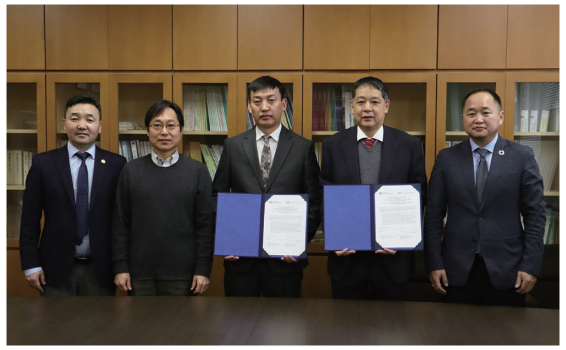
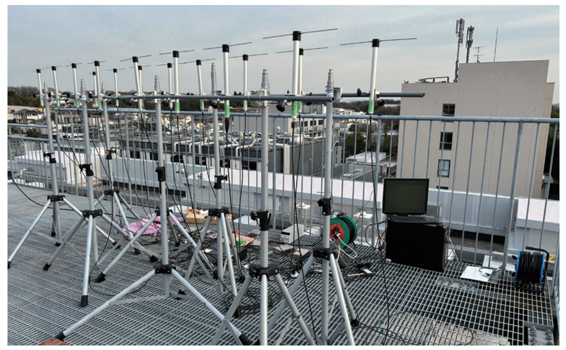


ISEE signed a Memorandum of Understanding (MOU) with Institute of Geography and Geoecology (IGG), Mongolia on March 6, 2024.

Korea-Japan Space Weather Workshop 2023 held at Nagoya University

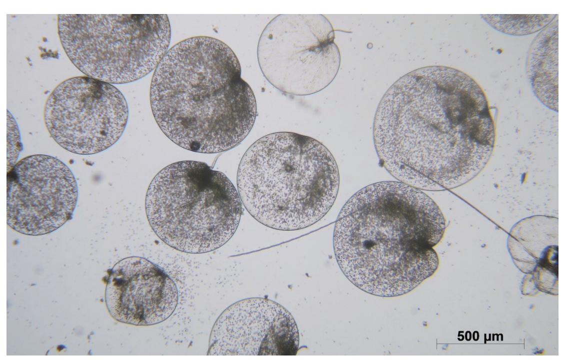
Photo from International cosmic ray conference (ICRC 2024). More than 1000 participants joined this conference to have exciting discussion about the new results of cosmic-ray studies.



Testing a prototype of the next-generation IPS observation instruments

Low-latitude auroras detected by Rikubetsu/Moshiri optical instruments and radar

Arctic aerosol sampling by the two samplers in Ny-Ålesund, Norway, in summer



Single cells of green *Noctiluca scintillans* with autotrophic endosymbionts*Protoeuglena noctilucae* , forming a bloom, collected in the Upper Gulf of Thailand on July 3, 2023

2023 ISEE Summer Experiential Learning Program: Children using hammers to break rocks at the Hanagaki Mine site in Shinshiro City

Institute for Space–Earth Environmental Research, Nagoya University

Address: Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8601, Japan
TEL: +81-52-747-6303, FAX: +81-52-747-6313, WEB: https://www.isee.nagoya-u.ac.jp/en/

Edited by Public Relations and Outreach Committee, Institute for Space–Earth Environmental Research, Nagoya University
Published in Sptember 2024

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

Institute for Space–Earth Environmental Research, Nagoya University Annual Report FY2023

ISEE

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

FY2023

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

Institute for
Space–Earth Environmental Research

April 2023–March 2024

Foreword

Our mission is
to clarify the mechanisms and relationships
between the Earth, the Sun, and cosmic space,
considering it as a seamless system.

The Institute for Space-Earth Environmental Research (ISEE) was established in October 2015. Since then, ISEE has acted as a joint usage/research center assigned by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT). ISEE received an “S” rating (highest rating) from MEXT in the term-end evaluation of its 3rd six-year term of 2016–2021 as a joint usage/research center. It was again approved as a joint usage/research center during the 4th six-year term of 2022–2027 by MEXT. In addition to continuing the previous 12 joint research categories, we have newly introduced five categories, mainly considering to support students and early-career scientists, as follows: “Aircraft Observation (Dropsonde),” “International Field Observation and Experiment for Young Scientists,” “International Technical Exchange,” “International School Support,” and “International Research Travel Support for Young Scientists.”

In addition, ISEE has strengthened interdisciplinary research during the 4th six-year term. The mission of ISEE is to comprehend the Earth, Sun, and universe as one system and elucidate the mechanisms and interactions of diverse phenomena that occur there. Therefore, we have promoted activities to cultivate new research by fusing diverse fields related to the Space-Earth environment. We newly established the Office for the Development of Interdisciplinary Research Strategy (ODIRS) in August 2022 to promote the development of integrated research in diverse fields. In 2023, we started ten interdisciplinary research projects in collaboration with other faculties and institutes at Nagoya University and Gifu University under the Tokai National Higher Education and Research System.

In these ten projects, in addition to collaborating with Space and Earth science, we initiated new interdisciplinary research of humanities and sciences, such as humanities and social sciences research using satellite images of the Earth, and developing methods of database construction in collaboration with university libraries.

We have also begun four new interdisciplinary research projects since 2022 based on a proposal from young faculty members of the ISEE. For example, Associate Professor Naoyuki Kurita et al. ran the project, "Assessment of the effects of climate restoration and space environment changes based on ice core analysis in the Eastern Antarctic ice sheet." This project focuses on the fact that changes in solar activity affect the cosmic radiation dose to the Earth and change the amount of cosmic-ray-producing nuclides (^{10}Be and HTO) in the stratosphere and upper troposphere. This project participates in Antarctic observations to collect snow and ice core samples and introduces numerical simulations used in the field of global climatology to clarify the effects of climate change, as well as develop a method to more accurately elucidate past solar activity variations. This research is an interdisciplinary study that combines solar and cosmic ray physics with Earth's climatology.

Several outstanding scientific findings emerged in 2023. For example, in a joint research project led by Prof. Lynn Kistler and Prof. Yoshizumi Miyoshi, we discovered that the number of ions originating from the Earth's atmosphere increased during space storms. Therefore, we need to reconsider our understanding of the solar-terrestrial coupling process, in which space storms develop not only from the Sun but also from the ions originating from the Earth's atmosphere. For these and other achievements, Professor Kistler received the Van Allen Lecture Award from the American Geophysical Union in December 2023. The research, led by Designated Assistant Professor Hisashi Hayakawa, in collaboration with 13 overseas institutions, identified sunspot groups that may have caused the 1872 solar storm by reviewing several hundred contemporaneous documents in various languages. They found that the scale of the magnetic storm and expansion of the aurora were comparable to or greater than those of the largest solar storm in history. These results have been reported worldwide in the Washington Post, Forbes, and Newsweek.

The COVID-19 influence was nearly eradicated by 2023. The activity of the 25th solar cycle reached its maximum, and severe space storms occurred. In modern society, the potential risk of space-weather disasters is increasing. As global warming continues, environmental changes and severe disasters are increasing. Therefore, the role of the ISEE, which contributes to the solution of global environmental problems and the development of human society in space, is even more significant. We wish to cooperate with collaborators in Japan and worldwide to develop further research activities that will open up the future. I hope this annual report will provide you with an understanding of ISEE activities in 2023. Thank you for your valuable support.

Kazuo Shiokawa
Director

ISEE Award ceremony and commemorative lecture were held on December 18, 2023.

The 5 th ISEE Award

Aiming to develop space–Earth environmental research, promote interdisciplinary research, and explore this new research discipline, the ISEE presents an award for prominent research activity based on the ISEE Joint Research Program.

The fifth ISEE Award was awarded to Dr. Goes, Joaquim Ignacio (Lamont Research Professor, Lamont Doherty Earth Observatory at Columbia University) and Gomes, Maria Fatima Helga do Rosário (Research Scientist, Lamont Doherty Earth Observatory at Columbia University) heir outstanding contribution to space-Earth environmental research through the study on interaction of climate change/material cycle and phytoplankton. The award ceremony and commemorative lecture were held as follows:

Date: December 18, 2023
Venue: Sakata and Hirata Hall (Naogoya University)
Title; Harnessing the Power of Earth Observations for Ocean Ecosystem Monitoring and Resource Management under Climate Change

ISEE Award 2023

Dr. J. I. Goes

Dr. H. do R. Gomes

Winners:,
Dr. Goes, Joaquim Ignacio, Lamont Research Professor
Dr. Gomes, Maria Fatima Helga do Rosário, Research Scientist

Affiliation: Lamont Doherty Earth Observatory, Columbia University, USA

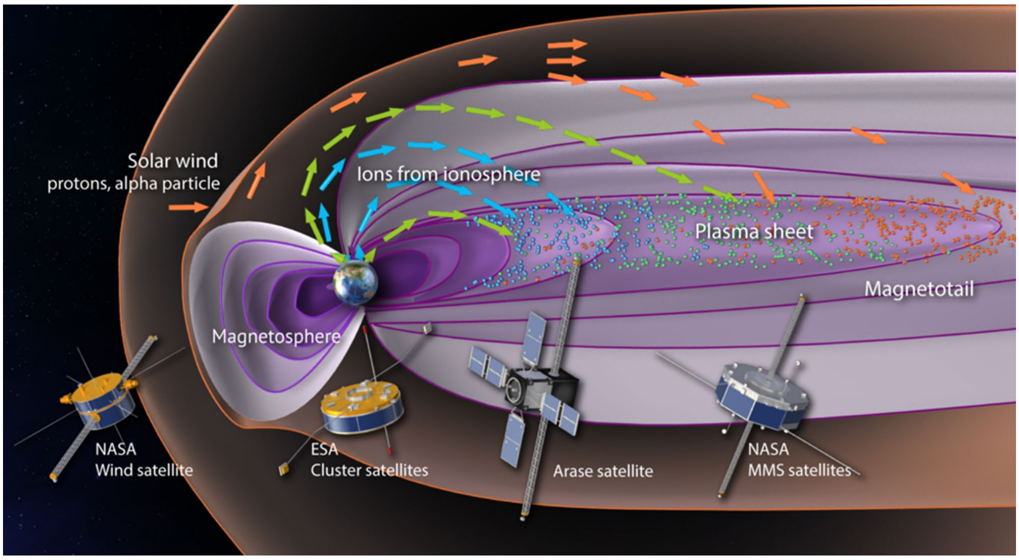
Title: Outstanding contribution to space-earth environmental research through the study on interaction of climate change/material cycle and phytoplankton

Citation: Dr. Goes and Dr. Gomes are leading experts in the study of phytoplankton dynamics and its impact on marine ecosystem health and biodiversity using satellite remote sensing. They are promoting international research that contributes to the elucidation of changes in marine primary production by phytoplankton and the assessment of its impact on material cycles. They have also conducted joint research with researchers and graduate students under the Institute's cooperative research and use programs and have made outstanding contributions to space and earth environment research.

Career summary of the award winners:

Dr. Goes, Joaquim Ignacio: Received Doctoral degree in Nagoya University on 1990. PD fellow in Institute for Hydropsheric-Atmoshperic Sciences of Nagoya University, on 1997-1999. After research at Bigelow Laboratory for Ocean Sciences, US, from 2010 to the present, Lamont Research Professor at the Lamont-Doherty Earth Observatory, Columbia University.

Dr. Gomes, Maria Fatima Helga do Rosário: Received Ph.D. degree from Bombay University on 1987. Researcher in Institute for Hydrospheric-Atmospheric Sciences, Nagoya University, on 1992-1998. After research positions at Soka University and the Bigelow Laboratory for Ocean Sciences in USA, she has been a Research Scientist at Lamont-Doherty Earth Observatory, Columbia University from 2010 onwards.



Development of Geomagnetic Storms Driven by Terrestrial-Origin Plasma

Through international collaborative research, Professor Lynn Kistler of the CICR, ISEE (cross-appointed with the University of New Hampshire, USA), Professor Yoshizumi Miyoshi, and Designated Associate Professor Tomoaki Hori of the CIDAS, ISEE discovered that geomagnetic storms are primarily caused by terrestrial-origin plasma rather than solar-origin plasma, as considered previously. This discovery was made using observation data from the Arase and US and European scientific satellites.

The research team analyzed data from a total of four scientific satellites and successfully discriminated the composition of solar-origin and terrestrial-origin plasma in near-Earth space (geospace) for the first time. They also identified that during the development of geomagnetic storms, terrestrial-origin hydrogen ions are initially dominant, followed by terrestrial-origin oxygen ions. This indicates that both solar- and terrestrial-origin ions influence the development of geomagnetic storms. This study demonstrates that to understand and predict the changes in the space environment owing to geomagnetic storms, it is essential to accurately understand the behavior of plasma from the Earth as well as from the Sun. This finding indicates a significant shift in the understanding of geomagnetic storms.

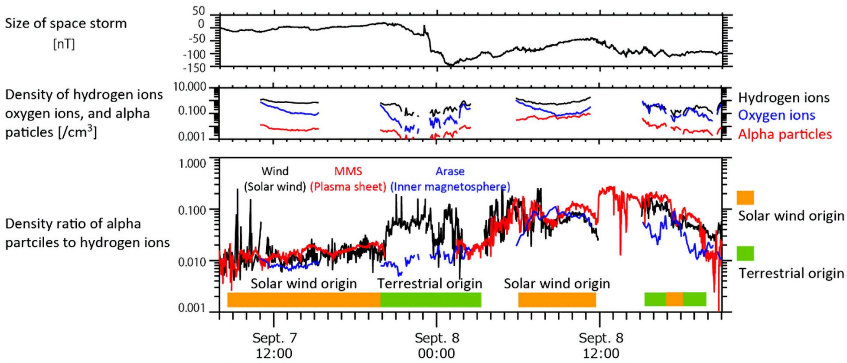


Fig.1: The Dst Index showing the magnitude of space storm (in nT: nanoteslas). The larger the move toward negative values, the stronger the space storm. The space storm is at its strongest at approximately 01:00 UT on September 8. (Middle) Densities of hydrogen ions, oxygen ions, and alpha particles measured in the inner magnetosphere by the Arase satellite. Prior to the space storm, the quantity of hydrogen ions (black lines) is high, but as the storm progresses, the quantity of oxygen ions (blue) exceeds that of hydrogen ions. Measurement results of the ratio of alpha particles to hydrogen ions in the solar wind (black), plasma sheet (red), and inner magnetosphere (blue). The overlaps with the black line indicate measurement points of the solar-origin plasma, whereas the deviations from the line indicate the measurement points of Earth-origin plasma. Until 20:00 UT on September 7, the plasma in the inner magnetosphere mainly originated from the solar wind. However, after that, as the space storm developed, the plasma predominantly originated from the terrestrial region.

Paper information

Journal: *Nat. Commun.*, 14, 6143, 2023
Authors: Kistler, L. M., K. Asamura, S. Kasahara, Y. Miyoshi, C. Mouikis, K. Keika, S. Petrinec, M. Stevens, T. Hori, S. Yokota, and I. Shinohara
Title: The variable source of the plasma sheet during a geomagnetic storm

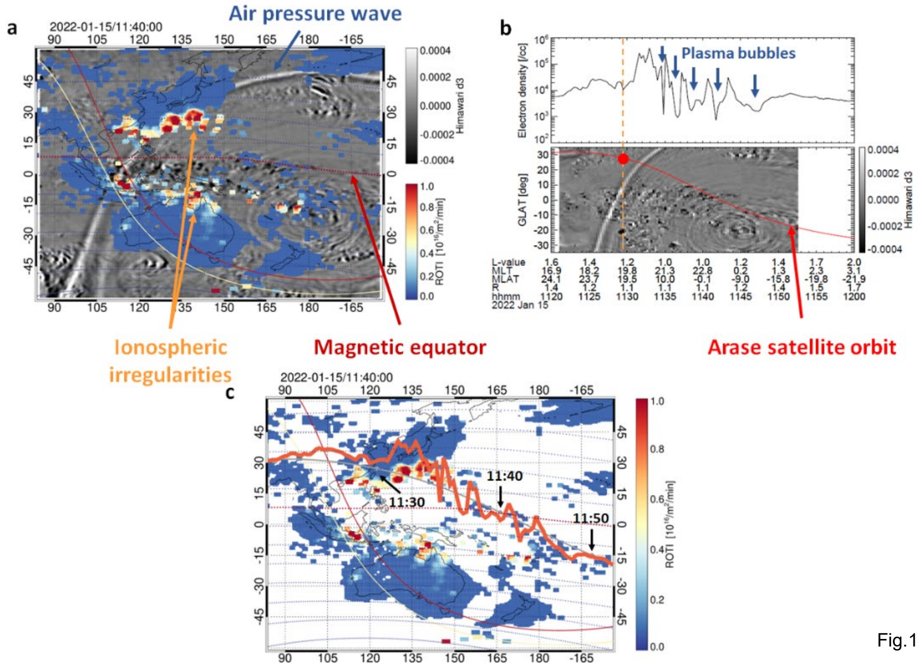


Fig.1

Ionospheric Halls (plasma bubbles) after the Tonga Volcanic Eruption Obtained via GNSS-TEC and Arase Observations

A research group led by Designated Assistant Professor Atsuki Shinbori from the Center for Integrated Data Science found that a hole in the ionosphere (plasma bubble) was created by a pressure wave generated by the explosive eruption of an undersea volcano off the coast of Tonga in the South Pacific Ocean, based on analysis of GNSS-total electron count (TEC) and electron density data obtained from the Exploration of energization and Radiation in Geospace satellite "Arase," and elucidated the generation mechanism of the plasma bubble owing to the volcanic eruption.

Ionospheric disturbances are known to occur in the vicinity of volcanic eruptions. The explosive eruption of a submarine volcano, which occurs once every 1000 years, in the South Pacific Ocean off the coast of Tonga in January 2022 resulted in the generation of plasma bubbles over the Pacific Ocean. We conducted an integrated analysis of GNSS-TEC, meteorological-satellite, and Arase observation data to elucidate the generation mechanism of plasma bubbles. We found that the plasma bubble was generated by the increasing altitude of the ionosphere owing to the air-pressure waves triggered by the volcanic eruption. Furthermore, direct observations by the Arase satellite revealed that the plasma bubble extended into space up to an altitude of 2000 km. These results are significant in that they elucidate how plasma bubbles that cause radio interferences can be attributed not only to solar activity but also to phenomena occurring on the Earth's surface.

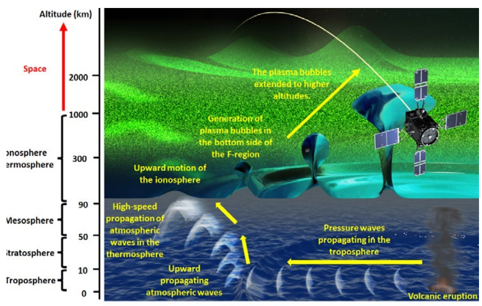


Fig.2

Paper Information

Journal: *Sci Rep*, 13, 6450, 2023

Authors: Shinbori, A., T. Sori, Y. Otsuka, M. Nishioka, S. Perwitasari, T. Tsuda, A. Kumamoto, F. Tsuchiya, S. Matsuda, Y. Kasahara, A. Matsuoka, S. Nakamura, Y. Miyoshi, and I. Shinohara

Title: Generation of equatorial plasma bubble after the 2022 Tonga volcanic eruption

DOI: 10.1038/s41598-023-33603-3

Fig.1: Two-dimensional map showing the ionospheric irregularities and air-pressure waves observed by the GNSS-TEC, Himawari meteorological satellite, and Arase satellite. TEC and brightness temperature variations are indicated in color and grayscale, respectively.

Fig.2: Schematic showing the mechanism of plasma-bubble generation observed after the Tonga volcano eruption.

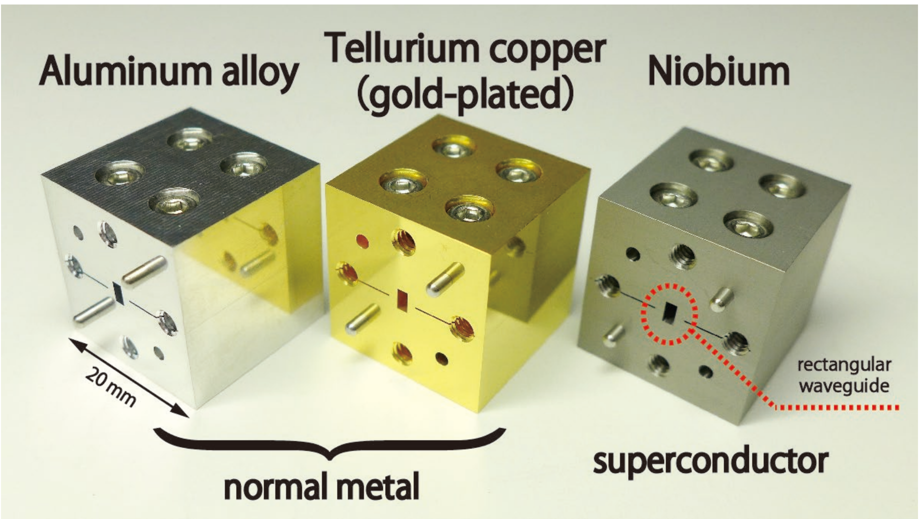


Fig.1

Superconducting Waveguide Achieves Ultra-Low-Loss Propagation

A team of researchers made a breakthrough discovery for high-frequency radio-wave transmission. Taku Nakajima (Assistant Professor, ISEE) and Kazuji Suzuki (Technical Assistant, ISEE) of Nagoya University, along with their collaborators, created a waveguide of niobium that reduced the transition losses in millimeter-wave signals.

The frequency of data waves has continued to increase as next-generation communication technologies Beyond5G/6G have been developed. Although the currently employed metal transmission lines can handle the millimeter/sub-millimeter (sub-terahertz) bands, studies have focused on superconducting metals such as niobium, which incur lower transmission losses and can handle higher frequencies. Nakajima et al. evaluated the use of niobium in a waveguide, which is a 3D transmission line comprising a metal tube that guides and confines waves along a specific path, thereby minimizing losses owing to radiation and absorption. They found that conductivity improved as the temperature of the metal was reduced, resulting in lower circuit losses. The conductivity of niobium in the superconducting state is 1000–10000 times higher than that of aluminum alloys. Furthermore, the transmission loss of niobium in the superconducting state was calculated to be several tenths that of other metals. These two factors contribute to a high-quality, high-precision communication environment. The results of this study can be employed to develop an unprecedented ultrasensitive receiving system for radio telescope receivers aimed at astronomical observations, where waveguide circuits are widely used, as well as for environmental measurement equipment for the Earth's atmosphere.

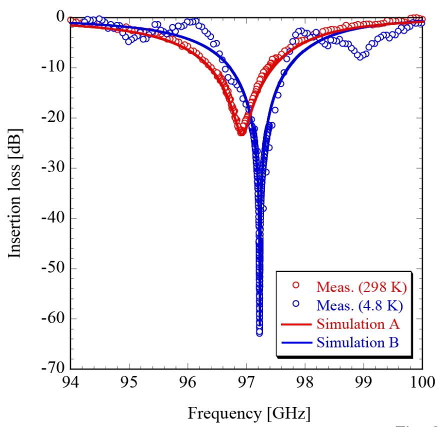


Fig. 2

Paper information

Journal: *J. Phys. Conf. Ser.*, 2545, 012021, 2023
Authors: Nakajima, T., K. Suzuki, T. Kojima, Y. Uzawa, M. Ishino, and I. Watanabe
Title: Propagation in superconducting niobium rectangular waveguide in the 100 GHz band
DOI: 10.1088/1742-6596/2545/1/012021

Fig.1: Waveguides 20 mm in length made of the superconducting metal niobium (right) compared with those made of normal metals such as gold-plated tellurium copper (middle) and aluminum alloy (left).

Fig.2: Frequency characteristics of the niobium resonator for transmission-loss estimation. The circles and lines represent the measurement and simulation results, respectively.

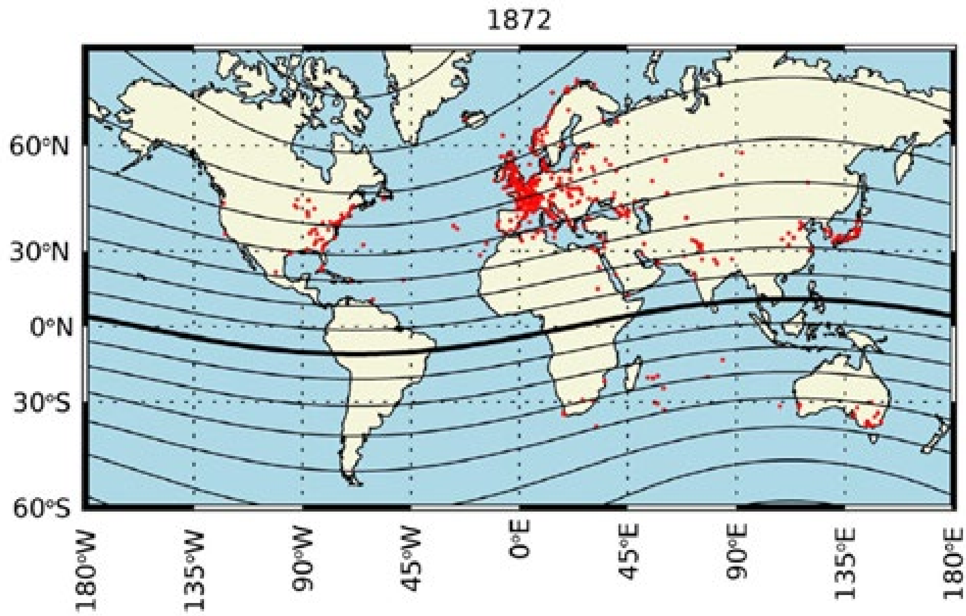


Fig.1

Quantification of the Extreme Solar Storm in 1872

The international collaborative team led by Hisashi Hayakawa and Yoshizumi Miyoshi from the ISEE investigated historical records for the extreme solar storm that occurred in 1872. This team quantified the data and revealed that a medium-sized sunspot active region triggered one of the greatest geomagnetic storms that most significantly extended the auroral oval in the observational history of Earth.

Solar eruptions occasionally trigger geomagnetic storms and extend the aurora equatorward, as observed most recently in May 2024. However, considerably more extreme historical events are occasionally forgotten. The extreme solar storm in 1872 Feb was one such case, where the aurora was visible as far as Nagoya and Okazaki. Our team investigated historical records, quantified the storm, and found that the source was a medium-sized sunspot active region. This region developed an extreme geomagnetic storm with a minimal Dst estimate ≤ −834 nT and extended auroral ovals down to 20° magnetic latitude. This storm was comparable to or even more extreme than the greatest storms recorded in observational history and allowed us to better understand the extremity of the space–Earth environment.

Fig.2

Paper Information
Journal: *Astrophys. J.*, 959(1), 23, 2023
Authors: Hayakawa, H. et al.
Title: The extreme space weather event of 1872 February: sunspots, magnetic disturbance, and auroral displays
DOI: 10.3847/1538-4357/acc6cc

Fig.1: Our reconstruction of the reported auroral visibility during the Great Aurora of 1872.

Fig.2: Auroral drawing from Okazaki (courtesy of Shounji Temple), with the date annotated using the traditional calendar.

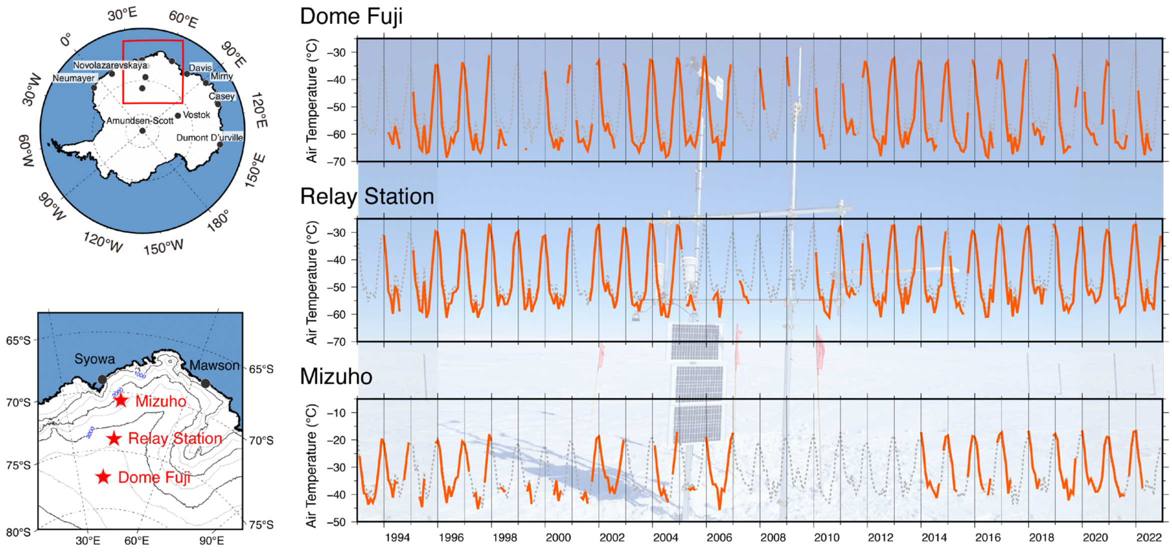


Fig.1

New Air Temperature Dataset for the Interior Antarctic Plateaus

Naoyuki Kurita (Associate Professor, ISEE) et al. have created a new dataset of monthly mean near-surface temperature for the interior of Dronning Maud Land (DML) in East Antarctica, which is one of the most data-sparse regions of Antarctica for studying climate change. A monthly temperature dataset comprising data from the last 30 years was compiled using historical records from three automatic weather stations (AWSs) in the region (Mizuho, Relay Station, and Dome Fuji). A quality-controlled database was obtained by identifying and correcting the systematic errors.

Antarctic climate change has been conventionally studied using temperature data from staffed stations. However, these stations are mainly located in the Antarctic Peninsula and coastal regions. Therefore, climate-change characteristics in the Antarctic Plateau remain largely unidentified, particularly in the western sector of the East Antarctic Plateau comprising areas such as the interior of the Dronning Maud Land (DML). To fill this gap, this study presents a new dataset of monthly mean near-surface climate data using historical observations from three AWSs. This dataset allows us to study temperature variabilities and changes over a data-sparse region, where climate change has been largely unexplored.

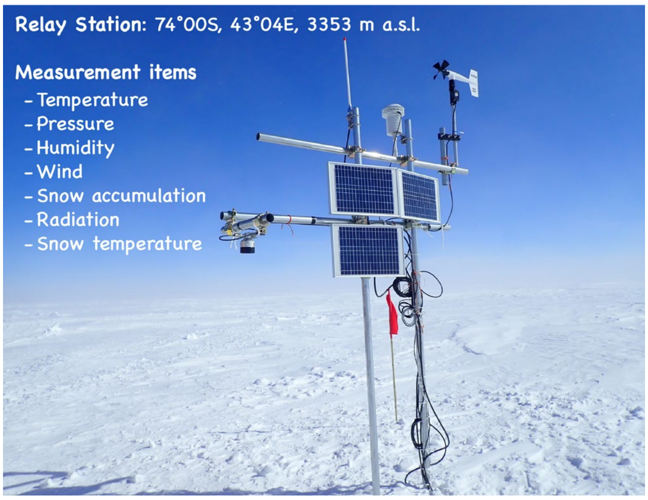


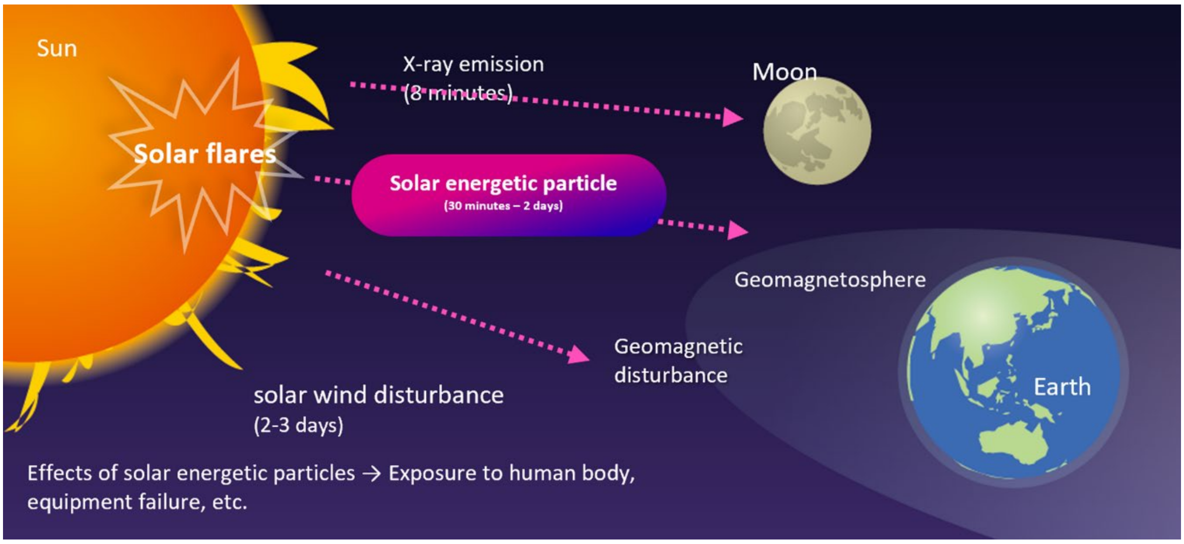
Fig. 2

Paper information

Journal: *J. Atmos. Ocean. Technol.*, 41(2), 179–188, 2024
Authors: Kurita, N., T. Kameda, H. Motoyama, N. Hirasawa, D. Mikolajczyk, et al.
Title: Near-surface air temperature records over the past 30 years in the interior of Dronning Maud Land, East Antarctica
DOI: 10.1175/JTECH-D-23-0092.1

Fig.1: Time-series of the new quality-controlled temperature dataset obtained from three AWSs in the DML. The dashed gray line represents 2-m temperatures obtained from ERA5.

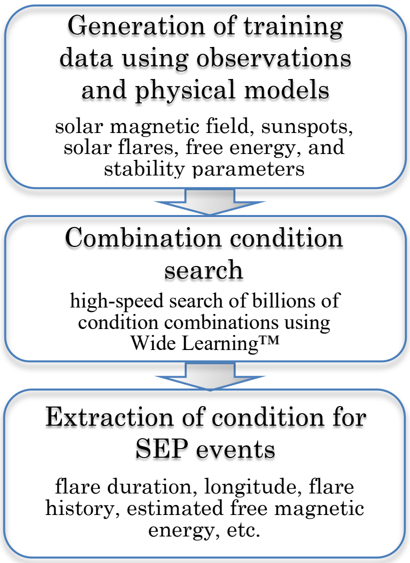
Fig.2: AWS installed at Relay Station.



Industry-academia Joint Research for Predicting Solar Energetic Particles

Solar eruptions, such as flares and coronal mass ejections (CMEs), release significant amounts of high-energy particles into the interplanetary space and can cause cosmic radiation exposure that can reach fatal levels in space. Therefore, accurately predicting their occurrence and impact is necessary for conducting safe and sustainable activities on the Moon and Mars. To this end, the ISEE has initiated joint industry-academia research in cooperation with Fujitsu Limited.

Based on a partnership agreement between Tokai National Higher Education and Research System and Fujitsu Limited, we conducted joint research for predicting space radiation, with the aim of ensuring safe and sustainable human activities in space. This year, by linking the solar-flare prediction scheme (κ-scheme) developed by this research institute with the explainable AI "Wide Learning™" developed by Fujitsu, we evaluated the properties of solar flares that cause solar energetic particle (SEP) events. Thus, we determined the condition combinations related to the location, size, duration, and history of flares that can cause SEP events. We also confirmed that the prediction accuracy of SEP events can be further improved by using free energy and stability parameters derived from 3D magnetic field models of solar active regions (ISEE-NLFFF Database). These results demonstrate that space-weather forecasting can be enhanced by combining physical models of solar flares with the latest AI technology.



Physics-based flare prediction scheme (κ-scheme):
Kusano et al. (2020), A physics-based method that can predict imminent large solar flares. *Science*, 369 (6503), 587–591.

Three-dimensional magnetic field model of solar active regions (ISEE-NLFFF Database):
https://hinode.isee.nagoya-u.ac.jp/nlfff_database/

Wide Learning™: https://widelearning.labs.fujitsu.com/ja/

Contents

1. History

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

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

Solar-Terrestrial Environment Laboratory (STEL)

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.

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.

Hydrospheric Atmospheric Research Center (HyARC)

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

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

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

Center for Chronological Research (CCR)

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

Institute for Space–Earth Environmental Research (ISEE)

October, 2015	Institute for Space–Earth Environmental Research (ISEE) was established.
January, 2016	Approved as one of the Joint Usage/Research Centers.

