月）間に生物起源物質フラックスの増加が観測された。NOAA表層ブイで観測されたSSTと表層付近の水温鉛直分布ならびに衛星クロロフィルデータから、この増加は冬季鉛直混合の発達による栄養塩の供給に伴う海洋表層付近の低次生物生産の増加に起因によるものと推定された。一方、表層付近の栄養塩が一般的に低い2014年10月および2014年12月ー2015年1月間にも生物起源物質フラックスの増加が観測された。海面高度偏差と水深5000m以浅の水温鉛直分布変化から2014年7月下旬ー8月初旬および11月に観測点KEOを低気圧性渦が通過し、中層水の湧昇が発生していたことが明らかとなった。これらのイベントが海洋浅層部に栄養塩を供給し亜表層水の低次生物生産を活発化させた結果、上記の秋季と冬季に観測された生物起源フラックスの増加を引き起こしたと推測された。本観測結果（低気圧性渦が低次生産を活発にすること）は３次元物理ー生物シミュレーションによっても定量的に説明することができた。セジメントトラップ観測を行なった2年間にいくつかの台風がKEO近辺を通過し、台風通過後に近慣性内部波が発生していたことがわかった。近慣性内部波による拡散混合の発達も低次生物生産を活発にする栄養塩の供給メカニズムの可能性があった。しかし数値シミュレーションの結果、拡散混合の発達による栄養塩供給量は推定される低次生物生産力の増加を引き起こすには少なすぎることが示唆された。

キーワード：観測点KEO、貧栄養海域、セジメントトラップ、低気圧性渦、栄養塩、台風
Keywords: KEO, Oligotrophic, Sediment trap, Cyclonic eddy, Nutrient, Typhoon

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本州南方海域のプランクトン群集に対する伊豆海嶺域の島陰効果
Island-mass effect on the phytoplankton and zooplankton community in south of Japan

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伊豆海嶺は本州南方の重要な海底構造であり、北緯30度付近まで連なる伊豆諸島を含む山脈状の地形が、駿河灘海域と常磐沖海域の境界となっている。その周辺では、島陰効果による表層への低温・高栄養塩な海水の湧昇とそれにともなうプランクトン分布量の増加が報告されている。しかしながら、これらの報告は、成層が進んでいる初夏から初秋にかけての事例であり、小型浮魚類の産卵と成長が起きる春季についての報告は乏しい。また、この海域は黒潮が通過していることから、増殖に要する時間の長い動物プランクトンについてはより下流で影響が現れることが考えられ、広域でその影響を検証する必要がある。今回は、衛星観測データと動物プランクトン現存量の広域データを元に、伊豆諸島周辺海域の島陰効果の影響について報告する。

衛星観測データについては、海表面クロロフィル濃度（MODIS-Aqua）について、東経135度30分から142度、北緯30度から37度、水深500m以深の範囲を集計した。動物プランクトン現存量データとしては、2月から3月にかけて水産研究・教育機構が本州南方で実施している観測のうち、目合334.5umのノルパックネットで0-150 mの範囲を鉛直曳網した試料を、Bench-top Video Plankton Recorder (B-VPR) によって分析して求めたカイアシ類現存量（体積および換算した生物量）を用いた。それぞれ、本州沿岸および伊豆海嶺域からの距離にともなうクロロフィル濃度およびカイアシ類現存量の変化を求めた。

海表面クロロフィル濃度は、本州沿岸から遠ざかるにつれて減少する傾向を示したが、本州沿岸から150～250 km 付近に、クロロフィル濃度が高くなる海域がみられた。これらは、伊豆海嶺周辺の北緯32～33.5度の範囲を中心としており、黒潮が離岸流路をとった際の島陰効果であると考えられた。一方でカイアシ類現存量については、本州沿岸部（50 km以内）で高い値がみられたほか、伊豆海嶺域からの距離で見た場合に100～200 km付近で特に現存量が高い海域がみられたが、これらは房総半島沿岸に位置していた。これらにより、伊豆海嶺域の島陰効果は、動物プランクトンについては現存量の変化では本州沿岸域の影響を排除できず、産卵速度や増殖速度を種レベルで検証することが必要であると考えられた。

キーワード：動物プランクトン、島陰効果
Keywords: zooplankton, island-mass effect

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Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

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There exists heat conduction from the oceanic lithosphere to the abyssal ocean. Its heat flux amounts to about 0.1 W m^{-2} in the global average. It is much smaller than the heat exchange between the atmosphere and ocean in the order of 10 W m^{-2}. However, it is known that this geothermal heat significantly enhances the deep circulation especially in the Pacific Ocean. For example, Adcroft et al. (2001) conduct numerical experiments with/without geothermal heating using an ocean general circulation model and report that constant heat flux at the sea bottom by 0.05 W m^{-2} results in enhancement of the Pacific meridional overturning circulation (PMOC) by 25 %. Other studies also report that the geothermal heat significantly enhances the oceanic deep circulation (e.g., Emile-Geay and Madec, 2009; Urakawa and Hasumi, 2009; Downes et al., 2016). The importance of the geothermal heat seems to be robust from the viewpoint of ocean dynamics but it has not been investigated to what extent the geothermal heat influences the biogeochemical cycle of the ocean. Here, we conduct two numerical experiments with/without the geothermal heat using an ocean general circulation model developed for the CMIP6 and investigate the effect of the geothermal heat on the biogeochemical tracer fields.
The geothermal heating enhances PMOC at 30º S by 17 % in this model, which leads to stronger ventilation in the North Pacific Ocean. This stronger ventilation results in increase of delta ^{14}C by more than 10 per mille, which means younger water masses, at the bottom of the North Pacific. The stronger PMOC also results in higher dissolved oxygen in the abyss especially in the eastern tropical Pacific. The geothermal heat leads to dissolved oxygen increase by more than 10 micro mol L^{-1} there, which corresponds to 10–70 % of hypoxic water in the control experiment without geothermal heating. This oxygenation near the sea bottom affects the oxygen-deficient water in the surface of the eastern tropical Pacific. Its thickness becomes thinner by around 100 m. The geothermal heat also plays an important role in the biogeochemical cycle in the Pacific Ocean.

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安定・不安定成層した表層海洋中での圧力ー歪み相関のパラメタリゼーション

The Parameterization of the Pressure-Strain Correlations in the Stably or Unstably Stratified Ocean Surface Layer.

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海洋表層の乱流は運動量や熱，栄養塩の鉛直混合を担うため，大気海洋相互作用や物質輸送などに重要であるが（e.g., Roxy et al. 2013, Obata et al. 1996），海洋大循環モデルのような大きなモデルの数値実験では格子間隔が大きく，小規模な海洋表層の乱流を直接再現することはできない。そのため，乱流完結モデルに基づいて，乱流による鉛直混合を精度良く表現するパラメタリゼーションスキームの開発が求められている。本研究では，近年流体力学の分野でその影響の大きさが指摘されている（Jakilic and Hanjalic 2013）圧力ー歪み相関に着目する。これまでの海洋や大気の2次の乱流完結モデル（eg. Mellor and Yamada 1982; Canuto et al. 2001; Nakanishi and Niino 2009）ではRotta (1951), Gibson and Launder (1978), Gertski et al. (1992)などの圧力ー歪み相関のパラメタリゼーションが用いられているが，Rotta (1951)のパラメタリゼーションには大気・海洋の境界層に普遍的に存在する成層の効果が考慮されておらず，他のパラメタリゼーションにおいてもその考慮は限定的である。そこで本研究では乱流の再現性が高いLarge-eddy simulation（LES）を用いて数値実験を行い，LESで直接計算された圧力ー歪み相関と従来の海洋・大気モデルでパラメタライズされている圧力ー歪み相関を様々な成層の下で比較することで，従来のモデルの検証を行った。その結果，両相関は安定度（または成層）の強さに応じて系統的な差が存在することが明らかになった。さらに結果を解析したところ，安定度に関する新たなパラメータを導入することで，その系統的な差を減少させることができることを見出した。

キーワード：圧力ー歪み相関のパラメタリゼーション、乱流クロージャーモデル、海洋表層乱流
Keywords: Parameterization of Pressure-Strain Correlations, Turbulent Closure Model, Turbulence in the Ocean Surface Layer

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台風に対する海洋の応答の非対称性についての数値実験
Numerical studies on asymmetric responses of the upper ocean to tropical cyclone

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Tropical cyclones (TCs) decrease sea surface temperature (SST), and the decreased SST weakens TC intensity. This SST decrease is asymmetric with respect to the TC track, known as “rightward bias”. Preceding numerical studies suggested that this asymmetry may influence on the course of the TC. The interaction between TC and the upper ocean is one of key ingredients for precisely predicting TC's development, and the upper ocean response to TC should also be clarified.
The SST decrease during TC passage is mainly caused by two processes; vertical turbulent mixing and advection (Ekman suction). The rightward bias is associated with the mixing which is more intense on the right side of the TC track due to resonant inertial currents with winds. Magnitude and distribution of SST decrease induced by the mixing should vary with parameters characterizing TC; transition speed U_T, radius of maximum wind R_{max}, the friction velocity U_*, and the Coriolis coefficient f. However, detailed physical processes of the mixing and its dependence on these parameters have not been well quantified, because of lack of in-situ data and complicated processes involved in the mixing.

The present study focuses on the vertical turbulent mixing effects on asymmetric SST response. To this aim, vertically one-dimensional model was used in which the vertical turbulent mixing was parameterized with the Nakanishi-Niino-Mellor-Yamada scheme modified by Kitamura (2010). We considered TC-like wind stress of magnitude U_*^2 at radius R_{max} from the TC center moving with transition speed U_T and investigated the mixing on both sides of TC track at distance *r*. Experiments with several friction velocities U_*, maximum wind radii R_{max}, transition speeds U_T and distances *r* were performed. No surface heat flux was considered for simplicity.
The results showed that the rightward bias of the SST response depended on these parameters. The location of the largest SST decrease moved away from the axis as U_T increased, but it depended less on U_*. The SST decreased more with larger U_* and smaller U_T. These results can be explained by energy flux at the surface. In our model configuration, the energy flux depends on two non-dimensional parameters, U_T/fR_{max} and U_*/U_T, and the energy flux had maximum and turbulent kinetic energy penetrated deeper at larger U_*/U_T and at U_T/fR_{max}~1, suggesting the resonance between wind and the inertial current. The SST decrease corresponded with the energy flux, but it depended largely on U_*/U_T, implying importance of wind forcing duration.
Thus, the asymmetric SST response due to the vertical turbulent mixing can be characterized with U_T/fR_{max} and U_*/U_T. Additional advection effects on the SST response will be discussed at the conference using three-dimensional simulation in which the advection as well as the mixing are fully included.

キーワード：台風、鉛直乱流混合、エクマンサクション、ライトワードバイアス
Keywords: Tropical cyclone, Vertical turbulent mixing, Ekman suction, Rightward bias

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Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

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Although the Southern Ocean is one of the turbulent mixing hotspots, we have not yet clarified quantitatively the turbulent mixing processes in this region, where the Antarctic Circumpolar Current (ACC) coexists with near-inertial internal waves generated by wind forcing and internal lee waves radiated by the impingement of eddy flows on topography.

Fine-scale parameterizations, based on the theory of energy cascade from internal waves to turbulence, are most widely used to estimate the turbulent dissipation rate, ε. It has been reported, however, that these fine-scale parameterizations tend to overestimate ε in the ACC (Waterman et al. 2014). Although Takahashi and Hibiya (2019) have suggested that “the distorted fine-scale shear and strain spectra” caused by the existence of eddies trapping near-inertial waves or upward-propagating internal lee waves might be responsible for the overestimates, the problem remains unresolved.

In this study, we use “eikonal” simulations (Henyey et al. 1986), which trace the propagation, refraction and breaking of test waves within a background internal wave field, to assess the evolution of the energy cascade in vertical wavenumber space. Our objective is to examine how the distortion of the vertical wavenumber spectrum affects the performance of fine-scale parameterizations.

In our simulations, in contrast to high vertical wavenumber test waves that are efficiently Doppler-shifted to their breaking limit, low vertical wavenumber test waves are not subject to dissipation processes. In the existing fine-scale parameterizations, however, the energy flux to dissipation scale is estimated using the integrated vertical wavenumber spectral values. This means that, if the range of this integration includes a spectral bump at the low-wavenumber end of the spectrum, the estimated energy flux and hence the resulting ε might be overestimated by these fine-scale parameterizations.

From the simulation results, it is confirmed that fine-scale parameterizations significantly overestimate ε in spectra with a low-wavenumber bump, in particular as the internal wave energy level becomes large and the shear/strain ratio becomes small. These results are supported by the microstructure and fine-structure dataset from the SOFine experiment carried out in the Kerguelen Plateau.

キーワード：乱流混合、ファインスケール・パラメタリゼーション、南極周極流域
Keywords: Turbulent Mixing, Fine-scale parameterizations, Antarctic Circumpolar Current region

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

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_11

[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)

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。

[AOS09-P01] 高速水温計データの補正について

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[AOS09-P02] 乱流計搭載深海フロートを用いた乱流混合の観測

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[AOS09-P03] Evaluation of the underwater glider flight model using the electromagnetic current sensor

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[AOS09-P04] Mixing processes observed by a slocum glider at the Oyashio-TWC front

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[AOS09-P05] 月の18.6年周期振動がエルニーニョ南方振動ENSOに与える影響

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[AOS09-P06] 潮汐18.6年周期振動が太平洋十年規模振動(PDO)に及ぼす影響

*濵本 真沙希[1]、安田 一郎[1] (1.東京大学大気海洋研究所)

[AOS09-P07] A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

*阿部 佑美[1]、見延 庄士郎[1,5]、Takamitsu Ito[2]、Curtis Deutsch[3]、Matthew Long[4] (1.北海道大学　理学院、2.ジョージア工科大学、3.ワシントン大学、4.アメリカ大気研究センター、5.北海道大学　理学部)

[AOS09-P08] Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

*増田 周平[1] (1.国立研究開発法人　海洋研究開発機構)

[AOS09-P09] Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

*Hung Wei Chou[1]、Humio Mitsudera[1]、Hatsumi Nishikawa[1]、Kaihe Yamazaki[2] (1.Hokkaido University, Institute of Low Temperature Science、2.Hokkaido University, Graduate School of Environmental Science)

[AOS09-P10] Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

*近藤 能子[1,2]、砂原 雄大[2]、西岡 純[3]、小畑 元[4]、武田 重信[1,2] (1.長崎大学大学院水産・環境科学総合研究科、2.長崎大学水産学部、3.北海道大学低温科学研究所、4.東京大学大気海洋研究所)

[AOS09-P11] Chemical and physical speciation of copper in the subarctic North Pacific

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[AOS09-P12] Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

*和賀 久朋[1]、平譯 享[1]、上野 洋路[1] (1.北海道大学)

[AOS09-P13] 黒潮栄養塩ストリームの構造とインパクト

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[AOS09-P14] Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

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[AOS09-P15] Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

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[AOS09-P16] **From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs**

*Siteng Zhu[1]、JING ZHANG[1]、Shota Kambayashi[2]、Takeshi Matsuno[3]、Eisuke Tsutsumi[3]、Shigenobu Takeda[4]、Seiya Nagao[5]、Hiroshi Inoue[5]、Hiroshi Ogawa[6]、Ichiro Yasuda[6] (1.University of Toyama、2.Fukushima university、3.Kyushu university、4.Nagasaki university、5.Kanazawa university、6.The University of Tokyo)

[AOS09-P17] 西部北太平洋亜熱帯観測点KEOにおける時系列観測で明らかとなった貧栄養海域の生物地球化学への低気圧性渦と台風の影響

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[AOS09-P18] 本州南方海域のプランクトン群集に対する伊豆海嶺域の島陰効果

*日高 清隆[1]、田所 和明[1]、宮本 洋臣[1]、市川 忠史[1] (1.水産研究・教育機構)

[AOS09-P19] Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

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[AOS09-P20] 安定・不安定成層した表層海洋中での圧力－歪み相関のパラメタリゼーション

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[AOS09-P21] 台風に対する海洋の応答の非対称性についての数値実験

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[AOS09-P22] Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

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高速水温計データの補正について
Correction method of fast-response thermistors data to estimate turbulence intensity

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高速水温計(FP07)は、乱流エネルギー散逸率 ε と水温消散率 χ を測定することができ、海洋内部についてより詳細なデータが得られるため有用である。しかし、時間分解能が低く、強乱流域で過小評価となるため、補正を施す必要がある。本研究では、0.6-0.7m/sで降下する自由落下型乱流計で得られた流速シア微細構造と水温微細構造の同時観測データを用いて、FP07からの ε _Tと、シアープローブからの ε _Sの２つの乱流エネルギー散逸率を比較し、FP07のデータにどのくらいの補正が必要かを見積もった。FP07の時定数を3m 秒で２次極補正または時定数を7m 秒で1次極補正をした場合に、 ε _S =10^{-10}– 10^{-7}W/kgの範囲でファクタ３で補正が可能であることが示された。発表では水温消散率 χ に及ぼす影響や２重拡散の影響についても議論する。

キーワード：鉛直混合、乱流
Keywords: vertical mixing, turbulence

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乱流計搭載深海フロートを用いた乱流混合の観測
Observation of turbulent mixing using a deep float with microstructure sensors

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海洋乱流の自動観測を目指し、乱流センサーを搭載した深海フロート(DeepNINJA)を用いた乱流評価手法を進めている。浮力調節時のモーター作動による振動は流速シア観測への悪影響を及ぼす他、浮上速度の下限値など、流速シア観測の妥当性について、同時に観測した高速水温計との比較で検討した。2016年8月に試験観測を行い、シア及び高速水温計両方の良好なデータが得られる区間を利用して、水温計からのデータを補正し、シアデータが不良な場合を補完するなど、適切にデータを取り除くことで、比較的信頼できるデータを取得できる。この機器を用いた三陸沖冬季の乱流時系列観測を現在行っており、乱流計搭載深海フロートの特徴を明らかにし、三陸沖乱流混合の時間変動について報告する予定である。

キーワード：鉛直混合、深海フロート、エネルギー散逸率
Keywords: vertical mixing , deep float, energy dissipation rate

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Evaluation of the underwater glider flight model using the electromagnetic current sensor

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Turbulence measurement by underwater gliders has become more common in recent years. For the accurate estimation of energy dissipation rates, the accurate measurement of the fall rate and gliding path angle is necessary. The gliding path angle should take the angle of attack (AOA) into account, which is the difference between the gliding path angle and the pitch angle. AOA calculation has been done by using the so-called flight model assuming dynamical force balance in the quasi-steady state. Due to the difficulty in measuring AOA directly, the validity of AOA derived from the flight model and the flight model itself has not been adequately evaluated so far. In this study, we put the electromagnetic current sensor (EM sensor) on the turbulence package to obtain AOA directly and to compare the AOA from EM sensor with that from the flight model. Using the dataset obtained by a Slocum glider in Jul. - Aug. 2017, we found that AOA from the EM sensor during descent and ascent has a mean (standard deviation) of 0.7 (1.2) deg. and -0.7 (1.1) deg., respectively, while AOA from the flight model is 4.9 (0.4) deg. and -4.5 (0.5) deg., respectively. In order to know what cause this difference, we discuss the validity of parameters given in the flight model. It is suggested that a drag coefficient due to parasite drag given in the flight model may be somewhat larger than that calculated using the EM sensor.

キーワード：水中グライダー、フライトモデル、電磁流速計、迎角
Keywords: underwater glider, flight model, electromagnetic current sensor, angle of attack

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Mixing processes observed by a slocum glider at the Oyashio-TWC front

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In order to grasp the detailed mixing processes along the frontal region between the Oyashio and the Tsugaru Warm Current (TWC), we conducted a zigzag survey crossing the front several times from the merging region of the two current systems to the down stream by an underwater glider (Slocum G2 Glider) equipped with a turbulence sensor, from July 24thto August 29thin 2017. The observed frontal structure indicated the subduction and the intrusion processes of the cold and fresh Oyashio water under the warm and salty TWC water, along layer between 26.5 to 26.8 sigma-theta, which resulted the favorable conditions to the salt finger convection at the upper interface along the 26.5 sigma-theta, and the diffusive convection at the lower interface along the 26.8 sigma-theta where the fresh and cold Oyashio water lying above the warm and salty water. The strong turbulence intensity is observed around the intruded layer, and the mean temperature and the salinity in the layer became warmer and saltier with the increase of the distance from the front, which suggested the time evolution of the vertical mixing driven by double diffusive convections between the three different water masses. Though the strongest turbulence intensity was observed around the frontal region, which may suggest the importance of the cabbeling effect as the additional source of the turbulent mixing.

キーワード：二重拡散対流、混合、キャベリング
Keywords: double diffusion, mixing, cabbeling

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月の18.6年周期振動がエルニーニョ南方振動ENSOに与える影響
Impact of the astronomical lunar 18.6-yr tidal cycle on El-Niño and Southern Oscillation

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Even though El-Niño and Southern Oscillation (ENSO) has a tremendous impact on global climate and society, its long-term forecast remains difficult. In this study, we discovered a statistically significant relationship between ENSO timing and the 18.6-year period lunar tidal cycle in the mature-phase (December –February) ENSO time-series during 1867–2015 and extending back to 1706 with proxy data. It was found that El-Niño tended to occur in the 1st, 10th, and 13th years after the maximum diurnal tide in the 18.6-yr cycle, and La-Niña tended to occur in the 3rd, 12th, and 16th years. These tendencies were also confirmed by corresponding sea-surface temperature (SST) and sea-level pressure (SLP) distributions; particularly Pacific SST and SLP spatial patterns in the third La-Niña and the tenth El-Niño year well resemble those of Pacific Decadal Oscillation (PDO). These findings contribute to understanding and forecasting long-term ENSO variability.

キーワード：エルニーニョ南方振動、大気海洋相互作用、潮汐、混合、気候
Keywords: El-Niño and Southern Oscillation, air-sea interaction, tide, mixing, climate

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潮汐18.6年周期振動が太平洋十年規模振動(PDO)に及ぼす影響
The effect of 18.6-year period lunar nodal cycle on Pacific Decadal Oscillation (PDO)

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Pacific Decadal Oscillation (PDO) is the most dominant decadal-inter-decadal ocean-climate variability over the North Pacific; however, the periodicity and cause have not been fully understood. Previous studies suggested that 18.6-year period lunar tidal cycle ($T_{18.6}$) regulate bi-decadal PDO variability through changes in the strength of diapycnal mixing of ocean around the Kuril Islands to result in ocean variability, together with air-sea interactions in the mid-latitude North Pacific and/or equatorial Pacific. In the present study, 297yr-long reconstructed PDO timeseries was re-examined, and 27.9yr (3/2 times 18.6-yr, henceforth, $T_{27.9}$) period variability was significantly detected, and the zero-crossing from minus to plus was found to occur simultaneously with $T_{18.6}$ variability in the interval of 55.4 years (3 times $T_{18.6}$). In the PDO spectrum, a broad multi-decadal 50-80-yr peak (corresponding to 3-5 times $T_{18.6}$, henceforth T_M) was also detected with the zero-crossing synchronized with $T_{18.6}$; this is the extension of previous studies during 1900-2000 back to 1700s on the synchronous changes of bi-decadal and penta-decadal variabilities. These $T_{18.6}$, $T_{27.9}$ and T_M explain 71% of the 10-year low-passed PDO variability. These imply that the 27.9-yr and the multi-decadal variabilities could be related to $T_{18.6}$ tide-induced variability, and may be excited by $T_{18.6}$ tidal forcing, considering that external periodic forcing for delayed oscillator models could excite 3 times period of the external forcing and some non-linear processes may make the half-period variability.

キーワード：潮汐18.6年周期振動、太平洋十年規模振動
Keywords: 18.6-year period lunar nodal cycle, Pacific Decadal Oscillation

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A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

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Recent studies revealed that the ocean deoxygenation has been accelerating since the 1980s over the global oceans (Schmidtko et al. 2017; Ito et al. 2017), and the observed trend in the last half-century appears to be much larger than the model simulations conducted for CMIP5 (Bopp et al. 2013). This discrepancy is an important issue of the ocean deoxygenation researches as highlighted by a review paper published in the last year (Oschlies et al. 2018).

In order to understand better the relations of oxygen variations between CMIP5 models and observations, we compare oxygen concentration simulated by CMIP5 models and gridded oxygen anomaly dataset used by Ito et al. (2017). For the global oceans, the observed oxygen reduction rate for the historical experiment period appears to be within uncertainty of the models, though this result can be sensitive to the choice of the analysis period associated with the rapid recent oxygen reduction. We also closely examined the two basins that are relatively well sampled, i.e., the North Pacific and the North Atlantic. It is found that the observed North Pacific oxygen reduction is much stronger than the simulated ones, but such a strong reduction of observed oxygen does not occur in the North Atlantic. These results suggest that there are substantial spatio-temporal variations of oxygen concentration on decadal timescales and their mechanism in each basin should be explored in future studies.

キーワード：北太平洋、北大西洋
Keywords: North Pacific, North Atlantic

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Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

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Our aim is to synthesize pre-existing ocean data with newly-acquired turbulence data using state-of-art assimilation technique. Available observations of turbulence strength in the ocean, will be “blended” with pre-existing ocean data applying dynamically self-consistent state estimation approach with 4D-VAR adjoint system. We propose some new techniques and schemes to assimilate turbulence data, which tends to include unique features. The obtained state estimation will provide improved description of ocean circulation, its heat and salt transports, and oceanic ecosystem at lower trophic level.

キーワード：OMIX、海洋、混合、データ同化
Keywords: OMIX, ocean , mixing , data assimilation

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Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

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The pattern of exchange flow between the Sea of Okhotsk and Pacific is a system composed by an Okhotsk-ward inflow through Kruzenshtern strait in north and a Pacific-ward outflow through Bussol strait in south. One of major theories for explaining the dynamic of water exchange through Kuril Island Chain is the turbulence induced by tidal vertical mixing. Turbulence is an important physical process in geostrophic boundary layer, and because of the complexity of topographic in Kuril island chain, the breaking of internal tides in island coast area leads to increase the thickness of surface mixing layer and causes tilting of isopycnal layer in vicinity. The tilting of isopycnal layer around islands forms a clockwise flow along the shore by geostrophic adjustment. However, above process is majorly broclinicly, and how can it impact to barotropic component is still unknown.

By setting the tidal force as a controlled variable, results from realistic OGCM model COCO show only the case with tidal forcing can consistent with the exchange flow pattern as historical observation (Fig.1). Besides, the vertical diffusivity values also show the magnitude difference in summer time, which the flow in north strait in non-tidal case is opposite to tidal one (Fig.2). Therefore, we designed four experiments for understanding the impact of tidal diffusive adjustment in summer: 1. install vertical diffusivity value generated by tidal case into non-tidal run; 2. install vertical diffusivity value generated by non-tidal case into tidal run; 3. set the vertical diffusivity value as zero in tidal case and 4. in non-tidal case as well. Further, for preventing the underestimates the depth of the mixing layer in Mellor-Yamada turbulence closure scheme, two more experiments with the larger vertical diffusivity mask are applied in both tidal and non-tidal case. After calculating the fraction of baroclinic and barotropic components in either north strait or southern strait, results show the vertical mixing dose influence the strength of volume transported but not the direction as original tidal and non-tidal case shows. Hence, for further understanding the impact of vertical diffusivity, we start a tidal forcing run with non-tidal initial conditions to detect the relationship between the flow direction and magnitiude of vertical diffusivity values by time developing. But the baroclinic result implies that the vertical mixing might not be the main reason to control the flow direction (Fig.3).

This study also implies the tidal impacts in OGCM is not only the vertical mixing, but other geostrophic fluid dynamics might occur, especially the interaction of topography with tidal waves. Therefore, for reproducing the real ocean phenomena, movement of tidal waves should be considered.

Keywords: OGCM, tidal mixing , Okhotsk, cross-basin exchange system

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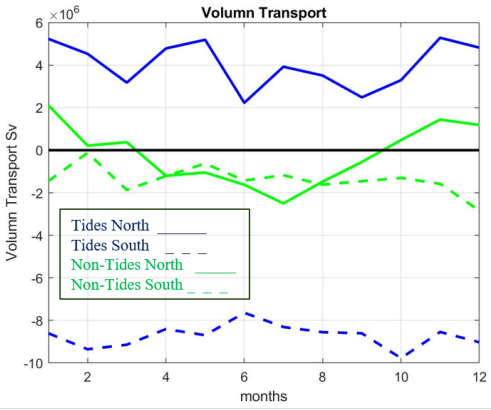


Fig.1: volume transportation in tidal and non-tidal run.
Positive value is Okhotsk-ward and negative value is Pacific-ward flow.

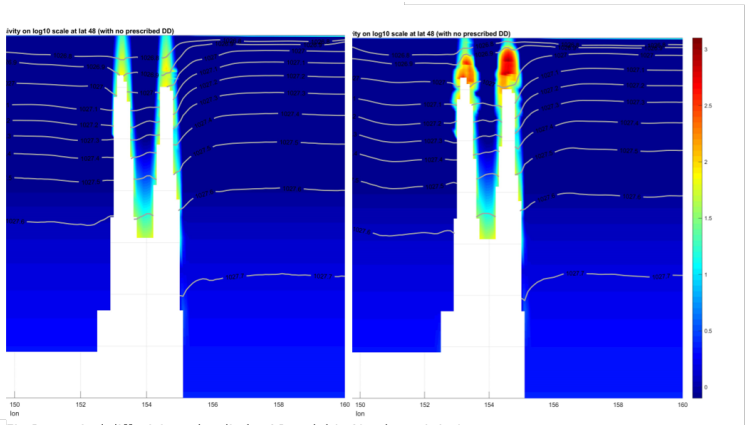


Fig.2: vertical diffusivity value (in log10 scale) in North strait in June, left one is non-tidal run and right is tidal run.

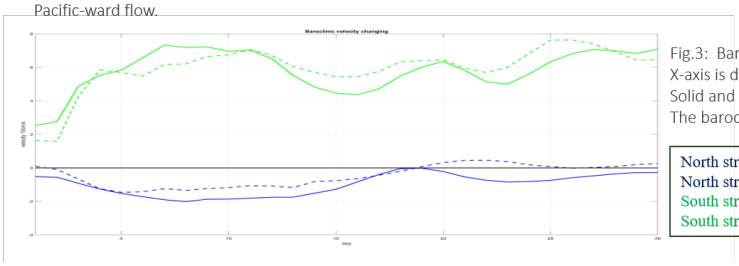


Fig.3: Baroclinic components in the tidal run with non-tidal initial condition.
X-axis is day and y-axis is velocity. Blue line is north strait and green line is south strait.
Solid and dot line are upper and lower isopycal layer, respectively.
The baroclinic velocity is stable after a week running.

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Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

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Iron (Fe) is well known as a key parameter for primary productivity in the ocean. To understand the distributions and biogeochemical cycle of Fe in the ocean, we need to investigate the sources and sinks of Fe. A recent study has demonstrated a concentration gradient of dissolved Fe in the North Pacific Intermediate Water (NPIW) between western and eastern areas (Nishioka and Obata, 2017), suggesting that Fe-rich intermediate water was transported laterally across the western subarctic gyre. Moreover, it has been demonstrated that most dissolved Fe in seawater is complexed with natural organic ligands. Since bioavailability of Fe in seawater depends on its species, the chemical speciation of Fe is needed to evaluate the nutrient status for phytoplankton. However, the distribution of natural organic ligands has not been revealed yet in the subarctic North Pacific. In this study, vertical distributions of organic Fe-binding ligands were investigated in the eastern and western subarctic North Pacific to clarify its impact on Fe cycle. Seawater samples were obtained through the whole water column during GEOTRACES-Japan cruise KH-17-03 using trace metal clean technique to avoid metal contaminations. Filtered seawater samples (<0.2 μm) for organic Fe-binding ligands analysis were collected in acid-washed bottles inside a laminar-flow clean booth, then they were stored at -20°C until just before analysis. The organic Fe-binding ligands' concentration and their conditional stability constants were determined by competitive ligand equilibration-adsorptive cathodic stripping voltammetry (CLE-ACSV) method using salicylaldoxime (Abualhaija and van den Berg, 2014). The concentration and conditional stability constants of organic ligands ranged from 0.7 nM to 5.9 nM and from $10^{10.1}$ M^{-1} to $10^{12.3}$ M^{-1}, respectively. The concentrations of organic ligands exceeded those of dissolved Fe concentration more than 1 nM in all samples except for the surface (10-m) at the Oyashio-Kuroshio transition zone station; consequently >99% of dissolved Fe was estimated to be complexed with these natural organic ligands. At the western station, high concentrations of organic ligands were observed in the intermediate layers (400 –600 m), which hydrographic data (27.2 σ_θ –27.3 σ_θ) were corresponding to the lower NPIW (Yasuda et al., 2004), suggesting that organic Fe-binding ligands might be transported within the lower NPIW.

キーワード：鉄、有機配位子、北太平洋亜寒帯域、GEOTRACES
Keywords: iron, organic ligand, subarctic North Pacific, GEOTRACES

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Chemical and physical speciation of copper in the subarctic North Pacific

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Organic complexation of Cu in seawater plays a major role in controlling the toxicity and bioavailability of Cu for marine microorganism. In this study, we determined the concentrations of Cu and its organic ligands in the soluble and dissolved phases in the subarctic North Pacific. Samples were taken from three stations in the subarctic NorthPacific, CL-2 (western), CL-5 (central) and CL-16 (eastern), during summer 2017.

Concentrations of total dissolved and soluble Cu ranged from 1.28 nM –4.82 nM, and 0.47 nM –2.75 nM, respectively, in the subarctic North Pacific. At both CL-2 and CL-16, soluble Cu accounted for 30% - 100% of total dissolved Cu. The proportion of the soluble Cu fraction was low in surface waters, increased a maximum in the intermediate waters, and decreased slightly in deep waters. Two classes of organic ligands were detected in the surface and intermediate waters of CL-5 and CL-16, and in the intermediate waters of CL-2. In all other depths, only one class of ligand was detected. Concentrations of the stronger ligand (L_1) and weaker ligand (L_2) ranged from 1.02 nM –2.95 nM, and 0.77 nM –8.78 nM, respectively. The distributions of L_1 followed closely that of total dissolved Cu in the surface waters, and no clear trend was observed in the intermediate waters. At CL-2, L_1 mainly existed in the soluble phase, whereas for CL-16, soluble L_1 accounted for 50% - 100% of total dissolved L_1. Concentrations of L_2 were relatively constant throughout the water column but elevated concentrations were detected in the surface waters of CL-5 and in the surface and intermediate waters of CL-16. On the other hand, there were a slight depletion of L_2 in the intermediate waters of CL-2.

キーワード：銅、有機錯体、北太平洋亜寒帯
Keywords: copper, organic ligands, subarctic North Pacific

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Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

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Phytoplankton plays a critical role in a number of key ocean processes. One of the most important functions of phytoplankton is to determine the energy transfer efficiency in marine ecosystems. Although the energy flow from the base of the food web to higher trophic levels depends on both the biomass and size structure of phytoplankton community, phytoplankton size structure is particularly important because energy flow in marine pelagic food webs is largely based on size specific predator-prey relationships. Therefore, spatiotemporal dynamics in size structure of phytoplankton community can trigger changes in the ecosystem’s functioning through trophic cascade effects in the trophic chain. With the development of remote sensing techniques, mesoscale eddies, nearly ubiquitous features of the World Ocean, has been recognizing as important feature for the distribution of phytoplankton not only the direct transport of phytoplankton and eddy trapping, but also the vertical flux of nutrients. Recent studies have examined regional variations in the influence of mesoscale eddies on phytoplankton community. Namely, phytoplankton production is enhanced in cyclonic eddies (CEs) than that of anticyclonic eddies (ACEs) because of upwelling inside the eddy; this view, on the other hand, does not hold for a substantial portion of eddies within oceanic subtropical gyres, the largest ecosystems in the ocean. However, previous efforts have focused mainly on variations in chl*a*, whereas quite a few studies have worked on that in the size structure of phytoplankton community because remote estimations of phytoplankton size structure are newly established techniques during the last decade. Here we improved a chl*a* size distribution (CSD) model which estimates the synoptic size structure of phytoplankton community, to assess the impact of mesoscale eddies on spatiotemporal variations in phytoplankton size structure. Original CSD model was based on the spectral features of the phytoplankton absorption coefficient ($a_{ph}(\lambda)$), which estimation accuracy becomes poor in areas of the low productivity, such as subtropical gyres. To avoid this, we used not only $a_{ph}(\lambda)$ but also chl*a* to improve estimation accuracy of the CSD model. The resulting estimation error of the improved CSD model was the median absolute percent difference of 26.0% between the measured and satellite-matched values, and global distribution of the phytoplankton size structure was reliable even in subtropical gyres. The phytoplankton size structure showed a clear latitudinal variation: larger and smaller assemblages in temperate (>30˚S and >30˚N) and low latitudes (30˚S–30˚N) latitudes, respectively. When comparing the phytoplankton size structure within ACEs and CEs, a larger phytoplankton size structure was found in ACEs especially in low latitudes. This result was consistent with a previous report that ACEs are more productive than CEs in subtropical gyres because of winter mixing. In addition, we found increasing trends ($p < 0.05$) in differences between the phytoplankton size structure within ACEs and CEs in low latitudes for the years 2003–2014, suggesting a growing importance of ACEs for phytoplankton and in turn marine ecosystem. Consequently, this study demonstrates significant advantages of satellite remote sensing for biogeochemical and ecological studies.

キーワード：衛星、中規模渦、植物プランクトン
Keywords: Satellite, Mesoscale eddy, Phytoplankton

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黒潮栄養塩ストリームの構造とインパクト
Structure and impact of the Kuroshio nutrient stream

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Recently the Kuroshio has drawn attention as an important supply route of nutrients in the western North Pacific. However, it is unknown whether nutrient concentrations are enhanced along the jet on isopycnal surfaces, as is the case for the “nutrient stream” along the Gulf Stream. We aim to ascertain the structure of nutrient concentration enhancement along the Kuroshio jet and to estimate the impact of nutrient transport downstream to the Kuroshio-Oyashio interfrontal zone (KOIZ), which is a highly productive region and a major global fishing ground. Recent multiple- transects and retrospective analyses of historic hydrographic data have revealed that the along-jet maximum nitrate concentration appears only in spring on the isopycnal surface $25<\sigma_\theta<26$ in the downstream region of the Kuroshio. The Kuroshio nutrient stream contributes significantly to productivity in the euphotic layer along its downstream trajectory, in conjunction with enhanced vertical turbulence. Analysis of the budget of epipycnal nitrate transport across transects that enclosed the KOIZ suggests that the Kuroshio nutrient stream has a non-negligible potential to significantly impact high productivity in the KOIZ.

キーワード：黒潮栄養塩ストリーム、黒潮親潮移行領域、等密度面輸送
Keywords: Kuroshio nutrient stream, Kuroshio-Oyashio interfrontal zone, epipycnal transport

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Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

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To understand nutrient supply and the biogeochemical response induced by internal waves in the deep basin of the northern South China Sea (NSCS), nitrate, chlorophyll *a* (Chl *a*), particulate organic carbon (POC) fluxes were measured during the passage of large internal waves using drifting sediment traps attached with hydrographic sensors. Results revealed large variations in temperature, nitrate and chlorophyll *a* (Chl *a*) concentrations during and after internal waves, suggesting that cold nutrient-replete waters may be brought to the euphotic zone in the dissipation zone during and after the passage of internal wave packets, resulted in phytoplankton flourished in oligotrophic water. The result reveals that ocean mixing triggered by internal waves in warm water of the NSCS may be important for phytoplankton species composition. Most importantly, POC fluxes (110.9±10.7 mg C m^{-2} d^{-1}) were significantly enhanced after internal waves compared to non-internal wave area (32.6–73.0 mg C m^{-2} d^{-1}) in the NSCS. Such elevated POC fluxes may be induced by downward flourished biogenic particles, particle aggregation or converged particles from mixed layer triggered by internal waves.

Keywords: internal waves, ocean mixing, South China Sea, nutrient dynamics

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Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

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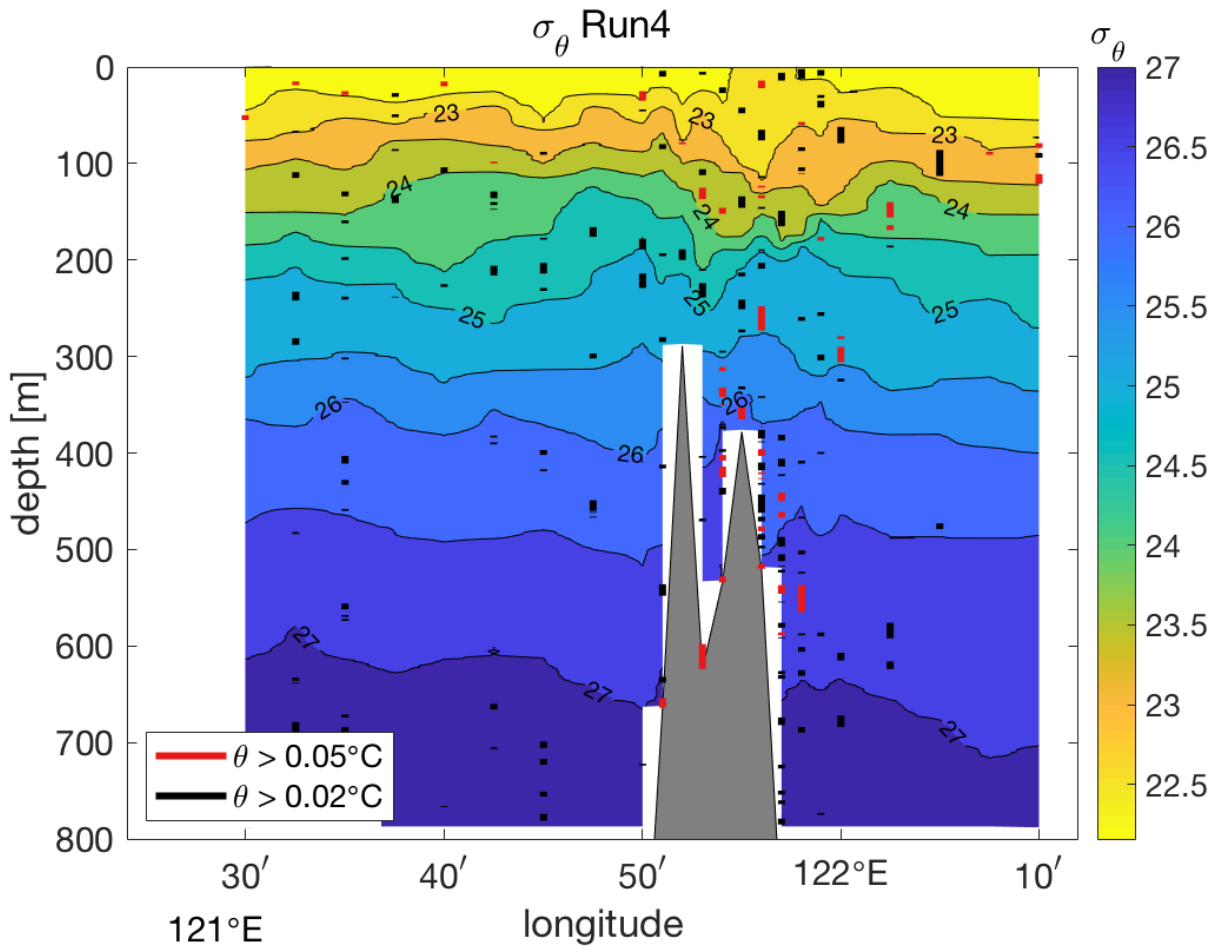
The Luzon Strait has two parallel ridges running from north to south, which is known to create large amplitude internal tides. To investigate the mixing processes accompanied by the internal tides, we carried out repeated observations with XBT, XCTD, CTD, and ADCP in the cruise of R/V Hakuho-maru KH-17-5, Leg-2, in November 2017 as part of the OMIX project. We obtained 6 cross sections around the eastern ridge between 121° 30’ E and 122° 10’ E along the line of 21° N.

The cross sections showed wavy structures of isopycnals over the ridge, with 4-7 km of horizontal scale and about 50 m of vertical scale. Velocity distributions by the shipboard ADCP showed strong vertical shear over the ridge, suggesting high-mode internal waves. Froude number of the high-mode internal waves exceeds unity around two summits of the ridge during the periods of strong tidal flow. This suggests that the high-mode internal waves stay over the ridge.

Many temperature inversions, especially large inversions (θ > 0.05 °C) were formed near the ridge (figure). Therefore, energy dissipation rate and vertical diffusivity assuming the model of Osborn (1980) were estimated by calculating Thorpe scale from the temperature profiles. Relatively large energy dissipation rate and vertical diffusivity were distributed over the ridge from surface to the bottom, as well as unstable regions of Ri < 0.25. These results reflect strong mixing over the ridge due to the high-mode internal waves.

キーワード：内部波、ルソン海峡
Keywords: internal waves, Luzon Strait

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From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs

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More than 95% of the water flowing into the Sea of Japan comes from the Tsushima Strait, and 80% of it is Kuroshio Intimidate Water (KIW), which is rich in nutrients compared with Kuroshio surface Water and Kuroshio Tropical Water. However, there is a lack of direct evidence based on surveys or measurement data. ^{137}Cs in the subtropical mode water (STMW) that originated in the Fukushima Dai-ichi Nuclear Power Plant (FNPP1) accident is an excellent tracer which can be transported from the Kuroshio upstream to the Sea of Japan crossing the shelf edge of the East China Sea (ECS) via the KIW. It is also useful for research on the transport of nutrients from the KIW.

Data and water samples were collected during the Hakuho-Maru KH-17-5 Cruise and the Nagasaki-Maru 464 Cruise in November and July 2017, respectively. Data from the KH-17-5 Cruise was used for the study of the area around the Luzon Strait and those of the Nagasaki-maru 464 Cruise was used for the study of area around the outer shelf region of the East China Sea and the Tsushima Strait. The ^{137}Cs active concentration was analyzed by γ-Ray spectrometry after preconcentration. The turbulence intensity was measured using TurboMAP and VMP2000.

The maximum ^{137}Cs concentration shows the existence of the subtropical mode water (STMW) in the Luzon Strait, the ECS and the Tsushima Strait, respectively, at the similar density (25.2-25.7 kg/m^3), temperature (15-17℃) and salinity (34.60-34.75). Although their depth changes from 400 m in the Luzon Strait to 150 m at the shelf edge of the ECS and 100m in the East Channel of the Tsushima Strait, they can all be identified as the KIW because of the similar density. It is noteworthy that around Luzon Strait, the distribution of ^{137}Cs is influenced by strong vertical mixing. The percentage of nutrients transported to the Sea of Japan by KIW is estimated and this is meaningful to the ecosystem of the Sea of Japan.

Keywords: 137Cs, subtropical mode water, water masses, KIW, nutrients

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西部北太平洋亜熱帯観測点KEOにおける時系列観測で明らかとなった貧栄養海域の生物地球化学への低気圧性渦と台風の影響
Impact of cyclonic eddies and typhoons on biogeochemistry in the oligotrophic ocean based on time-series observation at the western Pacific subtropical station KEO

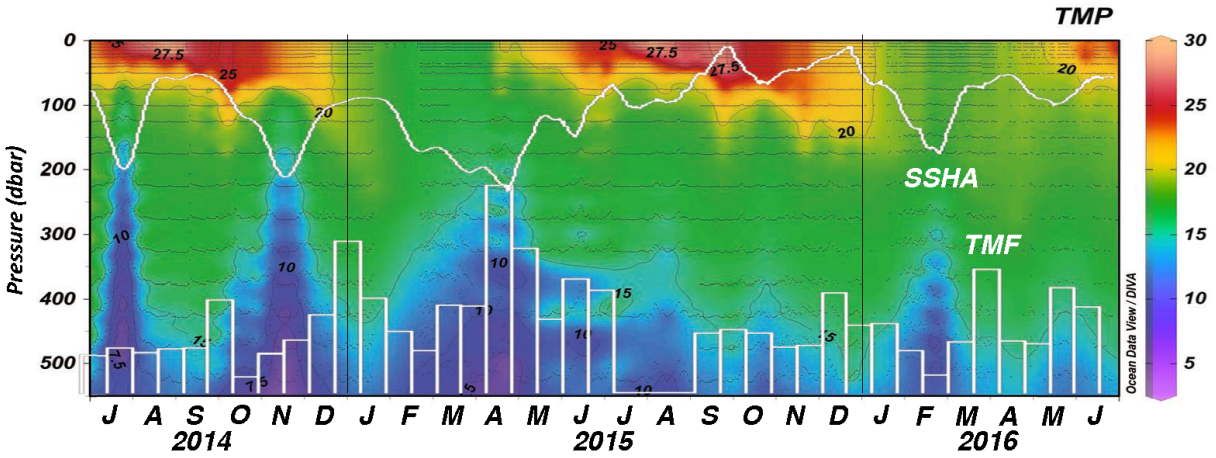
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2014年, NOAA PMELの表層ブイの隣でセジメントトラップ実験を開始した。水深5000mに設置した2年間のセジメントトラップデータから、晩冬（3月）ー晩春（6月）間に生物起源物質フラックスの増加が観測された。NOAA表層ブイで観測されたSSTと表層付近の水温鉛直分布ならびに衛星クロロフィルデータから、この増加は冬季鉛直混合の発達による栄養塩の供給に伴う海洋表層付近の低次生物生産の増加に起因によるものと推定された。一方、表層付近の栄養塩が一般的に低い2014年10月および2014年12月ー2015年1月間にも生物起源物質フラックスの増加が観測された。海面高度偏差と水深5000m以浅の水温鉛直分布変化から2014年7月下旬ー8月初旬および11月に観測点KEOを低気圧性渦が通過し、中層水の湧昇が発生していたことが明らかとなった。これらのイベントが海洋浅層部に栄養塩を供給し亜表層水の低次生物生産を活発化させた結果、上記の秋季と冬季に観測された生物起源フラックスの増加を引き起こしたと推測された。本観測結果（低気圧性渦が低次生産を活発にすること）は３次元物理ー生物シミュレーションによっても定量的に説明することができた。セジメントトラップ観測を行なった2年間にいくつかの台風がKEO近辺を通過し、台風通過後に近慣性内部波が発生していたことがわかった。近慣性内部波による拡散混合の発達も低次生物生産を活発にする栄養塩の供給メカニズムの可能性があった。しかし数値シミュレーションの結果、拡散混合の発達による栄養塩供給量は推定される低次生物生産力の増加を引き起こすには少なすぎることが示唆された。

キーワード：観測点KEO、貧栄養海域、セジメントトラップ、低気圧性渦、栄養塩、台風
Keywords: KEO, Oligotrophic, Sediment trap, Cyclonic eddy, Nutrient, Typhoon

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本州南方海域のプランクトン群集に対する伊豆海嶺域の島陰効果
Island-mass effect on the phytoplankton and zooplankton community in south of Japan

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伊豆海嶺は本州南方の重要な海底構造であり、北緯30度付近まで連なる伊豆諸島を含む山脈状の地形が、駿河灘海域と常磐沖海域の境界となっている。その周辺では、島陰効果による表層への低温・高栄養塩な海水の湧昇とそれにともなうプランクトン分布量の増加が報告されている。しかしながら、これらの報告は、成層が進んでいる初夏から初秋にかけての事例であり、小型浮魚類の産卵と成長が起きる春季についての報告は乏しい。また、この海域は黒潮が通過していることから、増殖に要する時間の長い動物プランクトンについてはより下流で影響が現れることが考えられ、広域でその影響を検証する必要がある。今回は、衛星観測データと動物プランクトン現存量の広域データを元に、伊豆諸島周辺海域の島陰効果の影響について報告する。

衛星観測データについては、海表面クロロフィル濃度（MODIS-Aqua）について、東経135度30分から142度、北緯30度から37度、水深500m以深の範囲を集計した。動物プランクトン現存量データとしては、2月から3月にかけて水産研究・教育機構が本州南方で実施している観測のうち、目合334.5umのノルパックネットで0-150 mの範囲を鉛直曳網した試料を、Bench-top Video Plankton Recorder (B-VPR) によって分析して求めたカイアシ類現存量（体積および換算した生物量）を用いた。それぞれ、本州沿岸および伊豆海嶺域からの距離にともなうクロロフィル濃度およびカイアシ類現存量の変化を求めた。

海表面クロロフィル濃度は、本州沿岸から遠ざかるにつれて減少する傾向を示したが、本州沿岸から150～250 km 付近に、クロロフィル濃度が高くなる海域がみられた。これらは、伊豆海嶺周辺の北緯32～33.5度の範囲を中心としており、黒潮が離岸流路をとった際の島陰効果であると考えられた。一方でカイアシ類現存量については、本州沿岸部（50 km以内）で高い値がみられたほか、伊豆海嶺域からの距離で見た場合に100～200 km付近で特に現存量が高い海域がみられたが、これらは房総半島沿岸に位置していた。これらにより、伊豆海嶺域の島陰効果は、動物プランクトンについては現存量の変化では本州沿岸域の影響を排除できず、産卵速度や増殖速度を種レベルで検証することが必要であると考えられた。

キーワード：動物プランクトン、島陰効果
Keywords: zooplankton, island-mass effect

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Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

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*Shogo Urakawa[1], Hideyuki Nakano[1], Hiroyuki Tsujino[1], Kei Sakamoto[1], Takahiro Toyoda[1], Goro Yamanaka[1]

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There exists heat conduction from the oceanic lithosphere to the abyssal ocean. Its heat flux amounts to about 0.1 W m^{-2} in the global average. It is much smaller than the heat exchange between the atmosphere and ocean in the order of 10 W m^{-2}. However, it is known that this geothermal heat significantly enhances the deep circulation especially in the Pacific Ocean. For example, Adcroft et al. (2001) conduct numerical experiments with/without geothermal heating using an ocean general circulation model and report that constant heat flux at the sea bottom by 0.05 W m^{-2} results in enhancement of the Pacific meridional overturning circulation (PMOC) by 25 %. Other studies also report that the geothermal heat significantly enhances the oceanic deep circulation (e.g., Emile-Geay and Madec, 2009; Urakawa and Hasumi, 2009; Downes et al., 2016). The importance of the geothermal heat seems to be robust from the viewpoint of ocean dynamics but it has not been investigated to what extent the geothermal heat influences the biogeochemical cycle of the ocean. Here, we conduct two numerical experiments with/without the geothermal heat using an ocean general circulation model developed for the CMIP6 and investigate the effect of the geothermal heat on the biogeochemical tracer fields.
The geothermal heating enhances PMOC at 30º S by 17 % in this model, which leads to stronger ventilation in the North Pacific Ocean. This stronger ventilation results in increase of delta ^{14}C by more than 10 per mille, which means younger water masses, at the bottom of the North Pacific. The stronger PMOC also results in higher dissolved oxygen in the abyss especially in the eastern tropical Pacific. The geothermal heat leads to dissolved oxygen increase by more than 10 micro mol L^{-1} there, which corresponds to 10–70 % of hypoxic water in the control experiment without geothermal heating. This oxygenation near the sea bottom affects the oxygen-deficient water in the surface of the eastern tropical Pacific. Its thickness becomes thinner by around 100 m. The geothermal heat also plays an important role in the biogeochemical cycle in the Pacific Ocean.

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安定・不安定成層した表層海洋中での圧力ー歪み相関のパラメタリゼーション

The Parameterization of the Pressure-Strain Correlations in the Stably or Unstably Stratified Ocean Surface Layer.

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海洋表層の乱流は運動量や熱，栄養塩の鉛直混合を担うため，大気海洋相互作用や物質輸送などに重要であるが（e.g., Roxy et al. 2013, Obata et al. 1996），海洋大循環モデルのような大きなモデルの数値実験では格子間隔が大きく，小規模な海洋表層の乱流を直接再現することはできない。そのため，乱流完結モデルに基づいて，乱流による鉛直混合を精度良く表現するパラメタリゼーションスキームの開発が求められている。本研究では，近年流体力学の分野でその影響の大きさが指摘されている（Jakilic and Hanjalic 2013）圧力ー歪み相関に着目する。これまでの海洋や大気の2次の乱流完結モデル（eg. Mellor and Yamada 1982; Canuto et al. 2001; Nakanishi and Niino 2009）ではRotta (1951), Gibson and Launder (1978), Gertski et al. (1992)などの圧力ー歪み相関のパラメタリゼーションが用いられているが，Rotta (1951)のパラメタリゼーションには大気・海洋の境界層に普遍的に存在する成層の効果が考慮されておらず，他のパラメタリゼーションにおいてもその考慮は限定的である。そこで本研究では乱流の再現性が高いLarge-eddy simulation（LES）を用いて数値実験を行い，LESで直接計算された圧力ー歪み相関と従来の海洋・大気モデルでパラメタライズされている圧力ー歪み相関を様々な成層の下で比較することで，従来のモデルの検証を行った。その結果，両相関は安定度（または成層）の強さに応じて系統的な差が存在することが明らかになった。さらに結果を解析したところ，安定度に関する新たなパラメータを導入することで，その系統的な差を減少させることができることを見出した。

キーワード：圧力ー歪み相関のパラメタリゼーション、乱流クロージャーモデル、海洋表層乱流
Keywords: Parameterization of Pressure-Strain Correlations, Turbulent Closure Model, Turbulence in the Ocean Surface Layer

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台風に対する海洋の応答の非対称性についての数値実験
Numerical studies on asymmetric responses of the upper ocean to tropical cyclone

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Tropical cyclones (TCs) decrease sea surface temperature (SST), and the decreased SST weakens TC intensity. This SST decrease is asymmetric with respect to the TC track, known as “rightward bias”. Preceding numerical studies suggested that this asymmetry may influence on the course of the TC. The interaction between TC and the upper ocean is one of key ingredients for precisely predicting TC's development, and the upper ocean response to TC should also be clarified.
The SST decrease during TC passage is mainly caused by two processes; vertical turbulent mixing and advection (Ekman suction). The rightward bias is associated with the mixing which is more intense on the right side of the TC track due to resonant inertial currents with winds. Magnitude and distribution of SST decrease induced by the mixing should vary with parameters characterizing TC; transition speed U_T, radius of maximum wind R_{max}, the friction velocity U_*, and the Coriolis coefficient f. However, detailed physical processes of the mixing and its dependence on these parameters have not been well quantified, because of lack of in-situ data and complicated processes involved in the mixing.

The present study focuses on the vertical turbulent mixing effects on asymmetric SST response. To this aim, vertically one-dimensional model was used in which the vertical turbulent mixing was parameterized with the Nakanishi-Niino-Mellor-Yamada scheme modified by Kitamura (2010). We considered TC-like wind stress of magnitude U_*^2 at radius R_{max} from the TC center moving with transition speed U_T and investigated the mixing on both sides of TC track at distance *r*. Experiments with several friction velocities U_*, maximum wind radii R_{max}, transition speeds U_T and distances *r* were performed. No surface heat flux was considered for simplicity.
The results showed that the rightward bias of the SST response depended on these parameters. The location of the largest SST decrease moved away from the axis as U_T increased, but it depended less on U_*. The SST decreased more with larger U_* and smaller U_T. These results can be explained by energy flux at the surface. In our model configuration, the energy flux depends on two non-dimensional parameters, U_T/fR_{max} and U_*/U_T, and the energy flux had maximum and turbulent kinetic energy penetrated deeper at larger U_*/U_T and at U_T/fR_{max}~1, suggesting the resonance between wind and the inertial current. The SST decrease corresponded with the energy flux, but it depended largely on U_*/U_T, implying importance of wind forcing duration.
Thus, the asymmetric SST response due to the vertical turbulent mixing can be characterized with U_T/fR_{max} and U_*/U_T. Additional advection effects on the SST response will be discussed at the conference using three-dimensional simulation in which the advection as well as the mixing are fully included.

キーワード：台風、鉛直乱流混合、エクマンサクション、ライトワードバイアス
Keywords: Tropical cyclone, Vertical turbulent mixing, Ekman suction, Rightward bias

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Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

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Although the Southern Ocean is one of the turbulent mixing hotspots, we have not yet clarified quantitatively the turbulent mixing processes in this region, where the Antarctic Circumpolar Current (ACC) coexists with near-inertial internal waves generated by wind forcing and internal lee waves radiated by the impingement of eddy flows on topography.

Fine-scale parameterizations, based on the theory of energy cascade from internal waves to turbulence, are most widely used to estimate the turbulent dissipation rate, ε. It has been reported, however, that these fine-scale parameterizations tend to overestimate ε in the ACC (Waterman et al. 2014). Although Takahashi and Hibiya (2019) have suggested that “the distorted fine-scale shear and strain spectra” caused by the existence of eddies trapping near-inertial waves or upward-propagating internal lee waves might be responsible for the overestimates, the problem remains unresolved.

In this study, we use “eikonal” simulations (Henyey et al. 1986), which trace the propagation, refraction and breaking of test waves within a background internal wave field, to assess the evolution of the energy cascade in vertical wavenumber space. Our objective is to examine how the distortion of the vertical wavenumber spectrum affects the performance of fine-scale parameterizations.

In our simulations, in contrast to high vertical wavenumber test waves that are efficiently Doppler-shifted to their breaking limit, low vertical wavenumber test waves are not subject to dissipation processes. In the existing fine-scale parameterizations, however, the energy flux to dissipation scale is estimated using the integrated vertical wavenumber spectral values. This means that, if the range of this integration includes a spectral bump at the low-wavenumber end of the spectrum, the estimated energy flux and hence the resulting ε might be overestimated by these fine-scale parameterizations.

From the simulation results, it is confirmed that fine-scale parameterizations significantly overestimate ε in spectra with a low-wavenumber bump, in particular as the internal wave energy level becomes large and the shear/strain ratio becomes small. These results are supported by the microstructure and fine-structure dataset from the SOFine experiment carried out in the Kerguelen Plateau.

キーワード：乱流混合、ファインスケール・パラメタリゼーション、南極周極流域
Keywords: Turbulent Mixing, Fine-scale parameterizations, Antarctic Circumpolar Current region

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2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_8

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

コンビーナ:Yuei-An Liou(National Central University)

Natural system, environmental quality, and anthropogenic processes interact with each other closely. Environmental changes and their causes increase the needs to address the consequences taking place in the structural and functional ecosystems. Much progress of anthropogenic activities has been made and significantly improves social economics. However, human system has been altering and raising burden on the natural system by alerting land use and land cover, bringing up water, soil and air pollution, changing regional and global climate, and increasing frequency of natural disasters, e.g., floods, landslides. Planners are increasingly pressured by the challenges in balance between demands and development, while lessening the detrimental impact of social processes on environment. Remote sensing and GIS have been proven with their advantages in providing data and tools to model and visualize spatiotemporally environmental changes and influential factors so that practical policy for environmental protection and management can be proposed.
This session seeks for papers on advancements in the development of techniques and models with remote sensing and GIS to contribute environmental applications, to exhibit and visualize influences of human activities on environmental changes, and to improve understanding of the relationship between anthropogenic activities and natural system and climate patterns. Solutions for environmental management in short- and long-term visions are very welcome.

[HGG01-P01] Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck

*Yan-Jyun Lin[1]、Shen Yu Hsiao[1]、REN-JHIH YANG[1]、Zhen-Yu Wu[1] (1.National Chung Hsing University)

[HGG01-P02] The environmental impact of mountaineering in the Mt. Manaslu region

*下嶋 聖[1] (1.東京農業大学)

[HGG01-P03] Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

*Kim-Anh Nguyen[1]、Yuei-An Liou[1] (1.Center for Space and Remote Sensing Research, National Central University)

[HGG01-P04] Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

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

[HGG01-P05] Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

*Joko Widodo[1]、Josaphat Tetuko Sri Sumantyo[1]、Daniele Perissin[2]、Katsunoshin Nishi[1]、Pakhrur Rozi[1] (1.JMRSL - Josaphat Microwave Remote Sensing Laboratory Center for Environmental Remote Sensing Graduate School of Advanced Integration Science Chiba University、2.Sarproz, Razer Limited, Hongkong)

[HGG01-P06] Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

*Peberlin Parulian Sitompul[1]、Josaphat Tetuko Sri Sumantyo[2] (1.Chiba University, and Indonesia National Institute of Aeronautic and Space、2.Center for Environmental Remote Sensing, Chiba University)

Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck

*Yan-Jyun Lin[1], Shen Yu Hsiao[1], REN-JHIH YANG[1], Zhen-Yu Wu[1]

1. National Chung Hsing University

We use the low-cost LiDAR sensor “the VLP-16 LiDAR Puck” to capture the surrounding scene for building high-resolution 360° panoramic images. The VLP-16 LiDAR Puck is mounted on a portable automatic lifting platform(see the attached figure) to increase spatial resolution while doing the experiments. The study locations include buildings, landslide areas, and soil&water conservation structures. The results from the VLP-16 LiDAR Puck will be well compared with those from the high-cost LiDAR sensors “the Trimble TX8” and ”The RIEGL VZ-1000”. The comparisons between three LiDAR sensors include their spatial resolution, accuracy, practicality, convenience, and cost–performance ratio. Overall, the purpose of this research is to analyze the feasibility of constructing high-resolution 3D panoramic images with the VLP-16 LiDAR Puck for applications of soil&water conservation. We also hope this new technique of remote sensing can contribute to environmental monitoring and anthropogenic activities.

