【International Leading Research】

International joint research of geospace variability by combining multi-point ground and satellite observations and modeling

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Purpose and Significance of the Research

The space around the Earth (geospace), including the upper atmosphere, is highly dynamic. This is due to ultraviolet and X-ray radiation from the Sun, magnetic storms caused by high-energy plasma particles from solar explosions, and atmospheric waves from the lower atmosphere (Figure 1). These geospace variations affect radio communications between satellites and the ground, causing satellite positioning and communication failures. Magnetic storms also cause the atmosphere to heat and expand resulting in alteration of satellites' orbits. In addition, high-energy plasma particles from solar explosions and magnetic storms cause radiation hazards to astronauts, satellites, and aircraft crews. As humanity's use of space continues to increase, understanding and predicting these geospace variabilities have become an urgent issue.

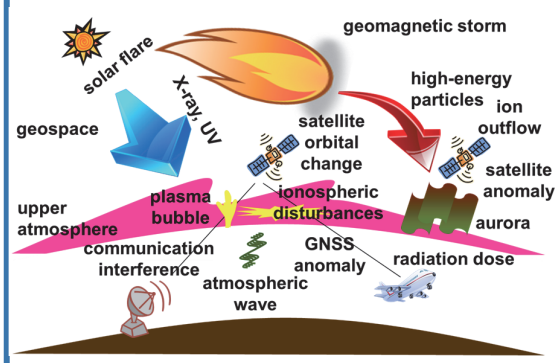

Fig.1 Variabilities and consequences in geospace and upper atmosphere.

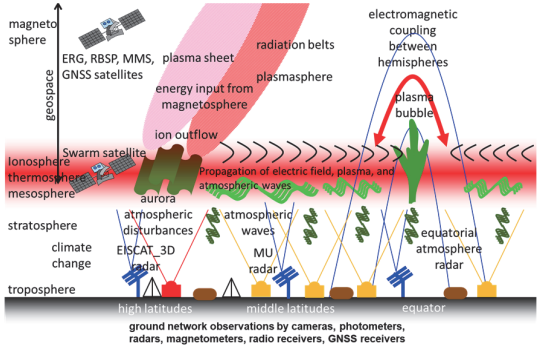

Fig.2 variabilities in geospace and the ground instruments and satellites that measure these variations.

To understand the mechanism behind geospace variability, it is necessary to combine ground instruments and satellites. This allows for comprehensive measurements of geospace. In addition, even with such an extensive observational network, sometimes we can also have a lack of detections. Therefore, there is also a need to coordinate with modeling through numerical simulations to compensate for the lack of observations and for quantitative evaluations, including space weather prediction. However, due to the lack of human resources and difficulty of integrating a wide variety of data, this type of combined research has been insufficiently conducted.

In this project, we will elucidate the mechanisms behind these geospace variabilities by combining ground-based and satellite observations and modeling, covering a wide area in both altitude and latitude/longitude directions (Figure 2). This project will significantly contribute to understanding and predicting geospace variabilities.

Organization of the Project Team

The Japanese members belonging to Nagoya, Kyoto and Kyushu Universities, and the National Institute of Polar Research (NIPR) operate comprehensive ground-based measurements shown in Figure 3. This team has already been identified as a top-level research group in Japan by the Science Council of Japan and the Ministry (MEXT) in the study of the solar-terrestrial coupling system including geospace. The international joint researchers (overseas Co-Is) are top-level scientists in satellite measurements and modeling, i.e., ionospheric satellites (Swarm) through Prof. Claudia Stolle (Germany) and geospace exploration satellites (RBSP, MMS, FAST, and Cluster) through Prof. Lynn Kistler (USA). Coordination will also be made to include modeling based on TIEGCM through Dr. Gang Lu (USA) and on the kinetic ring current-atmosphere interactions model, jointly developed by Japan and the USA.

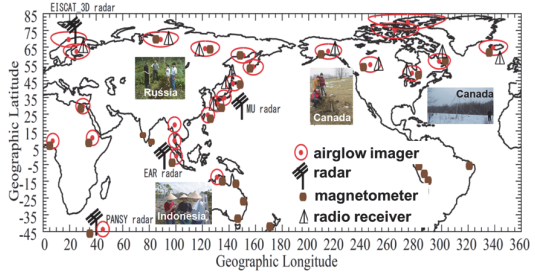

Fig.3 Ground stations and instruments that are operated by the Japanese team.

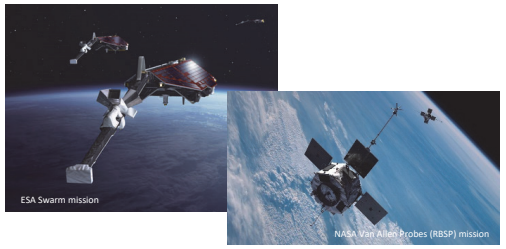

Fig.4 ESA's Swarm satellites (left) and NASA's Van Allen Probes (RBSP) satellites (right).

Plan for Fostering Early-career Researchers

Ten early-career researchers including five newly hired PDs, eleven Ph.D students are participating in this program (as of FY2022). All these students and early career scientists will be promoting research focusing on ground-based observation and modeling. They will stay overseas Co-I's institutes to compare their own ground observations and modeling, with satellite observations/modeling. This experience will let them develop broad research skills to approach scientific topics using different methods. We also support their field trips for their experience of ground-based measurements. We also invite overseas students and early-career scientists to stay in Japan for 3 months for collaborative research. The overseas Co-I, Prof. Kistler (USA), is also employed by ISEE on a cross-appointment basis until at least 2024.

Table 1 Planned support programs for students and early-career researchers.

	Number of people
Post-Doctoral Researcher	5 /year
Student Research Assistant	8 /year
Oversea Stay (3 month to 1 year)	2-6 /year
Invitation to Japan from abroad (3 months)	5 /year
Oversea Field Trip	5 /year
Total per year	25 /year
Total per 6 years	150 / 6 year

Fig.5 International school held in Indonesia on March 2018.

Homepage Address, etc.	https://www.isee.nagoya-u.ac.jp/dimr/PBASE/