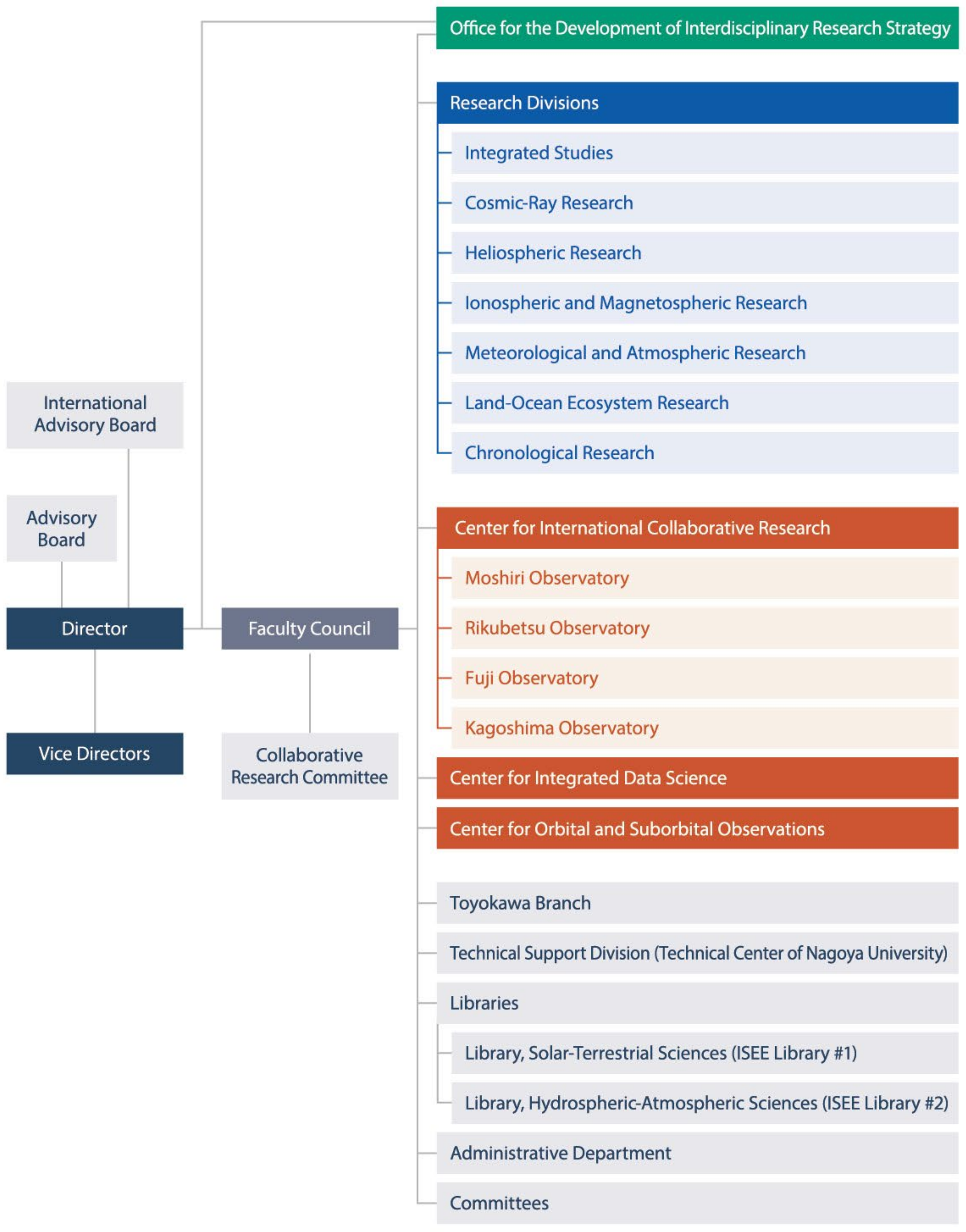
Past Directors

Oct. 1, 2015—Mar. 31, 2017	Shinobu Machida
Apr. 1, 2017—Mar. 31, 2023	Kanya Kusano
Apr. 1, 2023—	Kazuo Shiokawa

Professors Emeritus

AY 2016	Ryoichi Fujii	Toshio Nakamura
AY 2018	Shinobu Machida	Yutaka Matsumi
AY 2019	Masaki Enami	
AY 2023	Munetoshi Tokumaru	
AY 2024	Joji Ishizaka	

2. Organization



3. Staff

Number of Faculty and Staff Members

March 31, 2024

	Male	Female	Total
SHOKEI Faculty Members	35	3	38
Technical Staff	17	12	29
Administrative Staff	5	43	48
Other	24	8	32
Total	81	66	147

＊"Technical Staff" Includes "Designated Technical Staff" and "Technical Assistant".

＊"RA" and " Invited Faculty Members" are not Included.

＊"Other"…"Designated Faculty Members", "Researcher (Full-time)", "Research Institution Researcher"

List of Faculty and Staff Members

April 1, 2023–March 31, 2024
✱: Concurrent post
▲: Left the Institute in the 2023 academic year
○: Joined the Institute in the 2023 academic year
*: Belongs to Institute for Advanced Research Section

Director	Kazuo Shiokawa
Vice Director	Tetsuya Hiyama
Vice Director	Masayo Minami

Division for Integrated Studies

Professor	Kanya Kusano
Professor	Hideyuki Hotta ○
Professor	Yoshizumi Miyoshi (✱)
Associate Professor	Satoshi Masuda
Associate Professor	Takayuki Umeda (✱) ▲
Assistant Professor	Akimasa Ieda
Designated Assistant Professor	Haruhisa Iijima
Designated Assistant Professor	Hisashi Hayakawa *
JSPS research fellowship (PD)	Ryohtaroh Ishikawa ○▲
JSPS research fellowship (PD)	Yoshiki Hatta
JSPS Postdoctoral Fellowships for Research in Japan (Standard)	Sandeep Kumar
JSPS Postdoctoral Fellowships for Research in Japan (Standard)	Shreedevi Radhakrishna Porunakatu
Technical Assistant	Ichiro Goto ○▲

Division for Cosmic-Ray Research

Professor	Yoshitaka Itow
Professor	Hiroyasu Tajima (✱)
Associate Professor	Fusa Miyake
Associate Professor	Shingo Kazama (✱) **
Designated Associate Professor	Kazutaka Yamaoka (✱)
Lecturer	Akira Okumura
Assistant Professor	Hiroaki Menjo
Designated Assistant Professor	Mitsunari Takahashi
Designated Technical Staff	Shozo Ohta
Designated Technical Staff	Kazuhiro Furuta
Technical Assistant	Yasuko Ito

** Kobayashi-Maskawa Institute for the Origin of Particles and the Universe

Division for Heliospheric Research

Professor	Kanya Kusano (✱)
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	Nozomu Nishitani (✱)
Associate Professor	Claudia Martinez-Calderon (✱)
Lecturer	Shin-ichiro Oyama
Researcher	Weizheng Fu ○

Division for Meteorological and Atmospheric Research

Professor	Akira Mizuno
Professor	Nobuhiro Takahashi (✱)
Professor	Kazuhisa Tsuboki (✱)
Professor	Michihiro Mochida (✱)
Associate Professor	Tomoo Nagahama
Associate Professor	Hirohiko Masunaga
Associate Professor	Taro Shinoda (✱)
Assistant Professor	Sho Ohata
Assistant Professor	Taku Nakajima
Designated Assistant Professor	Shinnosuke Ishizuka *▲
Researcher	Ruichen Zhou ▲
Researcher	Fumie Furuzawa
Research Institution Researcher	Bhagawati Kunwar ○
Technical Assistant (Research Support Facilitator)	Kazuji Suzuki
Technical Assistant	Michiko Nishizawa ○

Division for Land–Ocean Ecosystem Research

Professor	Tetsuya Hiyama
Professor	Joji Ishizaka (✱) ▲
Associate Professor	Hidenori Aiki
Associate Professor	Naoyuki Kurita
Lecturer	Hatsuki Fujinami
Assistant Professor	Yoshihisa Mino
Researcher	Hironari Kanamori ▲
Researcher	Yuto Tashiro ▲
Researcher	Yoshiki Fukutomi
Researcher	Zimeng Li ○

Divison for Chronological Research

Professor	Hiroyuki Kitagawa
Professor	Masayo Minami
Associate Professor	Takenori Kato (✱)
Assistant Professor	Hirotaka Oda
Research Institution Researcher	Satoshi Sasaki ▲
Research Institution Researcher	Narges Daneshvar ○
Designated Technical Staff	Yuriko Hibi
Technical Assistant (Research Support Facilitator)	Jyunko Tamura ○
Technical Assistant	Sayaka Takasu ○
Technical Assistant	Masami Nishida

Office for the Development of Interdisciplinary Research Strategy

Office Manager • Professor	Kazuo Shiokawa (✱)
Professor	Kanya Kusano (✱)
Professor	Nobuhiro Takahashi (✱)
Professor	Tetsuya Hiyama (✱)
Professor	Masayo Minami (✱)
Professor	Yoshizumi Miyoshi (✱)
Professor	Michihiro Mochida (✱)
Associate Professor	Claudia Martinez-Calderon (✱)
Designated Associate Professor	Ryota Kikuchi ○
Designated Associate Professor	Satoko Nakamura ▲

Center for International Collaborative Research

Director • Professor • Director of Moshiri Observatory	Michihiro Mochida
Professor	Joji Ishizaka ▲
Professor	Kazuo Shiokawa
Professor	Tetsuya Hiyama (✱)
Professor • Director of Rikubetsu Observatory	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	Claudia Martinez-Calderon
Associate Professor • Director of Fuji Observatory	Kazumasa Iwai (✱)
Associate Professor • Director of Kagoshima Observatory	Yuichi Otsuka (✱)
Associate Professor	Naoyuki Kurita (✱)
Associate Professor	Satonori Nozawa (✱)
Lecturer	Hatsuki Fujinami (✱)
Assistant Professor	Hiroaki Menjo (✱)
Designated Assistant Professor	Masafumi Shoji ▲
Designated Assistant Professor	Denis Pavel Cabezas Huaman ○

Foreign Visiting Research Fellow

Jan. 30 – May 24, 2023	Po-Hsiung Lin
Feb. 1 – Apr. 30, 2023	Pavlo Ponomarenko
Feb. 12 – May 13, 2023	Pekka Tapani Verronen
Mar. 7 – Jun. 2, 2023	Vyacheslav Anatolevich Pilipenko
Sep. 1 – Dec. 28, 2023	Khan-Hyuk Kim
Feb. 1 – May 31, 2024	Dong-in Lee

Center for Integrated Data Science

Director • Professor	Yoshizumi Miyoshi
Professor	Kazuhisa Tsuboki
Professor	Joji Ishizaka (✱) ▲
Professor	Yoshitaka Itow (✱)
Professor	Kanya Kusano (✱)
Professor	Hideyuki Hotta (✱)○
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
Designated Associate Professor	Satoko Nakamura (✱)▲
Assistant Professor	Akimasa Ieda (✱)
Designated Assistant Professor	Sachie Kanada
Designated Assistant Professor	Naritoshi Kitamura
Designated Assistant Professor	Takuya Sori ○▲
Designated Assistant Professor	Takuma Matsumoto
Designated Assistant Professor	Kazuhiro Yamamoto ○
Designated Assistant Professor	Chae-Woo Jun
Designated Assistant Professor	Diptiranjan Rout ○▲
Designated Assistant Professor	YunHee Kang
Designated Assistant Professor	Atsuki Shinbori
Researcher	Masaya Kato
Researcher	Tomohito Hioki ○
Research Institution Researcher	Kumar Pankaj Soni ○
Designated Technical Staff	Mariko Kayaba
Designated Technical Staff	Nanako Hirata
Designated Technical Staff	Asayo Maeda ▲
Designated Technical Staff	Kingi Morikawa
Technical Assistant	Tomoko Ito ○

Center for Orbital and Suborbital Observations

Director • Professor	Nobuhiro Takahashi
Professor	Hiroyasu Tajima
Professor	Joji Ishizaka (✱)▲
Professor	Kazuhisa Tsuboki (✱)
Professor	Masafumi Hirahara (✱)
Designated Professor	Masataka Murakami ▲
Associate Professor	Taro Shinoda
Associate Professor	Hidenori Aiki (✱)
Designated Associate Professor	Kazutaka Yamaoka
Designated Associate Professor	Ryota Kikuchi (✱)○
Assistant Professor	Sho Ohata (✱)
Designated Assistant Professor	Ryouichi Yoshimura ○

Visiting Academic Staff/Visiting Faculty Members

Visiting Professor	Shinsuke Imada
Visiting Professor	Takayuki Umeda ○
Visiting Professor	Yasunobu Ogawa
Visiting Professor	Yoshiya Kasahara
Visiting Professor	Tomo'omi Kumagai ▲
Visiting Professor	Daikou Shiota
Visiting Professor	Iku Shinohara
Visiting Professor	Nobuo Sugimoto ▲
Visiting Professor	Kanako Seki
(Emeritus Professor)	Munetoshi Tokumaru ○
Visiting Professor	Hotaek Park
Visiting Associate Professor	Fumio Abe
Visiting Associate Professor	Fumikazu Ikemori ○
Visiting Associate Professor	Shinji Saito
Visiting Associate Professor	Takuo Tsuda ○
Visiting Associate Professor	Hiroki Mizuochi
Visiting Associate Professor	Shoichiro Yokota
Visiting Associate Professor	Shigeyuki Wakagi
	Shun Ohishi
(Emeritus Professor)	Yutaka Matsumi

Foreign Visiting Cooperation Researcher

Mar. 31, 2022—Mar. 31, 2024	Yaru Zhao
Apr. 20—May 4, 2023	Dang Xuan Tung
Jun. 1—Jul.12, 2023	Grandhi Kishore Kumar
Jun. 10—Aug. 20, 2023	Ardra Kozhikottuparambil
Jun. 29—9.3, 2023	HajiHossein Azizi
Oct. 1—Dec. 29, 2023	Manu Varghese
Oct. 1—Dec. 29, 2023	Upadhyay Kshitiz
Oct. 1—Dec. 29, 2023	Lalitha G Krishnan
Oct. 2—Dec. 29, 2023	Akshay Shivaji Patil
Oct. 4—Nov. 5, 2023	Jyrki kalervo Manninen
Oct. 18—Nov. 28, 2023	Radek Lhotka
Nov. 20, 2023—Feb. 20, 2024	Rajesh Kumar Barad
Dec. 1, 2023—May 1, 2024	Liudmila Lebedeva
Jan. 10—Mar. 29, 2024	George Chieng Ondede
Feb. 5—Mar. 20, 2024	Tadei Virginia
Feb. 13—Mar. 14, 2024	John Backman
Mar. 14—Apr. 16, 2024	Jih-Hong Shue

Technical Center of Nagoya University

Senior Technician	Akiko Ikeda
Senior Technician	Yasusuke Kojima
Senior Technician	Haruya Minda
Technician	Wataru Okamoto
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

Administration Department

Director, Administration Department	Makoto Ito ○
General Affairs Division	
Manager, General Affairs Division	Masao Yamamori
Deputy Manager, General Affairs Division	Mayumi Muto ○▲
Specialist, General Affairs Section	Risa Oosawa
Section Head, General Affairs Section	Takamasa Sato
Section Head, General Affairs Section	Noriaki Tonouchi
Section Head, Budget Planning Section	Mirei Miyao ▲
Section Head, Budget Planning Section	Naoaki Harada ○
Leader, General Affairs Section	Ayako Tsukasaki ○
Administrator	Honami Ishizaki
Administrator	Junpei Okada ▲
Administrator	Tomoka Shibata
Administrator	Kahori Nishi
Designated Supervisor	Satoshi Furuhashi ○
Deputy Manager, Research Funding Division, Research Cooperation Department	Toshiyuki Yokoi

Toyokawa Branch

Office Manager • Associate Professor	Kazumasa Iwai (✱)
Designated Technical Staff	Kayoko Asano
Technical Assistant (Research Support Facilitator)	Yasuo Kato

4. Committee of Other Organizations

Committee of Other Organizations

(40 in total)

Contact Post	Job Title	Organizations	Name of Committee / Title
Tetsuya Hiyama	Professor	International Arctic Science Committee (IASC)	Member, Terrestrial Working Group (TWG)
Hideyuki Hotta	Professor	Tata Institute of Fundamental Research	Thesis Examiner
Joji Ishizaka	Professor	North Pacific Marine Science Organization (PICES)	Co-Chair, Advisory Panel for a CREAMS/PICES Program in East Asian Marginal Seas
Joji Ishizaka	Professor	Northwest Pacific Action Plan (NOWPAP)	Focal Point of Center for Special Monitoring and Coastal Environmental Assessment Regional Active Center (CEARAC)
Hiroyuki Kitagawa	Professor	Geosciences	Editor
Yoshizumi Miyoshi	Professor	EISCAT Scientific Association	Counsil Member, Strategy Group on the Future of EISCAT
Yoshizumi Miyoshi	Professor	Committee on Space Research (COSPAR)	Chair, Panel on Radiation Belt Environment Modeling
Yoshizumi Miyoshi	Professor	Committee on Space Research (COSPAR)	Member, Task Group on Establishing a Constellation of Small Satellites (TGCSS) Sub-Group for Radiation Belt
Yoshizumi Miyoshi	Professor	Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)	Bureau Member
Yoshizumi Miyoshi	Professor	National Science Foundation/ Geospace Environment Modeling (NSF/GEM)	Member, Steering Committee
Yoshizumi Miyoshi	Professor	Annales Geophysicae	Editor
Yoshizumi Miyoshi	Professor	Earth and Planetary Physics	Editor
Yoshizumi Miyoshi	Professor	Scientific Reports	Member, Editorial Board
Yoshizumi Miyoshi	Professor	Frontiers in Astronomy and Space Sciences	Associate Editor
Akira Mizuno	Professor	Network for the Detection of Atmospheric Composition Change	Member, Steering Committee (Japanese Co-Representative)
Michihiro Mochida	Professor	International Commission on Atmospheric Chemistry and Global Pollution (iCACGP)	Member
Michihiro Mochida	Professor	Atmospheric Environment	Member, Editorial Advisory Board
Michihiro Mochida	Professor	Elsevier Beijing	Member, Editorial Advisory Board
Kazuo Shiokawa	Professor	Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)	President
Hiroyasu Tajima	Professor	Institute of Particle and Nuclear Studies, KEK	Member, B-factory Programme Advisory Committee
Hiroyasu Tajima	Professor	Progress of Theoretical and Experimental Physics	Executive Editor

Contact Post	Job Title	Organizations	Name of Committee / Title
Hiroyasu Tajima	Professor	The Scientific World Journal	Member, Editorial Board
Nobuhiro Takahashi	Professor	National Aeronautics and Space Administration (NASA)	Member, Global Precipitation Measurement (GPM) Joint Precipitation Science Team (JPST)
Nobuhiro Takahashi	Professor	National Aeronautics and Space Administration (NASA)	Member, Aerosol and Cloud, Convection and Precipitation (ACCP) Science and Application Transition Team (SATT)
Nobuhiro Takahashi	Professor	National Aeronautics and Space Administration (NASA)	Member, Aerosol and Cloud, Convection and Precipitation (ACCP) Algorithm Working Group (AWG)
Nobuhiro Takahashi	Professor	European Space Agency (ESA)	Member, Joint Mission Advisory Group for EarthCARE
Hidenori Aiki	Associate Professor	Journal of Physical Oceanography	Associate Editor
Hidenori Aiki	Associate Professor	Journal of Atmospheric and Oceanic Technology	Associate Editor
Hirohiko Masunaga	Associate Professor	National Aeronautics and Space Administration (NASA)	Member, Atmosphere Observing System (AOS), Science and Applications Team (SAT), Algorithm Working Group (AWG)
Hirohiko Masunaga	Associate Professor	World Climate Research Programme (WCRP) Global Energy and Water cycle Exchanges (GEWEX)	Co-Chair / Member, GEWEX Data and Analysis Panel (GDAP)
Hirohiko Masunaga	Associate Professor	National Aeronautics and Space Administration (NASA) and JAXA	Member, Joint Precipitation Measurement Mission Science Team
Hirohiko Masunaga	Associate Professor	Brussels Institute for Advanced Studies	Fellow
Hirohiko Masunaga	Associate Professor	Sorbonne Université	Member, Ph.D. Monitoring Committee
Nozomu Nishitani	Associate Professor	Super Dual Auroral Radar Network (SuperDARN)	Vice Chair, Executive Council
Satonori Nozawa	Associate Professor	EISCAT Scientific Association	Council Member
Yuichi Otsuka	Associate Professor	Committee on Space Research (COSPAR)	Chair, Sub-Commission C1: The Earth's Upper Atmosphere and Ionosphere
Yuichi Otsuka	Associate Professor	AGU: Geophysical Research Letters	Editor
Yuichi Otsuka	Associate Professor	Journal of Astronomy and Space Sciences	Editor
Hatsuki Fujinami	Lecturer	Climate and Ocean: Variability, Predictability and Change (CLIVAR)/ Global Energy and Water cycle Exchanges (GEWEX)	Member, Monsoons Panel Asian-Australian Monsoon Working Group
Hisashi Hayakawa	Designated Assistant Professor	International Association of Geomagnetism and Aeronomy (IAGA)	Co-Chair, Interdivisional Commission on History

5. Joint Research Programs

The ISEE was certified by the MEXT of Japan as a joint usage/research center for the fourth medium-term goal/planning period (FY2022 to FY2027) of national universities on October 29, 2021. During this period, we promoted and performed collaborative research on space–Earth Environmental Sciences with researchers from universities and institutes outside the ISEE as an international hub connecting diverse fields to contribute to solving global environmental issues affecting humankind and the development of human society by understanding the Earth, Sun, and space as a single system through the integration of space and Earth science and by elucidating the mechanisms and interrelationships of diverse phenomena occurring in the system.

The following 17 categories of open-call joint research programs were promoted using ground, ocean, aircraft, and satellite observations, laboratory experiments, data analysis, numerical simulations, etc.,: 00) ISEE International symposium, 01) International joint research, 02) Invited foreign researcher joint research, 03) International workshop, 04) General joint research, 05) Encouraged joint research for graduate students, 06) Research meetings, 07) Computing infrastructure, 08) Database management, 09) Accelerator mass spectrometry analysis, 10) Carbon-14 analysis, 11) SCOSTEP Visiting Scholar (SVS) Program, 12) Aircraft observation (dropsonde), 13) International travel support for field and laboratory experiments by students and early career scientists, 14) International technical exchange program, 15) International school support, and 16) International travel support for students (international presentation / institutional stay).

During the fourth medium-term goal/planning period, we aimed to establish an international joint research center to connect diverse disciplines by fostering young researchers, promoting international collaboration, and integrating different fields of space and Earth sciences. Concerning interdisciplinary research, four new projects led by ISEE were selected through an internal call for proposals and initiated in 2021. In addition, since 2022, we have been calling for the application of bottom-up interdisciplinary/exploratory research proposed by researchers at institutions other than ISEE. In 2023, 59 interdisciplinary projects, including 37 symposia, and nine exploratory projects, including two symposia, were approved.

The 6th ISEE Symposium “Interaction of Ocean, Atmosphere, and Land by Remote Sensing and Numerical Model” was held in a hybrid format at Sakata and Hirata Hall, NEOREX place at Nagoya University, and partly online from December 17 to 19, 2023. This symposium integrated four research meetings proposed to the ISEE joint research program in the field of oceanography, and active discussions were conducted on the interactions between the ocean, atmosphere, and land using remote sensing and numerical modeling. There were 132 participants: 73 from Japan and 59 from overseas. At this symposium, the 5th ISEE Award was presented to Dr. Goes Joaquim Ignacio and Dr. Gomes Maria Fatima Helga do Rosário, and Dr. Goes gave a commemorative lecture titled “Harnessing the Power of Earth Observations for Ocean Ecosystem Monitoring and Resource Management under Climate Change.”

The 5th ISEE community meeting was held online on November 2 with the main theme of interdisciplinary research. Three presentations selected from bottom-up interdisciplinary projects were given, in addition to the ordinary research reports presented by each technical committee. The Office for the Development of Interdisciplinary Research Strategy (ODIRS) was also established in August 2022. These meetings were attended by approximately 60 people. Active discussions were held on the significance of interdisciplinary research, and opinions were exchanged across disciplines to improve ISEE joint usage/research for the future.

Regarding the application procedures, the web-based application and final report submission system based on the JROIS2-ISEE system were improved, the application guidelines were completely revised, and the application form was changed from Excel to Word. In addition, a program to automatically read applicant information from Word files was developed, and the efficiency of work, such as sorting applications and sending them to reviewers, was drastically improved.

Through wide-ranging open-call joint research activities, the ISEE aims to solve issues pertaining to global warming and extreme weather disasters, such as typhoons, torrential rains, and space weather disasters for satellites, communications, positioning, electric power, and aviation systems. We also aim to establish an international joint research center connecting diverse fields, with particular emphasis on fostering young researchers, promoting international joint research, and strengthening the integration of diverse fields of space and Earth science through interdisciplinary joint research.

List of Accepted Proposals

■ 02) ISEE International Joint Research Program (17 in total)

Project title	Proposer (Job title*, Affiliation*)	Corresponding ISEE researcher
Creation of a new high-quality dataset of East Antarctic meteorological observations	Matthew Lazzara (Senior Scientist, University of Wisconsin-Madison, USA)	Naoyuki Kurita
Ion physics and energy budget in reconnection region	Wai-Leong Teh (Lecturer, Universiti Kebangsaan Malaysia)	Takayuki Umeda
Understanding the impact of solar proton events on middle atmospheric dynamics	Kishore Kumar Grandhi (Assistant Professor, University of Hyderabad, India)	Satonori Nozawa
Development of a calibration scheme for the next-generation digital phased array system	Shinichiro Asayama (System Scientist, Square Kilometre Array Observatory (SKAO), UK)	Kazumasa Iwai
Geochronology and geochemistry of apatite grains in granitic rocks as a new method for discrimination of tectonic setting	HajiHossein Azizi (Professor, University of Kurdistan, Iran)	Masayo Minami
Advancing predictability of coronal mass ejection occurrence by combining photospheric observations and coronal modeling	Johan Muhamad (Researcher, National Research and Innovation Agency, Indonesia)	Kanya Kusano
Impact of Indian Ocean dipole on South Indian Ocean surface circulation and productivity- Remote sensing perspective	Benny N. Peter (Adjunct Faculty, Kerala University of Fisheries and Ocean Studies, India)	Joji Ishizaka
Academic exchange of weather radar research and application experiences between ISEE and NCDR	Chih-Chien Tsai (Associate Researcher, National Science and Technology Center for Disaster Reduction (NCDR), Taiwan)	Nobuhiro Takahashi
Multipoint spacecraft investigations on the solar wind and solar erupted magnetic flux ropes propagating from the solar surface to the inner heliosphere	Takuya Hara (Assistant Research Physicist, University of California Berkeley, USA)	Kazumasa Iwai
Reconstructing atmospheric ^{14}C across the Inter Tropical Convergence Zone using Vietnamese tree rings	Dang Xuan Phong (Department Director, Vietnam academy of Science and Technology)	Hiroyuki Kitagawa
Relationship between natural fine aerosol chemical composition investigated by application of online and offline mass spectrometry techniques	Petr Vodicka (Scientist, Institute of Chemical Process Fundamentals, Czech Academy of Sciences)	Michihiro Mochida
Cross-calibration of low-energy electron measurement obtained by Mio/BepiColombo with Solar Orbiter on the 10th of August 2021 and its solar wind property	Sae Aizawa (Research Fellow, University of Pisa, Italy)	Yoshizumi Miyoshi
Diagnosing the origin of solar energetic particles in the solar corona	Nariaki Nitta (Senior Staff Physicist, Lockheed Martin Solar and Astrophysics Laboratory, USA)	Satoshi Masuda
Analysis of whistler-mode waves in the Earth's magnetosphere using spacecraft and ground-based measurements	Ondrej Santolik (Professor, Institute of Atmospheric Physics, Czech Academy of Sciences)	Yoshizumi Miyoshi
Influence of large-scale interplanetary coronal mass ejections (ICMEs) structures on the propagation of solar energetic particles (SEPs)	Beatriz Sanchez-Cano (Lecturer and Ernest Rutherford Fellow, University of Leicester, UK)	Kazumasa Iwai
Unique observations of ELF-VLF waves at OUJ, KAN, and other PWING locations	Jyrki Manninen (Deputy Director, University of Oulu, Finland)	Claudia Martinez-Calderon
The influence of Indian Ocean Dipole on sea surface temperature and sea surface chlorophyll-a variations in the Andaman Sea based on satellite imageries	Anukul Buranapratheprat (Assistant Professor, Burapha University, Thailand)	Joji Ishizaka

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

■ 03) ISEE International Workshop

(3 in total)

Workshop title	Proposer (Job title*, Affiliation*)	Corresponding ISEE researcher
Study of interplanetary coronal mass ejections propagation in the inner heliosphere combining MHD modeling, ground-based observations, and in-situ multi-spacecraft data	Lina Hadid (Researcher, CNRS/LPP/École Polytechnique, France)	Kazumasa Iwai
Origin of high-energy protons responsible for late-phase pion-decay gamma-ray continuum from the Sun	Nat Gopalswamy (Astrophysicist, Goddard Space Flight Center, USA)	Satoshi Masuda
Science objectives of SOLAR-C and numerical modeling workshop	Shinsuke Imada (Professor, The University of Tokyo, Japan)	Satoshi Masuda

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

■ 11) SCOSTEP Visiting Scholar (SVS) Program

(7 in total)

Project title	Proposer (Job title*, Affiliation*)	Corresponding ISEE researcher
The impact of geomagnetic storms on GNSS within the low and mid latitude sector during the 24th solar cycle	George Ochieng Ondede (Graduate Student, The Technical University of Kenya)	Yuichi Otsuka
To study the variation in TEC scintillation during the propagation of Equatorial Plasma Bubbles (EPBs)	Akshay Shivaji Patil (Graduate Student, Sanjay Ghodawat University, Kolhapur, India)	Yuichi Otsuka
Interrelation between electron temperature and O(1D) emission intensity	Kshitiz Upadhyay (Graduate Student, Physical Research Laboratory, Ahmedabad, India)	Kazuo Shiokawa
Space weather during initial phase of solar cycle 25 and its impact on thermosphere-ionosphere system at different latitudes	Lalitha G. Krishnan (Graduate-course Student, Vikram Sarabhai Space Centre, India)	Kazuo Shiokawa
Study on the generation and evolution of equatorial plasma bubbles under extreme weather, space weather, and natural hazard events and their connections to the mid-latitude processes	Rajesh Kumar Barad (Graduate Student, Indian Institute of Geomagnetism, India)	Yuichi Otsuka
Association of peak intensity of all low latitude auroras and high latitude magnetic field data with the corresponding geomagnetic activity indices and solar wind-IMF parameters	Manu Varghese (Graduate Student, Shandong University, China)	Kazuo Shiokawa
Large scale changes in the polar ionosphere during CME and CIR storms, its relation to Sub-Auroral Polarization Streams (SAPS) and particle precipitation	Ardra K P (India)	Nozomu Nishitani

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

■ 13) International Travel Support for Field and Laboratory Experiments by Students and Early-carrier Scientists

(6 in total)

Project title	Proposer (Job title*, Affiliation*)	Corresponding ISEE researcher
Spectroscopic measurement of upflow through Doppler shift of auroral 427.8-nm molecular nitrogen ion emission using a Fabry-Perot interferometer at Tromsoe, Norway	Taiki Kikuchi (Undergraduate Student, Nagoya University)	Kazuo Shiokawa
Intensive observation of aurora at subauroral latitude using an all-sky camera in Athabasca	Rei Sugimura (Graduate Student, Nagoya University)	Kazuo Shiokawa
Development of an on-demand FPGA-based data acquisition system and its test observations using by Tromsø Na resonance scattering lidar	Ren Watanabe (Graduate Student, University of Electro-Communications)	Satonori Nozawa
Observation of electron precipitation associated with omega-band auroras using a spectral riometer in Finland	Koyo Takano (Undergraduate Student, University of Electro-Communications)	Sinichiro Oyama
Field observations of phytoplankton dynamic in the upper gulf of Thailand for development of the hydrodynamic-ecosystem model	Dudsadee Leenawarat (Graduate Student, Nagoya University)	Joji Ishizaka
Validating and calibrating satellite-based observations of red tides in the Gulf of Thailand	Jutarak Luang-on (Postdoctoral Researcher, JAMSTEC, Japan)	Joji Ishizaka

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

■ 14) International Technical Exchange Program (3 in total)

Project title	Proposer (Job title*, Affiliation*)	Corresponding ISEE researcher
Technical exchange for accurate and precise ^{14}C Measurement by Accelerator Mass Spectrometer	Masayo Minami (Professor, Nagoya University)	Masayo Minami
Technology exchange on the state-of-art weather radar data analysis	Nobuhiro Takahashi (Professor, Nagoya University)	Nobuhiro Takahashi
IPS Time-dependent tomography boundaries for SUSANOO 3-D MHD, and comparison of the IPS-driven ENLIL model	Bernard V. Jackson (Research Scientist, University of California San Diego, USA)	Kazumasa Iwai

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

■ 15) ISEE International School Support (5 in total)

School title	Proposer (Job title*, Affiliation*)	Corresponding ISEE researcher
Short Course on AMS Radiocarbon Dating	Hiroyuki Kitagawa (Professor, Nagoya University)	Hiroyuki Kitagawa
Satellite Data Analysis for Studying Ocean and Atmosphere/Land Interaction	Joji Ishizaka (Professor, Nagoya University)	Joji Ishizaka
Iberian Space Science Summer School (i4s)	Anna Morozova (University of Coimbra, Portugal)	Kazuo Shiokawa
International Colloquium on Equatorial and Low-Latitude Ionosphere	Babatunde Rabiu (Professor and Executive Director, United Nations African Regional Centre for Space Science and Technology Education in English, Nigeria)	Kazuo Shiokawa
ICTP-SCOSTEP-ISWI Workshop on the Predictability of the Variable Solar-Terrestrial Coupling (PRESTO)	Ramon Lopez (Professor, The University of Texas at Arlington, USA)	Kazuo Shiokawa

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

■ 16) International Travel Support for Students (International Presentation / Institutional Stay) (6 in total)

Support title	Proposer (Job title*, Affiliation*)	Corresponding ISEE researcher
Oral presentation at the WISA 2023 conference	Hidetaka Kuniyoshi (Graduate Student, The University of Tokyo)	Satoshi Masuda
Visit to NASA/MSFC for ground calibration tests of X-ray telescopes onboard a solar sounding rocket FOXSI-4	Koki Sakuta (Graduate Student, Nagoya University)	Yoshizumi Miyoshi
Simultaneous Observations of Auroras Using a Wide-Angle Digital Camera and Satellites in Kiruna, Sweden	Sota Nanjo (Graduate Student, University of Electro-Communications)	Yoshizumi Miyoshi
Presentation about "Statistical analysis of magnetospheric molecular ions from the Arase observations" at AGU Fall Meeting 2023	Akari Nagatani (Graduate Student, Nagoya University)	Yoshizumi Miyoshi
Presentation about "First observation of temporal variation of STEVE heights by triangulation using two all-sky cameras at Athabasca, Canada" at AGU Fall Meeting 2023	Liwei Chen (Graduate Student, Nagoya University)	Kazuo Shiokawa
Simultaneous Observations of Auroras Using a Wide-Angle Digital Camera and Satellites in Kiruna, Sweden	Taishin Okiyama (Graduate Student, The University of Tokyo)	Yoshizumi Miyoshi

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

Lists of Collaboration Resources

as of April 1, 2023

■ Instruments

(23 in total)

Name	Contact Person
Multi-Directional Cosmic Ray Muon Telescope (Nagoya)	Hiroaki Menjo
Multi-Station IPS Solar Wind Observation System (Toyokawa, Fuji, and Kiso)	Kazumasa Iwai
ELF/VLF Network	Kazuo Shiokawa
ISEE Magnetometer Network	Kazuo Shiokawa
ISEE Riometer Network	Kazuo Shiokawa
Optical Mesosphere Thermosphere Imagers	Kazuo Shiokawa
Sodium LIDAR (Tromsø)	Satonori Nozawa
MF Radar (Tromsø)	Satonori Nozawa
Five-Wavelength Photometer (Tromsø)	Satonori Nozawa
Meteor Radar (Alta)	Satonori Nozawa
SuperDARN Hokkaido Pair of (HOP) Radars (Rikubetsu)	Nozomu Nishitani
Upper Air Sounding Systems (two sets)	Kazuhisa Tsuboki
Polarimetric Radar Systems (two sets)	Kazuhisa Tsuboki
Ka-Band Polarimetric Radar	Kazuhisa Tsuboki
Hydrometeor Video Sonde (HYVIS) System	Kazuhisa Tsuboki
Fourier Transform Infrared (FTIR) Spectrometer for Atmospheric Composition Measurement (Rikubetsu)	Tomoo Nagahama
Sea Spray Aerosol Optical Particle Counter	Hidenori Aiki
Low-Background Beta-Ray Counter	Naoyuki Kurita
Water Isotope Analyzer (Picarro L2130-i)	Naoyuki Kurita
CHN Analyzer, Isotope Ratio Mass Spectrometer	Yoshihisa Mino
CHNS Elemental Analyzer	M. Minami
X-Ray Fluorescence Spectrometer (XRF)	Takenori Kato
X-Ray Diffractometer (XRD)	Takenori Kato

■ Software/Databases

(20 in total)

Name	Contact Person
Center for Heliospheric Science	Yoshizumi Miyoshi Kanya Kusano
QL Plot Archive of Satellite Data for Integrated Studies	Yoshizumi Miyoshi
MHD Simulation on the Magnetospheric Environment	Takayuki Umeda
Numerical Simulation Codes for Plasma Kinetics	Takayuki Umeda
Interplanetary Scintillation Data	Kazumasa Iwai
Solar Wind Speed Data	Kazumasa Iwai
Remei Satellite Observation Database	Masafumi Hirahara
Coordinated Magnetic Data Along 210° Magnetic Meridian (Moshiri, Rikubetsu, Kagoshima, and Overseas MM Stations)	Kazuo Shiokawa

Name	Contact Person
Database of the Optical Mesosphere Thermosphere Imagers	Kazuo Shiokawa
ELF/VLF Wave Data	Kazuo Shiokawa
ISEE Riometer Network Database	Kazuo Shiokawa
All-Sky Auroral Data (Canada, Alaska, and Siberia)	Kazuo Shiokawa, Yoshizumi Miyoshi
VHF Radar/GPS Scintillation (Indonesia)	Yuichi Otsuka
EISCAT Database	Satonori Nozawa, Shin-ichiro Oyama
SuperDARN Hokkaido Pair of (HOP) Radars Database	Nozomu Nishitani
Cloud Resolving Strom Simulator (CReSS)	Kazuhisa Tsuboki
Atmospheric Composition Data by FTIR Measurements (Moshiri and Rikubetsu)	Tomoo Nagahama
NO_2 and O_3 Data by UV/Visible Spectrometer Measurements (Moshiri and Rikubetsu)	Tomoo Nagahama
Satellite Data Simulator Unit (SDSU)	Hirohiko Masunaga
Energy Flux Diagnosis Code for Atmospheric and Oceanic Waves	Hidenori Aiki

■ Facilities

(10 in total)

Name	Contact Person
CIDAS System	Satoshi Masuda, Takayuki Umeda, Yoshizumi Miyoshi
Ion/Electron Beamline and Calibration Facility	Masafumi Hirahara
Clean Room Facility for Instrument Development	Masafumi Hirahara
Tandetron Accelerator Mass Spectrometry	Hiroyuki Kitagawa, Masayo Minami
Electron Probe Microanalyzer (EPMA)	Takenori Kato
Facilities at Moshiri Observatory	Akira Mizuno
Facilities at Rikubetsu Observatory	Akira Mizuno
Facilities at Kiso Station	Kazumasa Iwai
Facilities at Fuji Observatory	Kazumasa Iwawi
Facilities at Kagoshima Observatory	Kazuo Shiokawa

6. Governance

As of March 31, 2024

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7. Finance

External Funding and Industry–Academia–Government Collaborations

Researchers of ISEE members as principal investigator were supported by the following external funds.