Keywords: the VLP-16 LiDAR Puck, 3D panoramic images, remote sensing

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The environmental impact of mountaineering in the Mt. Manaslu region

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*Hijiri SHIMOJIMA[1]

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1. Tokyo University of Agriculture

Manaslu is one of the 8,000-meter peaks ranking as the 8th highest peak in the world, located 130 km northwest of Kathmandu, the capital of Nepal. Since Manaslu's normal route (general climbing route) is relatively less difficult, the number of Manaslu's climbers have increased rapidly over the last 10 years. Sixty years have passed since Manaslu was first conquered by a Japanese expedition. The popularity of its scaling and the rapidly growing tourism in the Nepal Himalayas after 1970 are noticeably affecting natural, social, and cultural environments in the area. This in turn, is creating serious environmental issues at the Manaslu Base Camp (4,800 m above mean sea level), the entry point for climbing Mt. Manaslu.
In this research, we aim to develop a system that can combine high resolution imagery and Digital Surface Model (DSM) in the base camp and simple monitoring into one method in order to estimate the environmental burden associated with the climbing activities in the Manaslu Base Camp. We performed aerial photography of the base camp using Unmanned Aerial Vehicle (UAV) and created DSM from Structure from Motion (SfM) of the obtained images. At the same time, positioning data of the feature was acquired through a Differential Global Positioning System (DGPS) survey, and a 3D topographic map was created.
The geographical area covered in this study is the Manaslu Base Camp in the Manaslu Conservation Area’s, Gorkha District which is located in Northwest Nepal. In order to elucidate the actual usage of the Manaslu Base Camp, a field survey was carried out in August, 2016 at and around the Manaslu Base Camp using UAV. We conducted the following investigations at the Manaslu Base Camp: survey of the Base Camp, questionnaires to all the mountaineering parties at the Base Camp. We monitored the actual usage of the Manaslu Base Camp in order to clarify the number of tents and their locations by photointerpretation using high resolution satellite images. In the survey of the Base Camp using UAV, we acquired a high resolution image using Phantom 4 of DJI. Using the obtained high resolution image, 3D terrain data and an ortho mosaic image was generated from the SfM, and a map of the Manaslu base camp was created. In the DGPS base camp survey, we recorded location information of features such as tents, toilets and routes in the Manaslu base camp.
A topographical survey of the Base Camp was conducted to pinpoint the location of each tent and to grasp the topographical features of the area. We were probably the first in the world to create a topographical map of the Manaslu Base Camp that shows detailed positioning of the campsite. There were 32 kitchen tents, 58 toilet tents, 42 altars (places to pray for safe climbs) in the post-monsoon season. The resolution of the obtained high-resolution image was 0.009 m.
Inquiries were made to every party staying at the Manaslu Base Camp in 2016 August. The questionnaires enquired about the following information: Number of members in each party; number of belongings brought in and out; number of donkeys used to carry equipment; and environmental considerations taken by each party.
A few of the findings of this study in August 2016 at and around the Manaslu Base Camp are as follows. (1) A topographical map of Base Camp was prepared pinpointing the location of each and every tent of the area. We are the first in the world to prepare such topographical map of the Manaslu Base Camp using UAV. (2) The results of the questionnaires show that during the pre-monsoon period in 2016 an

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astounding 46 tons of goods were brought into the Base Camp. Furthermore, over 780 donkeys were used for transportation. (3) Water quality research was also conducted at water collection points of the Base Camp. The water was found to be badly contaminated because of the urine and excrement of donkeys that were found scattered over the Base Camp.

キーワード：ヒマラヤ、GIS、UAV
Keywords: Himalaya, GIS, UAV

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Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

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1. Center for Space and Remote Sensing Research, National Central University

Typhoon is one of the most natural disastrous phenomena that have devastating impacts on human system around the world. In the context of climate change, Asian countries particularly in tropical climate zone with high humidity and unevenly-distributed abundant precipitation tend to have frequent occurrence of typhoons and flooding. Here, we present a conceptual framework that incorporates 21 indicators across three dimensions, including vulnerability, exposure/sensitivity, and adaptive capacity to classify vulnerability and adaptive capacity (VAC) using geospatial techniques at regional scales over Vietnam. Results indicate that large spatial differences in VAC are obtained and identify top-priority regions that need enhanced adaptation to typhoons. The Southern Coastal area, South East and Red River Delta exhibit high and very high vulnerability because their physical features tend to be affected by the intensity of typhoons that frequently cross these parts. The lower Mekong Delta and Northern Coastal areas are vulnerable to typhoon-driven flood threats and, in particular, compounded by sea-level rise. Findings of this study are useful in making efficient policy decisions to minimize vulnerability to typhoons in Vietnam. In addition, the framework can be potentially applied to the other regions.

Keywords: human system vulnerability, Typhoon, Adaptive capacity, Geospatial techniques

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Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

*Ramadan Gamal Abdelrehim[1], Josaphat Tetuko Sri Sumantyo[1]

1. Center for Environmental Remote Sensing, Chiba University

More than 95% of the Egyptian lands are desert, Groundwater in this arid desert area is considered as a very valuable and unique source of water for agricultural and manufacturing development projects; therefore environmental impact evaluation of these projects is very important step to protect groundwater from pollution. Three geophysical techniques used for groundwater exploration and upper geological layers evaluation, these techniques are, Vertical electrical sounding, two dimension electrical imaging, and Time Domain electromagnetic techniques. And depending on this study we described the hydro-geological settings of the area, detect the best locations for drilling groundwater wells, safe environmental injection points, and finally safe environmental landfill.

Keywords: Geophysics, Groundwater, Environmental evaluation, Arid Desert lands

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Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

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1. JMRSL - Josaphat Microwave Remote Sensing Laboratory Center for Environmental Remote Sensing Graduate School of Advanced Integration Science Chiba University, 2. Sarproz, Razer Limited, Hongkong

Indonesia has the lagerst tropical peatland ecosystem in the world around 22 million hectares separate in Sumatera Island, Kalimantan Island, and Papua island. Peatlands can be a source of food, clean water, and provide other benefits for the surrounding community. Peatland is also useful for preventing drought, flooding and mixing salt water for irrigation in agricultural areas. Peatlands are important for biodiversity because they are home to rare species. Peatlands play an important role in climate change mitigation and adaptation. Since subsidence is important phenomenon in peatland, DInSAR provide ability and effective aproach to detect subsidence in peatland area. Subsidence phenomenon in peatland related with groundwater table, carbon emision, and others. In this research, DInSAR is very effective as a basis for an approach to conducting peatland assessment in Kalimantan.

Keywords: DInSAR, Peatland, Assessment, ALOS 2 PALSAR 2

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Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

*Peberlin Parulian Sitompul[1], Josaphat Tetuko Sri Sumantyo[2]

1. Chiba University, and Indonesia National Institute of Aeronautic and Space, 2. Center for Environmental Remote Sensing, Chiba University

Indonesia is located at equatorial region and also has long coastline that often suffer the earthquakes. In some cases, ionospheric activity level increases just before to an earthquake event and shows a different behaviour 5–10 days before the event, when the seismic event has a magnitude greater than 4–4.5 degrees. The nanosatellite development is very important to get more ionospheric data and reletively cheaper than bigger satellite.

Keywords: Nanosatellite, Circular polarization, Earthquake prediction, Ionosphere

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

コンビーナ:Yuei-An Liou(National Central University)

Natural system, environmental quality, and anthropogenic processes interact with each other closely. Environmental changes and their causes increase the needs to address the consequences taking place in the structural and functional ecosystems. Much progress of anthropogenic activities has been made and significantly improves social economics. However, human system has been altering and raising burden on the natural system by alerting land use and land cover, bringing up water, soil and air pollution, changing regional and global climate, and increasing frequency of natural disasters, e.g., floods, landslides. Planners are increasingly pressured by the challenges in balance between demands and development, while lessening the detrimental impact of social processes on environment. Remote sensing and GIS have been proven with their advantages in providing data and tools to model and visualize spatiotemporally environmental changes and influential factors so that practical policy for environmental protection and management can be proposed.
This session seeks for papers on advancements in the development of techniques and models with remote sensing and GIS to contribute environmental applications, to exhibit and visualize influences of human activities on environmental changes, and to improve understanding of the relationship between anthropogenic activities and natural system and climate patterns. Solutions for environmental management in short- and long-term visions are very welcome.

[HGG01-P01] Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck

*Yan-Jyun Lin[1]、Shen Yu Hsiao[1]、REN-JHIH YANG[1]、Zhen-Yu Wu[1] (1.National Chung Hsing University)

[HGG01-P02] The environmental impact of mountaineering in the Mt. Manaslu region

*下嶋 聖[1] (1.東京農業大学)

[HGG01-P03] Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

*Kim-Anh Nguyen[1]、Yuei-An Liou[1] (1.Center for Space and Remote Sensing Research, National Central University)

[HGG01-P04] Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

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

[HGG01-P05] Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

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[HGG01-P06] Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

*Peberlin Parulian Sitompul[1]、Josaphat Tetuko Sri Sumantyo[2] (1.Chiba University, and Indonesia National Institute of Aeronautic and Space、2.Center for Environmental Remote Sensing, Chiba University)

Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck

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We use the low-cost LiDAR sensor “the VLP-16 LiDAR Puck” to capture the surrounding scene for building high-resolution 360° panoramic images. The VLP-16 LiDAR Puck is mounted on a portable automatic lifting platform(see the attached figure) to increase spatial resolution while doing the experiments. The study locations include buildings, landslide areas, and soil&water conservation structures. The results from the VLP-16 LiDAR Puck will be well compared with those from the high-cost LiDAR sensors “the Trimble TX8” and ”The RIEGL VZ-1000”. The comparisons between three LiDAR sensors include their spatial resolution, accuracy, practicality, convenience, and cost–performance ratio. Overall, the purpose of this research is to analyze the feasibility of constructing high-resolution 3D panoramic images with the VLP-16 LiDAR Puck for applications of soil&water conservation. We also hope this new technique of remote sensing can contribute to environmental monitoring and anthropogenic activities.

Keywords: the VLP-16 LiDAR Puck, 3D panoramic images, remote sensing

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The environmental impact of mountaineering in the Mt. Manaslu region

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Manaslu is one of the 8,000-meter peaks ranking as the 8th highest peak in the world, located 130 km northwest of Kathmandu, the capital of Nepal. Since Manaslu's normal route (general climbing route) is relatively less difficult, the number of Manaslu's climbers have increased rapidly over the last 10 years. Sixty years have passed since Manaslu was first conquered by a Japanese expedition. The popularity of its scaling and the rapidly growing tourism in the Nepal Himalayas after 1970 are noticeably affecting natural, social, and cultural environments in the area. This in turn, is creating serious environmental issues at the Manaslu Base Camp (4,800 m above mean sea level), the entry point for climbing Mt. Manaslu.
In this research, we aim to develop a system that can combine high resolution imagery and Digital Surface Model (DSM) in the base camp and simple monitoring into one method in order to estimate the environmental burden associated with the climbing activities in the Manaslu Base Camp. We performed aerial photography of the base camp using Unmanned Aerial Vehicle (UAV) and created DSM from Structure from Motion (SfM) of the obtained images. At the same time, positioning data of the feature was acquired through a Differential Global Positioning System (DGPS) survey, and a 3D topographic map was created.
The geographical area covered in this study is the Manaslu Base Camp in the Manaslu Conservation Area’s, Gorkha District which is located in Northwest Nepal. In order to elucidate the actual usage of the Manaslu Base Camp, a field survey was carried out in August, 2016 at and around the Manaslu Base Camp using UAV. We conducted the following investigations at the Manaslu Base Camp: survey of the Base Camp, questionnaires to all the mountaineering parties at the Base Camp. We monitored the actual usage of the Manaslu Base Camp in order to clarify the number of tents and their locations by photointerpretation using high resolution satellite images. In the survey of the Base Camp using UAV, we acquired a high resolution image using Phantom 4 of DJI. Using the obtained high resolution image, 3D terrain data and an ortho mosaic image was generated from the SfM, and a map of the Manaslu base camp was created. In the DGPS base camp survey, we recorded location information of features such as tents, toilets and routes in the Manaslu base camp.
A topographical survey of the Base Camp was conducted to pinpoint the location of each tent and to grasp the topographical features of the area. We were probably the first in the world to create a topographical map of the Manaslu Base Camp that shows detailed positioning of the campsite. There were 32 kitchen tents, 58 toilet tents, 42 altars (places to pray for safe climbs) in the post-monsoon season. The resolution of the obtained high-resolution image was 0.009 m.
Inquiries were made to every party staying at the Manaslu Base Camp in 2016 August. The questionnaires enquired about the following information: Number of members in each party; number of belongings brought in and out; number of donkeys used to carry equipment; and environmental considerations taken by each party.
A few of the findings of this study in August 2016 at and around the Manaslu Base Camp are as follows. (1) A topographical map of Base Camp was prepared pinpointing the location of each and every tent of the area. We are the first in the world to prepare such topographical map of the Manaslu Base Camp using UAV. (2) The results of the questionnaires show that during the pre-monsoon period in 2016 an

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astounding 46 tons of goods were brought into the Base Camp. Furthermore, over 780 donkeys were used for transportation. (3) Water quality research was also conducted at water collection points of the Base Camp. The water was found to be badly contaminated because of the urine and excrement of donkeys that were found scattered over the Base Camp.

キーワード：ヒマラヤ、GIS、UAV
Keywords: Himalaya, GIS, UAV

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Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

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Typhoon is one of the most natural disastrous phenomena that have devastating impacts on human system around the world. In the context of climate change, Asian countries particularly in tropical climate zone with high humidity and unevenly-distributed abundant precipitation tend to have frequent occurrence of typhoons and flooding. Here, we present a conceptual framework that incorporates 21 indicators across three dimensions, including vulnerability, exposure/sensitivity, and adaptive capacity to classify vulnerability and adaptive capacity (VAC) using geospatial techniques at regional scales over Vietnam. Results indicate that large spatial differences in VAC are obtained and identify top-priority regions that need enhanced adaptation to typhoons. The Southern Coastal area, South East and Red River Delta exhibit high and very high vulnerability because their physical features tend to be affected by the intensity of typhoons that frequently cross these parts. The lower Mekong Delta and Northern Coastal areas are vulnerable to typhoon-driven flood threats and, in particular, compounded by sea-level rise. Findings of this study are useful in making efficient policy decisions to minimize vulnerability to typhoons in Vietnam. In addition, the framework can be potentially applied to the other regions.

Keywords: human system vulnerability, Typhoon, Adaptive capacity, Geospatial techniques

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Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

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More than 95% of the Egyptian lands are desert, Groundwater in this arid desert area is considered as a very valuable and unique source of water for agricultural and manufacturing development projects; therefore environmental impact evaluation of these projects is very important step to protect groundwater from pollution. Three geophysical techniques used for groundwater exploration and upper geological layers evaluation, these techniques are, Vertical electrical sounding, two dimension electrical imaging, and Time Domain electromagnetic techniques. And depending on this study we described the hydro-geological settings of the area, detect the best locations for drilling groundwater wells, safe environmental injection points, and finally safe environmental landfill.

Keywords: Geophysics, Groundwater, Environmental evaluation, Arid Desert lands

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Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

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Indonesia has the lagerst tropical peatland ecosystem in the world around 22 million hectares separate in Sumatera Island, Kalimantan Island, and Papua island. Peatlands can be a source of food, clean water, and provide other benefits for the surrounding community. Peatland is also useful for preventing drought, flooding and mixing salt water for irrigation in agricultural areas. Peatlands are important for biodiversity because they are home to rare species. Peatlands play an important role in climate change mitigation and adaptation. Since subsidence is important phenomenon in peatland, DInSAR provide ability and effective aproach to detect subsidence in peatland area. Subsidence phenomenon in peatland related with groundwater table, carbon emision, and others. In this research, DInSAR is very effective as a basis for an approach to conducting peatland assessment in Kalimantan.

Keywords: DInSAR, Peatland, Assessment, ALOS 2 PALSAR 2

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Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

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Indonesia is located at equatorial region and also has long coastline that often suffer the earthquakes. In some cases, ionospheric activity level increases just before to an earthquake event and shows a different behaviour 5–10 days before the event, when the seismic event has a magnitude greater than 4–4.5 degrees. The nanosatellite development is very important to get more ionospheric data and reletively cheaper than bigger satellite.

Keywords: Nanosatellite, Circular polarization, Earthquake prediction, Ionosphere

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2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_10

[H-SC06] Role of Geosciences for sustainable use of marine and coastal ecosystems in urbanized world.

コンビーナ:Kalpana Chaudhari(Institute For Sustainable Development and Research)

As per the United Nations estimates, the world population reached 7.3 billion as of mid-2015, implying that world has added approximately one billion people in the span of the last 12 years. The total population on earth is predicted to increase by more than one billion people within the next 15 years, reaching 8.5 billion in 2030, and to increase further to 9.7 billion in 2050 and 11.2 billion by 2100. Urban planning and management plays an important role in achieving the social sustainability through geosciences, environmental sustainability for urban transformation. Over the next generation of greatest increase in population, in production and in poverty will occur in cities in Asia and Africa. Due to this rapid urbanization and industrialization, the problems of urban organizational management, which often linked with geosciences and other socio-political aspects include, management of different urban planning and management, disaster management and resources mobilization, coastal zone management etc. for sustainable urban development will need better understanding of geosciences and linked with societal issues .Therefore it would be necessary to study the urban policies for sustainable development in Developed countries in Europe, Asia-Pacific and its impacts on the public life and also on the social-economic development of the urban region through systematic study of geosciences. This joint session will open up the opportunity for the researchers, scientists and students from AGU, EGU and AOGS to present their research/case studies on this topic and to network for future joint research programs. The joint session focuses on policy formulation for resources planning, coastal risk and vulnerability, social-ecological vulnerability and disaster resilience in coastal communities, Human Pressures on Coastal Environments, land water-seawater interactions for sustaining urban development in Asia-Pacific, Europe, South America and Africa region.

[HSC06-P01] Research on Diffusion Method of Factor in Urban Land Classification

★Invited Papers

*Jun Zhou[1] (1.Tianjin Normal University)

[HSC06-P02] Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

*Zhang Hanqiu[1]、Xiang Qiongying[1]、Shi Jiaying[1]、Zhang Junchi[1]、Mao Yingming[1]、Min Kyung-hun[1]、Chen Ge、 Oka Tokiya[1]、 Xie Zijiao[1]、Kashima Minami[1]、Natawiguna I Made、Furuya Katsunori [1] (1.千葉大学大学院園芸学研究科)

[HSC06-P03] Study on Green Tourism Experience —— Cases of Popular Strawberry Farms in Chiba Prefecture

*WU YILIN[1]、Gao Mengying[1]、Sato Kazuhei[1]、Lu Tingyu[1]、Zhang Fumeng[1]、Xing Siqi[1]、Brandt Karolina[1]、Uemura Mai、Furuya Katsunori[1] (1.千葉大学大学院園芸学研究科)

[HSC06-P04] **Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.**

*I Made Pradnyan Natawiguna[1]、Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

Research on Diffusion Method of Factor in Urban Land Classification

*Jun Zhou[1]

1. Tianjin Normal University

In urban classification, it is rather difficult and complex to calculate the classification factor diffusion. The purpose of this paper is resolve calculation efficiency in more barriers and more pass points condition. Topological processing of obstacle and evaluation extent to generate more evaluation zonings, use Dijkstra algorithm to calculate the shortest distance between any two pass points in advance. The method successfully resolve the spatial operation as distance operation, can effectively resolve calculation efficiency. A case study in Jilin province in 2016 show that the technical roadmap is feasible, and the results are reasonable

Keywords: evaluation zoning, urban land classification, obstacle, diffusion, shortest path

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Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

*Zhang Hanqiu[1]、Xiang Qiongying[1]、Shi Jiaying[1]、Zhang Junchi[1]、Mao Yingming[1]、Min Kyung-hun[1]、Chen Ge、 Oka Tokiya[1]、 Xie Zijiao[1]、Kashima Minami[1]、Natawiguna I Made、Furuya Katsunori [1]
*Hanqiu Zhang[1], Qiongying Xiang[1], Jiaying Shi[1], Junchi Zhang[1], Yingming Mao[1], Kyung-hun Min[1], Ge Chen, Tokiya Oka[1], Zijiao Xie[1], Minami Kashima[1], I Made Pradnyan Dana Natawiguna, Katsunori Furuya[1]

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1. Graduate School of Horticulture, Chiba University

Background and Objectives

Green tourism is a dynamic and growing global trend. Cities are seeking ways to development by building tourism based on sustainable, environmentally friendly, and responsible activities. City planners are increasingly aware of the great possibilities of the relationship between tourism and cities' natural environments. This study's goal was to develop an objective assessment of green tourism regarding non-human conditions. A scientific evaluation might reveal the specific tourist attractions or places that receive the most tourist attention in Japan.

Methods

The Green Destinations Standard (available on the Green Destinations website) was modified for the purposed assessment. After studying and modifying the standard of green tourism, two types of variables were chosen for the analysis: dichotomous variables (indicators) and continuous variables. The indicators were nature conservation, facilities, popular seasons, management, and resources. The continuous variables were access (types of transportation), capacity/volume (numbers of tourists), and average cost (JPY). We found eight cases of green tourism in eight different regions of Japan and coded their data into the variables for the analysis. Ultimately, 56 indices were created.

The data were analyzed using reliability analysis, binary variables, and descriptive statistics in JASP software. The reliability analysis determined the reliability of the data, and the binary variables assessed the data regarding non-human conditions. The descriptive statistics were used to assess green tourism in the different regions of Japan regarding non-human conditions.

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Results

The reliability analytical results were not satisfactory, and the reason might be that the alpha reliability test was not appropriate for binary data. The binary variable and descriptive analyses were performed to assess the data.

First, it seemed that nature conservation was a necessary condition for green tourism because the mean of this variable was 0.88. The data indicated that green tourism in Japan was mainly about the development of nature, and protecting cultural heritage was a less frequent response. Second, most of the areas had perfect and diverse methods of transit, including bicycles, cable cars, boats, walkways, and tourist buses. Although Japan has many mountains and seas, there were just a few cable cars and boats. The tourist attractions were easily reached by walking to them. We concluded that, when Japan developed green tourism, it first considered people's needs and convenience. In addition, most areas were government-managed, although a large proportion was privately administered. Last, the mean amount of tourism for the winter season was low (0.71), which was the lowest mean among the seasons. Apparently, although there are holidays in the winter, green tourist attractions open during the winter is less attractive. (**Table 1.** Descriptive statistics)

Conclusion

In sum, the scores were summarized by region. The highest score computed by the binary variable method was in the Chuba region, and the lowest score was in the Shikoku region. The Kansai cultural center and the Kanto economic center were not major areas of green tourism. If we have an opportunity to conduct in-depth research to explore this phenomenon, our findings might benefit the development of green tourism in Japan. (**Figure 1**. Total scores by region)

キーワード：Green tourism、assessment、 binary variable、Japan
Keywords: Green tourism, assessment, binary variable, Japan

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Table 1. Descriptive statistics

Descriptive Statistics														
	Nature Protection	Bicycle	Pedestrain	Cable car/ Rope way(Mountain)	Tourism bus/ Train	Water transport	Spring	Summer	Autumn	Winter	Official	Private	Natural	Cultural (Heritage)
Valid	56	56	56	56	56	56	55	56	56	56	56	56	56	56
Missing	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Mean	0.8750	0.5179	0.9643	0.1607	0.6071	0.3750	0.9091	0.9286	0.8929	0.7143	0.8750	0.5536	0.9286	0.6786
Std. Deviation	0.3337	0.5042	0.1873	0.3706	0.4928	0.4885	0.2901	0.2599	0.3121	0.4558	0.3337	0.5016	0.2599	0.4713

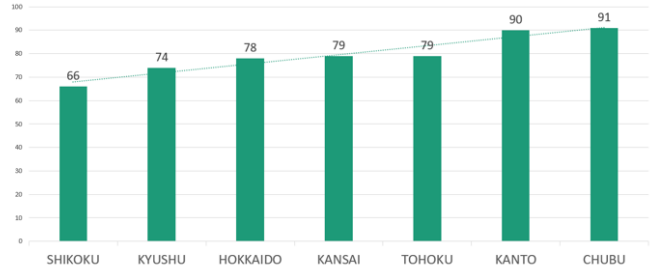


Figure 1. Total scores by region.(The full score is 112 points.)

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Study on Green Tourism Experience ——Cases of Popular Strawberry Farms in Chiba Prefecture

*WU YILIN[1]、Gao Mengying[1]、Sato Kazuhei[1]、Lu Tingyu[1]、Zhang Fumeng[1]、Xing Siqi[1]、Brandt Karolina[1]、Uemura Mai、Furuya Katsunori[1]
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Background and Objectives

The notion of ‘green tourism’, in which people are encouraged to pursue rural leisure activities in a manner that will benefit the countryside, rather than harm, is gaining popularity. (A. Jones, 1987)

Due to today’s enormous social pressure, many people need proximity to nature in order to get recreation in their leisure time. To promote green tourism in cooperation and participation, MAFF (Ministry of Agriculture, Forestry and Fisheries, Japan) arranges green tourism experiences into five categories; farmer restaurants (to taste), local products shops (to buy), farmhouses (to stay), experience of agriculture, forestry and fisheries (to enjoy) and citizen farms (to make). (MAFF HP,2018)

Chiba prefecture is having an advantage in the location as it adjoins to Tokyo metropolitan area, this means that agriculture, fishery experiences and other wide ranges of green-blue tourism activities that can be done on a one-day-trip from the big city. Therefore, it is convenient for urban residents, travelers and visitors to interact and communicate with local farmers and valuable knowledge and experience can easily be exchanged.

Method

The research was conducted in two stages; by collecting literature information and by analysis. Chiba-ken has been chosen as the study area because of the rich nature and beautiful seascape from three sides surrounded. We chose strawberry farms for research because in recent years strawberry picking has received more and more attention and formed a new trend.

Results and Considerations

According to statistics, it is concluded that the largest agricultural experience project in Chiba prefecture is the strawberry picking (Table). The area with the largest distribution of strawberry farms is Kimitsu area, and especially Kimitsu city (Fig.1). Through the study, we found the main reasons for the prosperity of strawberry picking agriculture in this specific area. First, Kimitsu city as a historic strawberry production area has superior geographical conditions. It is possible for the visitors to do the sightseeing in a one-day-trip as the ride is about one hour from Tokyo or Kanagawa when using the Tokyo Bay

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Aquarain/Tsuchiyama Auto Roadway (Fig.2). Another crucial reason is the strong support from the agricultural office on the improvement of cultivation technology and management improvement of producers. Producers in Kimitsu city are working diligently and making efforts by participating in a workshop held by ‘JA Kimito Strawberry Committee’.

As a kind of agricultural management, sightseeing farms are often used as a sideline by farmers. Therefore, facilities and services are often inadequate from a tourism perspective. Sightseeing agriculture in Kimitsu city has benefited from the direct sales system of strawberries, and it can be said to be a model in sightseeing agriculture. For the consideration of development within tourism agriculture, more regional characteristics should be combined, and more emphasis should be placed on promoting regional advantages.

キーワード：green tourism、agriculture、tourism agriculture、MAFF
Keywords: green tourism, agriculture, tourism agriculture, MAFF

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Table over the quantity of experiences in Chiba Prefecture

Activities	Strawberry	Sweet Potato	Bamboo Shoot	Rice	Blueberry
Amount	60	32	27	24	22
Activities	Peanut	Pear	Livestock	Flower Picked	Cauliflower
Amount	20	20	18	16	14
Activities	Corn	Potato	Grapes	Soybeans	Chestnut
Amount	13	13	12	12	12
Activities	Char-grilled	Fishery	Nature	Dairy Farm	Aquatic Food
Amount	11	11	10	9	9
Activities	Orange	Wild Vegetable	Broad Bean	Beach Comb	Shiitake
Amount	9	8	6	6	5
Activities	Loquat	Tomato	Persimmon	Fig	Apple
Amount	5	4	4	4	3
Activities	Taro	Kiwi Fruit	Melon	Carrot	Radish
Amount	3	3	3	3	2
Activities	Broccoli	Onion			
Amount	2	2			

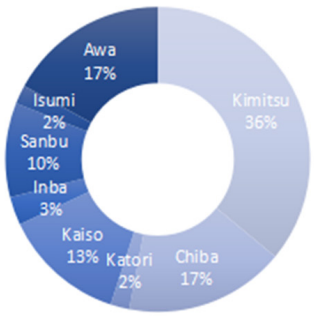


Fig.1 The distribution of strawberry fields



Fig.2 The location of Kimitsu City

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Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.

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Background and Purpose of the research

Balinese people used various types of plants for offering ceremonies. This ceremonial activity is based on the beliefs of the Balinese Hindu community, namely the philosophy of *Tri Hita Karana* which upholds the harmonization of the three good relations of fellow human beings, environment, and God. The role of plants is very vital because each ceremony, the community uses plant parts from roots, stems, leaves, flowers, and fruit. The plants used for offering ceremony means are known as ritual plants. The role of the Balinese community in maintaining plant diversity can be seen from the variety of types of ritual facilities. This study will reveal the diversity of plant species used in ceremonial facilities such as *Canang Sari*, *Kwangen*, *Segehan*, *Daksina*, *Pejati*, *Peras*, *Ajuman*, *Sesayut*, and *Penjor*. The existence of ancient ritual plants is effortless to find in the natural environment of Bali. However, the rapid development of tourism led to the conversion of land from agriculture into a built-in space, enabling the loss of the diversity of ritual plant species. Changes in the components of ritual means can occur due to the loss of ritual diversity. Educating the community regarding the importance of the existence of ritual plants is essential to maintain and preserve ritual plants so that in the future Balinese people, especially those living in urban areas, can re-coexist with ritual plants. This study aims to identify plants found in ritual ceremonies, analyzing plant species potentially used in landscape design, and arranging the landscape plan of the riverside in Denpasar by utilizing selected plant species.

Method

Literary studies were carried out to identify the types of plants contained in each ceremonial facility. Descriptive and quantitative analysis of plant species was carried out to determine the value of these plants both functionally and aesthetically. In preparing a landscape plan, a case study was carried out at the border of the *Tukad Mati* River in Denpasar City. The research steps taken are inventory, analysis, synthesis, and planning.

Results

The results of this study revealed that there were 16 plant species in *Canang Sari*, 13 plant species in *Kwangen*, 18 plant species in *Segehan*, 30 plant species in *Daksina*, 43 plant species in *Pejati*, 15 plant species in *Peras*, 23 plant species in *Ajuman*, 21 species plants in *Sesayut*, and 16 plant species at *Penjor* . Several species such as coconut, areca nut, betel and banana are used in 9 types of ritual facilities. Potential plants in landscape design number 25 species, 9 of which fulfill conservation functions, ten species accomplish aesthetic services, and six species perform architectural roles. The green governance plan in the case study carried out at the border of the Tukad Mati River in addition to maintaining existing plants also utilizes potential ritual plant species. The concept of a green governance plan refers to the function of protecting riverside areas, recreational purposes, and public education functions related to the existence of ritual plants.

Conclusion

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The diversity of plants has been identified from 9 types of ceremonial facilities of the Balinese Hindu community. *Pejati* ceremony facilities have the highest plant diversity is 43 species of plants and the Kwangen ceremony facilities have the lowest diversity of plants, namely 13 plant species. 25 plant species have the potential to be used as landscape plants. This plant is recommended for riverside landscape planning in Denpasar city. The concept of green governance refers to the function of protecting river areas, recreational functions, and public education functions.

Keywords: ritual plants, plants diversity, bali, landscape plants, green space, riverbank

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2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_17

[H-SC06] Role of Geosciences for sustainable use of marine and coastal ecosystems in urbanized world.

コンビーナ:Kalpana Chaudhari(Institute For Sustainable Development and Research)

As per the United Nations estimates, the world population reached 7.3 billion as of mid-2015, implying that world has added approximately one billion people in the span of the last 12 years. The total population on earth is predicted to increase by more than one billion people within the next 15 years, reaching 8.5 billion in 2030, and to increase further to 9.7 billion in 2050 and 11.2 billion by 2100. Urban planning and management plays an important role in achieving the social sustainability through geosciences, environmental sustainability for urban transformation. Over the next generation of greatest increase in population, in production and in poverty will occur in cities in Asia and Africa. Due to this rapid urbanization and industrialization, the problems of urban organizational management, which often linked with geosciences and other socio-political aspects include, management of different urban planning and management, disaster management and resources mobilization, coastal zone management etc. for sustainable urban development will need better understanding of geosciences and linked with societal issues .Therefore it would be necessary to study the urban policies for sustainable development in Developed countries in Europe, Asia-Pacific and its impacts on the public life and also on the social-economic development of the urban region through systematic study of geosciences. This joint session will open up the opportunity for the researchers, scientists and students from AGU, EGU and AOGS to present their research/case studies on this topic and to network for future joint research programs. The joint session focuses on policy formulation for resources planning, coastal risk and vulnerability, social-ecological vulnerability and disaster resilience in coastal communities, Human Pressures on Coastal Environments, land water-seawater interactions for sustaining urban development in Asia-Pacific, Europe, South America and Africa region.

[HSC06-P01] Research on Diffusion Method of Factor in Urban Land Classification

★Invited Papers

*Jun Zhou[1] (1.Tianjin Normal University)

[HSC06-P02] Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

*Zhang Hanqiu[1]、Xiang Qiongying[1]、Shi Jiaying[1]、Zhang Junchi[1]、Mao Yingming[1]、Min Kyung-hun[1]、Chen Ge、 Oka Tokiya[1]、 Xie Zijiao[1]、Kashima Minami[1]、Natawiguna I Made、Furuya Katsunori [1] (1.千葉大学大学院園芸学研究科)

[HSC06-P03] Study on Green Tourism Experience —— Cases of Popular Strawberry Farms in Chiba Prefecture

*WU YILIN[1]、Gao Mengying[1]、Sato Kazuhei[1]、Lu Tingyu[1]、Zhang Fumeng[1]、Xing Siqi[1]、Brandt Karolina[1]、Uemura Mai、Furuya Katsunori[1] (1.千葉大学大学院園芸学研究科)

[HSC06-P04] **Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.**

*I Made Pradnyan Natawiguna[1]、Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

Research on Diffusion Method of Factor in Urban Land Classification

*Jun Zhou[1]

1. Tianjin Normal University

In urban classification, it is rather difficult and complex to calculate the classification factor diffusion. The purpose of this paper is resolve calculation efficiency in more barriers and more pass points condition. Topological processing of obstacle and evaluation extent to generate more evaluation zonings, use Dijkstra algorithm to calculate the shortest distance between any two pass points in advance. The method successfully resolve the spatial operation as distance operation, can effectively resolve calculation efficiency. A case study in Jilin province in 2016 show that the technical roadmap is feasible, and the results are reasonable

Keywords: evaluation zoning, urban land classification, obstacle, diffusion, shortest path

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Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

*Zhang Hanqiu[1]、Xiang Qiongying[1]、Shi Jiaying[1]、Zhang Junchi[1]、Mao Yingming[1]、Min Kyung-hun[1]、Chen Ge、 Oka Tokiya[1]、 Xie Zijiao[1]、Kashima Minami[1]、Natawiguna I Made、Furuya Katsunori [1]
*Hanqiu Zhang[1], Qiongying Xiang[1], Jiaying Shi[1], Junchi Zhang[1], Yingming Mao[1], Kyung-hun Min[1], Ge Chen, Tokiya Oka[1], Zijiao Xie[1], Minami Kashima[1], I Made Pradnyan Dana Natawiguna, Katsunori Furuya[1]

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Background and Objectives

Green tourism is a dynamic and growing global trend. Cities are seeking ways to development by building tourism based on sustainable, environmentally friendly, and responsible activities. City planners are increasingly aware of the great possibilities of the relationship between tourism and cities' natural environments. This study's goal was to develop an objective assessment of green tourism regarding non-human conditions. A scientific evaluation might reveal the specific tourist attractions or places that receive the most tourist attention in Japan.

Methods

The Green Destinations Standard (available on the Green Destinations website) was modified for the purposed assessment. After studying and modifying the standard of green tourism, two types of variables were chosen for the analysis: dichotomous variables (indicators) and continuous variables. The indicators were nature conservation, facilities, popular seasons, management, and resources. The continuous variables were access (types of transportation), capacity/volume (numbers of tourists), and average cost (JPY). We found eight cases of green tourism in eight different regions of Japan and coded their data into the variables for the analysis. Ultimately, 56 indices were created.

The data were analyzed using reliability analysis, binary variables, and descriptive statistics in JASP software. The reliability analysis determined the reliability of the data, and the binary variables assessed the data regarding non-human conditions. The descriptive statistics were used to assess green tourism in the different regions of Japan regarding non-human conditions.

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Results

The reliability analytical results were not satisfactory, and the reason might be that the alpha reliability test was not appropriate for binary data. The binary variable and descriptive analyses were performed to assess the data.

First, it seemed that nature conservation was a necessary condition for green tourism because the mean of this variable was 0.88. The data indicated that green tourism in Japan was mainly about the development of nature, and protecting cultural heritage was a less frequent response. Second, most of the areas had perfect and diverse methods of transit, including bicycles, cable cars, boats, walkways, and tourist buses. Although Japan has many mountains and seas, there were just a few cable cars and boats. The tourist attractions were easily reached by walking to them. We concluded that, when Japan developed green tourism, it first considered people's needs and convenience. In addition, most areas were government-managed, although a large proportion was privately administered. Last, the mean amount of tourism for the winter season was low (0.71), which was the lowest mean among the seasons. Apparently, although there are holidays in the winter, green tourist attractions open during the winter is less attractive. (**Table 1.** Descriptive statistics)

Conclusion

In sum, the scores were summarized by region. The highest score computed by the binary variable method was in the Chuba region, and the lowest score was in the Shikoku region. The Kansai cultural center and the Kanto economic center were not major areas of green tourism. If we have an opportunity to conduct in-depth research to explore this phenomenon, our findings might benefit the development of green tourism in Japan. (**Figure 1**. Total scores by region)

キーワード：Green tourism、assessment、 binary variable、Japan
Keywords: Green tourism, assessment, binary variable, Japan

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Table 1. Descriptive statistics

Descriptive Statistics														
	Nature Protection	Bicycle	Pedestrain	Cable car/ Rope way(Mountain)	Tourism bus/ Train	Water transport	Spring	Summer	Autumn	Winter	Official	Private	Natural	Cultural (Heritage)
Valid	56	56	56	56	56	56	55	56	56	56	56	56	56	56
Missing	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Mean	0.8750	0.5179	0.9643	0.1607	0.6071	0.3750	0.9091	0.9286	0.8929	0.7143	0.8750	0.5536	0.9286	0.6786
Std. Deviation	0.3337	0.5042	0.1873	0.3706	0.4928	0.4885	0.2901	0.2599	0.3121	0.4558	0.3337	0.5016	0.2599	0.4713

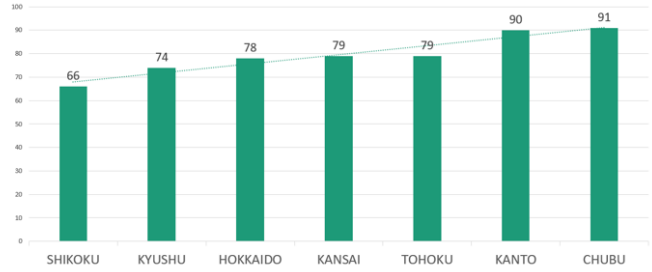


Figure 1. Total scores by region.(The full score is 112 points.)

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Study on Green Tourism Experience ——Cases of Popular Strawberry Farms in Chiba Prefecture

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Background and Objectives

The notion of ‘green tourism’, in which people are encouraged to pursue rural leisure activities in a manner that will benefit the countryside, rather than harm, is gaining popularity. (A. Jones, 1987)

Due to today’s enormous social pressure, many people need proximity to nature in order to get recreation in their leisure time. To promote green tourism in cooperation and participation, MAFF (Ministry of Agriculture, Forestry and Fisheries, Japan) arranges green tourism experiences into five categories; farmer restaurants (to taste), local products shops (to buy), farmhouses (to stay), experience of agriculture, forestry and fisheries (to enjoy) and citizen farms (to make). (MAFF HP,2018)

Chiba prefecture is having an advantage in the location as it adjoins to Tokyo metropolitan area, this means that agriculture, fishery experiences and other wide ranges of green-blue tourism activities that can be done on a one-day-trip from the big city. Therefore, it is convenient for urban residents, travelers and visitors to interact and communicate with local farmers and valuable knowledge and experience can easily be exchanged.

Method

The research was conducted in two stages; by collecting literature information and by analysis. Chiba-ken has been chosen as the study area because of the rich nature and beautiful seascape from three sides surrounded. We chose strawberry farms for research because in recent years strawberry picking has received more and more attention and formed a new trend.

Results and Considerations

According to statistics, it is concluded that the largest agricultural experience project in Chiba prefecture is the strawberry picking (Table). The area with the largest distribution of strawberry farms is Kimitsu area, and especially Kimitsu city (Fig.1). Through the study, we found the main reasons for the prosperity of strawberry picking agriculture in this specific area. First, Kimitsu city as a historic strawberry production area has superior geographical conditions. It is possible for the visitors to do the sightseeing in a one-day-trip as the ride is about one hour from Tokyo or Kanagawa when using the Tokyo Bay

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Aquarain/Tsuchiyama Auto Roadway (Fig.2). Another crucial reason is the strong support from the agricultural office on the improvement of cultivation technology and management improvement of producers. Producers in Kimitsu city are working diligently and making efforts by participating in a workshop held by ‘JA Kimito Strawberry Committee’.

As a kind of agricultural management, sightseeing farms are often used as a sideline by farmers. Therefore, facilities and services are often inadequate from a tourism perspective. Sightseeing agriculture in Kimitsu city has benefited from the direct sales system of strawberries, and it can be said to be a model in sightseeing agriculture. For the consideration of development within tourism agriculture, more regional characteristics should be combined, and more emphasis should be placed on promoting regional advantages.

キーワード：green tourism、agriculture、tourism agriculture、MAFF
Keywords: green tourism, agriculture, tourism agriculture, MAFF

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Table over the quantity of experiences in Chiba Prefecture

Activities	Strawberry	Sweet Potato	Bamboo Shoot	Rice	Blueberry
Amount	60	32	27	24	22
Activities	Peanut	Pear	Livestock	Flower Picked	Cauliflower
Amount	20	20	18	16	14
Activities	Corn	Potato	Grapes	Soybeans	Chestnut
Amount	13	13	12	12	12
Activities	Char-grilled	Fishery	Nature	Dairy Farm	Aquatic Food
Amount	11	11	10	9	9
Activities	Orange	Wild Vegetable	Broad Bean	Beach Comb	Shiitake
Amount	9	8	6	6	5
Activities	Loquat	Tomato	Persimmon	Fig	Apple
Amount	5	4	4	4	3
Activities	Taro	Kiwi Fruit	Melon	Carrot	Radish
Amount	3	3	3	3	2
Activities	Broccoli	Onion			
Amount	2	2			

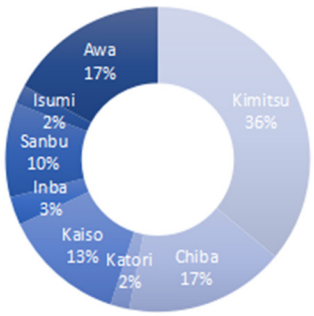


Fig.1 The distribution of strawberry fields



Fig.2 The location of Kimitsu City

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Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.

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Background and Purpose of the research

Balinese people used various types of plants for offering ceremonies. This ceremonial activity is based on the beliefs of the Balinese Hindu community, namely the philosophy of *Tri Hita Karana* which upholds the harmonization of the three good relations of fellow human beings, environment, and God. The role of plants is very vital because each ceremony, the community uses plant parts from roots, stems, leaves, flowers, and fruit. The plants used for offering ceremony means are known as ritual plants. The role of the Balinese community in maintaining plant diversity can be seen from the variety of types of ritual facilities. This study will reveal the diversity of plant species used in ceremonial facilities such as *Canang Sari*, *Kwangen*, *Segehan*, *Daksina*, *Pejati*, *Peras*, *Ajuman*, *Sesayut*, and *Penjor*. The existence of ancient ritual plants is effortless to find in the natural environment of Bali. However, the rapid development of tourism led to the conversion of land from agriculture into a built-in space, enabling the loss of the diversity of ritual plant species. Changes in the components of ritual means can occur due to the loss of ritual diversity. Educating the community regarding the importance of the existence of ritual plants is essential to maintain and preserve ritual plants so that in the future Balinese people, especially those living in urban areas, can re-coexist with ritual plants. This study aims to identify plants found in ritual ceremonies, analyzing plant species potentially used in landscape design, and arranging the landscape plan of the riverside in Denpasar by utilizing selected plant species.

Method

Literary studies were carried out to identify the types of plants contained in each ceremonial facility. Descriptive and quantitative analysis of plant species was carried out to determine the value of these plants both functionally and aesthetically. In preparing a landscape plan, a case study was carried out at the border of the *Tukad Mati* River in Denpasar City. The research steps taken are inventory, analysis, synthesis, and planning.

Results

The results of this study revealed that there were 16 plant species in *Canang Sari*, 13 plant species in *Kwangen*, 18 plant species in *Segehan*, 30 plant species in *Daksina*, 43 plant species in *Pejati*, 15 plant species in *Peras*, 23 plant species in *Ajuman*, 21 species plants in *Sesayut*, and 16 plant species at *Penjor* . Several species such as coconut, areca nut, betel and banana are used in 9 types of ritual facilities. Potential plants in landscape design number 25 species, 9 of which fulfill conservation functions, ten species accomplish aesthetic services, and six species perform architectural roles. The green governance plan in the case study carried out at the border of the Tukad Mati River in addition to maintaining existing plants also utilizes potential ritual plant species. The concept of a green governance plan refers to the function of protecting riverside areas, recreational purposes, and public education functions related to the existence of ritual plants.

Conclusion

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The diversity of plants has been identified from 9 types of ceremonial facilities of the Balinese Hindu community. *Pejati* ceremony facilities have the highest plant diversity is 43 species of plants and the Kwangen ceremony facilities have the lowest diversity of plants, namely 13 plant species. 25 plant species have the potential to be used as landscape plants. This plant is recommended for riverside landscape planning in Denpasar city. The concept of green governance refers to the function of protecting river areas, recreational functions, and public education functions.

Keywords: ritual plants, plants diversity, bali, landscape plants, green space, riverbank

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

2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_11

[H-TT20] Environmental Remote Sensing

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

Our human beings are encountering various environmental issues on the Earth, and it is urgent to find out the solutions. Remote sensing is currently the only feasible means to observe the Earth environment at regional/continental /global scales over long periods, and consequently detects the environmental changes occurred all over the world. This session invites presentations on theory, science, technology, and applications of remote sensing to study the Earth environment from regional to global scales. Both oral and poster presentations are sincerely welcome.

[HTT20-P01] **Classification of Winter Wheat using high spatial resolution data in North China Plain**

*Chunyang Wang[1,2]、Wei Yang[2]、Xifang Wu[3]、Zhichao Chen[1]、Junjun Lu[1]、Zongze Zhao[1]、Hebing Zhang[1] (1.School of Surveying and Land Information Engineering, Henan Polytechnic University、2.Center for Environmental Remote Sensing, Chiba University、3.Graduate School of Science and Engineering, Chiba University)

[HTT20-P02] Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

*楊 偉[1]、小林 秀樹[2]、近藤 昭彦[1] (1.千葉大学、2.海洋研究開発機構)

[HTT20-P03] ***Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)***

*Sarah Kentsch[1,2]、Larry Maximo Lopez Caceres[1]、Yago Diez[1]、Motohisa Fukuda[1] (1.Yamagata University、2.United Graduate School of Agricultural Sciences)

[HTT20-P04] Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

*はりぷ あいふまる[1]、Bhattarai Richa[1]、LIU Wen[1]、Kondoh Akihiko[1,2] (1.Graduate School of Science and Engineering、2.Center for Environmental Remote Sensing, Chiba University)

[HTT20-P05] Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

*楊 偉[1]、陳 晋[2] (1.千葉大学、2.北京師範大学)

Classification of Winter Wheat using high spatial resolution data in North China Plain

*Chunyang Wang[1,2], Wei Yang[2], Xifang Wu[3], Zhichao Chen[1], Junjun Lu[1], Zongze Zhao[1], Hebing Zhang[1]

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Winter Wheat in North China Plain (NCP) is one of the key food sources for securing food safety of China. Mapping the spatial distributions of winter wheat plays crucial roles in monitoring of planting areas and estimation of winter wheat production, which is usually carried out through classification of satellite images. The traditional classification methods are mainly based on data collection, download storage, and local analysis. However, these approaches are not capable of dealing with the quick mapping of massive satellite data including high spatial-temporal resolutions over large-scale areas. To overcome this challenge, this study developed a processing chain for mapping winter wheat of NCP at 10 m resolution using Sentinel-2-based NDVI time series on the google earth engine (GEE) platform, a cloud computing platform for Earth science data and analysis. First, the influence of phenology between the north and the south of the NCP on classification is eliminated by using the locally selected training data sets. Second, the data contaminated by clouds were all removed. Third, the training sample sets are constructed, and the typical features are searched. Last, two machine learning algorithms were applied to yield the classification result map, that is, Random Forest (RF) method and Regression Trees (CART) method. Validation results showed that the final maps and classification accuracy of RF method was better than SVM and CART method, with total accuracy of 81%. Moreover, this study also demonstrated that the GEE platform can yield dramatically higher efficiency than conventional classification methods by reducing downloading time and local storage capacity. Consequently, we recommend that the GEE cloud computing platform is a more suitable research tool for large-scale geospatial analysis and application.

Keywords: Google earth engine, Cloud computing, Big data, Classification, Sentinel-2, Winter wheat

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Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

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*Wei Yang[1], Hideki Kobayashi[2], Akihiko Kondoh[1]

1. 千葉大学、2. 海洋研究開発機構
1. Chiba University, 2. JAMSTEC

Satellite monitoring of vegetation phenology is crucial to understanding the biological impacts of climate change. Nevertheless, satellite-based phenology estimation can be biased by effects of snow using conventional vegetation indices (VIs), such as the normalized difference vegetation index (NDVI). To eliminate effects of snow, snow-free VIs that take advantage of the shortwave infrared (SWIR) band have been proposed (i.e., phenology index [PI] and normalized difference phenology index [NDPI]). However, PI cannot properly capture the presence of sparse vegetation, and NDPI does not account for the influence of dry vegetation. Here, we propose a novel snow-free VI, designated the normalized difference greenness index (NDGI), using reflectance of green, red, and near-infrared (NIR) bands. NDGI is a semi-analytical index deduced based on the linear spectral mixture model and the spectral characteristics of vegetation, snow, soil, and dry grass. Its performance for estimating the start of growing season (SOS) and end of growing season (EOS) was evaluated using simulation datasets, time-lapse camera data of tundra sites, and flux tower gross primary production (GPP) data of grassland sites. Simulation results demonstrated that NDGI can exclude the influence of snow on SOS and EOS estimations. In the camera sites, NDGI markedly outperformed NDVI, PI, and NDPI for SOS estimation with RMSE=6.46 days and Bias=-1.32 days (vs. RMSE range 12.39–14.8 days and Bias>3.5 days for the other VIs), and for EOS estimation with RMSE=8.33 days and Bias=0.11 days (vs. RMSE range 8.00–26.74 days and Bias>2.67 days for the other VIs). In the GPP sites, NDGI also outperformed the other VIs for SOS estimation with RMSE=10.32 days and Bias=-4.91 days (vs. RMSE range 12.9–24.74 days and Bias>6.13 days for the other VIs). Although its performance was lower for monitoring EOS than SOS in GPP sites, it still outperformed the other VIs in EOS estimation. These results indicate the potential of NDGI for operational monitoring of plant phenology in the tundra and grassland ecosystems based on satellite observations.

キーワード：植生フェノロジー、リモートセンシング、雪、MODIS
Keywords: plant phenology, remote sensing, snow, MODIS

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Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)

*Sarah Kentsch[1,2], Larry Maximo Lopez Caceres[1], Yago Diez[1], Motohisa Fukuda[1]

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A low degree of knowledge combined with a complex structure of mixed forests is the reason why researchers still investigate in mixed forest research for getting a deeper understanding. Especially mixed forests in Japan are influenced by the characteristically relief and the climate conditions. There is a high demand on accurate information about tree species of mixed forests. This high demand requires accurate investigation possibilities included by an easier access to the needed information' s (Fritz, 2013). Methods to get accurate information on a large scale with easy access to the desired information are needed. Previous studies show the applicability of drones for forest applications (Torresan et. al, 2016). Images taken with a drone offer new methods to get information of forests like distribution, health condition or automatically classifications of tree species. For example, Onishi & Ise (2018) reached accuracies of up to 90 %. But these studies also illustrated that there are limitations and gaps in knowledge for the applicability of using UAV. Especially, a lot of those high accuracies were reached in forest plantations. There is a need of more detailed information about how to get more accurate information in real forests by using drones (Michez et al., 2016).

The Yamagata Research Forest offers the opportunity to study mixed forests with different conditions in different parts of the forest for doing automatically classifications of tree species. Till now two study sites were defined and image were taken with a camera detecting the visual spectrum of the light. Also, images were taken during different seasons (summer and autumn). After taking the images they needed to be processed. A first step is to generate orthomosaics by merging the images using Photoscan from Agisoft. As a result, DEMs, orthomosaics and 3D models were generated and can be further analyzed. In the next step the segmentation and classification of tree species should be done in an object-based way using feature information of the trees. After processing the images, it should be possible to create a model for deep machine learning which will be able to do the classification on its own.

During the last year the first image taking took place in different seasons in the Yamagata University Research Forest. Also, the image processing with Photoscan was finished. The first images were analyzed manually to check how it is possible to separate tree species automatically. To find out what are the important factors for doing automatically classification is the actual research status. Further, the presentation handles the comparison of manually and automatically ways for doing separations in this research. The results will be first approaches to do automatically classification/separations of tree species.

Literature:

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Keywords: tree species classification, UAV, Yamagata Research Forest, Image processing, Photoscan

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Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

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Land subsidence seriously influences the safety of our property. There have been many studies on the deformation of the ground surface due to the groundwater or natural gas extraction. Recently, a large amount of land subsidence had occurred in the Quaternary upland areas in the inland areas of Chiba Prefecture, Japan. There is less evidence of big wells of groundwater or natural gas, and the mechanism of subsidence is not yet clear. So far, SBAS-InSAR (Small Baseline Subset algorithm -Interferometric Synthetic Aperture Radar) technology had been used in the investigation process to clarify the phenomenon of land subsidence in some inland areas of Chiba Prefecture. The ALOS-PALSAR and ALOS-2 PALSAR-2 data for 2006-2010 and 2014-2018 were collected, respectively. The maps of the land subsidence phenomena in Yachimata-Tomisato area are created, and the maps reveal the spatial and temporal distribution of upland area land subsidence. The extent of the subsidence zone are almost consistent with the land survey results. Next step is to reveal the mechanism of land subsidence. At the JpGU2019, we will make a discussion on the possibility of decline of fluid pressure in deep layer.

キーワード：SBAS-InSAR技術、地盤沈下、千葉県
Keywords: SBAS-InSAR technology, Land subsidence, Chiba Prefecture

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Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

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Normalized Difference Vegetation Index (NDVI) is one of the most commonly used vegetation indices for monitoring ecosystem dynamics and modeling biosphere processes. However, global NDVI products are usually provided with relatively coarse spatial resolutions that lack important spatial details. Producing NDVI time-series data with high spatiotemporal resolution is indispensable for monitoring land surfaces and ecosystem changes, especially in spatiotemporally heterogeneous areas. We therefore proposed an Improved Flexible Spatiotemporal DAta Fusion (IFSDAF) method to fill this need. In accord with the distinctive characteristics of NDVIs with large data variance and high spatial autocorrelation compared with raw reflectance bands, the IFSDAF method first produces a time-dependent increment with linear unmixing and a space-dependent increment via thin plate spline interpolation. It then makes a final prediction by optimal integration of these two increments with the constrained least squares method. Moreover, the IFSDAF was developed with the capacity to use all available finer-scaled images, including those partly contaminated by clouds. NDVI images with coarse spatial resolution (MODIS) and fine spatial resolution (Landsat and Sentinel) in areas with great spatial heterogeneity and significant land cover changes were used to test the performance of the IFSDAF method. The root mean square error and relative root mean square error of predicted relative to observed results were 0.0884 and 22.12%, respectively, in 3 heterogeneous areas, and 0.0546 and 25.77%, respectively, in areas of land-cover change. These promising results demonstrated the strength and robustness of the IFSDAF method in providing reliable NDVI datasets with high spatial and temporal resolution to support research on land surface processes. The efficiency of the proposed IFSDAF method can be greatly improved by using only the space-dependent increment. This simplification will make IFSDAF a feasible method for monitoring global vegetation.

キーワード：Spatiotemporal data fusion、High spatial and temporal resolution、Weighted integration
Keywords: Spatiotemporal data fusion, High spatial and temporal resolution, Weighted integration

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

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_18

[H-TT20] Environmental Remote Sensing

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

Our human beings are encountering various environmental issues on the Earth, and it is urgent to find out the solutions. Remote sensing is currently the only feasible means to observe the Earth environment at regional/continental /global scales over long periods, and consequently detects the environmental changes occurred all over the world. This session invites presentations on theory, science, technology, and applications of remote sensing to study the Earth environment from regional to global scales. Both oral and poster presentations are sincerely welcome.

[HTT20-P01] **Classification of Winter Wheat using high spatial resolution data in North China Plain**

*Chunyang Wang[1,2]、Wei Yang[2]、Xifang Wu[3]、Zhichao Chen[1]、Junjun Lu[1]、Zongze Zhao[1]、Hebing Zhang[1] (1.School of Surveying and Land Information Engineering, Henan Polytechnic University、2.Center for Environmental Remote Sensing, Chiba University、3.Graduate School of Science and Engineering, Chiba University)

[HTT20-P02] Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

*楊 偉[1]、小林 秀樹[2]、近藤 昭彦[1] (1.千葉大学、2.海洋研究開発機構)

[HTT20-P03] ***Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)***

*Sarah Kentsch[1,2]、Larry Maximo Lopez Caceres[1]、Yago Diez[1]、Motohisa Fukuda[1] (1.Yamagata University、2.United Graduate School of Agricultural Sciences)

[HTT20-P04] Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

*はりぷ あいふまる[1]、Bhattarai Richa[1]、LIU Wen[1]、Kondoh Akihiko[1,2] (1.Graduate School of Science and Engineering、2.Center for Environmental Remote Sensing, Chiba University)

[HTT20-P05] Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

*楊 偉[1]、陳 晋[2] (1.千葉大学、2.北京師範大学)

Classification of Winter Wheat using high spatial resolution data in North China Plain

*Chunyang Wang[1,2], Wei Yang[2], Xifang Wu[3], Zhichao Chen[1], Junjun Lu[1], Zongze Zhao[1], Hebing Zhang[1]

1. School of Surveying and Land Information Engineering, Henan Polytechnic University, 2. Center for Environmental Remote Sensing, Chiba University, 3. Graduate School of Science and Engineering, Chiba University

Winter Wheat in North China Plain (NCP) is one of the key food sources for securing food safety of China. Mapping the spatial distributions of winter wheat plays crucial roles in monitoring of planting areas and estimation of winter wheat production, which is usually carried out through classification of satellite images. The traditional classification methods are mainly based on data collection, download storage, and local analysis. However, these approaches are not capable of dealing with the quick mapping of massive satellite data including high spatial-temporal resolutions over large-scale areas. To overcome this challenge, this study developed a processing chain for mapping winter wheat of NCP at 10 m resolution using Sentinel-2-based NDVI time series on the google earth engine (GEE) platform, a cloud computing platform for Earth science data and analysis. First, the influence of phenology between the north and the south of the NCP on classification is eliminated by using the locally selected training data sets. Second, the data contaminated by clouds were all removed. Third, the training sample sets are constructed, and the typical features are searched. Last, two machine learning algorithms were applied to yield the classification result map, that is, Random Forest (RF) method and Regression Trees (CART) method. Validation results showed that the final maps and classification accuracy of RF method was better than SVM and CART method, with total accuracy of 81%. Moreover, this study also demonstrated that the GEE platform can yield dramatically higher efficiency than conventional classification methods by reducing downloading time and local storage capacity. Consequently, we recommend that the GEE cloud computing platform is a more suitable research tool for large-scale geospatial analysis and application.

Keywords: Google earth engine, Cloud computing, Big data, Classification, Sentinel-2, Winter wheat

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Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

*楊 偉[1]、小林 秀樹[2]、近藤 昭彦[1]
*Wei Yang[1], Hideki Kobayashi[2], Akihiko Kondoh[1]

1. 千葉大学、2. 海洋研究開発機構
1. Chiba University, 2. JAMSTEC

Satellite monitoring of vegetation phenology is crucial to understanding the biological impacts of climate change. Nevertheless, satellite-based phenology estimation can be biased by effects of snow using conventional vegetation indices (VIs), such as the normalized difference vegetation index (NDVI). To eliminate effects of snow, snow-free VIs that take advantage of the shortwave infrared (SWIR) band have been proposed (i.e., phenology index [PI] and normalized difference phenology index [NDPI]). However, PI cannot properly capture the presence of sparse vegetation, and NDPI does not account for the influence of dry vegetation. Here, we propose a novel snow-free VI, designated the normalized difference greenness index (NDGI), using reflectance of green, red, and near-infrared (NIR) bands. NDGI is a semi-analytical index deduced based on the linear spectral mixture model and the spectral characteristics of vegetation, snow, soil, and dry grass. Its performance for estimating the start of growing season (SOS) and end of growing season (EOS) was evaluated using simulation datasets, time-lapse camera data of tundra sites, and flux tower gross primary production (GPP) data of grassland sites. Simulation results demonstrated that NDGI can exclude the influence of snow on SOS and EOS estimations. In the camera sites, NDGI markedly outperformed NDVI, PI, and NDPI for SOS estimation with RMSE=6.46 days and Bias=-1.32 days (vs. RMSE range 12.39–14.8 days and Bias>3.5 days for the other VIs), and for EOS estimation with RMSE=8.33 days and Bias=0.11 days (vs. RMSE range 8.00–26.74 days and Bias>2.67 days for the other VIs). In the GPP sites, NDGI also outperformed the other VIs for SOS estimation with RMSE=10.32 days and Bias=-4.91 days (vs. RMSE range 12.9–24.74 days and Bias>6.13 days for the other VIs). Although its performance was lower for monitoring EOS than SOS in GPP sites, it still outperformed the other VIs in EOS estimation. These results indicate the potential of NDGI for operational monitoring of plant phenology in the tundra and grassland ecosystems based on satellite observations.

キーワード：植生フェノロジー、リモートセンシング、雪、MODIS
Keywords: plant phenology, remote sensing, snow, MODIS

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Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)

*Sarah Kentsch[1,2], Larry Maximo Lopez Caceres[1], Yago Diez[1], Motohisa Fukuda[1]

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A low degree of knowledge combined with a complex structure of mixed forests is the reason why researchers still investigate in mixed forest research for getting a deeper understanding. Especially mixed forests in Japan are influenced by the characteristically relief and the climate conditions. There is a high demand on accurate information about tree species of mixed forests. This high demand requires accurate investigation possibilities included by an easier access to the needed information' s (Fritz, 2013). Methods to get accurate information on a large scale with easy access to the desired information are needed. Previous studies show the applicability of drones for forest applications (Torresan et. al, 2016). Images taken with a drone offer new methods to get information of forests like distribution, health condition or automatically classifications of tree species. For example, Onishi & Ise (2018) reached accuracies of up to 90 %. But these studies also illustrated that there are limitations and gaps in knowledge for the applicability of using UAV. Especially, a lot of those high accuracies were reached in forest plantations. There is a need of more detailed information about how to get more accurate information in real forests by using drones (Michez et al., 2016).

The Yamagata Research Forest offers the opportunity to study mixed forests with different conditions in different parts of the forest for doing automatically classifications of tree species. Till now two study sites were defined and image were taken with a camera detecting the visual spectrum of the light. Also, images were taken during different seasons (summer and autumn). After taking the images they needed to be processed. A first step is to generate orthomosaics by merging the images using Photoscan from Agisoft. As a result, DEMs, orthomosaics and 3D models were generated and can be further analyzed. In the next step the segmentation and classification of tree species should be done in an object-based way using feature information of the trees. After processing the images, it should be possible to create a model for deep machine learning which will be able to do the classification on its own.

During the last year the first image taking took place in different seasons in the Yamagata University Research Forest. Also, the image processing with Photoscan was finished. The first images were analyzed manually to check how it is possible to separate tree species automatically. To find out what are the important factors for doing automatically classification is the actual research status. Further, the presentation handles the comparison of manually and automatically ways for doing separations in this research. The results will be first approaches to do automatically classification/separations of tree species.

Literature:

Fritz, A.; Kattenborn, T.; Koch, B., 2013: UAV-based photogrammetric point clouds –tree stem mapping in open stands in comparison to terrestrial laser scanner point clouds; International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-1/W2.

Michez, Adrien et. al, 2016: Classification of riparian forest species and health condition using multi-temporal and hyperspatial imagery from unmanned aerial system; Environ Monit Assess (2016) 188:

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146; DOI 10.1007/s10661-015-4996-2; Springer International Publishing Switzerland 2016.

Onishi, Masanori and Ise, Takeshi, 2018: Automatic classification of trees using a UAV onboard camera and deep learning, https://arxiv.org/abs/1804.10390.

Torresan, C. et. al, 2016: Forestry applications of UAVs in Europe: A review, International journal of remote sensing, https://doi.org/10.1080/01431161.2016.1252477

Keywords: tree species classification, UAV, Yamagata Research Forest, Image processing, Photoscan

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Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

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Land subsidence seriously influences the safety of our property. There have been many studies on the deformation of the ground surface due to the groundwater or natural gas extraction. Recently, a large amount of land subsidence had occurred in the Quaternary upland areas in the inland areas of Chiba Prefecture, Japan. There is less evidence of big wells of groundwater or natural gas, and the mechanism of subsidence is not yet clear. So far, SBAS-InSAR (Small Baseline Subset algorithm -Interferometric Synthetic Aperture Radar) technology had been used in the investigation process to clarify the phenomenon of land subsidence in some inland areas of Chiba Prefecture. The ALOS-PALSAR and ALOS-2 PALSAR-2 data for 2006-2010 and 2014-2018 were collected, respectively. The maps of the land subsidence phenomena in Yachimata-Tomisato area are created, and the maps reveal the spatial and temporal distribution of upland area land subsidence. The extent of the subsidence zone are almost consistent with the land survey results. Next step is to reveal the mechanism of land subsidence. At the JpGU2019, we will make a discussion on the possibility of decline of fluid pressure in deep layer.

キーワード：SBAS-InSAR技術、地盤沈下、千葉県
Keywords: SBAS-InSAR technology, Land subsidence, Chiba Prefecture

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Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

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1. Chiba University, 2. Beijing Normal University

Normalized Difference Vegetation Index (NDVI) is one of the most commonly used vegetation indices for monitoring ecosystem dynamics and modeling biosphere processes. However, global NDVI products are usually provided with relatively coarse spatial resolutions that lack important spatial details. Producing NDVI time-series data with high spatiotemporal resolution is indispensable for monitoring land surfaces and ecosystem changes, especially in spatiotemporally heterogeneous areas. We therefore proposed an Improved Flexible Spatiotemporal DAta Fusion (IFSDAF) method to fill this need. In accord with the distinctive characteristics of NDVIs with large data variance and high spatial autocorrelation compared with raw reflectance bands, the IFSDAF method first produces a time-dependent increment with linear unmixing and a space-dependent increment via thin plate spline interpolation. It then makes a final prediction by optimal integration of these two increments with the constrained least squares method. Moreover, the IFSDAF was developed with the capacity to use all available finer-scaled images, including those partly contaminated by clouds. NDVI images with coarse spatial resolution (MODIS) and fine spatial resolution (Landsat and Sentinel) in areas with great spatial heterogeneity and significant land cover changes were used to test the performance of the IFSDAF method. The root mean square error and relative root mean square error of predicted relative to observed results were 0.0884 and 22.12%, respectively, in 3 heterogeneous areas, and 0.0546 and 25.77%, respectively, in areas of land-cover change. These promising results demonstrated the strength and robustness of the IFSDAF method in providing reliable NDVI datasets with high spatial and temporal resolution to support research on land surface processes. The efficiency of the proposed IFSDAF method can be greatly improved by using only the space-dependent increment. This simplification will make IFSDAF a feasible method for monitoring global vegetation.

