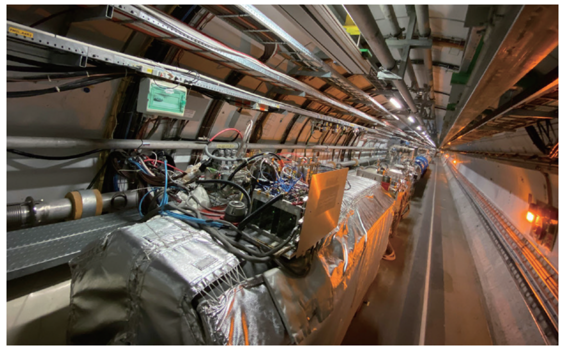
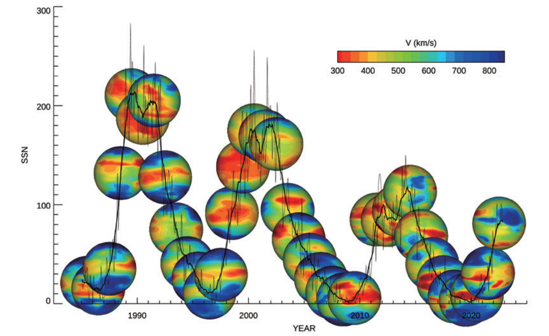
ISEE Award ceremony and commemorative lecture were held on Nov. 16, 2022

Group photo of 'Prof. Yohsuke Kamide Memorial Meeting' held at Nagoya on 14 November 2022



LHCf detector installed into the LHC tunnel for an operation in 2022

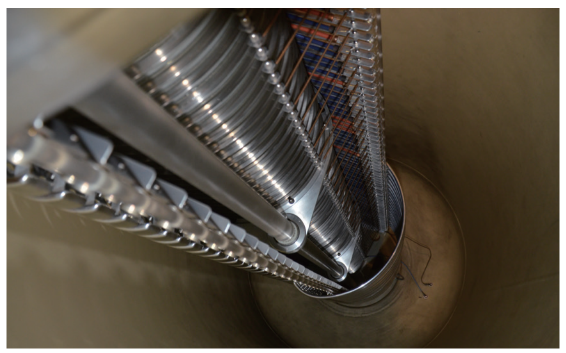


Solar wind structure from 1985 to 2022

STEVE aurora seen at Athabasca, Canada, during an auroral campaign observation (September 3, 2022, 06:18 UT)

Collaborative radar observation at Yonaguni Island in the summer season

Shallow ice-core drilling at a site on the East Antarctic coastal site



Accelerator tube mentanance of ISEE AMS

Institute for Space–Earth Environmental Research, Nagoya University

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Edited by Public Relations and Outreach Committee, Institute for Space–Earth Environmental Research, Nagoya University
Published in Sptember 2023

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

Institute for Space–Earth Environmental Research, Nagoya University Annual Report FY2022

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

FY2022

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

Institute for
Space–Earth Environmental Research

April 2022–March 2023

Foreword

To solve global environmental issues and contribute to the development of the human society that is now expanding into space, we have a role as the only joint usage/research center in Japan that links space and earth sciences.

Since its establishment in October 2015, the Institute for Space-Earth Environmental Research (ISEE) has been acting as a joint usage/research center assigned by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT). During the 3rd 6-year term of Japanese national universities in 2016–2021, the ISEE performs joint research activities in approximately 200 subjects every year in 12 categories, including international workshops and joint research for overseas researchers. The ISEE received an S rating (highest rating) from MEXT in the term-end evaluation of its 3rd 6-year term as a joint usage/research center. The evaluation committee stated that "ISEE plays a unique role as a center that integrates space and earth science. Activities for international collaboration with related research institutes should be evaluated. We thank all the collaborators who have supported this institute with their continuous active research since its establishment.

The ISEE was again approved as a joint usage/research center during the 4th 6-year term of 2022–2027 by MEXT. In addition to continuing the previous 12 joint research categories, we have newly introduced five categories, i.e., "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." The Aircraft Observation (Dropsonde) provides opportunities for dropsonde measurements from aircraft at a location specified by the applicant. The International Field Observation and Experiment program supports Japanese graduate students and young researchers who perform the observation or experiments in other countries in cooperation with the faculty members of this institute. The International Technical Exchange aims to provide technical experiences through international collaboration for researchers and engineers in Japan and overseas. The International School Support aids to support international schools to increase opportunities for students and young researchers. The International Research Travel Support provides opportunities for graduate students in Japan to visit overseas institutions and present their research results at international meetings.

The other new significant effort of ISEE during the 4th 6-year term is the strengthening of interdisciplinary research. The mission of ISEE is to comprehend the Earth, Sun, and universe as one system and to 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. During the 4th 6-year term, we established the Office for the Development of Interdisciplinary Research Strategy (ODIRS) in August 2022 to promote the development of integrated research in diverse fields. Faculty members of ISEE and researchers and staff from diverse Nagoya University departments and other institutes participate in this new office. Two new Designated Assistant Professors have been employed since April 2023. We will develop strategies for further interdisciplinary studies effectively utilizing the ISEE joint research programs.

Since 2022, we have begun four new interdisciplinary research projects based on a proposal from young faculty members of ISEE. For example, there is an energetic particle chain – the effect of high-energy plasma precipitation on the middle and lower atmosphere. This study attempts to comprehend the connection between energetic plasma particles from the Sun and atmosphere of Earth as a chain. New results have been obtained using diverse new instruments and facilities, such as the Japanese Arase satellites, the EISCAT radar in the Arctic, and millimeter-wave radiometers.

Several outstanding scientific findings will emerge in 2022. For example, new rocket measurements have been performed in Alaska. The rocket was successfully launched into an active pulsating aurora and succeeded in the first simultaneous measurement of pulsating auroras and relativistic electron bursts. During the huge eruption of the Tonga volcano in January 2023, ISEE researchers found that atmospheric waves associated with the eruption caused traveling ionospheric disturbances that immediately propagated to other hemispheres over Japan through geomagnetic field lines as electromagnetic disturbances. These results provide new insights into the connection between space plasma and the atmosphere of Earth.

In 2022, though the COVID-19 influence was still going, several joint international research projects were being performed. The 5th International Symposium Toward the Future of Space–Earth Environmental Research was held at the Sakata-Hirata Hall of Nagoya University on November 15–17, 2022. Active discussions were held in six sessions and three panel discussions.

The activity of the 25th solar cycle is increasing and is expected to reach its maximum by the 2020s. In modern society, the potential risk of space weather disasters is increasing. As global warming continues, environmental changes and severe disasters are increasing globally. Therefore, the role of ISEE, which contributes towards the solution of global environmental problems and the development of human society in space, is even more significant. We want to cooperate with collaborators in Japan and the world to develop further research activities that will open the future. I hope that this annual report will provide you with an understanding of ISEE activities in 2022. Thank you for your continued support and cooperation.

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Kazuo Shiokawa
Director

ISEE Award ceremony and commemorative lecture were held on November 16, 2022.

The 4th 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 fourth ISEE Award was awarded to Dr. Satoshi Kasahara (Associate Professor, The University of Tokyo) for his outstanding contribution to space-Earth environmental research by demonstrating the relationship between electron scattering and pulsating auroras in space. The award ceremony and commemorative lecture were held as follows:

Date: November 16, 2022
Venue: Sakata and Hirata Hall (Naogoya University) and online
Title; One solar cycle with the ERG (Arase) mission

ISEE Award 2022

Winner: **Dr. Satoshi Kasahara,** Associate Professor, The University of Tokyo

Title: Outstanding contribution to space-earth environmental research by demonstrating the relationship between electron scattering and pulsating auroras in space

Citation: Dr. Kasahara has led the development of the MEP-e and MEP-i instruments onboard the ERG (Arase) satellite and has produced excellent results by demonstrating the relationship between electron scattering processes by plasma waves in space and pulsating auroras on the ground. These are outstanding contributions to space and Earth environment research; therefore, Dr. Kasahara is the most deserving recipient of the ISEE Award in 2022.

Career summary of the award winner: Dr. Kasahara received a Ph.D. in science from the University of Tokyo in 2009. As a JAXA project researcher (2009–2011) and assistant professor at the Institute of Space and Astronautical Science (2011–2016), he played a leading role in the development of medium-energy particle analyzers onboard the Arase satellite. Since September 2016, he has been an associate professor at the University of Tokyo, working on analyzing data from Arase.

Fig.1

5th ISEE Symposium
Toward the Future of Space–Earth Environmental Research

The 5th ISEE Symposium, titled "Toward the Future of Space–Earth Environmental Research," was held at the Sakata-Hirata Hall of Nagoya University on November 15–17, 2022, in a hybrid format with simultaneous online sessions.

The symposium aimed to deepen the exchange and integration of space and Earth science within the space–Earth environmental research framework, coinciding with the start of the 4th medium-term goal period (FY2022 to FY2027) and marking the 7th year since the establishment of the institute, which merged the Solar–Terrestrial Environment Laboratory, the Hydrospheric Atmospheric Research Center, and the Center for Chronological Research.

The symposium included one award lecture, eight keynote lectures, 18 invited lectures, and 91 poster presentations. A total of 255 participants attended the symposium, including 138 attendees from Japan (45 students), 29 from East and Southeast Asia (16 students), 31 from South and West Asia (10 students), 26 from Europe (2 students), 11 from the United States (1 student), seven from South America (2 students), and 18 from Africa (9 students). The ratio of on-site to online participants was approximately 2:3.

The program comprised six sessions, three panel discussions, and two poster sessions. During these sessions, researchers from diverse fields engaged in discussions on common themes. Panel discussions were held at the end of each day to facilitate diverse exchanges of opinions and discussions among space and Earth researchers regarding topics encompassed in the lectures of the day. Furthermore, the poster sessions provided an interactive platform for active participation by several students and young researchers, fostering vibrant discussions. The symposium highlights the institute's unique interdisciplinary nature and is expected to stimulate the development of new interdisciplinary research.

Fig. 2

Fig. 3

Fig. 4

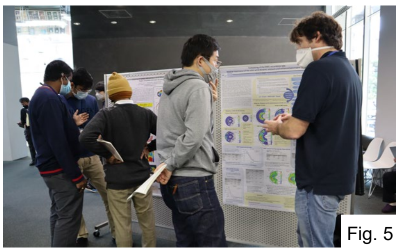


Fig. 5

Fig.1: Panel discussion in progress. **Fig.2**: Greeting by Chairman Prof. Kusano of the SOC. **Fig.3**: Participants asking questions. **Fig.4**: View of the venue. **Fig.5**: Poster sessions.

Fig.1

Sounding Rocket Hits the Pulsating Aurora!

At 2:27:30 a.m. (local time) on March 5, 2022, Yoshizumi Miyoshi (Professor, ISEE), Masahito Nose (Associate Professor, ISEE), and their colleagues launched the sounding rocket LAMP. It was not easy to hit the rapidly changing aurora, but the LAMP rocket successfully hit the pulsating aurora and made detailed observations of the electrons, optical emissions, and magnetic fields at aurora altitudes.

A pulsating aurora changes every few seconds and is a universal phenomenon observed after the auroral breakup. In recent years, Prof. Miyoshi and his colleagues have proposed a model that a “killer electron” and (relativistic electron) is a high-energy tail of the pulsating aurora electron (keV electron). The “killer electrons” precipitate into the middle atmosphere at an altitude of tens of kilometers below where the “pulsating aurora” is occurring and destroy the ozone at that location. However, there have been no simultaneous measurements of “pulsating auroras” and “killer electrons,” and it has not been proven whether the two are truly related.

Prof. Miyoshi and his colleagues, together with researchers from JAXA, the University of Electro-Communications, and Tohoku University, performed a joint Japan-U.S. souding rocket experiment called LAMP (loss through auroral microburst pulsation). The experiment successfully demonstrated that relativistic electrons exceeding several hundred keV simultaneously precipitated into a pulsating aurora.

Fig.2

Fig.1: The LAMP sounding rocket was launched at the Poker Flat Research Range, AK, USA (Justin Hartney).

Fig.2: A pulsating aurora was observed at the Poker Flat Research Range, AK, on March 4, 2022.

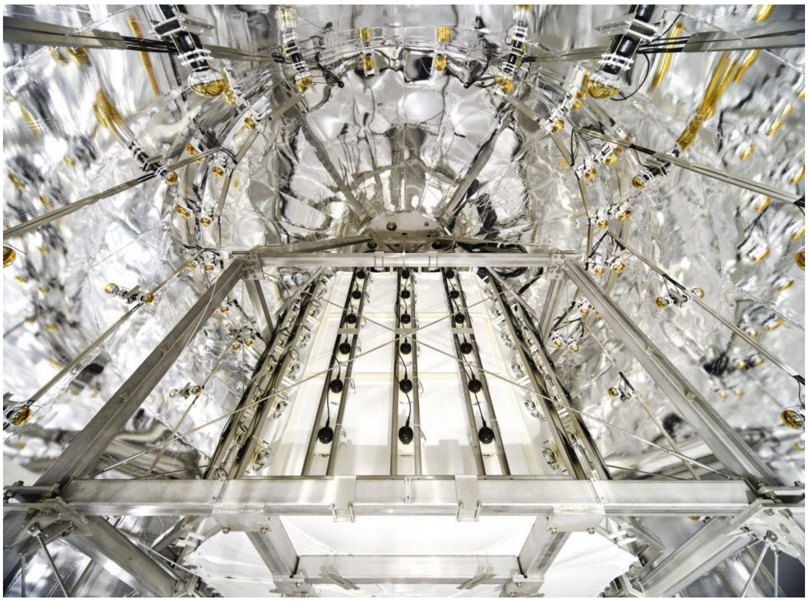


Fig.1

Search for New Physics in Electronic Recoil Data from XENONnT

The XENONnT experiment, led by Yoshitaka Itow (Professor, ISEE) and the cosmic-ray research group, achieved a significant reduction in radioactive background events in the detector, reaching an unprecedented level. This success has improved the sensitivity of exploring extremely rare and unknown physical phenomena, such as dark matter. Additionally, the team analyzed approximately 97 days of observed data and examined the excess events observed in the previous XENON1T experiment. No significant excess above the background model was observed, which led to very strong constraints on unknown physical phenomena, such as solar axion and dark photon.

The XENONnT experiment aims to discover and elucidate the nature of dark matter, an unknown matter that exists in the universe. This experiment utilized approximately six tons of liquid xenon to observe the light and electron signals generated by the interaction between xenon nuclei and dark matter. To achieve this, XENONnT carefully selected the detector materials and built a dedicated Xe distillation system to remove the radioactive background originating from radon, resulting in a successful reduction of radioactive background events to approximately 20% of the XENON1T experiment.

The analysis group led by Shingo Kazama (Associate Professor, ISEE) from the cosmic ray research group analyzed approximately 97 days of observed data obtained during the 2021 fiscal year. The results demonstrated no significant excess events above the expected background, which led to the most stringent limits on diverse new physical phenomena that could cause electronic recoil, such as solar axions, neutrinos with anomalous magnetic moment, axion-like particles, and dark photons magnetic moment, axion-like particles, and dark photons.

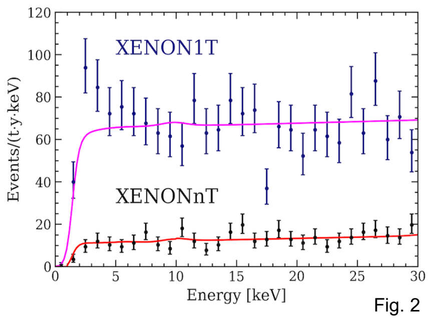


Fig. 2

Paper information

Journal： *Phys. Rev. Lett.*, Vol.129, 161805, 2022
Authors： Aprile et al. (XENON Collaboration)
Title： Search for New Physics in Electronic Recoil Data from XENONnT
DOI： 10.1103/PhysRevLett.129.161805

Fig.1: The XENONnT Detector. credit: XENON Collaboration (E. Sacchetti).

Fig.2: Observed recoil energy spectrum and best-fit background model below 30 keV. No significant excess was observed above the background level. The results of the XENON1T experiment are also depicted to illustrate the background levels.

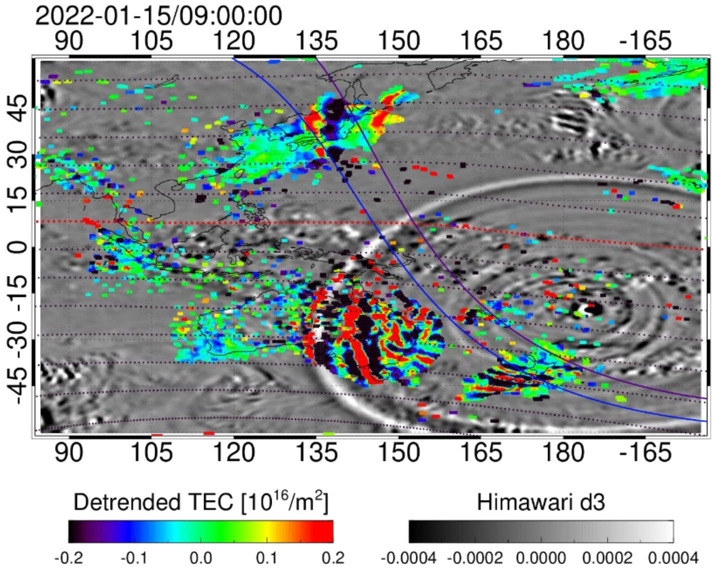


Fig.1

Ionospheric Variations after the Tonga Eruption Observed by GNSS Total Electron Content and SuperDARN Hokkaido Pair of Radars

Based on the evaluation of the Global Navigation Satellite System (GNSS) total electron content (TEC) and the SuperDARN Hokkaido pair of radar data, Atsuki Shinbori (Designated Assistant Professor, ISEE) and his colleagues found that ionospheric disturbances appeared over Japan earlier than the initial arrival of air pressure waves triggered by a large eruption of an undersea volcano off the coast of Tonga in the South Pacific and elucidated the mechanism of high-speed transmission of ionospheric disturbances.

It is well-known that ionospheric disturbances occur during volcanic eruptions. A large submarine volcanic eruption occurred off the coast of Tonga in the South Pacific region, and a global ionospheric disturbance was observed after the eruption. To elucidate the mechanism of this ionospheric disturbance, an integrated analysis of the GNSS-TEC, SuperDARN radar, and meteorological satellite observation data was performed. It was found that the ionospheric disturbance, which appeared over Japan several hours earlier than the initial arrival of an air pressure wave, was generated by an electric field propagating at high speed from the Southern Hemisphere to the Northern Hemisphere along magnetic field lines. The results of this study also suggest that information regarding the arrival of air pressure waves and related tsunamis can be detected in advance by monitoring rapidly propagating ionospheric disturbances.

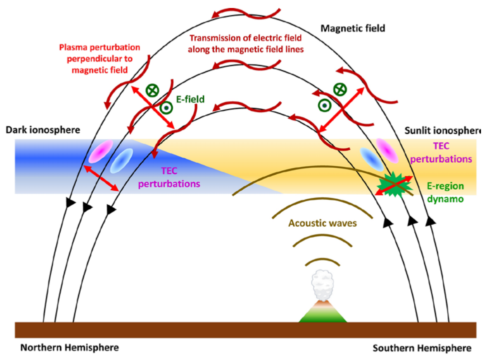


Fig.2

Paper information

Journal： *Earth Planets Space*, 74, 106, 2022
Authors： Shinbori, A., Y. Otsuka, T. Sori, M. Nishioka, S. Perwitasari, T. Tsuda, and N. Nishitani
Title：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 observations
DOI： 10.1186/s40623-022-01665-8

Fig.1： Two-dimensional map demonstrating ionospheric disturbances and pressure waves from GNSS-TEC and the Himawari meteorological satellite with TEC variations.

Fig.2：Schematic of the ionospheric disturbance mechanism observed after the Tonga eruption. An ionospheric electric field generated in the Southern Hemisphere is transmitted at a high speed to the Northern Hemisphere along magnetic field lines.

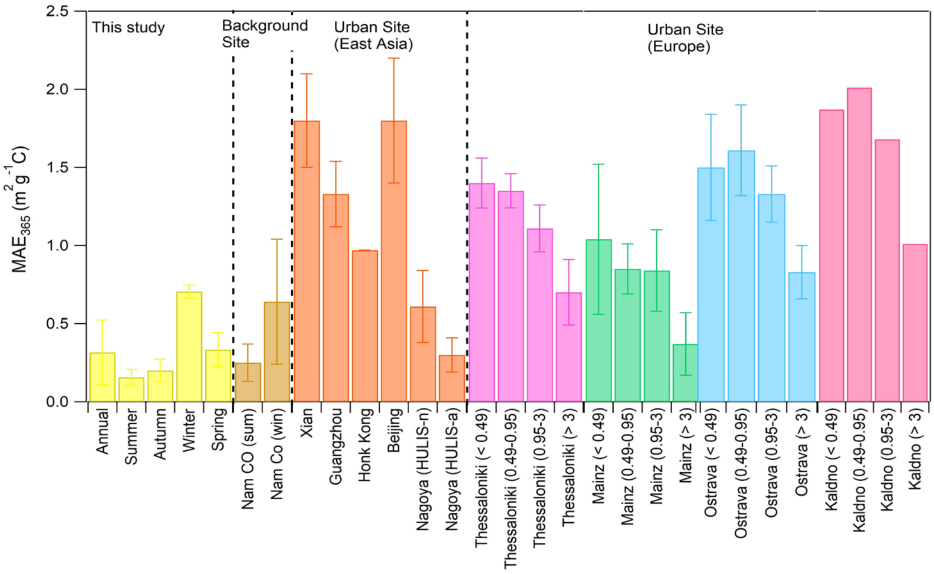


Fig.1

Weak Light Absorption Property of Biogenic Organic Aerosol Components

Sonia Afsana (alumna) and Michihiro Mochida (Professor, ISEE) and their research team have characterized the abundance, chemical structure, and light absorption property of atmospheric organic aerosols in a forest in Hokkaido. Furthermore, they demonstrated that the formation of aerosols from organic vapors of biogenic origin contributed significantly to the abundance of organic compound group named humic-like substances (HULIS), and that the HULIS measured in the forest had weaker light-absorption property than that of HULIS in urban sites.

Atmospheric organic aerosols can absorb light, and their effect on the radiative balance of the Earth has recently been highlighted. In this study, the abundance, chemical structure, and light absorption property of atmospheric organic aerosols in a forest in Hokkaido were characterized by extracting and fractionating organic compound groups in aerosol samples. The light-absorption properties of HULIS and another organic fraction were enhanced in winter, the causes of which may include the contribution of long-range transported aerosols. The concentration of HULIS was high in summer, and the results indicated that aerosol formation from organic vapors of biogenic origin contributed significantly to the abundance of HULIS, and that HULIS measured in the forest had weaker light-absorption property than that of HULIS measured at urban sites. Recently, it has been suggested that the enhanced release of organic vapors of biogenic origin by warming could mitigate warming through the effect of the generated aerosols on the radiative balance. The results from this study suggest that such aerosols have weak light absorption property (i.e., they are not efficient in warming the air) and are considered a clue to understanding the relationship between climate and aerosols originating from vegetation.

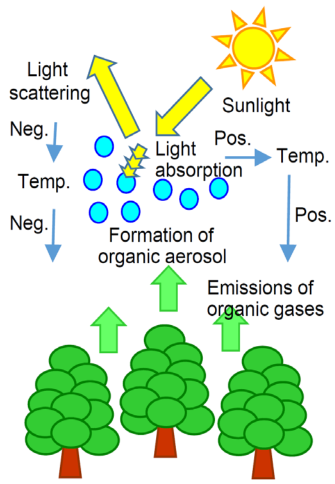


Fig. 2

Fig.1: Mass absorption efficiency of HULIS from this study (365 nm) and literature values for other locations. Afsana et al. (2022) (left).

Fig.2 : A possible feedback mechanism through the influence of biogenic organic gas emissions and subsequent aerosol formation on radiation.

Paper information

Journal： *Scientific Reports*, Vol.12, 14379, 2022

Authors： Afsana, S., R. Zhou, Y. Miyazaki, E. Tachibana, D. K. Deshmukh, K. Kawamura, and M. Mochida

Title： Abundance, chemical structure, and light absorption properties of humic-like substances (HULIS) and other organic fractions of forest aerosols in Hokkaido

DOI： 10.1038/s41598-022-18201-z

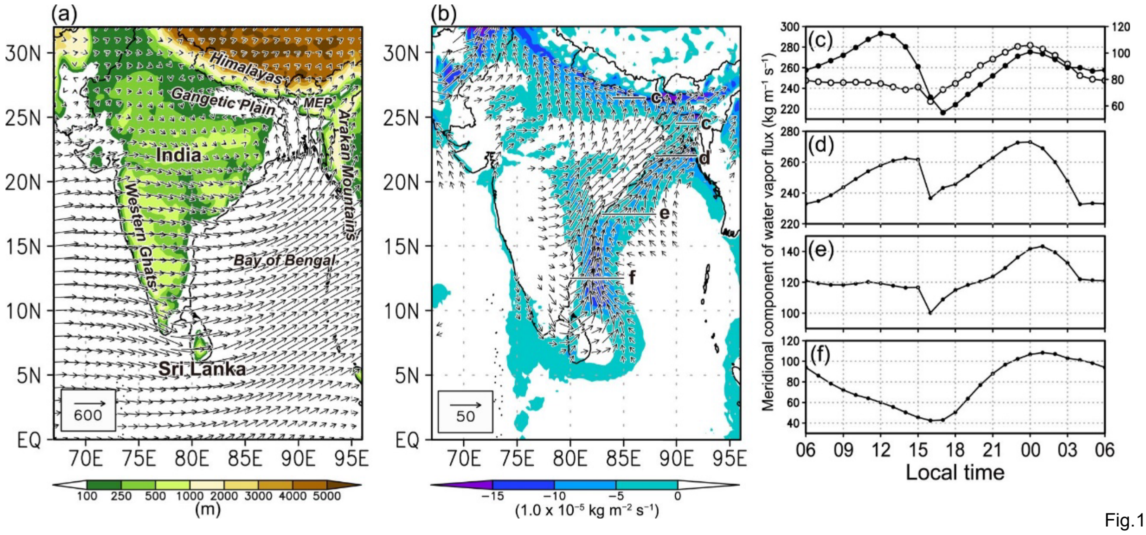


Fig.1

Nocturnal Southerly Moist Surge Parallel to the Coastline over the Western Bay of Bengal

Hatsuki Fujinami (Lecturer, ISEE) and his colleagues revealed that low-level moist southerlies are greatly enhanced at night parallel to the coastline over the western Bay of Bengal (BoB) and then flow onto the Gangetic Plain, enhancing moisture transport toward land and nocturnal precipitation in South Asia. These results contribute to a better understanding of the growth of Himalayan glaciers and the formation mechanisms of heavy rainfall zones in South Asia.

Nocturnal precipitation is a well-known phenomenon around the Himalayas and the Meghalaya Plateau in South Asia during the summer. Such precipitation is a major supply source for glaciers in the central and -eastern Himalayas and the headwaters of major rivers, such as the Ganges and the Brahmaputra. Using hourly ERA5 reanalysis data, we found that low-level moist southerlies are enhanced at night, parallel to the coastline over the western Bay of Bengal (BoB), and then flow onto the Gangetic Plain, enhancing moisture transport toward land and nocturnal precipitation in South Asia. We refer to this phenomenon as a nocturnal southerly moist surge. This nocturnal surge is strongly affected by the diurnal cycle of the thermal and topographic effects of the Indian subcontinent. These findings provide important clues for understanding the formation mechanisms of mountain hydroclimate with glaciers around the Himalayas.

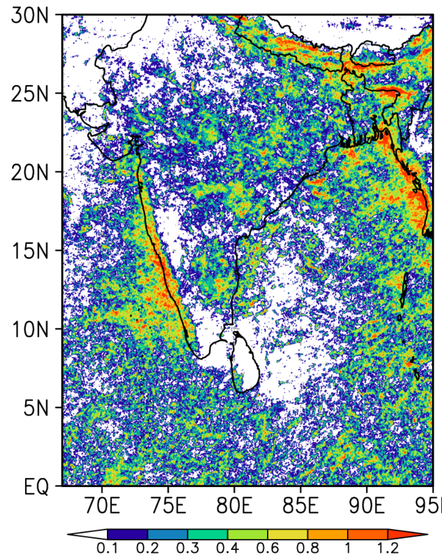


Fig.2

Paper information

Journal： *Geophysical Research Letters*, Vol. 49, e2022GL100174
Authors： Fujinami, H., T. Sato, H. Kanamori and M. Kato
Title ： Nocturnal Southerly Moist Surge Parallel to the Coastline Over the Western Bay of Bengal
DOI： 10.1029/2022GL100174

Fig.1: (a) Climatological mean water vapor flux (vectors) during summer (June–September). (b) Difference in water vapor flux (vectors) and its divergence (shading) between night-time (23:00–02:00 LT) and daily mean values. (c)–(f) Time series of the meridional component of water vapor flux south of the Nepalese Himalayas in lines c, d, e, and f in (b).

Fig.2: Distribution of precipitation rate (mm h^{-1}) during 23:00–02:00 LT.

Contents

1. History

Solar-Terrestrial Environment Laboratory

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

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

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

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

April, 2003
The Rikubetsu Observatory was organized.

April, 2004
The Geospace Research Center was established.

March, 2006
Laboratory was relocated to the Higashiyama Campus.

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

Hydrospheric Atmospheric Research Center (HyARC)

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

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

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

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

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

The Nagoya University Center for Chronological Research

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

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

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

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

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

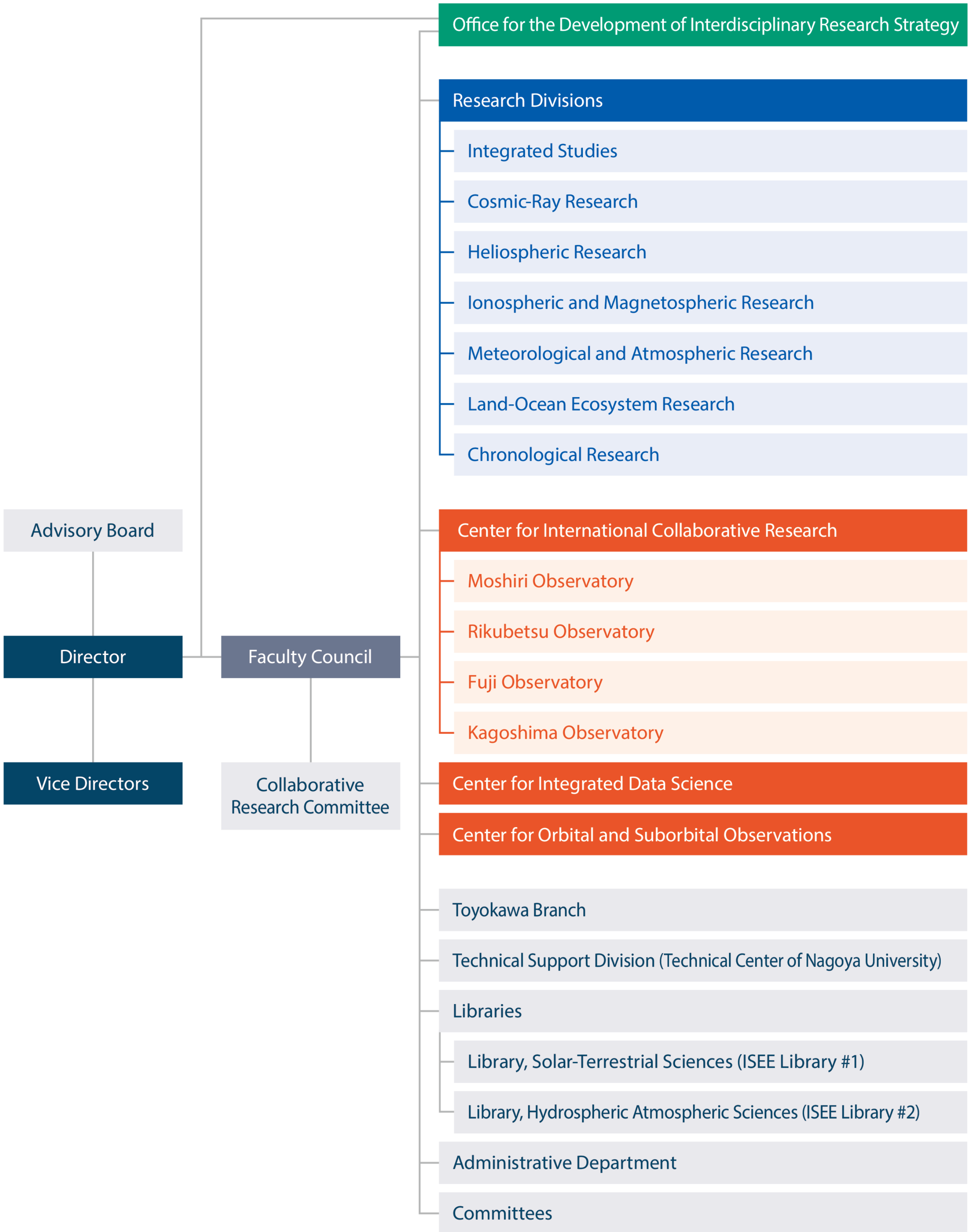
April, 2000
The Nagoya University Center for Chronological Research was organized.The CHIME dating system was transferred from the School of Science.