Kakenhi category	Number of subjects	Total amount (JPY)
Grant-in-Aid for Scientific Research on Innovative Areas	1	7,800,000
Grant-in-Aid for Transformative Research Areas (A)	1	26,000,000
Grant-in-Aid for Scientific Research (S)	3	139,739,398
Grant-in-Aid for Scientific Research (A)	9	95,731,298
Grant-in-Aid for Scientific Research (B)	10	57,856,901
Grant-in-Aid for Scientific Research (C)	7	9,490,000
Grant-in-Aid for Challenging Research (Exploratory)	7	14,690,000
Grant-in-Aid for Early-Career Scientists	6	9,360,000
Grant-in-Aid for Research Activity Start-up	1	1,170,000
Fund for the Promotion of Joint International Research (International Leading Research）	1	110,500,000
Fund for the Promotion of Joint International Research (Fostering Joint International Research (B))	3	8,710,000
Fund for the Promotion of Joint International Research (International Collaborative Research)	2	6,500,000
Grant-in-Aid for JSPS Fellows	3	4,520,000
Total	54	492,067,597

- Fifty-four research subjects listed in the table were supported by the JSPS Kakenhi.
- Thirty-one research subjects received total 152,654,431 JPY from governmental funds except KAKENHI, and from other universities and companies. Twelve of them were collaborative researches between ISEE and companies, or national institutes.
- Three research subjects received total 3,099,550 JPY of donation.

Libraries

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

Books

Japanese	3,146
Foreign	11,159

Journals

Japanese	47
Foreign	207

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

Books

Japanese	4,469
Foreign	8,816

Journals

Japanese	288
Foreign	261

Properties

	Site (m^2)	Buildings (m^2)	Location
Higashiyama Campus (Main campus of Nagoya University)	-	8,442	Aichi
Toyokawa Campus	94,212	1,461	Aichi
Moshiri Observatory	110,534	325	Hokkaido
Rikubetsu Observatory	28,146	167	Hokkaido
Kagoshima Observatory	13,714	287	Kagoshima
Fuji Observatory	19,926	174	Yamanashi
Kiso Station	6,240	66	Nagano
Total	272,772	10,922	

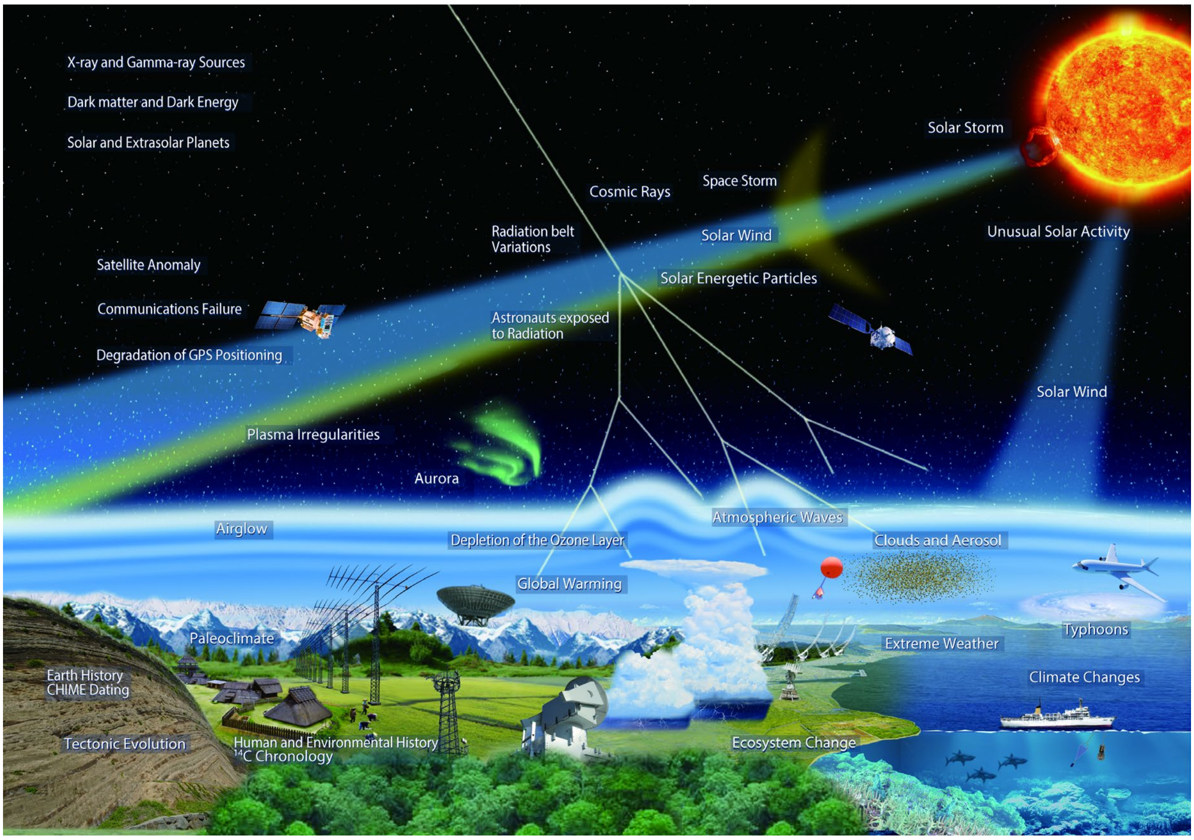
8. Research Topics

The mission of the ISEE is to comprehend the mechanisms and interactions of diverse processes occurring in the integrated space–Sun–Earth system to deal with global environmental problems and contribute to human society in the space age. Diverse research topics have been studied under seven research Divisions for Integrated Studies, Cosmic Ray Research, Heliospheric Research, Ionospheric and Magnetospheric Research, Meteorological and Atmospheric Research, Land–Ocean Ecosystem Research, and Chronological Research. Additionally, to develop new interdisciplinary research, the Institute will perform the following four interdisciplinary research projects in 2023 based on proposals from young faculty members using the director's Leadership Funds:

1) Energetic Particle Chain -Effects on the middle/lower atmosphere from energetic particle precipitations-
2) Direct Search for Dark Matter with Paleo-detector
3) Data Rescues of the Analog Observational Records for the Past Solar-Terrestrial Environment
4) Changes in Surface Temperature at Dome-Fuji in East Antarctica from the Mid-Twentieth Century and the Impact of Solar Activity

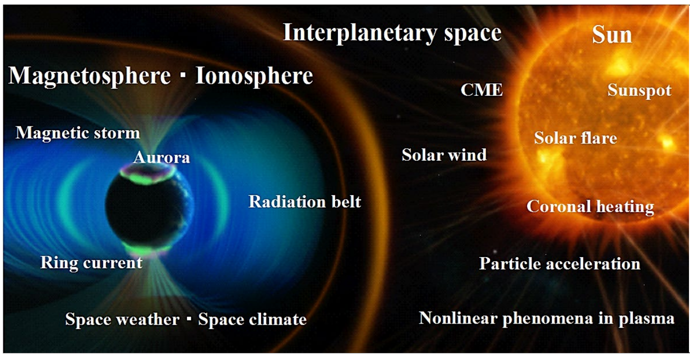
The seven research divisions are introduced in Section 8.1. The Research Divisions and Office for the Development of Interdisciplinary Research Strategy and its interdisciplinary research projects are introduced in Section 8.3. Interdisciplinary Research.

The ISEE also has three research centers that contribute to the 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 using four domestic observatories (Moshiri, Rikubetsu, Fuji, and Kagoshima) and a global observation network to enhance collaboration and joint research between domestic and international researchers and institutions. The Center for Integrated Data Science (CIDAS) is developing infrastructure and research for 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) performs planning and technological research using orbital and suborbital observation vehicles, such as aircraft, balloons, rockets, and satellites, with domestic and international networks. More information on these Research Centers can be found in "8.2 Research Centers"



Research Subjects at the ISEE

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

The Division for Integrated Studies conducts scientific research aimed at comprehensively understanding and predicting of various phenomena in the solar-terrestrial system based on advanced computer simulations and data analyses. In particular, we promote studies to elucidate various phenomena, such as solar cycles, solar flares, coronal mass ejections (CMEs), geomagnetic storms, and auroras, where the nonlinear interactions and intercoupling between different systems play an important role. We also promote scientific satellite mission projects (Hinode and ERG satellites) for observing the Sun and geospace in cooperation with the Institute of Space and Astronautical Science (ISAS)/JAXA and the National Astronomical Observatory of Japan (NAOJ). The faculty members of this Division are responsible for education at the Graduate School of Science and Engineering at Nagoya University.

Main Activities in FY2023

Reconstructions of past solar-terrestrial environments

Our team has steadily progressed with reconstructing past solar-terrestrial events using analog observational records and historical documents. Among extreme space-weather events, we reconstructed and quantified the Carrington Event in September 1859 (Hayakawa et al., 2023, *ApJL*), the extreme geomagnetic storm in Feb 1872 (Hayakawa et al., 2023, *ApJ*), the extreme solar particle storm in Feb 1956 (Hayakawa et al., 2024, *A&A*), and East Asian auroral activity in July 1959 (Hayakawa et al., 2024a, *MNRAS*). To assess long-term solar variability, we investigated past Sunspot records and obtained significant results for Misawa's observations (Hayakawa et al., 2024b, *MNRAS*), the Dalton Minimum (Hayakawa et al., 2023, *JSWSC*), and the early Maunder Minimum (Hayakawa et al., 2024c, *MNRAS*). Additionally, we analyzed drawings of a total solar eclipse that occurred during the Medieval Grand Maximum (Hayakawa et al., 2024d, *MNRAS*).

Estimating the scales of past large solar flares based on the correlations between the peak fluxes of radio bursts and GOES X-ray classes

The GOES X-ray class is widely used to determine the scale of solar flares. Although, estimating the scale of large past flares is crucial for space-weather research, this is challenging for those that occurred before the GOES satellite began operating in the late 1970s. Therefore, we developed a method to estimate the scale of past large flares based on the correlation between GOES X-ray classes and flare peak fluxes of solar radio emissions (3.75 and 9.4 GHz), which have been continuously observed since the 1950s. Subsequently, we quantitatively determined the scale and X-ray intensity variations between the two large flares that occurred in 1956 (Matsumoto et al., 2023, *PASJ*).

Numerical and observational study on the contributions of coronal holes to interplanetary magnetic flux

Coronal holes are dark regions on the solar surface with extremely low X-ray emissions and have long been considered the primary source of interplanetary magnetic flux. Recently, however, several studies have noted that the total magnetic flux dispensed by coronal holes is several times less than that measured by *in-situ* satellites in the interplanetary space. In this study, we investigated a scenario wherein the interplanetary magnetic-flux is supplied not only by coronal holes but also by other brighter coronas. To achieve this, we used coronal hole simulations with the radiative magnetohydrodynamic code RAMENS and observations from the NASA SDO satellite. We found that regions with active coronas filled with closed loops can supply "open" magnetic-flux into the interplanetary space, which may be detected as miniature coronal holes or regions slightly brighter than the coronal hole (Iijima, 2024, in *prep*).

On the anomalous UV emission from Li-, Na-like ions

The intensities of solar ultraviolet spectral lines from Li- and Na-like ions have been observed to exceed expectations based on coronal approximation plasma models. This deviation from the coronal approximation can be partly attributed to nonequilibrium ionization (NEI) resulting from dynamic processes near the transition region. To study the effects of these dynamics in Alfvén wave-heated coronal loops, numerical solutions were obtained for equations governing NEI across multiple ion species, alongside 1.5-dimensional magnetohydrodynamic equations. Upon injection of Alfvén waves from the photosphere, the system undergoes a time-evolution characterized by phases of evaporation, condensation, and quasi-steady states. During evaporation, ionization fractions of Li- and Na-like ions were observed to increase compared to equilibrium levels, leading to an intensity enhancement of up to 1.6. This excess ionization was attributed to the evaporation process. Although shocks colliding with the transition region caused temporary deviations from ionization equilibrium, these deviations averaged out over time and were negligible. Conversely, decreased ionization fractions resulted in intensity reductions down to 0.9 during condensation and quasi-steady states. As the over/under-fractionation depends on mass exchanges between the chromosphere and corona, these findings offer valuable benchmarks for validating Alfvén wave models and other coronal heating mechanisms.

Super-high resolution solar convective simulations approaching numerical convergence

In the solar interior, the interaction of turbulence and magnetic fields maintains large-scale flows and activity cycles. We have succeeded in reproducing the previously impossible solar differential rotation in the world largest solar interior simulation, which resolved the solar interior with 5.4 billion grid points (Hotta & Kusano, 2021). However, at present, the results change as the resolution is increased, and a reliable simulation has not been achieved. Therefore, by using Fugaku to its more marginal limit, we were able to achieve a calculation of 38.4 billion points and achieved numerical convergence with almost no difference in the distribution of differential rotation from previous simulations. In the future, we plan to analyze the simulation results in detail to investigate the factors that led to the numerical convergence.

Semi-analytical study of high-order g modes

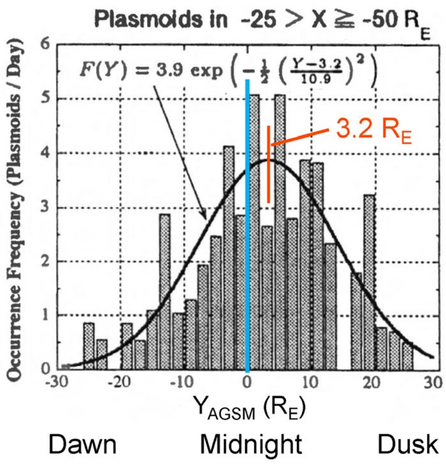
The chemical composition gradients (CCG) within stars contain considerable information on internal mixing processes, such as convection and rotationally induced mixing. Gravity (g) modes, whose restoring force is buoyancy, are especially important because they are sensitive to the CCGs within the deep radiative regions of stars. Using an asymptotic approximation and a simple model of the Brunt–Väisälä frequency, we derived a semi-analytical expression for high-order g-mode periods (Hatta 2023, *ApJ*). This expression can be used in observational studies of CCGs within intermediate-mass main-sequence stars, for which high-order g modes have been often observed.

Spatiotemporal evolution of SAPS associated with pseudobreakup

Observations of the Arase and geosynchronous satellites, as well as an ionospheric high-frequency radar network called SuperDARN, were examined to investigate the evolution of subauroral polarization streams (SAPS) at subauroral latitudes in association with a pseudobreakup of aurora. The results indicated that the SAPS region exhibits an intermittent, multi-step expansion both longitudinally and latitudinally immediately after a pseudobreakup aurora, following the individual occurrences of energetic particle injections in the nightside magnetosphere. These findings imply that the SAPS observed during pseudobreakup auroras are driven by the same mechanism as that during full-fledged substorms.

Duskward displacement of plasmoids and reconnection in the near-Earth magnetotail

Based on observations of tailward-moving plasmoids, the Geotail spacecraft mission discovered that the reconnection location was displaced toward dusk. However, recent spacecraft observations have indicated that the reconnection was displaced toward dawn in Mercury's magnetotail. In response to this controversy, our study aims to clarify the dawn–dusk location of fast plasma flows in the near-Earth magnetotail. Through a comprehensive reinterpretation and integration of previous statistical results, we found that the dusk preference is generally evident for tailward flows but is often absent for earthward flows. These results indicate that the statistical results of earthward flows are sensitive to event selection criteria. We conclude that the dawn–dusk location of earthward flow is statistically unclear at the time of substorm onset. (Ieda and Miyashita, *EPS*, 2024, doi:10.1186/s40623-024-02003-w).



The occurrence rate of tailward-moving plasmoids in the near-Earth magnetotail. Geotail discovered that the reconnection location was displaced toward dusk.

Comparative study of ions and electrons pressure distribution in the inner magnetosphere during CIR and CME driven storms observed by Arase satellite

Geomagnetic storms are caused by corotating interaction regions (CIRs) associated with high-speed solar wind streamers (HSSs), and CMEs. There are significant differences in the storm evolution between these two storm drivers due to the distinct solar wind structures. It has been shown that the ion and electron distributions of CME/CIR-driven storms are different, especially for the recovery phase (Miyoshi and Kataoka, 2005). The spatial and temporal distribution of electrons and ions pressure during the main phase, early recovery, and late recovery phases for the selected CIR and CME storms is examined statistically for the first time using *in situ* plasma/particle data obtained by Arase during 2017–2023. The total ring current is often dominated by the H+ and the electron contribution is not well established. Recent statistical study of CIR storms (2017–2022) using Arase observations revealed that the electron contribution is significant (~ 22%) to the total pressure in 03-09 MLT sector during the main and early recovery phase (Kumar et al., 2023). In the present work, it is found that the O+ contribution to the total pressure is significant (~ 25%) during main and early recovery phases of the CMEs storm highlighting the importance of ionospheric outflow during intense magnetic storms. However, electrons play a significant role (~22%) in CIR storms and have a non-negligible role (~13%) in CME storms to the ring current during main and early recovery phases in dawn sector. The results indicate the importance of electrons in the ring current build-up (Kumar et al., *JGR*, 2023).

Long-term variations of terrestrial molecular ions in the inner magnetosphere

A study was conducted on the variation of molecular ions from 2017 to 2023 using data from the Low-Energy Ion Energy Mass Analyzer (LEPi) aboard the Arase satellite. A new analysis method for time-of-flight analyzers was developed, establishing a technique for accurately detecting molecular ion counts. The results of data analysis revealed that the increase in molecular ions in the inner magnetosphere is strongly correlated with the increase in solar wind pressure and shows different variations from oxygen ions. Based on these findings, a new model proposing the increase in solar wind pressure and the increase in molecular ions in the inner magnetosphere was suggested.

Pitch-angle distribution of energetic electrons obtained using ERG/Arase satellite data

Charged particles from solar origin enter the Earth's magnetosphere and become trapped in its closed magnetic cavity. The energies of these particles vary from a few keV to a few MeV. The flux of these magnetospheric trapped particles first decreases during the main phase of the geomagnetic storm and then increase during the early and late recovery phases. The correlation between the electron-flux variations and their effect on the changes in electron pitch-angle distributions is not well understood. Therefore, this study aimed to understand the variations in the energetic-electron flux and pitch-angle distribution in the outer radiation belt during different phases of geomagnetic storms. We selected geomagnetic storms from 2017 to 2023 with SYM-H < −40 nT. Using data from Arase's High-Energy Electron experiments (HEP) and Magnetic Field Experiment (MGF) instruments, we derived the pitch-angle distribution as a function of L, energy, and storm phases. Subsequently, we fitted them based on the Legendre function with sixth-order accuracy to model the pitch-angle distribution and classified them into three types: pancake, butterfly, and flattop. We analyzed the storm-phase dependence of the pitch-angle distribution for multi-hundred and multi-MeV electrons. The L-MLT dependence of the pitch-angle distribution was examined for different energies. Currently, we consider the different physical mechanisms responsible for the observed L-MLT-dependent pitch-angle distribution to be the major contributors.

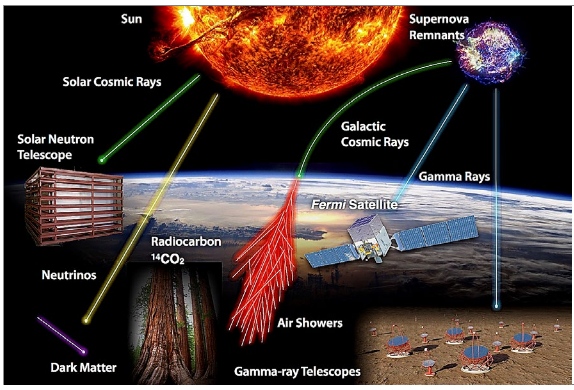
Studies of nonlinear EMIC waves driven by the compression of the dayside magnetosphere

The electromagnetic ion cyclotron (EMIC) wave-particle interactions are believed to play a significant role in controlling the dynamics of energetic particles in the magnetosphere. In particular, nonlinear processes can cause rapid losses of relativistic electrons in the outer radiation belt. Using the Arase and Van Allen Probes satellite observations, we investigate the nonlinear EMIC rising-tone emissions with an increase of the solar wind dynamic pressure in the dayside magnetosphere. We find that EMIC rising-tone emissions are accompanied by the extended dayside uniform zone (DUZ) over magnetic latitudes (MLAT) < 25° due to the dayside magnetospheric compression by an increase in the solar wind dynamic pressure. Using the observed plasma and magnetic field data, we modeled the threshold amplitude for the nonlinear EMIC waves and compared it with the observation. The small gradient of the ambient magnetic field strongly contributes to the reduction in the threshold amplitude of nonlinear wave growth compared to other parameters. When the threshold amplitude falls to comparable level of pre-existing EMIC waves, EMIC rising-tone emissions are immediately triggered, suggesting direct evidence that the DUZ is the preferred condition to cause the nonlinear EMIC rising-tone emission in the dayside magnetosphere. We also investigate the variations of relativistic electron distributions between structureless EMIC wave events and nonlinear EMIC rising-tone emission events due to dayside magnetospheric compression using the Van Allen Probes and Arase satellites. We find a clear depression in phase space density of relativistic electrons (E < 4 MeV) coincident with when EMIC rising-tone emissions are observed. This result suggests that rapid loss of relativistic electrons is caused by EMIC wave-particle interactions and the nonlinear process leads to extend the minimum resonance energy to sub-relativistic electrons (E ~ several hundred keV). We will discuss the influence of nonlinear process on loss of relativistic electrons in the outer radiation belt through EMIC wave-particle interactions.

Modeling EMIC-wave-induced proton precipitation into the subauroral ionosphere

The gyroresonant interaction of EMIC waves with ring-current ions is a crucial mechanism that can cause ions to precipitate into the subauroral ionosphere. Therefore, realistic predictions of ionospheric dynamics require accurate representations of the EMIC-wave–particle interactions in space-weather models. Specifically, the spatial–temporal evolution of the modeled precipitation and its relationships with the time and location of EMIC-wave excitations as well as the local plasma conditions in the inner magnetosphere require further verification through *in-situ* observations. We used the BATS-R-US+RAM-SCB model to understand the evolution of EMIC waves in the inner magnetosphere and their association with proton precipitation in the subauroral ionosphere. During the storm that occurred on 27 May 2017, the Arase and RBSP-A satellites observed typical EMIC-wave signatures in the inner magnetosphere. Within this interval, the DMSP and NOAA/MetOp satellites observed significant proton precipitation in the dusk-midnight sector. Ground magnetometer observations from mid-latitude stations confirmed EMIC-wave activity in the dusk sector. The simulation results showed that H- and He-band EMIC waves were excited within regions of strong temperature anisotropy near the plasmapause. The simulated growth rates of the EMIC waves exhibited a similar trend similar to that of the EMIC-wave powers observed by the Arase and RBSP-A satellites. However, the simulated H-band waves in the dusk sector were stronger than the He-band waves, possibly owing to the presence of excess protons in the boundary conditions obtained from the BATS-R-US code. The simulated precipitating proton fluxes agreed well with the DMSP and NOAA/MetOp satellite observations. Therefore, we suggest that the EMIC-wave scattering of ring-current ions can account for the proton precipitation observed by the DMSP and MetOp satellites during the 27 May 2017 storm.

Division for Cosmic-Ray Research



- Acceleration and propagation of CRs
  - – Cosmic gamma-ray observations
  - – Solar neutron observations
- CR interactions with the Earth's atmosphere
  - – Hadron interactions of very high-energy CRs
  - – Past solar activity probed by cosmogenic nuclides
- Particle astrophysics and non-accelerator physics
  - – Dark matter and neutrino physics

Cosmic rays (CRs), which primarily comprise protons and 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 (IMFs) before reaching the Earth. The Division for Cosmic Ray Research observes cosmic gamma-rays using the Fermi Gamma-ray Space Telescope (Fermi satellite), Cherenkov Telescope Array (CTA), and high-altitude solar neutron observations to elucidate 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 the laboratory. We conducted large hadron collider forward (LHCf) and relativistic heavy ion collider forward (RHICf) experiments to study the hadronic interactions between ultra-high-energy CRs using accelerators such as the LHC and RHIC. This Division also conducted neutrino physics research using the Super-Kamiokande experiment and promoted the Hyper-Kamiokande project as a future prospect. The group intensively worked on direct dark-matter searches using the XENONnT experiment at the Gran Sasso National Laboratory (LNGS) in Italy.

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

Main Activities in FY2023

Search for dark matter and research on the CR origins using gamma-ray observations

Cosmic gamma rays are produced through interactions between dark matter, CRs, and the interstellar medium. Therefore, they can serve as indicators to search for dark matter and investigate the properties and distribution of CRs and interstellar media.

We are currently developing a next-generation gamma-ray observatory, called the CTA, to observe cosmic gamma-rays in the energy range from well below 100 GeV to above 100 TeV. This involves overseeing the development, procurement, and calibration of silicon photomultipliers (SiPMs) for small-sized telescopes (SSTs) installed in the CTA. Currently, we are building a camera for the first SST and have procured all SiPM modules required for one camera and some spares.

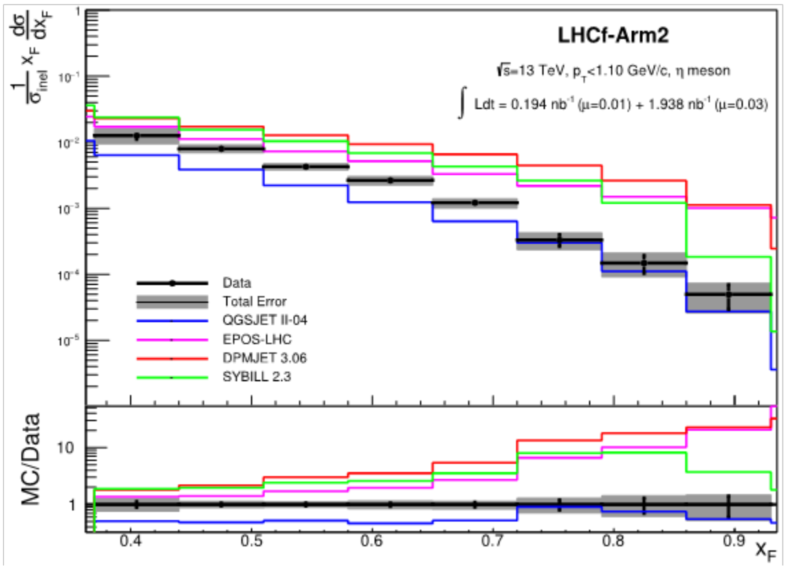
Since we plan to build more than 40 SSTs with 2048 SiPMs, it is important to understand their failure modes and rates. In an initial test, we measured the leakage current of a SiPM module, totaling 64 SiPMs, for more than half a year and found that it was fairly stable in most SiPMs and did not cause any issues during the observations. Although one SiPM exhibited a 10-hold increase in the leakage current, no visible increase was observed in its dark count rate, indicating that the increase was not caused by a higher dark count rate. Additionally, the voltage dependence of the leakage current exhibited resistor-like behavior, verifying the existence of a current source parallel to the SiPMs. We speculate that this increase in current was caused by a circuit-board defect.

Furthermore, the leakage current in 20% of the SiPMs jumped by fixed amounts and some SiPMs exhibited several jump modes. We speculate that these modal jumps are caused by the activation and deactivation of a certain defect, and that multimodal behavior is caused by multiple defects. In fact, we observed localized light emission from hot-carrier luminescence at these defect sites and found that the luminosity was proportional to the current. Additionally, emission sites tended to be located at microcell corners, indicating the structural cause of the defects. Hence, we could reduce the defect rate by correcting these structural issues.

CR interaction-focused accelerator experiments

Many CR studies have been conducted worldwide to understand where and how CR particles accelerate to higher energy. CRs are observed through the air-shower technique, which involves the observation of particle cascades caused by interactions between CRs and atmospheric atomic nuclei using particle detectors or fluorescence telescopes. A precise understanding of the hadronic interactions between CR particles and the atmosphere is essential for estimating primary CR information from the observed air showers. Additionally, the interpretation of their chemical composition is strongly dependent on the hadronic interaction model used in the air-shower simulation. Therefore, we studied high-energy interactions at the large-particle colliders, LHC and RHIC, located at the European Organization for Nuclear Research and Brookhaven National Laboratory, respectively, through the LHCf and RHICf experiments, respectively.

Proton–proton collision measurements with a center-of-mass collision energy $\sqrt{s}$ = 13.6 TeV were conducted at the LHC in September 2022, wherein approximately 300 million events were obtained, which was approximately seven times higher than those obtained in 2015. In FY2023, we checked and calibrated the data before conducting physical analyses. Because a calorimeter was employed as the detector, energy calibrations were imperative for measuring the differential production cross-sections of photons and neutrons. In previous measurements, calibrations were performed using the results of beam tests conducted with the SPS accelerator, either before or after the LHC measurements. However, taking advantage of high-statistics data, we developed a new calibration method using the data acquired from the LHC, thereby reducing the energy-scale uncertainty to a smaller value than those in previous studies. Additionally, preparations for joint analyses with the ATLAS experiment are underway, the process of finding and matching the same collision events in the LHCf and ATLAS data has been completed, and we are ready to conduct physical analyses using this combined dataset.



Differential production cross-section measurements of η mesons at √s = 13 TeV proton-proton collisions obtained using various hadronic models (colored lines) in LHCf experiments.

Simultaneously, are working toward analyzing data from past experiments. The results of differential production cross-section measurements of η mesons in proton–proton collisions at a center-of-mass collision energy $\sqrt{s}$ = 13 TeV obtained in 2015 are shown in the figure on the right. The results were compared with the predictions of hadron interaction models, and no model was found to perfectly reproduce the data.

Historic CR-intensity variation measurements using cosmogenic radioisotopes

The CRs reaching Earth interact with the atmosphere to produce secondary particles. Among them, long-lived cosmogenic nuclides, such as ^{14}C and ^{10}Be, have been conventionally employed as excellent indicators for determining CR intensities. Therefore, we measured ^{14}C concentrations in tree-rings and ^{10}Be concentrations in ice cores to investigate past CR variations. These analyses revealed rapid CR-increase events during several periods, such as 774/775 CE, 993/994 CE, and ~660 BCE, and are considered to be caused by SEP events, whose scales are estimated to be tens of times larger than the largest recorded event. Such extreme SEP events pose a major threat to the current space-exploration era. Therefore, we aimed to identify other CR events and determine the frequency of extreme SEP events by measuring ^{14}C concentrations in tree-rings.

We comprehensively searched for extreme SEP events (rapid increases in ^{14}C concentrations), such as that in 774 CE, over the past ~10000 years, by measuring the ^{14}C concentration in tree-rings at an annual time resolution. This year, we investigated the period from 3000s to 2000s BCE primarily through Russian and Japanese tree samples.

We found signficant gaps, on the scale of several tens of times, between the largest SEP event (774 CE) and those detected by modern observations. However, intermediate-scale events were not detected primarily owing to uncertainties in the analyses of cosmogenic nuclides and insufficient separation from background fluctuations. This year, we focused on seasonal variation, which is a type of ^{14}C background variation, and investigated differences in ^{14}C concentrations in early- and late-woods using ring samples obtained from multiple regions and tree species. Although the ^{14}C concentration between early- and late-woods is expected to differ by several permil, assuming a general tree-ring growth period, such differences were not observed in the Alaskan samples analyzed in this study. This indicates that the ^{14}C fluctuations may differ among annual layers based on factors such as the use of stored carbon for tree-ring formation or the tree-ring growth period. Addiitonally, we conducted high-precision ^{14}C-analysis of 19th century tree-rings, including the years of the largest solar flares and geomagnetic storms in the past ~150 years (1859 and 1872 CE). However, no significant increase in ^{14}C was observed, and the occurrence of an SEP event at ~1/10 the scale of the 774 CE event was not confirmed in the analyzed data (Miyake et al. 2023). Therefore, it is crucial to conduct further surveys of other time intervals and understand the background variations in ^{14}C concentrations to detect intermediate-scale events.

Neutrino studies through underground experiments

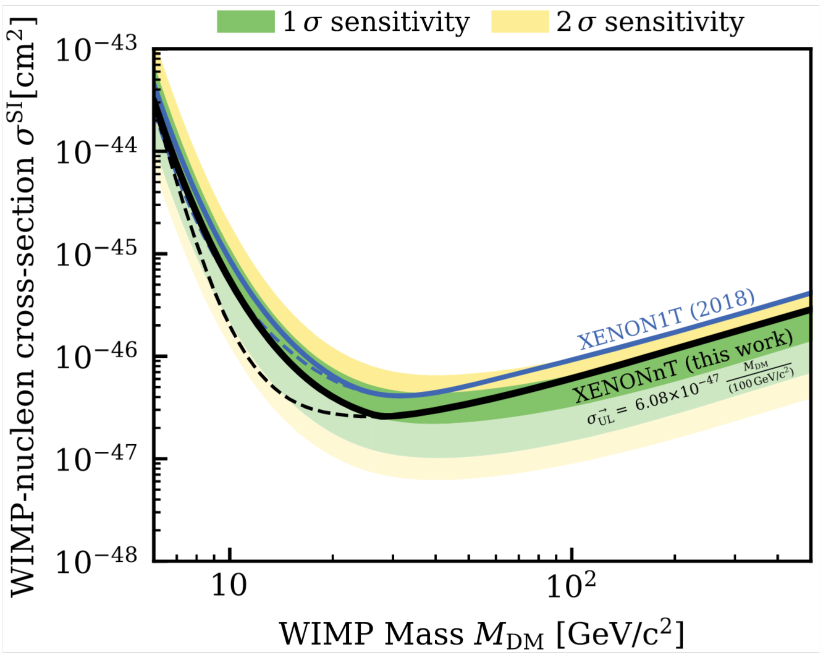
Neutrinos are elusive elementary particles with nearly zero mass or electric charge and interact only through weak interactions. Their properties, such as mass, can be studied through oscillations, wherein the neutrino flavor, electrons, muons, and tau neutrinos can change into each other as they travel through space. Our group is researching neutrinos at the Super-Kamiokande (SK) experiment in the underground Kamioka Observatory and is also promoting the future Hyper-Kamiokande (HK) experiment, whose effective volume will be eight times higher than that of SK.

In this FY, we investigated the feasibility of conducting a sterile-neutrino search using the Super-Kamiokande detector. Sterile neutrinos are hypothetical neutrinos and differ from the other three well-known neutrinos in that they only interact via gravity and do not interact with matter at all, and their existence has been suggested in the results of some experiments. Because sterile neutrinos do interact weakly, we conducted sterile-neutrino detection using the up-down asymmetry of proton events produced by the neutral-current interactions of atmospheric neutrinos in SK. The search sensitivity was evaluated through a Monte Carlo simulation and was found to be sensitive with a 90% confidence level within a specific mass range. In the future, we will enhance the evaluation method and conduct analysis using actual data.

