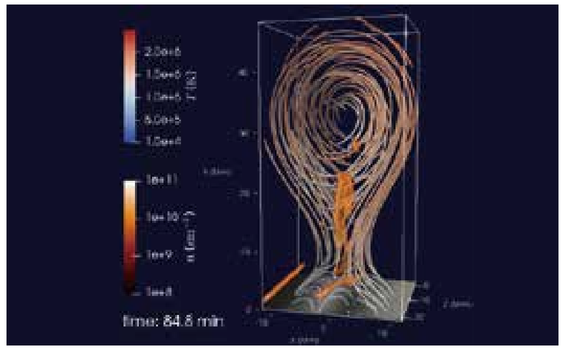
Special public lecture held at Homecoming Day 2019



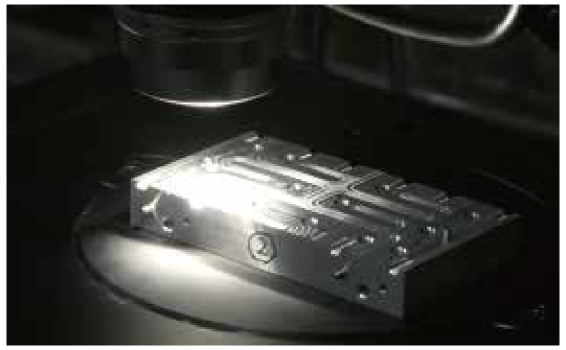
MHD simulation of prominence eruption. Lines represent magnetic field. Colors on the lines denote plasma temperature. (see p.35)

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

ISEE Institute for Space–Earth Environmental Research, Nagoya University

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Edited by Public Relations and Outreach Committee, Institute for Space–Earth Environmental Research, Nagoya University
Published in October 2020

MAKE NEW STANDARDS. 東海国立大学機構 NAGOYA UNIVERSITY

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

ISEE

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

FY2019

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

Institute for
Space–Earth Environmental Research

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

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

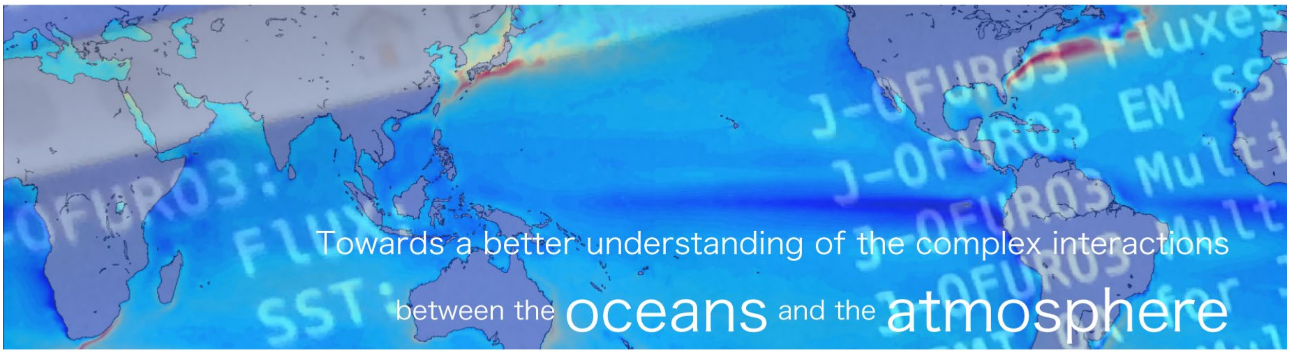


Fig.1

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.

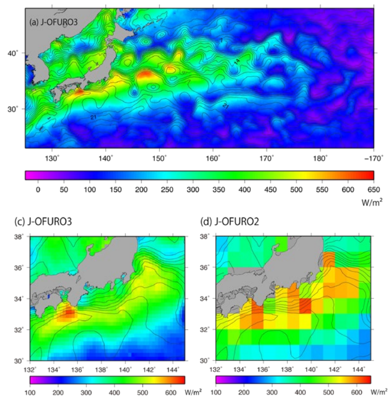


Fig.2

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

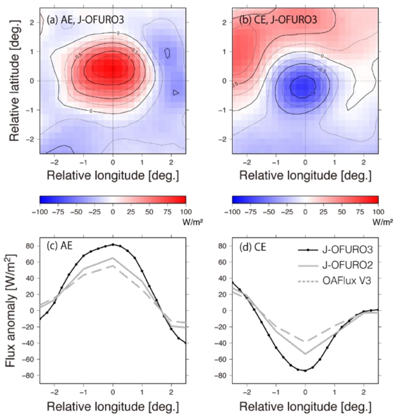


Fig.3

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.

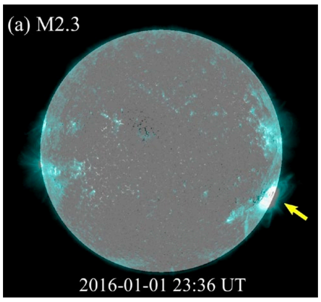


Fig.2

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

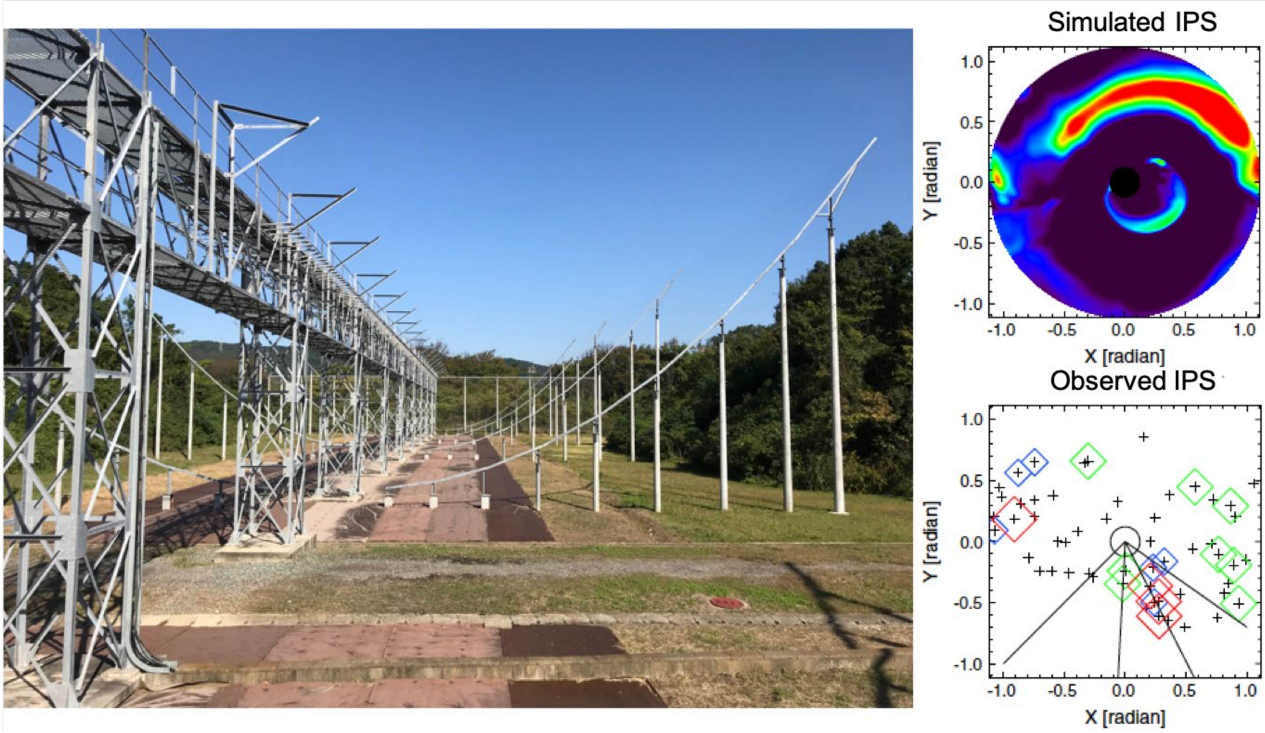


Fig.1

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.

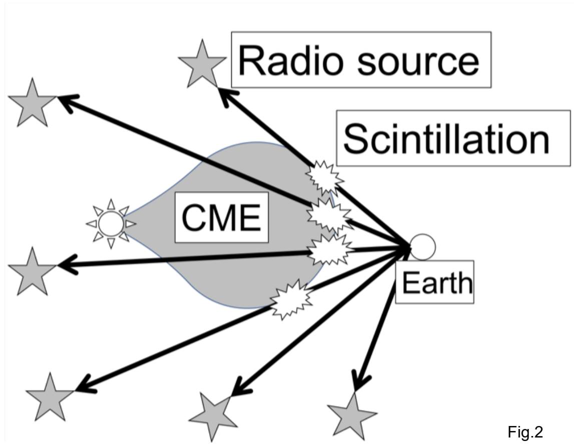


Fig.2

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.

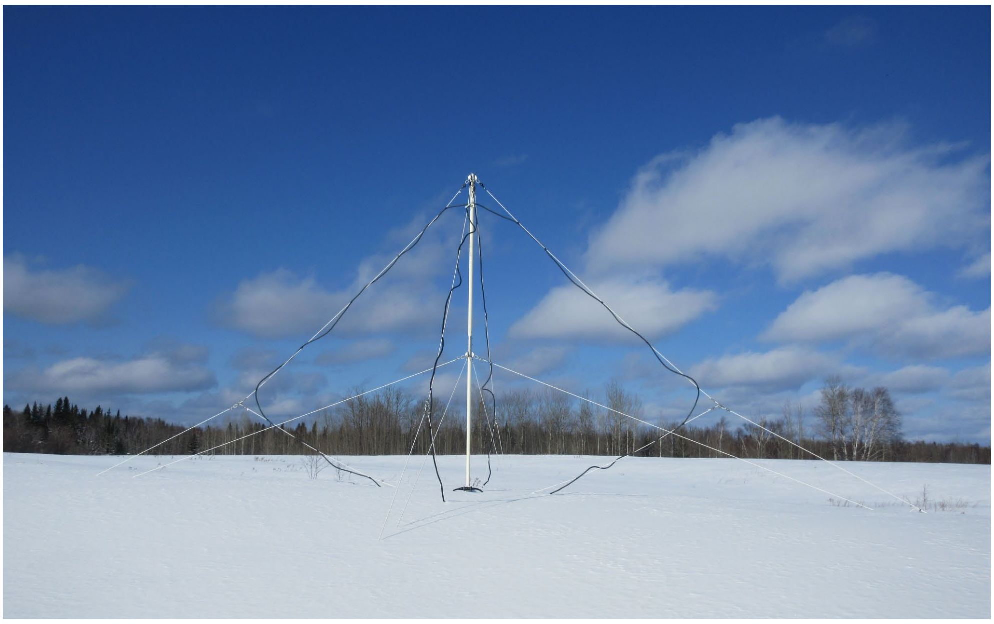


Fig.1

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.

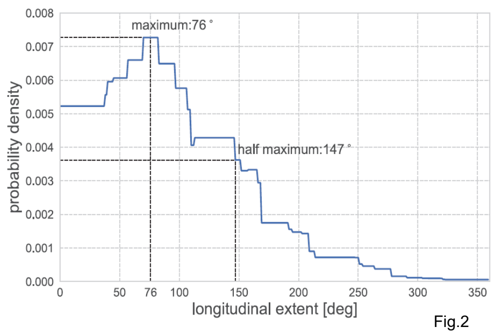


Fig.2

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

Contents

1. History

Solar-Terrestrial Environment Laboratory

May, 1949
Research Institute of Atmospherics, Nagoya University was established.

April, 1958
Cosmic-ray Research Laboratory, Faculty of Science, Nagoya University was established.

June, 1990
The Solar-Terrestrial Environment Laboratory (STEL) was established.

April, 1995
The Center for Joint Observations and Data Processing was organized.

April, 2003
The Rikubetsu Observatory was organized.

April, 2004
The Geospace Research Center was established.

March, 2006
Laboratory was relocated to the Higashiyama Campus.

April, 2010
Approved as one of the Joint Usage/Research Centers.

Hydrospheric Atmospheric Research Center (HyARC)

April, 1957
The Water Research Laboratory, Faculty of Science, Nagoya University was established.

September, 1973
The Water Research Institute (WRI), Nagoya University was organized.

April, 1993
The Institute for Hydrospheric-Atmospheric Sciences (IHAS), Nagoya University was organized.

April, 2001
The Hydrospheric Atmospheric Research Center (HyARC), Nagoya University was established.

April, 2010
Approved as one of the Joint Usage/Research Centers.

The Nagoya University Center for Chronological Research

February, 1981
The Tandetron Accelerator Laboratory was established in the Radioisotope Research Center of Nagoya University.

March, 1982
Installation of the Tandetron Accelerator Mass Spectrometry (AMS) machine No.1 was completed.

January, 1987
Inter-University Service of ^{14}C measurements was started with the Tandetron AMS machine No.1.

June, 1990
The Nagoya University Dating and Material Research Center was established.

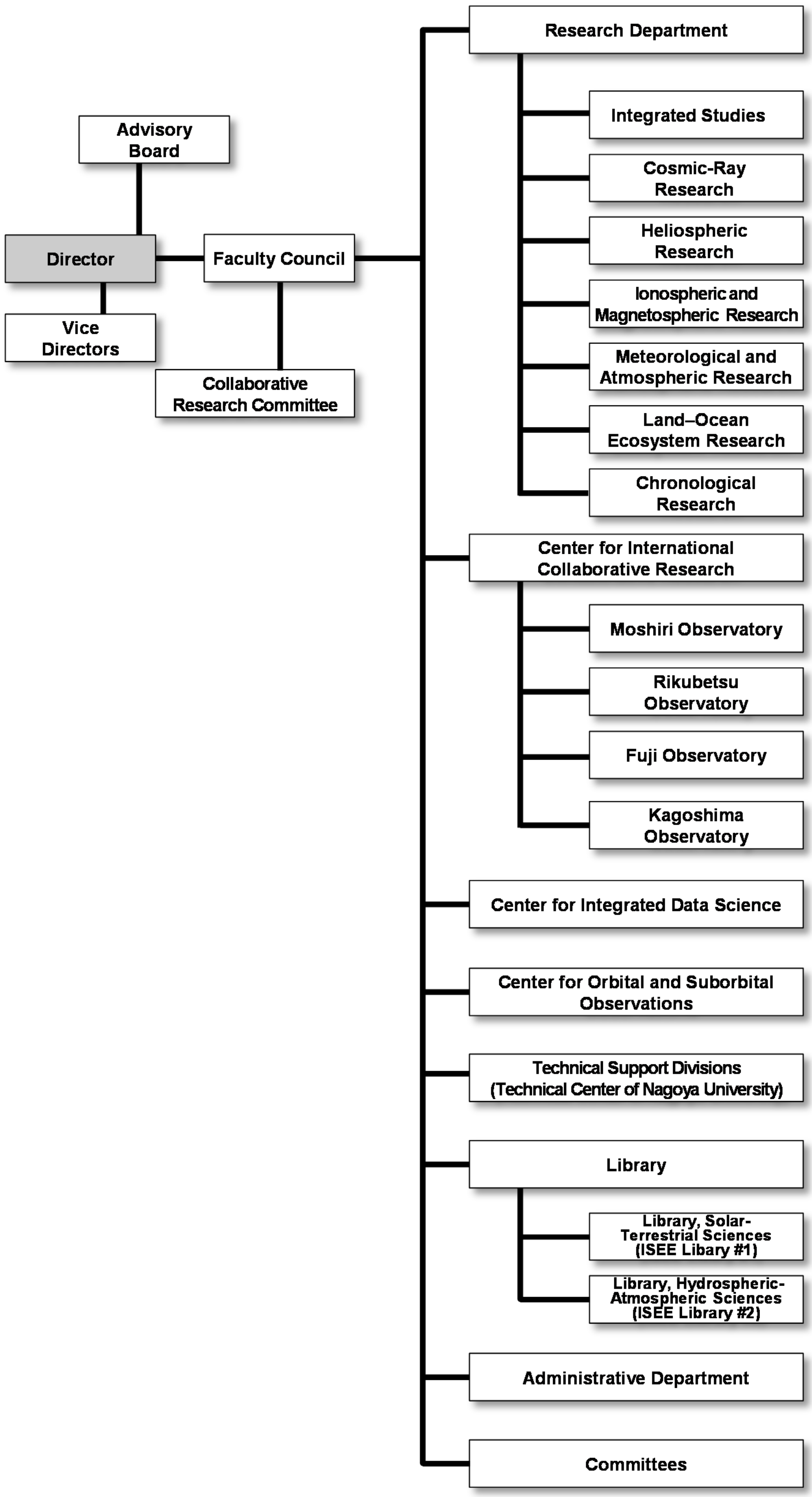
March, 1997
The Tandetron AMS machine No. 2 was newly introduced.

April, 2000
The Nagoya University Center for Chronological Research was organized.The CHIME dating system was transferred from the School of Science.

October, 2015,
Institute for Space–Earth Environmental Research (ISEE), merging the laboratory and two centers, was established.

January, 2016
ISEE was approved as one of the Joint Usage/Research Centers.

2. Organization



3. Staff

Director	Kanya Kusano
Vice Director	Joji Ishizaka
Vice Director	Kazuo Shiokawa

April 1, 2019–March 31, 2020
✱: Concurrent post
▲: Left the Institute in the 2019 academic year
○: Joined the Institute in the 2019 academic year
※: Belongs to Institute for Advanced Research Section

Division for Integrated Studies

Professor	Kanya Kusano
Professor	Yoshizumi Miyoshi (✱)
Associate Professor	Satoshi Masuda
Associate Professor	Takayuki Umeda (✱)
Lecturer	Shinsuke Imada
Assistant Professor	Akimasa Ieda
Designated Assistant Professor	Yumi Bamba ○※

Division for Cosmic-Ray Research

Professor	Yoshitaka Itow
Professor	Hiroyasu Tajima (✱)
Associate Professor	Yutaka Matsubara
Associate Professor	Fusa Miyake
Associate Professor	Fumio Abe (✱)▲
Lecturer	Akira Okumura
Assistant Professor	Hiroaki Menjo
Designated Assistant Professor	Shingo Kazama ※
Designated Assistant Professor	Kazufumi Sato ○
Technical Assistant	Kazuhiro Huruta
Technical Assistant	Kinji Morikawa

Division for Heliospheric Research

Professor	Munetoshi Tokumaru
Associate Professor	Kazumasa Iwai
Assistant Professor	Ken-ichi Fujiki

Division for Ionospheric and Magnetospheric Research

Professor	Masafumi Hirahara
Professor	Kazuo Shiokawa (✱)
Associate Professor	Yuichi Otsuka
Associate Professor	Satonori Nozawa
Associate Professor	Masahito Nosé
Associate Professor	Nozomu Nishitani (✱)
Lecturer	Shin-ichiro Oyama
Designated Assistant Professor	Atsuki Shinbori
Researcher	Priyanka Ghosh ○▲
Researcher	Sivakandan Mani ○
JSPS Research Fellowship	Shun Imajo ▲ To CIDAS

Division for Meteorological and Atmospheric Research

Professor	Akira Mizuno
Professor	Michihiro Mochida
Professor	Nobuhiro Takahashi (✱)
Professor	Kazuhisa Tsuboki (✱)
Associate Professor	Tomoo Nagahama
Associate Professor	Hirohiko Masunaga
Associate Professor	Taro Shinoda (✱)
Assistant Professor	Sho Ohata ※
Assistant Professor	Taku Nakajima
Researcher	Daichi Tsutsumi ○
Researcher	Yange Deng ▲
Researcher	Fumie Furuzawa
Research Institution Researcher	Minrui Wang ▲

Division for Land–Ocean Ecosystem Research

Professor	Joji Ishizaka
Professor	Tetsuya Hiyama (✱)
Associate Professor	Hidenori Aiki
Associate Professor	Naoyuki Kurita
Lecturer	Hatsuki Fujinami
Assistant Professor	Yoshihisa Mino
Researcher	Shun Ohishi ▲ To Visiting Academic Staff
Researcher	Akiko Mizuno
Researcher	Mengmeng Yang ○
Research Institution Researcher	Qingyang Song
JSPS Research Fellowship	Yuki Kanno ▲

Divison for Chronological Research

Professor	Hiroyuki Kitagawa
Professor	Masayo Minami
Associate Professor	Takenori Kato (✱)
Assistant Professor	Hirotaka Oda
Designated Assistant Professor	Masako Yamane
Research Institution Researcher	Yukiko Kozaka ○
Designated Technical Staff	Masami Nishida
Designated Technical Staff	Yuriko Hibi
Technical Assistant	Yuki Wakasugi ○

Center for International Collaborative Research

Director • Professor	Kazuo Shiokawa
Professor	Tetsuya Hiyama
Professor	Akira Mizuno (✱)
Professor	Masayo Minami (✱)
Designated Professor (Cross Appointment)	K. D. Leka
Designated Professor (Cross Appointment)	Lynn Marie Kistler
Associate Professor	Nozomu Nishitani
Associate Professor	Naoyuki Kurita (✱)
Associate Professor	Satonori Nozawa (✱)
Lecturer	Hatsuki Fujinami (✱)
Assistant Professor	Hiroaki Menjo (✱)
Designated Assistant Professor	Masafumi Shoji
Designated Assistant Professor	Claudia Martinez-Calderon ○※
Designated Assistant Professor	Sung-Hong Park
Researcher	Hironari Kanamori

Foreign Visiting Research Fellow

April 24 – July 24, 2019	Stephen Michael Playfer
May 15 – August 15, 2019	Wen-Yih Sun
August 1 – September 30, 2019	Jean-Pierre St-Maurice
September 24 – December 20, 2019	Abraham Chian-Long Chian
January 25 – May 30, 2020	Veenadhari Bhasakarapantula
March 1 – March 31, 2020	Khan-Hyuk Kim

Center for Integrated Data Science

Director • Professor	Kazuhisa Tsuboki
Professor	Yoshizumi Miyoshi
Professor	Joji Ishizaka (✱)
Professor	Kanya Kusano (✱)
Associate Professor	Fumio Abe ▲
Associate Professor	Takayuki Umeda
Associate Professor	Takenori Kato
Associate Professor	Hidenori Aiki (✱)
Associate Professor	Satoshi Masuda (✱)
Associate Professor	Hirohiko Masunaga (✱)
Designated Associate Professor	Tomoaki Hori
Lecturer	Shinsuke Imada (✱)
Assistant Professor	Akimasa Ieda (✱)
Designated Assistant Professor	Haruhisa Iijima
Designated Assistant Professor	Satoshi Inoue ▲
Designated Assistant Professor	Shun Imajo ○ From Div. for Ionospheric and Magnetospheric Res.
Designated Assistant Professor	Sachie Kanada
Designated Assistant Professor	Satoshi Kurita ▲
Designated Assistant Professor	Satoko Nakamura ○
Designated Assistant Professor	Chae-Woo Jun ○
Researcher	YunHee Kang ○
Researcher	Norio Umemura
Researcher	Masaya Kato
Researcher	Takafumi Kaneko
Researcher	Yoshiki Fukutomi
Researcher	Yukie Moroda ▲
Researcher	Sandeep Kumar ○
Designated Technical Staff	Mariko Kayaba
Designated Technical Staff	Asayo Maeda
Technical Assistant	Takako Kondo ▲
Technical Assistant (Research Support Facilitator)	Nanako Hirata

Center for Orbital and Suborbital Observations

Director • Professor	Nobuhiro Takahashi
Professor	Hiroyasu Tajima
Designated Professor	Hidetaka Tanaka
Designated Professor	Masataka Murakami
Professor	Joji Ishizaka (✱)
Professor	Kazuhisa Tsuboki (✱)
Professor	Masafumi Hirahara (✱)
Associate Professor	Taro Shinoda
Associate Professor	Hidenori Aiki (✱)
Designated Associate Professor	Kazutaka Yamaoka
Assistant Professor	Sho Ohata (✱)※
Designated Assistant Professor	Hiroyuki Tomita
Designated Assistant Professor	Mayumi Yoshioka
Researcher	Takeharu Kouketsu ○
Researcher	Yutaka Matsumi
Researcher	Youko Yoshizumi
Research Institution Researcher	Ji Hyun Park ○
Designated Technical Staff	Tomoko Tanaka

Visiting Academic Staff/Visiting Faculty Members

Visiting Professor	Yoshiya Kasahara
Visiting Professor	Tomo'omi Kumagai
Visiting Professor	Yoshikatsu Kuroda
Visiting Professor	Yoko Kokubu ○
Visiting Professor	Hiroyuki Shinagawa
Visiting Professor	Kiyoto Shibasaki ▲
Visiting Professor	Nobuo Sugimoto ○
Visiting Professor	Kanako Seki
Visiting Professor	Hotaek Park
Visiting Professor	Yoshinobu Harazono ▲
Visiting Associate Professor	Christian Leipe ○
Visiting Associate Professor	Yasunobu Ogawa
Visiting Associate Professor	Shinji Saito ○
Visiting Associate Professor	Daikou Shiota
Visiting Associate Professor	Iku Shinohara
Visiting Associate Professor	Toru Tamura ○
Visiting Associate Professor	Yasutaka Narusawa
(Emeritus Professor)	Toshio Nakamura
	Shun Ohishi ○ From Div. for Land–Ocean Ecosystem Res.

Technical Center of Nagoya University

Senior Technician	Akiko Ikeda
Senior Technician	Yasusuke Kojima
Senior Technician	Haruya Minda
Technician	Tetsuya Kawabata
Technician	Tomonori Segawa
Technician	Yoshiyuki Hamaguchi
Technician	Ryuji Fujimori
Technician	Yasushi Maruyama
Technician	Takayuki Yamasaki
Technician	Yuka Yamamoto
Assistant Technician	Takumi Adachi
Assistant Technician	Moeto Kyushima

Cooperating Research Fellow

	Xiuchun Qin
	Tzu-Fang Chang
	Keisuke Tamura ○

Foreign Visiting Cooperation Researcher

May 7 – July 10, 2019	Wen-Chien Lee
Jun 5, 2019 – May 29, 2020	Sneha Yadav
Jun 16 – July 18, 2019	Rangaiah Kariyappa
August 1, 2019 – July 31, 2020	Yuan Xia
September 16 – August 31, 2020	Hyangpyo Kim
September 20 – November 4, 2019	Artem Yu. Gololobov
September 23 – December 13, 2019	Gilda de Lourdes González
October 1 – December 20, 2019	Ram Singh
October 1 – December 31, 2019	Edith Liliana Macotela Cruz
October 1, 2019 – March 31, 2020	Hiroatsu Sato
October 21 – November 21, 2019	Samuel Krucker
December 10, 2019 – January 15, 2020	Viswanathan Lakshmi Narayanan
December 23, 2019 – February 7, 2020	Sudarsanam Tulasiram

Administration Department

Director, Administration Department	Takashi Murate ○
General Affairs Division	
Manager, General Affairs Division	Mitsuyuki Hirokawa ○
Senior Specialist, Research Support Office	Toshiyuki Yokoi ▲
Specialist, General Affairs Section	Keisuke Yokoe ▲
Specialist, General Affairs Section	Hideaki Yano ○
Section Head, General Affairs Section	Kazuhiro Yokoyama
Section Head, General Affairs Section	Seiji Tsuruta ▲
Section Head, General Affairs Section	Shoji Asano
Section Head, Personnel Affairs Section	Munetika Mizuno
Section Head, Research Support Office	Tadayosi Ito ▲
Section Head, Research Support Office	Naoko Hiramatsu ○▲
Section Head, Budget Planning Section	Mirei Miyao ○
Leader, General Affairs Section	Yoko Nokura ▲
Administrator	Yuka Ito
Administrator	Anna Kato ▲
Administrator	Asana Goto ○
Administrator	Yuka Suzuki ▲
Administrator	Hisako Watabe ○
Accounting Division	
Manager, Accounting Division	Hiroyuki Ichioka ▲
Specialist, Maintenance Section	Yoshiyuki Nakano ▲
Section Head, Accounting Section	Masashi Shimamura ▲
Section Head, Supplies Section	Kiyoko Hasegawa ▲
Section Head, Supplies Section	Koji Hattori ○▲
Section Head, Maintenance Section	Shinichi Nakagawa ▲
Leader, Accounting Section	Youko Yasui ▲
Leader, Supplies Section	Yuka Matsuoka ▲
Leader, Supplies Section	Tomoyuki Furuhashi ○▲
Designated Supervisor	Tadashi Tsuboi

Toyokawa Branch

Designated Technical Staff	Kayoko Asano
Technical Assistant (Research Support Facilitator)	Yasuo Kato

4. Committee of Other Organizations

Committee of Other Organizations

Contact Post	Job Title	Organizations	Name of Committee / Title
Joji Ishizaka	Professor	North Pacific Marine Science Organization (PICES)	Co-Chair of Advisory Panel for a CREAMS/PICES Program in East Asian Marginal Seas
Joji Ishizaka	Professor	North Pacific Marine Science Organization (PICES)	Member of Working Group 35: Third North Pacific Ecosystem Report
Joji Ishizaka	Professor	Northwest Pacific Action Plan (NOWPAP)	Focal Point of Center for Special Monitoring and Coastal Environmental Assessment Regional Active Center (CEARAC)
Yoshitaka Itow	Professor	Iternational Union of Pure and Applied Physics	Commission C4 member
Yoshitaka Itow	Professor	Institute of Particle and Nuclear Studies, KEK	J-Parc Program Advisory Committee member
Yoshitaka Itow	Professor	International Symposium for Very High Energy Cosmic Ray Interactions	International Advisory Committee member
Yoshitaka Itow	Professor	Ultra High Energy Cosmic Ray Conference	International Advisory Committee member
Kanya Kusano	Professor	Earth, Planets and Space (EPS)	Lead Guest Editor
Kazuo Shiokawa	Professor	Committee on Space Research (COSPAR)	Chair of the COSPAR Sub-Commission C1 (The Earth's Upper Atmosphere and Ionosphere)
Kazuo Shiokawa	Professor	Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)	President
Kazuo Shiokawa	Professor	Journal of Atmospheric and Solar-Terrestrial Physics	Chief Guest Editor
Hiroyasu Tajima	Professor	B-factory Programme Advisory Committee	Committee member
Hiroyasu Tajima	Professor	Progress of Theoretical and Experimental Physics	Editor
Hiroyasu Tajima	Professor	The Scientific World Journal	Editorial Board member
Hiroyasu Tajima	Professor	IEEE Nuclear Science Symposium Program Committee	Member for IEEE Nuclear Science Symposium Program Committee
Hiroyasu Tajima	Professor	Multidisciplinary Digital Publishing Institute (MDPI)	Guest Editor
Hiroyasu Tajima	Professor	SiPM workshop Scientific Organizing Committee	Member for SiPM workshop Scientific Organizing Committee
Tetsuya Hiyama	Professor	Integrated Land Ecosystem - Atmosphere Processes Study (iLEAPS), a global research project of the Future Earth	Scientific Steering Committee (SSC) member

Contact Post	Job Title	Organizations	Name of Committee / Title
Tetsuya Hiyama	Professor	International Arctic Science Committee (IASC)	Terrestrial Working Group (TWG) member
Yoshizumi Miyoshi	Professor	Annales Geophysicae	Editor
Yoshizumi Miyoshi	Professor	Earth and Planetary Physics	Editor
Yoshizumi Miyoshi	Professor	Earth, Planets and Space (EPS)	Guest Editor
Yoshizumi Miyoshi	Professor	Scientific Committee on Solar-Terrestrial Physics （SCOSTEP）	Bureau member
Yoshizumi Miyoshi	Professor	National Science Foundation/Geospace Environment Modeling （NSF/GEM)	Steering Committee member
Yoshizumi Miyoshi	Professor	EU-Horizon 2020: SafeSpace	Advisory Panel
Yoshizumi Miyoshi	Professor	Polar Research	Guest Editor
Michihiro Mochida	Professor	Atmospheric Research	Associate Editor
Michihiro Mochida	Professor	Atmospheric Environment	Member of Editorial Advisery Board
Michihiro Mochida	Professor	International Commission on Atmospheric Chemistry and Global Pollution (iCACGP)	Comission member
Yuichi Otsuka	Associate Professor	Journal of Astronomy and Space Sciences	Editor
Nozomu Nishitani	Associate Professor	Earth, Planets and Space (EPS)	Vice Editors-in-Chief /Guest Editor
Nozomu Nishitani	Associate Professor	Polar Science	Guest Editor
Nozomu Nishitani	Associate Professor	Super Dual Auroral Radar Network (SuperDARN)	Vice chair of Executive Council
Nozomu Nishitani	Associate Professor	SuperDARN 2019 Workshop Organizing Committee	Scientific Organizing Committee (SOC) chair
Satonori Nozawa	Associate Professor	EISCAT Scientific Association	Council member
Satonori Nozawa	Associate Professor	Earth, Planets and Space (EPS)	Guest Editor
Masahito Nosé	Associate Professor	Earth, Planets and Space (EPS)	Editor /Guest Editor

Contact Post	Job Title	Organizations	Name of Committee / Title
Masahito Nosé	Associate Professor	International Association of Geomagnetism and Aeronomy (IAGA)	Division V Chair
Hirohiko Masunaga	Associate Professor	World Climate Research Programme (WCRP) Global Energy and Water cycle Exchanges (GEWEX)	GEWEX Data and Analysis Panel (GDAP) member
Hirohiko Masunaga	Associate Professor	National Aeronautics and Space Administration (NASA)	ACCP Science Community Cohort
Toshio Nakamura	Visiting Faculty	Radiocarbon	Member of Editorial Board

5. Joint Research Programs

One of the major functions of ISEE is to promote and conduct collaborative research on Space–Earth Environmental Science together with researchers from universities and institutes outside ISEE. On January 14, 2016, ISEE was certified as a core research institution of Space–Earth Environmental Science, a “Joint Usage/Research Center” as defined by the MEXT of Japan. We prepared application forms for joint research programs focusing on the following two research issues: he “Study of coupling processes in the solar–terrestrial system using ground-based observation networks” and the “Establishment of an international collaborative research hub to solve research issues in the global (terrestrial) environment and space applications based on comprehensive studies of the space–Sun–Earth system.” The former focuses on coupling processes in the solar–terrestrial system and the interactions of neutral and plasma components in the Earth’s atmosphere by establishing an international ground-based observation network ranging from low- to high- latitude regions, especially in Asia and Africa. The latter aims to establish an international collaborative research hub for comprehensive studies of the space–Sun–Earth system, space applications, space weather forecasting, and environmental problems such as global warming. The following 10 research programs were prepared for application during the 2019 Japanese fiscal year. The ISEE symposium became an independent category from the ISEE/CICR International Workshop and the announcement for the 2020–2021 ISEE symposium was conducted three months prior to other programs. In addition, the SCOSTEP Visiting Scholar program, which was conducted by the ISEE/CICR, will be incorporated into joint use and joint research from FY2020.

