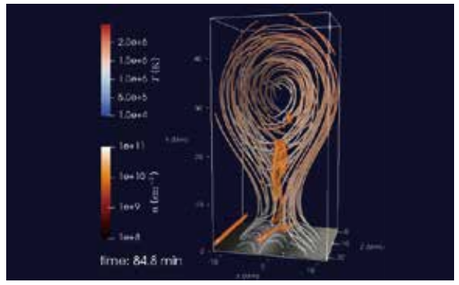
Special public lecture held at Homecoming Day 2019



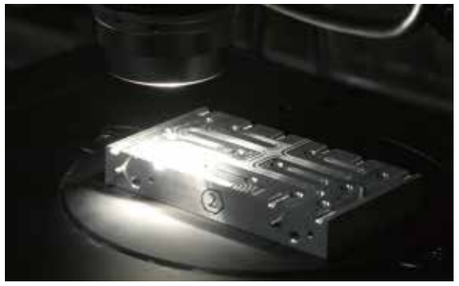
MHD simulation of prominence eruption. Lines represent magnetic field. Colors on the lines denote plasma temperature. (see p.35)

Auto Graphitization Equipment for ^{14}C analysis

ISEE Award Lecture by Dr. Jackson

An ELF/VLF radio wave receiver installed at the Kagoshima Observatory by Geogia Tech in USA

Antarctic snow survey expedition to the Dome Fuji (JARE 60 activity)



A noval waveguide-type multiplexer for a millimeter-wave spectroral radiometer operated at Syowa station, Antactica

Zendan-e Soleyman “Solomon’ s Prison”, a travertine hill in the Takab area, NW Iran

Institute for Space–Earth Environmental Research,
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Published in October 2020

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東海国立大学機構
NAGOYA UNIVERSITY

Institute for Space–Earth Environmental Research, Nagoya University
Annual Report
FY2019

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

FY2019

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

April 2019–March 2020

Foreword

Last year (FY2019) was the fifth since the Institute for Space-Earth Environmental Research (ISEE), Nagoya University was established. As a Japanese and international research center, we will continue our educational and research activities and produce different results.

More than 200 scientific papers are published annually as a result of our academic research, and we continue to contribute to the promotion of a wide range of scientific fields and interdisciplinary and international joint research. For example, a research group led by assistant professor H. Tomita in the Land–Ocean Ecosystem Research division published the open dataset, J-OFURO3 (Tomita et al. 2019 *J. Oceanogr.*). The dataset was constructed by integrating a large amount of air–sea surface flux variation data over the last 30 years, attracting international attention as a valuable dataset that contributes to the understanding of climate variability. The results of the ISEE International Workshop "Benchmarks for Operational Solar Flare Forecasts" were published in three consecutive papers (Leka et al. 2019 *ApJS*; Leka et al. 2019 *ApJ*; Park et al. 2020 *ApJ*). This work was the first-ever quantitative comparison of solar flare predictions from different countries; it clarifies the state of and issues in operations to predict solar flares. Furthermore, the first assimilation model of interplanetary scintillation (IPS) data and magnetohydrodynamic (MHD) simulation has been developed by Iwai et al. (2019 *EPS*). Each of these studies are important for accurately predicting solar storms and their impacts, and they are gaining international attention as the results of the nation-wide "Solar and Earth Environment Prediction (PSTEP)" project led by the ISEE.

As a result of the domestic project "PWING (study of dynamical variation of Particles and Waves in the INner magnetosphere using Ground-based network observations)," Mr. Takeshita, a graduate student in the Division for Ionospheric and Magnetospheric Research, published a paper that statistically clarified, for the first time, the longitudinal spread of electromagnetic waves in the Earth's inner magnetosphere from ground observations (Takeshita et al. 2019 *JGR*). In addition, Ms. Li, a graduate student in the Division for Land–Ocean Ecosystem Research, published a study that analyzed the energy transfer pathways of atmospheric ocean waves in the Indian Ocean and revealed, for the first time, the cycle of seasonal ocean waves (Li & Aiki 2020 *GRL*). These are the results of the wide range of educational activities conducted at the ISEE.