The construction of HK is on schedule. The access tunnel has been constructed and excavation of the main cavity is underway. Additionally, the manufacturing of the new 20-inch box & line PMTs for the HK detector is progressing smoothly, with approximately 20000 PMTs to be manufactured. These PMTs have been installed in the SK tank since 2018 and are used to evaluate stability under long-term underwater operations. This year, an automated analysis system was developed to evaluate the stability of the HK-PMT gain in SK; the PMT gain can be obtained by comparing the PMT output charge with the light intensity expected in a muon event. The HK-PMT was confirmed to have better gain stability than the SK-PMT.

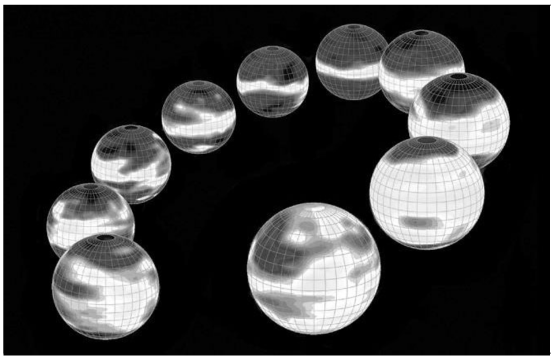
Dark matter search using a liquid-Xenon detector

Dark matter in space is difficult to observe owing to its weak interactions and is considered to comprise undiscovered elementary weakly interacting massive particles (WIMPs). In collaboration with Kobayashi-Maskawa Institute our group conducted a direct dark-matter search using the XENONnT experiment with liquid xenon, which is currently underway at the underground facility of the Gran Sasso National Laboratory in Italy, and developed detectors for a future project, the DARWIN/XLZD experiment. This year, using the initial data (1.1 t-year) obtained through the XENONnT experiment, we obtained the results of the first WIMP search through xenon nuclear recoil and published them in Physical Review Letters. No significant WIMP signal was observed and an upper limit of 2.58×10^{-47} cm^2 (for WIMPs with 28-GeV mass) was obtained for the spin-independent scattering cross-section between WIMPs and nucleons. This represents the most sensitive WIMP search result in th world, surpassing that of the XENON1T experiment. Additionally, the analysis of electron recoil events has laid the foundation for solar pp-neutrino detection. As R&D efforts toward future liquid-xenon dark-matter detectors continue, we are also developing a sealed liquid xenon TPC detector comprising a quartz container, which prevents radon from entering the detector components, and a low-background UV detector. This year, we verified the radon-blocking capability of the quartz-flange vessel in the sealed liquid xenon TPC detector. Furthermore, a fine-wire-coated quartz electrode was developed to fabricate a single-phase liquid TPC. To create the UV sensor, we developed a low-dark-count SiPM and hybrid PMT using a SiPM and evaluated their performances.



WIMP search result of XENONnT. The line represents the upper limit of the spin-independent scattering cross-section between WIMPs and nucleons.

Division for Heliospheric Research



- Solar wind and heliosphere
- Interplanetary scintillation (IPS)
- Coronal mass ejection (CME)
- Long-term variation of the heliosphere
- Space-weather forecast
- Radio astronomy
- Development of telescopes and instruments
- Pulsar

A supersonic plasma flow (speed = 300–800 km/s), known as solar wind, emanates from the Sun and permanently engulfs the Earth. Although the magnetic field of the Earth acts as a barrier to protect its atmosphere from direct interactions with the solar wind, a considerable fraction of its significant energy enters the near-surface layer via various processes. Thus, the solar wind acts as a carrier that transfers 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 reaches the Earth and generates intense disturbances in the geospace and upper atmosphere. Space environmental conditions that significantly change with solar activity are known as "space weather" and are currently a topic of significant interest. Therefore, an accurate understanding of the solar wind is necessary to reliably predict space-weather disturbances.

We have observed solar-wind velocities and density irregularities for several decades using three large antennas to investigate important unresolved issues such as the acceleration and propagation mechanisms of the solar wind, space-weather forecasting, global structure of the heliosphere and its variation. Additionally, laboratory and field experiments were performed to improve data quality and upgrade the instruments.

Main Activities in FY2023

Overview of solar-wind observations using the IPS system

Since the 1980s, our research group has been conducting remote sensing of the solar wind using a 327 MHz multi-station system for interplanetary scintillation (IPS). By analyzing the obtained IPS data using tomography, we can accurately determine the global distributions of solar-wind velocity and density fluctuations. This is particularly valuable for high-latitude solar wind, as there are currently no spacecraft observations available, making IPS observations a crucial source of information regarding the global distribution of the solar wind.

The IPS multi-station system currently operates three large antennas located at Toyokawa, Fuji, and Kiso. The Toyokawa antenna (Solar Wind Imaging Facility, SWIFT) is the largest and most sensitive among the three. It commenced observations in 2008 and has been operating daily since then. Additionally, the receivers of the Fuji and Kiso antennas were upgraded between 2013 and 2014, resulting in improved sensitivity. However, as they are situated in mountainous areas, they suspend operations during winter because of snow. Consequently, solar-wind velocity data from multi--station observations are unavailable during winter. By contrast, data on solar-wind density fluctuations from the Toyokawa antenna are available around the year.

The obtained IPS data are immediately made available via our institute's FTP server and utilized in various international collaborative research projects. During this FY, IPS observations began at the Toyokawa and Fuji antennas, whereas the Kiso antenna could not commence observations owing to a drive-system failure that occurred in September 2022. Repairs were completed in August and three-station observations resumed in September 2023. However, almost simultaneously, drive-system failure occurred in the Fuji antenna. Therefore, from September 8th , the observation range was changed from the traditional zenith- angle range of N20–S60 to N20–S50 for safety reasons. This limited the observations of the southern side of the Sun, hindering adequate reconstructions of solar-wind structures in the Southern Hemisphere. This issue has since been resolved and the observation range will be restored in the next FY.

Additionally, owing to the frequent amplifier failures caused by lightning surges at Toyokawa, surge absorbers were installed on its RF signal cables. This measure has proven to be highly effective with no subsequent failures. Therefore, surge absorbers will also be installed at the Fuji and Kiso antennas in the next FY.

International joint research

International joint research was conducted to compare the solar wind data acquired by the BepiColombo spacecraft, which is a joint mission of the European Space Agency and the Japan Aerospace Exploration Agency to the planet Mercury, during its cruise phase with the IPS observations and global magnetohydrodynamic (MHD) simulations. The ISEE International Workshop proposed by Dr. Hadid of CNES, France, was held in January 2024, and a review paper will be submitted to the Earth, Planets and Space (EPS) journal. Additionally, a special issue will be proposed to the EPS. Dr. Sanches-Cano from the University of Leicester, UK, visited ISEE using the ISEE International Joint Research Project during the ISEE International Workshop to compare the CME and SEP phenomena observed by BepiColombo with the IPS observations of ISEE.

Dr. Takuya Hara of the University of California, Berkeley, was invited under the ISEE International Joint Research Project to study the extraction of solar wind in the Martian orbit from the global MHD simulation (IPS-SUSANOO), which includes the IPS observation data, and compare it with the data from the US Martian orbiter.

Dr. Jackson and Mr. Bracamontes of the University of California, San Diego (UCSD) were invited through the International Technical Exchange Program to conduct numerical experiments on including the ISEE IPS observation data into the inner boundary of a global MHD simulation by applying UCSD’s tomography method and using it to drive the Enlil simulation developed in the US and SUSANOO developed in Japan.

Additionally, Dr. Asayama of the SKA Observatory (SKAO) in the UK was invited under the ISEE International Joint Research Project to study the development and evaluate the performances of the next-generation solar wind observation system by applying the knowledge obtained from the SKA project. During his stay, he also conducted a test observation using dipole antennas developed for the next-generation instrument that was deployed on the roof of the Research Institutes Building I.

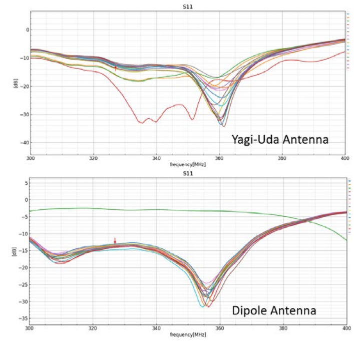
Next generation solar wind observation system project

The project for the next generation solar-wind observation system has been promoted by the KAKENHI Grant-in-Aid for Scientific Research (A) since FY2021, and research has been conducted to install a core array of 5% the size of the Fuji station. Three new graduate students joined the project this year to accelerate the experiments, which included performance evaluations of a 64-channel digital backend, a 16-port analog beam conbiner, and two antenna prototypes.

This project was proposed to Roadmap 2023 as a joint project of “Study of coupling processes in solar-terrestrial system,” but was not selected. However, it was accepted for a Grant-in-Aid for Scientific Research (S) for FY2024. We are planning to construct an antenna array approximately 1/3rd the size of the total size (1200–1500 m^2) at the Fuji observatory at a total cost of 160 million yen beginning in the next FY.

Performance measurement of element antennas for next generation solar-wind observation system

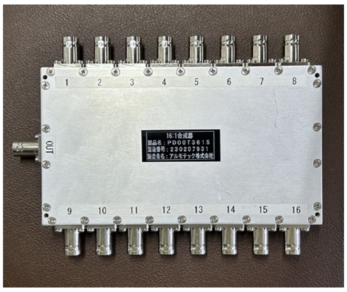
In this study, we developed a phased-array antenna system as part of a next-generation solar-wind-observation system. For Phase I of the next-generation system, we plan to develop a flat phased-array antenna system comprising 64 sets of subarrays with 16 antennas, for a total of 1024 antennas. The antenna candidates for use in the subarrays are the 2-element Yagi-Uda and half-wavelength dipole antennas. Additionally, we must determine the yield rate for the mass production of antennas in the future. Therefore, in FY2023, we evaluated the performances of the 16 antennas to determine the yield rate. Among the 16 antennas, three exhibited different characteristics for the Yagi-Uda antenna, whereas one exhibited different characteristics for the dipole antenna. This is because, in the Yagi antenna, the elements are not mounted in parallel owing to a human error during manufacturing. Additionally, in the half-wavelength dipole antenna, an abnormality may exist within the power feeder; however, the cause is unknown.



S11 parameters of two types of antenna elements

Development of an analog signal combination system for the next-generation solar wind observation system

We have developed an analog signal combination system for the next-generation solar wind observation system. It combines the 16 analog signals received by the 16 antennas to form a subarray and minimizes power losses of signals obtained from each antenna to ensure a high-gain performance of the subarray. Additionally, we constructed a prototype a 16-port signal combiner that simultaneously combines the 16 signals from each antennas. Subseqently, we conducted an experiment to evaluate the insertion loss of the combiner using amplified white noise as the input signal and determined the insertion loss to be 0.54 dB, which is approximately equal to the required specification of 0.5 dB. In the future, we aim to determine the appropriate configuration and equipment for this analog signal combination system by evaluating the transitions of gain and noise levels in the entire analog signal system. We also plan to develop an amplification and filtering system and finally propose the configuration and equipment for the analog signal system and evaluate its performance for the next-generation solar wind observation system.


16 port power combiner.

Development of a digital multi-beamformer for the next-generation solar-wind-observation system

During the development of the next-generation solar-wind-observation system, the digital backend was evaluated, with the aim of debugging the implemented program and identifying hardware-related issues. This project aims to observe up to 1000 radio sources per day with 1024 analog inputs at 327 MHz by installing a wide-field-of-view large-aperture array. To achieve, multi-beam systems and wide-field optics must be developed.


Setup for evaluation test of digital backend.

A prototype instrument and 64-channel digital backend, which are parts of this system, have already been developed. They were evaluated in a laboratory using a pseudo-signal containing white noise as the input signal and employing four metrics: linearity, grating lobe, filter curve, and Allan dispersion.

The prototype instrument, which was a one-dimensional array, comprised eight analog-input channels and synthesized four beams. It exhibited a dynamic range of approximately 50 dB, along with grating lobes. However, during the tests, the beamformer and control computer frequently disconnecte.

The 64-channel digital backend, which was a 2D planar array, could select either the 4- or 8-beam mode comprising 16384 and 8192 FFT points, respectively. Owing to this FFT-point difference, the output range in the two modes differed by approximately

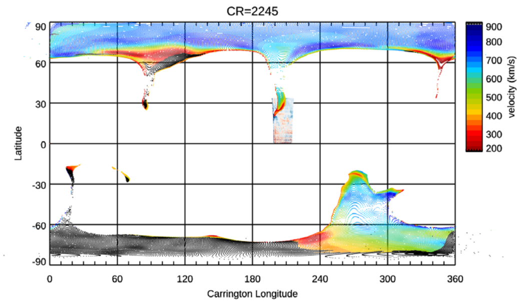
5.4 ± 0.6 dB, with a dynamic range of approximately 60 dB or higher. Additionally, some issues in the installed program were also identified and the reasons behind the program or quantization errors due to digital conversion are being investigated. Although extremely rare, packet losses were observed during beamforming and their causes are alsso being investigated.

Relationship between solar-wind source region and upflow

The source region and acceleration mechanism of slow solar winds (generally less than 500 km/s) are still unknown, and upflow, which is an upwelling of plasma observed at the edge of an active region, is considered a strong candidate. In FY2023, we investigated the relationship between upflow and slow solar winds by superimposing and analyzing the global solar-wind structure obtained from interplanetary scintillation observations, Doppler-velocity images obtained from the extreme-UV imaging spectrometer onboard the Hinode satellite, and a magnetic-field model calculated assuming a potential magnetic-field. We analyzed the upflow observed on June 18, 2021 and discovered magnetic-field lines extending from the upflow region to the heliosphere; the velocity of the solar wind resulting in the magnetic-field lines was 200–450 km/s. Therefore, we suggest that the upflow region analyzed in this study was the source of the slow solar wind.

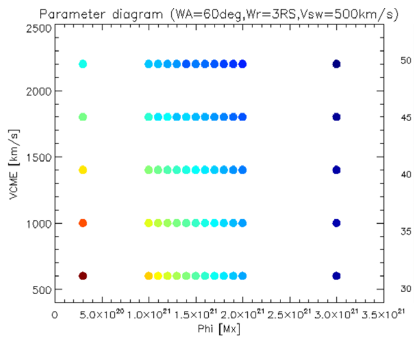
To conclude that the upflow is indeed the source of slow solar winds, it is necessary to interpret the physical quantities obtained from the remote-sensing of the Hinode satellite in conjunction with those obtained through *in-situ* observations. Additionally, there is concern that the Hinode satellite images are projected to a different position than originally projected, and detailed alignment with an error margin of a few arcseconds is necessary to compare the results obtained in this study with the physical quantities obtained through *in-situ* observations.

In FY2024, we plan to analyze many upflows to further clarify their relationship with slow solar winds and invetigaate other physical quantities to determine the acceleration mechanism of slow solar wind.



Comparison of Doppler Velocities of plasma upflow (Hinode/EIS), Solar Wind Sources (PFSS), and Solar Wind Speeds (IPS).

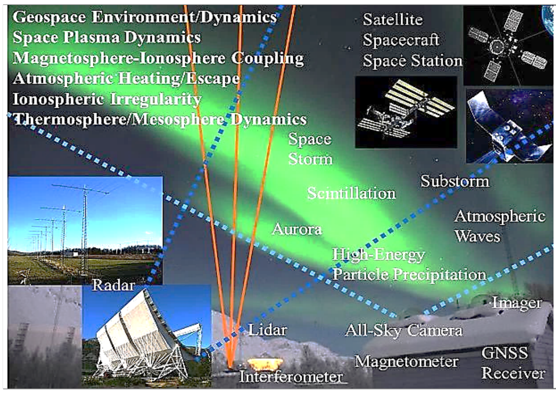
Evaluation of the relationship between initial parameters and predicted time of arrival of CMEs on Earth using the SUSANOO-CME model



Parameter diagram of the ToA.

SUSANOO-CME is a global heliospherical MHD simulation model developed by the ISEE and NICT. We used this model to evaluate the relationship between the given initial parameters and the time of arrival of CMEs on Earth. As CMEs are the primary sources of space-weather disturbances, there is an urgent demand to predict their scales and times of arrival on Earth. However, the current model needs improvements in its physical reproduction and prediction accuracy. These issues can be addressed by individually evaluating and revising each component of the model. Therefore, we conducted numerious simulations by varying the CME parameters and ambient-solar-wind speed individually over a range of typically observed values, and quantified the deviations in the arrival times of CMEs on Earth. Specifically, this was this first study to investigate the relationship between the magnetic flux in the spheromak CME model characteristics of SUSANOO-CME and the arrival times by applying a method to estimate the magnetic flux in CMEs indirectly obtained through statistical observational studies. The results indicated that the arrival-time variations caused by magnetic-flux errors determined using this method was approximately 19–48 h. This implies that the variations in the magnetic flux estimated using current observations can cause the predictions to deviate significantly compared with other parameters. We also introduced parameter diagrams indicating the relationships between the predicted arrival times and the initial conditions employed in the simulation for the first time. These results could effectively minimize the simulation times for real-time forecasting.

Division for Ionospheric and Magnetospheric Research



- Energy transfer from the solar wind to the magnetosphere and ionosphere
- Magnetosphere-ionosphere-thermosphere coupling system
- Ground-based and network observations
- 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, which are collectively called geospace. We studied these effects and the associated phenomena via international cooperation, primarily through various observational approaches using ground-based instruments, such as 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 were developed by our Division. We also paved the way for future space exploration missions based on our expertise.

Main Activities in FY2023

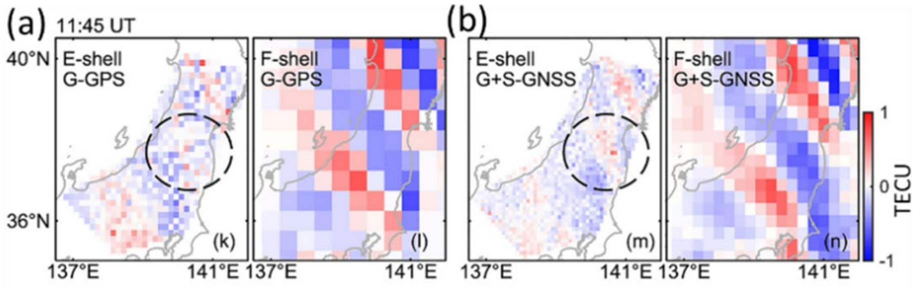
Auroral and electromagnetic-wave measurements at subauroral latitudes

Aurora/airglow imagers and electromagnetic-wave receivers have been operated at eight stations around the North Pole at MLATs of ~60° in Canada, Russia, Alaska, Finland, and Iceland since 2016 through the study of dynamical variation of particles and waves in the inner magnetosphere using ground-based network observations (PWING) project to investigate the plasma and wave dynamics in the inner magnetosphere. Although the PWING project concluded in FY2022, the instruments continued to be operated under the new PBASE program, and several new results were obtained in FY2023. The longitudinal development of cosmic-noise absorption, which corresponds to high-energy (30–100 keV) electron precipitation, was first clarified based on multipoint observations by riometers at subauroral latitudes during storm-time substorms from August 25–28, 2018. Statistical analysis of the low-latitude boundary of polar-type medium-scale traveling ionospheric disturbances (MSTIDs) was performed using a 630-nm airglow imager in Finland, and the existence of a latitudinal boundary between the polar-type and mid-latitude MSTIDs was confirmed.

Upper-atmosphere imaging using OMTIs

Optical mesosphere thermosphere imagers (OMTIs), which comprise five sky-scanning Fabry–Perot interferometers, 21 all-sky charge-coupled device imagers, three tilting photometers, and three airglow-temperature photometers, are continued to be operated. They have been used to investigate the dynamics of the mesosphere, thermosphere, and ionosphere, and several new results were obtained from OMTI measurements in FY2023. This included the observation of three low-latitude auroras associated with high solar activity at Moshiri and Rikubetsu in Hokkaido, Japan. The creation, depletion, and end of polar-cap patches of ionospheric plasma were clarified through 630-nm airglow images obtained from high latitudes.

Ionospheric disturbances observed by GNSS networks

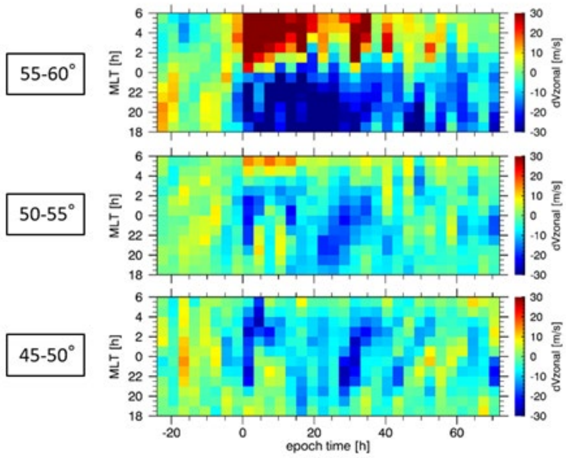


TEC perturbation maps for the (left) E- and (right) F-layers. Figures a and b show the reconstruction results using only GPS data from GEONET and multi-GNSS data from both GEONET and SoftBank, respectively (Fu et al., 2023).

We developed a database of global 2D total electron content (TEC) maps with high temporal and spatial resolutions using more than 20 years of data. In the current FY, we began research using ultra-dense TEC data in Japan by incorporating data from approximately 3000 GNSS receivers maintained by the SoftBank Corporation, in addition to the GNSS Earth Observation NETwork System (GEONET) of the Geospatial Information Authority of Japan. Assuming that TEC variations exist in the E- and F-layers, we developed a method for determining the horizontal distribution of TEC variations in each layer by applying tomographic techniques to these datasets. As a result, the spatial resolution was improved from 0.15° to 0.1° along the latitude and longitude for the E-layer and 0.5° to 0.3° for the F-layer, successfully elucidating the spatial-structure of electron-density variations in the E-layer associated with MSTIDs. These results indicate that the electric fields in the E layers could play a crucial role in the generation of MSTIDs.

SuperDARN Hokkaido Pair of (HOP) HF radars

We used the SuperDARN Hokkaido HF East and West radars in Rikubetsu, Hokkaido, to study the storm-time ionospheric convection at mid-latitudes through a Superposed Epoch Analysis technique. We demonstrated that the mid-latitude ionospheric convection is driven by the directly penetrating electric field, shielding effect of the inner magnetosphere, and disturbance dynamo effects due to ion-neutral interactions. We also studied the statistical characteristics of nighttime MSTIDs using a 3D FFT algorithm and confirmed that the dependence of MSTID occurrences on solar activities during the latest solar cycle was the same as that in the previous cycle. Additionally, we have been developing a full-spec imaging receiver system for implementation in the Hokkaido East Radar.



East–west component ionospheric plasma velocity during geomagnetic storms as a function of geomagnetic latitude range, MLT, and the time after the initial negative excursion of the Dst index (beginning of the storm main phase).

Promotion of EISCAT and EISCAT_3D projects

We conducted the EISCAT project in collaboration with NIPR that included the following: (1) ten EISCAT SP experiments for Japanese colleagues, (2) the EISCAT_3D project, and (3) a special session for the Master Plan 2020 proposed at the JpGU 2023. We also operated a sodium LIDAR, a photometer, an all-sky digital camera, an MF radar in Tromsø (69.6 °N, 19.2 °E), and a meteor radar in Alta in northern Norway. Additionally, we collaborated with Japanese and foreign colleagues for studies on auroral phenomena, gravitational waves, mesoscale wind dynamics, and meteoric smoke particles in the MLT region.

SDI-3D project

The Scanning Doppler Imager (SDI) is a ground-based Fabry–Perot Doppler spectrometer operating in the all-sky imaging mode with a separation-scanned etalon to resolve the Doppler spectra at heights of 90–400 km. A single station can estimate the horizontal wind vector and temperature on a horizontal plane with a 1000-km diameter. We established an international team in 2018 that included researchers from Japan, Scandinavian countries, and the US. The team commenced the "SDI-3D" project to deploy three SDIs in the same area as EISCAT_3D. Additionally, an international exchange program (or cross-appointment system) was established between Nagoya University and University of Oulu (Finland) in 2018. This was the first time that Nagoya University developed a framework to prepare for international collaboration by sending a faculty member to a foreign university. Since then, the development of SDIs has progressed satisfactorily and they have been deployed at three locations (two in Finland and one in Sweden) through a grant awarded by the National Science Foundation in the US. The first SDI was deployed in Sweden in this FY. As a preliminary work toward simultaneous observations with EISCAT_3D and SDIs, measurements obtained through optical instruments (Fabry–Perot interferometer and all-sky imager), Dynasonde, and the EISCAT radar were evaluated. This study elucidated the thermospheric wind variations caused by geomagnetic activities, IMF conditions, and geomagnetic storms (Oyama et al., 2023a, 2023b, 2024).

Fabry–Perot interferometer in Skibotn, Norway

Summary and publication of in-situ measurement techniques for simultaneous energy analyses of electrons and ions in space plasma

We summarized the results of the measurement capabilities and properties, including the sensitivities of the particle-energy and flight-direction analyses, based on the experimental performance of an innovative triple-dome electrostatic analyzer for electrons and ions comprising the space plasma present in the vicinity of Earth and other planets in our solar system. The expected reductions in the dimensions and weights were roughly estimated through comparisons with the prevailing types consisting of two sets of sensor heads for electrons and ions. We have previously published a paper reporting the performance results and properties of the triple-dome analyzer based on the fundamental development of its prototype model.

Summarization and publication of in-situ measurement technique for detecting space-plasma particles using "floating-mode" APD

Experiments have already confirmed that not only photons but also electrons and ions with energies below 1 keV can be detected using a floating-mode avalanche photodiode (APD) applied with an appropriate high voltage of several kVs. Specifically for ion analyses, the combination of an electrostatic energy analyzer with a floating-mode APD allows roughly discriminating between ion masses. We proposed that the combination of the floating-mode APD with a sensor head of the triple-dome electrostatic energy analyzer for electrons and ions can analyze the energies and masses of ions in addition to the electron energy, and published two research papers in international academic journals to report the results of these new instrumentations, including the independent properties of the floating-mode APD.

Data analysis of space plasma and auroral emission observations by an exploration satellite in the terrestrial polar region coupling the ionosphere and magnetosphere

We summarized the results of the electron energy distributions and motion directions observed by a polar-orbiting satellite (Reimei) at high time-resolutions to address the earthward (geomagnetically field-aligned) acceleration mechanisms of electrons in space plasmas, which fill the geospace surrounding the Earth. The terrestrial intrinsic magnetic field and space plasmas also connect the terrestrial polar ionosphere with the magnetosphere. We confirmed that energetic electrons accelerated by anti-earthward electric fields along geomagnetic field lines cause several types of discrete auroras. Two papers reporting field-aligned accelerated electrons by dispersive Alfvén waves associated with small-size active auroras were submitted to an international academic journal.

Development of magnetometers using Magneto-Impedance sensors for sounding rocket and ground-based measurements

A magnetometer with magnetoimpedance sensors was installed on the sounding rocket Loss through Auroral Microburst Pulsations (LAMP) launched from Poker Flat, Alaska, to observe magnetic field variations associated with pulsating auroras. The observation data indicated that the pulsating auroral patches were accompanied by a pair of field-aligned currents, one downward on the polar side and the other upward on the equatorial side. A low-cost geomagnetic observation system (approximately one-tenth in the cost of a fluxgate magnetometer) was developed using Raspberry Pi, commercial AD converters, electronic components, etc. This system, named MIM-Pi, was installed at Kawatabi, Miyagi Prefecture; Shirakami and Mutsu, Aomori Prefecture; and Tomakomai, Hokkaido Prefecture, and began monitoring magnetic field variations.

Data archives

The following data archives are open to the public:

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

Division for Meteorological and Atmospheric Research

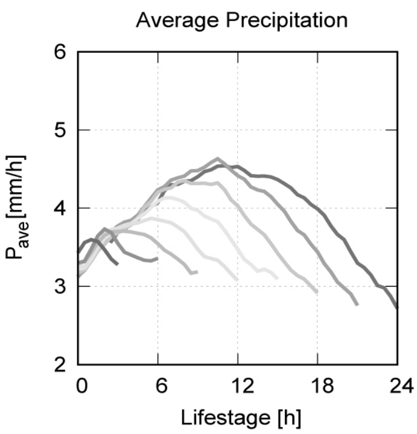
- Precipitation measurements by advanced polarimetric radars and hydrometeor videosondes
- Development of new instrumental technology
- Clouds and precipitation observed by multiple satellites
- Millimeter-wave/infrared spectroscopy of green house gases and ozone-depleting materials
- Measurements and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

The ongoing global warming caused by increasing carbon dioxide concentrations and other greenhouse gases is expected to result in gradual climate changes, intensification of weather extremes, and ecological catastrophes. An urgent task for effectively addressing these environmental issues is meticulous atmosphere monitoring through different observation methods and gaining a better understanding of the atmosphere via theoretical insights and numerical modeling. The Division for Meteorological and Atmospheric Research is dedicated to several research projects aimed a exploring the atmosphere from various perspectives.

Main Activities in FY2023

The Energetics of the Lagrangian Evolution of Tropical Convective Systems

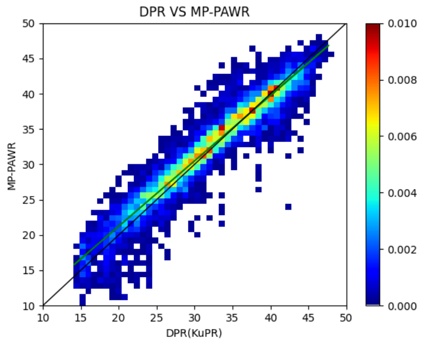
Convective lifecycle is often conceptualized as progressing from congestus to deep convection and developing further to stratiform anvil clouds or sequential shifts from one convective regime to another. This archetype scenario has been largely developed based on the Eulerian viewpoint and is yet to be explored in a moving system tracked in a Lagrangian manner. To address this, Lagrangian tracking was applied to tropical convective systems in conjuction with thermodynamic budget analysis forced by satellite-retrieved precipitation and radiation data. The major findings are that the Lagrangian evolution of convective systems is dominated by an dynamic-equilibrium state between different convective regimes, rather than a monotonic progress from one regime to the next.



Lagrangian evolution of precipitation for different lifecycles.

Calibration and analysis methods for phased-array weather radars

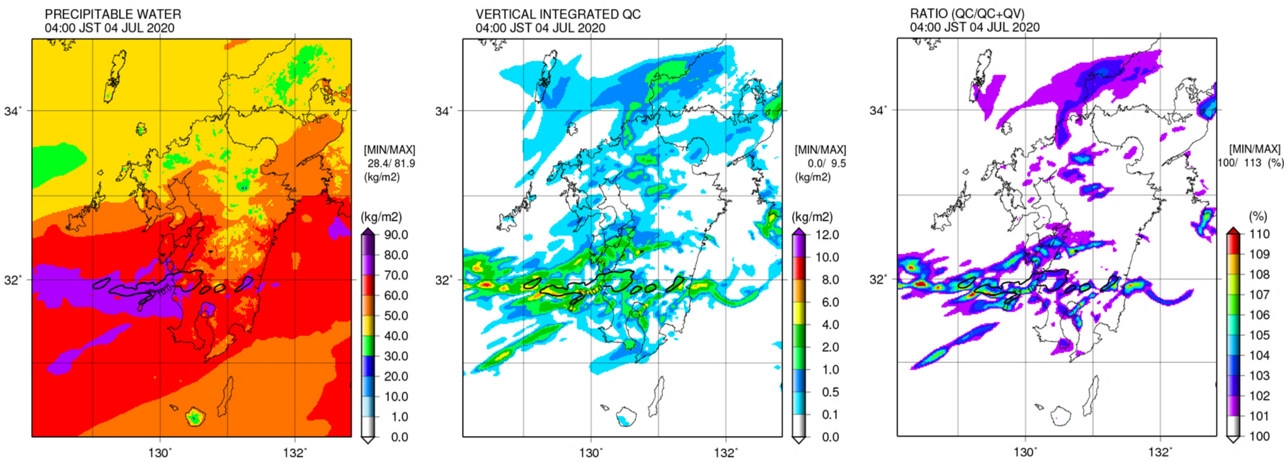
Multiparameter phased-array weather radar (MP-PAWR), which is the most advanced radar technology, features a new and unique functional that is not possible with conventional radars, namely, high-speed 3D observations without breaks. Therefore, we developed an analysis method using the self-consistency of the polarization function and a calibration method for the MP-PAWR by comparing it with an externally calibrated radar system. The 3D data of an MP-PAWR calibrated in this manner were compared with those obtained from the Ku-band precipitation radar onboard the GPM core observatory, and they exhbited good agreement (Fig.). Furthermore, we developed an analysis method that takes advantage of the characteristics of MP-PAWR. Specifically, it focuses on vertical air motion using the multielevation angle VAD rechnique and vertical-pointing Doppler velocity. These methods were combined with dual-Doppler radar analysis and a method that uses ZDR and KDP columns as indicators of updrafts. Each method can be used in a complementary manner owing to the different conditions under which they can be observed and analyzed. However, a common issue is that the fall-velocity estimation of precipitation particles is key for estimating vertical air motion.



Comparison of radar reflectivity factor (Z) between the calibrated MP-PAWR and KuPR onboard the GPM core observatory.

MAUL contributions in the windward region during heavy rainfall

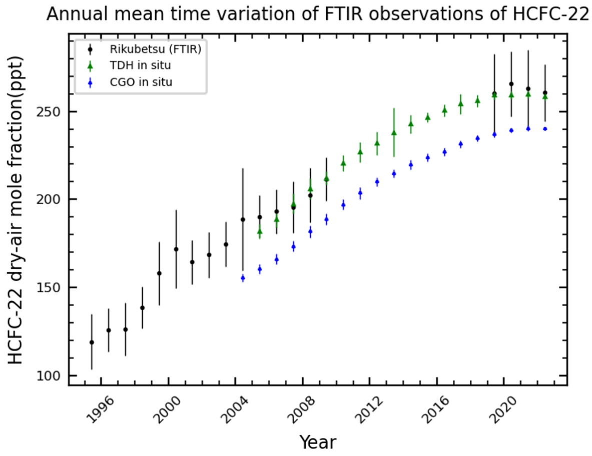
Heavy rainfall associated with the Baiu front and typhoons is caused by the intrusion of abundant water vapor not only in the lower troposphere but also in the mid-troposphere. Recently, the formation of a moist absolutely unstable layer (MAUL) around heavy-rainfall regions was observed. This study investigated the spatiotemporal distribution of the MAUL and rainfall regions during a heavy-rainfall event that caused flooding in the Kuma River Basin in Kumamoto Prefecture on July 4, 2020. We confirmed that MAUL regions were formed over a wide area of windward (southwestern) sides of the heavy-rainfall regions. In the MAUL regions, vertically integrated cloud water (liquid; >2 kg/m^2) is added to vertically integrated water vapor (total precipitable water; >60 kg/m^2) flowing into the heavy-rainfall regions. The intrusion of liquid water, in addition to abundant water vapor, could be the reason behind the heavy rainfall in the convergence area of the Baiu front. Furthermore, we confirmed that the volume in the MAUL region tends to increase up to approximately 2 h before the onset of heavy rainfall.



Horizontal distributions of vertically integrated water vapor (shaded in the left panel, kg/m^2), vertically integrated cloud water (shaded in the middle panel, kg/m^2), and ratio of vertically integrated water vapor and cloud water to that of water vapor (shaded in the right panel, %) during the Kuma River Heavy Rainfall event at 04:00 JST on July 4, 2020 obtained through the CReSS reanalysis experiment. The solid black lines indicate the areas of heavy rainfall defined using a threshold of > 10 mm/ 10 min.

Long-term atmospheric variations and emission estimates of HCFC-22 and HFC-23 using high-resolution infrared spectroscopy

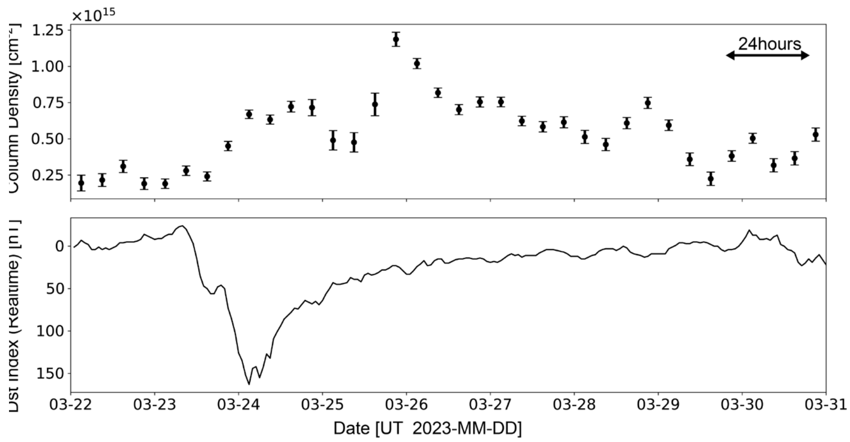
HCFC-22 and HFC-23 have significant greenhouse effects, with global-warming potentials of 1800 and 11700, respectively. Additionally, HCFC-22 contains ozone-depleting materials that cause ozon-layer depletion (WMO, 2022), and their use is internationally regulated under the Montreal Protocol. Therefore, understanding the long-term changes in the atmospheric concentrations and emissions of HCFC-22 and HFC-23 before and after their regulation is vital for conserving the global atmospheric environment. We analyzed the total column amounts of HCFC-22 and HFC-23 in the solar-absorption spectra from 1995–2023 obtained using high-resolution Fourier-transform infrared spectrometers at the Rikubetsu Observatory. The long-term trend from 1995 shows that the increasing trend of HCFC-22 slows down after 2019, and the estimated annual emissions in recent years have decreased. However, no changes were observed in the increasing trend of HFC-23 in the total column in recent years, indicating no significant change in the estimated HFC-23 emissions. These results are critical for assessing the effectiveness of emission-control measures employed by the Montreal Protocol.