01) Joint Research Program (International)
02) ISEE International Joint Research Program (*)
03) ISEE/CICR International Workshop
04) Joint Research Program (General)
05) Joint Research Program (Student Encouragement)
06) Joint Research Program (Symposium)
07) Joint Research Program (Computing Infrastructure)
08) Joint Research Program (Database Management)
09) Joint Research Program (Accelerator Mass Spectrometry Analysis)
10) Carbon 14 Analysis Service

(*) Applicable only to foreign researchers

These collaborative research programs will be executed using the instruments, software/databases, and facilities of ISEE. Joint research programs 01) to 03), described above, will be managed by the Center for International Collaborative Research (CICR), and those of 07) and 08) will be managed by the Center for Integrated Data Science (CIDAS) and 09) –10) will be managed by the Division for Chronological Research.

In 2019, the second ISEE symposium was held at Nagoya University from January 28 to 30, 2020, entitled “Toward the Solar–Terrestrial Environmental Prediction as Science and Social Infrastructure,” and was co-hosted with the 4th PSTEP International Symposium (PSTEP-4), a program led by Professor Kanya Kusano who is the director of ISEE. The second ISEE Award was awarded to the UCSD IPS group (Dr. B. V. Jackson, Dr. H. S. Yu, Dr. P. P. Hick, Dr. A. Buffington, and Dr. D. Odstrcil) for their great contribution to space–Earth environmental research through their studies on the improvement of space weather forecasting through the computer-assisted tomography of IPS data. The award ceremony and memorial lecture were held at Nagoya University on January 29, 2020.

One of the notable activities in FY2019 was a community meeting held in June 2019 inviting the researchers of the Joint Usage/Research program to provide opportunities to communicate among research projects. In addition, we switched the proposal application system from an email basis to a web-basis with support from the Research Organization of Information and Systems. The new system was introduced for the FY2020 program applications.

Lists of Accepted Proposals

■ ISEE International Joint Research Program

Proposer	Affiliation*	Job title*	Corresponding ISEE researcher	Title of the research program
David Tsiklauri	Queen Mary University of London	Senior Lecturer (Tenured Associate Professor)	Kusano, K.	Investigation of the role of kink MHD waves in flare trigger model
Stepan Poluianov	University of Oulu, Finland	Postdoctoral Researcher	Kurita, N.	Model of production-transport-deposition of cosmogenic isotopes over Antarctica with verification with experimental data
R. Kariyappa	Indian Institute of Astrophysics	former Professor & Chairman	Kusano, K. Imada, S.	UV & EUV Solar Irradiance Variability and their impacts on Earth's Climate & Space Weather
Tulasiram Sudarsanam	Indian Institute of Geomagnetism	Associate Professor	Shiokawa, K.	Prompt penetration of convection/overshielding electric fields during the onset of substorms
Baolin Tan	National Astronomical Observatories of Chinese Academy of Sciences (NAOC)	Professor	Masuda, S.	Testing diagnosing of the coronal magnetic field from solar radio observations
Matthias Förster	GFZ German Research Centre for Geosciences	Senior Scientist (retired)	Nishitani, N.	Relation of Swarm satellite and SuperDARN ground-based ion drift measurements
Iskhaq Iskandar	Sriwijaya University	Professor	Ishizaka, J.	Variability in satellite-derived surface chlorophyll-a, Ekman transport and sea surface temperature in the Banda Sea
Anukul Buranapratheprat	Burapha University	Assistant Professor, Faculty of Science	Ishizaka, J.	Detection and modeling of green Noctiluca bloom in the Gulf of Thailand using satellite ocean color
Mykola Gordovskyy	University of Manchester	Research Associate	Kusano, K.	Fluid-kinetic modelling of magnetic reconnection in solar flares and their impact on the heliosphere
Viswanathan L. Narayanan	National Atmospheric Research Laboratory	INSPIRE Faculty	Shiokawa, K. Otsuka, Y.	Investigation of the relationship between nighttime electrified medium scale traveling ionospheric disturbances and middle latitude spread F
Seth Claudepierre	The Aerospace Corporation	Member of the Technical Staff	Miyoshi, Y.	Collaborative radiation belt science: Using multi-spacecraft observations to further our understanding of wave-particle interactions in the Earth's magnetosphere
Samuel Krucker	Univeristy of Applied Sciences Northwestern Switzerland	Professor	Masuda, S.	The NoRH/RHESSI flare catalogue: statistical paper and planning for the future
Kim Nielsen	Utah Valley University	Associate Professor	Nozawa, S.	Energetics of Arctic stratospheric and mesospheric coupling due to small-scale gravity waves
Pravata K. Mohanty	Tata Institute of Fundamental Research (TIFR)	Fellow	Matsubara, Y.	Tomographic study of galactic cosmic anisotropy in near-Earth space by multi-directional cosmic ray observations
Ondrej Santolik	Institute of Atmospheric Physics	Senior Research Scientist / Professor	Miyoshi, Y.	Investigation of electromagnetic wave phenomena using multipoint measurements
Hiroatsu Sato	German Aerospace Center (DLR)	Research Scientist	Otsuka, Y.	Imaging meter-scale density irregularities associated with midlatitude TIDs

* Proposer's affiliation and job title are as of the proposal submission date.

■ ISEE/CICR International Workshop

Proposer	Affiliation*	Job title*	Corresponding ISEE researcher	Title of the research program
Kazuo Shiokawa	Nagoya University	Professor	Shiokawa, K.	VarSITI summarizing workshop
Toru Terao	Kagawa University	Professor	Fujinami, H.	International workshop on decadal challenges for the convincing climate projection and S2S scale prediction of Asian monsoon system
Noriyuki Narukage	National Astronomical Observatory of Japan	Assistant Professor	Tajima, H. Masuda, S.	FOXSI data analysis workshop

* Proposer's affiliation and job title are as of the proposal submission date.

List of Collaboration Resources

■ Instruments

Name	Contact Person
Fourier Transform Infrared (FTIR) Spectrometer for Atmospheric Composition Measurement (Rikubetsu)	T. Nagahama
Optical Mesosphere Thermosphere Imagers	K. Shiokawa
ISEE Magnetometer Network	K. Shiokawa
ELF/VLF Network	K. Shiokawa
Sodium LIDAR (Tromsø)	S. Nozawa
MF Radar (Tromsø)	S. Nozawa
Meteor Radar (Alta)	S. Nozawa
Solar Neutron Telescope (Norikura Observatory, Institute for Cosmic Ray Research, the University of Tokyo)	Y. Matsubara
Low-Background Beta-Ray Counter	N. Kurita
Multi-Station IPS Solar Wind Observation System (Toyokawa, Fuji, and Kiso)	M. Tokumaru
Nobeyama Radioheliograph	S. Masuda
Multi-Directional Cosmic Ray Muon Telescope (Nagoya)	Y. Matsubara
SuperDARN Hokkaido Pair of (HOP) Radars (Rikubetsu)	N. Nishitani
Upper Air Sounding Systems (two sets)	K. Tsuboki
Polarimetric Radar Systems (two sets)	K. Tsuboki
Ka-Band Polarimetric Radar	K. Tsuboki
Hydrometeor Video Sonde (HYVIS) System	K. Tsuboki
ISEE Riometer Network	K. Shiokawa
Sea Spray Aerosol Optical Particle Counter	H. Aiki
Five-Wavelength Photometer (Tromsø)	S. Nozawa

■ Software/Databases

Name	Contact Person
Atmospheric Composition Data by FT-IR Measurements (Moshiri and Rikubetsu)	T. Nagahama
NO_2 and O_3 Data by UV/Visible Spectrometer Measurements (Moshiri and Rikubetsu)	T. Nagahama

Name	Contact Person
Coordinated Magnetic Data Along 210° Magnetic Meridian (Moshiri, Rikubetsu, Kagoshima, and Overseas MM Stations)	K. Shiokawa
All-Sky Auroral Data (Canada, Alaska, and Siberia)	K. Shiokawa, Y. Miyoshi
Database of the Optical Mesosphere Thermosphere Imagers	K. Shiokawa
VHF Radar/GPS Scintillation (Indonesia)	Y. Otsuka
EISCAT Database	S. Nozawa, S. Oyama
ELF/VLF Wave Data	K. Shiokawa
Interplanetary Scintillation Data	M. Tokumaru
Solar Wind Speed Data	M. Tokumaru
Cosmic Ray Intensity Database	Y. Matsubara
MHD Simulation on the Magnetospheric Environment	T. Umeda
S-RAMP Database	F. Abe
CAWSES Database	F. Abe
Hinode Science Center, Nagoya University	K. Kusano
ERG Science Center	Y. Miyoshi
QL Plot Archive of Satellite Data for Integrated Studies	Y. Miyoshi
Remei Satellite Observation Database	M. Hirahara
MOA Database	F. Abe
SuperDARN Hokkaido Pair of (HOP) Radars Database	N. Nishitani
Numerical Simulation Codes for Plasma Kinetics	T. Umeda
Cloud Resolving Strom Simulator (CReSS)	K. Tsuboki
Satellite Data Simulator Unit (SDSU)	H. Masunaga
ISEE Riometer Network Database	K. Shiokawa
Energy Flux Diagnosis Code for Atmospheric and Oceanic Waves	H. Aiki

■ Facilities

Name	Contact Person
Computer System for Solar-Terrestrial Environmental Research (Supercomputer System)	F. Abe, T. Umeda
CHN Analyzer, Isotope Ratio Mass Spectrometer	Y. Mino
Tandetron Accelerator Mass Spectrometry	H. Kitagawa, M. Minami
Electron Probe Microanalyzer (EPMA)	T. Kato
Ion/Electron Beamline and Calibration Facility	M. Hirahara
Clean Room Facility for Instrument Development	M. Hirahara
CIDAS System	S. Masuda, T. Umeda, Y. Miyoshi
X-Ray Fluorescence Spectrometer (XRF)	T. Kato
X-Ray Diffractometer (XRD)	T. Kato

Name	Contact Person
Facilities at Moshiri Observatory	A. Mizuno
Facilities at Rikubetsu Observatory	A. Mizuno
Facilities at Kiso Station	M. Tokumaru
Facilities at Fuji Observatory	M. Tokumaru
Facilities at Kagoshima Observatory	K. Shiokawa

ISEE Award

Winner	Title	Date of Award Ceremony
University of California San Diego IPS Group (Dr. B. V. Jackson, Dr. H. S. Yu, Dr. P. P. Hick, Dr. A. Buffington, Dr. D. Odstrcil)	Contribution to Space-Earth Environmental Research through Studies on the Improvement of Space Weather Forecasting by the Computer-Assisted Tomography of Interplanetary Scintillation Data	Jan. 29, 2020

6. Governance

As of Mar 31, 2020

Advisory Board

Mamoru Ishii	Space Environment Laboratory, Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology
Takaaki Kajita	Institute for Cosmic Ray Research, The University of Tokyo
Takeshi Kawano	Japan Agency for Marine-Earth Science and Technology
Nobuko Saigusa	Center for Global Environmental Research, National Institute for Environmental Studies
Yukari N. Takayabu	Atmosphere and Ocean Research Institute, The University of Tokyo
Takuji Nakamura	National Institute of Polar Research, Research Organization of Information and Systems
Tsuneto Nagatomo	Nara University of Education
Toru Hada	Interdisciplinary Graduate School of Engineering Sciences, Kyushu University
Hironobu Hyodo	Research Institute of National Sciences, Okayama University of Science
Masahiro Hoshino	Graduate School of Science, The University of Tokyo
Kazuhisa Mitsuda	Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency
Tetsuzo Yasunari	Research Institute for Humanity and Nature, National Institutes for the Humanities
Mamoru Yamamoto	Research Institute for Sustainable Humanosphere, Kyoto University
Junichi Watanabe	National Astronomical Observatory of Japan, National Institutes of Natural Sciences
Hiroshi Ikuta	Graduate School of Engineering, Nagoya University
Yasushi Yamaguchi	Graduate School of Environmental Studies, Nagoya University
Tomohiko Watanabe	Graduate School of Science, Nagoya University
Joji Ishizaka	Institute for Space–Earth Environmental Research, Nagoya University
Yoshitaka Itow	Institute for Space–Earth Environmental Research, Nagoya University
Hiroyuki Kitagawa	Institute for Space–Earth Environmental Research, Nagoya University
Kazuo Shiokawa	Institute for Space–Earth Environmental Research, Nagoya University
Nobuhiro Takahashi	Institute for Space–Earth Environmental Research, Nagoya University
Munetoshi Tokumaru	Institute for Space–Earth Environmental Research, Nagoya University
Masafumi Hirahara	Institute for Space–Earth Environmental Research, Nagoya University

Collaborative Research Committee

Akira Kadokura	Polar Environment Data Science Center, Joint Support -Center for Data Science Research, Research Organization of Information and Systems
Kazuyuki Kita	College of Science, Ibaraki University
Yuki Kubo	Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology
Yoko S. Kokubu	Tono Geoscience Center, Japan Atomic Energy Agency
Akinori Saitou	Graduate School of Science, Kyoto University
Takeshi Sakanoi	Graduate School of Science, Tohoku University
Shoichi Shibata	College of Engineering, Chubu University
Kanako Seki	Graduate School of Science, The University of Tokyo
Yoichiro Hanaoka	National Astronomical Observatory of Japan, National Institutes of Natural Sciences
Atsushi Higuchi	Center for Environmental Remote Sensing, Chiba University
Ayako Matsuoka	Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency
Hiroyuki Matsuzaki	The University Museum, The University of Tokyo
Takashi Minoshima	Japan Agency for Marine-Earth Science and Technology
Akihiko Morimoto	Center for Marine Environmental Studies, Ehime University
Hiroyuki Yamada	Faculty of Science, University of the Ryukyus
Yuichi Otsuka	Institute for Space–Earth Environmental Research, Nagoya University
Takenori Kato	Institute for Space–Earth Environmental Research, Nagoya University
Kanya Kusano	Institute for Space–Earth Environmental Research, Nagoya University
Naoyuki Kurita	Institute for Space–Earth Environmental Research, Nagoya University
Kazuo Shiokawa	Institute for Space–Earth Environmental Research, Nagoya University
Taro Shinoda	Institute for Space–Earth Environmental Research, Nagoya University
Nobuhiro Takahashi	Institute for Space–Earth Environmental Research, Nagoya University
Munetoshi Tokumaru	Institute for Space–Earth Environmental Research, Nagoya University
Nozomu Nishitani	Institute for Space–Earth Environmental Research, Nagoya University
Masahito Nosé	Institute for Space–Earth Environmental Research, Nagoya University
Satoshi Masuda	Institute for Space–Earth Environmental Research, Nagoya University
Hirohiko Masunaga	Institute for Space–Earth Environmental Research, Nagoya University
Yutaka Matsubara	Institute for Space–Earth Environmental Research, Nagoya University
Masayo Minami	Institute for Space–Earth Environmental Research, Nagoya University
Kazuhisa Tsuboki	Institute for Space–Earth Environmental Research, Nagoya University

Joint Research Technical Committee

Integrated Studies Technical Committee

Ayumi Asai	Graduate School of Science, Kyoto University
Yuto Katoh	Graduate School of Science, Tohoku University
Iku Shinohara	Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency
Kanako Seki	Graduate School of Science, The University of Tokyo
Hirohisa Hara	National Astronomical Observatory of Japan, National Institutes of Natural Sciences
Akimasa Yoshikawa	Graduate School of Sciences, Kyushu University
Takayuki Umeda	Institute for Space–Earth Environmental Research, Nagoya University
Kanya Kusano	Institute for Space–Earth Environmental Research, Nagoya University
Satoshi Masuda	Institute for Space–Earth Environmental Research, Nagoya University
Yoshizumi Miyoshi	Institute for Space–Earth Environmental Research, Nagoya University

Heliospheric and Cosmic-Ray Research Technical Committee

Chihiro Kato	Faculty of Science, Shinshu University
Shoichi Shibata	College of Engineering, Chubu University
Tomoko Nakagawa	Faculty of Engineering, Tohoku Institute of Technology
Yasuhiro Nariyuki	University of Toyama
Tohru Hada	Interdisciplinary Graduate School of Engineering Sciences, Kyushu University
Yoichiro Hanaoka	National Astronomical Observatory of Japan, National Institutes of Natural Sciences
Yoshitaka Itow	Institute for Space–Earth Environmental Research, Nagoya University
Kazumasa Iwai	Institute for Space–Earth Environmental Research, Nagoya University
Munetoshi Tokumaru	Institute for Space–Earth Environmental Research, Nagoya University
Yutaka Matsubara	Institute for Space–Earth Environmental Research, Nagoya University

Ionospheric and Magnetospheric Research Technical Committee

Takumi Abe	Institute of Space and Astronautical Science, Japan Aerospace Exploration Agenc
Yoshiya Kasahara	Information Media Center, Kanazawa University
Akinori Saito	Graduate School of Science, Kyoto University
Shin Suzuki	Faculty of Regional Policy, Aichi University
Yuichi Otsuka	Institute for Space–Earth Environmental Research, Nagoya University
Satonori Nozawa	Institute for Space–Earth Environmental Research, Nagoya University
Masahito Nosé	Institute for Space–Earth Environmental Research, Nagoya University

Meteorological, Atmospheric and Land-Ocean Ecosystem Research Technical Committee

Yoshizumi Kajii	Graduate School of Human and Environmental Studies, Kyoto University
Kenshi Takahashi	Research Institute for Sustainable Humanosphere, Kyoto University
Atsushi Higuchi	Center for Environmental Remote Sensing, Chiba University
Masafumi Hirose	Department of Environmental Science and Technology, Faculty of Science and Technology, Meijo University
Akihiko Morimoto	Center for Marine Environmental Studies, Ehime University
Naoyuki Kurita	Institute for Space–Earth Environmental Research, Nagoya University
Tomoo Nagahama	Institute for Space–Earth Environmental Research, Nagoya University
Hirohiko Masunaga	Institute for Space–Earth Environmental Research, Nagoya University
Akira Mizuno	Institute for Space–Earth Environmental Research, Nagoya University

Chronological Research Technical Committee

Yoko S. Kokubu	Tono Geoscience Center, Japan Atomic Energy Agency
Motohiro Tsuboi	Department of Applied Chemistry for Environment, School of Science and Technology, Kwansei Gakuin University
Hiroyuki Matsuzaki	The University Museum, The University of Tokyo
Katsuyoshi Michibayashi	Graduate School of Environmental Studies, Nagoya University
Hiromi Yamazawa	Graduate School of Engineering, Nagoya University
Naoto Yamamoto	Graduate School of Humanities, Nagoya University
Takenori Kato	Institute for Space–Earth Environmental Research, Nagoya University
Hiroyuki Kitagawa	Institute for Space–Earth Environmental Research, Nagoya University
Masayo Minami	Institute for Space–Earth Environmental Research, Nagoya University
Fusa Miyake	Institute for Space–Earth Environmental Research, Nagoya University

Airplane Usage Technical Committee

Seiho Uratsuka	Applied Electromagnetic Research Institute, National Institute of Information and Communications Technology
Kazuyuki Kita	College of Science, Ibaraki University
Makoto Koike	Graduate School of Science, The University of Tokyo
Akihiko Kondo	Center for Environmental Remote Sensing, Chiba University
Hiroyuki Yamada	Faculty of Science, University of the Ryukyus
Taro Shinoda	Institute for Space–Earth Environmental Research, Nagoya University
Nobuhiro Takahashi	Institute for Space–Earth Environmental Research, Nagoya University
Hiroyasu Tajima	Institute for Space–Earth Environmental Research, Nagoya University

Steering Committee of the Center for International Collaborative Research

Yusuke Ebihara	Research Institute for Sustainable Humanosphere, Kyoto University
Wallis Simon	Graduate School of Science, The University of Tokyo
Yoichiro Hanaoka	Solar Science Observatory, National Astronomical Observatory of Japan, National Institute of Natural Science
Akihiko Morimoto	Center for Marine Environmental Studies, Ehime University
Kazuo Shiokawa	Institute for Space–Earth Environmental Research, Nagoya University
Nozomu Nishitani	Institute for Space–Earth Environmental Research, Nagoya University
Tetsuya Hiyama	Institute for Space–Earth Environmental Research, Nagoya University

Steering Committee of the Center for Integrated Data Science

Shin-ichiro Shima	Graduate School of Simulation Studies, University of Hyogo
Tohru Hada	Interdisciplinary Graduate School of Engineering Sciences, Kyushu University
Masahiro Hoshino	Graduate School of Science, The University of Tokyo
Kazuhisa Mitsuda	Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency
Koshi Yamamoto	Graduate School of Environmental Studies, Nagoya University
Junichi Watanabe	National Astronomical Observatory of Japan, National Institutes of Natural Sciences
Fumio Abe	Institute for Space–Earth Environmental Research, Nagoya University
Takenori Kato	Institute for Space–Earth Environmental Research, Nagoya University
Kanya Kusano	Institute for Space–Earth Environmental Research, Nagoya University
Kazuhisa Tsuboki	Institute for Space–Earth Environmental Research, Nagoya University
Yoshizumi Miyoshi	Institute for Space–Earth Environmental Research, Nagoya University

Steering Committee of the Center for Orbital and Suborbital Research

Riko Oki	Earth Observation Research Center, Space Technology Directorate I, Japan Aerospace Exploration Agency
Kazuyuki Kita	College of Science, Ibaraki University
Masato Nakamura	Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency
Hiroyuki Yamada	Faculty of Science, University of the Ryukyus
Nobuhiro Takahashi	Institute for Space–Earth Environmental Research, Nagoya University
Hiroyasu Tajima	Institute for Space–Earth Environmental Research, Nagoya University
Masafumi Hirahara	Institute for Space–Earth Environmental Research, Nagoya University

7. Finance

External Funding and Industry–Academia–Government Collaborations

Researches of ISEE members as principle investigator were supported by the following external funds.

Kakenhi category	Number of subjects	Total amount (JPY)
Grant-in-Aid for Specially Promoted Research	1	60,320,000
Grant-in-Aid for Scientific Research on Innovative Areas	8	93,540,000
Grant-in-Aid for Scientific Research (S)	3	105,170,000
Grant-in-Aid for Scientific Research (A)	5	66,080,000
Grant-in-Aid for Scientific Research (B)	12	58,110,000
Grant-in-Aid for Scientific Research (C)	6	7,280,000
Challenging Research (Exploratory)	6	13,910,000
Grant-in-Aid for Young Scientists (A)	1	3,120,000
Grant-in-Aid for Young Scientists (B)	2	2,210,000
Early-Career Scientists	3	4,550,000
Grant-in-Aid for JSPS Research Fellow	2	14,300,000
Fund for the Promotion of Joint International Research (International Group)	1	14,950,000
Fund for the Promotion of Joint International Research (Fostering Joint International Research (B)	4	2,600,000
Total	54	446,140,000

- Fifty-four research subjects listed in the table were supported by the JSPS Kakenhi.
- Thirty research subjects received total 174,038,009 JPY from governmental funds except KAKENHI, and from other universities and companies. Thirteen of them were collaborative researches between ISEE and companies, or national institutes.
- Nine research subjects received total 5,730,160 JPY of donation.

Library

■ Library, Solar-Terrestrial Sciences (ISEE Libary #1)

Book

Japanese	2,985
Foreign	11,154

Journals

Japanese	47
Foreign	207

■ Library, Hydrospheric-Atmospheric Sciences (ISEE Library #2)

Book

Japanese	4,726
Foreign	8,869

Journals

Japanese	275
Foreign	249

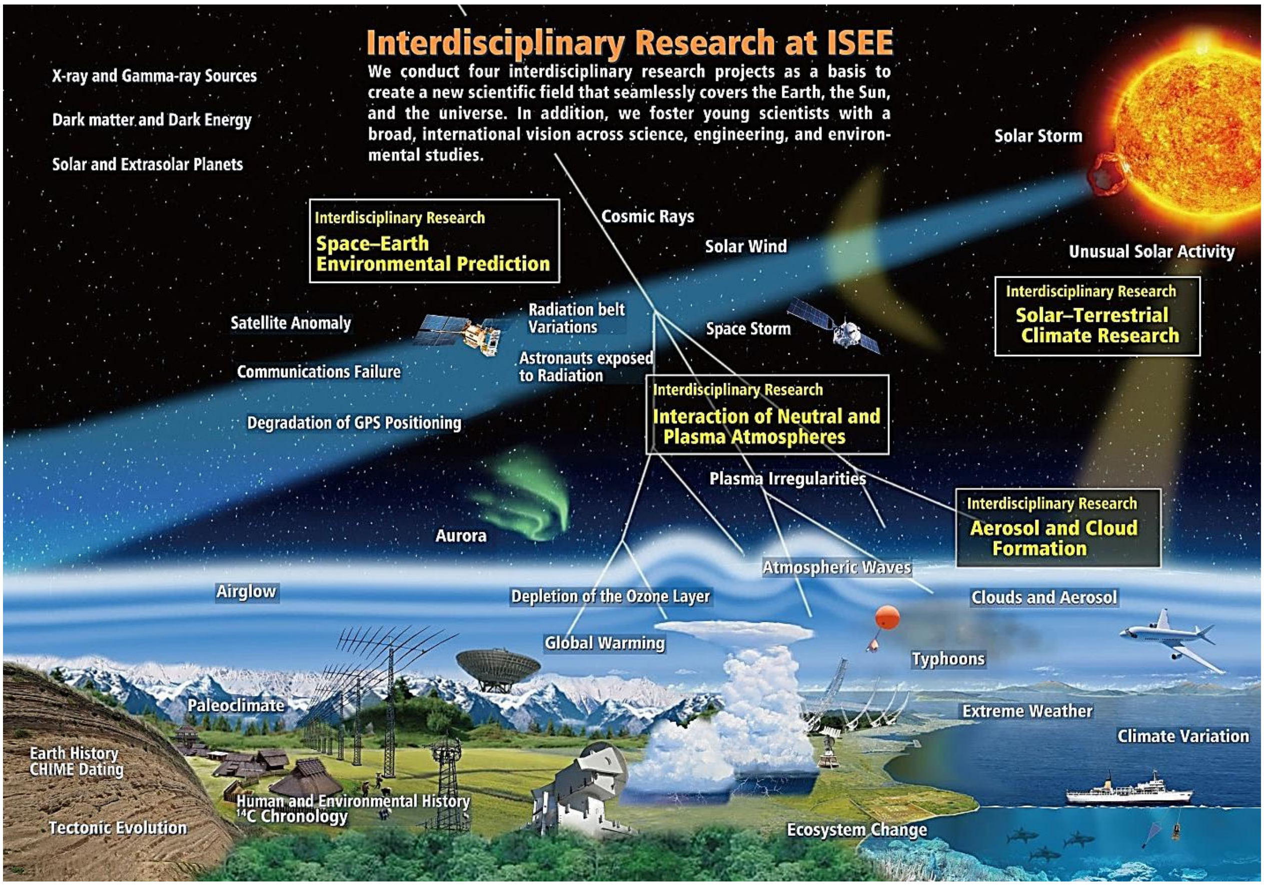
Properties

	Site (m^2)	Bulidings (m^2)	Location
Higashiyama Campus (Main campus of Nagoya University)	-	9,005	Nagoya
Toyokawa Campus	94,212	1,461	Toyokawa
Moshiri Observatory	110,534	325	Hokkaido
Rikubetsu Observatory	24,580	167	Hokkaido
Kagoshima Observatory	13,449	287	Kagoshima
Fuji Observatory	19,926	174	Yamanashi
Sugadaira Station	3,300	0	Nagano
Kiso Station	6,240	66	Nagano
Total	272,241	11,485	

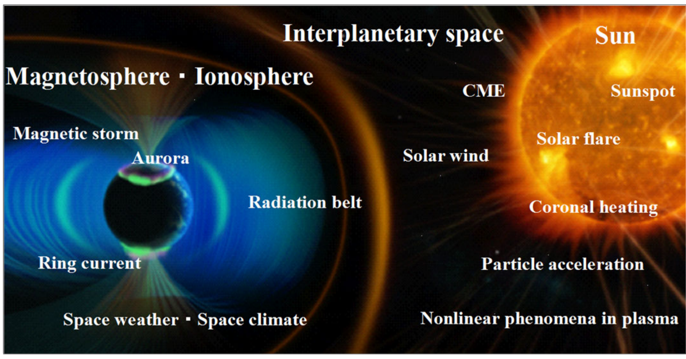
8. Research Topics

The mission of the ISEE is to understand the mechanisms and interactions of diverse processes occurring in the integrated space–Sun–Earth system to deal with global environmental problems and to contribute to human society in the space age. To develop this new research field, four Projects of Interdisciplinary Research are being studied with seven Research Divisions (Divisions for Integrated Studies, Cosmic Ray Research, Heliospheric Research, Ionospheric and Magnetospheric Research, Meteorological and Atmospheric Research, Land–Ocean Ecosystem Research, and Chronological Research). The "Project for Space–Earth Environmental Prediction" aims to develop our understanding and predictive capabilities of the influences of solar dynamics and atmosphere–ocean activities on the global environment. The "Project for the Interaction of Neutral and Plasma Atmospheres" aims to improve our understanding of the relation between the Earth's atmosphere and space using a global observation network of interactions between the upper plasma and middle atmosphere. The "Project for Solar–Terrestrial Climate Research" aims to observe the long-term variability in the solar activity over more than several thousands of years through radioisotopes and to examine the influences of the solar activity on the atmosphere using observations and models to understand the influence of solar activity on global climate variability. The "Project for Aerosol and Cloud Formation" aims to understand the processes that form cloud and precipitation particles from aerosol particles considering the influence of cosmic rays and the processes of scattering and absorption of radiation by clouds and aerosol particles using experiments, field observations, and simulations.

ISEE has also three Research Centers to contribute to national and international research development of the relevant disciplines in cooperation with the Research Divisions. The Center for International Collaborative Research (CICR) conducts extensive observations with four domestic observatories (Moshiri, Rikubetsu, Fuji, and Kagoshima) and a global observation network and enhances collaboration and joint research with domestic and international researchers and institutions. The Center for Integrated Data Science (CIDAS) conducts infrastructure and research development of intensive studies of the space–Sun–Earth system through the analysis of big data and advanced computer simulations. The Center for Orbital and Suborbital Observation (COSO) conducts planning and technological development of research using orbital and suborbital observation vehicles, such as aircraft, balloons, rockets, and satellites, with national and international networks.



Division for Integrated Studies



- Solar flare · CME
- Inner-magnetosphere · Radiation belt
- Aurora substorm
- Space weather · Space storm
- Space climate · Long-term variations of the Sun
- Space plasma
- Computer simulation
- Data assimilation

In the Division for Integrated Studies, we conduct a study aiming at the comprehensive understanding and prediction of various phenomena in the solar-terrestrial system, using advanced computer simulation and data analysis. In particular, we promote studies leading to the elucidation of various phenomena, such as solar cycle, solar flares, coronal mass ejections (CMEs), geomagnetic storms, and aurora, where the nonlinear interaction and intercoupling reaction between different systems play an important role. We are leading a nationwide project for the understanding and prediction of solar-terrestrial environment variability and the various influences of these phenomena on social life based on the Grant-in-Aid for Scientific Research on Innovative Area from Ministry of Education, Culture, Sports, Science and Technology (MEXT). We are also promoting scientific projects of satellite missions (Hinode and ERG satellites) observing the Sun and geo-space in cooperation with the Institute of Space and Astronautical Science, JAXA, and National Astronomical Observatory of Japan. The faculty members of this division are responsible for the education in Graduate Schools of Science and Engineering at Nagoya University. The graduate students of both schools and the undergraduate students of the Engineering School cooperate in a multilateral way and advance the integrated study of the solar-terrestrial environment.

