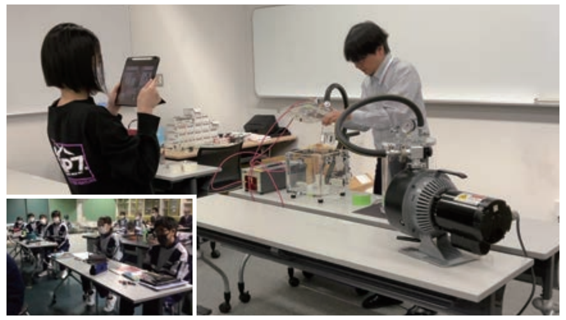
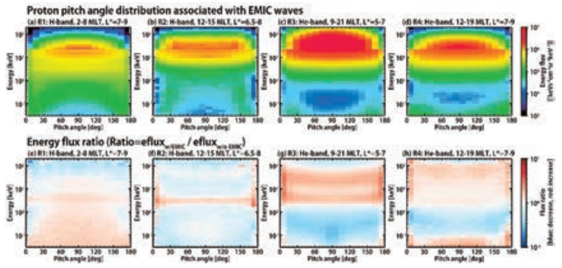
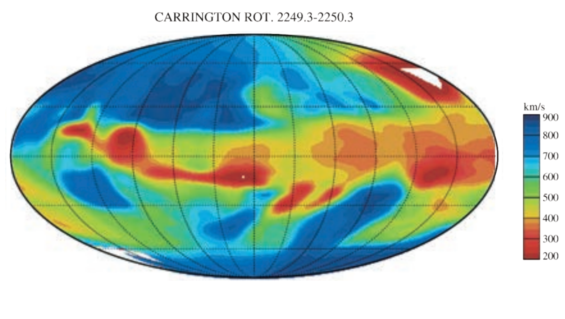


Photo of an online experimental demonstration using vacuum vessels and pumps in a live lesson for Rikubetsu junior high school in Hokkaido (November 5, 2021)



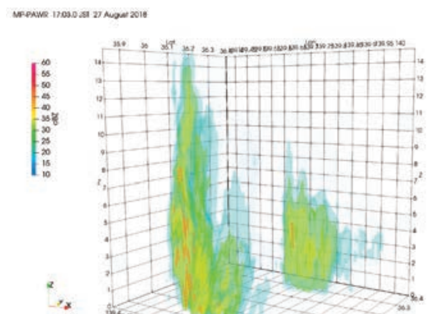
Top: Proton pitch-angle distribution associated with EMIC waves as a function of energy and pitch angle. Bottom: Energy flux ratio with and without EMIC waves at each peak occurrence region (see pp.32-33)

Photo for a beam test of LHCf detectors at CERN-SPS

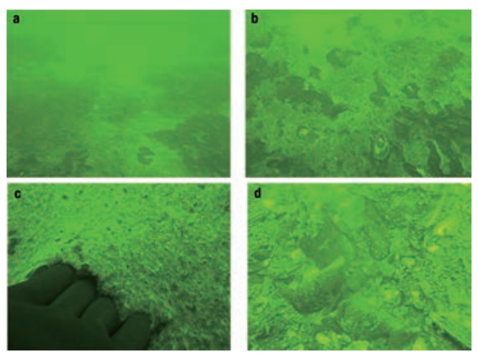


Global distribution of the solar wind on autumn 2021 derived from the IPS observation of ISEE

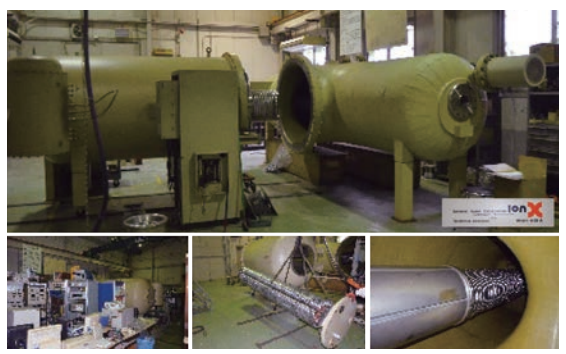
Installation of a magnetometer at Sata, Japan (October 2021)



A 3D image of reflectivity (Z) obtained by MP-PAWR at 1703 JST on August 27, 2018