Temporal variations in the observed annual average of the mole fraction of HCFC-22 in dry air. In addition to the Rikubetsu data, ground-sampling observations from the Trinidad Head and Cape Grim are also illustrated. The error bars indicate the standard deviations of the variations in each year.

Simultaneous multiline observations for understanding atmospheric-composition changes in polar regions owing to precipitation of energetic particles

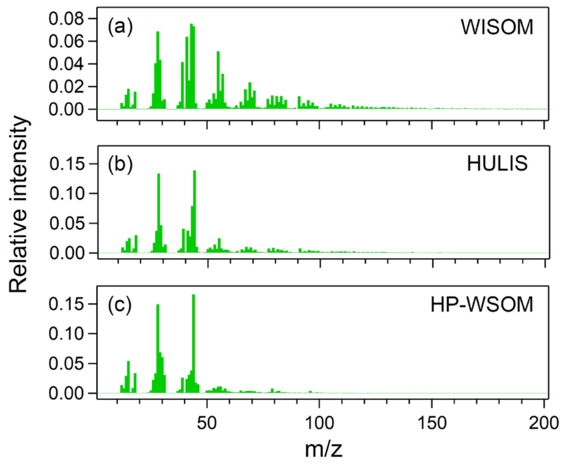
Millimeter-wave spectral radiometers are installed at Syowa Station in Antarctica and EISCAT facility in Tromsø, Norway, to understand the effects and mechanisms of composition changes in the middle atmosphere caused by energetic particle precipitation into the polar regions related to the solar activity. The spectral-radiometer system at Syowa Station was enhanced in 2020 to simultaneously observe the frequency ranges of O_3, NO, CO, NO_2, and HO_2 molecular lines in the 230 and 250 GHz bands. We began steady observations using the new system in July 2022. For the NO observations, the signal-to-noise ratio was improved by detecting six hyperfine structure lines to derive the partial column density. Using a time resolution of 12 h, we revealed two different NO-enhancement events in late March 2023, corresponding to the CME origin in the main phase of the magnetic storm and fast-solar-wind origin in the recovery phase. For ozone observations, a retrieval program for deriving the column densities above the mesospheric altitude was developed in collaboration with a group from the Tohoku University. Operations at Tromsø in Norway have been suspended since the COVID-19 pandemic and in December 2023, onsite maintenance was conducted to resume the operations. Although the cryo-refrigerator and superconducting receiver system were confirmed to be working properly, some mechanical parts were not moving. The defective parts were repaired to resume observations in the next FY.



Variations in the Nitrogen Oxide (NO) column-density (upper panel) and Dst index (lower panel) in March 2023.

Analyses of the composition and hygroscopicity of aerosols over a boreal forest in Northern Europe

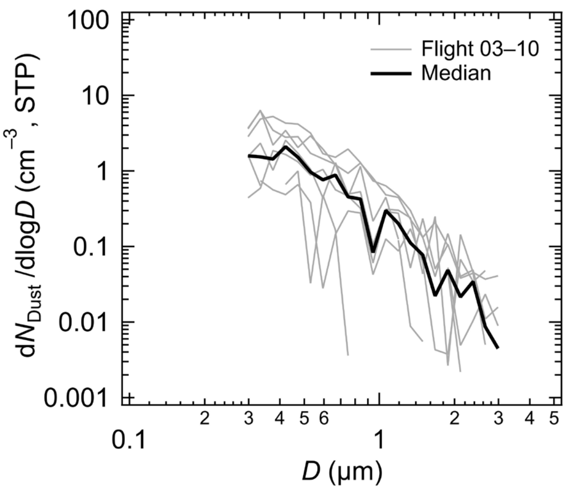
Biogenic volatile organic compounds (BVOC) emitted from forests react in the atmosphere, leading to the formation of small particles called biogenic secondary organic aerosol (BSOA). If the production amount of BSOA changes as a result of the changes in the emissions of BVOC under climate change, it could lead to the feedback to climate through its effect on radiation; to understand the factors regulating the feedback is crucial for assessing this mechanism. In this study, three fractions, namely water-insoluble organics, humic-like substances (HULIS), and high-polarity organics, were extracted from atmospheric aerosol samples collected at Hyytiälä Forest Station in Finland, and the quantification of these fractions and the analysis of the elemental ratios (e.g., O:C) were underway based on an offline aerosol mass spectrometry technique. Further, the water-soluble component was extracted and nebulized to generate small particles, followed by hygroscopicity analysis using a hygroscopicity tandem DMA. Further analyses are expected to clarify the hygroscopicity of BSOA that is generated in boreal forests in Northern Europe, and its contribution to the hygroscopicity of total aerosol components.



Example of offline aerosol mass spectrometry for aerosol samples collected at Hyytiälä Forest Station. The analysis was performed for the fractions of (a) water-insoluble organics, (b) HULIS, and (c) high-polarity organics (Courtesy of Qianzhe Sun).

Analysis of the number concentrations of mineral dust over the western North Pacific

Mineral dust is a major component in atmospheric aerosols and influences the climate through interactions with radiation and clouds. In this study, we analyzed aerosol samples collected over the western North Pacific at altitudes of 0.2–8 km using an aircraft based at Memanbetsu Airport during the summer of 2022. The size-resolved number concentrations of the mineral dust particles (N_{Dust}) were quantified using a complex scattering amplitude sensor. During eight observation flights, the N_{Dust} for diameter range of approximately 0.3–3.0 µm was 0.8 ± 0.6 cm^{-3} (mean ± 1 σ). Comparisons with the data obtained through other instruments onboard the aircraft suggested that most aerosol particles larger than 0.8 µm were mineral dust. The unique dataset of background mineral dust over the western North Pacific obtained in this study is useful for validating numerical models aimed at assessing the climatic impacts of mineral dust.



Number size distributions of mineral dust particles obtained during eight observation flights (Flight No. 03–10) under standard temperature and pressure (STP, 0°C and 1 atm) conditions. The bold line indicates the median value.

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 the regional and global energies, water and material cycles, and physical/biogeochemical processes in the land–ocean ecosystem.

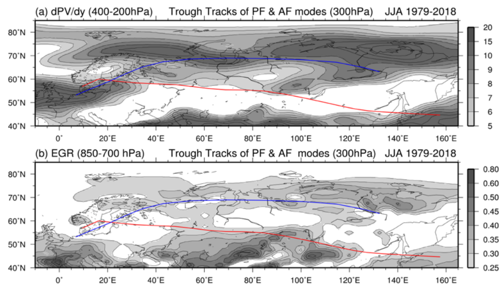
The land-research group contributes to advancing our understanding of the mechanisms through which global warming and anthropogenic activities influence the terrestrial water cycle. Using field observations, satellite remote-sensing, global meteorological data analysis, laboratory analysis, and model-simulation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

Ocean research was conducted through satellite remote-sensing, numerical simulations, and *in-situ* observations. We also conducted synthesis studies of the physical and biogeochemical processes in the ocean and their interactions with the atmosphere and climate. Specifically, we are investigating the interactions of oceanic heat content, circulation, and surface waves with the atmosphere and their association with climate and meteorological phenomena, such as tropical cyclones. Additionally, we are investigating the influences of ocean-circulation variations, mixing processes, and air–sea fluxes on marine ecosystems, wherein phytoplankton are the primary producers. Moreover, we are interested in clarifying the possible impact of marine ecosystems on physical processes and climate in the ocean and atmosphere.

Main Activities in FY2023

Synoptic-scale waves of Siberian storm track during summer

We examined the dominant structure and characteristics of synoptic-scale (2–8 day) waves over Siberia during 40 summers (June–August, 1979–2018) using JRA-55 atmospheric reanalysis and MSWEP v2.8 precipitation data. Wave patterns can be classified into polar frontal (PF) and Arctic frontal (AF) modes. PF-mode waves are initiated in the North Atlantic sector west of the British Isles. They propagate eastward across Siberia into the North Pacific and generate precipitation, mainly over the Eurasian PF zone. The AF-mode waves originate near the Scandinavian Peninsula and arc along the Arctic frontal zone (AFZ), producing precipitation along the AFZ during their eastward passage. The development of synoptic-scale waves is reflected by the unique background conditions in Siberia. The lower-tropospheric baroclinicity in southern Siberia and Central Asia favor the baroclinic growth of PF-mode waves, whereas the AF-mode waves are trapped in a well-organized baroclinic zone along the northern coast of the Eurasian continent. The baroclinic zone is coupled with a band of large meridional gradient of

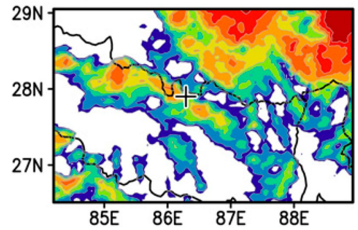


(a) Mean meridional gradient of potential vorticity averaged over the 400–200-hPa layer during summer. (b) is similar to (a) but indicates the Eady growth rate averaged over the 850–700-hPa layer. Wave trough centers of the AF- and PF-mode waves are represented by the blue and red curves, respectively.

potential vorticity in the upper troposphere, suggesting that this band acts as a waveguide for AF-mode waves.
(Reference: Fukutomi, Y., and T. Hiyama (2024): Structure and characteristics of synoptic-scale waves in the northern Eurasian storm track during summer. *Monthly Weather Review*, 152, 227–243, doi:10.1175/MWR-D-23-0084.1)

Multiscale processes leading to heavy precipitation in the Eastern Nepal Himalayas

The processes underlying heavy rainfall at higher elevations of the Himalayas are not yet well understood despite their importance. We examined the detailed processes behind the heavy-rainfall event (112 mm in one day) on 8 July, 2019, at Dongang (2790-m above sea level), observed through our rain gauge network in the Rolwaling Valley, Eastern Nepal Himalayas, using ERA5 and a regional cloud-resolving numerical simulation. The synoptic-scale environment is characterized by a monsoon low-pressure system (LPS) over northeastern India. The LPS lifted moisture upward from the lower troposphere and then horizontally transported it into the eastern Nepalese Himalayas within the mid-troposphere, increasing the water vapor content around Dongang. A mesoscale convective system passed over Dongang around the time of the intense precipitation. Surface-heat fluxes prevailed under the mid-tropospheric southeasterly flow associated with the LPS around a mountain ridge upwind of Dongang until 19:00 LT, thereby enhancing convective instability. The topographic lifting let to the release of the enhanced instability, triggering the development of a mesoscale precipitation system. The southeasterly flow pushed the precipitation system northward and then passed over Dongang between 20:00–22:00 LT, resulting in heavy precipitation.

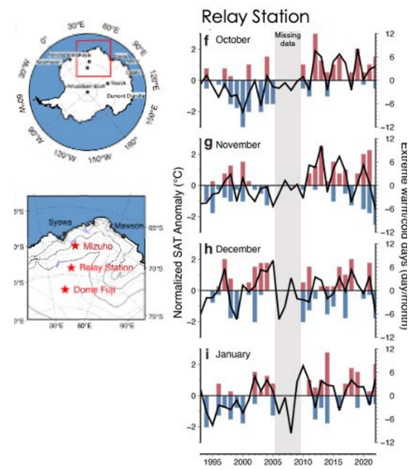


Spatial distribution of clouds (shaded) at 20:00 LST on July 9, 2019, as observed by Meteosat. The cross indicates the location of Dongang.

(Reference: Hirata, H., H. Fujinami, H. Kanamori, Y. Sato, M. Kato, R. B. Kayastha, M. L. Shrestha, and K. Fujita, (2023): Multiscale processes leading to heavy precipitation in the eastern Nepal Himalayas. *J. Hydrometeor.*, 24, 641–658, doi:10.1175/JHM-D-22-0080.1)

Increase in extremely warm days in East Antarctica interior

The interior of the East Antarctic Plateau is one of the most climate change data-sparse regions in Antarctica owing to its remoteness and harsh environment. Herein, we present a monthly mean near-surface temperature dataset for the last 30 years at Mizuho, Relay Station, and Dome Fuji, where historical records of automatic weather stations (AWSs) have been corrected. Since the 1990s, multiple AWSs have been installed along the route to Dome Fuji and observations are still ongoing. The reconstructed records from Relay Station (Dome Fuji) reveal a statistically significant warming of 0.50 ± 0.41 (0.45 ± 0.41) °C per decade over the last three decades. Although this warming trend was not observed in all months, it was evident in January, October, and November, with the highest warming in October. Interestingly, these months correspond to those in which the number of extremely warm days has increased significantly over the last three decades. We found that the interannual variability in monthly temperature matched the changes in the number of extremely warm days. Most high-temperature events were recorded during the period when a high-pressure system over Enderby Land transported warm coastal air toward Dome Fuji. This pattern was consistent with the spatial correlations between surface-air temperatures at the Relay Station (Dome Fuji) and the 500-hPa geopotential height (Z500) field from 1993 to 2022. Additionally, the atmospheric circulation trend showed the Z500 anomaly strengthening over Enderby Land, suggesting that the more frequent occurrences of extreme temperature events can be attributed to the positive trend of the annual mean temperature in the interior region of East Antarctica.

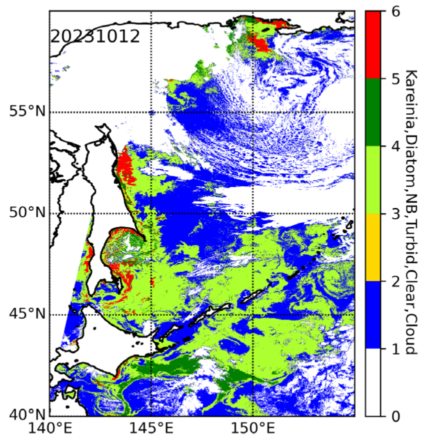


Comparison between the surface temperature anomalies and extreme warm or cold temperature days at Relay Station (see the map in the right Figure) from 1995 to 2021.

(Reference: Kurita et al. (2023): A regime shift in surface temperature over the East Antarctic Plateau in the twentieth century, IUGG 2023, Berlin, Germany, 11/07/2023)

Detection of *Karenia selliformis* red tide off the southeast coast of Hokkaido by satellite remote sensing

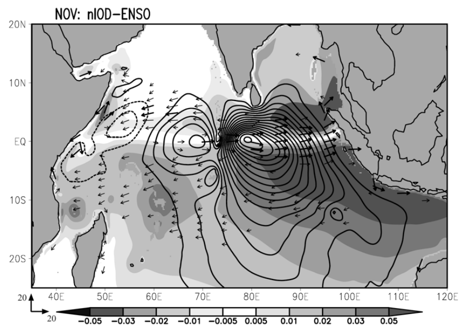
A large-scale red tide of the dinoflagellate *Karenia selliformis* occurred off the southeast coast of Hokkaido in the autumn of 2021, causing large-scale damage by killing many marine lifeforms such as sea urchins, salmon, and shellfish. Although this species has not been previously reported to cause red tides around Japan, it caused major damage along the Kamchatka Peninsula coast for the first time in the autumn of 2020. The cause of this red tide is debated and it is possible that it moved south from the Kamchatka Peninsula. Addiitonally, its relationship with marine heat waves has been suggested. Regarding the distribution of the red tide in 2021, the Japanese satellite GCOM-C (SGLI) and other ocean color satellites detected its occurrence and disappearance in areas with high chlorophyll a concentrations. However, the high concentration was observed during autumn in the 20 years without any damages. The damage caused by red tides to fisheries can be mitagated by quickly determining whether they occur because of the toxic *K. selliformis* or non-toxic diatoms. Methods for identifying specific red tides caused by closely related species such as *K. brevis* and *K. mikimotoi* have been developed. In this study, *K. selliformi*s and diatom red tides were distinguished based on chlorophyll a concentrations and a scattering index with longer wavelengths, which was used to distinguish red tides in the Ariake and East China Seas. A discrimination method and criterion were developed using satellite data from 2021 when *K. selliformis* red tides occurred, as well as from years when they did not, and this information was shared with the Hokkaido Research Organization. Using this criterion, it was confirmed that *K. selliformis* was not present in 2022; however, as the satellite data were updated in 2023, it was necessary to change the identification criterion. Furthermore, satellite data from the autumn of 2023 indicated that *K. selliformis* red tides might have occurred, whereas a survey revealed the presence of another dinoflagellate. Therefore, it is necessary to improve the discrimination accuracy in the future.



Classification results of the of water around Hokkaido on October 12, 2023. *K. selliformis* red tide (5–6), diatom red tide (4–5). non-red tide (3–4), turbid (2–3), clear (1–2), and cloud or land (0–1).

Interpreting negative IOD events based on the transfer routes of wave energy in the upper ocean

The Indian Ocean Dipole (IOD) event is an atmospheric and oceanic coupled variabilities in the tropical Indian Ocean with both positive and negative phases. A new perspective of the positive-phase mechanism was proposed in a recent study by the authors of this work by adopting an energy-based approach. This approach offers a unified framework for identifying the interactions between equatorial and off-equatorial regions based on the group velocity of linear waves. This approach was applied in this study to enhance the interpretation of the negative phase IOD (nIOD) events using the outputs of linear model hindcast experiments from 1958 to 2018. We conducted a composite analysis of a set of nIOD events to distinguish between independent and concurrent nIOD events with the El Niño–Southern Oscillation (ENSO). Both the first and third baroclinic modes exhibited interannual variations characterized by a distinct packet of eastward energy flux associated with equatorial Kelvin waves. From October–December, westerly wind anomalies induce the propagation of eastward-moving equatorial waves, leading to thermocline deepening in the central-eastern equatorial Indian Ocean, a feature absent in neutral IOD years. In the concurrent nIOD–ENSO years, the intense eastward transfer of wave energy became prominent as early as October, differing significantly from the observations during independent nIOD years. The intensity of the energy-flux

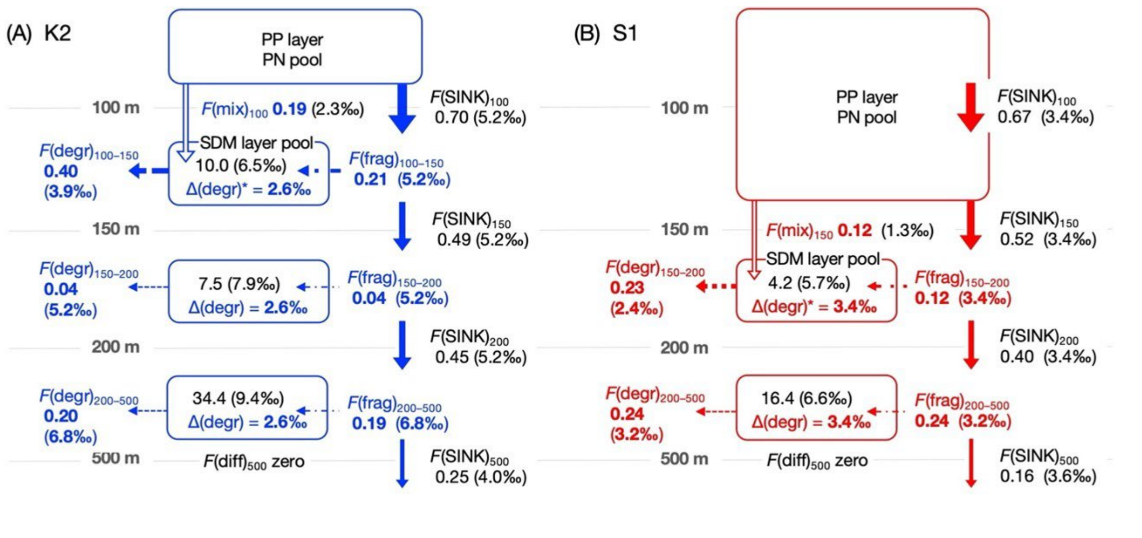


The wave energy flux in the upper ocean during a concurrent nIOD-ENSO event as shown by its streamfunction (shading: clockwise and anticlockwise in the Southern and Northern Hemispheres, respectively) and potential (contour).

streamfunction/potential peaked around November and then rapidly diminished in December during both types of nIOD years. These results suggest that the reflection of Kelvin and Rossby waves at the eastern and western boundaries of the Indian Ocean, respectively, accompanied by variations in thermocline depth, plays a crucial role in the development of IOD events.
(Reference: Li, Z., and H. Aiki (2024): Interpreting negative IOD events based on the transfer routes of wave energy in the upper ocean. *J. Phys. Oceanogr.*, 54(1), 95–113, doi:10.1175/JPO-D-22-0267.1)

Sequestration of particulate organic matter into the mesopelagic layer by a mixed-layer pump in the western North Pacific

Recently, new spatiotemporal-scale particle observations by autonomous profiling floats equipped with bio-optical sensors have revealed that in addition to gravitational particle sinking, the downward transport of surface particles by physical mixing events, which has been previously overlooked, contributes to particulate organic carbon export. However, the subsequent behavior of these exported particles in the mesopelagic zone (e.g., particle fragmentation and degradation) remains unclear, although it may influence the efficiency of carbon transport to deeper depths. This study successfully depicted new annual mean mesopelagic particulate nitrogen (PN) dynamics with multilayer, steady-state suspended PN pools by reanalyzing seasonal data of the stable nitrogen isotopic compositions of both suspended and sinking particles, each with different profiles, from subarctic station K2 and subtropical station S1 in the North Pacific, which are both CO_2 sinks located in different oceanic settings. We assumed that the net loss of sinking PN was entirely due to abiotic fragmentation of particle aggregates to non-sinking particles, and that the apparent ^{15}N enrichment associated with heterotrophic degradation in the suspended PN pools was vertically constant. The ^{15}N mass balance of the PN supply to the uppermost mesopelagic pool, derived from such constraints, allowed estimating the PN export through the mixed-layer pump, which was 1.6 times higher at K2 than that at S1. However, its contribution to the total export (including gravitational PN sinking) from the surface layer was approximately 20% at both stations. Moreover, the ratio of PN supplied to the uppermost pool by the mixed-layer pump and the fragmentation of particle aggregates was also similar at both stations (approximately 1:1). Using these ratios, together with separate observations of the mixed-layer pump-driven flux, the efficiency of particulate organic carbon transport owing to the biological gravitational pump responsible for carbon sequestration in the deep sea can be estimated.
(Reference: Mino, Y., C. Sukigara, H. Kawakami, M. Wakita, and M. C. Honda (2023): Mesopelagic particulate nitrogen dynamics in the subarctic and subtropical regions of the western North Pacific. *Frontiers in Earth Science*, 11, 1176889, doi:10.3389/feart.2023.1176889）



Schematic of the annual mean PN dynamics with fluxes (mmol m^{-2} d^{-1}) and $\delta^{15}N$ (‰) in the mesopelagic column for subarctic station K2 (A) and subtropical station S1 (B). The K2 column (100–500 m) is divided into three layers and the S1 column (150–500 m) into two layers. The suspended PN pools (mmol m^{-2}) and $\delta^{15}N$ values for each layer are also illustrated.

Division for Chronological Research

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

Short- and long-term forecasts of global environmental changes and countermeasures against them are urgent issues. Determining when an event occurred in the past via “dating” is crucial for understanding the current state of the Earth and predicting its future. The Division for Chronological Research promotes chronological studies on a broad range of subjects, ranging from events in Earth’s history, spanning 4.6 billion years, to archeological materials, cultural properties, and modern cultural assets.

Our Division conducts interdisciplinary research involving carbon 14 (^{14}C) dating using accelerator mass spectrometry to understand changes in the Earth’s environment and the cultural history of mankind from approximately 50000 years ago to the present day. We also focus on developing new ^{14}C analyses and dating methods. Additionally, our laboratory investigates near-future forecasts of Earth and space environments, with a particular emphasis on spatiotemporal variations in cosmogenic nuclides, such as ^{14}C and ^{10}Be, and conducts research on integrating art and science through collaborations between researchers in archeology, historical science, and other fields. Furthermore, using the chemical U–Th–total Pb isochron method (CHIME), which was first developed at Nagoya University, and radiometric dating of long-half-life radioisotopes (Sr-Nd-Hf), we provide insights into events in Earth’s history, from its formation 4.6 billion years ago to approximately one million years ago. An electron probe microanalyzer (EPMA) is used to perform nondestructive microanalyses of rocks and other materials to reveal complex events recorded in zircon, monazite, and other samples.

Main Activities in FY2023

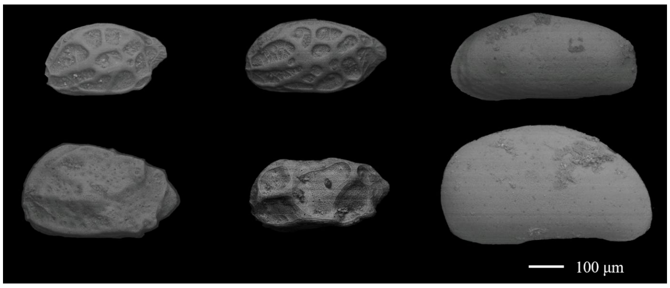
^{14}C calibration dataset in subtropical regions

Tree-ring analysis has indicated a north–south gradient in the ^{14}C concentration of atmospheric CO_2. The Southern Hemisphere samples generally exhbit ^{14}C ages several decades to 50 years older than the Northern Hemisphere samples. As a result, two calibration datasets have been established globally: IntCal for samples from the Northern Hemisphere and SHCal for those from the Southern Hemisphere. However, there is ongoing debate regarding which dataset is more suitable for calibrating the ^{14}C age in subtropical regions influenced by the north–south movement of the Intertropical Convergence Zone (ITCZ). To address this issue, a collaborative international project has been launched with Dang Xuan Phong and Nguen Tran Quoc Trung from the Institutes of Geography and Southern Ecology, respectively, at the Vietnam Academy of Science and Technology (VAST). It involves sampling tree-ring cores from the giant Fokienia hodginsii and Pinus krempfii in the mountainous forest on the outskirts of Dalat, Lam Dong Province, Vietnam. These trees comprise rings dating back several hundred years. By conducting high-precision ^{14}C measurements on cellulose extracted from these annual tree-rings, we aim to create a ^{14}C calibration dataset of the past several hundred years for the subtropical Northern Hemisphere.

Collection of tree-ring samples from giant Fokienia hodginsii (Cyperaceae) in Lam Dong Province, Vietnam.

Fossil ostracods from the tsunami deposit in Onuma in the southern part of the Sanriku Coast, Northeast Japan

The 2011 Tohoku-oki Earthquake triggered a large tsunami that affected various coastal areas in Japan. After the Earthquake, tsunami deposit reports were obtained from the coastal areas of Japan. Ishimura and Miyauchi (2017) conducted excavation and coring surveys and reconstructed the paleoenvironment at Onuma on the southern Sanriku Coast based on sedimentary facies, age (radiocarbon dating and tephra), fossil (diatoms and mollusks), and topography data. However, fossil assemblages constituted partial analyses that were required to clarify the mechanism of the tsunami deposit formation using other fossil taxonomic groups. In this study, we collected data from two sand layers such as tsunami deposits S1 and S2 and estimated their source based on ostracod assemblages. The ages of the S1 and S2 layers were estimated to be 690–1040 cal BP and 4030–4400 cal BP, respectively (Ishimura, 2019). A total of 41 species belonging to 20 genera of ostracods were identified in the five samples collected from the two sand layers. The mud content and valve-number of ostracods per 1 g of sediment sample (density) increased toward the upper layers. Additionally, some fossil ostracod valves were well-preserved, whereas others were not, exhbiting white or black color and abrasions. Furthermore, ostracod assemblages were abundant in shallow-sea and phytal species but could not confirm deep-sea species. Therefore, we suggest that the two sand layers formed by several shallow sediments were transported by the tsunami.



Scanning Electron Microscope photographs of the selected ostracod species.

Genetic diversity of cetaceans from the late Jōmon period excavated from the Shomyoji shell mound

The Shomyoji shell mound, located in Kanazawa-ku, Yokohama, dates back to the early Jōmon period and provides insights into the prehistoric whaling activities in Tokyo Bay. Among the artifacts found at the site are a harpoon, yasushi (a type of fishing tool), and many bones of marine animals, indicating the hunting of marine mammals. To further explore this historical context, we extracted DNA from the bones of small cetaceans, specifically dolphins, excavated from the shell mound. Their mitochondrial sequences were analyzed and ^{14}C dating of collagen in the bones was performed to determine the period of whaling activities and examine the genetic diversity of cetaceans in Tokyo Bay. The ^{14}C dating results showed that the oldest bone dates back to 4643–5217 cal BP, whereas the most recent one dates back to 3240–3740 cal BP, with most bones being over 4000 years old. This timeframe aligns with the period when the Jōmon sea-level began declining, leading to receding shorelines. Additionally, analysis of the dolphin bones revealed that they primarily belonged to southern bottlenose or Pacific white-sided dolphins. A significant discovery was the presence of mitochondrial haplotypes unique to the current Mikurashima population in Tokyo, along with haplotypes related to the modern population that were absent in Mikurashima. This finding suggests a direct maternal lineage connection between dolphins from Jōmon-era Tokyo Bay and those in the contemporary Mikurashima population. However, the genetic diversity during the Jōmon period was higher than that in the current Mikurashima population. Additionally, identical haplotypes have been found in the Pacific white-sided dolphin population in the Tokyo Bay area, both historically and in the present day. These findings suggest a continuity of maternal lineage settlement near Tokyo Bay over the past 4000 years, despite the high mobility of dolphins (Kishida et al., 2024, *Biological Journal of the Linnean Society*, doi:10.1093/biolinnean/blad159).

Mandible bone of a Pacific white-sided dolphin excavated from the Shomyoji shell mound. The part indicated by the arrow was used for DNA analysis. The ^{14}C age was determined as 4643–5217 cal BP; scale-bar length = 10 cm. Adopted from Kishida et al. (2024).

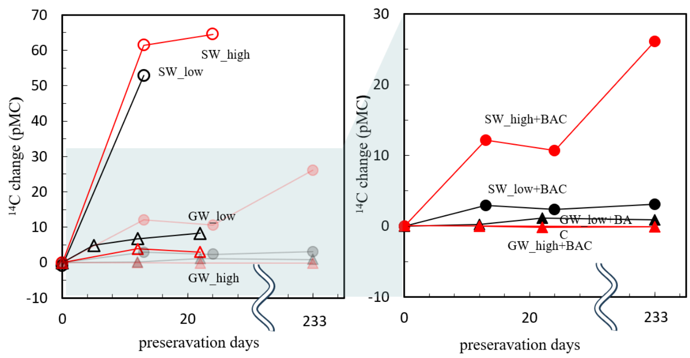
Changes in ^{14}C and inorganic metal element concentrations in urban atmospheric aerosols between 2019 and 2020 in Nagoya, Japan

The quality and quantity of anthropogenic materials emitted into the urban atmosphere between 2019 and 2020 may have changed owing to the implementation of heavy-oil regulations (enforced by the International Maritime Organization) in January 2020 to reduce the sulfur (S) content in marine fuels used in general marine areas to 0.5% or less and the curbs on industrial activities (from April 2020) because of the COVID-19 pandemic. In this study, ^{14}C, heavy metal elements, and S concentrations in atmospheric aerosol samples (TSP) collected from the roof of the Nagoya City Environmental Science Research Center in 2019–2020 were measured to examine their seasonal variations. The concentrations of vanadium (V), nickel (Ni), and S in atmospheric aerosols in 2020 were significantly lower than those in 2019, indicating a reduction in the influence of materials originating from heavy-oil combustions in ships around the Port of Nagoya in 2020. Additionally, concentrations of lead (Pb), zinc (Zn), and carbon derived from fossil fuel were at the lowest levels in April–May 2020, with the smallest intra-month variability, demonstrating a reduction in the emission of anthropogenic materials. Thus, this study qualitatively and quantitatively clarified the reduction in emissions of anthropogenic substances owing to heavy-oil regulations and the restraint of industrial activities during the COVID-19 pandemic by analyzing organic and inorganic components of atmospheric aerosol samples, thereby offering a new development for the studies of atmospheric geochemistry using atmospheric aerosols.

High-volume air sampler for collecting aerosol samples.

Examining BAC as a disinfectant for ^{14}C analysis of water samples: Differences in BAC effects relative to salt concentration

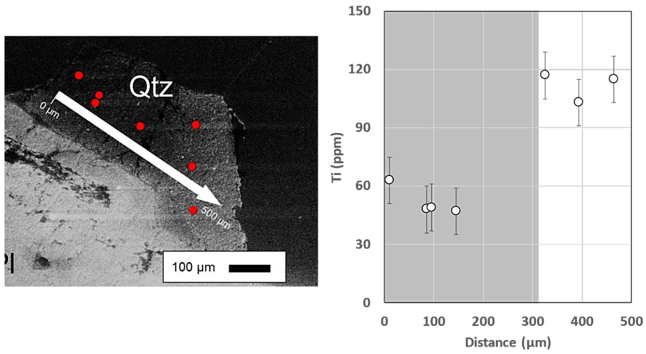
The concentrations of dissolved inorganic carbon (DIC) and ^{14}C in natural waters change during storage because of microbial activity in water. To suppress this, $HgCl_2$ is typically added to the collected water samples. However, owing to the environmental impact of $HgCl_2$, benzalkonium chloride (BAC), which is safer and easier to handle, has been gaining attention as a disinfectant in recent years. We investigated the disinfection effects of BAC in several types of water samples and examined whether it is an effective disinfectant. Although we found that BAC has disinfection effects similar to $HgCl_2$ for groundwater, its effectiveness in seawater decreases after approximately two weeks (Takahashi et al., 2019; Takahashi and Minami, 2022). As salt concentration is a primary difference between seawater and groundwater, we evaluated whether it decreased the BAC effect in seawater using samples of seawater and groundwater with high and low salt concentrations and artificial seawater reagents. The results showed that the change in ^{14}C concentration was greater in seawater samples with high salt concentrations (SW_high + BAC) than in those with low salt concentrations (SW_low + BAC), indicating a reducting in the BAC effect. By contrast, no difference in the BAC effect was observed in groundwater samples according to the salt concentration. Therefore, it was inferred that although high salt concentrations in water samples reduce the BAC effect, in the case of groundwater, even if the BAC effect is reduced under high salt concentrations, it is sufficient to sterilize the microbes. Furthermore, increasing the BAC concentration in seawater resulted in a higher disinfection effect. Therefore, BAC can be used as a viable alternative to $HgCl_2$ by adding an appropriate quantity according to the sample characteristics.



Changes in ^{14}C concentrations in seawater and groundwater samples during storage. ○ : Seawater, △ : Groundwater. The filled symbols indicate samples with BAC, whereas the unfilled symbols indicate those without BAC.

EPMA quantitative analysis of ultra-trace amounts of titanium in quartz

Quartz is the second most abundant mineral in the Earth's crust and is a major constituent of siliciclastic plutonic rocks. Therefore, its crystallization information, such as its internal structural temperature conditions, contains data on the penetration and emplacement of granitic magmas. Therefore, obtaining crystallization data from quartz and elucidating its crystallization process can be used for elucidating the formation process of the entire plutonic body. A method that combines cathodoluminescence (CL) images and titanium (Ti) concentrations, which can elucidate the mode of crystal growth as they reflect disturbances in the crystal structure and trace components in the crystal, for estimating the formation process of quartz has been proposed. Additionally, the Ti concentration in quartz can be used to estimate its crystallization temperature. Therefore, a method was developed to calculate the characteristic X-rays of Ti using four spectrometers (the detection limit for Ti was 16 ppm). In FY2023, the 3D internal structure of quartz from the Kuki granite was analyzed, and a quantitative electron probe microanalysis (EPMA) of trace elements was conducted to enhance our understanding of the quartz crystallization process. The quartz was separated from the rock, and CL patterns of multiple cross-sections were obtained via repetitive polishing and CL imaging. Although the quartz from the Kuki granite did not exhibit pronounced oscillatory zoning, its growth mode could be assessed from the luminosity variations among the cross-sections. Quantitative EPMA of Ti and Al concentrations was conducted on cross-sections of 15 grains. In the Ti concentration data, 80 points exhbited values exceeding the detection limit, ranging from 31 ± 14 to 224 ± 11 ppm. The figure below shows a CL image of the quartz particles and the line profile of the Ti concentration. A positive correlation can be observed between the Ti concentration and the brightness of the CL image; calculations using the geological thermometer employed by Thomas et al. (2010) showed that values of 31 ± 14 ppm corresponded to a crystallization temperature of 522 ± 28°C, whereas a value of 224 ± 11 ppm indicated a crystallization temperature of 815 ± 5°C. The TiO_2 activity required to derive the crystallization temperature was estimated from whole-rock chemical composition using the rhyolite-MELTS program (Gualda et al., 2015).