One of the important missions of this institute is to create a new academic field by combining space and earth science at a joint usage/research center in Japan. We initiated the ISEE Community Meeting in 2019 for this purpose. This meeting presents the current status and achievements of joint research in various fields to researchers all over Japan and we discuss strategies for developing new interdisciplinary studies. To this end, the first meeting was held on June 19, 2019, and the results of the previous year's work and plans for the future were reviewed for each expert committee. We will continue conducting this meeting every year.

In addition, the ISEE has since last year conferred the ISEE award to an excellent research activity based on its joint usage/research program for the purpose of developing the new fields of space–earth environmental research. In FY2019, the IPS Research Group at the University of California, San Diego, was awarded the 2nd ISEE Award. The award ceremony was held on January 29, 2020 and Dr. B. V. Jackson, the representative of the group, gave an award-winning lecture. We will continue to provide this award based on a wide range of recommendations from Japan and the international communities.

Another of the ISEE's important missions is to act as an international research center. In July 2019, Prof. Shiokawa—the Deputy Director of the ISEE—was elected president of the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP). This will be the first time that a Japanese scientist will serve as the president of this organization. SCOSTEP is a member of the International Science Council and promotes a five-year international joint program on solar-terrestrial science. The ISEE would like to play a central role in SCOSTEP's activities and develop its role as an international research center. As part of this, we signed a memorandum of understanding regarding the SCOSTEP Visiting Scholar (SVS) program.

In addition, the "ISEE Summer Internship," which aims to provide an opportunity for undergraduate students from Japan and other countries to stay at the ISEE to participate in space–earth environmental research was launched. As part of this, three students from Mexico, France, and the Philippines stayed at the ISEE from August 26 to September 6, 2019, and studied space and ionospheric dynamics at the Division for Ionospheric and Magnetospheric Research. At the same time, they participated in research using actual data and equipment such as atmospheric electric fields, equatorial plasma bubbles, and thermospheric satellites. We will continue developing this program and contribute to the training of young researchers.

The ISEE hosts more than 50 research meetings every year based on proposals from all over Japan. The ISEE symposium is a leading international symposium. In FY2019, the 2nd ISEE symposium was held jointly with the 4th International Symposium of the Project for Solar-Terrestrial Environment Prediction (PSTEP) from January 28 to 30, 2020. More than 100 researchers from several countries (Japan, the United States, the United Kingdom, Germany, Italy, Canada, Belgium, Mexico, India, and Peru) participated in this symposium.

The ISEE is also actively engaged in outreach activities to spread the latest research results widely in society. Of particular note is the special event titled "Science for the Future Society: Space and Earth" that the ISEE led on Nagoya University Homecoming Day, on October 19, 2019. We invited Dr. Yuichi Tsuda, the project manager for "Hayabusa 2" at the Institute of Space and Astronautical Science at JAXA, and Dr. Hiroko Miyahara of Musashino Art University, a former graduate of the ISEE. They gave lectures and a panel discussion titled "Future of the Universe and Humans" with researchers from the ISEE. Together with the general participants who filled the venue, we took a valuable opportunity to consider the future of space–earth environmental research. We also co-sponsored the Rikubetsu Starlight Festival with the Rikubetsu Space and Earth Science Museum and the Ashoro Animal Fossil Museum. In addition, we organized open laboratories at the Nagoya University Festival (July 13), lectures for high school students in Aichi Prefecture (July 26), a summer vacation learning for elementary school students titled "Learn about earthquakes and active faults around Nagoya"(January 31 to August 1), and an open seminar titled "Forefront of Astronomy"(August 4) that was co-sponsored by the Nagoya City Science Museum and Nagoya University Graduate School of Science. Furthermore, to support women researchers and in an effort increase their number in the field, we hosted special lectures by Dr. Kazuyo Tachikawa of the French National Center for Scientific Research and Dr. Naomi Harada of JAMSTEC, who are globally active female researchers (October 30).