October, 2015

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

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

2. Organization



3. Staff

Director	Kanya Kusano
Vice Director	Kazuo Shiokawa
Vice Director	Nobuhiro Takahashi

April 1, 2022–March 31, 2023
✱: Concurrent post
▲: Left the Institute in the 2022 academic year
○: Joined the Institute in the 2022 academic year
*: Belongs to Institute for Advanced Research Section

Division for Integrated Studies

Professor	Kanya Kusano
Professor	Yoshizumi Miyoshi (✱)
Associate Professor	Satoshi Masuda
Associate Professor	Takayuki Umeda (✱)
Assistant Professor	Akimasa Ieda
Designated Assistant Professor	Haruhisa Iijima
Designated Assistant Professor	Yoshiki Hatta ○
Designated Assistant Professor	Hisashi Hayakawa *
Designated Assistant Professor	Yumi Bamba *▲
JSPS Postdoctoral Fellowships for Research in Japan (Standard)	Sandeep Kumar
JSPS Postdoctoral Fellowships for Research in Japan (Standard)	Shreedevi Radhakrishna Porunakatu ○
Technical Assistant	Keitaro Matsumoto ○▲

Division for Cosmic-Ray Research

Professor	Yoshitaka Itow
Professor	Hiroyasu Tajima (✱)
Associate Professor	Yutaka Matsubara ▲
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
JSPS Postdoctoral Fellowships for Research in Japan (Standard)	Ken Ohashi ○▲
JSPS Postdoctoral Fellowships for Research in Japan (Standard)	Masatoshi Kobayashi
Designated Technical Staff	Shozo Ohta
Technical Assistant	Yasuko Ito ○
Technical Assistant	Ayano Nagata ○▲
Technical Assistant	Kazuhiro Furuta

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

Division for Heliospheric Research

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Associate Professor	Kazumasa Iwai
Assistant Professor	Ken-ichi Fujiki

Division for Ionospheric and Magnetospheric Research

Professor	Masafumi Hirahara
Professor	Kazuo Shiokawa (✱)
Associate Professor	Yuichi Otsuka
Associate Professor	Satonori Nozawa
Associate Professor	Masahito Nosé ▲
Associate Professor	Nozomu Nishitani (✱)
Associate Professor	Claudia Martinez-Calderon (✱)
Lecturer	Shin-ichiro Oyama
Designated Assistant Professor	Naritoshi Kitamura ○
Designated Assistant Professor	Atsuki Shinbori
JSPS Postdoctoral Fellowships for Research in Japan (Standard)	Shibaji Chakraborty ○

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Professor	Michihiro Mochida
Professor	Nobuhiro Takahashi (✱)
Professor	Kazuhisa Tsuboki (✱)
Associate Professor	Tomoo Nagahama
Associate Professor	Hirohiko Masunaga
Associate Professor	Taro Shinoda (✱)
Assistant Professor	Sho Ohata *
Assistant Professor	Taku Nakajima
Designated Assistant Professor	Shinnosuke Ishizuka *
Researcher	Ruichen Zhou
Researcher	Fumie Furuzawa
Researcher	Gemma Mizoguchi ▲
Researcher	Sonia Afsana ○▲
JSPS Postdoctoral Fellowships for Research in Japan (Standard)	Yunhua Chang ▲
Technical Assistant (Research Support Facilitator)	Kazuji Suzuki

Division for Land–Ocean Ecosystem Research

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Professor	Joji Ishizaka (✱)
Associate Professor	Hidenori Aiki
Associate Professor	Naoyuki Kurita
Lecturer	Hatsuki Fujinami
Assistant Professor	Yoshihisa Mino
Designated Assistant Professor	Masayuki Kondo ▲
Researcher	Nao Esashi ○▲
Researcher	Hironari Kanamori
Researcher	Yuto Tashiro
Researcher	Yoshiki Fukutomi
Research Institution Researcher	HanumanThu Himabindu ▲

Divison for Chronological Research

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Professor	Masayo Minami
Associate Professor	Takenori Kato (✱)
Assistant Professor	Hirotaka Oda
Researcher	Masako Yamane ▲
Research Institution Researcher	Ryusei Kuma ▲
Research Institution Researcher	Satoshi Sasaki ○
Designated Technical Staff	Masami Nishida
Designated Technical Staff	Yuriko Hibi

Office for the Development of Interdisciplinary Research Strategy

Office Manager • Professor	Kanya Kusano (✱)
Professor	Nobuhiro Takahashi (✱)
Professor	Kazuo Shiokawa (✱)
Professor	Yoshizumi Miyoshi (✱)
Associate Professor	Claudia Martinez-Calderon (✱)

Center for International Collaborative Research

Director • Professor	Kazuo Shiokawa
Professor	Joji Ishizaka
Professor	Munetoshi Tokumaru (✱) ▲
Professor	Tetsuya Hiyama (✱)
Professor	Akira Mizuno (✱)
Professor	Masayo Minami (✱)
Professor	Michihiro Mochida (✱)
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	Naoyuki Kurita (✱)
Associate Professor	Satonori Nozawa (✱)
Lecturer	Hatsuki Fujinami (✱)
Assistant Professor	Hiroaki Menjo (✱)
Designated Assistant Professor	Masafumi Shoji

Foreign Visiting Research Fellow

Apr. 3 – Jul. 2, 2022	Jyrki Kalervo Manninen
Apr. 16 – Jul. 15, 2022	Rangaiah Kariyappa
Jun. 22 – Sep. 20, 2022	HajiHossein Azizi
Nov. 1, 2022– Jan. 31, 2023	Rumi Nakamura
Nov. 18, 2022 – Jan. 20, 2023	Jong-Dao Jou
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

Center for Integrated Data Science

Director • Professor	Yoshizumi Miyoshi
Professor	Kazuhisa Tsuboki
Professor	Joji Ishizaka (✱)
Professor	Yoshitaka Itow (✱)
Professor	Kanya Kusano (✱)
Associate Professor	Takayuki Umeda
Associate Professor	Takenori Kato
Associate Professor	Hidenori Aiki (✱)
Associate Professor	Masahito Nosé (✱)▲
Associate Professor	Satoshi Masuda (✱)
Associate Professor	Hirohiko Masunaga (✱)
Designated Associate Professor	Tomoaki Hori
Assistant Professor	Akimasa Ieda (✱)
Designated Assistant Professor	Sachie Kanada
Designated Assistant Professor	Satoko Nakamura *
Designated Assistant Professor	Takuma Matsumoto ○
Designated Assistant Professor	Chae-Woo Jun
Designated Assistant Professor	YunHee Kang
Designated Assistant Professor	Atsuki Shinbori (✱)
Researcher	Masaya Kato
Designated Technical Staff	Mariko Kayaba
Designated Technical Staff	Nanako Hirata
Designated Technical Staff	Asayo Maeda
Designated Technical Staff	Kingi Morikawa

Center for Orbital and Suborbital Observations

Director • Professor	Nobuhiro Takahashi
Professor	Hiroyasu Tajima
Professor	Joji Ishizaka (✱)
Professor	Kazuhisa Tsuboki (✱)
Professor	Masafumi Hirahara (✱)
Designated Professor	Jong-Dao Jou ○▲
Designated Professor	Masataka Murakami
Associate Professor	Taro Shinoda
Associate Professor	Hidenori Aiki (✱)
Designated Associate Professor	Kazutaka Yamaoka
Assistant Professor	Sho Ohata (✱)*
Designated Assistant Professor	Takeharu Kouketsu ▲
Technical Assistant	Ryuta Kiuchi ○▲

Visiting Academic Staff/Visiting Faculty Members

Visiting Professor	Shinsuke Imada
Visiting Professor	Yoshiya Kasahara
Visiting Professor	Tomo'omi Kumagai
Visiting Professor	Yoshikatsu Kuroda ▲
Visiting Professor	Yoko Kokubu ▲
Visiting Professor	Iku Shinohara
Visiting Professor	Nobuo Sugimoto
Visiting Professor	Kanako Seki
Visiting Professor	Toru Tamura ▲
Visiting Professor	Hotaek Park
Visiting Associate Professor	Fumio Abe
Visiting Associate Professor	Yasunobu Ogawa
Visiting Associate Professor	Shinji Saito
Visiting Associate Professor	Daikou Shiota
Visiting Associate Professor	Hiroki Mizuochi
Visiting Associate Professor	Kikuko Miyata ▲
Visiting Associate Professor	Shoichiro Yokota
Visiting Associate Professor	Shigeyuki Wakagi
	Shun Ohishi
(Emeritus Professor)	Yutaka Mtsumi

Foreign Visiting Cooperation Researcher

Jun. 26, 2021 – Jun. 25, 2022	Xiaolong Li
Apr. 1 – Oct. 31, 2022	Bindu H. Hima
Apr. 1, 2022 – Mar. 31, 2023	XiangXiang Yan
Apr. 16 – Jul. 15, 2022	Adithya H.N.
May 1 – Jul. 10, 2022	Mengesha Cherkos Alemayehu
May 11 – Aug.15, 2022	Francesc Junyent
May 11 – Aug.15, 2022	Jim George
May 11 – Aug.15, 2022	Corby Tay Thompson
May 11 – Aug.15, 2022	Eun Yeol Kim
May 11 – Aug.15, 2022	Warittha Panasawatwong
May 11 – Aug.15, 2022	Theresa Marie Lincheck
May 11 – Aug.15, 2022	Erin Mary Dougherty
Jun. 1 – Aug.15, 2022	Michael Monroe Bell
Jun. 11 – Aug.15, 2022	Brenda Dolan Cabel
Jun. 11 – Aug.15, 2022	Katherine Louise Ackerman
Jun. 11 – Aug.15, 2022	Mya Jocelyn Sears
Jun. 13 – Jul. 29, 2022	Andrew Oke-'Ovie Akala
Jun. 24 – Oct. 25, 2022	Po-Hsiung Lin
Jun. 27 – Jul. 6, 2022	Bernard V. Jackson
Jul. 11 – Jul. 22, 2022	Takuya Hara
Jul. 11 – Aug.16, 2022	Nicole Rocque Marquette
Jul. 11 – Aug.16, 2022	Kelly Marie Nunez Ocasio
Jul. 11 – Aug.16, 2022	Chaehyeon Nam
Jul. 22 – Aug.15, 2022	Venkatachalam Chandrasekaran
Aug. 4 – Aug.16, 2022	Mateo Enriq Lovato
Sep. 8 – Sep.16, 2022	Amore Nel
Sep. 8 – Sep.16, 2022	John Bosco Habarulema
Sep. 8 – Sep.16, 2022	Zama Thobeka Katamzi-Joseph
Sep. 12 – Dec.10, 2022	Onyinye Gift Nwankwo
Sep. 24 – Oct. 5, 2022	Ulrike Maria Langematz
Sep. 26 – Oct.12, 2022	Konstantin Schaar
Sep. 27 – Oct. 5, 2022	Tobias Christian Spiegl
Oct. 4 – Dec. 27, 2022	Veera Kumar Maheswaran
Oct. 5 – Dec. 20, 2022	Pankaj Soni
Oct. 12 – Dec. 7, 2022	Venkata Ratnam Devanaboyina
Oct. 13 – Nov. 16, 2022	Ravindra Pratap Singh
Oct. 17 – Oct. 27, 2022	Wan Hong
Oct. 19, 2022 – Aug. 31, 2023	Rui Chen
Oct. 26 – Nov. 16, 2022	Wee Cheah
Nov. 1, 2022 – Jan. 31, 2023	Nilesh Arvind Chauhan
Nov. 1 – Nov. 13, 2022	Jong-Dao Jou
Nov. 10 – Dec. 5, 2022	Andrzej Zbingniew Rakowski
Nov. 12 – Nov. 23, 2022	Bruce Tsurutani
Nov. 12 – Nov. 26, 2022	Brian Thomas Welsch
Nov. 13 – Nov. 17, 2022	James Crawford
Nov. 13 – Nov. 17, 2022	Ilya Usoskin
Nov. 14 – Nov. 19, 2022	Ivana Kolmašová
Nov. 14 – Nov. 19, 2022	Benjamin Grison
Nov. 14 – Nov. 19, 2022	Ulrich Taubenschuss
Nov. 15 – Nov. 17, 2022	Natchimuthukonar Gopalswamy
Nov. 15 – Nov. 17, 2022	Go Iwahana
Nov. 18, 2022 – Feb. 15, 2023	Chukwuma Moses Anoruo
Nov. 23 – Nov. 30, 2022	Manabu Shimoyama
Nov. 27 – Dec. 4, 2022	Rangaiah Kariyappa
Nov. 27 – Dec. 1, 2022	Wai-Leong Teh
Dec. 3, 2022 – Feb. 28, 2023	Wellen Rukundo
Dec. 4, 2022 – Jan. 20, 2023	Maurya Ajeet Kumar
Dec. 7, 2022 – Mar. 6, 2023	Rahul Rathi
Jan. 10 – Jan. 29, 2023	Po-Hsiung Lin
Jan. 31 – Mar. 1, 2023	Samuel Krucker
Feb. 12 – Mar. 12, 2023	Hermann Opgenoorth
Feb. 15 – Feb. 27, 2023	Kevin Krieger
Mar. 31, 2023 – Mar. 31, 2024	Yaru Zhao

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	Satoshi Furuhashi ▲
General Affairs Division	
Manager, General Affairs Division	Masao Yamamori ○
Specialist, General Affairs Section	Hideaki Yano ▲
Section Head, General Affairs Section	Takamasa Sato
Section Head, General Affairs Section	Noriaki Tonouchi ○
Section Head, Personnel Affairs Section	Yohei Sato ▲
Section Head, Budget Planning Section	Mirei Miyao
Leader, General Affairs Section	Risa Oosawa ○
Leader, Personnel Affairs Section	Yoshikazu Akamatsu ▲
Administrator	Honami Ishizaki ○
Administrator	Junpei Okada
Administrator	Asana Goto ▲
Administrator	Megumi Goto ▲
Administrator	Tomoka Shibata ○
Administrator	Kahori Nishi ○
Designated Supervisor	Tadashi Tsuboi ▲
Deputy Manager, Research Funding Division, Research Cooperation Department	Toshiyuki Yokoi ○

Toyokawa Branch

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

4. Committee of Other Organizations

Committee of Other Organizations

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

Contact Post	Job Title	Organizations	Name of Committee / Title
Hiroyasu Tajima	Professor	Progress of Theoretical and Experimental Physics	Editorial Board member
Nobuhiro Takahashi	Professor	National Aeronautics and Space Administration (NASA)	Global Precipitation Measurement (GPM) Joint Precipitation Science Team (JPST) member
Nobuhiro Takahashi	Professor	National Aeronautics and Space Administration (NASA)	Aerosol and Cloud, Convection and Precipitation (ACCP) Science and Application Transition Team (SATT) member
Nobuhiro Takahashi	Professor	National Aeronautics and Space Administration (NASA)	Aerosol and Cloud, Convection and Precipitation (ACCP) Algorithm Working Group (AWG) member
Nobuhiro Takahashi	Professor	European Space Agency (ESA)	Member, Joint Mission Advaisory Group for EarthCARE
Hirohiko Masunaga	Associate Professor	National Aeronautics and Space Administration (NASA)	Atmosphere Observing System (AOS), Science and Applications Team (SAT), Algorithm Working Group (AWG) member
Hirohiko Masunaga	Associate Professor	World Climate Research Programme (WCRP) Global Energy and Water cycle Exchanges (GEWEX)	GEWEX Data and Analysis Panel (GDAP) member
Hirohiko Masunaga	Associate Professor	National Aeronautics and Space Administration (NASA) and JAXA	Joint Precipitation Measurement Mission Science Team member
Nozomu Nishitani	Associate Professor	Super Dual Auroral Radar Network (SuperDARN)	Vice chair, Executive Council
Nozomu Nishitani	Associate Professor	Earth, Planets and Space (EPS)	Guest editor for the special issue of 20th Anniversary Issue: Earth, Planetary, and Space Sciences in the Next Decade
Masahito Nosé	Associate Professor	International Association of Geomagnetism and Aeronomy (IAGA)	Chair, Division V
Masahito Nosé	Associate Professor	International Union of Geodesy and Geophysics	Resolution Committee member
Masahito Nosé	Associate Professor	Earth, Planets and Space (EPS)	Vice editors-in-chief
Masahito Nosé	Associate Professor	Polar Data Journal	Editorial Board member
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	Czech Science Foundation	Reviewer
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)	Monsoons Panel Asian-Australian Monsoon Working Group member

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 will promote and perform 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 towards 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., during FY2022: 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). Owing to the continuing impact of COVID-19, some international joint research and workshops have been postponed or rescheduled, and research meetings have been held hybridically or online.

The 5th ISEE Symposium "Toward the Future of Space–Earth Environmental Research" was held in a hybrid format at the Sakata and Hirata Hall at Nagoya University from November 15 to 17, 2022, to deepen exchange and integration between space and Earth science within the space–Earth environmental research framework. There were 255 participants, 138 from Japan and 117 from overseas and 85 students, 40 from Japan and 45 from overseas. At this symposium, the 4th ISEE Award was presented to Dr. Satoshi Kasahara of the Graduate School of Science, University of Tokyo. He gave a commemorative lecture titled "One solar cycle with the ERG (ARASE) mission".

The ISEE community meeting was also held online on November 18, the day after the 5th ISEE Symposium, to improve ISEE joint research and develop new interdisciplinary collaboration. In addition to the usual ISEE joint research activity reports and joint research introductions, several newly initiated fusion studies in the fields of space, Earth, computational science, planetary science, and plasma science were introduced. Additionally, opinions were exchanged on how ISEE should operate as a central hub for space-Earth environmental research. The meeting was attended by 48 and 37 participants from outside and within the institute, respectively, for a total of 85 participants, including seven students. Active discussions and exchanges of opinions occurred across disciplines.

In FY2022, the ISEE Joint-Research Online Integrated System was updated in the cooperation of the Research Organization of Information and Systems. In this successor system, JROIS2-ISEE, the format for submitting applications and reports was changed, and all categories shifted to a completely web-based application format from FY2023.

Through wide-ranging open-call joint research activities, the ISEE aims to contribute to solving 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

■ ISEE International Joint Research Program

Proposer (Affiliation* Job title*)	Title of the research program	Corresponding ISEE researcher
Rangaiah Kariyappa (Former Professor, Indian Institute of Astrophysic)	Solar X-ray Irradiance, Temperature & Magnetic Field Variabilities of the Spatially Resolved Coronal Features	Satoshi Masuda
Ratnam Venkata Devanaboyina (Professor, KL Deemed to be University, India)	Investigation of Extreme Global Total Electron Content Events using Statistical and Fractal Methods	Yuichi Otsuka
Andrew Oke-'Ovie Akala (Associate Professor, University of Lagos, Nigeria)	A study on responses of global equatorial/low-latitude ionosphere to CIR-driven and CME-driven intense geomagnetic storms during solar cycle 24	Yuichi Otsuka
Ravindra Pratap Singh, (Academic Faculty, Physical Research Laboratory, India;)	SSW influence on the MLT dynamics, temperature, and meridional circulation	Satonori Nozawa
Linjie Chen (Associate Researcher/Professor, National Astronomical Observatories, Chinese Academy of Sciences)	Estimation of solar wind speed using the multi-station IPS telescope	Kazumasa Iwai
Ajeet Kumar Maurya (Assistant Professor, Babasaheb Bhimrao Ambedkar University, Lucknow, India)	Understanding vertical atmosphere-ionosphere (AI) coupling through atmospheric gravity waves	Yuichi Otsuka
Prayitno Abadi (Researcher, Other Institution)	Developing a nowcasting capability for the occurrence of post-sunset equatorial plasma bubble in Southeast Asia	Yuichi Otsuka
Wai Leong Teh (Lecturer, Universiti Kebangsaan Malaysia)	Understanding the Role of Magnetic Island in Plasma Acceleration and Energy Conversion during Magnetic Reconnection	Takayuki Umeda
Hermann Opgenoorth (Professor Emeritus, Umeå University, Sweden)	Study of sub-auroral storm time magnetic and convection disturbances and their effects for GIC and GNSS impacts	Nozomu Nishitani
Dedong Wang (Scientist, GFZ German Research Centre for Geosciences)	Analytical Chorus Wave Models Derived from Van Allen Probe and Arase Observations	Yoshizumi Miyoshi
Sudarsanam Tulasiram (Professor, Indian Institute of Geomagnetism)	Geomagnetically Induced Currents at equator due to IP shocks and solar wind discontinuities	Kazuo Shiokawa
Shibaji Chakraborty (Postdoctoral Associate, Virginia Polytechnic Institute and State University, USA)	Influence of Solar Flare-Driven Changes in the Ionospheric Conductance and Electric Fields on HF Radar Observed Doppler Flash	Nozomu Nishitani
Ondrej Santolik (Professor, Institute of Atmospheric Physics, Czech Republic)	Investigation of electromagnetic waves in space plasmas	Yoshizumi Miyoshi
Takuya Hara (Assistant Research Physicist, University of California Berkeley, USA)	Multi-point spacecraft investigations on the solar erupted magnetic flux ropes propagating through the inner heliosphere	Kazumasa Iwai
Viktor Fedun (Professor, The University of Sheffield, UK)	Analysis of solar active regions based on Lagrangian methodology	Kanya Kusano
Matthew Lazzara (Senior Scientist, University of Wisconsin-Madison, USA)	Creation of a new high-quality longterm temperature dataset of East Antarctic meteorological observations	Naoyuki Kurita
Samuel Krucker (Professor, Fachhochschule Nordwestschweiz, Switzerland)	The NoRH/RHESSI flare catalogue: time-dependent analysis	Satoshi Masuda
Brian Welsch (Associate Professor, University of Wisconsin-Green Bay, USA)	Exploring Magnetic Energies to Understand and Predict CME Onset	Kanya Kusano
Sae Aizawa (Postdoc, Institut de Recherche en Astrophysique et Planetologie, France)	Investigation of the solar wind propagation and its characteristics in the inner heliosphere using multispacecraft, ground-based observations and numerical simulations	Yoshizumi Miyoshi
Matthias Foerster (Senior Scientist, GFZ German Research Centre for Geosciences)	Subauroral phenomena observed by SuperDARN and the Swarm satellite constellation	Nozomu Nishitani
Thomas Berger (Research Staff, University of Colorado at Boulder, USA)	Investigation of Solar Polar Magnetic Fields using Hinode/SP and SDO/HMI Data	Kanya Kusano

Proposer （Affiliation* Job title*）	Title of the research program	Corresponding ISEE researcher
Andrzej Rakowski (Associate Professor, Silesian University of Technology, Poland)	Establishment of master dendrochronological calibration curve around 660 BC using annual tree ring samples from Poland	Masayo Minami
Tobias Spiegl (Professor, Freie Universität Berlin, Germany)	Modelling the transport and deposition of ^{14}C produced by extreme solar proton events and 7 Be produced by galactic cosmic rays during the satellite era	Fusa Miyake

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

■ ISEE/CICR International Workshop

Proposer （Affiliation* Job title*）	Title of the workshop	Corresponding ISEE researcher
Go Murakami (Assistant Professor, Japan Aerospace Exploration Agency, Japan)	Contribution of the BepiColombo mission to heliospheric system science	Yoshizumi Miyoshi
K. D. Leka, (Senior Research Scientist, NorthWest Research Associates, USA)	What is a Magnetic Flux Rope? Do we know it when we have one?	Kanya Kusano

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

■ SCOSTEP Visiting Scholar (SVS) Program

Proposer （Affiliation* Job title*）	Title of the program	Corresponding ISEE researcher
Rahul Rathi (graduate course student, Indian Institute of Technology Roorkee, India)	Determination of local geomagnetic index and its correlation with TEC and airglow intensity	Kazuo Shiokawa
Veera Kumar Maheswaran (graduate-course student, SASTRA Deemed University, India)	Investigation of latitudinal dependence of medium-scale traveling ionospheric disturbances detected from GNSS TEC data over equatorial regions	Yuichi Otsuka
Chukwuma Anoruo (graduate-course student University of Nigeria, Nsukka, Nigeria)	Study of TEC variations during geomagnetic storms	Yuichi Otsuka
Pankaj Kumar Soni (graduate-course student, Indian Institute of Geomagnetism, India)	Investigation of flux enhancement and associated changes in pitch angle distributions of radiation belt particles	Yoshizumi Miyoshi
Nilesh Chauhan (graduate-course student, Indian Institute of Geomagnetism, India)	Study of mesospheric bores from middle and high latitude region	Kazuo Shiokawa
Wellen Rukundo (graduate-course student, Egypt-Japan University of Science and Technology, Egypt)	Detection of equatorial plasma bubbles (EPBs) using a low-cost 630.0 nm all-sky imager	Kazuo Shiokawa
Adithya H. N. (*SVS 2021 Recipient*) (graduate-course student, Scikraft Education and Engineering Design Pvt. Ltd. India)	Coronal temperature variability from spatially resolved images of the Sun from Hinode/XRT	Satoshi Masuda
Onyinye Gift Nwankwo (graduate-course student, University of Michigan, USA)	Extensive investigation, comparison and validation of the thermospheric wind observations during geomagnetic quiet and disturbed periods using the data surveys from ground-based equipment and results from model calculations	Kazuo Shiokawa

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

■ International Technical Exchange Program

Proposer (Affiliation* Job title*)	Title of the program	Corresponding ISEE researcher
Bernhard Kleim (Research Senior Astrophysicist, University of Potsdam, Germany)	Modeling the Source Region of the Extreme Space Weather Event of 1921 May 14–15	Satoshi Masuda
Kevin Krieger (Head Research Engineer, University of Saskatchewan, Canada)	SuperDARN Hokkaido Pair of radars (HOP) system hardware and software development	Nozomu Nishitani
Manabu Shimoyama (Senior Scientist, Swedish Institute of Space Physics, Sweden,)	Joint technology development of ultra-low energy neutral atmospheric analyzer for future Earth and planetary explorers	Masafumi Hirahara
Masayo Minami (Professor, Nagoya University, Japan)	Technical exchange on accelerator mass spectrometry (AMS) for accurate and precise ^{14}C measurement	Masayo Minami

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

■ ISEE International School Support

Proposer (Affiliation* Job title*)	Title of the program	Corresponding ISEE researcher
Jyrki Manninen (Deputy Director, University of Oulu, Finland)	VERSIM Workshop	Claudia Maria Martinez-Calderon
Hiroyuki Kitagawa (Professor, Nagoya University, Japan)	Short course on AMS radiocarbon dating	Masayo Minami

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

Lists of Collaboration Resources

■ Instruments

Name	Contact Person
Multi-Directional Cosmic Ray Muon Telescope (Nagoya)	Yutaka Matsubara
Multi-Station IPS Solar Wind Observation System (Toyokawa, Fuji, and Kiso)	Munetoshi Tokumaru
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

■ Software/Databases

Name	Contact Person
Hinode Science Center, Nagoya University	Kanya Kusano
ERG Science Center	Yoshizumi Miyoshi
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
Cosmic Ray Intensity Database	Yutaka Matsubara
Interplanetary Scintillation Data	Munetoshi Tokumaru
Solar Wind Speed Data	Munetoshi Tokumaru
Remei Satellite Observation Database	Masafumi Hirahara
Coordinated Magnetic Data Along 210° Magnetic Meridian (Moshiri, Rikubetsu, Kagoshima, and Overseas MM Stations)	Kazuo Shiokawa
Database of the Optical Mesosphere Thermosphere Imagers	Kazuo Shiokawa
ELF/VLF Wave Data	Kazuo Shiokawa

Name	Contact Person
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

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
CHN Analyzer, Isotope Ratio Mass Spectrometer	Yoshihisa Mino
Tandetron Accelerator Mass Spectrometry	Hiroyuki Kitagawa, Masayo Minami
Electron Probe Microanalyzer (EPMA)	Takenori Kato
X-Ray Fluorescence Spectrometer (XRF)	Takenori Kato
X-Ray Diffractometer (XRD)	Takenori Kato
Facilities at Moshiri Observatory	Akira Mizuno
Facilities at Rikubetsu Observatory	Akira Mizuno
Facilities at Kiso Station	Munetoshi Tokumaru
Facilities at Fuji Observatory	Munetoshi Tokumaru
Facilities at Kagoshima Observatory	Kazuo Shiokawa

6. Governance

As of March 31, 2023

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Hiroyuki Kitagawa	Institute for Space–Earth Environmental Research, Nagoya University
Yoshizumi Miyoshi	Institute for Space–Earth Environmental Research, Nagoya University
Akira Mizuno	Institute for Space–Earth Environmental Research, Nagoya University
Kazuo Shiokawa	Institute for Space–Earth Environmental Research, Nagoya University
Nobuhiro Takahashi	Institute for Space–Earth Environmental Research, Nagoya University
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Masayo Minami	Institute for Space–Earth Environmental Research, Nagoya University
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Taro Shinoda	Institute for Space–Earth Environmental Research, Nagoya University
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Munetoshi Tokumaru	Institute for Space–Earth Environmental Research, Nagoya University
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Integrated Studies Technical Committee

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Yoshizumi Miyoshi	Institute for Space–Earth Environmental Research, Nagoya University
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Hiroyasu Tajima	Institute for Space–Earth Environmental Research, Nagoya University
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Kazumasa Iwai	Institute for Space–Earth Environmental Research, Nagoya University
Hiroyuki Kitagawa	Institute for Space–Earth Environmental Research, Nagoya University
Kanya Kusano	Institute for Space–Earth Environmental Research, Nagoya University
Claudia Martinez-Calderon	Institute for Space–Earth Environmental Research, Nagoya University
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Kazuo Shiokawa	Institute for Space–Earth Environmental Research, Nagoya University
Hiroyasu Tajima	Institute for Space–Earth Environmental Research, Nagoya University
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7. Finance

External Funding and Industry–Academia–Government Collaborations

Researches 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	12,610,000
Grant-in-Aid for Scientific Research (S)	3	115,050,000
Grant-in-Aid for Scientific Research (A)	8	69,030,000
Grant-in-Aid for Scientific Research (B)	10	62,400,000
Grant-in-Aid for Scientific Research (C)	4	7,639,243
Grant-in-Aid for Challenging Research (Exploratory)	7	22,419,521
Grant-in-Aid for Early-Career Scientists	7	13,256,374
Grant-in-Aid for Research Activity Start-up	2	3,383,317
Fund for the Promotion of Joint International Research (Fostering Joint International Research (B))	3	17,236,240
Grant-in-Aid for JSPS Fellows	5	5,970,000
Total	50	328,994,695

- Fifty research subjects listed in the table were supported by the JSPS Kakenhi.
- Twenty-seven research subjects received total 178,873,632 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.
- Thirteen research subjects received total 19,236,220 JPY of donation.