CL image of quartz and line-profile of Ti concentration in Kuki granite.

FY2023 special program for regional contribution "Invitation to Earth Science and Geochronology for Upper Elementary School Students"

Each year, ISEE hosts a hands-on learning program for upper elementary school students as part of its regional contribution to the community. In FY2023, we focused on igneous rocks, which are one of the most important rocks for unraveling the history of Earth. The "Invitation to Earth Science and Geochronology for Upper Elementary School Students" was conducted on August 3–4, 2023, and 17 students participating. On the first day, we chartered a bus to visit the Houraiji-san Natural Science Museum in Shinshiro City, Aichi Prefecture; Shinshiro Granodiorite outcrop at Ayutaki; Hanagaki mining site distributed volcanic and sedimentary rock outcrops within the Ryoke Belt area; and Nagashino outcrop of the Median Tectonic Line (MTL) to observe rocks and minerals. The second day comprised lectures on igneous rocks and MTL faults, hands-on crystal-formation experiments, and microscopic observations of thin rock sections conducted at ISEE, Nagoya University, aimed at fostering a comprehensive understanding of igneous rocks. In the afternoon, the students were divided into three groups and summarized what they had learned from their hands-on experience into A0-sized posters. Using those posters, each group gave a presentation on their newfound knowledge and insights.


Children crushing rocks with a hammer at the Hanagaki mining site.

Center for International Collaborative Research (CICR)

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

To promote international collaborative studies, the Center for International Collaborative Research (CICR) provides leadership to comprehend the physical mechanisms of phenomena occurring in the space–Sun–Earth environmental system and their interactions. The CICR encourages programs for developing ground-based observation networks and international satellite projects and hosting international workshops and conferences. It also supports international exchanges between foreign and Japanese researchers and students, and encourages capacity-building activities in developing countries through training courses and schools. CICR took over the Geospace Research Center of the former Solar-Terrestrial Environment Laboratory at Nagoya University. It was initially established in October 2015 for a fixed 5-year term until FY2020. However, another 5-year term (FY2021–2026) to continue the activities was approved by Nagoya University.

The phenomena in solar activity have various timescales, from solar flares and coronal holes to the 11-year cycle and further long-term variations. Scientists across the globe are greatly interested in these types of solar activities and their effects on Earth's geospace environment and climate change. The Scientific Committee on Solar-Terrestrial Physics (SCOSTEP), under the International Science Council (ISC), commenced a 5-year international program titled "Predictability of the variable Solar-Terrestrial Coupling (PRESTO)" for 2020–2024. The main objective of this program is to identify the predictability of the variable solar-terrestrial coupling performance metrics through modeling, measurements, and data analysis while strengthening the communication between scientists and users of space around the Earth. The President of SCOSTEP is also a member of the CICR and is responsible for running this international program. On January 8, 2021, the ISEE and SCOSTEP signed a Memorandum of Understanding to define the conditions under which ISEE will contribute to SCOSTEP activities. Based on this Memorandum of Understanding, CICR publishes the SCOSTEP/PRESTO newsletter every three months, organizes online seminars and capacity-building lectures, 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). Since 2016, the CICR has participated in or operated ground-based observation projects, such as the EISCAT radar project, OMTIs, the ISEE VLF/ELF and magnetometer network, and SuperDARN radar network (including the Hokkaido HF radars). It also has four domestic observatories at Moshiri, Rikubetsu, Fuji, and Kagoshima that conduct solar-wind, geomagnetic-field, and upper-atmosphere observations, with some of them being conducted for more than 30 years.

Observation sites and ISEE's overseas collaborating organizations compiled by CICR.

Main Activities in FY2023

In FY2023, CICR approved the following international collaborative research as the projects of Joint Usage/Research Center and conducted/supported them: 1) twenty-one International Joint Research programs for domestic scientists; 2) seventeen ISEE International Joint Research programs, inviting researchers from overseas; 3) three ISEE/CICR International Workshops; 13) seven International Travel Support programs for field and laboratory experiments by students and early career scientists; 14) three International Technical Exchange programs; 15) five ISEE International School Support programs (one was canceled); and 16) six International Travel Support programs for students. Further, researches by two designated professors from the US, who were hired through cross-appointments, and associated two designated assistant professors were promoted. In collaboration with SCOSTEP, the CICR hosted five international online seminars and four online lectures for students in FY2022. It has also supported eight graduate students with their presentations at international conferences and a visit to a foreign institution (one was also supported under a project of the Joint Usage/Research Center). Through the PRESTO program (2020–2024), the CICR published four newsletters in FY2023 (April, July, October, and January). Additionaly, CICR supported four international schools in Italy, Portugal, Nigeria, and Japan. Seven students from India, Kenya, and China visited the ISEE for three months for collaborative research under SCOSTEP Visiting Scholar Program. Seven English-speaking staff members in total provided administrative support for these activities.

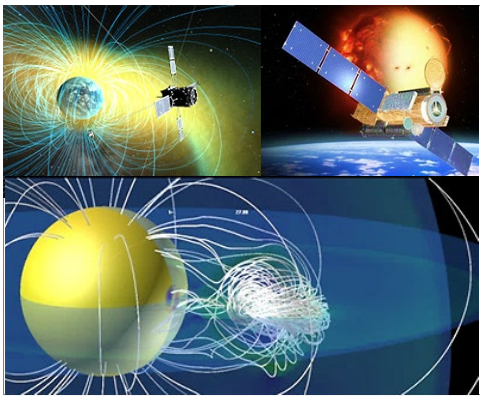
SCOSTEP/PRESTO Newsletter vol. 38 (January 2024)

The EISCAT radar project was undertaken in collaboration with a group from the NIPR and ten EISCAT special experiments proposed by Japanese colleagues were conducted. Discussions regarding the EISCAT_3D radar were organized with foreign EISCAT associate members. More than 20 stations were operated around the North Pole at MLATs of ~60° and at mid- and low-latitudes under the OMTIs and ISEE magnetometer/ELF/VLF networks. A research project titled “Pan-Arctic Water-Carbon Cycles (PAWCs)” for FY2019–2024 was conducted to integrate atmospheric–terrestrial water and carbon cycles in northern Eurasia, for which limited data on the fluxes of greenhouse gases exist. Additionally, an observational study of urban atmospheric aerosol was conducted under the JSPS International Joint Research Program.

The Moshiri Observatory became unmanned in FY2018 but is still supported for observations. The observatory has continued to operate fluxgate and induction magnetometers, auroral photometers, and ELF/VLF receivers. Additionally, continuous measurements of atmospheric black carbon were initiated in FY2022. The 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, SuperDARN Hokkaido radar for ionospheric disturbances, and an ELF atmospheric receiver. In FY2023, the observations of low-latitude auroras were successful for three times. Additionally, multistation IPS observations were conducted at the Fuji and Toyokawa observatories from April to December. The anntena at Kiso, which had been out of service since the previous fiscal year, was restored in September, and multistation IPS observations continued at all three stations. An open-house event was held at the Kiso Observatory during September 16–17 in cooperation with the Kiso Observatory at the University of Tokyo. The Kagoshima Observatory and Sata Station operate an all-sky camera, a photometer for airglow detection, VLF/LF radiowave receivers, and induction magnetometers. Electromagnetic waves were observed at the Kagoshima Observatory in collaboration with Tohoku University, the University of Electro-Communications, Chiba University, and Georgia Institute of Technology. Moreover, visual IoT-based monitoring and infrasound observations of the Sakurajima Volcano was performed in collaboration with National Institute of Information and Communications Technology.


Rikubetsu Observatory

Center for Integrated Data Science (CIDAS)



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

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

Center for Heliospheric Science: Arase, Mio, Hinode, and SOLAR-C

The Center for Heliospheric Science (CHS), which is responsible for the development and release of integrated analysis tools and data from the Arase, Mio, Hinode, and SOLAR-C satellites, as well as ground-based observations and simulations, is operated by the ISEE, Nagoya University, ISAS/JAXA, and NAOJ. The CHS operates an Integrated Data Science Computer System (CIDAS system) that provides an analysis environment for researchers.

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 of Nagoya University and other universities and institutes. Additionally, it mints DOIs for ISEE research data (DOI prefix: 10.34515) to ensure permanent accessibility and promote data reusability. CIDAS 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 database server and data-analysis software. It is also responsible for ISEE activities as a member of the High-Performance Computing Infrastructure Consortium (HPCI) in Japan.

Research and development of advanced simulations

CIDAS leads the research and development of the following advanced computer simulation models: Space Weather Forecast Usable System Anchored by Numerical Operations and Observations (SUSANOO), cloud-resolving storm simulator (CReSS), and Monte Carlo simulations for accurate Th–U–Pb dating. The CReSS was designed for all types of parallel computers to simulate the detailed structures of clouds and storms and can be freely used by the scientific community. It has been used for meteorological research and real-time weather forecast experiments, including tropical-cyclone, heavy-rainfall event, snow-cloud, and tornado simulations, as well as downscaling experiments of future tropical cyclones.

Main Activities in FY2023

Development of a data-analysis system for the ERG (Arase) and Mio (BepiColmbo/MMO) projects

Scientific data from the ERG (Arase) satellite, ground-network observations, and modeling/simulations are archived at the CHS, which is operated by ISAS/JAXA and the ISEE/Nagoya University. These files are in the CDF format, which is a de facto format used by the solar-terrestrial physics community, and the metadata of each file is included. The Space Physics Environment Data Analysis System (SPEDAS), a commonly used software by the solar-terrestrial physics community, can easily read and manipulate CDF files. The CHS has developed CDF files and the SPEDAS plug-in software for the ERG project. We also joined the International Heliosphere Data Environment Alliance to discuss common data formats within the international framework. The CHS has organized training sessions for the SPEDAS in Japan and Taiwan, providing crucial opportunities for learning the methods of using SPEDAS and ERG data. Additionally, it is developing a data-analysis environment for the CIDAS system, which can be accessed by users via the Internet and used to analyze ERG project data using SPEDAS (https://ergsc.isee.nagoya-u.ac.jp/research/index.shtml.en). The CHS is also working toward the development of Mercury magnetospheric orbiter "MIO" (MMO) data files and related tools based on the heritage of the ERG project.

Databases related to solar research

The Hinode Science Center is promoting solar research using precise data from Hinode, as well as the development of a database and analysis environment in collaboration with NAOJ and ISAS/JAXA to analyze the data. It continues to maintain, manage, and publish a list of dissertations employing data from Hinode (104 doctoral and 70 master's theses), a flare catalog (approximately 24400 events since October 2006), 3D magnetic-field data of active regions in the corona, and a solar polar magnetic-field database. Additionally, it released new EUV emission line full-disk mosaic and solar soft X-ray and EUV radiation variation databases in 2023.

IUGONET

IUGONET has been promoting the use and application of upper-atmospheric observation data by providing metadata databases and analysis tools in collaboration with other institutions (e.g., the Research Organization of Information and Systems), and has been developing a universal infrastructure to disclose and cite data. In FY2023, when updating the SPASE metadata schema, which is employed as a standard in the field of space physics, the original extension of IUGONET was incorporated. We defined and implemented a mapping from the SPASE metadata schema to a general schema used for academic information distribution and converted our metadata. The converted metadata were registered in the Nagoya University institutional repository to ensure that various communities can access them. We also developed a web-based XML file-input system that allows data providers to easily create metadata to mint DOIs.

Operation of the CIDAS supercomputer system

A new computer system for integrated data analysis (CIDAS supercomputer system) was installed in April 2021. It comprises 16 compute nodes, each of which has two Intel Xeon Gold 6230R CPUs and 384 GB of RAM. In FY2023, 120 researchers/students were registered as users of the system. Data analyses related to the Hinode Science Center and ERG/Arase Science Center, as well as computer simulations, were conducted.

Development of the CReSS model

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

Center for Orbital and Suborbital Observations (COSO)

- Establishment of an aircraft-based observation system
- Aircraft observations of clouds, aerosols, and typhoons
- Solar-observation missions using micro satellites
- Promotion of observations using unmanned aerial vehicles
- Human resource development for space applications
- Promotion of Earth-observing satellites

Based on the ISEE research objectives, which encompass natural phenomena ranging from the Earth's surface to outer space, COSO is expected to conduct empirical and advanced research through observations, especially via collaborations among industry, academia, and government, result in remarkable technological developments in aircraft, balloons, sounding rockets, and spacecrafts. COSO aims to be at the core of aircraft-based observations in Japan and investigates and promotes future space-exploration missions to obtain new knowledge regarding physical phenomena through cooperation with domestic and foreign research institutions. By promoting interdisciplinary activities and efficient common technology development, COSO can improve observation capabilities for future orbital and suborbital missions. The Hydrospheric Atmospheric Research Laboratory contributed to the Virtual Laboratory with four universities using X- and Ka-band radars together with numerical modeling studies. The Space Exploration and Research Office (SERO) is undertaking nanosatellite and human resource development programs for space applications, whereas the Aircraft Observation Promotion Office was established to promote aircraft-based observations.

Main Activities in FY2023

Promotion of aircraft-based observations

The Tropical cyclones-Pacific Asian Research Campaign for Improvement of Intensity estimations/forecasts (T-PARCII), funded by a Grant-in-Aid for Scientific Research (S) (PI: Kazuhisa Tsuboki), is planning to conduct typhoon observations again this year but was unable to conduct aircraft-based observations during September 2023 as no typhoons occurred in the observation area. Therefore, the planned expenses will be carried over to the next FY and observations will be conducted. Meanwhile, we made the following two improvements to the dropsondes that will be used for aircraft-based observations this year: the built-in GPS receiver module was improved to enhance reception sensitivity and the real-time transmission method of the dropsonde data was enhanced. Previously, data were transmitted using the Temp method; however, it lacked location information. Therefore, the Bufr method was developed and modified to transmit more detailed data. Additionally, a validation experiment that included verification of the humidity sensor was conducted over the Minami-Daitō Island, wherein the conventional and improved versions were simultaneously lifted using a balloon and dropped from an altitude of approximately 12 km. Data from both instuments were received to verify the improvements and accuracy of the new humidity sensor.

In a research project funded by the Ministry of Land, Infrastructure, Transport, and Tourism, aerosol, cloud, and precipitation data acquired via aircraft-based observations in July and September, 2022, were analyzed to clarify the effects various aerosols on the physicochemical properties, CCN ability, INP ability, and microphysical structures of anvil clouds. The relationship between the aerosol concentration acting as CCN/INP, strength of the updraft in cumulus clouds, and entrainment of ambient dry air was also investigated.

Data analysis of aircraft-based observations of aerosols over the western North Pacific during the summer of 2022 was conducted to clarify variations in the mineral-dust concentration.

We have prepared for data assimilation experiments using the cloud-resolving model of the CReSS, developed by ISEE and

NIED, to investigate the impact of dropsonde observation data from the T-PARCII project on typhoon intensity forecasts. Additionally, we conducted observational simulation experiments and verified the operation of the CReSS data assimilation system.

Promotion of observation projects using unmanned aerial vehicles

In collaboration with the Department of Aerospace Engineering at Nagoya University and JAXA's Aeronautics and Space Technology Division, we launched an initiative to promote observations of the atmospheric environment, meteorology, and space using unmanned aircraft. During discussions on their utilization, as a specific research theme, we developed a new route-optimization technology for unmanned aircraft that prioritizes flight paths using a considerable amount of physical information.

Aircraft Observation Promotion Office

ISEE submitted a proposal for aircraft-based observations to Roadmap 2023 of the Ministry of Education, Culture, Sports, Science and Technology (MEXT); however, it was not accepted. This proposal followed the previous proposal of the Science Council of Japan's Master Plan. Additionally, ten seminars (online) on aircraft-based observations were conducted, each comprising 20–50 participants.

Hydrospheric Atmospheric Research Laboratory

A workshop was held at the National Taiwan University to exchange information on the progress of research in each country, primarily to enhance and exchange data obtained from the international joint observations conducted last year by the United States, Taiwan, and Japan. A workshop on aircraft-based observations in the western North Pacific was also conducted to exchange opinions on cooperation and future plans for aircraft-based observations in the region, and it was agreed that observations will be conducted through cooperation and collaborations.

Solar-observation mission using nanosatellites

We are developing a solar neutron and gamma-ray detector intended for nanosatellites weighing less than 10 kg. Nanosatellites were selected because they offer more launch opportunities than 50-kg satellites, such as ChubuSat. We are currently developing an engineering model that will be proposed for the JAXA Innovative Satellite Technology Demonstration-5 program. We have successfully fabricated the signal processing boards, procured all sensor components, and assembled the instrument in FY2023. We are now conducting structural verification of the instrument and will conduct functional and performance verifications in the next FY.

Space Exploration and Research Office (SERO)

The SERO was established as the first step toward forming a research center to consolidate all space-related activities at the university and promote hardware development and observational research for space-exploration and science. Although the development of nanosatellites is a critical SERO research activity, educational activities are also important. We held a basic 2-week training course in August 2023 and an advanced 2-week training course in March 2024. The basic course attracted 28 applicants, whereas the advanced course attracted 42. Approximately 80% of the applicants were from outside Nagoya University and 50% were from industries.

Promotion of observations using Earth-observing satellites

A member led the GPM/DPR algorithm development team, worked as a project scientist on JAXA's PMM mission, and another member promoted applied research on JAXA's GCOM-C. He also conducted joint research with the Hokkaido Institute of General Research to identify harmful red tides. Additionally, mission proposals (precipitation and oceanographic observations) were made to TF's remote sensing subcommittee for future missions.

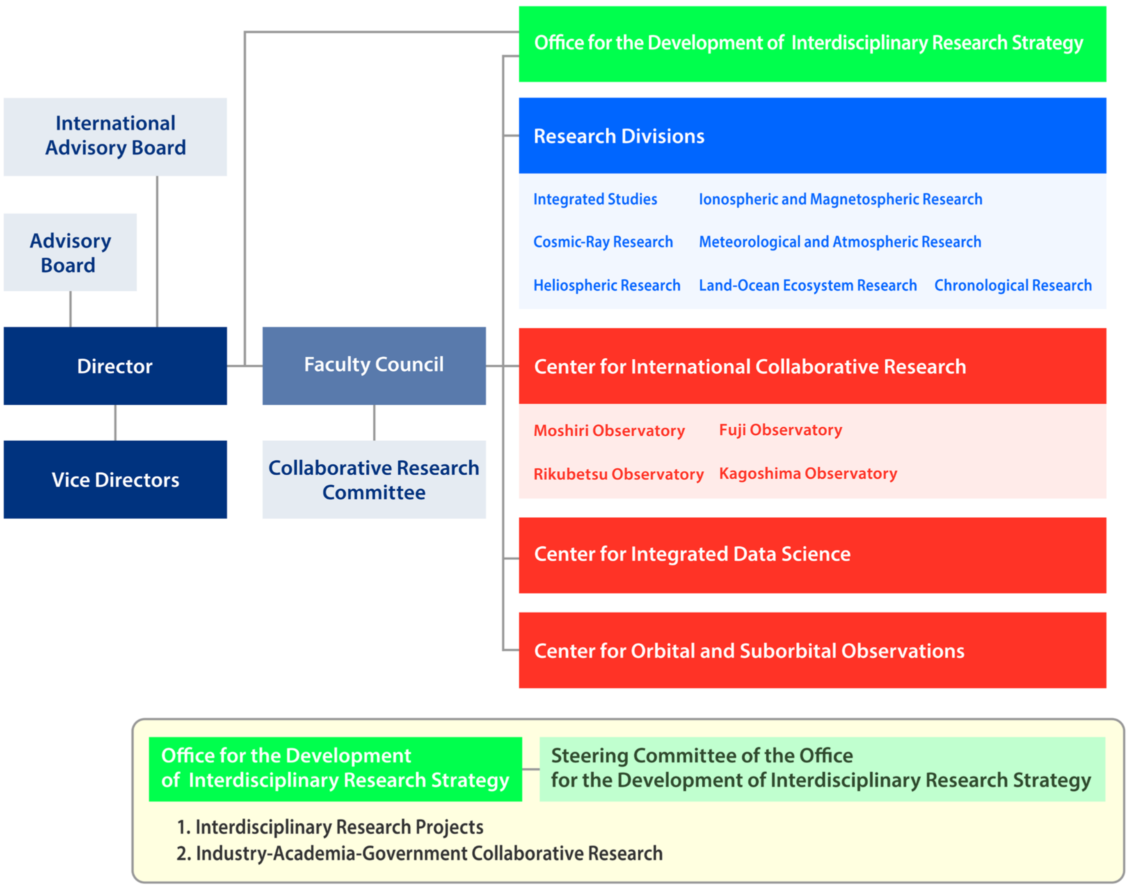
Office for the Development of Interdisciplinary Research Strategy

A primary objective of the ISEE is to encourage the development of new interdisciplinary research by merging space and earth sciences. The Office for the Development of the Interdisciplinary Research Strategy (ODIRS), established in August 2022, promotes interdisciplinary studies in cooperation with scientists from related fields based on their specialties across diverse ISEE research topics. Additionally, the ODIRS office benefits from the ISEE's involvement as a joint usage/research center, facilitating the promotion of interdisciplinary research in numerous institutions and faculties both inside and outside Nagoya University.

The ODIRS staff comprises the Director and Deputy Director of the Institute, directors of three affiliated centers, and a foreign faculty member from the Center for International Collaborative Research. Additionally, two designated faculty members were recruited to serve concurrently in the ODIRS from April 2023. The ODIRS also has a steering committee comprising faculty members from the related Departments of Nagoya University and some external members. The Committee is working to formulate a new strategy for interdisciplinary research encompassing various fields.

Furthermore, in 2023, Call for proposals for Interdisciplinary Research Strategy Projects was conducted to explore and promote new interdisciplinary research linking space and earth sciences and other diverse fields. In FY2023, ten new projects initiating new interdisciplinary research were adopted. Additionally, under the leadership of the Institute's Director, the following four projects were promoted:

1) Energetic Particle Chain -Effects on the Middle/Lower Atmosphere from Energetic Particle Precipitations-
2) Direct Search for Dark Matter with Paleo-detector
3) Data Rescues of the Analog Observational Records for the Past Solar-Terrestrial Environment
4) Changes in Surface Temperature at Dome-Fuji in East Antarctica from the Mid-Twentieth Century and the Impact of Solar Activity



Main Activities in FY2023

Call for proposals and promotion of Interdisciplinary Research Strategy Projects

We initiated a call for proposals of Interdisciplinary Research Strategy Projects linking space and earth sciences with other fields, and 10 new projects were adopted in FY2023. These projects cover a wide range, including collaborative initiatives with the School of International Development, engineering-related device and product development projects, novel ideas that have not yet been unexplored, and projects aimed at further enhancing the capabilities of the Tokai National University system. These efforts will continue into FY2024 and beyond, with the goal of fostering collaboration among researchers from different fields to generate new knowledge and solutions, pushing the boundaries beyond space and earth sciences to explore unknown territories and create new research areas.

Promoting Interdisciplinary Research Projects and opening-up new academic fields

Under the leadership of the Institute's Director, four interdisciplinary research projects were promoted: "Energetic Particle Chain -Effects on the Middle/Lower Atmosphere from Energetic Particle Precipitations," "Direct Search for Dark Matter using a Paleo-detector," "Data Rescue of Analog Observational Records of the Past Solar-Terrestrial Environment," and "Changes in Surface Temperature at Dome-Fuji in East Antarctica from the Mid-Twentieth Century and the Impact of Solar Activity".

Hosting workshops to promote interdisciplinary research across various fields

Workshops involving researchers from Interdisciplinary Research Strategy Projects and stakeholders within the institution were also conducted. These workshops not only introduced the research undertaken in the Interdisciplinary Research Strategy Projects but also broadly considered the formation of a vision for promoting interdisciplinary research, as well as the development of support and promotion structures, transcending institutional and disciplinary boundaries.

Promotion of joint research projects with corporations

Centered on the Interdisciplinary Research Strategy Office, we actively worked on strengthening industry–government–academia collaborations. This year, through a partnership with Fujitsu Limited, we explored the various challenges associated with space activities and promoted innovative projects related to space-weather forecasting. Additionally, in collaboration with Chitose Laboratory Corp., we began research on developing and optimizing production systems that utilize microbes for material production from CO_2. These efforts are crucial for creating a model wherein industry, academia, and government work together to generate new insights and technological innovations that contribute to society. In the future, we will continue to strengthen the collaboration between various industries, governmental bodies, and academia by actively promoting joint projects for the exploration and practical applications of new research areas.

Collaboration in joint-use/research programs

The joint-use/research programs of ISEE related to interdisciplinary research included 1 ISEE Symposium, 10 international collaborative research projects, 10 general collaborative research projects, 37 research meetings, and 3 instances of facility usage such as the accelerator mass spectrometer for joint-use, thereby promoting collaboration with ISEE's joint-use/research programs.

Collaboration and promotion of joint-projects with Industry–Government–Academia Collaboration Departments within the Institution

In cooperation with the Office for Promotion of Academic Research/Industry–Government–Academia Collaboration of the Tokai National Higher Education and Research System, we will continue to plan workshops with corporations and advance the consideration of plans for promoting joint research.

Energetic Particle Chain -Effects on the Middle/Lower Atmosphere from Energetic Particle Precipitations-

Research aims and background

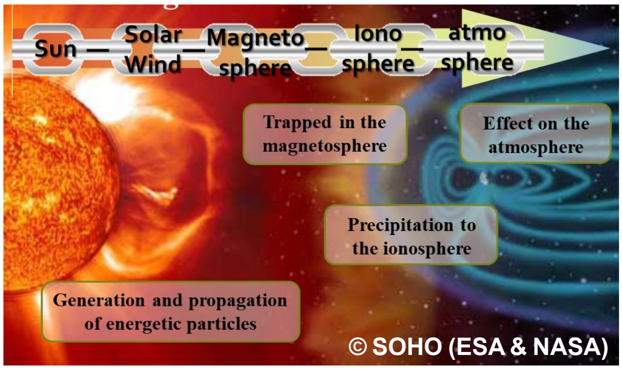


Fig.1: Image of a causal chain reaction system.

Energetic particle precipitation (EPP) due to solar activity, such as solar proton events and magnetic storms, occurs at the polar regions. EPP particles create odd nitrogen (NOx) and hydrogen (HOx), which can affect the neutral chemistry in the mid-atmosphere and the ozone (O_3) concentration. This is related to a key question in the SCOSTEP/PRESTO program: "What is the chemical and dynamical response of the middle atmosphere to solar and magnetospheric forcing?" To answer this question, it is important to understand the behavior of energetic particles in the magnetosphere, ionosphere, and upper/middle atmosphere as a causal chain reaction system (Fig.1) based on observations from each region and comprehensive simulations.

In this context, we initiated a new research project called energetic particle chain, which aims to conduct multipoint and long-term observations of the trapped particles in the magnetosphere using data from the Arase satellite, EEP-induced ionization in the ionosphere observed through the EISCAT_3D radar and riometers, and the variations in atmospheric molecules from the lower thermosphere to the upper stratosphere determined through millimeter-wave spectroradiometers in the polar region of the Northern Hemisphere (Fig.2). These measurement data will be used as inputs and constraints for creating models, such as integrated simulation codes of the EPP, ion chemistry in the atmosphere, and global dynamics/temperature fields. These measurements are also useful for assessing the validity of the model outputs.

In the previous fiscal year, we completed Phase 1 (feasibility study, two years) and started Phase 2 (full-study, five years) of the 7-year project. In the first year of Phase 2, we started data analysis using a dataset about Arase, EISCAT, Spectral Riometer, sodium lidar, all-sky EMCCD imagers, and millimeter-wave radiometer data of remarkable magnetic storm events to compare and connect the model calculations under the international consortium.

Fig.2: (a): Dr. Verronen from FMI (third left), who was a visiting professor at the ISEE, and collaborators. (b): Energetic Particle Chain project workshop at Nagoya University. (c): Containers of sodium lidar and millimeter-wave radiometer in Tromsø, Norway. (d): Installation of a Spectral Riometer in Oulujärvi, Finland. (e): Operating the all-sky EMCCD imagers in Tjautjas, Sweden. (f): New mm-wave spectral radiometer with a multifrequency receiver system at the Syowa station, Antarctica.

Main Activities in FY2023

Phase 2 (full-study phase) of the Interdisciplinary Research Project

On April 20, 2023, we held a kickoff meeting in the small workshop of the EPC project to initiate Phase 2. All domestic consortium members met at Nagoya University and reported the current status of each research field and observation instrument. Additionally, we discussed the strategy and plan for Phase 2. The second workshop was held from February 21–22, 2024, at the end of the fiscal year., where we discussed the results of some observational and theoretical studies related to EPP and its effects on the mid/low atmosphere.

Organization of international consortium

Researchers at The University of Electro-Communications, Tohoku University, and the Institute for Space and Astronautical Science (ISAS) joined the consortium to reveal the elementary physical process of wave–particle interactions and expand the observation field in the magnetosphere and ionosphere through optical observations of auroras and VLF/LF and rocket observations. To model the middle atmosphere change due to EPPs, we invited Prof. Pekka Verronen of FMI as a visiting professor to the ISEE from February–May 2023. Recently, we compared the long-term monitoring observational data of nitric oxide variations using a millimeter-wave radiometer at the Syowa station in Antarctica with the calculations of the Whole Atmosphere Community Climate Model (WACCM), a global simulation model.

Simultaneous observations of minor constituents via millimeter-wave spectroradiometer

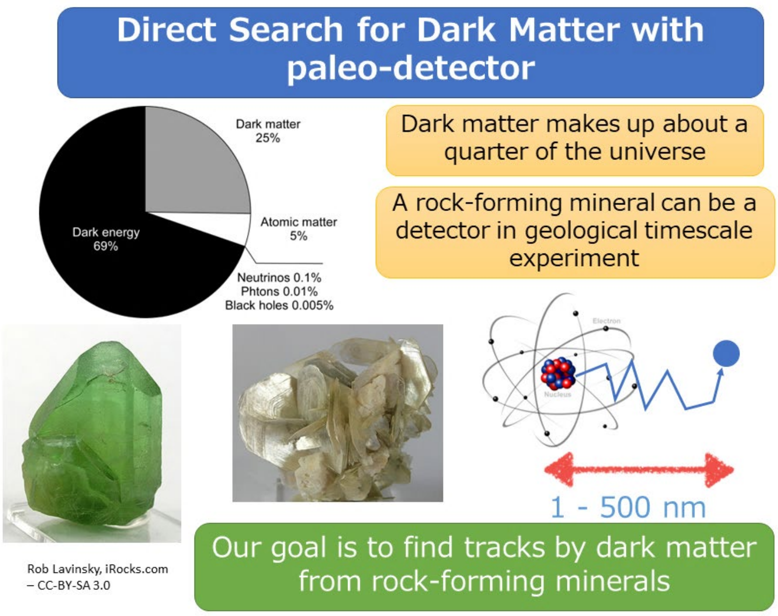
Since July 2022, simultaneous observations of ozone (O_3), nitrogen oxides (NO, NO_2), hydrogen oxide (HO_2), and carbon monoxide (CO) have been conducted at Syowa Station using a multifrequency millimeter-wave spectroradiometer. Six hyperfine-structure lines around 250 GHz allowed determining the column densities of NO, which is a key molecule for understanding ion chemistry, with a time resolution of less than one day, at a 12-h resolution and on a 6-h grid. This new system allows for a more detailed discussion of the correlations between NO column densities and magnetospheric dynamics, such as high-energy electron fluxes and Dst indices. NO responses to different electron precipitations were detected in late March 2023; one originated in a CME during the main phase of a magnetic storm and the other in a fast solar wind during the recovery phase.

- A new method was developed to estimate the energy spectra of precipitating electrons via wave-particle interactions using the Arase in-situ satellite, in accordance with the quasi-linear approach. The estimated energy spectra was verified through comparisons with the EISCAT data.
- The sounding-rocket experiments and low-altitude satellite observations confirmed the theory proposed by Miyoshi et al. (2020) that relativistic electron microbursts are high-energy tails of pulsating auroral precipitating electrons.
- As the sodium lidar system in Tromsø ceased operations for approximately four years, we rebuilt it in October 2023. Subsequently, we successfully operated it and obtained 126-h of temperature, sodium density, and wind velocity data from the polar MLT region.
- A spectral riometer (SR) was installed in Oulujärvi, Finland, and observations began in October 2023. Together with the SR installed in Kilpisjärvi in the previous year, we established a north–south and east–west SR network by participating in the SR project operated by the Sodankylä Geophysical Observatory (Finland).
- The all-sky EMCCD imagers at four stations (Tromsø in Norway, Tjautjas in Sweden, Sodankylä, and Kevo in Finland) in Scandinavia, and two stations (Gakona and Poker Flat) in Alaska were operated continuously and simultaneous measurements with the Arase satellite were regularly conducted.

Direct Search for Dark Matter with Paleo-Detectors

Dark matter constitutes approximately one quarter of the universe and is considered essential for the formation of galaxies, stars, and other large-scale structures. However, it cannot be observed optically, and its true nature remains unidentified. If it is revealed, we will gain crucial insights into a new paradigm of physics beyond the Standard Theory as well as the birth and history of the universe. Therefore, various attempts have been made to determine the nature of dark matter. For example, XENONnT uses tons of liquid xenon for a direct search of dark matter; however, the detection sensitivity in a direct search is limited by the product of the detector mass and experimental time, which cannot be extended indefinitely in experiments conducted by humans. Additionally, the liquid xenon methods are reaching their scale limits, which has resulted in the focus shifting to using minerals as detectors, known as “paleo-detectors.” Minerals interact with dark matter on geological time scales and can therefore be treated as detectors with extremely long experimental times. This suggests the possibility of searching for dark matter with a sensitivity beyond that of conventional experimental methods, even with small sample volumes. Furthermore, the existence of dark matter that exceeds the Planck mass is theoretically allowed; incredibly, dark matter that forms complex quantum states is called "composite dark matter" (e.g., Q-balls, quark nuggets, and magnetic monopoles), which can be detected in extremely high quantities. The amount of dark matter in a complex quantum state is extremely small, making future searches with higher sensitivities challenging if geological timescale events are detected by a detector. This project aims to directly search for dark matter and other unknown subatomic particles using paleo-detectors in collaboration with researchers inside and outside the ISEE, integrating petrology, geochronology, particle astrophysics, X-ray spectroscopy, electron microscopy, and analytical chemistry.

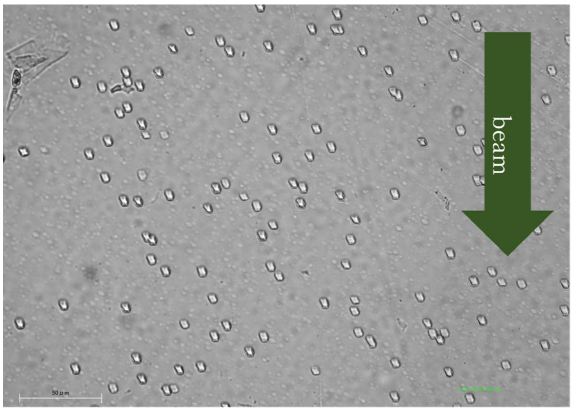
The direct search for unknown particles by paleo-detectors has a long history, starting with the search for magnetic monopoles using muscovite in the 1980s. In 1995, Snowden-Ifft et al. attempted a direct search for dark matter using muscovite. However, none of the studies successfully discovered unknown elementary particles. In recent years, paleo-detectors have attracted considerable attention, and various research groups worldwide have conducted theoretical investigations and experiments to prove the underlying principle. In our project, researchers from petrology, geochronology, particle physics, electron microscopy, geochemistry, and analytical chemistry worked toward proving the principle of paleo-detectors. In collaboration with other national and international research groups, we aim to concatenate the latest knowledge and techniques from various fields in a direct search for dark matter.



Direct search for dark matter using rock-forming minerals.

Main Activities in FY2023

Shape analysis of tracks formed in muscovite



Photomicrograph of tracks in muscovite after HF etching.

Weakly interacting massive particles (WIMPs) and Q-balls are possible dark-matter candidates. This study aims to establish a method for detecting dark-matter tracks using muscovite, olivine, and other rock-forming minerals to evaluate both possibilities. The mechanisms of track formation in minerals differ among regions wherein fast electronic stopping power is dominant and wherein slow nuclear stopping power is dominant. Dark matter is thought to fall to Earth at approximately 1/1000th the speed of light. In this region, the dominant stopping power becomes the nuclear stopping power, or near the boundary between the dominant electronic stopping power and nuclear stopping power regions. From FY2022, the experimental focus has been on muscovite, which is easy to use Q-ball searches, where the search volume is determined by area rather than volume. Additionally, based on previous studies, tracks in both the electronic stopping power-dominant and nuclear stopping power-dominant regions are expected to be observed. Muscovite has distinct cleavages and can be thinly peeled. Therefore, many samples can be obtained from a single mineral particle to conduct large-scale observations. Additionally, samples can be observed using both the transmitted and reflected light, and dating by, for example, the potassium-argon method is possible. Therefore, irradiation experiments were conducted under various conditions using muscovite with a potassium-argon age of approximately 600 million years, and the relationship between the velocity and the track shape was analyzed.