Technological development and rapid changes in the environment will change human society itself. In that context, the perspective that considers the universe and the Earth as one system will become increasingly important. The ISEE studies the Earth, the Sun, and the universe as one system and contributes to solving global environmental problems and the development of human achievements in outer space by elucidating the mechanisms and interactions of the various phenomena that occur therein. I would like to continue to challenge new research. I hope that this annual report provides you much information on the activities of the ISEE. We appreciate your continued support and cooperation.

Kanya Kusano
Director, ISEE

ISEE Award

The 2nd ISEE Award Ceremony and Commemorative Lecture was held on Jan. 29, 2020.

The 2nd ISEE Award

Aiming to develop space–earth environmental research, promoting interdisciplinary research, and exploring the new discipline of space–earth environmental research, the ISEE is presenting an ISEE Award to a prominent research activity that is based on the ISEE Joint Research Program.

The 2nd ISEE Award Winner is University of California San Diego (UCSD) IPS Group, who contributes to space–earth environmental research through the studies on the improvement of space weather forecasting by the computer-assisted tomography of interplanetary scintillation data. On behalf of the research group, Dr. B. V. Jackson received an award certificate and commemorative gift (a trophy). After the award ceremony, a commemorative lecture was held by Dr. B. V. Jackson. More than 100 participants participated and made an active discussion with the award winner.

Date: January 29, 2020, 16:35–18:00

Venue: Sakata and Hirata Hall in the Nagoya University Higashiyama Campus

Title of the Award Lecture: Global Heliospheric Remote Sensing: A Brief Recent History

ISEE Award 2019

Winner：UCSD IPS group (Dr. B. V. Jackson, Dr. H. S. Yu, Dr. P. P. Hick, Dr. A. Buffington, Dr. D. Odstrcil)

Title : Contribution to Space-Earth Environmental Research through Studies on the Improvement of Space Weather Forecasting by the Computer-Assisted Tomography of Interplanetary Scintillation Data

Citation: Dr. Jackson and his colleagues (the UCSD group) have developed a time-dependent tomography that enables reliable determination of the solar wind speed and density from IPS observations, with collaboration from the ISEE. Through these ISEE joint research programs, they have developed advanced systems to predict various solar wind parameters including the magnetic field through the combination of a solar magnetic field model and a solar wind numerical model, known as ENLIL. The studies have revealed new aspects of the relationship between the coronal and interplanetary magnetic fields. The results of these studies have been used at the Community Coordinated Modeling Center of NASA and the Korean Space Weather Center.

Dr. B. V. Jackson

Affiliation and job title of award winners: Dr. Bernard V. Jackson (Research Scientist, CASS/UCSD), Dr. Hsiu-Shan Yu (Post-Doctoral Scholar, CASS/UCSD), Dr. Paul P. Hick (Data Administrator, San Diego Supercomputer Center/UCSD), Dr. Andrew Buffington (Research Scientist, CASS/UCSD), Dr. Dusan Odstrcil (Research Professor, George Mason University)