Hypoxic bottom layer of Mikawa Bay with anaerobic bacterial mats spread across the seafloor



Tandetron Accelerator Mass Spectrometer I that produced many ^{14}C important papers (Discarded in May 2021)

ISEE Institute for Space–Earth Environmental Research, Nagoya University

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Edited by Public Relations and Outreach Committee, Institute for Space–Earth Environmental Research, Nagoya University
Published in October 2022

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

Institute for Space–Earth Environmental Research, Nagoya University Annual Report FY2021

ISEE

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

FY2021

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

Institute for
Space–Earth Environmental Research

April 2021–March 2022

Foreword

The Institute for Space-Earth Environmental Research (ISEE), established in October 2015, had received approval from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) as a joint usage/research center during the third medium-term goal period of the national university. We conduct joint research activities in approximately 200 subjects every year in 11 categories, including international workshops. The ISEE received an S rating (highest rating) in the term-end evaluation of the 3rd medium-term goal period of the joint usage/research center conducted by MEXT. In addition, the evaluation committee stated that "ISEE plays a unique role as a center that integrates space science and earth science. In particular, activities for international collaboration with related research institutes can be highly evaluated." We thank all collaborators who have supported this institute with their continued active research since its establishment.

The ISEE was approved continuously as a joint usage/research center during the 4th medium-term goal period, which started in 2022. We will develop more active joint research activities based on previous results. Therefore, we plan to continue our activities and strengthen our joint research program on the following two priority items. First, we will enhance the opportunity for the training of young researchers, especially the training of young researchers who can play an active role internationally. Therefore, from 2022, we have newly established four programs: "International Field Observation and Experiment for Young Scientists," "International Technical Exchange," "International School Support," and "International Research Travel Support for Young Scientists." The International Field Observation and Experiment program supports Japanese graduate students and young researchers who conduct the observation or experiments in other countries in cooperation with the faculty members of this institute. The International Technical Exchange aims to provide practical experience through international collaboration for researchers and engineers in Japan and overseas. The International School Support aids the holding of international schools to increase opportunities for students and young researchers to share international joint research. In addition, the International Research Travel Support provides opportunities for graduate students in Japan to present the research results obtained in the ISEE joint research program at international meetings. We will also support the cost of international joint research for young scientists at institutes outside Japan.

The second priority item is the strengthening of interdisciplinary research. The mission of ISEE is to understand the Earth, Sun, and universe as one system and to elucidate the mechanisms and interactions of various phenomena that occur there. Therefore, we have promoted activities to cultivate new research by fusing various fields related to the space-Earth environment. During the 3rd medium-term goal period, four projects (the solar influence on climate, the prediction of space-Earth environmental variability, the atmosphere and plasma coupling, and the cloud and aerosol process) were carried out with the support of external research funds. These produced excellent research results. In the 4th medium-term goal period, we established the Interdisciplinary Research Strategy Office to promote the development of integrated research in various fields. Faculty members of ISEE and researchers and staff from different departments of Nagoya University and other institutes participate in this new office. In addition, we develop strategies for further interdisciplinary studies effectively utilizing the ISEE joint research programs.

In 2021, we started several new interdisciplinary research projects based on a proposal from young faculty members of ISEE. For example, there is "Data Rescue of Analog Observation Records of the Past Solar and Terrestrial Environment" by Dr. Hisashi Hayakawa. This research attempts to reproduce long-term variations and extreme events in the past space-Earth environment using historical literature and analog records. He had already obtained important results to clarify the characteristics of the Dalton Minimum, in which solar activity was extremely low in the early 19th century, based on the observation records of sunspots preserved in Wilten Monastery in Austria.

Furthermore, we produced many novel results in 2021. For instance, we demonstrated a close relationship between solar wind acceleration and density turbulence from long-term interplanetary scintillation (IPS) observations since 1985. In addition, we discovered that plasma bubbles in the ionosphere, which may cause radio communication failure, appear even during the daytime in Japan.

In addition, with support from the headquarters of Nagoya University, we are developing a dropsonde device for observing typhoons by aircraft and a data archiving system for space-Earth environmental research. The former will be used for aircraft joint usage observation, which is a new ISEE joint usage program that started in 2022, while the latter will contribute to Nagoya University's digital university initiative.