Main Activities in FY2019

Operational solar flare forecasting: International workshop on benchmarks, performance, and future challenges

Solar flares are sudden, explosive brightenings in the solar corona; they and their associated phenomena can have major impacts not only on the space environment, but also on social infrastructure such as satellites, astronauts, electric power, communication, and aviation. For this reason, predicting the occurrence of solar flares is a critical issue both scientifically and socially, and many space weather forecasting organizations across the world, including government agencies and research centers, work to predict solar flares every day. However, a quantitative comparison of operational flare prediction performance had not been previously conducted. Prof. Leka and Dr. Park of the Division for Integrated Studies organized the ISEE international workshop “Benchmarks for Operational Solar Flare Forecasts,” cooperating with 16 institutes from Japan, the USA, the UK, Korea, Australia, Ireland, Greece, and Belgium, to undertake this task for the first time. The comparison focused on the predictive ability of 18 different methods over the January 2016 to December 2017 timeframe. The analysis involved both overall quantitative evaluation metrics and an investigation into why the various methods performed differently. The results found no particularly excellent predictive system but did give some indication of how the systems might be improved. Of note, Leka and Park developed a new method of evaluating multi-day forecasts, a crucial measure of performance when the solar flaring rate fluctuates. Unfortunately, it was found that none of the operational systems could reliably predict the first large flare from a solar active region. The developed methodologies and results clarify our present prediction capabilities and will play an essential role in the advancement of space weather forecasting in the future.（Leka et al., *ApJ Suppl*, 2019, Leka et al., *ApJ*, 2019, and Park et al., *ApJ*, 2020)

Effect of the morphological asymmetry of sunspot on solar cycle prediction

Leading sunspots are more coherent than following spots. This well-known feature of sunspots was first described in the 1950s. However, the impact of this asymmetry on the evolution of the solar surface magnetic field have not been discussed. We, for the first time, investigated the importance of the morphological asymmetry between leading and following sunspots to solar cycle prediction. Using the surface flux transport model to mimic the evolution of the magnetic field on the solar surface, we found that this morphological asymmetry strongly reduces the polar magnetic field, resulting in the reduction of the next cycle amplitude. SFT simulations based on the observed sunspot record show that the introduction of morphological asymmetry reduces the difference from the observed polar magnetic field by 30%–40%. These results indicate the strong impact of morphological asymmetry on solar cycle prediction. (Iijima, Hotta, and Imada, *ApJ*, 2019)

Ion–neutral collision frequencies for calculating ionospheric conductivity

Molecular oxygen collides with its first positive ion in the Earth’s ionosphere. The collision frequency of this particle pair is used to calculate the electric conductivity of the ionosphere. However, for this parental pair there are two collision types, resonant and nonresonant, and the selection of the collision type has differed among previous studies on the calculation of conductivity. In the present study, we clarify that nonresonant collision is physically essential for this pair because the relevant temperatures are low. The ionospheric conductivity peak occurs at altitudes between 100 and 130 km, where the temperatures of the ions and neutral particles are usually lower than 600 K, and at these temperatures nonresonant collisions are dominant. The collision frequency would be underestimated by 30% if resonant collision was assumed at an altitude of 110 km (where the temperature is 240 K). The impact of this difference on the conductivity is estimated to be small (3%), primarily because molecular nitrogen is much more abundant than molecular oxygen. Although we have confirmed that nonresonant collision is essential, we also include resonant-type collision, primarily to allow for possible elevated temperature events. A set of ion–neutral collision frequency coefficients for calculating the conductivity, including other particle pairs, are summarized in the Appendices. Small corrections to the traditional coefficients are mad. (Ieda, *JGR Space Physics*, 2020)

Vlasov-code simulation of contact discontinuities

The stability of contact discontinuities formed by the relaxation of two Maxwellian plasmas with different number densities but the same plasma thermal pressure was studied by means of a one-dimensional electrostatic full-Vlasov simulation. Our simulation runs, with various combinations of ion-to-electron ratio in the high-density and low-density regions, showed that transition layers of density and temperature without a jump in plasma thermal pressure, are obtained when the electron temperatures in the high-density and low-density regions are almost equal to each other. However, a stable structure of the contact discontinuity with a sharp transition layer on the Debye scale is not maintained. It is suggested that non-Maxwellian velocity distributions are necessary for a stable structure of contact discontinuity. (Umeda et al., *Phys. Plasma*, 2019)

Propagation and mode conversion of plasmaspheric equatorial noise

We investigated the propagation process of equatorial noise (X-mode whistler waves from Arase and the Van Allen Probes). We discovered a mode conversion from equatorial noise to electromagnetic ion cyclotron (EMIC) waves, associated with ion composition variations, which contributes to the origin of plasmaspheric EMIC waves. Moreover, we found that equatorial noise contributes to the significant heating of a few keV ions inside the plasmasphere. (Miyoshi et al., *GRL*, 2019)

Ion outflow and transportation of oxygen ions, from Arase and MMS observations

Whether the oxygen in the plasma sheet and the inner magnetosphere originates from the dayside cusp and/or nightside aurora region is not well understood. Using simultaneous observations of Arase and MMS, together with particle trajectory tracing, we found that the oxygen ions in the lobe regions come from the cusp, while the oxygen burst comes from the night side aurora region. (Kistler, Miyoshi, Hori et al., *JGR Space Physics*, 2019)

Meridional distribution of plasma parameters and currents in the inner magnetosphere

We examined the average meridional distribution of plasma parameters and pressure-driven currents in the inner magnetosphere using data from the Arase satellite. We found that plasma pressure decreases significantly with increasing magnetic latitude (MLAT). The pressure anisotropy, derived as the perpendicular pressure divided by the parallel pressure minus 1, decreased with radial distance and showed a weak dependence on MLAT. The theoretical value of the plasma pressure, estimated from the magnetic strength and anisotropy, was roughly consistent with the observed plasma pressure. The azimuthal pressure-gradient current derived from the plasma pressure was distributed over MLAT 0–20°, while the curvature current was limited within MLAT 0–10°. We suggest that latitudinal dependence should be considered in the interpretation of plasma parameters in successive orbits during magnetic storms. (Imajo et al., *JGR Space Physics*, 2019)

Nonlinear wave–particle interaction analysis between EMIC waves and ions: Arase observations

EMIC emissions with various frequency changes are observed by the Arase spacecraft. The EMIC rising tone wave has been previously studied by applying a wave–particle interaction analysis (WPIA) method to the spacecraft data. By the same method, we obtain the phase angle between the particle and the wave field, to analyze the nonlinear resonant currents controlling the energy transfer and wave frequency drift. We use the WPIA method with Arase electromagnetic field and ion particle data to analyze the nonlinear mechanisms of the EMIC emissions with different frequency evolutions. The WPIA of an EMIC falling tone emission, observed on November 15, 2017, indicated that nonlinear resonant currents controlled the frequency decrease and significant wave growth. The existence of the proton hill predicted by the nonlinear growth theory is shown in the phase angle distribution of the proton flux. The motion of the proton hill in phase space, which forms the nonlinear resonant currents, is also discussed. Concurrent generation of rising and falling tone emissions at different frequencies with the same proton energy is also suggested by the WPIA results.

Azimuthally propagating ionospheric flow fluctuations

Ionospheric flow fluctuations observed by the Super Dual Auroral Radar Network (SuperDARN) radars during magnetic storms were examined using plasma and field observations made by satellites in the Earth's inner magnetosphere. The radar observations showed that the flow fluctuations had a frequency of ~1 mHz and propagated westward with a speed of several hundreds of m/s. Simultaneous satellite observations at conjugate points in the magnetosphere revealed an association between flow fluctuations and ring current pressure enhancement. These results indicate that westward-propagating ionospheric flow fluctuations could be directly driven by westward-drifting ring current ions.

Statistical investigation of chorus wave propagation in the inner magnetosphere

Chorus emissions are electromagnetic waves in nature that are spontaneously generated in the magnetosphere. These waves have attracted attention as they play crucial roles in the acceleration and loss of high-energy electrons in the inner magnetosphere. Chorus waves are generated near the magnetic equator, and propagate toward higher latitudes. Based on ray tracing studies, it is predicted that the wave-vector of chorus waves deviates from the local magnetic field as the wave propagates toward higher latitudes. However, based on the statistical investigation of chorus observations by the Arase satellite, we found that the majority of chorus wave vectors are aligned to the local magnetic field, even when the waves are observed at higher latitudes. These results indicate that canonical ray tracing studies require correction to explain the wave-vector direction observed by the Arase satellite.

Investigation of ion transportation: Arase observations

We investigated the "trunk structures" that show specific ion distribution characteristics in the energy–time diagram. Using two-year data from the Arase/LEPi instrument, we found that: 1) most of the trunk structures were seen pre-midnight; 2) the MLT distribution depends on the ion energy; and 3) trunk structures can frequently be found for He^{+}, while their occurrence for H^{+} is very rare, suggesting that charge exchange controls trunk occurrence. We conducted a particle tracing computer simulation, and found that not only large-scale potential electric fields, but local electric fields like subauroral polarization streams, are essential to form trunk structures. This result suggests that the deformation of the electric fields associated with substorms plays an essential role in the transport of plasma sheet ions into the inner magnetosphere.

Spatial distributions of EMIC waves, depending on geomagnetic conditions

EMIC waves are known to be excited in the magnetic equator of the magnetosphere by ion cyclotron instability owing to energetic ion temperature anisotropy. To determine the influence of geomagnetic conditions on the generation of EMIC waves, Arase and the Van Allen Probes observed EMIC waves in the inner magnetosphere, under various geomagnetic conditions, in 2017–2018. We found that the occurrence of EMIC waves shows clear dependence on geomagnetic conditions. During quiet geomagnetic conditions, H^+ EMIC waves have peak occurrences in the morning sector at higher L shells, without any energetic particle input, while He^+ EMIC waves are frequently observed on the dayside of the magnetosphere where the cold plasmaspheric ions and hot ring current plasma are mixed. In contrast, during disturbed conditions, EMIC waves were mainly detected in the noon to afternoon sector, owing to the increasing temperature anisotropy caused by injected energetic ions and ring current development. The present study provides observational evidence that the major driver of EMIC waves is dependent on geomagnetic conditions and generation region.

Modulation of Pc1 wave ducting by equatorial plasma bubbles

Based on the Swarm satellite observations, Kim and his colleagues presented the first observational evidence that ducting Pc1 waves are modulated by equatorial plasma bubbles. They also showed excellent correspondence between wave intensity and electron density. (Kim, Shiokawa et al., *GRL*, 2020)

Establishment of a scheme for predicting extreme ultraviolet radiation associated with solar flares

Extreme ultraviolet radiation from solar flares can cause serious harm, such as loss of communication or satellite drag. Therefore, there is an urgent need to establish a method for predicting extreme ultraviolet emissions from solar flares. We performed a prediction of the flare soft X-ray light curve using a convolutional neural network 2 h before the occurrence of the flare, and calculated the extreme ultraviolet radiation using the soft X-ray light curve and numerical simulations. We attempted to reproduce the extreme ultraviolet spectrum of past flares using this method, and were able to reproduce the observations of the EVE onboard the SDO. (Kawai, Imada et al., submitted to *J. Atmos. Sol.-Terr. Phys*.)

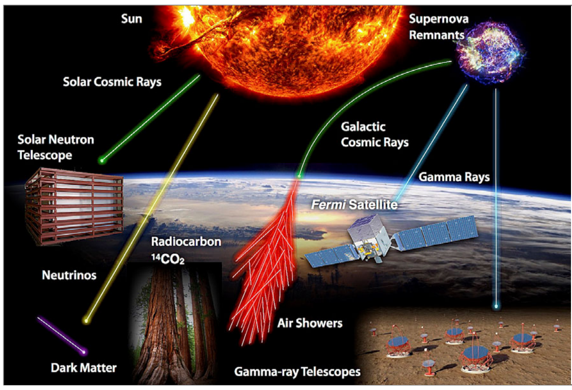
Simulation study on precursory phenomenon of solar prominence eruption

The interior of a solar prominence contains turbulent flows. Recent observations revealed that the standard deviation of the internal velocity field increases before eruption, suggesting a relationship between turbulence and magnetohydrodynamic (MHD) instability. In this study, we carried out MHD simulations, including radiative cooling, thermal conduction, and gravity. We confirmed that the increasing standard deviation of the internal velocity field is caused by Kelvin-Helmholtz instability (KHI). We also found that KHI gradually changes the coronal magnetic field sustaining the prominence and facilitates the onset of MHD instability.

Relationship between microwave intensity and hard X-ray intensity in solar flares

Microwave intensity and hard X-ray intensity were compared for all solar flares (40 events) above GOES M7-class that were simultaneously observed with the Nobeyama Radioheliograph/Nobeyama Radio Polarimeters and the RHESSI satellite. Although the emission mechanism and energy range of the accelerating electrons are different, they showed a very strong correlation, with a correlation coefficient of about 0.9. Considering that microwave emission depends strongly on magnetic field strength, this result may indicate that there is no difference in magnetic field strength in the region where the accelerated electrons exist. This work was undertaken by the ISEE International Joint Research Program. (Krucker, Masuda, and White, *ApJ,* 2020)

Division for Cosmic-Ray Research



- Acceleration and propagation of cosmic rays
  - Cosmic gamma-ray observations
  - Solar neutron observations
- Cosmic-ray interactions with the Earth's atmosphere
  - Hadron interactions of very-high-energy cosmic rays
  - Past solar activities probed by cosmogenic nuclides
- Particle astrophysics and non-accelerator physics
  - Dark matter and neutrino physics
- Wide-field transient survey by an optical telescope

Cosmic rays (CRs), which are mostly protons with small amounts of charged particles, such as electrons or nuclei, and neutral particles, such as gamma rays or neutrinos, are produced in space and propagate through interstellar and interplanetary magnetic fields before reaching the Earth. The Division for Cosmic-Ray Research performs cosmic gamma-ray observations using the Fermi Gamma-ray Space Telescope (Fermi satellite) and the Cherenkov Telescope Array (CTA), as well as high-altitude solar neutron observations, to reveal the CR acceleration mechanisms as common space plasma phenomena.

CRs also provide hints for ultra-high energy phenomena and unknown particles that cannot be explored in a laboratory. We conducted the Large Hadron Collider forward (LHCf) and the Relativistic Heavy Ion Collider forward (RHICf) experiments to study the hadronic interactions of ultra-high energy CRs using accelerators such as LHC or RHIC. This division also conducts neutrino physics research with the Super-Kamiokande experiment and promotes the Hyper-Kamiokande project as a future prospect. The group intensively works for direct dark matter searches in the XMASS liquid xenon experiment at the Kamioka Observatory and has recently started a new commitment to the XENONnT experiment in LNGS in Italy.

CRs deeply penetrate the atmosphere, producing ionization and cosmogenic nuclides. Our division studies past solar activities and sudden changes in CR flux that are recorded in the carbon-14 (^{14}C) fractions of ancient tree rings and other cosmogenic nuclides from Antarctic ice cores.

In addition, this division conducts the MOA experiment with a dedicated 1.8-m wide-field optical telescope at Mt. John University Observatory in Tekapo, New Zealand. It conducts surveys of gravitational microlensing due to massive astrophysical compact halo objects (MACHOs) or exoplanets and optical follow-up observations of gamma-ray bursts, super-nova neutrino detections, and gravitational wave events.

Main Activities in FY2019

Search for dark matter and research on the origin of cosmic rays using gamma-ray observations

Cosmic gamma rays are expected to be produced through the interactions of dark matter, CRs, and the interstellar medium. This makes gamma rays a useful probe to search for dark matter and investigate the properties and distribution of CRs and the interstellar medium.

We are developing the next-generation gamma-ray observatory, the CTA, to observe cosmic gamma rays in an energy range from well below 100 GeV to above 100 TeV. We are in charge of the development of silicon photomultipliers (SiPMs) for the Gamma-ray Cherenkov Telescope (GCT), which is one of three telescope designs for small-sized telescopes (SSTs) in the CTA. The GCT camera was selected as the final SST camera and we are in charge of the SiPM procurement and calibration. Meanwhile, we studied the properties of the origin of SiPM optical crosstalk in detail, where it produces additional signals to the incident photon signal. We found a relatively high rate of delayed crosstalk, which requires further careful study of its effects.

We also studied the feasibility of replacing the photomultipliers (PMTs) with SiPMs for the medium-sized telescopes (MSTs) of the CTA. Originally, PMTs were selected as they were less expensive for covering the area required for the MST camera. However, as SiPM costs became comparable to PMT costs, SiPMs became an attractive alternative because they can operate under moonlight, which can double the observation time of the MST. Simulation studies, combined with experimental verification at several wavelengths, found that an SiPM can collect 62% more signal photons and 6.53 times more background photons than a PMT. Since the signal tends to be blue while the background tends to be red, the simulation found that the signal and background photons for the SiPM are similar to those of the PMT with proper color filtering. These results confirm that we can use SiPMs for the MST.

Acceleration mechanism of solar energetic particles

We observe solar neutrons produced by the interaction of accelerated ions with the solar atmosphere to study the acceleration mechanism of solar energetic particles. It is expected that understanding the acceleration mechanism of solar energetic particles could help to elucidate the acceleration mechanism of cosmic rays in space. Since neutrons are not deflected by interplanetary magnetic fields, they keep the information on the time when charged particles are accelerated at the solar surface. It is essential to measure the energy of neutrons because they have mass, and the period of flight of a neutron from the Sun to the Earth differs depending on its energy. ISEE has developed a worldwide network of solar neutron telescopes to detect solar neutrons (>100 MeV) over an entire day..

We obtained the energy spectra of neutrons from more than 10 events, if we assume neutrons are produced at the same time as electromagnetic waves on the solar surface. The energy spectra obtained indicate that very efficient acceleration, such as shock acceleration, does not work in the case of neutron-producing solar flares. To derive a conclusive understanding of the acceleration mechanism, we need to observe a solar neutron event in which the energy spectrum of the neutrons can be determined without assuming the production time of the neutrons. For this purpose, we need a solar neutron telescope with better sensitivity to neutrons and a higher energy resolution than the one which ISEE developed.

A new solar neutron telescope was installed at the Mt. Sierra Negra volcano (4,580 m above sea level) in Mexico. The new detector is called the SciBar Cosmic Ray Telescope (SciCRT). SciBar was used in accelerator experiments, and this installation was realized with support from Kyoto University, the High Energy Accelerator Research Organization (KEK), the National Autonomous University of Mexico, and the National Institute for Astrophysics, Optics and Electronics in Mexico. SciCRT uses 15,000 scintillator bars to measure particle tracks, providing much better sensitivity to neutrons, and better energy resolution and particle discrimination. The performance of SciCRT was investigated using Monte Carlo simulation, and we can discriminate the production time of neutrons, whether it is instantaneous or continues for more than 5 minutes, while discriminating between shock acceleration and stochastic acceleration. As for the worldwide network of solar neutron telescopes, the operation at Gornergrat in Switzerland ceased in the fiscal year (FY) 2017. The operation at Mauna Kea in Hawaii also ceased in FY 2018.

The activity of solar cycle 24 reached a maximum in February 2014 and has since decreased. At the end of FY 2019, it is just between the end of solar cycle 24 and the beginning of solar cycle 25. No solar neutron events were detected in FY2019. Since the installation of SciCRT, no large solar flares with which solar neutrons are expected have yet occurred. The procedure to search for solar neutrons is under developing in association with solar flares, which are not strong enough for neutrons to be produced in usual.

This study was performed in collaboration with Chubu University, Shinshu University, the National Astronomical

Observatory of Japan, RIKEN, the Institute for Cosmic Ray Research (ICRR) of the University of Tokyo, the Institute of Space and Astronautical Science/Japan Aerospace Exploration Agency (ISAS/JAXA), the Japan Atomic Energy Agency (JAEA), the National Defense Academy, the Aichi Institute of Technology, and many other institutions around the world.

Cosmic-ray interaction-focused accelerator experiment

Where and how are cosmic-ray particles accelerated to high energies? To answer this question, many observations and studies of cosmic rays have been performed worldwide. In particular, ultra-high energy cosmic rays (UHECRs) with the energies above 10^{19} eV, whose sources are expected to be highly energetic objects in the universe such as active galactic nuclei, are actively studied. These cosmic rays are observed using the so-called air-shower technique; the observation of particle cascades caused by interactions between cosmic rays and atmospheric atomic nuclei, using particle detectors and/or fluorescence telescopes. A precise understanding of the hadronic interactions between cosmic-ray particles and the atmosphere is key to estimating primary cosmic-ray information from the observed air showers. Therefore, we studied high-energy interactions at the large particle colliders, LHC and RHIC, located at the European Organization for Nuclear Research and the Brookhaven National Laboratory (BNL).

This year, we continued our analyses of the data obtained from these operations at LHC and RHIC, and accelerated preparations for our future operations. Preliminary results for the production cross-section of very forward neutral pions at proton–proton collisions, with a center of mass energy of 13 TeV, were reported at the 36th International Cosmic Ray Conference (ICRC2019). A neutral pion produced at a collision decays immediately into a photon pair. Our calorimeter detector detects the photon pair simultaneously, and the kinematics of the pion can be reconstructed from the results. This measurement is very important for understanding air-shower development in the atmosphere because most of the particles in air showers originate from neutral pions produced during cosmic-ray interactions. We are now attempting to improve the analysis methods for better measurement precision. Additionally, we are planning new measurements at both LHC and RHIC for further understanding of these interactions. Our international collaboration for measurement at LHC, LHCf, submitted a “Technical Report,” including our operation and detector upgrade plans, to the LHC committee in June, and the proposals for the new operations in 2021 and 2023 have been approved. We will accelerate preparations for these operations.

Cosmic neutrinos and dark matter

Super-Kamiokande (SK) is the 50-kton water Cherenkov detector housed underground at the Kamioka Observatory, Gifu, dedicated to the observation of neutrinos and possible proton decay. SK has been preparing for the observation of supernova relic neutrinos emitted by all the supernova explosions by adding gadolinium (Gd) to the pure water in the detector. In 2019, the preparation of the Gd-water system was completed and the detector is now ready for the Gd-loading operation, which has been suspended owing to the COVID-19 situation. The analysis of neutrino/anti-neutrino separation techniques using decay-electrons or tagged neutron information have been carried out. A new analysis on non-standard neutrino interactions through atmospheric neutrino oscillation is also underway. We have also started real-time analysis with gravitational wave alerts to search for possible coincidences of neutrino events in SK. In addition, we have initiated intensive efforts to develop a new atmospheric neutrino flux modeling code to refurbish the Honda -model to cope with the newest hadronic interaction models.

Hyper-Kamiokande (HK) is the next generation of large-scale 260-kt water Cherenkov detector, with a fiducial volume nearly eight times larger. We have been making continuous contributions to starting and promoting the project by delivering intensive seminars in overseas institutions (four Taiwanese institutions in April and four Australian institutions in May). Since the beginning of 2020, the project has been officially approved by the government, and has proceeded to the construction phase.

The XMASS experiment is a direct dark matter search using a single-phase liquid xenon detector. In February 2019, the experiment had completed the data collection phase. Analysis is ongoing to finalize these dark matter search results, using a few years of continuous operation data.

Historic cosmic-ray intensity variation with cosmogenic radioisotopes

Cosmic rays falling on the Earth interact with the atmosphere and produce various secondary particles. Among them, long-lived cosmogenic nuclides, such as ^{14}C and ^{10}Be, are used as excellent proxies for past cosmic-ray intensities. We measured ^{14}C concentrations in tree rings and ^{10}Be and ^{36}Cl concentrations in ice cores to investigate historic cosmic-ray variations. From such analyses of cosmogenic nuclides, we found cosmic-ray increase events in 774/775 CE and 993/994 CE. A possible cause of these cosmic-ray events is solar energetic particle (SEP) events, and the scale of these SEP events is estimated to be tens of times larger than the largest event on record. We aim to clarify the frequency of such extreme SEP events by searching for other cosmic-ray events.

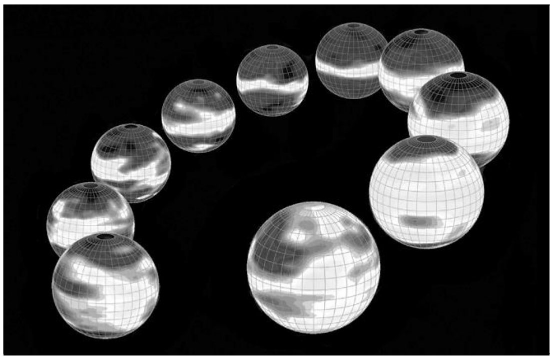
This year, we revealed the detailed ^{14}C variations of a cosmic-ray event in ~660 BCE using earlywood-latewood separated ^{14}C analyses of a Choukai-cedar tree sample. We showed that the duration of this event was longer than the two cosmic-ray events mentioned above, 41 months at the longest (Sakurai et al., 2020). We also measured ^{10}Be and ^{36}Cl concentrations in ice cores from the Antarctic Dome Fuji station to clarify the cause of a cosmic-ray event in ~5480 BCE. We presented the cosmogenic evidence of past extreme SEP events and the detailed ^{10}Be variations around 5480 BCE at the 36th International Cosmic- Ray Conference (ICRC2019) ICRC2019 and the 8th East Asia Accelerator Mass Spectrometry Symposium (EA-AMS 8), respectively.

We have been developing automated graphitization equipment for ^{14}C analyses with the ISEE Technical Support Division. This year, we confirmed its operation and evaluated its performance. The developed graphitization equipment is capable of fully automatic graphite sample preparation and samples can be processed in a lower background environment than the existing manual equipment allows. In addition, we tested methods of separating tree rings (microtome method and plate-state cellulose extract method) for ^{14}C analysis with high temporal resolution of less than one year. We also introduced pretreatment equipment for ice-core ^{10}Be analysis and evaluated its performance. It was confirmed that the ^{10}Be treatment can be performed with a sufficiently low background level.

Wide-field optical surveys for gravitational microlensing and gravitational sources

In 2018, we detected 448 microlensing events and issued real-time alerts to follow-up groups. Several extrasolar planet candidates have been found, and their analyses are in progress. Follow-up observations of gravitational waves in the O3 observation period are in progress.

Division for Heliospheric Research



- Solar wind
- Coronal mass ejection
- Interplanetary scintillation
- Global heliospheric structure
- Space weather forecast
- Radio astronomy
- Development of telescopes and instruments
- Pulsar

A supersonic (with a speed of 300–800 km/s) plasma flow, known as the solar wind, emanates from the Sun and permanently engulfs the Earth. While the magnetic field of the Earth acts as a barrier to protect the atmosphere from a direct interaction with the solar wind, a considerable fraction of its vast energy enters the near-surface layer via various processes. Thus, the solar wind acts as a carrier to transfer the Sun's energy to the Earth.

The solar wind varies dramatically with solar activity. In association with eruptive phenomena on the Sun's surface, a high-speed stream of the solar wind sometimes arrives at the Earth and generates intense disturbances in geospace and the upper atmosphere. Space environment conditions that significantly change with the solar activity are known as "space weather," and are currently a topic of significant interest. An accurate understanding of the solar wind is needed to make reliable predictions of space weather disturbances.

We have observed solar wind velocity and density irregularities for several decades using three large antennas to investigate unsolved important issues such as acceleration and propagation mechanisms of the solar wind, space weather forecasting, global structure of the heliosphere, and its variation. In addition, laboratory and fieldwork experiments are performed for improving data quality and upgrading the instruments.

Main Activities in FY2019

Solar wind observations using the IPS system

Broken Fuji antenna structure in March 2019.

We have been performing remote-sensing observations of the solar wind since the 1980s using the multi-station interplanetary scintillation (IPS) system. Tomographic analysis of IPS observations enables the accurate determination of the global distribution of solar wind speed and density fluctuations. IPS observations provide valuable information, particularly for high-latitude solar wind, where in-situ observations are currently unavailable. The IPS system currently consists of three large antennas in Toyokawa, Fuji, and Kiso. The Toyokawa antenna (called the Solar Wind Imaging Facility Telescope) has the largest aperture and highest sensitivity among our three antennas and started daily observations in 2008. The Fuji and Kiso antennas were upgraded in 2013–2014 by installing new low-noise amplifiers, which led to a great improvement in their sensitivity. These two antennas are in mountainous areas and are not used for observations during winter owing to heavy snowfall. The solar wind density fluctuations were derived from Toyokawa IPS observations, measured throughout the year. The IPS data were made available to the public in real time via an ftp server, and were used for various international collaborations, as described below. In March 2019 (i.e., prior to the start of the IPS observations in this FY), we found that the eastern part of the Fuji antenna reflector had been significantly damaged by snow, and we restored the antenna in April. After finishing the restoration, 3-station IPS observations were conducted until early December. The Fuji IPS observations were briefly interrupted in July by reinforcement work on the antenna. The observation system and network equipment of the Fuji observatory were seriously damaged by lighting on August 1. It took one month to repair this damage, and the Fuji IPS observations restarted on September 1. On November 29, we fixed a misalignment of the Fuji antenna structure which occurred in October and November. We also replaced the driving chains of the Kiso antenna on November 27–28, which had deteriorated owing to long-term operation.

International collaboration for space weather forecast

We performed collaborative research with Dr. B. V. Jackson and his colleagues at the University of California, San Diego (UCSD), on the 3-dimensional reconstruction of the time-varying heliosphere using tomographic analysis of long-term IPS observations. A time-dependent tomography program was developed through this collaborative research, and this program is now available on the NASA Community Coordinated Modeling Center web server, and is running in real time at the Korean Space Weather Center (KSWC) to predict the solar wind reaching the Earth. ISEE has a on research exchange and cooperation agreement with KSWC to promote research on space weather forecasting using IPS data. A combined analysis system using IPS observations and the ENLIL solar wind model was developed to improve space weather forecasting through collaborative research. The UCSD IPS group, represented by Dr. Jackson, won the ISEE Award in this FY, as the UCSD–ISEE collaboration was favorably evaluated.

With the growing awareness of the utility of IPS observations for space weather forecasting, an increasing number of IPS observations have been conducted globally. Besides Japan, Russia, and India, where IPS observations have been conducted for a long time, new dedicated antennas for IPS observations have been constructed in Mexico and Korea, and IPS observations using low-frequency large radio array systems, such as the Low-Frequency Array and the Murchison Widefield Array, have been conducted on a campaign basis. A construction project of a large-aperture antenna dedicated to IPS observations is in progress in China. The integrated analysis of IPS data from these stations enables higher-resolution 3-dimensional reconstructions of the solar wind, which varies rapidly with solar activity. The establishment of WIPSS was proposed at the IPS workshop held in Morelia, Mexico, in 2015. The IPS workshop was held at the Arecibo Observatory in Puerto Rico in December.

Effect of line-of-sight integration in the IPS sky projection map

The Sun-centered sky projection map of g-values derived from IPS observations enables the effective detection of coronal mass ejections (CMEs) propagating in the solar wind, and it has been used in many previous studies. The radial distance of a CME has been determined from the elongation angle between the Sun and the location where the g-value enhancements occur, and CME propagation speed and radial variation have also been addressed using these data. However, CME location on the sky projection map includes the effect of line-of-sight (LOS) integration, and there is a possibility that an apparent change in CME speed may arise from the integration effect. In this FY, we examined the effect of LOS integration on CME location by producing sky projection maps from calculations with a simple CME model. Here, we assumed an axis-symmetrical structure and constant CME speed propagation. We found that the apparent distance of a CME near the Sun becomes smaller than the actual distance when the CME propagation is directed to the Earth, and that the apparent distance approaches the actual distance as the CME moves away from the Sun. This means that the LOS integration brings about an apparent CME acceleration. This effect is remarkable either when the angular width of the CME is small or when the CME expansion speed is non-uniform. Such CME acceleration has seldom been reported from IPS observations, and this implies that the CMEs observed by IPS have a sufficiently wide angular width, and that the apparent acceleration is counterbalanced or overwhelmed by intrinsic deceleration.

Comparative study of the global structures of solar wind and the heliospheric current sheet

The solar wind is composed of a slow wind (~450 km/s) and a fast wind (~800 km/s), known as the bimodal signature of solar wind velocity. These slow and fast winds are the main components of solar wind in the low-mid and high latitudes of the heliosphere, respectively. ISEE-IPS and spacecraft observations have revealed that the boundary latitude of the bimodal structure changes significantly throughout the solar cycle. In this study, we compare the long-term variations of the solar wind structure with the coronal magnetic field structure. The latitudinal structure of the bimodal solar wind is derived from the solar wind synoptic map of each Carrington rotation and compared with the maximum tilt angle of the heliospheric current sheet (HCS), derived from observations by the Wilcox Solar Observatory. The results show that the HCS tilt angle correlates well with the latitudinal average of a solar wind speed of 600 km/s (correlation coefficient 0.8). Since 600 km/s is the average value of the fast and slow wind, the HCS tilt angle is consistent with the latitude of the boundary between the fast and slow wind. The empirical results allow us to estimate the latitudinal structure of the solar wind from the bimodal solar wind velocity after the 1970s, when continuous magnetic field observations of the Sun began.

Solar wind observations using the IPS system

Interplanetary flux ropes (IFRs) are magnetic field structures which are expelled from the Sun into interplanetary space. These ropes have helical magnetic field lines around their central axial field line. To estimate the magnetic field properties of IFRs, force-free IFR models (FF models) are often fitted to *in-situ* observations of IFRs. The Lundquist (cylindrical geometry) and Romashets–Vandas models are often used as FF models. In the fitting of these models, the pitch angle of the magnetic field at the IFR boundary (boundary pitch angle α_p) is conventionally fixed to 90° (conventional method) without sufficient proof. We developed fitting methods in which the assumption that $\alpha_p = 90°$ is relaxed (generalized method) and estimated the difference between the results of the conventional and generalized methods. We found that the fitted axis direction or magnetic flux of IFRs are significantly different between the conventional and generalized methods. From these results, we conclude that the generalized method is more appropriate than the conventional method to estimate the correct magnetic field properties of IFRs.

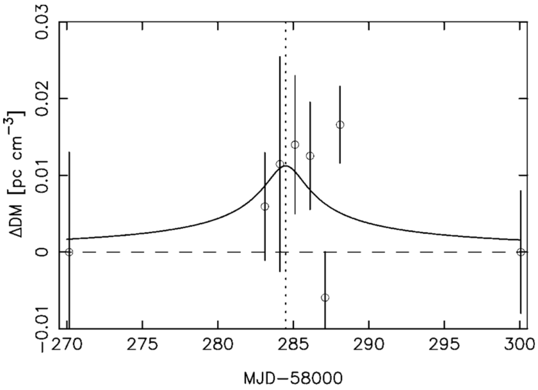
Model	Significance of effect[a]			
	Axis direction		Magnetic flux	
	γ^b	β^c	Φ_t^d	Φ_p^e
Lundquist	–	○	○	○
Romashets-Vandas	–	–	○	–

Magnetic field properties of IFRs for which the fitting results of the conventional and generalized methods are significantly different. ○ indicates that the difference is significant. The second and third columns are two angles which determine the axis direction of the IFR. The fourth and fifth columns are two components of magnetic flux.

Estimation of solar coronal density using the Crab pulsar

T Frequency dispersion is observed in the radio waves from a pulsar when we observe them from the Earth. The magnitude of this frequency dispersion (dispersion measure, DM) allows us to estimate the plasma density along the LOS. We have collected remote-sensing measurements of the plasma density of the solar corona using DM data obtained with Toyokawa IPS antenna. Solar wind density significantly drops in response to declining solar activity in some years. This suggests that a remarkable change likely takes place in the solar corona, which is the source region of solar wind. The target of our observations was the Crab pulsar, whose LOS approaches the Sun (to 5 solar radii) every June. Hence, observation of the Crab pulsar enables investigations of the plasma density near the Sun. In addition, the Crab pulsar enables the effective determination of DM, as it emits extremely intense radio waves called giant pulses. From our observations of the Crab pulsar made in June 2018, a marked increase in DM was found around the period of the closest

LOS approach to the Sun. We determined the distribution of the solar corona plasma density by fitting a spherically symmetrical model to the observed DM data. The result was associated with a large error, and one of the causes of this is likely to be the effect of latitudinal/longitudinal variation in the solar corona. To examine this, we analyzed white light data from LASCO coronagraph observations and solar wind speed data from ISEE-IPS observations for June 2018. We found that the streamer associated with the slow wind and the coronal hole associated with the fast wind were located in the equatorial and polar regions, respectively, for the period of our observations, and that the observation point moved from a low-density to a high-density region as the LOS moved away from the Sun. A high DM value observed at a location distant from the Sun (on June 19) is ascribed to the effect of the high-density plasma of the equatorial streamer.