J-OFURO Japanese Ocean Flux Data Sets with Use of Remote Sensing Observations

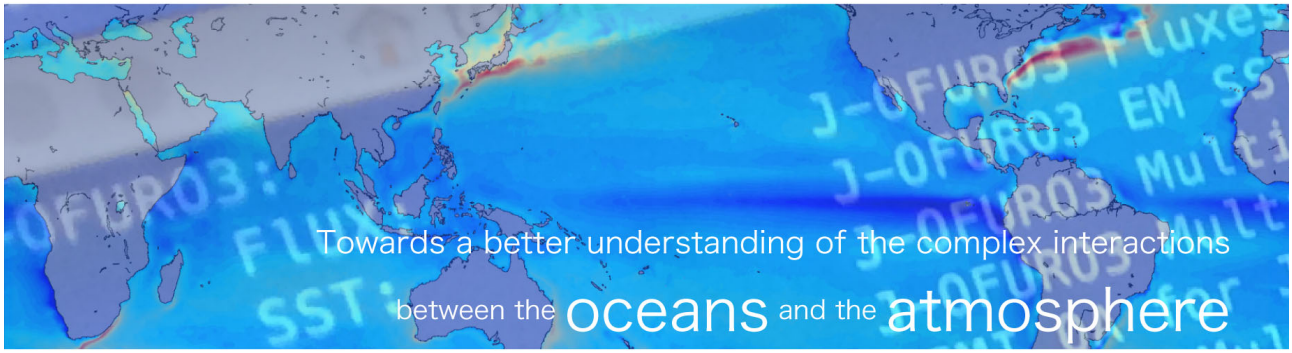

Fig.1

A new satellite-derived air-sea flux dataset

Accurate estimations of global sea surface heat, momentum, and freshwater fluxes are required to understand global climate change and its complex ocean–atmosphere interactions. A research group led by assistant professor H. Tomita in the Land–Ocean Ecosystem Research division succeeded in publishing the third-generation open dataset, J-OFURO3. The dataset was constructed by integrating a large amount of satellite observation data, including observations by the latest satellite sensors, and allows users to investigate surface flux variation over the last 30 years.

The ocean and atmosphere interact with each other, exchanging energy and matter and driving our global climate system. To understand the air–sea interactions that control climate change, it is necessary to understand the actual state of these interactions, the "air–sea flux." The use of satellite remote-sensing technology is indispensable in covering the vast ocean area. This research utilizes multi-satellite observations, including the latest satellite microwave sensor on GCOM-W (JAXA). By developing an advanced estimation algorithm for multiple satellite sensors, we have succeeded in estimating air–sea fluxes over the last 30 years with high accuracy and at a high spatial resolution. This work has revealed fine-scale flux structures associated with ocean currents and meso-scale eddies, which were not clear in previous studies. The results have also been published as an open dataset that can be used in a wide range of research interests.

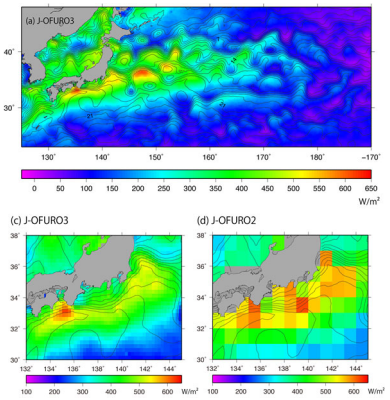

Fig.2

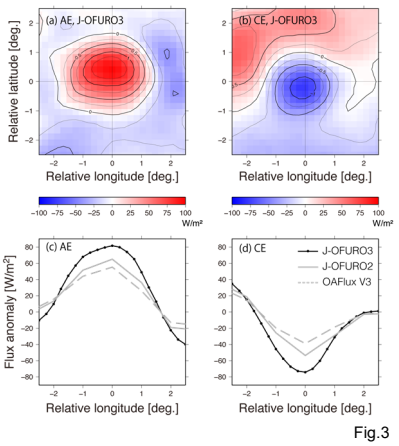

Fig.3

Paper information

Journal： *Journal of Oceanography*, Vol.75, 171–194, 2019
Authors：Tomita, H., T. Hihara, S. Kako, M. Kubota, and K. Kutsuwada
Title： An introduction to J-OFURO3, a third-generation Japanese ocean flux data set using remote-sensing observations
DOI： 10.1007/s10872-018-0493-x

Fig. 1: Logo of the J-OFURO.
Fig. 2: Spatial distribution of surface net heat flux around Japan. J-OFURO3 accurately describes the distribution of heat release associated with complex ocean structures owing to ocean currents and eddies.
Fig. 3: Surface net heat flux distribution associated with oceanic mesoscale eddies: (a, c) anticyclonic, (b, d) cyclonic eddies.