Libraries

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

Books

Japanese	3,079
Foreign	11,141

Journals

Japanese	47
Foreign	207

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

Books

Japanese	4,565
Foreign	8,926

Journals

Japanese	282
Foreign	257

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	24,580	167	Hokkaido
Kagoshima Observatory	13,449	287	Kagoshima
Fuji Observatory	19,926	174	Yamanashi
Kiso Station	6,240	66	Nagano
Total	268,941	10,922	

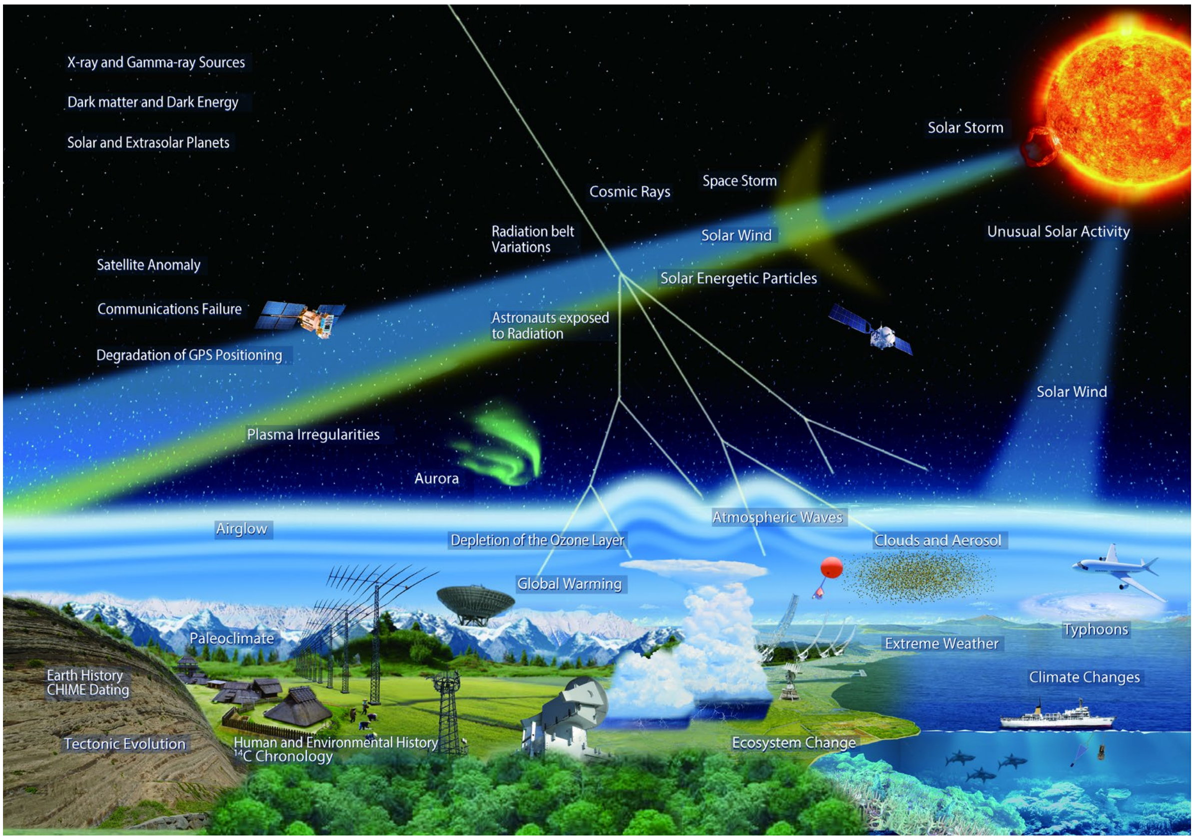
8. Research Topics

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 2022 based on proposals from 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

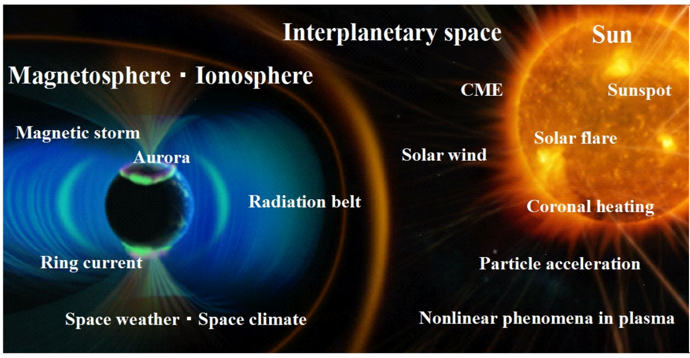
The seven research divisions are introduced in Section 8.1. The Research Divisions and Office for the Development of Interdisciplinary Research Strategy and its interdisciplinary research projects are introduced in Section 8.3. Interdisciplinary Research.

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

In the Division for Integrated Studies, we conduct scientific research aimed at the comprehensive understanding and prediction 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 aurora, where the nonlinear interaction and intercoupling between different systems play an important role. We also promote scientific projects of satellite missions (Hinode and ERG satellites) by 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 in the Graduate Schools of Science and Engineering at Nagoya University.

Main Activities in FY2022

Reconstructions of the past solar-terrestrial environments with historical documents and analog records

Analog records and historical documents are of vital importance for chronologically extending our scientific knowledge of the extremities of the solar-terrestrial environment. Our team exploited historical records of solar storms and long-term solar variability. In the fiscal year 2022, our team evaluated sunspot records from 1727 to 1748, where the data were extremely scarce and revised the sunspot group number and newly derived sunspot positions in this interval. Our team exploited sunspot drawings in the Kawaguchi Science Museum and quantitatively evaluated data stability. Our team also exploited eclipse records to evaluate rotational variability of Earth in the 4th–7th centuries and the solar coronal structure in the Dalton Minimum. Our team has also contributed to an invited review of sunspot number recalibration, which extensively covers recent developments in this field (Clette et al., 2023).

Simulation Study on the mechanism of magnetic helicity formation in solar active region

Solar active regions are formed when magnetic flux in the solar interior rises to the solar surface, often causing flare explosions. This is attributed to the sudden release of energy associated with the twisting of the magnetic field (magnetic helicity) accumulated in active regions. However, the formation mechanism of magnetic helicity in active regions has not been completely elucidated. The research team of the Integrated Studies Division, in collaboration with Lockheed Martin Solar Astrophysics Laboratory, Chiba University, and ISAS/JAXA, has systematically computed the process of magnetic flux rising inside complex convection in the solar interior using the supercomputer "Fugaku," and found that the downward flow in the solar interior plays an important role in the formation of large magnetic helicity. This is because the downward flow causes collisions between positive and negative magnetic poles on the solar surface. Then, the magnetic poles can rotate and form a large magnetic helicity in the active region because the magnetic helicity is converted from the twist of magnetic field lines to the writhe of the flux tube. They also found that even when a non-twisting magnetic flux tube emerges on the solar surface, magnetic helicity can form enough to generate small-to medium-sized flares due to the pair production of positive and negative magnetic helicity as the magnetic poles collide (Toriumi et al., submitted to *Sci. Rep.*).

New database of “AIA Active Region Patches”

Dr. KD Leka, CICR Designated Professor (cross-appointment) with colleagues at NorthWest Research (Boulder, Colorado, USA) established a new database of “AIA Active Region Patches” which extract time-series coronal and chromospheric E/UV images from AIA on the Solar Dynamics Observatory over 8 years (over 256,000 images). The database is curated for DEM inversions and readily applicable for Machine Learning and other large-sample cycle-long solar science (Dissauer et al 2023, *Astrophysical J.*, 942, 83; 10.3847/1538-4357/ac9c06). Using this database, the team constructed active-region summarizing parameters that characterized the solar corona and chromosphere (including high-frequency dynamics and longer-term evolution) for the full sample. These publicly available parameters were then used with NonParametric Discriminant Analysis to ask “are flare-ready regions distinguishable by their coronal and chromospheric behaviors?” The answer is “yes” at a level similar to how well we can answer this question already using photospheric magnetic field data (e.g., True Skill Statistics in the 0.68–0.82 range, depending on event definition; Leka et al 2023, *Astrophysical J.*, 942, 84; 10.3847/1538-4357/ac9c04). Thus, future research efforts (including Machine Learning efforts using these new flare-related parameters) may combine the coronal dynamics information with photospheric magnetic field data to improve forecasting for solar flares.

Examining global 3-d MHD simulations of thermal convection in solar like-stars from asteroseismic perspectives

Recent asteroseismic evaluations have revealed that some solar-like stars exhibit latitudinal differential rotation, the degree of which is much stronger than that of the Sun, suggesting a variety of dynamic mechanisms. In this study, we compared internal rotation profiles with those obtained based on global 3-d MHD simulations of thermal convection in solar-like stars. We adopted the numerical regime established by Hotta and Kusano (2021) (HK21 regime). No significant inconsistency was found between observations and theory (in the HK regime). However, observational uncertainties are large for slow rotators; thus, the comparison is inconclusive for slowly rotating solar-like stars. A larger number of asteroseismic studies on the internal rotation of solar-like stars is desirable.

First-principles simulation of solar wind using the Fugaku Supercomputer

Turbulent plasma flows and dynamo actions within the solar interior have long been regarded as direct energetic sources of solar wind acceleration. However, owing to significant differences in spatiotemporal scales, addressing this issue without relying on empirical assumptions has been challenging. For the first time, we successfully simulated solar winds with minimal empirical assumptions by utilizing large-scale numerical simulations on RIKEN’s Fugaku supercomputer. The realized solar wind is consistent with diverse observational constraints from the photosphere and corona to solar wind, suggesting that our simulation captures some aspects of the real solar wind acceleration process. Detailed evaluation revealed that magnetic reconnection is quantitatively significant in the energy transport process, which has primarily been attributed to Alfvén waves.

Development of higher-order FDTD method

A new explicit and non-dissipative finite-difference time-domain (FDTD) method in two and three dimensions is proposed for the Courant condition relaxation. Third-degree spatial difference terms with second- and fourth-order accuracies were incorporated with coefficients to the time-development equations of the FDTD (2,4). The optimal coefficients are obtained by a brute-force search of the dispersion relations, which reduces the phase velocity errors but also satisfies the numerical stabilities. The new method is stable with large Courant numbers, whereas the conventional FDTD methods are unstable. The new method also has smaller numerical errors in the phase velocity than the conventional FDTD methods with small Courant number (10.1109/TAP.2023.3234097).

Fit of atomic oxygen ion-neutral collision cross section at ionospheric temperatures

Atomic oxygen and its ions are the major species in the ionosphere of Earth, Venus, and Mars. Collisions between them control the ionosphere structure and are expressed by collision cross-sections or frequency models. Recently, it has been suggested that textbook high-energy models should be replaced with wide energy models. However, there are three wide-energy-type models, and it is obscure which of these is the most appropriate for ionospheric studies. The valid temperature range of their fits was obscure, although it was probably between 300 and 2000 K, which is typically sufficient only for the quiet-time F-region ionosphere of the Earth. This study elucidates the differences among the three models and proposes a new fit by including the curved trajectory effect in the fitting basis function. Consequently, the valid temperature range was improved to 75–9000 K, which is sufficient for the entire ionospheres of Earth, Venus, and Mars, including rare occasions.

Spatial relation of enhanced electric field and particle boundaries associated with SAPS

Fast westward flow, called subsutural polarization streams (SAPS), is often observed at subauroral latitudes on the night side during magnetically disturbed times. We analyzed Arase satellite and SuperDARN radar data to investigate how the inner boundary of the SAPS electric field corresponds to those of the ring current and plasma sheet. The results demonstrated that the inner boundary of the ion ring current appears to often extend further inward from SAPS. It is interpreted that previously injected ions and fresh ring current ions coexist in the inner magnetosphere and only the latter contributes to the SAPS formation.

Computer simulation on pulsating aurora by non-linear wave particle interaction

Pulsating auroras are caused by the intermittent precipitation of electrons into the thermosphere, which are scattered in the pitch angle by wave-particle interactions caused by chorus waves. The nonlinear interaction between chorus waves and electrons often results in a complex relationship between the intensity of the waves, the flux of incoming electrons, and the intensity of auroral emissions. In this study, we employed a wave-particle interaction code based on test particle computations and an auroral emission code to investigate the variation of auroral emissions with the intensity of chorus waves. Our findings indicate that when phase trapping dominates, the intensity of the auroral emission decreases and the number of electrons causing the aurora is suppressed. Conversely, in the case of dislocations, the number of electrons causing the aurora, including optical emission, significantly increased. These results suggest that the auroral luminosity intensity is not simply related to the chorus waves intensity but undergoes complex variations owing to nonlinear wave-particle interactions. The results of this study are expected to contribute substantially to the understanding of the nature of pulsating auroras that exhibit a variety of responses to plasma waves.

Studies of energetic ion behaviors and structured EMIC waves using the Arase satellite observations

We performed two statistical studies using the Arase satellite observations from March 2017 to December 2021: 1) energetic ions (H^+, He^+, and O^+) depending on geomagnetic conditions and 2) the characteristics of structured electromagnetic ion cyclotron (EMIC) waves in the inner magnetosphere. In the first study, we found four distinct ion populations within different energy ranges: (1) plasmaspheric ($E<30$ eV) ions at $L<5$, (2) warm plasma cloak at energies of 10s eV–several keV, (3) the ring current population (E = 1 keV–10s keV) with nose structures, (4) high-energy ring current particles ($E>30$ keV) with symmetric distributions in MLT, and these populations exhibited different behaviors as Kp increases. In this study, we discussed the underlying physical dynamics and the possible origins of the different populations and compare the observational results with a model calculation using simple electric and magnetic fields. In the second study, we found the preferred conditions of structured EMIC waves. They are predominantly observed on the dayside of the magnetosphere at MLAT > 20 deg with stronger curvature forces than other types of EMIC waves. These waves were observed in an increase of solar wind dynamic pressure before the EMIC wave onset. We suggest that increasing solar wind dynamic pressure causes inhomogeneity of the dayside magnetic field, driving the preferred conditions to trigger non-linear wave growth. This leads to a more frequent occurrence of structured EMIC waves at higher latitudes on the dayside of the magnetosphere.

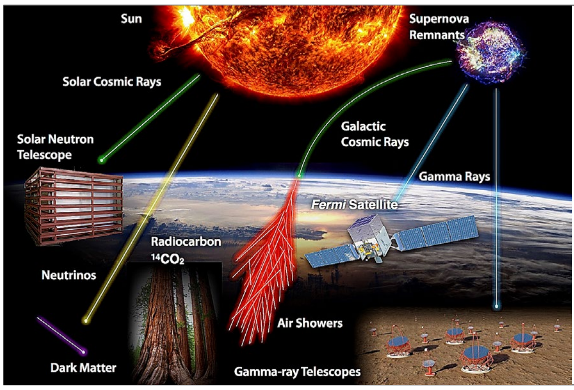
Global modeling and observations of proton precipitation in the sub-auroral latitudes during the 27 May 2017 storm and its association to EMIC waves

Recent studies have demonstrated that ion precipitation induced by EMIC waves can contribute significantly to the total energy flux deposited into the ionosphere and severely affect the magnetosphere-ionosphere coupling. During the geomagnetic storm of May 27–28, 2017, the DMSP and NOAA METOP satellites observed enhanced proton precipitation in the dusk-midnight sector during the major phase of the storm. The ARASE and RBSP-A satellites observed the typical signatures of EMIC waves in the inner magnetosphere. To comprehend the evolution of proton precipitation into the ionosphere, its correspondence to the time and location of wave excitation, and its relation to the source and distribution of proton temperature anisotropy, we performed two BATSRUS+RAMSCBE model simulations with and without EMIC waves. In regions where the Arase/RBSP-A satellite measurements recorded EMIC wave activity, an increase in the simulated growth rates of H- and He-band EMIC waves was observed. The H- and He-band EMIC waves were excited within regions of strong proton temperature anisotropy in the vicinity of the plasma pause, which is consistent with previous observations. The simulated precipitation fluxes were found to be in good agreement with DMSP and NOAA MetOP satellite observations. These results suggest that the RAM-SCBE model can capture EMIC wave activity and qualitatively reproduce precipitating fluxes in the pre-midnight sector. Our results demonstrate that the EMIC wave scattering of ring current ions gave rise to proton precipitation in the pre-midnight sector at subauroral latitudes during the major phase of the May 27, 2017, storm.

Plasma pressure distribution of ions and electrons in the inner magnetosphere during CIR driven storms observed during Arase era

The storm-time ring current is driven by the plasma pressure in the inner magnetosphere. The plasma pressure is predominantly contributed by protons in the energy range of a few keV to a few hundred keV. O+ contribution increases during the geomagnetically active period. However, the contribution of electrons to the ring current has not been well studied. Using Arase observations during 26 CIR-driven geomagnetic storms (Sym-H < −40 nT), we investigated the ring current pressure development of ions (H^+, He^+, O^+) and electrons during the pre-storm, main, early recovery, and late recovery phases with an L-shell and magnetic local time (MLT). During the main and early recovery phases of the storm, the ion pressure was asymmetric in the inner magnetosphere, which led to a strong partial-ring current. H^+ with an energy of approximately 55 keV contributed more to the ring current pressure during the main phase. O^+ with an energy of approximately 10–20 keV, contributed significantly to the main and early recovery phases. Electrons with energies of < 50 keV contributed to the ring current pressure during the main/early recovery phase of the storm. Overall, the electron contribution to the total ring current was approximately 11% to the total ring current during the main and early recovery phases. However, the electron contribution was significant at approximately 22% in the 03–09 MLT sector during the main and early recovery phases. These results indicate the important role of electrons in the ring current build-up. Therefore, the contribution of electrons to the ring current should be carefully studied.

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 activities probed by cosmogenic nuclides
- Particle astrophysics and non-accelerator physics
  - – Dark matter and neutrino physics

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

CRs also provide hints for ultra-high-energy phenomena and unknown particles that cannot be explored in a laboratory. We conducted large hadron collider forward (LHCf) and relativistic heavy ion collider forward (RHICf) experiments to study the hadronic interactions of ultra-high-energy CRs using accelerators such as the LHC or RHIC. This division also conducted neutrino physics research with the Super-Kamiokande experiment and promoted the Hyper-Kamiokande project as a future prospect. The group intensively worked on direct dark matter searches in the XMASS liquid xenon experiment at the Kamioka Observatory and has recently started a new commitment to the XENONnT experiment in Gran Sasso National Laboratory (LNGS) in Italy.

CRs deeply penetrate the atmosphere, producing ionization 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 from Antarctic ice core

Main Activities in FY2022

Search for dark matter and research on the origin of CRs 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. In the design finalization stage of the SST camera, the avalanche cell size was one of the most important specification parameters for SiPMs because it affects the amplification gain, photon detection efficiency, optical crosstalk, and power consumption. We selected a cell size of 50 μm instead of 75 μm owing to its lower power consumption. Although a 75-μm cell offers 10% better photon detection efficiency, its gain is higher by a factor of two, resulting in higher current, power, and optical crosstalk. The heat produced in the SiPMs is conducted through a heat sink attached to the posterior of the SiPM module using a heat conductive adhesive. A heat conductive (~1 W/m/K) substrate was selected for the module loaded with SiPMs and their bias circuits. After finalizing the SST camera design, we initiated the procurement of components for the engineered camera, which is the first of the 42 cameras planned to be installed in the CTA; this camera will be assembled in 2023. The nominal lead time for SiPM module production was six to eight months. However, owing to the limited supply of heat conductive substrates for printed circuit boards, the lead time was extended to 15 months.

Meanwhile, we prepared a test to measure the infant mortality rate and lifespan of the SiPMs. The test included accelerated aging tests using a high current under high-temperature and high- humidity condition.

Acceleration mechanism of SEPs

The acceleration mechanism of SEPs, which are accelerated owing to energetic solar flares, was studied through ground observations of solar neutrons with energies greater than 100 MeV. These accelerated ions produce neutrons through interactions with the solar atmosphere. It is considered that neutron observations can provide a better understanding of the acceleration mechanism of SEPs than directly observing accelerated ions because neutrons are not reflected by the interplanetary magnetic field and are attenuated in the Earth's atmosphere. Therefore, the ISEE program has developed a worldwide network of solar neutron detectors located on high mountains at different longitudes.

To date, more than 10 solar neutron events have been reported. The energy spectra of neutrons at the solar surface can be obtained based on the assumption that neutrons are produced simultaneously with the electromagnetic waves during solar flare events. The obtained spectra indicate that stochastic acceleration occurs when energetic neutrons are produced by the sun. To comprehensively understand the acceleration mechanism, we must observe a solar neutron event wherein the energy spectrum of neutrons can be determined without assuming their production time. However, the neutron sensitivities and energy resolutions of solar neutron detectors used worldwide are insufficient for determining the acceleration mechanism of SEPs.

A new solar neutron telescope, called the SciBar Cosmic Ray Telescope (SciCRT), has been installed at the top of Mt. Sierra Negra (4,580 m above sea level) in Mexico. The SciBar detector was used in the accelerator experiments. This installation was realized with the support of Kyoto University, the High Energy Accelerator Research Organization (KEK), the National Autonomous University of Mexico, and the National Institute for Astrophysics, Optics, and Electronics in Mexico. SciCRT employs 15,000 scintillator bars to measure particle tracks, providing significantly better sensitivity to neutrons, energy resolution, and particle discrimination. The performance of SciCRT was investigated using Monte Carlo simulations, which showed that it can identify the production time of neutrons, whether instantaneous or continuous, for more than 5 min, and also discriminate between shock and stochastic accelerations. In addition to solar neutron observations, CR intensity variations in different directions were simultaneously monitored using the SciCRT.

However, maintaining a worldwide network of solar neutron detectors is challenging. There were seven solar neutron detectors worldwide in 2003; however, this number has decreased recently, with two stations remaining in the fiscal year 2022: SciCRT in Mexico and Chacaltaya (5,250 m above sea level) in Bolivia. Both are maintained by the respective scientists in both countries and are expected to detect solar neutron events during the current solar cycle 25, which started in 2020.

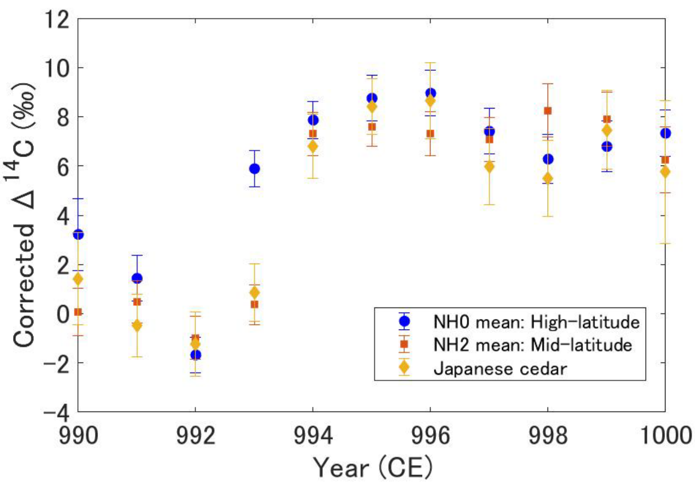
This study was performed in collaboration with Chubu University, Shinshu University, the Institute for Cosmic Ray Research (ICRR) of the University of Tokyo, ISAS/JAXA, Japan Atomic Energy Agency (JAEA), National Defense Academy, and other institutions worldwide.

Historic CR intensity variation measurements using cosmogenic radioisotopes

The CRs reaching the 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 used as excellent indicators for determining CR intensity. Therefore, we measured ^{14}C concentrations in tree rings and ^{10}Be concentrations in ice cores to investigate past CR variations. These analyses of the cosmogenic nuclides revealed that CR events increased during 774/775 CE, 993/994 CE, and ~660 BCE. The possible causes of these CR events are SEP events at scales estimated to be tens of times larger than the largest recorded event. Such large-scale SEP events pose a major threat in the current space exploration era. Therefore, we aimed to identify other signatures of CR events and clarify the frequency of extreme SEP events by measuring ^{14}C concentrations in tree rings over the past 10,000 years. This year, we investigated the period from 4000 to 3000 BCE and detected several event candidates (^{14}C increases).

We reported that there are clear regional differences in the timings of increases in ^{14}C concentrations during the 993 CE cosmic ray event based on the re-measurement results of Japanese cedar located on Yaku-island (Miyake et al., 2022, Fig. *). As shown in Fig.*, ^{14}C concentrations in mid-latitude trees, including the Japanese cedar, increased one year later than that in high-latitude trees. However, further research is required to determine whether these differences are because of atmospheric transport or variations in the timing of carbon fixation in trees.

We also investigated the geographical distribution of ^{10}Be concentrations in Antarctica using snow samples to understand the background variation exhibited in ^{10}Be data from Antarctic ice core.



Differences in ^{14}C variations for the 993 CE cosmic ray event (Miyake et al. 2022, High-latitude, mid-latitude, and Japanese cedar)

Study of neutrinos and dark matter through underground experiments

Super-Kamiokande (SK) is a 50-kton underground water Cherenkov detector located at the Kamioka Observatory dedicated to neutrino and possible proton decay observations. Gadolinium (Gd) was added to the pure water in the SK to prepare it for observing supernova relic neutrinos emitted by all supernova explosions. In the summer of 2022, an additional 0.02% of Gd was successfully introduced to increase the total to 0.03% without significantly impacting the detector performance. A new Honda neutrino flux model was developed by employing hadron production models tuned using existing accelerator data. The initial results were compared with those of the new Bartol neutrino flux model, which were discussed at a dedicated annual workshop on atmospheric neutrino production (WANP2023). Additionally, the construction of the Hyper-Kamiokande (HK) detector is ongoing. In 2022, the access tunnel to the main cavern was completed, and excavation of the main cavity is ongoing. The Nagoya Group has contributed intensively to study the performance of the new 136 20” B&L PMTs installed in the SK tank in 2018. This is the first extensive long-term test in the water. We confirmed that the new HK-PMTs worked as expected through a previous study conducted in air.

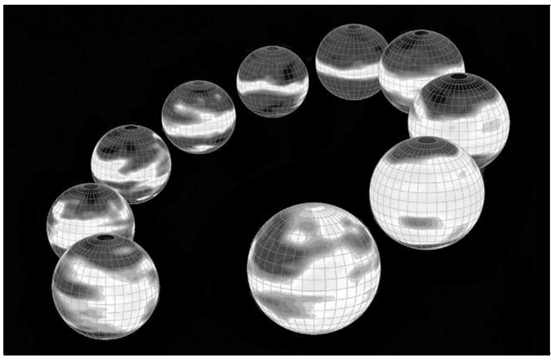
Dark matter constitutes undiscovered heavy neutral particles that are difficult to observe because of their weak interactions. We directly searched for dark matter during the XENONnT experiment using a double-phase xenon time-projection chamber (TPC) located at the Gran Sasso Underground Laboratory, Italy. After successful construction and commissioning of the detector from spring 2020 to spring 2021, the first set of scientific data “SR0” were obtained over 97.1 days, from July 6 to November 10, 2021. In this year, we analyzed this data and obtained more sensitive rejection of possible electron recoil excess previously reported in the preceding XENON1T experiment, with a background improvement by a factor of five. We also released the result of the first WIMP search from SR0, providing 2.58×10^{-47} cm^2 as the upper limit of the WIMP-nucleon cross section. We are also conducting various R&D studies on the DARWIN 50-ton liquid xenon TPC for future direct dark matter detections. We built a dedicated setup to measure the quantum efficiency (QE) of the electrode materials in liquid xenon using a dedicated VUV light system and found that by applying a thin layer, such as MgF2, helps reduce the QE of electrode materials by a factor of 10. We also developed a hermetic liquid-xenon TPC, wherein the inner volume of the TPC was enclosed by a quartz vessel, which prevented radon emanation from the detector material. We expect that this technology can play a key role in building a DARWIN-sized dark matter detector with radon background improved by one order of magnitude.

CR interaction-focused accelerator experiments

Many studies on CRs have been conducted worldwide to understand where and how CR particles accelerate to higher energies. CRs are observed using 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 observed air showers. The interpretation of the chemical composition is strongly dependent on the hadronic interaction model used in the air shower simulation. Therefore, we studied the high-energy interactions at large-particle colliders, LHC and RHIC, located at the European Organization for Nuclear Research and Brookhaven National Laboratory.

The LHCf experiment was conducted in September 2022, wherein proton beams were accelerated to 6.8 TeV and collided to produce photons and neutrons in the very forward region of the collisions, which were measured using LHCf calorimeter detectors. The center-of-mass collision energy was 13.6 TeV, which corresponded to CR interactions with an energy of 10^{17} eV. Owing to the high-energy collisions close to the ultra-high-energy cosmic ray energy of 10^{20} eV, the obtained data are crucial for studying CR interactions. The detectors were installed in the LHC tunnel in September, and the data were obtained during a successful 4-day operation, from 23– 27 September. We obtained statistics seven times larger than those of the previous operation conducted in 2015. These high-statistics data can be used to obtain a new measurement of the forward K0 meson that may help solve the muon puzzle, which is a critical problem in high-energy CR observations on the ground. Additionally, this operation included a joint operation with the ATLAS experiment.

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

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

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

Main Activities in FY2022

Solar wind observations using the IPS system

Remote-sensing observations of solar wind have been performed since the 1980s using a multistation interplanetary scintillation (IPS) system. Tomographic evaluation of IPS observations enables accurate determination of the global distribution of solar wind speed and density fluctuations. IPS observations provide valuable information, particularly for high-latitude solar winds, wherein *in situ* observations are currently unavailable. Currently, IPS systems comprise three large antennas: Toyokawa, Fuji, and Kiso. The Toyokawa antenna (SWIFT) has the largest aperture and highest sensitivity among the three antennas and began daily observations in 2008. The Fuji and Kiso antennas were upgraded in 2013–2014 by installing new receivers, which significantly improved their sensitivities. These antennas are located in mountainous areas and are not used for observations during winter due to heavy snowfall. Hence, solar wind speed data from the three station observations were unavailable during winter. Instead, solar wind density fluctuations were derived from the Toyokawa IPS observations, which were measured throughout the year. The IPS data were made available to the public in real time via an FTP server and used for diverse international collaborations. In this FY, three-station IPS observations were initiated in early April using the Toyokawa, Fuji, and Kiso antennas. The IPS observations at Fuji stopped owing to a failure of the antenna driving shaft on July 28, and restarted after restoration work on August 12. However, the IPS observations at Kiso stopped due to a failure of the antenna driving system on September 14. Although several attempts were made to fix the Kiso antenna issue, we could not successfully restore the antenna and deferred restarting the IPS observations at Kiso.

