

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

🏠 Fri. Jun 4, 2021 3:30 PM - 5:00 PM JST | Fri. Jun 4, 2021 6:30 AM - 8:00 AM UTC | 🏠 Ch.06 Zoom Room 06

[P-EM08] Space Weather and Space Climate

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

We share the latest scientific papers to understand how the space environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct the long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards. Focused topics in 2021 include extreme events, theoretical maxima and benchmarks for hazard assessments, and space weather and deep space human spaceflight activities at Moon and at Mars.

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

[PEM08-07] Impacts of solar energetic particles at Mars: Global diffuse aurora and atmospheric chemistry

★Invited Papers

*Yuki Nakamura^{1,2}, Naoki Terada¹, Francois Leblanc², Hiromu Nakagawa¹, Shotaro Sakai¹, Sayano Hiruba¹, Ryuho Kataoka³, Kiyoka Murase⁴ (1. Department of Geophysics, Graduate School of Science, Tohoku University, 2. LATMOS, Sorbonne University, 3. National Institute of Polar Research, 4. The Graduate University for Advanced Studies)

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

[PEM08-08] Relativistic Electron Precipitation Detections with CALET on the International Space Station

*Alessandro Bruno^{1,2}, Georgia A. de Nolfo², Anthony W. Ficklin³, T. Gregory Guzik³, Lauren Blum⁴ (1. Department of Physics, Catholic University of America, Washington, DC, USA, 2. Heliophysics Science Division, NASA Goddard Space Flight Center, Greenbelt, MD, USA, 3. Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA, USA, 4. University of Colorado, Boulder, CO, USA)

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

[PEM08-09] Energetic electron precipitation events as identified in the mesosphere during substorms

*Kiyoka Murase¹, Ryuho Kataoka^{1,2}, Takanori Nishiyama^{1,2}, Koji Nishimura^{1,2,3}, Taishi Hashimoto^{1,2}, Yoshimasa Tanaka^{1,2,3}, Akira Kadokura^{1,2,3}, Yoshihiro Tomikawa^{1,2}, Masaki Tsutsumi^{1,2}, Herbert Akihito Uchida¹, Kaoru Sato⁴, Satoshi Kasahara⁴, Takefumi Mitani⁵, Shoichiro Yokota⁶, Tomoaki Hori⁷, Kunihiro Keika⁴, Takeshi Takashima⁵, Yoshiya Kasahara⁸, Shoya Matsuda⁵, Masafumi Shoji⁷, Ayako Matsuoka⁹, Iku Shinohara⁵, Yoshizumi Miyoshi⁷, Tatsuhiko Sato¹⁰ (1. The Graduate University for Advanced Studies, 2. National Institute of Polar Research, 3. Polar Environment Data Science Center, 4. The University of Tokyo, 5. Institute of Space and Astronautical Science, 6. Osaka University, 7. Nagoya University, 8. Kanazawa University, 9. Kyoto University, 10. Japan Atomic Energy Agency)

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

[PEM08-10] Numerical Proton Flux Response in South Atlantic Anomaly during Geomagnetic Storm

*Kirolosse Mina Girgis^{1,2}, Tohru Hada^{1,4}, Shuichi Matsukiyo^{1,4}, Akimasa Yoshikawa^{3,4} (1.Department of Earth System Science and Technology, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2.Aerospace Engineering Department, Faculty of Engineering, Cairo University, Egypt, 3.Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, 4.International Center for Space Weather Science and Education (ICSWSE), Kyushu University, Fukuoka, Japan)

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

[PEM08-11] Operational space weather monitoring from Japanese geostationary satellites: future mission

*Kaori Sakaguchi¹, Mamoru Ishii¹, Yuki Kubo¹, Tsutomu Nagatsuma¹, Shinji Saito¹, Otsuji Kenichi¹, Daikou Shiota¹, Naoto Nishizuka¹, Takefumi Mitani², Takeshi Takashima², Hiroaki Miyake³, Takeshi Sakanoi⁴, Akinori Saito⁵ (1.National Institute of Information and Communications Technology, 2.Japan Aerospace Exploration Agency, 3.Tokyo City University, 4.Tohoku University, 5.Kyoto University)

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

[PEM08-12] Correct reproduction of solar differential rotation in high-resolution simulation with Fugaku

★Invited Papers

*Hideyuki Hotta¹, Kanya Kusano² (1.Graduate School of Science, Chiba University, 2. Institute for Space-Earth Environmental Research, Nagoya University)

Impacts of solar energetic particles at Mars: Global diffuse aurora and atmospheric chemistry

*Yuki Nakamura^{1,2}, Naoki Terada¹, Francois Leblanc², Hiromu Nakagawa¹, Shotaro Sakai¹, Sayano Hiruba¹, Ryuho Kataoka³, Kiyoka Murase⁴

1. Department of Geophysics, Graduate School of Science, Tohoku University, 2. LATMOS, Sorbonne University, 3. National Institute of Polar Research, 4. The Graduate University for Advanced Studies

After 2020s, human activities in space exploration will be extended to Mars. For future exploration, it is important to assess the impacts of solar energetic particles (SEPs) on spacecraft and biological systems (e.g., radiation doses to crews, prebiotic synthesis of organic compounds) in the near-Mars environment.