In 2021, due to the influence of COVID-19, many international joint programs were postponed or canceled. However, the ISEE actively continued international research using the internet. For example, the 4th ISEE International Symposium, "International Conference on Heavy Rainfall and Tropical Cyclone in East Asia," was held online in March 2022 led by Prof. Kazuhisa Tsuboki of the Department of Meteorological and Atmospheric Research. Many researchers participated in Japan and other countries and active discussions were conducted.

The activity of the 25th solar cycle is increasing and is expected to reach its maximum in the middle of the 2020s. In modern society, the potential risks of space weather disasters are increasing. In addition, as global warming continues, environmental changes and severe disasters are increasingly occurring worldwide. Therefore, the role of ISEE, which contributes to the solution of global environmental problems and the development of human society spreading in space, is even more significant. We want to cooperate with collaborators in Japan and the world to develop further activities that will open the future through research. I hope that this annual report provides you with an understanding of ISEE's activities and we appreciate your continued support and cooperation.

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Kanya Kusano
Director

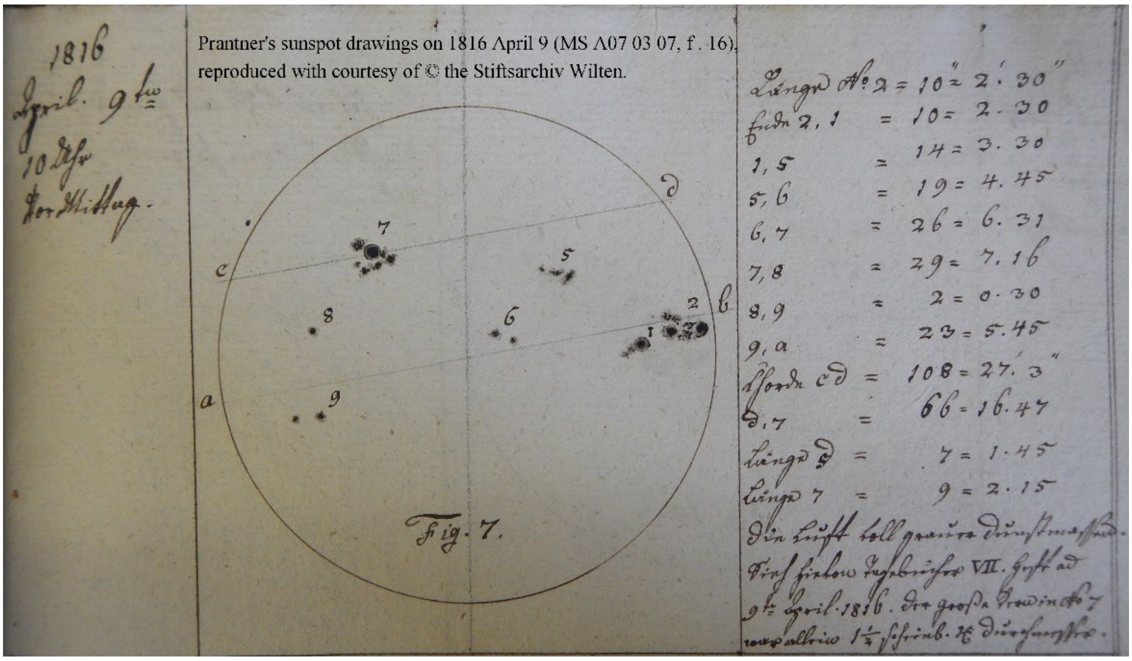


Fig.1

Archival Investigations for the Dalton Minimum

Hisashi Hayakawa (ISEE) and colleagues analyzed solar activity in the Dalton Minimum based on Stephan Prantner's sunspot records in the Wilten Stiftsarchiv. Their analyses confirmed several sunspot groups in both solar hemispheres and contrasted the Dalton Minimum with the Maunder Minimum.