キーワード：Spatiotemporal data fusion、High spatial and temporal resolution、Weighted integration
Keywords: Spatiotemporal data fusion, High spatial and temporal resolution, Weighted integration

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

2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_13

[S-SS04] New methods for seismicity characterization

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

In the last two decades the number of high quality seismic instruments being installed around the world has grown exponentially and probably will continue to grow in the coming decades. This data explosion has shown the limits of the current standard routine seismic analysis, often performed manually by seismologists. Exploiting the massive amount of data is a challenge that can be overcome by using new generation, fully automated and noise robust seismic processing techniques. In the last years waveform-based detection and location methods have grown in popularity and their application have dramatically improved seismic monitoring capability. More recently, Machine Learning techniques, which are a perfect playground for data-intensive applications, are showing promising results in seismicity characterization applications opening new horizons for the development of innovative, fully automated and noise robust seismic analysis methods. Such techniques are particularly useful when working with datasets characterised by a massive number of weak events with low signal-to-noise ratio, such as those collected in induced seismicity and volcanic monitoring operations. This session aims to bring to light new methods that can be applied to large datasets, either retro-actively or in near-real time, to characterize seismicity (i.e. detection, location, magnitude and source mechanisms estimation) at different scales and in different environments. We thus encourage contributions that demonstrate how the proposed methods helps improve our understanding of earthquake and/or volcanic processes.

[SSS04-P01] **Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress**

*椋平 祐輔[1]、直井 誠[2]、Michael Fehler[3]、森谷 祐一[5]、伊藤 高敏[1]、浅沼 宏[4]、Markus Häring[6] (1.東北大学 流体科学研究所、2.京都大学　防災研究所、3.マサチューセッツ工科大学　地球資源研究所、4.産業技術総合研究所　福島再生可能エネルギー研究所、5.東北大学　工学部、6.Häring GeoProject)

[SSS04-P02] Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1]、Eszter Király-Proag[2]、Pascal Bernard[1]、Stefan Wiemer[2] (1.Institut de Physique du Globe de Paris, France、2.ETH Swiss Federal Institute of Technology Zurich, Switzerland)

[SSS04-P03] **Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers**

*Francesco Grigoli[1]、Simone Cesca[2]、Alessandro Vuan[3]、Filippo Broggini[1]、John Clinton[1]、Stefan Wiemer[1] (1.ETH-Zurich, Switzerland、2.GFZ-Potsdam, Germany、3.OGS-Trieste, Italy)

[SSS04-P04] Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

★Invited Papers

*Hilary Chang[1]、Alison Malcolm[1]、Frédérick Massin[2]、Francesco Grigoli[2] (1.Memorial University of Newfoundland, Earth Sciences, Canada、2. ETH Zurich, Department of Earth Sciences, Zürich, Switzerland)

[SSS04-P05] Earthquake nowcasting: further development and application to Japan

*楠城 一嘉[1]、ランドル ジョン[2]、櫻田 哲生[3] (1.静岡県立大学、2.カルフォルニア大学デービス校、3.櫻田商会)

Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress

*椋平 祐輔[1]、直井 誠[2]、Michael Fehler[3]、森谷 祐一[5]、伊藤 高敏[1]、浅沼 宏[4]、Markus Häring[6]
*Yusuke Mukuhira[1], Makoto Naoi[2], Michael C Fehler[3], Hirokazu Moriya[5], Takatoshi Ito[1], Hiroshi Asanuma[4], Markus O Häring[6]

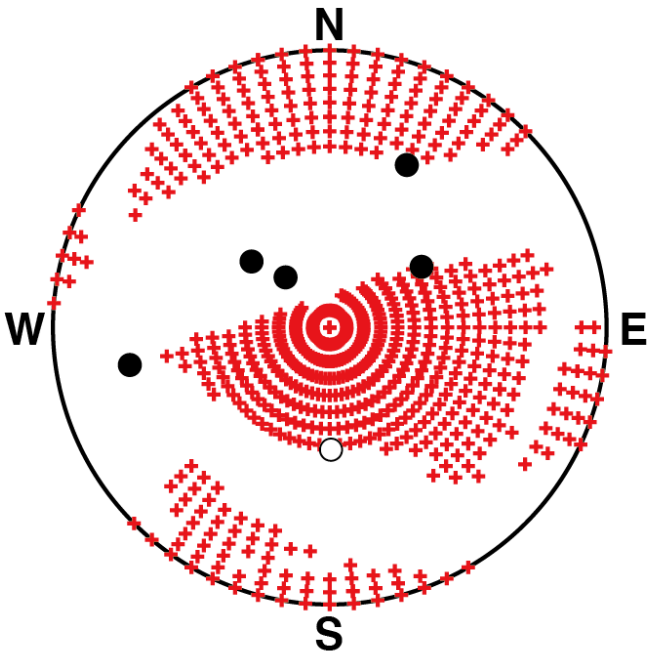
1. 東北大学　流体科学研究所、2. 京都大学　防災研究所、3. マサチューセッツ工科大学　地球資源研究所、4. 産業技術総合研究所　福島再生可能エネルギー研究所、5. 東北大学　工学部、6. Häring GeoProject
1. Institute of Fluid Science, Tohoku University, 2. Disaster Prevention Research Institute, Kyoto University, 3. Earth Resources Laboratory, MIT, 4. FREA, AIST, 5. School of Engineering, Tohoku University, 6. Häring GeoProject

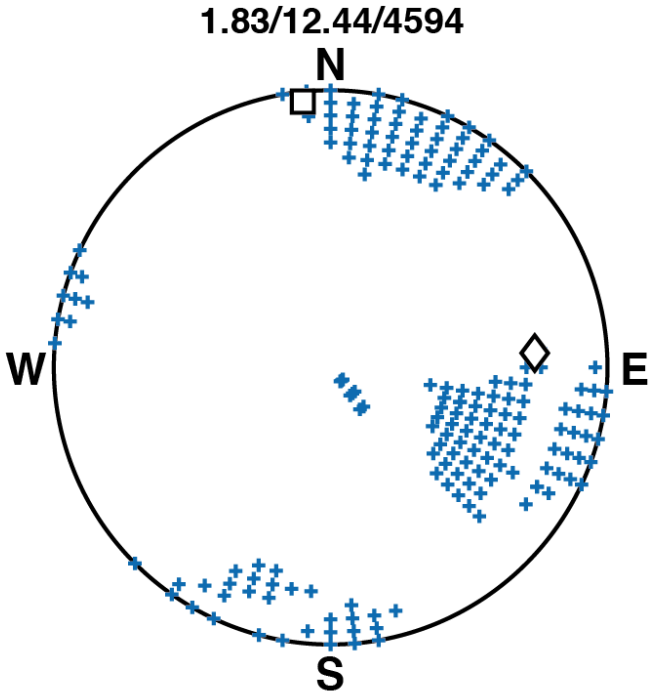
Microseismic monitoring is essential for successful hydraulic stimulation/fracking in unconventional oil/gas development, engineered geothermal system development and carbon capture and sequestration. In addition to the hypocenter location of the microseismicity, knowledge of the geometry of the fracture is also crucial for better understanding of fractured reservoir, fluid flow, and design of the energy extraction. Geofluid flows in the fracture and its permeability are correlated with the relation of the geometry of the fracture and in-situ stress. Fracture orientation can be estimated by the seismological method such as moment tensor inversion or focal mechanism analysis, only when the waveforms of the events are well recorded by a number of well-distributed stations. However, in realistic microseismic monitoring situations, it is often difficult to constrain the focal mechanism of microseismicity from first motion information due to the small number of stations.

We proposed a method to improve the estimates of focal mechanisms by introducing in-situ stress information from borehole logging information. We eliminate candidate focal mechanisms that are consistent with first motion data but cannot have shear slip under a given stress state and pore pressure increase. In this study, we also check the consistency between the shear slip vector estimated from the stress state and the rakes. We compare the shear slip vector and the slip vector from the rake. Then we reject the fault if the difference in the two vectors is significantly large. With this process, we reject the fault planes and auxiliary planes which are not consistent with stress state. We apply this method to induced seismicity dataset from Basel, Switzerland, where we already have well-constrained focal mechanisms estimated by many surface stations over a large region. We use these focal mechanisms as references to check whether our method can constrain the range of focal mechanisms using a small number of nearby stations. We find that the consistency check between two vectors significantly and reliably limits the range of focal mechanisms. Furthermore, we combine the constrained range of focal mechanism by this method and that by stability analysis to have more constraint of focal mechanisms satisfying the conditions of the geomechanical problem.

キーワード：誘発地震、断層面解、地殻応力
Keywords: Induced seismicity, Focal mechanism, In-situ stress

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Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

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In most models and analyses, small earthquakes (i.e., M<4) are considered either point sources or "penny-shaped" solid surfaces with homogeneous or isotropic source properties. While these assumptions may be valid, details of individual earthquakes are more complex. Due to the insufficient resolution of most monitoring networks, micro-earthquakes (M<2) must be still approximated as dislocation on penny-shaped surfaces. But in case of larger events (M>3) recorded on well-distributed local seismic stations, detailed space-time slip pattern within the rupture area can be imaged.

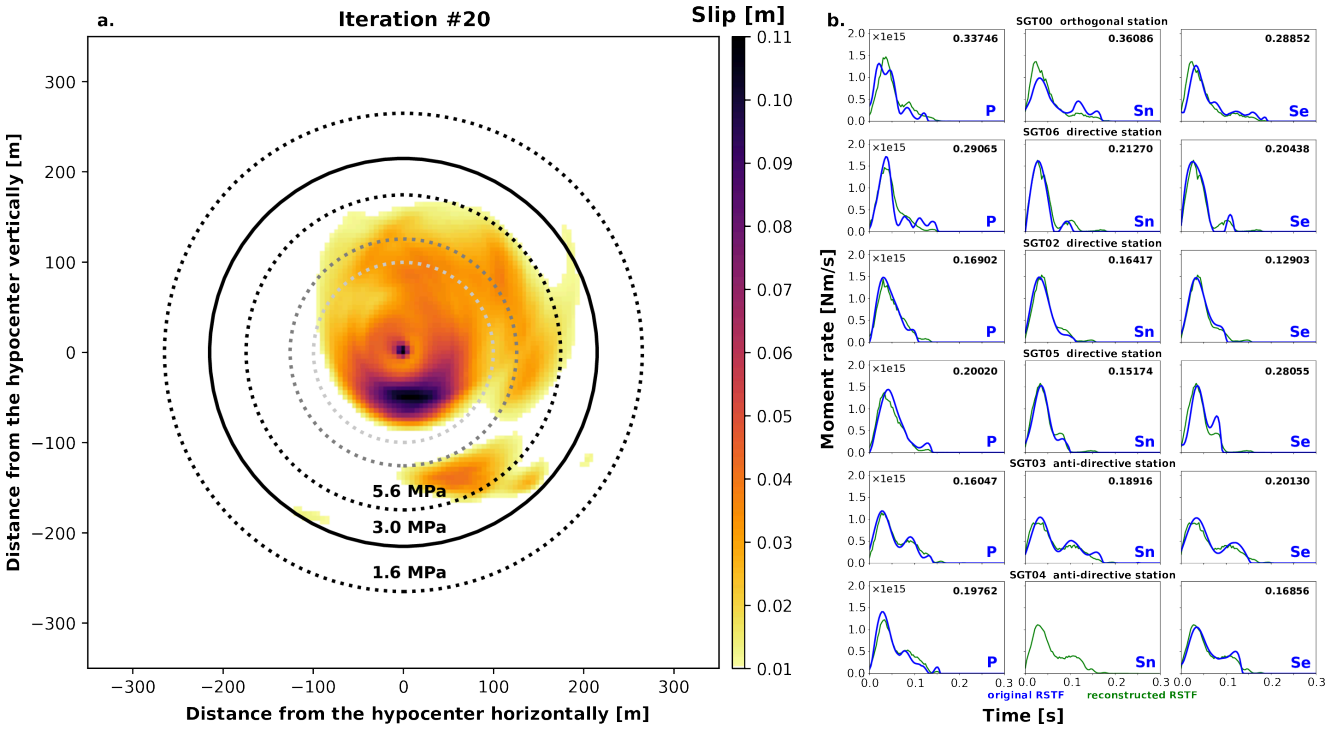
Here, we analyze slip distribution and rupture kinematics of a moderate induced event (ML 3.5) occurred in the St. Gallen geothermal reservoir (NE Switzerland) in 2013. To image the slip of such a small magnitude earthquake, we carry out a two-step procedure: (1) we deconvolve the propagation effects from the seismograms using an empirical Green's function resulting in relative source time functions (RSTF) at all seismic stations; (2) the RSTFs are back-projected to the fault plane using the position of equal time delays, i.e., isochrones.

Results reveal that the mainshock rupture propagates towards NNE from the hypocenter with an average velocity of about 2000 m/s. Spatio-temporal organization of fore- and aftershocks suggests that the mainshock released a previously less active portion of the fault and that the sequence is mainly stress-driven.

Applying this method in an operational environment could enable to quickly map seismic slip allowing assessment of fault asperities and structures involved in the reservoir creation process.

Keywords: Earthquake Source, Earthquake Kinematics, Back Projection, Induced Seismicity

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Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers

*Francesco Grigoli[1], Simone Cesca[2], Alessandro Vuan[3], Filippo Broggini[1], John Clinton[1], Stefan Wiemer[1]

1. ETH-Zurich, Switzerland, 2. GFZ-Potsdam, Germany, 3. OGS-Trieste, Italy

Microseismic monitoring networks are nowadays extensively used, in combination with risk analysis tools, to ensure the safety of the industrial operations which may trigger or induce earthquakes. However, in many cases the lack of dense enough microseismic monitoring networks affects the performance of the routine data analysis procedures limiting the application of adequate risk mitigation strategies. In this work we propose a novel approach based on the combination of Coda Wave Interferometry (CWI) and Distance Geometry Solvers (DGS) that allow to locate microseismic events by using a single seismic station. The use of CWI allows to determine, for pairs of earthquakes characterized by high similarity of waveforms (i.e. with similar location and focal mechanism), the absolute inter-event distance of each pair (Snieder and Vrijlandt, 2005), while DGS allow to determine their location based only on the given values of the distances between member pairs. Microseismic events can be classified in different families by combining a waveform correlation analysis and a clustering technique. Clustered events are characterized by a high similarity of waveforms, which implies a similarity in both source mechanism and location. In these conditions, the analysis of seismic coda recorded at a single receiver can be used to infer a measure of the spatial separation between two seismic sources. Coda waves are radiated in all directions with a radiation pattern determined by the source mechanism and a small change in the source position affects the interference pattern of the scattered waves that constitute the coda. This change in the coda waves is used to constrain the inter-event distance for each events pair. Absolute locations can be then retrieved by using DGS and considering all inter-event distances, a procedure which requires at least four reference locations. In order to show the potential of this approach we firstly validated the method with a synthetic dataset, then we applied it to the September-October 2013 induced seismicity sequence associated to the underground gas storage operations performed in the offshore Spain. The largest event of the sequence, a magnitude Mw 4.3 earthquake occurred on 2013 October 4th, was preceded by about 1000 seismic events, mostly with magnitude below 2. However, the poor monitoring network in the area (the closest seismic station was located at about ~20 km distance from the platform) did not allow to properly locate these small events. In this work we relocate these low magnitude events, showing that our approach provides better results than those obtained by using standard location methods, making this method particularly useful in poorly monitored areas where only a limited number of stations is available.

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Snieder, R., and Vrijlandt, M., 2005. Constraining the source separation with coda wave interferometry: Theory and application to earthquake doublets in the Hayward fault, California, J. Geophys. Res., doi:10.1029/2004JB003317

Keywords: Coda Wave Interferometry, Microseismicity, Induced Seismicity

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Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

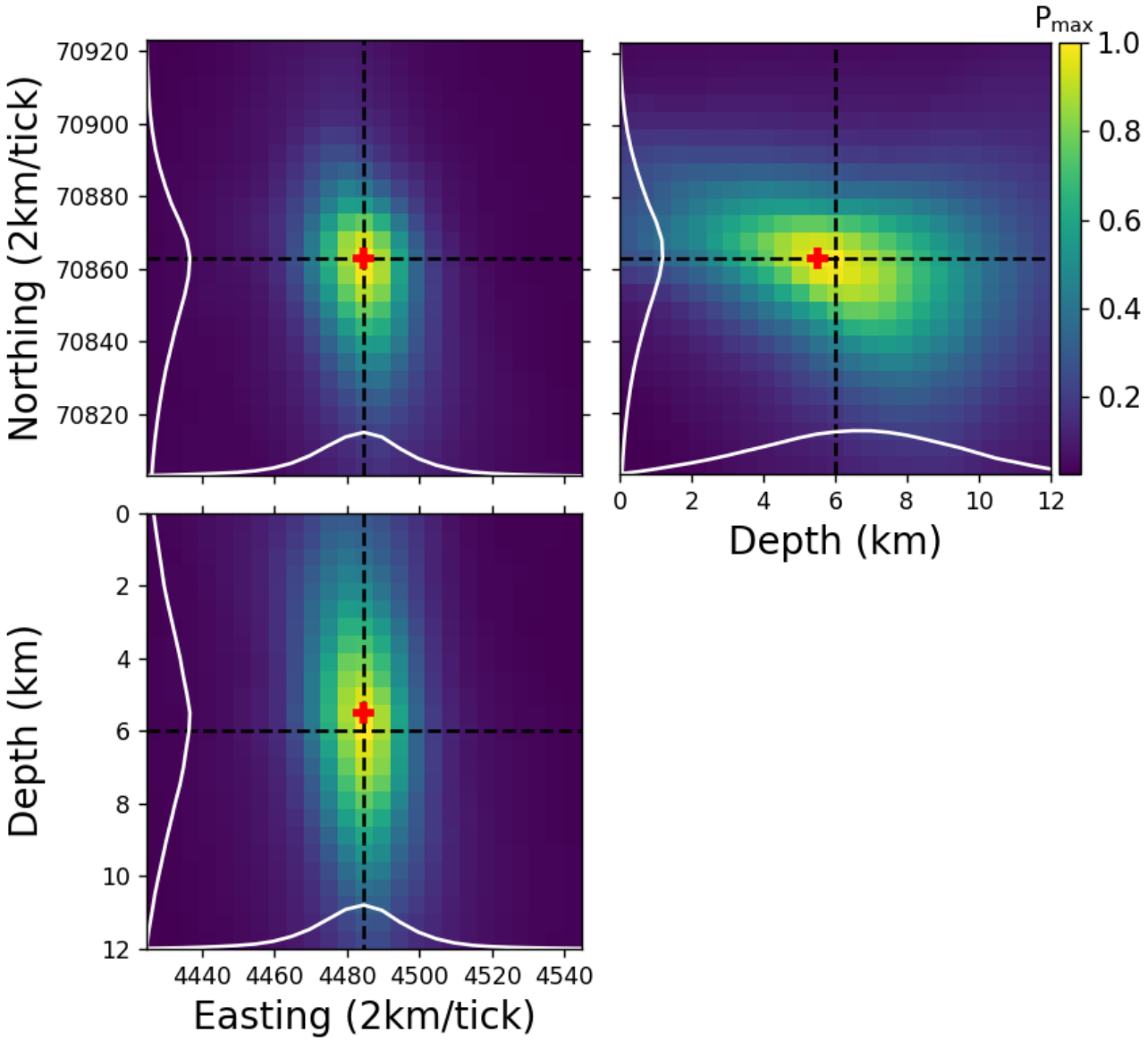
*Hilary Chang[1], Alison Malcolm[1], Frédérick Massin[2], Francesco Grigoli[2]

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Exact source locating for microseismic events helps us understand subsurface structures, monitor volcanic activities and assess earthquake hazards. Conventionally, the locating problem can be solved by picking phase arrivals. However, for microseismicity which contains large numbers of low-magnitude events, phase picking is often difficult and time-consuming. In this research, we use an improved waveform-based method to locate microseismic events without phase picking. We use the Source Scanning Algorithm (SSA) to stack the Characteristic Functions (CFs) in time and space, where the maximum stack gives the best estimate of the event origin time and source location. This approach allows us to locate the event automatically by evaluating waveform coherency in terms of changes in amplitude and polarization. We conduct synthetic test using the geometry of the SIL network in Reykjane Peninsula, SW Iceland. The results show that we can locate the synthetic source with error <1km, <0.1s when the noise amplitude is less than the amplitude of the target phase. In addition, stacking CFs that evaluate changes in amplitudes gives more stable results at all noise level, while stacking CFs that consider changes in polarization gives more stable results when the noise varies with frequency. We also conduct field data test using 215 microseismic events (M<2) occurred during Aug 2010 and Mar 2011 recorded by the same network. Our results show that stacking CFs that considers changes in amplitudes gives the closest results to the manually picking method, while stacking a combined version of CF rejects more outliers. In summary, stacking CFs in the SSA provides us with the ability to consider different waveform characteristics and improved noise-robustness in source locating problems. This improved automatic waveform-based procedure offers reliable solutions to large data set with low SNR and helps reduce human intervention.

Keywords: earthquake location, source scanning algorithm, waveform characteristics

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Earthquake nowcasting: further development and application to Japan

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*Kazuyoshi Nanjo[1], John B. Rundle[2], Tetsuo Sakurada[3]

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We adopted and further developed the earthquake nowcasting method (Rundle et al., 2016). This method determines the current state of the fault system in a predefined region and its current level of progress through the earthquake cycle, using only empirical data: magnitudes (M) and times of earthquakes in the region. The characteristic is that the method does not involve any model other than the idea of an earthquake cycle. We performed a case study from southern Kanto, using the earthquake catalog maintained by Japan Meteorological Agency (JMA). Two earthquake magnitudes are selected, one large ($M \geqq M_L$), and one small ($M \geqq M_S$), where $M_L > M_S$. The method utilizes the number of small earthquakes that occurs between pairs of large earthquakes. The cumulative probability distribution of these values is obtained. The earthquake potential score (EPS), an index of the current level of the progress through the earthquake cycle, is defined by the “natural time”, the number of small earthquakes that has occurred since the last large earthquake, the point where this number falls on the cumulative probability distribution. For southern Kanto, we used earthquakes since 1926 with depths shallower than 150 km and set M_L=6.0 and M_S=4.2. The obtained result as of December 20, 2018 is EPS of 8%. This is interpreted as an indication that if a large (M6+) earthquake occurred on this date, the recurrence interval would be relatively short. Errors that arise from statistics-based estimation such as this must be considered so that we introduced the calculation of uncertainties to the earthquake nowcasting, using a bootstrap approach. Taking into account the contribution of these errors to the EPS calculations, we conclude that the earthquake nowcasting generates stable estimates of EPS for southern Kanto (Nanjo, 2018). To check the stability estimation for other regions, we computed EPS and its uncertainty for selected regions in Japan. We also discuss a technique of spatial mapping of EPS over the Japan’s mainlands. This technique allows us to move towards a full description of current EPS as a function of space, providing possible usability for ranking locations on the earthquake hazard.

キーワード：ナウキャスティング、地震、ナチュラルタイム
Keywords: nowcasting, earthquake, natural time

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

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_24

[S-SS04] New methods for seismicity characterization

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

In the last two decades the number of high quality seismic instruments being installed around the world has grown exponentially and probably will continue to grow in the coming decades. This data explosion has shown the limits of the current standard routine seismic analysis, often performed manually by seismologists. Exploiting the massive amount of data is a challenge that can be overcome by using new generation, fully automated and noise robust seismic processing techniques. In the last years waveform-based detection and location methods have grown in popularity and their application have dramatically improved seismic monitoring capability. More recently, Machine Learning techniques, which are a perfect playground for data-intensive applications, are showing promising results in seismicity characterization applications opening new horizons for the development of innovative, fully automated and noise robust seismic analysis methods. Such techniques are particularly useful when working with datasets characterised by a massive number of weak events with low signal-to-noise ratio, such as those collected in induced seismicity and volcanic monitoring operations. This session aims to bring to light new methods that can be applied to large datasets, either retro-actively or in near-real time, to characterize seismicity (i.e. detection, location, magnitude and source mechanisms estimation) at different scales and in different environments. We thus encourage contributions that demonstrate how the proposed methods helps improve our understanding of earthquake and/or volcanic processes.

[SSS04-P01] Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress

*椋平 祐輔[1]、直井 誠[2]、Michael Fehler[3]、森谷 祐一[5]、伊藤 高敏[1]、浅沼 宏[4]、Markus Häring[6] (1.東北大学 流体科学研究所、2.京都大学　防災研究所、3.マサチューセッツ工科大学　地球資源研究所、4.産業技術総合研究所　福島再生可能エネルギー研究所、5.東北大学　工学部、6.Häring GeoProject)

[SSS04-P02] Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1]、Eszter Király-Proag[2]、Pascal Bernard[1]、Stefan Wiemer[2] (1.Institut de Physique du Globe de Paris, France、2.ETH Swiss Federal Institute of Technology Zurich, Switzerland)

[SSS04-P03] Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers

*Francesco Grigoli[1]、Simone Cesca[2]、Alessandro Vuan[3]、Filippo Broggini[1]、John Clinton[1]、Stefan Wiemer[1] (1.ETH-Zurich, Switzerland、2.GFZ-Potsdam, Germany、3.OGS-Trieste, Italy)

[SSS04-P04] Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

★Invited Papers

*Hilary Chang[1]、Alison Malcolm[1]、Frédérick Massin[2]、Francesco Grigoli[2] (1.Memorial University of Newfoundland, Earth Sciences, Canada、2. ETH Zurich, Department of Earth Sciences, Zürich, Switzerland)

[SSS04-P05] Earthquake nowcasting: further development and application to Japan

*楠城 一嘉[1]、ランドル ジョン[2]、櫻田 哲生[3] (1.静岡県立大学、2.カルフォルニア大学デービス校、3.櫻田商会)

Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress

*椋平 祐輔[1]、直井 誠[2]、Michael Fehler[3]、森谷 祐一[5]、伊藤 高敏[1]、浅沼 宏[4]、Markus Häring[6]
*Yusuke Mukuhira[1], Makoto Naoi[2], Michael C Fehler[3], Hirokazu Moriya[5], Takatoshi Ito[1], Hiroshi Asanuma[4], Markus O Häring[6]

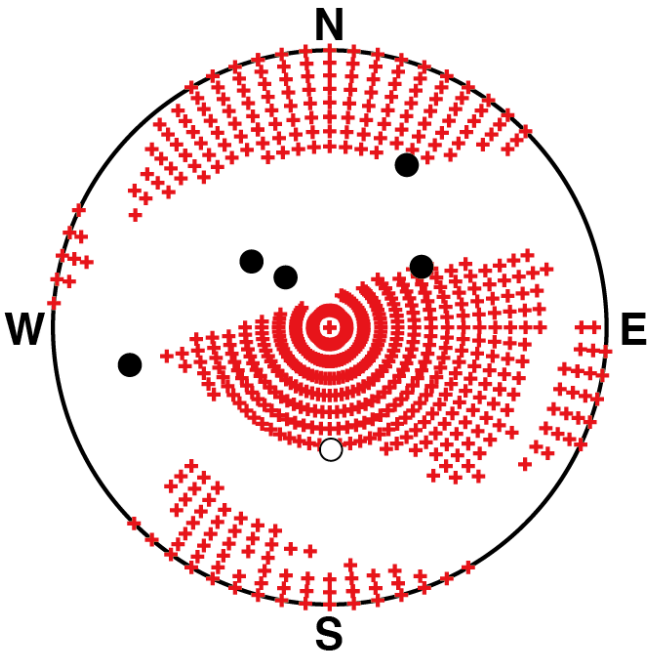
1. 東北大学　流体科学研究所、2. 京都大学　防災研究所、3. マサチューセッツ工科大学　地球資源研究所、4. 産業技術総合研究所　福島再生可能エネルギー研究所、5. 東北大学　工学部、6. Häring GeoProject
1. Institute of Fluid Science, Tohoku University, 2. Disaster Prevention Research Institute, Kyoto University, 3. Earth Resources Laboratory, MIT, 4. FREA, AIST, 5. School of Engineering, Tohoku University, 6. Häring GeoProject

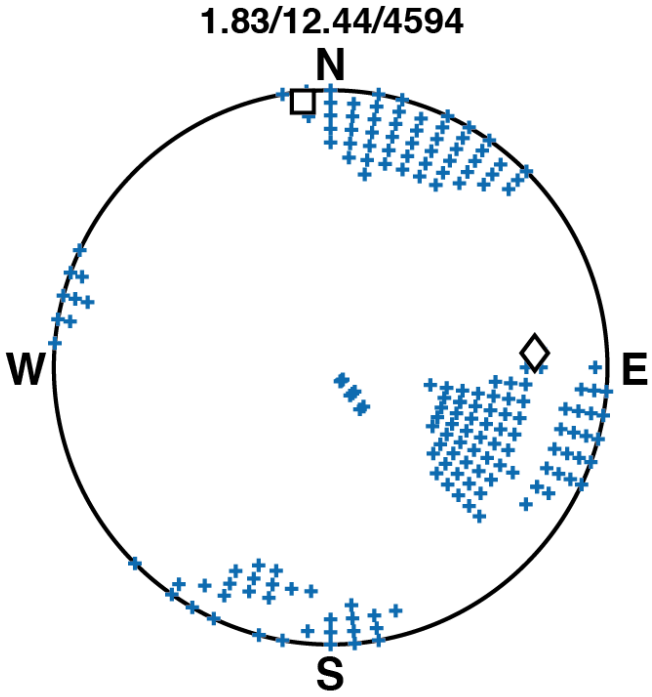
Microseismic monitoring is essential for successful hydraulic stimulation/fracking in unconventional oil/gas development, engineered geothermal system development and carbon capture and sequestration. In addition to the hypocenter location of the microseismicity, knowledge of the geometry of the fracture is also crucial for better understanding of fractured reservoir, fluid flow, and design of the energy extraction. Geofluid flows in the fracture and its permeability are correlated with the relation of the geometry of the fracture and in-situ stress. Fracture orientation can be estimated by the seismological method such as moment tensor inversion or focal mechanism analysis, only when the waveforms of the events are well recorded by a number of well-distributed stations. However, in realistic microseismic monitoring situations, it is often difficult to constrain the focal mechanism of microseismicity from first motion information due to the small number of stations.

We proposed a method to improve the estimates of focal mechanisms by introducing in-situ stress information from borehole logging information. We eliminate candidate focal mechanisms that are consistent with first motion data but cannot have shear slip under a given stress state and pore pressure increase. In this study, we also check the consistency between the shear slip vector estimated from the stress state and the rakes. We compare the shear slip vector and the slip vector from the rake. Then we reject the fault if the difference in the two vectors is significantly large. With this process, we reject the fault planes and auxiliary planes which are not consistent with stress state. We apply this method to induced seismicity dataset from Basel, Switzerland, where we already have well-constrained focal mechanisms estimated by many surface stations over a large region. We use these focal mechanisms as references to check whether our method can constrain the range of focal mechanisms using a small number of nearby stations. We find that the consistency check between two vectors significantly and reliably limits the range of focal mechanisms. Furthermore, we combine the constrained range of focal mechanism by this method and that by stability analysis to have more constraint of focal mechanisms satisfying the conditions of the geomechanical problem.

キーワード：誘発地震、断層面解、地殻応力
Keywords: Induced seismicity, Focal mechanism, In-situ stress

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Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1], Eszter Király-Proag[2], Pascal Bernard[1], Stefan Wiemer[2]

1. Institut de Physique du Globe de Paris, France, 2. ETH Swiss Federal Institute of Technology Zurich, Switzerland

In most models and analyses, small earthquakes (i.e., M<4) are considered either point sources or "penny-shaped" solid surfaces with homogeneous or isotropic source properties. While these assumptions may be valid, details of individual earthquakes are more complex. Due to the insufficient resolution of most monitoring networks, micro-earthquakes (M<2) must be still approximated as dislocation on penny-shaped surfaces. But in case of larger events (M>3) recorded on well-distributed local seismic stations, detailed space-time slip pattern within the rupture area can be imaged.

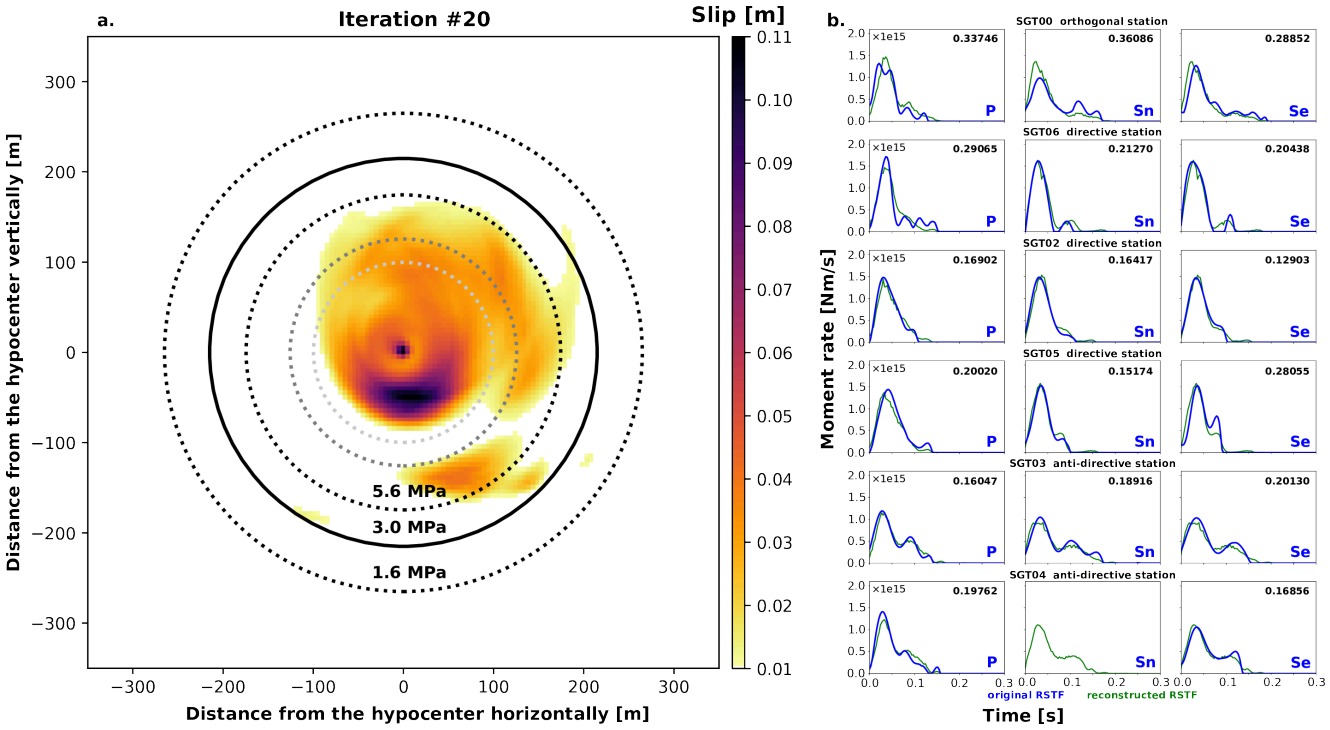
Here, we analyze slip distribution and rupture kinematics of a moderate induced event (ML 3.5) occurred in the St. Gallen geothermal reservoir (NE Switzerland) in 2013. To image the slip of such a small magnitude earthquake, we carry out a two-step procedure: (1) we deconvolve the propagation effects from the seismograms using an empirical Green's function resulting in relative source time functions (RSTF) at all seismic stations; (2) the RSTFs are back-projected to the fault plane using the position of equal time delays, i.e., isochrones.

Results reveal that the mainshock rupture propagates towards NNE from the hypocenter with an average velocity of about 2000 m/s. Spatio-temporal organization of fore- and aftershocks suggests that the mainshock released a previously less active portion of the fault and that the sequence is mainly stress-driven.

Applying this method in an operational environment could enable to quickly map seismic slip allowing assessment of fault asperities and structures involved in the reservoir creation process.

Keywords: Earthquake Source, Earthquake Kinematics, Back Projection, Induced Seismicity

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Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers

*Francesco Grigoli[1], Simone Cesca[2], Alessandro Vuan[3], Filippo Broggini[1], John Clinton[1], Stefan Wiemer[1]

1. ETH-Zurich, Switzerland, 2. GFZ-Potsdam, Germany, 3. OGS-Trieste, Italy

Microseismic monitoring networks are nowadays extensively used, in combination with risk analysis tools, to ensure the safety of the industrial operations which may trigger or induce earthquakes. However, in many cases the lack of dense enough microseismic monitoring networks affects the performance of the routine data analysis procedures limiting the application of adequate risk mitigation strategies. In this work we propose a novel approach based on the combination of Coda Wave Interferometry (CWI) and Distance Geometry Solvers (DGS) that allow to locate microseismic events by using a single seismic station. The use of CWI allows to determine, for pairs of earthquakes characterized by high similarity of waveforms (i.e. with similar location and focal mechanism), the absolute inter-event distance of each pair (Snieder and Vrijlandt, 2005), while DGS allow to determine their location based only on the given values of the distances between member pairs. Microseismic events can be classified in different families by combining a waveform correlation analysis and a clustering technique. Clustered events are characterized by a high similarity of waveforms, which implies a similarity in both source mechanism and location. In these conditions, the analysis of seismic coda recorded at a single receiver can be used to infer a measure of the spatial separation between two seismic sources. Coda waves are radiated in all directions with a radiation pattern determined by the source mechanism and a small change in the source position affects the interference pattern of the scattered waves that constitute the coda. This change in the coda waves is used to constrain the inter-event distance for each events pair. Absolute locations can be then retrieved by using DGS and considering all inter-event distances, a procedure which requires at least four reference locations. In order to show the potential of this approach we firstly validated the method with a synthetic dataset, then we applied it to the September-October 2013 induced seismicity sequence associated to the underground gas storage operations performed in the offshore Spain. The largest event of the sequence, a magnitude Mw 4.3 earthquake occurred on 2013 October 4th, was preceded by about 1000 seismic events, mostly with magnitude below 2. However, the poor monitoring network in the area (the closest seismic station was located at about ~20 km distance from the platform) did not allow to properly locate these small events. In this work we relocate these low magnitude events, showing that our approach provides better results than those obtained by using standard location methods, making this method particularly useful in poorly monitored areas where only a limited number of stations is available.

References:

Snieder, R., and Vrijlandt, M., 2005. Constraining the source separation with coda wave interferometry: Theory and application to earthquake doublets in the Hayward fault, California, J. Geophys. Res., doi:10.1029/2004JB003317

Keywords: Coda Wave Interferometry, Microseismicity, Induced Seismicity

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Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

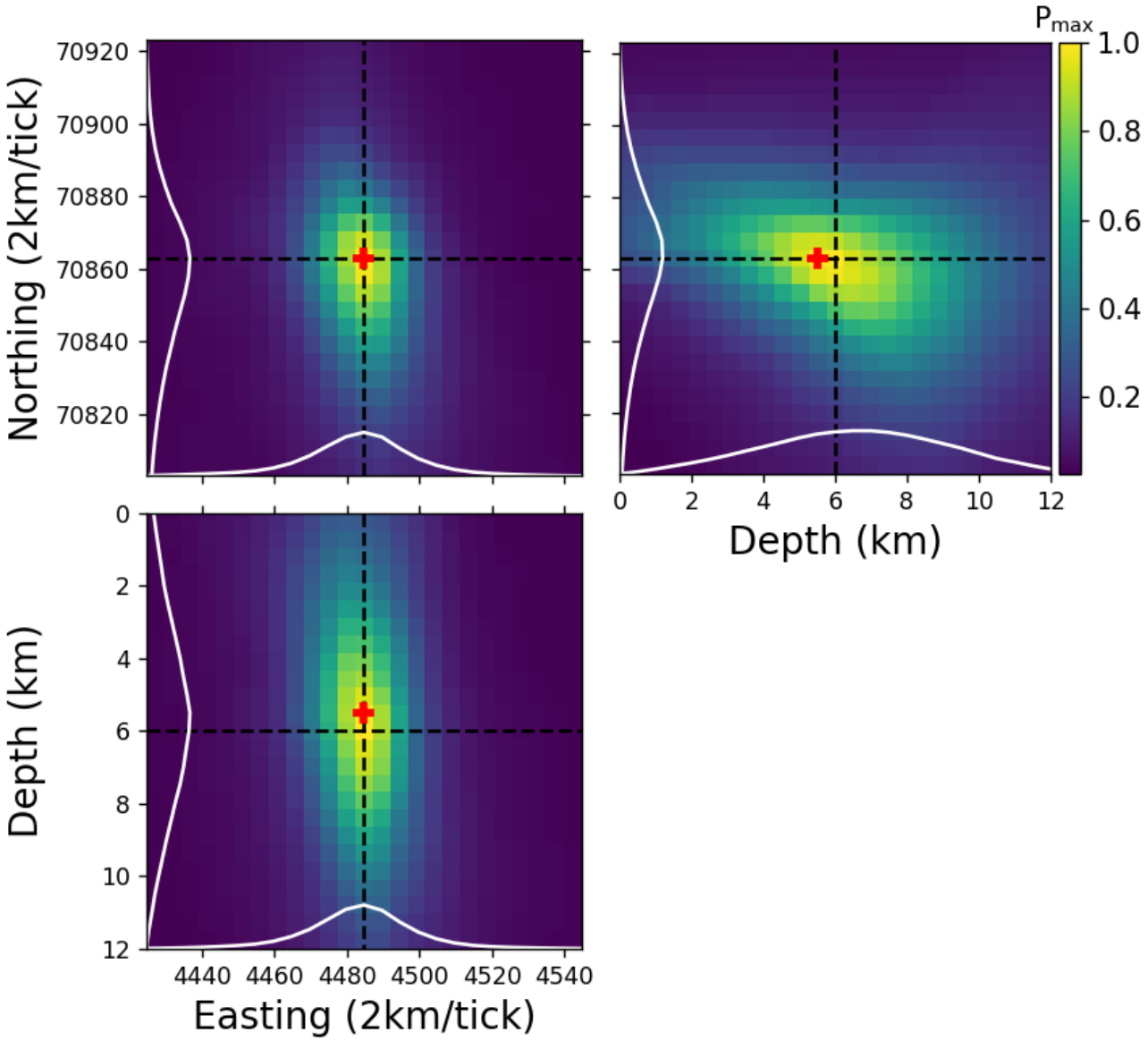
*Hilary Chang[1], Alison Malcolm[1], Frédérick Massin[2], Francesco Grigoli[2]

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Exact source locating for microseismic events helps us understand subsurface structures, monitor volcanic activities and assess earthquake hazards. Conventionally, the locating problem can be solved by picking phase arrivals. However, for microseismicity which contains large numbers of low-magnitude events, phase picking is often difficult and time-consuming. In this research, we use an improved waveform-based method to locate microseismic events without phase picking. We use the Source Scanning Algorithm (SSA) to stack the Characteristic Functions (CFs) in time and space, where the maximum stack gives the best estimate of the event origin time and source location. This approach allows us to locate the event automatically by evaluating waveform coherency in terms of changes in amplitude and polarization. We conduct synthetic test using the geometry of the SIL network in Reykjane Peninsula, SW Iceland. The results show that we can locate the synthetic source with error <1km, <0.1s when the noise amplitude is less than the amplitude of the target phase. In addition, stacking CFs that evaluate changes in amplitudes gives more stable results at all noise level, while stacking CFs that consider changes in polarization gives more stable results when the noise varies with frequency. We also conduct field data test using 215 microseismic events (M<2) occurred during Aug 2010 and Mar 2011 recorded by the same network. Our results show that stacking CFs that considers changes in amplitudes gives the closest results to the manually picking method, while stacking a combined version of CF rejects more outliers. In summary, stacking CFs in the SSA provides us with the ability to consider different waveform characteristics and improved noise-robustness in source locating problems. This improved automatic waveform-based procedure offers reliable solutions to large data set with low SNR and helps reduce human intervention.

Keywords: earthquake location, source scanning algorithm, waveform characteristics

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Earthquake nowcasting: further development and application to Japan

*楠城 一嘉[1]、ランドル ジョン[2]、櫻田 哲生[3]
*Kazuyoshi Nanjo[1], John B. Rundle[2], Tetsuo Sakurada[3]

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1. University of Shizuoka, 2. University of California at Davis, 3. SAKURADA&Company

We adopted and further developed the earthquake nowcasting method (Rundle et al., 2016). This method determines the current state of the fault system in a predefined region and its current level of progress through the earthquake cycle, using only empirical data: magnitudes (M) and times of earthquakes in the region. The characteristic is that the method does not involve any model other than the idea of an earthquake cycle. We performed a case study from southern Kanto, using the earthquake catalog maintained by Japan Meteorological Agency (JMA). Two earthquake magnitudes are selected, one large ($M \geqq M_L$), and one small ($M \geqq M_S$), where $M_L > M_S$. The method utilizes the number of small earthquakes that occurs between pairs of large earthquakes. The cumulative probability distribution of these values is obtained. The earthquake potential score (EPS), an index of the current level of the progress through the earthquake cycle, is defined by the “natural time”, the number of small earthquakes that has occurred since the last large earthquake, the point where this number falls on the cumulative probability distribution. For southern Kanto, we used earthquakes since 1926 with depths shallower than 150 km and set M_L=6.0 and M_S=4.2. The obtained result as of December 20, 2018 is EPS of 8%. This is interpreted as an indication that if a large (M6+) earthquake occurred on this date, the recurrence interval would be relatively short. Errors that arise from statistics-based estimation such as this must be considered so that we introduced the calculation of uncertainties to the earthquake nowcasting, using a bootstrap approach. Taking into account the contribution of these errors to the EPS calculations, we conclude that the earthquake nowcasting generates stable estimates of EPS for southern Kanto (Nanjo, 2018). To check the stability estimation for other regions, we computed EPS and its uncertainty for selected regions in Japan. We also discuss a technique of spatial mapping of EPS over the Japan’s mainlands. This technique allows us to move towards a full description of current EPS as a function of space, providing possible usability for ranking locations on the earthquake hazard.

キーワード：ナウキャスティング、地震、ナチュラルタイム
Keywords: nowcasting, earthquake, natural time

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

2019年5月26日(日) 10:45 ~ 12:15 | ポスター会場 幕張メッセ国際展示場 8ホール_6

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

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

Induced and triggered seismicity occurs in conjunction with human activities such as reservoir impoundments, mining operations, conventional and non-conventional hydrocarbon production, geothermal energy exploitation, wastewater disposal, CO2 sequestration and gas storage operations as well as volcanic and hydrogeological processes. The stability of faults is affected by external solicitations such as pore-pressure diffusion, relaxation effects as well as stress field perturbations related to mass and/or volume changes, dike intrusions and earthquake-earthquake interactions. A better understanding of the physical processes governing induced and triggered seismicity is important for the assess the risk of current and future industrial activities, including the geological disposal of nuclear waste.

The study of Induced and triggered seismicity is inherently an interdisciplinary problem, which requires the combination of seismological, hydrogeological, geodetic data and a wide range of modeling approaches. This session welcome contributions covering the analysis and modeling of induced and triggered seismicity at different spatial scales and environments.

Relevant topics to be presented include but are not limited to case-studies of induced and triggered seismicity, spatio-temporal variations of physical parameters (including stress, pressure and temperature changes), spatio-temporal patterns of seismicity, modeling and risk mitigation strategies.

The goal of the session is to cover both theoretical and experimental aspects of these topics.

[SSS05-P01] 遠地地震により励起されたharmonicな地震波

*村上 理[1] (1.地震予知総合研究振興会　東濃地震科学研究所)

[SSS05-P02] **Dynamic triggering of microseismicity around Yunnan following the 2004 Sumatra and 2012 Indian Ocean Earthquakes**

*Lu Li[1]、Baoshan Wang[1,4]、Zhigang Peng[2]、Danning Li[3] (1.Institute of Geophysics, CEA、2.Georgia Tech、3.Yunnan Earthquake Agency、4.USTC)

[SSS05-P03] Megathrust-inducing azimuthal seismic anisotropy in local and regional crusts

*Tae-Kyung Hong[1]、Junhyung Lee[1]、Ilgoo Kim[1]、Seongjun Park[1] (1.Department of Earth System Sciences, Yonsei University)

[SSS05-P04] **A Novel Method to Estimate Fracture Permeability: Combining microseismic observational data and reservoir engineering model**

*Meihua Yang[1,2]、Yusuke Mukuhira[2]、Takatoshi Ito[2] (1.State Key Laboratory of Oil and Gas Geology and Exploitation, Chendu University of Technology (China) 、2.Institute of Fluid Science, Tohoku University (Japan))

[SSS05-P05] Doublet Earthquake Triggering for the April 2014 Events in the Solomon Islands

*Calvin Luiramo Qwana[1]、Masatoshi Miyazawa[2]、James Mori[2] (1.Graduate School of Science, Kyoto University、2.DPRI, Kyoto Univ.)

[SSS05-P06] Thermal pressurization in a deep geological repository as a possible mechanism for fault reactivation

*Luca Urpi[1]、Antonio Pio Rinaldi[1]、Jonny Rutqvist[2]、Stefan Wiemer[1] (1.Swiss Seismological Service, ETH Zurich, Switzerland、2.Energy Geosceinces Division, LBNL, USA)

遠地地震により励起されたharmonicな地震波
Harmonic seismic waves excited by far-field earthquakes

*村上 理[1]
*Osamu Murakami[1]

1. 地震予知総合研究振興会　東濃地震科学研究所
1. Tono Rearch Institute of Earthquake Science, Association for the Development of Earthquake Prediction

It was observed the very harmonic seismic waves with a period of 17 s after 09:30 (UT) on Nov. 11 in 2018, at the mostly seismic stations in the global broadband seismograph network. It is assumed that the hypocenter of the harmonic waves was off Mayotte Island in the northern Mozambique channels between the continent of Africa and Madagascar Island. The physical cause of these waves remains unclear.

In order to understand such characteristic seismic waves, I firstly calculated the running spectra from Nov. 1 to Nov. 20 in 2018, using the observed seismograms at the station, ABPO, operated by IRIS/IDA. This station is the nearest station from the assumed hypocenter among the stations of the global seismograph network. From these running spectra, I found that the harmonic waves excited by the near- and far-field earthquakes. There were 10 far-field earthquakes whose magnitudes were larger than 6, in this period. Because the depths of 3 earthquakes in these 10 earthquakes were deeper than 100 km, I considered the remaining 7 shallow earthquakes. I investigated 2 larger earthquakes than others. The first one occurred in Jan Mayen Island region on Nov. 9 in 2018 (Mw6.7, hereafter EQ-J2018), and the second one occurred in South Sandwich Islands region on Nov. 15 in 2018 (Mw6.4, EQ-S2018). There was another earthquake near EQ-J2018. It occurred on Aug. 20 in 2012 (Mw6.7, EQ-J2012). There were two similar earthquakes near EQ-S2018, occurred on Dec. 8 in 2010 (Mw6.3, EQ-S2010) and on May 10 in 2017 (Mw6.5, EQ-S2017). From the comparison of the observed seismic waves between the similar hypocenter earthquakes, I found that the amplitudes of the surface waves in the earthquakes in 2018 (EQ-J2018, EQ-S2018) were several times as much as the ones in the previous earthquakes (EQ-J2012, EQ-S2010, EQ-S2017), at some stations.

In this study, I will show the features of these harmonic waves and to discuss the possible mechanisms.

キーワード：harmonicな地震波、マヨット島、表面波
Keywords: harmonic seismic waves, Mayotte Island, surface waves

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Dynamic triggering of microseismicity around Yunnan following the 2004 Sumatra and 2012 Indian Ocean Earthquakes

*Lu Li[1], Baoshan Wang[1,4], Zhigang Peng[2], Danning Li[3]

1. Institute of Geophysics, CEA, 2. Georgia Tech, 3. Yunnan Earthquake Agency, 4. USTC

We conduct a systematic detection of microseismicity around Yunnan following the 2004 Mw9.1 Sumatra and 2012 Mw8.6 Indian Ocean earthquakes to better understand the physical mechanism of dynamic triggering. Based on seismicity analysis on China Earthquake Network Center (CENC) catalog and spectral analysis of continuous waveforms, we find clear evidence of triggered seismicity in Yunnan immediately after the 2004 mainshock and a lack of instantaneous triggering following the 2012 mainshock. We further apply a matched filter technique to detect microearthquakes in Tengchong volcanic region 15 days before and 15 days after the 2012 mainshock. The seismicity rate remains stable immediately after the 2012 mainshock, and increases in the next few days, indicating a possible delayed triggering. In addition, we find possible evidence of remote triggering near the city of Yibin in Southern Sichuan Province, near the sites with ongoing shale gas development. We also examine other magnitude > 8 earthquakes from the Sumatra region and do not find any additional evidence of dynamic triggering around Yunnan. We suggest that the absolute value of dynamic stress change is the most important factor to explain why the 2004 Sumatra event triggered a widespread seismicity rate increase around Yunnan, while other great events around Sumatra did not.

Keywords: dynamic triggering, dynamic stress changes, Yunnan region

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Megathrust-inducing azimuthal seismic anisotropy in local and regional crusts

*Tae-Kyung Hong[1], Junhyung Lee[1], Ilgoo Kim[1], Seongjun Park[1]

1. Department of Earth System Sciences, Yonsei University

Megathrust earthquakes produce large coseismic and postseismic lithospheric displacements. The 2011 M9.0 Tohoku-Oki megathrust earthquakes produced large displacements up to regional distances. The lithospheric displacements directing to the epicenter on the convergent plate boundary developed transient uniaxial tension field over the backarc lithospheres. The Vp/Vs changes display characteristic 2 theta azimuthal variations in the upper crust of the Japanese islands, ranging between -0.0458 and 0.0422. Large lateral variations in Vp/Vs changes suggest medium-dependent perturbation. The lower crust of the Korean Peninsula in distances of ~1300 km displayed coseismic velocity changes of 3 % after the megathrust earthquake. The Vp/Vsratios and seismic velocities recovered gradually over time. Peak Vp/Vs and seismic velocity changes were observed along paths subparallel or subperpendicular to the directions toward the megathrust earthquake. The azimuthal seismic anisotropy may have developed from preferential crack orientation and azimuthal lithostatic stress changes. It appears that recovery of the medium properties may take decades. A series of moderate-sized earthquakes occurred as a consequence of medium response to the temporal evolution of stress field in the Korean Peninsula.

Keywords: megathrust earthquake, crustal deformation, induced seismicity

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A Novel Method to Estimate Fracture Permeability: Combining microseismic observational data and reservoir engineering model

*Meihua Yang[1,2], Yusuke Mukuhira[2], Takatoshi Ito[2]

1. State Key Laboratory of Oil and Gas Geology and Exploitation, Chendu University of Technology (China) , 2. Institute of Fluid Science, Tohoku University (Japan)

Effective utilization of geothermal resources is crucial to realize a sustainable society. Geothermal resources are widely present in Japan and the western United States, and the usage of geothermal resources are gradually increasing with many efforts. Meanwhile, the exploration and exploitation of geothermal resources in China has gradually developed. One of the challenges in conventional/next generation geothermal development (Enhanced/Engineered Geothermal System: EGS) is to understand the hydraulic properties of the geothermal reservoir. We often attempt to measure the hydraulic property (permeability or diffusivity) by wellbore tests or by using indicators such as migration of microseismicity. However, these quantities are often interpreted as representative value of hydraulic property for entire reservoir. Meanwhile, geothermal fluid circulates or flows in the existing/nucleated fracture system where permeability varies depending on condition of each fractures. Geothermal fluid is extracted from those permeable fractures very locally throughout production well drilled into the specific part of reservoir. Therefore, we need to have the best estimates of permeability for each fracture (local permeability) beyond representative permeability (global permeability). In addition, it is important to consider how the hydraulic properties can be affected by changes in the state of stress in the subsurface. This information is beneficial for design of geothermal energy extraction system and understanding of hydrology in the reservoir.

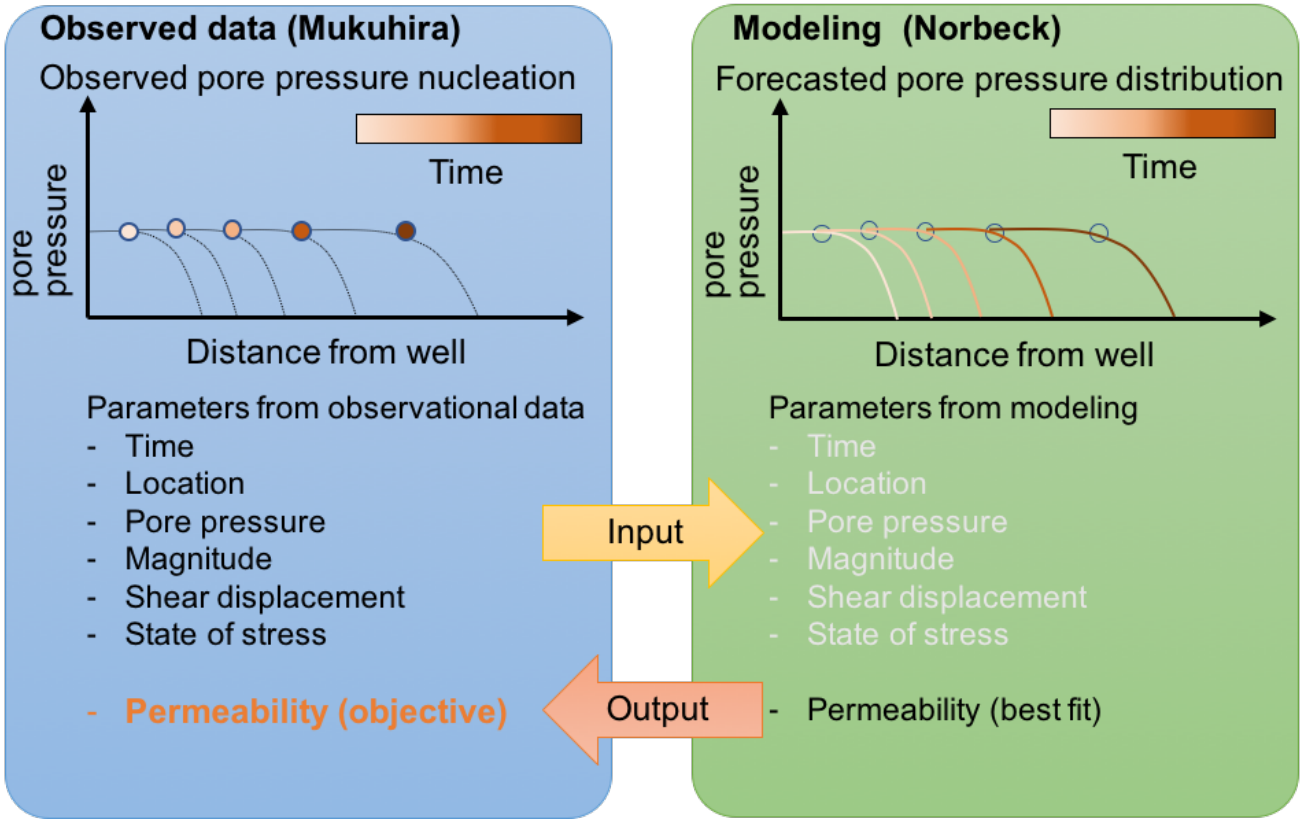
In this paper, we propose a novel method to estimate permeability of each individual fractures which experience shear slip at hydraulic stimulation. The spatiotemporal distribution of reservoir fluid pressure will be estimated using microseismic data. Using a hydromechanical fractured reservoir model, we will invert for the shear-dilation enhanced permeability change that controls the evolution of pressure along fractures and faults.

The first step is to estimate pore pressure distribution with microseismic data from real EGS field and observe how pore pressure migrated within single fracture (Figure 1 left: coloured circles). Meanwhile, using the hydromechanical fractured reservoir numerical model, we simulate pore pressure distribution within one fracture of given permeability and evaluate the evolution of hydraulic properties during a stimulation treatment (Figure 1 right: coloured sold lines). Therefore, we can use parameters from observational data as input parameters into hydromechanical model and estimate the best permeability which explain observed pore pressure distribution. We will also simulate all microseismic clusters and estimate permeability of each fractures. Then analyse the fracture permeability distribution (permeability mapping) in the study area.

In this research, it is the first attempt to estimate local permeability for each fracture. So far, only global permeability can be estimated by wellbore test or microseismic data and this permeability is not effective for each fracture in subsurface. Information of local permeability is quite valuable for designing a sustainable energy extraction system. Local permeability information also brings the way to model the flow of geothermal fluid in the reservoir, which is important for long-term management of geothermal resources.

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Keywords: Permeability, Microseismic, Reservoir engineering model



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Doublet Earthquake Triggering for the April 2014 Events in the Solomon Islands

*Calvin Luiramo Qwana[1], Masatoshi Miyazawa[2], James Mori[2]

1. Graduate School of Science, Kyoto University, 2. DPRI, Kyoto Univ.

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Keywords: Earthquake doublet , Triggering, Aftershock, Solomon Islands

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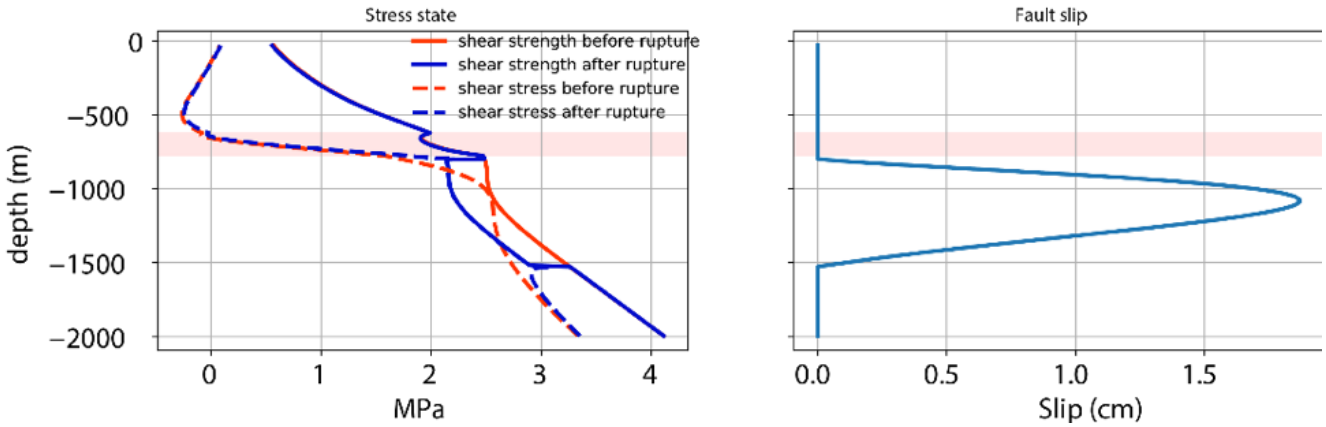
Thermal pressurization in a deep geological repository as a possible mechanism for fault reactivation

*Luca Urpi[1], Antonio Pio Rinaldi[1], Jonny Rutqvist[2], Stefan Wiemer[1]

1. Swiss Seismological Service, ETH Zurich, Switzerland, 2. Energy Geosceinces Division, LBNL, USA

A safe geological disposal site of radioactive waste requires identification of a rock formation that guarantees isolation to prevent unacceptable concentrations of radionuclides from migrating to the accessible environment. A common design for spent nuclear fuel disposal is the emplacement of specifically engineered canisters containing vitrified high-level radioactive waste (HLW) in a clay formation. The increase of temperature of a low permeability, fluid-saturated, media may trigger significant thermal pressurization, where the expansion of pore fluid cannot be accommodated by the thermal expansion of the pore space. With the aid of a coupled thermo-hydro-mechanical numerical simulator, we investigate the possible impact of thermal pressurization during the life of a deep geological repository on the stability of a nearby plane of weakness, assuming that the clay formation mantains its sealing properties. In our model, we represent the fault as a planar structure embedded in a thermo-poro-elastic material and shear activation evaluated by a strain-softening Mohr-Coulomb failure criterion. The results show that stress changes caused by temperature and thermal pressurization of a rock mass volume around the emplacement tunnels may trigger a slip event on a fault plane in proximity of the disposal site, with rupture nucleating at depth, hundreds of meter below the repository itself. We found that stress transfer plays an important role, while a direct hydraulic connection between the repository and the nucleation zone is not necessary in order to reach failure conditions. With a critical stress state (low horizontal to vertical stress ratio) the occurrence of slip may happen for a fault at a distance of up to 600m from the outermost tunnel. Intrinsic properties of the fault dictates the occurrence of seismic or aseismic slip, which may vary with depth. These results stress the need of investigating hydromechanical properties and local stress conditions to guarantee safe operations and predictable behavior of the HLW disposal site.

Keywords: Fault reactivation, thermal pressurization, stress transfer, deep geological repository high level storage, Rupture nucleation, Geomechanics



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

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_25

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

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

Induced and triggered seismicity occurs in conjunction with human activities such as reservoir impoundments, mining operations, conventional and non-conventional hydrocarbon production, geothermal energy exploitation, wastewater disposal, CO2 sequestration and gas storage operations as well as volcanic and hydrogeological processes. The stability of faults is affected by external solicitations such as pore-pressure diffusion, relaxation effects as well as stress field perturbations related to mass and/or volume changes, dike intrusions and earthquake-earthquake interactions. A better understanding of the physical processes governing induced and triggered seismicity is important for the assess the risk of current and future industrial activities, including the geological disposal of nuclear waste.

The study of Induced and triggered seismicity is inherently an interdisciplinary problem, which requires the combination of seismological, hydrogeological, geodetic data and a wide range of modeling approaches. This session welcome contributions covering the analysis and modeling of induced and triggered seismicity at different spatial scales and environments.

Relevant topics to be presented include but are not limited to case-studies of induced and triggered seismicity, spatio-temporal variations of physical parameters (including stress, pressure and temperature changes), spatio-temporal patterns of seismicity, modeling and risk mitigation strategies.

The goal of the session is to cover both theoretical and experimental aspects of these topics.

[SSS05-P01] 遠地地震により励起されたharmonicな地震波

*村上 理[1] (1.地震予知総合研究振興会　東濃地震科学研究所)

[SSS05-P02] **Dynamic triggering of microseismicity around Yunnan following the 2004 Sumatra and 2012 Indian Ocean Earthquakes**

*Lu Li[1]、Baoshan Wang[1,4]、Zhigang Peng[2]、Danning Li[3] (1.Institute of Geophysics, CEA、2.Georgia Tech、3.Yunnan Earthquake Agency、4.USTC)

[SSS05-P03] Megathrust-inducing azimuthal seismic anisotropy in local and regional crusts

*Tae-Kyung Hong[1]、Junhyung Lee[1]、Ilgoo Kim[1]、Seongjun Park[1] (1.Department of Earth System Sciences, Yonsei University)

[SSS05-P04] **A Novel Method to Estimate Fracture Permeability: Combining microseismic observational data and reservoir engineering model**

*Meihua Yang[1,2]、Yusuke Mukuhira[2]、Takatoshi Ito[2] (1.State Key Laboratory of Oil and Gas Geology and Exploitation, Chendu University of Technology (China) 、2.Institute of Fluid Science, Tohoku University (Japan))

[SSS05-P05] Doublet Earthquake Triggering for the April 2014 Events in the Solomon Islands

*Calvin Luiramo Qwana[1]、Masatoshi Miyazawa[2]、James Mori[2] (1.Graduate School of Science, Kyoto University、2.DPRI, Kyoto Univ.)