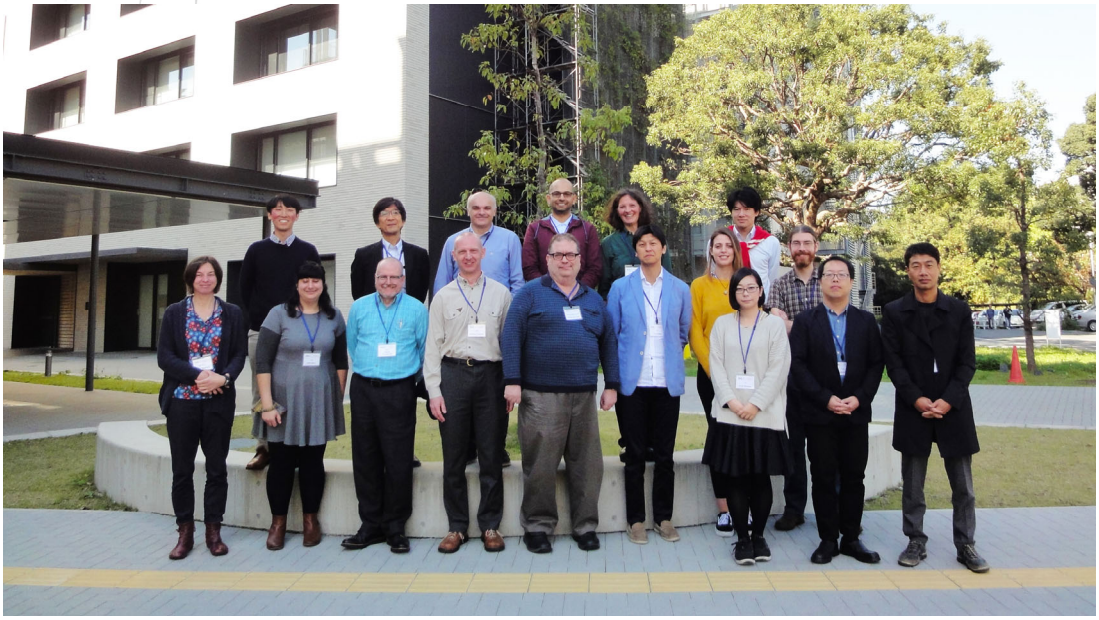

Fig.1

Operational Solar Flare Forecasting: Benchmarks and Future Challenges

Prof. Leka and Dr. Park organized the ISEE International Workshop “Benchmarks for Operational Solar Flare Forecasts”, in order to undertake for the first time collaborative research on this topic with 16 institutes from around the world; three workshop papers from the resulting research have been published in international peer-reviewed journals.

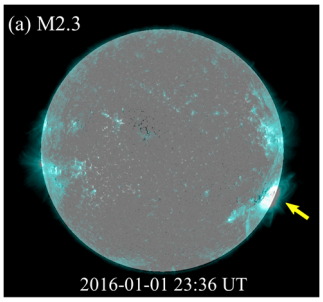

Fig.2

Solar flares are sudden, explosive brightenings in the solar corona; they and their associated energetic phenomena can have major impacts on the space environment as well as on economic and social infrastructure. Thus, predicting the occurrence of solar flares is a critical issue, and many space weather forecasting facilities across the world, based at both government agencies and research centers, provide predictions for solar flares every day. However, no comprehensive and quantitative comparison of operational flare prediction performance had yet been conducted.

Prof. Leka and Dr. Park of the Division for Integrated Studies organized the ISEE International Workshop “Benchmarks for Operational Solar Flare Forecasts”, which saw participation by 16 institutes from around the world. They led the comparison of performance for 19 different prediction methods over the period 2016–2017, using both established quantitative evaluation metrics and novel analysis methodologies. There was no single excellent method, but some distinct performance characteristics were found depending on particular methodologies. In addition, several diagnostics point toward key future improvements to space weather forecasts that can be evaluated against the benchmarks developed through this ISEE international effort.