The irradiation experiments were conducted at the Heavy Ion Medical Accelerator in Chiba (HIMAC) of the National Institutes for Quantum Science and Technology and the Tandem Accelerator of the Japan Atomic Energy Agency. The irradiated specimens were etched with hydrofluoric acid and observed via phase-contrast microscopy. The relationship between the energy of the irradiated particles and the length of the formed track was analyzed.

Development of a high-speed automatic track-reading system

QTS in development

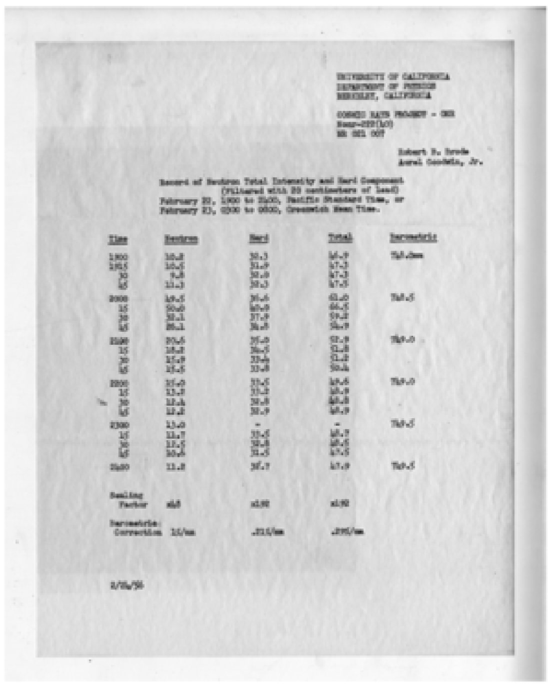
To search over a large area and increase the sensitivity, a high-speed automatic Q-ball track-reading system (QTS) is being developed in cooperation with the Graduate School of Science and other institutions. In this QTS, a stage drive scans the entire sample surface, and a camera acquires images to automatically identify the tracks. During the development of the track-recognition algorithm, we discovered cases wherein it is difficult to distinguish between α-recoil tracks (ARTs), which originally exist in muscovite, and tracks. Therefore, to perform a more accurate analysis, irradiation experiments will be conducted in the future using samples of muscovite that have been preheated to eliminate ARTs. Preliminary experiments have shown that ARTs can be erased through heating at 600 °C for 8 h. However, as muscovite decomposes at high temperatures, Raman spectroscopy was used to determine whether the crystal structure of muscovite was retained under these conditions. The results showed that the structure was maintained and it did not decompose under these heating conditions.

Data Rescues of the Analog Observational Records for the Past Solar-Terrestrial Environment

Since the International Geophysical Year (1957–1958), human civilization has developed a technological infrastructure, but in turn has become more vulnerable to disturbances in the solar-terrestrial environment. In fact, solar storms have influenced our basic infrastructure, such as satellites and power grids. Our country has also had to work on hazard mitigation, including the initiative of the Ministry of Internal Affairs and Communications. Meanwhile, debates on the interactions of solar activities with the terrestrial environment have intensified, as the lowest solar activities in the past century were recorded in 2009 and 2019.

Although past observational data form the basis for such discussions regarding the solar-terrestrial environment, most of them are systematically available only from the International Geophysical Year 1957–1958. However, their chronological coverage is not sufficiently rich for extreme solar storms and long-term variability owing to their rarity frequency and temporal evolutions.

To overcome these challenges, this project works toward preserving, sorting, and recalibrating past analog records and their metadata and aims at quantitatively reconstructing the past and extremities of solar activity and geomagnetic disturbances.

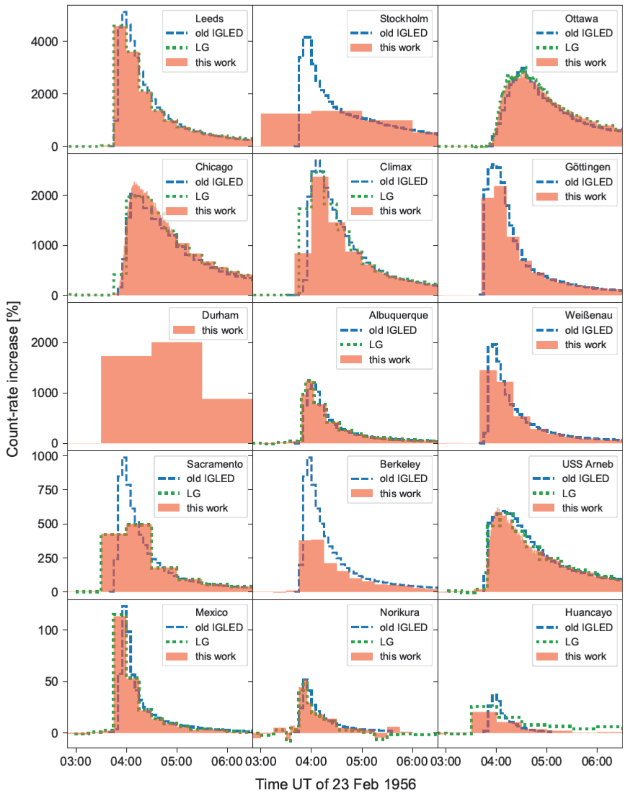


Examples of archival records of GLE5 that occurred on 23 February 1956. Specifically, these records are from the USS Arneb and Berkeley vessels (MS Simpson B218 F1 and MS Simpson B216 F12), reproduced courtesy of the Hanna Holborn Gray Special Collections Research Center of the University of Chicago (Hayakawa et al., 2024, *A&A*, 684, A46).

Main Activities in FY2023

In this fiscal year, our team focused on cosmic-ray measurement records of extreme solar particle storms in the past. Such extreme solar particle storms significantly impact the basic infrastructure of modern human civilization, such as satellites, communications, and aircraft. Neutron monitors have been used to monitor particle storms since the 1950s. Their cosmic-ray measurement data were gathered and published in the International GLE Database (IGLED) of the University of Oulu. Among them, GLE5 on February 23, 1956, exhibited high-fluence and hard-spectrum. Our team has worked on the archival records of this GLE by consulting collections at the University of Chicago Archives and contemporaneous reports to tabulate their source, digitize their plots, and drastically revise the cosmic-ray data obtained during this GLE. During this process, we found that the existing data most probably rely on Lev Dorman's hand-drawn spline curves in his book (Dorman, 1957). Therefore, we replaced them with the values from those of the actual observations at the time, newly derived 1-min data for three observational sites, and obtained a slightly softer spectrum and larger integral fluence for this GLE than that considered previously (Hayakawa et al., 2024, *A&A*, 684, A46).

Our team has also analyzed extreme geomagnetic storms that occurred in the past, especially those in February 1872 and July 1959. For the former, our team revealed that the probable active source region had a moderate size but complex magnetic structure; it developed to a minimal Dst estimate of ≤ −834 nT based on geomagnetic measurements conducted in India and Georgia, and the auroral visibility down to the Indian Ocean, India, the Arabian Peninsula, and northern and southern Africa (Hayakawa et al., 2023, *The Astrophysical Journal*, 959, 23).



Overall revisions of cosmic-ray variability measurements with the neutron monitors at the time of GLE5 on 23 February 1956 (Hayakawa et al., 2024, *A&A*, 684, A46)

The latter storm has been considered the second greatest storm since 1957 according to the Dst index, whereas little is known about its auroral activity. Our team analyzed auroral records from Chinese local meteorological observatories and a USSR expedition team to reconstruct the equatorward boundary of the auroral oval down to 35.4° ILAT (Hayakawa et al., 2024, *Monthly Notices of the Royal Astronomical Society*, 527, 7298–7305).

For past solar flares, our team has worked on Carrington's original manuscripts at the Royal Astronomical Society archives to analyze the descriptions and depictions of the area, duration, and brightness of the white-light Carrington flare and reconstructed the flare magnitude as ≈ X80 (X46–X126).

Additionally, our team has analyzed past solar-surface characteristics and long-term solar activity, as exemplified with comprehensive record surveys and data revisions for the early part of the Maunder Minimum (Hayakawa et al., 2024, *Monthly Notices of the Royal Astronomical Society*, 528, 6280–6291) and Polish records of the Dalton Minimum (Hayakawa et al., 2023, *Journal of Space Weather and Space Climate*, 13, 33).

Our team has also surveyed sunspot activity from 1921–1934 based on Katsue Misawa's records and assessed their values for sunspot number recalibrations (Hayakawa et al., 2024, *Monthly Notices of the Royal Astronomical Society*, in press).

Our results have been widely broadcasted, particularly those of our studies on past solar storms. Specifically, our results for the February 1872 storm (*i.e.*, the Chapman–Silverman storm) have been widely covered, became the most read article in the Astrophysical Journal and Altemetrics (over 500), and were broadcast in international media such as the Washington Post.

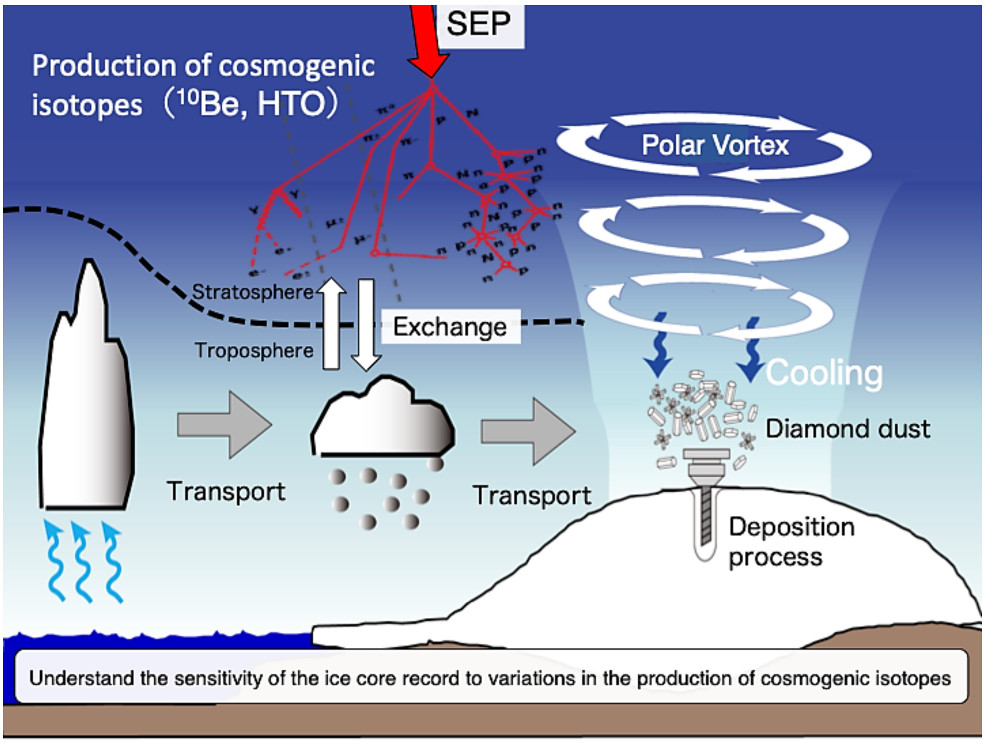
The PI has joined the editorial members of the special issue ("Old Records for New Knowledge"; https://rmets.onlinelibrary.wiley.com/toc/20496060/2023/10/1) for data rescue of the Geoscience Data Journal to publish a preface for their overall activity (Batlló, Hayakawa et al., 2024). The PI's efforts have been partially recognized in the scientific community and have led to his appointment as co-chair of the Interdivisional Commission on History. Hence, data rescue activities have expanded globally.

Changes in Surface Temperature at Dome Fuji in East Antarctica from the Mid-Twentieth Century and the Impact of Solar Activity

As society has become more sophisticated, changes in the space-earth environment have significantly impacted social life. For example, a solar eruptive event in 1989 generated severe magnetic storms, resulting in the failure of several satellites. The 2017 solar eruptive event affected the GPS increasing positioning errors. Solar activity is constantly monitored using satellites and space weather forecasts have been initiated. However, our knowledge of solar eruptive events is limited because our observational history encompasses only a few decades and excludes extreme events. To improve our understanding of solar events and enhance their predictability, it is essential to reveal the long-term history of solar eruptive events using paleo-proxy methods.

Past intense solar eruptive events are thought to have been recorded as positive anomalies of cosmogenic isotopes (e.g., ^{10}Be) in paleoarchives, such as ice cores. The cosmogenic isotope method has been widely used to detect past extreme solar events. The extreme solar events of 774 and 993 AD were recorded as abnormal ^{10}Be peaks in ice-core records. However, the strength of these events reconstructed using the cosmogenic isotope method is uncertain because the cosmogenic isotopes archived in the ice cores reflect not only changes in the production of cosmogenic isotopes in the upper atmosphere but also the transport and deposition processes at the site. Therefore, to reconstruct the strength of past solar eruptive events, it is essential to understand the sensitivity of ice-core records to variations in the production of cosmogenic isotopes in the upper atmosphere.

In this study, we attempted to estimate the sensitivity of the cosmogenic isotope method for detecting extreme solar eruptive events by collaborating with researches from diverse disciplines, including solar physics, geo-electromagnetics, meteorology/climatology, and glaciology. Currently, we are focusing on the East Antarctic region to elucidate the process of cosmogenic isotopes recordings (^{10}Be and HTO) in ice cores.

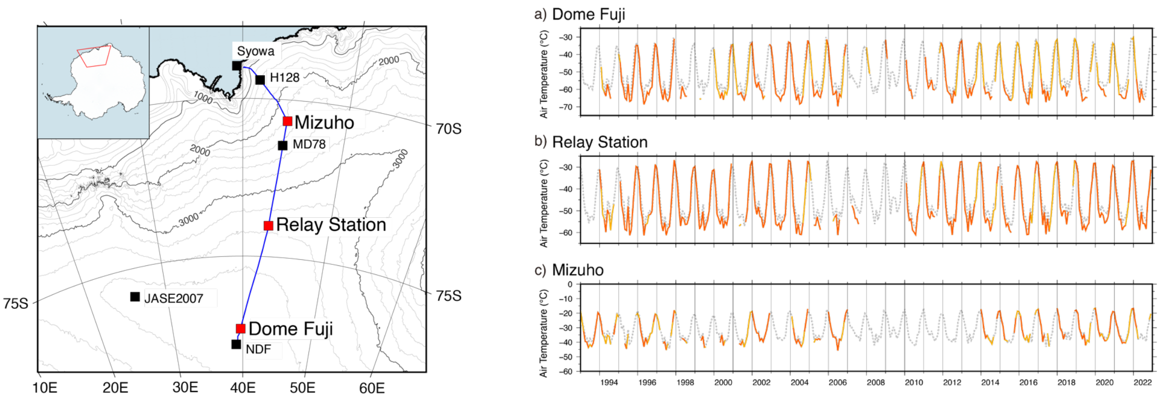


Objectives and research subjects of the project.

Main Activities in FY2023

Near-surface air-temperature records of the past 30 years in the interior of Antarctic Ice sheet

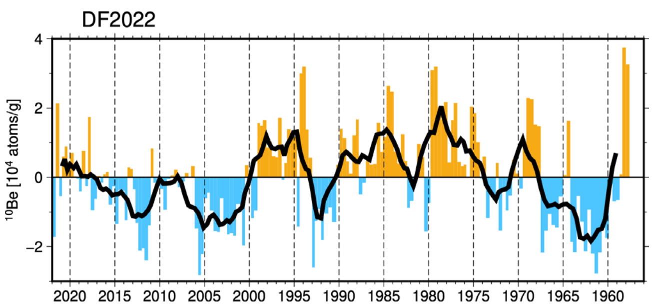
Antarctic climate change has been conventionally studied using temperature data from staffed stations. However, these stations are primarily located in the Antarctic Peninsula and coastal regions, and climate-change characteristics in the Antarctic Plateau remain largely unidentified. To fill this gap, this study presents a new dataset of monthly mean near-surface climate data using historical observations from three automatic weather stations (AWSs). Multiple AWSs have been installed along the route to Dome Fuji since the 1990s, and observations continue today. The use of passive-ventilated radiation shields for the temperature sensors at the AWSs may have caused a warm bias in the temperature measurements; however, this was owing to insufficient ventilation in the summer, when solar radiation is high and winds are low. In this study, warm biases were quantified and subsequently removed using a regression model. Additionally, several other systematic errors that occurred in the early days of the AWSs were identified and corrected. After correction, multiple AWS records were integrated to create a time-series for each station. The percentage of missing data over the three decades was 21% for Relay Station and 28% for Dome Fuji. However, 49% of data from Mizuho was missing which is more than double that of the Relay Station.



A map of the Dome Fuji region in the East Antarctica (Left) and monthly mean temperature time series from the corrected AWS observations (red and orange lines) and monthly 2-m temperature from ERA5 (dashed gray).

Development and evaluation of new proxy for past solar activity

To estimate the sensitivity of cosmogenic isotopes in the ice cores to variation in past solar activities, we collected a snow-pit sample from a depth of 5.4 m Dome Fuji in December 2022. Subsequently, we measured the ^{10}Be at 3-cm intervals and obtained a ^{10}Be profile with high temporal resolution. Additionally, we analyzed the stable water isotopes, tritium, and ion concentrations, and determined the age of the snow pit from volcanic signals recorded as the highest peaks of non-sea-salt sulfate ($nssSO_4^{2-}$) and tritium peaks from past bomb tests. Theoretically, the ^{10}Be time-series shows good agreement with the variations in ^{10}Be production owing to solar activity. However, ^{10}Be variations related to solar cycles were unclear, although multi-year variations in ^{10}Be were evident. This may be because ^{10}Be is strongly influenced by atmospheric circulation. Thus, we developed a new ^{10}Be-anomaly proxy that is less affected by atmospheric circulation. As shown in the figure, the new ^{10}Be proxy exhibits clear inter-decadal variability associated with solar cycles.



Time-series of ^{10}Be-anomaly proxy for snow pit.

9. Publications and Presentations

Papers (in refereed Journals, April 2023–March 2024)

(250 in total, incl.20 articles in press)

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4 more books were published in Japanese.

Publication of Proceedings (April 2023–March 2024)

Title	Date of Publication
The 28th Symposium on Atmospheric Chemistry, Book of Abstracts	Nov. 2023
iLEAPS-Japan 2023 Workshop: Book of Abstracts	Nov. 20, 2023
The Nagoya University Bulletin of Chronological Research Vol. 8	Mar. 24, 2024

Conference Presentations (April 2023–March 2024)

■ International Conferences

*Session Conveners

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staff and PDs	Students	Total	Invited
KPS-JPS Joint Symposium, 2023 KPS Spring Meeting	Daejeon, Korea	Apr. 20, 2023	0	1	0	1	1
EGU General Assembly 2023	Hybrid Conference/ Vienna, Austria	Apr. 23–28, 2023	0	2	0	2	0
Myth and Science in Ancient World: Novel Research from Eurasia	Samarkand, Uzbekistan	May 2, 2023	0	1	0	1	0
International Reference Ionosphere (IRI) workshop 2023	Daejeon, Korea	May 15–19, 2023	0	1	0	1	1
Japan Geoscience Union (JpGU) Meeting 2023	Hybrid Conference/ Chiba, Japan	May 21–26, 2023	29*	44	31	75	4
15th International Conference on Mesoscale Convective Systems and High-Impact Weather (ICMCS-XV)	Hybrid Conference/ Fort Collins, CO, USA	May 22–25, 2023	0	1	0	1	1
6th GST Workshop 2023	Daejeon, Korea	May 23–26, 2023	0	1	0	1	1
7th International Workshop on Earthquake Preparation Process ~ Observation, Validation, Modeling, Forecasting ~ (IWEP7)	Chiba, Japan	May 24–25, 2023	0	2	0	2	1
SuperDARN Workshop 2023	Himeville, South Africa	May 29–Jun. 2, 2023	0	2	0	2	1
ICTP-SCOSTEP-ISWI Workshop on the Predictability of the Solar-Terrestrial Coupling - PRESTO	Trieste, Italy	May 29–Jun. 2, 2023	1	1	0	1	0
18th Workshop on Antarctic Meteorology and Climate (WAMC)	Hybrid Conference/ Madison, WI, USA	May 31–Jun. 28 2023	0	1	0	1	0
The 34th International Symposium on Space Technology and Science	Hybrid Conference/ Kurume, Japan	Jun. 3–9, 2023	0	1	0	1	0
Flux Emergence Workshop 2023	Santorini, Greece	Jun. 5–9, 2023	0	1	0	1	0
GEM 2023 Workshop	Hybrid Conference/ San Diego, CA, USA	Jun. 11–16, 2023	0	2	1	3	0
NDACC-IRWG-TCCON-COCCON Annual Meeting 2023	Spa, Belgium	Jun. 12–16, 2023	0	2	0	2	0
CEDAR 2023 Workshop	Hybrid Conference/ San Diego, CA, USA	Jun. 25–30, 2023	0	0	1	1	0
MR2023 Workshop	Shima, Japan	Jun. 26–29, 2023	1	2	0	2	1
Iberian Space Science Summer School	Coimbra, Portugal	Jun. 26–30, 2023	1	0	0	0	0
Joint CFMIP-GASS 2023 Meeting	Paris, France	Jul. 9–13, 2023	0	1	0	1	0
28th IUGG General Assembly in Berlin (IUGG2023)	Berlin, Germany	Jul. 11–20, 2023	1*	3	1	4	1
38th International Cosmic Ray Conference (ICRC2023)	Hybrid Conference/ Nagoya, Japan	Jul. 26– Aug. 3, 2023	7	7	4	11	0
Asia Oceania Geosciences Society (AOGS) 2023	Singapore	Jul. 30–Aug. 4, 2023	2*	4	2	6	2
2nd Asian Palaeontological Congress	Tokyo, Japan	Aug. 3–7 2023	0	1	0	1	0

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staff and PDs	Students	Total	Invited
34th IUPAP Conference on Computational Physics (CCP2023)	Hybrid Conference/ Kobe, Japan	Aug. 4–8, 2023	0	2	1	3	1
Water-Rock Interaction WRI-17/ Applied Isotope Geochemistry AIG-14	Sendai, Japan	Aug. 18–22, 2023	1*	0	0	0	0
XXXVth General Assembly and Scientific Symposium of the International Union of Radio Science (URSI GASS 2023)	Sapporo, Japan	Aug. 19–26, 2023	4*	17	2	19	5
IAU Symposium 365 Dynamics of Solar and Stellar Convection Zones and Atmospheres	Yerevan, Armenia	Aug. 21–25, 2023	1	0	0	0	0
ISAS Planetary Exploration Workshop 2023	Hybrid Conference/ Tokyo, Japan	Aug. 28–30, 2023	0	1	0	1	0
40th Conference on Radar Meteorology	Hybrid Conference/ Minneapolis, MN, USA	Aug. 28–Sep. 1, 2023	0	2	0	2	0
VII Convective Permitting Climate Modelling 2023 workshop	Bergen, Norway	Aug. 29–31, 2023	0	1	0	1	1
International Colloquium on Equatorial and Low-Latitude Ionosphere (ICELLI 2023)	Kwara, Nigeria	Sep. 4–8, 2023	1	0	0	0	0
Workshop: Astro AI with Fugaku	Tokyo, Japan	Sep. 11–12, 2023	1	0	0	0	0
3rd International Workshop on Equatorial Plasma Bubble (EPB-3)	Navi Mumbai, India	Sep. 13–15, 2023	0	2	0	2	1
International Meridian Circle Program (IMCP) 2023 International Workshop & Space Weather School	Beijing, China	Sep. 14–23, 2023	0	2	0	2	1
PMM Science Team Meeting	Hybrid Conference/ Minneapolis, MN, USA	Sep. 18–22, 2023	0	1	0	1	0
International Symposium on Natural and Artificial Radiation Exposures and Radiological Protection Studies (NARE2023)	Hirosaki, Japan	Sep. 19–22, 2023	0	0	1	1	0
Hinode-16 Iris-13 Meeting 2023	Niigata, Japan	Sep. 25–29, 2023	0	7	1	8	2
The 3rd DMNet International Symposium “Dark Matter Studies in Accelerator Physics”	Hybrid Conference/ Padova, Italy	Sep. 26–28, 2022	2	1	0	1	0
8th International Conference on Space Science and Communication (IconSpace 2023)	Penang, Malaysia	Oct. 3–4, 2023	1	0	0	0	0
Korea-Japan Space Weather Workshop 2023	Nagoya, Japan	Oct. 11, 2023	1	9	0	9	0
1st International Workshop for Aviation Weather and Forecasting (IWAWF) 2023	Gyeongju, Korea	Oct. 11–13, 2023	0	1	0	1	0
Dropsonde Specialist Invitation Seminar and Cooperation Meeting	Jeju, Korea	Oct. 12, 2023	0	1	0	1	0
International Heliophysics Data Environment Alliance (IHDEA) 2023 Annual Meeting	Hybrid Conference/ Laurel, MD, USA	Oct. 12–13, 2023	2	2	0	2	0
15th International Conference on Substorms (ICS15)	Hybrid Conference/ Deqing, China	Oct. 16–20, 2023	1	1	1	2	0
2023 Sun-Climate Symposium	Flagstaff, AZ, USA	Oct. 16–20, 2023	0	2	0	2	1
Origin of High-Energy Protons Responsible for Late-Phase Pion-Decay Gamma-Ray Continuum from the Sun	Nagoya, Japan	Oct. 16–20, 2023	1	0	0	0	0
Symposium on Frontiers of Underground Physics	Chengdu, China	Oct. 29– Nov. 2, 2023	0	1	0	1	1

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staff and PDs	Students	Total	Invited
The Federal Aviation Administration's (FAA) "New and Emerging Aviation Technologies" (NEAT) Series	Online	Nov. 1, 2023	0	1	0	1	0
2023 IEEE Nuclear Science Symposium and Medical Imaging Conference	Vancouver, Canada	Nov. 4–11, 2023	1*	0	0	0	0
The Joint PI Meeting of JAXA Earth Observation Missions FY2023	Hybrid Conference/ Tokyo, Japan	Nov. 6–10, 2023	1*	4	0	4	1
Challenges and Innovations in Computational Astrophysics V	Online	Nov. 7–9, 2023	0	1	0	1	1
7th Asia-Pacific Conference on Plasma Physics (AAPPS-DPP2023)	Nagoya, Japan	Nov. 13–17, 2023	1*	4	0	4	3
Focus Week on Primordial Black Holes	Kashiwa, Japan	Nov. 13–17, 2023	0	1	0	1	0
EarthCARE Pre-Launch Science and Validation Workshop	Hybrid Conference/ Rome, Italy	Nov. 13–17, 2023	0	2	0	2	1
14th Symposium on Polar Science	Hybrid Conference/ Tachikawa, Japan	Nov. 14–17, 2023	0	5	2	7	0
ARCI Final Research Conference	Oulu, Finland	Nov. 16–17, 2023	0	1	0	1	0
International Symposium on Satellite Navigation 2023 (ISSN2023)	Henan, China	Nov. 20–22, 2023	0	1	0	1	0
19th European Space Weather Week (ESWW) 2023 -	Hybrid Conference/ Toulouse, France	Nov. 20–24, 2023	0	2	0	2	0
The 9th East Asia Accelerator Mass Spectrometry Symposium (EA-AMS9)	Soul, Korea	Nov. 22–24, 2023	0	3	1	4	0
CWA-Fujitsu Seminar	Taipei, Taiwan	Nov. 29, 2023	0	1	0	1	0
2023 TAHOPE Experiment Data Analysis and Scientific Research Workshop	Taipei, Taiwan	Nov. 29–30, 2023	1	2	0	2	0
International Conference on Materials and Systems for Sustainability (ICMaSS) 2023	Nagoya, Japan	Dec. 1–3, 2023	0	0	1	1	0
Annual Meeting on Multi Messenger Astrophysics	Gero, Japan	Dec. 4–6, 2023	0	1	2	3	0
Kashiwa Dark Matter Symposium 2023	Hybrid Conference/ Kashiwa, Japan	Dec. 5–8, 2023	0	0	1	1	0
AGU Annual Meeting 2023	Hybrid Conference/ San Francisco, CA, USA	Dec. 11–15, 2023	0	17	5	22	4
6th ISEE Symposium	Hybrid Conference/ Nagoya, Japan	Dec. 17–19, 2023	5	5	6	11	0
ALMA/45m/ASTE Users Meeting 2023	Hybrid Conference/ Mitaka, Japan	Dec. 21–22, 2023	0	2	0	2	0
SGO XV Observatory Days	Hybrid Conference/ Sodankyla, Finland	Jan. 10–12, 2024	0	2	0	2	0
Nagoya Workshop on Technology and Instrumentation in Future Liquid Noble Gas Detectors	Nagoya, Japan	Feb. 14–16, 2024	2	1	2	3	0
Ocean Sciences Meeting 2024	New Orleans, LA, USA	Feb. 18–23, 2024	0	0	1	1	0
The Extreme Universe Viewed in Very-high-energy Gamma Rays 2023	Hybrid Conference/ Kashiwa, Japan	Feb. 19–20, 2024	1	2	0	2	0

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staff and PDs	Students	Total	Invited
PAWCs International Symposium	Hybrid Conference/ Nagoya, Japan	Mar. 4–7, 2024	1	4	2	6	0
SOLAR-C Science Meeting	Hybrid Conference/ Nagoya, Japan	Mar. 5–6, 2024	1	1	0	1	1
KMI School 2024 “Quantum Computing for Particle Physics and Astrophysics”	Nagoya, Japan	Mar. 5–7, 2024	2	0	1	1	0
Total			36 20*	197	70	267	38

■ Domestic Conferences

*Session Conveners

Number of Conferences	Organizers	Number of Presentations			
		Staff and PDs	Students	Total	Invited
88	46 10*	151	87	238	24

■ Lectures for Researchers

Date	Title	Number of Participants
Apr. 19, 2023 Aug. 24, 2023 Oct. 26, 2023 Jan. 23, 2024 Feb. 13, 2024	SCOSTEP/PRESTO Online Seminar (16th–20th)	105 49 68 86 24
Jun. 30, 2023 Jul. 24, 2023 Sep. 21, 2023 Jan. 25, 2024	SCOSTEP Online Capacity Building Lecture (17th–20th)	27 61 42 65
May 12, 2023 Jul. 7, 2023 Dec. 20, 2023 Feb. 9, 2024 Feb. 26, 2024	ISEE/CICR colloquium (70th–74th)	23 31 39 34 14
May 12, 2023 Jun. 8, 2023 Jul. 20, 2023 Jul. 27, 2023 Aug. 10, 2023 Oct. 5, 2023 Oct. 12, 2023 Jan. 25, 2024	Solar Seminar	20 14 15 16 16 16 16 12
May 30, 2023 Jun. 28, 2023 Nov. 24, 2023	Special Seminar	15 15 15
Dec. 14–15, 2023	Research Workshop: Monitoring sustainable development in the era of AI	31
Total	43	1422

Awards

■ Staff and PhD

(9 in total)

Award Winners	Date	Awards	Title
Yoshizumi Miyoshi	Apr. 5, 2023	2023 - Research. com Earth Science in Japan Leader Award	The 2023 Award for Outstanding Earth Science Scientist in Japan by Research.com
Hisashi Hayakawa	Apr. 19, 2023	The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology The Young Scientists' Award 2023	Research on Extreme Space Weather Events Based on Historical Documents
Hideyuki Horita	May 19, 2023	Encouragement Award, HPCI Software Development Category	Software : R2D2 (Radiation and RSST for Deep Dynamics)
Atsuki Shinbori (co-authors: Y. Otsuka, T. Sori, N. Nishitani)	Sep. 26, 2023	SGEPSS Outstanding Paper Award	Shinbori, A., Y. Otsuka, T. Sori, M. Nishioka, S. Perwitasari, T. Tsuda, and N. Nishitani, Electromagnetic conjugacy of ionospheric disturbances after the 2022 Hunga Tonga- Hunga Ha'apai volcanic eruption as seen in GNSS-TEC and SuperDARN Hokkaido pair of radars observation. *Earth, Planets and Space*, **74**, 106, 2022
Lynn M. Kistler	Dec. 14, 2023	AGU Van Allen Lecture Award	Significant contributions to magnetospheric ion studies
Sachie Kanada (co-author: A. Nishii)	Feb. 1, 2024	MSJ SOLA Award in 2023	Kanada, S., and A. Nishii, 2023: Observed concentric eyewalls of Supertyphoon Hinnamnor (2022). *SOLA*, **19**, 70−77, 2023
Atsuki Shinbori (co-authors: Y. Otsuka, T. Sori, N. Nishitani, S. Nakamura, Y. Miyoshi)	Feb. 25, 2024	Highlighted Papers 2023, Earth, Planets and Space	Shinbori, A., Y. Otsuka, T. Sori, M. Nishioka, P. Septi, T. Tsuda, N. Nishitani, et al., New aspects of the upper atmospheric disturbances caused by the explosive eruption of the 2022 Hunga Tonga‑Hunga Ha'apai volcano. *Earth Planets Space,* **75**, 175, 2023
Atsuki Shinbori	Feb. 25, 2024	Excellent Reviewers 2023, Earth, Planets and Space	Important contribution as a reviewer of the journal "Earth, Planets and Space"
Ryota Kikuchi	Mar. 19, 2024	SICE Best Presentation Award of the Multi-Symposium on Control Systems: Technology Area 2023	Hamada, Y., R. Kikuchi, and H. Inokuchi, Aircraft Gust Alleviation Control Using Robust Preview Feedforward against Wind Velocity Errors. *Transactions of the Society of Instrument and Control Engineers*, **60(3)**, 209–217, 2024

■ Students

(6 in total)

Award Winners	Date	Awards	Title
Hirotaka Koyama	May 27, 2023	JpGU 2023 Outstanding Student Presentation Award	Solar activity dependence of the semidiurnal tide and that modulation source in the polar lower thermosphere
Nozomi Tamura			Intensity sensitivity of Typhoon Mindulle (2021) on the initial values of sea surface temperature in the forecast experiment
Kentaro Kataoka	Sep. 23, 2023	Student Encouragement Award of the Geochemical Society of Japan 2023	Variations in ^{14}C, $\delta^{13}C$ and trace elements in Nagoya atmospheric aerosols from 2019 to 2020
Harune Sekido	Nov. 17, 2023	7th Asia-Pacific Conference on Plasma Physics（AAPPS-DPP2023）Poster Prize	Low-cost Magnetometers Using Magneto-impedance (MI) Sensors
Hiroyasu Tokuue	Dec. 15, 2023	Matsuno Prize, 2023 Autumn Meeting of the Meteorological Society of Japan	Modeling of drag effect considering the unsteady descent of precipitation particles
Yuki Ido	Mar. 8, 2024	Outstanding Presentation Award, 4th UGAP Workshop for Young Researchers	Research and development for the exploration of unknown cosmic ray events using billion-year-scale mineral track detectors

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 offers the graduate course for the space-earth physics in the Department of Physics (Division of Particle and Astrophysical Science before the 2021 Academic Year) 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 Natural Science					Department of Electrical Engineering		Department of Earth and Environmental Sciences						
		Department of physics (space–earth physics group)					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		●		●						●	●	●		●

*Before the 2021 Academic Year：Heliospheric and Geospace Physics, Division of Particle and Astrophysical Science

Faculty Members

(April 1, 2023–March 31, 2024)

■ Department of physics, Division of Natural Science / Division of Particle and Astrophysical Science, Graduate School of Science

Field/Topics	Professor	Associate Professor	Lecturer	Assistant Professor
Department of physics (space-earth physics group)	Akira Mizuno	Tomoo Nagahama		
	Masafumi Hirahara	Satonori Nozawa	Shin-ichiro Oyama	
	Kanya Kusano	Satoshi Masuda		Akimasa Ieda
	Hideyuki Hotta			
	Yoshitaka Itow	Fusa Miyake	Akira Okumura	Hiroaki Menjo
	Hiroyasu Tajima	Shingo Kazama*		
		Kazumasa Iwai		Ken-ichi Fujiki

*Kobayashi-Maskawa Institute for the Origin of Particles and the Universe

■ Department of Electrical Engineering, Graduate School of Engineering

Field/Topics	Professor	Associate Professor	Lecturer	Assistant Professor
Space Electromagnetic Environment	Kazuo Shiokawa	Nozomu Nishitani		Taku Nakajima
		Yuichi Otsuka*[1]		
		Claudia Martinez-Calderon		
	Yoshizumi Miyoshi	Takayuki Umeda*[2]		

*[1] Transfer from the Graduate School of Science to the Graduate School of Engineering in April 2023
*[2] Left the Institute on January 31, 2024

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

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

Number of Students supervised by ISEE Staff

(April 1, 2023–March 31, 2024)

	M1	M2	D1	D2	D3	Undergraduate Students	Non-regular students	Total	Master's Degree	Doctor's Degree
Graduate School of Science	21	9	4	1	1	-	2	38	8	0
Graduate School of Engineering	6	10	0	1	0	-	0	17	10	0
Graduate School of Environmental Studies	11	13	5	2	8	-	2	41	10	1
School of Science	-	-	-	-	-	7	0	7	-	-
School of Engineering	-	-	-	-	-	11	1	12	-	-
ISEE	-	-	-	-	-	-	0	0	-	-
Total	38	32	9	4	9	18	5	115	28	1

Cumulative total in AY 2023

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 2023 Academic Year, The Following Courses were offered;