Solar cycle amplitudes have been declining for several decades. If the upcoming solar cycles further reduce their amplitudes, they may go beyond the range known to the modern scientific community. The amplitude of the solar cycle was significantly moderate in the early 19th century. While this period has been specifically called the Dalton Minimum, little is known about the actual sunspot group numbers and sunspot positions during this period. Hisashi Hayakawa and his colleagues worked on the Dalton Minimum and analyzed Prantner's sunspot records in the Wilten Stiftsarchiv. Their analyses confirmed several sunspot groups in both solar hemispheres and contrasted the Dalton Minimum with the Maunder Minimum. This result is consistent with the contrasts in the visual structure of the solar coronal streamers and is expected to benefit further scientific discussions on the physical mechanism of the 'prolonged solar minima'.

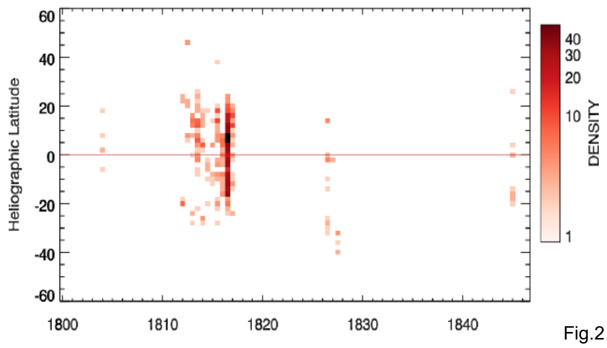


Fig.2

Fig.1: The Sunspot drawing by Plantner on April 19, 1816, at monastery Wilten, Austria (MS A07 03 07, ©Archive Premonstratensian Canons monastery Wilten).

Fig.2: Latitudinal distributions of the sunspot groups around the Dalton Minimum, as reported in Prantner's manuscripts.

Paper Information

Journal: *The Astrophysical Journal,* Vol. 919, 1(8pp),, 2021
Authors: Hayakawa, H., S. Uneme, P. B. Besser, T. Iju, and S. Imada
Title: Stephan Prantner's sunspot observations during the Dalton Minimum
DOI: 10.3847/1538-4357/abee1b

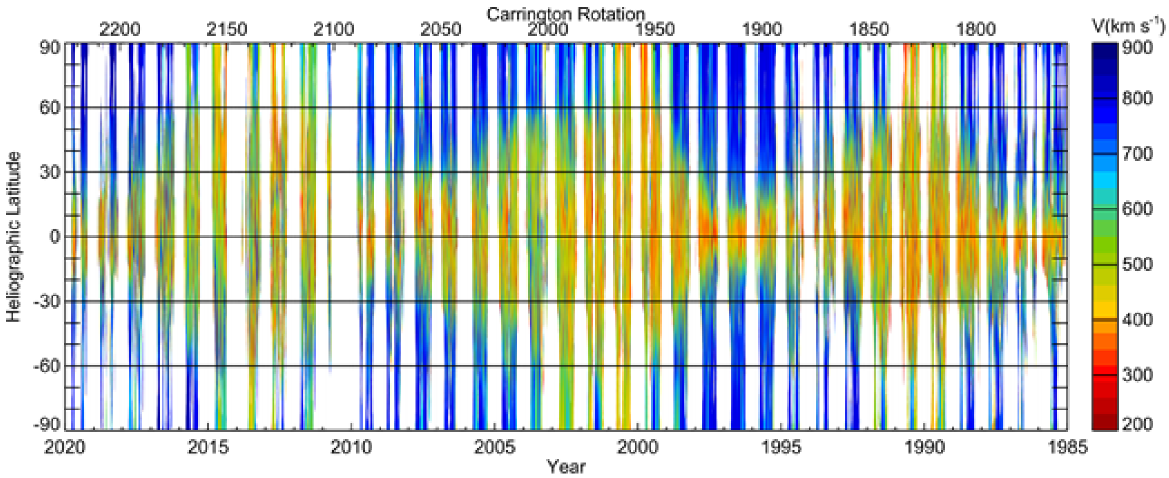


Fig.1

Relation between Solar Wind Acceleration and Density Turbulence Revealed from Long-Term Radio Observations

Munetoshi Tokumaru (ISEE) and colleagues determined the dependence between solar wind density fluctuations and speeds from the analysis of interplanetary scintillation (IPS) observations and found that the dependence varied with the long-term decline in solar activity. These results suggest that density fluctuations play an important role in solar wind acceleration.