[SSS05-P06] Thermal pressurization in a deep geological repository as a possible mechanism for fault reactivation

*Luca Urpi[1]、Antonio Pio Rinaldi[1]、Jonny Rutqvist[2]、Stefan Wiemer[1] (1.Swiss Seismological Service, ETH Zurich, Switzerland、2.Energy Geosceinces Division, LBNL, USA)

遠地地震により励起されたharmonicな地震波
Harmonic seismic waves excited by far-field earthquakes

*村上 理[1]
*Osamu Murakami[1]

1. 地震予知総合研究振興会　東濃地震科学研究所
1. Tono Rearch Institute of Earthquake Science, Association for the Development of Earthquake Prediction

It was observed the very harmonic seismic waves with a period of 17 s after 09:30 (UT) on Nov. 11 in 2018, at the mostly seismic stations in the global broadband seismograph network. It is assumed that the hypocenter of the harmonic waves was off Mayotte Island in the northern Mozambique channels between the continent of Africa and Madagascar Island. The physical cause of these waves remains unclear.

In order to understand such characteristic seismic waves, I firstly calculated the running spectra from Nov. 1 to Nov. 20 in 2018, using the observed seismograms at the station, ABPO, operated by IRIS/IDA. This station is the nearest station from the assumed hypocenter among the stations of the global seismograph network. From these running spectra, I found that the harmonic waves excited by the near- and far-field earthquakes. There were 10 far-field earthquakes whose magnitudes were larger than 6, in this period. Because the depths of 3 earthquakes in these 10 earthquakes were deeper than 100 km, I considered the remaining 7 shallow earthquakes. I investigated 2 larger earthquakes than others. The first one occurred in Jan Mayen Island region on Nov. 9 in 2018 (Mw6.7, hereafter EQ-J2018), and the second one occurred in South Sandwich Islands region on Nov. 15 in 2018 (Mw6.4, EQ-S2018). There was another earthquake near EQ-J2018. It occurred on Aug. 20 in 2012 (Mw6.7, EQ-J2012). There were two similar earthquakes near EQ-S2018, occurred on Dec. 8 in 2010 (Mw6.3, EQ-S2010) and on May 10 in 2017 (Mw6.5, EQ-S2017). From the comparison of the observed seismic waves between the similar hypocenter earthquakes, I found that the amplitudes of the surface waves in the earthquakes in 2018 (EQ-J2018, EQ-S2018) were several times as much as the ones in the previous earthquakes (EQ-J2012, EQ-S2010, EQ-S2017), at some stations.

In this study, I will show the features of these harmonic waves and to discuss the possible mechanisms.

キーワード：harmonicな地震波、マヨット島、表面波
Keywords: harmonic seismic waves, Mayotte Island, surface waves

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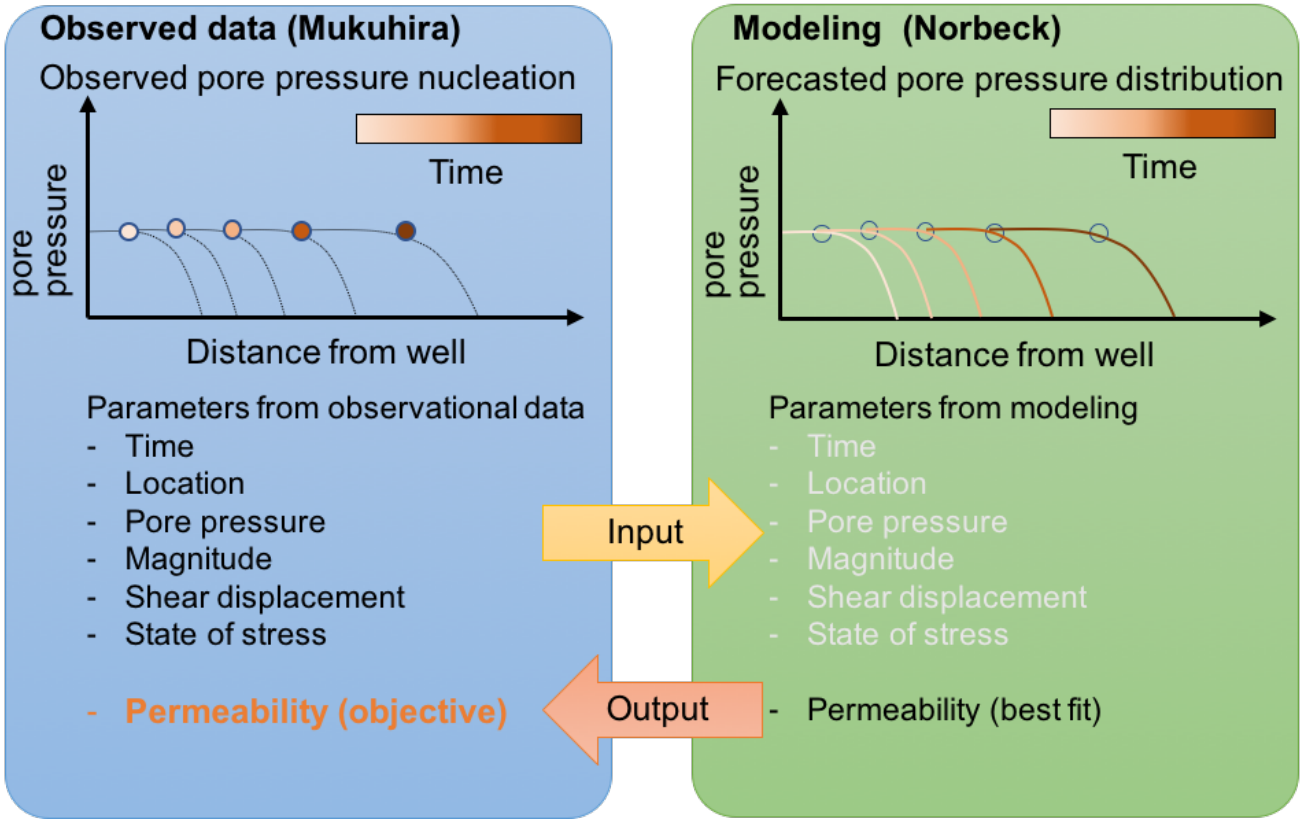
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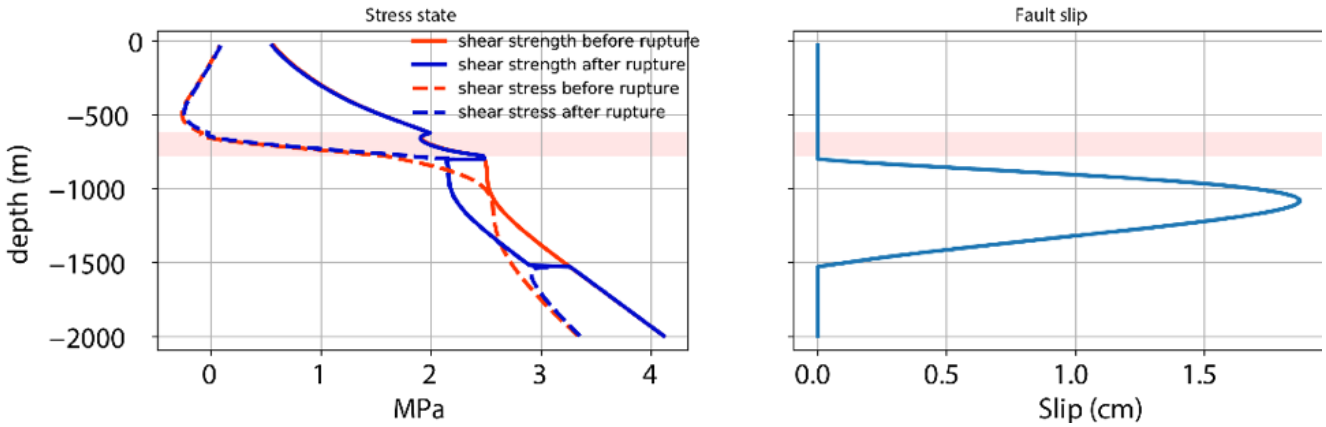
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Keywords: Fault reactivation, thermal pressurization, stress transfer, deep geological repository high level storage, Rupture nucleation, Geomechanics



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

2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_16

[S-IT20] 地球型惑星内部での液体の特性とその役割

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

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

[SIT20-P01] Melting relations in the Fe-P system at high pressures

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[SIT20-P02] Elastic property and structure of pyrope glass at high pressure

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[SIT20-P03] **The effect of water and redox state on melting at the top of the lower mantle**

*中嶋 彩乃[1]、坂巻 竜也[1]、鈴木 昭夫[1] (1.東北大学)

[SIT20-P04] Sound velocity measurements on liquid Fe-P alloy up to 80 GPa

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[SIT20-P05] High-pressure structural investigations for hydrous sodium silicate melts

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[SIT20-P06] **Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure**

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[SIT20-P07] Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

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Melting relations in the Fe-P system at high pressures

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The present-day temperature profile of the Earth's core is key to understanding of the thermal history and dynamics of the core. The temperature in the outer core region is over the melting temperature of the core material and crossovers it at the inner-outer core boundary. Thus, the melting temperature of the core material under relevant high-pressure conditions is crucial to constrain the core temperature. It is well known that the core is composed mainly of Fe, but including 10% lighter elements [1], though the nature of the light elements is still unclear. Phosphorous is also one of the candidates for the core light elements because it is found in iron-meteorites [2] and depleted in the silicate mantle relative to chondrites [3]. In this study, we performed melting experiments on Fe_3P up to 80 GPa by using a laser-heated diamond anvil cell.

The melting relation was determined from in-situ X-ray diffraction measurements at the beamline BL10XU of the SPring-8 synchrotron facility. During heating, we observed a peritectic melting of Fe_3P to liquid + Fe_2P and complete melting up to 60 GPa. The onset and complete melting of the sample were judged from the intensity of diffuse scattering signals from the liquid. This melting phase relation was also confirmed from the chemical analysis on some recovered samples. Above 60 GPa, we observed the change in diffraction pattern of the Fe_3P sample at subsolidus temperature conditions, which might be the decomposition to iron-rich and Fe_2P phases. For this two-phase mixture, we also determined the solidus and liquidus temperatures. In the present experimental pressure conditions, the peritectic (or solidus) and liquidus temperatures of the Fe_3P composition are ~700 K and ~200-300 K lower, respectively, relative to the melting temperature of Fe [4]. These indicate that phosphorous reduces strongly the melting temperature of Fe.

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キーワード：地球核、核軽元素、融解関係、高圧

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Keywords: Earth's core, Core light element, Melting relations, High pressure

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Elastic property and structure of pyrope glass at high pressure

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Structural properties of magma are closely correlated to their physical, chemical, and thermal properties. One of approaches for obtaining insights of magmas is an examination of silicate glasses. Aluminum is one of the major elements in the Earth and an important element for controlling the silicate network in melts and glasses because Al^{3+} behaves as an intermediate species in the silicate melts. Aluminum cation can act as either a network former or a modifier, depending on the composition. In the case of a fully-polymerized melt, such as jadeite and albite composition, all TO_4 tetrahedra (where T represents cations, such as Si, Al, etc.) are interconnected via oxygen anions, forming a three-dimensional network structure. Compositional differences are generally considered in terms of variety of alkaline (e.g., Na^{+}) and alkaline-earth (e.g., Mg^{2+}, Ca^{2+}) cations in the melts. These cations are called network modifiers and tend to cut Si-O-Si bonds between a SiO_4 tetrahedron and the adjacent ones. In addition to aluminum cation, other network modifiers also affect the melt behavior. A Mg-aluminosilicate, pyrope ($Mg_3Al_2Si_3O_{12}$) is an important mineral of mantle because of its abundance in the Earth’s upper mantle. Change in the slope of melting curve of pyrope around 7-10 GPa has been reported, and pressure-induced Al-coordination change was suggested. Although investigations of structure and elasticity of Mg-aluminosilicate glasses and pyrope-composition glasses have been conducted at ambient pressure, those observations at high pressures are still poor.
Here, we have measured sound velocities of pyrope glass at pressures up to 12.9 GPa using ultrasonic technique at BL04B1 of SPring-8. Longitudinal and transverse wave velocities decreased up to 5.6 GPa, and then the velocities started to increase with pressure. Pressure dependence of elastic moduli and Poisson’s ratio of the glass also changed around 7-8 GPa. The structural determination of the glass was conducted based on the energy-dispersive X-ray diffraction method at beamline NE5C of PF-AR in order to understand the mechanism of changes in microscopic physical properties in terms of macroscopic structural evolution. The characteristic shrinkage of the intermediate-range ordering in silicate network was observed around 7 GPa. We could find some correlation between elastic properties and structure. Detailed discussion will be shown in the meeting.

キーワード：ケイ酸塩ガラス、弾性波速度、X線回折、構造、超音波法
Keywords: silicate glass, elastic wave velocity, X-ray diffraction, structure, ultrasonic measurement

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The effect of water and redox state on melting at the top of the lower mantle

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There are various igneous activities in the Earth. On the surface of the Earth, for example, igneous activities occur in island arcs, mid-ocean ridges, hot spots and petit spots. However, not only on the surface, but also in the interior, melting phenomena are also suggested at the top of the asthenosphere [e.g., Barazangi & Isacks, 1971 *JGR*; Schmerr, 2012 *Science*] and the bottom of the upper mantle [e.g., Bercovici & Karato, 2003 *Nature*; Song *et al.*, 2004 *Nature*]. In this study, we focused on the melting of hydrous peridotite at the top of the lower mantle because seismological observation indicates the low velocity anomaly [Schmandt *et al.*, 2014 *Science*; Liu *et al.*, 2016 *GRL*; Liu *et al.*, 2018 *EPSL*]. The low-velocity region is expected to be caused by mantle melting due to dehydration decomposition of ringwoodite to bridgmanite and ferro-periclase with a downward flow.

Here, we performed melting experiments of peridotite with 2.0 wt. % H_2O at 26 GPa and 1600 ˚C - 2000 ˚C. As a starting material, two peridotite samples were synthesized: one was Fe_2O_3-bearing sample and the other was FeO-bearing. The samples were sealed by gold capsules. Recovered product of reductive sample (= FeO-bearing) from 2000 ˚C and 26 GPa showed a partial melting texture. This indicates that mantle melting can be occurred under this experimental condition. On the other hand, there are no melting texture of recovered sample of Fe_2O_3 system from 2000 ˚C and 26 GPa. In short, the materials constituting the lower mantle melts in the reduced state but not in the oxidized state. It is reported that ferric iron occupies a majority in the redox state at the top of the lower mantle [McCammon, 1997 *Nature* ; Frost *et al.*, 2004 *Nature*]. Thus, it is considered that melting phenomenon may or may not occur due to the regional difference of redox state. At 2000 ˚C, compared to bridgmanite in this study, the composition of melt was SiO_2- and Al_2O_3-poor and MgO- and CaO-rich. Although the FeO component concentrated in the melt, this behavior is closer to the tendency of the anhydrous melting experiments (2400 ˚C or more) [Ito & Takahashi, 1987 *Nature*; Trønnes & Frost, 2002 *EPSL*] than the hydrous system (~1400 ˚C) [Kawamoto, 2004 *PEPI*] because of the small amount of water. We calculated the density and compressibility of the magma based on the obtained melt composition. Comparing with seismological model, this melt is lighter than the lower mantle rock. This implies that a small amount of water (2.0 wt. %) can cause a light melt at the top of lower mantle and form the seismological low velocity zone.

キーワード：脱水溶融、下部マントル、含水マグマ、酸化還元状態
Keywords: dehydration melting, lower mantle, hydrous magma, redox state

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Sound velocity measurements on liquid Fe-P alloy up to 80 GPa

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The Earth’ s liquid outer core is composed mainly of iron, alloying with 5% nickel and 10% lighter elements [1]. The core composition is important to understand the environment and mechanism of the core formation process and the present-day magnetic field. The sound velocity of liquid iron alloys under relevant high-pressure and -temperature conditions in the core is key to constraining the core composition because the direct observations for the core is seismologic wave passing through the core only. Phosphorous is one of the candidates for light elements in the core because it is found in iron-meteorites [2] and depleted in the silicate mantle relative to chondrites [3]. In this study, we determined the P-wave velocity of liquid $Fe_{75}P_{25}$ up to 80 GPa using a laser-heated diamond-anvil cell in combination with an inelastic X-ray scattering (IXS) spectroscopy. We performed IXS measurements at a beamline BL43LXU [4] of the RIKEN SPring-8 Center in Japan. The P-wave velocity of liquid $Fe_{75}P_{25}$ were obtained based on the observed acoustic phonon dispersion. The present results exhibit that the influence of phosphorus on liquid iron sound velocity is almost negligible under the present experimental conditions. On the other hands, the density of liquid Fe can be reduced by phosphorous.

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キーワード：外核、音速、高圧
Keywords: outer core, sound velocity, high pressure

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High-pressure structural investigations for hydrous sodium silicate melts

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The behaviors of high-pressure silicate melts, which is controlled by their physico-chemical properties, are important to understand the magma activity in the deep Earth. Particularly, the H_2O content significantly affects the properties, such as density (e.g., Sakamaki et al., 2006) and viscosity (e.g., Suzuki et al., 2011; Poe et al., 2006). Since such macroscopic properties are known to be largely determined by the microscopic structure, there are considerable interests in revealing how the structure changes with increasing pressure.

Here, structures of hydrous Na_2O-8/3SiO_2 melts with 5 wt% (NS8/3_H5) and with 9 wt% H_2O (NS8/3_H9) were determined under high pressure and temperature by the in-situ X-ray diffraction (XRD). The in-situ XRD study was carried out using a cubic-type multi-anvil apparatus MAX80, which is installed at the AR-NE5C beamline of PF-AR at Tsukuba, Japan. The experimental *P-T* conditions were about 1.5–3.0 GPa and 550–970 ˚C, respectively.

The obtained total structure factors, $S(Q)$ of both liquids show that the position of the first sharp diffraction peaks (FSDP) shift to higher-Q with pressure. This positional shift indicates the intermediate-range order structure of present melts become compact. The reduced radial distribution functions, $G(r)$ indicate different pressure evolutions in the average Si-O bond lengths ($r_{Si\text{-}O}$) depending on their water contents. The $r_{Si\text{-}O}$ in the NS8/3_H9 melt shows the monotonic decrease with increasing pressure, however, the $r_{Si\text{-}O}$ of the NS8/3_H5 melt hardly changes after its contraction below 1.6 GPa. The structure of the NS8/3_H9 melt is assumed to be slightly more depolymerized than the NS8/3_H5 melt at ambient pressure (Zotov and Keppler, 1998). This difference might be due to a phenomenon that the number of strongly hydrogen-bonded SiOH groups, which are favored in sodium silicate glasses and melts (Xue and Kanzaki, 2004), increase more significantly during pressure-induced depolymerization in the NS8/3_H9 melt than in the NS8/3_H5 melt. This raises Si(-NBO)/Si(-BO) (NBO: non-bridging oxygen, BO: bridging oxygen) ratio, and hence, the $r_{Si\text{-}O}$ becomes shorter.

キーワード：含水珪酸塩融体、水の影響、非晶質構造、高温高圧
Keywords: hydrous silicate melt, effect of water, amorphous structure, high pressure and temperature

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Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure

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The Earth’s liquid outer core is composed mainly of iron, alloying with ~5% nickel and ~10% some light elements [1]. Nitrogen is one of candidates for the light elements. The abundance of nitrogen in the silicate mantle relative to that in primordial meteorites is less than those of similar volatile components such as H_2O, C and Ar, so that large portion of nitrogen in bulk Earth can be stored in the core [2,3]. In order to examine the possibility of nitrogen in the core, it is benefit to compare the sound velocity of liquid Fe-N alloy under high-pressure and -temperature relevant to the core conditions with the seismological observations. In this study, we performed inelastic X-ray scattering (IXS) measurements on liquid Fe-N alloy and determined its longitudinal velocity of the liquid Fe-N alloy under high pressure and temperature.

We carried out high-pressure and -temperature IXS measurements using a laser-heated diamond-anvil cell (LH-DAC) at the beamline BL43LXU of SPring-8 [4]. We used an Fe_4N foil (hereafter called $Fe_{80}N_{20}$) as a starting sample and single crystal Al_2O_3 discs as a thermal insulator. We judged the sample melting based on X-ray diffraction measurements during heating and then measured IXS of the liquid sample. The longitudinal sound wave (P-wave) velocity of liquid $Fe_{80}N_{20}$ was determined from the dispersion relation of the longitudinal acoustic phonon mode of the sample. We obtained the velocity of liquid $Fe_{80}N_{20}$ up to 76 GPa and 2200 K. We found that the P-wave velocity of liquid $Fe_{80}N_{20}$ is slightly faster by c.a. 4% than that of liquid Fe [5]. The P-wave velocity of liquid outer core is faster by 4% than liquid Fe [5]. Therefore, the present results give the upper limit of 5.9 wt.% (20 at.%) for the nitrogen content in the outer core.

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キーワード：地球液体外核、軽元素、P波速度、高圧
Keywords: Earth's liquid outer core, Light element, P-wave velocity, High pressure

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Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

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Anorthite ($CaAl_2Si_2O_8$) is a Ca-endmember of plagioclase, and it is a main component of a crust on the astral bodies, such as Moon and 4 Vesta, Thick anorthite-rich crust has been formed through a process of magma ocean. Here we conduct high-pressure and high-temperature experiments and *in-situ* X-ray analysis to simultaneously assess the viscosity and structure of anorthite magmas under pressures of up to 6.6 GPa. We find contrasting behavior in the viscosity between liquid anorthite and albite ($NaAlSi_3O_8$), which is Na-endmember of plagioclase. The big difference in viscosity between anorthite and albite melts has important implications for planetary differentiation. Na-poor astral bodies (Moon, 4 Vesta, etc.) have been dominated by low-viscous magma ocean and, eventually caused an efficient differentiation between crystal and magma. This process prevented the melt from trapping in the grain boundaries of floating anorthites. This makes the highly pure anorthite crust on the Moon observed by the remote sensing.

キーワード：アノーサイトメルト、粘度、構造、高圧、高温、月のマグマオーシャン
Keywords: anorthite melt, viscosity, structure, high pressure, high temperature, lunar magma ocean

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[S-IT20] 地球型惑星内部での液体の特性とその役割

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

[SIT20-P01] Melting relations in the Fe-P system at high pressures

*中島 陽一[1,2]、小畑 晴幹[2]、木下 大輔[2]、舘野 繁彦[3]、廣瀬 敬[3,4]、平尾 直久[5]、河口 沙織[5]、大石 泰生[5] (1.熊本大学大学院先導機構、2.熊本大学物理科学講座、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)

[SIT20-P02] Elastic property and structure of pyrope glass at high pressure

*久野 直毅[1]、坂巻 竜也[1]、大橋 智典[1]、舟越 賢一[2]、肥後 祐司[3]、柴崎 裕樹[4]、鈴木 昭夫[1] (1.東北大学大学院理学研究科地学専攻、2.総合科学研究機構　中性子科学センター、3.（財）高輝度光科学研究センター、4.国立研究開発法人　物質・材料研究機構　若手国際研究センター)

[SIT20-P03] **The effect of water and redox state on melting at the top of the lower mantle**

*中嶋 彩乃[1]、坂巻 竜也[1]、鈴木 昭夫[1] (1.東北大学)

[SIT20-P04] Sound velocity measurements on liquid Fe-P alloy up to 80 GPa

*木下 大輔[1]、中島 陽一[1,2]、桑山 靖弘[2,3]、廣瀬 敬[3]、石川 大介[2,4]、Baron Alfred[2] (1.熊本大学、2.理研 MDL、3.東京大学、4.JASRI)

[SIT20-P05] High-pressure structural investigations for hydrous sodium silicate melts

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[SIT20-P06] **Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure**

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[SIT20-P07] Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

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Melting relations in the Fe-P system at high pressures

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The present-day temperature profile of the Earth's core is key to understanding of the thermal history and dynamics of the core. The temperature in the outer core region is over the melting temperature of the core material and crossovers it at the inner-outer core boundary. Thus, the melting temperature of the core material under relevant high-pressure conditions is crucial to constrain the core temperature. It is well known that the core is composed mainly of Fe, but including 10% lighter elements [1], though the nature of the light elements is still unclear. Phosphorous is also one of the candidates for the core light elements because it is found in iron-meteorites [2] and depleted in the silicate mantle relative to chondrites [3]. In this study, we performed melting experiments on Fe_3P up to 80 GPa by using a laser-heated diamond anvil cell.

The melting relation was determined from in-situ X-ray diffraction measurements at the beamline BL10XU of the SPring-8 synchrotron facility. During heating, we observed a peritectic melting of Fe_3P to liquid + Fe_2P and complete melting up to 60 GPa. The onset and complete melting of the sample were judged from the intensity of diffuse scattering signals from the liquid. This melting phase relation was also confirmed from the chemical analysis on some recovered samples. Above 60 GPa, we observed the change in diffraction pattern of the Fe_3P sample at subsolidus temperature conditions, which might be the decomposition to iron-rich and Fe_2P phases. For this two-phase mixture, we also determined the solidus and liquidus temperatures. In the present experimental pressure conditions, the peritectic (or solidus) and liquidus temperatures of the Fe_3P composition are ~700 K and ~200-300 K lower, respectively, relative to the melting temperature of Fe [4]. These indicate that phosphorous reduces strongly the melting temperature of Fe.

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キーワード：地球核、核軽元素、融解関係、高圧

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Keywords: Earth's core, Core light element, Melting relations, High pressure

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Elastic property and structure of pyrope glass at high pressure

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Structural properties of magma are closely correlated to their physical, chemical, and thermal properties. One of approaches for obtaining insights of magmas is an examination of silicate glasses. Aluminum is one of the major elements in the Earth and an important element for controlling the silicate network in melts and glasses because Al^{3+} behaves as an intermediate species in the silicate melts. Aluminum cation can act as either a network former or a modifier, depending on the composition. In the case of a fully-polymerized melt, such as jadeite and albite composition, all TO_4 tetrahedra (where T represents cations, such as Si, Al, etc.) are interconnected via oxygen anions, forming a three-dimensional network structure. Compositional differences are generally considered in terms of variety of alkaline (e.g., Na^{+}) and alkaline-earth (e.g., Mg^{2+}, Ca^{2+}) cations in the melts. These cations are called network modifiers and tend to cut Si-O-Si bonds between a SiO_4 tetrahedron and the adjacent ones. In addition to aluminum cation, other network modifiers also affect the melt behavior. A Mg-aluminosilicate, pyrope ($Mg_3Al_2Si_3O_{12}$) is an important mineral of mantle because of its abundance in the Earth’s upper mantle. Change in the slope of melting curve of pyrope around 7-10 GPa has been reported, and pressure-induced Al-coordination change was suggested. Although investigations of structure and elasticity of Mg-aluminosilicate glasses and pyrope-composition glasses have been conducted at ambient pressure, those observations at high pressures are still poor.
Here, we have measured sound velocities of pyrope glass at pressures up to 12.9 GPa using ultrasonic technique at BL04B1 of SPring-8. Longitudinal and transverse wave velocities decreased up to 5.6 GPa, and then the velocities started to increase with pressure. Pressure dependence of elastic moduli and Poisson’s ratio of the glass also changed around 7-8 GPa. The structural determination of the glass was conducted based on the energy-dispersive X-ray diffraction method at beamline NE5C of PF-AR in order to understand the mechanism of changes in microscopic physical properties in terms of macroscopic structural evolution. The characteristic shrinkage of the intermediate-range ordering in silicate network was observed around 7 GPa. We could find some correlation between elastic properties and structure. Detailed discussion will be shown in the meeting.

キーワード：ケイ酸塩ガラス、弾性波速度、X線回折、構造、超音波法
Keywords: silicate glass, elastic wave velocity, X-ray diffraction, structure, ultrasonic measurement

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The effect of water and redox state on melting at the top of the lower mantle

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There are various igneous activities in the Earth. On the surface of the Earth, for example, igneous activities occur in island arcs, mid-ocean ridges, hot spots and petit spots. However, not only on the surface, but also in the interior, melting phenomena are also suggested at the top of the asthenosphere [e.g., Barazangi & Isacks, 1971 *JGR*; Schmerr, 2012 *Science*] and the bottom of the upper mantle [e.g., Bercovici & Karato, 2003 *Nature*; Song *et al.*, 2004 *Nature*]. In this study, we focused on the melting of hydrous peridotite at the top of the lower mantle because seismological observation indicates the low velocity anomaly [Schmandt *et al.*, 2014 *Science*; Liu *et al.*, 2016 *GRL*; Liu *et al.*, 2018 *EPSL*]. The low-velocity region is expected to be caused by mantle melting due to dehydration decomposition of ringwoodite to bridgmanite and ferro-periclase with a downward flow.

Here, we performed melting experiments of peridotite with 2.0 wt. % H_2O at 26 GPa and 1600 ˚C - 2000 ˚C. As a starting material, two peridotite samples were synthesized: one was Fe_2O_3-bearing sample and the other was FeO-bearing. The samples were sealed by gold capsules. Recovered product of reductive sample (= FeO-bearing) from 2000 ˚C and 26 GPa showed a partial melting texture. This indicates that mantle melting can be occurred under this experimental condition. On the other hand, there are no melting texture of recovered sample of Fe_2O_3 system from 2000 ˚C and 26 GPa. In short, the materials constituting the lower mantle melts in the reduced state but not in the oxidized state. It is reported that ferric iron occupies a majority in the redox state at the top of the lower mantle [McCammon, 1997 *Nature* ; Frost *et al.*, 2004 *Nature*]. Thus, it is considered that melting phenomenon may or may not occur due to the regional difference of redox state. At 2000 ˚C, compared to bridgmanite in this study, the composition of melt was SiO_2- and Al_2O_3-poor and MgO- and CaO-rich. Although the FeO component concentrated in the melt, this behavior is closer to the tendency of the anhydrous melting experiments (2400 ˚C or more) [Ito & Takahashi, 1987 *Nature*; Trønnes & Frost, 2002 *EPSL*] than the hydrous system (~1400 ˚C) [Kawamoto, 2004 *PEPI*] because of the small amount of water. We calculated the density and compressibility of the magma based on the obtained melt composition. Comparing with seismological model, this melt is lighter than the lower mantle rock. This implies that a small amount of water (2.0 wt. %) can cause a light melt at the top of lower mantle and form the seismological low velocity zone.

キーワード：脱水溶融、下部マントル、含水マグマ、酸化還元状態
Keywords: dehydration melting, lower mantle, hydrous magma, redox state

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Sound velocity measurements on liquid Fe-P alloy up to 80 GPa

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The Earth’ s liquid outer core is composed mainly of iron, alloying with 5% nickel and 10% lighter elements [1]. The core composition is important to understand the environment and mechanism of the core formation process and the present-day magnetic field. The sound velocity of liquid iron alloys under relevant high-pressure and -temperature conditions in the core is key to constraining the core composition because the direct observations for the core is seismologic wave passing through the core only. Phosphorous is one of the candidates for light elements in the core because it is found in iron-meteorites [2] and depleted in the silicate mantle relative to chondrites [3]. In this study, we determined the P-wave velocity of liquid $Fe_{75}P_{25}$ up to 80 GPa using a laser-heated diamond-anvil cell in combination with an inelastic X-ray scattering (IXS) spectroscopy. We performed IXS measurements at a beamline BL43LXU [4] of the RIKEN SPring-8 Center in Japan. The P-wave velocity of liquid $Fe_{75}P_{25}$ were obtained based on the observed acoustic phonon dispersion. The present results exhibit that the influence of phosphorus on liquid iron sound velocity is almost negligible under the present experimental conditions. On the other hands, the density of liquid Fe can be reduced by phosphorous.

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キーワード：外核、音速、高圧
Keywords: outer core, sound velocity, high pressure

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High-pressure structural investigations for hydrous sodium silicate melts

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The behaviors of high-pressure silicate melts, which is controlled by their physico-chemical properties, are important to understand the magma activity in the deep Earth. Particularly, the H_2O content significantly affects the properties, such as density (e.g., Sakamaki et al., 2006) and viscosity (e.g., Suzuki et al., 2011; Poe et al., 2006). Since such macroscopic properties are known to be largely determined by the microscopic structure, there are considerable interests in revealing how the structure changes with increasing pressure.

Here, structures of hydrous Na_2O-8/3SiO_2 melts with 5 wt% (NS8/3_H5) and with 9 wt% H_2O (NS8/3_H9) were determined under high pressure and temperature by the in-situ X-ray diffraction (XRD). The in-situ XRD study was carried out using a cubic-type multi-anvil apparatus MAX80, which is installed at the AR-NE5C beamline of PF-AR at Tsukuba, Japan. The experimental *P-T* conditions were about 1.5–3.0 GPa and 550–970 ˚C, respectively.

The obtained total structure factors, $S(Q)$ of both liquids show that the position of the first sharp diffraction peaks (FSDP) shift to higher-Q with pressure. This positional shift indicates the intermediate-range order structure of present melts become compact. The reduced radial distribution functions, $G(r)$ indicate different pressure evolutions in the average Si-O bond lengths ($r_{Si\text{-}O}$) depending on their water contents. The $r_{Si\text{-}O}$ in the NS8/3_H9 melt shows the monotonic decrease with increasing pressure, however, the $r_{Si\text{-}O}$ of the NS8/3_H5 melt hardly changes after its contraction below 1.6 GPa. The structure of the NS8/3_H9 melt is assumed to be slightly more depolymerized than the NS8/3_H5 melt at ambient pressure (Zotov and Keppler, 1998). This difference might be due to a phenomenon that the number of strongly hydrogen-bonded SiOH groups, which are favored in sodium silicate glasses and melts (Xue and Kanzaki, 2004), increase more significantly during pressure-induced depolymerization in the NS8/3_H9 melt than in the NS8/3_H5 melt. This raises Si(-NBO)/Si(-BO) (NBO: non-bridging oxygen, BO: bridging oxygen) ratio, and hence, the $r_{Si\text{-}O}$ becomes shorter.

キーワード：含水珪酸塩融体、水の影響、非晶質構造、高温高圧
Keywords: hydrous silicate melt, effect of water, amorphous structure, high pressure and temperature

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Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure

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The Earth’s liquid outer core is composed mainly of iron, alloying with ~5% nickel and ~10% some light elements [1]. Nitrogen is one of candidates for the light elements. The abundance of nitrogen in the silicate mantle relative to that in primordial meteorites is less than those of similar volatile components such as H_2O, C and Ar, so that large portion of nitrogen in bulk Earth can be stored in the core [2,3]. In order to examine the possibility of nitrogen in the core, it is benefit to compare the sound velocity of liquid Fe-N alloy under high-pressure and -temperature relevant to the core conditions with the seismological observations. In this study, we performed inelastic X-ray scattering (IXS) measurements on liquid Fe-N alloy and determined its longitudinal velocity of the liquid Fe-N alloy under high pressure and temperature.

We carried out high-pressure and -temperature IXS measurements using a laser-heated diamond-anvil cell (LH-DAC) at the beamline BL43LXU of SPring-8 [4]. We used an Fe_4N foil (hereafter called $Fe_{80}N_{20}$) as a starting sample and single crystal Al_2O_3 discs as a thermal insulator. We judged the sample melting based on X-ray diffraction measurements during heating and then measured IXS of the liquid sample. The longitudinal sound wave (P-wave) velocity of liquid $Fe_{80}N_{20}$ was determined from the dispersion relation of the longitudinal acoustic phonon mode of the sample. We obtained the velocity of liquid $Fe_{80}N_{20}$ up to 76 GPa and 2200 K. We found that the P-wave velocity of liquid $Fe_{80}N_{20}$ is slightly faster by c.a. 4% than that of liquid Fe [5]. The P-wave velocity of liquid outer core is faster by 4% than liquid Fe [5]. Therefore, the present results give the upper limit of 5.9 wt.% (20 at.%) for the nitrogen content in the outer core.

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キーワード：地球液体外核、軽元素、P波速度、高圧
Keywords: Earth's liquid outer core, Light element, P-wave velocity, High pressure

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Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

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Anorthite ($CaAl_2Si_2O_8$) is a Ca-endmember of plagioclase, and it is a main component of a crust on the astral bodies, such as Moon and 4 Vesta, Thick anorthite-rich crust has been formed through a process of magma ocean. Here we conduct high-pressure and high-temperature experiments and *in-situ* X-ray analysis to simultaneously assess the viscosity and structure of anorthite magmas under pressures of up to 6.6 GPa. We find contrasting behavior in the viscosity between liquid anorthite and albite ($NaAlSi_3O_8$), which is Na-endmember of plagioclase. The big difference in viscosity between anorthite and albite melts has important implications for planetary differentiation. Na-poor astral bodies (Moon, 4 Vesta, etc.) have been dominated by low-viscous magma ocean and, eventually caused an efficient differentiation between crystal and magma. This process prevented the melt from trapping in the grain boundaries of floating anorthites. This makes the highly pure anorthite crust on the Moon observed by the remote sensing.

キーワード：アノーサイトメルト、粘度、構造、高圧、高温、月のマグマオーシャン
Keywords: anorthite melt, viscosity, structure, high pressure, high temperature, lunar magma ocean

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2019年5月26日(日) 10:45 ~ 12:15 | ポスター会場 幕張メッセ国際展示場 8ホール_7

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

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

Interdisciplinary approach can lead to a better understanding of dynamics and evolution of the deep interiors of the Earth and planets. We welcome any submissions of recent results in observational, theoretical and experimental studies on seismology, geomagnetism, mineral physics, dynamics of deep interiors, and any other relevant fields from researchers in many countries. Integration of such results is also welcome. In particular, we encourage any contributions focusing on "plate and mantle dynamics in Earth and terrestrial planets". We also encourage papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community.

[SIT23-P01] Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

*Walid Ben Mansour[1]、Guust Nolet[2]、Mario Ruiz[3]、Juan Carlos Afonso[1] (1.Department of Earth and Planetary Sciences, Macquarie University, Sydney (Australia)、2.Geoazur, Université Cote d'Azur, Sophia Antipolis (France)、3.Instituto Geofisco, Escuela Politecnica Nacional, Quito (Ecuador))

[SIT23-P02] **Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets**

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[SIT23-P03] **The distribution of Cenozoic conglomerates and its sedimentological constraint on the uplift of the South Tianshan, NW China**

*SUN HAITAO[1] (1.China University of Petroluem-Beijing)

[SIT23-P04] **Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH**

*Ran Wang[1] (1.Institute for Planetary Materials, Okayama University)

[SIT23-P05] Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

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[SIT23-P06] Mapping multi-mode surface wave phase speeds in North America using mode-branch waveforms decomposed by linear Radon transform

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[SIT23-P07] Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_K parameter: Application to the Pacific and Australian regions

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[SIT23-P08] Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

*谷部 功将[1]、平賀 岳彦[1] (1.東京大学大学院理学系研究科)

[SIT23-P09] Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

*堀内 美咲[3]、杉岡 裕子[3]、大林 政行[1]、末次 大輔[1]、塩原 肇[2]、伊藤 亜妃[1]、石原 靖[1]、田中 聡[1]、一瀬 建日[2]、利根川 貴志[1]、吉光 淳子[1]、小林 拓史[3] (1.国立研究開発法人海洋研究開発機構、2.東京大学地震研究所、3.神戸大学)

[SIT23-P10] Shear wave structure of the upper mantle beneath the Ontong Java Plateau

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[SIT23-P11] Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

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[SIT23-P12] 幌満かんらん岩から回収されたTiに富む特異的なコランダムの報告

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[SIT23-P13] Deformation experiments on akimotoite

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[SIT23-P14] Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

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Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

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The Galápagos archipelago, located west of Ecuador, is a good example where a mantle plume interacts with a spreading center and modifies physical and chemical properties of the oceanic lithosphere. The Galápagos Spreading Center (GSC) and the Galápagos hotspot interact over more than 1,000 km with unusual features for a hot spot region (large number of historical active volcanoes, large range of lavas composition, alignment of volcanic centers and seamounts). To bring new information on the physical and chemical properties of this region, we are constructing a new P-wave velocity model of this region by combining data from 10 seismic broadband stations and from 9 MERMAIDS (Mobile Earthquake Recorder in Marine Areas by Independent Divers) deployed in this region between 2014 and 2016. We focus on Pn head waves to better constraint the Moho depth in this region and image the interaction between the hot spot and the GSC. We selected150 seismic events between May 2014 and September 2016, with epicentral distance between $3^{o}$and 35^{o} and picked more than 2,500 Pn phases that we will invert in a probabilistic tomography inversion in a second step. In this presentation, we will show examples and statistics of Pn data. We will discuss the benefits of developing a multi-observable thermochemical tomography in this region to better image the intricate interaction of a hot spot with the overlying oceanic lithosphere and evaluate current physio-chemical evolutionary models.

Keywords: Pn tomography, mantle plume, thermochemical structure

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Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets

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Knowledge of thermal transport properties of mantle materials is essential for understanding the thermal state and dynamics of the Earth and planetary interiors. Previous studies have suggested that temperature and pressure dependences of thermal conductivity can affect mantle convection and plate tectonics involving subduction dynamics. Olivine is the most abundant mineral in the Earth's upper mantle and chemical composition of olivine in the Earth's upper mantle is characterized by high forsterite content around Fo_{90}. For other terrestrial planets, Mercury is believed to have a FeO-poor mantle along with end member silicates, whereas olivine in the Martian mantle would be more Fe-rich, speculated to be Fo_{67}. Recent studies suggested that surface of some asteroids is dominated by olivine of composition from Fo_{49} to Fo_{70}. Hence, the effect of Fe content in olivine on thermal conductivity could be significant for understanding the thermal structure and cooling history of these terrestrial planets and asteroids.

In this study, thermal conductivity and diffusivity of olivine were determined simultaneously by combining multi-anvil high pressure experimental technique and pulse heating method. Thermal properties of olivine with six different Fe contents (Fo, Fo_{90}, Fo_{70}, Fo_{50}, Fo_{31}, Fo_{0}) were measured under the Earth's upper mantle condition in a 5000-ton Kawai type multi-anvil press. The minimum λ was found to be at composition near Fo_{31}; the absolute λ value of Fo_{31} is about 65% lower than that of Fo. Small amounts of minor elements can strongly reduce the thermal conductivity at low temperature; λ value of Fo90 is about 50% of Fo at room temperature. As temperature increases, the difference in λ among olivine samples with various Fe contents tends to become smaller. Thermal conductivities of polycrystalline olivine have smaller absolute values and weak pressure and temperature dependences, compared with those of natural single crystal olivine determined by previous studies. Heat capacity of olivine calculated from λ and κ is independent of pressure and is controlled by nearly constant thermal expansion coefficient of Fo_{70} and Fo_{50} with increasing temperature. Smaller λ of olivine aggregate with high Fe content would produce thicker crust in the Fe-rich Mars, while heat in the Fe-poor Mercury can escape faster than the other terrestrial planets. Olivine-dominant asteroids with high Fe concentration could have longer cooling history and lower thermal inertia on the surface.

Keywords: Thermal conductivity, Olivine, Heat capacity, High pressure, Mantle

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The distribution of Cenozoic conglomerates and its sedimentological constraint on the uplift of the South Tianshan, NW China

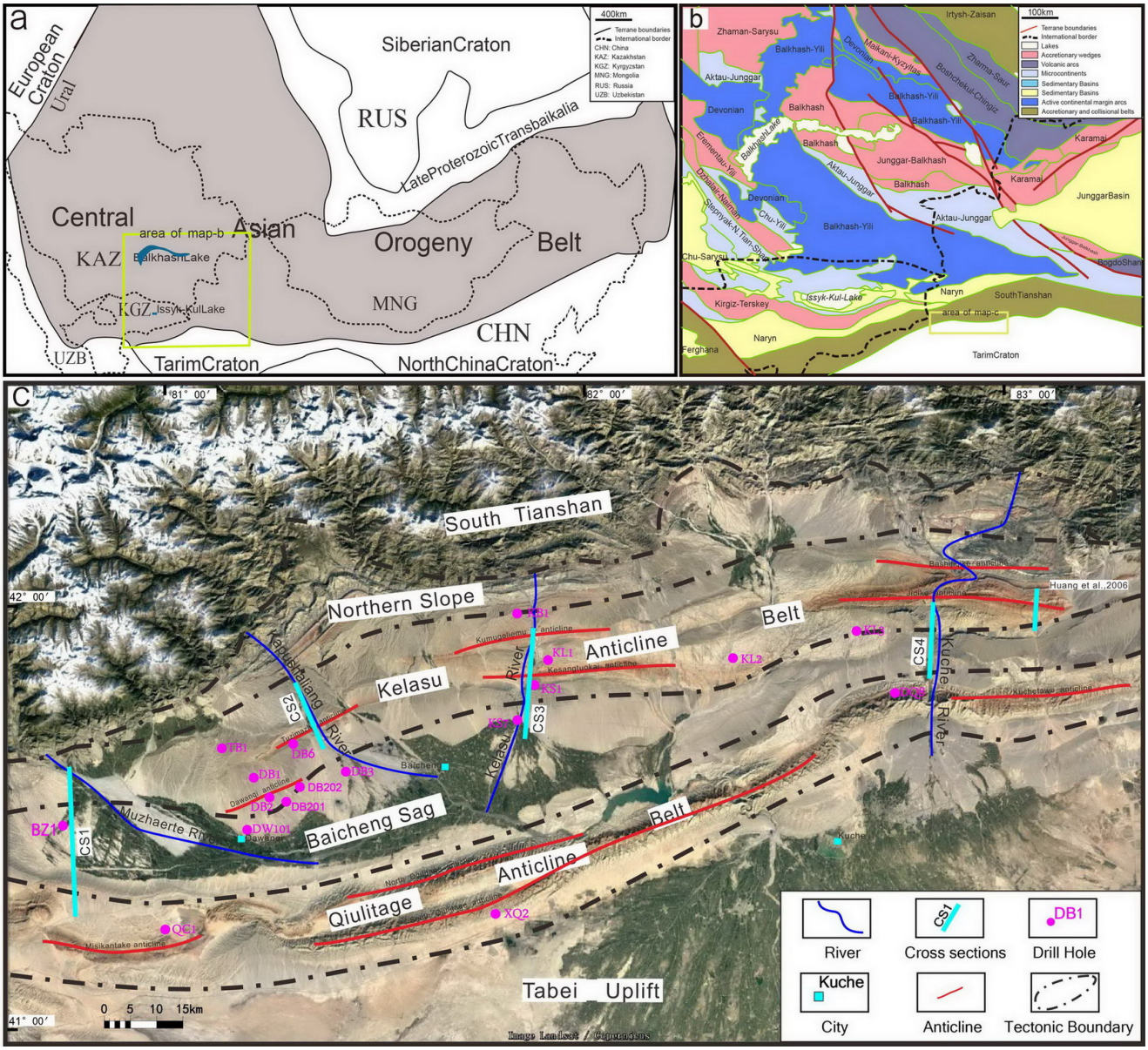
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The Cenozoic alluvial fan deposits in the Kuqa Depression of Tarim Basin, likely in response to a tectonic event, can provide critical evidence for constraining the timing of the South Tianshan uplift and reconstructing the paleotectonic evolution of the Central Asian Orogenic Belt. The sedimentological analysis shows that the conglomerates were deposited in alluvial fan environment. The initial uplift stage was started from the Jidike Formation at ~23Ma, resulting only small but angular gravels. Then the rapid uplift was since 15.97 Ma leading to the deposition of Kangcun conglomerate layers. And the next rapid and intensely uplift was started at ~4 Ma of the deposition of Kuqa Formation, according to ~2000m thick alluvial fan conglomerates. After a short quiescence, the most remarkable uplift of South Tianshan regenerated and caused the most extensive alluvial fan conglomerates of Xiyu Formation since 2.58 Ma and continuing to the present.

Keywords: Cenozoic, Central Asian Orogenic Belt, Conglomerate

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Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH

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FeOOH and AlOOH are dominant hydrous phases in sedimentary rocks deposited in the sea or lake basins which were considered to be possibly related to the deep water cycle by slab subduction. Therefore, understanding of the electrical conductivity behaviors of these phases are essential to explore the nature and dynamic process of the Earth's interior. In this study, electrical conductivity of diaspore (α-AlOOH), δ-AlOOH and ε-FeOOH was measured by impedance spectroscopy with a frequency range from 10^{-1} to 10^{6} Hz at pressures up to 15, 20 and 12 GPa and temperatures of 1200, 1200 and 1000 K well below the dehydration temperatures of these phases under the relevant pressures. For diaspore at 8, 10, and 12 GPa, the relationship between electrical conductivity and reciprocal temperature could be well fitted by the Arrhenius formula: $\sigma = \sigma_0 \exp[-(\Delta E + P\Delta V)/kT]$ and shows the pre-exponential factor (σ_0), activation energy (ΔE) and activation volume (ΔV) of 55.94 ±1.16 S/m, 0.547 ±0.016 eV and 1.683 ±0.123 cm^3/mol, respectively. However, data of diaspore obtained below 6 GPa could not be fitted by the Arrhenius formula, which was thought to be due to the remnant of free water in the sample caused by heating to insufficient temperature to proceed dehydration of interstitial water. Thus, it is quite difficult to measure the electrical conductivity of diaspore at low pressures. The electrical conductivity of diaspore increased with pressures ranging from 8 to 12 GPa by half order of magnitude and then the conductivity change with pressures from 12 to 15 GPa became negligibly small. The dominant conduction mechanism of diaspore is regarded as proton conduction. δ-AlOOH and ε-FeOOH show one and two orders of magnitude higher electrical conductivity than diaspore. Due to isostructural $CaCl_2$-type hydroxide structure, δ-AlOOH and ε-FeOOH display the nearly identical activation enthalpy (0.384 ±0.007 eV, 0.330 ±0.048 eV) which is relatively lower than that of diaspore.

Keywords: Electrical conductivity, Diaspore, δ-AlOOH, ε-FeOOH

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Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

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Azimuthal anisotropy in the upper mantle derived from seismic surface waves provides us with the information of mantle dynamics, such as the present-day mantle flow and the remnant of past deformation in the lithosphere and asthenosphere.The Australian plate is currently the fastest-moving tectonic plate including a large continent, encompassed by the intensive seismicity, particularly in its north (Indonesia) and east (Tonga-Kermadec to New Zealand). Thus, the entire continent can be covered by dense ray paths utilizing broad-band seismic stations deployed throughout the continent. This unique tectonic setting of Australian plate allows us to reconstruct high-resolution tomography models in the Australian region (e.g., Fishwick et al., 2008, Tectonics; Yoshizawa, 2014, PEPI).

In this study, we construct new phase speed maps in and around the Australian continent incorporating azimuthal anisotropy for both multi-mode Love and Rayleigh waves using the method developed by Yoshizawa & Kennett (2004, JGR). We employ the data base of path-specific multi-mode phase speeds for the fundamental mode and up to the fourth-higher modes by Yoshizawa (2014, PEPI), which has been measured by using the non-linear waveform fitting method (Yoshizawa & Ekstrom, 2010, GJI). We have performed checkerboard resolution tests as well as jackknife resampling tests, which suggest that our current phase speed data set can provide us with the robust estimation of azimuthally anisotropic phase speed maps in the Australasian region.

The multi-mode phase speed models indicate that the fastest directions of azimuthal anisotropy estimated from the different modes are consistent each other as far as they have the maximum sensitivity at the common depth. Comparisons between the direction of absolute plate motion (HS2-NUVEL-1) by Gripp & Gordon (1990, GRL) and the fastest direction of azimuthal anisotropy suggests that they agree well particularly at around the depth of 100km under the ocean area (Coral and Taman Seas) off the east-coast of the Australian continent and 300km under the continental area of Australia. These results are likely to reflect the differences in the depth of asthenosphere where the effects of the lattice preferred orientation of mantle materials due to the present-day mantle flow can be more significant.

キーワード：方位異方性、表面波トモグラフィー、オーストラリア
Keywords: Azimuthal anisotropy, Surface wave tomography, Australia

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Mapping multi-mode surface wave phase speeds in North America using mode-branch waveforms decomposed by linear Radon transform

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The use of higher-mode surface waves is inevitable for further enhancement of vertical resolution of tomography model since they are much more sensitive to the deep structure of the Earth’s upper mantle than the fundamental modes. However, measuring the multi-mode phase speeds is not a straightforward issue since wavetrains of different modes overlap each other in a seismogram.

We have developed the two-step array-based method for higher-mode analysis, which consists of (1) multi-mode phase speed measurements based of a classical *f-k* analysis using a long-range linear array with several-thousand kilometers (e.g., Nolet, 1975, GRL) and (2) modal waveform decomposition for the centroid location of the linear array using the linear Radon transform (e.g. Luo *et al.*, 2015, GJI).

We have previously applied the method to a large data set of seismograms observed at Transportable Array stations of USArray and employed the average phase speeds of linear array to map phase speed distributions in North America (Matsuzawa and Yoshizawa, SSJ Fall Meeting 2018; AGU Fall Meeting 2018). We could obtain phase speed maps of the fundamental-mode and the first four higher-mode surface waves. Although the large-scale anomalies (i.e., fast phase speeds in cratons in the stable eastern U.S., slow phase speeds in the tectonically-active western U.S.) can be identified, the lateral resolution of the phase speed maps were insufficient compared to inter-station/array based tomography models. This suggests that the small-scale tectonic features have been blurred and averaged out due to the direct use of long linear array (2000–4000 km) with relatively large measurement errors.

In this study, we apply the inter-station dispersion analysis with nonlinear waveform fitting (Hamada and Yoshizawa, 2015, GJI) to the decomposed modal waveforms of the fundamental-mode surface waves derived from method using the centroids of the linear array as imaginary stations.The lateral resolution of resultant phase speed maps has been improved up to about 2.0 degrees owing to the relatively shorter inter-station (inter-centroid) distances used in the inversions.We can find typical small-scale tectonic features in the inland region of eastern and central US. Average phase speeds along each short ray path (several-hundred kilometers) have been measured stably without interference by overtones, which is likely to be of help in improving the accuracy of the resultant tomography maps.

The decomposed modal waveforms of the higher modes as well as the fundamental mode can be applied to the secondary dispersion analyses such as the inter-station dispersion measurements as done in this study and/or a 2-D beamforming analysis, which can be expected to enhance both the lateral and vertical resolutions of surface wave tomography models.

キーワード：表面波、高次モード、アレイ解析、トモグラフィー、北米大陸

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Keywords: Surface wave, Higher mode, Array-based analysis, Tomography, North America

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Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_κ parameter: Application to the Pacific and Australian regions

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Radial anisotropy can be described by five elastic parameters; four parameters related to seismic wave speeds (β_v, β_h, α_h, α_v) and an additional fifth anisotropic parameter (η). One of the anisotropic parameters, η, was originally defined by Anderson (1961), but its physical proprieties have been rather unclear compared with other four parameters related to elastic velocity.

The re-defined fifth anisotropic parameter η_κ by Kawakatsu et al. (2015) makes it easier to understand its physical proprieties compared with conventional η. The introduction of η_κ affects the shape of sensitivity kernels of Rayleigh wave phase speeds with respect to η_κ, PH-wave speeds α_h and PV-wave speeds α_v (Kawakatsu, 2016b). Since the sensitivity of Rayleigh wave phase speeds to η_κ becomes greater than that to η, we can expect a possibility of resolving the η_κ parameter. However, since the inverse correlation between the sensitivity kernels of SV-wave speed β_v and η_κ becomes rather stronger, the trade-off between β_v and may easily occur. Therefore, the independent determination of η_κ parameter from the inversions of surface-wave dispersion curves is not a straightforward issue.

In this study, incorporating η_κ, we performed inversions for five elastic parameters in the upper mantle, employing a classical iterativenonlinear least-squares inversion method (Tarantola and Valette, 1982). We used multi-mode dispersion data sets of surface waves in the Australian region (Yoshizawa, 2014, PEPI) and Pacific (Isse et al., 2019, EPSL) to reconstruct 3-D radially anisotropic model. In these inversions, we used isotropic PREM as a starting model to avoid the influence of reference anisotropy model.

The retrieved spatial distribution of the η_κ parameter can be mostly explained by trade-offs with SV wave speed β_v at many locations in Australia and Pacific. Still, we can find structural features in our 3-D β_v and η_κ models, particularly in some major structural boundaries such as ridges and the Tasman Line in eastern Australia, which cannot simply be attributed to the trade-off between β_v and η_κ, indicating possible intrinsic character of η_κ in the upper mantle.

キーワード：鉛直異方性、表面波、インバージョン
Keywords: radial anisotropy, surface waves, inversion

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Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

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There has been a large discrepancy in creep properties of olivine aggregates in dry diffusion creep regime between Minnesota group (Hirth and Kohlstedt, 1995) and ANU group (Faul and Jackson, 2007). Our recent deformation experiments on undoped and doped olivine aggregate synthesized by a new method different from previous studies demonstrate (i) the activation energy of grain boundary diffusion creep of undoped olivine is 465 kJ/mol, (ii) the creep rate is enhanced by doping of Ca and Al above ~1200 C with very high temperature sensitivity well represented by activation energy of ~700 kJ/mol, and (iii) presence of melt phase had little contribution to the change in the creep strength. Such observations are consistent with Yamauchi and Takei (2016) which attributed the observation to pre-melting at near solidus.

In this study, we compile all rheological data of olivine diffusion creep based on solidus which changes with the chemical compositions and amount of water. The solidi of dry samples are estimated from experiments and/or phase diagrams. The solidi of wet samples are calculated by cryoscopic approach following Hirshmann et al. (2009). We demonstrate that not only dry but also wet data are well explained by the operation of grain boundary diffusion creep with activation energy of 465 kJ/mol at <~0.93 × solidus and 700 kJ/mol at >~0.93 ×solidus. The controversy on the effect of water on grain boundary diffusion by Mei and Kohlstedt (2000) and Fei et al. (2016) is explained by the experimental temperatures with respect to the solidus of their systems. The viscosity depth profile in the upper mantle based on our new diffusion creep model will be presented.

キーワード：マントルレオロジー、オリビン多結晶体、拡散クリープ
Keywords: mantle rheology, olivine aggregates, diffusion creep

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Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

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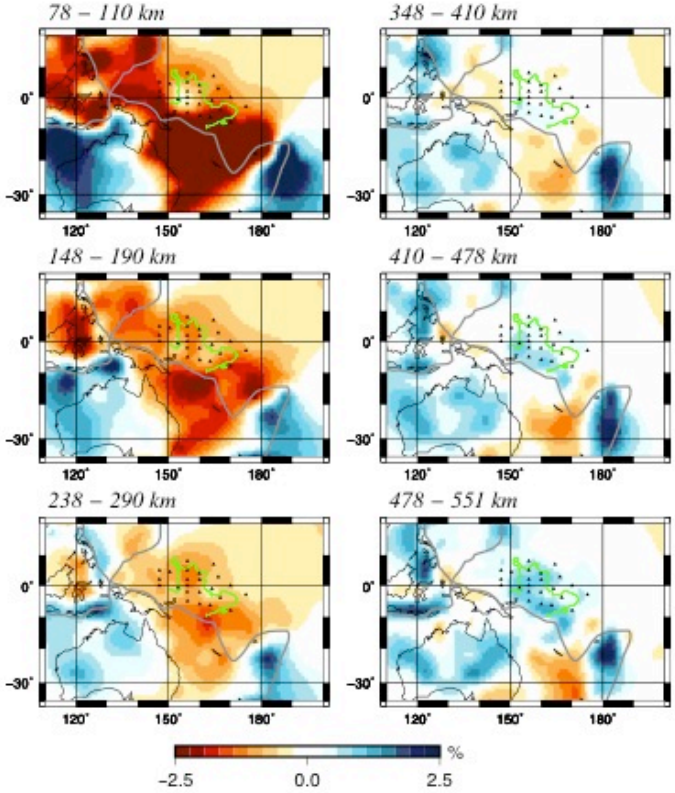
1. 国立研究開発法人海洋研究開発機構、2. 東京大学地震研究所、3. 神戸大学
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We determined three-dimensional S wave model beneath the Ontong Java Plateau (OJP) by finite frequency tomography using data recorded by broadband seismographs deployed at ocean bottom covered the OJP and at neighbor islands (Suetsugu *et al.*, 2018). Our dataset contains absolute and period-depended differential travel time data. The former consists of ~1,100,000 direct S-wave onset times reported by International Seismological Centre (ISC) and ~400 direct S-wave onset times picked up on broadband waveform records around the OJP and the latter is composed of ~3,000 differential traveltimes between two different stations around the OJP measured by waveform cross correlation at 7 different passband of which center periods varies from 5.3 sec to 42 sec. We used adaptive stacking method (Rawlinson and Kennett, 2004) to measure absolute travel time data near the OJP. These data were inverted based on the infinite frequency travel time tomography method for the absolute travel time data (Inoue *et al.*, 1990; Fukao *et al.*, 1992; Obayashi *et al.*, 2013) and the finite frequency travel time method for the relative travel time data (Dahlen *et al.*, 2000; Obayashi *et al.*, 2013). We obtained a well resolved S wave velocity model beneath the OJP. It shows significant high velocity anomalies in the mantle transition zone, which are considered as stagnant Pacific slabs related to the trench retreating as well as seafloor spreading in the Santa Cruz Basin and Melanesia Basin during the Eocene and Oligocene. It also reveals that S wave velocity just below the OJP is a little higher than the surrounding strong slow anomalies in the mantle shallower than 200 km. We will discuss these remarkable features beneath the OJP in comparison with P wave tomographic model (Obayashi *et al.*, 2018) in this presentation.

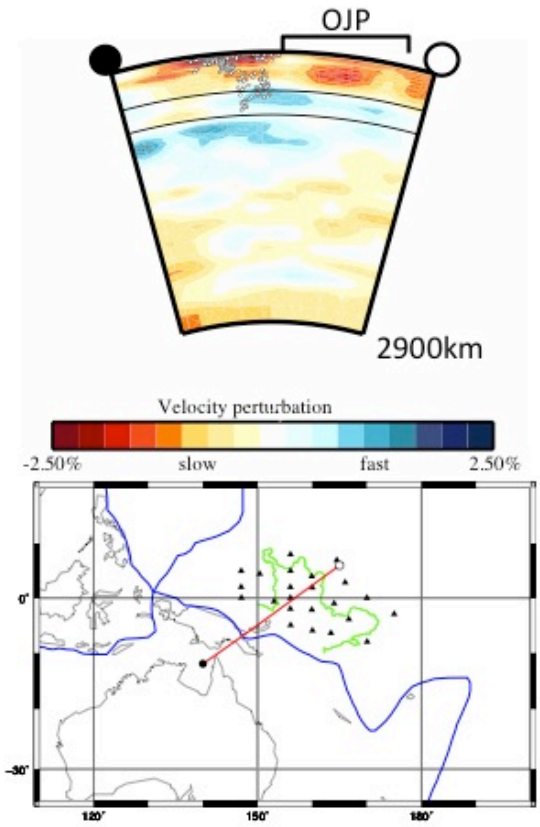
キーワード：有限波長トモグラフィー、S波速度構造
Keywords: finite frequency tomography, S wave velocity structure

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(a)



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Shear wave structure of the upper mantle beneath the Ontong Java Plateau

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Ontong Java Plateau (OJP) is the vastest Large Igneous Provinces (LIPs) in the oceanic region of the Earth. The OJP was emplaced at 122 and 90 Ma by massive volcanism, but the origin of this volcanism is still under discussion.
Richardson et al. (2000) obtained a large low-velocity root of the OJP extending as deep as 300km, though its existence and cause are still in debating.
One reason for poor understanding of the OJP is the insufficient information about the crust and mantle structure beneath the OJP because of the lack of long-term seafloor observation. Between 2014 and 2017, we conducted the first seismological and electromagnetic observations on the seafloor and islands in the OJP, named "OJP array", to clarify the origin of the OJP.
Using the broadband data from the OJP array as well as those from stations on land and seafloor in the western Pacific Ocean, we constructed three-dimensional shear wave speed structure beneath the OJP by surface wave tomography. using phase speed dispersions of Love and Rayleigh waves up to the 4th higher modes. Checkerboard resolution tests suggests that the spatial resolution of the obtained model is ~300km, which is higher than previous studies.

Obtained shear wave speed structure down to the depth of 300 km shows the following new features:
(1) In the center of the OJP at depths between 70–150 km, about 2% fast anomalies exists;
(2) No strong slow anomaly is found beneath the OJP at depths down to 300 km;
(3) Beneath the Caroline Islands, in the north of the OJP, 2 % slow anomalies exist, which may be associated with the Caroline hotspot activity.

These newly found features suggest that further investigation to reveal the origin of the OJP is necessary.

キーワード：上部マントル、オントンジャワ、表面波トモグラフィー、広帯域海底地震計
Keywords: upper mantle structure, Ontong Java, surface wave tomography, BBOBS

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Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

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Several computational studies have predicted post-post-perovskite transitions in MgSiO3 at ultrahigh pressures and temperatures which can occur at deep interiors of super-Earths: $MgSiO_3$ --> Mg_2SiO_4+ $MgSi_2O_5$ --> Mg_2SiO_4+ SiO_2 --> MgO + SiO_2) and recombination (MgO + $MgSiO_3$ --> Mg_2SiO_4 or SiO_2 + $MgSiO_3$ --> $MgSi_2O_5$) [1-5]. As demonstrated in a very recent numerical simulation, these transitions are crucially important in modeling interiors of super-Earths up to 20 times Earth’ s mass [6]. However, in the previous studies, these post-post-perovskite transitions were considered only for pure Mg-Si-O. In actual super-Earths, impurities, Fe, Al, or so forth, should exist. Here we will investigate effects of impurities on post-post-perovskite transitions: transition pressures, local atomic structures, and equation of states.