Daily variation of Crab pulsar DM for the period around its closest approach to the Sun. Circles with vertical bars are observed DMs. Solid line represents the best fit model. Vertical dotted line indicates the time of the closest approach of LOS to the Sun.

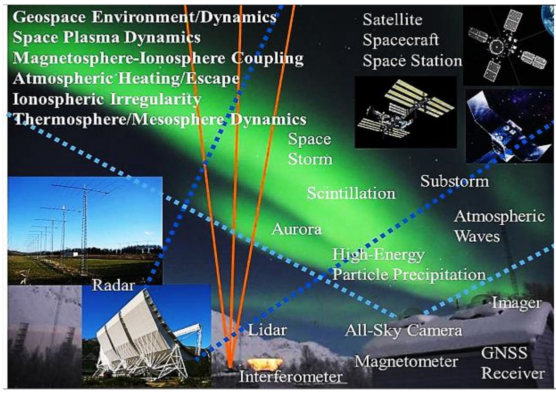
Validation of CME arrival time forecasted by MHD simulations based on IPS observations

We developed an IPS estimation system, based on a global MHD simulation of the inner heliosphere, to predict the arrival time of CMEs. We demonstrated how the simulation system works using a halo CME event generated by a X9.3 flare observed on September 5, 2017. We found that the CME simulation that best estimated the IPS observations could accurately predict the time of arrival of the CME at the Earth. We validated this system using more than 10 halo CMEs and found that the error in the arrival time is reduced to less than 5 h when using the IPS-based forecasting system. These results suggest that the accuracy of CME arrival time can be improved by including IPS data in our current MHD simulations. Part of this system has been installed in NICT, the space weather forecasting center of Japan, and is used for daily forecasting.

Next-generation interplanetary scintillation observation system

We investigated the design of next-generation IPS observation instruments and developed their pathfinders. To continue IPS observations even in the snowfall season, we considered a flat, two-dimensional phased array with a wide field of view. This structure is also resistant to natural disasters, such as typhoons, as it eliminates the drive unit. A real-time digital signal processing receiver system is required for the digital multi-beam that observes multiple directions simultaneously. This system will enable us to take several all-sky IPS maps within a day to track fast CMEs. It is also able to detect the passage of CMEs and derive their structures by tracking a specific radio source. We designed and developed a low-cost digital board dedicated to IPS observations, using ADCs and FPGAs, and found that it showed adequate performance. The developed prototype can process eight signals simultaneously and has a size of 37 cm × 27 cm, which is a reasonable size for mass-production.

Division for Ionospheric and Magnetospheric Research



- Energy transfer from the solar wind to the magnetosphere and ionosphere
- Magnetosphere-ionosphere-thermosphere coupled system
- Ground-based and network observation
- Space and planetary exploration

The plasma and energy carried by the solar wind to the Earth and other planets exert physical effects on the magnetosphere and ionosphere, known as the geospace. We study these effects and associated phenomena with international cooperation, primarily, through various observational approaches using ground-based instruments; for example, European Incoherent Scatter (EISCAT) radars, high-frequency (HF)/very high frequency (VHF) radars, Global Navigation Satellite System (GNSS) receivers, high-sensitivity passive/active optical instruments, magnetometers, and instruments onboard satellites/spacecraft, which are developed in our division. We also lead the way to future space exploration missions based on our expertise.

Main Activities in FY2019

Measurements of aurora and electromagnetic waves at subauroral latitudes (PWING Project)

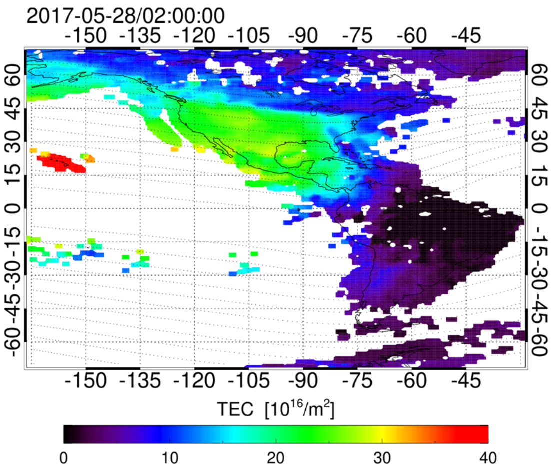
We operate aurora/airglow imagers and electromagnetic wave receivers under the PWING project at eight stations around the north pole, at MLATs of about 60° (in Canada, Russia, Alaska, Finland, and Iceland), to investigate plasma and wave dynamics in the inner magnetosphere. Various new results were obtained in FY2018. Using this longitudinal network, we found that the typical longitudinal extent of magnetospheric ELF/VLF waves is ~80 longitudinal degrees. This finding contributes to our quantitative understanding of high-energy electron acceleration in the radiation belts. By combining these ground-based network stations with the Arase satellite, we also obtain various interesting results in FY2019, including the propagation characteristics of magnetospheric ELF/VLF waves from the magnetosphere to the ground and the relationship between these waves and pulsating aurorae.

Upper atmosphere imaging using the optical mesosphere thermosphere imagers

The optical mesosphere thermosphere imagers (OMTIs) consist of five sky-scanning Fabry-Perot interferometers, 21 all-sky charge-coupled device imagers, three tilting photometers, and three airglow temperature photometers, which are used to investigate the dynamics of the mesosphere, thermosphere, and ionosphere. Various new results were obtained from OMTI measurements in FY2019. As an example, we obtained wavenumber spectra of small-scale gravity waves and medium-scale traveling ionospheric disturbances for more than 10 years, with their seasonal and long-term variations, using airglow images obtained at Magadan (Russia), Athabasca (Canada), Rikubetsu, and Shigaraki (both in Japan).

Ionospheric disturbances using GNSS receiver network

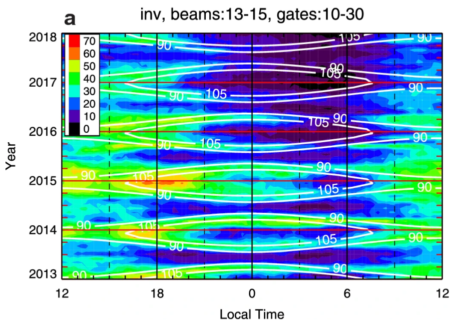
To clarify the characteristics of ionospheric disturbances during geomagnetic storms, we analyzed the total electron content data obtained from dense regional GNSS networks that were extended globally, and found new storm enhanced density (SED) generation characteristics. SED was believed to be generated by plasma transportation from low latitudes to high latitudes. However, we have shown that SED firstly appears at mid-latitudes and then extends to higher latitudes. Furthermore, we found that equatorial plasma bubbles, which are localized plasma depletions, extend to high latitudes, and reach 50 MLAT degrees during geomagnetic storms. These ionospheric disturbances could be caused by eastward electric fields induced during magnetic storm.



Map of Total Electron Content (TEC) during a geomagnetic storm. A plasma bubble can be seen as a TEC depletion extending from the low latitudes to the high latitudes.

SuperDARN Hokkaido HF radars

Using the SuperDARN Hokkaido HF East and West radars at Rikubetsu, Hokkaido, as well as other SuperDARN radars, we studied the statistical characteristics of Medium-Scale Traveling ionospheric Disturbances using the 3D-FFT algorithm, and SAPS occurrence. We also clarified the statistical occurrence characteristics of high-latitude ionospheric irregularities as a function of local time, season and solar activity.



Local time and seasonal distribution of the occurrence rates of ionospheric backscatter echoes in the polar cap region.

Promotion of FACTORS as the next space exploration mission for demonstrative integrated research on the space–Earth coupling system

The new space exploration mission, FACTORS, which is the next ERG (Arase) satellite mission led by our institute for terrestrial radiation belt exploration, is being promoted for simultaneous multi-point observations with multiple satellites in the near-Earth space and the terrestrial upper atmosphere. The following issues were particularly investigated, based on the FACTORS working group activities in ISAS/JASA: the international collaboration of three compact/micro satellite developments, cluster launch configurations for multiple satellites using an Epsilon rocket, and the science targets and observational objectives/techniques of the mission.

Fabrication and initial experimental checks of technical developments in an engineering model of a double-shell type electrostatic energy analyzer for next-generation in-situ observations of space plasmas

For the miniaturization/mass-reduction/power-saving of space plasma energy analyzers and their possible applications in micro-satellites and CubeSat, we completed a detailed design, created an engineering fabrication, and performed initial experimental checks of a double-shell type electrostatic energy analyzer enabling the simultaneous measurement of ions and electrons with one sensor head, using our charged-particle beamline facility. After the mechanical design and fabrication of the double-layered collimator and double-dome electrostatic analyzer, we compared experimental results with those of a numerical simulation and confirmed that the performance requirements and design objectives were almost achieved.

Maintenance of the charged-particle beamline calibration system as the developmental facility for particle analyzers in future space exploration missions

The charged-particle beamline facility was maintained in a clean room of our institute, which is crucial for the development of new particle analyzers for the future geospace and terrestrial upper atmosphere exploration. Following monitoring system developments for two-dimensional cross-sections and energy-angle distributions, we realized the prompt switching between the ion and electron beam emissions, the intensity/cross-section enlargements of the beams, and the electron flux enhancements, by tuning the cubic Helmholtz coils, and calibrating the two-dimensional particle imaging detector.

Promotion of EISCAT and EISCAT_3D projects

We proceeded with the EISCAT project in collaboration with NIPR: (1) we performed nine EISCAT SP experiments for Japanese colleagues; (2) we proceeded with the EISCAT_3D project, the master plan 2020 "Study of coupling processes in the solar–terrestrial system" has been selected as one of the 31 most important big projects; and (3) we had a special session for the master plan 2020 in JpGU2019. We have also operated the sodium LIDAR, a photometer, an MF radar, and a meteor radar in northern Scandinavia, and have collaborated with Japanese and foreign colleagues in studies on atmospheric stability, gravity waves, sporadic sodium layers, and vertical winds.

Oxygen density enhancement and EMIC waves in the inner magnetosphere

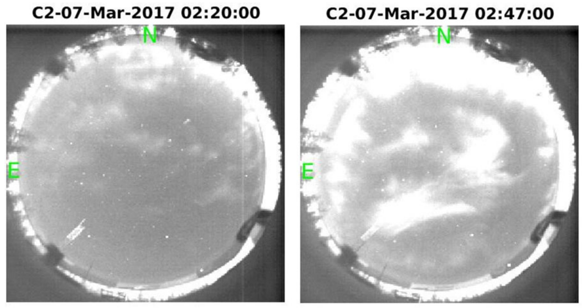
The O^+ density is sometimes enhanced in a limited range of altitudes in the deep inner magnetosphere, and is named the oxygen torus. We investigated the longitudinal structure of the oxygen torus using simultaneous observations from the Arase and Van Allen Probe satellites. We found that the oxygen torus is localized to the dawn sector, indicating a crescent-shaped torus. It was newly found that an electromagnetic ion cyclotron (EMIC) wave in the H^+ band appeared coincidently with the oxygen torus. The linearized dispersion relation for EMIC waves shows that the growth rate increases in the oxygen torus than in the adjacent regions in the plasma trough and the plasmasphere. We conclude that the oxygen torus in the inner magnetosphere may play an important role in the excitation of EMIC waves.

Development of a magnetometer system using a magneto-impedance sensor

The magneto-impedance (MI) effect was discovered about 25 years ago, and a micro-sized magnetic sensor that utilizes this effect has now become commercially available. We made some modifications to the commercially available MI sensors as they can cover the range of the geomagnetic field (±70,000 nT). Experimental observations showed that the MI sensors can detect geomagnetic variations with amplitudes of ~1 nT, which were also detected with a fluxgate magnetometer. We developed an instrument for ground measurements including MI sensors, a Raspberry Pi-based data logger, an A/D converter, and so on, which is only ~1/10 of the usual cost of a fluxgate magnetometer. We also developed an onboard instrument for a future sounding rocket.

International collaboration to study the impacts of EEP on atmospheric minor species

Energetic electron precipitation (EEP) can modify the density of atmospheric minor species, such as NO_x and O_3, which affect the atmospheric temperature and dynamical field through chemical reactions. We have organized an international collaborative team to study this topic and analyzed data from ground-based instruments, such as the EISCAT radar and optical cameras, and instruments onboard satellites. This year we analyzed data from the high-speed EMCCD all-sky camera operated by the Japanese team in Sodankylä (Finland) and the meridional chain of the riometer in Finland, to investigate pulsating aurorae and lower ionospheric ionization. We found that the EEP energy flux tends to increase in the lower latitude parts of the pulsating aurora, coinciding with the enlargement and intensification of patch-like pulsating aurorae. This result was presented at the CHAMOS meeting in Finland.



All-sky images taken with the high-speed EMCCD camera operated in Sodankylä, Finland. The aurorae in the left image are characterized by darker and smaller patches than those shown in the right image, which was taken in a period of EEP flux enhancement at lower latitudes in the auroral appearance.

SDI-3D project

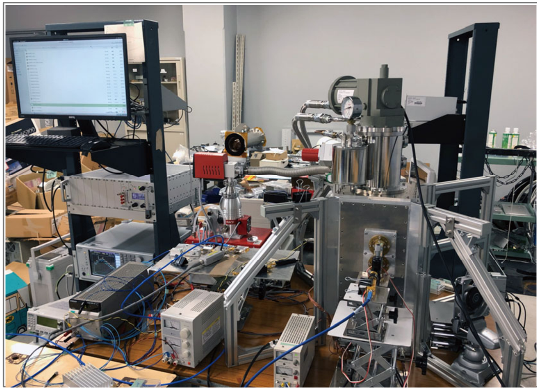
The scanning Doppler imager (SDI) is a ground-based Fabry-Perot Doppler spectrometer, operating in an all-sky imaging mode with a separation scanned etalon to resolve Doppler spectra at heights of 90–400 km. Even a single station can estimate the horizontal wind vector and temperature of a horizontal plane of 1,000-km diameter. In 2018, we established an international team of researchers from Japan, Scandinavian countries, and the US. This team started the “SDI-3D” project, which aims to deploy three SDIs in the same areas as EISCAT_3D, which may be operational in 2022. To progress this project, an international exchange program (or cross-appointment system) was conducted between Nagoya University and the University of Oulu (Finland) in 2018 (a first at Nagoya University), and a faculty member stayed in Oulu for three months in 2019. We officially participated in administrative-level meetings with the MoU, which were conducted by institutes to integrate the ground-based observation networks in Finland, Norway, and Sweden.

Data archives

The following data archives are available to the public:

Database	Web site
OMTIs	http://stdb2.isee.nagoya-u.ac.jp/omti/
GPS scintillation	http://stdb2.isee.nagoya-u.ac.jp/QL-S4/
VHF (30.8 MHz) radar	http://stdb2.isee.nagoya-u.ac.jp/vhfr/
SuperDARN Hokkaido radar	http://cicr.isee.nagoya-u.ac.jp/hokkaido/
210-mm magnetic field data	http://stdb2.isee.nagoya-u.ac.jp/mm210/
ISEE magnetometer network	http://stdb2.isee.nagoya-u.ac.jp/magne/
ISEE VLF/ELF data	http://stdb2.isee.nagoya-u.ac.jp/vlf/
EISCAT radar, Sodium Lidar, MF/Meteor radar, Optics	http://www.isee.nagoya-u.ac.jp/~eiscat/data/EISCAT.html
Reimei satellite data	http://reimei.stelab.nagoya-u.ac.jp/
Wp geomagnetic index	http://www.isee.nagoya-u.ac.jp/~nose.masahito/s-cubed/

Division for Meteorological and Atmospheric Research



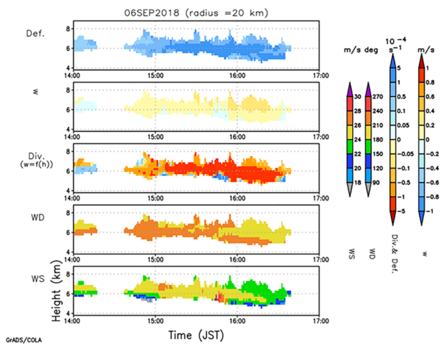
- Precipitation measurements by advanced polarimetric radars and hydrometeor videosondes
- Development of new instrumental technology
- Clouds and precipitation observed by multiple satellites
- Millimeter-wave/infrared spectroscopy of green house gases and ozone-depleting substances
- Measurements and analyses of properties and behaviors of aerosols using advanced techniques

Ongoing global warming caused by increasing concentrations of carbon dioxide and other greenhouse gases will result in both gradual climate change and intensification of weather extremes and ecological catastrophes. Among the most urgent tasks for confronting global environmental problems more effectively is a close monitoring of the atmosphere using different observation methods and a better understanding of the atmosphere through theoretical insights and numerical modeling. To address these problems, the Division for Meteorological and Atmospheric Research is dedicated to several research projects for exploring the atmosphere from various angles.

Main Activities in FY2019

New understanding of precipitation through MP-PAWR observations

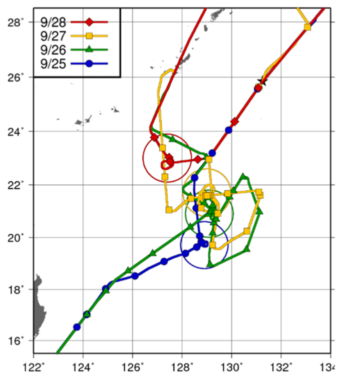
The multi-parameter phased array weather radar (MP-PAWR), with its state-of-the-art technology, can provide three-dimensional observation data within 30 s. Since the MP-PAWR can accurately capture rapidly changing convective precipitation systems, it is possible to analyze the formation mechanisms of convective storms. MP-PAWR can even be used to analyze the dynamic structure of stratiform precipitation systems, using data from various elevations.



Time series of a dynamic field of stratiform precipitation that did not produce surface precipitation.

Estimation of typhoon central pressure from dropsonde observations

Typhoon central pressure is operationally estimated from satellite observations. Consequently, its uncertainty is large for intense typhoons. The Tropical Cyclone-Pacific Asian Research Campaign for Improvement of Intensity Estimations/Forecasts performed aircraft observations of the intense typhoon Trami with the SATREPS Understanding Lightning and Thunderstorm project in 2018. During the period from September 25 to 28, 64 dropsondes were launched in and around the inner core region of the typhoon. The observed data were transmitted to the Japan Meteorological Agency in real time. There is a problem that the error of GPS height increases near the surface. We developed a new

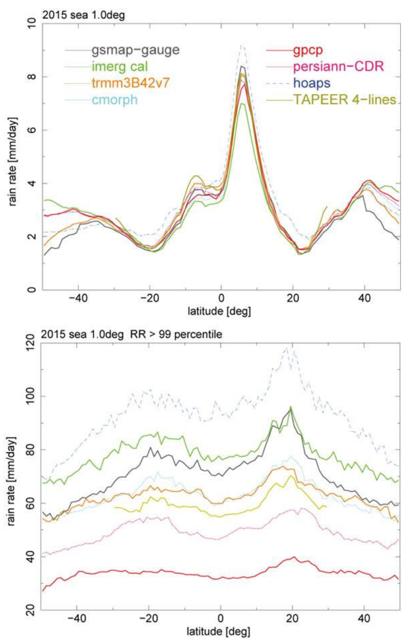


Aircraft flight passes and dropsonde launching points during the period from September 25 to 28.

method to estimate sea level pressure, with a correction for dropsonde height data. Penetration observation through the eye of Trami was achieved six times. Using the dropsonde penetration data, accurate estimations of sea level pressure were obtained. The central sea level pressure estimates were 919.6, 950.0, 956.0, and 960.0 hPa on 25, 26, 27, and 28 September, respectively. The maximum difference between the observed pressure and the Japan Meteorological Agency best track data was about 10 hPa.

Inter-product biases in global precipitation extremes

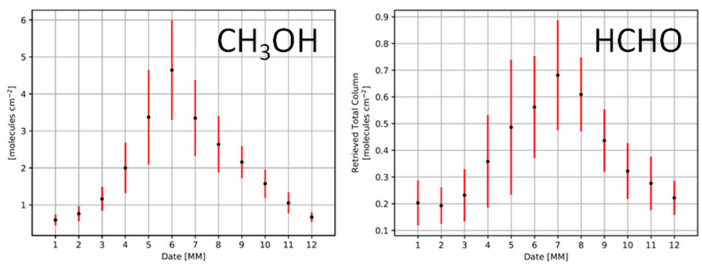
Given the importance of monitoring extreme precipitation for disaster prevention, we studied the reliability of global precipitation data products. Biases in climatological and extreme-precipitation estimates were assessed for 11 global observational datasets constructed from merged satellite measurements and/or rain gauge networks. Extreme precipitation was defined by a 99th percentile threshold (R99p) in a daily 1° × 1° grid, for 50 °S–50 °N. The spatial pattern of extreme precipitation lacks distinct features, such as the ITCZ that is evident in the global climatological map, and the climatology and extremes share little in terms of the spatial characteristics of inter-product biases. The time series, when analyzed from 2001 to 2013, showed relatively consistent decadal stability in the climatology over the ocean, while the dispersion was larger for the extremes over the ocean. This contrast is not observed over land. Overall, the results suggest that the inter-product biases apparent in the climatology are a poor predictor of the extreme-precipitation biases, even in a qualitative sense.



Inter-product comparison of zonal mean precipitation (2015 annual mean) over the ocean for climatology (top) and extremes (bottom).

Monitoring of greenhouse gases and atmospheric minor constituents using a high-resolution infrared spectrometer

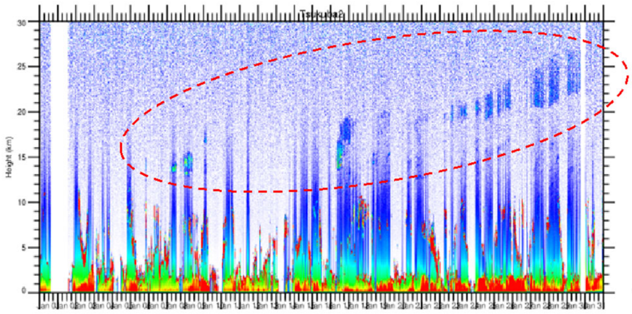
In collaboration with the National Institute for Environmental Studies (NIES), solar absorption spectra have been continuously measured using a ground-based high-resolution Fourier transform infrared spectroscopy instrument operated at Rikubetsu, and the total column amounts and vertical profiles of 14 molecular species, including O_3, CH_4, and CO, are retrieved from the spectrum. This year, in addition to HCHO (which was analyzed last year) we started to analyze CH_3OH, which is produced through the oxidation of biogenic volatile organic compounds. The observed column amount of CH_3OH reached its maximum in June, although that of HCHO was in July. The difference between the two maximum periods is mainly owing to the difference in the loss rate of oxidation by OH.



Seasonal variations of the total column amount of CH_3OH (left) and HCHO and (right) observed with FTIR at Rikubetsu.

Aerosol and UV/ozone observations in Patagonia, South America

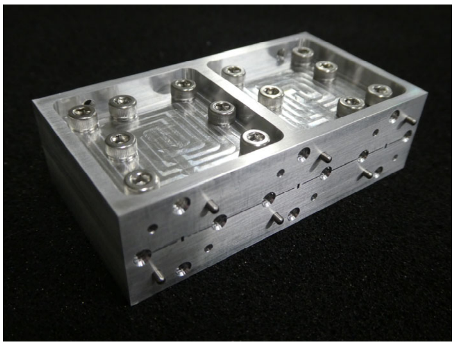
ISEE and the NIES have been operating an observation network, named SAVER-Net, monitoring aerosol and UV/ozone in Argentina and Chile with the support of KAKENHI and ISEE International Joint Research. Some lidar observations were suspended owing to age-related instrument changes and damage to a laser in 2018, but the optical system was changed to improve its stability in this fiscal year. At the end of the year, five of the nine lidars—Aeroparque, Cordoba, Neuquen, Comodoro, and Punta Arenas—were operating well. We will restart operation of the remaining four lidars next year. The millimeter-wave spectrometer for ozone measurement was almost suspended during the year because of serious damage to the water chiller of the cryogenic system for the superconducting receiver system. We must discuss essential improvements with the manufacturer to fix the problem. In terms of observational results, we detected the long-distance transport of an aerosol plume that may have originated from a large Australian forest fire in late 2019. The plume was detected in Punta Arenas and Buenos Aires and had reached stratospheric altitude.



Time series of attenuated backscattering coefficient at 532 nm in Buenos Aires in January 2020. Dashed circle indicates the aerosols thought to originate from the large forest fire in Australia.

Development of a new millimeter-wave spectrometer for multi-line observation in Syowa, Antarctica

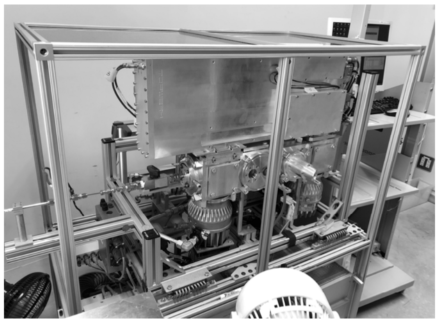
We developed the front-end and back-end for a wide-band receiver system in the millimeter wavelength range, and a new observation project “multi-line simultaneous observation of minor atmospheric molecules” in Syowa station, Antarctica, has been started. For the front-end, the waveguide-type multiplexer was developed through collaborative research with the National Institute of Communication and Technology. We measured its performance in cryogenic temperatures using a superconducting mixer in the laboratory, and a good image rejection ratio (>25 dB) was obtained. For the back-end, a multi-channel intermediate frequency circuit using a superconducting dual-band filter, which was designed and developed in Yamanashi University, was successfully developed for the observation of the O_3, NO, NO_2, HO_2, and CO molecular lines with the 2-GHz bandwidth digital Fourie spectrometer. This observation system was transported to Syowa station with the 61st Japanese Antarctic Research Expedition. We are constructing the new millimeter-wave spectrometer to start multi-line observations in 2020.



Newly developed waveguide-type multiplexer.

Analysis of the chemical structure and sources of atmospheric organic aerosol

Organic matter is one of the major components of atmospheric aerosols. Our current knowledge on the budget and properties of organic aerosols (OAs) is limited, although it is important for understanding the effects of aerosols on air quality and climate. In this study, extracts from atmospheric aerosol samples collected in an urban area were atomized, and the generated particles were transferred into an aerosol mass spectrometer to obtain their mass spectra. The spectra were analyzed by positive matrix factorization, and the factors associated with the sources and formation processes of OAs were obtained. Further, excitation-emission matrix (EEM) fluorescence spectroscopy was applied to forest aerosol samples, which are thought to be influenced by biogenic secondary organic aerosols (BSOAs). The contributions of different fluorescent components to the EEM spectra were obtained, and are expected to be useful for the analysis of OA sources. Moreover, rainwater and aerosol samples were collected in an urban area and the samples were subjected to EEM fluorescence spectroscopy and Fourier transform infrared spectroscopy. Through further analysis of these samples, we expect to find clues to understanding the formation and aging of OA components in cloud water. Atmospheric aerosol samples were also collected from a forest site in Australia, for the analysis of the chemical structures of BSOA and biomass-burning OA, and for the analysis of their contribution to the abundance of OA.



Aerosol mass spectrometer for the analysis of aerosol sample extracts.

Analysis of the surface tension of atmospheric aerosol components from the perspective of cloud droplet formation

Surface active materials in atmospheric aerosols are thought to promote the activation of aerosol particles to form cloud droplets, by lowering the surface tension of the particles. In this study, to investigate the possible effect of water-soluble inorganic salts on surface tension via the salting-out effect, surface tension measurements were performed for aqueous solutions containing water-soluble components from atmospheric aerosol samples collected in an urban area, in the presence of different concentrations of ammonium sulfate. We obtained preliminary results showing the relationships between surface tension and the concentrations of water-soluble organic carbon and ammonium sulfate, and are planning to analyze the effects of surface tension reduction at the time of cloud droplet formation, based on the results of the surface tension measurements.

Evaluation of the method for the long-term measurements of black carbon aerosols

In the Arctic, where the surface temperature is increasing more rapidly than the global average, the forcing and feedback mechanisms associated with light-absorbing aerosols, such as black carbon (BC), need to be elucidated. Long-term surface measurements of BC at various locations are important to understand the spatial and temporal variations of BC and to validate the numerical models that estimate BC climate impacts. However, the measurement uncertainty of the filter-based instrument (COSMOS) used for the long-term observation of BC mass concentration has not been fully evaluated. In this study, we analyzed the data obtained simultaneously by the COSMOS and a single-particle soot photometer (SP2, based on a laser-induced incandescence technique) at three locations, including a remote Arctic site (Ny-Ålesund in Spitsbergen). Thus, we evaluated the uncertainty of the COSMOS measurements. On average, the BC mass concentrations measured by the COSMOS and SP2 were consistent to within 10% at all the sites and the COSMOS measurements depended little on variations of BC microphysical properties, such as size distribution and mixing state. Our results demonstrate the high reliability of COSMOS measurements under various environments.

Division for Land–Ocean Ecosystem Research

- Global warming and changes in terrestrial water-material cycles in the Arctic circumpolar region
- Effects of climate change and anthropogenic forcing on the terrestrial ecosystem
- Cloud/rainfall variability in Asian monsoon regions
- Dynamics of phytoplankton in marginal seas and coastal areas
- Climate variability and changing open ocean ecosystem dynamics and biogeochemical cycle
- Interaction between oceanic waves and climate variations

The Land–Ocean Ecosystem Research Division investigates regional and global energy, water and material cycles, and physical/biogeochemical processes in the land–ocean ecosystem.

The land research group contributes to advancing our understanding of the mechanisms of how on-going global warming and anthropogenic activity influence the terrestrial water cycle and ecosystem. Using field observations, satellite remote sensing, global meteorological data analysis, laboratory analysis, and model simulation approaches, our group works to understand the impact of global warming on hydrological and greenhouse gas cycles in the Arctic region, the dynamics of the continental scale water cycle, the processes that drive weather and climate over Asia, the interplay between the terrestrial ecosystem and the climate, and the detection of early signs of influence of global warming in Antarctica.

Ocean research is conducting using satellite remote sensing, numerical simulations, and in situ observations. We also performing synthesis studies of physical and biogeochemical processes in the ocean and their interactions with the atmosphere and climate. In particular, we are investigating the manner in which oceanic heat content, circulation, and surface waves interact with atmospheric environments and how they are linked to climate and meteorological phenomena such as tropical cyclones. We are also investigating how variations in ocean circulation, mixing processes, and air–sea fluxes influence marine ecosystems where phytoplankton is a primary producer. Moreover, we are interesting the possible impact of the marine ecosystem on physical processes and climate in the ocean and atmosphere.

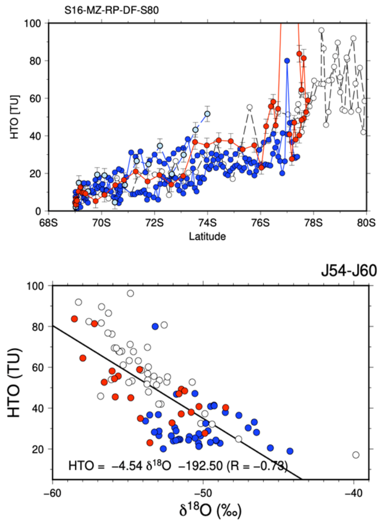
Main Activities in FY2019

Canopy-scale methane flux measurements in a larch forest in eastern Siberia

Focusing on a larch forest in eastern Siberia, canopy-scale methane fluxes measured using an eddy covariance method were compared with previously obtained methane fluxes measured using a chamber method. In previous warm seasons, the methane fluxes obtained using the chamber method showed negative values (i.e., methane absorption) in the forest floor. However, chamber methods cover a limited area, and do not represent canopy-scale fluxes. Thus, we applied an open-path eddy covariance methane flux measurement system to the larch forest. The canopy-scale methane flux results showed positive values (i.e., methane emission) in the warm season. This is because there are humid wetlands in the vicinity of the eddy covariance flux tower. In addition, there could be methane emitted from above-ground vegetation (i.e., trees including trunks, branches, and leaves). Recently, methane emissions from above-ground vegetation were also observed in tropical rain forests. We need to collect long-term methane flux measurements in several forests with different climates.

(Reference: Nakai, T., T. Hiyama, R. E. Petrov, A. Kotani, T. Ohta, and T. C. Maximov, 2020. Application of an open-path eddy covariance methane flux measurement system to a larch forest in eastern Siberia. *Agric. For. Meteorol.*, 282–283, 107860, doi:10.1016/j.agrformet.2019.107860.)

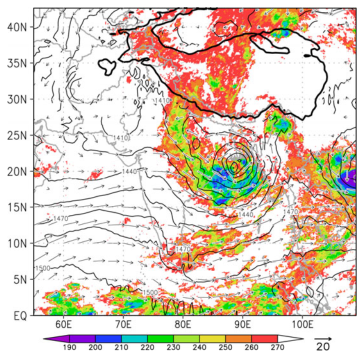
Understanding of the spatial distribution of oxygen isotopic composition in surface snow over East Antarctica



HTO distribution from coastal site to inland station (Top), The relationship between HTO and oxygen isotopic composition of snow over the Plateau in East Antarctica (Bottom).