Fig.1: Photo of ISEE flare forecasting workshop participants.
Fig.2: GOES M2.3 flare event (marked by yellow arrow) at the western limb.

Paper information

Journal： *Astrophys. J. Suppl. Ser.*, Vol.243, 36, 2019
Authors：Leka, K. D. et al.
Title： A Comparison of Flare Forecasting Methods. II. Benchmarks, Metrics, and Performance Results for Operational Solar Flare Forecasting Systems
DOI： 10.3847/1538-4365/ab2e12

Journal： *Astrophys. J.*, Vol.881, 101, 2019
Authors：Leka, K. D. et al.
Title： A Comparison of Flare Forecasting Methods. III. Systematic Behaviors of Operational Solar Flare Forecasting Systems
DOI： 10.3847/1538-4357/ab2e11

Journal： *Astrophys. J.*, Vol.890, 124, 2020
Authors：Park, S.-H. et al.
Title： A Comparison of Flare Forecasting Methods. IV. Evaluating Consecutive-day Forecasting Patterns
DOI： 10.3847/1538-4357/ab65f0

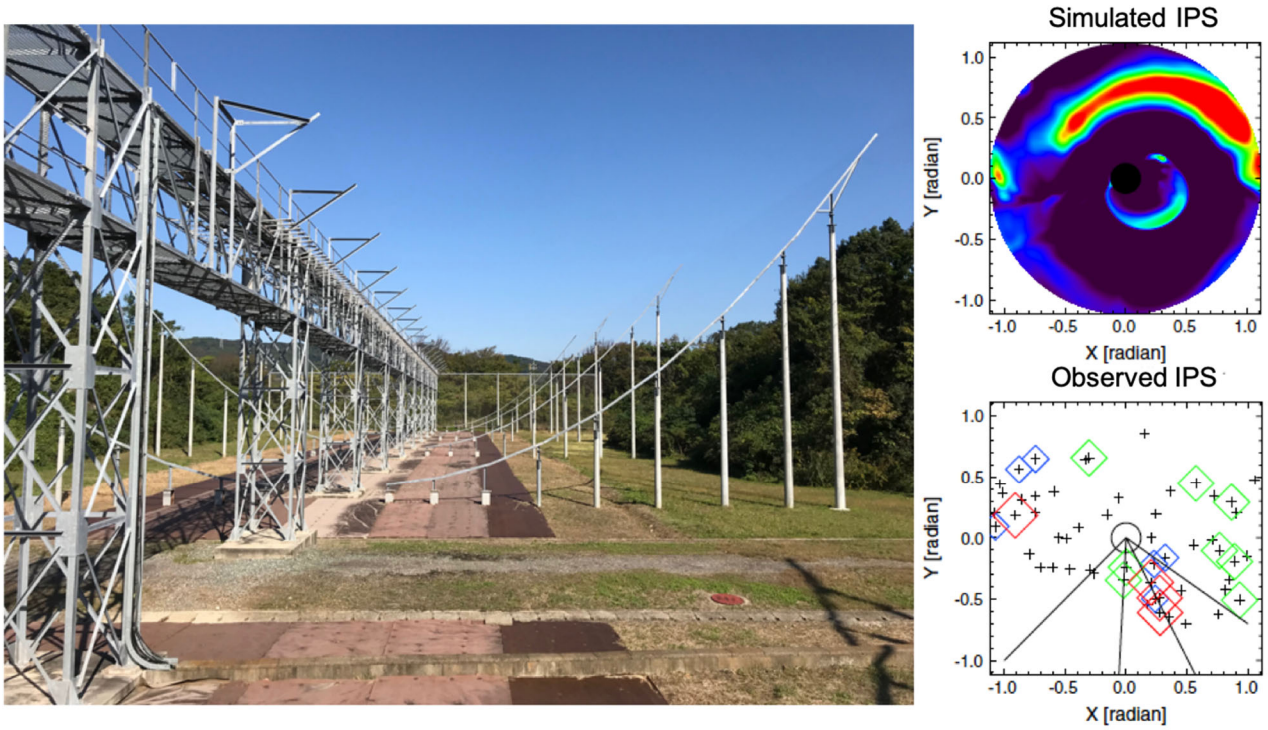

Fig.1

Forecasting CMEs using IPS observations

Iwai et al (2019) have developed a new coronal mass ejection (CME) arrival time forecasting system, based on interplanetary scintillation (IPS) observation data derived from ground-based radio telescopes operated by ISEE. This system, which can be applied to future space weather forecasting, improves the accuracy of CME arrival time estimates.