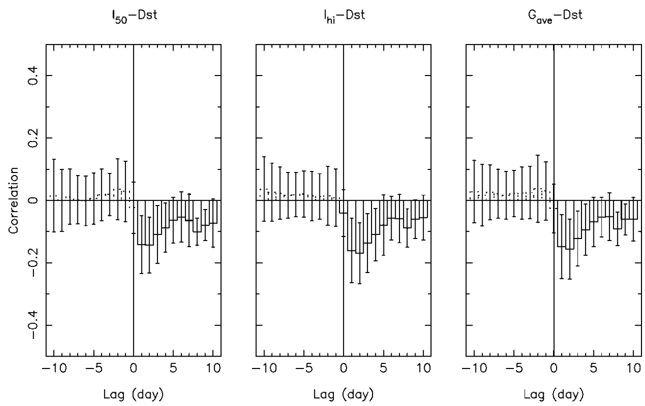
International collaboration for space weather forecast and heliospheric sciences

Since 1996, we have performed collaborative research with Dr. B. V. Jackson and his colleagues at the University of California, San Diego (UCSD) on the three-dimensional reconstruction of the time-varying heliosphere using tomographic analysis of IPS observations. A time-dependent tomography (TDT) program was developed for this collaborative study. Furthermore, a combined analysis system using IPS observations and an ENLIL solar wind model was developed to improve space-weather forecasting. These programs are now available on the NASA Community Coordinated Modeling Center web server and run in real time at the Korean Space Weather Center (KSWC) to predict solar winds reaching Earth. Furthermore, the IPS-driven ENLIL model installation is under consideration by the UK Met Office.

With growing awareness of the utility of IPS observations for space weather forecasting, an increasing number of IPS observations have been performed globally. In Japan, Russia, and India, where IPS observations have been performed for a long time, a new dedicated antenna for IPS observations was constructed in Mexico, and IPS observations using low-frequency large radio array systems, such as the low-frequency array (LoFAR, EU), were performed on a campaign basis. In this FY, the UCSD TDT evaluation was compared with the dispersion measures (DMs) of the pulsars obtained from LoFAR observations. DM represents the integrated plasma density along the line of sight of the pulsar. The observed DMs exhibited variations in the solar elongation angles. The variations in the observed DMs were consistent with the integrated plasma density of the solar wind derived from the TDT analysis. Furthermore, we collaborated with the research group of Dr. Bzowski (Poland) in this FY on the global modeling of solar wind distribution using ISEE IPS observations. Bzowski et al. studied the charge exchange process between solar wind plasma and interstellar neutrals and required a model that determines solar wind global distribution, evolving with solar activity is essential in their study. The model developed in this collaboration enabled reliable and continuous determination of the global distribution of solar wind and interpolation of gaps in IPS observations during winter. This result will contribute to a better understanding of Interstellar Boundary Explorer (IBEX) observations.

Study of solar wind disturbances using g-value data

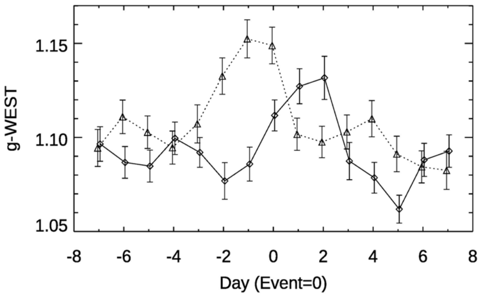
The space environment (space weather) near Earth drastically changes when the CME or stream interaction region (SIR) arrives, and its influence affects radio communications and electric power facilities on the ground. Therefore, early solar wind disturbances detection is essential. IPS observations, which are remote sensing techniques, may have the potential to detect solar wind disturbances earlier than *in situ* measurements at the L1 point. To apply IPS observations to space weather forecasts, we examined the variations in IPS data associated with the arrival of solar wind disturbances in this FY. We evaluated g-value data obtained from ISEE IPS observations during Solar Cycles 23 (SC23) and 24 (SC24). The g-value represents the relative change in the integrated level of solar wind density fluctuations along the line of sight. The g-value is equal to unity for quiet solar winds and increases above one when solar wind disturbances intersect the line of sight. We computed the IPS indices from the g-value on daily basis and compared them with the solar wind density and speed data observed *in situ* near Earth. We found weak but significant positive correlations between the IPS indices and solar wind density/speed. The correlation coefficients peaks occurred at a time delay of zero days for the IPS indices for density and at a time delay of 1–2 days for speed. This suggests that enhancements in the IPS indices represent the compression region at the IP shock front. We also compared the IPS indices with geomagnetic Dst indices and found weak but significant negative correlations with the IPS indices at a time delay of 1–2 days to the IPS indices. Additionally, we determined the annual variation in the occurrence rate of solar wind



Correlations between the IPS indices (I_{50}, I_{hi}, G_{ave}).

disturbances from the IPS indices and found that the occurrence rates tended to increase at the solar maximum and minimum, unlike the sunspot number. This can be elucidated by the combined effects of CME and SIR. The occurrence rates at the solar maximum for SC24 were lower than those for SC23, which is consistent with the solar activity weakening in SC24. Thus, these results demonstrate that the g-values are useful for detecting solar wind disturbances.

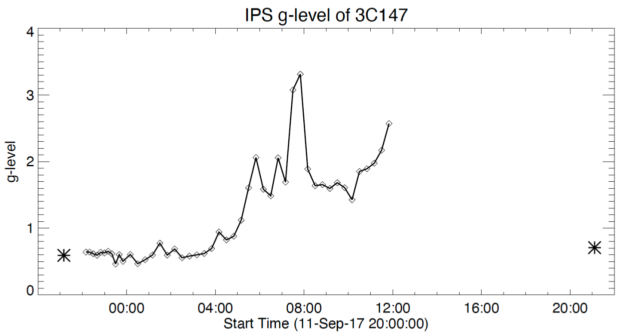
Additionally, the daily changes in the g-values were computed separately or on the East and West sides of the Sun, and the typical g-value profiles for ICME and SIR were obtained by Superposed Epoch Analysis. The results demonstrated a clear difference between the ICME and SIR profiles in the daily variation of the solar western g-value. That is, ICME (dotted line) had a maximum between -1 and 0 days, whereas SIR (solid line) had a maximum between +1 and +2 days.



Typical g-profiles of ICMEs and SIRs in SC23

Three-dimensional reconstruction of CMEs using MHD simulation with IPS data observed from radio sites ISEE and LOFAR

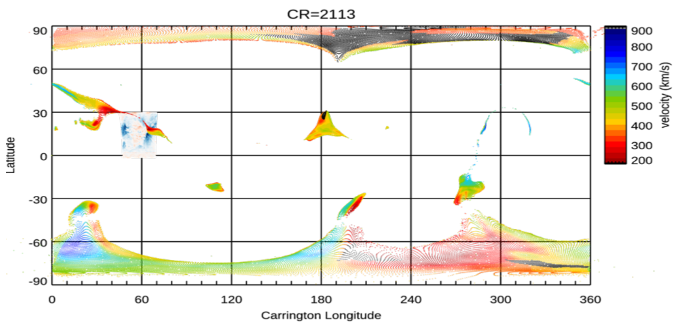
The IPS is a useful tool for detecting the interplanetary space of a CME. In this study, we demonstrated an MHD simulation that included IPS data from multiple ground-based stations to improve the 3D reconstruction of CME modelling. The CMEs, which occurred on 09–10, 2017, were observed from September 10 to 12, 2017, using the Low-Frequency (LOFAR) and IPS array of the Institute for Space-Earth Environmental Research (ISEE), Nagoya University, as they tracked through the inner heliosphere. We simulated CME propagation using a global MHD simulation called SUSANOO-CME. We found that the MHD simulation that best fitted both LOFAR and ISEE data provided a better CMEs 3D reconstruction and a forecast of their arrival at Earth than the measurements when these simulations were fit from the ISEE site alone. More IPS data observed from multiple stations at different local times in this study can help reconstruct the global structure of the CME, thus improving and evaluating CME modelling.



Time validation of the IPS g-level of a radio source 3C147 by ISEE (*) and LOFAR (◇)

Study on the relationship between plasma upflow and slow solar wind by Hinode/EIS and IPS observations

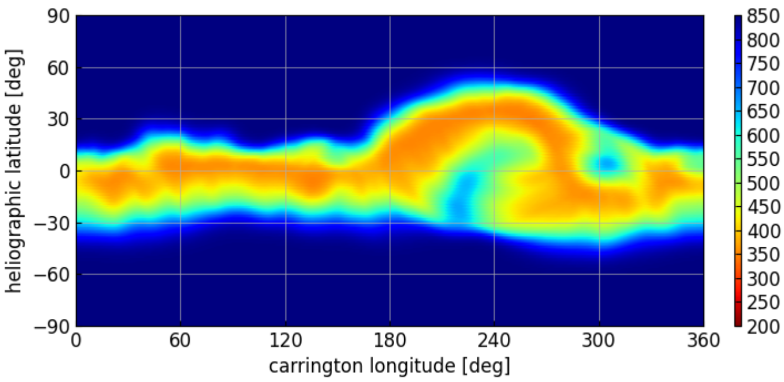
We studied the plasma upflows at both active region ends, which have been suggested to be the source of slow solar wind due to their elemental composition similarity to slow solar wind. We studied the relationship between the plasma upflow and open magnetic field lines by comparing the position of the upflow observed using an Extreme Ultraviolet Imaging Spectrometer (EIS) on the Hinode satellite and the photospheric magnetic field computed using the Potential-Field-Source-Surface (PFSS) model. The relationship between the plasma upflow and the open magnetic field lines was studied using the PFSS



The EIS data (rectangular area around 60° longitude) and the footprint at $R=1.01R_0$ (solar radius) of the open magnetic field determined by the PFSS were superimposed. The color represents the solar wind velocity to which the open magnetic field lines are connected. In this figure, the upflow is connected to the open magnetic field lines. A color figure is included in the PDF version.

model. Furthermore, using the IPS data, the solar wind velocity connected to the open magnetic field lines were evaluated. It was found that some upflows were magnetically connected to slow solar winds, whereas some upflows were trapped in a closed magnetic field. EIS data evaluation demonstrated that, in the upflow region connected to the closed magnetic field, the excess broadening of the spectral linewidth, called the nonthermal velocity, was larger than that in the open magnetic field region.

Optimization of DCHB model of the solar wind using IPS observation



Solar wind velocity map reproduced by the DCHB model

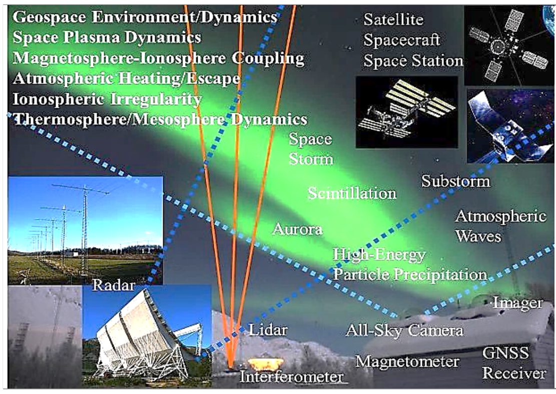
However, the sources of solar wind and its acceleration mechanisms are not yet completely understood. Several models have been proposed to empirically link the topology of the solar coronal magnetic field to solar wind velocity. We examined a solar wind model, the Distance of Coronal Hole Boundary (DCHB) model, using IPS data. The parameters of the DHCB model were optimized for the solar wind velocity data from the IPS observations, and the reproduced solar wind distribution was assessed. We computed the (PCC) between the solar wind speed reproduced by the DCHB model and that derived from the IPS observation and determined the parameters that maximize the PCC as the optimal parameters. Unlike *in-situ* observations, IPS observations enable the determination of the global distribution of solar wind speed. Therefore, the DCHB model can be validated more effectively using the IPS observations. In this evaluation, we also used the Potential Field Source Surface (PFSS) model to estimate the coronal magnetic field and magnetograms structure from the Air Force Data Assimilative Photospheric Flux Transport (ADAPT) as its lower boundary condition. Consequently, during the solar minimum, the PCC was as high as 0.81. This high correlation is mostly attributed to the excellent reproduction of the solar wind bimodal structure at the solar minimum by the DCHB model, and it is known that high- and low-speed winds dominate at high and low latitudes, respectively, at the solar minimum. It is also known that high-speed wind almost disappears at the solar maximum, and low-speed wind dominates at all latitudes.

Next generation IPS observation system

We promoted a next-generation solar wind observation system to dramatically improve IPS observations at the Division for Heliospheric Research. In FY2021, a Grant-in-Aid for Scientific Research (A) was adopted, and the construction of a core array with a scale of 5% of the total for Fuji Station began. In FY2022, we developed a digital backend system that can digitize 64-channel signals with eight AD modules installed directly below the front end and synthesize up to eight beams in real time with an FPGA array connected by optical fibers. All digital devices were delivered by the end of March. Additionally, we designed an antenna system. We considered the dipole- and Yagi-type antenna systems and developed their prototypes.

We promoted the next generation IPS observation system to propose it to “Future Plan for Academic Advancement.” We received a hearing from the Earth and Planetary Science community at the JpGU 2022 union session. This project was also proposed in a booklet summarizing the plans of the astronomy and astrophysics community. The proposal was submitted to the future academic promotion plan as a part of the “Study of coupling processes in the solar-terrestrial system” project by merging with some ground-based future projects of the upper atmosphere community.

Division for Ionospheric and Magnetospheric Research



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

The plasma and energy carried by the solar wind to the Earth and other planets exert physical effects on the magnetosphere and ionosphere, known as the geospace. We studied these effects and associated phenomena with 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 in our division. We also led the way to future space exploration missions based on our expertise.

Main Activities in FY2022

Measurements of aurora and electromagnetic waves at sub-auroral latitudes (PWING project)

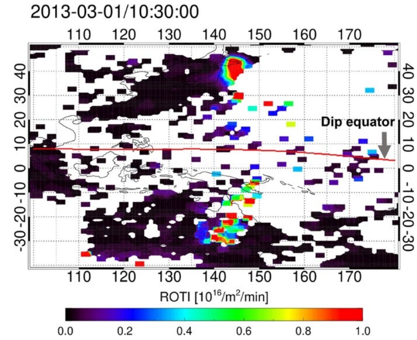
Since 2016, the PWING project has operated aurora/airglow imagers and electromagnetic wave receivers at eight stations around the North Pole at MLATs of approximately 60° (Canada, Russia, Alaska, Finland, and Iceland). They were used to investigate plasma and wave dynamics in the inner magnetosphere. The PWING project will be concluded at the end of FY2022, but the operation of the instruments will continue under the new PBASE program that was initiated in the second half of FY2022. Several new results have been obtained for FY2022. We determined the instantaneous longitudinal extent of Pc1 geomagnetic pulsations based on a statistical study of 1-year geomagnetic field measurements at seven ground stations at subauroral latitudes. A new report was made on spot-like ozone depletion in the upper stratosphere due to energetic particle accretion associated with Pc1 geomagnetic pulsations. Eight cases of simultaneous observations of nighttime medium-scale propagating ionospheric disturbances (MSTIDs) with the Arase satellite in the inner magnetosphere elucidated the conditions under which the electric field and density variations of the MSTIDs propagate into the magnetosphere. Several new results have been obtained predominantly through simultaneous satellite- and ground-based observations.

Upper atmosphere imaging using the OMTIs

We continued to operate the optical mesosphere thermosphere imagers (OMTIs) comprising of five sky-scanning Fabry-Perot interferometers, 21 all-sky charge-coupled device imagers, three tilting photometers, and three airglow-temperature photometers. OMTIs were used to investigate the dynamics of the mesosphere, thermosphere, and ionosphere. Several new results were obtained from OMTI measurements in FY2022. We succeeded in observing a low-latitude aurora at Rikubetsu, Hokkaido, Japan, for the first time in eight years. We elucidated the propagation characteristics of mesospheric atmospheric gravity waves and MSTIDs by using data from Darwin, Australia and Sata, Japan over a 10-year period.

Ionospheric disturbances observed by GNSS networks

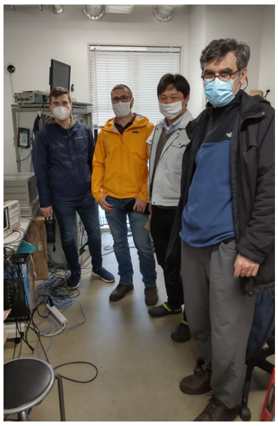
We developed a database providing global 2-dimensional total electron content (TEC) maps with high temporal and spatial resolutions including more than 20 years of data. We found that equatorial plasma bubbles extending to mid-latitudes have geomagnetic conjugate structures between both the Northern and Southern hemispheres during the main phase of a magnetic storm, and that the plasma bubbles disappeared earlier in the Northern hemisphere than in the Southern hemisphere. A comparison with Super Dual Auroral Radar Network (SuperDARN) radar data during geomagnetic storms on May 27 and 28, 2017 revealed that plasma density irregularities associated with plasma bubbles extending to mid-latitudes were observed by the radar.



Distribution of Rate of TEC Index (ROTI) during a magnetic storm. ROTI enhancement corresponding to plasma bubbles had a geomagnetic conjugate structure between Northern and Southern hemispheres (Sori et al., 2022).

SuperDARN Hokkaido HF radars

Using SuperDARN Hokkaido HF East and West radars in Rikubetsu, Hokkaido, we studied the ionospheric disturbances caused by the Tonga volcanic eruption. We compared them with GNSS TEC data to demonstrate that disturbances were observed in the Northern Hemisphere earlier than the arrival of pressure waves. This result was interpreted as the projection of a dynamic electric field onto the opposite hemisphere. We also studied the statistical characteristics of diverse Pc5 pulsation parameters and suggested that Pc5 waves observed at geomagnetic latitudes of 45–55° were global waves generated by solar wind disturbances. Additionally, we developed a full-spec imaging receiver system for implementation at the Hokkaido East Radar. Five international researchers visited the institute to perform joint research on diverse topics using SuperDARN and other ground-based satellite observation.



Group photo of the international technical exchange program activity between Canadian and Japanese scientists / engineers on the development of the SuperDARN imaging system

Promotion of EISCAT and EISCAT_3D projects

We proceeded with the EISCAT project in collaboration with the NIPR: (1) we performed 10 EISCAT SP experiments for Japanese colleagues, (2) we proceeded with the EISCAT_3D project, and (3) we held a special session for the Master Plan 2020 in JpGU2022. We also operated a photometer, an MF radar in Tromsø, and a meteor radar in Alta, Northern Norway, and collaborated with Japanese and international colleagues on mesoscale wind dynamics and sporadic sodium layers in the MLT region. By using all-sky digital camera images, we have created the “Tromsø AI” that can alert us when an auroral display shows up above Tromsø (69.6ºN, 19.2ºE).

Atmospheric stabilities in the polar upper mesosphere above Tromsø

We have studied atmospheric stabilities of the polar winter upper mesosphere region (80–100 km) using temperature and wind data of 6-min and 1-km resolutions obtained with the sodium lidar at Tromsø. The probability of convective (dynamic) instability varied from approximately 1% (4%) to 24% (20%), with a mean value of 9% (10%). The probability of convective instability demonstrates a dependence on the geomagnetic activity (local K-index) between 94 and 100 km, suggesting an auroral influence on atmospheric stability. The probability of dynamic instability demonstrates a solar cycle dependence, including a dependence on the 12 h wave amplitude. The probability of convective instability at Tromsø appears to be higher than that at middle/low latitudes, whereas the probability of dynamic instability is similar to that at middle/low latitudes.

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 with researchers from Japan, Scandinavian countries, and the US. This team commenced the "SDI-3D" project to deploy three SDIs in the same area as the EISCAT_3D, which might begin operation in 2023. In 2018, an international exchange program (or cross-appointment system) was established between Nagoya University and the University of Oulu (Finland). This was the first time for Nagoya University, and resulted in a faculty member staying at Oulu for three months in 2022. The development of SDIs has progressed satisfactorily to deploy them at three locations (two in Finland and one in Sweden) based on a budget awarded by the National Science Foundation from the US. As a preliminary work toward simultaneous observations with EISCAT_3D and SDIs, measurements from optical instruments (Fabry-Perot interferometer and all-sky imager), Dynasonde, and Swarm satellites were evaluated. This study presented a delay of approximately 10 min in the thermospheric wind reversal to ionospheric ion velocity reversal in the vicinity of an ionospheric trough (Oyama et al., 2022).

FACTORS mission for *in-situ* plasma observations by formation flight in the space–Earth coupling system

To realize simultaneous *in situ* observations of space-Earth coupling physical mechanisms using multi-satellite formation flight, a new space exploration mission, FACTORS, after the ERG (Arase) satellite mission has been proposed in the next small satellite mission category of ISAS/JAXA. Although the separation distance (1–50 km) between two satellites in polar orbit at 350–3500 km altitudes was planned to be controlled by new types of formation flight operations, our proposal has not been approved because the total cost of the mission and the new formation flight techniques would not meet ISAS/JAXA requirements. Countermeasures and further improvements toward mission reconstruction still need to be considered.

Experiments to lower the detectable energy of electrons using floating mode APD

We attempted to detect electrons with energies of less than several keV using the electrostatic acceleration of a floating-mode avalanche photodiode (APD). We succeeded in detecting down to 10-eV electrons due to 5-keV acceleration. We also performed experiments to install the APD at the electrostatic energy analyzer exit and detect electrons passing through the analyzer using a floating-mode APD. We verified that the floating-mode APD could detect down to 10-eV electrons while retaining the characteristics of the analyzer in terms of the energies and angles of the incident electrons.

Development of ion mass analyzing technology in combination with an electrostatic analyzer

We performed ion mass spectrometry experiments using an APD in combination with an electrostatic analyzer. In this experiment, we detected H^+, He^{2+}, He^+, and N^+ (as a substitute for O^+) from 5 to 80 keV/q. We found that we were able to distinguish between H^+ and He^{2+} at incident energies above 10 keV/q and between H^+ and N^+ at incident energies above 20 keV. Additionally, an experiment to accelerate ions by floating the entire APD at a -5 kV potential was also performed, and 5 keV H^+ was successfully detected by using the floating mode.

Magnetic field variations in pulsating auroras observed by the LAMP sounding rocket

We observed magnetic field variations in association with pulsating auroras using a magneto-impedance sensor magnetometer (MIM) carried by the Loss through Auroral Microburst Pulsations (LAMP) sounding rocket that was launched at 11:27:30 UT on March 5, 2022, from the Poker Flat Research Range, Alaska. At 200–250 km altitude, the MIM detected clear enhancements in the magnetic field by 15–25 nT. From simultaneous observations with the ground all-sky camera, we found that the LAMP footprint at an altitude of 100 km was located near the center of a pulsating auroral patch. These observations were compared with the results of a simple model computation, wherein local electron precipitation into the thin-layer ionosphere caused an elliptical auroral patch. We conclude that a pulsating auroral patch is fundamentally associated with a one-pair field-aligned current comprising downward (upward) currents at the poleward (equatorward) edge of the patch.

Development and deployment of a low-cost magnetometer using MI sensor

We made some modifications to commercially available magneto-impedance (MI) sensors, as they cover the geomagnetic field (±80,000 nT) range. We developed an instrument for ground measurements, including MI sensors, a Raspberry Pi-based data logger, and an A/D converter, which cost only approximately 1/10 of the usual cost of a fluxgate magnetometer. Experimental field observations over a few months demonstrated that the MI sensors could detect geomagnetic variations, such as Sq variations, geomagnetic storms, and geomagnetic pulsations. We named this instrument MIM-Pi and installed it at Kawatabi, Miyagi, Shirakami, and Aomori in the autumn of 2022 for continuous observations. In the future, we plan to deploy MIM-Pi in the Kanto-Tohoku region and construct a dense network of geomagnetic field observations. Network data will be used to estimate the plasma mass density in the inner magnetosphere. The operating principles of the MI sensor and its pilot observational results were published in *Journal of Geophysical Research*).

Data archives

The following data archives are available 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	http://reimei.stelab.nagoya-u.ac.jp/ (past) http://reimei.isee.nagoya-u.ac.jp/ (present)
Wp geomagnetic index	https://www.isee.nagoya-u.ac.jp/~nose.masahito/s-cubed/

Division for Meteorological and Atmospheric Research

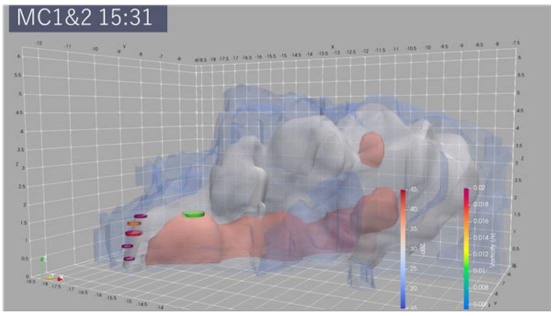
- Precipitation measurements by advanced polarimetric radars and hydrometeor videosondes
- Development of new instrumental technology
- Clouds and precipitation observed by multiple satellites
- Millimeter-wave/infrared spectroscopy of green house gases and ozone-depleting substances
- Measurements and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

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

Main Activities in FY2022

Analysis of misocyclones producing waterspouts using PAWR

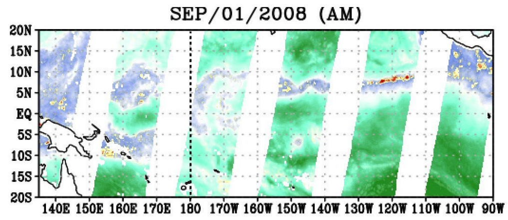
Phased Array Weather Radar (PAWR), the latest radar technology, is approximately 10 times shorter in observation time than conventional radar and can make three-dimensional observations with no gaps in the elevation direction, demonstrating its effectiveness in the analysis of torrential rains and tornadoes. In this study, we used NICT's PAWR in Onna Village, Okinawa Prefecture, to detect misocyclones, which are vortices less than 4 km in diameter in the parent cloud that generate waterspouts, and analyzed the changes in their three-dimensional structure along with the development of precipitation echoes. In this case, two misocyclones were detected at the leading edge of the developed echo. The analysis of vorticities demonstrated that the potential vorticities of earlier misocyclones increased with time, suggesting that the vortices were enhanced by the outflow from the dissipation of the strong echo.



Misocyclones and radar echo observed on May 15, 2017 at 15:31. The vorticity of the misocyclones is depicted in color, and the diameter of the vortex is depicted as the size of circles.

The edge intensification of eastern Pacific ITCZ Convection

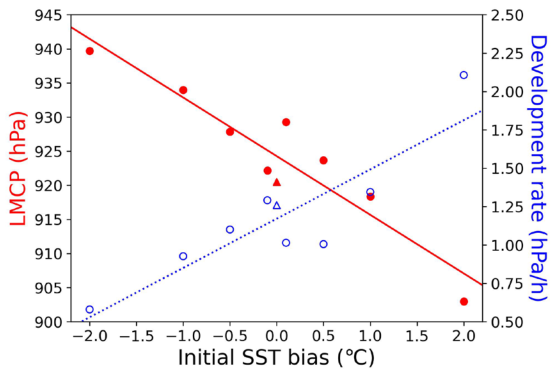
Tropical precipitation is climatologically most intense at the heart of the intertropical convergence zone (ITCZ); however, this is not always true in instantaneous snapshots. Precipitation is amplified along the ITCZ edge rather than at its center from time to time. In this study, satellite observations of column water vapor, precipitation, and radiation as well as the thermodynamic field from reanalysis data are analyzed to investigate the behavior of ITCZ convection in light of the local atmospheric energy imbalance. The key findings are as follows: When precipitation peaks at the ITCZ center, suppressed radiative cooling forms a prominent positive peak in the diabatic forcing to the atmosphere, which is counteracted by the export of moist static energy (MSE) owing to deep vertical advection and a large horizontal export of MSE. Conversely, when convection develops at the ITCZ edges, a positive peak of the diabatic forcing is only barely present. An import of MSE due to a shallow ascent on the ITCZ edges presumably allows edge intensification to occur despite the weak diabatic forcing.



Example of ITCZ edge intensification illustrated with column water vapor overlaid by precipitation

Intensity sensitivity of Typhoon Mindulle (2021) on initial SST

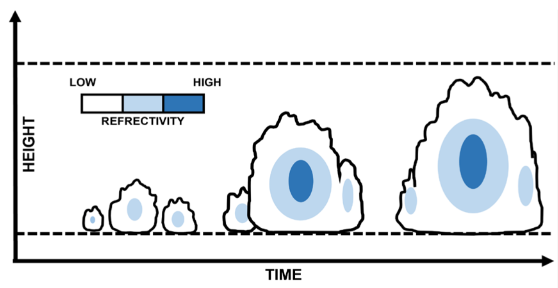
There is a strong relationship between sea surface temperature (SST) and typhoon intensity, and a small difference in SST may cause large differences in maximum intensity. However, SSTs given as initial conditions in numerical models have some types of uncertainty. To elucidate the sensitivity of typhoon intensity to initial SST values for Typhoon Mindulle (2021), one control and two sets of sensitivity experiments were performed using Cloud Resolving Storm Simulator (CreSS), a cloud-resolving model that incorporates a vertical 1-D ocean model. The sensitivity experiment set I examined the sensitivity of SST biases ranging from −2 to +2 °C in the initial SST. The results indicate that there is a clear negative correlation between the initial SST bias and lifetime minimum central pressure (LMCP), and a positive correlation between the initial SST bias and the intensifying rate in the development period from the initial time to the LMCP time (Figure). These results verify that the maximum intensity of a typhoon strongly depends on its initial SST bias. The sensitivity experiment set II examined the intensity sensitivity to perturbations ranging from ±0.01 to ±2.0 °C in initial SST. No correlation was found between the amplitude of the perturbations and the LMCP or the intensifying rate until the LMCP. This indicates that the forecast error of the typhoon intensity does not depend on the amplitude of the random error of the initial SST values.



Scatter diagram of the initial SST bias, LMCP, and intensifying rate. Black circles and triangles (left axis) indicate the LMCP, and white circles and triangles (right axis) indicate the intensifying rate. Dotted lines represent regression lines.

Early detection of rapidly developing convective echoes using a Ka-band radar

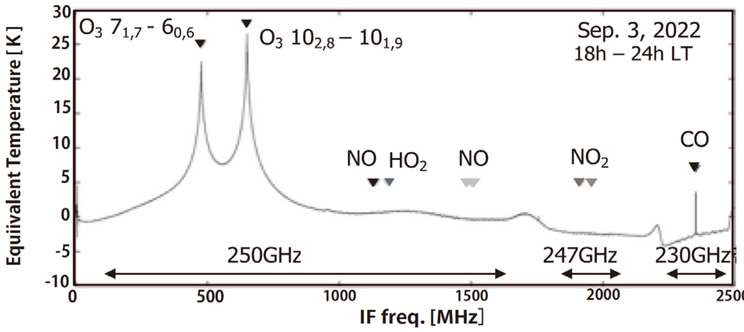
The rapid development of isolated convective cells bring about sudden heavy precipitation. This study attempts to early detection of developing isolated convective echoes using horizontal distributions of reflectivity obtained every 2 min by a Ka-band radar installed in Kobe City in the summer of 2018. We define the "developing" convective echoes as the maximum rainfall intensity exceeds 20 mm/h in an isolated convective precipitation region obtained every 1 min by the X-band radar network. Fourteen convective echoes are analyzed on August 6 and 16, 2018, and two echoes are evaluated as the developing convective echoes. There is no significant difference in the time series of the vertically averaged reflectivity (VAR) between the developing and non-developing echoes; however, the time series of the VAR area of the developing echoes is clearly larger than those of the non-developing echoes. The developing echoes tend to merge with the surrounding small/weak echoes and rapidly increase their are.



Conceptual model of the time series of early development of a convective precipitation cell. Shading depicts the reflectivity obtained by the Ka-band radar.