The space environment of Mars is remarkably different from that of the Earth. Energetic particles can easily penetrate deep into the atmosphere to reach the surface owing to insufficient magnetospheric and atmospheric shielding of Mars. Recently, the Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft discovered a new type of diffuse aurora that spanned across nightside Mars, resulting from the interaction of SEPs with the Martian atmosphere [Schneider et al., 2015, 2018]. This new type of diffuse aurora on Mars is characterized by global brightening and by its low peak altitude of ~ 60 km, which indicates more energy is deposited deep in the Martian atmosphere than previously thought. This presentation will provide an overview of the impacts of SEPs on the Martian environment observed by orbiters and rovers, and give some implications for the effect of crustal magnetic fields and atmospheric chemistry based on our Monte-Carlo and photochemical models.

Keywords: Mars, Solar energetic particle, Aurora

Relativistic Electron Precipitation Detections with CALET on the International Space Station

*Alessandro Bruno^{1,2}, Georgia A. de Nolfo², Anthony W. Ficklin³, T. Gregory Guzik³, Lauren Blum⁴

1. Department of Physics, Catholic University of America, Washington, DC, USA, 2. Heliophysics Science Division, NASA Goddard Space Flight Center, Greenbelt, MD,, 3. Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA, USA, 4. University of Colorado, Boulder, CO, USA

The CALorimetric Electron Telescope (CALET) is a high-energy astroparticle experiment installed on the International Space Station and operating since October 2015. While conceived for the investigation of the origin and the propagation of galactic cosmic-rays, CALET has been also providing a continuous monitoring of space weather phenomena in the near-Earth environment, including solar energetic particle and relativistic electron precipitation (REP) events. In particular, the low-Earth orbit detections from CALET complement the equatorial observations made by other spacecraft at higher altitudes, such as the twin Van Allen Probes, enabling a more complete picture of energetic electron precipitation and its contribution to the radiation belt dynamics. In this work we present the preliminary results obtained over a four-year (2015-2019) acquisition time.

Keywords: Relativic Electron Precipitation, Space Weather, Cosmic Rays, Spacecraft Measurements

Energetic electron precipitation events as identified in the mesosphere during substorms

*Kiyoka Murase¹, Ryuho Kataoka^{1,2}, Takanori Nishiyama^{1,2}, Koji Nishimura^{1,2,3}, Taishi Hashimoto^{1,2}, Yoshimasa Tanaka^{1,2,3}, Akira Kadokura^{1,2,3}, Yoshihiro Tomikawa^{1,2}, Masaki Tsutsumi^{1,2}, Herbert Akihito Uchida¹, Kaoru Sato⁴, Satoshi Kasahara⁴, Takefumi Mitani⁵, Shoichiro Yokota⁶, Tomoaki Hori⁷, Kunihiro Keika⁴, Takeshi Takashima⁵, Yoshiya Kasahara⁸, Shoya Matsuda⁵, Masafumi Shoji⁷, Ayako Matsuoka⁹, Iku Shinohara⁵, Yoshizumi Miyoshi⁷, Tatsuhiko Sato¹⁰

1. The Graduate University for Advanced Studies, 2. National Institute of Polar Research, 3. Polar Environment Data Science Center, 4. The University of Tokyo, 5. Institute of Space and Astronautical Science, 6. Osaka University, 7. Nagoya University, 8. Kanazawa University, 9. Kyoto University, 10. Japan Atomic Energy Agency

Auroral activities have significant impacts on the polar atmosphere. One of the important aspects is the energy deposition to the neutral atmosphere by the precipitation of energetic electrons, which is known as a possible cause of the mesospheric ozone depletion. Energetic electron precipitation (EEP) will provide clues to the understanding of the links between the space and the atmospheric environment via energetic particles. We report EEP events during substorms, in which conjugate observations were conducted between Syowa Station in the Antarctic region and the Arase satellite in the magnetosphere. First, the mesospheric ionization reaching at 70 km altitude was identified during the growth phase. The mechanism of the growth phase EEP event was presumed to be the current sheet scattering because of the observed latitudinal energy dispersion of precipitating electrons, as identified from the all-sky imager and imaging riometer. During the expansion phase, the Arase satellite detected the increase of the loss-cone electron flux with the initiation of whistler mode waves. The estimated atmospheric ionization level due to the loss-cone electrons was consistent with the observed amplitude of the cosmic noise absorption. During the recovery phase, long-lasting enhanced activities of whistler mode waves were observed with the pulsating aurora. These results indicate that the current sheet scattering plays an essential role to cause EEP events during the growth phase, while the wave-particle interaction plays an essential role after the substorm onset.