Solar eruptions generate CMEs. Forecasting the arrival of CMEs is important because they cause significant disturbances in the Earth environment. CMEs propagating in interplanetary space scatter radio waves; this phenomenon is called IPS. The IPS observations using ground-based radio telescopes operated by ISEE is a useful tool in detecting CMEs. This study developed a new CME arrival time forecasting system, based on a global magnetohydrodynamic (MHD) simulation of the inner heliosphere and IPS observation data. This study found that the CME simulation that best fitted the ISEE-IPS observations could accurately predict the time of arrival on Earth of CMEs. These results suggest that CME arrival time accuracy can be improved if current MHD simulations are extended to include IPS data.

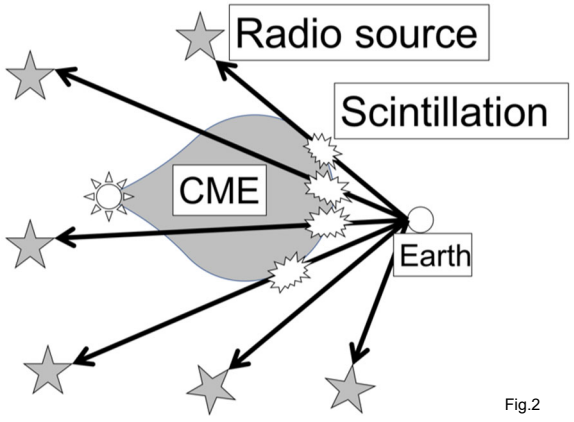

Fig.2

Paper information
Journal： *Earth, Planets and Space*, Vol.71, 39, 2019
Authors： Iwai, K., D. Shiota, M. Tokumaru, K. Fujiki, M. Den, and Y. Kubo
Title：Development of a coronal mass ejection arrival time forecasting system using interplanetary scintillation observations
DOI： 10.1186/s40623-019-1019-5

Fig. 1：(Left) ISEE IPS radio telescope at the Toyokawa Branch. (Right) Estimated IPS data derived from the MHD simulation and observed IPS data.
Fig. 2：Schematic image of IPS observations detecting a propagating CME in interplanetary space.