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キーワード：スーパーアース、ポストポストペロブスカイト転移、第一原理計算
Keywords: super-Earth, post-post-perovskite transition, first principles

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幌満かんらん岩から回収されたTiに富む特異的なコランダムの報告
Unsusual high-Ti corundum recovered from the Horoman peridotites, Hokkaido, Japan

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マントル内部物資循環において海洋地殻、大陸地殻が海洋プレート沈み込みによりマントル内へリサイクルし、マントル対流を通して地殻物質がマントル内に混染している可能性が指摘されているW.Xu et al.,(2008)。しかしその実態は不明であり、マントル-地殻鉱物大循環の解明のためリサイクル地殻鉱物を用いた物質科学的制約が急務である。北海道日高山脈に位置するマントル由来造山帯かんらん岩の幌満かんらん岩は蛇紋岩化していない新鮮なかんらん岩として知られ、メルトマントル反応による交代作用からレールゾライト、ハルツバージャイトの顕著な層序構造を示す。近年、Li et al.,(2017)により幌満かんらん岩からジルコンやルチル、低い炭素同位体比を有するダイヤモンドの産出が報告されており、幌満かんらん岩中に地殻由来鉱物が存在することが示唆されている。しかし問題点としてかんらん岩中の地殻鉱物は回収例が少なく、その起源に関しても不明確であるため、かんらん岩中に残存する地殻鉱物分離技術の改善・分離回収された鉱物の記載を目的とする。

本研究では、東邦オリビン工業（株）の採石場より採取したかんらん岩試料、ハルツバージャイト764㎏、レールゾライト 954㎏、それぞれを板状に切断し移送したものを用いた。ジョークラッシャーおよび連続式粉砕機を用いて0、1㎜大まで粉砕した後、粒度分離、比重分離、磁選処理を行い、ハンドピッキングおよびエポキシ樹脂への包埋、研磨を行った。レールゾライト内からジルコン６粒、ルチル(TiO) １粒が回収された。一方で、ハルツバージャイト内から非磁性鉱物を濃集させた粒子を樹脂に包埋し、EPMA(YNU機器分析評価センター)を用いた鉱物探査・鉱物同定を行った結果、コランダム(AlO) 12粒が分離回収され、包有物および付着鉱物が共生している様子が観察された。コランダム６粒子のSEM-EDS分析から、これらは①Si-Al-Kに富む珪酸塩相 ②Ti-Zr酸化物 ③Si-Ti合金　からなる包有物が確認された。

Morishita et al.,(1998; 2000)より幌満かんらん岩体ポンサヌシベツ川流域のハンレイ岩転石中から微量のCrを含むコランダムの産出が報告されている。本研究で得られたコランダムは、①Crがほぼ含まれない、②TiO2を最大で2.3 wt%程度含む、③Ti-Zr酸化物やSi-Ti合金といった特異な包有物を含む事などから異なる起源のコランダムであることが考えられる。世界中のコランダムの産出を比較した結果(Griffine et al.,2016; 2018)よりイスラエルMt.Carmelのアルカリ玄武岩由来捕獲鉱物中コランダム内に特異な包有物として（Ti-Zr酸化物、Si-Ti合金）が報告されている。また高いTiO2濃度(最大2,6wt%)、捕獲結晶としてダイヤモンドの産出も報告され、リサイクル海洋地殻玄武岩由来であると考えられている。以上より本研究で幌満ハルツバージャイトから分離回収されたコランダムとGriffine et al.,(2016; 2018)で報告されたコランダムは組成も共存鉱物も非常に類似していることから同様の起源を持つことを意味し、幌満ハルツバージャイト中コランダムもリサイクル海洋地殻由来コランダムであり、幌満かんらん岩中に鉱物レベルで地殻鉱物が存在することを示唆する。

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キーワード：マントルかんらん岩、リサイクル、コランダム、チタン
Keywords: mantle peridotite , recycle, corundum, Titanium

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Deformation experiments on akimotoite

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The ilmenite structure of $MgSiO_3$, known as akimotoite, is inferred to occur in cold subducting slabs in the bottom of Earth’ s mantle transition zone and the uppermost lower mantle along a low-temperature geotherm (Akaogi et al., 2002). Akimotoite is thought to be the most anisotropic mineral in the Earth’ s mantle transition zone (Zhang et al., 2005; Weidner & Ito,1985). The elastic anisotropy caused by the lattice preferred orientation of akimotoite due to slab-induced deformation may be used plausibly to interpret the significant seismic anisotropy observed in mid-mantle (depths 410-670km) (Nowacki et ali.,2015; Foley & Long, 2011). However, previous studies did not determine the slip plane or the dominant slip system precisely (Shiraishi et al., 2008). In this study, therefore, we conducted deformation experiment on akimotoite aggregates to investigate precise and detailed microstructures. For the preparation of starting material of akimotoite aggregates for deformation experiment, high pressure experiments using $MgSiO_3$ glass as starting material have been performed at 20-22GPa and 1400 ℃, in the Kawai-type multi anvil apparatus. The recovered samples were investigated by X-ray diffraction, electron probe microanalysis and scanning electron microscopy to identify phase, measure chemical composition and observe microstructure, respectively, showing that samples were well-sintered and no-crack akimotoite aggregates with grain size of 2-8 μm. These akimotoite aggregates were suitable as a starting material for deformation experiments. We subsequently conducted pure shear deformation experiment on such akimotoite aggregates at ~21 GPa and 1200 ˚C by using high pressure deformation apparatus, so called D-111 type apparatus, installed at Institute for Planetary Materials, Okayama University. The relationship between displacement and load of D-rams may suggest the mechanism change from elastic to plastic deformation with the progress of deformation. As a result, we observed the plastic deformation on the recovered sample and the strain and average strain rate were estimated to be ~0.12 and ~1.6×10^{-5} s^{-1}, respectively. It is considered that the strain of ~0.12 is sufficient to form the lattice preferred orientation which can be analyzed by electron backscattered diffraction technique.

Keywords: akimotoite, lattice preferred orientation, deformation at high pressure, anisotropy , mantle

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Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

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Fe- and Al-hydroxides (FeOOH and AlOOH) in sedimentary rocks form the top part of the subducted oceanic lithosphere and are known to be stable along a normal geotherm in the lower mantle. Banded Iron Formations (BIFs) and bauxite ore deposits formed in the Earth’s oceans can transport significant amount of water into the Earth’s deep interior by subduction of FeOOH and AlOOH and may occasionally serve water to the core. However, stabilities of these hydrous phases have not been well constrained in upper mantle conditions. We determined dehydration curves for FeOOH and AlOOH in upper mantle and mantle transition zone conditions (5–20 GPa, 673–1573K)by quench and *in situ*X-ray diffraction to constrain their capability of water transport to the deep mantle. Dehydration temperatures of these minerals increase with increasing pressure. Comparison between our results and geothermal gradients of subducting slab surfaces demonstrates dehydration of FeOOH in early subduction stage (around 2 GPa). In most cases, diaspore (AlOOH) also dehydrates in early subduction. Despite the implications of the stability of these phases at high pressure, our results show that the sediments located at the slab surface are unlikely candidates for transporting water to the deep mantle.

キーワード：水、堆積物、脱水、含水鉱物、沈み込み帯
Keywords: water, sediment, dehydration, hydrous minerals, subduction

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2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_29

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

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

Interdisciplinary approach can lead to a better understanding of dynamics and evolution of the deep interiors of the Earth and planets. We welcome any submissions of recent results in observational, theoretical and experimental studies on seismology, geomagnetism, mineral physics, dynamics of deep interiors, and any other relevant fields from researchers in many countries. Integration of such results is also welcome. In particular, we encourage any contributions focusing on "plate and mantle dynamics in Earth and terrestrial planets". We also encourage papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community.

[SIT23-P01] Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

*Walid Ben Mansour[1]、Guust Nolet[2]、Mario Ruiz[3]、Juan Carlos Afonso[1] (1.Department of Earth and Planetary Sciences, Macquarie University, Sydney (Australia)、2.Geoazur, Université Cote d'Azur, Sophia Antipolis (France)、3.Instituto Geofisco, Escuela Politecnica Nacional, Quito (Ecuador))

[SIT23-P02] **Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets**

*Youyue Zhang[1]、Takashi Yoshino[1]、Akira Yoneda[1]、Masahiro Osako[2] (1.Institute for Planetary Materials, Okayama University、2.Division of Physical Sciences, National Museum of Nature and Science)

[SIT23-P03] **The distribution of Cenozoic conglomerates and its sedimentological constraint on the uplift of the South Tianshan, NW China**

*SUN HAITAO[1] (1.China University of Petroluem-Beijing)

[SIT23-P04] **Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH**

*Ran Wang[1] (1.Institute for Planetary Materials, Okayama University)

[SIT23-P05] Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

*西村 祐香[1]、吉澤 和範[2] (1.北海道大学大学院理学院、2.北海道大学大学院理学研究院)

[SIT23-P06] Mapping multi-mode surface wave phase speeds in North America using mode-branch waveforms decomposed by linear Radon transform

*松澤 仁志[1]、吉澤 和範[2] (1.北海道大学大学院理学院、2.北海道大学大学院理学研究院)

[SIT23-P07] Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_K parameter: Application to the Pacific and Australian regions

奥山 秀弥[1]、*吉澤 和範[1,2]、川勝 均[3]、一瀬 建日[3] (1.北海道大学大学院理学院、2.北海道大学大学院理学研究院、3.東京大学地震研究所)

[SIT23-P08] Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

*谷部 功将[1]、平賀 岳彦[1] (1.東京大学大学院理学系研究科)

[SIT23-P09] Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

*堀内 美咲[3]、杉岡 裕子[3]、大林 政行[1]、末次 大輔[1]、塩原 肇[2]、伊藤 亜妃[1]、石原 靖[1]、田中 聡[1]、一瀬 建日[2]、利根川 貴志[1]、吉光 淳子[1]、小林 拓史[3] (1.国立研究開発法人海洋研究開発機構、2.東京大学地震研究所、3.神戸大学)

[SIT23-P10] Shear wave structure of the upper mantle beneath the Ontong Java Plateau

*一瀬 建日[1]、末次 大輔[2]、塩原 肇[1]、杉岡 裕子[3]、伊藤 亜妃[2]、石原 靖[2]、田中 聡[2]、大林 政行[2]、利根川 貴志[2]、吉光 淳子[2]、小林 拓史[3]、吉澤 和範[4] (1.東京大学地震研究所、2.海洋研究開発機構、3.神戸大学、4.北海道大学大学院理学研究院)

[SIT23-P11] Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

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[SIT23-P12] 幌満かんらん岩から回収されたTiに富む特異的なコランダムの報告

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[SIT23-P13] Deformation experiments on akimotoite

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[SIT23-P14] Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

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Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

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The Galápagos archipelago, located west of Ecuador, is a good example where a mantle plume interacts with a spreading center and modifies physical and chemical properties of the oceanic lithosphere. The Galápagos Spreading Center (GSC) and the Galápagos hotspot interact over more than 1,000 km with unusual features for a hot spot region (large number of historical active volcanoes, large range of lavas composition, alignment of volcanic centers and seamounts). To bring new information on the physical and chemical properties of this region, we are constructing a new P-wave velocity model of this region by combining data from 10 seismic broadband stations and from 9 MERMAIDS (Mobile Earthquake Recorder in Marine Areas by Independent Divers) deployed in this region between 2014 and 2016. We focus on Pn head waves to better constraint the Moho depth in this region and image the interaction between the hot spot and the GSC. We selected150 seismic events between May 2014 and September 2016, with epicentral distance between $3^{o}$and 35^{o} and picked more than 2,500 Pn phases that we will invert in a probabilistic tomography inversion in a second step. In this presentation, we will show examples and statistics of Pn data. We will discuss the benefits of developing a multi-observable thermochemical tomography in this region to better image the intricate interaction of a hot spot with the overlying oceanic lithosphere and evaluate current physio-chemical evolutionary models.

Keywords: Pn tomography, mantle plume, thermochemical structure

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Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets

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Knowledge of thermal transport properties of mantle materials is essential for understanding the thermal state and dynamics of the Earth and planetary interiors. Previous studies have suggested that temperature and pressure dependences of thermal conductivity can affect mantle convection and plate tectonics involving subduction dynamics. Olivine is the most abundant mineral in the Earth's upper mantle and chemical composition of olivine in the Earth's upper mantle is characterized by high forsterite content around Fo_{90}. For other terrestrial planets, Mercury is believed to have a FeO-poor mantle along with end member silicates, whereas olivine in the Martian mantle would be more Fe-rich, speculated to be Fo_{67}. Recent studies suggested that surface of some asteroids is dominated by olivine of composition from Fo_{49} to Fo_{70}. Hence, the effect of Fe content in olivine on thermal conductivity could be significant for understanding the thermal structure and cooling history of these terrestrial planets and asteroids.

In this study, thermal conductivity and diffusivity of olivine were determined simultaneously by combining multi-anvil high pressure experimental technique and pulse heating method. Thermal properties of olivine with six different Fe contents (Fo, Fo_{90}, Fo_{70}, Fo_{50}, Fo_{31}, Fo_{0}) were measured under the Earth's upper mantle condition in a 5000-ton Kawai type multi-anvil press. The minimum λ was found to be at composition near Fo_{31}; the absolute λ value of Fo_{31} is about 65% lower than that of Fo. Small amounts of minor elements can strongly reduce the thermal conductivity at low temperature; λ value of Fo90 is about 50% of Fo at room temperature. As temperature increases, the difference in λ among olivine samples with various Fe contents tends to become smaller. Thermal conductivities of polycrystalline olivine have smaller absolute values and weak pressure and temperature dependences, compared with those of natural single crystal olivine determined by previous studies. Heat capacity of olivine calculated from λ and κ is independent of pressure and is controlled by nearly constant thermal expansion coefficient of Fo_{70} and Fo_{50} with increasing temperature. Smaller λ of olivine aggregate with high Fe content would produce thicker crust in the Fe-rich Mars, while heat in the Fe-poor Mercury can escape faster than the other terrestrial planets. Olivine-dominant asteroids with high Fe concentration could have longer cooling history and lower thermal inertia on the surface.

Keywords: Thermal conductivity, Olivine, Heat capacity, High pressure, Mantle

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The distribution of Cenozoic conglomerates and its sedimentological constraint on the uplift of the South Tianshan, NW China

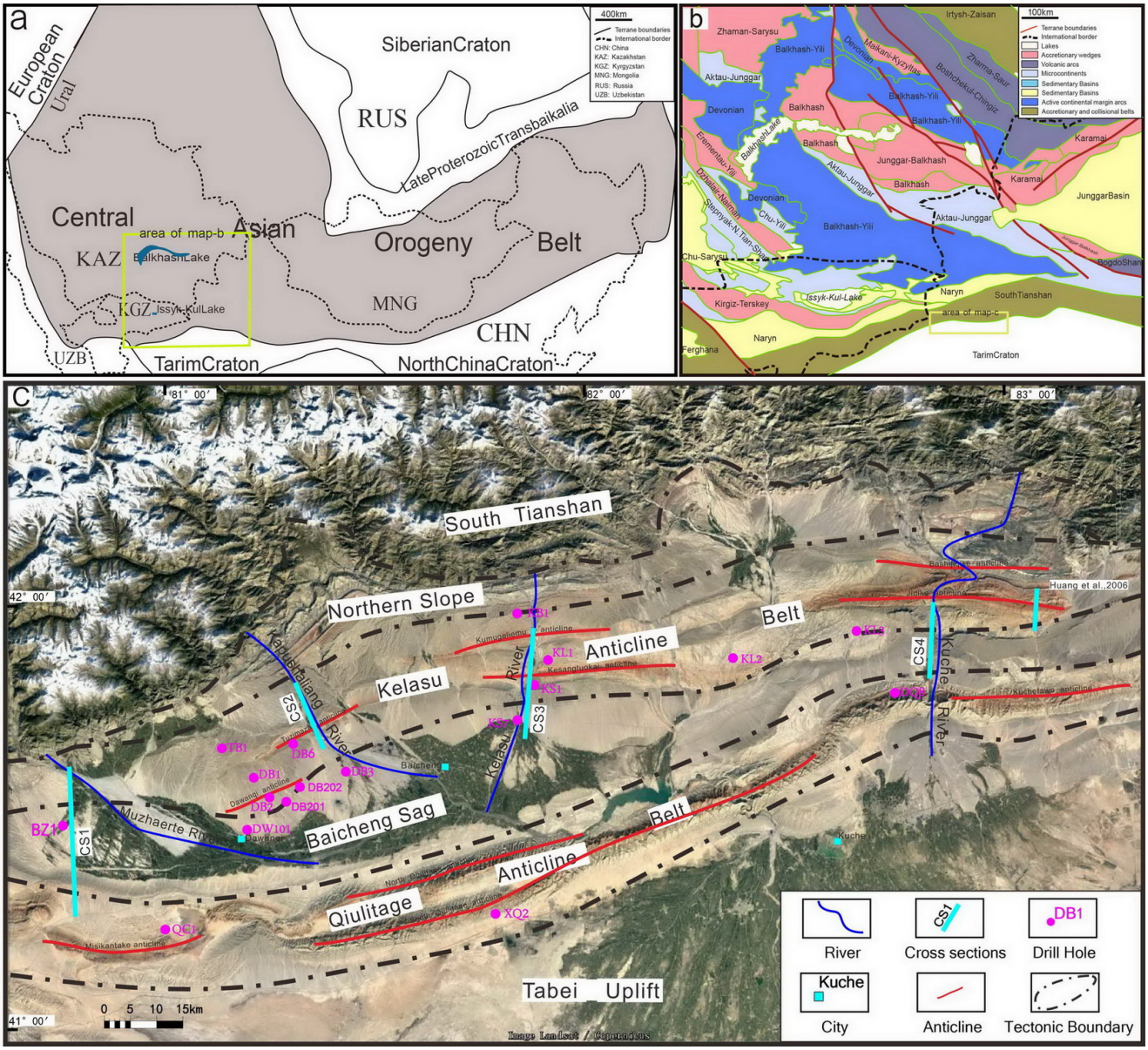
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The Cenozoic alluvial fan deposits in the Kuqa Depression of Tarim Basin, likely in response to a tectonic event, can provide critical evidence for constraining the timing of the South Tianshan uplift and reconstructing the paleotectonic evolution of the Central Asian Orogenic Belt. The sedimentological analysis shows that the conglomerates were deposited in alluvial fan environment. The initial uplift stage was started from the Jidike Formation at ~23Ma, resulting only small but angular gravels. Then the rapid uplift was since 15.97 Ma leading to the deposition of Kangcun conglomerate layers. And the next rapid and intensely uplift was started at ~4 Ma of the deposition of Kuqa Formation, according to ~2000m thick alluvial fan conglomerates. After a short quiescence, the most remarkable uplift of South Tianshan regenerated and caused the most extensive alluvial fan conglomerates of Xiyu Formation since 2.58 Ma and continuing to the present.

Keywords: Cenozoic, Central Asian Orogenic Belt, Conglomerate

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Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH

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FeOOH and AlOOH are dominant hydrous phases in sedimentary rocks deposited in the sea or lake basins which were considered to be possibly related to the deep water cycle by slab subduction. Therefore, understanding of the electrical conductivity behaviors of these phases are essential to explore the nature and dynamic process of the Earth's interior. In this study, electrical conductivity of diaspore (α-AlOOH), δ-AlOOH and ε-FeOOH was measured by impedance spectroscopy with a frequency range from 10^{-1} to 10^{6} Hz at pressures up to 15, 20 and 12 GPa and temperatures of 1200, 1200 and 1000 K well below the dehydration temperatures of these phases under the relevant pressures. For diaspore at 8, 10, and 12 GPa, the relationship between electrical conductivity and reciprocal temperature could be well fitted by the Arrhenius formula: $\sigma = \sigma_0 \exp[-(\Delta E + P\Delta V)/kT]$ and shows the pre-exponential factor (σ_0), activation energy (ΔE) and activation volume (ΔV) of 55.94 ±1.16 S/m, 0.547 ±0.016 eV and 1.683 ±0.123 cm^3/mol, respectively. However, data of diaspore obtained below 6 GPa could not be fitted by the Arrhenius formula, which was thought to be due to the remnant of free water in the sample caused by heating to insufficient temperature to proceed dehydration of interstitial water. Thus, it is quite difficult to measure the electrical conductivity of diaspore at low pressures. The electrical conductivity of diaspore increased with pressures ranging from 8 to 12 GPa by half order of magnitude and then the conductivity change with pressures from 12 to 15 GPa became negligibly small. The dominant conduction mechanism of diaspore is regarded as proton conduction. δ-AlOOH and ε-FeOOH show one and two orders of magnitude higher electrical conductivity than diaspore. Due to isostructural $CaCl_2$-type hydroxide structure, δ-AlOOH and ε-FeOOH display the nearly identical activation enthalpy (0.384 ±0.007 eV, 0.330 ±0.048 eV) which is relatively lower than that of diaspore.

Keywords: Electrical conductivity, Diaspore, δ-AlOOH, ε-FeOOH

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Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

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Azimuthal anisotropy in the upper mantle derived from seismic surface waves provides us with the information of mantle dynamics, such as the present-day mantle flow and the remnant of past deformation in the lithosphere and asthenosphere.The Australian plate is currently the fastest-moving tectonic plate including a large continent, encompassed by the intensive seismicity, particularly in its north (Indonesia) and east (Tonga-Kermadec to New Zealand). Thus, the entire continent can be covered by dense ray paths utilizing broad-band seismic stations deployed throughout the continent. This unique tectonic setting of Australian plate allows us to reconstruct high-resolution tomography models in the Australian region (e.g., Fishwick et al., 2008, Tectonics; Yoshizawa, 2014, PEPI).

In this study, we construct new phase speed maps in and around the Australian continent incorporating azimuthal anisotropy for both multi-mode Love and Rayleigh waves using the method developed by Yoshizawa & Kennett (2004, JGR). We employ the data base of path-specific multi-mode phase speeds for the fundamental mode and up to the fourth-higher modes by Yoshizawa (2014, PEPI), which has been measured by using the non-linear waveform fitting method (Yoshizawa & Ekstrom, 2010, GJI). We have performed checkerboard resolution tests as well as jackknife resampling tests, which suggest that our current phase speed data set can provide us with the robust estimation of azimuthally anisotropic phase speed maps in the Australasian region.

The multi-mode phase speed models indicate that the fastest directions of azimuthal anisotropy estimated from the different modes are consistent each other as far as they have the maximum sensitivity at the common depth. Comparisons between the direction of absolute plate motion (HS2-NUVEL-1) by Gripp & Gordon (1990, GRL) and the fastest direction of azimuthal anisotropy suggests that they agree well particularly at around the depth of 100km under the ocean area (Coral and Taman Seas) off the east-coast of the Australian continent and 300km under the continental area of Australia. These results are likely to reflect the differences in the depth of asthenosphere where the effects of the lattice preferred orientation of mantle materials due to the present-day mantle flow can be more significant.

キーワード：方位異方性、表面波トモグラフィー、オーストラリア
Keywords: Azimuthal anisotropy, Surface wave tomography, Australia

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Mapping multi-mode surface wave phase speeds in North America using mode-branch waveforms decomposed by linear Radon transform

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The use of higher-mode surface waves is inevitable for further enhancement of vertical resolution of tomography model since they are much more sensitive to the deep structure of the Earth’s upper mantle than the fundamental modes. However, measuring the multi-mode phase speeds is not a straightforward issue since wavetrains of different modes overlap each other in a seismogram.

We have developed the two-step array-based method for higher-mode analysis, which consists of (1) multi-mode phase speed measurements based of a classical *f-k* analysis using a long-range linear array with several-thousand kilometers (e.g., Nolet, 1975, GRL) and (2) modal waveform decomposition for the centroid location of the linear array using the linear Radon transform (e.g. Luo *et al.*, 2015, GJI).

We have previously applied the method to a large data set of seismograms observed at Transportable Array stations of USArray and employed the average phase speeds of linear array to map phase speed distributions in North America (Matsuzawa and Yoshizawa, SSJ Fall Meeting 2018; AGU Fall Meeting 2018). We could obtain phase speed maps of the fundamental-mode and the first four higher-mode surface waves. Although the large-scale anomalies (i.e., fast phase speeds in cratons in the stable eastern U.S., slow phase speeds in the tectonically-active western U.S.) can be identified, the lateral resolution of the phase speed maps were insufficient compared to inter-station/array based tomography models. This suggests that the small-scale tectonic features have been blurred and averaged out due to the direct use of long linear array (2000–4000 km) with relatively large measurement errors.

In this study, we apply the inter-station dispersion analysis with nonlinear waveform fitting (Hamada and Yoshizawa, 2015, GJI) to the decomposed modal waveforms of the fundamental-mode surface waves derived from method using the centroids of the linear array as imaginary stations.The lateral resolution of resultant phase speed maps has been improved up to about 2.0 degrees owing to the relatively shorter inter-station (inter-centroid) distances used in the inversions.We can find typical small-scale tectonic features in the inland region of eastern and central US. Average phase speeds along each short ray path (several-hundred kilometers) have been measured stably without interference by overtones, which is likely to be of help in improving the accuracy of the resultant tomography maps.

The decomposed modal waveforms of the higher modes as well as the fundamental mode can be applied to the secondary dispersion analyses such as the inter-station dispersion measurements as done in this study and/or a 2-D beamforming analysis, which can be expected to enhance both the lateral and vertical resolutions of surface wave tomography models.

キーワード：表面波、高次モード、アレイ解析、トモグラフィー、北米大陸

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Keywords: Surface wave, Higher mode, Array-based analysis, Tomography, North America

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Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_κ parameter: Application to the Pacific and Australian regions

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Radial anisotropy can be described by five elastic parameters; four parameters related to seismic wave speeds (β_v, β_h, α_h, α_v) and an additional fifth anisotropic parameter (η). One of the anisotropic parameters, η, was originally defined by Anderson (1961), but its physical proprieties have been rather unclear compared with other four parameters related to elastic velocity.

The re-defined fifth anisotropic parameter η_κ by Kawakatsu et al. (2015) makes it easier to understand its physical proprieties compared with conventional η. The introduction of η_κ affects the shape of sensitivity kernels of Rayleigh wave phase speeds with respect to η_κ, PH-wave speeds α_h and PV-wave speeds α_v (Kawakatsu, 2016b). Since the sensitivity of Rayleigh wave phase speeds to η_κ becomes greater than that to η, we can expect a possibility of resolving the η_κ parameter. However, since the inverse correlation between the sensitivity kernels of SV-wave speed β_v and η_κ becomes rather stronger, the trade-off between β_v and may easily occur. Therefore, the independent determination of η_κ parameter from the inversions of surface-wave dispersion curves is not a straightforward issue.

In this study, incorporating η_κ, we performed inversions for five elastic parameters in the upper mantle, employing a classical iterativenonlinear least-squares inversion method (Tarantola and Valette, 1982). We used multi-mode dispersion data sets of surface waves in the Australian region (Yoshizawa, 2014, PEPI) and Pacific (Isse et al., 2019, EPSL) to reconstruct 3-D radially anisotropic model. In these inversions, we used isotropic PREM as a starting model to avoid the influence of reference anisotropy model.

The retrieved spatial distribution of the η_κ parameter can be mostly explained by trade-offs with SV wave speed β_v at many locations in Australia and Pacific. Still, we can find structural features in our 3-D β_v and η_κ models, particularly in some major structural boundaries such as ridges and the Tasman Line in eastern Australia, which cannot simply be attributed to the trade-off between β_v and η_κ, indicating possible intrinsic character of η_κ in the upper mantle.

キーワード：鉛直異方性、表面波、インバージョン
Keywords: radial anisotropy, surface waves, inversion

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Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

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There has been a large discrepancy in creep properties of olivine aggregates in dry diffusion creep regime between Minnesota group (Hirth and Kohlstedt, 1995) and ANU group (Faul and Jackson, 2007). Our recent deformation experiments on undoped and doped olivine aggregate synthesized by a new method different from previous studies demonstrate (i) the activation energy of grain boundary diffusion creep of undoped olivine is 465 kJ/mol, (ii) the creep rate is enhanced by doping of Ca and Al above ~1200 C with very high temperature sensitivity well represented by activation energy of ~700 kJ/mol, and (iii) presence of melt phase had little contribution to the change in the creep strength. Such observations are consistent with Yamauchi and Takei (2016) which attributed the observation to pre-melting at near solidus.

In this study, we compile all rheological data of olivine diffusion creep based on solidus which changes with the chemical compositions and amount of water. The solidi of dry samples are estimated from experiments and/or phase diagrams. The solidi of wet samples are calculated by cryoscopic approach following Hirshmann et al. (2009). We demonstrate that not only dry but also wet data are well explained by the operation of grain boundary diffusion creep with activation energy of 465 kJ/mol at <~0.93 × solidus and 700 kJ/mol at >~0.93 ×solidus. The controversy on the effect of water on grain boundary diffusion by Mei and Kohlstedt (2000) and Fei et al. (2016) is explained by the experimental temperatures with respect to the solidus of their systems. The viscosity depth profile in the upper mantle based on our new diffusion creep model will be presented.

キーワード：マントルレオロジー、オリビン多結晶体、拡散クリープ
Keywords: mantle rheology, olivine aggregates, diffusion creep

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Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

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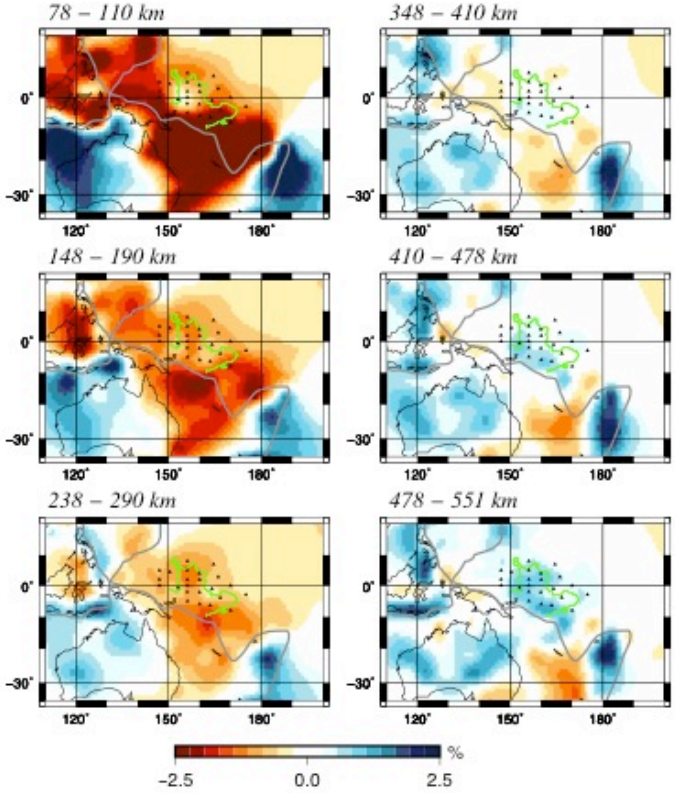
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We determined three-dimensional S wave model beneath the Ontong Java Plateau (OJP) by finite frequency tomography using data recorded by broadband seismographs deployed at ocean bottom covered the OJP and at neighbor islands (Suetsugu *et al.*, 2018). Our dataset contains absolute and period-depended differential travel time data. The former consists of ~1,100,000 direct S-wave onset times reported by International Seismological Centre (ISC) and ~400 direct S-wave onset times picked up on broadband waveform records around the OJP and the latter is composed of ~3,000 differential traveltimes between two different stations around the OJP measured by waveform cross correlation at 7 different passband of which center periods varies from 5.3 sec to 42 sec. We used adaptive stacking method (Rawlinson and Kennett, 2004) to measure absolute travel time data near the OJP. These data were inverted based on the infinite frequency travel time tomography method for the absolute travel time data (Inoue *et al.*, 1990; Fukao *et al.*, 1992; Obayashi *et al.*, 2013) and the finite frequency travel time method for the relative travel time data (Dahlen *et al.*, 2000; Obayashi *et al.*, 2013). We obtained a well resolved S wave velocity model beneath the OJP. It shows significant high velocity anomalies in the mantle transition zone, which are considered as stagnant Pacific slabs related to the trench retreating as well as seafloor spreading in the Santa Cruz Basin and Melanesia Basin during the Eocene and Oligocene. It also reveals that S wave velocity just below the OJP is a little higher than the surrounding strong slow anomalies in the mantle shallower than 200 km. We will discuss these remarkable features beneath the OJP in comparison with P wave tomographic model (Obayashi *et al.*, 2018) in this presentation.

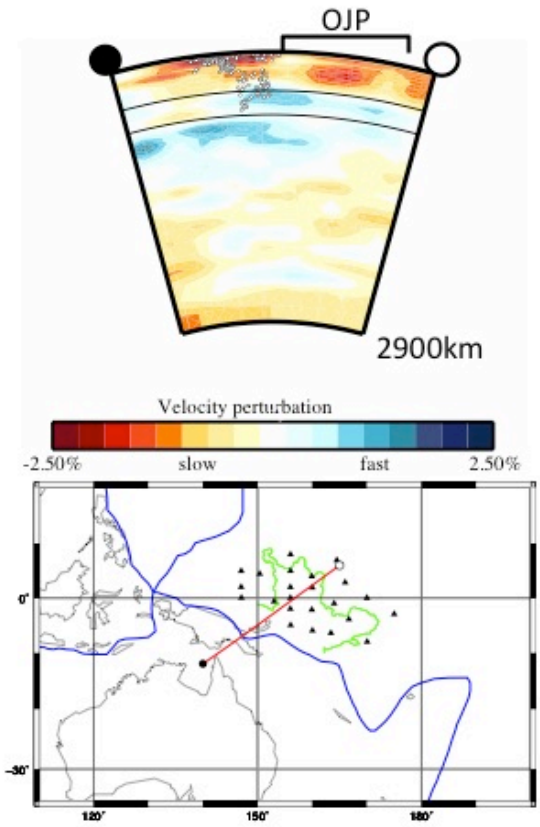
キーワード：有限波長トモグラフィー、S波速度構造
Keywords: finite frequency tomography, S wave velocity structure

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(a)



(b)



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Shear wave structure of the upper mantle beneath the Ontong Java Plateau

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Ontong Java Plateau (OJP) is the vastest Large Igneous Provinces (LIPs) in the oceanic region of the Earth. The OJP was emplaced at 122 and 90 Ma by massive volcanism, but the origin of this volcanism is still under discussion.
Richardson et al. (2000) obtained a large low-velocity root of the OJP extending as deep as 300km, though its existence and cause are still in debating.
One reason for poor understanding of the OJP is the insufficient information about the crust and mantle structure beneath the OJP because of the lack of long-term seafloor observation. Between 2014 and 2017, we conducted the first seismological and electromagnetic observations on the seafloor and islands in the OJP, named "OJP array", to clarify the origin of the OJP.
Using the broadband data from the OJP array as well as those from stations on land and seafloor in the western Pacific Ocean, we constructed three-dimensional shear wave speed structure beneath the OJP by surface wave tomography. using phase speed dispersions of Love and Rayleigh waves up to the 4th higher modes. Checkerboard resolution tests suggests that the spatial resolution of the obtained model is ~300km, which is higher than previous studies.

Obtained shear wave speed structure down to the depth of 300 km shows the following new features:
(1) In the center of the OJP at depths between 70–150 km, about 2% fast anomalies exists;
(2) No strong slow anomaly is found beneath the OJP at depths down to 300 km;
(3) Beneath the Caroline Islands, in the north of the OJP, 2 % slow anomalies exist, which may be associated with the Caroline hotspot activity.

These newly found features suggest that further investigation to reveal the origin of the OJP is necessary.

キーワード：上部マントル、オントンジャワ、表面波トモグラフィー、広帯域海底地震計
Keywords: upper mantle structure, Ontong Java, surface wave tomography, BBOBS

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Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

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Several computational studies have predicted post-post-perovskite transitions in MgSiO3 at ultrahigh pressures and temperatures which can occur at deep interiors of super-Earths: $MgSiO_3$ --> Mg_2SiO_4+ $MgSi_2O_5$ --> Mg_2SiO_4+ SiO_2 --> MgO + SiO_2) and recombination (MgO + $MgSiO_3$ --> Mg_2SiO_4 or SiO_2 + $MgSiO_3$ --> $MgSi_2O_5$) [1-5]. As demonstrated in a very recent numerical simulation, these transitions are crucially important in modeling interiors of super-Earths up to 20 times Earth’ s mass [6]. However, in the previous studies, these post-post-perovskite transitions were considered only for pure Mg-Si-O. In actual super-Earths, impurities, Fe, Al, or so forth, should exist. Here we will investigate effects of impurities on post-post-perovskite transitions: transition pressures, local atomic structures, and equation of states.

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キーワード：スーパーアース、ポストポストペロブスカイト転移、第一原理計算
Keywords: super-Earth, post-post-perovskite transition, first principles

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幌満かんらん岩から回収されたTiに富む特異的なコランダムの報告
Unsusual high-Ti corundum recovered from the Horoman peridotites, Hokkaido, Japan

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マントル内部物資循環において海洋地殻、大陸地殻が海洋プレート沈み込みによりマントル内へリサイクルし、マントル対流を通して地殻物質がマントル内に混染している可能性が指摘されているW.Xu et al.,(2008)。しかしその実態は不明であり、マントル-地殻鉱物大循環の解明のためリサイクル地殻鉱物を用いた物質科学的制約が急務である。北海道日高山脈に位置するマントル由来造山帯かんらん岩の幌満かんらん岩は蛇紋岩化していない新鮮なかんらん岩として知られ、メルトマントル反応による交代作用からレールゾライト、ハルツバージャイトの顕著な層序構造を示す。近年、Li et al.,(2017)により幌満かんらん岩からジルコンやルチル、低い炭素同位体比を有するダイヤモンドの産出が報告されており、幌満かんらん岩中に地殻由来鉱物が存在することが示唆されている。しかし問題点としてかんらん岩中の地殻鉱物は回収例が少なく、その起源に関しても不明確であるため、かんらん岩中に残存する地殻鉱物分離技術の改善・分離回収された鉱物の記載を目的とする。

本研究では、東邦オリビン工業（株）の採石場より採取したかんらん岩試料、ハルツバージャイト764㎏、レールゾライト 954㎏、それぞれを板状に切断し移送したものを用いた。ジョークラッシャーおよび連続式粉砕機を用いて0、1㎜大まで粉砕した後、粒度分離、比重分離、磁選処理を行い、ハンドピッキングおよびエポキシ樹脂への包埋、研磨を行った。レールゾライト内からジルコン６粒、ルチル(TiO) １粒が回収された。一方で、ハルツバージャイト内から非磁性鉱物を濃集させた粒子を樹脂に包埋し、EPMA(YNU機器分析評価センター)を用いた鉱物探査・鉱物同定を行った結果、コランダム(AlO) 12粒が分離回収され、包有物および付着鉱物が共生している様子が観察された。コランダム６粒子のSEM-EDS分析から、これらは①Si-Al-Kに富む珪酸塩相 ②Ti-Zr酸化物 ③Si-Ti合金　からなる包有物が確認された。

Morishita et al.,(1998; 2000)より幌満かんらん岩体ポンサヌシベツ川流域のハンレイ岩転石中から微量のCrを含むコランダムの産出が報告されている。本研究で得られたコランダムは、①Crがほぼ含まれない、②TiO2を最大で2.3 wt%程度含む、③Ti-Zr酸化物やSi-Ti合金といった特異な包有物を含む事などから異なる起源のコランダムであることが考えられる。世界中のコランダムの産出を比較した結果(Griffine et al.,2016; 2018)よりイスラエルMt.Carmelのアルカリ玄武岩由来捕獲鉱物中コランダム内に特異な包有物として（Ti-Zr酸化物、Si-Ti合金）が報告されている。また高いTiO2濃度(最大2,6wt%)、捕獲結晶としてダイヤモンドの産出も報告され、リサイクル海洋地殻玄武岩由来であると考えられている。以上より本研究で幌満ハルツバージャイトから分離回収されたコランダムとGriffine et al.,(2016; 2018)で報告されたコランダムは組成も共存鉱物も非常に類似していることから同様の起源を持つことを意味し、幌満ハルツバージャイト中コランダムもリサイクル海洋地殻由来コランダムであり、幌満かんらん岩中に鉱物レベルで地殻鉱物が存在することを示唆する。

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キーワード：マントルかんらん岩、リサイクル、コランダム、チタン
Keywords: mantle peridotite , recycle, corundum, Titanium

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Deformation experiments on akimotoite

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The ilmenite structure of $MgSiO_3$, known as akimotoite, is inferred to occur in cold subducting slabs in the bottom of Earth’ s mantle transition zone and the uppermost lower mantle along a low-temperature geotherm (Akaogi et al., 2002). Akimotoite is thought to be the most anisotropic mineral in the Earth’ s mantle transition zone (Zhang et al., 2005; Weidner & Ito,1985). The elastic anisotropy caused by the lattice preferred orientation of akimotoite due to slab-induced deformation may be used plausibly to interpret the significant seismic anisotropy observed in mid-mantle (depths 410-670km) (Nowacki et ali.,2015; Foley & Long, 2011). However, previous studies did not determine the slip plane or the dominant slip system precisely (Shiraishi et al., 2008). In this study, therefore, we conducted deformation experiment on akimotoite aggregates to investigate precise and detailed microstructures. For the preparation of starting material of akimotoite aggregates for deformation experiment, high pressure experiments using $MgSiO_3$ glass as starting material have been performed at 20-22GPa and 1400 ℃, in the Kawai-type multi anvil apparatus. The recovered samples were investigated by X-ray diffraction, electron probe microanalysis and scanning electron microscopy to identify phase, measure chemical composition and observe microstructure, respectively, showing that samples were well-sintered and no-crack akimotoite aggregates with grain size of 2-8 μm. These akimotoite aggregates were suitable as a starting material for deformation experiments. We subsequently conducted pure shear deformation experiment on such akimotoite aggregates at ~21 GPa and 1200 ˚C by using high pressure deformation apparatus, so called D-111 type apparatus, installed at Institute for Planetary Materials, Okayama University. The relationship between displacement and load of D-rams may suggest the mechanism change from elastic to plastic deformation with the progress of deformation. As a result, we observed the plastic deformation on the recovered sample and the strain and average strain rate were estimated to be ~0.12 and ~1.6×10^{-5} s^{-1}, respectively. It is considered that the strain of ~0.12 is sufficient to form the lattice preferred orientation which can be analyzed by electron backscattered diffraction technique.

Keywords: akimotoite, lattice preferred orientation, deformation at high pressure, anisotropy , mantle

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Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

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Fe- and Al-hydroxides (FeOOH and AlOOH) in sedimentary rocks form the top part of the subducted oceanic lithosphere and are known to be stable along a normal geotherm in the lower mantle. Banded Iron Formations (BIFs) and bauxite ore deposits formed in the Earth’s oceans can transport significant amount of water into the Earth’s deep interior by subduction of FeOOH and AlOOH and may occasionally serve water to the core. However, stabilities of these hydrous phases have not been well constrained in upper mantle conditions. We determined dehydration curves for FeOOH and AlOOH in upper mantle and mantle transition zone conditions (5–20 GPa, 673–1573K)by quench and *in situ*X-ray diffraction to constrain their capability of water transport to the deep mantle. Dehydration temperatures of these minerals increase with increasing pressure. Comparison between our results and geothermal gradients of subducting slab surfaces demonstrates dehydration of FeOOH in early subduction stage (around 2 GPa). In most cases, diaspore (AlOOH) also dehydrates in early subduction. Despite the implications of the stability of these phases at high pressure, our results show that the sediments located at the slab surface are unlikely candidates for transporting water to the deep mantle.

キーワード：水、堆積物、脱水、含水鉱物、沈み込み帯
Keywords: water, sediment, dehydration, hydrous minerals, subduction

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

2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_17

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

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

Most tomographic studies have been focused upon drawing maps of seismic velocity (SV) structures based on seismic data, with the ultimate goal of learning more about the structure and the composition of the mantle. Another key physical property that is accessible from seismic data is seismic attenuation (SA). Due to complications in isolating its intrinsic causes - e.g. local physical changes - and its extrinsic contributions - mainly scattering and other wave-propagation effects - SA has been underutilized. Yet, advances in waveform inversion have in association with recent enhancements of data permitted for a finer, more comprehensive determination of SA, opening the way to structural interpretations.
Difficulties in classifying and modelling the possible causes of intrinsic SA - e.g. temperature, melt, volatiles, and grain size - have also been raised. Increasingly, theoretical and experimental mineral physics have come to document the relationship between the behavior of SA and an assortment of other phenomena - most particularly, partial melt. These results can subsequently be used interpret seismological observations.
Seismic attenuation is critically implicated in structure, composition, and in fine mantle dynamics at the local, regional, and global scales. It may be used to constrain the existence of water in the transition zone; the presence of melt in various regions - for instance around subduction zones; and in the temperature field of the deep mantle - which would, in turn, help to resolve the chemical contribution to SV observed in this region.
In this session, we would like to discuss aspects of mantle attenuation, with the aim of sharing the current state of all relevant fields of study. We welcome contributions from different fields - in particular, from seismology, mineral physics, and geodynamics, as these may advance our mutual comprehension of SA and its implications; and lay the groundwork for future research and applications thereof.

[SIT24-P01] 水に飽和した花崗岩の三軸試験中での地震波減衰の測定

*片山 郁夫[1]、山田 恵也[1]、財間 寛太[1] (1.広島大学大学院理学研究科地球惑星システム学専攻)

[SIT24-P02] Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

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

[SIT24-P03] 3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

*小西 健介[1]、冨士 延章[2]、Deschamps Frederic[1] (1.台湾中央研究院地球科学研究所、2.パリ地球物理研究所)

[SIT24-P04] **Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies**

*Frederic Deschamps[1]、Kensuke Konishi[1]、Nobuaki Fuji[2]、Laura J Cobden[3] (1.Academia Sinica、2.Institut de Physique du Globe de Paris、3.Utrecht University)

[SIT24-P05] Intrinsic attenuation factor Q of partially molten Fe–S–O system

*Chao Liu[1]、Takashi Yoshino[1] (1.Institute for Planetary Materials, Okayama University)

[SIT24-P06] サーマルクラックの入った花崗岩における間隙水圧の弾性波減衰への影響

*山田 恵也[1]、澤山 和貴[2]、片山 郁夫[1] (1.広島大学、2.九州大学)

水に飽和した花崗岩の三軸試験中での地震波減衰の測定

Attenuation of seismic wave in water-saturated granite during triaxial deformation

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Rock microfracturing significantly affects attenuation of seismic wave as well as seismic velocity. In this study, seismic wave attenuation in fluid-saturated granite was estimated during triaxial deformation experiments, with particular attention focused on how microfracturing affects the attenuation.
Fine-grained Aji granite was used for experiments, with 40 mm long and 20 mm in diameter. Triaxial experiments were carried at a constant strain-rate of ~10^{-6} s^{-1} under confining pressure of 20 MPa and pore pressure of 10 MPa. During deformation, elastic wave was monitored by a pulse transmission method using both P and S wave transducers with a resonant frequency of 2 MHz. In the early stage of deformation, amplitudes of both P and S waves increase slightly due to closure of preexisting cracks and then decrease due to nucleation and growth of microcracks as the sample approaches failure, with agreement of changes in seismic velocity. Change in amplitude of shear wave tends to be larger than compressional wave, similar to those observed in fluid-saturated sandstone, suggesting that inter-crack fluid flow acts as a main source of energy dissipation. We use these wavelets to estimate attenuation (quality factor) using the spectral ratio method described by Toksoz et al. (1979); the results will be presented during the meeting.

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Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

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The origin of velocity anomalies in the lowermost mantle, e.g., thermal, chemical, or due to phase transition, is still debated. Intrinsic seismic attenuation (Q) strongly depends on temperature, thus could provide additional constraints on the thermal contribution to seismic anomalies in the lowermost mantle. In this study, we investigate the radial (1-D) elastic (Vs) and anelastic (Q) structure of the lowermost mantle beneath Central America and the Caribbean using waveform inversion. We use ~50 intermediate and deep focus earthquakes in South America recorded at the USArray and other small networks between 2004–2015. Waveforms are filtered between 12.5–200 s and cut ~20 s before the arrival of the direct S phase, and ~60 s after the arrival of the ScS phase. We use the S phase as a reference phase to correct for the effects of the structure near the events and receivers on the travel-time and amplitude of ScS waveforms (Konishi et al., 2017). Synthetic tests show that we can resolve the 1-D Q and Vs structures of the lowermost mantle, with some amount of tradeoff between them. In an attempt to reduce the tradeoff between the Vs and Q structure, we perform iterative inversion inferring in a first step the Vs structure only, and in a second step the Vs and Q structures simultaneously.

Keywords: Seismic attenuation, Waveform inversion, Lowermost mantle

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3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

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We introduce a finite-frequency tomography method as to simultaneously obtain 3-D shear velocity (V_S) and seismic attenuation (described as quality factor Q) structures using travel time and amplitude data. We apply this method to the mapping of V_S and Q structure in the lowermost mantle beneath the western Pacific, at an edge of the Pacific large low shear velocity province (LLSVP). We used S and ScS waves of seismograms for 31 earthquakes which occurred around the region of Tonga and Fiji. Our dataset consists of the transverse components of 1341 traces obtained from the F-net Japanese seismic station network. The waveform data is rendered to a bandpass filter of a range of 12.5–200 s, corresponding to 0.005–0.08 Hz. Both shear velocity and attenuation (Q) have lower values than PREM at the center of the bottom depth range. This feature is robust per a variety of inversions in different inversion configurations. Based upon the obtained shear velocity and attenuation (Q), we also predict possible temperature anomalies in this region. Discrepancy between the temperature anomalies predicted by the two data sets suggests that shear velocity anomalies result not only from temperature anomalies but chemical anomalis. Assuming that Q-anomalies are a good proxy for temperature, and that compositional anomalies primarily consist of an excess in iron oxide and depletion, we propose a possible thermal and compositional structure for this region. Revisions to fundamental analytical software have been effected such that more varieties of waveform analysis may be performed, utilizing progressively larger datasets. The design of packages for the computation of forward propagation has been refined to greater efficiency. The purpose, for the present, is to enable the Montecarlo inversion of waveforms. We will present the current version of the software, and demonstrate preliminary attempts to perform the Montecarlo inversion.

キーワード：非弾性減衰、最下部マントル、波形インバージョン
Keywords: attenuation, lowermost mantle, waveform inversion

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Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies

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1. Academia Sinica, 2. Institut de Physique du Globe de Paris, 3. Utrecht University

The Earth’ s deep mantle seismic structure is dominated by two large low shear-wave velocity provinces (LLSVPs) located beneath Africa and the Pacific. These structures have been observed by many studies and data sets, but their nature, purely thermal or thermo-chemical, is still debated. Due to trade-off between temperature and composition, maps of shear-wave velocity anomalies (d$\ln V_S$) alone are unable to discriminate between purely thermal and thermo-chemical hypotheses. Seismic shear-wave attenuation, measured by the quality factor Q_S, strongly depends on temperature and may bring additional information on this parameter, allowing to resolve the trade-off between temperature and composition. Here, we invert seismic waveform data jointly for radial models of d$\ln V_S$, and Q_S at two different locations beneath the Pacific, and from a depth of 2000 km down to the core-mantle boundary (CMB). At the Northern Pacific (NP) location, sampling a region around 50º N latitude and 180º E longitude, around V_S and Q_S remain close to the PREM values, representing the horizontal average mantle, throughout the investigated depth-range, with d$\ln V_S$ ~ -0.1% and Q_S ~ 300 (compared to Q_{PREM} = 312). At the Western Pacific (WP) location, sampling the western tip of the Pacific LLSVP and the Caroline plume, both V_S and Q_S are substantially lower than PREM. Importantly, d$\ln V_S$ and Q_S sharply decrease in the lowermost 500 km, from -0.6 % and 255 at 2500 km, to -2.5% and 215 close to the CMB. We then show that WP models cannot be explained by thermal anomalies alone, but require excess in iron of 3.5 to 4.5 % from the CMB up to 2600 km, and about 0.4 to 1.0 % at shallower depths. This later enrichment may be due to the entrainment of small amounts of the Pacific LLSVP material by the Caroline plume. The values of Q_S we observe give an estimate of the temperature anomalies, around 300-400 K close to the CMB, and 150 K at shallower depths. By contrast, NP models may have a purely thermal origin and can be explained by a temperature excess of about 50 K.

Keywords: Seismic waveform, Seismic attenuation, Mantle structure, LLSVP

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Intrinsic attenuation factor Q of partially molten Fe–S–O system

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Heterogeneous seismic structures have been found at the top of the Earth’ s inner core in terms of attenuation and velocity (Iritani et al., 2014; Souriau and Romanowicz, 1997; Tanaka, 2012). The outermost part of the inner core with approximately 30 km thickness shows low attenuation, then attenuation increases beneath this layer (Cao and Romanowicz, 2004; Ibourichene and Romanowicz, 2018; Waszek and Deuss, 2013). The positive and negative correlations between velocity and attenuation were observed from the uppermost inner core in different areas: Pacific center in the inner core has negative correlation and the rest area has positive correlation (Attanayake et al., 2014; Godwin et al., 2018). In this study, experiments on attenuation of partially molten Fe–S–O system were performed to explain the possibility that could cause seismic anomalies.

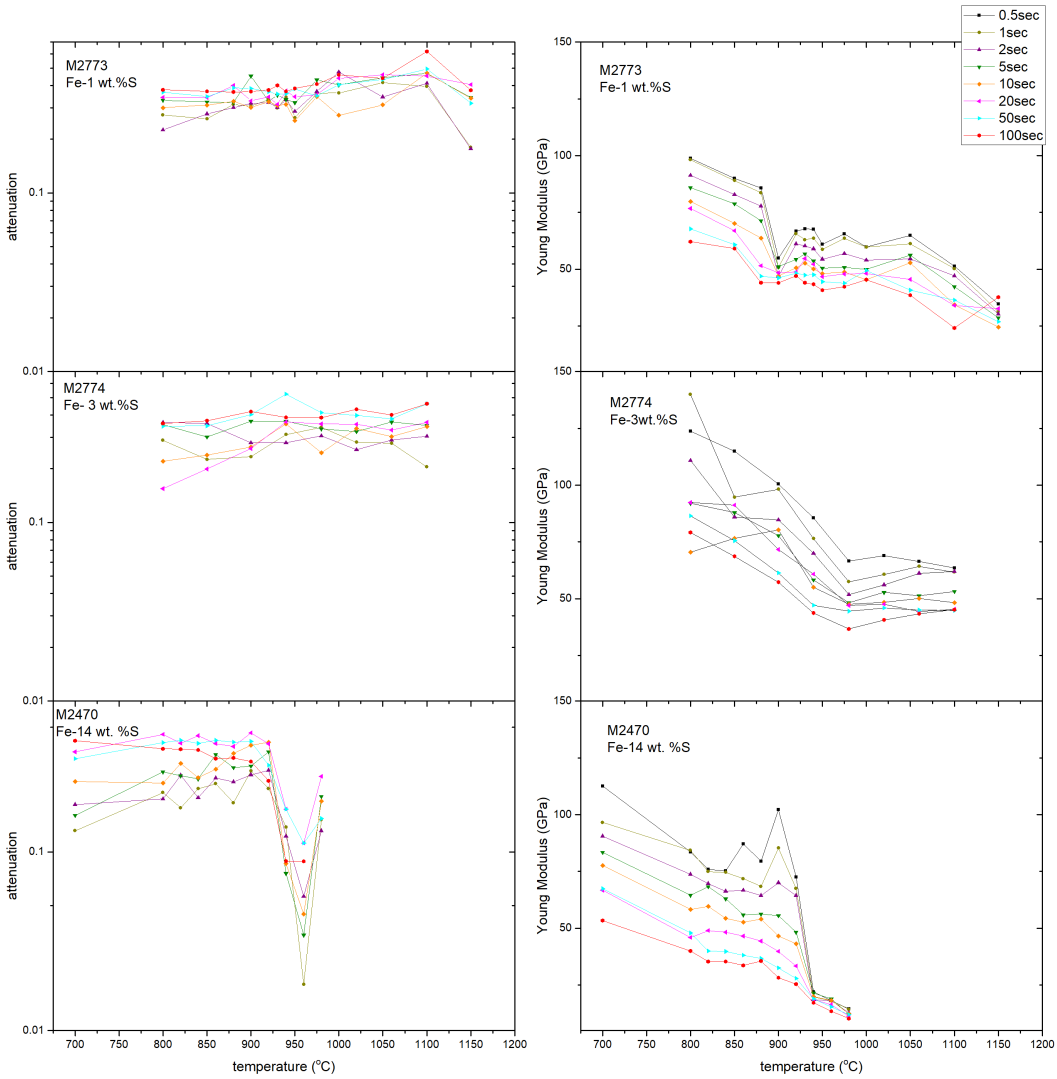
We investigated Fe-S-O system. Sulfur and oxygen are regarded as the representative light element in the Earth’ s core. Fe samples with 1, 3 and 14 wt. % S were synthesized in piston cylinder apparatus at 900° C and 1 GPa. a small amount of oxygen was included accidentally. In-situ X-ray radiographic observations were performed at the bending magnet beam line BL04B1 at SPring-8. Deformation-DIA press with a facility of cyclic loading was used. This system could produce sinusoidal displacement in a wide range of oscillation periods from 0.2 to 100 s and generating variable amplitudes (Yoshino et al., 2016). Q value characterizing intrinsic attenuation was determined by phase lag of sample strain against the reference material at 1 GPa and up to 1200°C.

The experimental results show that frequency dependence of attenuation is not remarkable except for a fine grained-sample, whereas decrease of attenuation was found at 1100 and 920°C for Fe- 1 wt. %S and Fe- 14 wt. %S samples, respectively. The attenuation drop would occur with increasing melt fraction. Experiments of Fe-14 wt. %S sample along heating and cooling paths were done to check the influence of grain growth during experiments. Data obtained from both heating and cooling paths show that abrupt change of the attenuation occurred at around 925°C. The Young’ s modulus calculated from the strain ratio of sample and reference shows strong temperature dependence. An obvious drop occurred between 900 and 980°C in association with the occurrence of partial melting. Relationship between velocity and attenuation anomalies of the Fe–S–O system shows a positive correlation when melt fraction reaches a certain value.

Partial melting could decrease Q^{-1}, which could explain the relative low attenuation on uppermost 30 km layer throughout the top of the inner core. Combing with the positive correlation between attenuation and velocity, a large amount of partial melting could occur on the uppermost 30 km layer of the rest area except the Pacific hemisphere in the inner core.

Keywords: attenuation, partially melting, Young Modulus, inner core

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サーマルクラックの入った花崗岩における間隙水圧の弾性波減衰への影響
Effect of pore pressure on attenuation of seismic waves in thermally cracked granite

*山田 恵也[1]、澤山 和貴[2]、片山 郁夫[1]
*Keiya Yamada[1], Kazuki Sawayama[2], Ikuo Katayama[1]

1. 広島大学、2. 九州大学
1. Hiroshima University, 2. Kyushu University

弾性波減衰は, 物理探査により地下構造を推定するための重要な物性の1つであり, それはクラックや間隙流体の存在に敏感である. 特に間隙水圧は, 地熱発電や地震に密接に関係する不可欠なパラメータである. 間隙水圧を定量的に推定することや経年変化を観測することは, 正確な地熱貯留層の評価や地震発生の予測に繋がり得る. したがって, 弾性波減衰と間隙水圧の定量的な関係を理解することが重要である. これまでの実験的研究では, 間隙水圧を一定にし, 封圧を増加させて弾性波減衰を測定している. しかしながら, 間隙水圧の変化に着目し弾性波減衰を測定した例は少ない. 本研究では, サーマルクラックの入った花崗岩を用いて三軸圧縮試験を行い, 間隙水圧が弾性波減衰に与える影響を検証した.

本研究で使用した試料は全て庵治花崗岩である. 試料は, 同一のブロックからコアリングし円柱状に成形した（直径20 mm, 長さ40 mm）. サーマルクラックは, 200, 400, 600℃までゆっくり加熱・冷却することで生じさせた. それにより, 空隙率（初期0.6%）は, それぞれ0.8, 0.9, 2.8%まで増加した. 三軸圧縮試験は, 広島大学設置の容器内変形透水試験機を用いて, 室温で無水条件と含水条件（完全な水飽和）で行った. 無水条件では封圧を60 MPaまで増加させ, 含水条件では封圧を60 MPaで一定に保ちながら間隙水圧を50 MPaから大気圧まで減少させた. 弾性波は, 試料の両側面に圧電素子を直接貼り付けてパルス透過法で測定した. 弾性波速度（Vp, Vs）はオシロスコープで記録した波形から算出し, 弾性波減衰（Qp^{-1}, Qs^{-1}）はフーリエスペクトル比法を用いて推定した.

その結果, VpとVsは, 無水条件では封圧の増加に伴い増加するが, 含水条件では間隙水圧の増加に伴い減少した. 減衰において, Qp^{-1}とQs^{-1}は, 無水条件では封圧の増加に伴い減少したが, 含水条件では間隙水圧の増加に伴い増加した. これは封圧によりクラックが閉鎖されることで摩擦による減衰が小さくなったと考えられる. 600℃まで加熱した試料の実験において, 含水条件ではP波の減衰がS波よりも著しく小さくなり, 無水条件と異なる傾向が見られた. これは, 含水条件では間隙水の移動に起因する減衰が生じ, S波へより大きな影響を与えるからだと考えられる. 本研究の結果から, 間隙水圧の増加に対する速度と減衰の応答性は異なり, Vp/Vsは増加するがQp^{-1}/Qs^{-1}は減少する. 減衰は速度よりも大きく変化し, 間隙水圧の変化に敏感であるので, 弾性波減衰は地下の間隙水圧の変化を観測するのに有効であると言える.

キーワード：弾性波減衰、間隙水圧、弾性波速度、庵治花崗岩、サーマルクラック
Keywords: Elastic wave attenuation, Pore pressure, Elastic wave velocity, Aji granite, Thermal cracking

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

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_30

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

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

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[SIT24-P01] 水に飽和した花崗岩の三軸試験中での地震波減衰の測定

*片山 郁夫[1]、山田 恵也[1]、財間 寛太[1] (1.広島大学大学院理学研究科地球惑星システム学専攻)

[SIT24-P02] Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

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

[SIT24-P03] 3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

*小西 健介[1]、冨士 延章[2]、Deschamps Frederic[1] (1.台湾中央研究院地球科学研究所、2.パリ地球物理研究所)

[SIT24-P04] **Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies**

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*山田 恵也[1]、澤山 和貴[2]、片山 郁夫[1] (1.広島大学、2.九州大学)

水に飽和した花崗岩の三軸試験中での地震波減衰の測定

Attenuation of seismic wave in water-saturated granite during triaxial deformation

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Rock microfracturing significantly affects attenuation of seismic wave as well as seismic velocity. In this study, seismic wave attenuation in fluid-saturated granite was estimated during triaxial deformation experiments, with particular attention focused on how microfracturing affects the attenuation.
Fine-grained Aji granite was used for experiments, with 40 mm long and 20 mm in diameter. Triaxial experiments were carried at a constant strain-rate of ~10^{-6} s^{-1} under confining pressure of 20 MPa and pore pressure of 10 MPa. During deformation, elastic wave was monitored by a pulse transmission method using both P and S wave transducers with a resonant frequency of 2 MHz. In the early stage of deformation, amplitudes of both P and S waves increase slightly due to closure of preexisting cracks and then decrease due to nucleation and growth of microcracks as the sample approaches failure, with agreement of changes in seismic velocity. Change in amplitude of shear wave tends to be larger than compressional wave, similar to those observed in fluid-saturated sandstone, suggesting that inter-crack fluid flow acts as a main source of energy dissipation. We use these wavelets to estimate attenuation (quality factor) using the spectral ratio method described by Toksoz et al. (1979); the results will be presented during the meeting.

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Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

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The origin of velocity anomalies in the lowermost mantle, e.g., thermal, chemical, or due to phase transition, is still debated. Intrinsic seismic attenuation (Q) strongly depends on temperature, thus could provide additional constraints on the thermal contribution to seismic anomalies in the lowermost mantle. In this study, we investigate the radial (1-D) elastic (Vs) and anelastic (Q) structure of the lowermost mantle beneath Central America and the Caribbean using waveform inversion. We use ~50 intermediate and deep focus earthquakes in South America recorded at the USArray and other small networks between 2004–2015. Waveforms are filtered between 12.5–200 s and cut ~20 s before the arrival of the direct S phase, and ~60 s after the arrival of the ScS phase. We use the S phase as a reference phase to correct for the effects of the structure near the events and receivers on the travel-time and amplitude of ScS waveforms (Konishi et al., 2017). Synthetic tests show that we can resolve the 1-D Q and Vs structures of the lowermost mantle, with some amount of tradeoff between them. In an attempt to reduce the tradeoff between the Vs and Q structure, we perform iterative inversion inferring in a first step the Vs structure only, and in a second step the Vs and Q structures simultaneously.

Keywords: Seismic attenuation, Waveform inversion, Lowermost mantle

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3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

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We introduce a finite-frequency tomography method as to simultaneously obtain 3-D shear velocity (V_S) and seismic attenuation (described as quality factor Q) structures using travel time and amplitude data. We apply this method to the mapping of V_S and Q structure in the lowermost mantle beneath the western Pacific, at an edge of the Pacific large low shear velocity province (LLSVP). We used S and ScS waves of seismograms for 31 earthquakes which occurred around the region of Tonga and Fiji. Our dataset consists of the transverse components of 1341 traces obtained from the F-net Japanese seismic station network. The waveform data is rendered to a bandpass filter of a range of 12.5–200 s, corresponding to 0.005–0.08 Hz. Both shear velocity and attenuation (Q) have lower values than PREM at the center of the bottom depth range. This feature is robust per a variety of inversions in different inversion configurations. Based upon the obtained shear velocity and attenuation (Q), we also predict possible temperature anomalies in this region. Discrepancy between the temperature anomalies predicted by the two data sets suggests that shear velocity anomalies result not only from temperature anomalies but chemical anomalis. Assuming that Q-anomalies are a good proxy for temperature, and that compositional anomalies primarily consist of an excess in iron oxide and depletion, we propose a possible thermal and compositional structure for this region. Revisions to fundamental analytical software have been effected such that more varieties of waveform analysis may be performed, utilizing progressively larger datasets. The design of packages for the computation of forward propagation has been refined to greater efficiency. The purpose, for the present, is to enable the Montecarlo inversion of waveforms. We will present the current version of the software, and demonstrate preliminary attempts to perform the Montecarlo inversion.