We launched a new project entitled “Factors controlling isotopic variability of snow over East Antarctica.” This was selected as a challenging exploratory research direction for the current Japanese Antarctic Research Project (JARE) Phase IX. The purpose of this research is to understand the physical mechanisms of the experimental relationship between surface temperature and oxygen isotopic composition in the snow over Antarctica. This year, we completed the first assessment research using snow samples collected along the traverse route from near Syowa station to Dome Fuji station in East Antarctica by the 2018/2019 summer campaign of the 60th JARE. The total number of samples is 227. The stable water isotopes of the snow were measured by cavity ringdown spectroscopy (L2130-I, Picarro Inc.). We also measured HTO concentration using a liquid scintillation counter (Quantulus 1220, Perkin-Elmer Inc.). Both instruments are registered as joint-use resources of ISEE. The top Figure shows the spatial variation of HTO between the coastal site and the interior station. There is a clear increase of HTO and then a rapid increase occurs over the plateau region exceeding an altitude of 3500 m. This means that moisture transport from the surrounding ocean is not a dominant contributor over the Antarctic plateau. It is well known that clear-sky deposition of diamond dust is frequently observed at inland stations, such as Dome Fuji. Thus, we speculate that local moisture may largely contribute to inland snowfall. Interestingly, the spatial features of HTO correspond well to those of oxygen isotopic composition (see bottom Figure). This enables us to set the following hypothesis: the spatial distribution of oxygen isotopic composition may largely reflect the relative contribution of both local Antarctic moisture (High HTO and low oxygen isotopic content) and moisture transported from the surrounding ocean (Low HTO and heavy isotopic content). To verify this hypothesis, a quantitative explanation is necessary. Thus, we are developing a new water transport model incorporating HTO and stable water isotopes.

A study on monsoon depressions over South Asia

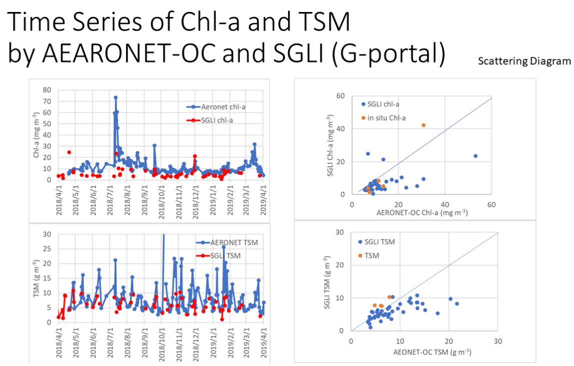


A monsoon repression that generated over the Bay of Bengal on 17 August 2016.

Synoptic-scale monsoon low-pressure systems contribute a large fraction of total summer monsoon rainfall, especially over land in South Asia. We investigated the three-dimensional structure of the mesoscale precipitation systems in the different stages of the life cycle of a monsoon depression, using observational data from multi-satellite sensors and a cloud-resolving regional model. The effects of latent heating from the precipitation system and the Bay of Bengal (BoB) on the development of the monsoon depression were also evaluated in sensitivity experiments using the model. In the rapid development phase, satellite observations revealed mesoscale convective systems with deep convective precipitation cells and stratiform precipitation near the head of the BoB. Extremely deep and intense convective cells appeared along a ring-like rain band when closed cyclonic circulation became obvious around the northernmost part of the BoB. Sensitivity experiments revealed that both cloud/precipitation processes and evaporation from the BoB are essential for the rapid development of monsoon depressions over the BoB.

(Reference: Fujinami et al., 2020, Mesoscale precipitation systems and their role in the rapid development of a monsoon depression over the Bay of Bengal. *Q. J. R. Meteorol. Soc.*, 146, 267– 283, doi:10.1002/qj.3672.)

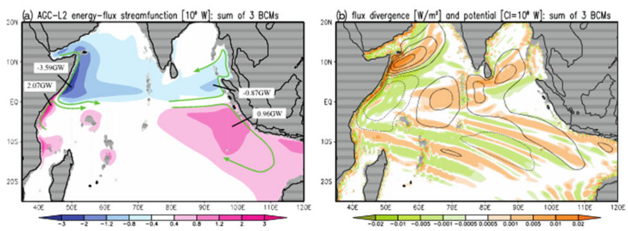
Variation of chlorophyll-a and total suspended matter in Ariake Bay and GCOM-C validation



Time series (left) of Chl-a (top-left) and TSM (bottom-left) from AERONET-OC and GCOM-C, and scatter diagrams (right).

Global Change Observation Mission–Climate (GCOM-C) was launched in December 2017, and the global observation of visible and infrared radiation, including ocean areas, with 250 m resolution and a two day interval was started. The new high frequency data with 250 m resolution is expected to be useful for coastal applications. To use the ocean color data, frequent sea-truth data is required, although it is difficult to obtain at sea. The aerosol robotic network–ocean color (AERONET-OC) is a network of spectral radiometers, which are modified from the radiometers developed for the observation of aerosols from land, to also observe sea surface radiance. For GCOM-C validation, ISEE set a JAXA-owned AERONET-OC on the Ariake Tower of Saga University from April 2018 (ISEE Newsletter 6). Chlorophyll-a (Chl-a), which is an indicator of phytoplankton biomass, and total suspended matter (TSM) were estimated from the AERONET-OC radiance data between April 2018 and March 2019 and compared with the GCOM-C data (Figure). Chl-a and TSM varied with the spring–neap tidal cycle, and were high at neap and spring tide, respectively. TSM is expected to increase with the resuspension of bottom sediments by the strong tidal current during spring tide and the reduced light limits phytoplankton growth. Chl-a also showed peaks in July and March after the high river discharge events. Similar variation was seen in the GCOM-C data. Both the Chl-a and TSM AERONET-OC data showed significant correlations with the relevant GCOM-C data, and the AERONET-OC data also showed consistency with water sampling data, while GCOM-C was underestimated. JAXA is currently improving the GCOM-C data to Version 2.

Energy circulation of ocean surface wave motion by the seasonal winds of the Indian Ocean



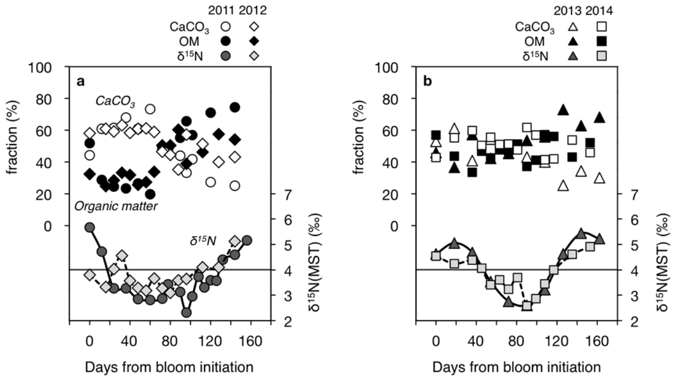
Circulation and budget of wave energy in the Indian Ocean revealed by the numerical experiments and analysis in this study. (a) Streamfunction and (b) divergence (shading) and potential (contours).

A significant task in climate and geophysical sciences is to clarify the role of synoptic-scale waves in the atmosphere and ocean by analyzing, for example, the global transfer routes of wave energy. This problem remained unsolved because conventional diagnostic schemes could not handle the tropics and mid-latitudes continuously. A recent theoretical work has developed a seamless diagnostic scheme for all latitudinal bands, which has the advantage of identifying the distribution of group velocity vectors, even in mixed gravitational and planetary wave situations. Li and Aiki (2020) have used this new scheme to perform the first analysis of the life cycle of seasonal waves in the upper layer of the Indian Ocean, and found that the eastward energy flux of Kelvin waves culminates when the equatorial zonal flow anomalies are maximized eastward and westward by the monsoon, and this occurs four times a year. Near the western boundary of the Indian Ocean, seasonal variations in the Somali jet and the East African coastal current led to equatorially oriented energy fluxes along the African continental coastline, forming a localized cyclonic circulation of wave energy in each hemisphere. These results are the foundation for a deeper understanding of tropical–extra-tropical interactions.

(Reference: Li, Z., and H. Aiki, 2020, The life cycle of annual waves in the Indian Ocean as identified by seamless diagnosis of the energy flux. *Geophysical Research Letters*, 47, e2019GL085670. doi:10.1029/2019GL085670)

Seasonal and interannual variations in nitrogen availability and particle export in the North Pacific subtropical gyre

Nutrient availability limits primary productivity in the low and mid-latitude oceans. This constrains the export of sinking biogenic particles, which removes carbon from the atmosphere, the so-called biological pump. We examined temporal variations in nitrogen availability and particle export in the northwestern North Pacific subtropical gyre (NPSG), using sediment trap time-series observations at 200 m depths between 2010 and 2014. We found that the nitrogen isotopic ratio ($\delta^{15}N$) of trapped particles varied according to the external input of "new" nitrogen. About 86–93% of the "new nitrogen" was nitrate supplied from subsurface waters. The reduced $\delta^{15}N$ of the high particle fluxes every winter indicated that nitrate was mainly supplied via convective mixing, triggering phytoplankton blooms. Interestingly, the magnitude of the convective nitrate supply varied from year to year, depending on winter monsoon intensity. This not only controls particle fluxes but also their composition. Stronger mixing in 2011–2012 than 2013–2014 enhanced $CaCO_3$ export, thus reducing the organic carbon to inorganic carbon export ratio, R(POC:PIC). Such interannual changes of winter R(POC:PIC) can affect air–sea CO_2 fluxes by modulating seawater CO_2 partial pressure in the northwestern NPSG.

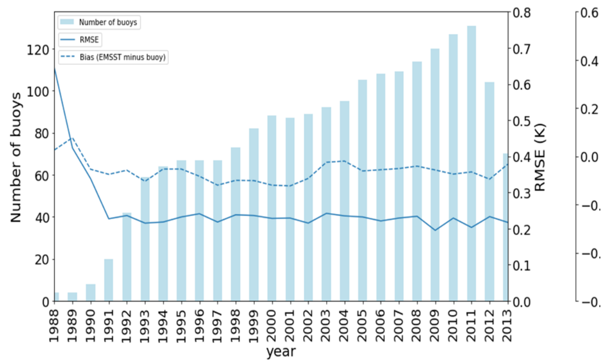


Influences of Changjiang river and upwelling water on phytoplankton community structure. Top: years with high anthropogenic nitrogen input from Changjiang river, Bottom: years with high influence of upwelling.

(Reference: Mino et al., 2020, Seasonal and interannual variations in nitrogen availability and particle export in the northwestern North Pacific subtropical gyre. *JGR-Oceans,* doi.org/10.1029/2019JC015600.)

Long-term consistency of a global satellite-derived air–sea flux dataset

Accurate estimation of global air–sea flux is indispensable to understanding the complex air–sea interactions in the climate system. We have released a new air–sea flux dataset, based on satellite observations over the past 25 years, through the use of multi-satellite observation data and the development of advanced estimation technology (J-OFURO3). Since such a long-term observational dataset is expected to be used for climate research, it is necessary to confirm the reliability of the data, as well as its long-term consistency. This study confirmed the long-term consistency of the dataset by establishing a verification system that comprehensively included in-situ observations in the global oceans. The Figure summarizes the verification results for sea surface temperature, which is the basis for estimating air–sea heat flux. Except for the first few years where the number of in-situ observations were extremely small, the root mean squared error and bias of the in-situ observations were very stable, approximately 0.2 K and -0.1 K, respectively. Similar comparisons were also conducted for surface winds (Koizumi et al., 2020). These results support the application of the dataset to climate research.



Verification results for J-OFURO3 daily mean sea surface temperature data. The bars show the number of observations from in situ buoys in the verification system, and the solid (dashed) line shows the yearly change in RMS error (bias), compared with the buoy data.

(Reference: Koizumi, A, M. Kubota, and H. Tomita, 2020, *Int. J. Remote Sens.* doi:10.1080/01431161.2019.1706113)

Division for Chronological Research

- Anthropogenic history and geochronology
- Accelerator mass spectrometry
- Electron probe microanalysis
- Paleoclimate reconstruction and future Earth
- Geosphere stability
- Isotope geoenvironmental chemistry
- CHIME dating
- Development of new analytical methods

Short- and long-term forecasts of global environmental changes and their countermeasures are issues of great urgency. Determining when an event occurred in the past, via "dating," is of importance understanding present and predicting future states of the Earth. We promote chronological studies on a broad range of subjects from events in Earth's history, spanning 4.6 billion years, to archaeological materials, cultural properties, and modern cultural assets. The Tandetron dating group conducts interdisciplinary research involving radiocarbon (^{14}C) dating using accelerator mass spectrometry to understand changes in the Earth's environment and the cultural history of humankind from about 50,000 years ago to the present day. In addition, the group studies near-future forecasts of Earth and Space environments, focusing on spatiotemporal variations in cosmogenic nuclides, such as ^{14}C and ^{10}Be, and conducts research that integrates art and science through collaboration between researchers in archeology, historical science, and other fields. The microscale spatial dating group uses the chemical U-Th total Pb isochron method (CHIME), which was firstly developed at Nagoya University, to shed light on events in Earth's history from its formation 4.6 billion years ago up to approximately 1 million years ago. An electron probe microanalyzer (EPMA) have been used to perform nondestructive microanalyses of rocks and other materials to reveal records of complex events recorded in zircon, monazite, and other samples.

Main Activities in FY2019

Reconstruction of paleoclimate in West Asia

Our goal is to reconstruct the paleoclimate of West Asia over a long period of time (from tens of thousands of years ago to several thousands of years ago), based on ^{14}C dating and isotopic analysis of stalagmites and travertines in Iran. This was in answer to a call for studies in the new academic field "The Essence of Urban Civilization: An Interdisciplinary Study of the Origin and Transformation of Ancient West Asian Cities," conducted in collaboration with the University of Kurdistan (Iran), the University of Tsukuba, and the University of Toyama. In recent years, past fluctuations in precipitation were reconstructed from chemical analyses of stalactites, showing that precipitation characteristics change notably with climate change. However, there are few studies on the reconstruction of the paleoclimate in West Asia (especially in Iran and Iraq), and how precipitation characteristics changed in this region owing to past climate change is not well understood. In the current fiscal year, we performed ^{14}C dating, elemental analysis, and isotopic analysis on travertine samples and spring waters in the Zendan-e Soleyman and Baba Gurgur, and examined whether travertine recorded paleoclimatic information. Furthermore, to identify fluctuations in the dust component that impacts elemental and isotopic fluctuations in travertine, we visited Iran in October 2019 to set up a high-volume air sampler at the University of Kurdistan, and began sampling atmospheric aerosols (PM10).

Sampling of travertines from Zendan-e Soleyman, Iran.

^{14}C dating and multi-Sr isotopic analysis of bioapatite from cremated bones

In archeological research targeting excavated bones, the organic components of the bones, the collagens, are generally used. Using isotopes of its main components, carbon, nitrogen, and oxygen, samples can be dated, and diet studied. However, the method cannot be used on cremated bones that have been through high temperatures at which the organic matter has decomposed. The use of inorganic chemicals as an index is necessary. In the present study, we have focused on bioapatite, which is the inorganic component of bones. It was the first systematic high-precision multi-Sr analysis – radiogenic Sr isotope analysis ($^{87}Sr/^{86}Sr$) and stable Sr isotope ratio ($^{88}Sr/^{86}Sr$, $\delta^{88}Sr$) – of cremated bones used in addition to ^{14}C analysis. The samples were cremated bones of Jokei (AD1155–1213) stored in an urn excavated from under the Gorin Tower in Jisho-in, Nara Prefecture, and cremated bones (600–900 BP) excavated from the Binman-ji burial site in Shiga Prefecture. First, we showed that the amount of Ba in the cremated bones was a good index for the quantitative analysis of secondary alterations that the bones went through during burial in the soil. Then, we selected bone fragments with low amounts of Ba and limited secondary alterations for high- precision ^{14}C dating (Minami et al., 2019; Radiocarbon). We also performed multi-Sr isotopic analysis and showed that the Jokei was likely a vegetarian, while ancient people buried at Binman-ji had a meat-heavy diet: their trophic levels differed. This result is a breakthrough as it shows that the stable Sr isotope ratio of bioapatite in cremated bones is a new and useful indicator of dietary analysis.

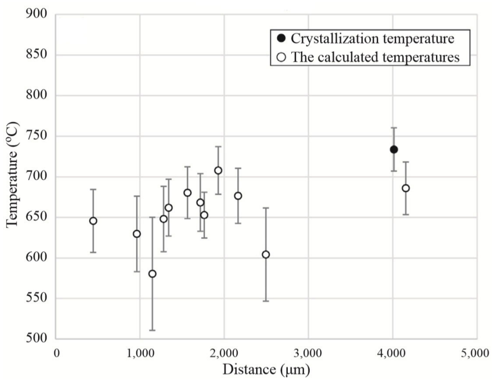
Binman-ji burial site in Shiga Prefecture.

Development of EPMA quantitative analysis of trace titanium (Ti) in quartz and application to estimate the cooling process of granitic magma

Quartz, silicon dioxide, may contain various trace elements. The Ti concentration of quartz reflects its crystallization temperature and the activity of Ti in the system; quartz crystallized at a higher temperature has a higher titanium concentration.

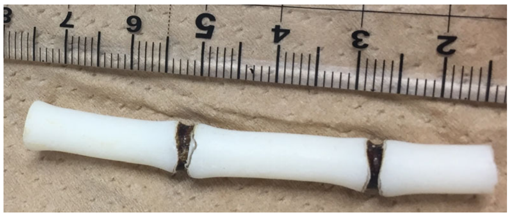
If the titanium concentration in a microvolume of a quartz grain is measured, the details of crystal growth and temperature change can be estimated, leading to elucidation of the formation process of the rock that contained the grain. A problem with this method is that, as Ti concentration becomes more sensitive at lower temperatures, for quartz not crystallized under super high temperatures, accuracy in addition to precision is required. Thus, we developed a method to measure the titanium concentration in an area to the order of microns, using accurate and non-destructive EPMA.

Since a method has already been developed to measure titanium at 10 μg/g or less in zircon, with a relative error of 10% or less (2σ) (Yuguchi et al., 2016), we applied this method to the quartz. However, as quartz is easily damaged by electron bombardment, we determined a new beam diameter and X-ray counting method suitable for quartz. We then applied this method to Toki Granite in Gifu Prefecture and estimated the crystallization temperature of the quartz. We revealed that the quartz crystals were formed in the range from 600°C to 750°C. The zonal structure observed by cathodoluminescence imaging reflected the temperature and diffusion of titanium in granitic magma. As such, it was shown that quartz that displays oscillatory zoning in cathodoluminescence imaging formed under a conditions of slow cooling.



Distance from the quartz grain boundary and estimated crystallization temperature (Yuguchi et al., 2020).

Elucidating the growth process of axial internode skeletons in deep-sea isidid octocorals

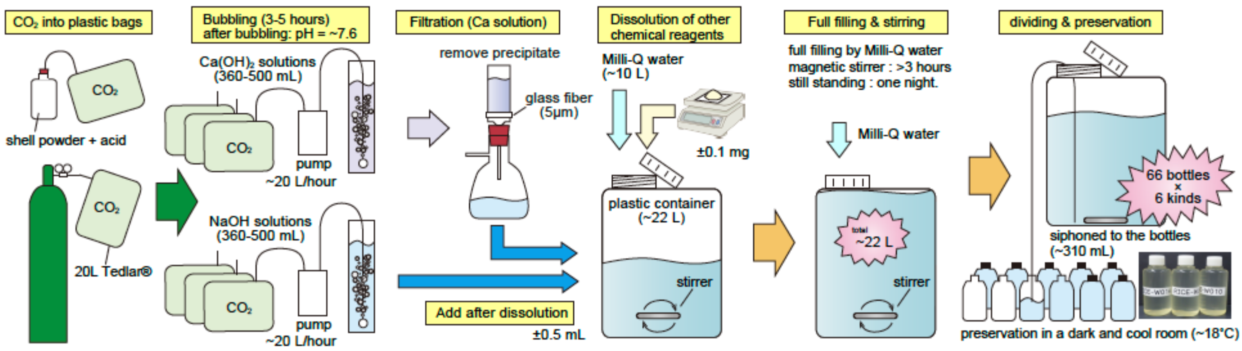


Isidid octocorals used for analysis.

The calcareous skeletons of deep-sea corals are being used as an archive of paleooceanic information; however, as growth processes differ depending on classification, it is necessary to understand the growth processes and growth rates for palaeoceanographic research. The isidid octocorals consist of elongated calcitic skeletons with hollow structures in the center. The skeletons of corals have annual rings, and their central axis is a thin opening. It was assumed that the center was old, and the outer part was young, but a previous study of ^{14}C dating reported that the age was younger in the center in multiple samples. It is unknown if the cause of this rejuvenation is growth from the center or a change in the age of the body of water in contact with the specimen. If there are two formation processes for the skeleton, the crystal orientation is likely different. Thus, in the present study, we performed a crystal orientation analysis of a thin section of isidid axis using electron backscatter diffraction. The crystal orientation analysis of the isidid bone axis showed that the whole specimen was structured with uniform regularity. This result supports the idea that skeleton formation only occurs at the surface of the bone axis. If there was no reversal of growth direction, ^{14}C dating of isidid skeletons can be used as a proxy for the age of water masses.

Preparation of water sample for the ^{14}C inter-comparison program

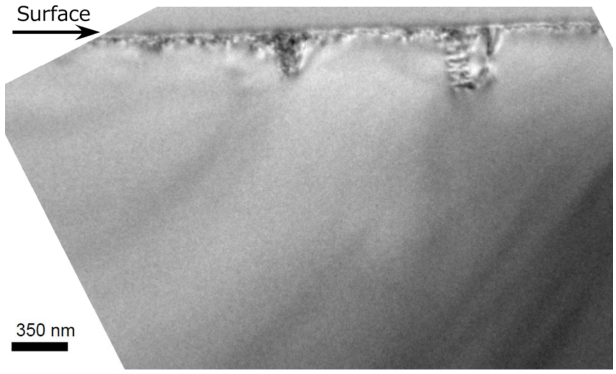
Since 2013, our research group, jointly with National Institute of Advanced Industrial Science and Technology, is conducting a basic verification to prepare for the full-scale operation of the ^{14}C analysis inter-comparison program for dissolved inorganic carbon in water samples (RICE-W: Radiocarbon Inter-comparison on Chemical Experiments, Water series). The important part of the inter-comparison verification is that water samples with the same ^{14}C concentration are distributed to each facility and that the ^{14}C concentration does not change from the time of distribution to the time of analysis. In this study, we verified what the containers and water samples meet these conditions well. We examined three types of containers made of glass, PAN resin, and PP resin. It was concluded that the PAN resin container was ideal because it showed superior gas barrier performance, and the handling such containers is convenient. In case of a natural sample, the effect of biological activity cannot be ignored. Thus, the addition of toxins such as $HgCl_2$ is necessary (Takahashi et al., 2018, NIMB). We abandoned the preparation of inter-comparison samples based on natural samples, and instead prepared inter-comparison samples that were completely and artificially controlled. We mixed some reagents to prepare a set of inter-comparison samples (RICE-W09-W14) with a chemical composition that mimics natural samples. The ^{14}C concentrations of RICE-W09-W14 covers the range from background to modern. We posted RICE-W09-W14 to some ^{14}C research facilities for ^{14}C comparison.



Preparation procedure for ^{14}C inter-comparison water sample (RICE-W09−W14).

Evaluation of surface damage by diamond polishing treatment

In the correction calculation generally used in EPMA quantitative analysis, it is assumed that electrons enter the surface of a homogeneous sample that has been mirror polished orthogonally. For mirror polishing, 0.25–0.5 μm diamond or alumina is generally used. Usually, this method does not cause any issues in quantitative analysis. However, this polishing method is assumed to damage a fraction or half of a grain diameter on the sample surface. Thus, when the analytical area is shallow, it is possible that the analysis is performed on the damaged area instead of the actual sample. To assess the surface damage, we observed the surface of an olivine sample that had been polished with 0.25 μm diamond with a transmission electron microscope. We observed dislocation that was likely caused by polishing in the area dozens of mm from the surface. In some areas, there were dislocations of several hundred nm to 1 μm. Therefore, when using particle polishing, surface analysis must be performed, considering the possibility that the damage can extend beyond the grain diameter in some areas.



Transmission electron microscope image of olivine (bright field image).

The 8th East Asia Accelerator Mass Spectrometry Symposium

The 8th East Asia Accelerator Mass Spectrometry Symposium was held in Sakata and Hirata Hall, Nagoya University from December 3 to December 6, 2019. EA-AMS is held every other year in Japan, South Korea, China, or Taiwan to present and discuss the development of measurement methods in the accelerator mass spectrometry of radiocarbon (^{14}C), iodine-129 (^{129}I), chlorine-36 (^{36}Cl), and so on, and their applications to environmental and Earth sciences. The 8th symposium was held jointly by the ISEE Division for Chronological Research and the JAEA Tono Geoscience Center. This symposium was attended by 115 accelerator mass spectrometry researchers from across the world, including East Asia (51 from Japan, 33 from China, eight from South Korea, and seven from Taiwan), Australia (four), the USA (three), Switzerland (three), and Poland (two). It started with an ice-breaker event on the evening of December 2nd, followed on the 3rd and 4th by presentations on technological developments, application research, and the current situations of facilities for accelerator mass spectrometry (40 oral presentations and 42 posters) along with discussions. On the 5th, there was a field trip to view an accelerator mass spectrometer, and on the final day (6th), there were oral presentations and a discussion on accelerator mass spectrometer research and future outlooks. There was meaningful information exchange and networking among accelerator mass spectrometry researchers.

Center for International Collaborative Research (CICR)

- Internationally coordinated programs
- Ground-based observation networks and satellite projects
- Hosting international workshops
- International exchange of foreign and Japanese researchers and students
- Capacity building in developing countries through training courses and schools
- Observatories

The Center for International Collaborative Research (CICR) was established in October 2015 under ISEE to promote international collaborative studies that attempt to understand the physical mechanisms of the phenomena occurring in the space–Sun–Earth environmental system and their interactions with each other. The CICR provides leadership to encourage and promote internationally coordinated programs, such as those carried out by the Scientific Committee On Solar–Terrestrial Physics (SCOSTEP) and Future Earth, ground-based observation networks, international satellite projects, the hosting of international workshops and conferences, the international exchange of foreign and Japanese researchers and students, and capacity building in developing countries through training courses and schools. The CICR has taken over from the Geospace Research Center of the former Solar–Terrestrial Environment Laboratory of Nagoya University.

Solar activity has various times scales, including solar flares, coronal hole, the 11-year cycle, and long-term variation. Recent solar activity has been the lowest in the past 100 years. World scientists have a strong interest in these solar activities and their consequences for Earth's geospace environment and climate change. SCOSTEP, under the International Science Council, commenced a 5-year international program entitled "Predictability of the variable Solar–Terrestrial Coupling (PRESTO)" for 2020–2024. The SCOSTEP president is a member of the CICR and responsible for operating this international program. The CICR publishes a SCOSTEP/PRESTO newsletter every three months, and coordinates international symposiums related to SCOSTEP/PRESTO. The CICR also contributes to other international programs related to the space–Sun–Earth environment, such as Future Earth and the Integrated Land Ecosystem-atmosphere Processes Study (iLEAPS). In addition to these international programs, the CICR also participates in/operates ground-based observation projects, i.e., the EISCAT radar project, OMTIs, ISEE magnetometer network, SuperDARN radar network including the Hokkaido HF radars, ISEE VLF/ELF network, and ArCS operation office.

CICR has been operating the international collaborative research programs since 2016. It also holds four domestic observatories at Moshiri, Rikubetsu, Fuji, and Kagoshima, which conduct observations of the solar wind, geomagnetic field, and upper atmosphere. Some of these observations have been conducted for more than 30 years.

Observation sites and foreign collaborative institutions of ISEE.

Main Activities in FY2019

In FY2019, CICR conducted the following international collaborative research programs: 1) the Joint Research Program (International, 28 projects); 2) the ISEE International Joint Research Program that invited 16 foreign researchers; and 3) two ISEE/CICR International Workshops, inviting seven foreign designated professors and associate professors. Two designated professors were hired through a 5-year cross-appointment with US universities and institutions. The ISEE/CICR International Workshop aimed to facilitate comprehensive discussions on a focused topic with 10–15 attendees over one week and summarize the results into international journal papers and/or books.


SCOSTEP

SCOSTEP/PRESTO NEWSLETTER

Vol. 21, December 2019

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Article 1:

SCOSTEP Executives and Bureau Members

Kazuo Shiokawa
Center for International Collaborative Research (CICR), Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Nagoya, Japan

Kazuo Shiokawa

The elections for the new SCOSTEP Executives took place during the IUGG assembly in Montreal, Canada on July 13, 2019. Dr. Kazuo Shiokawa, of Nagoya University in Japan, was elected President. Professor Daniel March, of the National Center for Atmospheric Research (USA) and the University of Leeds (UK) was elected Vice President. Dr. Nat Gopalswamy, who served SCOSTEP as President since 2011, will continue to serve as Past-President. Patricia Doherty, of Boston College, was appointed as the Scientific Secretary on July 1, 2019.

The SCOSTEP Bureau is comprised of the Executives together with representatives of participating organizations. The representatives are appointed by the Secretary General of their organizations. For the quadrennial beginning in July 2019, the bureau members include:

Kazuo Shiokawa (President), Daniel Marsh (Vice President), Nat Gopalswamy (Past President), Patricia Doherty (Scientific Secretary, ex-officio), Yoshizumi Miyoshi (COSPAR), Renata Lukianova (IAGA/IUGG), Peter Pilewskie (IAMAS), Kyung-Suk Cho (IAU), and Prasad Subramanian (IUPAP), Annika Seppälä (SCAR), Jorge Chau (URSI), Aude Chambodut (WDS).

President Kazuo Shiokawa, Vice-President Daniel Marsh, Past President Nat Gopalswamy, Scientific Secretary Patricia Doherty, COSPAR Yoshizumi Miyoshi, IAGA Renata Lukianova, IAMAS Peter Pilewski, IAU Kyung-Suk Cho, IUPAP Prasad Subramanian, SCAR Annika Seppälä, URSI Jorge L. Chau, ISC-WDS Aude Chambodut

Figure 1. The 2019-2022 SCOSTEP Bureau.

SCOSTEP/PRESTO Newsletter vol. 21 (December 2019).

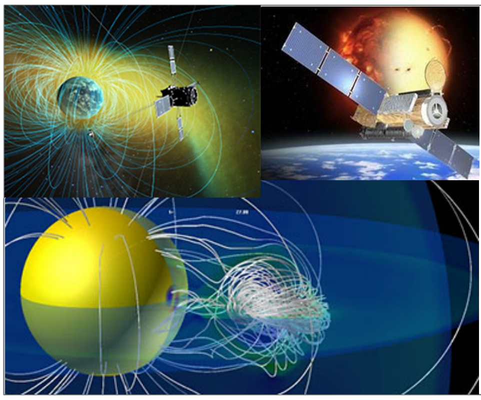
Sixteen CICR colloquiums were held with senior foreign scientists from eight countries, including the US, the UK, Germany, and Australia. For the SCOSTEP VarSITI (2014–2018) and PRESTO (2020–2024) programs, we published three newsletters in FY2019, in May, December, and January. We also organized the VarSITI Summarizing Workshop in Nagoya, Japan, in November 2019 to summarize the 5-year VarSITI activities. Three young scientists from India, Argentina, and Peru were invited to ISEE for collaborative research under the SCOSTEP Visiting Scholar program.

The Nobeyama radioheliograph was shut down at the end of March 2019. Under the ICCON Project, 34 scientists from the US, the UK, China, Korea, Russia, Germany, Switzerland, Belgium, and Japan joined its operation for five years. All the data are openly available at NAOJ and CIDAS/ISEE. The EISCAT radar project was carried out in collaboration with an NIPR group; nine EISCAT special experiments proposed by Japanese colleagues were conducted. Discussions about the EISCAT_3D radar have been conducted with foreign EISCAT associate members. The PWING projects continued running eight stations around the north pole at MLATs of ~60°, with links to the OMTIs, ISEE magnetometer, and ELF/VLF network projects. A research project entitled "Pan-Arctic Water-Carbon Cycles (PAWCs)" was newly funded for 2019–2024. PAWCs is designed to integrate atmospheric–terrestrial water and carbon cycles in northern Eurasia, for which very limited data on the fluxes of greenhouse gases exists.

The four domestic observatories continued to operate in FY2019. Moshiri Observatory became an unmanned observatory in FY2018, but continued running electromagnetic instruments, i.e., an auroral photometer, magnetometers, and VLF receivers. Rikubetsu Observatory operates several spectrometers for comprehensive measurements of ozone and other minor constituents in the atmosphere, all-sky imagers and photometers for aurora and airglow monitoring, and SuperDARN Hokkaido radars for ionospheric disturbances, as well as a new ELF atmospheric receiver. A new induction magnetometer was also installed at Rikubetsu in October 2018. Multi-station IPS observations using the Fuji, Kiso, and Toyokawa antennas were conducted in FY2019. The IPS antenna at Fuji were seriously damaged by snow in winter, and restored in April before the multi-station IPS observations started. The Kiso Observatory was opened to the public on August 3–4, 2019. Kagoshima Observatory and Sata Station operate instruments for electromagnetic wave detection, an all-sky camera, and a photometer for airglow detection. A new VLF/ELF wave receiver was installed at Kagoshima Observatory by Georgia Tech., USA, in November 2019 to observe electromagnetic waves from lightning.

A VLF/ELF wave receiver installed at Kagoshima Observatory by Georgia Tech., USA, to observe electromagnetic waves from lightning.

Center for Integrated Data Science (CIDAS)



- Hinode Science Center
- ERG Science Center
- Research and development of advanced simulations (SUSANOO, CReSS, Monte Carlo simulations for high-precision age calculations, etc.)
- Construction of various databases (IUGONET, WDS-CR, etc.)
- Operation of CIDAS supercomputer system
- Membership activity of HPCI consortium

The Center for Integrated Data Science (CIDAS) aimed to construct infrastructure and conduct research and development to realize a cutting-edge scientific study of the space–Earth environmental system through integrated analyses using various observational data and advanced computer simulations. CIDAS operates many projects in cooperation with the research divisions and centers of ISEE, as well as other universities and institutes.