- Astrophysics III
- Electric Circuits with Exercise
- Electromagnetic Wave Engineering
- Environmental Chemistry
- Experimental Physics
- Experiments in Physics - Advanced Course
- Experiments on Electrical, Electronic and Information Engineering 2
- First Year Seminar
- Frontier of Earth and Planetary Sciences
- Fundamentals of Earth Science II
- Geology Experiments
- Graduation Thesis A・B
- Introduction to Hydrospheric-Atmospheric Sciences
- Introduction to Physics I・II
- Laboratory in Physics
- Linear Circuit with Exercises
- Mathematics I and Tutorial A・B
- Meteorology
- Physics Experiments I・II
- Probability Theory and Numerical Analysis with Exercises
- Remote sensing
- Solar System Science
- Topics in Advanced Physics

11. International Relations

Academic Exchange

(27 in total)

Institution	Country/Region	Establishment
Bangladesh University of Engineering & Technology, Department of Physics	Bangladesh	Mar. 4, 2008
Institute of High Energy Physics, Chinese Academy of Sciences	China	Feb. 20, 2001
Polar Research Institute of China	China	Nov. 11, 2005
Pukyong National University, College of Fisheries Sciences	Korea	Oct. 2, 2006
Korea Institute of Ocean Science and Technology, Korea Ocean Satellite Center	Korea	Apr. 17, 2014
Institute of Geography and Geoecology of the Mongolian Academy of Sciences	Mongolia	Mar. 6, 2024
Department of Atmospheric Sciences, National Taiwan University	Taiwan	Oct. 30, 2009
Center for Weather Climate and Disaster Research, National Taiwan University	Taiwan	Sep. 3, 2014
Geophysical Institute, University of Alaska Fairbanks	USA	Jul. 16, 1990
Space Environment Center, National Oceanic and Atmospheric Administration	USA	Dec. 15, 1992
National Geophysical Data Center, National Oceanic and Atmospheric Administration	USA	Jan. 5, 1993
Haystack Observatory, Massachusetts Institute of Technology	USA	October 24, 1994
Center for Astrophysics and Space Sciences, University of California at San Diego.	USA	Dec. 22, 1997
Center for Space Science and Engineering Research, Virginia Polytechnic Institute and State University	USA	Jan. 23, 2013
Chacaltaya Cosmic Ray Observatory, Faculty of Sciences, Universidad Mayor de San Andres, La Paz	Bolivia	Feb. 20, 1992
National Institute for Space Research	Brazil	Mar. 5, 1997
Yerevan Physics Institute	Armenia	Oct. 18, 1996
Department of Geophysics, Finnish Meteorological Institute	Finland	Oct. 21, 1994
Faculty of Science, UiT The Arctic University of Norway	Norway	May 3, 2019 (since Oct. 8, 1993)
Institute of Cosmophysical Research and Radiowave Propagation, Far Eastern Branch, Russian Academy of Sciences	Russia	Apr. 14, 2007
Institute of Solar-Terrestrial Physics, Siberian Branch of the Russian Academy of Sciences	Russia	Oct. 28, 2008
Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy, Siberian Branch of the Russian Academy of Sciences	Russia	Nov. 28, 2012
The Polar Geophysical Institute, Murmansk	Russia	Mar. 13, 2017
Swedish Institute of Space Physics	Sweden	Sep. 1, 2005 (since Mar. 25, 1993)
National Institute of Water and Atmospheric Research	New Zealand	Jul. 26, 1989
Centre for Geophysical Research, University of Auckland	New Zealand	Dec. 7, 1992
Faculty of Science, University of Canterbury	New Zealand	Jul. 30, 1998

Number of exchanges: visitors:20, going abroad:7

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

Other Exchange

Institution	Country/Region	Establishment
Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)	International Science Council	Jul. 30, 2019

Observation Sites and Foreign Collaborative Institutions

（As of May 2024）

Name	Country/Region	Institution	Obs. Site	Latitude	Longitude
SuperDARN Executive Council	(UK)	●		—	—
Syowa Station	Antarctic		●	−69	39.59
Atmospheric Observatory of Austral Patagonia	Argentine		●	−51.62	290.8
Lasar Application and research Center	Argentine		●	−33.5	301.9
Darwin	Australia		●	−12.44	130.96
Kakadu Observatory, Geoscience Australia	Australia	●		−12.69	132.47
Athabasca University	Canada	●		54.7	246.7
Athabasca	Canada		●	54.6	246.36
Resolute	Canada		●	74.73	265.07
Eureka	Canada		●	80	274.1
Kapuskasing	Canada		●	49.39	277.81
Nain	Canada		●	56.5	298.3
Atacama highland	Chile		●	−23	292.3
Egypt-Japan University of Science and Technology	Egypt	●	●	30.867	29.583
Nyrola	Finland		●	62.34	25.51
Sodankyla	Finland		●	67.4	26.6
Kevo	Finland		●	69.76	27.01
VLF receiver at Oulujarvi, Finland (OUJ)	Finland		●	64.51	27.23
University of Oulu	Finland	●		65.1	25.5
Zugspitze	Germany		●	47.42	10.98
Husafell	Iceland		●	64.67	338.97
Decan College	India	●		18.55	73.9
Observation Site for Methane in Sonepat, India	India		●	29	77
National Research and Innovation Agency (BRIN)	Indonesia	●		−6.2	106.8
Kototabang	Indonesia		●	−0.2	100.32
University of Kurdistan	Iran	●		35.2	46.6
Mexican Array Radio Telescope, Universidad Nacional Autonoma de Mexico	Mexico		●	19.32	261
Top of the Sierra Negra volcano, National Institute of Astrophysics, optics, and electonics	Mexico		●	18.98	262.7
Kathmandu University (KU)	Napal	●		27.62	85.54
International Centre for Integrated Mountain Development (ICIMOD)	Napal	●		27.65	85.32
Nepal Academy of Science and Technology (NAST)	Napal	●		27.66	85.32
The Rolwaling valley in the Himalayas (six places)	Napal		●×6	27.9	86.38
National Space Research and Development Agency	Nigeria	●		8.99	7.38
Abuja	Nigeria		●	8.99	7.38
University Centre in Svalbard (UNIS)	Norway	●		78.2	15.63
Alta	Norway		●	69.9	23.3
Tromsø	Norway		●	69.59	19.227
Skibotn	Norway		●	69.35	20.36
Ny-Ålesund	Norway		●	78.9	11.9
Muntinlupa	Philippines		●	14.373	121.02

Name	Country/Region	Institution	Obs. Site	Latitude	Longitude
Institute for Biological Problems of Cryolithozone, Siberian Branch of Russian Academy of Sciences	Russia	●		62.25	129.2
Pushchino Radio Astronomy Observatory, Lebedev Physical Institute	Russia		●	54.82	37.63
Istok	Russia		●	70.03	88.01
Zhigansk	Russia		●	66.78	123.37
Magadan	Russia		●	60.05	150.73
Paratunka	Russia		●	52.97	158.248
EISCAT Scientific Association	Sweden	●		67.8	20.4
European Organization for Nuclear Research	Switzerland	●		46.2	6
Chiang Mai University	Thailand	●		18.79	98.92
Chiang Mai	Thailand		●	18.79	98.92
Chumphon	Thailand		●	10.73	99.37
Brookhaven National Laboratory	USA	●		40.9	287.1
The University of Arizona	USA	●		32.2	249
Gakona	USA		●	62.39	214.78
University of Alaska, Fairbanks, Poker Flat Research Range	USA		●	65.1	213
Ishigaki	Japan		●	24.4	124.1
Sata	Japan		●	31.02	130.68
Shigaraki	Japan		●	34.8	136.1
Toyokawa	Japan		●	34.84	137.37
Kiso	Japan		●	35.8	137.63
Chihara Campus, University of the Ryukyus	Japan		●	26.3	127.8
SuperDARN Hokkaido East	Japan		●	43.5	143.6
SuperDARN Hokkaido West	Japan		●	43.5	143.6
Kamioka Observatoty, Institute for Cosmic Ray Research, University of Tokyo	Japan		●	36.1	137.55
Kunigami	Japan		●	26.76	128.21
Inabu Crustal Deformation Observatory	Japan		●	35.2	137.53
Kawatabi Observatory, Graduate School of Science, Tohoku University	Japan		●	38.75	140.76
The Shirakami Natural Science Park, Hirosaki University	Japan		●	40.52	140.22
Moshiri	Japan		●	44.37	142.27
Kagoshima	Japan		●	31.48	130.72
Fuji	Japan		●	35.43	138.64
Rikubetsu	Japan		●	43.5	143.8
Total 77	23 countries exc. Japan	19	59*	–	–

*Including 18 domestic sites

Research Projects

■ Major International Collaborative Projects (86 in total)

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Modeling Study of Inner Magnetosphere	Yoshizumi Miyoshi	USA	1	Los Alamos National Laboratory
Collaborative Study on ERG Project	Yoshizumi Miyoshi	Taiwan	1	Academia Sinica Institute of Astronomy and Astrophysics
International Heliophysics Data Environment Alliance	Yoshizumi Miyoshi	USA Europe (Member States of ESA)	23	NASA (SPDF, SDAC, HPDE, SPASE, CCMC) ESA, Centre National d'Études Spatiales
Experiment of geomagnetic field with sounding rocket LAMP	Yoshizumi Miyoshi	U.S.A.	1	NASA, University of Iowa, University of New Hampshire, Dartmouth College
Collaborative Researches Based on Solar Radio Observations with MUSER	Satoshi Masuda	China Korea	2	National Astronomical Observatory of China KASI
Physics of Energetic and Non-Thermal Plasmas in the X (= magnetic reconnection) Region (PhoENiX) Mission	Satoshi Masuda	USA UK Switzerland Hungary Germany Austria	6	NASA, UCB, University of Minnesota, University of Colorado, New Jersey Institute of Technology, Southwest Research Institute, Princeton University Northumbria University, University of Glasgow University of Applied Sciences and Arts Northwestern Switzerland Eötvös Loránd University Leibniz Institute for Astrophysics Potsdam Austrian Academy of Sciences
Study in Cosmic Neutrinos by using a Large Water Cherenkov Detector	Yoshitaka Itow	USA Canada UK 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
Study in Interaction of Very High Energy Cosmic Rays by using Large Hadron Collider	Yoshitaka Itow	Italy France Switzerland USA	4	University of Florence, Catania University École Polytechnique CERN Lawrence Berkeley National Laboratory
Study in Interaction of Very High Energy Cosmic Rays by using Relativistic Heavy Ion Collider	Yoshitaka Itow	Italy USA Korea	3	University of Florence, Catania University Brookhaven National Laboratory Korea University
Study of Dark Matter and Solar Neutrinos using a Liquid Xenon Detector	Yoshitaka Itow	Korea	1	Seoul National University, Sejong University, Korea Research Institute of standards and Science
A Search for Dark Objects using the Gravitational Microlensing Effect	Yoshitaka Itow	New Zealand USA	2	University of Auckland, University of Canterbury, Victoria University of Wellington, Massey University University of Maryland, NASA

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Research and Development for the Next Generation Water Cherenkov Detector, Hyper-Kamiokande	Yoshitaka Itow	USA Korea China UK 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	Yoshitaka Itow	Germany Italy Switzerland USA Sweden Israel Portugal *France, UAE, Netherlands*	10	Deutsches Elektronen-Synchrotron, Albert-Ludwigs-Universität Freiburg, Max-Planck-Institut INFN, Università di Bologna University of Zurich Columbia University, University of Chicago, Purdue University, UCSD Stockholm University Weizmann Institute of Science University of Coimbra *and other institutions*
Research on Origin of Cosmic Rays with CTA (Cherenkov Telescope Array)	Hiroyasu Tajima	Germany France Italy Spain Switzerland UK USA *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 of Madrid 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	Hiroyasu Tajima	USA 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, 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	Hiroyasu Tajima	USA	1	UCB, MSFC/NASA, Air Force Research Laboratory
Solar Flare Research with Gamma-Ray Spectral Imaging Observations with Polarimetry	Hiroyasu Tajima	USA	1	UCB, Lawrence Berkeley National Laboratory, GSFC/NASA
Research on Origin of Cosmic Rays with MAGIC Telescope	Hiroyasu Tajima	Spain Germany Italy Switzerland Bulgaria Croatia	6	Institute for High Energy Physics (IFAE), University of Barcelona, Complutense University of Madrid Max Planck Institute for Physics, TU Dortmund University, University of Würzburg University of Padova, University of Siena, University of Udine CERN Institute for Nuclear Research and Nuclear Energy Croatian MAGIC Consortium
Study of Solar Neutrons	Hiroaki Menjo	Bolivia Armenia Mexico	3	Research Institute of Physics, University of San Andrés Yerevan Physics Institute National Autonomous University of Mexico
Search for Cosmic-Ray Excursions in the Past by Single-Year Measurements of ^{14}C in Tree Rings	Fusa Miyake	USA Switzerland	2	The University of Arizona Swiss Federal Institute of Technology Zürich
Observations of Interplanetary Disturbances using the International IPS Network	Kazumasa Iwai	UK 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	Kazumasa Iwai	USA	1	CASS/UCSD
Study of the Heliospheric Boundary Region using Observations of Interplanetary Scintillation	Kazumasa Iwai	USA	1	Interstellar Boundary Explorer, IMAP
Study of Interplanetary Coronal Mass Ejections Propagation in the Inner Heliosphere Combining MHD Modeling, Ground Based Observations, and *in-situ* Multi-spacecraft Data	Kazumasa Iwai	France UK Netherland USA	4	CNRS, Laboratoire de Physique des Plasmas University of Leicester ESA/ European Space Research and Technology Centre UCB
Study of Acceleration Mechanisms of the Slow Solar-wind by Using 2.5D MHD simulation	Ken-ichi Fujiki	India	1	Physical Research Laboratory, National Institute of Technology, National Atmospheric Research Laboratory
Study of Acceleration Mechanisms of the Slow Solar-wind by Using 2.5D MHD simulation	Ken-ichi Fujiki	USA	1	Harvard-Smithsonian Center for Astrophysics
Research and Development of the Plasma/Particle Instrument Suite for the Mercury Magnetospheric Exploration Mission	Masafumi Hirahara	France Sweden UK USA 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

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Study on Science Subjects and Developmental Techniques of Observational Instruments toward Future Spacecraft Exploration Missions for the Space-Earth Coupling System	Masafumi Hirahara	Sweden	1	Swedish Institute of Space Physics
PRESTO（Predictability of Variable Solar-Terrestrial Coupling）	Kazuo Shiokawa	U.S.A., France, Germany, U.K., Italy, Canada, Australia, India, China, *and other countries*	30	SCOSTEP
High-Sensitive Imaging Measurements of Airglow and Aurora and Electromagnetic Waves in Canadian Arctic	Kazuo Shiokawa	USA 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	Kazuo Shiokawa	Australia	1	IPS Radio and Space Service
Comparison of Dynamical Variations of the Mesosphere, Thermosphere, and Ionosphere between Asian and Brazilian Longitudes	Kazuo Shiokawa	Brazil	1	INPE
Ground and Satellite Measurements of Geospace Environment in the Far-Eastern Russia	Kazuo 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	Kazuo Shiokawa	Nigeria	1	National Space Research and Development Agency, Federal University of Technology Akure, Tai Solarin University of Education
Observations of Waves and Particles in the Inner Magnetosphere in the Siberian Region of Russia	Kazuo Shiokawa	Russia	1	Institute of Cosmophysical Research and Aeronomy/SB RAS, ISTP/SB RAS
Study of the Low-latitude and Equatorial Ionosphere at Eastern Africa	Kazuo Shiokawa	Egypt Ethiopia	2	Egypt-Japan University of Science and Technology (E-JUST) Bahir Dar University
Study of the Middle Latitude Ionosphere at Ukraine	Kazuo Shiokawa	Ukraine	1	Institute of Ionosphere (IION)
Observations of the Mid-Latitude Ionosphere in Germany	Kazuo Shiokawa	Germany	1	National Aeronautics and Space Research Centre of the Federal Republic of Germany (DLR)
Study of the Polar/Midlatitude Ionosphere and Magnetosphere using the SuparDARN HF Radar Network	Nozomu Nishitani	USA UK 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
Study of the Polar Upper Atmosphere using the EISCAT Radars and Other Instruments	Satonori Nozawa	Norway Sweden, Finland, Germany, UK, China	6	UiT The Arctic University of Norway EISCAT Scientific Association
Collaborative Research and Operation in the Field of Space Weather Observations	Yuichi Otsuka	Indonesia	1	BRIN
Observations and Researches of Ionosphere and Upper Atmosphere in Thailand	Yuichi Otsuka	Thailand	1	Chiang Mai University, King Mongkut's Institute of Technology Ladkrabang
Study on the Occurrence Characteristics of Ionospheric Irregularity and its Day-to-Day Variability over Southern China and Southeast Asia Regions	Yuichi Otsuka	China Indonesia Thailand	3	Institute of Geology and Geophysics Chinese Academy of Sciences BRIN King Mongkut's Institute of Technology Ladkrabang

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Global Study of Midlatitude Plasma Bubbles using Multi-instrument Observations and Models	Yuichi Otsuka	South Africa	1	South African National Space Agency
Study of Ionospheric Disturbances in East Asia: Impacts on GNSS Positioning at Low and Mid-Latitudes	Yuichi Otsuka	China	1	National Astronomical Observatory of China
SDI-3D Project: Development of SDI	Shin-ichiro Oyama	USA Finland Sweden	3	Geophysical Institute of the University of Alaska Fairbanks University of Oulu, Finnish Meteorological Institute, Sodankylä Geophysical Observatory, The Swedish Institute of Space Physics
Study of Auroral Energetic Electron Precipitation (EEP) Impacts on the Upper/Middle Atmosphere	Shin-ichiro Oyama	Finland New Zealand UK Norway USA	5	University of Oulu, Finnish Meteorological Institute University of Otago British Antarctic Survey University Centre in Svalbard University of Alaska Fairbanks
Study of Aerosols and Atmospheric Trace Gases by using SAVER-Net Observation Network in South America	Akira Mizuno	Argentina Chile Bolivia	3	CEILAP, Servicio Meteorológico Nacional University of Magallanes, Dirección Meteorológica de Chile University of La Frontera, Universidad Mayor de San Andrés
High Energy Particles in Geospace: The Acceleration Mechanism and the Role in Earth's Climate	Akira Mizuno	USA Norway Sweden	3	University of Colorado Boulder, UCLA, University of Arizona UiT The Arctic University of Norway EISCAT Scientific Association
Optical Property of Atmospheric Organic Aerosol in Beijing	Michihiro Mochida	China	1	Tianjin University
Characterization of Atmospheric Aerosols in Central Europe	Michihiro Mochida	Czech	1	Institute of Chemical Process Fundamentals
Diagnosing Air Pollution by Organic Aerosol: toward Air Quality Management in the Emerging Era of Organic Haze	Michihiro Mochida	Switzerland	1	Swiss Federal Institute of Technology in Lausanne
Characterizing Organics and Aerosol Loading over Australia (COALA)	Michihiro Mochida Sho Ohata	Australia	1	University of Wollongong, Commonwealth Scientific and Industrial Research Organisation, Australian Nuclear Science and Technology Organisation, University of Melbourne
Characterization of atmospheric organic aerosol over a boreal forest in northern Europe	Michihiro Mochida Sho Ohata	Finland	1	University of Helsinki
Tropical Cyclones-Pacific Asian Research Campaign for Improvement of Intensity Estimations/Forecasts (T-PARCII)	Kazuhisa Tsuboki Taro Shinoda Nobuhiro Takahashi	Taiwan USA	2	National Taiwan University Atmospheric Sciences Colorado State University
Technology Exchange on the State-of-art Weather Radar Data Analysis	Nobuhiro Takahashi	Taiwan	1	National Taiwan University
Academic Exchange of Weather Radar Research and Application Experiences between ISEE and NCDR	Nobuhiro Takahashi	Taiwan	1	National Science and Technology Center for Disaster Reduction (NCDR)
EarthCARE Mission	Nobuhiro Takahashi	Europe (Member States of ESA)	22	ESA
Global Precipitation Measurement Mission (GPM)	Nobuhiro Takahashi Hirohiko Masunaga	USA	1	NASA
Satellite Algorithm Development for Tracking Precipitating Clouds	Hirohiko Masunaga	USA	1	NASA Jet Propulsion Laboratory

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Development and Validation of a Satellite-Based Scheme to Estimate In-Cloud Vertical Velocity	Hirohiko Masunaga	USA	1	City University of New York
The Mutual Evolution of Satellite-Observed Atmospheric Moisture, Clouds, and Precipitation	Hirohiko Masunaga	USA	1	UC Davis
Energetic Particle Chain -Effects on the Middle/Lower Atmosphere from Energetic Particle Precipitations-	Taku Nakajima	Finland	1	University of Oule, Finnish Meteorological Institute
Long-Term Observation of Black Carbon Aerosols in the Arctic	Sho Ohata	Norway USA Canada Finland	4	Norwegian Polar Institute National Oceanic and Atmospheric Administration Government of Canada Finnish Meteorological Institute
High Aerosol High Ice Water Content project	Masataka Murakiami	USA	1	Federal Aviation Administration, NASA
Continuous Observation of Methane at a Paddy Field in Northern India	Yutaka Matsumi	India	1	University of Delhi
Observation of PM2.5 in Ulan Bator	Yutaka Matsumi	Mongolia	1	National University of Mongolia
Observation of PM2.5 in Hanoi	Yutaka Matsumi	Vietnam	1	Hanoi University of Science and Technology
Observational Study of Vegetation, Energy and Water in Eastern Siberia Towards Elucidation of Climate and Carbon Cycle Changes	Tetsuya Hiyama	Russia	1	Institute for Biological Problems of Cryolithozone/SB RAS
Arctic Challenge for Sustainability II (ArCS II) Project	Tetsuya Hiyama	USA	1	International Arctic Research Center of the University of Alaska Fairbanks
Estimating Permafrost Groundwater Age in Central Mongolia	Tetsuya Hiyama	Mongol	1	Institute of Geography and Geoecology of the Mongolian Academy of Sciences
Exploiting Multi-platform, Multi-sensor Data for Improved Measurements of Net Primary Production from GCOM-C SGLI for Climate Change Studies	Joji Ishizuka	USA	1	Columbia University
Collection of Validation Dataset of GCOM-C Coastal Products	Joji Ishizuka	Thailand China	2	Burapha University Second Institute of Oceanography, Ministry of Natural Resources, Zhejiang Ocean University, Suzhou University of Science and Technology, Taishan University, Nanjing University of Science and Technology
Investigating the Optical Characteristics of Red Tides in the Upper Gulf of Thailand	Joji Ishizuka	Thailand	1	University of Burapa, Kasetsart University
Study on Carbon Storage in Coastal Seagrass meadows in Thailand	Yoshihisa Mino	Thailand	1	Burapha University
Asian Precipitation Experiment (AsiaPEX)	Hatsuki 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 Technology, Kathmandu University Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Tsinghua University Pusan National University *and other institutions*
An International Study on Precipitation Variability in High-Altitude Areas of the Himalayas in Nepal	Hatsuki Fujinami	Nepal	1	Kathmandu University, Tribhuvan University

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
International Continental Scientific Drilling Program - Dead Sea Deep Drilling Project (ICDP-DSDDP)	Hiroyuki Kitagawa	Israel USA Germany Switzerland	4	Geological Survey of Israel, Hebrew University of Jerusalem Columbia University, University of Minnesota Twin Cities GFZ Helmholtz Centre Potsdam, Max Planck Institute for Chemistry University of Geneva
Climate Change Reconstruction of the Central Highlands in Vietnam	Hiroyuki Kitagawa	Vietnam	1	Vietnam Academy of Science and Technology
Geochronology and Geochemistry of Apatite Grains in Granitic Rocks as a New Method for Discrimination of Tectonic Setting	Masayo Minami	Iran	1	University of Kurdistan
Establishment of Master Dendrochronological Calibration Curve Around 660 BC using Annual Tree Ring Samples from Poland	Masayo Minami	Poland	1	Silesian University of Technology
Technical Exchange for Accurate and Precise ^{14}C Measurement by Accelerator Mass Spectrometer	Masayo Minami	Korea	1	Korea Institute of Geoscience and Mineral Resources
Geochemistry and ^{14}C Dating of Guano Deposits in Kurdistan, Iran: Implication for Paleoenvironment	Masayo Minami	Iran Mexico	2	University of Kurdistan National Autonomous University of Mexico
Measurements of Cosmic-Ray-Produced ^{14}C in Iron Meteorites	Masayo Minami	USA	1	UCB
Geochronological Research on the Basement Rocks in Japan and Korea	Takenori Kato	Korea	1	Korea Institute of Geoscience and Mineral Resources
Development of New Analytical Techniques and Accurate Quantification of Electron Microprobe Analysis	Takenori Kato	Korea	1	Pusan National University

Visitors from Foreign Institutes

(April 1, 2023–March 31, 2024)

Country/Region		Number of Visitors	
Asia (10)	Bangladesh	2	66
	China	6	
	India	16	
	Indonesia	8	
	Korea	19	
	Malaysia	1	
	Mongolia	2	
	Taiwan	10	
	Thailand	1	
	Vietnam	1	
North America (2)	Canada	2	47
	USA	45	
Europe (14) (Including New Independent States)	Austria	3	60
	Belgium	4	
	Czech	5	
	Finland	5	
	France	6	
	Germany	5	
	Greece	1	
	Italy	12	
	Netherland	2	
	Norway	2	
	Poland	1	
	Russia	2	
	Switzerland	4	
	UK	8	
Oceania (1)	Australia	1	1
Middle East (2)	Iran	2	4
	Israel	2	
Africa (2)	Kenya	1	3
	South Africa	2	
Total	31	181	

Funding Source	Number of Visitors
Ministry of Education, Culture, Sports, Science and Technology	4
Japan Society for the Promotion of Science	12
Nagoya University	72
Self-funding	34
Other funding sources	59
Total	181

Purpose	Number of Visitors
Conferences/Symposiums	33
Joint Research	80
Others	68
Total	181

Overseas Business Trips of Faculty

(April 1, 2023–March 31, 2024)

<table>
<tr><th colspan="2">Country/Region</th><th colspan="2">Number of Travelers</th></tr>
<tr><td rowspan="8">Asia (8)</td><td>China</td><td>4</td><td rowspan="8">31</td></tr>
<tr><td>India</td><td>5</td></tr>
<tr><td>Korea</td><td>10</td></tr>
<tr><td>Philippines</td><td>2</td></tr>
<tr><td>Singapore</td><td>4</td></tr>
<tr><td>Taiwan</td><td>2</td></tr>
<tr><td>Thailand</td><td>3</td></tr>
<tr><td>Vietnam</td><td>1</td></tr>
<tr><td rowspan="2">North America (2)</td><td>Canada</td><td>2</td><td rowspan="2">21</td></tr>
<tr><td>USA</td><td>19</td></tr>
<tr><td rowspan="2">Latin America and the Caribbean (2)</td><td>Argentina</td><td>1</td><td rowspan="2">2</td></tr>
<tr><td>Chile</td><td>1</td></tr>
<tr><td rowspan="12">Europe (12)
(Including New Independent States)</td><td>Austria</td><td>2</td><td rowspan="12">45</td></tr>
<tr><td>Czech</td><td>1</td></tr>
<tr><td>Finland</td><td>6</td></tr>
<tr><td>France</td><td>4</td></tr>
<tr><td>Germany</td><td>8</td></tr>
<tr><td>Greece</td><td>1</td></tr>
<tr><td>Italy</td><td>2</td></tr>
<tr><td>Norway</td><td>10</td></tr>
<tr><td>Spain</td><td>5</td></tr>
<tr><td>Sweden</td><td>1</td></tr>
<tr><td>Switzerland</td><td>3</td></tr>
<tr><td>UK</td><td>2</td></tr>
<tr><td>Middle East (1)</td><td>UAE</td><td>1</td><td>1</td></tr>
<tr><td>Africa (1)</td><td>South Africa</td><td>2</td><td>2</td></tr>
<tr><td>Total</td><td>26</td><td colspan="2">102</td></tr>
</table>

Seminars by Foreign Scientists

Date	Name	Affiliation	Title	Number of Participants
Apr. 13, 2023	Pekka T. Verronen*	Finnish Meteorological Institute, Finland	70th ISEE/CICR colloquium(hybrid)/ Ozone impact from solar energetic particles cools the polar stratosphere	23
Apr. 19, 2023	Annilka Seppala	University of Otago, New Zealand	16th SCOSTEP/PRESTO Online Seminar/ Solar Influence on climate via energetic particle precipitation: Why is it important and what are the current challenges?	105
May 18, 2023	Nariaki Nitta	Lockheed Martin Solar and Astrophysics Laboratory, USA	ISEE Solar Seminar/ Where do electrons in gradual solar energetic particle events come from?	20
May 18, 2023	Vyacheslav Pilipenko*	Institute of Physics of the Earth, Moscow, Russia	71st ISEE/CICR colloquium/ Electromagnetic Pollution of the Near-Earth Space by ULF-ELF Ground-Based Transmitters	31
May 30, 2023	Shin Ohtani	Johns Hopkins University Applied Physics Laboratory, USA	Seminar of the Division for Integrated Studies/ Geomagnetic Activity at Earth: A Global Phenomena	15
Jun. 8, 2023	Bernhard Kliem	University of Potsdam, Germany	ISEE Solar Seminar/ Flux Rope and Current Sheet Formation and Plasmoid Instability in Flux-cancellation Simulations	14
Jun. 28, 2023	Bruce Tsurutani	NASA Jet Propulsion Laboratory, USA	ISEE Solar Wind Group Special Seminar (hybrid)/ Recent interplanetary scintillation predictions and forecast analyses from UCSD	15
Jul. 20, 2023	KD Leka*	NorthWest Research Associates, USA	ISEE Solar Seminar/ What is a Magnetic Flux Rope? Would we know one if we saw it?	15
Jul. 24, 2023	Bidya Binay Karak	Indian Institute of Technology (BHU), India	18th SCOSTEP Online Capacity Building Lecture / Solar Spectral Irradiance (SSI) variability	61
Jul. 27, 2023	Nikolai Pogorelov	University of Alabama in Huntsville, USA	ISEE Solar Seminar/ Improving Space Weather Predictions with the New Sequence of Data-driven Models of the Solar Atmosphere and Inner Heliosphere	16
Aug. 10, 2023	Max Mcmurdo	University of Sheffield, UK	ISEE Solar Seminar/ Phase mixing in partially ionized plasmas	16
Aig 24, 2023	Tomoko Matsuo	University of Colorado at Boulder, USA	17th SCOSTEP/PRESTO Online Seminar/ From Earth to the Edge of Space: How Data Assimilation Advances the Science and Engineering of Forecasting Near Earth Space Environments	49
Sep 21, 2023	Kyung-Suk Cho	Korea Astronomy and Space Science Institute, Korea	19th SCOSTEP Online Capacity Building Lecture/ Geospace Exploration Project: ERG/Arase: Recent highlights	42
Oct. 5, 2023	Cosima Breu	Virginia Tech, USA	ISEE Solar Seminar/ A coronal loop in a box: From energy generation to observations	16
Oct. 12, 2023	Julian Carlin	University of Melbourne, Australia	ISEE Solar Seminar/ Are solar flares the result of stress accumulating until a threshold is reached?	16
Oct. 26, 2023	Sergio Dasso	Institute of Astronomy and Space Physics, Argentina	18th SCOSTEP/PRESTO Online Seminar/ Geo-effectiveness of interplanetary coronal mass ejections: How much can be affected due to their evolution in the heliosphere?	68

Date	Name	Affiliation	Title	Number of Participants
Oct. 26, 2023	Jyrki Manninen	Sodankyla Geophysical Observatory, University of Oulu, Finland	72nd ISEE/CICR colloquium/ What has happened in the 'VLF field' since summer 2022 in Finland?	39
Nov 24, 2023	Chih-Chien Tsai	National Science and Technology Center for Disaster Reduction (NCDR), Taiwan	Seminar of Division for Meteorological and Atmospheric Research/ Overview of recent radar- and satellite-related achievements in NCDR	15
Nov. 30, 2023	Khan-Hyuk Kim	Department of Astronomy & Space Science, Kyung Hee University, Korea	73rd ISEE/CICR colloquium (hybrid)/ Transversely heated low-energy helium ions by EMIC waves in the plasmasphere	34
Jan. 23, 2024	Eugene Rozanov	Physikalisch-Meteorologisches Observatorium Davos/ World Radiation Center (PMOD/ WRC), Switzerland	19th SCOSTEP/PRESTO Online Seminar/ Climate implications of solar irradiance and energetic particles: my way in science	24
Jan. 25, 2024	Jorge L. Chau	Leibniz Institute for Atmospheric Physics, Kuhlungsborn, Germany	20th SCOSTEP Online Capacity Building Lecture/ Exploring mesoscale dynamics in the mesosphere and lower thermosphere with multistatic specular meteor radars	67
Feb. 6, 2024	Irina Panyushkina	Laboratory of Tree-Ring Research, University of Arizona, USA	74th ISEE/CICR colloquium (FtF)/ Tracking the impact of Arctic amplification on terrestrial hydrology with tree rings	14
Feb. 13, 2024	Xianglei Huang	University of Michigan, USA	20th SCOSTEP/PRESTO Online Seminar/ Response of high-latitude surface climate to the variation of solar spectral irradiance: sensitivity studies for a bottom-up mechanism	68
Total:		23		783

* Foreign Visiting Staff

＜Abbreviations＞

BRIN:	Badan Riset dan Inovasi Nasional
CASS:	Center for Astrophysics and Space Sciences
CCMC:	Community Coordinated Modeling Center
CEA:	Commissariat à l'énergie atomique et aux énergies alternatives
CEILAP:	Centro de Investigaciones en Láseres y Aplicaciones
CENS:	Centre d'Etude Nucleaire de Saclay
CERN:	Conseil Européen pour la Recherche Nucléaire
CESR:	Centre d'Etude Spatiale des Rayonnements
CETP:	Centre d'étude des environnements terrestres et planétaires
CNRS:	Centre National de la Recherche Scientifique
EISCAT:	European Incoherent Scatter Scientific Association
ESA:	European Space Agency
ESTEC:	European Space Technology and Research Centre
GFZ:	Geoforschungszentrum
GSFC:	Goddard Space Flight Center
HPDE:	Heliophysics Data Environment
IFSI:	Istituto di Fisica dello Spazio Interplanetario
IMAP:	Interstellar Mapping and Acceleration Probe
INFN:	Istituto Nazionale di Fisica Nucleare
INPE:	Instituto Nacional de Pesquisas Espaciais, Brazilian Institute of Space Research
iLEAPS:	Integrated Land Ecosystem-Atmosphere Processes Study
IPS:	Ionospheric Prediction Services
IPSL:	Institut Pierre-Simon Laplace
ISTP:	Institute of Solar-Terrestrial Physics
JHUAPL:	Johns Hopkins University Applied Physics Laboratory
KASI:	Korea Astronomy and Space Science Institute
LoFAR:	Low Frequency Array
LPC2E:	Laboratoire de Physique et Chimie de l'Environnement et de l'Espace
MAGIC:	Major Atmospheric Gamma Imaging Cherenkov Telescopes
MSFC:	Marshall Space Flight Center
NASA:	National Aeronautics and Space Administration
RAS:	Russian Academy of Sciences
SB RAS:	Siberian Branch, Russian Academy of sciences
SCOSTEP:	Scientific Committee on Solar Terrestrial Physics
SDAC:	Solar Data Analysis Center
SLAC:	Stanford Linear Accelerator Center
SPASE:	Space Physics Archive Search and Extract
SPDF:	Space Physics Data Facility
TRIUMF:	Canada's national particle accelerator centreL
UCB:	University of California, Berkeley
UC Davis:	University of California, Davis
UCI:	University of California, Irvine
UCLA:	University of California, Los Angeles
UCSC:	University of California, Santa Cruz
UCSD:	University of California, San Diego
UiT:	University of Tromsø

12. Outreach

Public Lectures, Open Labs, and School Visits

The ISEE organizes various outreach events and activities either online or in person, whereas some have also been conducted in a hybrid format. Specifically, two public lectures, one visiting lecture at a school, eight high-school student visits, two open-laboratory events, two hybrid training courses for young researchers, one five-day tour for university students, two workshops for children, and one field trip and workshop for children were organized. Additionally, ISEE members contributed to public education through 42 public talks.

We also distributed a series of booklets in Japanese that answered 50 questions on various topics as well as several comic (manga) books related to space–Earth subjects to enhance science education; they are suitable for both the general public and students. This year, we have added two new comic books that can be accessed and downloaded from the ISEE website (https://www.isee.nagoya-u.ac.jp/hscontent/books.html). The comic books have also been translated into English in collaboration with SCOSTEP's CAWSES program (https://www.isee.nagoya-u.ac.jp/en/outreach.html). Translations in other languages are available at the SCOSTEP website (https://scostep.org/space-science-comic-books/). Additionally, we published two newsletters and posted some research results, event reports, and English columns.

The ISEE website continues to publish the latest laboratory science activities and results that can be freely accessed by the public (https://www.isee.nagoya-u.ac.jp/en/).

Public Lecture at the ISEE open laboratory (June 10, 2023).

Addresses of Facilities

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