Simultaneous multi-line observations for understanding the process of atmospheric composition changes in the polar regions due to precipitating energetic particles

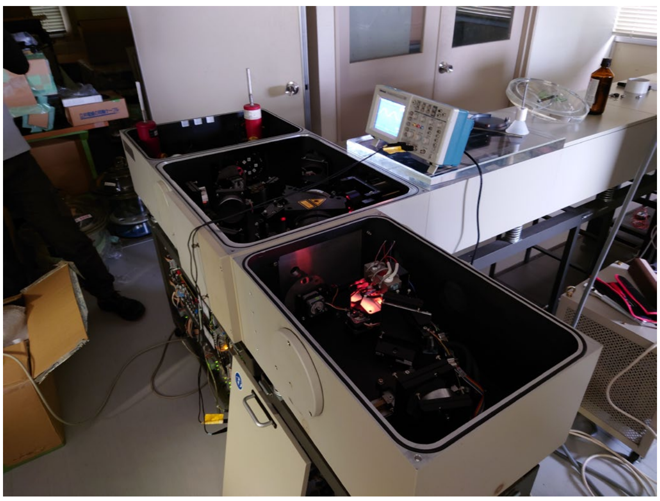
Millimeter-wave spectral radiometers have been installed at Syowa Station in Antarctica and at the EISCAT facility in Tromsø, Norway, to comprehend the effects and mechanisms of composition changes in the middle atmosphere caused by energetic charged particles precipitating into the polar regions as a result of solar activity. At Syowa Station, we began simultaneous multi-line observations in 2020 by modifying the receiver to multi-frequency using a waveguide multiplexer that we developed independently. However, because it could not achieve the expected performance as initially planned, owing to component defects, further modification of the receiver system was initiated in January 2022. The receiver cooling system was improved to achieve a minimum temperature of 4.9 to 5.0 K and a temperature instability smaller than 50 mK (p-p), resulting in a receiver noise temperature of 120 to 235 K (SSB). Furthermore, with the implementation of a superconducting filter in the receiver system and the extension of the bandwidth of the digital spectrometer to 2.5 GHz, the frequency bands of O_3, NO, CO, NO_2, and HO_2 emissions can now be observed as initially planned. In particular, for NO, the simultaneous observation of six hyperfine structure lines in the 250 GHz band improved the signal-to-noise ratio and reliability of the data. However, we could not perform observations in Tromsø in FY2022 owing to the COVID-19 pandemic.



Example of spectral data obtained by simultaneous multi-line observations of the new millimeter-wave spectral radiometer at Syowa Station

Establishment of an urban air quality monitoring site using high-resolution FTIR in Nagoya, Japan

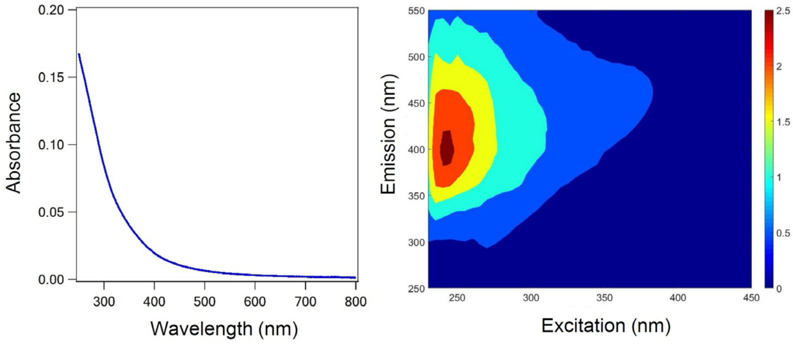
ISEE newly installed a high-resolution Fourier Transform Infrared spectrometer (FTIR) at the Higashiyama campus of Nagoya University and measured the tropospheric and stratospheric minor constituents, including air pollutants in the urban area. The air pollutants are harmful and induce health issues; therefore, their long-term variability is crucial for protecting air quality in urban areas. Various minor constituents in the troposphere and stratosphere can be retrieved simultaneously from a solar absorption spectrum measured using a ground-based high-resolution FTIR spectrometer. Therefore, it is one of the most powerful tools for this purpose. We built up the FTIR spectrometer and measured the instrumental line function. Additionally, the installation of a solar tracker and meteorological instruments at the site is in progress. The vertical distribution and column amount data for more than 20 species of the minor constitutes obtained from the monitoring observations with the FTIR in ISEE will be made publicly available as part of the ISEE Joint Usage/Research program.



Nagoya Higashiyama FTIR system under optical alignment

Analysis of the light absorption property of organic aerosol

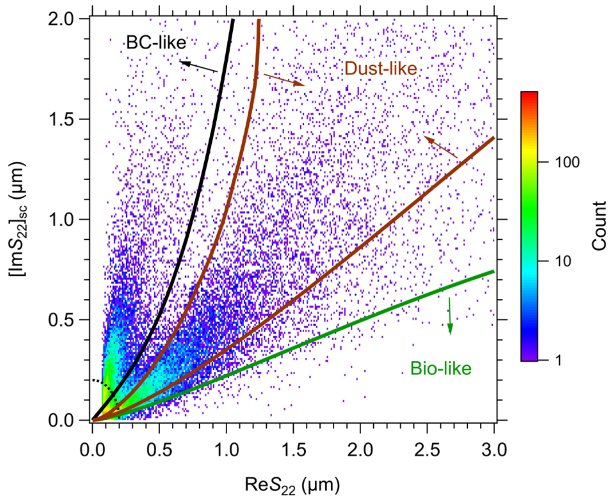
The absorption of solar radiation by atmospheric organic aerosols, in addition to that by black carbon, would affect the radiation balance and chemical reactions in gas and particle phases. Therefore, understanding the relationship between the types of organic aerosols and their light absorption properties is important to comprehend the roles of organic aerosols and their evolution processes in the atmosphere. In this study, we analyzed the light absorption properties of organic aerosol components in atmospheric aerosol samples collected during the COALA-2020 campaign in Australia. The results demonstrated that the mass absorption efficiency of organic aerosol components extracted from the aerosol samples on carbon basis (wavelength: 365 nm) was closely associated with the relative abundances of tracer compounds in biogenic secondary organic aerosols and biomass burning organic aerosols. Both of these aerosols are considered to be originated from biomass, but emitted through different pathways. This result is expected to contribute to the understanding of the contribution of these two pathways to the contrasting light absorption properties. We also measured the fluorescence spectra of the samples to further characterize the studied organic aerosols.



Examples of light-absorption and fluorescence spectra measured for the extracts (water-insoluble organic aerosol components) from atmospheric aerosol samples collected in Australia (Courtesy of Sonia Afsana)

Evaluation of a method to measure water-insoluble aerosol particles

Water-insoluble aerosol particles (WIAPs), such as black carbon (BC) and mineral dust, affect climate by interacting with radiation and clouds. However, methods for identifying WIAP types and quantifying their number concentrations are limited, leading to an insufficient understanding of their atmospheric abundance and behavior. In this study, we classified WIAPs and quantified their number concentrations using a novel approach, wherein atmospheric aerosols were collected on a filter, dispersed in water, and the complex scattering amplitude (S) of individual particles was measured. The complex scattering amplitude depends on the complex refractive index, volume, and shape of particles. The WIAPs collected from the urban atmosphere of Nagoya in the spring of 2021 were classified as BC-like, dust-like, and Bio-like particles based on their complex amplitude data. The number concentrations of BC-like particles were strongly correlated with the number concentrations of refractory BC particles measured by another instrument. BC-like and dust-like particles were the dominant WIAPs during the observation period, and the number concentrations of dust-like particles significantly increased during an Asian dust event, which was consistent with the electron microscopy analyses observations. These results indicate that our method has the potential to become a new technique for quantifying the spatio-temporal distributions of WIAPs under various atmospheric environments.



Complex amplitude (S) data for all particles from filter samples collected in Nagoya. The colored bar indicates the number of detected particles. Lines for particle classification into BC-like, dust-like, and Bio-like particles are also depicted.

Division for Land–Ocean Ecosystem Research

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

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

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

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

Main Activities in FY2022

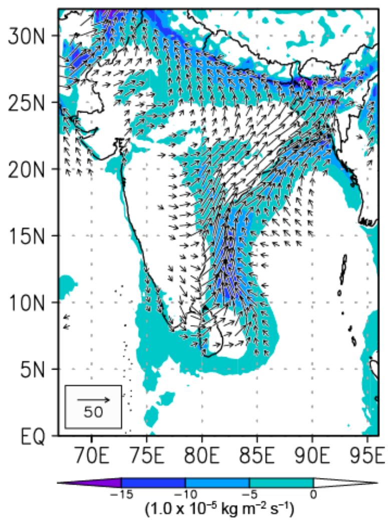
Contribution of summer net precipitation to winter river discharge in permafrost zone of the Lena River basin

Winter discharge from the Lena River in eastern Siberia has increased over recent decades. However, the impact of permafrost thawing and changing hydrological processes induced by climate change on the winter discharge of rivers has not been well quantified. Herein, using a coupled land surface and a distributed discharge model, we performed trend evaluations to examine the sensitivity of winter discharge to permafrost thawing and water budget changes in the Lena River basin from 1979 to 2016. An increasing trend in winter baseflow was found in the upper part of the Lena River basin, where the summer net precipitation demonstrated a statistically significant increase. The increased summer net precipitation resulted in higher soil moisture in the deepened active layer in late summer and early autumn, which was linked to the autumn and winter baseflow. These implications were examined from the perspective of the interrelations among the trends in active layer thickness, soil moisture, and baseflow in the cold season by identifying regions, wherein all variables exhibited positive trends. The identified source regions were primarily in the upper and lower parts of the Lena River basin, although winter baseflow was more dominant in the upper regions owing to the freezing effect of the active layer in the lower region. The thinning of river ice induced by warming temperatures also contributes to an increase in winter river discharge. These results suggest that increased winter discharge was strongly associated with the climate change-related enhancement of permafrost thawing and an increase in net precipitation that affected soil hydrological processes, which will be strengthened further in the context of global warming.

(Reference: Hiyama, T., H. Park, K. Kobayashi, L. Lebedeva, D. Gustafsson (2023): Contribution of summer net precipitation to winter river discharge in permafrost zone of the Lena River basin. *Journal of Hydrology*, 616, 128797, doi:10.1016/j.jhydrol.2022.128797)

Nocturnal southerly moist surge parallel to the coastline over the western Bay of Bengal

Nocturnal precipitation is a well-known phenomenon around the Himalayas and the Meghalaya Plateau in South Asia during the summer. Such precipitation is a major supply source for glaciers in the central and –eastern Himalayas and the headwaters of major rivers, such as the Ganges and Brahmaputra. In this study, we demonstrate that low-level moist southerlies are significantly enhanced at night parallel to the coastline over the western Bay of Bengal (BoB), and then flow onto the Gangetic Plain, enhancing moisture transport toward land and nocturnal precipitation in South Asia. We refer to this phenomenon as a nocturnal southerly moist surge. This nocturnal surge was strongly affected by the diurnal cycle of the thermal and topographic effects of the Indian subcontinent. At night, a strong low-level westerly jet appears above the nocturnal stable layer over the Indian subcontinent. Strong low-level southwesterlies with a low-level jet structure also appear over the western BoB, extending from the strait between the southernmost tip of the Indian subcontinent and Sri Lanka. The low-level westerlies flowing from the subcontinent and the southwesterlies merge into a single strong southwesterly flow, forming the low-level moist surge over the western BoB.

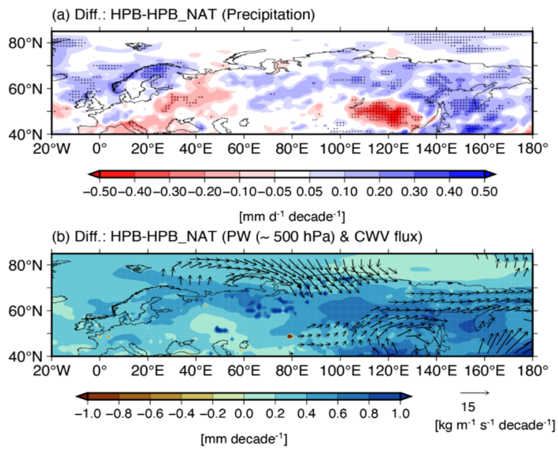


Difference in water vapor flux (vectors) and its divergence (shading) between nighttime (23:00–02:00 LT) and daily mean values

(Reference: Fujinami, H., T. Sato, H. Kanamori, and M. Kato (2022): Nocturnal southerly moist surge parallel to the coastline over the western Bay of Bengal. *Geophysical Research Letters*, 49, e2022GL100174, doi:10.1029/2022GL100174)

Impacts of global warming on summer precipitation trend over northeastern Eurasia during 1990–2010

Summer precipitation in Siberia increased significantly during the 2000s, particularly in eastern Siberia. However, the mechanism controlling this increase in precipitation remains obscure. This study investigated the impact of global warming on summer precipitation over northeastern Eurasia using large-ensemble data from historical warming and non-warming simulations for the period 1990–2010. The positive summer precipitation trends across Siberia reproduced in the ensemble mean of the historical simulation were similar to the observed data; however, the negative trends observed over northeast China and Mongolia were not found in the ensemble mean. An empirical orthogonal function analysis was applied to the summer precipitation trend over Siberia for each

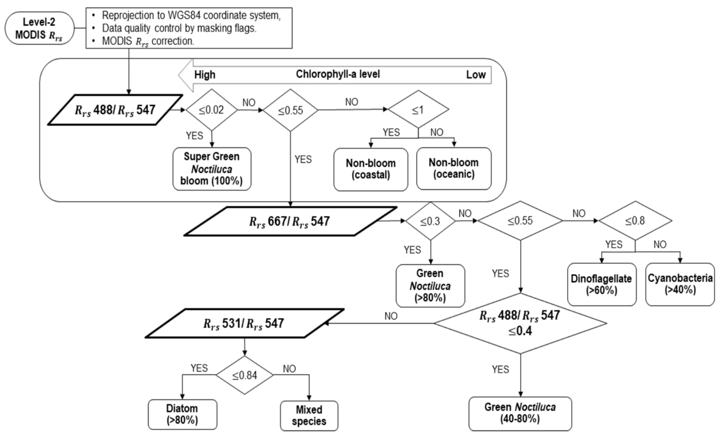


The composite differences in the linear trends of (a) summer precipitation and (b) column water vapor flux and low-level precipitable water between the warming and non-warming experiments contributed to the strength of the westerly moisture flux over eastern Siberia simulation to extract the members with a precipitation trend pattern similar to that of the observations. The first leading mode in each simulation demonstrated an increase (decrease) in precipitation over eastern Siberia (northeast China), which is consistent with the spatial features of the observations. In the extracted members, the spatial pattern of the cyclonic (anticyclonic) circulation trend over the northern parts of eastern Siberia (northeast China), associated with decadal and multidecadal variations, was amplified by global warming, resulting in an increasing trend of the westerly moisture flux into eastern Siberia from western Siberia (Figure). Additionally, surface heating in northeast China, enhanced by global warming, may have concurrently intensified the cyclonic circulation over eastern Siberia. Furthermore, the results suggest that the reduced extent of Arctic sea ice coverage played a role in strengthening the cyclonic circulation over eastern Siberia and enhancing water vapor transport from the Arctic Ocean, which contributed to the strength of the westerly moisture flux over eastern Siberia.

(Reference: Kanamori, H., M. Abe, H. Fujinami, and T. Hiyama (2023): Impacts of global warming on summer precipitation trend over northeastern Eurasia during 1990-2010 using large-ensemble experiments. I*nternational Journal of Climatology*, 43, 615-631, doi:10.1002/joc.7798)

Algorithm development for satellite-based green *Noctiluca* red tide and the seasonal variation in the Upper Gulf of Thailand

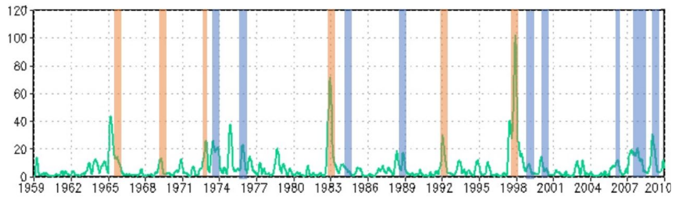
Red tides of diverse species occur in coastal tropical areas, and in recent decades, red tides of green Noctiluca scintillans red tides have been particularly frequent. In this study, we developed a red-tide classification algorithm for a satellite ocean color sensor in the upper Gulf of Thailand (uGoT) to study seasonal variations in red tides. High green *Noctiluca* concentrations demonstrated clear spectral characteristics at blue to green and red to near-infrared wavelengths with *in situ* remote-sensing reflectance observations. According to the red tide spectral characteristics, a classification algorithm using remote sensing reflectance of 488, 531, and 667 nm normalized to the value of 565 nm was developed to distinguish between green *Noctiluca* red tides at three concentration levels and other red tides (dinoflagellates, diatoms, blue-green algae, and mixed species), including offshore and coastal waters in non-red tide conditions (Figure) . Monthly composite data from MODIS from 2003 to 2021 revealed seasonal variations in the surface distribution and frequency of green *Noctiluca* and other red tides during the Southwestern (May–September) and Northeastern (October–January) monsoons. Green *Noctiluca* red tides occurred more offshore from the shore and estuaries than other red tides (dinoflagellates and blue-green algae) and occurred more frequently than other red tides between the mouths of the Tachin and Chao Phraya rivers during non-monsoon periods (February–April). The frequency and distribution of green *Noctiluca* and other red tides varied during the monsoon season. By comparing the red tide distribution identified by the satellite with factors caused by the monsoon (ocean wind, precipitation, and river flow), we were able to elucidate, the spatiotemporal distribution of red tides across the uGoT under Asian monsoon conditions. This study will help us comprehend the impact of climate change on phytoplankton dynamics.



Red tide classification algorithm in the upper Gulf of Thailand

(References: Luang-on, J., J. Ishizaka, A. Buranapratheprat, J. Phaksopa, J. I. Goes, E. R. Maure, E. Siswanto, Y. Zhu, Q. Xu, P. Nakornsantiphap, H. Kobayashi, and S. Matsumura (2023): MODIS-derived green *Noctiluca* blooms in the upper Gulf of Thailand: Algorithm development and seasonal variation mapping. *Frontiers in Marine Science*, 10, 1031901, doi:10.3389/fmars.2023.1031901)

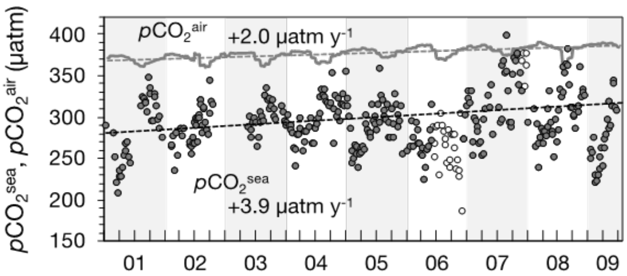
Zonal interaction of interannual oceanic waves in the Tropical Pacific



Peak values of the energy-flux stream function [Watts] in the eastern equatorial Pacific Ocean

This study examined how oceanic upper-layer wave motions associated with El Niño and La Niña events and play a role in the interaction between the western, central, and eastern parts of the ocean basin from the energy circulation perspective. Recent studies have made it possible to trace wave energy circulation paths by tracing group velocity vectors without any borders between the equatorial and mid-latitude dynamics. It is not possible to trace or quantify the generation, transfer, and dissipation of perturbations in a chain simply by displaying the distribution of these energy-flux vectors on a map. To resolve this problem, this study proposes a method to apply Helmholtz decomposition to the energy flux distribution and diagnose the time series of the peak values of the stream function and potential components. This time series implies that the energy flux is integrated across its path, and its time variation can be compared with a well-known index in climate studies called the Niño 3. In making this comparison, we note that the energy fluxes in this study demonstrate eastward transfer events during both El Niño and La Niña events and cannot distinguish between downwelling and upwelling Kelvin waves. However, the Niño 3 index, which represents climatological anomalies in sea surface temperature in the eastern equatorial Pacific, can distinguish between downwelling and upwelling Kelvin waves, whereas its quantitative meaning reflects only the physical component related to potential energy and does not consider the physical component related to kinetic energy. This study aims to resolve these problems and provide useful validation using the output of hindcast simulations for 51 years.

Rapid increase of surface water pCO_2 during 2001–2009 in Sagami Bay

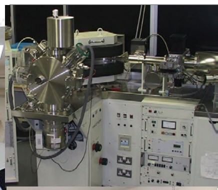


Time series data for (a) pCO_2^{sea} (circle) and atmospheric pCO_2 (pCO_2^{air}, solid line) in the central part of Sagami Bay from 2001 to 2009

Little Little is known about the rate of increase in coastal seawater pCO_2 (pCO_2^{sea}) despite its necessity for evaluating future oceanic CO_2 uptake capacity. We examined temporal changes in pCO_2^{sea} in central Sagami Bay during 2001–2009. The weekly pCO_2^{sea} was reconstructed using a time series of the particulate organic carbon isotope delta (POC-δ^{13}C) of settling particles at 150 m from moored sediment trap deployments. For pCO_2^{sea} estimation, an empirical relationship between suspended POC-δ^{13}C and aqueous CO_2 concentrations from repeated ship observations in 2007 and 2008 was applied to the trapped POC-δ^{13}C. The air–sea CO_2 flux was calculated using the air-sea pCO_2 difference with the gas transfer velocity. The estimated Bay pCO_2^{sea} varied by 190 μatm (mean 294 μatm) and was mostly below atmospheric pCO_2 (pCO_2^{air}), resulting in a mean oceanic CO_2 uptake of 30 g m^{-2} y^{-1}, suggesting that Sagami Bay is an efficient sink for atmospheric CO_2. Meanwhile, carbon sequestration to the mesopelagic layer by particulate carbon export accounted for 60–75% of the CO_2 uptake, with the rest likely removed horizontally via surface water exchange. The pCO_2^{sea} demonstrated an increasing trend of +3.9 μatm y^{-1}, approximately twice that of pCO_2^{air}, resulting in the two converging. Concurrently, a decreasing trend in POC export flux and an increasing trend in the nitrogen isotope delta of the trapped particles were observed. A large summer pCO_2^{sea} increasing rate (+4.9 μatm y^{-1}) was observed accompanied by POC concentration decreasing, which resulted in a decrease in CO_2 uptake over time. Long-term summer nutrient depletion and reduced primary production may increase pCO_2^{sea} in the bay.

(References: Mino, Y., C. Sukigara, A. Watanabe, A. Morimoto, K. Uchiyama-Matsumoto, M. Wakita, and T. Ishimaru (2023): Rapid increase of surface water pCO_2 revealed by settling particulate organic matter carbon isotope time series during 2001–2009 in Sagami Bay, Japan. *Journal of Oceanography,* 79, 317–331, doi:10.1007/s10872-023-00688-3)

Division for Chronological Research



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

Short- and long-term forecasts of global environmental changes and their countermeasures are urgent issues. Determining when an event occurred in the past, via "dating," is important for understanding the present state of the Earth and predicting its future. We promote chronological studies on a broad range of subjects, from events in Earth's history, spanning 4.6 billion years, to archeological materials, cultural properties, and modern cultural assets.

The Division for Chronological Research conducts interdisciplinary research involving radiocarbon (^{14}C) dating using accelerator mass spectrometry to understand changes in the Earth's environment and the cultural history of humankind from approximately 50,000 years ago to the present day, as well as research on and development of new ^{14}C analyses and dating methods. In addition, the laboratory studies near-future forecasts of Earth and space environments, focusing on spatio-temporal variations in cosmogenic nuclides, such as ^{14}C and ^{10}Be, and conducts research that integrates 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 have shed light on events in Earth's history from its formation 4.6 billion years ago to approximately 1 million years ago. An electron probe microanalyzer (EPMA) has been used to perform nondestructive microanalyses of rocks and other materials to reveal records of complex events recorded in zircon, monazite, and other samples.

Main Activities in FY2022

Validation of the stability of the West Antarctic ice sheet of the Amundsen Sea sediment core

A sector of the West Antarctic ice sheet draining into the Amundsen Sea is currently experiencing the largest ice loss in Antarctica, and there is serious concern regarding a large-scale ice collapse in this area caused by global warming. The International Ocean Discovery Program Expedition 379 drilled two sites in the Amundsen Sea area of the Southern Ocean using the D/V JOIDES Resolution. The shipboard physical properties and sedimentological data of sediment cores demonstrated strongly variable physical properties, high diatom abundance, and ice-rafted debris occurrence from 4.2 to 3.2 million years ago. This was interpreted to have been caused by the dynamic West Antarctic ice sheet during an extended warm period (Gohl et al., 2021; Wellner et al., 2021; Gille-Petzoldt et al., 2022). Further research is expected to elucidate the stability of the West Antarctic ice sheet and the linkage between West Antarctic ice sheet changes and climate change.

An ice sheet in the Amundsen Sea, West Antarctica

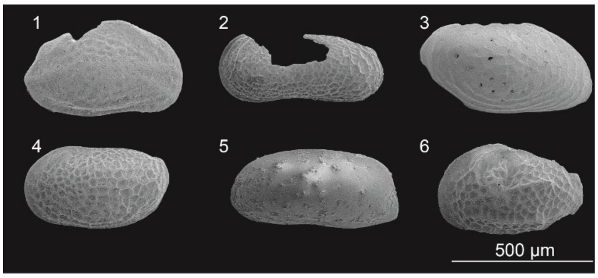
Radiocarbon dating of Ezo-Nishiki silk fabrics

In Japan, silk fabrics, known as Ezo Nishiki, are distributed throughout the Hokkaido and Tohoku areas of the Honshu Islands. On Ezo Nishiki, elegant designs of dragons, huge snakes, peonies, and other animals or plants are laced with gold, silver, and other color threads. Although silk fabrics were originally made in China as cloth for the uniformity of government officials, they were also given to the chieftains of the tribes and Amur Basin villages and imported into Sakhalin Island over the Mamiya Strait. Trade was performed by indigenous peoples in the Amur Basin and Sakhalin Island, including the Nivkh, Nanai, and the Ul'ch. Santan is a generic name for the indigenous people living in the Amur Basin and Sakhalin Island. Silk fabrics were then spread southward into Hokkaido Island by the Ainu people living on Sakhalin and Hokkaido islands. Silk fabrics were brought to Honshu Island in Japan through the trade between the Ainu and Matsumae clans, which ruled the southwest edge of Hokkaido. The route in which the Ezo Nishiki was introduced from China to Japan via the Amur Basin and Sakhalin Island is called "the Silk Road of Northeast Asia" and the trade is called the Ezo-NishikiSantan trade. Although the origin of the trade was obscure, Ezo-Nishiki radiocarbon dating indicated that it began at the end of the 14th century or the early 15th century, when Emperor Yongle of the Ming Dynasty (1368–1644) expanded their territory.

The Ezo Nishi silk wrapping cloth was owned by the Esashi Town Board of Education (photograph presented by the Esashi Town Board of Education)

The analysis of fossil ostracod assemblage from the Sakari Shell Mound in Minamichita Town, Chita District, Aichi Prefecture

The melting of glacier ice and ice sheets has been reported to increase the sea level associated with global warming since the 20th century, and the rise in sea level after several hundred years has been estimated by several researchers. Estimating sea-level changes in the future based on these data on the paleo-environment and sea level is important to predict the highly sensitive sea level. To reconstruct the paleo-environments and sea-level changes, we studied the reconstruction of the sea-level curve using fossil ostracods during the Holocene around Japan. In this study, a borehole core was excavated from the Mazukari shell mound in Minamichita to reconstruct its paleoenvironment and paleowater depth based on fossil ostracod assemblages. Six species belonging to five ostracods genera were found in a sample at approximately 9,600–8,600 cal BP. Meanwhile, the paleo-water depth was estimated to be 12 m based on a comparison with the fossil ostracod assemblage in this study and modern ostracod assemblages from Ise Bay. (In this sample, we used the part of the archival document "Mazukari shell mound unearthed information materials" of the Minamichita town board of education.)



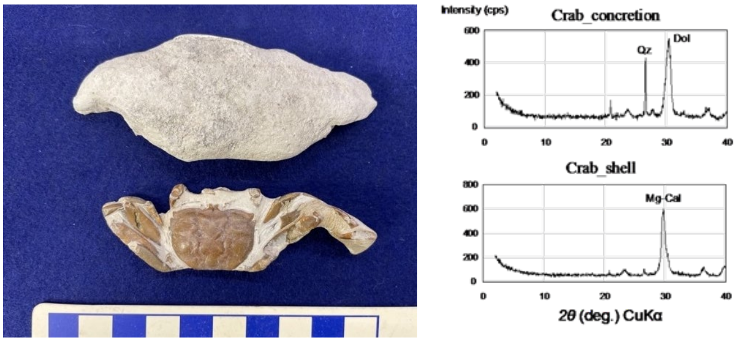
GSEM photographs of the selected ostracod species

Radiocarbon dating to bronze implement

Radiocarbon dating is a useful method for samples containing carbon derived from CO_2 in the atmosphere. Verdigris, $CuCO_3$ and $Cu(OH)_2$, is the rust produced on bronze implements. The reactants used were bronze, copper, and CO_2 in the atmosphere. When a verdigris is formed, it is a closed film that restrains the generation of new rust. Therefore, the verdigris should preserve atmospheric carbon when formed. We improved the carbon extraction method using $CuCO_3$ and $Cu(OH)_2$. We then applied this method to archaeological samples of known age, measured radiocarbon ages, and accumulated examples of verdigris radiocarbon dating to demonstrate that verdigris is suitable for radiocarbon dating.

Radiocarbon age of Holocene carbonate concretions at Nagoya and Shimizu port

Carbonate concretions occur in diverse geological formations worldwide. We studied carbonate concretions from Nagoya and Shimizu ports. Concretion samples often contain biological remains, and organic matter, such as organisms, and is thought to be involved in the formation of concretion. To elucidate the formation process of concretions, it is important to conduct geochemical evaluations of concretions with known formation ages. In this study, to elucidate the formation rate of concretions, we measured ^{14}C and δ^{13}C ages of the shell and concrete parts of concretion samples collected from the Nagoya and Shimizu ports The ^{14}C ages of the shells are approximately 7850–7600 cal BP (Nagoya port) and 7700–7500 cal BP (Shimizu port), and the ^{14}C ages of the Shimizu port concretion are approximately 7840–7620 cal BP. Conversely, the ^{14}C age of the Nagoya port concrete part was older than the ^{14}C age of the encapsulated shell; however, after age correction by estimating the contribution of soil organic carbon with old age from the δ^{13}C value, the age was close to that of the shell (8000–7800 cal BP). Oyama (2009) reported that the area near the mouth of the Nagoya port changed from marine transgression to regression at 7800–7300 cal BP, suggesting that the carbonate concretions in the Nagoya and Shimizu ports formed rapidly after the death of organisms in an environment with the highest sea level and stagnant currents. Further research is expected to estimate sea level and paleoenvironmental changes during the sea level rise of the Jomon period. (Minami, Kuma et al., 2022, J*ournal of Geology*, 128, 239-244.)