Science centers for space missions: Hinode and ERG

The Hinode Science Center is operated as a joint project with NAOJ and developed the database and analytical environment for the data provided by the Japanese solar observation satellite Hinode. At the same time, it plays an important role in considering research topics of oncoming solar missions such as Solar-C EUVST. In addition, ERG Science Center operates as a joint research center in cooperation with the Institute of Space and Astronautical Science/Japan Aerospace Exploration Agency (ISAS/JAXA), which releases the data files from ERG (Arase) and ground-based observations. The ERG Science Center also develops the data analysis software. The CIDAS computer system has been used for the data analysis environment for Hinode and ERG projects.

Cooperative research program for database construction and supercomputing

CIDAS produces various databases for space–Earth environmental research and provides supercomputing facilities in collaboration with the Information Technology Center (ITC) of Nagoya University and other universities and institutes. CIDAS has also joined the inter-university network project (Inter-university Upper atmosphere Global Observation NETwork: IUGONET) with Tohoku University, NIPR, Kyoto University, Kyushu University, and Nagoya University to develop a metadata server and data analysis software. CIDAS is in charge of activities in ISEE as a member of the High-Performance Computing Infrastructure Consortium (HPCI) in Japan.

Research and development of advanced simulations

CIDAS plays a leading role in research and development of the following advanced computer simulation models: Space Weather Forecast Usable System Anchored by Numerical Operations and Observations (SUSANOO), the Cloud Resolving Storm Simulator (CReSS), and Monte Carlo simulations for accurate Th-U-Pb dating. The CReSS model is designed for all types of parallel computers to simulate a detailed structure of clouds and storms. CReSS is free to use for scientific community. It has been used for meteorological research and real-time weather forecast experiments, for example, simulation experiments of tropical cyclones, heavy rainfall events, snow clouds, tornados, and downscaling experiments of future tropical cyclones.

Main Activities in FY2019

Development of a data analysis system for the ERG (Arase) project

Scientific data from the ERG (Arase) satellite, ground-network observations, and modeling/simulations are archived at the ERG Science Center, which is operated by ISAS/JAXA and ISEE/Nagoya University. The format of these data files is CDF, and includes the metadata of each file. This is a de facto format in the solar–terrestrial physics community. The Space Physics Environment Data Analysis System (SPEDAS), a commonly used software in the solar–terrestrial physics community, can easily read and manipulate CDF files. The ERG Science Center has developed CDF files and SPEDAS plug-in software for the ERG project. We also join the International Heliosphere Data Environment Alliance (IHDEA) to discuss the common data formats in the international framework. The ERG Science Center has organized the training sessions for SPEDAS in Japan and Taiwan, providing important opportunities to learn to use SPEDAS and the ERG data. The ERG Science Center is also developing a data analysis environment in the CIDAS system. Users can access the CIDAS system via the Internet and analyze the ERG project data using SPEDAS.

Coronal mass ejection arrival time forecasting system using IPS observations

MEs cause disturbances in the environment around the Earth. CIDAS has installed a dedicated computing system for CME forecasting and developed a CME forecasting system under a collaborative study with the ISEE Division for Heliospheric Research and NICT. In this system, CME propagation is calculated using a global MHD simulation, SUSANOO-CME. The IPS response is estimated by the 3-dimensional density distribution of the inner heliosphere derived from the MHD simulation. The simulated IPS response is then compared with actual IPS observations performed by the Division for Heliospheric Research, providing a forecast with better accuracy than before. This system will be included in the real-time forecasting system of NICT.

Activity of Inter-university Global Upper atmosphere Observation NETwork (IUGONET)

We have promoted the use and application of upper atmospheric observation data, through database and analysis software in collaboration with other institutions (e.g., the Research Organization of Information and Systems (ROIS)), and developed the foundation for a universal infrastructure for disclosing and citing data promptly. We also abstracted a database design and have now provided these developments to each institute and committee to promote data activity. We have held several international data analysis workshops in collaboration with several international programs, including VarSITI/PRESTO and World Data System (WDS) affiliated with the International Science Council (ISC), and supported the construction of infrastructure for disclosing data and data integrity to them.

Operation of the CIDAS supercomputer system

The CIDAS supercomputer system for integrated data analysis is under operation since FY2016. The system consists of 20 computer nodes, with each node having two Intel Xeon E5-2660 v3 CPUs and 256 GB memory. In FY2019, 170 researchers/students were registered as users of the CIDAS supercomputer system and data analyses related to the Hinode Science Center and ERG/Arase Science Center, as well as computer simulation studies, were conducted.

Development of the CReSS model

The CReSS model has been developed and improved for physical processes. It is available for scientific research from CIDAS. The CReSS model is used for simulation experiments and daily weather forecasts. The simulated daily forecast data are openly available from the website of the meteorological laboratory. CIDAS also plans to make the simulation output data from the CReSS model available.

Center for Orbital and Suborbital Observations (COSO)

- Establishment of an aircraft observing system
- Aircraft observations of cloud, aerosol and typhoon
- Development of validation equipment for Earth observing satellites
- Promotion of Exploration of energization and Radiation in Geospace (ERG) mission
- Solar observation missions using micro satellites
- Study for simultaneous development of multiple satellites for future space science

Based on ISEE research subjects, which encompass natural phenomena ranging from the Earth's surface to outer space, COSO is expected to perform empirical and advanced research through observation, especially through collaborations among industry, academia, and government, leading to remarkable technological developments for aircraft, balloons, sounding rockets, and spacecraft observations. COSO plays a key role in, and promotes, aircraft observations in Japan. We also investigate and promote future space exploration missions in collaboration with institutions in Japan and overseas to gain new insights into physical phenomena. We assist in advancing observation capabilities for future orbital and suborbital observations by developing an efficient common technological and development environment via interdisciplinary activities. The Hydrospheric Atmospheric Research Laboratory contributes to COSO's activities by using X-and Ka-band radars, together with numerical model studies under VL activities. The Space Exploration and Research Office (SERO) was newly established in 2018.

Main Activities in FY2019

Promotion of aircraft observations

Aircraft observations of water vapor on the upstream side of heavy rainfall was implemented, in collaboration with DOTSTAR in Taiwan. In addition, ground-based observation equipment such as radar was installed on Yonagunijima island to carry out joint observations with the US, Taiwan, and Korea, targeting typhoons in 2021.

Ka-band radar installed on Yonagunijima.

In the United Arab Emirates Precipitation Intensification Science Program "Advanced Research on Precipitation Intensification in Arid and Semi-arid Regions," the investigation of the effects of cloud-aerosol processes on cumulus development and precipitation efficiency using a numerical cloud-resolution model has continued. The Ministry of Land, Infrastructure, Transport, and Tourism's Transport Technology Development Promotion System research project, "Basic study on understanding high ice water content clouds causing jet engine power loss and air data probe failures and development of their detection and prediction methods," has started. We are also preparing for ice cloud observations conducted jointly with the US, which are scheduled in 2021.

The proposal "Promotion of Climate and Earth System Science Research by Aircraft Observation," jointly proposed by the Meteorological Society of Japan, the Japan Society of Atmospheric Chemistry, and the Japan Aeronautics and Astronautics Society for the Master Plan 2020 of the Science Council of Japan, was selected as a high priority project. In this proposal, COSO is the core base for the aircraft observations.

Promotion of international collaboration in satellite missions for terrestrial upper atmospheric exploration

Regarding future space exploration missions, we investigated integrated observational methodologies for space plasmas, upper atmospheric particles, plasma waves, electric/magnetic fields, and auroral emissions in the terrestrial magnetosphere/ionosphere/thermosphere, collaborating mostly with Swedish research institutes. Centering around specialty Swedish scientific instruments, we discussed concrete measurement techniques, based on collaborative research and development on the Japanese side, through on-site science meetings and remote discussions via email.

Solar observation mission using nano-satellites

We are developing a solar neutron and gamma-ray detector, weighing less than 10 kg, intended for nano-satellites weighing less than 10 kg. The nano-satellitesare chosen because they have more launch opportunities than 50-kg satellites like ChubuSat. We plan to launch an engineering prototype in 2021 and a satellite with scientific instruments in 2022 or later, in time for the next solar maximum. In FY2019, we designed components specifically required for the scientific satellite. We also developed a signal processing board for low-power integrated circuits.

Space Exploration and Research Office

The Space Exploration and Research Office (SERO) has been established as the first step toward forming a research center to consolidate all space-related activities at the university, and to promote hardware development and observational research for space exploration and science. The development of nano-satellites is one of SERO's most crucial activities. Educational activities are also important to SERO. We held two-week basic training courses for space applications in August and February. We also held a two-week advanced training course in March. All the courses drew close to 30 applicants. About 40% of the applicants were from outside Nagoya University.

Investigation on the simultaneous development of multiple satellites for future space exploration missions

2-week training course for space applications.

Cooperating with a domestic manufacturer with substantial achievements in spaceborne component development for previous space missions, we have been designing a standard bus system for the compact (150–200 kg) satellite missions applicable to future demonstrative space exploration. We have also been investigating the technical issues required for the simultaneous development, cluster launch, and operation of multiple satellites to realize multi-point observations. We discussed electric/mechanical interfaces, simultaneous ground-based test configuration/subjects, mechanical structures and electronics for launch and separation, and satellite–satellite communication operations, including time synchronization methods.

Promotion of observations using Earth-observing satellites

Regarding the future concept of an Earth-observation satellite, studies on the future spaceborne precipitation radar were implemented. A new radar called DPR2, which is an upgraded version of the dual frequency precipitation radar onboard the GPM core observatory, was proposed in the grand design of the Earth-observation satellite program, as a key sensor for the cloud-precipitation observation mission. In cooperation with JAXA, we participated in discussions on the NASA cloud-precipitation observation mission.

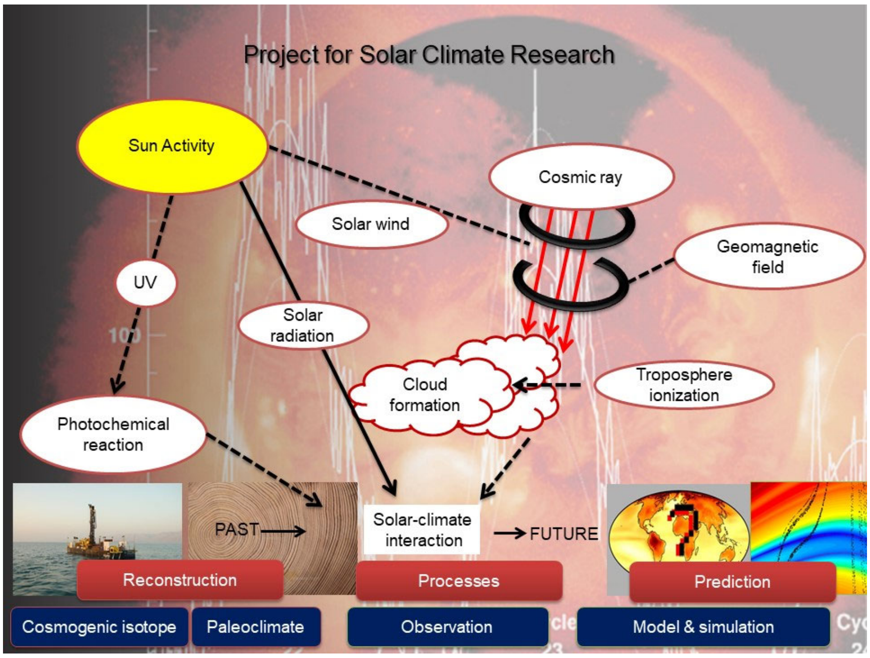
Using J-OFURO3, the third-generation dataset of heat–momentum–freshwater flux between the atmosphere and the ocean, which is important for accurately understanding the energy balance and climate change of the Earth system, long-term (30 years) global heat flux fluctuations were analyzed. Furthermore, a new algorithm applicable to severe weather conditions, such as typhoons, was developed.

Project for Solar–Terrestrial Climate Research

Do variations in solar activity influence our weather and climate? Researchers specializing in fields such as astronomy, solar physics, meteorology, climatology, paleoclimatology, and oceanography have grappled with this question for the past two hundred years or more. Two thousand years ago, astronomers of the Chinese imperial court chronicled sunspot activity for exploring variations in solar activity. In 1801 the British astronomer William Herschel discovered a significant correlation between the number of sunspots and the market value of wheat in London and reported his findings in a paper published by the Royal Society. He concluded that a reduction in the number of sunspots affected a change in climate that altered wheat yields, and as a result, influenced the price of wheat. This study is considered as the first attempt to examine correlations among the Sun, climate, and society (human life). Even now, correctly identifying the characteristic variations of solar activity and investigating their effects on climate change and modern society remain important research topics in academics and society.

There is much evidence indicating that at least the Atlantic Ocean and surrounding areas, including Europe and North America, experienced significantly colder temperatures during the Maunder Minimum (a 70-year period from 1645 to 1715) in which very few sunspots were observed and solar activity appeared nearly stagnant. Historical records show that New York Harbor froze in the winter of 1780, enabling people to walk from Manhattan to Staten Island, and that sea ice surrounding Iceland extended for miles, closing the harbors and dealing a blow to the fishing industry and trade over a long period of time. While it is premature to conclude that the quieting of solar activity leads to a period of cooling, many researchers believe that variations in solar activity influence medium-to-long-term climate changes. However, to obtain conclusive evidence, it is necessary to reconstruct climate changes quantitatively and to continue accumulating data on annual variations in solar activity.

Very few sunspots were observed from March 7 to March 20, 2017. The cycle length of solar magnetic activity corresponding to the sunspot cycle was estimated at about 14 years during the Maunder Minimum. The sunspot cycle in Solar Cycle 24, which began in 2008, has grown to about 13 years, similar to that in the Maunder Minimum. This indicates that we are entering a period of low solar activity, where a cooling on a global scale can occur in the near future. To offer a qualified opinion on the likelihood of this prediction, we must examine diverse viewpoints on how solar activity affects climate.



A scheme of the ISEE project for Solar–Terrestrial Climate Research. The latest developments in solar physics, meteorology & climatology, environmental studies, paleoclimatology, geomagnetism, and cosmic-ray physics are integrated.

The globally averaged surface temperature showed a clear upward trend after the latter half of the 20th century. However, it continued to increase in the temperature range of 0.03–0.05°C per ten years from 1998 to 2012, and the global warming pause or the global warming slowdown is called the “global warming hiatus.” Nonetheless the atmospheric greenhouse gas concentration increases yearly, but a clear rise is not recognized in the observation of surface temperature. The topic “global warming hiatus” was taken up on the Internet news and blogs, went over the scientific community, and then had a huge impact on the general public. Based on a detailed analysis of the meteorological dataset from the land and ocean temperatures (e.g., HadCRUT3) and computer experiments with climate models such as MIRCO, it was indicated that the global warming hiatus was caused by natural characteristics. Although we still cannot provide sufficient explanation, it is evidenced that the decadal-centurial-time scale climate change is indirectly driven by secular variation in solar activity. Encouraging the understanding of the characteristics and mechanisms of short-term natural fluctuations that appear in the age of global warming will make the prediction of anthropogenic climate change more reliable. It is extremely important to draw up an environmental policy that stands on the influence on human society.

Radiocarbon (^{14}C) and Beryllium-10 (^{10}Be), known as cosmogenic isotopes, are produced at a rate that varies according to the intensity of the incoming cosmic rays to Earth, which in turn are influenced by solar activity. Analyzing ^{14}C in tree rings and ^{10}Be in ice cores is an effective way to study long-term variations in solar activity going back tens of thousands of years. Such analyses of ^{14}C and ^{10}Be suggest that episodes of declining solar activity resembling the Maunder Minimum have occurred repeatedly 12 times throughout the Holocene, which spans the past ten thousand years. Comparing cosmogenic isotopes against paleoclimate data can improve the understanding of solar-driven climate change on a long time-scale.

We have accumulated evidences over the past quarter century that will be effective in studying the mechanisms by which variations in solar activity affect climate and human society. The interdisciplinary project for Solar-Terrestrial Climate Research at ISEE integrates the latest knowledge in solar physics, meteorology, climatology, environmental studies, paleoclimatology, space physics, and cosmic ray physics with the aim of better understanding the variability in solar activity, fostering an understanding of solar-driven earth systems, and contributing to predictions of future global environments.

Main Activities in FY2019

The 8th East Asia Mass Spectrometry Symposium

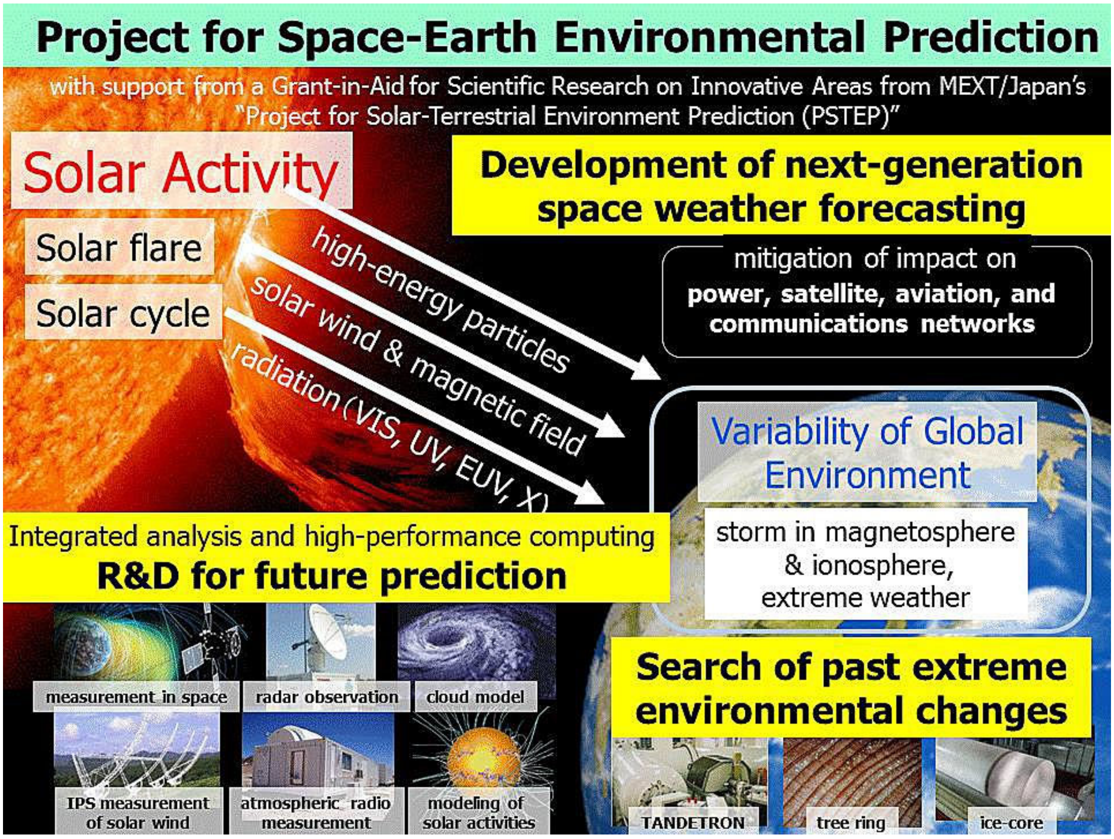
In recent years, the installation of accelerator mass spectrometry has been encouraged in many institutes in East Asian countries. Under these circumstances, the 8th East Asia Accelerator Mass Spectrometry Symposium was held under the auspices of ISEE, Nagoya University, from December 3 to December 6, 2019. A total of 115 participants jointed from Korea, China, Taiwan, Hong Kong, the US, Australia, Switzerland, the Netherlands, the Philippines, and Poland.

One prevalent topic was studies dealing with historical solar activity by performing high-precision ^{14}C and ^{10}Be accelerator mass spectrometry analyses of annual tree rings and ice sheet cores. In the session “Space and Earth Environmental Science,” the latest studies about past solar changes were presented; e.g., “Evidence for solar-flare and other cosmic-ray events in the ^{14}C record in tree rings and in the other records” by A. J. T. Jull (Dept. of Geosciences, University of Arizona), F. Miyake (ISEE, Nagoya University), and I. Panyushkina (Lab. for tree-ring research, University of Arizona).

The participants of the 8th East Asia Mass Spectrometry Symposium.

Project for the Space–Earth Envionmental Prediction

Over the past 50 years, space exploration has expanded rapidly and now gone past the edge of the heliosphere. Consequently, it is known that solar activity and the dynamics of the space environment can significantly impact human socio-economic systems as well as the global environment. For example, the giant solar flare observed by the British astronomer Richard Carrington in 1859 caused powerful magnetic storms, called the Carrington Event. If such an event occurred in the modern era, power, satellite, aviation, and communication networks could possibly be damaged on a global scale. Moreover, analyses of the latest stellar observations and of cosmogenic isotopes in tree rings suggest even larger solar flares. However, the mechanisms of the onset of solar flares and their subsequent processes have not yet been fully explained. Thus, modern society is at risk from severe space-weather disturbances, caused by such solar explosions, and understanding and predicting variations in the space–Earth environment is both an important scientific subject and a crucial issue for modern society. Furthermore, because the accurate prediction of complex phenomena is a common problem in science, the prediction is also a crucial subject for various scientific disciplines. The Project for Space–Earth Environmental Prediction is a new joint research project aimed at synergistically developing our predictive capability for the space–Earth environment through the cooperation and interaction of solar physics, geomagnetism, space sciences, meteorology, climatology, space engineering, and other related fields. This project addresses the various issues shown in the figure below, based on ISEE Collaborative Research Programs and the support of a Grant-in-Aid for Scientific Research on Innovative Areas from MEXT Japan's "Project for Solar-Terrestrial Environment Prediction (PSTEP)."



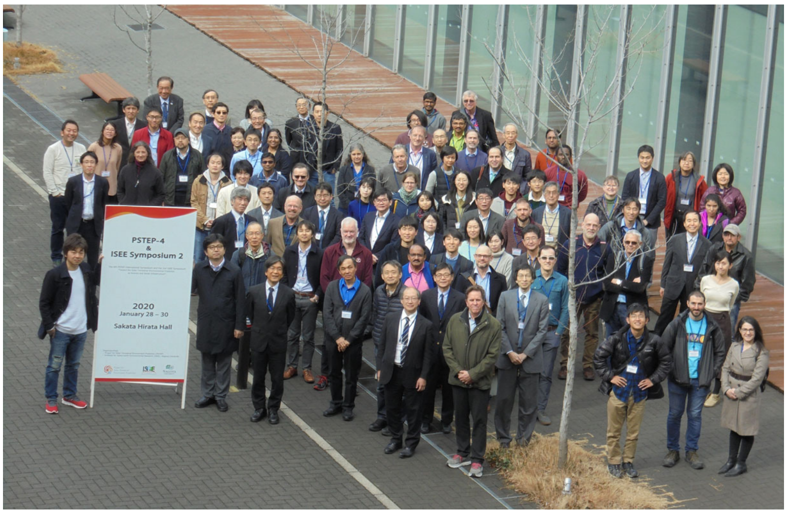
The objectives and subjects of the Project for Space–Earth Environmental Prediction.

Main Activities in FY2019

The 2nd ISEE Symposium, PSTEP-4: Toward the Solar–Terrestrial Environmental Prediction as Science and Social Infrastructure

The 2nd ISEE symposium was held as the 4th international symposium “PSTEP-4: Toward the Solar–Terrestrial Environmental Prediction as Science and Social Infrastructure” from January 28 to January 30 at the Sakata and Hirata Halls of Nagoya University. This was the final international symposium of the PSTEP, which is a nation-wide project on space weather and space climate in Japan (https://www.pstep.jp/). More than 100 researchers from Japan, the US, the UK, Germany, Italy, Canada, Belgium, Mexico, India, and Peru attended the symposium to discuss four topics: forecasting systems, solar storms, geomagnetic fluctuations, and solar cycle activity. In the oral session, 48 presentations were made by invited speakers from abroad and domestic researchers, and 59 presentations were made in the poster session. Please refer to the PSTEP WEB page http://www.pstep.jp/news/20200127.html for the agenda of the symposium.

This project has been aimed at overcoming the gap, called “death valley,” between the basic science of space and Earth environment prediction, and forecast operation. At this symposium, discussions focused on this point were developed for predictive studies of solar flares, coronal mass emission, radiation belts in the geo-magnetosphere, ionospheric disturbance, geomagnetically induced current, solar radiation exposure, satellite charging, radio wave propagation, and the next solar cycle and its influence on climate. The contribution of these studies was highly valued.



The participants of the 2nd ISEE Symposium.

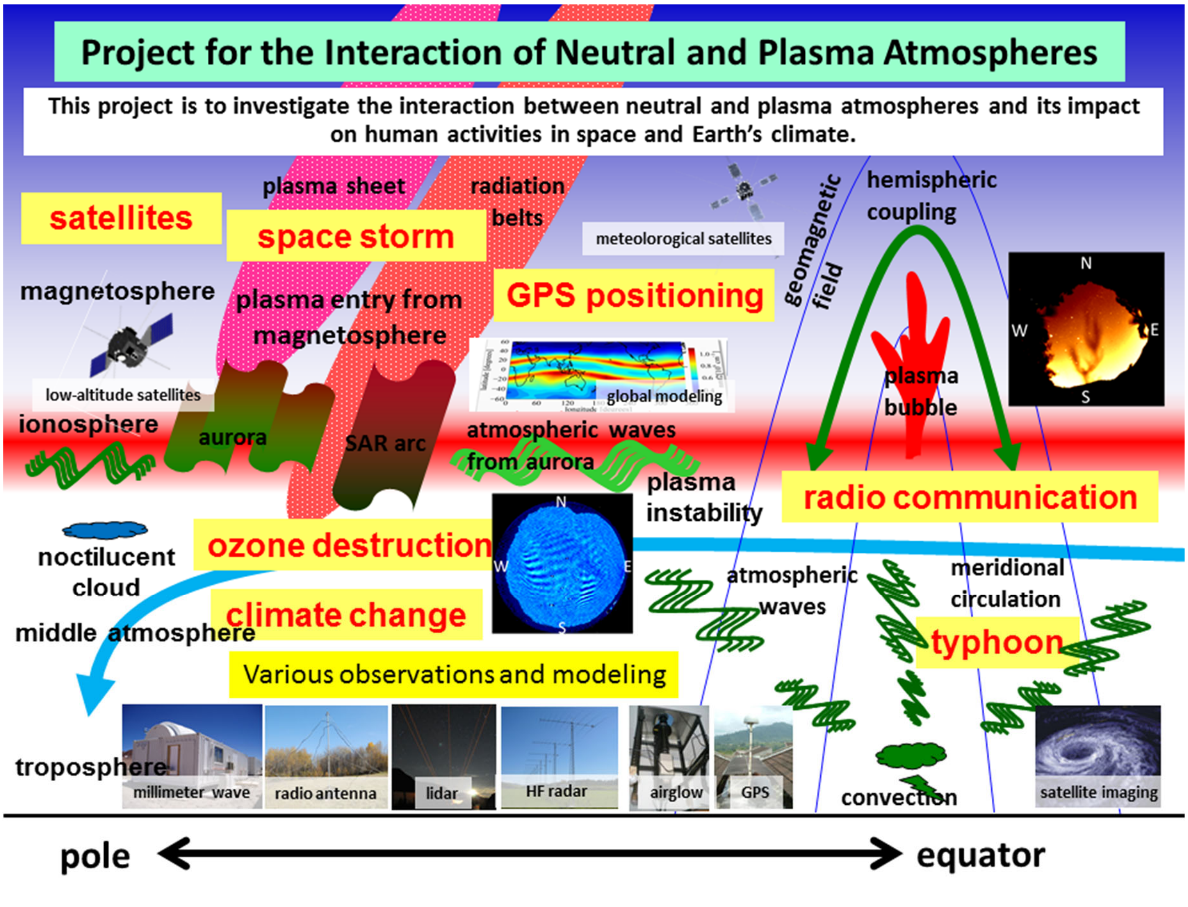
Korea-Japan Space Weather Workshop 2019

We organized the Korea-Japan Space Weather Workshop 2019 with the Korean Astronomical Research Institute (KASI) in Daejeon, South Korea on November 28–29, 2019. This workshop is held every two years, alternately by ISEE and KASI, to develop international joint research on space weather prediction through cooperation between Japan and South Korea. We were able to exchange opinions on the latest research achievements in both countries and actively discuss plans for future international joint research.

The participants of the Korea-Japan Space Weather Workshop 2019.

Project for the Interaction of Neutral and Plasma Atmospheres

The Earth's upper atmosphere is partly ionized because of solar ultraviolet emissions, forming the ionosphere. Ionospheric plasma affects human activities in space, such as radio communications and GPS positioning. The consequences of climate change appear significant in the upper atmosphere and ionosphere. As shown in the Figure below, neutral–plasma interaction processes in the upper atmosphere and ionosphere can be observed as various phenomena occurring from high to low latitudes. The aurora in the polar regions is caused by the precipitation of high-energy plasma, which heats the upper atmosphere and generates atmospheric waves and disturbances that propagate toward low latitudes. However, ionospheric plasma instabilities, known as plasma bubbles, occur in the equatorial upper atmosphere, interfering with satellite–ground communication and GPS positioning. These phenomena can be measured using various ground-based remote-sensing instruments, such as airglow imagers, magnetometers, radars and lidars, and millimeter-wave telescopes. This interdisciplinary project investigates the interactions between the neutral and plasma components of the Earth's atmosphere, using various ground remote-sensing techniques and *in-situ* satellite measurements, as well as global and regional high-resolution modeling of neutral–plasma interactions. The project contributes to the reliable use of space by humans and to our understanding of possible plasma effects on the Earth's climate change.



Research topics of the project for the interaction of neutral and plasma atmospheres.

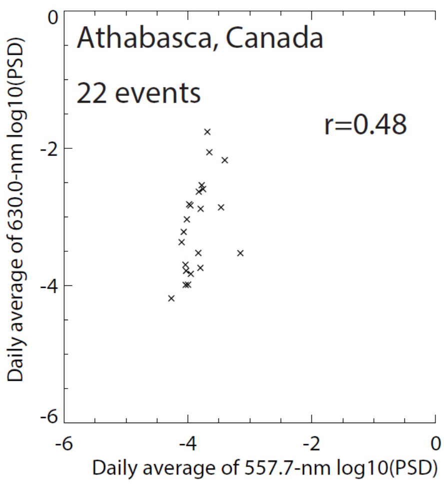
Main Activities in FY2019

In FY2019, we conducted nine international collaborative studies, nine domestic collaborative projects, and 20 domestic meetings under ISEE. Various scientific results have been obtained through these collaborative projects.

Polar aurora as an indicator of plasma–atmosphere interactions (photo taken at Athabasca, Canada on October 4, 2019, during an ERG-ground campaign observation).

As mentioned in the previous paragraph, the interaction of neutral and plasma components is an essential and important issue for understanding the partially ionized atmosphere, or the ionosphere and thermosphere. We are expecting a dramatic improvement in ground-based ionospheric measurement accuracy with the initiation of EISCAT_3D in Scandinavia in 2022. However, as the measurement of neutral components in the thermosphere is theoretically impossible for EISCAT_3D, preparations for diagnosing neutral components or the thermosphere are perceived as an urgent issue. The international project team (SDI-3D: established in 2018 by Japan, the US, Finland, Sweden, and Norway) has made budget requests to deploy three SDIs, which are capable of measuring thermospheric wind vectors and temperatures within 1000 km2. Collaboration between the EISCAT_3D and the three SDIs in Scandinavia will create an ideal environment for studying the coupled polar ionosphere–thermosphere system with state-of-the-art ground-based instruments. We newly developed a multi-frequency millimeter-wave spectrometer to simultaneously observe spectral lines of O_3, CO, NO, NO_2, and HO_2 within a 230–255 GHz range. At the end of FY2020, the new spectrometer was shipped and is now being re-assembled at Syowa station to start steady monitoring of those atmospheric molecules. The new scientific satellite Arase (ERG) was launched by ISAS/JAXA in December 2016 to investigate wave–particle interactions between high-energy electrons and ions in the inner magnetosphere. We have conducted several ERG-ground campaign observations in FY2019. From the combined ground–satellite measurements, including EISCAT and newly installed high-speed EMCCD cameras, several interesting results, especially concerning wave–particle interactions, have been reported in various scientific journals, including *Nature*, *Nature Communications*, and *Nature Scientific Reports*. An ISEE researcher was hired by the University of Oulu in Finland through a cross-appointment and will conduct collaborative research related to this interdisciplinary project.

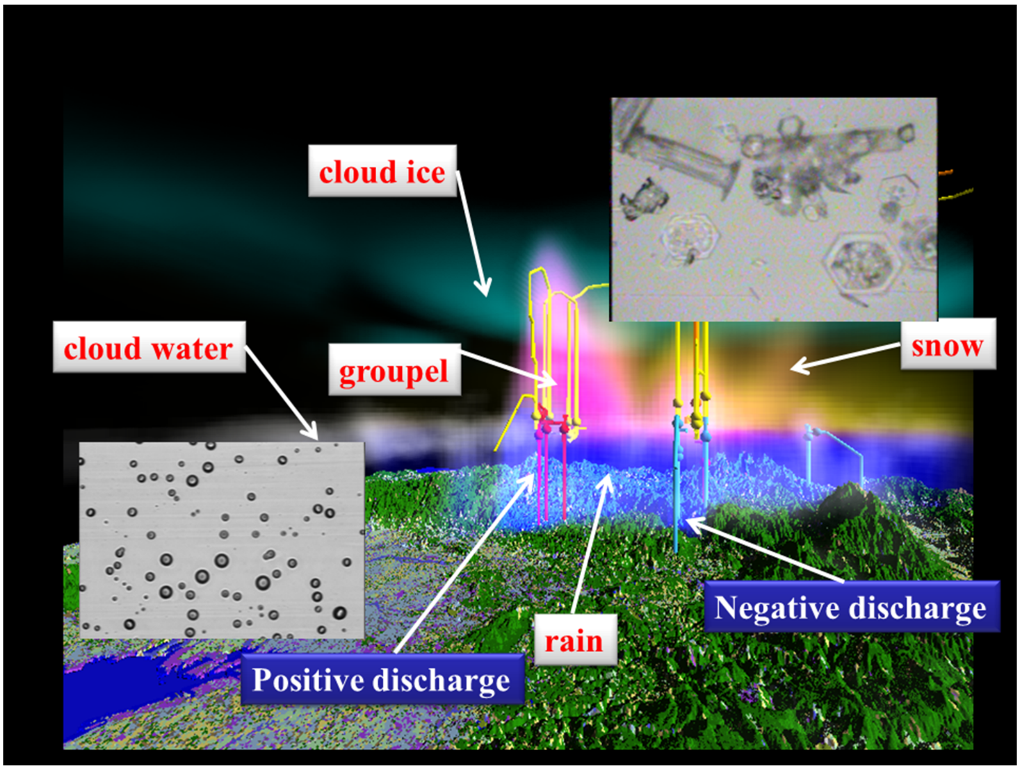
At middle- and low latitudes, various scientific results have been obtained in FY2019, mainly using multi-point ground-based airglow and GNSS observations. As an example, we studied atmospheric gravity waves (AGWs) and medium-scale traveling ionospheric disturbances (MSTIDs) using more than 10 years of airglow images obtained in Canada, Russia, and Japan. We show positive correlations between the power of the AGWs in the mesosphere and MSTIDs in the ionosphere, suggesting the generation of MSTIDs by AGWs from the lower atmosphere A 3-dimensional Fourier analysis of these airglow images also provided wavenumber spectra and their latitudinal, longitudinal, local time, and solar activity dependences in the mesosphere and ionosphere.