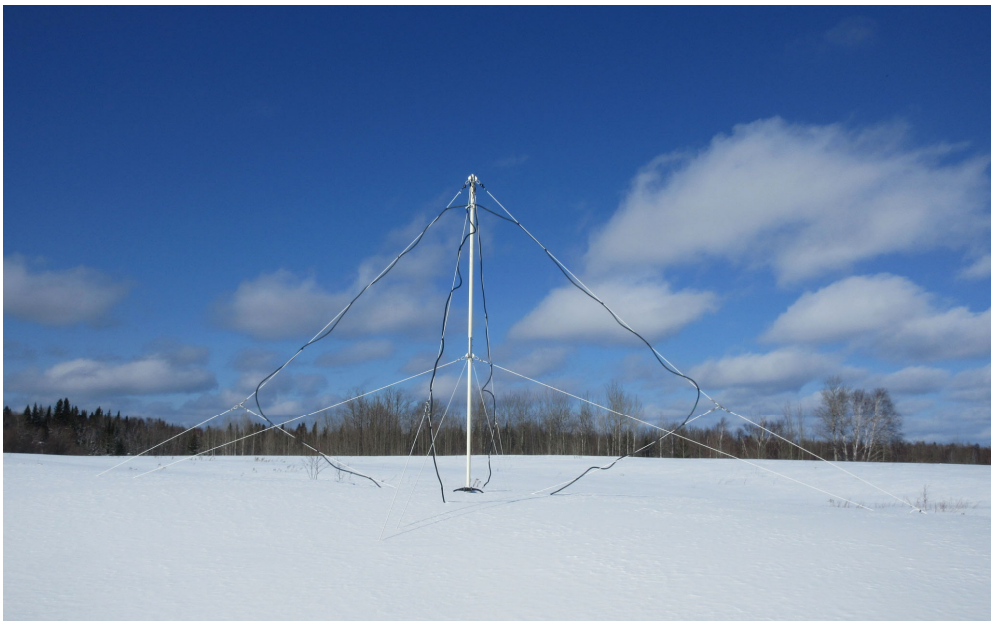

Fig.1

Global observation of the electromagnetic waves that can create radiation belt electrons

A team, led by Mr. Yuhei Takeshita (a student in his second year of the Electrical Engineering Masters course in the Graduate School of Engineering) and Prof. Kazuo Shiokawa, analyzed electromagnetic wave data obtained from six stations in Canada, Alaska, Russia, and Finland at subauroral latitudes and determined the longitudinal extent of magnetospheric ELF/VLF waves for the first time.

Magnetospheric ELF/VLF waves, which have typical frequencies of a few kHz, can accelerate electrons in geospace and produce radiation belts around the Earth. The quantitative evaluation of radiation belt electrons is important for safe and secure space use, because radiation belt electrons contribute to astronaut radiation doses and can cause spacecraft malfunctions.

The research group of Prof. Kazuo Shiokawa in the Division for Ionospheric and Magnetospheric Research have deployed geospace observation stations at magnetic latitudes of about 60 degrees around the north pole, in collaboration with several foreign institutes. Mr. Yuhei Takeshita (a student in his second year of the Electrical Engineering Masters course in the Graduate School of Engineering) analyzed electromagnetic wave data obtained from six stations in Canada, Alaska, Russia, and Finland, and determined the longitudinal extent of magnetospheric ELF/VLF waves for the first time. The results contribute to the quantitative evaluation of dynamic variation in radiation belt electrons.

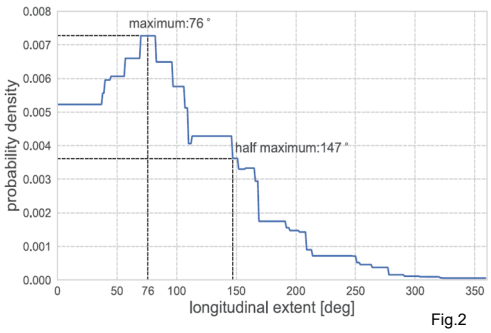

Fig.2

Fig.1： Antenna to receive electromagnetic radio waves in ELF/VLF frequency range installed at Kapuskasing, Canada.
Fig.2: Probability density of magnetospheric ELF/VLF waves at given longitudinal extent (horizontal axis). The maximum probability of longitudinal extent can be found at 76 degree.

Paper information
Journal： *J. Geophys.Res. Space Physics*, Vol. 124, 9881-9892, 2019
Authors： Takeshita, Y., K. Shiokawa, M. Ozaki, J. Manninen, S. Oyama, M. Connors, D. Baishev, V. Kurkin, and A. Oinats
Title： Longitudinal extent of magnetospheric ELF/VLF waves using multipoint PWING ground stations at subauroral latitudes
DOI： 10.1029/2019JA026810

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