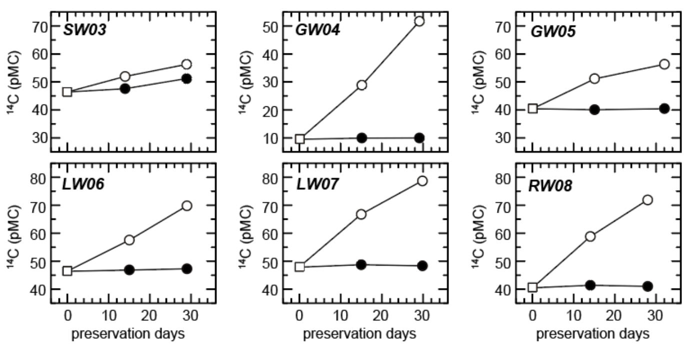


Left: Concretions and inclusions of crab fossils collected from the Nagoya port
Right: Mineral composition of crab shell and concrete (Qtz: Quartz, Cal: calcite, Dol: dolomite) From Minami et al. (2022)

Effect of benzalkonium chloride addition on ^{14}C analysis of dissolved inorganic carbon

The ^{14}C concentration of dissolved inorganic carbon (DIC) in water is an important indicator of the actual state of biological activity and other conditions in seawater and terrestrial water. However, after sample collection and storage, the ^{14}C concentration may change owing to DIC formation or decomposition by microbial activity in the sample water. Sterilization with $HgCl_2$ is commonly used to prevent DIC changes due to microbial activity; however, the use of mercury, which has a high environmental impact, is highly restrictive. Therefore, we investigated benzalkonium chloride (BAC) as a disinfectant that can be used to disinfect medical devices and that is easy to handle.

We investigated the changes in ^{14}C concentrations in DIC due to microbial activity during water storage and found that ^{14}C concentrations in natural waters (groundwater, seawater, river water, and lake water) without BAC increased considerably in two weeks, whereas all BAC-added water samples, except seawater, demonstrated no change in ^{14}C concentrations. Furthermore, the incorporation of carbon into the water sample due to the BAC decomposition or microbial degradation by BAC was negligible in the ^{14}C analysis. These results indicate that BAC is very effective in ^{14}C analysis of freshwater samples as an inhibitor of DIC changes, although to a lesser extent in seawater samples.(Takahashi and Minami, 2022, *Limnol. Oceanogr.: Methods,* 20, 605–617)



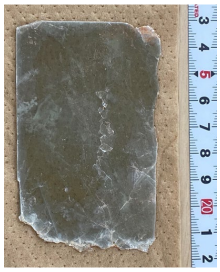
^{14}C concentrations in natural water samples (seawater: SW03; groundwaters: GW04, GW05; lake waters: LW06, LW07; river water: RW08) for approximately 15-d and 30-d preservation periods (□ : initial water, ○ : BAC-free water, ● : BAC-added water)

Direct search for dark matter using minerals

Approximately a quarter of the universe is thought to be occupied by an unknown elementary particle called dark matter. Dark matter is an unknown elementary particle with mass that hardly interacts with ordinary matter and cannot be directly observed optically. Diverse studies have been performed to detect dark matter.

In recent years, a direct search for unknown elementary particles, such as dark matter, using minerals has attracted attention. When dark matter interacts with atoms in minerals, it leaves tracks in the crystals. Using minerals on a geological timescale, it is possible to realize a sensitivity exceeding that of large-scale experiments, even with small samples. For example, 100 mg of a 100-million-year-old mineral has a sensitivity equivalent to that of a 10-year experiment with 1 t material (e.g., liquid xenon).

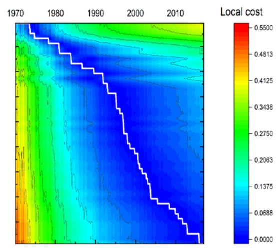
In FY2022, a feasibility study of the optical readout of tracks was performed by focusing on muscovite. Additionally, we obtained muscovite specimens for which a sufficient number of samples were available for future proof of principle. We carried out dating of the muscovite sample using the K-Ar method, and an age of approximately 650 million years was obtained. In the future, we will aim to directly search for unknown elementary particles using diverse minerals, including the muscovite sample.



Muscovite sample

A growth curve estimate of Christ's thorn jujube in Northcentral Oman determined by a series of radiocarbon measurements

Ziziphus spina-christi, also known as Christ's Thorn Jujube, is a deciduous species. It is distributed in warm-temperate and subtropical regions, including North Africa, Southern Europe, the Mediterranean, Australia, tropical America, Southeast Asia, and the Middle East. This tree was used as a medicinal plant in ancient Egypt. Due to its extensive range of applications in human health, its commercial demand is increasing. Recently, habitat area expansion was observed in the Mediterranean region. It is speculated that this expansion may have been facilitated by the rise in temperature caused by global warming, although the exact cause remains unknown. This study was performed to comprehend the effects of temperature and precipitation on the growth of mature Ziziphus spina-christi trees and to gain insights into their future geographical distribution. To construct the growth curve of Ziziphus spina-christi, which lacks clear annual rings, a 24 cm-long core sample was collected from Northcentral Oman and subjected to radiocarbon dating. Time-series data comprising approximately 100 radiocarbon measurements were compared with a carbon-14 calibration dataset using the dynamic time wrapping (DTW) method. By aligning the data, we were able to determine temporal changes in the growth rate of Ziziphus spina-christi and shed light on how it is affected by climate change.



Estimating growth curve of Omani Christ's Thorn Jujube using DTW method

A special support project for regional contribution in FY2022, "How do we determine the ages of rocks and archeological sites?”

On March 18 and 25, 2023, an experiential learning program targeting upper elementary school students was implemented. On the first day, a large bus was chartered to visit the Nakatsugawa City Mineral Museum, where students learned about the formation of granite and quartz. They also used a portable radiation detector to measure the radiation levels in rocks and minerals. Additionally, they had the opportunity to create micromounted quartz specimens. On the second day, the program took place at Nagoya University, where students learned about radioactive materials, radiation, natural radiation levels, and radiometric dating. Each student created a cloud chamber and observed the emission of radiation by placing a pitchblende sample inside. This experiential learning provided a valuable experience that could not be obtained through regular school life and served as a catalyst for increasing interest of children in natural and earth science.

Children measuring radiation levels in Naegi granite

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 to develop ground-based observation networks and international satellite projects and to host international workshops or conferences. It also supports international exchanges between overseas 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 5-year fixed term until FY2020. However, another 5-year term (FY2021–2026) for continued activity was approved by Nagoya University.

The phenomena contained in solar activity have various timescales, from solar flares and coronal holes, to the 11-year cycle, and further long-term variations. World scientists are greatly interested in these types of solar activities and their consequences on the 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 entitled "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 using modeling, measurements, and data analysis while strengthening the communication between scientists and users. The President of SCOSTEP is also a member of the CICR and is responsible for operating this international program. On January 8, 2021, ISEE and SCOSTEP exchanged a Memorandum of Understanding to define the conditions under which ISEE will contribute to SCOSTEP activities. In agreement with this Memorandum of Understanding, the 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 operates ground-based observation projects, such as the EISCAT radar project, OMTIs, the ISEE VLF/ELF and magnetometer network, SuperDARN radar network (including the Hokkaido HF radars), and the Arctic Challenge for Sustainability operation office. It also has four domestic observatories at Moshiri, Rikubetsu, Fuji, and Kagoshima, which conduct observations of the solar wind, geomagnetic field, and upper atmosphere. Some of these observations have been conducted for more than 30 years.


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

Main Activities in FY2022

In FY2022, CICR performed the following international collaborative research: 1) Twenty International Joint Research programs for domestic scientists; 2) twenty-three ISEE International Joint Research programs, inviting researchers from overseas; 3) two ISEE/CICR International Workshops; 13) ten International Travel Support programs for field and laboratory experiments by students and early career scientists; 14) four International Technical Exchange programs; 15) two ISEE International School Support programs; and 16) two International Travel Support programs for students. Two designated professors from overseas were hired through cross-appointments with U.S. universities and institutions. Four English-speaking staff members were hired to provide the administrative support. In collaboration with the SCOSTEP, the CICR hosted four international online seminars and four online lectures for students in FY2022. It has also supported six graduate students in their presentations at international conferences. Through the PRESTO program (2020–2024), the CICR published four newsletters in FY2022 (April, July, October, and January). The CICR also supports three international schools in Nigeria, Spain, and Finland. Nine students from India, Nigeria, Ethiopia, Egypt, and the United States visited the ISEE for three months for collaborative research under the SCOSTEP Visiting Scholar program.


SCOSTEP/PRESTO NEWSLETTER

Vol. 34, January 2023

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Article 1:

Interoperable Database for Citizen Science Observations of STEVE

Michael Hunnekuhl[1]
[1]Independent Scientist, Germany

Michael Hunnekuhl

STEVE (Strong Thermal Emission Velocity Enhancement) is a subauroral aurora-like phenomenon that is related to untypical high temperatures and ion drift velocities in SAID (Subauroral Ion Drift). Citizen Scientists recognized the peculiarity of this phenomenon and brought it to the attention of the scientific community. Figures 1 and 2 show photographs from two STEVE observations in Canada. MacDonald et al. [1] reported for the first time on the connec-

Figure 1. Steve observed on April 10 2018 in Alberta, Canada. Credit: Alexei Chernenkoff.

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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 about the EISCAT_3D radar were organized with foreign EISCAT associate members. The PWING project continued running eight stations around the North Pole at MLATs of ~60° connecting the OMTIs, ISEE magnetometer, and ELF/VLF networks. A research project entitled "Pan-Arctic Water-Carbon Cycles (PAWCs)" was funded for 2019–2024. PAWCs are designed to integrate atmospheric–terrestrial water and carbon cycles in northern Eurasia, for which very limited data on the fluxes of greenhouse gases exist.

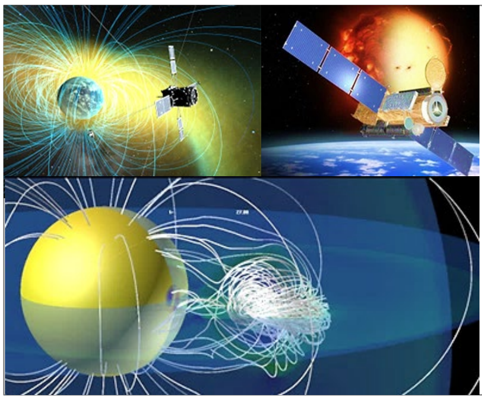
Our four domestic observatories will continue to operate until FY2022. The Moshiri Observatory became an unmanned observatory in FY2018, but has continued to run electromagnetic instruments, such as auroral photometers, magnetometers, and ELF/VLF receivers. The fluxgate and induction magnetometers will be repaired in 2021. 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 radars for ionospheric disturbances, and an ELF atmospheric receiver.

Multistation IPS observations using Fuji, Kiso, and Toyokawa antennas were performed between April and December 2021. However, IPS observations at Kiso stopped due to a serious failure of the antenna and did not restart in this FY, despite intensive restoration. The Kiso Observatory was opened to the public on August 6, 2022.

The Kagoshima Observatory and Sata Station operate an all-sky camera, a photometer for airglow detection, VLF/LF radio wave receivers, and induction magnetometers in collaboration with Tohoku University, the University of Electro-Communications, Chiba University, and the Georgia Institute of Technology.


Rikubetsu Observatory

Center for Integrated Data Science (CIDAS)



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

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

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

The Center for Heliospheric Science (CHS), which is responsible for the development and release of integrated analysis tools and data files from Arase, Mio, Hinode, and SOLAR-C, including ground-based observations and simulations, is operated by ISEE, Nagoya University, ISAS/JAXA, and NAOJ. For this purpose, 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. CIDAS mints DOIs for ISEE research data (DOI prefix: 10.34515) to ensure permanent accessibility and promote the reusability of the data. CIDAS has also joined the inter-university network project (Inter-university Upper atmosphere Global Observation NETwork: IUGONET) with Tohoku University, NIPR, Kyoto University, Kyushu University, and Nagoya University to develop a metadata databases server and data analysis software. CIDAS is responsible for activities in ISEE as a member of the High-Performance Computing Infrastructure Consortium (HPCI) in Japan.

Research and development of advanced simulations

CIDAS plays a leading role in researching and developing 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 model was designed for all types of parallel computers to simulate the detailed structure of clouds and storms. CReSS is free to use for the scientific community. It has been used for meteorological research and real-time weather forecast experiments, such as simulation experiments of tropical cyclones, heavy rainfall events, snow clouds, tornados, and downscaling experiments of future tropical cyclones cyclones.

Main Activities in FY2022

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

Scientific data from the ERG (Arase) satellite, ground-network observations, and modeling/simulations were archived at the Center for Heliospheric Science (CHS), which is operated by ISAS/JAXA and ISEE/Nagoya University. The format of these data files is CDF, and includes the metadata of each file. This is a de facto format in the solar–terrestrial physics community. The Space Physics Environment Data Analysis System (SPEDAS), a commonly used software in the solar–terrestrial physics community, can easily read and manipulate CDF files. The CHS has developed CDF files and SPEDAS plug-in software for the ERG project. We also joined the International Heliosphere Data Environment Alliance to discuss common data formats in the international framework. The CHS has organized training sessions for SPEDAS in Japan and Taiwan, providing important opportunities to learn to use SPEDAS and ERG data. The CHS is also developing a data analysis environment for the CIDAS system. Users can access the CIDAS system via the internet and analyze ERG project data using SPEDAS (https://ergsc.isee.nagoya-u.ac.jp/research/index.shtml.en). The CHS is also working for development of the Mercury magnetospheric orbiter Mio (MMO) data files and related tools based on the heritage of the ERG project.

Synthesis of infrared Stokes spectra in an evolving chromospheric jet

Chromospheric jets are believed to play an imperative role in energy and mass transfer within the solar chromosphere, although their driving mechanisms remain unknown. Accurate measurements of magnetic fields are essential to identify these mechanisms. We performed a full Stokes synthesis in the infrared range using a realistic radiative magnetohydrodynamic simulation to generate a chromospheric jet and predict spectropolarimetric observations from the Sunrise Chromospheric Infrared Spectropolarimeter (SCIP) aboard the SUNRISE III balloon telescope. The jet's launch was initiated by the collision between the transition region and upflow, driven by the ascending motion of the twisted magnetic field at the flux tube's envelope. This motion aligns with the upwardly propagating nonlinear Alfvénic waves. The upflow can be detected as continuous Doppler signals in the Ca ii 849.8 nm line at the envelope, where the dark line core intensity and strong linear polarization coincide. The axis of the flux tube was bright in both the Fe i 846.8 and Ca ii 849.8 nm lines, with the downflow plasma inside it. Our study's predicted structure, time evolution, and Stokes signals will enhance future spectropolarimetric observations with SUNRISE III/SCIP.

IUGONET activity

IIUGONET 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 FY2022, the IUGONET metadata schema was updated, and metadata were recreated as they followed the international standard. Furthermore, we defined and implemented a mapping from the metadata schema used in the field of space physics to a general schema used for academic information distribution and converted our metadata. The converted metadata were registered in the Nagoya University institutional repository so that research data could be searched from a vast range of communities. We also developed a web-based XML file input system that allows data providers to easily create metadata to mint DOI.

Operation of the CIDAS supercomputer system

A new computer system for integrated data analysis (CIDAS computer system) was installed on April 2021. The system consists of 16 compute nodes, each of which has two Intel Xeon Gold 6230R CPUs and 384 GiB memory. In FY2022, 140 researchers/students were registered as users of the CIDAS supercomputer system. Data analyses related to the Hinode Science Center and ERG/Arase Science Center and computer simulation studies were conducted.

Development of the CReSS model

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

Center for Orbital and Suborbital Observations (COSO)

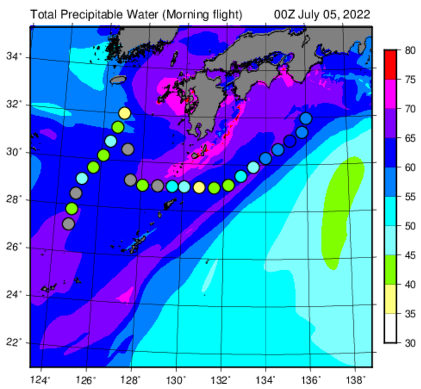
- Establishment of an aircraft observing system
- Aircraft observations of cloud, aerosol and typhoon
- Solar observation missions using micro satellites
- Studies of multiple small satellite operations for future space science exploration programs
- Human resource development for space applications
- Promotion of Earth observing satellites

Based on ISEE research objectives, which encompass natural phenomena ranging from the Earth's surface to outer space, the Center for Orbital and Suborbital Observations (COSO) is expected to perform empirical and advanced research through observation, especially through collaboration among industry, academia, and government, leading to remarkable technological developments for aircraft, balloons, sounding rockets, and spacecraft observations. COSO aims to be the core of aircraft observation in Japan and investigates and promotes future space exploration missions to obtain new knowledge of physical phenomena in 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 observations. The Hydrospheric Atmospheric Research Laboratory contributed to the Virtual Laboratory with four universities using X- and Ka-band radars, together with numerical model studies. The Space Exploration and Research Office (SERO) is undertaking nanosatellite and human resource development programs for space applications. The Aircraft Observation Promotion Office was established in FY2021 to further promote aircraft observations in Japan.

Main Activities in FY2022

Promotion of aircraft observations

Aircraft observations of Typhoon Nanmadol were performed using dropsondes on September 16 and 17, 2022. Nanmadol was a super-typhoon that rapidly intensified and made landfall in Kagoshima at its fourth lowest pressure. We made penetrating observations of the eye twice daily, and 50 dropsondes were launched. A detailed analysis is currently underway. As part of the SIP program, we performed aircraft observations of water vapor and optimized the aircraft observation system on July 5, 2022, over the East China Sea. High-frequency observations of the horizontal and vertical water vapor profiles on the upwind side of the precipitation area were performed. Although the numerical model forecast demonstrated a large area of precipitable water around East China Sea, the aircraft observation results indicated that the amount of precipitable water was considerably lower than the numerical model results. Observations also indicated that the variability of precipitable precipitation was large in fine scales. Drop sonde observations were also performed on these flights within the framework of the joint usage program of the ISEE. In the research project under the MLIT program, aerosol measurement system, cloud nuclei counter, and ice nuclei counter were installed on NASA/DC-8, and observations were performed in Florida and Cape Verde. They participated in simultaneous aircraft and ship observations of aerosols and clouds in the western North Pacific during the summer of 2022. New analytical methods have been introduced, particularly for solid aerosols, which act as important ice nuclei.



Precipitable water computed by CReSS at 09:00 JST on July 5, 2022, and the precipitable water (circles with color) obtained from drop-sonde observations.

Aircraft Observation Promotion Office

A proposal was submitted as a joint proposal by the Meteorological Society of Japan, the Atmospheric Chemistry Society of Japan, and the Japan Society for Aeronautical and Space Sciences to the "Future Science Promotion Initiative," the successor to the Science Council of Japan's Master Plan. Additionally, ten aircraft observation seminars were held.

Hydrospheric Atmospheric Research Laboratory

From June to August 2022, joint observations of the Baiu fronts and typhoons were performed on Yonaguni Island jointly with the United States (Colorado State University) and Taiwan. Synchronized observations were performed using C-band radar by the U.S. and X-band radar by ISEE, and continuous sonde observations were performed jointly by Japan and the U.S.

Investigations on the ground operation system realizing the formation flight observations of multiple satellites by the orbital controls due to the aerodynamics

Multiple satellite missions performing formation flight observations are required to modify the conventional ground operation system to control and maintain the formation flight configurations of multiple satellites. Functions of the ground system need to be incorporated to accomplish quick satellite orbit determination based on GPS data and the precise prediction of satellite orbit corrections by computing atmospheric drag characteristics during perigee passage based on a precise model of the terrestrial upper atmosphere and the accurate control of satellite attitudes. The modified ground operation system is also used to generate onboard programs, so-called "timelines," to implement accurate satellite attitude control for the required precise satellite orbit corrections. System functions newly incorporated to the current ground system for multiple satellite missions should perform the above procedures within three days.

Solar observation mission using nanosatellites

We are developing a solar neutron and gamma-ray detector intended for nanosatellites weighing less than 10 kg. Nanosatellites are chosen because they have more launch opportunities than 50-kg satellites, such as ChubuSat. Although we planned to launch an engineering prototype in October FY2022 in the framework of the JAXA Innovative Satellite Technology Demonstration-3 program and it was unsuccessful due to a failure of the launch vehicle. Subsequently, we submitted a new proposal for a scientific instrument to the JAXA Innovative Satellite Technology Demonstration-4 program. We added functionality to send quick information on the space weather detected by the instrument via low-power, wide-area network technology. This proposal was not selected for the program partly because many proposals from the previous failed launch were selected. Currently, we are developing an engineering model which will be proposed for the JAXA Innovative Satellite Technology Demonstration-5 program.

Space Exploration and Research Office (SERO)

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. The development of nanosatellites is one of the most critical SERO research activities. Educational activities are also important in SERO. We held a basic 2-week training course in August/September and an advanced 2-week training course in March. There were 61 applicants for the basic course and 53 for the advanced course. More than 85% of the applicants were from outside Nagoya University and more than 50% of the applicants were from industries.

Promotion of observations using Earth-observing satellites

Led the algorithm development team for GPM/DPR and promoted the development of PMM mission of JAXA as a project scientist. An algorithm for estimating phytoplankton species was developed and used to identify red tides. Regarding future missions, mission proposals (precipitation and oceanographic observations) were made to the TF Remote Sensing subcommittee.

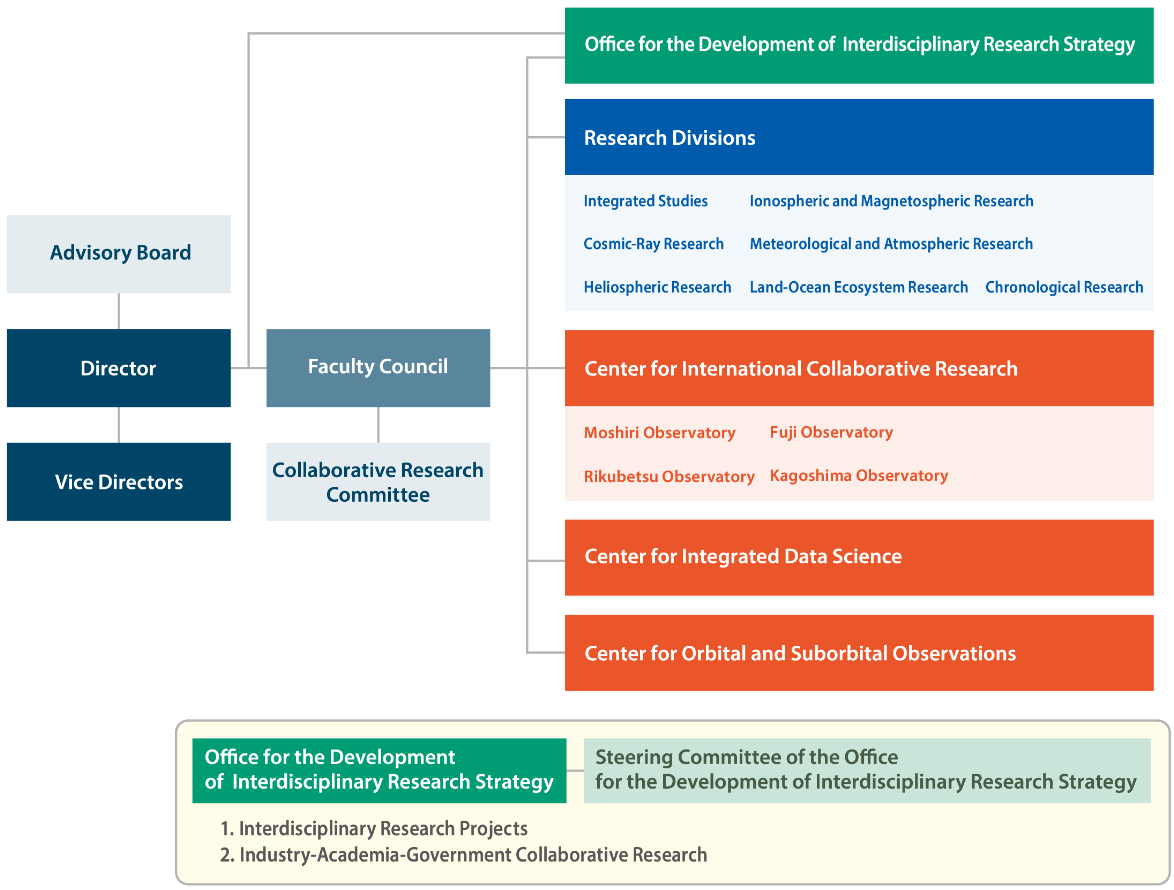
Office for the Development of Interdisciplinary Research Strategy

One of the major objectives of the ISEE is to encourage the development of new interdisciplinary research by merging Space and Earth sciences. It was established by August 2022 the Office for the Development of the Interdisciplinary Research Strategy (ODIRS). The ODIRS will promote interdisciplinary studies in cooperation with scientists in related fields based on their specialties in diverse ISEE research topics. Additionally, the ODIRS office will also benefit from the ISEE's involvement as a joint usage/research center. This will facilitate 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, the directors of three affiliated centers, and a foreign faculty member from the Center for International Collaborative Research. Additionally, and two designated faculty members were recruited to serve concurrently in the ODIRS starting 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 a vast range of fields.

Additionally, in 2022, under the leadership of the Institute's Director (General Manager), 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



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

Research aims and background

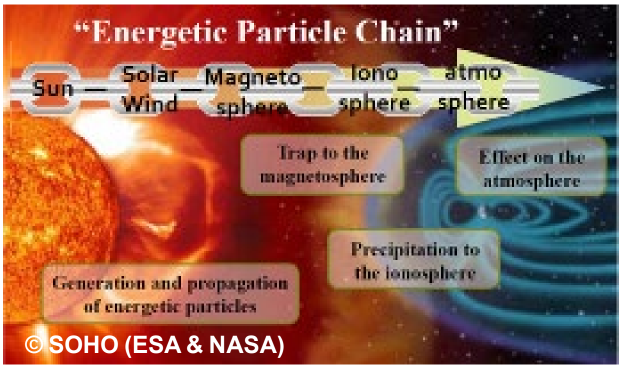


Fig.1: Image of a causal chain reaction system.

Energetic particle precipitation (EPP) due to solar activity, such as solar proton events and magnetic storms, occurs in polar regions. EPP particles create odd nitrogen (NO_x) and odd hydrogen (HO_x), which can affect the neutral chemistry of the middle atmosphere and the ozone (O_3) concentration. This is related to a problem which is one of the key questions in the SCOSTEP/PRESTO program: "What is the chemical and dynamical response of the middle atmosphere to solar and magnetospheric forcing?" To answer this, 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 in each region and comprehensive simulations.

In this context, we started a new research project called the energetic particle chain. This project plans to conduct multi-point and long-term observations of the trapped particles in the magnetosphere with the Arase satellite, EEP-induced ionization in the ionosphere with the EISCAT_3D radar and riometers, and the variation of atmospheric molecules from the lower thermosphere to the upper stratosphere with millimeter-wave spectroradiometers in the polar region of the Northern Hemisphere (Fig.2). These measurement data will be used as inputs and constraints in modeling, such as integrated simulation codes of EPP, ion chemistry in the atmosphere, and global dynamics/temperature fields. Measurements are also useful for assessing the validity of the model output.

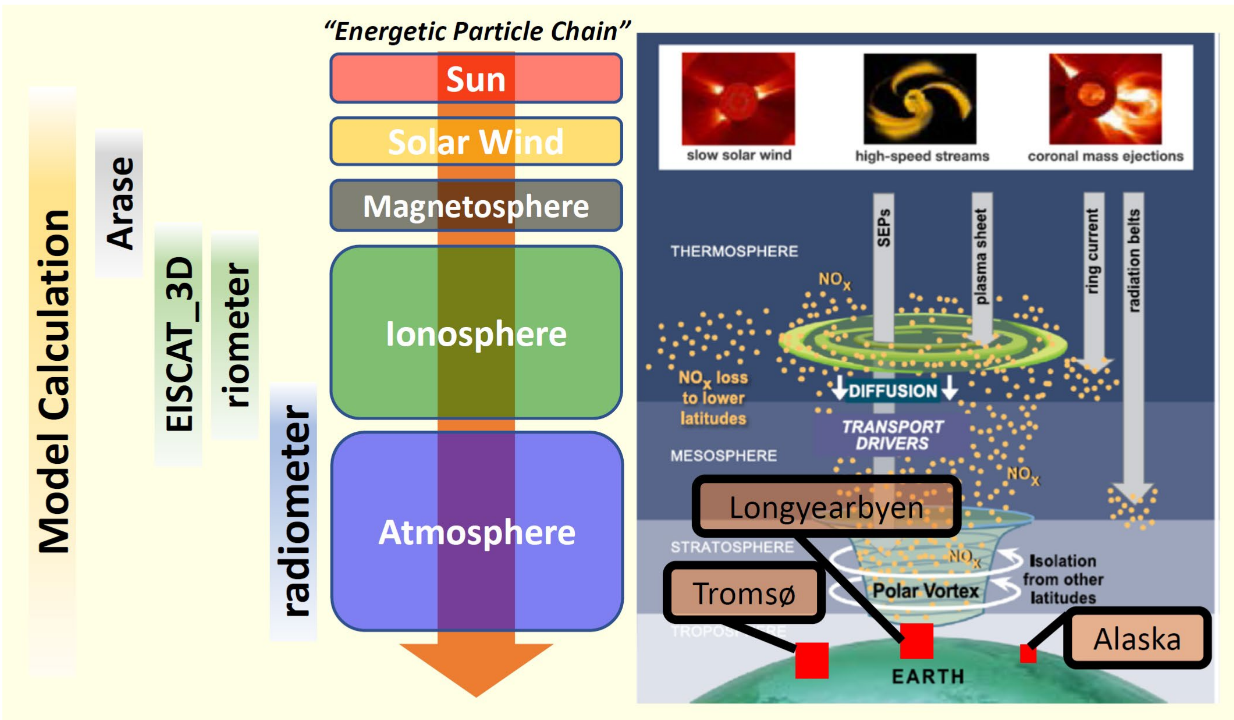


Fig.2: (left side) Observational region with each instrument and data fusion with simulation. (right side; modified from Marshall et al., 2020) Relationship between the energetic particle precipitations and new observation sites.

Main Activities in FY2022

Organization of international consortium

We have begun collaborative studies on model computations and ionospheric observations at the University of Oulu and the Finnish Meteorological Institute (FMI) in Finland. To model the middle atmosphere change due to EPPs, we invited Prof. Pekka Verronen in FMI as a visiting professor at ISEE from February to May 2023. Additionally, we have tried a new challenge to investigate the effect of EPPs on the lower atmosphere, which is the troposphere and ground-level environment, to further extend the Energetic Particle Chain. Researchers from the Divisions for Land Ocean Ecosystem, Cosmic-Ray, and Ionospheric and Magnetospheric Research were included as consortium members.

Development of a simulation code for electron precipitation

We have extended a model of wave-particle interaction - optical auroral emission - Cosmic Noise Absorption (CNA) computation to 1) compute scattering by quasi-linear wave-particle interaction due to ambient whistler-mode waves using stochastic differential equations, and 2) implement a method to compute nonlinear scattering and contribution to the electron precipitation when the magnetospheric chorus wave amplitude is increased. The results demonstrated that nonlinear wave-particle interactions, called phase trapping and dislocation, demonstrate different electron dynamics than those expected from the quasi-linear approach.