The acceleration mechanism of solar wind, which significantly affects Earth, remains an open question. The solar wind is in a turbulent state and its density fluctuates over various scales; however, the physical properties of solar wind turbulence are not yet fully understood. According to a recent theoretical study, the efficiency of solar wind acceleration is significantly enhanced through the reflection of MHD waves by density fluctuations. Solar wind density fluctuations cause interplanetary scintillation (IPS) of radio sources. The IPS serves as a useful tool for remote sensing of the solar wind and IPS observations were conducted using the multi-station system at ISEE. The IPS observations collected over three solar cycles (cycles 22–24) were analyzed to investigate the relationship between solar wind density fluctuations and speed. As a result, the relationship between them was found to vary with the reduction of the solar activity in Cycle 24, providing a clue to elucidate the detailed process of solar wind acceleration.

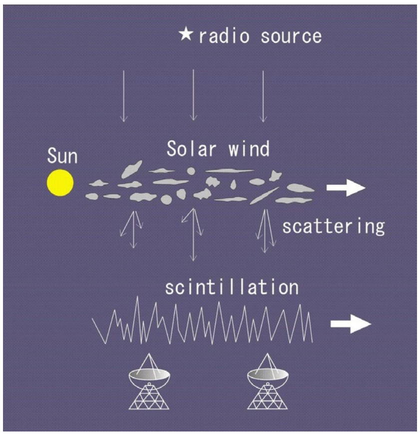


Fig. 2

Paper information

Journal： *The Astrophysical Journal*, Vol. 922, 73(18pp), 2021
Authors： Tokumaru, M., K. Fujiki, M. Kojima, and K. Iwai
Title： Global distribution of the solar wind speed reconstructed from improved tomographic analysis of interplanetary scintillation observations between 1985 and 2019
DOI：: 10.3847/1538-4357/ac1862

Fig.1: Synoptic map of the solar wind speed derived from IPS observations between 1998 and 2019. This map was derived from a tomographic analysis of IPS observations.

Fig.2: Multi-station observations of IPS, which is caused by solar wind density fluctuations, enables determination of solar wind.

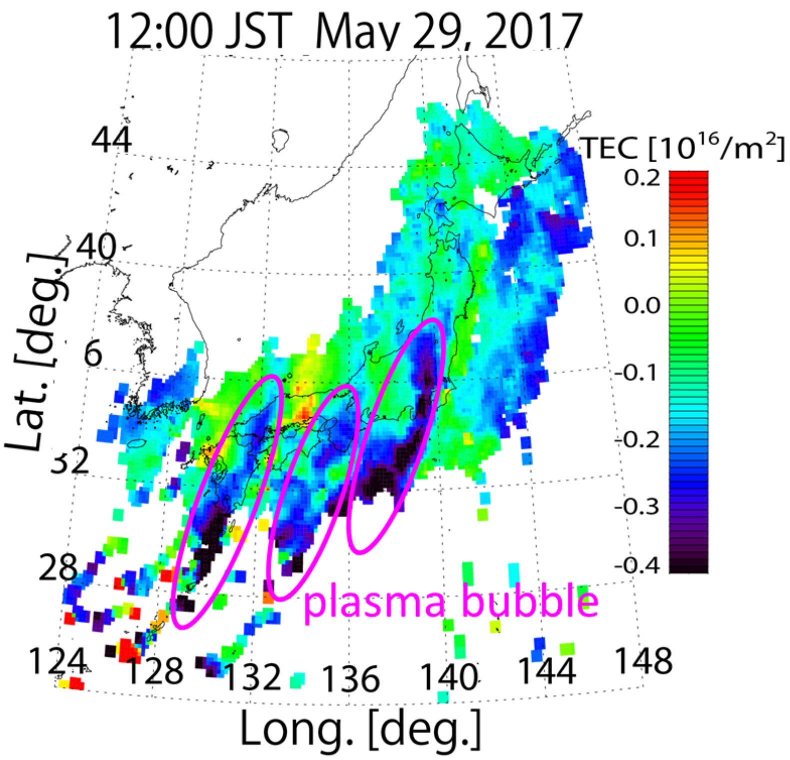


Fig.1

GPS Observation of Daytime Plasma Bubbles

Using a nationwide network of GPS receivers installed in Japan, Yuichi Otsuka (ISEE) and colleagues revealed that plasma bubbles, which can affect radio wave propagation, appeared over Japan after sunrise and remained until the afternoon. This study clarified the reason why plasma bubbles, which usually exist only during the nighttime, survived during the daytime.