キーワード：非弾性減衰、最下部マントル、波形インバージョン
Keywords: attenuation, lowermost mantle, waveform inversion

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Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies

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The Earth’ s deep mantle seismic structure is dominated by two large low shear-wave velocity provinces (LLSVPs) located beneath Africa and the Pacific. These structures have been observed by many studies and data sets, but their nature, purely thermal or thermo-chemical, is still debated. Due to trade-off between temperature and composition, maps of shear-wave velocity anomalies (d$\ln V_S$) alone are unable to discriminate between purely thermal and thermo-chemical hypotheses. Seismic shear-wave attenuation, measured by the quality factor Q_S, strongly depends on temperature and may bring additional information on this parameter, allowing to resolve the trade-off between temperature and composition. Here, we invert seismic waveform data jointly for radial models of d$\ln V_S$, and Q_S at two different locations beneath the Pacific, and from a depth of 2000 km down to the core-mantle boundary (CMB). At the Northern Pacific (NP) location, sampling a region around 50º N latitude and 180º E longitude, around V_S and Q_S remain close to the PREM values, representing the horizontal average mantle, throughout the investigated depth-range, with d$\ln V_S$ ~ -0.1% and Q_S ~ 300 (compared to Q_{PREM} = 312). At the Western Pacific (WP) location, sampling the western tip of the Pacific LLSVP and the Caroline plume, both V_S and Q_S are substantially lower than PREM. Importantly, d$\ln V_S$ and Q_S sharply decrease in the lowermost 500 km, from -0.6 % and 255 at 2500 km, to -2.5% and 215 close to the CMB. We then show that WP models cannot be explained by thermal anomalies alone, but require excess in iron of 3.5 to 4.5 % from the CMB up to 2600 km, and about 0.4 to 1.0 % at shallower depths. This later enrichment may be due to the entrainment of small amounts of the Pacific LLSVP material by the Caroline plume. The values of Q_S we observe give an estimate of the temperature anomalies, around 300-400 K close to the CMB, and 150 K at shallower depths. By contrast, NP models may have a purely thermal origin and can be explained by a temperature excess of about 50 K.

Keywords: Seismic waveform, Seismic attenuation, Mantle structure, LLSVP

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Intrinsic attenuation factor Q of partially molten Fe–S–O system

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Heterogeneous seismic structures have been found at the top of the Earth’ s inner core in terms of attenuation and velocity (Iritani et al., 2014; Souriau and Romanowicz, 1997; Tanaka, 2012). The outermost part of the inner core with approximately 30 km thickness shows low attenuation, then attenuation increases beneath this layer (Cao and Romanowicz, 2004; Ibourichene and Romanowicz, 2018; Waszek and Deuss, 2013). The positive and negative correlations between velocity and attenuation were observed from the uppermost inner core in different areas: Pacific center in the inner core has negative correlation and the rest area has positive correlation (Attanayake et al., 2014; Godwin et al., 2018). In this study, experiments on attenuation of partially molten Fe–S–O system were performed to explain the possibility that could cause seismic anomalies.

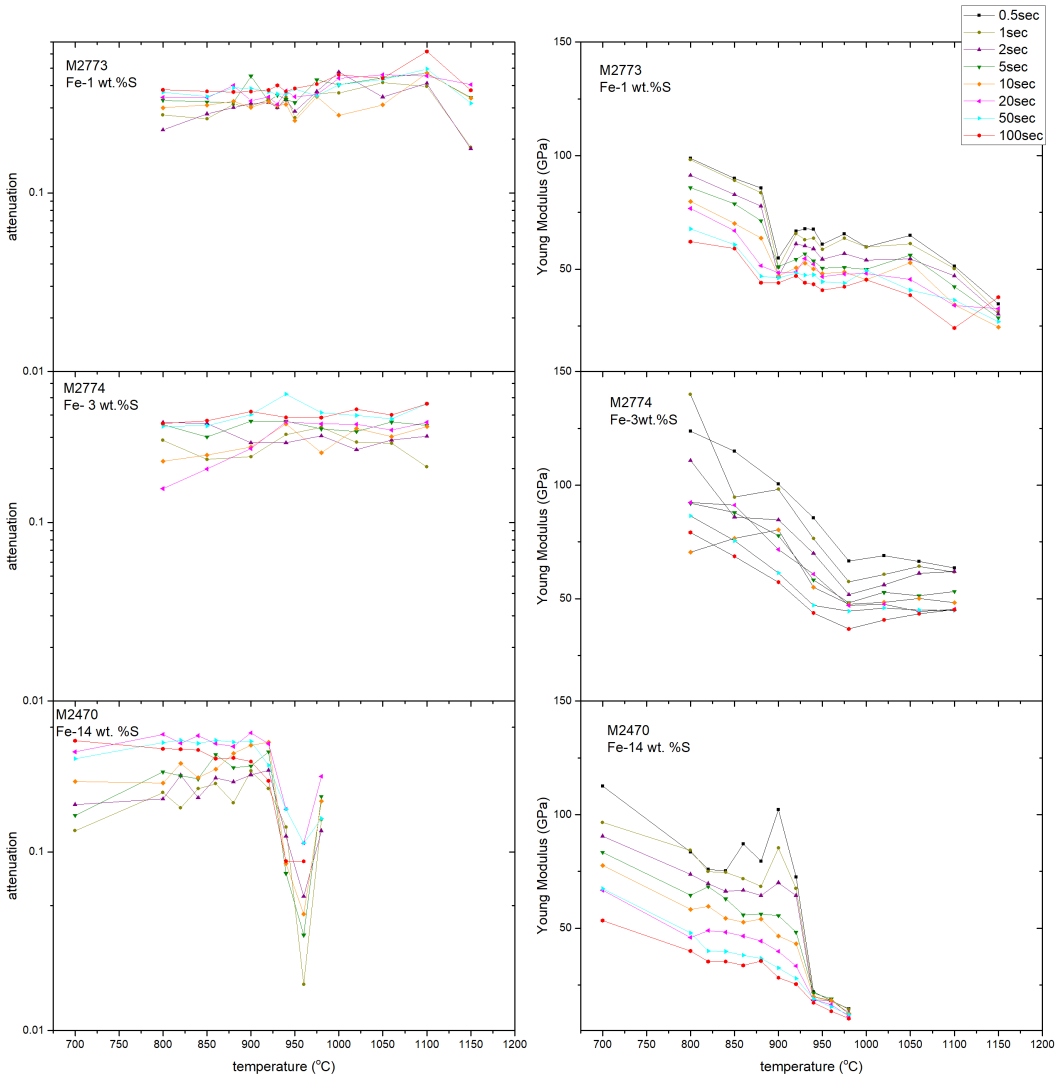
We investigated Fe-S-O system. Sulfur and oxygen are regarded as the representative light element in the Earth’ s core. Fe samples with 1, 3 and 14 wt. % S were synthesized in piston cylinder apparatus at 900° C and 1 GPa. a small amount of oxygen was included accidentally. In-situ X-ray radiographic observations were performed at the bending magnet beam line BL04B1 at SPring-8. Deformation-DIA press with a facility of cyclic loading was used. This system could produce sinusoidal displacement in a wide range of oscillation periods from 0.2 to 100 s and generating variable amplitudes (Yoshino et al., 2016). Q value characterizing intrinsic attenuation was determined by phase lag of sample strain against the reference material at 1 GPa and up to 1200°C.

The experimental results show that frequency dependence of attenuation is not remarkable except for a fine grained-sample, whereas decrease of attenuation was found at 1100 and 920°C for Fe- 1 wt. %S and Fe- 14 wt. %S samples, respectively. The attenuation drop would occur with increasing melt fraction. Experiments of Fe-14 wt. %S sample along heating and cooling paths were done to check the influence of grain growth during experiments. Data obtained from both heating and cooling paths show that abrupt change of the attenuation occurred at around 925°C. The Young’ s modulus calculated from the strain ratio of sample and reference shows strong temperature dependence. An obvious drop occurred between 900 and 980°C in association with the occurrence of partial melting. Relationship between velocity and attenuation anomalies of the Fe–S–O system shows a positive correlation when melt fraction reaches a certain value.

Partial melting could decrease Q^{-1}, which could explain the relative low attenuation on uppermost 30 km layer throughout the top of the inner core. Combing with the positive correlation between attenuation and velocity, a large amount of partial melting could occur on the uppermost 30 km layer of the rest area except the Pacific hemisphere in the inner core.

Keywords: attenuation, partially melting, Young Modulus, inner core

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サーマルクラックの入った花崗岩における間隙水圧の弾性波減衰への影響
Effect of pore pressure on attenuation of seismic waves in thermally cracked granite

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弾性波減衰は, 物理探査により地下構造を推定するための重要な物性の1つであり, それはクラックや間隙流体の存在に敏感である. 特に間隙水圧は, 地熱発電や地震に密接に関係する不可欠なパラメータである. 間隙水圧を定量的に推定することや経年変化を観測することは, 正確な地熱貯留層の評価や地震発生の予測に繋がり得る. したがって, 弾性波減衰と間隙水圧の定量的な関係を理解することが重要である. これまでの実験的研究では, 間隙水圧を一定にし, 封圧を増加させて弾性波減衰を測定している. しかしながら, 間隙水圧の変化に着目し弾性波減衰を測定した例は少ない. 本研究では, サーマルクラックの入った花崗岩を用いて三軸圧縮試験を行い, 間隙水圧が弾性波減衰に与える影響を検証した.

本研究で使用した試料は全て庵治花崗岩である. 試料は, 同一のブロックからコアリングし円柱状に成形した（直径20 mm, 長さ40 mm）. サーマルクラックは, 200, 400, 600℃までゆっくり加熱・冷却することで生じさせた. それにより, 空隙率（初期0.6%）は, それぞれ0.8, 0.9, 2.8%まで増加した. 三軸圧縮試験は, 広島大学設置の容器内変形透水試験機を用いて, 室温で無水条件と含水条件（完全な水飽和）で行った. 無水条件では封圧を60 MPaまで増加させ, 含水条件では封圧を60 MPaで一定に保ちながら間隙水圧を50 MPaから大気圧まで減少させた. 弾性波は, 試料の両側面に圧電素子を直接貼り付けてパルス透過法で測定した. 弾性波速度（Vp, Vs）はオシロスコープで記録した波形から算出し, 弾性波減衰（Qp^{-1}, Qs^{-1}）はフーリエスペクトル比法を用いて推定した.

その結果, VpとVsは, 無水条件では封圧の増加に伴い増加するが, 含水条件では間隙水圧の増加に伴い減少した. 減衰において, Qp^{-1}とQs^{-1}は, 無水条件では封圧の増加に伴い減少したが, 含水条件では間隙水圧の増加に伴い増加した. これは封圧によりクラックが閉鎖されることで摩擦による減衰が小さくなったと考えられる. 600℃まで加熱した試料の実験において, 含水条件ではP波の減衰がS波よりも著しく小さくなり, 無水条件と異なる傾向が見られた. これは, 含水条件では間隙水の移動に起因する減衰が生じ, S波へより大きな影響を与えるからだと考えられる. 本研究の結果から, 間隙水圧の増加に対する速度と減衰の応答性は異なり, Vp/Vsは増加するがQp^{-1}/Qs^{-1}は減少する. 減衰は速度よりも大きく変化し, 間隙水圧の変化に敏感であるので, 弾性波減衰は地下の間隙水圧の変化を観測するのに有効であると言える.

キーワード：弾性波減衰、間隙水圧、弾性波速度、庵治花崗岩、サーマルクラック
Keywords: Elastic wave attenuation, Pore pressure, Elastic wave velocity, Aji granite, Thermal cracking

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

2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_19

[S-TT42] Recent Advances in Exploration Geophysics 2019

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

Geophysical exploration methods are widely used to estimate physical or chemical properties of media that are located in the environment where it is difficult for human beings to access. We would welcome presentations and discussions on theories, applications, case studies in which geophysical exploration schemes are applied for using artificial/natural signals or potentials. A proceeding paper within 4 A4 pages for each submission is to be asked to prepare after the acceptance based on the quality of the abstract of the submission and will be published electronically with doi on EarthDoc (http://earthdoc.eage.org/publication/eventoverview?p=78) under MoU with the European Association of Geoscientists and Engineers.

[STT42-P01] DISCRIMINATION OF HYDRATE BEARING MARINE SEDIMENTS BY USING FREQUENCY BASED ATTENUATION

*Nisar Ahmed[1]、Mubasher Ahmad[1]、Perveiz Khalid[1] (1.Institute of Geology, University of the Punjab, Lahore 54590, Pakistan)

[STT42-P02] Evaluation of methane hydrate based on attenuation parameter in seismic exploration

*川部 瑞貴[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

[STT42-P03] Estimating the earthquake source mechanism using full waveform inversion

*Jang Iktae[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

[STT42-P04] A quantitative analysis of the passive seismic emission tomography using the lattice Boltzmann method

*酒見 祐一[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学 工学部)

[STT42-P05] 超臨界地熱環境下における人工貯留層の造成による地熱資源開発の実現可能性

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DISCRIMINATION OF HYDRATE BEARING MARINE SEDIMENTS BY USING FREQUENCY BASED ATTENUATION

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We have examined the seismic wave attenuation and dispersion effects due to wave-induced fluid flow (WIFF) in heterogeneous porous marine sediments at mesoscopic scale of heterogeneity. The mesoscopic is the scale
larger as compared to the reservoir rock pore size but smaller than the seismic the wavelength and considered most significant scale for fluid related P wave attenuation and velocity dispersion. White’ s model
has been used for the current study which calculates a relaxation mechanism, because of pressure equilibrium, attenuation-dispersion of seismic waves occurred. Gas hydrates-bearing marine sediments of the Makran offshore, Pakistan are considered as numerical example for this study. The numerical results show that the seismic wave attenuation and velocity dispersion can be used as a good indicator to identify gas hydrates and both attenuation-dispersion increases with the increase of saturation of gas hydrates. The
maximum P wave attenuation is observed at 64 % gas hydrate saturation. However, in the case of free gas in the
marine sediments, low gas saturation level causes of high attenuation and velocity dispersion.

Keywords: Seismic attenuation, Velocity dispersion, Marine sediments, Gas hydrates, White model, Elastic wave theory

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Evaluation of methane hydrate based on attenuation parameter in seismic exploration

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In recent years, methane hydrate (MH) has drawn attention as a new domestic energy resource in Japan. Although field production experiments have been conducted in real fields, some MH samples collected in real fields revealed the difficulty to evaluate the amount of MH based quantitative only with the evaluation of bottom simulating reflector (BSR). For efficient development of MH reservoirs, it is therefore important to estimate the thickness of MH concentrated zones accurately. Since MH layer has high attenuation that takes place as a function of propagation path through the attenuating medium, the evaluation of MH using seismic exploration could be an effective approach. However, the previous studies indicated that it is difficult to estimate attenuation structure even if the full-waveform information is utilized. On the other hand, the amplitude of seismic waves passing through MH layer must be affected by its high attenuation, but the approach of full waveform inversion (FWI) has been reported ineffective due to its back-propagation process. In the present study, we hypothesize that additional constraint enables us to estimate attenuation parameter of MH layer without any back propagation of residual wavefield. We assume that the layer structure in the subsurface is known, and the physical properties of MH layer are unknown. Based on the above assumption, we conducted numerical experiments to investigate the effectiveness of inversion based on utilization of full-waveform to provide information on estimation of the amount of MH resources based on the linearized general inverse theory.
In our numerical model, the seismic source and receivers are put in the sea water and on the sea bed, respectively. Synthetic waveforms are created by solving the visco-elastic equation using the finite-difference method. Our numerical experiments revealed that simultaneous inversion of the Lame’s parameter and attenuation parameter of P-wave (Qp) is difficult. To overcome this, we proposed a kind of the relaxation method, i.e. we separately solve the Lame’s parameters (and) and Qp in our inversion process. The proposed method can obtain the true value not only the Lame’s parameters but also Qp with sufficient accuracy. Our numerical results indicate that the seismic exploration can provide valuable information on MH layer by estimating physical properties including the attenuation parameter.

キーワード：メタンハイドレート、地震探査、数値実験、有限差分法
Keywords: methane hydrate, seismic exploration, numerical experiment, finite-difference method

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Estimating the earthquake source mechanism using full waveform inversion

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An immediate understanding of the source mechanism of an earthquake after the occurrence is an important task for disaster mitigation to realize a safe society. One of the most important tasks for considering the mechanism of an earthquake is estimating the earthquake source mechanism. Due to the lack of seismic data and computational requirements, the centroid-moment tensor (CMT) solution has been widely used to estimate the focal mechanism until recent years. However, long term observation of the spatial distribution of aftershocks is required to identify the nodal plane that caused the fault motion. Since the earthquake waveform caused by a nodal plane becomes different from that caused by the other conjugate nodal plane, the analysis of full-waveform could be utilized to identify which nodal plane has caused the fault motion so that the focal mechanism of the earthquake could be estimated before the observation of aftershocks. Although some numerical experiments revealed that the possibility of FWI to inversion of earthquake source mechanism, the sensitivity of each fault parameter to full-waveforms has not been fully investigated yet.

In this study, we investigate the applicability of full-waveform inversion (FWI) to determine focal mechanism using numerical experiments. In FWI, L2-norm error function is often used as an objective function to be minimized. We evaluate the effect of some fault parameters (strike, dip, and rake) on the difference of recorded waveforms.

We make a three-dimensional numerical model with an earthquake source, and simulate elastic wave propagation using the finite-difference method. The seismic waves are recorded by receivers located on the ground surface. Subsequently, we slightly change the fault parameters, and then, simulate elastic wave propagation. We calculate the residuals between two recorded waveforms. This procedure enables us to investigate the sensitivity of the parameters on the L2-norm error function. Our numerical results indicate that rake has poor sensitivity whereas the change of strike and dip has a large effect on the recorded waveforms.

キーワード：全波形逆解析、震源メカニズム、数値実験
Keywords: Full-Waveform Inversion (FWI), Earthquake Source Mechanism, Numerical Experiment

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A quantitative analysis of the passive seismic emission tomography using the lattice Boltzmann method

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In recent years, monitoring seismic emission caused by subsurface fluid motion has been widely used in development of hydrocarbon reservoirs. Although this technique can provide the position and the depth of fluid flow in the reservoir, it is difficult to obtain further kinematic information such as flow velocity, fluid viscosity, or pore shape. Previous studies suggested that utilizing waveform analysis of seismic emission would make it possible to image the location of fluid flow, but the mechanism of such seismic emission has not been well revealed. Recently we proposed a model of seismic emission due to fluid flow but found our method has a problem that needs to be worked out, i.e. the utilization of inappropriate sound velocity to reduce the cost of calculation in Lattice Boltzmann method (LBM). In LBM, the incorrect fluid properties are often used since the correct properties induce a numerical instability. This means that it is difficult to evaluate our results in a quantitative manner. In the present study, we focused on this problem and set two types of models to tackle the problem of sound velocity in fluid; one is normal LBM model and the other one has the real sound velocity. We conducted numerical experiments using these models. We have found that the result calculated by the normal model can be modified to fit the results with the real properties by using an appropriate correction coefficient. Therefore, we have concluded that the normal LBM calculation could be adopted to reduce the cost of numerical simulation, and therefore, it is possible to quantitatively evaluate their experimental reuslts.

キーワード：パッシブサイスミック、流体流動、格子ボルツマン法
Keywords: Passive seismic, Fluid flow, Lattice Boltzmann method

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超臨界地熱環境下における人工貯留層の造成による地熱資源開発の実現可能性

A feasibility study for supercritical geothermal energy in enhanced geothermal system

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Japan has many volcanoes and large potential of geothermal energies. However, since 1996, the construction of large-scale geothermal plants in Japan has been stopped, and the amount of electricity generated by the geothermal plants decreased by about 30 percent compared to the peak time in 1997. Existing geothermal energy development has mainly targeted shallow geothermal resources. However, shallow geothermal resources are eccentrically located so we can generate power at narrow area and obtain the limited amount of energy. On the other hand, geothermal power generation using supercritical water is expected to increase power output with one power plant than the conventional geothermal power plants. Moreover, by constructing artificial reservoir, it becomes possible to introduce it in wide area and it is expected to contribute to reduction of development and attenuation risk. However, the feasibility of the geothermal power plants using supercritical water has not been fully investigated yet. In this research, we focus on artificial geothermal reservoir under supercritical environment, and quantitatively investigate its feasibility using numerical simulations. Specifically, artificial supercritical geothermal power generation with a downhole coaxial heat exchanger and a single U-shaped pipe method are considered as the heat exchanger method. We solve the unsteady thermal conduction problem using the finite-difference method with various flow rate and injection pressure conditions. As the result of numerical simulation, it was confirmed that in the case of both the double pipe system and the single U-shaped pipe, it is possible to extract supercritical water. Moreover, it was also found that high-performance heat insulating tubes are required for the inner pipe or the production well in either the double pipe type or the single U-shaped pipe type.

キーワード：超臨界地熱発電、数値シミュレーション、差分法
Keywords: supercritical geothermal power generation, numerical simulation, finite-difference method

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[S-TT42] Recent Advances in Exploration Geophysics 2019

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Geophysical exploration methods are widely used to estimate physical or chemical properties of media that are located in the environment where it is difficult for human beings to access. We would welcome presentations and discussions on theories, applications, case studies in which geophysical exploration schemes are applied for using artificial/natural signals or potentials. A proceeding paper within 4 A4 pages for each submission is to be asked to prepare after the acceptance based on the quality of the abstract of the submission and will be published electronically with doi on EarthDoc (http://earthdoc.eage.org/publication/eventoverview?p=78) under MoU with the European Association of Geoscientists and Engineers.

[STT42-P01] DISCRIMINATION OF HYDRATE BEARING MARINE SEDIMENTS BY USING FREQUENCY BASED ATTENUATION

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[STT42-P02] Evaluation of methane hydrate based on attenuation parameter in seismic exploration

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[STT42-P03] Estimating the earthquake source mechanism using full waveform inversion

*Jang Iktae[1]、三ケ田 均[1]、武川 順一[1] (1.京都大学)

[STT42-P04] A quantitative analysis of the passive seismic emission tomography using the lattice Boltzmann method

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[STT42-P05] 超臨界地熱環境下における人工貯留層の造成による地熱資源開発の実現可能性

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DISCRIMINATION OF HYDRATE BEARING MARINE SEDIMENTS BY USING FREQUENCY BASED ATTENUATION

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We have examined the seismic wave attenuation and dispersion effects due to wave-induced fluid flow (WIFF) in heterogeneous porous marine sediments at mesoscopic scale of heterogeneity. The mesoscopic is the scale
larger as compared to the reservoir rock pore size but smaller than the seismic the wavelength and considered most significant scale for fluid related P wave attenuation and velocity dispersion. White’ s model
has been used for the current study which calculates a relaxation mechanism, because of pressure equilibrium, attenuation-dispersion of seismic waves occurred. Gas hydrates-bearing marine sediments of the Makran offshore, Pakistan are considered as numerical example for this study. The numerical results show that the seismic wave attenuation and velocity dispersion can be used as a good indicator to identify gas hydrates and both attenuation-dispersion increases with the increase of saturation of gas hydrates. The
maximum P wave attenuation is observed at 64 % gas hydrate saturation. However, in the case of free gas in the
marine sediments, low gas saturation level causes of high attenuation and velocity dispersion.

Keywords: Seismic attenuation, Velocity dispersion, Marine sediments, Gas hydrates, White model, Elastic wave theory

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Evaluation of methane hydrate based on attenuation parameter in seismic exploration

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In recent years, methane hydrate (MH) has drawn attention as a new domestic energy resource in Japan. Although field production experiments have been conducted in real fields, some MH samples collected in real fields revealed the difficulty to evaluate the amount of MH based quantitative only with the evaluation of bottom simulating reflector (BSR). For efficient development of MH reservoirs, it is therefore important to estimate the thickness of MH concentrated zones accurately. Since MH layer has high attenuation that takes place as a function of propagation path through the attenuating medium, the evaluation of MH using seismic exploration could be an effective approach. However, the previous studies indicated that it is difficult to estimate attenuation structure even if the full-waveform information is utilized. On the other hand, the amplitude of seismic waves passing through MH layer must be affected by its high attenuation, but the approach of full waveform inversion (FWI) has been reported ineffective due to its back-propagation process. In the present study, we hypothesize that additional constraint enables us to estimate attenuation parameter of MH layer without any back propagation of residual wavefield. We assume that the layer structure in the subsurface is known, and the physical properties of MH layer are unknown. Based on the above assumption, we conducted numerical experiments to investigate the effectiveness of inversion based on utilization of full-waveform to provide information on estimation of the amount of MH resources based on the linearized general inverse theory.
In our numerical model, the seismic source and receivers are put in the sea water and on the sea bed, respectively. Synthetic waveforms are created by solving the visco-elastic equation using the finite-difference method. Our numerical experiments revealed that simultaneous inversion of the Lame’s parameter and attenuation parameter of P-wave (Qp) is difficult. To overcome this, we proposed a kind of the relaxation method, i.e. we separately solve the Lame’s parameters (and) and Qp in our inversion process. The proposed method can obtain the true value not only the Lame’s parameters but also Qp with sufficient accuracy. Our numerical results indicate that the seismic exploration can provide valuable information on MH layer by estimating physical properties including the attenuation parameter.

キーワード：メタンハイドレート、地震探査、数値実験、有限差分法
Keywords: methane hydrate, seismic exploration, numerical experiment, finite-difference method

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Estimating the earthquake source mechanism using full waveform inversion

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An immediate understanding of the source mechanism of an earthquake after the occurrence is an important task for disaster mitigation to realize a safe society. One of the most important tasks for considering the mechanism of an earthquake is estimating the earthquake source mechanism. Due to the lack of seismic data and computational requirements, the centroid-moment tensor (CMT) solution has been widely used to estimate the focal mechanism until recent years. However, long term observation of the spatial distribution of aftershocks is required to identify the nodal plane that caused the fault motion. Since the earthquake waveform caused by a nodal plane becomes different from that caused by the other conjugate nodal plane, the analysis of full-waveform could be utilized to identify which nodal plane has caused the fault motion so that the focal mechanism of the earthquake could be estimated before the observation of aftershocks. Although some numerical experiments revealed that the possibility of FWI to inversion of earthquake source mechanism, the sensitivity of each fault parameter to full-waveforms has not been fully investigated yet.

In this study, we investigate the applicability of full-waveform inversion (FWI) to determine focal mechanism using numerical experiments. In FWI, L2-norm error function is often used as an objective function to be minimized. We evaluate the effect of some fault parameters (strike, dip, and rake) on the difference of recorded waveforms.

We make a three-dimensional numerical model with an earthquake source, and simulate elastic wave propagation using the finite-difference method. The seismic waves are recorded by receivers located on the ground surface. Subsequently, we slightly change the fault parameters, and then, simulate elastic wave propagation. We calculate the residuals between two recorded waveforms. This procedure enables us to investigate the sensitivity of the parameters on the L2-norm error function. Our numerical results indicate that rake has poor sensitivity whereas the change of strike and dip has a large effect on the recorded waveforms.

キーワード：全波形逆解析、震源メカニズム、数値実験
Keywords: Full-Waveform Inversion (FWI), Earthquake Source Mechanism, Numerical Experiment

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A quantitative analysis of the passive seismic emission tomography using the lattice Boltzmann method

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In recent years, monitoring seismic emission caused by subsurface fluid motion has been widely used in development of hydrocarbon reservoirs. Although this technique can provide the position and the depth of fluid flow in the reservoir, it is difficult to obtain further kinematic information such as flow velocity, fluid viscosity, or pore shape. Previous studies suggested that utilizing waveform analysis of seismic emission would make it possible to image the location of fluid flow, but the mechanism of such seismic emission has not been well revealed. Recently we proposed a model of seismic emission due to fluid flow but found our method has a problem that needs to be worked out, i.e. the utilization of inappropriate sound velocity to reduce the cost of calculation in Lattice Boltzmann method (LBM). In LBM, the incorrect fluid properties are often used since the correct properties induce a numerical instability. This means that it is difficult to evaluate our results in a quantitative manner. In the present study, we focused on this problem and set two types of models to tackle the problem of sound velocity in fluid; one is normal LBM model and the other one has the real sound velocity. We conducted numerical experiments using these models. We have found that the result calculated by the normal model can be modified to fit the results with the real properties by using an appropriate correction coefficient. Therefore, we have concluded that the normal LBM calculation could be adopted to reduce the cost of numerical simulation, and therefore, it is possible to quantitatively evaluate their experimental reuslts.

キーワード：パッシブサイスミック、流体流動、格子ボルツマン法
Keywords: Passive seismic, Fluid flow, Lattice Boltzmann method

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超臨界地熱環境下における人工貯留層の造成による地熱資源開発の実現可能性

A feasibility study for supercritical geothermal energy in enhanced geothermal system

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Japan has many volcanoes and large potential of geothermal energies. However, since 1996, the construction of large-scale geothermal plants in Japan has been stopped, and the amount of electricity generated by the geothermal plants decreased by about 30 percent compared to the peak time in 1997. Existing geothermal energy development has mainly targeted shallow geothermal resources. However, shallow geothermal resources are eccentrically located so we can generate power at narrow area and obtain the limited amount of energy. On the other hand, geothermal power generation using supercritical water is expected to increase power output with one power plant than the conventional geothermal power plants. Moreover, by constructing artificial reservoir, it becomes possible to introduce it in wide area and it is expected to contribute to reduction of development and attenuation risk. However, the feasibility of the geothermal power plants using supercritical water has not been fully investigated yet. In this research, we focus on artificial geothermal reservoir under supercritical environment, and quantitatively investigate its feasibility using numerical simulations. Specifically, artificial supercritical geothermal power generation with a downhole coaxial heat exchanger and a single U-shaped pipe method are considered as the heat exchanger method. We solve the unsteady thermal conduction problem using the finite-difference method with various flow rate and injection pressure conditions. As the result of numerical simulation, it was confirmed that in the case of both the double pipe system and the single U-shaped pipe, it is possible to extract supercritical water. Moreover, it was also found that high-performance heat insulating tubes are required for the inner pipe or the production well in either the double pipe type or the single U-shaped pipe type.

キーワード：超臨界地熱発電、数値シミュレーション、差分法
Keywords: supercritical geothermal power generation, numerical simulation, finite-difference method

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

2019年5月26日(日) 15:30 ~ 17:00 | ポスター会場 幕張メッセ国際展示場 8ホール_22

[B-PT04] Biomineralization and the Geochemistry of Proxies

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

Biomineralization and the Geochemistry of Proxies - Biology, laboratory culture-experiments and their applications to the paleo-research -
In order to reconstruct the Earth climate system, marine paleoclimatologists resort to transfer functions or geochemical proxies, which are produced or affected by organisms. The relationships used for reconstructions are generally based on field calibrations or derived from laboratory experiments. The danger of these so-called empirical relationships is that they may be valid only within the restricted parameter space of their calibration. Application of proxy relationships to very different environmental settings (e.g. high vs. low latitude or glacial vs. interglacial) requires a mechanistic understanding of these relationships. Much progress can be expected by a better understanding of the biomineralization mechanisms and the incorporation of proxy signals.
In this session we facilitate contributions related to the biomineralization, calibration and validation of marine proxies from field study, laboratory culture experiment and paleo-environmental reconstruction.

[BPT04-P01] Living (stained) benthic foraminifera in the West-Gironde mud patch (Bay of Biscay, France): An ongoing survey for the European Community.

*Christophe Fontanier[1,2]、Bruno Deflandre[1]、Sylvain Rigaud[3]、Sabine Schmidt[1]、Bastien Lamarque[1]、Pascal Lebleu[1]、Dominique Poirier[1]、Antoine Grémare[1] (1. Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE、2.FORAM Research Group, F-49140 Villevêque, FRANCE、3.Nîmes University, GIS Laboratory, EA 7352 CHROME, F-30035 Nïmes, FRANCE)

[BPT04-P02] Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

*Pauline Duros[1]、Christophe Fontanier[1,2,3]、Briony Mamo[4,5]、Deborah Mille[6]、Olivier Herlory[6] (1.FORAM Research Group, F-49140 Villevêque, FRANCE、2.Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE、3.Angers University, 4 boulevard Lavoisier, F-49000 Angers, FRANCE.、4.School of Biological Sciences, University of Hong Kong, Pokfulam Road Sai Wan, Hong Kong SAR, CHINA. 、5.Department of Biology, Macquarie University, North Ryde, NSW, 2109, AUSTRALIA.、6.CREOCEAN, Agence PACA Corse, 230 Avenue de Rome, Valparc-Bât B, F-83500 La Seyne sur Mer, FRANCE.)

[BPT04-P03] 瀬戸内海表層堆積物中の珪藻遺骸群集組成とバイオマーカー組成の比較

*廣瀬 孝太郎[1]、中村 英人[2]、安藤 卓人[4]、浅岡 聡[3]、沢田 健[5] (1.早稲田大学　大学院創造理工学研究科　地球・環境資源理工学専攻、2.大阪市立大学大学院　理学研究科、3.神戸大学 内海域環境教育研究センター、4.北海道大学　極域研究センター、5.北海道大学　大学院理学研究院　地球惑星科学部門)

[BPT04-P04] Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

*Laurie Marie Charrieau[1]、Helena L. Filipsson[2]、Yukiko Nagai[1]、Sachiko Kawada[1]、Karl Ljung[2]、Emma Kritzberg[3]、Takashi Toyofuku[1,4] (1.Japan Agency for Marine-Earth Science and Technology、2.Department of Geology, Lund University, Sweden、3.Department of Biology, Lund University, Sweden、4.Tokyo University of Marine Science and Technology (TUMSAT), Japan)

[BPT04-P05] Effects on larger benthic foraminiferal shell density under global warming

★Invited Papers

*木下 峻一[1]、黒柳 あずみ[2]、西 弘嗣[2]、佐々木 理[2]、藤田 和彦[3]、鈴木 淳[4]、川幡 穂高[5] (1.東北大学大学院理学研究科、2.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、3.琉球大学理学部物質地球科学科、4.独立行政法人産業技術総合研究所地質情報研究部門、5.東京大学　大気海洋研究所)

[BPT04-P06] Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

*長井 裕季子[1,2]、植松 勝之[3]、豊福 高志[2,4] (1.独立行政法人　国立科学博物館、2.国立研究開発法人　海洋研究開発機構、3.マリンワークジャパン、4.東京海洋大学)

[BPT04-P07] Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

*豊福 高志[1,2]、長井 裕季子[1,3] (1.国立研究開発法人海洋研究開発機構、2.東京海洋大学、3.国立科学博物館)

[BPT04-P08] Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

*高木 悠花[1]、木元 克典[2]、藤木 徹一[2]、守屋 和佳[3]、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.早稲田大学教育学部)

[BPT04-P09] 硬骨海綿の骨格化学組成の古海洋プロキシとしての有用性

*浅海 竜司[1]、成瀬 貫[2]、水山 克[3]、植村 立[3]、新城 竜一[3]、伊勢 優史[4]、藤田 喜久[5]、坂巻 隆史[6] (1.東北大学大学院理学研究科、2.琉球大学熱帯生物圏研究センター、3.琉球大学理学部、4.マレーシア科学大学、5.沖縄県立芸術大学、6.東北大学大学院工学研究科)

Living (stained) benthic foraminifera in the West-Gironde mud patch (Bay of Biscay, France): An ongoing survey for the European Community.

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During an environmental survey performed in summer 2017 (JERICObent-2 Cruise), living (stained) benthic foraminiferal faunas were investigated at 7 stations sampled within the West-Gironde mud patch, a mud belt located on the marine shelf in front of the Gironde River (Bay of Biscay, France). This study area is really strategic for local fisheries since substantial marine resources (demersal fishes, shrimps...) are easily accessible for coastal fishermen. Moreover, the mud belt is considered an important hotspot for marine biodiversity as far as food (i.e. sedimentary organic matter), which is naturally abundant there, could sustain an assumedly enhanced heterogeneity of benthic habitats for various taxon. In the framework of the European project JERICONext (ID 654410), we have been studying biological (prokaryotes, benthic meiofauna and macrofauna), sedimentary and geochemical patterns of mud-flat ecosystems in order to better understand how both spatial and temporal variability of riverine regime and coastal hydrodynamics impact the dynamics of the benthic life, especially foraminifera. Stations investigated in this presentation are located between 39 and 69 m water depth from the inner shelf to the mid-shelf. At most sites, surface sediment is characterized by clay-silt facies more or less enriched in organic matter. Oxygen penetration depth within the sediment is less than 7±3 mm. Foraminiferal simple diversity (S) presents relatively moderate values ranging between 15 and 35 taxa. According to Shannon Index H' and Rarefaction Index ES(100), foraminiferal diversity tends to slightly increase with water depth. This trend is supported by *Eggerelloides scabrus;* its contribution decreases from the shallower stations (~50%) of the proximal mud patch (<55 m depth) to the deeper stations (<30%) of the distal mud patch (>55 m depth). This agglutinated species is generally considered a reliable bio-indicator of organic-matter enriched sediment in front of river mouths. It is noteworthy that the shallowest station (station 1, 39 m) is also characterised by the exclusive contribution of *Quinqueloculina lata/laevigata* and *Ammonia beccarii,* which are both typical of inner-shelf environments. There, surface sediment is made of fine sand. The deeper stations (>55 m depth) located in the distal mud patch are characterised by a remarkable contribution (~30%) of *Pseudoeponides falsobeccarii* and Buliminids (~30% respectively). They are accompanied by *Rectuvigerina phlegeri* and *Nonion fabum*, which are typical of mid- and outer-shelf ecosystems. The contribution of Buliminids underline the gradual increase of sedimentary organic content (>1.2% DW) with water depth.

Keywords: Living Benthic Foraminifera, Mud Belt, Environmental Spatial Variability, Sedimentary Organic Matter, Oxygenation Level

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Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

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During an environmental survey performed in autumn 2016, living (stained) benthic foraminiferal faunas were investigated at 16 stations sampled within the Cassidaigne Canyon (NW Mediterranean Sea) and surrounding area. For many decades, industrial bauxite residues of red mud have drained into the canyon via a submarine pipe, causing physical disturbance and chemical contamination. In January 2016, solid waste disposal ceased and was replaced with the dumping of a low-density liquid effluent. Stations investigated in this paper are located between 265–2500 m water depth from the shelf break to the deeper basin and from a distance between 4–70 km from the pipe outlet. At many sites, surface sediment is characterized by historical deposits of red mud and their geochemical imprints. Our ecological observations at the 725 m-depth station closest to the Cassidaigne Canyon submarine pipe show the highest concentration of the opportunistic and stress-tolerant species *Bulimina marginata* d' Orbigny, 1826, commonly identified as a recolonizer of disturbed areas. At the other fifteen stations, foraminiferal standing stocks and simple diversity (S) decrease with decreasing food input to the seafloor and increasing water depth. There, foraminiferal composition is characterized by a minor contribution of stress-tolerant species and echoes the overall meso-oligotrophic patterns of a relatively stable ecosystem. Our study clearly shows that in September 2016, 10 months after a historical shift in discharged industrial wastes (from dense red mud to liquid effluent), foraminiferal diversity close to the pipe outlet in the Cassidaigne Canyon remains altered, but appears to be slowly recovering.

Keywords: Benthic foraminifera, Bauxite residues, Cassidaigne Canyon, Resilience

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瀬戸内海表層堆積物中の珪藻遺骸群集組成とバイオマーカー組成の比較
Comparison between assemblages of diatom fossil and biomarkers in surface sediments from Seto Inland Sea

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1. Faculty of Science & Engineering, Waseda University, 2. Faculty of Science, Osaka City University, 3. Research Center for Inland Seas & Department of Planetology, Kobe University, 4. Arctic Research Center, Hokkaido University, 5. Department of Earth & Planetary Science, Faculty of Science, Hokkaido University

We investigate the fossil diatom abundances and biomarker concentrations in marine sediment to assess their relationships. 14 sample of surface (uppermost 5 cm of sea bottom) sediments are taken in 5 areas (Aki-nada Bay, Hiuchi-nada Bay, Harimanada-Bay, Osaka Bay and Kii Strait) of Seto Inland Seas in July 2015. Additional 8 samples are taken in Harimanada-Bay in October 2015. Although the precise age of the core has not been determined yet, it could be deposited within 10 years, according to the sedimentation rates by previous study (Yasuhara et al., 2007).
Diatom species such as small *Thalassiosira*spp., *skeletonema costatum*, resting spore of *Chaetoceros* spp. and *Neodelphyneis pelagica*, which were reported by previous study (Hirose et al., 2008), are observed as the dominant taxa in all samples. *Rhizosolenia* spp. and *Pleurosigma* spp., known HBI producers, were occurred in low proportions. As specific diatom biomarkers, we identified C25 di- and tri-unsaturated highly branched isoprenoids (HBIs), along with relatively minor amount of C25 and C35 cyclic HBIs. Total abundances of diatom valves and HBIs were generally correlated, probably reflecting variations of diatom production. Meanwhile, Aki-bay and some samples of Harima-nada Bay were characterized with relatively low abundance of HBIs relative to valves. In these area, focused analysis on the minor diatom taxa would be needed to provide quantitative dataset to discuss further relation of HBIs and produces and their spatial distribution.

キーワード：珪藻群集、珪藻バイオマーカー、HBI、表層堆積物、瀬戸内海
Keywords: diatom assemblage, diatom biomarkers, HBIs, surface sediment, Seto Inland Seas

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Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

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Coastal areas display natural large environmental variability such as frequent changes in salinity, pH, and carbonate chemistry. Anthropogenic impacts –especially ocean acidification –increase this variability, which may affect the living conditions of coastal species, particularly, calcifiers, such as foraminifera.

The purpose of this study was to evaluate the combined effect of two typical environmental stressors on the coast - salinity and pH –on calcifying organisms. We performed culture experiments on living benthic foraminifera to study the combined effects of lowered pH and salinity on the calcification abilities and survival of the coastal, calcitic species Ammonia sp. and *Elphidium crispum*.

We found that these two species could tolerate low pH and low salinity, which reflects the environmental variations in their natural habitats. However, in open ocean conditions (salinity ~35) and lower pH treatment, the species displayed resistance to test dissolution for a longer time than in brackish conditions (salinity ~5 to 20). Moreover, the response of foraminifera to the different treatments was species-specific, and *Ammonia* sp. appeared more resistant than *E. crispum* when placed in the same conditions of pH and salinity. We also observed living dissolved specimens of juveniles *Ammonia* sp. under the combined effect of low pH and very low salinity, and we showed that desalination is one cause for the decalcification. However, they were not able to recalcify when returned to higher salinities, probably due to a sensitive balance in environmental parameters. Finally, we highlight the ability of foraminifera to survive under $\Omega calc < 1$, and that high salinity and $[Ca^{2+}]$ as building blocks are crucial for the foraminiferal calcification process.

We conclude that coastal benthic foraminifera will not immediately be affected by ocean acidification, but rather by a combination of decreasing salinity and lowered pH.

Keywords: Coastal ocean acidification, Desalination, Culture experiment, Benthic foraminifera, Calcification process

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Effects on larger benthic foraminiferal shell density under global warming

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On the recent ocean environment, due to progresses of global warming and ocean acidification, it is concerned that calcifying organisms will be seriously affected from these environmental changes. Larger benthic foraminifers (LBFs) build calcium carbonate shells. Their carbonate productivity is the third highest rate in coral reef area next to reef corals and calcareous algae. Therefore, it is important to clarify the relationship between ocean environmental changes and the response of LBFs for predicting future ocean environment including carbon cycle. Based upon test diameter and shell weight, previous studies expected how foraminifers react to sea water conditions where they are living. However, in those reports, it is still not clear whether the changing of shell weight is due to changing of shell thickness (shell volume) or shell density, also whether that changing is depending sea water temperature or acidity. Thus, this study was performed for clarifying the relationships between water temperature and LBFs shell parameters with laboratory experiments and means of micro computed tomography (CT).

In this study, we cultured the LBF *Sorites orbiculus* in filtered sea water until reproduction. Soon after *S. orbiculus* reproduced, clonal individuals from same mother individual were picked and separated into seven groups. One group was selected as initial stage sample, and other six groups were provided for culture experiments. We cultured each groups under six different temperature conditions (19, 21, 23, 25, 27 and 29 ˚C). Because clonal specimens were reproduced asexually from same individual, it was expected the genetic factors were kept to a minimum. We used micro CT to investigate mean CT number (proxy of density), shell volume, test diameter and chamber number of every clonal specimen after culturing. The results show the high correlation of mean CT number with temperature in contrast to the correlation of shell volume and temperature. This suggests changing in temperature of sea water causes shell density difference, furthermore, LBFs build the higher density shell in the higher temperature as long as they lives in 19 to 29 C˚ environment.

キーワード：大型底生有孔虫、殻密度、マイクロCT、室内飼育実験、地球温暖化
Keywords: Larger benthic foraminifer, shell density, micro CT, laboratory experiments, global warming

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Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

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The process of biomineralization of foraminiferal test is essential for its characteristic morphogenesis and the composition of element and isotope to be taken in is used also as paleo environmental proxy, numerous studies have been approched to reveal the mechanism of shell formation. However, how fast the foraminifera calicification and how much calcium carbonate deposits depends on the species, which is not well understood in most species.
The foraminifera *Spirillina vivipara* does not form a chamber, but elongate a tubular test spirally with their cytoplasmic growth. *Spirillina vivipara* is also known to be rapidly changing generations that can be reproduced in a several days after division of mother cells (Myers, 1936). From our current observations, it was also found that the shell formation is repeatedly carried out in the day, and the elongation rate of the shell is very fast. Therefore, in this study, Spirillina vivipara was used to estimate calcification rate.
In this presentation, we report on the fastest shell extending rate in foraminifera.

キーワード：石灰化、有孔虫、FIB-SEM
Keywords: Calcification, foraminifera, FIB-SEM

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Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

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Calcareous foraminifera have been thought a major carbonate producer in ocean. Their tests (shells) are fundamental tools as paleo-environmental indicators in various studies because their calcareous tests have been archived as numerous fossils in sediment for geologic time and various environmental information are brought by faunal structure, shell morphology and geochemical compsitions of calccitic test. The other hand, the calcification process itself is interested for us. Pseudopodia sticking out into sea water build organic templates in the form of chamber. Calcium carbonate is precipitated on the both side of template within several hours. Calcium and carbonate are fixed at there by foraminiferal biological process. The newly added chamber wall was flexible in a first day, the chamber solidified in a few days and became a solid test. It is very interesting to record this process in video. Our studies showed the variable change of pH and Ca during the biomineralization of foraminifera by the application of fluorescent indicators (e.g. Toyofuku et al., 2017). Recently, we also apply the method to clear cut the site of calcification under SEM by focused ion beam (FIB-SEM)(Nagai et al., 2018). The nano-scale fine structures have been revealed the distribution of soft orgnic structures (i.e. pseudopodia) and hard tissue (precipitated calium carbonate)by this observation.

キーワード：石灰化、有孔虫、イメージング
Keywords: calcification, foraminifera, imaging

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Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

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Geochemistry of planktic foraminiferal tests is an important archive to understand paleoenvironment. However, many biotic factors can affect the geochemical composition and thus may lead misinterpretation of the proxy signals. Photosymbiosis (endosymbiosis with autotrophic algae) is thought to give specific effects on foraminiferal test geochemistry such as $\delta^{13}C$ due to photosynthetic activity of the symbionts. This is because photosynthesis can alter the geochemical condition of the vicinity of the foraminiferal test where calcification takes place, and eventually elevate the $\delta^{13}C$ of the test. Therefore, whether foraminiferal species have photosymbiotic ecology or not, and how active the photosynthesis is are important information for precise paleoenvironmental reconstructions. However, photosymbiotic information of planktic foraminifers is still limited even for extant species which are often utilized to generate proxy records.
In this study, we investigated 30 species of modern planktic foraminifers covering four families; Globigerinidae, Hastigerinidae, Globorotaliidae, and Candeinidae, using active chlorophyll fluorometry (fast repetition rate fluorometry; FRRF). FRRF performs non-destructive and non-invasive measurements of algal physiology based on real-time variable fluorescence profiles. When it is applied to symbiotic consortia of planktic foraminifers, it enables us to quantify chlorophyll content of a specimen, and to qualify of photophysiological features that are useful diagnostics of symbiont photosynthetic fitness. It can provide us with convincing information on individual-based photosymbiosis.
Specimens were collected from various oceanic settings; from tropical to subpolar region, encompassing Pacific to Atlantic. We have sampled across much of the northern hemisphere tropical-subtropical gradient to get the endemic species and to replicate for the others. The detection rate of photosymbiosis in each species, the biomass of symbionts (indicated by chlorophyll content), and the state of symbionts (indicated by photophysiological parameters) were investigated. Using principal component analysis, species were ranked by their “strength” of photosymbiosis. This thorough investigation will provide a more systematic understanding of photosymbiosis in modern planktic foraminifers and will help us to choose which species to use to reconstruct paleoenvironment.

キーワード：浮遊性有孔虫、光共生
Keywords: planktic foraminifers, photosymbiosis

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硬骨海綿の骨格化学組成の古海洋プロキシとしての有用性
Evaluation of geochemistry in hypercalcified demosponges as a paleoceanographic proxy

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Hypercalcified sponges (hereafter, “sclerosponges”), living in dark environments of tropical to subtropical shallow oceans, precipitate calcium carbonate skeleton with growth bands. They grow slowly at an approximate rate of <1 mm/year unlike corals (ca. 1 cm/year) but can be so long-lived for several decades to hundred years like corals (e.g., Benavides and Druffel, 1986 Coral Reefs). Skeletal oxygen isotopic ratios in sclerosponges can reflect variations in sea surface temperature and seawater with the latter being potentially related to salinity reflecting the precipitation–evaporation balance at the sea surface and changes in water mass transport (e.g., Grottoli et al., 2010 J. Geophys. Res.). In contrast to zooxanthellate corals, which occasionally show positive correlations between skeletal oxygen and carbon isotopic ratios, it is considered that there do not exist vital effects in the secretion of sclerosponge skeleton. Previous studies showed significant decrease trends in the carbon isotope records toward the present, which is probably a result of isotopically-light carbon dioxide added into the atmosphere/ocean from fossil fuel burning (e.g., Swart et al., 2010 Geophys. Res. Lett.). Therefore, sclerosponges are shown to provide annually resolved time series of proxy records of ocean environments since the Industrial Revolution. However, few evaluation studies on the environmental proxy of sclerosponges are reported, and temporally longer (>100 year-continuous-long) records from sclerosponges were derived only from the Atlantic Ocean.
Here we present stable oxygen and carbon isotope ratios and trace elements (Mg, Ca, Sr, Ba, Pb and U) from sclerosponges (*Astrosclera willeyana* and *Acanthochaetetes wellsi*) collected from Kume-jima, Okinawa-jima and Miyako-jima, Ryukyu Islands in the North Pacific. In order to evaluate the utility of sclerosponge as an environmental proxy, within-skeleton and intraspecific variations in stable isotopic and trace elemental records of 37 samples were investigated. Soft X-ray images of large-size sclerosponges showed highly developed skeletal growth bands with >100 high/low density layers. The secular changes in radiocarbon-dated time series of the sclerosponge carbon records were consistent with previously reported data from Atlantic and Pacific corals and sclerosponges. The long-term oxygen isotopic trends of the samples are characterized by slight depletions throughout their living periods, indicative of an overall trend toward warmer ocean environment around the Ryukyu Islands. Our sclerosponge-based estimates of sea surface temperature and salinity may document thermal and hydrologic variations in the Ryukyu Islands, furthering a better understanding of northwestern tropical-subtropical Pacific climate change for the last several centuries in conjunction with coral-based long proxy records.

キーワード：硬骨海綿、酸素同位体組成、炭素同位体組成、微量元素、古海洋、沖縄

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Keywords: sclerosponge, oxygen isotope, carbon isotope, trace element, paleoceanogrpahy, Okinawa

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

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_36

[B-PT04] Biomineralization and the Geochemistry of Proxies

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Biomineralization and the Geochemistry of Proxies - Biology, laboratory culture-experiments and their applications to the paleo-research -
In order to reconstruct the Earth climate system, marine paleoclimatologists resort to transfer functions or geochemical proxies, which are produced or affected by organisms. The relationships used for reconstructions are generally based on field calibrations or derived from laboratory experiments. The danger of these so-called empirical relationships is that they may be valid only within the restricted parameter space of their calibration. Application of proxy relationships to very different environmental settings (e.g. high vs. low latitude or glacial vs. interglacial) requires a mechanistic understanding of these relationships. Much progress can be expected by a better understanding of the biomineralization mechanisms and the incorporation of proxy signals.
In this session we facilitate contributions related to the biomineralization, calibration and validation of marine proxies from field study, laboratory culture experiment and paleo-environmental reconstruction.

[BPT04-P01] Living (stained) benthic foraminifera in the West-Gironde mud patch (Bay of Biscay, France): An ongoing survey for the European Community.

*Christophe Fontanier[1,2]、Bruno Deflandre[1]、Sylvain Rigaud[3]、Sabine Schmidt[1]、Bastien Lamarque[1]、Pascal Lebleu[1]、Dominique Poirier[1]、Antoine Grémare[1] (1. Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE、2.FORAM Research Group, F-49140 Villevêque, FRANCE、3.Nîmes University, GIS Laboratory, EA 7352 CHROME, F-30035 Nïmes, FRANCE)

[BPT04-P02] Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

*Pauline Duros[1]、Christophe Fontanier[1,2,3]、Briony Mamo[4,5]、Deborah Mille[6]、Olivier Herlory[6] (1.FORAM Research Group, F-49140 Villevêque, FRANCE、2.Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE、3.Angers University, 4 boulevard Lavoisier, F-49000 Angers, FRANCE.、4.School of Biological Sciences, University of Hong Kong, Pokfulam Road Sai Wan, Hong Kong SAR, CHINA. 、5.Department of Biology, Macquarie University, North Ryde, NSW, 2109, AUSTRALIA.、6.CREOCEAN, Agence PACA Corse, 230 Avenue de Rome, Valparc-Bât B, F-83500 La Seyne sur Mer, FRANCE.)

[BPT04-P03] 瀬戸内海表層堆積物中の珪藻遺骸群集組成とバイオマーカー組成の比較

*廣瀬 孝太郎[1]、中村 英人[2]、安藤 卓人[4]、浅岡 聡[3]、沢田 健[5] (1.早稲田大学　大学院創造理工学研究科　地球・環境資源理工学専攻、2.大阪市立大学大学院　理学研究科、3.神戸大学 内海域環境教育研究センター、4.北海道大学　極域研究センター、5.北海道大学　大学院理学研究院　地球惑星科学部門)

[BPT04-P04] Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

*Laurie Marie Charrieau[1]、Helena L. Filipsson[2]、Yukiko Nagai[1]、Sachiko Kawada[1]、Karl Ljung[2]、Emma Kritzberg[3]、Takashi Toyofuku[1,4] (1.Japan Agency for Marine-Earth Science and Technology、2.Department of Geology, Lund University, Sweden、3.Department of Biology, Lund University, Sweden、4.Tokyo University of Marine Science and Technology (TUMSAT), Japan)

[BPT04-P05] Effects on larger benthic foraminiferal shell density under global warming

★Invited Papers

*木下 峻一[1]、黒柳 あずみ[2]、西 弘嗣[2]、佐々木 理[2]、藤田 和彦[3]、鈴木 淳[4]、川幡 穂高[5] (1.東北大学大学院理学研究科、2.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、3.琉球大学理学部物質地球科学科、4.独立行政法人産業技術総合研究所地質情報研究部門、5.東京大学　大気海洋研究所)

[BPT04-P06] Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

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[BPT04-P07] Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

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[BPT04-P08] Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

*高木 悠花[1]、木元 克典[2]、藤木 徹一[2]、守屋 和佳[3]、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.早稲田大学教育学部)

[BPT04-P09] 硬骨海綿の骨格化学組成の古海洋プロキシとしての有用性

*浅海 竜司[1]、成瀬 貫[2]、水山 克[3]、植村 立[3]、新城 竜一[3]、伊勢 優史[4]、藤田 喜久[5]、坂巻 隆史[6] (1.東北大学大学院理学研究科、2.琉球大学熱帯生物圏研究センター、3.琉球大学理学部、4.マレーシア科学大学、5.沖縄県立芸術大学、6.東北大学大学院工学研究科)

Living (stained) benthic foraminifera in the West-Gironde mud patch (Bay of Biscay, France): An ongoing survey for the European Community.

*Christophe Fontanier[1,2], Bruno Deflandre[1], Sylvain Rigaud[3], Sabine Schmidt[1], Bastien Lamarque[1], Pascal Lebleu[1], Dominique Poirier[1], Antoine Grémare[1]

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During an environmental survey performed in summer 2017 (JERICObent-2 Cruise), living (stained) benthic foraminiferal faunas were investigated at 7 stations sampled within the West-Gironde mud patch, a mud belt located on the marine shelf in front of the Gironde River (Bay of Biscay, France). This study area is really strategic for local fisheries since substantial marine resources (demersal fishes, shrimps...) are easily accessible for coastal fishermen. Moreover, the mud belt is considered an important hotspot for marine biodiversity as far as food (i.e. sedimentary organic matter), which is naturally abundant there, could sustain an assumedly enhanced heterogeneity of benthic habitats for various taxon. In the framework of the European project JERICONext (ID 654410), we have been studying biological (prokaryotes, benthic meiofauna and macrofauna), sedimentary and geochemical patterns of mud-flat ecosystems in order to better understand how both spatial and temporal variability of riverine regime and coastal hydrodynamics impact the dynamics of the benthic life, especially foraminifera. Stations investigated in this presentation are located between 39 and 69 m water depth from the inner shelf to the mid-shelf. At most sites, surface sediment is characterized by clay-silt facies more or less enriched in organic matter. Oxygen penetration depth within the sediment is less than 7±3 mm. Foraminiferal simple diversity (S) presents relatively moderate values ranging between 15 and 35 taxa. According to Shannon Index H' and Rarefaction Index ES(100), foraminiferal diversity tends to slightly increase with water depth. This trend is supported by *Eggerelloides scabrus;* its contribution decreases from the shallower stations (~50%) of the proximal mud patch (<55 m depth) to the deeper stations (<30%) of the distal mud patch (>55 m depth). This agglutinated species is generally considered a reliable bio-indicator of organic-matter enriched sediment in front of river mouths. It is noteworthy that the shallowest station (station 1, 39 m) is also characterised by the exclusive contribution of *Quinqueloculina lata/laevigata* and *Ammonia beccarii,* which are both typical of inner-shelf environments. There, surface sediment is made of fine sand. The deeper stations (>55 m depth) located in the distal mud patch are characterised by a remarkable contribution (~30%) of *Pseudoeponides falsobeccarii* and Buliminids (~30% respectively). They are accompanied by *Rectuvigerina phlegeri* and *Nonion fabum*, which are typical of mid- and outer-shelf ecosystems. The contribution of Buliminids underline the gradual increase of sedimentary organic content (>1.2% DW) with water depth.

Keywords: Living Benthic Foraminifera, Mud Belt, Environmental Spatial Variability, Sedimentary Organic Matter, Oxygenation Level

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Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

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During an environmental survey performed in autumn 2016, living (stained) benthic foraminiferal faunas were investigated at 16 stations sampled within the Cassidaigne Canyon (NW Mediterranean Sea) and surrounding area. For many decades, industrial bauxite residues of red mud have drained into the canyon via a submarine pipe, causing physical disturbance and chemical contamination. In January 2016, solid waste disposal ceased and was replaced with the dumping of a low-density liquid effluent. Stations investigated in this paper are located between 265–2500 m water depth from the shelf break to the deeper basin and from a distance between 4–70 km from the pipe outlet. At many sites, surface sediment is characterized by historical deposits of red mud and their geochemical imprints. Our ecological observations at the 725 m-depth station closest to the Cassidaigne Canyon submarine pipe show the highest concentration of the opportunistic and stress-tolerant species *Bulimina marginata* d' Orbigny, 1826, commonly identified as a recolonizer of disturbed areas. At the other fifteen stations, foraminiferal standing stocks and simple diversity (S) decrease with decreasing food input to the seafloor and increasing water depth. There, foraminiferal composition is characterized by a minor contribution of stress-tolerant species and echoes the overall meso-oligotrophic patterns of a relatively stable ecosystem. Our study clearly shows that in September 2016, 10 months after a historical shift in discharged industrial wastes (from dense red mud to liquid effluent), foraminiferal diversity close to the pipe outlet in the Cassidaigne Canyon remains altered, but appears to be slowly recovering.

Keywords: Benthic foraminifera, Bauxite residues, Cassidaigne Canyon, Resilience

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瀬戸内海表層堆積物中の珪藻遺骸群集組成とバイオマーカー組成の比較
Comparison between assemblages of diatom fossil and biomarkers in surface sediments from Seto Inland Sea

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We investigate the fossil diatom abundances and biomarker concentrations in marine sediment to assess their relationships. 14 sample of surface (uppermost 5 cm of sea bottom) sediments are taken in 5 areas (Aki-nada Bay, Hiuchi-nada Bay, Harimanada-Bay, Osaka Bay and Kii Strait) of Seto Inland Seas in July 2015. Additional 8 samples are taken in Harimanada-Bay in October 2015. Although the precise age of the core has not been determined yet, it could be deposited within 10 years, according to the sedimentation rates by previous study (Yasuhara et al., 2007).
Diatom species such as small *Thalassiosira*spp., *skeletonema costatum*, resting spore of *Chaetoceros* spp. and *Neodelphyneis pelagica*, which were reported by previous study (Hirose et al., 2008), are observed as the dominant taxa in all samples. *Rhizosolenia* spp. and *Pleurosigma* spp., known HBI producers, were occurred in low proportions. As specific diatom biomarkers, we identified C25 di- and tri-unsaturated highly branched isoprenoids (HBIs), along with relatively minor amount of C25 and C35 cyclic HBIs. Total abundances of diatom valves and HBIs were generally correlated, probably reflecting variations of diatom production. Meanwhile, Aki-bay and some samples of Harima-nada Bay were characterized with relatively low abundance of HBIs relative to valves. In these area, focused analysis on the minor diatom taxa would be needed to provide quantitative dataset to discuss further relation of HBIs and produces and their spatial distribution.

キーワード：珪藻群集、珪藻バイオマーカー、HBI、表層堆積物、瀬戸内海
Keywords: diatom assemblage, diatom biomarkers, HBIs, surface sediment, Seto Inland Seas

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Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

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Coastal areas display natural large environmental variability such as frequent changes in salinity, pH, and carbonate chemistry. Anthropogenic impacts –especially ocean acidification –increase this variability, which may affect the living conditions of coastal species, particularly, calcifiers, such as foraminifera.

The purpose of this study was to evaluate the combined effect of two typical environmental stressors on the coast - salinity and pH –on calcifying organisms. We performed culture experiments on living benthic foraminifera to study the combined effects of lowered pH and salinity on the calcification abilities and survival of the coastal, calcitic species Ammonia sp. and *Elphidium crispum*.

We found that these two species could tolerate low pH and low salinity, which reflects the environmental variations in their natural habitats. However, in open ocean conditions (salinity ~35) and lower pH treatment, the species displayed resistance to test dissolution for a longer time than in brackish conditions (salinity ~5 to 20). Moreover, the response of foraminifera to the different treatments was species-specific, and *Ammonia* sp. appeared more resistant than *E. crispum* when placed in the same conditions of pH and salinity. We also observed living dissolved specimens of juveniles *Ammonia* sp. under the combined effect of low pH and very low salinity, and we showed that desalination is one cause for the decalcification. However, they were not able to recalcify when returned to higher salinities, probably due to a sensitive balance in environmental parameters. Finally, we highlight the ability of foraminifera to survive under $\Omega calc < 1$, and that high salinity and $[Ca^{2+}]$ as building blocks are crucial for the foraminiferal calcification process.

We conclude that coastal benthic foraminifera will not immediately be affected by ocean acidification, but rather by a combination of decreasing salinity and lowered pH.

Keywords: Coastal ocean acidification, Desalination, Culture experiment, Benthic foraminifera, Calcification process

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Effects on larger benthic foraminiferal shell density under global warming

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On the recent ocean environment, due to progresses of global warming and ocean acidification, it is concerned that calcifying organisms will be seriously affected from these environmental changes. Larger benthic foraminifers (LBFs) build calcium carbonate shells. Their carbonate productivity is the third highest rate in coral reef area next to reef corals and calcareous algae. Therefore, it is important to clarify the relationship between ocean environmental changes and the response of LBFs for predicting future ocean environment including carbon cycle. Based upon test diameter and shell weight, previous studies expected how foraminifers react to sea water conditions where they are living. However, in those reports, it is still not clear whether the changing of shell weight is due to changing of shell thickness (shell volume) or shell density, also whether that changing is depending sea water temperature or acidity. Thus, this study was performed for clarifying the relationships between water temperature and LBFs shell parameters with laboratory experiments and means of micro computed tomography (CT).

In this study, we cultured the LBF *Sorites orbiculus* in filtered sea water until reproduction. Soon after *S. orbiculus* reproduced, clonal individuals from same mother individual were picked and separated into seven groups. One group was selected as initial stage sample, and other six groups were provided for culture experiments. We cultured each groups under six different temperature conditions (19, 21, 23, 25, 27 and 29 ˚C). Because clonal specimens were reproduced asexually from same individual, it was expected the genetic factors were kept to a minimum. We used micro CT to investigate mean CT number (proxy of density), shell volume, test diameter and chamber number of every clonal specimen after culturing. The results show the high correlation of mean CT number with temperature in contrast to the correlation of shell volume and temperature. This suggests changing in temperature of sea water causes shell density difference, furthermore, LBFs build the higher density shell in the higher temperature as long as they lives in 19 to 29 C˚ environment.

キーワード：大型底生有孔虫、殻密度、マイクロCT、室内飼育実験、地球温暖化
Keywords: Larger benthic foraminifer, shell density, micro CT, laboratory experiments, global warming

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Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

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The process of biomineralization of foraminiferal test is essential for its characteristic morphogenesis and the composition of element and isotope to be taken in is used also as paleo environmental proxy, numerous studies have been approched to reveal the mechanism of shell formation. However, how fast the foraminifera calicification and how much calcium carbonate deposits depends on the species, which is not well understood in most species.
The foraminifera *Spirillina vivipara* does not form a chamber, but elongate a tubular test spirally with their cytoplasmic growth. *Spirillina vivipara* is also known to be rapidly changing generations that can be reproduced in a several days after division of mother cells (Myers, 1936). From our current observations, it was also found that the shell formation is repeatedly carried out in the day, and the elongation rate of the shell is very fast. Therefore, in this study, Spirillina vivipara was used to estimate calcification rate.
In this presentation, we report on the fastest shell extending rate in foraminifera.

キーワード：石灰化、有孔虫、FIB-SEM
Keywords: Calcification, foraminifera, FIB-SEM

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Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

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Calcareous foraminifera have been thought a major carbonate producer in ocean. Their tests (shells) are fundamental tools as paleo-environmental indicators in various studies because their calcareous tests have been archived as numerous fossils in sediment for geologic time and various environmental information are brought by faunal structure, shell morphology and geochemical compsitions of calccitic test. The other hand, the calcification process itself is interested for us. Pseudopodia sticking out into sea water build organic templates in the form of chamber. Calcium carbonate is precipitated on the both side of template within several hours. Calcium and carbonate are fixed at there by foraminiferal biological process. The newly added chamber wall was flexible in a first day, the chamber solidified in a few days and became a solid test. It is very interesting to record this process in video. Our studies showed the variable change of pH and Ca during the biomineralization of foraminifera by the application of fluorescent indicators (e.g. Toyofuku et al., 2017). Recently, we also apply the method to clear cut the site of calcification under SEM by focused ion beam (FIB-SEM)(Nagai et al., 2018). The nano-scale fine structures have been revealed the distribution of soft orgnic structures (i.e. pseudopodia) and hard tissue (precipitated calium carbonate)by this observation.