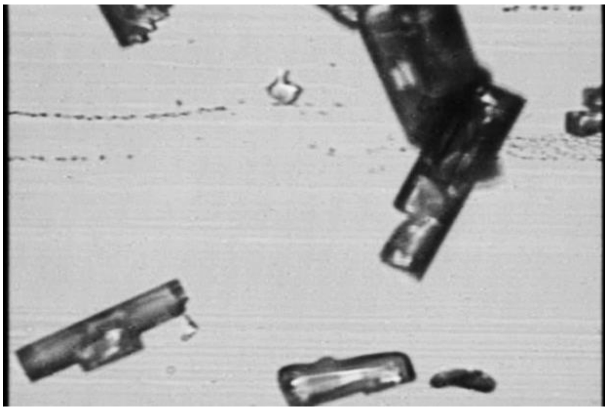


Positive correlation between the power of the atmospheric gravity wave in the mesosphere and medium-scale traveling ionospheric disturbances in the ionosphere, obtained at Athabasca, Canada.

Project for Aerosol and Cloud Formation

Hydrometeors and aerosols closely interact with each other in their generation and dissipation, and play important roles in atmospheric water circulation, formation of convective clouds and typhoons, as well as in the Earth radiation budget. However, they are some of the most unknown quantities in the atmosphere. Thus far, hydrometeors and cloud-precipitation systems have been studied in the Hydrospheric Atmospheric Research Center, whereas aerosols and related processes have been studied in the Solar-Terrestrial Environmental Laboratory. In the joint research program, researchers from both centers will cooperate to study the interaction between aerosols and hydrometeors, their variations in the formation of precipitation, and cloud-aerosol-radiation interactions by field observations and numerical simulations. On the basis of field observations, the numerical model will be improved for quantitative simulation of cloud and aerosol processes. In cooperation with the Center for Orbital and Suborbital Observations, we will conduct in situ observations of typhoons using an aircraft, balloons, and drones. This research will improve CReSS and study the impact of aerosols on typhoon clouds.



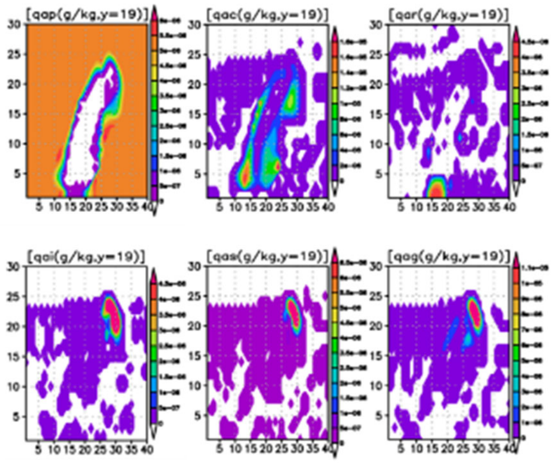


Upper: A mesoscale convective system and hydrometeors simulated by the CReSS model.
Lower: The superimposed images show hydrometeors expected to be present in the convective system. Balloon observation of typhoon clouds. Launching balloon (left) and observed hydrometeors (right).

Main Activities in FY2019

Cloud and aerosol observations in the UAE and aerosol modeling

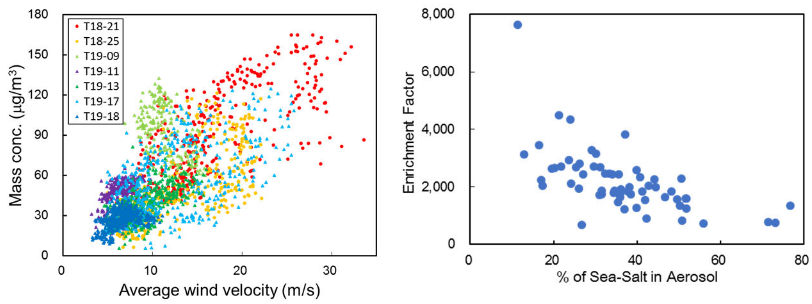
To investigate the effects of aerosols on diurnal convective clouds and their precipitation, using aircraft observations collected in the UAE in September 2017, the spatio-temporal variation of atmospheric aerosols acting as CCNs and INPs, and the microphysical structures of the clouds were analyzed in detail. The aerosols that act as CCNs are activated at water supersaturations of 0.2 to 0.5% in updraft cores near cloud bases, and the number concentrations of activated cloud droplets decreases with altitude owing to the collision-coalescence of cloud droplets and the entrainment of the surrounding dry air, except near cloud tops. Ice particles show a characteristic spatial distribution with larger particle sizes and smaller number concentrations in the updraft cores compared to the surrounding areas. An investigation of the effects of atmospheric aerosols over the UAE on the formation of diurnal convective clouds and their precipitation formation processes is planned, using CReSS implemented with aerosol–cloud-precipitation–integrated cloud microphysics parameterization (Fig.), including various types of aerosols (sea-salt, mineral dust, sulfate, inorganic carbon, organic carbon, etc.) as prognostic variables.



The effect of aerosols on convective precipitation clouds (vertical cross-section through the center of the cloud). Mass mixing ratios of atmospheric aerosols, aerosols present in cloud water, and rainwater (from upper left to upper right), and aerosols present in cloud ice, snow, and hail (from the lower left to lower right) in 1 kg of air.

Observation of aerosol particles in Okinawa

As part of the KAKENHI research project (PI: K. Tsuboki), observations were conducted in collaboration with the University of Ryukyus and Nagasaki University. We measured the size distribution of aerosol particles in the summer and autumn of 2018 and 2019, and PM2.5 mass concentrations continuously from August 2018, using an optical particle analyzer and a low-cost optical sensor, respectively, at the University of Ryukyus. For the seven typhoons that passed near the site, the effect of wind speed on the mass concentration of aerosol particles (mainly sea-salt) with diameters between 0.3 and 10 μm was analyzed. Mass concentration was found to increase by 50 μg/m^3 for a 10 m/s increase in wind speed. In addition, to study the concentrations of sea-salt and dissolved organic carbon (DOC) in the aerosols, we have been collecting bulk aerosols continuously since September 2018, even during typhoon days. The amount of sea-salt in the aerosols showed a good positive correlation with wind speed. It has been reported that when sea-salt is emitted from the surface of seawater, it attracts organic compounds to itself and can thus enrich the concentrations of DOC by several hundred to a couple of thousand times. By studying the concentrations of sea-salt and DOC in aerosols with varying wind speed, we were able to estimate that the enrichment factor was about 700 in the natural environment.



Left: Relationship between mass concentration of aerosol particles with diameters between 0.3 and 10 μm and wind speed during the passage of seven typhoons.
Right: Enrichment factor of DOC in the aerosols with respect to seawater DOC.

9. Publications and Presentations

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Books (April 2019–March 2020)

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Kusano, K., E. Cliver, H. Hayakawa, G. A. Kovaltsov, and I. G. Usoskin, Chapter 2: What Can Be Learned from Modern Data? 2.1–2.38, *Extreme Solar Particle Storms: The hostile Sun*, edited by **F. Miyake**, I. Usoskin, and S. Poluianov, 300pp, IOP Publishing Ltd, U.K., Feb. 28, 2020 (10.1088/2514-3433/ab404ach2).

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Miyake, F., Y. Ebihara, H. Hayakawa, H. Maehara, Y. Mitsuma, I. Usoskin, F. Wang, and D. M Willis, Chapter7: Further Search for Extreme Events, 7.1–7.41, *Extreme Solar Particle Storms: The hostile Sun*, edited by **F. Miyake**, I. Usoskin, and S. Poluianov, 300pp, IOP Publishing Ltd, U.K., Feb. 28, 2020 (10.1088/2514-3433/ab404ach7).

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Sibeck, D. G., and Soft X-Ray Imaging International Team (**Y. Miyoshi**), *Imaging Plasma Density Structures in the Soft X-Rays Generated by Solar Wind Charge Exchange with Neutrals*, 124pp, Springer, Netherlands, May 10, 2019 (ISBN 9402416919, 9789402416916)

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One more book was published in Japanese.

Publication of Proceedings (April 2019‐March 2020)

Title	Date of Publication
Proceedings, 20th International Symposium on Very High Energy Cosmic Ray Interactions (ISVHECRI 2018): Nagoya, Japan, May 21-25, 2018. Edited by B. Pattison(ed.), Y. Itow(ed.), T. Sako(ed.), H. Menjo(ed.) Published in: EPJ Web Conf. 208 (2019), Contribution to: ISVHECRI 2018	May 13, 2019
Book of Abstracts: iLEAPS/IGAC-Japan Joint Workshop 2019	Sep. 6, 2019
Book of Abstracts: JpSAC Annual Meeting 2019	Nov. 5, 2019
The 8th East Asia Accelerator Mass Spectrometry Symposium (EA-AMS 8) Agenda & Abstract	Dec. 3, 2019
Extreme Solar Particle Storms, Miyake, F., I. G. Usoskin, S. Poluianov, Eds. IOP Publishing, doi:10.1088/2514-3433/ab404a	Dec. 12, 2019
Proceedings of the 8th East Asia Accelerator Mass Spectrometry Symposium and the 22nd Japan Accelerator Mass Spectrometry Symposium	Mar. 31, 2020

Conference Presentations (April 2019–March 2020)

■ International Conferences

＊Session Conveners

Title	Country/ Region	Date	Orga-nizers	Number of Presentations			
				Staffs and PDs	Students	Total	Invited
European Geosciences Union General Assembly	Vienna, Austria	Apr. 7–12, 2019	0	2	0	2	2
Tropical Cyclone Conference, NOAA	Honolulu, HI, USA	Apr.10–12, 2019	0	1	0	1	0
The 40th Anniversary Symposium of the US-Japan Science and Technology Cooperation Program in High Energy Physics	Honolulu, HI, USA	Apr. 15–16, 2019	0	1	0	1	1
SOLAS Open Science Conference	Sapporo, Japan	Apr. 21–25, 2019	0	1	1	2	0
GODAE Ocean View Symposium 2019 – Ocean Predict ‘19	Halifax, Canada	May 6–10, 2019	0	1	0	1	0
World Data System Asia-Oceania Conference 2019	Beijing, China	May 7–8, 2019	0	1	0	1	0
Workshop on International Space Weather Initiative (ISWI)	Trieste, Italy	May 20–24, 2019	0	1	0	1	1
2019 Joint NDACC-IRWG and TCCON Meeting	Wanaka, New Zealand	May 20–24, 2019	0	2	0	2	0
Radiocarbon and Archaeology 9th International Symposium	Athens, GA, USA	May 20–24, 2019	0	1	0	1	0
EISCAT_3D user meeting	Uppsala, Sweden	May 21–22, 2019	0	1	0	1	0
Taiwan Geosciences Assembly	Taipei, Taiwan	May 21–25, 2019	0	2	0	2	2
Japan Geoscience Union Meeting 2019	Chiba, Japan	May 26–30, 2019	0	34	14	48	6
SuperDARN workshop 2019	Fuji, Japan	Jun. 2–7, 2019	1	9	3	12	3
Magnetosphere of Outer Planets	Sendai, Japan	Jun. 3–7, 2019	0	1	0	1	1
VarSITI Closing Symposium	Sofia, Bulgaria	Jun. 10–14, 2019	1	4	0	4	3
2nd International Conference on Environmental Science and Technology 2019	Ulanbaatar, Mongolia	Jun. 13–14, 2019	0	0	1	1	0
The TCOI 2019 Workshop	Jeju, Korea	Jun. 19, 2019	0	1	0	1	1
22nd Conference on Atmospheric and Oceanic Fluid Dynamics	Portland, ME, USA	Jun. 24–28, 2019	0	1	0	1	0
14th International Conference on Numerical Modeling of Space Plasma Flows (ASTRONUM 2019)	Paris, France	Jul. 1–5, 2019	0	2	0	2	1
Pulsating Aurora Workshop	Nagoya, Japan	Jul. 2–3, 2019	1	2	2	4	0
JSPS- Bilateral Project: Japan-Russia Meeting	Nagoya, Japan	Jul. 4, 2019	1	4	0	4	0
27th IUGG General Assembly	Montreal, Canada	Jul. 8–18, 2019	0	12	2	14	0
Workshop of Solar Radio Astronomy	Beijing, China	Jul. 22–24, 2019	0	1	0	1	0
36th International Cosmic Ray Conference（ICRC2019)	Madison, WI, USA	Jul. 24–Aug. 1, 2019	0	3	3	6	1
20th Congress of the International Union for Quaternary Research (INQUA)	Dublin, Ireland	Jul. 25–31, 2019	0	1	0	1	0
Asia Oceania Geosciences Society (AOGS) 16th Annual Meeting	Singapore	Jul. 28–Aug. 2, 2019	2*	7	1	8	5
Ion Composition in the Sun-Earth System (ICSES) meeting	Durango, CO, USA	Jul. 28–Aug. 3, 2019	0	1	0	1	1
9th East-Asia School and Workshop on Laboratory, Space, and Astrophysical Plasmas	Nagoya, Japan	Jul. 29–Aug. 2, 2019	4	2	3	5	0

Title	Country/ Region	Date	Orga- nizers	Number of Presentations			
				Staffs and PDs	Students	Total	Invited
48th International Conference on Parallel Processing (ICPP2019)	Kyoto, Japan	Aug. 5–8, 2019	0	1	0	1	0
Goldschmid 2019	Barcelona, Spain	Aug. 18–23, 2019	0	1	0	1	0
19th International EISCAT Symposium 2019 and 46th Annual European Meeting on Atmospheric Studies by Optical Methods	Oulu, Finland	Aug. 19–23, 2019	0	2	1	3	1
11th Circum-Pan-Pacific Symposium on High Energy Spin Physics	Miyazaki, Japan	Aug. 27–30, 2019	0	1	0	1	1
AsiaPEX Kickoff Conference 2019	Sapporo, Japan	Aug. 28–30, 2019	0	2	0	2	0
Hinode-13/IPELS 2019 meeting	Tokyo, Japan	Sep. 2–6, 2019	0	6	2	8	3
URSI-Japan Radio Science Meeting (URSI-JRSM) 2019	Chofu, Japan	Sep. 5–6, 2019	0	7	0	7	2
CLICCS Workshop on Waves	Bad Segeberg, Germany	Sep. 9–10, 2019	0	1	0	1	1
16th International Conference on Topics in Astroparticle and Underground Physics (TAUP2019)	Toyama, Japan	Sep. 9–13, 2019	0	2	1	3	0
The 2nd EPB Workshop on Scientific Challenges in Ionospheric Plasma Bubble	Beijing, China	Sep. 14–15, 2019	1	1	0	1	1
39th International Conference on Radar Meteorology	Nara, Japan	Sep. 16–20, 2019	1	4	1	5	0
The International Symposium on Space Science 2019	Bandung, Indonesia	Sep. 25, 2019	0	1	0	1	1
14th International Conference on Substorms	Tromsø, Norway	Sep. 29–Oct. 4, 2019	1	0	0	0	0
SiPM Workshop	Bari, Italy	Oct. 2–4, 2019	1	0	1	1	0
The Xth International Symposium on "C/H_2O/Energy balance and climate over the boreal and Arctic regions with special emphasis on Eastern Eurasia" & 1st Joint Research Laboratory meeting on Sustainable Development of the North	Sapporo, Japan	Oct. 4–6, 2019	1	1	0	1	0
Chemical Aeronomy in the Mesosphere and Ozone in the Stratosphere (CHAMOS) Workshop	Helsinki, Finland	Oct. 8–11, 2019	0	2	0	2	0
National Institute of Meteorological Sciences	Jeju, Korea	Oct. 10–11, 2019	0	2	0	2	2
SEVERE WEATHER and TAHOPE Planning workshop	Taipei, Taiwan	Oct. 15, 2019	0	1	0	1	1
2019 NDACC Steering Committee Meeting	Tsukuba, Japan	Oct. 15–17, 2019	1	0	0	0	0
NDACC Science Workshop in Tsukuba	Tsukuba, Japan	Oct. 17–19, 2019	1	2	0	2	1
PICES-2019 Annual Meeting: Connecting Science and Communities in a Changing North Pacific	Victoria, Canada	Oct. 16–27, 2019	1*	0	0	0	0
2019 TCCIP International Workshop on Climate Change (IWCC2019)	Taipei, Taiwan	Oct. 22–24, 2019	0	1	0	1	0
The 4th COSPAR Symposium	Herzliya, Israel	Nov. 4–8, 2019	0	1	0	1	0
3rd Asia-Pacific Conference on Plasma Physics	Hefei, China	Nov. 4–8, 2019	0	1	0	1	1
Approaches for Hydrospheric-Atmospheric Environmental Studies in Asia-Oceania	Nagoya, Japan	Nov. 8–9, 2019	1	3	2	5	0
Dark matter searches in the 2020s -At the crossroads of the WIMP	Kashiwa, Japan	Nov. 11–13, 2019	0	0	1	1	0
VarSITI Summarizing Workshop	Nagoya, Japan	Nov. 11–15, 2019	1	0	0	0	0
Forum of U.S.-Japan Alliance in a New Space Age: Back to the Moon	Cambridge, MA, USA	Nov. 15, 2019	0	1	0	1	1

Title	Country/ Region	Date	Orga-nizers	Number of Presentations			
				Staffs and PDs	Students	Total	Invited
Workshop on Radio Science and Wave Measurement Technology in Space Plasma	Kanazawa, Japan	Nov. 19, 2019	0	3	0	3	0
8th International EarthCARE Science Workshop	Fukuoka, Japan	Nov. 25–27, 2019	1	1	0	1	0
High Frequency Radar Data Application Seminar	Beijing, China	Nov. 27, 2019	0	1	0	1	1
Korea-Japan Space Weather Workshop 2019	Daejeon, Korea	Nov. 28–29, 2019	0	8	0	8	0
The Tenth Symposium on Polar Science	Tchikawa, Japan	Dec. 3–5, 2019	0	6	2	8	0
The 8th East Asia Accelerator Mass Spectrometry Symposium (EA-AMS 8)	Nagoya, Japan	Dec. 3–6, 2019	4	5	1	6	0
Interplanetary Scintillation (IPS) 2019 Workshop	Arecibo, Puerto Rico	Dec. 4–7, 2019	1	0	0	0	0
Astrophysical and Solar MHD Workshop at RIMS	Kyoto, Japan	Dec. 9, 2019	0	1	0	1	1
AGU fall meeting 2019	San Francisco, CA, USA	Dec. 9–13, 2019	1*	18	6	24	1
The 7th Asian/16th Korea-Japan Workshop on Ocean Color (7th AWOC/16th KJWOC)	Chonburi, Thailand	Dec. 11–14, 2019	1	2	3	5	0
Observatory Days 2020	Sodankylä, Finland	Jan. 8–10, 2020	0	1	0	1	0
2020 ERG Science and Space Weather Workshop	Taoyuan, Taiwan	Jan. 13–15, 2020	1	6	0	6	0
International Conference on High Performance Computing in Asia-Pacific Region (HPCAsia2020)	Fukuoka, Japan	Jan. 15–17, 2020	0	1	0	1	0
GNSS Positioning and Total Electron Content Analysis Workshop	Chumphon, Thailand	Jan. 17–18, 2020	0	2	0	2	2
The Joint PI Meeting of JAXA Earth Observation Missions FY2019	Tokyo, Japan	Jan. 20–24, 2020	0	4	0	4	0
2020 GEWEX Data and Analysis Panel (GDAP) Meeting	Tucson, AZ, USA	Jan. 22–24, 2020	0	1	0	1	1
The 4th PSTEP International Symposium (PSTEP-4) and the 2nd ISEE Symposium "Toward the Solar-Terrestrial Environmental Prediction as Science and Social Infrastructure"	Nagoya, Japan	Jan. 28–30, 2019	7	18	7	25	0
United Nations Office for Outer Space Affairs, Science and Technical Subcommittee (STSC), Space Weather Agenda	Vienna, Austria	Feb. 3–4, 2020	0	1	0	1	0
Ocean Sciences Meeting 2020	San Diego, CA, USA	Feb. 16–21, 2020	0	2	1	3	0
Japanese-Czech Symposium on Space Physics	Prague, Czech	Mar. 3–4, 2020	0	1	0	1	0
The 43rd annual Apatity seminar "Physics of Auroral Phenomena"	Apatity, Russia	Mar. 10–12, 2020	0	1	0	1	0
ISAR-6 online meeting	(online)	Mar. 27–Apr. 10, 2020	1	2	0	2	0
Total			33 4*	228	59	287	50

■ Domestic Coferences

* Session Conveners

Number of Conferences	Organizers	Number of Presentations			
		Staffs and PDs	Students	Total	Invited
84	40 24*	222	78	300	14

■ Lectures for Researchers

Date	Title	Number of Paticipants
Apr. 16, 2019, Jun. 18, 2019, Jun. 27, 2019, Jul. 22, 2019, Spt. 20, 2019, Nov. 26, 2019, Dec. 23, 2019, Feb. 27, 2020	PSTEP Seminar	60 a time on average
Apr. 4, 2019, Apr. 23, 2019, Jun. 14, 2019, Jun. 18, 2019, Jun. 26, 2019, Jul. 18, 2019, Sep. 19, 2019, Sep. 24, 2019, Sep. 25, 2019, Oct. 3, 2019, Oct. 23, 2019, Oct. 30, 2019, Jan. 31, 2020, Feb. 6, 2020, Feb. 26, 2020	ISEE/CICR Colloquium	20 a time on average
Apr. 18, 2019, Apr. 25, 2019, May 9, 2019, May 16, 2019, May 30, 2019	ROOT Training Workshop 2019	100
Jun. 8–9, 2019	SuperDARN 2019 Onsite School	4
Sep. 9–10, 2019	Virtual Laboratory for the Earth's Climate Diagnostics Program Tutorial/lecture	34
Sep. 19, 2019	SPEDAS Training Session I & II	75
Sep. 26–27, 2019	Seminar for Young Scientists and Graduate Student	30
Sep. 30, 2019	Seminar for Young Scientists and Graduate Student	8
Nov. 27–Dec. 6, 2019	The Twenty-ninth IHP Training Course in Nagoya “Changing Global Water Cycle and the Regional Responses”	6
Jan. 15, 2020	SPEDAS Training Session I & II	10
Feb. 12, 2020	Joint Meeting of ISEE Technical Support Division and JAXA/ISAS Advanced Machining Technology Group	30

Awards

■ Staffs and PDs

Award Winners	Date	Awards	Title
Hirohiko Masunaga	May 16, 2019	Award of the Meteorological Society of Japan	Studies of tropical convective dynamics by combined analysis of satellite observations
Yuichi Otsuka	May 29, 2019	Tanakadate Award of Society of Geomagnetism and Earth, Planetary and Space Sciences (SGEPSS)	Study of ionospheric disturbances at low and middle latitudes using GPS and radar observations
Yuichi Otsuka	May 30, 2019	AGU's Outstanding Reviewers of 2018	Radio Science
Masayo Minami (F.A. Shigeyuki Wakaki)	Jul. 2, 2019	13th Outstanding Poster Award, The 36th Annual Meeting of Japan Society for Scientific Studies on Cultural Properties	Radiogenic and stable Sr isotope study of cremated bone apatite: dietary analysis and the effect of diagenetic alteration
Masafumi Shoji	Oct. 25, 2019	Obayashi Early Career Scientist Award（SGEPPS)	Study on nonlinear wave-particle interaction of electromagnetic ion cyclotron waves
Minrui Wang	Sep. 19, 2019	Outstanding Papar of AJAE, Japan Society for Atmospheric Environment,	Minrui Wang, Kenji Kai, Nobuo Sugimoto, and Sarangerel Enkhmaa, Meteorological Factors Affecting Winter Particulate Air Pollution in Ulaanbaatar from 2008 to 2016. *AJAE*, Vol. 12, No. 3
Sneha Yadav	Dec. 18, 2019	INSA Medal for Young Scientists	Contribution towards understanding of low latitude ionosphere specific to Indian longitudes under varying space weather conditions

■ Students

Award Winners	Date	Awards	Title
Ken Ohashi	May, 2019	Student Presentation Award of the Physical Society of Japan	MC study for the effect of diffractive events on the air shower developments
Riku Ishijima	May 29, 2019	SGEPSS Student Presentation Award (Aurora Medal)	A statistical analysis of ozone depletion in the polar mesosphere caused by precipitating solar protons
Heqiucen Xu	Jul. 10, 2019	JpGU 2019 Outstanding Student Presentation Award	Study of quiet-time high-latitude thermospheric winds using a Fabry-Perot interferometer at Tromsoe: Averages and exceptional events
Toshiki Kawai			Detection and energy derivation of nano-flares based on deep learning
Kosuke Ozaki	Sep. 12, 2019	16th International Conference on Topics in Astroparticle and Underground Physics TAUP 2019 Poster Honourable Mention	Characterization of new photo-detectors for the future dark matter experiments with liquid xenon

Additionally, one domestic award

10. Education

The Institute for Space–Earth Environmental Research (ISEE) primarily offers graduate programs in the Science, Engineering, and Environmental Studies schools of Nagoya University. The ISEE has its own graduate course for Heliospheric and Geospace Physics in the Division of Particle and Astrophysical Science of the Graduate School of Science. ISEE also cooperates with the Department of Electrical Engineering, through the Space Electromagnetic Environment group in the Graduate School of Engineering, and the Department of Earth and Environmental Sciences, through the Chronology and Natural History, and Global Water Cycle groups, in the Graduate School of Environmental Studies, by teaching / training graduate students in disciplines related to space–earth environmental research.

Our graduate students use various methodologies and techniques, including ground observation, fieldwork, laboratory experiments, radioactive dating, numerical simulations and modeling, and theoretical research. Their work includes the development of satellite, balloon, and aircraft instruments—and the analysis of observational data. As ISEE members conduct research that involves analyzing data captured by both domestic and international instrument platforms, and / or by collaborative research with foreign researchers, our students are actively pioneering new research fields, through their involvement with other scholars in international collaborations, and in interdisciplinary research. Their studies mature as MSc or PhD theses, which are presented at international workshops and conferences, and published in academic journals. We nurture researchers who can apply their knowledge to benefit society, who have a broad perspective, and who demonstrate an international perspective.

Staff association between the research divisions in the ISEE and the graduate schools

		Graduate School of Science					Graduate School of Engineering		Graduate School of Environmental Studies						
		Division of Particle and Astrophysical Science					Department of Electrical Engineering and Computer Science		Department of Earth and Environmental Sciences						
		Heliospheric and Geospace Physics					Electrical Engineering Course Space Electromagnetic Environment		Earth and Planetary Sciences Course Chronology and Natural History		Hydrospheric-Atmospheric Sciences Course Global Water Cycle				
		Atmospheric and Environmental Science (AM)	Space Science – Experiment (SS_E)	Solar and Space Physics - Theory (SS_T)	Cosmic-Ray Physics (CR)	Heliospheric Plasma Physics (SW)	Space Observation	Information Engineering	Geochronology	Environmental History	Meteorology	Cloud and Precipitation Sciences	Atmospheric Chemistry	Hydroclimatology	Oceanography
Institute for Space–Earth Environmental Research	Integrated Studies			●				●							
	Cosmic-Ray Research				●										
	Heliospheric Research					●									
	Ionospheric and Magnetospheric Research		●				●								
	Meteorological and Atmospheric Research	●					●				●	●	●		
	Land–Ocean Ecosystem Research													●	●
	Chronological Research								●	●					
	Center for International Collaborative Research	●	●		●		●		●					●	
	Center for Intergrated Data Science			●	●			●	●		●	●			●
	Center for Orbital and Suborbital Observations	●	●		●						●	●	●		●

Number of Students Supervised by ISEE Staff

(April 1, 2019–March 31, 2020)

	M1	M2	D1	D2	D3	Undergraduate Students	Non-regular students	Total
Graduate School of Science	10	15	2	3	6	-	1 *1	37
Graduate School of Engineering	8	5	0	0	2	-	-	15
Graduate School of Environmental Studies	16	9	1	2	7	-	-	35
School of Science	-	-	-	-	-	7	-	7
School of Engineering	-	-	-	-	-	11	3 *2	14
ISEE	-	-	-	-	-	-	2 *2	2
Total	34	29	3	5	15	18	6	110

Cumulative total in FY 2019 *1 Special Research Student, *2 Research Student

Faculty Members

(April 1, 2019–March 31, 2020)

■ Graduate School of Science Division of Particle and Astrophysical Science

Field/Topics	Professor	Associate Professor	Lecturer	Assistant Professor
Solar-Terrestrial Environmental Science	Akira Mizuno	Tomoo Nagahama		
Solar-Terrestrial Interrelation Science	Masafumi Hirahara	Satonori Nozawa	Shin-ichiro Oyama	
		Yuichi Otsuka		
	Kanya Kusano	Satoshi Masuda		Akimasa Ieda
Solar-Terrestrial Physics	Yoshitaka Itow	Fumio Abe	Akira Okumura	Hiroaki Menjo
	Hiroyasu Tajima	Yutaka Matsubara		
		Fusa Miyake		
	Munetoshi Tokumaru	Kazumasa Iwai		Ken-ichi Fujiki

■ Graduate School of Engineering Department of Electrical Engineering and Computer Science

Field/Topics	Professor	Associate Professor	Lecturer	Assistant Professor
Space Electromagnetic Environment	Kazuo Shiokawa	Nozomu Nishitani		Taku Nakajima
		Masahito Nosé		
	Yoshizumi Miyoshi	Takayuki Umeda	Shinsuke Imada	

■ Graduate School of Environmental Studies Department of Earth and Environmental Sciences

Field/Topics	Professor	Associate Professor	Lecturer	Assistant Professor
Hydrospheric-Atmospheric Sciences Course Global Water Cycle	Kazuhisa Tsuboki	Taro Shinoda		
	Nobuhiro Takahashi	Hirohiko Masunaga		
	Michihiro Mochida			Sho Ohata
	Tetsuya Hiyama	Naoyuki Kurita	Hatsuki Fujinami	
	Joji Ishizaka	Hidenori Aiki		Yoshihisa Mino
Earth and Planetary Sciences Course Chronology and Natural History	Masayo Minami	Takenori Kato		
	Hiroyuki Kitagawa			Hirotaka Oda

Undergraduate Education

Based on demand, the faculty of the institute offers numerous undergraduate courses in the School of Science, the School of Engineering, and in other departments and at other universities in the adjacent area.

■ During the 2019 Academic Year, The Following Courses were Offered;

- Astrophysics and Space Science
- Astrophysics III
- Atmospheric and Hydrospheric Sciences
- Earth and Planetary Science Researches
- Electric Circuits with Exercise
- Electromagnetic Wave Engineering
- Environmental Earth Sciences (Geosphere Environmental Chemistry)
- Experimental Physics
- Experiments in Physics - Advanced Course
- First Year Seminar A
- Frontier of Earth and Planetary Sciences
- Fundamentals of Atmospheric and Hydrospheric Sciences
- Geochemical Analysis II and Experiments
- Geology Experiments
- Graduation Thesis A・B
- Introduction to Earth Science
- Introduction to Electrical/ Electronic and Information Engineering for Automobiles
- Introduction to Physics I, II
- Isotope Geochemistry
- Laboratory in Physics
- Mathematics 1 with Exercises A/B
- Petrology Experiments
- Physics Experiments I, II
- Probability Theory and Numerical Analysis with Exercises
- Remote sensing
- Science of Atmospheric-Hydrospehric Environment
- Solar System Science
- Technical Visits in Companies and Laboratories B
- Topics in Advanced Physics
- View of Advanced Electrical/ Electronic and Information Engineering

11. International Relations

Academic Exchange

(29 in total)

Institution	Country/Region	Establishment
Indonesian National Institute of Aeronautics and Space	Indonesia	May 31,1988
Korean Space Weather Center	Korea	December 24, 2012
Pukyong National University, College of Fisheries Sciences	Korea	October 2, 2006
Institute of High Energy Physics, Chinese Academy of Sciences	China	February 20, 2001
Polar Research Institute of China	China	November 11, 2005
Department of Atmospheric Sciences, National Taiwan University	Taiwan	October 30, 2009
Center for Weather Climate and Disaster Research, National Taiwan University	Taiwan	September 3, 2014
Bangladesh University of Engineering & Technology, Department of Physics	Bangladesh	March 4, 2008
National Institute of Water and Atmospheric Research	New Zealand	July 26, 1989
Centre for Geophysical Research, University of Auckland	New Zealand	December 7, 1992
Faculty of Science, University of Canterbury	New Zealand	July 30, 1998
Geophysical Institute, University of Alaska Fairbanks	U.S.A.	July 16, 1990
Space Environment Center, National Oceanic and Atmospheric Administration	U.S.A.	December 15, 1992
National Geophysical Data Center, National Oceanic and Atmospheric Administration	U.S.A.	January 5, 1993
Haystack Observatory, Massachusetts Institute of Technology	U.S.A.	October 24, 1994
Center for Astrophysics and Space Sciences, University of California at San Diego.	U.S.A.	December 22, 1997
Center for Space Science and Engineering Research, Virginia Polytechnic Institute and State University	U.S.A.	January 23, 2013
Chacaltaya Cosmic Ray Observatory, Faculty of Sciences, Universidad Mayor de San Andres, La Paz	Bolivia	February 20, 1992
National Institute for Space Research	Brazil	March 5, 1997
Swedish Institute of Space Physics	Sweden	September 1, 2005 (since March 25, 1993)
Department of Geophysics, Finnish Meteorological Institute	Finland	October 21, 1994
Yerevan Physics Institute	Armenia	October 18, 1996
Institute of Cosmophysical Research and Radiowave Propagation, Far Eastern Branch, Russian Academy of Sciences	Russia	April 14, 2007
Institute of Solar-Terrestrial Physics, Siberian Branch of the Russian Academy of Sciences	Russia	October 28, 2008
Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy, Siberian Branch of the Russian Academy of Sciences	Russia	November 28, 2012
The Polar Geophysical Institute, Murmansk	Russia	March 13, 2017
Korea Institute of Ocean Science and Technology, Korea Ocean Satellite Center	Korea	March 13, 2018 (since April 17, 2014)
Faculty of Science, UiT The Arctic University of Norway	Norway	May 3, 2019 (since October 8, 1993)
Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)	International Science Council	July 30, 2019

Visitor : 13／Going Abroad : 34

Note: The List includes the academic exchanges established in the former organizations before ISEE.