Radio waves used for GPS and satellite broadcasting and communication pass through the ionosphere, which is partially ionized by solar radiation. “Plasma bubbles,” localized decreases in ionospheric plasma density, occur in the equatorial ionosphere and are among the most severe disturbances in the ionosphere. Therefore, it is important to know when and where plasma bubbles appear. In this study, the horizontal two-dimensional structure of plasma bubbles was disclosed for the first time during the day using GPS data. Furthermore, we showed that the appearance of plasma bubbles at mid-latitudes after an increase in ionospheric plasma density at sunrise is a necessary condition for plasma bubbles to survive during the daytime. This research could contribute to mitigating the degradation of GPS positioning and satellite broadcasting/communications, which use radio waves passing through the ionosphere.

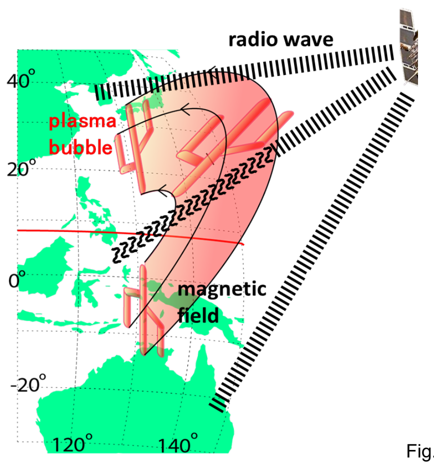


Fig.2

Fig.1: Map of total electron content (TEC). Decrease in ionospheric electron density due to plasma bubbles is seen.

Fig.2: Schematics showing a plasma bubble and its effect on radio waves propagating through the ionosphere.

Paper Information

Journal: *Earth and Planetary Physics*, Vol. 5 (5), 427-434, 2021
Authors: Otsuka, Y., A. Shinbori, T. Sori, T. Tsugawa, M. Nishioka, and J. D. Huba
Title: Plasma depletions lasting into daytime during the recovery phase of a geomagnetic storm in May 2017: Analysis and simulation of GPS total electron content observations
DOI: 10.26464/epp2021046

Fig.1

A New Dropsonde Observation System

One of the objectives of the Center for Orbital and Suborbital Observations is aircraft observation of typhoons. As one of its main instruments, a dropsonde observation system was installed on the Gulfstream IV jet aircraft. This is an instantaneous image of a dropsonde launched from the jet ejection port, taken from another jet, M300, at an altitude of 20,000 ft over the Sea of Japan. (Courtesy of Diamond Air Service Inc.).

With the Discretionary Fund of the President's Office of Nagoya University in FY2021, a dropsonde observation system was installed on a Gulfstream IV (G-IV) jet aircraft to observe typhoons that can cause severe disasters. A launching experiment was conducted to confirm that the dropsondes were successfully launched from a G-IV jet flying at a speed of approximately 200 m/s. A high-speed camera on the other jet tracked the G-IV captured images ejecting a dropsonde over the Sea of Japan and it was confirmed that the dropsonde was successfully ejected from the ejection port. This enabled dropsonde observations of a typhoon, and the aircraft observation of Typhoon Mindulle in 2021 was successfully carried out at a high altitude using this observation system. This instrument will be used not only for typhoon observations but also for various aircraft observation projects, and will also be available for ISEE Joint Research.

Fig. 2

Paper information

Journal： *J. Meteor. Soc. Japan*, Vol. 99, 1297-1327, 2021
Authors： Yamada, H., K. Ito, K. Tsuboki, T. Shinoda, T. Ohigashi, M. Yamaguchi, T. Nakazawa, N. Nagahama, and K. Shimizu
Title： The double warm-core structure of Typhoon Lan (2017) as observed through the first Japanese eyewall-penetrating aircraft reconnaissance
DOI：: 10.2151/jmsj.2021-063

Fig.1: Dropsonde ejected from a Gulfstream IV jet captured by a high-speed camera.