キーワード：石灰化、有孔虫、イメージング
Keywords: calcification, foraminifera, imaging

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Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

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Geochemistry of planktic foraminiferal tests is an important archive to understand paleoenvironment. However, many biotic factors can affect the geochemical composition and thus may lead misinterpretation of the proxy signals. Photosymbiosis (endosymbiosis with autotrophic algae) is thought to give specific effects on foraminiferal test geochemistry such as $\delta^{13}C$ due to photosynthetic activity of the symbionts. This is because photosynthesis can alter the geochemical condition of the vicinity of the foraminiferal test where calcification takes place, and eventually elevate the $\delta^{13}C$ of the test. Therefore, whether foraminiferal species have photosymbiotic ecology or not, and how active the photosynthesis is are important information for precise paleoenvironmental reconstructions. However, photosymbiotic information of planktic foraminifers is still limited even for extant species which are often utilized to generate proxy records.
In this study, we investigated 30 species of modern planktic foraminifers covering four families; Globigerinidae, Hastigerinidae, Globorotaliidae, and Candeinidae, using active chlorophyll fluorometry (fast repetition rate fluorometry; FRRF). FRRF performs non-destructive and non-invasive measurements of algal physiology based on real-time variable fluorescence profiles. When it is applied to symbiotic consortia of planktic foraminifers, it enables us to quantify chlorophyll content of a specimen, and to qualify of photophysiological features that are useful diagnostics of symbiont photosynthetic fitness. It can provide us with convincing information on individual-based photosymbiosis.
Specimens were collected from various oceanic settings; from tropical to subpolar region, encompassing Pacific to Atlantic. We have sampled across much of the northern hemisphere tropical-subtropical gradient to get the endemic species and to replicate for the others. The detection rate of photosymbiosis in each species, the biomass of symbionts (indicated by chlorophyll content), and the state of symbionts (indicated by photophysiological parameters) were investigated. Using principal component analysis, species were ranked by their “strength” of photosymbiosis. This thorough investigation will provide a more systematic understanding of photosymbiosis in modern planktic foraminifers and will help us to choose which species to use to reconstruct paleoenvironment.

キーワード：浮遊性有孔虫、光共生
Keywords: planktic foraminifers, photosymbiosis

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硬骨海綿の骨格化学組成の古海洋プロキシとしての有用性
Evaluation of geochemistry in hypercalcified demosponges as a paleoceanographic proxy

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Hypercalcified sponges (hereafter, “sclerosponges”), living in dark environments of tropical to subtropical shallow oceans, precipitate calcium carbonate skeleton with growth bands. They grow slowly at an approximate rate of <1 mm/year unlike corals (ca. 1 cm/year) but can be so long-lived for several decades to hundred years like corals (e.g., Benavides and Druffel, 1986 Coral Reefs). Skeletal oxygen isotopic ratios in sclerosponges can reflect variations in sea surface temperature and seawater with the latter being potentially related to salinity reflecting the precipitation–evaporation balance at the sea surface and changes in water mass transport (e.g., Grottoli et al., 2010 J. Geophys. Res.). In contrast to zooxanthellate corals, which occasionally show positive correlations between skeletal oxygen and carbon isotopic ratios, it is considered that there do not exist vital effects in the secretion of sclerosponge skeleton. Previous studies showed significant decrease trends in the carbon isotope records toward the present, which is probably a result of isotopically-light carbon dioxide added into the atmosphere/ocean from fossil fuel burning (e.g., Swart et al., 2010 Geophys. Res. Lett.). Therefore, sclerosponges are shown to provide annually resolved time series of proxy records of ocean environments since the Industrial Revolution. However, few evaluation studies on the environmental proxy of sclerosponges are reported, and temporally longer (>100 year-continuous-long) records from sclerosponges were derived only from the Atlantic Ocean.
Here we present stable oxygen and carbon isotope ratios and trace elements (Mg, Ca, Sr, Ba, Pb and U) from sclerosponges (*Astrosclera willeyana* and *Acanthochaetetes wellsi*) collected from Kume-jima, Okinawa-jima and Miyako-jima, Ryukyu Islands in the North Pacific. In order to evaluate the utility of sclerosponge as an environmental proxy, within-skeleton and intraspecific variations in stable isotopic and trace elemental records of 37 samples were investigated. Soft X-ray images of large-size sclerosponges showed highly developed skeletal growth bands with >100 high/low density layers. The secular changes in radiocarbon-dated time series of the sclerosponge carbon records were consistent with previously reported data from Atlantic and Pacific corals and sclerosponges. The long-term oxygen isotopic trends of the samples are characterized by slight depletions throughout their living periods, indicative of an overall trend toward warmer ocean environment around the Ryukyu Islands. Our sclerosponge-based estimates of sea surface temperature and salinity may document thermal and hydrologic variations in the Ryukyu Islands, furthering a better understanding of northwestern tropical-subtropical Pacific climate change for the last several centuries in conjunction with coral-based long proxy records.

キーワード：硬骨海綿、酸素同位体組成、炭素同位体組成、微量元素、古海洋、沖縄

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Keywords: sclerosponge, oxygen isotope, carbon isotope, trace element, paleoceanogrpahy, Okinawa

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

2019年5月26日(日) 10:45 ~ 12:15 | ポスター会場 幕張メッセ国際展示場 8ホール_9

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

コンビーナ:Groisman Pavel(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA)、Shamil Maksyutov(National Institute for Environmental Studies)、Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS)、Dmitry A Streletskiy(George Washington University)

We invite presentations on the biogeochemical cycles, the surface energy budget and water cycle, and climate and ecosystem interactions in Northern Eurasia (land-cover and land-use change, atmospheric aerosols, soil, and permafrost changes that affect and are being affected by climate and ecosystem change), human dimension, and tools to address the Northern Eurasia studies. In environmental studies, our Session foci are on the carbon cycle of Northern Eurasia and on the permafrost changes in Siberia, Asian Mountains, and the Arctic coastal regions.
In the regional water cycle studies, our Session foci are on the changing distribution of precipitation intensity, frequency, especially, in the cold/shoulder season transition periods when surface air temperature is close to 0 deg.C, and on the pattern and seasonal cycle changes of runoff.
In the human dimension studies, our Session foci are on assessments of impact of the ongoing environmental changes in Northern Eurasia on the human well-being and on mitigation strategies development in response to harmful consequences of these changes
The particular foci of this Session will be the studies of changes that impacts regional sustainable development in the Dry Latitudinal Belt of Northern Eurasia that expands through the continent from Pannonian Steppes in the west to the drylands of northern China in the east.
We invite also early career scientists associated with (or interested in) the Northern Eurasia Earth Science Partnership Initiative and its continuation, Northern Eurasia Future Initiative (http://nefi-neespi.org/NEFI-WhitePaper.pdf).

Conveners:
Pavel Groisman, NC State University, USA (pasha.groisman@noaa.gov)
Shamil Maksyutov, National Institute for Environmental JAPAN (shamil@nies.go.jp)
Evgeny Gordov, Siberian Center for Environmental Research and Training, RUSSIA (gordov@scert.ru)
Yizhao Chen, Nanjing Forestry University, CHINA (chenyzvest@gmail.com)

[MIS01-P01] Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3]、Maria Dyachenko[3]、Polina Mangura[3]、Alexander Krupenko[3]、*Alexander Olchev[1,2] (1.Faculty of Geography, Lomonosov Moscow State University、2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences、3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P02] Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

*Alexander Olchev[1,2]、Natalia Levashova[3]、Dmitry Lukyanenko[3] (1.Faculty of Geography, Lomonosov Moscow State University 、2.Severtsov Institute of Ecology and Evolution, Russian Academy of Science、3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P03] Satellite-derived Burned Area for Siberia (1979 – 2000)

*Soja Amber[1]、Stocks Brian[2]、Potter Stefano[3]、Rogers Brendan[3]、Cahoon Donald[4]、Jurko Natasha[5]、Conard Susan[6]、deGroot William 'Bill'[5]、Tchebakova Nadezhda[7] (1.National Iinstitute of Aerospace / NASA Langley Research Center、2.B.J. Stocks Wildfire Investigations Ltd.、3.Woods Hole Research Center 、4.Terra Systems Research、5.Canadian Forest Service/Service canadien des forêts、6.George Mason University,Fairfax, VA、7.Sukachev Institute of Forestry, Siberian Branch of the Russian Academy of Sciences)

[MIS01-P04] Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

*Irina Repina[1,2] (1.A.M.Obukhov Institute of Atmospheric Physics RAS、2.Lomonosov Moscow State University)

[MIS01-P05] **Recent baric and climatic conditions over East Europe with a focus on Belarus**

*Irina Danilovich[1]、Vladimir Loginov[1]、Pavel Groisman[2] (1. Institute for Nature Management National Academy of Science, Minsk, Belarus、2. NC State University at NOAA National Centers for Environmental Information, Asheville, USA)

[MIS01-P06] **Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)**

★Invited Papers

*Aleksandra Alekseevna Mikheeva[1]、Margarita Syromyatina[1]、Yurii Kurochkin[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

[MIS01-P07] **Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia**

*Kiunnei Kirillina[1]、Wanglin Yan[1] (1.Graduate School of Media and Governance, Keio University SFC)

[MIS01-P08] 北日本の冬季日降水量の定量評価

*増田 南波[1]、谷田貝 亜紀代[1]、仲江川 敏之[2]、上口 賢治[3] (1.弘前大学大学院理工学研究科、2.気象庁気象研究所、3.気象庁)

[MIS01-P09] Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

*Shamil Maksyutov[1]、Alexandre Fofonov[2]、Denis Davydov[2]、Oleg Krasnov[2]、Tadanobu Nakayama[1]、Mikhail Glagolev[3] (1.National Institute for Environmental Studies、2.V.E. Zuev Institute of Atmospheric Optics、3.M.V. Lomonosov Moscow State University)

[MIS01-P10] Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

*Elena I. Parfenova[1]、Nadezhda M. Tchebakova[1] (1.V.N.Sukachev Institute of Forest SB RAS, FRC SB RAS)

Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3], Maria Dyachenko[3], Polina Mangura[3], Alexander Krupenko[3], *Alexander Olchev[1,2]

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To estimate the possible effects of clear-cutting on the air flow disturbances within the atmospheric surface layer as well as on the spatial patterns of vertical carbon dioxide (CO2) fluxes and horizontal advection terms within and around the clear-cut area a process-based three-dimensional (3D) hydrodynamic momentum, energy and CO2 exchange model was developed. Clear-cutting is one of the most widespread logging practice, which can substantially transform the energy, water vapor and CO2 exchange between forest ecosystems and atmosphere and affect the climate system at multiple scales. Developed 3D hydrodynamic model is based on a 1.5-order closure scheme and uses a system of averaged Navier-Stokes and continuity equations for the mean wind speed components, as well as the reaction-advection-diffusion equation for CO2 transfer within the atmospheric surface layer (Mukhartova et al. 2015). The model applies Reynolds's decomposition and expresses the wind speed and concentrations of CO2 as sums of their mean values and deviations. The 1.5-closure scheme assumes that the turbulent fluxes can be expressed using the turbulent exchange coefficients (that depend on turbulent kinetic energy and its dissipation rate) and the gradients of corresponding functions (wind speed components and CO2 concentrations).
The clear-cut area selected for the study is situated in the south-western part of Valdai Hills in European Russia. The area of the clear-cut is about 4.5 ha and it is surrounded by a mixed forest stand represented mainly by Norway spruce, White birch and Eurasian aspen species with tree heights ranged between 18 and 22 m (Mamkin et al. 2016, 2019). The vegetation at the clear-cut area is mainly represented by herbaceous species and a small number of juvenile aspen trees.
Results of numerical experiments with the developed 3D model showed that clear-cutting has significant effect on spatial distributions of wind speed components as well as atmospheric momentum and CO2 fluxes. Spatial flux heterogeneity is also enhanced by complex shape of the clear-cut boundary. The largest effect of the clear-cut on the air flows is mainly appeared along the windward forest edge whereas at the leeward forest edge this effect is less pronounced. The leeward part of the clear-cut is characterized by prevailed downward air flows (with negative values of vertical wind component) whereas the upward air flows (with prevailed positive values of vertical wind component) are appeared at its windward part. It is very important to point out that the horizontal gradients of vertical and horizontal wind velocities at the lowest part of the atmospheric surface layer (up to the height 3-4 m above the ground surface) as well as horizontal turbulent and non-turbulent CO2 advection terms in the central part of the clear-cut is relatively small that can be used as important criteria indicating sufficient reestablishing of the air flow in this part of the clear-cut after its disturbance at the leeward forest edge.

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Keywords: turbulent exchange model, clear-cut, momentum fluxes, CO2 fluxes

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Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

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A three-dimensional model was developed to derive the reflection, absorption and transmission of photosynthetically active radiation (PAR) by a non-uniform forest canopy with a multi-species structure (Levashova et al., 2018). The model algorithm describing solar radiation transfer through a forest canopy considers direct and diffuse radiation penetrating through gaps in the canopy, transmitted by leaves and reflected from leaves, bark and soil surface. To estimate the canopy the reflection, absorption and transmission the model uses external data about 3D structure of each tree species in the forest stand, about the spectral properties of photosynthesizing and non-photosynthesizing parts of the different trees species, and about spectral reflectance of soil surface. Moreover it uses also information about incoming solar radiation, sun elevation, the ratio of incoming direct and diffuse solar radiation, and surface topography. The model is based on steady-state transport equations initially suggested by Ross (Ross, 1981) and further developed and described by Myneni and Knyazikhin (Myneni et al., 1990; Knyazikhin et al., 2005). Calculation of the direct solar radiation fluxes within the canopy is based on estimation of the probability that a ray of light passing through the foliage reaches a given location within the canopy without interception. Diffuse solar radiation is calculated taking into account both diffuse solar radiation from the sky penetrating through foliage gaps and direct and diffuse radiation scattered by canopy foliage and woody components. The numerical scheme for solving the integro-differential equations is based on the discrete ordinates method.

The model was used to describe the spatial patterns of solar radiation reflection and transmission by non-uniform mixed forest canopy and to develop an algorithm that allows to retrieve the proportion of different tree species in a mixed forest stand from measured canopy reflection coefficients for blue, green, red and near-infrared spectral bands (obtained from e.g. the Landsat satellite imagery). This approach allowed us to quantify the proportion of different tree species (both coniferous and deciduous) in a forest stand in case if their spectral reflection properties of the leaves are not the same. The accuracy of assessing the proportion of vegetation species using this method depended on the number of reflection measurements under various solar conditions (e.g. different sun elevations) that can reached by several measurements during the growing seasons. An increase of the input data volume (determined by the number of the measurements) resulted in higher accuracies for prediction of the proportions of different tree species.

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Keywords: radiative transfer, three-dimensional model, mixed forest, canopy reflection, inverse problem

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Satellite-derived Burned Area for Siberia (1979 –2000)
Satellite-derived Burned Area for Siberia (1979 –2000)

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Siberia is a distinct and crucial region because it has the physical size necessary to effect regional and global climate. The circumboreal zone contains the largest stock of terrestrial carbon on Earth, and Russia holds roughly two-thirds of that carbon pool. Fire is the primary natural disturbance in boreal forest, which acts to cycle carbon and maintain ecosystem diversity in sync with the climate. Under current climate change scenarios, the Russian boreal is expected to experience temperature increases that exceed the global mean. We have developed a long-term burned area database that will enable novel analyses on the multi-decadal time scale that is ultimately required for robust assessments, including those focused on carbon cycling, fire emissions, and importantly the links between fire regimes, fire weather, ecosystems, and climate.

In this presentation, we present a long-term burned area database that has been developed using Advanced Very High Resolution Radiometer (AVHRR) Global Area Coverage (GAC) data from 1979-2000. Burned area has been verified using Total Ozone Mapping Spectrometer data and validated using available Landsat imagery (160 scenes thus far representing 5.6 Mha of burned area, 219 fire events, and 11% of the total area burned in the AVHRR database). Visually the burned scar data compare well. Validation is in ongoing, though initial analyses show an intersection of 42% with commission and omission errors of 31% and 25%, respectively. Most commission and omission errors are related to spatial inconsistencies using imagery with significantly different spatial resolutions. Of the fire events missed by AVHRR (i.e., omissions), 86% are related to fires <10,000 ha (~ 6 AVHRR pixels) and 44% are related to fires <3,000ha (~ 2 AVHRR pixels). Total burned area compares well, with the AVHRR database under-representing burned area by 10% compared to the Landsat data analyzed. Correlation in burned scar area between the AVHRR and Landsat data is 0.98 for all fires and 0.68 for fires that are < 0.1 Mha.

キーワード：Wildland Fire、Remote Sensing、Biomass Burning、Russia
Keywords: Wildland Fire, Remote Sensing, Biomass Burning, Russia

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Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

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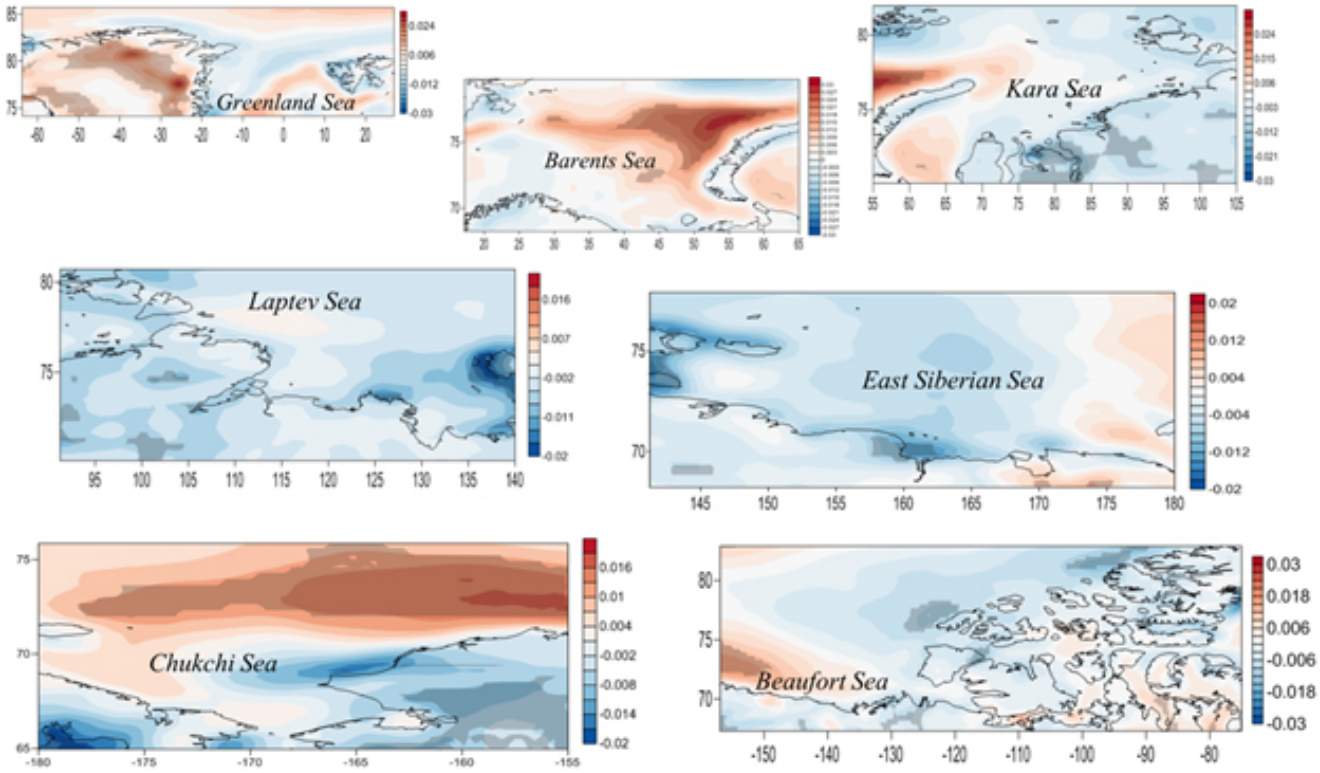
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Currently, the Arctic is attracting increased attention not only as a region with the most noticeable climate change, but also as a world mineral storage, whose development prospects are being actively discussed. For Russia, which owns the bulk of the Arctic shelf, the Arctic is also a promising trade and transport artery, as in recent decades new opportunities for using the Northern Sea Route have been discovered. But climate change can lead to less favorable consequences. The increase in the ice-free sea surface enhances the role of wind waves in the Arctic basin, which threatens platforms for the extraction of hydrocarbons on the continental shelf, vessels navigating the Northern Sea Route or its sections, as well as onshore structures, including by increasing the rate of erosion shore. Reducing the duration of the ice season activates the dynamics of ice, increasing its hummocking, and, as a result, the effect of drifting formations drifting to the ice in the ice fields increases. The development of important economic sectors in the difficult climatic conditions of the Arctic is impossible without the development of reliable systems for forecasting regional changes in weather and climate. The main objective of the work is to analyze changes in wind-wave conditions and mesoscale atmospheric processes in the coastal regions of the Russian Arctic in recent decades and forecast their dynamics under conditions of a decrease in the ice extent of the Arctic Ocean. Unique archives of satellite and hydrometeorological data, reanalysis data, climatic, regional and wind-wave models are used. The main goal of the work is to improve the accuracy of regional forecasts of hazardous hydrometeorological phenomena in the polar regions based on the development of integrated monitoring technology for mesoscale atmospheric processes in the coastal zones of the Arctic seas of the Russian Federation based on a joint analysis of ground and satellite observations and mathematical modeling results. Most of the work's tasks - namely, the development of forecasting systems for leeward storms, mesoscale cyclones, assessment of the risks of their occurrence in the context of modern climate changes, are being solved for the first time.Currently, the Arctic is attracting increased attention not only as a region with the most noticeable climate change, but also as a world mineral storage, whose development prospects are being actively discussed. For Russia, which owns the bulk of the Arctic shelf, the Arctic is also a promising trade and transport artery, as in recent decades new opportunities for using the Northern Sea Route have been discovered.
But climate change can lead to less favorable consequences. The increase in the ice-free sea surface enhances the role of wind waves in the Arctic basin, which threatens platforms for the extraction of hydrocarbons on the continental shelf, vessels navigating the Northern Sea Route or its sections, as well as onshore structures, including by increasing the rate of erosion shore. Reducing the duration of the ice season activates the dynamics of ice, increasing its hummocking, and, as a result, the effect of drifting formations drifting to the ice in the ice fields increases. The development of important economic sectors in the difficult climatic conditions of the Arctic is impossible without the development of reliable systems for forecasting regional changes in weather and climate. The main objective of the work is to analyze changes in wind-wave conditions and mesoscale atmospheric processes in the coastal regions of the Russian Arctic in recent decades and forecast their dynamics under conditions of a decrease in the ice extent of the Arctic Ocean. Unique archives of satellite and hydrometeorological data, reanalysis data, climatic, regional and wind-wave models are used. The main goal of the work is to improve the accuracy of regional forecasts of hazardous hydrometeorological phenomena in the polar regions based on the development of integrated monitoring technology for mesoscale atmospheric processes in the coastal

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zones of the Arctic seas of the Russian Federation based on a joint analysis of ground and satellite observations and mathematical modeling results. Most of the work's tasks - namely, the development of forecasting systems for leeward storms, mesoscale cyclones, assessment of the risks of their occurrence in the context of modern climate changes, are being solved for the first time.
The figure shows the linear trend of the average for December-February wind speed (m / s / year) in different regions of the Arctic according to the CFSR data from 1979 to 2017. Gray indicates significant trends.

Keywords: Arctic climate, wind-wave-ice interaction, polar low



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Recent baric and climatic conditions over East Europe with a focus on Belarus

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The global and regional climate changes are the object of intent monitoring and research works. The results of climatic investigations are highly demanded and taken into account in projecting of any kinds of economic and social activities. At the same time the reasons of climate changes still remain as a point of scientific discussion. Despite the heightened attention to the anthropogenic contribution to the climate change, the natural factors still lead in the climatic system fluctuations. In this connection the aim of the present study is an analysis of current peculiarities of the atmospheric circulation as a main natural climatic driver, estimation of the prevailing cyclonic passes over East Europe region and its climatology.

The hypothesis of the research work is that climatic changes observed in the study region in the recent decades (increase of air temperature, especially in winter season, regional changes of the moistening pattern, number and spatial distribution of extreme events) are caused by changes in the frequency of cyclones of different origin which led to various hydrometeorological conditions on their passes. According to the pattern of cyclones movement over the Atlantic-European region, we analyzed cyclonic activity by approaching cyclone selection in groups by their origin: (a) cyclones originated in the North Atlantic and sampled by two sub-groups: the West (with zonal west-east pass from Atlantic to the continent) and the Scandinavian (with meridian pass from the Scandinavia to the south); (b) cyclones that originate in the Mediterranean Sea, the Balkan Peninsula, and the Black Sea and are moving in the northward direction. The frequency of occurrence, radius, duration, and atmospheric pressure in the cyclone center (cyclone depth) have been studied for all types of cyclones.

The input information for the study is presented as two data-sets of cyclone tracks derived with the algorithms developed by different groups of authors: (1) the P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences and (2) the A.M. Obukhov Institute of Atmospheric Physics of the Russian Academy of Sciences. Both algorithms were applied to the ECMWF Era-Interim reanalysis. The study period is 1979-2016 (37 years). The cyclonic data-sets presented as coordinates and sea level pressure in the cyclone center during their life. The correspondent meteorological phenomena are used to investigate the long-term climatological anomalies in the study region such as invasions of warm and cold air masses, severe droughts, intensive precipitation, etc.

In our previous study (Partasenok *et al* 2014), we established some peculiarities of cyclone tracks change in the Atlantic-European region in winter season and in this connection the streamflow freshet formation in Belarus. The main feature of the study was an increase of the West cyclones number in the Atlantic-European region and detection the third sub-group of the Atlantic cyclones named the North cyclones. The increase this type of cyclones and its shift to the northward led to the precipitation growth in the northern part of Belarus in winter and formation the special hydrometeorological conditions for smaller than average snow-melting floods in the country during recent decades. The present study is a continuation of this research work with spreading calculations to all seasons of the year and emphasizing on the long-living climatological anomalies and extreme events connected with cyclones of the different origin.

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Keywords: East Europe, regional climatic change, regional changes in atmospheric circulation, Belarus

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Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)

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Currently there is a large investment project of the Kyzyl-Kuragino railway line construction mostly along the mountainous territory of Tuva and Krasnoyarsk Krai. The main relevance of the project is the possibility of more active involvement of the Tuva coal complex in commercial operation, which means economic development of the region. At the same time it is planned also to extend the road to Mongolia with the prospect to reach China thereby take into account international interests.

Despite the positive economic and social effects there are significant difficulties in the realization of the project due to the natural and climatic conditions. The projected railway track is mostly located in the Western Sayan Mountains and is characterized by complex environmental conditions, in particular geological and geomorphological, as well as extreme climatic characteristics, permafrost etc. The main goal of this research was to conduct an independent scientific expertise of assessment of the environmental conditions during the implementation of one the largest transport projects in Siberian region.

The natural conditions were assessed according to the following indicators: extreme values of air temperature and precipitation, strong winds, snow cover thickness, avalanche danger, seismicity and some slope processes. Analysis was made using various map documents, statistical data, results of expert interviews with the representatives of regional ministries of transport and ministries of economic development, universities and research institutes. For the analysis of extreme climatic characteristics data from weather stations of the study region were used. The entire area of projected road construction was divided into several sections, where it is necessary to take into account certain parameters mainly extreme natural phenomena. As a result the assessment of the potential natural risks during the construction and further operation of the railway was made.

Keywords: natural conditions, railway line construction, mountains, Tuva and Krasnoyarsk Krai

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Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia

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Forest fires play a critical role in shaping the ecosystem and atmospheric patterns. In turn, fire regimes are highly influenced by climate and human activities. Natural cycles, human activities like land-use changes and fire exclusion, and human-caused climate change can also influence the likelihood of fires. This study aimed to identify the causes underlying the increase of fire activity in one of the most fire-hazardous regions of Russia, the Republic of Sakha (Yakutia). The forest in this republic is performing the important function of permafrost protection. Deforestation might cause a catastrophic permafrost degradation, as the decrease of forests there mainly occurs due to fires.

To understand the patterns of historical fire activity, we analyzed the past history of fire events in the Sakha Republic through a newly developed approach for historical fire regimes characterization. Then, to identify the exact cause of intensification of fire activity was constructed an analytical approach for the assessment of interlinkages among industrialization, climate change, and forest fire activity. The study found that the main contributor to the increased historical fire activity in the republic was climate warming documented there since the 1960s, especially in spring season, which affected the overall duration of the fire season. As one main cause of recent expansion of fires, this research identified as significant the socioeconomic and land use changes undergone on the territory of the republic since the 2000s, which have resulted in extensive use of forest and forested land, and increased number of anthropogenic fires and related atmospheric changes.

Keywords: forest fires and climate change, land use changes, anthropogenic fires, GHG emissions

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北日本の冬季日降水量の定量評価
Quantitative Evaluation of Winter Daily Precipitation over Northern Japan

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*Minami Masuda[1], Akiyo Yatagai[1], Toshiyuki Nakaegawa[2], Kenji Kamiguchi[3]

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Snowfall is an important parameter for water resources. An accurate, quantitative evaluation is needed to clarify the impact of global warming on snowfall and vice versa. For that evaluation, a gridded precipitation data set based on rain-gauges is suitable, because rain-gauges measure precipitation directly. However, rain-gauge data include systematic biases due to interpolation and observation biases. For example, the long-term average, daily gridded precipitation data from APHRO_JP (P) underestimates by 30% the sum of evapotranspiration (E) and inflow (R) from dam catchments located in Northern Japan. We know this because if APHRO_JP was accurate, P should be equal to $R+E$ and it is not. It was reported that the annual mean precipitation of Japan was well simulated in the non-hydrostatic regional climate model (NHRCM, spatial resolutions 5 km/2 km) produced by the Meteorological Research Institute (MRI). From the above, we validated the interpolation bias of APHRO_JP using precipitation from the NHRCM to quantitatively evaluate winter precipitation over Northern Japan. The bias in the water balance from the dam catchments was reduced to 1% after adjusting for three systematic biases.

First, we validated and adjusted the interpolation bias. We created daily precipitation gridded data based on the distribution of the Automated Meteorological Data Acquisition System (AMeDAS) using hourly precipitation from the NHRCM (spatial distribution 2 km) and we compared it with precipitation from the NHRCM. We found that precipitation from the Mesh precipitation climatology which is used in APHRO_JP underestimated precipitation over mountain areas where rain-gauges were not set up. Because of this, APHRO_JP underestimated winter precipitation over mountain areas by approximately 3 mm/day. This daily precipitation bias over mountain areas was halved when we used climatology based on precipitation from the NHRCM instead of Mesh precipitation climatology.

Even with this adjustment, precipitation over mountain areas was still underestimated. This stemmed from the interpolation method used to predict rainfall, because the climatology indicate that the ratio of precipitation increases seasonally with elevation over mountain areas. This underestimation was controlled by an adjustment to the interpolation bias from the precipitation pattern detected by an Empirical Orthogonal Function (EOF) analysis.

On the basis of these validation results, we created daily precipitation gridded data based on the AMeDAS rain-gauge. We then applied the three adjustments from the climatology, precipitation pattern and precipitation undercatch and evaluated their contribution. We found that the annual precipitation over Japan was 2054 mm/year, which was an 18% increase on APHRO_JP. Furthermore, at the four dam catchments in Northern Japan, this adjusted precipitation explained 99% of the precipitation estimated by inflow from the dam catchments and evapotranspiration.

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Finally, we measured the contribution of the systematic bias in winter precipitation in Northern Japan (138.5–141˚E, 36.8–38.8˚N). Precipitation was increased 11% by changing the climatology and increased 12% by adjusting for precipitation undercatch. The impact of the precipitation pattern adjustment was small. For extreme events, the adjustment effect was different. On average, in the four dam catchments, precipitation was increased 18% by the change of climatology 7% by adjustment for precipitation undercatch. However, these ratios were different at each dam, and in dams where the catchments were in high mountain regions, there was a much greater effect from a change in the climatology. Because there are few rain-gauges in high mountain regions, it important to change climatology used in APHRO_JP. Furthermore, our results indicate uncertainty in precipitation from internal variability when the precipitation pattern adjustment was not used. Our application of these adjustments to APHRO_JP reduced systematic bias and improved precipitation measurements.

キーワード：APHRO_JP、冬季降水、水資源
Keywords: APHRO_JP, winter precipitation, water resource

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Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

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Wetland CO_2 and CH_4 fluxes were observed at the Bakchar bog (N56˚, E82˚), West Siberia. Measurements were performed by two solar powered automated systems, each consisting of NDIR Li-820 CO_2 analyzer, an SnO_2-based methane sensor, six static chambers installed along transects, the air drying and distribution unit, and a datalogger. Observations were made during the May to October period in 2014 to 2017 at two types of open wetlands: mesotrophic open bog and patterned wetland with forested ridges, flat hollows and water pool. Each chamber is automatically opened and closed with pneumatic actuator. Water level is measured in the wetland and surrounding forest locations. Net uptake of CO_2 is observed from the beginning of June through the end of August with a maximum from mid-June through the end of July. Seasonal pattern of methane fluxes showed that CH_4 emission increases at the beginning of June, then weakens gradually in autumn. Seasonal variation of the emissions correlates well with the soil temperature at 5-10 cm depth. Carbon dioxide and methane fluxes correlate spatially; higher methane emissions are observed at wet mesotrophic locations with higher photosynthesis/respiration rates. Lower CH_4 emissions were observed on oligotrophic patterned wetland.

Keywords: methane emissions, wetland, Siberia, CO2 fluxes

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Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

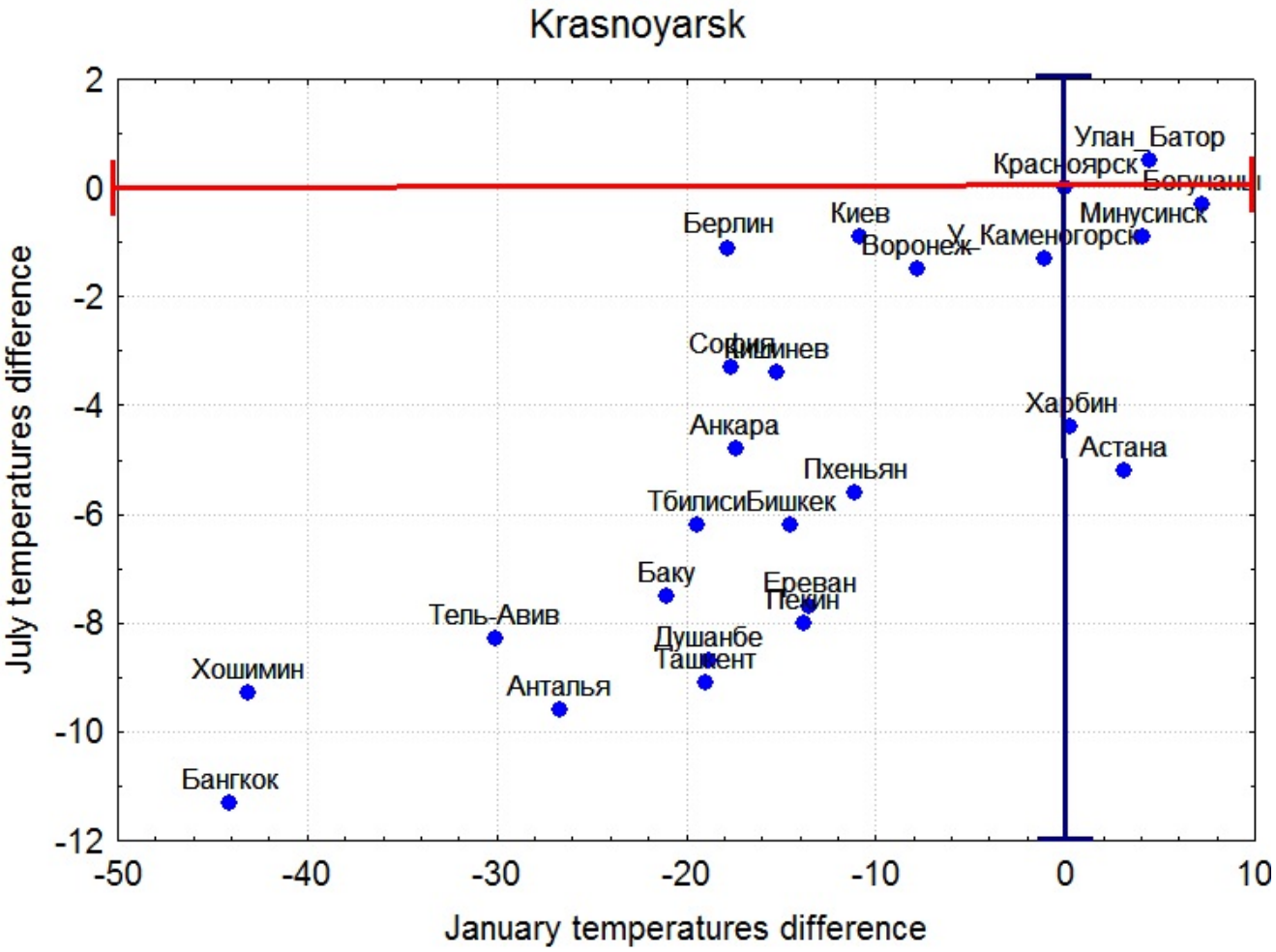
*Elena I. Parfenova[1], Nadezhda M. Tchebakova[1]

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The goals of our work were to evaluate climatic distances between climates from which potential migrants originate and climates of various regions over Siberia for which they migrate; and evaluate Siberian regions from view points of comfort-discomfort for migrants in current and future climates by the end of the century. We have completed this research from the example of the Krasnoyarsk Territory that is located in the center of Siberia and stretches from the south to north at a distance 2,000 km. Statistics on migrations show that migrants arrive to the Krasnoyarsk Territory from the European Russia and far abroad: Northern Korea, China, Vietnam. We studied four large industrial regions of the Territory for labor migrations. We used two climate variables that reflect winter and summer conditions: mean January and July temperatures. In total, 30 cities were ordinated in the axes of the differences in these temperatures between migrants' origins and migration locations. To characterize the future climates by the end of the century we used January and July temperature departure means from the ensemble of twenty general circulation models from the CMIP5. Two scenarios were used to characterize the range of climate change: a mild RCP 2.6 and a sharp RCP 8.5 climate scenarios. In total, 12 portraits of potential labor migrations were outlined in current and future climates. The "null" point in each portrait showed conditions for the natives of a particular region and the distance from the null to a country of origin showed physiological and psychological discrepancy that migrants should overcome to live in new climate.

Keywords: migration, climate change, transfer function, Siberia, January and July temperatures

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

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_40

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

コンビーナ:Groisman Pavel(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA)、Shamil Maksyutov(National Institute for Environmental Studies)、Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS)、Dmitry A Streletskiy(George Washington University)

We invite presentations on the biogeochemical cycles, the surface energy budget and water cycle, and climate and ecosystem interactions in Northern Eurasia (land-cover and land-use change, atmospheric aerosols, soil, and permafrost changes that affect and are being affected by climate and ecosystem change), human dimension, and tools to address the Northern Eurasia studies. In environmental studies, our Session foci are on the carbon cycle of Northern Eurasia and on the permafrost changes in Siberia, Asian Mountains, and the Arctic coastal regions.
In the regional water cycle studies, our Session foci are on the changing distribution of precipitation intensity, frequency, especially, in the cold/shoulder season transition periods when surface air temperature is close to 0 deg.C, and on the pattern and seasonal cycle changes of runoff.
In the human dimension studies, our Session foci are on assessments of impact of the ongoing environmental changes in Northern Eurasia on the human well-being and on mitigation strategies development in response to harmful consequences of these changes
The particular foci of this Session will be the studies of changes that impacts regional sustainable development in the Dry Latitudinal Belt of Northern Eurasia that expands through the continent from Pannonian Steppes in the west to the drylands of northern China in the east.
We invite also early career scientists associated with (or interested in) the Northern Eurasia Earth Science Partnership Initiative and its continuation, Northern Eurasia Future Initiative (http://nefi-neespi.org/NEFI-WhitePaper.pdf).

Conveners:
Pavel Groisman, NC State University, USA (pasha.groisman@noaa.gov)
Shamil Maksyutov, National Institute for Environmental JAPAN (shamil@nies.go.jp)
Evgeny Gordov, Siberian Center for Environmental Research and Training, RUSSIA (gordov@scert.ru)
Yizhao Chen, Nanjing Forestry University, CHINA (chenyzvest@gmail.com)

[MIS01-P01] Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3]、Maria Dyachenko[3]、Polina Mangura[3]、Alexander Krupenko[3]、*Alexander Olchev[1,2] (1.Faculty of Geography, Lomonosov Moscow State University、2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences、3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P02] Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

*Alexander Olchev[1,2]、Natalia Levashova[3]、Dmitry Lukyanenko[3] (1.Faculty of Geography, Lomonosov Moscow State University 、2.Severtsov Institute of Ecology and Evolution, Russian Academy of Science、3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P03] Satellite-derived Burned Area for Siberia (1979 – 2000)

*Soja Amber[1]、Stocks Brian[2]、Potter Stefano[3]、Rogers Brendan[3]、Cahoon Donald[4]、Jurko Natasha[5]、Conard Susan[6]、deGroot William 'Bill'[5]、Tchebakova Nadezhda[7] (1.National Iinstitute of Aerospace / NASA Langley Research Center、2.B.J. Stocks Wildfire Investigations Ltd.、3.Woods Hole Research Center 、4.Terra Systems Research、5.Canadian Forest Service/Service canadien des forêts、6.George Mason University,Fairfax, VA、7.Sukachev Institute of Forestry, Siberian Branch of the Russian Academy of Sciences)

[MIS01-P04] Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

*Irina Repina[1,2] (1.A.M.Obukhov Institute of Atmospheric Physics RAS、2.Lomonosov Moscow State University)

[MIS01-P05] **Recent baric and climatic conditions over East Europe with a focus on Belarus**

*Irina Danilovich[1]、Vladimir Loginov[1]、Pavel Groisman[2] (1. Institute for Nature Management National Academy of Science, Minsk, Belarus、2. NC State University at NOAA National Centers for Environmental Information, Asheville, USA)

[MIS01-P06] **Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)**

★Invited Papers

*Aleksandra Alekseevna Mikheeva[1]、Margarita Syromyatina[1]、Yurii Kurochkin[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

[MIS01-P07] **Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia**

*Kiunnei Kirillina[1]、Wanglin Yan[1] (1.Graduate School of Media and Governance, Keio University SFC)

[MIS01-P08] 北日本の冬季日降水量の定量評価

*増田 南波[1]、谷田貝 亜紀代[1]、仲江川 敏之[2]、上口 賢治[3] (1.弘前大学大学院理工学研究科、2.気象庁気象研究所、3.気象庁)

[MIS01-P09] Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

*Shamil Maksyutov[1]、Alexandre Fofonov[2]、Denis Davydov[2]、Oleg Krasnov[2]、Tadanobu Nakayama[1]、Mikhail Glagolev[3] (1.National Institute for Environmental Studies、2.V.E. Zuev Institute of Atmospheric Optics、3.M.V. Lomonosov Moscow State University)

[MIS01-P10] Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

*Elena I. Parfenova[1]、Nadezhda M. Tchebakova[1] (1.V.N.Sukachev Institute of Forest SB RAS, FRC SB RAS)

Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3], Maria Dyachenko[3], Polina Mangura[3], Alexander Krupenko[3], *Alexander Olchev[1,2]

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To estimate the possible effects of clear-cutting on the air flow disturbances within the atmospheric surface layer as well as on the spatial patterns of vertical carbon dioxide (CO2) fluxes and horizontal advection terms within and around the clear-cut area a process-based three-dimensional (3D) hydrodynamic momentum, energy and CO2 exchange model was developed. Clear-cutting is one of the most widespread logging practice, which can substantially transform the energy, water vapor and CO2 exchange between forest ecosystems and atmosphere and affect the climate system at multiple scales. Developed 3D hydrodynamic model is based on a 1.5-order closure scheme and uses a system of averaged Navier-Stokes and continuity equations for the mean wind speed components, as well as the reaction-advection-diffusion equation for CO2 transfer within the atmospheric surface layer (Mukhartova et al. 2015). The model applies Reynolds's decomposition and expresses the wind speed and concentrations of CO2 as sums of their mean values and deviations. The 1.5-closure scheme assumes that the turbulent fluxes can be expressed using the turbulent exchange coefficients (that depend on turbulent kinetic energy and its dissipation rate) and the gradients of corresponding functions (wind speed components and CO2 concentrations).
The clear-cut area selected for the study is situated in the south-western part of Valdai Hills in European Russia. The area of the clear-cut is about 4.5 ha and it is surrounded by a mixed forest stand represented mainly by Norway spruce, White birch and Eurasian aspen species with tree heights ranged between 18 and 22 m (Mamkin et al. 2016, 2019). The vegetation at the clear-cut area is mainly represented by herbaceous species and a small number of juvenile aspen trees.
Results of numerical experiments with the developed 3D model showed that clear-cutting has significant effect on spatial distributions of wind speed components as well as atmospheric momentum and CO2 fluxes. Spatial flux heterogeneity is also enhanced by complex shape of the clear-cut boundary. The largest effect of the clear-cut on the air flows is mainly appeared along the windward forest edge whereas at the leeward forest edge this effect is less pronounced. The leeward part of the clear-cut is characterized by prevailed downward air flows (with negative values of vertical wind component) whereas the upward air flows (with prevailed positive values of vertical wind component) are appeared at its windward part. It is very important to point out that the horizontal gradients of vertical and horizontal wind velocities at the lowest part of the atmospheric surface layer (up to the height 3-4 m above the ground surface) as well as horizontal turbulent and non-turbulent CO2 advection terms in the central part of the clear-cut is relatively small that can be used as important criteria indicating sufficient reestablishing of the air flow in this part of the clear-cut after its disturbance at the leeward forest edge.

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Keywords: turbulent exchange model, clear-cut, momentum fluxes, CO2 fluxes

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Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

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A three-dimensional model was developed to derive the reflection, absorption and transmission of photosynthetically active radiation (PAR) by a non-uniform forest canopy with a multi-species structure (Levashova et al., 2018). The model algorithm describing solar radiation transfer through a forest canopy considers direct and diffuse radiation penetrating through gaps in the canopy, transmitted by leaves and reflected from leaves, bark and soil surface. To estimate the canopy the reflection, absorption and transmission the model uses external data about 3D structure of each tree species in the forest stand, about the spectral properties of photosynthesizing and non-photosynthesizing parts of the different trees species, and about spectral reflectance of soil surface. Moreover it uses also information about incoming solar radiation, sun elevation, the ratio of incoming direct and diffuse solar radiation, and surface topography. The model is based on steady-state transport equations initially suggested by Ross (Ross, 1981) and further developed and described by Myneni and Knyazikhin (Myneni et al., 1990; Knyazikhin et al., 2005). Calculation of the direct solar radiation fluxes within the canopy is based on estimation of the probability that a ray of light passing through the foliage reaches a given location within the canopy without interception. Diffuse solar radiation is calculated taking into account both diffuse solar radiation from the sky penetrating through foliage gaps and direct and diffuse radiation scattered by canopy foliage and woody components. The numerical scheme for solving the integro-differential equations is based on the discrete ordinates method.

The model was used to describe the spatial patterns of solar radiation reflection and transmission by non-uniform mixed forest canopy and to develop an algorithm that allows to retrieve the proportion of different tree species in a mixed forest stand from measured canopy reflection coefficients for blue, green, red and near-infrared spectral bands (obtained from e.g. the Landsat satellite imagery). This approach allowed us to quantify the proportion of different tree species (both coniferous and deciduous) in a forest stand in case if their spectral reflection properties of the leaves are not the same. The accuracy of assessing the proportion of vegetation species using this method depended on the number of reflection measurements under various solar conditions (e.g. different sun elevations) that can reached by several measurements during the growing seasons. An increase of the input data volume (determined by the number of the measurements) resulted in higher accuracies for prediction of the proportions of different tree species.

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Keywords: radiative transfer, three-dimensional model, mixed forest, canopy reflection, inverse problem

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Satellite-derived Burned Area for Siberia (1979 –2000)
Satellite-derived Burned Area for Siberia (1979 –2000)

*Soja Jeanine Amber[1]、Stocks Brian[2]、Potter Stefano[3]、Rogers Brendan[3]、Cahoon Donald[4]、Jurko Natasha[5]、Conard Susan[6]、deGroot William 'Bill'[5]、Tchebakova Nadezhda[7]
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Siberia is a distinct and crucial region because it has the physical size necessary to effect regional and global climate. The circumboreal zone contains the largest stock of terrestrial carbon on Earth, and Russia holds roughly two-thirds of that carbon pool. Fire is the primary natural disturbance in boreal forest, which acts to cycle carbon and maintain ecosystem diversity in sync with the climate. Under current climate change scenarios, the Russian boreal is expected to experience temperature increases that exceed the global mean. We have developed a long-term burned area database that will enable novel analyses on the multi-decadal time scale that is ultimately required for robust assessments, including those focused on carbon cycling, fire emissions, and importantly the links between fire regimes, fire weather, ecosystems, and climate.

In this presentation, we present a long-term burned area database that has been developed using Advanced Very High Resolution Radiometer (AVHRR) Global Area Coverage (GAC) data from 1979-2000. Burned area has been verified using Total Ozone Mapping Spectrometer data and validated using available Landsat imagery (160 scenes thus far representing 5.6 Mha of burned area, 219 fire events, and 11% of the total area burned in the AVHRR database). Visually the burned scar data compare well. Validation is in ongoing, though initial analyses show an intersection of 42% with commission and omission errors of 31% and 25%, respectively. Most commission and omission errors are related to spatial inconsistencies using imagery with significantly different spatial resolutions. Of the fire events missed by AVHRR (i.e., omissions), 86% are related to fires <10,000 ha (~ 6 AVHRR pixels) and 44% are related to fires <3,000ha (~ 2 AVHRR pixels). Total burned area compares well, with the AVHRR database under-representing burned area by 10% compared to the Landsat data analyzed. Correlation in burned scar area between the AVHRR and Landsat data is 0.98 for all fires and 0.68 for fires that are < 0.1 Mha.

キーワード：Wildland Fire、Remote Sensing、Biomass Burning、Russia
Keywords: Wildland Fire, Remote Sensing, Biomass Burning, Russia

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Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

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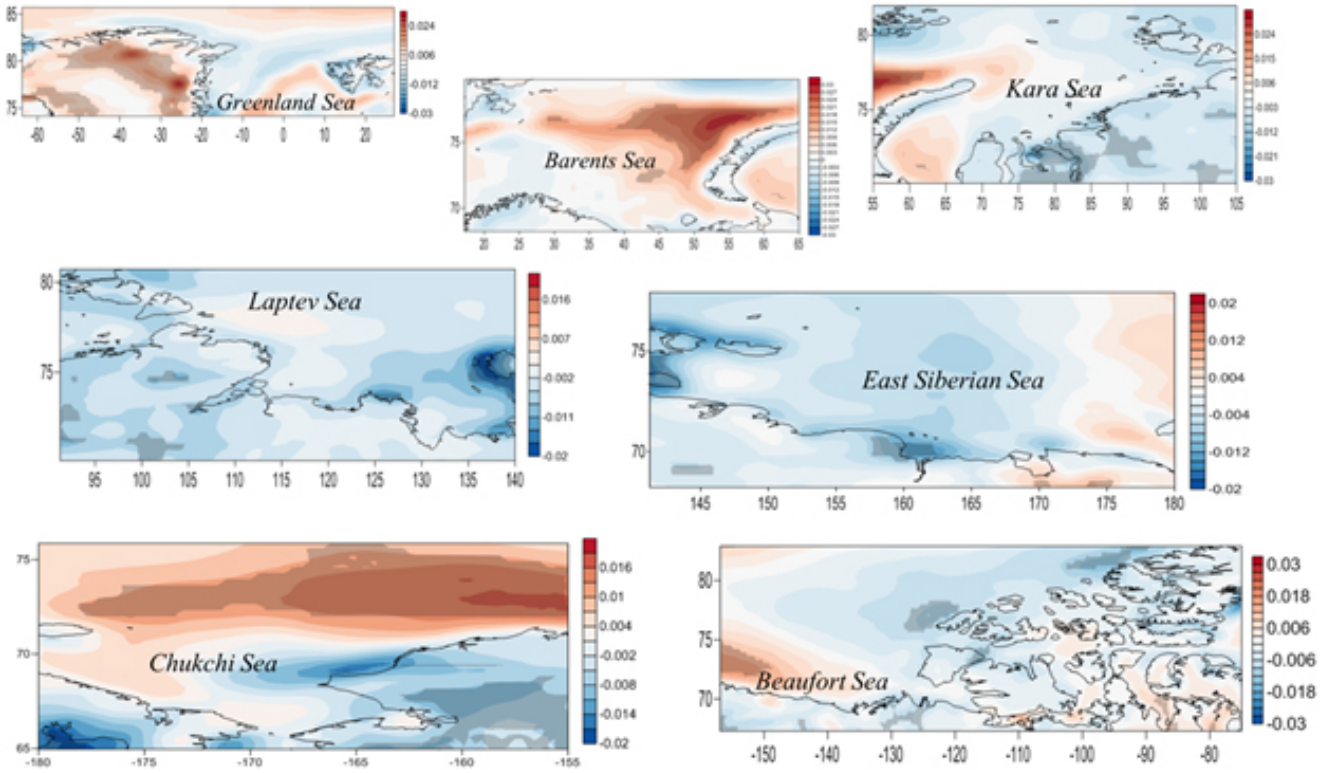
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Currently, the Arctic is attracting increased attention not only as a region with the most noticeable climate change, but also as a world mineral storage, whose development prospects are being actively discussed. For Russia, which owns the bulk of the Arctic shelf, the Arctic is also a promising trade and transport artery, as in recent decades new opportunities for using the Northern Sea Route have been discovered. But climate change can lead to less favorable consequences. The increase in the ice-free sea surface enhances the role of wind waves in the Arctic basin, which threatens platforms for the extraction of hydrocarbons on the continental shelf, vessels navigating the Northern Sea Route or its sections, as well as onshore structures, including by increasing the rate of erosion shore. Reducing the duration of the ice season activates the dynamics of ice, increasing its hummocking, and, as a result, the effect of drifting formations drifting to the ice in the ice fields increases. The development of important economic sectors in the difficult climatic conditions of the Arctic is impossible without the development of reliable systems for forecasting regional changes in weather and climate. The main objective of the work is to analyze changes in wind-wave conditions and mesoscale atmospheric processes in the coastal regions of the Russian Arctic in recent decades and forecast their dynamics under conditions of a decrease in the ice extent of the Arctic Ocean. Unique archives of satellite and hydrometeorological data, reanalysis data, climatic, regional and wind-wave models are used. The main goal of the work is to improve the accuracy of regional forecasts of hazardous hydrometeorological phenomena in the polar regions based on the development of integrated monitoring technology for mesoscale atmospheric processes in the coastal zones of the Arctic seas of the Russian Federation based on a joint analysis of ground and satellite observations and mathematical modeling results. Most of the work's tasks - namely, the development of forecasting systems for leeward storms, mesoscale cyclones, assessment of the risks of their occurrence in the context of modern climate changes, are being solved for the first time.Currently, the Arctic is attracting increased attention not only as a region with the most noticeable climate change, but also as a world mineral storage, whose development prospects are being actively discussed. For Russia, which owns the bulk of the Arctic shelf, the Arctic is also a promising trade and transport artery, as in recent decades new opportunities for using the Northern Sea Route have been discovered.
But climate change can lead to less favorable consequences. The increase in the ice-free sea surface enhances the role of wind waves in the Arctic basin, which threatens platforms for the extraction of hydrocarbons on the continental shelf, vessels navigating the Northern Sea Route or its sections, as well as onshore structures, including by increasing the rate of erosion shore. Reducing the duration of the ice season activates the dynamics of ice, increasing its hummocking, and, as a result, the effect of drifting formations drifting to the ice in the ice fields increases. The development of important economic sectors in the difficult climatic conditions of the Arctic is impossible without the development of reliable systems for forecasting regional changes in weather and climate. The main objective of the work is to analyze changes in wind-wave conditions and mesoscale atmospheric processes in the coastal regions of the Russian Arctic in recent decades and forecast their dynamics under conditions of a decrease in the ice extent of the Arctic Ocean. Unique archives of satellite and hydrometeorological data, reanalysis data, climatic, regional and wind-wave models are used. The main goal of the work is to improve the accuracy of regional forecasts of hazardous hydrometeorological phenomena in the polar regions based on the development of integrated monitoring technology for mesoscale atmospheric processes in the coastal

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zones of the Arctic seas of the Russian Federation based on a joint analysis of ground and satellite observations and mathematical modeling results. Most of the work's tasks - namely, the development of forecasting systems for leeward storms, mesoscale cyclones, assessment of the risks of their occurrence in the context of modern climate changes, are being solved for the first time.
The figure shows the linear trend of the average for December-February wind speed (m / s / year) in different regions of the Arctic according to the CFSR data from 1979 to 2017. Gray indicates significant trends.

Keywords: Arctic climate, wind-wave-ice interaction, polar low



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Recent baric and climatic conditions over East Europe with a focus on Belarus

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The global and regional climate changes are the object of intent monitoring and research works. The results of climatic investigations are highly demanded and taken into account in projecting of any kinds of economic and social activities. At the same time the reasons of climate changes still remain as a point of scientific discussion. Despite the heightened attention to the anthropogenic contribution to the climate change, the natural factors still lead in the climatic system fluctuations. In this connection the aim of the present study is an analysis of current peculiarities of the atmospheric circulation as a main natural climatic driver, estimation of the prevailing cyclonic passes over East Europe region and its climatology.

The hypothesis of the research work is that climatic changes observed in the study region in the recent decades (increase of air temperature, especially in winter season, regional changes of the moistening pattern, number and spatial distribution of extreme events) are caused by changes in the frequency of cyclones of different origin which led to various hydrometeorological conditions on their passes. According to the pattern of cyclones movement over the Atlantic-European region, we analyzed cyclonic activity by approaching cyclone selection in groups by their origin: (a) cyclones originated in the North Atlantic and sampled by two sub-groups: the West (with zonal west-east pass from Atlantic to the continent) and the Scandinavian (with meridian pass from the Scandinavia to the south); (b) cyclones that originate in the Mediterranean Sea, the Balkan Peninsula, and the Black Sea and are moving in the northward direction. The frequency of occurrence, radius, duration, and atmospheric pressure in the cyclone center (cyclone depth) have been studied for all types of cyclones.

The input information for the study is presented as two data-sets of cyclone tracks derived with the algorithms developed by different groups of authors: (1) the P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences and (2) the A.M. Obukhov Institute of Atmospheric Physics of the Russian Academy of Sciences. Both algorithms were applied to the ECMWF Era-Interim reanalysis. The study period is 1979-2016 (37 years). The cyclonic data-sets presented as coordinates and sea level pressure in the cyclone center during their life. The correspondent meteorological phenomena are used to investigate the long-term climatological anomalies in the study region such as invasions of warm and cold air masses, severe droughts, intensive precipitation, etc.

In our previous study (Partasenok *et al* 2014), we established some peculiarities of cyclone tracks change in the Atlantic-European region in winter season and in this connection the streamflow freshet formation in Belarus. The main feature of the study was an increase of the West cyclones number in the Atlantic-European region and detection the third sub-group of the Atlantic cyclones named the North cyclones. The increase this type of cyclones and its shift to the northward led to the precipitation growth in the northern part of Belarus in winter and formation the special hydrometeorological conditions for smaller than average snow-melting floods in the country during recent decades. The present study is a continuation of this research work with spreading calculations to all seasons of the year and emphasizing on the long-living climatological anomalies and extreme events connected with cyclones of the different origin.

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Reference: Partasenok (Danilovich) I.S., P. Ya. Groisman, R.S. Chekan, and V. I. Melnik, 2014: Winter cyclone frequency and following freshet streamflow formation on the rivers in Belarus. *Environ. Res. Lett.*, **9,** 09005 (13 pp). doi:10.1088/1748-9326/9/9/095005 *Environ. Res. Lett.* **9** (2014) 109602 (2 pp) doi:10.1088/1748-9326/9/10/109602

Keywords: East Europe, regional climatic change, regional changes in atmospheric circulation, Belarus

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Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)

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Currently there is a large investment project of the Kyzyl-Kuragino railway line construction mostly along the mountainous territory of Tuva and Krasnoyarsk Krai. The main relevance of the project is the possibility of more active involvement of the Tuva coal complex in commercial operation, which means economic development of the region. At the same time it is planned also to extend the road to Mongolia with the prospect to reach China thereby take into account international interests.

Despite the positive economic and social effects there are significant difficulties in the realization of the project due to the natural and climatic conditions. The projected railway track is mostly located in the Western Sayan Mountains and is characterized by complex environmental conditions, in particular geological and geomorphological, as well as extreme climatic characteristics, permafrost etc. The main goal of this research was to conduct an independent scientific expertise of assessment of the environmental conditions during the implementation of one the largest transport projects in Siberian region.

The natural conditions were assessed according to the following indicators: extreme values of air temperature and precipitation, strong winds, snow cover thickness, avalanche danger, seismicity and some slope processes. Analysis was made using various map documents, statistical data, results of expert interviews with the representatives of regional ministries of transport and ministries of economic development, universities and research institutes. For the analysis of extreme climatic characteristics data from weather stations of the study region were used. The entire area of projected road construction was divided into several sections, where it is necessary to take into account certain parameters mainly extreme natural phenomena. As a result the assessment of the potential natural risks during the construction and further operation of the railway was made.

Keywords: natural conditions, railway line construction, mountains, Tuva and Krasnoyarsk Krai

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Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia

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Forest fires play a critical role in shaping the ecosystem and atmospheric patterns. In turn, fire regimes are highly influenced by climate and human activities. Natural cycles, human activities like land-use changes and fire exclusion, and human-caused climate change can also influence the likelihood of fires. This study aimed to identify the causes underlying the increase of fire activity in one of the most fire-hazardous regions of Russia, the Republic of Sakha (Yakutia). The forest in this republic is performing the important function of permafrost protection. Deforestation might cause a catastrophic permafrost degradation, as the decrease of forests there mainly occurs due to fires.

To understand the patterns of historical fire activity, we analyzed the past history of fire events in the Sakha Republic through a newly developed approach for historical fire regimes characterization. Then, to identify the exact cause of intensification of fire activity was constructed an analytical approach for the assessment of interlinkages among industrialization, climate change, and forest fire activity. The study found that the main contributor to the increased historical fire activity in the republic was climate warming documented there since the 1960s, especially in spring season, which affected the overall duration of the fire season. As one main cause of recent expansion of fires, this research identified as significant the socioeconomic and land use changes undergone on the territory of the republic since the 2000s, which have resulted in extensive use of forest and forested land, and increased number of anthropogenic fires and related atmospheric changes.

Keywords: forest fires and climate change, land use changes, anthropogenic fires, GHG emissions

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北日本の冬季日降水量の定量評価
Quantitative Evaluation of Winter Daily Precipitation over Northern Japan

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*Minami Masuda[1], Akiyo Yatagai[1], Toshiyuki Nakaegawa[2], Kenji Kamiguchi[3]

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Snowfall is an important parameter for water resources. An accurate, quantitative evaluation is needed to clarify the impact of global warming on snowfall and vice versa. For that evaluation, a gridded precipitation data set based on rain-gauges is suitable, because rain-gauges measure precipitation directly. However, rain-gauge data include systematic biases due to interpolation and observation biases. For example, the long-term average, daily gridded precipitation data from APHRO_JP (P) underestimates by 30% the sum of evapotranspiration (E) and inflow (R) from dam catchments located in Northern Japan. We know this because if APHRO_JP was accurate, P should be equal to $R+E$ and it is not. It was reported that the annual mean precipitation of Japan was well simulated in the non-hydrostatic regional climate model (NHRCM, spatial resolutions 5 km/2 km) produced by the Meteorological Research Institute (MRI). From the above, we validated the interpolation bias of APHRO_JP using precipitation from the NHRCM to quantitatively evaluate winter precipitation over Northern Japan. The bias in the water balance from the dam catchments was reduced to 1% after adjusting for three systematic biases.

First, we validated and adjusted the interpolation bias. We created daily precipitation gridded data based on the distribution of the Automated Meteorological Data Acquisition System (AMeDAS) using hourly precipitation from the NHRCM (spatial distribution 2 km) and we compared it with precipitation from the NHRCM. We found that precipitation from the Mesh precipitation climatology which is used in APHRO_JP underestimated precipitation over mountain areas where rain-gauges were not set up. Because of this, APHRO_JP underestimated winter precipitation over mountain areas by approximately 3 mm/day. This daily precipitation bias over mountain areas was halved when we used climatology based on precipitation from the NHRCM instead of Mesh precipitation climatology.

Even with this adjustment, precipitation over mountain areas was still underestimated. This stemmed from the interpolation method used to predict rainfall, because the climatology indicate that the ratio of precipitation increases seasonally with elevation over mountain areas. This underestimation was controlled by an adjustment to the interpolation bias from the precipitation pattern detected by an Empirical Orthogonal Function (EOF) analysis.

On the basis of these validation results, we created daily precipitation gridded data based on the AMeDAS rain-gauge. We then applied the three adjustments from the climatology, precipitation pattern and precipitation undercatch and evaluated their contribution. We found that the annual precipitation over Japan was 2054 mm/year, which was an 18% increase on APHRO_JP. Furthermore, at the four dam catchments in Northern Japan, this adjusted precipitation explained 99% of the precipitation estimated by inflow from the dam catchments and evapotranspiration.

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Finally, we measured the contribution of the systematic bias in winter precipitation in Northern Japan (138.5–141˚E, 36.8–38.8˚N). Precipitation was increased 11% by changing the climatology and increased 12% by adjusting for precipitation undercatch. The impact of the precipitation pattern adjustment was small. For extreme events, the adjustment effect was different. On average, in the four dam catchments, precipitation was increased 18% by the change of climatology 7% by adjustment for precipitation undercatch. However, these ratios were different at each dam, and in dams where the catchments were in high mountain regions, there was a much greater effect from a change in the climatology. Because there are few rain-gauges in high mountain regions, it important to change climatology used in APHRO_JP. Furthermore, our results indicate uncertainty in precipitation from internal variability when the precipitation pattern adjustment was not used. Our application of these adjustments to APHRO_JP reduced systematic bias and improved precipitation measurements.