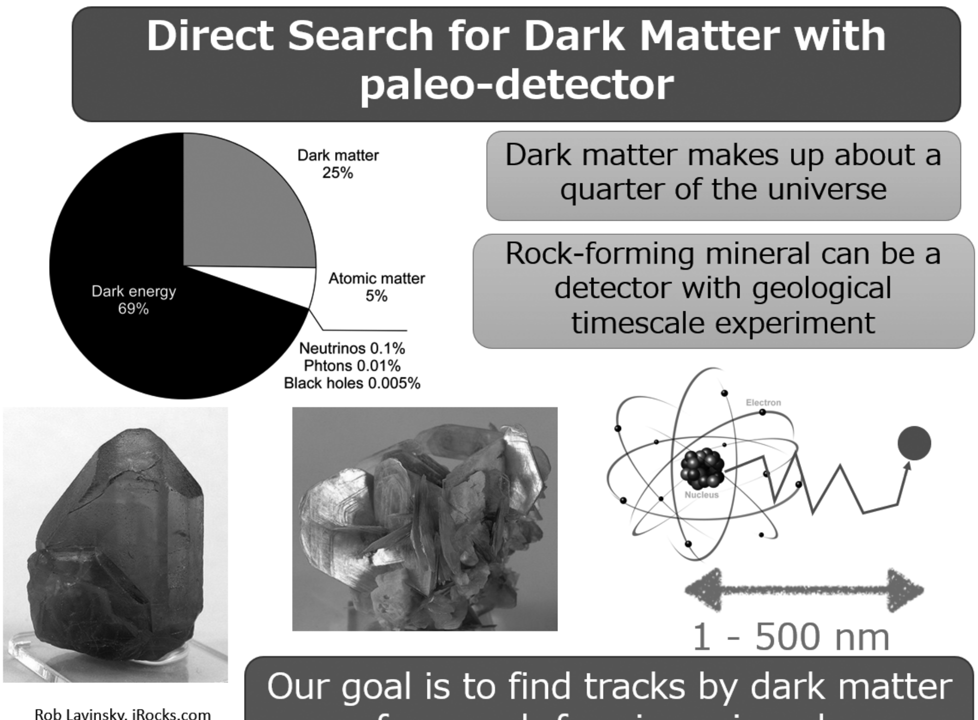
Simultaneous multi-line observation of minor constituents using a new mm-wave spectral radiometer

A researcher at Mizuno Lab attended the 63rd Japan Antarctic Research Expedition and stayed at Syowa Station until February 2023. Using a new mm-wave spectral radiometer equipped with a newly developed multifrequency receiver system, the simultaneous observation of five molecular species, O_3, NO, NO_2, HO_2, and CO, started. For NO, which is a key molecule for understanding ion chemistry, six hyperfine lines could be obtained simultaneously, and the S/N ratio was successfully improved by taking an average of the six lines. There have been no simultaneous observations of these six NO hyperfine lines worldwide, which is a unique achievement of this study.

- We estimated the pitch-angle diffusion coefficient derived from the Arase observations. Compared with the energy spectrum derived from EISCAT observations, we demonstrated that the observed chorus waves cause wide-energy electron precipitation if the waves propagate to higher latitudes along the magnetic field line.
- The LAMP sounding rocket experiment was performed in Alaska in March 2022 and demonstrated the precipitation of relativistic electron microbursts associated with pulsating auroras, as predicted by the Miyoshi et al. (2020) model.
- A spectral riometer was deployed in Kilpisjärvi, Finland, and the observations began in October 2022. This observation was performed simultaneously with the EISCAT radar and captured ionization in the lower ionosphere, which showed CNA increases by energetic electron precipitation. An increase in CNA during a geomagnetic storm event on February 26, 2023, was also successfully observed.
- In the temporal variation of NO due to electron precipitation, a steep rise and slow decline in the NO column density were observed a few times, particularly during winter and early spring. These features may reflect the difference in the NO production timescales by ion chemistry and NO dissociation by photochemistry, and the fact that the photodissociation timescale becomes shorter with increasing daylight hours toward the summer. Time series data obtained by the mm-wave spectral radiometer were compared with the results of the global chemical-climate model WACCM and ion chemistry model SIC in detail.

Direct Search for Dark Matter with Paleo-Detectors

Dark matter constitutes approximately one-quarter of the universe. The formation of galaxies, stars, and other large-scale structures is essential. However, they cannot be observed optically, and their true nature remains obscure. If the true nature of dark matter is revealed, it will provide important insights into new physics beyond Standard Theory, and the birth and history of the universe. Diverse attempts have been made worldwide to determine the nature of this unknown matter. For example, XENONnT uses tonnes of liquid xenon in a direct search, such as XENONnT, the detection sensitivity is limited by the product of the mass of the detector and the experimental time. This time cannot be extended indefinitely in human experiments, and liquid xenon methods have reached their scale limits. The scale limits have led to a focus on using minerals as detectors, a technique known as ‘paleodetectors.’ Minerals interact with dark matter at geological scales and can, therefore, be treated as detectors with extremely long experimental times. This suggests the possibility of searching for dark matter in small sample volumes with a sensitivity that exceeds that of scintillation methods that use liquid xenon. This project aims to combine petrology, geochronology, particle astrophysics, X-ray spectroscopy, electron microscopy, and analytical chemistry in collaboration with researchers from within and outside the ISEE to directly search for dark matter and other unknown elementary particles using paleodetectors. The direct search for unknown elementary particles by paleodetectors has a long history, starting with the search for magnetic monopoles using white mica in the 1980s. In 1995, Snowden-Ifft et al. attempted to search for dark matter directly using mica. However, none of these studies led to the discovery of unknown elementary particles. In recent years, paleodetectors have attracted attention, and diverse research groups worldwide have performed theoretical investigations and experiments to prove this principle. In our project, researchers from petrology, geochronology, particle physics, electron microscopy, geochemistry, and analytical chemistry work towards a proof of principle. In collaboration with other national and international research groups, we directly searched for dark matter using the latest findings from each field.



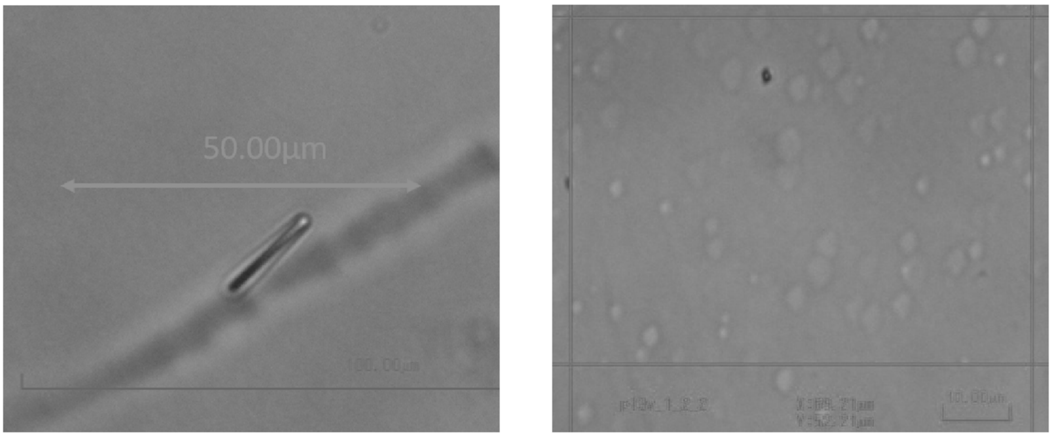
Direct search for dark matter using paleodetector.

Main Activities in FY2022

Development of a white mica track reading method

Weakly Interacting Massive Particles (WIMPs) and Q-balls are possible candidates for dark matter. The goal of this study was to establish a track detection method using olivine and muscovite for both possibilities. In FY2022, we established a plan to detect tracks using the dark matter in rock-forming minerals. Based on previous research, we focused on muscovite, which is easy to use in the search for Q-balls, where the search volume is determined by area rather than volume and where we can expect to observe tracks in both regions where the electronic stopping power is dominant and tracks in regions where the nuclear stopping power is dominant. Muscovite has distinct cleavages and can be thinly peeled. Therefore, it is possible to obtain several samples from a single mineral particle and perform large-area observations. The observation of the sample using both transmitted and reflected light is also possible. Furthermore, it is known that there are fission tracks, which occur in regions where electronic stopping power is dominant, and α-recoil, which occurs in regions where nuclear stopping power is dominant. This makes them suitable for verifying whether automated optical readings can discriminate between the two.

To verify whether the particles left a track on white mica, a heavy-ion cancer therapy machine (HIMAC) from the National Institute of Quantum Science and Technology (NIST) was used to irradiate the sample with Fe at 500 MeV/n. Post irradiation, the white mica samples were etched with hydrofluoric acid and observed under an optical microscope; clear tracks were observed. Tracks due to α-recoil, which existed before irradiation, were also observed simultaneously. This suggests the possibility of distinguishing and simultaneously observing the tracks produced in regions where the electronic stopping power is dominant from those produced in regions where the nuclear stopping power is dominant.



Photomicrograph of fission track (left) and α recoil track (right).

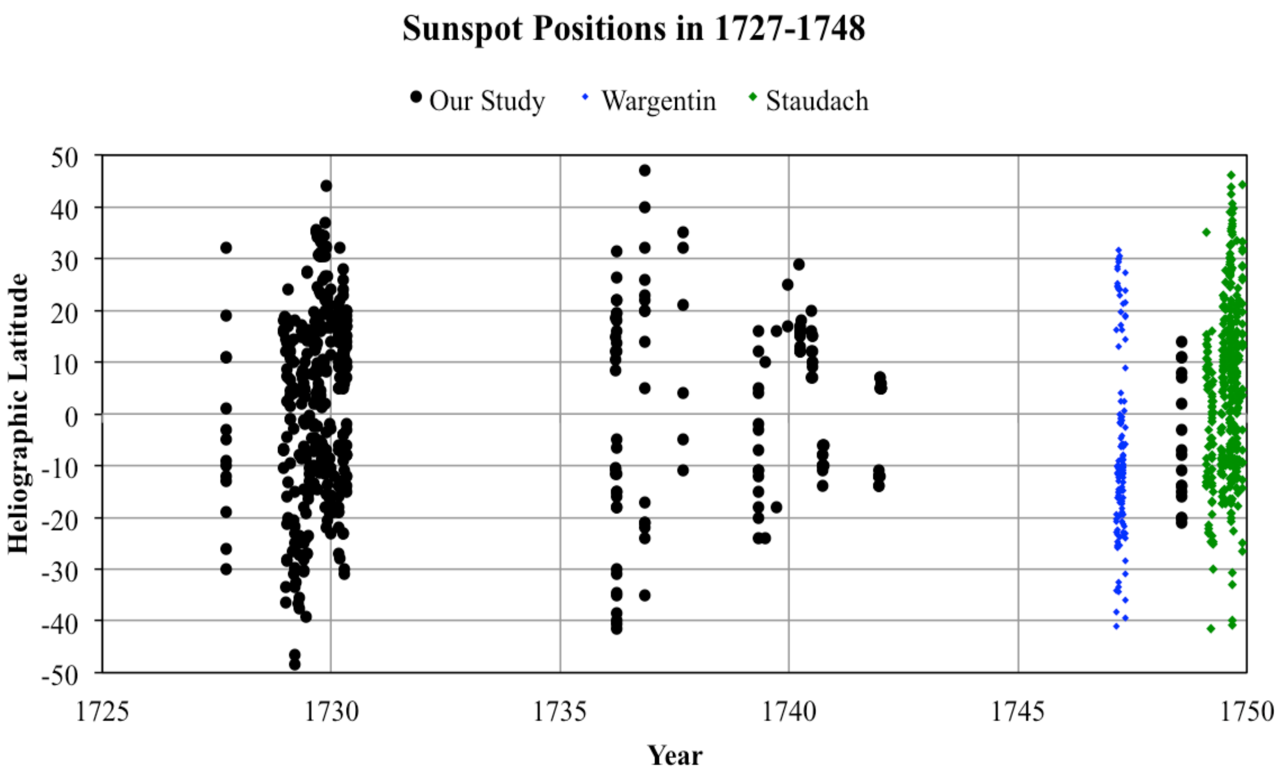
Initiatives for collaboration between research institutions

In recent years, diverse groups have attempted direct searches for dark matter and neutrino detection using minerals. In FY2022, our group and the JAMSTEC group held three joint meetings to report on their status and discuss the situation, strengthening collaboration towards the realization of direct dark matter searches.

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

Since the beginning of the space age (1957), modern civilization has continuously developed technological infrastructure and conducted space explorations, increasing our understanding of the solar–terrestrial environment. In this context, it is known that extreme solar storms seriously impact satellites, power plants, and power grids. In this regard, it is important for us to prepare to protect our civilization from such space weather hazard.

The solar–terrestrial environment is analyzed based on observational datasets. However, such datasets were systematically developed only for the International Geophysical Year (1957–1958). Such a short timespan (66 years) is one of the major limitations to studying infrequent extreme solar storms and long-term solar variability. Our project aims to overcome these difficulties by preserving, organizing, and recalibrating the data in past analog records, and quantitatively reconstruct past solar activity and geomagnetic disturbances on their basis. In this fiscal year, we have made significant advances in analyses on sunspot records and solar coronal records. The most significant results are briefly summarized below.



Sunspot positions in 1727–1748 (Hayakawa et al., 2022a, The Astrophysical Journal, 941, 151). This result has revealed previously undocumented sunspot positions in 1727–1748 and verified regular solar cycles between the Maunder Minimum (1645–1715) and the SILSO monthly database (1749 onward).

Main Activities in FY2022

Our team collected and analyzed old analog datasets for past solar-terrestrial environments and reconstructed the long-term variability and extreme events of the heliosphere, cosmic rays, ionosphere, and magnetosphere. In this fiscal year, our team has significantly developed research on the long-term variability of the terrestrial environments with considerable media exposure, as summarized below.

Our team has developed analyses of sunspot and eclipse records for the long-term variability of solar-terrestrial environments. Among the four centuries of solar cycles, the early 18th century and the Dalton Minimum have been considered two of the greatest fault lines for recalibration (Section 5 of Clette et al., 2023). For the former, our team comprehensively evaluated the original records of the known sunspot datasets in 1727–1748 and acquired forgotten records (e.g., Van Coesfeld, Duclos, and Martin) to revise sunspot group numbers and newly derived butterfly diagrams for this period. Our team also collaborated with the Royal Observatory of Belgium to recalibrate sunspot numbers in the 19th century and jointly published a status report for the international collaboration of sunspot number recalibration under Frédéric Clette (Clette et al., 2023, *Solar Physics*, 298, 44).

Our team has also developed evaluations of solar eclipse records to determine past solar-coronal structures. We comprehensively evaluated the great solar eclipses in Hokkaido from the 18th to 19th centuries and identified the total solar eclipse in Ainu folklore as that of 1824. This folklore account indicates probable coronal streamers despite their chronological position around the end of the Dalton Minimum. This is consistent with the 1806 eclipse account, in contrast to the Maunder Minimum without significant coronal streamers. As a by-product of our investigations of the Byzantine eclipse records, our team also revised the rotation speed of Earth in the 4th to 7th centuries. This article has especially attracted considerable media exposure, recording 403 Altmetrics, and most read and discussed in the Publications of the Astronomical Society of the Pacific.

For solar storms, our team has comprehensively evaluated solar eruptions, geomagnetic disturbances, low-latitude aurorae, and cosmic-ray variability, visualizing magnitudes of the source flare (≈ X35) and the resultant geomagnetic storms (min Dst ≈ −389 nT), auroral visibility down to Tsugaru Strait and Tajikistan, and magnetopause standoff down to ≈ 3.4 RE.

Additionally, our team comprehensively evaluated the extreme solar storms in February 1872 in terms of the contemporaneous solar surface, geomagnetic disturbance, and auroral activity. Our results verified this storm to be a Carrington-class storm. This manuscript is currently in press (Hayakawa et al., *The Astrophysical Journal*, 10.3847/1538-4357/acc6cc).

The achievements of our team have been broadcast internationally in Israel, Taiwan, the US, and Finland. One of our results from the previous FY was extensively broadcast and recorded Altmetrics of 351. Our team’s achievements have been broadcasted in the NHK too – “Cosmic Front and Hokkaido Do.”

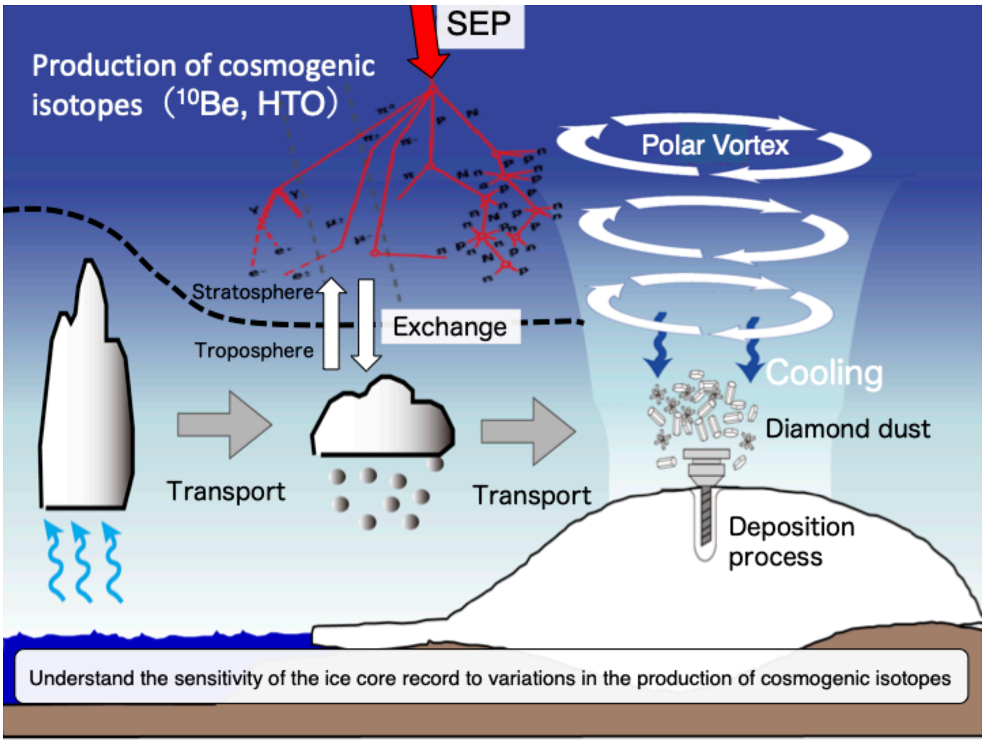
Additionally, the team PI joined a guest editorial board for the special issue in the Geoscience Data Journal, accommodating four data papers, six data service papers, two reviews, and one invited article. As such, data rescue activities have accelerated not only at Nagoya University but also worldwide.

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

Human society has become more sophisticated, and changes in the space environment have significantly impacted social life. For example, a solar eruptive event in 1989 caused several satellites to fail and generated severe magnetic storms. The 2017 solar eruptive event affected the Global Positioning System (GPS) and increased 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 their future predictability, it is essential to reveal the long-term history of solar eruptive events using a paleo-proxy method.

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 is extensively used to detect past extreme solar events. The extreme solar events that occurred in 774 and 993 AD were recorded as abnormal ^{10}Be peaks in the ice core records. However, it is well known that there is uncertainty in the strength of these events reconstructed using the cosmogenic isotope method. This is 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 comprehend the sensitivity of ice core records in terms of 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 across 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 recording cosmogenic isotopes (^{10}Be and HTO) in ice cores.



The objectives and research topics of the project.

Main Activities in FY2022

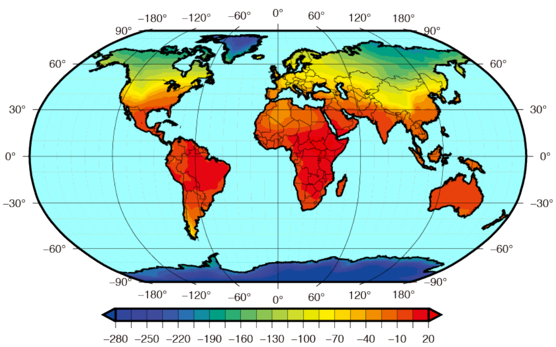
Antarctic field observation “Quantitative evaluation of solar eruptive events detected in cosmogenic nuclides of ice core”

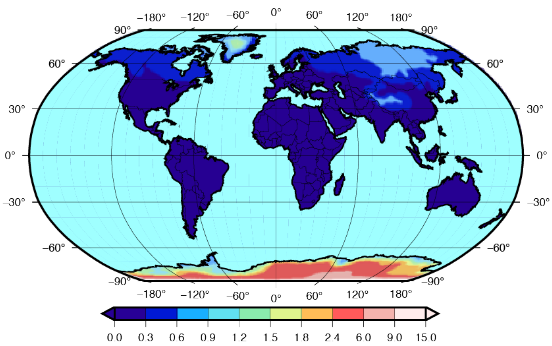
We joined the 64th Japanese Antarctic Research Expedition (JARE) and performed a field research program entitled “Quantitative evaluation of solar energetic storms detected in cosmogenic nuclides of ice core (Principal Investigator: Naoyuki Kurita)”. The purpose of this study is to elucidate the mechanism by which variations in the production of cosmogenic isotopes in the upper atmosphere have been recorded as positive anomalies in isotope proxy records. In this fiscal year, we performed shallow ice core drilling at two sites along the route to Dome Fuji: H15 site, 50 km inland from the coast (observation period: December 22–31, 2022) and site H128, 100 km inland from the coast (observation period: January 4–15, 2023). The ice samples collected were 35 m deep at site H15, representing snow deposited after the 1900s, and 26 m deep at site H128, representing snow deposited approximately 150 years ago. Since it is difficult to collect near-surface snow samples using drilling techniques, surface snow samples were also corrected at 3 cm intervals from the snow pit at a depth of 1.5 m at H15 and 3.0 m at H128. The collected samples were stored in cardboard boxes and shipped back to Japan under frozen conditions.

Left: Observation field at H128 site.　Right: Shallow ice core drilling at H15.

The global distribution of natural HTO in precipitation simulated with 3-D water transport model

We developed a global atmospheric water transport model to evaluate Antarctic observational data. The model incorporates a water isotopologue scheme into an atmospheric circulation model forced by reanalysis data. The production of cosmogenic tritium was obtained from a simulation combining the computed neutron and proton spectra with yield function techniques. The simulated natural HTO distribution reproduced the observed data well and is expected to be useful for elucidating the transport of cosmic-ray-produced nuclides to the Antarctic ice sheet.





Left: Simulated global HDO distribution in precipitation. Right: Simulated global HTO distribution in precipitation.

9. Publications and Presentations

Papers (in refereed Journals, April 2022–March 2023)

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5 more books were published in Japanese.

Publication of Proceedings (April 2022–March 2023)

Title	Date of Publication
The 27th Symposium on Atmospheric Chemistry, Book of Abstracts	Nov. 2022
iLEAPS-Japan 2022 Workshop: Book of Abstracts	Dec. 2022
The Nagoya University Bulletin of Chronological Research Vol. 7	Mar. 24, 2023

Conference Presentations (April 2022–March 2023)

■ International Conferences

*Session Conveners

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staff and PDs	Students	Total	Invited
EGU Geosciences Information for Teachers virtual workshop (vGIFT) 2022	Online	Apr. 4–8, 2022	0	1	0	1	1
From Forests to Heritage	Hybrid Conference/ Amsterdam, Netherlands	Apr. 19–21, 2022	0	1	0	1	1
24th AVAPS Users Group Meeting	Online	Apr. 20–21, 2022	0	1	0	1	0
8th MMS Community workshop	Hybrid Conference/ Daytona Beach, FL, USA	May 9–13, 2022	0	1	0	1	0
Physics in LHC and Beyond	Hybrid Conference/ Matsue, Japan	May 12–18, 2022	0	1	0	1	1
International Symposium on Remote Sensing 2022 (ISRS 2022)	Online	May 16–18, 2022	0	1	0	1	0
10th Edition of the Large Hadron Collider Physics Conference (LHCP 2022)	Online	May 16–22, 2022	0	1	0	1	0
Japan Geoscience Union Meeting 2022	Hybrid Conference/ Chiba, Japan	May 22–27, 2022	7*	45	20	65	1
XeSAT 2022 -International Workshop on Applications of Noble Gas Xenon to Science and Technology	Coimbra, Portugal	May 23–26, 2022	0	2	0	2	1
EGU General Assembly 2022	Hybrid Conference/ Vienna, Austria	May 23–27, 2022	0	2	1	3	0
21st International Symposium on Very High Energy Cosmic Ray Interactions (ISVHECRI 2022)	Online	May 23–28, 2022	1	1	1	2	1
URSI AT-AP-RASC 2022	Hybrid Conference/ Gran Canaria, Spain	May 29–Jun. 3, 2022	1*	3	0	3	1
SuperDARN Workshop 2022	Online	May 30–Jun. 3, 2022	0	3	2	5	0
ISSI meeting (Team of F. Miyake and I. Usoskin: Solar Extreme Events: Setting Up a Paradigm)	Hybrid Conference/ Bern, Switzerland	Jun. 7–10, 2022	1	1	0	1	1
12th Asian Aerosol Conference (AAC2022)	Hybrid Conference/ Taipei, Taiwan	Jun. 12–16, 2022	0	1	0	1	0
Unraveling the History of the Universe and Matter Evolution with Underground Physics (UGAP2022)	Hybrid Conference/ Chiba, Japan	Jun. 13–15, 2022	0	1	1	2	1
8th International HEPPA-SOLARIS Meeting	Bergen, Norway	Jun. 13–15, 2022	0	1	0	1	1
AmeriDendro2022	Hybrid Conference/ Montréal, Canada	Jun. 27–30, 2022	0	1	0	1	1
9th Conference on New Developments in Photodetection	Troyes, France	Jul. 4–8, 2022	0	1	0	1	0
International Conference on High Energy Physics (ICHEP 2022)	Hybrid Conference/ Bologna, Italy	Jul. 6–13, 2022	0	1	0	1	0
EU SafeSpace 2022	Athens, Greece	Jul. 14–15, 2022	0	1	0	1	1
QCD Workshop	Hybrid Conference/ Wako, Japan	Jul. 15, 2022	0	1	0	1	0

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staff and PDs	Students	Total	Invited
COSPAR 2022, 44th Scientific Assembly	Hybrid Conference/ Athens, Greece	Jul. 16–24, 2022	0	7	0	7	3
3rd Pan-GASS Meeting, Understanding and Modeling Atmospheric Processes (UMAP 2022)	Monterey, CA, USA	Jul. 25–29, 2022	0	1	0	1	0
AOGS2022	Online	Aug. 1–5, 2022	4*	3	2	5	2
IBS-KMI joint Workshop	Online	Aug. 3–5, 2022	1	1	0	1	1
Advances in Solar MHD Numerical Simulations in the Era of High-Resolution Observations	Hybrid Conference/ Eastbourne, UK	Aug. 7–10, 2022	0	1	0	1	1
Triennial Earth-Sun Summit (TESS) 2022	Hybrid Conference/ Bellevue, WA, USA	Aug. 8–11, 2022	0	1	0	1	1
20th International EISCAT Symposium	Hybrid Conference/ Uppsala, Sweden	Aug. 15–19, 2022	0	2	1	3	0
11th European Conference on Radar in Meteorology and Hydrology (ERAD2022)	Hybrid Conference/ Locarno, Switzerland	Aug. 29–Sep. 2, 2022	0	2	0	2	0
2022 URSI-Japan Radio Science Meeting	Tokyo, Japan	Sep. 1–2, 2022	0	2	3	5	0
Science with LLAMA 2022	Hybrid Conference/ Salta, Argentina	Sep. 5–8, 2022	0	1	0	1	0
Plasma Explosions in the Universe 2022	Hybrid Conference/ Kyoto, Japan	Sep. 6–8, 2022	1	2	2	4	1
24th Radiocarbon – 10th ^{14}C & Archaeology international conferences	Zurich, Switzerland	Sep. 11–16, 2022	1	1	0	1	0
Asian Association of World Histories 2022	Hybrid Conference/ New Delhi, India	Sep. 12–13, 2022	0	1	0	1	0
16th International Symposium on Equatorial Aeronomy (ISEA-16)	Hybrid Conference/ Uji, Japan	Sep. 12–16, 2022	1*	4	3	7	0
The 14th International School for Space Simulations	Online	Sep. 12–17, 2022	0	0	1	1	0
The 2nd DMNet International Symposium “Direct and indirect detection of dark matter”	Heidelberg, Germany	Sep. 13–15, 2022	3	1	0	1	0
DM3 workshop	Hybrid Conference/ Kobe, Japan	Sep. 15–17, 2022	0	1	0	1	1
Space Climate 8 Symposium	Krakow, Poland	Sep. 19–22, 2022	0	3	0	3	3
International Colloquium on Equatorial and Low-Latitude Ionosphere	Hybrid Conference/ Abuja, Nigeria	Sep. 19–23, 2022	1	1	0	1	1
LIDINE 2022	Warsaw, Poland	Sep. 21–23, 2022	0	1	1	2	0
Workshop on Land-Atmosphere Coupling	Takamatsu, Japan	Sep. 26, 2022	0	1	0	1	0
Workshop on “Challenges in the Understanding of the Global Water Energy Cycle and its Changes in Response to Greenhouse Gases Emissions”	Bern, Switzerland	Sep. 26–30, 2022	0	1	0	1	0
2022 International Heliopspheric Data Environment Alianace (HDEA) meeting	Online	Oct. 3–7, 2022	2	1	0	1	1
6th International Symposium on Ultra High Energy Cosmic-Rays (UHECR 2022)	L’Aquila, Italy	Oct. 3–7, 2022	0	1	1	2	0

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staff and PDs	Students	Total	Invited
MMS Fall 2022 Science Working Team Meeting	Online	Oct. 3–7, 2022	0	1	0	1	0
Internationa Atmospheric Rivers Conference 2022	Hybrid Conference/ Santiago, Chile	Oct. 10–14, 2022	0	1	0	1	0
Spase Physics meeting	Oulu, Finland	Oct. 20, 2022	0	1	0	1	0
The Applied Superconductivity Conference 2022	Honolulu, HI, USA	Oct. 23–28, 2022	0	0	1	1	0
European Space Weather Week 2022	Zagreb, Croatia	Oct. 24–28, 2022	0	1	0	1	1
1st VERSIM School	Hybrid Conference/ Sodankylä, Finland	Nov. 5–6, 2022	1	1	0	1	1
10th VERSIM Workshop	Hybrid Conference/ Sodankylä, Finland	Nov. 7–11, 2022	1	2	0	2	1
The Solar Polarization Workshop 10	Hybrid Conference/ Kyoto, Japan	Nov. 7–11, 2022	1	0	0	0	0
The 31st International Toki Conference on Plasma and Fusion Research	Online	Nov. 8–11, 2022	0	1	0	1	0
The 5th ISEE Symposium: Toward the Future of Space–Earth Environmental Research	Hybrid Conference/ Nagoya, Japan	Nov. 15–17, 2022	15	39	20	59	0
3rd Workshop for Atmospheric Neutrino Production in the MeV to PeV range (WANP2022)	Hybrid Conference/ Nagoya, Japan	Nov. 17–18, 2022	2	1	0	1	1
The 9th International Seminar on Aerospace Science and Technology (ISAST 20222)	Online	Nov. 22–23, 2022	0	1	0	1	1
The 35th International Symposium on Superconductivity (ISS2022)	Hybrid Conference/ Nagoya, Japan	Nov. 29–Dec.1, 2022	0	1	0	1	1
AGU Fall Meeting 2022	Hybrid Conference/ Chicago, IL, USA	Dec. 12–26, 2022	0	19	11	30	4
10th Asian - 19th Japan/Korean Workshop on Ocean Color (AWOC/JKWOC)	Online	Dec. 13–15, 2022	0	1	3	4	0
RIKEN-NICT-East Asia Receiver Joint Workshop	Hybrid Conference/ Wako, Japan	Dec. 14–15, 2022	1	1	0	1	1
The 4th KMI School - Statistical Data Analysis and Anomalies in Particle Physics and Astrophysics	Hybrid Conference/ Nagoya, Japan	Dec. 14–17, 2022	3	0	0	0	0
iLEAPS - OzFlux Joint 2023 Conference	Hybrid Conference/ Auckland, New Zealand	Jan. 31–Feb. 3, 2023	1*	0	0	0	0
The 5th KMI International Symposium (KMI2023)	Nagoya, Japan	Feb. 20–21, 2023	3	2	0	2	2
The Seventh International Symposium on Arctic Research (ISAR-7)	Hybrid Conference/ Tachikawa, Japan	Mar. 6–10, 2023	1	16	0	16	1
2nd International Workshop on Forward Physics and Forward Calorimeter Upgrade in ALICE)	Tsukuba, Japan	Mar. 13–15, 2023	0	1	0	1	1
Joint Workshop of “Physics and application of whistler waves” and “Future perspective of study on nonlinear wave-particle interaction”	Hybrid Conference/ Uji, Japan	Mar. 16–17, 2023	0	1	0	1	0
Russian Conference with International Participation, Commemorating 150th Birthday of Mikhail Sumgin; Coupled natural and technical systems in permafrost regions under changing climate	Hybrid Conference/ Yakutsk, Russia	Mar. 22–23, 2023	0	1	0	1	0