Numerical Proton Flux Response in South Atlantic Anomaly during Geomagnetic Storm

*Kirolosse Mina Girgis^{1,2}, Tohru Hada^{1,4}, Shuichi Matsukiyo^{1,4}, Akimasa Yoshikawa^{3,4}

1. Department of Earth System Science and Technology, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2. Aerospace Engineering Department, Faculty of Engineering, Cairo University, Egypt, 3. Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, 4. International Center for Space Weather Science and Education (ICSWSE), Kyushu University, Fukuoka, Japan

In this research, we have developed a test particle simulation code to study the inner proton belt dynamics and the proton flux variations inside the South Atlantic Anomaly (SAA) during the geomagnetic storm event of 15 May 2005. The Tao-Chan-Brizard guiding center model was implemented to evaluate the trajectories of 140-400 MeV protons. The time-varying magnetic field model was evaluated by the Tsyganenko model TS05 with the corresponding inductive electric field. The South Atlantic Anomaly is an important feature of the Low-Earth Orbit (LEO) environment which creates a significant radiation source affecting most of the LEO mission performance. Numerical results showed that during the storm main phase, the SAA proton flux was decreased, while during the initial and recovery phases, the SAA proton flux was increased at most of the altitudes. The latter conclusion was confirmed using satellite measurements.

Keywords: South Atlantic Anomaly, Inner Proton Belt, Test Particle Simulations, Geomagnetic Storm, Inductive Electric Field, Tsyganenko Model

Operational space weather monitoring from Japanese geostationary satellites: future mission

*Kaori Sakaguchi¹, Mamoru Ishii¹, Yuki Kubo¹, Tsutomu Nagatsuma¹, Shinji Saito¹, Otsuji Kenichi¹, Daikou Shiota¹, Naoto Nishizuka¹, Takefumi Mitani², Takeshi Takashima², Hiroaki Miyake³, Takeshi Sakanoi⁴, Akinori Saito⁵

1. National Institute of Information and Communications Technology, 2. Japan Aerospace Exploration Agency, 3. Tokyo City University, 4. Tohoku University, 5. Kyoto University

Operational space weather monitoring in space, which means routine observations of space environment for long years from spacecraft and its data distribution in quasi-realtime to public, is necessary for space weather forecasting and end users. We are proposing two space weather monitoring missions as hosted payloads on future Japanese geostationary satellite. The first mission aims to monitor space radiation that cause spacecraft malfunction and exposure of astronauts and aircrews. Currently, space radiation in the geostationary orbit of Japanese meridian is observed by SEDA (Space Environment Data Acquisition monitor) onboard Himawari 8 and 9. We consider continuing space radiation monitoring by next Japanese meteorological satellite with new sensors which can observe wider energy ranges and higher sensitivities than current one, and with a new charging monitor for the purpose of measuring distribution of charges in spacecraft materials. The second mission aims to monitor disturbances of ionosphere and plasmasphere that affect radio propagation, e.g., satellite communications, navigations, etc. We consider developing two sensors for the second mission: one is a global imager of far ultraviolet emission that can detect occurrences of equatorial plasma bubbles, second is a multi-frequency GNSS receiver for the purpose of plasma observation in the plasmasphere by radio-occultation diagnostics. These sensors are considered as hosted payloads on a geostationary satellite near the Japanese meridian. We will present details and latest status of our mission.

Keywords: space weather, mission plan, geostationary satellite

Correct reproduction of solar differential rotation in high-resolution simulation with Fugaku

*Hideyuki Hotta¹, Kanya Kusano²

1. Graduate School of Science, Chiba University, 2. Institute for Space-Earth Environmental Research, Nagoya University

We carry out high-resolution simulations in supercomputer Fugaku to understand the generation mechanism of the solar differential rotation.

The sun is rotating differentially with the slow pole and the fast equator. While the observation for the solar differential rotation has a long history from the 1600s, we still do not understand the maintenance mechanism of the solar differential rotation. The anisotropic turbulence in the solar convection zone is thought to generate the differential rotation. Recent high-resolution simulations fall into the anti-solar differential rotation regime, i.e., the fast pole and the slow equator. The reason why we cannot reproduce the solar differential rotation is that the numerical simulation tends to show fast convection.

In order to deal with this problem, we carry out unprecedentedly high-resolution simulations with supercomputer Fugaku. We optimize our R2D2 code especially for Fugaku to obtain the best performance in the supercomputer. Using the optimized code, we carry out the high-resolution simulation with more than 5 billion grid points and we for the first time reproduce the solar differential rotation without using any artificial technique. In the simulation, the magnetic field becomes unexpectedly strong and suppresses the convection. As a result, the convection generates the solar differential rotation correctly. The new simulation totally changes our view of the solar convection zone.

Keywords: Sun, Convection zone, Magnetic field