Research Projects

■ Major International Collaborative Projects

(80 in total)

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Study of the Onset Mechanism of Solar Eruptions	K. Kusano	Germany	1	University of Potsdam
Observational Study of the Onset Mechanism of Solar Eruptions	K. Kusano	U.S.A China	2	New Jersey Institute of Technology University of Science and Technology of China
Study of Modeling of Solar Eruptions	K. Kusano	U.S.A.	1	Harvard-Smithsonian Center for Astrophysics
Study of Triggering Mechanism of Solar Flares	K. Kusano	U.K.	1	UCL-Mullard Space Science Laboratory
Study of Magnetic Reconnection	K. Kusano	U.K.	1	University of Manchester
Radiation Belt Storm Probes (RBSP) Project	Y. Miyoshi	U.S.A	1	NASA, JHUAPL
Modeling Study of Inner Magnetosphere	Y. Miyoshi	U.S.A	1	Los Alamos National Laboratory
Collaborative study on ERG project	Y. Miyoshi	Taiwan	1	Institute of Astronomy and Astrophysics, Academia Sinica
International Heliophysics Data Environment Alliance	Y. Miyoshi	U.S.A Europe (Member States of ESA)	23	NASA (SPDF, SDAC, HPDE, SPASE, CCMC) European Space Agency (ESA), CNES
Solar Researches with Nobeyama Radioheliograph	S. Masuda	U.S.A. China Korea Russia U.K. Germany Switzerland Belgium	8	GSFC/NASA, Catholic University of America, New Jersey Institute of Technology National Astronomical Observatories, Chinese Academy of Sciences, Shandong University KASI, Russian Academy of Sciences University of Warwick Georg-August-Universität Göttingen University of Applied Sciences and Arts Northwestern Switzerland Katholieke Universiteit Leuven
Study in Interaction of Very High Energy Cosmic Rays by Using Large Hadron Collider	Y. Itow	Italy France Switzerland U.S.A.	4	University of Florence, Catania University École Polytechnique CERN Lawrence Berkeley National Laboratory
Study in Cosmic Neutrinos by Using a Large Water Cherenkov Detector	Y. Itow	U.S.A. Canada U.K. Spain Korea China Poland	7	Boston University, Brookhaven National Laboratory, UCI, Duke University, George Mason University, University of Hawaii, Indiana University, Los Alamos National Laboratory, University of Maryland, State University of New York, University of Washington University of British Columbia, University of Toronto, TRIUMF Queen Mary University of London, Imperial College London, University of Liverpool, University of Oxford, University of Sheffield Complutense University of Madrid Chonnam National University, Seoul National University, Sungkyunkwan University Tsinghua University University of Warsaw

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Study of Dark Matter and Solar Neutrinos Using a Liquid Xenon Detector	Y. Itow	Korea	1	Seoul National University, Sejong University, Korea Research Institute of standards and Science
Study in Interaction of Very High Energy Cosmic Rays by Using Relativistic Heavy Ion Collider	Y. Itow	Italy U.S.A.	2	University of Florence, Catania University Brookhaven National Laboratory
Research and Development for the Next Generation Water Cherenkov Detector, Hyper-Kamiokande	Y. Itow	U.S.A. Korea China U.K. Italy France Switzerland Spain Poland Brazil *Canada, Russia* *Portugal*	13	Boston University, Brookhaven National Laboratory, UCI, Duke University, George Mason University, Indiana University, University of Hawaii, Los Alamos National Laboratory, University of Maryland, State University of New York, University of Washington Chonnam National University, Seoul National University, Sungkyunkwan University Tsinghua University Imperial College London, Lancaster University, University of Oxford, Queen Mary University of London, University of Sheffield, Rutherford Appleton Laboratory INFN Sezione di Bari, INFN Sezione di Napoli, INFN Sezione di Padova, INFN Sezione di Roma CEA Saclay, École Polytechnique University of Bern, Swiss Federal Institute of Technology Zurich Autonomous University of Madrid University of Warsaw University of São Paulo *and other Institutions*
Study of Dark Matter and Solar Neutrinos Using a 2-phase Liquid Xenon TPC Detector	Y. Itow	Germany Italy Switzerland U.S.A Sweden Israel Portugal *France, UAE, Netherlands*	10	Max-Planck-Institut, Albert-Ludwigs-Universität Freiburg INFN, Università di Bologna University of Zurich Columbia University, University of Chicago, Purdue University, UCSD Stockholms universitet Weizmann Institute of Science Universidade de Coimbra *and other institutions*
Research on Origin of Cosmic Rays with CTA (Cherenkov Telescope Array)	H. Tajima	Germany France Italy Spain Switzerland U.K. U.S.A. *Brazil, Argentina, Poland, Armenia, Australia, Czech, Bulgaria, Croatia, Finland, Greece, Sweden Slovenia, India, Ireland, South Africa*	22	Deutsches Elektronen-Synchrotron, Max-Planck-Institut, Heidelberg University CENS, École Polytechnique, University of Paris INFN, IFSI University of Barcelona, Complutense University University of Zürich Durham University, University of Leicester, University of Leeds SLAC National Accelerator Laboratory, Argonne National Laboratory, University of Washington, Iowa State University, UCLA, UCSC, University of Chicago, Smithsonian Observatory *and other institutions*

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Research on Origin of Cosmic Rays with Fermi Satellite	H. Tajima	U.S.A. France Italy Sweden	4	Stanford University, SLAC National Accelerator Laboratory, GSFC/NASA, U.S. Naval Research Laboratory, UCSC, Sonoma State University University of Washington, Purdue University, Ohio State University, University of Denver CENS, CNRS, École Polytechnique INFN, Italian Space Agency, IFSI Royal Institute of Technology, Stockholm University
Solar Flare Research with Hard X-ray Spectral Imaging Observations	H. Tajima	U.S.A.	1	UCB, MSFC/NASA, Air Force Research Laboratory
Solar Flare Research with Gamma-ray Spectral Imaging Observations with Polarimetry	H. Tajima	U.S.A.	1	UCB, Lawrence Berkeley National Laboratory, GSFC/NASA
Study of Solar Neutrons	Y. Matsubara	Bolivia Armenia China Mexico	4	Research Institute of Physics, University of San Andrés Yerevan Physics Institute Institute of High Energy Physics, Chinese Academy of Sciences National Autonomous University of Mexico
Search for Cosmic-ray Excursions in the Past by Single-year Measurements of ^{14}C in Tree Rings	F. Miyake	U.S.A. Switzerland	2	The University of Arizona Swiss Federal Institute of Technology
A Search for Dark Objects Using the Gravitational Microlensing Effect	F. Abe	New Zealand U.S.A.	2	University of Auckland, University of Canterbury, Victoria University of Wellington, Massey University University of Maryland, NASA
Observations of Interplanetary Disturbances Using the International IPS Network	M. Tokumaru	U.K. Russia India Mexico Australia	5	LOFAR-UK Lebedev Physical Institute Tata Institute of Fundamental Research National Autonomous University of Mexico Murchison Widefield Array
Study of 3-D Solar Wind Structure and Dynamics Using Heliospheric Tomography	M. Tokumaru	U.S.A.	1	CASS/UCSD
Study on the Application of Interplanetary Scintillation Observations to Space Weather Forecast	M. Tokumaru	Korea	1	Korean Space Weather Center
Study of the Heliospheric Boundary Region Using Observations of Interplanetary Scintillation	M. Tokumaru	U.S.A.	1	Interstellar Boundary Explorer, IMAP
Research and Development of the Plasma/Particle Instrument Suite for the Mercury Magnetospheric Exploration Mission	M. Hirahara	France Sweden U.K. U.S.A. Switzerland	5	CESR-CNRS, CETP-IPSL Institute for Solar Physics of the Royal Swedish Academy of Sciences Rutherford Appleton Laboratory Boston University University of Bern
Future Satellite Mission for the Terrestrial Magnetosphere-Ionosphere-Thermosphere Explorations by Formation Flight Observations and its Feasibility Study and Collaboration of the Satellite and Ground-Based Observations	M. Hirahara	Sweden	1	Swedish Institute of Space Physics (IRF), Swedish National Space Board
Study on Science Subjects and Developmental Techniques of Observational Instruments toward Future Spacecraft Exploration Missions for the Space-Earth Coupling System	M. Hirahara	U.S.A. Canada Sweden	3	University of Colorado Boulder, UCB University of Calgary Swedish Institute of Space Physics (IRF)
VarSITI (Variability of the Sun and Its Terrestrial Impact)	K. Shiokawa	U.S.A., France, Germany, U.K., Italy, Canada, Australia, India, China, *and other countries*	9	SCOSTEP

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
High-Sensitive Imaging Measurements of Airglow and Aurora and electromagnetic waves in Canadian Arctic	K. Shiokawa	U.S.A. Canada	2	University of California, Augsburg College Virginia Polytechnic Institute and State University University of Calgary, Athabasca University
Magnetic Conjugate Observations of Midlatitude Thermospheric Disturbances	K. Shiokawa	Australia	1	Radio and Space Service/IPS
Comparison of Dynamical Variations of the Mesosphere, Thermosphere, and Ionosphere between Asian and Brazilian Longitudes	K. Shiokawa	Brazil	1	INPE
Ground and Satellite Measurements of Geospace Environment in the Far-Eastern Russia	K. Shiokawa	Russia	1	Institute of Cosmophysical Research and Radiowave Propagation, Far Eastern Branch, RAS
Observations of the Equatorial Ionosphere in South-East Asia and West Africa	K. Shiokawa	Nigeria Cote d'Ivoire	3	National Space Research and Development Agency, Federal University of Technology, Akure Université Félix Houphouët-Boigny
Observations of Waves and Particles in the Inner Magnetosphere in the Siberian Region of Russia	K. Shiokawa	Russia	1	IKFIA/SB RAS, ISTP/SB RAS
Collaborative Research and Operation in the Field of Space Weather Observations	Y. Otsuka	Indonesia	1	LAPAN
Observations and researches of ionosphere and upper atmosphere in Thailand	Y. Otsuka	Thailand	1	Chiang Mai University, King Mongkut's Institute of Technology Ladkrabang
Study of the Polar Upper Atmosphere Using the EISCAT Radars and Other Instruments	S. Nozawa	Norway Sweden, Finland, Germany, U.K., China	6	UiT The Arctic University of Norway EISCAT Scientific Association
Derivation of substorm index from low-latitude geomagnetic field data	M. Nosé	Australia Turkey Germany Spain Denmark U.S.A.	6	Geoscience Australia Boğaziçi University Ludwig-Maximilians-Universität München Universitat Ramon Llull Technical University of Denmark United States Geological Survey (USGS)
Study of the Polar/Midlatitude Ionosphere and Magnetosphere Using the SuparDARN HF Radar Network	N. Nishitani	U.S.A. U.K. France South Africa Australia Canada Italy Russia China	9	JHUAPL, Virginia Polytechnic Institute and State University University of Leicester LPC2E/CNRS University of KwaZulu-Natal La Trobe University University of Saskatchewan IFSI ISTP/SB RAS Polar Research Institute of China
SDI-3D project: Development of SDI	S. Oyama	U.S.A Finland Sweden	3	Geophysical Institute/UAF University of Oulu, Finnish Meteorological Institute, Sodankylä Geophysical Observatory, Lappeenranta-Lahti University of Technology The Swedish Institute of Space Physics (IRF), KTH Royal Institute of Technology
Study of Auroral Energetic Electron Precipitation (EEP) Impacts on the Upper/Middle Atmosphere	S. Oyama	Finland New Zealand U.K. Norway U.S.A.	5	Sodankylä Geophysical Observatory, University of Oulu, Finnish Meteorological Institute University of Otago British Antarctic Survey University Centre in Svalbard University of Alaska Fairbanks
Study of aerosols and armospheric trace gases by using SAVER-Net observation network in South America	A. Mizuno	Argentina Chile	3	CEILAP, Servicio Meteorológico Nacional Argentina University of Magallanes (UMAG), Dirección Meteorológica de Chile

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
		Bolivia		University of La Frontera, Universidad Mayor de San Andrés
High Energy Particles in Geospace: the Acceleration Mechanism and the Role in Earth's Climate	A. Mizuno	U.S.A. Norway Sweden	3	University of Colorado Boulder, UCLA, University of Arizona UiT The Arctic University of Norway EISCAT Scientific Association
Source Apportionment of Organic Aerosols in Beijing	M. Mochida	China	1	Tianjin University
Characterizing Organics and Aerosol Loading over Australia (COALA)	M. Mochida S. Ohata	Australia U.S.A. U.K	3	University of Wollongong, CSIRO, ANSTO, NSW Department of Planning, Industry, and Environment Georgia Institute of Technology, UCI Lancaster University
Tropical Rainfall Measuring Mission	N. Takahashi	U.S.A.	1	NASA
Global Precipitation Measurement Mission (GPM)	H. Masunaga N. Takahashi	U.S.A.	1	NASA
Tropical Cyclones-Pacific Asian Research Campaign for Improvement of Intensity Estimations/Forecasts (T-PARCII)	K. Tsuboki T. Shinoda	Taiwan	1	National Taiwan University Atmospheric Sciences
Advanced Study on Precipitation Enhancement in Arid and Semi-Arid Regions	M. Murakami	United Arab Emirates	1	National Centre of Meteorology, Khalifa University
Study on tropical convective-radiative interactions	H. Masunaga	France	1	Laboratoire de Meteorology Dynamique/CNRS
Study on tropical-subtropical atmospheric dynamics	H. Masunaga	U.S.A.	1	University of Miami
Observatoinal study on convective self-aggregation	H. Masunaga	U.K.	1	University of Reading
Aircraft observation of aerosols and clouds in the Arctic	S. Ohata	Germany	1	Alfred Wegener Institute for Polar and Marine Research
Long-term observation of black carbon aerosols in the Arctic	S. Ohata	Norway U.S.A Canada Russia	4	Norwegian Polar Institute National Oceanic and Atmospheric Administration Government of Canada Arctic and Antarctic Research Institute
Continuous Observation of Methane at a Paddy Field in Northern India	Y. Matsumi	India	1	University of Delhi
Observation of PM2.5 in Hanoi	Y. Matsumi	Vietnam	1	Hanoi University of Science and Technology
Observation of PM2.5 in Ulan Bator	Y. Matsumi	Mongolia	1	National University of Mongolia
Validation of GOCI Products and Application to Environmental Monitoring of Japanese Coastal Waters	J. Ishizuka	Korea	1	Korea Institute of Ocean Science and Technology
Collection of Validation Dataset of GCOM-C Coastal Products	J. Ishizaka	Korea U.S.A. Taiwan Thailand China Estonia	6	Korea Institute of Ocean Science and Technology Columbia University, East Carolina University National Cheng Kung University Burapha University First Institute of Oceanography, Nanjing, University of Science and Technology University of Tartu
Sea Surface Nitrate and Nitrate Based New Production - two innovative research products from SGLI on board GCOM-C	J. Ishizaka	U.S.A.	1	Columbia University
Validation of ocean color products in the western North Pacific and Japanese coastal waters: Collaboration with JAXA GCOM-C project	J. Ishizaka	Member States of EUMETSAT: Germany, UK, France, Italy, Spain, Netherlands *and others countries*	30	European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Investigating the optical characteristics of red tides in the upper Gulf of Thailand	J. Ishizaka	Thailand	1	University of Burapa, Kasetsart University
Integrated Land Ecosystem - Atmosphere Processes Study (iLEAPS), one of the Global Research Projects (GRPs) of the Future Earth	T. Hiyama	U.K., India, Finland, New Zealand, China, Koria *and others countries*	6	iLEAPS/Future Earth
Observational Study of Vegetation, Energy and Water in Eastern Siberia Towards Elucidation of Climate and Carbon Cycle Changes	T. Hiyama	Russia	1	Institute for Biological Problems of Cryolithozone /SB RAS
Arctic Challenge for Sustainability (ArCS) Project	T. Hiyama	U.S.A.	1	International Arctic Research Center of the University of Alaska Fairbanks (IARC)
Estimating Permafrost Groundwater age in Central Mongolia	T. Hiyama	Mongol	1	Institute of Geography and Geoecology of the Mongolian Academy of Sciences
Study of methane flux observation in Eastern Siberia and the obtained data analysis	T. Hiyama	Russia	1	Institute for Natural Science, North Eastern Federal University
Study of Equatorial Waves in the Atmosphere and Ocean	H. Aiki	Germany	1	GEOMAR Helmholtz Centre for Ocean Research Kiel
An international study on precipitation variability in high-altitude areas of the Himalayas in Nepal	H.Fujinami	Nepal	1	Kathmandu University, Nepal Academy of Science and Tecnology, International Centre for Integrated Mountain Development
Asian Precipitation Experiment (AsiaPEX)	H.Fujinami	India Nepal China Korea Bangladesh	5	India Meteorological Department, Indian Institute of Tropical Meteorology, University of Rajasthan International Centre for Integrated Mountain Development, Nepal Academy of Science and Tecnology, Kathmandu University Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Tsinghua University Pusan National University *and other institutions*
Climate change reconstruction of the Central Highlands in Vietnam	H. Kitagawa	Vietnam	1	Vietnam Academy of Science and Technology
International Continental Scientific Drilling Program - Dead Sea Deep Drilling Project （ICDP-DSDDP)	H. Kitagawa	Israel U.S.A Germany Switzerland	3	Geological Survey of Israel, Hebrew University of Jerusalem Columbia University, University of Minnesota GFZ Helmholtz Centre Potsdam, Max-Planck-Institute Mainz for Chemistry Université de Genève
Study of Grand-Water Circulation Based on ^{14}C Ages of Underground Water and Hot-Spring Water Samples from Korea	M. Minami	Korea	1	Korea Institute of Geoscience and Mineral Resources (KIGAM)
Climate reconstruction using travertine from Takht-e-Soleyman area in Kurdistan, Iran	M. Minami	Iran	1	University of Kurdistan
Geochronological Research on the Basement Rocks in Japan and Korea	T. Kato	Korea	1	Korea Institute of Geoscience and Mineral Resources (KIGAM)
Development of New Analytical Techniques and Accurate Quantification of Electron Microprobe Analysis	T. Kato	Korea	1	Pusan National University (PNU)
International Ocean Discovery Program (IODP) Expedition 379: Amundsen Sea West Antarctic Ice Sheet History	M. Yamane	U.S.A	10	University of Houston, Texas A&M University, Appalachian State University, U.S. Army Engineer Research and Development Center, The University of Massachusetts, University of South Florida, Montclair State University,

Research Project	ISEE Representative	Collaborating Country/Region	Collaborating Organization
			University of Florida, Northern Illinois University, Colorado College
		Germany	Alfred Wegener Institute for Polar and Marine Research, Christian-Albrechts-Universität zu Kiel, Universität Bremen, Museum für Naturkunde
		U.K.	University of Southampton, University of Birmingham, British Antarctic Survey
		France	Université de Perpignan
		Sweden	Stockholms universitet
		Norway	UiT The Arctic University of Norway
		China	China University of Geosciences, Tongji University
		Korea	Korea Insti- tute of Geoscience & Mineral. Resources
		India	National Centre for Antarctic and. Ocean Research
		New Zealand	GNS Science

Visitors from Foreign Institutes

(April 1, 2019–March 31, 2020)

Country/Region			
Asia （8）	India	22	106
	Indonesia	4	
	Korea	19	
	Singapore	3	
	Taiwan	5	
	China	49	
	Nepal	3	
	Bangladesh	1	
North America （2）	Canada	4	103
	USA	99	
Latin America and the Caribbean （4）	Argentina	1	4
	Jamaica	1	
	Brazil	1	
	Peru	1	
Europe（17）（Including New Independent States）	Italy	2	102
	England	23	
	Austria	1	
	Croatia	1	
	Switzerland	6	
	Sweden	3	
	Spain	2	
	Czech	14	
	Germany	14	
	Norway	11	
	Hungary	2	
	Finland	5	
	France	4	
	Bulgaria	2	
	Belgium	3	
	Poland	2	
	Russia	7	
Oceania（2）	Australia	6	8
	New Zealand	2	
Middle East （2）	Israel	1	2
	Iran	1	
Africa（1）	Nigeria	1	1
Total	31	326	

Funding Source	
Government-funding	52
Nagoya University	74
Self-funding	184
Others	16
Total	326

Purpose	
Academic Conference, Symposium	246
Joint Research	62
Training	2
Others	16
Total	326

Seminars by Foreign Visitors

(34 in total)

Date	Name	Affiliation	Title	Number of Participant
April 4, 2019	Vania Jordanova✱	Los Alamos National Laboratory, USA	46th ISEE/CICR colloquium/ Geomagnetic Storms: New Insights from Multi-Spacecraft Observations and Self-Consistent Simulations	21
April 19, 2019	Ava Maxam	Coastal Dynamics Modelling Laboratory, Mona GeoInformatics Institute, University of the West Indies, Jamaica	Special Seminar/ Coastal modeling studies of Mona GeoInformatics Institute, the University of the West Indies, Jamaica	10
April 23, 2019	Lynn M. Kistler✱	University of New Hampshire, USA	47th ISEE/CICR colloquium/ The Development of the Storm-Time Ring Current, and Its Effects on Wave Generation	31
June 14, 2019	Jing Chen	Kyoto University/ Prof. at Indian Institute of Geomagnetism, India	48th ISEE/CICR colloquium/ Kinetic Alfvén waves in space plasmas	12
June 18, 2019	Satyavir Singh	Nanyang Technological University, Singapore	49th ISEE/CICR colloquium/ Atmospheric processing promotes the water uptake by organic-rich biomass burning particles in Southeast Asia	10
June 26, 2019	Rangaiah Kariyappa✱	Indian Institute of Astrophysics, India	50th ISEE/CICR colloquium/ Coronal & Photospheric Magnetic Features from Spatially Resolved Images to Understand EUV & UV Solar Irradiance Variability & their impacts on Earth's Climate and Space Weather	17
July 3, 2019	Linda Sugiyama	MIT, USA	Special Seminar/ Coronal loop model and ideal MHD quasi-interchange model	17
July 4, 2019	Boris Kozelov	Polar Geophysical Institute, Russia	Japan-Russia bilateral project seminar/ Information about ionosphere-magnetosphere plasma: extracting from optical and VLF observations	10
July 4, 2019	Andrei Demekhov	Polar Geophysical Institute, Russia	Japan-Russia bilateral project seminar/ Comparison of spacecraft data on quasi-periodic VLF emissions with the flow cyclotron maser model	10
July 18, 2019	Stephen Playfer✱	University of Edinburgh, UK	51th ISEE/CICR colloquium/ Hyper-Kamiokande & the future of neutrino physics	11
July 18, 2019	K. D. Leka✱	Senior Research Scientist at NorthWest Research Associates, USA	52th ISEE/CICR colloquium/ Results from the ISEE/CICR Workshop, "Benchmarks for Operational Flare Forecasting" and Future Prospects	19
August 7, 2019	J.-P. St-Maurice✱	University of Saskatchewan, Canada/ University of Western Ontario, Canada	Special Seminar/ What are STEVE?	20
August 29, 2019	Vanessa Polito	Lockheed Martin Solar and Astrophysics Laboratory, USA	Solar Seminar/ UV spectroscopy of solar flares: some recent insights from IRIS and EIS	7
September 19, 2019	J.-P. St-Maurice✱	University of Saskatchewan, Canada/ University of Western Ontario, Canada	53th ISEE/CICR colloquium/ E region phenomena and what they reveal about ionospheric processes	14
September 24, 2019	Mariko Oue	Stony Brook University, USA	54th ISEE/CICR colloquium/ Ka-band Radar Polarimetric and Doppler Spectrum Measurements for Snowbands Along the U.S. Northeast Coast	22
September 25, 2019	Seth Claudepierre	Aerospace Corporation & UCLA, USA	55th ISEE/CICR colloquium/ Empirically estimated electron lifetimes in the Earth’s radiation belts	15

Date	Name	Affiliation	Title	Number of Participant
October 3, 2019	Abraham Chian✱	University of Adelaide, Australia/ National Institute for Space Research (INPE), Brazil	56th ISEE/CICR colloquium/ Nonlinear Dynamics of Space-Earth Environment	25
October 17, 2019	Gilda de Lourdes Gonzalez✱	National University of Tucuman, Argentina	Division for Ionospheric and Magnetospheric Research Seminar/ Ionospheric studies in Tucumn - Argentina	34
October 17, 2019	Artem Yu Gololobov✱	North-Eastern Federal University, Russia	Division for Ionospheric and Magnetospheric Research Seminar/ Conjugate measurements of the SAR-arc detachment from the auroral oval using DMSP satellites and an all-sky camera at Athabasca, Canada	34
October 23, 2019	Samuel Krucker✱	University of Applied Sciences Northwestern Switzerland, Switzerland/ Space Science Laboratory, University of California, Berkeley, USA	57th ISEE/CICR colloquium/ Solar X-ray Observations with NuSTAR	15
October 30, 2019	Baolin Tan	National Astronomical Observatories of China, China	58th ISEE/CICR colloquium/ Radio precursors of solar flare	15
October 31, 2019	Edith Liliana Macotela Cruz	University of Oulu	Division for Ionospheric and Magnetospheric Research Seminar/ Disturbances Obseved in the VLF signal propagate in the Earth-ionosphere waveguide	37
October 31, 2019	Ram Singh✱	Indian Institute of Geomagnetism, India	Division for Ionospheric and Magnetospheric Research Seminar/ Prompt penetration and Disturbance dynamo electric and their impact on equatorial and low latitude ionosphere	37
November 6, 2019	Abraham Chian✱	University of Adelaide, Australia/ National Institute for Space Research (INPE), Brazil	Solar Seminar/ Magnetic reconnection and intermittent turbulence in solar corona and solar wind	8
November 14, 2019	Abraham Chain✱	University of Adelaide, Australia/ National Institute for Space Research (INPE), Brazil	Division for Ionospheric and Magnetospheric Research Seminar/ Role of pre-reversal enhancement in the generation of equatorial plasma bubble using observation and model simulations	36
November 15, 2019	Aaron Hendry	Czech Academy of Science	Special Seminar/ EMIC-driven sub-MeV electron precipitation: evidence, theory, and future research	12
November 20, 2019	Stanislav Gunar	Astronomical Institute of the Czech Academy of Sciences	Solar Seminar/ Modelling of entire prominences with their multiple fine structures: the 3D Whole-Prominence Fine Structure models	18
January 9, 2020	Viswanathan Lakshmi Narayanan✱	The Arctic University of Norway, Norway	Division for Ionospheric and Magnetospheric Research Seminar/ A discussion of midlatitude ionospheric instabilities and associated spread F	36
January 9, 2020	Tulasiram Sudarsanam✱	Indian Institute of Geomagnetism, India	Division for Ionospheric and Magnetospheric Research Seminar/ A new Artificial Neural Network based 3D Ionospheric Model (ANNIM-3D) - Discussion	36
January 31, 2020	D. Knipp	University of Colorado, Boulder	59th ISEE/CICR colloquium/ Reconstructing Large Scale Field Aligned Currents from Short Segments of AMPERE Data	20
February 6, 2020	Iskhaq Iskandar	University of Sriwijaya, Palembang, South Sumatera, Indonesia	60th ISEE/CICR colloquium/ Recent Progress on the Study of Satellite-Observed Surface Chlorophyll-a Variability within the Indonesian Waters and Its Relation to Physical Environmental Changes	14
February 20, 2020	Hiroatsu Sato✱	German Aerospace Center, Germany	Division for Ionospheric and Magnetospheric Research Seminar/ Recent advances in ionospheric density imaging with spaceborne synthetic aperture radar	27

Date	Name	Affiliation	Title	Number of Participant
February 20, 2020	Matthias Förster	GFZ German Research Centre for Geosciences, Germany / Max-Planck-Institute for Solar System Research (MPS), Germany	61st ISEE/CICR colloquium/ Symmetries and asymmetries of the Earth's magnetic field and their implications for the magnetosphere-ionosphere-thermosphere (M-I-T) coupling	15
February 25, 2020	S. Gupta	Tata, India	Seminar on STP topics at Grape-3 air shower experiment/ "STP topics at Grape-3 air shower experiment	10

＊ Foreign Visiting Staff

＜Abbreviations＞

ANSTO	Australia Nuclear Sience and Technology Organization
CNES	Centre National D'Etudes Spatiales
CNRS: CESR: LPC2E:	Centre National de la Recherche Scientifique Centre d'Etude Spatiale des Rayonnements Laboratoire de Physique et Chimie de l’Environnement et de l’Espace
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EISCAT:	European Incoherent Scatter Scientific Association
IBEX:	Interstellar Boundary Explorer
IFSI:	Istituto di Fisica dello Spazio Interplanetario
IMAP:	Interstellar Mapping and Acceleration Probe
INFN:	Istituto Nazionale di Fisica Nucleare
RAS:	Russian Academy of Sciences
IPS:	Ionospheric Prediction Services
IPSL: CETP:	Institut Pierre-Simon Laplace Centre d'étude des environnements terrestres et planétaires
JHUAPL:	Johns Hopkins University Applied Physics Laboratory
KASI:	Korea Astronomy and Space Science Institute
LAPAN:	Lembaga Penerbangan dan Antariksa Nasional, National Institute of Aeronautics and Space
LOFAR:	Low Frequency Array
MWA:	Murchison Widefield Array
NASA: CCMC: GSFC: HPDE MSFC: SDAC: SPASE: SPDF:	National Aeronautics and Space Administration Community Coordinated Modeling Center Goddard Space Flight Center High Performance Driving Education Marshall Space Flight Center Solar Data Analysis Center Space Physics Archive Search and Extract Space Physics Data Facility
SCOSTEP:	Scientific Committee on Solar Terrestrial Physics
SLAC:	Stanford Linear Accelerator Center
UCB:	University of California, Berkeley
UCI:	University of California, Irvine
UCLA:	University of California, Los Angeles
UCSC:	University of California, Santa Cruz
UCSD: CASS:	University of California, San Diego Center for Astrophysics and Space Sciences
UiT:	University of Tromsø

12. Outreach

Public Lectures, Open Labs, and School Visits

ISEE members contributed to public education through 22 lecture visits, three public lectures at Nagoya University, two open laboratory events, two public laboratory demonstrations, one field trip for children, six high-school student visits, three summer internship programs, and three training courses for young researchers.

ISEE held open laboratory sessions and special lectures for the public on June 15 and 16 during the 2019 Nagoya University Festival, and a half-day public lecture meeting on October 19, 2019 during the 2019 Nagoya University Home Coming Day 2019.

ISEE and the former STEL have maintained a close relationship with the town of Rikubetsu in Hokkaido since 2003. Public lectures were held on November 8, 2019 at Rikubetsu Elementary School and Rikubetsu Junior High School. Public laboratory demonstrations were presented on November 9, 2019 at the Rikubetsu Space Earth Science Museum.

ISEE distributes a series of booklets that answer 50 questions on various topics, as well as informative comic books related to space–Earth subjects for the public.

An English version of the video introducing ISEE for young students and the public was produced, and is available on the ISEE website (http://www.isee.nagoya-u.ac.jp/).

The ISEE website continues to publish the most up-to-date activities and outcomes of laboratory science to the public. The digitized booklet series can also be browsed at this site.

Public lecture on the ISEE open laboratory (June 15, 2019).

Addresses of Facilities

Location		Name	Address	TEL/FAX
Nagoya	①	ISEE Research Institutes Buildings I/II	Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8601	TEL:+81-52-747-6303 FAX:+81-52-747-6313
Toyokawa	②	Toyokawa Branch	3-13 Honohara, Toyokawa-shi, Aichi 442-8507	TEL:+81-533-89-5206 FAX:+81-533-86-3154
Hokkaido	③	Moshiri Observatory	Moshiri, Horokanai, Uryu, Hokkaido 074-0741	TEL:+81-165-38-2345 FAX:+81-165-38-2345
	④	Rikubetsu Observatory	Uenbetsu, Rikubetsu-cho, Ashoro-gun, Hokkaido 089-4301	TEL:+81-156-27-8103
			58-1, 78-1, 78-5, 129-1, 129-4 Pontomamu, Rikubetsu-cho, Ashoro-gun, Hokkaido 089-4300	TEL:+81-156-27-4011
Yamanashi	⑤	Fuji Observatory	1347-2 Fujigane, Fujikawaguchiko-machi, Minamitsuru-gun, Yamanashi 401-0338	TEL:+81-555-89-2829
Kagoshima	⑥	Kagoshima Observatory	3860-1 ShimoHonjo Honjo, Tarumizu-shi, Kagoshima 891-2112	TEL:+81-994-32-0730