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staff and PDs	Students	Total	Invited
ICCP-GSRA Workshop 2023, jointly with 2nd EarthCARE Modeling Workshop for improving cloud and radiation of climate models	Izu, Japan	Mar. 27–29, 2023	0	1	0	1	0
Symposium on the Future of Heliospheric Science: From Geotail and Beyond	Hybrid Conference/ Tokyo, Japan	Mar. 28–31, 2023	2	6	0	6	3
Total			41 14*	211	74	285	45

■ Domestic Conferences

＊Session Conveners

Number of Conferences	Organizers	Number of Presentations			
		Staff and PDs	Students	Total	Invited
86	42 4*	171	88	259	24

■ Lectures for Researchers

Date	Title	Number of Participants
May 11, 2022 Jun. 16, 2022 Jul. 5, 2022 Sep. 23, 2022	SCOSTEP/PRESTO Online Seminar (12th–15th)	48 32 30 61
Apr. 28, 2022 Jul. 12, 2022 Sep. 8, 2022 Oct. 25, 2022	SCOSTEP Online Capacity Building Lecture (13th–16th)	68 61 99 65
May 12, 2022 Jul. 7, 2022 Dec. 20, 2022 Feb. 9, 2023 Feb. 20, 2023 Feb. 27, 2023 Mar. 30, 2023	ISEE/CICR colloquium (63rd–69th)	35 16 22 38 16 11 11

Awards

■ Staff and PhD

Award Winners	Date	Awards	Title
Kanya Kusano	Apr. 20, 2022	Awards for Science and Technology, The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology	Study of accurate prediction and onset mechanism of giant solar flares
Kazuhisa Tsuboki			Research for typhoon intensity by aircraft observation and numerical model.
Fusa Miyake	Jun. 30, 2022	Tree-Ring Society José A. Boninsegna Frontiers in Dendrochronology Award	Contributions to applied researches on radiocarbon of tree-rings such as a radiocarbon dating and extension of tree-ring chronology, by discovering radiocarbon spikes
Joji Ishizaka	Sep. 5, 2022	Uda Prize, Oceanographic Society of Japan Research Awards	Promotion of ocean research using ocean color satellite information
Yuto Tashiro	Oct. 7, 2022	Best Presentation Award, 2022 Annual Conference, Japan Society of Hydrology and Water Resources/Japanese Association of Hydrological Sciences	Increase in Dissolved Iron Concentration in the Amur River from 1995 to 1997: Initial Analysis using Atmospheric Reanalysis Data
Haruhisa Iijima	Oct. 28, 2022	HPCI Excellent Achievement Award	Three-dimensional radiation magnetohydrodynamic simulation of slow solar wind
Satoko Nakamura	Nov. 6, 2022	Obayashi Early Career Scientist Award	Studies of electromagnetic ion cyclotron waves in the Earth's magnetosphere by using satellite observations
Satoko Nakamura	Nov. 25, 2022	NF Foundation R&D Encouragement Award	Risk prediction model for Japan's power grid in unexperienced space weather disasters
Satoko Nakamura	Nov. 30, 2022	11th Nagoya University Ishida Prize	A preliminary risk assessment of geomagnetically induced currents on Japanese power grids
Hirohiko Masunaga	Jan. 11, 2023	2022 ASLI (Atmospheric Science Librarians International) Choice (Science and Technology) Award	The book “Satellite Measurements of Clouds and Precipitation: Theoretical Basis” (Springer)
Satoko Nakamura	Jan. 31, 2023	Excellence Award in the Basic Research Division of the Aichi Prefecture "Wakashachi Encouragement Award"	The risk assessment against the severe space weather disaster: the observation network in the Tokai region
Atsuki Shinbori (co-author: Y. Otsuka, T. Sori, N. Nishitani)	Feb. 24, 2023	Highlighted Papers 2022 in the journal Earth Planets Space (EPS)	Shinbori, A., Y. Otsuka, T. Sori, M. Nishioka, S. Perwitasari, T. Tsuda and N. Nishitan, 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 observations
Haruhisa Iijima	Mar. 8, 2023	Next-Generation Researcher Award, Research Meeting of Program for Promoting Research on the Supercomputer Fugaku.	Supersonic plasma wind driven by the magnetohydrodynamic turbulence in the Sun

■ Students

Award Winners	Date	Awards	Title
Keitaro Matsumoto	Jun. 4, 2022	JpGU 2022 Outstanding Student Presentation Award	Study of electron acceleration/propagation processes in a solar flare using Nobeyama Radioheliograph
Sora Nakata			Analysis of the plasma upflows and the global structure of the magnetic field lines using Hinode/EIS observation and PFSS extrapolation
Naoki Aoyama	Jun. 15, 2022	Unraveling the History of the Universe and Matter Evolution with Underground Physics（UGAP2022）Best Poster Award	Development of coated electrodes with low quantum efficiency for the DARWIN experiment
Taiki Maeda	Aug. 5, 2022	Asia Oceania Geosciences Society (AOGS) 2022 Best Student Poster Award	Low-cost Magnetometers Using Magneto-impedance (MI) Sensors

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				
Institute for Space–Earth Environmental Research	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
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

Number of Students supervised by ISEE Staff

(April 1, 2022–March 31, 2023)

	M1	M2	D1	D2	D3	Undergraduate Students	Non-regular students	Total
Graduate School of Science	8	12	1	0	2	-	1	24
Graduate School of Engineering	9	12	1	0	0	-	0	22
Graduate School of Environmental Studies	10	14	2	3	5	-	1	35
School of Science	-	-	-	-	-	6	-	6
School of Engineering	-	-	-	-	-	10	-	10
ISEE	-	-	-	-	-	-	0	0
Total	27	38	4	3	7	16	2	97

Cumulative total in AY 2022

Faculty Members

(April 1, 2022–March 31, 2023)

■ 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	
		Yuichi Otsuka		
	Kanya Kusano	Satoshi Masuda		Akimasa Ieda
	Yoshitaka Itow	Yutaka Matsubara	Akira Okumura	Hiroaki Menjo
	Hiroyasu Tajima	Fusa Miyake		
		Shingo Kazama*		
	Munetoshi Tokumaru	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
		Masahito Nosé		
		Claudia Martinez-Calderon		
	Yoshizumi Miyoshi	Takayuki Umeda		

■ 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

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 2022 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
- First Year Seminar
- Frontier of Earth and Planetary Sciences
- Fundamentals of Earth Science II
- Geology Experiments
- Graduation Thesis A・B
- Introduction to Physics I・II
- Laboratory in Physics
- Mathematics I and Tutorial A・B
- Mathematics II and Tutorial
- Meteorology
- Physics Experiments I・II
- Probability Theory and Numerical Analysis with Exercises
- Remote sensing
- Science of Atmospheric-Hydrospehric Environment
- Solar System Science
- Topics in Advanced Physics

11. International Relations

Academic Exchange

(27 in total)

Institution	Country/Region	Establishment
Indonesian National Institute of Aeronautics and Space	Indonesia	May 31,1988
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 High Energy Physics, Chinese Academy of Sciences	China	Feb. 20, 2001
Polar Research Institute of China	China	Nov. 11, 2005
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
Bangladesh University of Engineering & Technology, Department of Physics	Bangladesh	Mar. 4, 2008
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
Geophysical Institute, University of Alaska Fairbanks	U.S.A.	Jul. 16, 1990
Space Environment Center, National Oceanic and Atmospheric Administration	U.S.A.	Dec. 15, 1992
National Geophysical Data Center, National Oceanic and Atmospheric Administration	U.S.A.	Jan. 5, 1993
Haystack Observatory, Massachusetts Institute of Technology	U.S.A.	October 24, 1994
Center for Astrophysics and Space Sciences, University of California at San Diego.	U.S.A.	Dec. 22, 1997
Center for Space Science and Engineering Research, Virginia Polytechnic Institute and State University	U.S.A.	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
Swedish Institute of Space Physics	Sweden	Sep. 1, 2005 (since Mar. 25, 1993)
Faculty of Science, UiT The Arctic University of Norway	Norway	May 3, 2019 (since Oct. 8, 1993)
Department of Geophysics, Finnish Meteorological Institute	Finland	Oct. 21, 1994
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

Number of exchanges: visitors:9, going abroad:5

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 February 2023）

Name	Country/Region	Institution	Obs. Site	Latitude	Longitude
SuperDARN Executive Council	(U.K.)	●		—	—
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
Rio Gallegos	Argentine		●	−51.6	290.8
Darwin	Australia		●	−12.44	130.96
Kakadu Observatory, Geoscience Australia	Australia	●		−12.7	132.5
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
Nyrola	Finland		●	62.34	25.51
Sodankyla	Finland		●	67.4	26.6
Kevo	Finland		●	69.76	27.01
University of Oulu	Finland	●		65.1	25.5
VLF receiver at Oulujarvi, Finland (OUJ)	Finland		●	64.51	27.23
Husafell	Iceland		●	64.67	338.97
Decan College	India	●		18.55	73.9
Radio Astronomy Centre, Tata Institute for Fundamental Research	India		●	18.9	72.8
Observation Site for Methane in Sonepat, India	India		●	29	77
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
Institute of Geography-Geoecology, Mongolian Academy of Sciences	Mongol	●		47.63	108.3
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
Tromsoe	Norway		●	69.59	19.227
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		●	56.78	60.88

Name	Country/Region	Institution	Obs. Site	Latitude	Longitude
Zhigansk	Russia		●	66.78	123.37
Magadan	Russia		●	60.05	150.73
Paratunka	Russia		●	52.97	158.25
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	U.S.A.	●		40.9	287.1
The University of Arizona	U.S.A.	●		32.2	249
Gakona	U.S.A.		●	62.39	214.78
Subaru Telescope, National Astronomical Observatory of Japan	U.S.A.		●	19.82	204.52
University of Alaska, Fairbanks, Poker Flat Research Range	U.S.A.		●	65.1	213
Norikura Observatory, Institute for Cosmic Ray Research, University of Tokyo	Japan		●	36.1	137.55
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
Kawatabi Observatory, Graduate School of Science, Tohoku University	Japan		●	38.75	140.8
The Shirakami Natural Science Park, Hirosaki University	Japan		●	40.52	140.2
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	69	18	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	U.S.A.	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	U.S.A. Europe (Member States of ESA)	23	NASA (SPDF, SDAC, HPDE, SPASE, CCMC) European Space Agency (ESA), Centre National d'Études Spatiales
LAMP(Loss through Auroral Microburst Pulsation)-2 souding rocket experiment	Yoshizumi Miyoshi	U.S.A.	1	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	U.S.A. U.K. 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	U.S.A. Canada U.K. Spain Korea China Poland	7	Boston University, Brookhaven National Laboratory, UCI, Duke University, George Mason University, University of Hawaii, Indiana University, Los Alamos National Laboratory, University of Maryland, State University of New York, University of Washington University of British Columbia, University of Toronto, TRIUMF Queen Mary University of London, Imperial College London, University of Liverpool, University of Oxford, University of Sheffield Complutense University of Madrid Chonnam National University, Seoul National University, Sungkyunkwan University Tsinghua University University of Warsaw
Study in Interaction of Very High Energy Cosmic Rays by using Large Hadron Collider	Yoshitaka Itow	Italy France Switzerland U.S.A.	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 U.S.A.	2	University of Florence, Catania University Brookhaven National Laboratory
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 U.S.A.	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	U.S.A. Korea China U.K. Italy France Switzerland Spain Poland Brazil *Canada, Russia Portugal*	13	Boston University, Brookhaven National Laboratory, UCI, Duke University, George Mason University, Indiana University, University of Hawaii, Los Alamos National Laboratory, University of Maryland, State University of New York, University of Washington Chonnam National University, Seoul National University, Sungkyunkwan University Tsinghua University Imperial College London, Lancaster University, University of Oxford, Queen Mary University of London, University of Sheffield, Rutherford Appleton Laboratory INFN Sezione di Bari, INFN Sezione di Napoli, INFN Sezione di Padova, INFN Sezione di Roma CEA Saclay, École Polytechnique University of Bern, Swiss Federal Institute of Technology Zurich Autonomous University of Madrid University of Warsaw University of São Paulo *and other Institutions*
Study of Dark Matter and Solar Neutrinos using a 2-Phase Liquid Xenon TPC Detector	Yoshitaka Itow	Germany Italy Switzerland U.S.A. 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 U.K. U.S.A. *Brazil, Argentina, Poland, Armenia, Australia, Czech, Bulgaria, Croatia, Finland, Greece, Sweden, Slovenia, India, Ireland, South Africa*	22	Deutsches Elektronen-Synchrotron, Max-Planck-Institut, Heidelberg University CENS, École Polytechnique, University of Paris INFN, IFSI University of Barcelona, Complutense University 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	U.S.A. France Italy Sweden	4	Stanford University, SLAC National Accelerator Laboratory, GSFC/NASA, U.S. Naval Research Laboratory, UCSC, Sonoma State University, University of Washington, Purdue University, 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	U.S.A.	1	UCB, MSFC/NASA, Air Force Research Laboratory
Solar Flare Research with Gamma-Ray Spectral Imaging Observations with Polarimetry	Hiroyasu Tajima	U.S.A.	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
cStudy of Solar Neutrons	Yutaka Matsubara	Bolivia Armenia Mexico	4	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	U.S.A. Switzerland	2	The University of Arizona Swiss Federal Institute of Technology Zürich
Observations of Interplanetary Disturbances using the International IPS Network	Munetoshi Tokumaru	U.K. Russia India Mexico Australia	5	LOFAR-UK Lebedev Physical Institute Tata Institute of Fundamental Research National Autonomous University of Mexico Murchison Widefield Array
Study of 3-D Solar Wind Structure and Dynamics Using Heliospheric Tomography	Munetoshi Tokumaru	U.S.A.	1	CASS/UCSD
Study of the Heliospheric Boundary Region using Observations of Interplanetary Scintillation	Munetoshi Tokumaru	U.S.A.	1	Interstellar Boundary Explorer, IMAP
Research and Development of the Plasma/Particle Instrument Suite for the Mercury Magnetospheric Exploration Mission	Masafumi Hirahara	France Sweden U.K. U.S.A. Switzerland	5	CESR-CNRS, CETP-IPSL Institute for Solar Physics of the Royal Swedish Academy of Sciences Rutherford Appleton Laboratory Boston University University of Bern
Future Satellite Mission for the Terrestrial Magnetosphere-Ionosphere-Thermosphere Explorations by Formation Flight Observations and its Feasibility Study and Collaboration of the Satellite and Ground-Based Observations	Masafumi Hirahara	Sweden	1	Swedish Institute of Space Physics, Swedish National Space Board
Study on Science Subjects and Developmental Techniques of Observational Instruments toward Future Spacecraft Exploration Missions for the Space-Earth Coupling System	Masafumi Hirahara	Sweden	1	Swedish Institute of Space Physics

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
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	U.S.A. Canada	2	University of California, Augsburg College, Virginia Polytechnic Institute and State University University of Calgary, Athabasca University
Magnetic Conjugate Observations of Midlatitude Thermospheric Disturbances	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)
Study of the Polar/Midlatitude Ionosphere and Magnetosphere using the SuparDARN HF Radar Network	Nozomu Nishitani	U.S.A. U.K. France South Africa Australia Canada Italy Russia China	9	JHUAPL, Virginia Polytechnic Institute and State University University of Leicester LPC2E/CNRS University of KwaZulu-Natal La Trobe University University of Saskatchewan IFSI ISTP/SB RAS Polar Research Institute of China
Derivation of Substorm Index from Low-Latitude Geomagnetic Field Data	Masahito Nosé	Australia Turkey Germany Spain Denmark U.S.A.	6	Geoscience Australia Boğaziçi University Ludwig-Maximilians-Universität München Universitat Ramon Llull Technical University of Denmark United States Geological Survey
Experiment of geomagnetic field with sounding rocket LAMP	Masahito Nosé	U.S.A.	1	NASA
Study of high-frequency geomagnetic field variations with low-latitude induction magnetometer network	Masahito Nosé	Australia New Zealand	2	Geoscience Australia Dr. Peter Jaquiery
Study of the Polar Upper Atmosphere using the EISCAT Radars and Other Instruments	Satonori Nozawa	Norway Sweden, Finland, Germany, U.K., 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

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
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
Global study of midlatitude plasma bubbles using multi-instrument observations and models	Yuichi Otsuka	South Africa	1	South African National Space Agency
SDI-3D Project: Development of SDI	Shin-ichiro Oyama	U.S.A. Finland Sweden	3	Geophysical Institute of the University of Alaska Fairbanks University of Oulu, Finnish Meteorological Institute, Sodankylä Geophysical Observatory, Lappeenranta-Lahti University of Technology 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 U.K. Norway U.S.A.	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	U.S.A. Norway Sweden	3	University of Colorado Boulder, UCLA, University of Arizona UiT The Arctic University of Norway EISCAT Scientific Association
Hygroscopicity of Humic-Like Substances in Beijing	Michihiro Mochida	China	1	Tianjin University
Characterizing Organics and Aerosol Loading over Australia (COALA)	Michihiro Mochida Sho Ohata	Australia U.S.A. U.K.	3	University of Wollongong, Commonwealth Scientific and Industrial Research Organisation, Australian Nuclear Science and Technology Organisation, NSW Department of Planning, Industry and Environment Georgia Institute of Technology, UCI Lancaster University
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 U.S.A.	2	National Taiwan University Atmospheric Sciences Colorado State University
Global Precipitation Measurement Mission (GPM)	Nobuhiro Takahashi Hirohiko Masunaga	U.S.A.	1	NASA
Observational Study on Convective Self-Aggregation	Hirohiko Masunaga	U.K.	1	University of Reading
Satellite Algorithm Development for Tracking Precipitating Clouds	Hirohiko Masunaga	U.S.A.	1	NASA Jet Propulsion Laboratory
Development and Validation of a Satellite-Based Scheme to Estimate In-Cloud Vertical Velocity	Hirohiko Masunaga	U.S.A.	1	City University of New York
Energetic Particle Chain -Effects on the middle/lower atmosphere from energetic particle precipitations-	Taku Nakajima	Finland	1	University of Oule, Finnish Meteorological Institute

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Long-Term Observation of Black Carbon Aerosols in the Arctic	Sho Ohata	Norway U.S.A. 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	U.S.A.	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
Integrated Land Ecosystem - Atmosphere Processes Study (iLEAPS), one of the Global Research Projects (GRPs) of the Future Earth	Tetsuya Hiyama	U.K., India, Finland, New Zealand, China, Koria *and others countries*	6	iLEAPS/Future Earth
Observational Study of Vegetation, Energy and Water in Eastern Siberia Towards Elucidation of Climate and Carbon Cycle Changes	Tetsuya Hiyama	Russia	1	Institute for Biological Problems of Cryolithozone/SB RAS
Arctic Challenge for Sustainability II (ArCS II) Project	Tetsuya Hiyama	U.S.A.	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
Study of Methane Flux Observation in Eastern Siberia and the Obtained Data Analysis	Tetsuya Hiyama	Russia	1	Institute for Natural Science, North Eastern Federal University
Validation of GOCI Products and Application to Environmental Monitoring of Japanese Coastal Waters	Joji Ishizuka	Korea	1	Korea Institute of Ocean Science and Technology
Sea Surface Nitrate and Nitrate Based New Production - Two Innovative Research Products from SGLI on board GCOM-C	Joji Ishizuka	U.S.A.	1	Columbia University
Collection of Validation Dataset of GCOM-C Coastal Products	Joji Ishizuka	Korea U.S.A. Taiwan Thailand China Estonia	6	Korea Institute of Ocean Science and Technology Columbia University, East Carolina University National Cheng Kung University Burapha University First Institute of Oceanography, Nanjing, University of Science and Technology University of Tartu
Investigating the Optical Characteristics of Red Tides in the Upper Gulf of Thailand	Joji Ishizuka	Thailand	1	University of Burapa, Kasetsart 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*

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
An International Study on Precipitation Variability in High-Altitude Areas of the Himalayas in Nepal	Hatsuki Fujinami	Nepal	1	Kathmandu University, Nepal Academy of Science and Technology, International Centre for Integrated Mountain Development
International Continental Scientific Drilling Program - Dead Sea Deep Drilling Project (ICDP-DSDDP)	Hiroyuki Kitagawa	Israel U.S.A. 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
Climate Reconstruction using Travertine from Takht-e-Soleyman Area in Kurdistan, Iran	Masayo Minami	Iran	1	University of Kurdistan
Study of Grand-Water Circulation Based on ^{14}C Ages of Underground Water and Hot-Spring Water Samples from Korea	Masayo Minami	Korea	1	Korea Institute of Geoscience and Mineral Resources
Establishment of Master Dendrochronological Calibration Curve Around 660 BC using Annual Tree Ring Samples from Poland	Masayo Minami	Poland	1	Silesian University of Technology
Measurements of Cosmic-Ray-Produced ^{14}C in Iron Meteorites	Masayo Minami	U.S.A.	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
International Ocean Discovery Program (IODP) Expedition 379: Amundsen Sea West Antarctic Ice Sheet History	Masako Yamane	U.S.A. Germany U.K. France Sweden Norway China Korea India New Zealand	10	University of Houston, Texas A&M University, Appalachian State University, U.S. Army Engineer Research and Development Center, University of Massachusetts, University of South Florida, Montclair State University, University of Florida, Northern Illinois University, Colorado College Alfred Wegener Institute for Polar and Marine Research, University of Bremen, University of Kiel, Museum für Naturkunde University of Southampton, University of Birmingham, British Antarctic Survey Université de Perpignan Stockholm University UiT The Arctic University of Norway China University of Geosciences, Tongji University Korea Institute of Geoscience and Mineral Resources National Centre for Antarctic and Ocean Research GNS Science

Visitors from Foreign Institutes

(April 1, 2022–March 31, 2023)

Country/Region		Number of Visitors	
Asia (7)	Bangladesh	1	32
	China	3	
	India	16	
	Indonesia	1	
	Korea	3	
	Malaysia	3	
	Taiwan	5	
North America (2)	Canada	2	18
	U.S.A.	16	
Europe (12) (Including New Independent States)	Austria	1	27
	Czech	5	
	Finland	3	
	France	1	
	Germany	6	
	Italy	1	
	Netherland	3	
	Poland	1	
	Sweden	2	
	Switzerland	1	
	Russia	1	
	U.K.	2	
Oceania (1)	Australia	1	1
Middle East (1)	Iran	1	1
Africa (5)	Egypt	1	8
	Ethiopia	1	
	Nigeria	2	
	South Africa	3	
	Uganda	1	
Total	28	87	

Funding Source	Number of Visitors
Ministry of Education, Culture, Sports, Science and Technology	4
Japan Society for the Promotion of Science	10
Nagoya University	61
Self-funding	3
Other funding sources	9
Total	87

Purpose	Number of Visitors
Conferences/Symposiums	11
Joint Research	76
Total	87

Overseas Business Trips of Faculty

(April 1, 2022–March 31, 2023)

Country/Region		Number of Travelers	
Asia (2)	Taiwan	1	2
	Vietnam	1	
North America (2)	Canada	2	18
	U.S.A.	16	
Latin America and the Caribbean (5)	Argentina	2	6
	Brazil	1	
	Chile	1	
	Paraguay	1	
	Uruguay	1	
Europe (13) (Including New Independent States)	Belgium	2	1
	Croatia	1	
	Finland	2	
	France	3	
	Germany	6	
	Greece	4	
	Italy	5	
	Norway	6	
	Poland	2	
	Spain	4	
	Switzerland	10	
	Sweden	2	
	U.K.	3	
Oceania (1)	Australia	2	2
Africa (2)	Cape Verde	1	2
	South Africa	1	
Other Area (1)	Antarctica	1	1
Total	26	81	

Online Seminars by Foreign Scientists

(24 in total)

Date	Name	Affiliation	Title	Number of Participants
Apr. 28, 2022	Evan G. Thomas	Dartmouth College, U.S.A.	13th SCOSTEP Online Capacity Building Lecture/ Space weather monitoring with the Super Dual Auroral Radar Network (SuperDARN)	68
May 11, 2022	David J. McComas	Princeton University, U.S.A.	12th SCOSTEP/PRESTO Online Seminar/ First solar cycle of observations of our heliosphere's interaction with the very local interstellar medium	48
May 12, 2022	Jyrki Manninen*	Sodankylä Geophysical Observatory, Finland	63rd ISEE/CICR Colloquium (online)/ VLF bursty-patches – new phenomena?	35
May 13, 2022	H. N. Adithya	Scikraft Education and Engineering Design Pvt. Ltd., India	ISEE Solar Seminar (online)/ Solar soft X-ray irradiance variability using Hinode XRT images for the solar cycle 24	13
May 19, 2022	Li Xiaolong	Environmental Engineering Center, Institute of Oceanology, Chinese Academy of Sciences, China	ISEE Oceanography Seminar (online)/ Global estimation of phytoplankton pigment concentrations from satellite data using a deep-learning-based model	11
Jun. 16, 2022	Theodosios Chatzistergos	Max Planck Institute for Solar System Research, Germany	13th SCOSTEP/PRESTO Online Seminar/ Ca II observations: Exploiting historical treasures for solar activity and variability studies	32
Jun. 29, 2022	Bernard V. Jackson	University of California, San Diego, U.S.A.	ISEE Solar Wind Group Special Seminar (hybrid)/ Recent interplanetary scintillation predictions and forecast analyses from UCSD	10
Jul. 5, 2022	Christine Gabrielse	The Aerospace Corporation, U.S.A.	14h SCOSTEP/PRESTO Online Seminar/ Mesoscales and their contribution to the global response: A focus on the magnetotail transition region and magnetosphere-ionosphere coupling	30
Jul. 7, 2022	Rangaiah Kariyappa*	Indian Institute of Astrophysics, India	64th ISEE/CICR Colloquium (online)/ Solar Spectral Irradiance (SSI) variability	16
Jul. 12, 2022	Lucilla Alfonsi	Istituto Nazionale di Geofisica e Vulcanologia, Italy	14th SCOSTEP Online Capacity Building Lecture/ Space weather ionospheric effects at high latitude	61
Sep. 8, 2022	Hugh Hudson	University of Glasgow, U.K.	15th SCOSTEP Online Capacity Building Lecture/ Global properties of solar flares and some recent sun-as-a-star discoveries	99
Sep. 23, 2022	Manolis K. Georgoulis	Research Center for Astronomy of the Academy of Athens, Greece	15th SCOSTEP/PRESTO Online Seminar/ Forecasting the extreme end of solar weather: Flares, coronal mass ejections and SEP event complexes	61
Oct. 25, 2022	Pekka Verronen	Finnish Meteorological Institute/ Sodankylä Geophysical Observatory, University of Oulu, Finland	16th SCOSTEP Online Capacity Building Lecture/ Response of the Earth's middle atmosphere to solar particle forcing	66
Nov. 10, 2022	Shibaji Chakraborty	Virginia Tech, U.S.A.	Division for Ionospheric and Magnetospheric Research Seminar (hybrid)/ Ionospheric response to solar flares observed in SuperDARN HF radars	36
Nov. 21, 2022	Brian Welsch	University of Wisconsin Green Bay, U.S.A.	ISEE Solar Seminar (online)/ Coronal currents and the storage & release of magnetic energy	14
Nov. 24, 2022	Cheh Wee	Institute of Ocean and Earth Sciences, Universiti Malaya, Malaysia	ISEE Oceanography Seminar (online)/ Performance of satellite-based sea surface temperature in the Malaysian waters	11

Date	Name	Affiliation	Title	Number of Participants
Dec.1, 2022	Joe Zender	ESA-ESTEC, Noordwijk, The Netherlands	ISEE Solar Seminar (online)/ Proba-3: Observe the solar corona by fine formation flying space weather geoelectromagnetic effects	11
Dec. 20, 2022	Rumi Nakamura*	Space Research Institute, Austrian Academy of Sciences, Austria	65th ISEE/CICR Colloquium (online)/ In-situ observation of magnetic reconnection: Diffusion region and outflow disturbances	22
Feb. 3, 2023	Matthew Igel	University California, Davis, U.S.A.	Prof. Matt Igel Seminar (hybrid)/ Conceptual models for tropical convective rainfall and dynamics	30
Feb. 9, 2023	Pavlo Ponomarenko*	University of Saskatchewan, Canada	66th ISEE/CICR Colloquium (hybrid)/ Towards empirical model of HF propagation at very high latitudes	38
Feb. 16, 2023	Samuel Krucker	University of Applied Sciences Northwestern Switzerland, Switzerland / University of California, Berkeley, U.S.A.	ISEE Solar Seminar (hybrid)/ Hard X-ray solar flare observations with Solar Orbiter/STIX	13
Feb. 20, 2023	Hermann Opgenoorth	University of Umea, Sweden	67th ISEE/CICR Colloquium (hybrid)/ On the origins and characteristics of three-dimensional current systems in near-Earth space and their implications for space weather	16
Feb. 27, 2023	Matthias Förster	GFZ German Research Centre for Geosciences, Germany	68th ISEE/CICR Colloquium (hybrid)/ Estimation of effective ion masses by Langmuir probes onboard the Swarm satellites	11
Mar. 30, 2023	Gary P. Zank	University of Alabama in Huntsville, U.S.A.	69th ISEE/CICR Colloquium (hybrid)/ Heating the solar corona and driving the solar wind: Are we nearing a solution?	11

* 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
GFZ:	Geoforschungszentrum
GNS Science:	Institute of Geological and Nuclear Sciences Limited
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
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
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
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 diverse outreach events and activities. Several events and activities are performed online or in a hybrid format. Some studies were also performed in person. Specifically, two public lectures, five visiting lectures for schools, one high school student visit, two open laboratory events, two hybrid training courses for young researchers, one five-day tour for university students, one children's workshop, and one field trip and workshop for children were organized. Additionally, ISEE members have contributed to public education through 25 public talks.

We also distributed a series of booklets in Japanese that answered 50 questions on various topics and a series of comic (manga) books. They are related to space–Earth subjects for science education and are suitable for the public and schoolchildren. We have added two new booklets this year. These booklets can also be browsed and downloaded from the ISEE website (https://www.isee.nagoya-u.ac.jp/hscontent/books.html). These comic books were 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 on the SCOSTEP website (https://scostep.org/space-science-comic-books/). We also published two newsletters. The research results, event reports, and English columns have been posted.

The ISEE website continues to publish the most up-to-date activities and outcomes of laboratory science to the public (https://www.isee.nagoya-u.ac.jp/en/).

Our Booklets were displayed and distributed at the Nagoya University Festival.

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
		58-1, 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