キーワード：APHRO_JP、冬季降水、水資源
Keywords: APHRO_JP, winter precipitation, water resource

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Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

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Wetland CO_2 and CH_4 fluxes were observed at the Bakchar bog (N56˚, E82˚), West Siberia. Measurements were performed by two solar powered automated systems, each consisting of NDIR Li-820 CO_2 analyzer, an SnO_2-based methane sensor, six static chambers installed along transects, the air drying and distribution unit, and a datalogger. Observations were made during the May to October period in 2014 to 2017 at two types of open wetlands: mesotrophic open bog and patterned wetland with forested ridges, flat hollows and water pool. Each chamber is automatically opened and closed with pneumatic actuator. Water level is measured in the wetland and surrounding forest locations. Net uptake of CO_2 is observed from the beginning of June through the end of August with a maximum from mid-June through the end of July. Seasonal pattern of methane fluxes showed that CH_4 emission increases at the beginning of June, then weakens gradually in autumn. Seasonal variation of the emissions correlates well with the soil temperature at 5-10 cm depth. Carbon dioxide and methane fluxes correlate spatially; higher methane emissions are observed at wet mesotrophic locations with higher photosynthesis/respiration rates. Lower CH_4 emissions were observed on oligotrophic patterned wetland.

Keywords: methane emissions, wetland, Siberia, CO2 fluxes

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Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

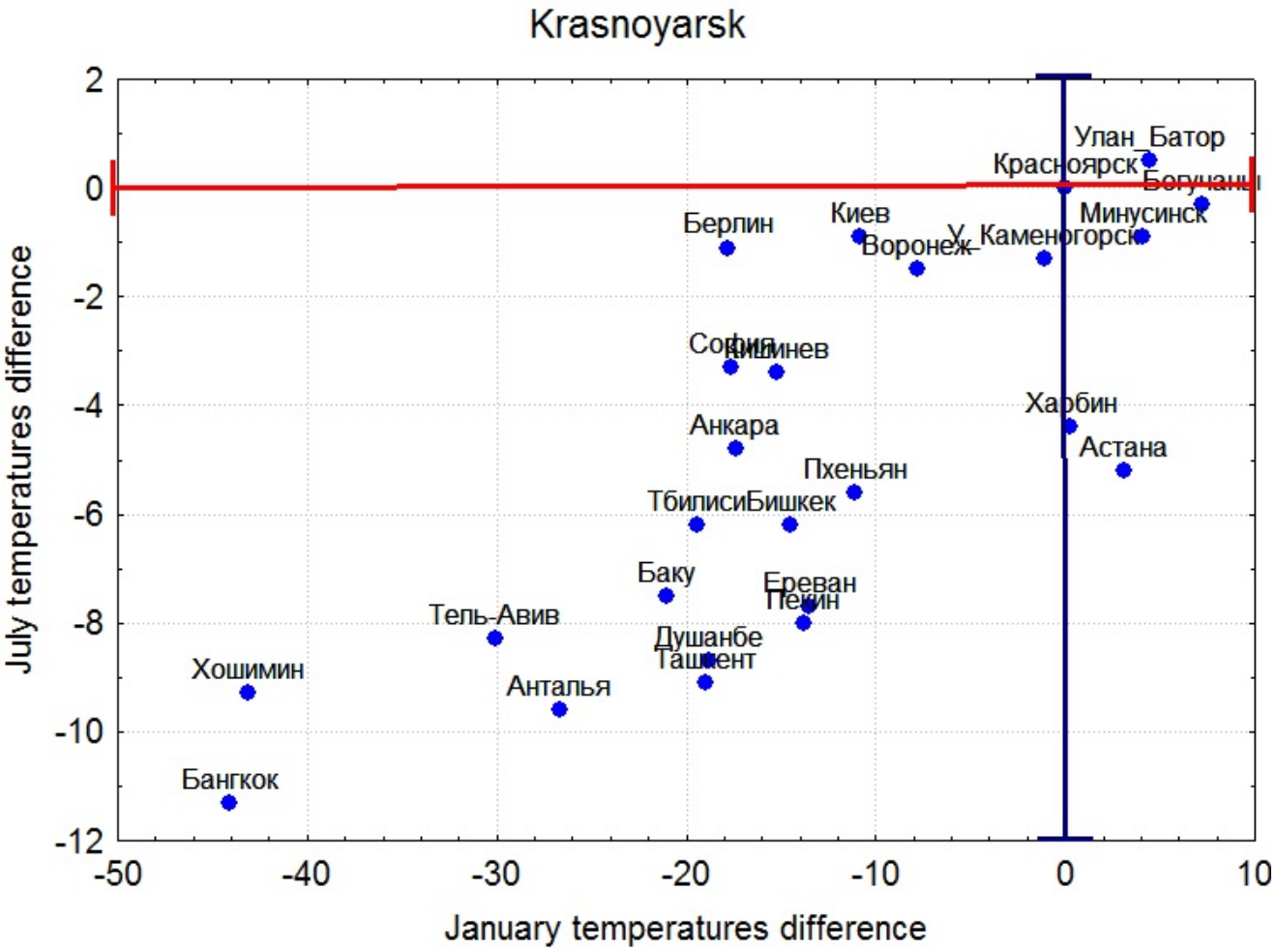
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The goals of our work were to evaluate climatic distances between climates from which potential migrants originate and climates of various regions over Siberia for which they migrate; and evaluate Siberian regions from view points of comfort-discomfort for migrants in current and future climates by the end of the century. We have completed this research from the example of the Krasnoyarsk Territory that is located in the center of Siberia and stretches from the south to north at a distance 2,000 km. Statistics on migrations show that migrants arrive to the Krasnoyarsk Territory from the European Russia and far abroad: Northern Korea, China, Vietnam. We studied four large industrial regions of the Territory for labor migrations. We used two climate variables that reflect winter and summer conditions: mean January and July temperatures. In total, 30 cities were ordinated in the axes of the differences in these temperatures between migrants' origins and migration locations. To characterize the future climates by the end of the century we used January and July temperature departure means from the ensemble of twenty general circulation models from the CMIP5. Two scenarios were used to characterize the range of climate change: a mild RCP 2.6 and a sharp RCP 8.5 climate scenarios. In total, 12 portraits of potential labor migrations were outlined in current and future climates. The "null" point in each portrait showed conditions for the natives of a particular region and the distance from the null to a country of origin showed physiological and psychological discrepancy that migrants should overcome to live in new climate.

Keywords: migration, climate change, transfer function, Siberia, January and July temperatures

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

2019年5月26日(日) 13:45 ~ 15:15 | ポスター会場 幕張メッセ国際展示場 8ホール_7

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

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Open Science is growing up as a new research paradigm to accelerate scientific innovation. Deployed by ICSU-WDS (2008), G8 Open Data Charter (2013), deployment of Research Data Alliance (2013), OECD Global Science Forum's research projects (2016), and G7 Science Ministers' Communique (2017), it commonly refers to the top-down policies to make results of publicly-funded research freely available and accessible. On the other hand, this term also refers to the participatory bottom-up approaches such as citizen science, crowdfunding, and transdisciplinary research (Kitamoto 2016). It is noted that both approaches envision the transformation of research process to more findable, accessible, interoperable, and reusable one (Wilkinson et al. 2016).
After the JpGU-AGU Great Debate "Role of open data and open science in Geoscience" in JpGU Annual Meeting 2018 and a follow-up session in the AGU Fall Meeting 2018, this session reviews the current broad spectrum of Open Science in an international context. The session welcomes a wide range of papers and posters covering (but not limited to) open research data, open source licenses, data papers and journals, data repository, data sharing infrastructures and platforms, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

[MGI31-P01] Open Science, Community Science, and AGU’s Thriving Earth Exchange.

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

[MGI31-P02] 研究データ利活用協議会（RDUF)の活動紹介：研究データに関わるオープンサイエンス、データ問題の議論のために

武田 英明[2]、*村山 泰啓[1]、研究データ利活用協議会 事務局[3] (1.国立研究開発法人情報通信研究機構 戦略的プログラムオフィス、2.国立情報学研究所、3.科学技術振興機構)

[MGI31-P03] Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

*今井 弘二[1]、村山 泰啓[1] (1.情報通信研究機構)

[MGI31-P04] Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

*木村 智樹[1]、山崎 敦[2]、吉岡 和夫[3]、村上 豪[2]、土屋 史紀[4]、北 元[2]、垰 千尋[5]、吉川 一朗[3]、熊本 篤志[6]、山内 千里[7] (1.東北大学学際科学フロンティア研究所、2.JAXA宇宙科学研究所、3.東京大学新領域創成科学研究科、4.東北大学惑星プラズマ大気研究センター、5.情報通信研究機構、6.東北大学宇宙地球電磁気学講座、7.みさと天文台)

[MGI31-P05] Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

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[MGI31-P06] Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

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[MGI31-P07] A case example of sharing meteor radio observational data by small laboratory

*小山 幸伸[1]、宮成 祐輔[1] (1.大分工業高等専門学校)

[MGI31-P08] 地球科学における市民参加型オープンサイエンスの推進：流星の超低周波帯における電波放射と異常聴音の観測・データ解析プロジェクト

*渡辺 堯[1] (1.ISC World Data System International Programme Office)

[MGI31-P09] Current status of minting DOIs for research data in JAMSTEC

*福田 和代[1]、川上 創[1]、佐々木 朋樹[1]、堀川 博紀[1]、齋藤 秀亮[1]、齊藤 千鶴[1]、園田 朗[1] (1.国立研究開発法人海洋研究開発機構)

[MGI31-P10] Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

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Open Science, Community Science, and AGU’s Thriving Earth Exchange.

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Climate change, environmental degradation, and increased vulnerability to natural hazards place humanity, and the planet, in a precarious position. Science is necessary, but not sufficient, to addresses these challenges and chart a course to a sustainable future. Traditional models of scientific research need be augmented with new models of engagement and application that are more open, more transparent, and better connect scientific evidence, data, and ways of thinking to civic action.

One such model of engagement is community science, in which scientist and community leaders design and carry out scientific activities to advance community priorities. Thriving Earth Exchange, a five-year old program of the AGU, contributes to open science by advancing Community Science. Thriving Earth Exchange has launched over 90 community science projects all over the United States and world. Projects include working with community leaders to improve the carbon inventories so that cities can identify and mitigate emissions by sector or region and working with neighborhood residents to design rain gardens that prevent local flooding and sequester carbon. AGU is seeking to expand Thriving Earth Exchange internationally and advance the practice of community science around the world.

Drawing on experience in Thriving Earth Exchange, this poster will document the practices of successful community science projects. Successful projects involve partnership and shared decision making at every stage of the scientific process—from defining scientific questions, to deciding how and what data to collect, to applying new understanding to local issues. The most successful projects put scientific knowledge in a larger context and offer science with awareness of and respect for local decision processes. Community science, therefor, appreciates other ways of knowing and deciding, and never insists on the superiority of scientific perspectives. Finally, successful community science projects advance equity by providing a way for communities—especially communities who have been historically neglected, marginalized or oppressed—to help guide and use science to advance their priorities.
This poster will offer also offer scientists tips for doing community science- tips gleaned from AGU’s experience with the Thriving Earth Exchange. These tips involve practicing humility, being willing to balance research and application, attending to equity and power, and respecting local and community knowledge. Community science also requires a willingness to work across disciplines, to get comfortable with messy problems, and to apply systems perspectives. Some of the things that scientists bring to this work, in addition to the deep expertise, are their ability to frame problems, their ability to find and access scientific knowledge and data, and the professional and personal networks that come with being part of privileged institutions.

Keywords: Community Science, Open Science

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研究データ利活用協議会（RDUF)の活動紹介：研究データに関わるオープンサイエンス、データ問題の議論のために

RDUF (Research Data Utilization Forum): an arena for community discussion of international and regional research data sharing and management

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Hideaki Takeda[2], *Yasuhiro Murayama[1], RDUF secretary office[3]

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1. Strategic Program Produce Office, National Institute of Information and Communications Technology, 2. National Institute of Informatics, 3. Japan Science and Technology Agency

2013年G8科学大臣会合を契機として、オープンサイエンスの推進が 国際的な大きなトピックとなっている。G8やOECD、AGU等でもとりあげられ ている研究データの共有や識別子、相互利用などへ向けた国際フォーラム Research Data Alliance（RDA)の活動が、国際的なデータ流通の デファクト標準化や国際合意の場として活発化している。 こうした活動を国内でも展開する重要性から、データへのDOI付与を 検討するグループから発展して、研究データ利活用協議会（RDUF)が 設立された。会員はオンラインで無料入会可能で、とくに 義務はなく、自発的なコミュニティ活動、情報交換の場として 機能している。ぜひ多くの方に興味を持っていただき参加いただ ければ幸いである。

キーワード：研究データ管理、オープンサイエンス
Keywords: research data management, open science

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Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

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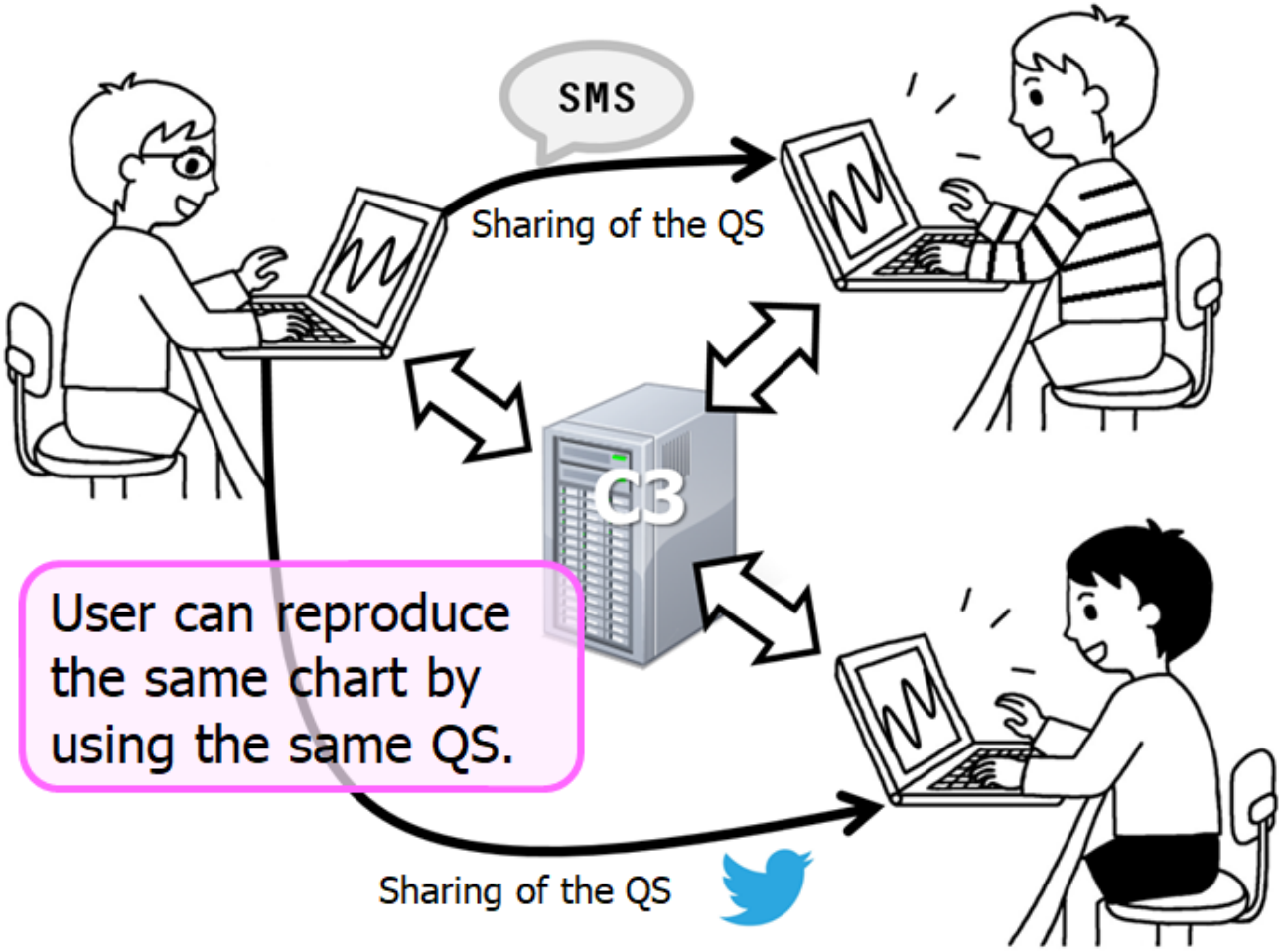
We propose a new method for sharable and reproducible data visualization on a web browser. Reproducibility is one of the foundations of the scientific method. Reproducible evidence is imperative to build new scientific knowledge. Most natural scientists use figures, graphs, plots or diagrams to understand a phenomenon in detail. Therefore, information and communication technology for reproducible charts needs to promote scientific development. However, it is not easy especially for studies dealing with scientific data of different fields, because each data set is usually stored in a different place and a different format. For this reason, we have been building a web service, Cross-Cutting Comparisons (C3; Imai et al., 2018; doi/10.20637/JAXA-RR-17-009/0001; https://www.darts.isas.jaxa.jp/C3/).
One of the features of C3 is the interactive interface. By the inductive entry form, it is easy to make flexible charts of earth, planetary and space sciences on a web browser. C3 also has a query string (QS)-controllable system which includes information of data handling procedures in the QS in an orderly manner as follow:

(URL of CGI program)?(header)+(data selection)+(data extraction)+(option).

The QS consists of four parts separated by plusses (+): header, data selection, data extraction, and option. The information of data set and figure type is described in the data selection part. The information of data extraction is in the data extraction part. By explicitly showing the inputted setting in an orderly manner in the URL, it is easy to understand how the charts are made. User can make the charts by directly enter the QS in an address bar and also share the QS with text-based communication tools.

キーワード：オープンサイエンス、データ可視化、共有、再現、ウェブサービス、クエリ文字列
Keywords: open science, data visualization, sharable, reproducible, web service, query string

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Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

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The Hisaki satellite is the first-ever space telescope mission that is dedicated to planetary sciences. Atmospheres and magnetospheres of our solar system planets are continuously monitored by the extreme ultraviolet (EUV) spectrometer onboard Hisaki. Here we describe a data pipeline system developed for processing high-level scientific and ancillary data products of the Hisaki mission. The telemetry data downlinked from the satellite is stored in a ground telemetry database, processed to imaging spectral data with a 1-min temporal resolution and ancillary data products in the pipeline, and archived in a public database. The imaging spectra are further reduced to higher-level data products for practical scientific use. For example, light curves of the power emitted from Jupiter’s aurora and plasma torus with a temporal resolution of 10 minutes are reduced from the imaging spectral data. The reduced light curve revealed transport process of energy and mass in Jupiter’s magnetosphere and associated interplanetary solar wind conditions. The continuous monitoring with Hisaki largely contributes to understanding of space weather the planets in our solar system.

キーワード：惑星宇宙天気、ひさき
Keywords: Planetary Space Weather, Hisaki

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Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

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The Inter-university Upper atmosphere Global Observation NETwork (IUGONET) is a scientific community by many Japanese institutes conducting observational research for upper atmosphere with 80km altitude and more. This region is a complex research field affected by both upper, for example solar radiations, and lower, for example atmospheric waves. Therefore, accelerating our science is not possible without data sharing infrastructures and platform for cross-sectional research. For the above reason, five Japanese institutes established IUGONET at 2009. IUGONET released many results for promoting the multidisciplinary research by using various kinds of data in the solar terrestrial science. IUGONET Type-A is a one-stop web service to provide data information (metadata) and visualization (quick look images and plots). Users can analysis data and make plots as you see on IUGONET Type-A by performing the indicated process on the analysis software, introduced below. UDAS (iUgonet Data Analysis Software) is a data analysis software written in Interactive Data Language (IDL). It works under SPEDAS (Space Physics Environment Data Analysis Software) as a plug-in. In addition, we developed program templates, called as UDAS egg (UDAS Easy Guide to Generate your load routines), for easily reading various kinds of data on SPEDAS. Users can easily load, analyze and visualize the data owned by each researcher by replacing a few codes (about 10 lines in total) marked on the template according to the instructions. This function is equipped to the latest version of the SPEDAS executables for users who do not own IDL licenses. It allows users to utilize data for interdisciplinary study, and supports the development of integrated solar terrestrial science. We also consider that it is one of our essential task for the future and development of the research field to develop both Japanese and foreign young researchers who can handle data easily. It is so difficult to accomplish it by only one project. Therefore, we holds many data analysis workshops each year in Japan and overseas countries in collaboration with other programs related to scientific research and data, for example ISELION, ISELLI, VarSITI, and WDS, etc. IUGONET developers join workshops and have lecture courses on these, and participants can practically learn how to get and analyze data. In last fiscal year, we held two times domestic lecture courses in Japan, and four international lecture courses in Malaysia, India, China, and Indonesia. The effects of this activity are very clear from the increase of scientific papers by using IUGONET products. In conclusion, Open Data activities of IUGONET mainly intend at the development of solar-terrestrial science, and make many scientific and educational results in our domain. We hope our activity will be helpful for other fields.

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Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

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Research Data Sharing is one element that constitutes Open Science. In recent discussion, it is said that scientists should share data that they collect and/or generate, to allow free and open access [1)].

Scientific data sharing are often carried out for responding to requests by funding agencies to open research data, for raising the transparency and fairness of research, for validation of research results, for increasing new research opportunities using shared data from multi-domains and interdisciplinary fields, and for increasing recognition of and rewarding achievement of scientists and experts of data management and publication [2)].

It is being promoted to cite research data like citing other articles in a research paper[3)]. When the data is cited, the DOI (Digital Object Identifier) is becoming to be used widely[4)]. Minting DOIs to a research paper or document is prevailing already. In the examples of data citations, the data is increasingly often cited with its DOI in the acknowledgement or the reference of a paper[5)]. It is expected that recognition of data creators, providers, curators, and managers will increase with help of data DOI through automatic surveillance of cited data DOIs on Internet [6)].

We are preparing sharing on a Web site of the neutral wind data observed with MF (Medium Frequency) radars at Wakkanai (45.36N, 141.81E) and Yamawaga (31.20N, 130.62E) of Japan. The 30 min. averaged data will be provided which is useful with increased confidence to analyze atmospheric dynamical phenomena (Original time interval of the observation are 3-4 min.). Currently FAIR data principle (Findable, Accessible, Interoperable and Re-usable) [7)] is being discussed to be a preferable condition for research data sharing. We are trying to increase FAIR-principle compliance level of the MF Radar data. Currently the data is: described in ASCII text format (difficult to lose readability if a human reads the data file), including the simple description in each data field in the file (although technical terms need to be improved since some are not very intelligible like "AVERAGED VELOCITY" "DATA COUNT” are to be , simpler HTML page having static URLs (dynamic data/web page generation can be a barrier for citability of online data objects). Minting the DOI is being planned.

In future, of open science activity, it is thought that research data sharing will become an important "building block" for researchers and stakeholders. This experiment in the present paper is a case study of simple data sharing, which is expected to lead to a case study for helping development of a research data sharing framework, our target is that what we will learn from this study will contribute to knowledge and techniques more universally adaptable to other data sharing practices in future.

キーワード：研究データ共有、デジタルオブジェクト識別子、中間圏・下部熱圏

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Keywords: Research Data Sharing, Digital Object Identifier, Mesosphere and Lower Thermosphere

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A case example of sharing meteor radio observational data by small laboratory

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As a result of being ionized by the meteor, the ionospheric electrical conductivity increases so much as to reflect the 50MHz radio waves which penetrates the ionosphere usually. We have been observing it in Oita of Japan for two years. However, there is not much information on the ionosphere obtained from one observatory. How to share data with other groups become the key in order to construct multipoint observation network to investigate the ionosphere in detail. In this presentation, we show a case example of data sharing, aware of FAIR principles, by using Google Drive with Google Apps Scripts.

キーワード：流星電波観測、データ共有、メタデータ、画像処理、深層学習
Keywords: Meteor radio observation, Data sharing, Metadata, Image processing, Deep learning

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地球科学における市民参加型オープンサイエンスの推進：流星の超低周波帯における電波放射と異常聴音の観測・データ解析プロジェクト
Promotion of an Open-Science Activity of the Earth Science - Coordinated Observations and Data Analyses of meteor-associated Low-Frequency Radio Emission and Anomalous Hearing

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1. ISC World Data System International Programme Office
1. ISC World Data System International Programme Office

オープンサイエンスに関連した主要な活動として、市民参加型科学研究の推進が謳われているが、超高層物理学などの物理系地球科学分野では、一般市民の関心を呼ぶテーマの設定は容易で無い。しかし流星の研究においては、眼視観測など特別な装置を必要としない観測が主流であったことなどから、大学や高校の天文クラブなどのアマチュア観測者の寄与が大きく、研究面においても高レベルの市民科学者を輩出している。一方流星観測者の間では、明るい流星（火球）の発生と同時に「音」が聞こえたような感覚があるという、流星異常聴音が長年の「謎」となっており、流星によって放射される強いkHz領域（ELF/VLF帯）における電波が、何らかの理由によって聴覚として感じられる可能性が示唆されていた（Keay, 1980）。そして1981年8月13日03時53分41秒前後に紀伊半島上空に出現した、-6等級の火球（ペルセウス流星群）に伴い、当時の名古屋大学空電研究所佐久島観測所と豊川市内において、通常の雷起源の空電とは異なる特異な周波数スペクトルを持った、強いVLF帯電波が観測された（Watanabe et al., 1988; Keay, 1992). その後同様の観測が各国で行われているが、個々の流星との対応は余り考慮されておらず、通常の空電との区別が明確でない。そこで上記のペルセウス群などの顕著な流星群の活動期に、アマチュア観測者によって全国的に行われる眼視、ビデオ、VHF流星エコーなどによる流星観測とELF/VLF帯電波研究者との連携態勢を構築し、流星電波放射の観測例を増やすとともに、流星異常聴音に関する情報も収集して、現象の解明を目指す。我が国では日本流星研究会を中心としたアマチュア流星観測者の組織化と観測データの保全が行われているため、市民参加型科学研究活動の好例として、流星電波放射と異常聴音に関わる現象の解明が進むことが期待される。なおこの研究は、大矢浩代（千葉大）、塩川和夫（名大ISEE）、加藤泰男（名大ISEE）、鈴木和博（日本流星研究会）の各氏との共同で推進される。

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キーワード：オープンサイエンス、流星電波放射、流星異常聴音
Keywords: Open Science, Meteoric Radio Emission, Meteoric Anomalous Hereing

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Current status of minting DOIs for research data in JAMSTEC

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has collected information of several precedent examples to clarify effective data Digital Object Identifier (DOI) workflow since 2015, and started to assign DOI to an oceanographic research data in 2017. In JpGU2018, we introduced development of the Data DOI Management System to manage DOI metadata and generate landing pages. We will report the current status including following topics in this presentation.

- Functional enhancement for related database
The Data and Sample Research System for Whole Cruise Information (DARWIN) disseminates information of research cruise, dive, observation data and samples obtained by JAMSTEC's research vessels and submersibles. DARWIN has been enhanced to allow linkage of DOI metadata with the Data DOI Management System via Web API to achieve effective DOI maintenance for a large amount of content.

- Survey of DOI for research data
A wide variety of databases depending on the disciplines, research project, and types of data are disseminated by several departments and groups within JAMSTEC. Therefore, a survey of minting DOI for research data is being conducted to grasp data creators' needs. We extracted the target databases from catalog metadata published in JAMSTEC data catalog. The questions in this survey ask about ownership of data, conditions for data usage, granularity of DOI assignment, and continuity of database services.

The first edition of guidelines for minting DOIs for research data in JAMSTEC will be developed based on the practical operation of systems and the survey results by the end of the year 2019.

Related URLs
JAMSTEC Data DOI, http://www.jamstec.go.jp/datadoi/doi/10.17596/e/about.html
DARWIN, http://www.godac.jamstec.go.jp/darwin/e
JAMSTEC data catalog, http://www.godac.jamstec.go.jp/catalog/data_catalog/e/

キーワード：オープンサイエンス、オープンリサーチデータ、DOI
Keywords: open science, open research data, DOI

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Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

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Taiwan is located in a special environment where geographical location and plate transfer, rainfall and earthquakes occur frequently, geological disasters are diverse and complex, and disaster prevention is an important issue that cannot be evaded by the whole people. In the face of such frequent natural disasters, the government’ s disaster prevention and relief work is particularly important.
On July 13, 1999, the Legislative Yuan officially read the "Disaster Prevention Act" [1] sub-amendment amendment, which not only allowed the Fire Department to transform into a disaster prevention and rescue department, but also assigned the national army to prevent disasters. Source of law. In keeping with the "disaster relief as a warfare" attitude, the National Army can, in response to each exercise and drill, be able to give full play to the rapid relief efforts of the national army in the golden rescue moment of major disasters, and avoid the national social disaster caused by environmental safety issues. The National Army has followed the policy guidance of "advance deployment, pre-set strength, and always-time rescue" for disaster relief, and is on standby to carry out disaster prevention and rescue missions such as preventive evacuation to protect the lives and property of the people.
To construct a multi-disaster information platform from the forward-looking command post to the users of the various levels of command posts at the back-end, to provide real-time information on the disaster relief center, to facilitate the disaster, and to control and issue orders through the information platform. For the officers and men, the mission is smooth and the delivery time is shortened. After the National Army has been refined, the number of people has been greatly reduced. In the future, in the implementation of disaster prevention, it is necessary to integrate and properly use the resources of the entire army to meet the needs of the people.

Keywords: disaster relief, military, information platform

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

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_43

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

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

Open Science is growing up as a new research paradigm to accelerate scientific innovation. Deployed by ICSU-WDS (2008), G8 Open Data Charter (2013), deployment of Research Data Alliance (2013), OECD Global Science Forum's research projects (2016), and G7 Science Ministers' Communique (2017), it commonly refers to the top-down policies to make results of publicly-funded research freely available and accessible. On the other hand, this term also refers to the participatory bottom-up approaches such as citizen science, crowdfunding, and transdisciplinary research (Kitamoto 2016). It is noted that both approaches envision the transformation of research process to more findable, accessible, interoperable, and reusable one (Wilkinson et al. 2016).
After the JpGU-AGU Great Debate "Role of open data and open science in Geoscience" in JpGU Annual Meeting 2018 and a follow-up session in the AGU Fall Meeting 2018, this session reviews the current broad spectrum of Open Science in an international context. The session welcomes a wide range of papers and posters covering (but not limited to) open research data, open source licenses, data papers and journals, data repository, data sharing infrastructures and platforms, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

[MGI31-P01] Open Science, Community Science, and AGU’s Thriving Earth Exchange.

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

[MGI31-P02] 研究データ利活用協議会（RDUF)の活動紹介：研究データに関わるオープンサイエンス、データ問題の議論のために

武田 英明[2]、*村山 泰啓[1]、研究データ利活用協議会 事務局[3] (1.国立研究開発法人情報通信研究機構 戦略的プログラムオフィス、2.国立情報学研究所、3.科学技術振興機構)

[MGI31-P03] Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

*今井 弘二[1]、村山 泰啓[1] (1.情報通信研究機構)

[MGI31-P04] Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

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[MGI31-P05] Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

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[MGI31-P06] Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

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[MGI31-P07] A case example of sharing meteor radio observational data by small laboratory

*小山 幸伸[1]、宮成 祐輔[1] (1.大分工業高等専門学校)

[MGI31-P08] 地球科学における市民参加型オープンサイエンスの推進：流星の超低周波帯における電波放射と異常聴音の観測・データ解析プロジェクト

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[MGI31-P09] Current status of minting DOIs for research data in JAMSTEC

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[MGI31-P10] Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

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Open Science, Community Science, and AGU’s Thriving Earth Exchange.

*Shelley Stall[1], Raj Pandya[1]

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Climate change, environmental degradation, and increased vulnerability to natural hazards place humanity, and the planet, in a precarious position. Science is necessary, but not sufficient, to addresses these challenges and chart a course to a sustainable future. Traditional models of scientific research need be augmented with new models of engagement and application that are more open, more transparent, and better connect scientific evidence, data, and ways of thinking to civic action.

One such model of engagement is community science, in which scientist and community leaders design and carry out scientific activities to advance community priorities. Thriving Earth Exchange, a five-year old program of the AGU, contributes to open science by advancing Community Science. Thriving Earth Exchange has launched over 90 community science projects all over the United States and world. Projects include working with community leaders to improve the carbon inventories so that cities can identify and mitigate emissions by sector or region and working with neighborhood residents to design rain gardens that prevent local flooding and sequester carbon. AGU is seeking to expand Thriving Earth Exchange internationally and advance the practice of community science around the world.

Drawing on experience in Thriving Earth Exchange, this poster will document the practices of successful community science projects. Successful projects involve partnership and shared decision making at every stage of the scientific process—from defining scientific questions, to deciding how and what data to collect, to applying new understanding to local issues. The most successful projects put scientific knowledge in a larger context and offer science with awareness of and respect for local decision processes. Community science, therefor, appreciates other ways of knowing and deciding, and never insists on the superiority of scientific perspectives. Finally, successful community science projects advance equity by providing a way for communities—especially communities who have been historically neglected, marginalized or oppressed—to help guide and use science to advance their priorities.
This poster will offer also offer scientists tips for doing community science- tips gleaned from AGU’s experience with the Thriving Earth Exchange. These tips involve practicing humility, being willing to balance research and application, attending to equity and power, and respecting local and community knowledge. Community science also requires a willingness to work across disciplines, to get comfortable with messy problems, and to apply systems perspectives. Some of the things that scientists bring to this work, in addition to the deep expertise, are their ability to frame problems, their ability to find and access scientific knowledge and data, and the professional and personal networks that come with being part of privileged institutions.

Keywords: Community Science, Open Science

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研究データ利活用協議会（RDUF)の活動紹介：研究データに関わるオープンサイエンス、データ問題の議論のために

RDUF (Research Data Utilization Forum): an arena for community discussion of international and regional research data sharing and management

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2013年G8科学大臣会合を契機として、オープンサイエンスの推進が 国際的な大きなトピックとなっている。G8やOECD、AGU等でもとりあげられ ている研究データの共有や識別子、相互利用などへ向けた国際フォーラム Research Data Alliance（RDA)の活動が、国際的なデータ流通の デファクト標準化や国際合意の場として活発化している。 こうした活動を国内でも展開する重要性から、データへのDOI付与を 検討するグループから発展して、研究データ利活用協議会（RDUF)が 設立された。会員はオンラインで無料入会可能で、とくに 義務はなく、自発的なコミュニティ活動、情報交換の場として 機能している。ぜひ多くの方に興味を持っていただき参加いただ ければ幸いである。

キーワード：研究データ管理、オープンサイエンス
Keywords: research data management, open science

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Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

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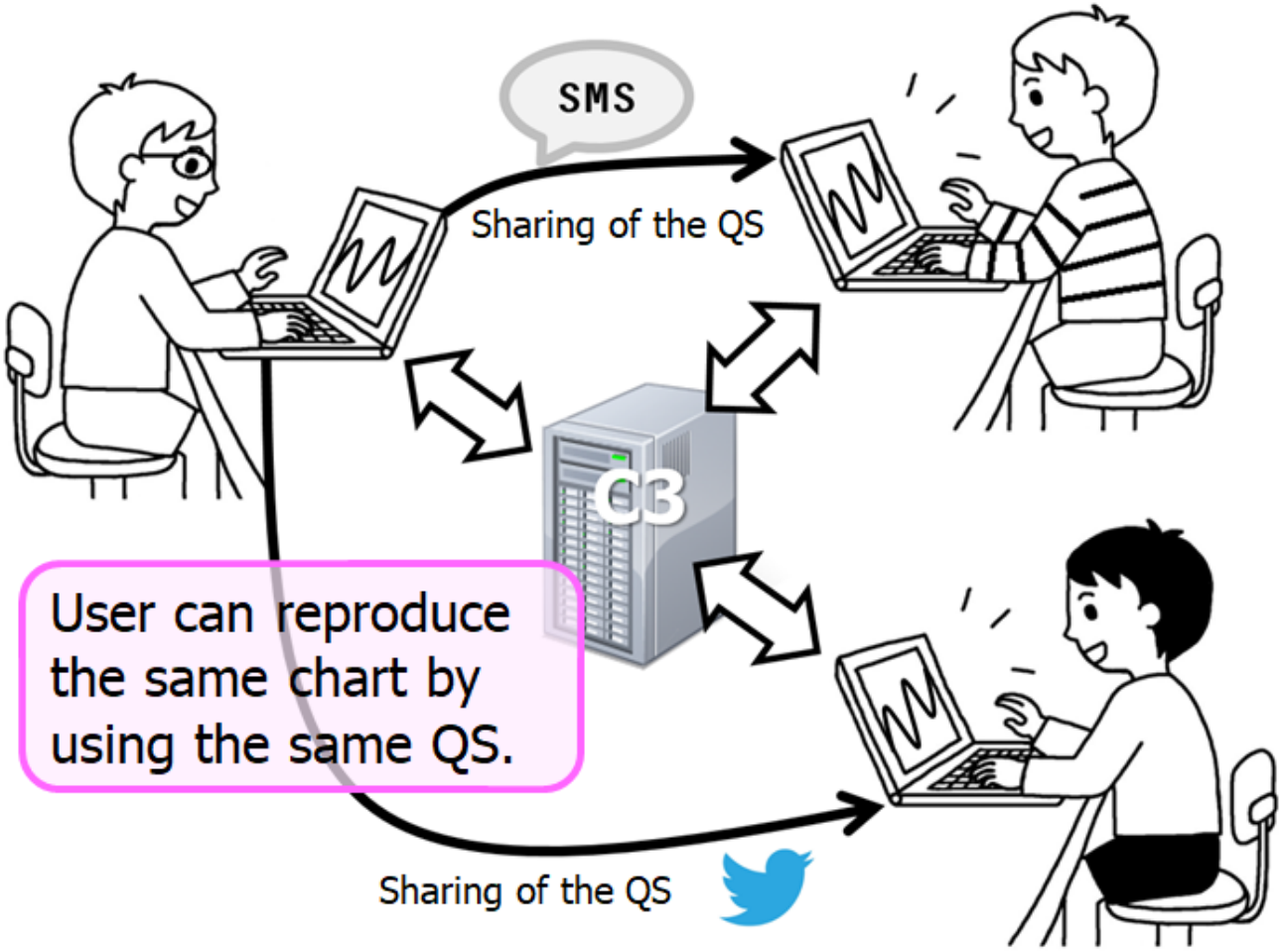
We propose a new method for sharable and reproducible data visualization on a web browser. Reproducibility is one of the foundations of the scientific method. Reproducible evidence is imperative to build new scientific knowledge. Most natural scientists use figures, graphs, plots or diagrams to understand a phenomenon in detail. Therefore, information and communication technology for reproducible charts needs to promote scientific development. However, it is not easy especially for studies dealing with scientific data of different fields, because each data set is usually stored in a different place and a different format. For this reason, we have been building a web service, Cross-Cutting Comparisons (C3; Imai et al., 2018; doi/10.20637/JAXA-RR-17-009/0001; https://www.darts.isas.jaxa.jp/C3/).
One of the features of C3 is the interactive interface. By the inductive entry form, it is easy to make flexible charts of earth, planetary and space sciences on a web browser. C3 also has a query string (QS)-controllable system which includes information of data handling procedures in the QS in an orderly manner as follow:

(URL of CGI program)?(header)+(data selection)+(data extraction)+(option).

The QS consists of four parts separated by plusses (+): header, data selection, data extraction, and option. The information of data set and figure type is described in the data selection part. The information of data extraction is in the data extraction part. By explicitly showing the inputted setting in an orderly manner in the URL, it is easy to understand how the charts are made. User can make the charts by directly enter the QS in an address bar and also share the QS with text-based communication tools.

キーワード：オープンサイエンス、データ可視化、共有、再現、ウェブサービス、クエリ文字列
Keywords: open science, data visualization, sharable, reproducible, web service, query string

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Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

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The Hisaki satellite is the first-ever space telescope mission that is dedicated to planetary sciences. Atmospheres and magnetospheres of our solar system planets are continuously monitored by the extreme ultraviolet (EUV) spectrometer onboard Hisaki. Here we describe a data pipeline system developed for processing high-level scientific and ancillary data products of the Hisaki mission. The telemetry data downlinked from the satellite is stored in a ground telemetry database, processed to imaging spectral data with a 1-min temporal resolution and ancillary data products in the pipeline, and archived in a public database. The imaging spectra are further reduced to higher-level data products for practical scientific use. For example, light curves of the power emitted from Jupiter’s aurora and plasma torus with a temporal resolution of 10 minutes are reduced from the imaging spectral data. The reduced light curve revealed transport process of energy and mass in Jupiter’s magnetosphere and associated interplanetary solar wind conditions. The continuous monitoring with Hisaki largely contributes to understanding of space weather the planets in our solar system.

キーワード：惑星宇宙天気、ひさき
Keywords: Planetary Space Weather, Hisaki

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Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

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1. International Center for Space Weather Science and Education, Japan, 2. National Institute of Polar Research, 3. Institute for Space-Earth Environmental Research, Nagoya University, 4. Kwasan & Hida Observatories, School of Science, Kyoto University

The Inter-university Upper atmosphere Global Observation NETwork (IUGONET) is a scientific community by many Japanese institutes conducting observational research for upper atmosphere with 80km altitude and more. This region is a complex research field affected by both upper, for example solar radiations, and lower, for example atmospheric waves. Therefore, accelerating our science is not possible without data sharing infrastructures and platform for cross-sectional research. For the above reason, five Japanese institutes established IUGONET at 2009. IUGONET released many results for promoting the multidisciplinary research by using various kinds of data in the solar terrestrial science. IUGONET Type-A is a one-stop web service to provide data information (metadata) and visualization (quick look images and plots). Users can analysis data and make plots as you see on IUGONET Type-A by performing the indicated process on the analysis software, introduced below. UDAS (iUgonet Data Analysis Software) is a data analysis software written in Interactive Data Language (IDL). It works under SPEDAS (Space Physics Environment Data Analysis Software) as a plug-in. In addition, we developed program templates, called as UDAS egg (UDAS Easy Guide to Generate your load routines), for easily reading various kinds of data on SPEDAS. Users can easily load, analyze and visualize the data owned by each researcher by replacing a few codes (about 10 lines in total) marked on the template according to the instructions. This function is equipped to the latest version of the SPEDAS executables for users who do not own IDL licenses. It allows users to utilize data for interdisciplinary study, and supports the development of integrated solar terrestrial science. We also consider that it is one of our essential task for the future and development of the research field to develop both Japanese and foreign young researchers who can handle data easily. It is so difficult to accomplish it by only one project. Therefore, we holds many data analysis workshops each year in Japan and overseas countries in collaboration with other programs related to scientific research and data, for example ISELION, ISELLI, VarSITI, and WDS, etc. IUGONET developers join workshops and have lecture courses on these, and participants can practically learn how to get and analyze data. In last fiscal year, we held two times domestic lecture courses in Japan, and four international lecture courses in Malaysia, India, China, and Indonesia. The effects of this activity are very clear from the increase of scientific papers by using IUGONET products. In conclusion, Open Data activities of IUGONET mainly intend at the development of solar-terrestrial science, and make many scientific and educational results in our domain. We hope our activity will be helpful for other fields.

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Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

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Research Data Sharing is one element that constitutes Open Science. In recent discussion, it is said that scientists should share data that they collect and/or generate, to allow free and open access [1)].

Scientific data sharing are often carried out for responding to requests by funding agencies to open research data, for raising the transparency and fairness of research, for validation of research results, for increasing new research opportunities using shared data from multi-domains and interdisciplinary fields, and for increasing recognition of and rewarding achievement of scientists and experts of data management and publication [2)].

It is being promoted to cite research data like citing other articles in a research paper[3)]. When the data is cited, the DOI (Digital Object Identifier) is becoming to be used widely[4)]. Minting DOIs to a research paper or document is prevailing already. In the examples of data citations, the data is increasingly often cited with its DOI in the acknowledgement or the reference of a paper[5)]. It is expected that recognition of data creators, providers, curators, and managers will increase with help of data DOI through automatic surveillance of cited data DOIs on Internet [6)].

We are preparing sharing on a Web site of the neutral wind data observed with MF (Medium Frequency) radars at Wakkanai (45.36N, 141.81E) and Yamawaga (31.20N, 130.62E) of Japan. The 30 min. averaged data will be provided which is useful with increased confidence to analyze atmospheric dynamical phenomena (Original time interval of the observation are 3-4 min.). Currently FAIR data principle (Findable, Accessible, Interoperable and Re-usable) [7)] is being discussed to be a preferable condition for research data sharing. We are trying to increase FAIR-principle compliance level of the MF Radar data. Currently the data is: described in ASCII text format (difficult to lose readability if a human reads the data file), including the simple description in each data field in the file (although technical terms need to be improved since some are not very intelligible like "AVERAGED VELOCITY" "DATA COUNT” are to be , simpler HTML page having static URLs (dynamic data/web page generation can be a barrier for citability of online data objects). Minting the DOI is being planned.

In future, of open science activity, it is thought that research data sharing will become an important "building block" for researchers and stakeholders. This experiment in the present paper is a case study of simple data sharing, which is expected to lead to a case study for helping development of a research data sharing framework, our target is that what we will learn from this study will contribute to knowledge and techniques more universally adaptable to other data sharing practices in future.

キーワード：研究データ共有、デジタルオブジェクト識別子、中間圏・下部熱圏

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Keywords: Research Data Sharing, Digital Object Identifier, Mesosphere and Lower Thermosphere

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A case example of sharing meteor radio observational data by small laboratory

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As a result of being ionized by the meteor, the ionospheric electrical conductivity increases so much as to reflect the 50MHz radio waves which penetrates the ionosphere usually. We have been observing it in Oita of Japan for two years. However, there is not much information on the ionosphere obtained from one observatory. How to share data with other groups become the key in order to construct multipoint observation network to investigate the ionosphere in detail. In this presentation, we show a case example of data sharing, aware of FAIR principles, by using Google Drive with Google Apps Scripts.

キーワード：流星電波観測、データ共有、メタデータ、画像処理、深層学習
Keywords: Meteor radio observation, Data sharing, Metadata, Image processing, Deep learning

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地球科学における市民参加型オープンサイエンスの推進：流星の超低周波帯における電波放射と異常聴音の観測・データ解析プロジェクト
Promotion of an Open-Science Activity of the Earth Science - Coordinated Observations and Data Analyses of meteor-associated Low-Frequency Radio Emission and Anomalous Hearing

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オープンサイエンスに関連した主要な活動として、市民参加型科学研究の推進が謳われているが、超高層物理学などの物理系地球科学分野では、一般市民の関心を呼ぶテーマの設定は容易で無い。しかし流星の研究においては、眼視観測など特別な装置を必要としない観測が主流であったことなどから、大学や高校の天文クラブなどのアマチュア観測者の寄与が大きく、研究面においても高レベルの市民科学者を輩出している。一方流星観測者の間では、明るい流星（火球）の発生と同時に「音」が聞こえたような感覚があるという、流星異常聴音が長年の「謎」となっており、流星によって放射される強いkHz領域（ELF/VLF帯）における電波が、何らかの理由によって聴覚として感じられる可能性が示唆されていた（Keay, 1980）。そして1981年8月13日03時53分41秒前後に紀伊半島上空に出現した、-6等級の火球（ペルセウス流星群）に伴い、当時の名古屋大学空電研究所佐久島観測所と豊川市内において、通常の雷起源の空電とは異なる特異な周波数スペクトルを持った、強いVLF帯電波が観測された（Watanabe et al., 1988; Keay, 1992). その後同様の観測が各国で行われているが、個々の流星との対応は余り考慮されておらず、通常の空電との区別が明確でない。そこで上記のペルセウス群などの顕著な流星群の活動期に、アマチュア観測者によって全国的に行われる眼視、ビデオ、VHF流星エコーなどによる流星観測とELF/VLF帯電波研究者との連携態勢を構築し、流星電波放射の観測例を増やすとともに、流星異常聴音に関する情報も収集して、現象の解明を目指す。我が国では日本流星研究会を中心としたアマチュア流星観測者の組織化と観測データの保全が行われているため、市民参加型科学研究活動の好例として、流星電波放射と異常聴音に関わる現象の解明が進むことが期待される。なおこの研究は、大矢浩代（千葉大）、塩川和夫（名大ISEE）、加藤泰男（名大ISEE）、鈴木和博（日本流星研究会）の各氏との共同で推進される。

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キーワード：オープンサイエンス、流星電波放射、流星異常聴音
Keywords: Open Science, Meteoric Radio Emission, Meteoric Anomalous Hereing

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Current status of minting DOIs for research data in JAMSTEC

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has collected information of several precedent examples to clarify effective data Digital Object Identifier (DOI) workflow since 2015, and started to assign DOI to an oceanographic research data in 2017. In JpGU2018, we introduced development of the Data DOI Management System to manage DOI metadata and generate landing pages. We will report the current status including following topics in this presentation.

- Functional enhancement for related database
The Data and Sample Research System for Whole Cruise Information (DARWIN) disseminates information of research cruise, dive, observation data and samples obtained by JAMSTEC's research vessels and submersibles. DARWIN has been enhanced to allow linkage of DOI metadata with the Data DOI Management System via Web API to achieve effective DOI maintenance for a large amount of content.

- Survey of DOI for research data
A wide variety of databases depending on the disciplines, research project, and types of data are disseminated by several departments and groups within JAMSTEC. Therefore, a survey of minting DOI for research data is being conducted to grasp data creators' needs. We extracted the target databases from catalog metadata published in JAMSTEC data catalog. The questions in this survey ask about ownership of data, conditions for data usage, granularity of DOI assignment, and continuity of database services.

The first edition of guidelines for minting DOIs for research data in JAMSTEC will be developed based on the practical operation of systems and the survey results by the end of the year 2019.

Related URLs
JAMSTEC Data DOI, http://www.jamstec.go.jp/datadoi/doi/10.17596/e/about.html
DARWIN, http://www.godac.jamstec.go.jp/darwin/e
JAMSTEC data catalog, http://www.godac.jamstec.go.jp/catalog/data_catalog/e/

キーワード：オープンサイエンス、オープンリサーチデータ、DOI
Keywords: open science, open research data, DOI

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Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

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Taiwan is located in a special environment where geographical location and plate transfer, rainfall and earthquakes occur frequently, geological disasters are diverse and complex, and disaster prevention is an important issue that cannot be evaded by the whole people. In the face of such frequent natural disasters, the government’ s disaster prevention and relief work is particularly important.
On July 13, 1999, the Legislative Yuan officially read the "Disaster Prevention Act" [1] sub-amendment amendment, which not only allowed the Fire Department to transform into a disaster prevention and rescue department, but also assigned the national army to prevent disasters. Source of law. In keeping with the "disaster relief as a warfare" attitude, the National Army can, in response to each exercise and drill, be able to give full play to the rapid relief efforts of the national army in the golden rescue moment of major disasters, and avoid the national social disaster caused by environmental safety issues. The National Army has followed the policy guidance of "advance deployment, pre-set strength, and always-time rescue" for disaster relief, and is on standby to carry out disaster prevention and rescue missions such as preventive evacuation to protect the lives and property of the people.
To construct a multi-disaster information platform from the forward-looking command post to the users of the various levels of command posts at the back-end, to provide real-time information on the disaster relief center, to facilitate the disaster, and to control and issue orders through the information platform. For the officers and men, the mission is smooth and the delivery time is shortened. After the National Army has been refined, the number of people has been greatly reduced. In the future, in the implementation of disaster prevention, it is necessary to integrate and properly use the resources of the entire army to meet the needs of the people.

Keywords: disaster relief, military, information platform

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[E] ポスター発表 | セッション記号 M (領域外・複数領域)：M-SD 宇宙開発・地球観測

2019年5月26日(日) 13:45 ~ 15:15 | ポスター会場 幕張メッセ国際展示場 8ホール_8

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

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

Microsatellites have great potential as remote sensing platforms, because of the cost-effective implementation of satellite constellations, which increase their overall temporal resolution and ground coverage for Earth observation. However, it is difficult for one single university or institution to maintain a satellite constellation composed of many microsatellites. Recently, the Asian Microsatellite Consortium (AMC) comprising 16 space agencies and universities from nine Asian nations has been created to develop microsatellite technologies and use collected data relating to the environment and natural disasters, etc. This international framework is the first step to share remote sensing data from the microsatellites by the members of the consortium, instead of making a satellite constellation by a single owner. The microsatellites such as the DIWATA-2 (Philippines), MicroDragon (Vietnam), and RISESAT (Japan) developed by the AMC members will be launched in the last quarter of 2018. This session is a unique opportunity to discuss microsatellite development and utilization in terms of international collaboration and data sharing. This session welcomes presentations on microsatellite remote sensing including satellite development and operation, sensor development and calibration, data analysis and utilization. We also seek presentations on ground and information systems, international collaborations, and educational programs using microsatellites.

[MSD42-P01] A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

*栗原 純一[1]、桒原 聡文[2]、藤田 伸哉[2]、坂本 祐二[2]、高橋 幸弘[1] (1.北海道大学 大学院理学研究院、2.東北大学 大学院工学研究科)

[MSD42-P02] Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

*國森 裕生[1]、竹中 秀樹[1]、桒原 聡文[2]、坂本 祐二[2]、藤田 伸哉[2]、冨尾 蓮花[2]、サカル モロコット[2]、栗原 純一[3] (1.情報通信研究機構、2.東北大学、3.北海道大学)

[MSD42-P03] 東北大地上局および運用システムの10年間の実績

*坂本 祐二[1]、桒原 聡文[1]、藤田 伸哉[1] (1.東北大学)

[MSD42-P04] Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

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A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

*栗原 純一[1]、桒原 聡文[2]、藤田 伸哉[2]、坂本 祐二[2]、高橋 幸弘[1]
*Junichi Kurihara[1], Toshinori Kuwahara[2], Shinya Fujita[2], Yuji Sakamoto[2], Yukihiro Takahashi[1]

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Microsatellites for Earth observation have been developed jointly by Hokkaido and Tohoku Universities in Japan. The High-Precision Telescope (HPT), which is a high (3-5 m) spatial resolution multispectral sensor, was developed by Hokkaido University. The HPT has been installed on the RISING-2 (launched in 2014), DIWATA-1 (2016), and DIWATA-2 (2018) microsatellites developed mainly by Tohoku University. However, the HPT installed on the RISESAT microsatellite using the liquid crystal tunable filter (LCTF) technology for wavelength scanning in the visible (420–700 nm) and the near-infrared region (650–1050 nm) is the greatest in terms of number of spectral bands. The advantages offered by the LCTF technology are reductions in the size, weight, and power consumption of the sensor, the flexibility of the spectral bands and data volume, and compatibility with off-nadir pointing. The central wavelength of the spectral bands is electrically tunable for every image acquisition; hence, the data volume could be reduced by choosing appropriate spectral bands for specific purposes. This flexibility allows a single multispectral sensor on a nano/microsatellite to be applied to various remote sensing fields, making it comparable with hyperspectral sensors.

The RISESAT microsatellite was successfully launched by the Epsilon-4 launch vehicle on 18 January 2019 from Uchinoura Space Center, Kagoshima, Japan. The satellite was injected into a Sun-synchronous, low Earth orbit at about 500 km. In this paper, we present preliminary results of multispectral imaging by the HPT and review its performance evaluation. We also discuss the scientific collaboration with other microsatellites and the possible contribution to the Asian Microsatellite Consortium.

キーワード：地球観測、超小型衛星、マルチスペクトルセンサ、リモートセンシング
Keywords: Earth observation, microsatellite, multispectral sensor, remote sensing

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Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

*國森 裕生[1]、竹中 秀樹[1]、桒原 聡文[2]、坂本 祐二[2]、藤田 伸哉[2]、冨尾 蓮花[2]、サカル モロコット[2]、栗原 純一[3]
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A 1 kg class optical transmitter on board a 50 kg class satellite Rapid International Scientific Experiment Satellite (RISESAT) launched by Epsilon rocket #4 in January 18, 2019. The transmitter named Very Small Optical Transmitter (VSOTA) has heritage from NICT space optical communication development over 2 decades and most recently the Small Optical Transponder (SOTA) equipped on board a micro satellite SOCRATES which NICT conducted demonstration from 2014 to 2016 between satellite and optical ground station in Japan and international partners.

VSOTA has 2 wavelengths laser diodes for optical downlink with no gimbal tracking function. The communication speed can be selected in the range from 10 kbps to a 6 Mbps. A retro reflector is located to assist satellite pointing and orbit prediction as well.

It is the most compact and lightweight optical communication device onboard for satellite developed in Japan so far. It narrowed down its function to the simplest form to adapt limited resource on satellite in size, weight and power consumption, aiming to expand its downlink capability for micro sat at the same time with lower cost. The goal of the mission is to acquire optical communication technology in micro satellites to apply an on-demand type remote sensing with featuring the high attitude control system such as target pointing needed as well for the optical communication to target ground station.

The orientation to the ground is based on satellite attitude control. It has a function of performing the guide beam for laser ranging from the ground using a camera for science such as High Precision Telescope (HPT) on board.

On January 21 and February 13, we confirmed that the electrical parts including Laser Diode (LD) was turned on and it operated normally by checking telemetry of power and temperature sensors built in LD circuit board.

We describe the features of communication and ranging experiment plan and initial check out result for the satellite as well as for the ground station.

キーワード：Micro satellite、Optical Space Communication、Satellite Laser Ranging
Keywords: Micro satellite, Optical Space Communication, Satellite Laser Ranging

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東北大地上局および運用システムの10年間の実績
Ten years history of Tohoku University ground station and operation system for micro and nano satellites

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*Yuji Sakamoto[1], Toshinori Kuwahara[1], Shinya Fujita[1]

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東北大学が主として開発または協力した3衛星、DIWATA-2、RISESAT、ALE-1が2018年10月からの3か月間で、立て続けに打ち上げられた。東北大学構内に設置している2.4m口径パラボラアンテナを有する地上局を用いて、3衛星を日々観測している。本講演では、2009年より継続・発展してきた運用システムをハード・ソフトの両面で解説する。また、フィリピン、スウェーデン、函館、福井など、連携中または準備中の地上局ネットワークについても紹介する。

本地上局は、東北大学の1号機衛星SPRITE-SATのために整備され、超小型衛星を対象として使用を開始した。基本的に低高度地球周回衛星が対象であり、約10～12分のパスにおいて、アンテナ指向方向を制御し、送受信機の周波数を制御して、通信を確立する。衛星追尾は対象衛星を登録するだけで、自動的に最新の軌道を収集し、上空通過時に自動追跡を開始・終了する。運用者は、衛星との通信に集中し、地上局の管理に気を払う必要はない。

現在、前期の最新3衛星に加え、DIWATA-1、RISING-2、SPRITE-SATとの通信も不定期に実施している。本地上局が対応できる通信仕様は、ITU国際通信連合にJCUBES-Bの群衛星として登録されており、今後も兄弟衛星が打ち上げられる予定である。国際機関への電波申請には申請準備も含めて、1年以上の時間を要する。企画から打上まで1年半以内で実現できる現状において、電波申請作業はプロジェクトにおいてトラブル要因となりうる。本地上局を使用する衛星ネットワークの輪が広がることで、衛星開発者に大きなメリットをもたらすと考えている。

キーワード：超小型衛星、衛星運用、地上局
Keywords: microsatellite, satellite operation, ground station

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Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

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Thunderstorm cloud, which growth vertically, has potential disaster risk like heavy rainfall, hail, micro-burst, and lightning. Cloud top altitude, volume, and growth speeds of thunderstorm cloud could be the parameter to predict its potential hazard. In this session, we will show our methodology to observe thunderstorm cloud using thermal infrared sensors camera which will be installed in the LAPAN-A4. This micro-satellite will be launched in 2020 FSY in the altitude ~ 500 kilometer with sun-synchronous polar orbit and inclination 97°. So, thermal infrared sensor camera will provide a temperature distribution with a resolution of ~ 180 meters and a field of view of ~ 56.3 x 42.2 kilometers. Using this high resolution thermal infrared sensor camera, the cloud top altitude can be estimated, assuming a temperature profile of the ambient atmosphere. By making such observation at some time interval, the developing speed of the thunderstorm cloud can be calculated in 3D.

Acknowledgement: This work was supported by Japan Society for the Promotion of Science (JSPS), Core-to-Core Program, B. Asia-Africa Science Platforms, by Japan Science and Technology Agency(JST) together with Technology and Higher Education(RISTEKDIKTI) of the of Indonesia under the e-ASIA Joint Research Program, and by Japan International Cooperation Agency (JICA) and JST, SATREPS.

キーワード：Thunderstorm cloud、thermal infrared sensor camera、LAPAN-A4
Keywords: Thunderstorm cloud, thermal infrared sensor camera, LAPAN-A4

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[E] ポスター発表 | セッション記号 M (領域外・複数領域)：M-SD 宇宙開発・地球観測

2019年5月26日(日) 17:15 ~ 18:30 | ポスター会場 幕張メッセ国際展示場 8ホール_47

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

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

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[MSD42-P02] Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

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[MSD42-P03] 東北大地上局および運用システムの10年間の実績

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[MSD42-P04] Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

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A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

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Microsatellites for Earth observation have been developed jointly by Hokkaido and Tohoku Universities in Japan. The High-Precision Telescope (HPT), which is a high (3-5 m) spatial resolution multispectral sensor, was developed by Hokkaido University. The HPT has been installed on the RISING-2 (launched in 2014), DIWATA-1 (2016), and DIWATA-2 (2018) microsatellites developed mainly by Tohoku University. However, the HPT installed on the RISESAT microsatellite using the liquid crystal tunable filter (LCTF) technology for wavelength scanning in the visible (420–700 nm) and the near-infrared region (650–1050 nm) is the greatest in terms of number of spectral bands. The advantages offered by the LCTF technology are reductions in the size, weight, and power consumption of the sensor, the flexibility of the spectral bands and data volume, and compatibility with off-nadir pointing. The central wavelength of the spectral bands is electrically tunable for every image acquisition; hence, the data volume could be reduced by choosing appropriate spectral bands for specific purposes. This flexibility allows a single multispectral sensor on a nano/microsatellite to be applied to various remote sensing fields, making it comparable with hyperspectral sensors.

The RISESAT microsatellite was successfully launched by the Epsilon-4 launch vehicle on 18 January 2019 from Uchinoura Space Center, Kagoshima, Japan. The satellite was injected into a Sun-synchronous, low Earth orbit at about 500 km. In this paper, we present preliminary results of multispectral imaging by the HPT and review its performance evaluation. We also discuss the scientific collaboration with other microsatellites and the possible contribution to the Asian Microsatellite Consortium.

キーワード：地球観測、超小型衛星、マルチスペクトルセンサ、リモートセンシング
Keywords: Earth observation, microsatellite, multispectral sensor, remote sensing

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A 1 kg class optical transmitter on board a 50 kg class satellite Rapid International Scientific Experiment Satellite (RISESAT) launched by Epsilon rocket #4 in January 18, 2019. The transmitter named Very Small Optical Transmitter (VSOTA) has heritage from NICT space optical communication development over 2 decades and most recently the Small Optical Transponder (SOTA) equipped on board a micro satellite SOCRATES which NICT conducted demonstration from 2014 to 2016 between satellite and optical ground station in Japan and international partners.

VSOTA has 2 wavelengths laser diodes for optical downlink with no gimbal tracking function. The communication speed can be selected in the range from 10 kbps to a 6 Mbps. A retro reflector is located to assist satellite pointing and orbit prediction as well.

It is the most compact and lightweight optical communication device onboard for satellite developed in Japan so far. It narrowed down its function to the simplest form to adapt limited resource on satellite in size, weight and power consumption, aiming to expand its downlink capability for micro sat at the same time with lower cost. The goal of the mission is to acquire optical communication technology in micro satellites to apply an on-demand type remote sensing with featuring the high attitude control system such as target pointing needed as well for the optical communication to target ground station.

The orientation to the ground is based on satellite attitude control. It has a function of performing the guide beam for laser ranging from the ground using a camera for science such as High Precision Telescope (HPT) on board.

On January 21 and February 13, we confirmed that the electrical parts including Laser Diode (LD) was turned on and it operated normally by checking telemetry of power and temperature sensors built in LD circuit board.

We describe the features of communication and ranging experiment plan and initial check out result for the satellite as well as for the ground station.

キーワード：Micro satellite、Optical Space Communication、Satellite Laser Ranging
Keywords: Micro satellite, Optical Space Communication, Satellite Laser Ranging

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東北大地上局および運用システムの10年間の実績
Ten years history of Tohoku University ground station and operation system for micro and nano satellites

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東北大学が主として開発または協力した3衛星、DIWATA-2、RISESAT、ALE-1が2018年10月からの3か月間で、立て続けに打ち上げられた。東北大学構内に設置している2.4m口径パラボラアンテナを有する地上局を用いて、3衛星を日々観測している。本講演では、2009年より継続・発展してきた運用システムをハード・ソフトの両面で解説する。また、フィリピン、スウェーデン、函館、福井など、連携中または準備中の地上局ネットワークについても紹介する。

本地上局は、東北大学の1号機衛星SPRITE-SATのために整備され、超小型衛星を対象として使用を開始した。基本的に低高度地球周回衛星が対象であり、約10～12分のパスにおいて、アンテナ指向方向を制御し、送受信機の周波数を制御して、通信を確立する。衛星追尾は対象衛星を登録するだけで、自動的に最新の軌道を収集し、上空通過時に自動追跡を開始・終了する。運用者は、衛星との通信に集中し、地上局の管理に気を払う必要はない。

現在、前期の最新3衛星に加え、DIWATA-1、RISING-2、SPRITE-SATとの通信も不定期に実施している。本地上局が対応できる通信仕様は、ITU国際通信連合にJCUBES-Bの群衛星として登録されており、今後も兄弟衛星が打ち上げられる予定である。国際機関への電波申請には申請準備も含めて、1年以上の時間を要する。企画から打上まで1年半以内で実現できる現状において、電波申請作業はプロジェクトにおいてトラブル要因となりうる。本地上局を使用する衛星ネットワークの輪が広がることで、衛星開発者に大きなメリットをもたらすと考えている。

キーワード：超小型衛星、衛星運用、地上局
Keywords: microsatellite, satellite operation, ground station

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Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

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Thunderstorm cloud, which growth vertically, has potential disaster risk like heavy rainfall, hail, micro-burst, and lightning. Cloud top altitude, volume, and growth speeds of thunderstorm cloud could be the parameter to predict its potential hazard. In this session, we will show our methodology to observe thunderstorm cloud using thermal infrared sensors camera which will be installed in the LAPAN-A4. This micro-satellite will be launched in 2020 FSY in the altitude ~ 500 kilometer with sun-synchronous polar orbit and inclination 97°. So, thermal infrared sensor camera will provide a temperature distribution with a resolution of ~ 180 meters and a field of view of ~ 56.3 x 42.2 kilometers. Using this high resolution thermal infrared sensor camera, the cloud top altitude can be estimated, assuming a temperature profile of the ambient atmosphere. By making such observation at some time interval, the developing speed of the thunderstorm cloud can be calculated in 3D.

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キーワード：Thunderstorm cloud、thermal infrared sensor camera、LAPAN-A4
Keywords: Thunderstorm cloud, thermal infrared sensor camera, LAPAN-A4

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