Fig.2: Dropsonde observation equipment installed in the wing root of a Gulfstream IV jet aircraft. The in-flight ejection device and the dropsonde data receiver rack. (top panel) and the ejection port outside (bottom panel)

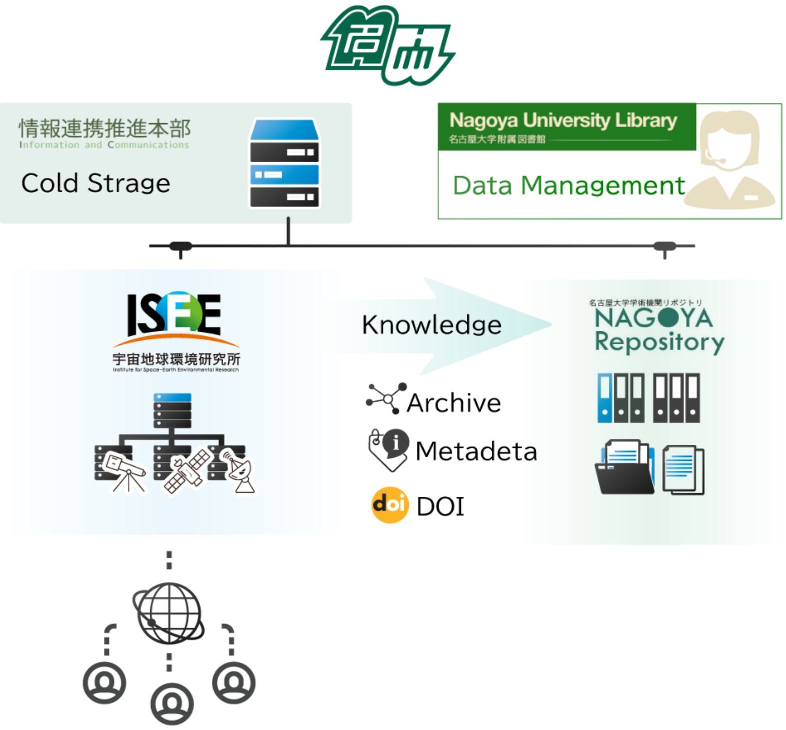


Fig.1

Demonstration Experiment on the Management of Academic Data

The team at ISEE, led by Prof. Yoshizumi Miyoshi, Assoc. Prof. Takayuki Umeda, Assoc. Prof. Yuichi Otsuka, Assoc. Prof. Masahito Nose, Assoc. Prof. Satoshi Masuda, and Prof. Kazuo Shiokawa, collaborated with Nagoya University Library, Information Technology Center, and Information Strategy Office to conduct a demonstration experiment on the infrastructure for academic data at Nagoya University. The findings from the experiment are expected to make a significant contribution to the development of a digital university in the Tokai National Higher Education and Research System in the future.

Currently, issues related to the storage, management, and publication of academic data are rapidly increasing in universities and other research institutions nationwide. Nagoya University is also required to establish a systematic maintenance system for academic data as part of its research infrastructure. ISEE has observation and measurement data and simulations of various forms and sizes related to space and earth science and has been promoting data archiving and publication at science centers in collaboration with other institutions, as well as its own DOI maintenance. In FY2021, a collaborative group including ISEE, the University Library, Information Technology Center, and the Information Strategy Office of Nagoya University, was selected for the Nagoya University President's Discretionary Fund for a project entitled “Demonstration Experiment of Large-scale Data Archiving, Publishing, and Metadata Assignment System for Digital University.” In particular, we conducted demonstration experiments on effective methods for archiving large amounts of data in cold storage (optical disks) and metadata allocation for academic data and discussed issues related to academic data maintenance in Japan through collaboration with the National Institute of Informatics. Through this project, we gained concrete knowledge of academic data archiving and metadata development and identified issues for the accumulation of large volumes of data and the development of general-purpose metadata across different academic fields, which are important for the future transformation of Nagoya University into a digital university. This kind of collaboration is scheduled to continue and is expected to contribute to the academic data development of the Tokai National Higher Education and Research System and the creation of a digital university in general through the development of space and Earth science data.

Fig.2

Fig.1: Concept of demonstration experiment on the management of academic data.

Fig.2: Optical disk system as a cold storage.

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.

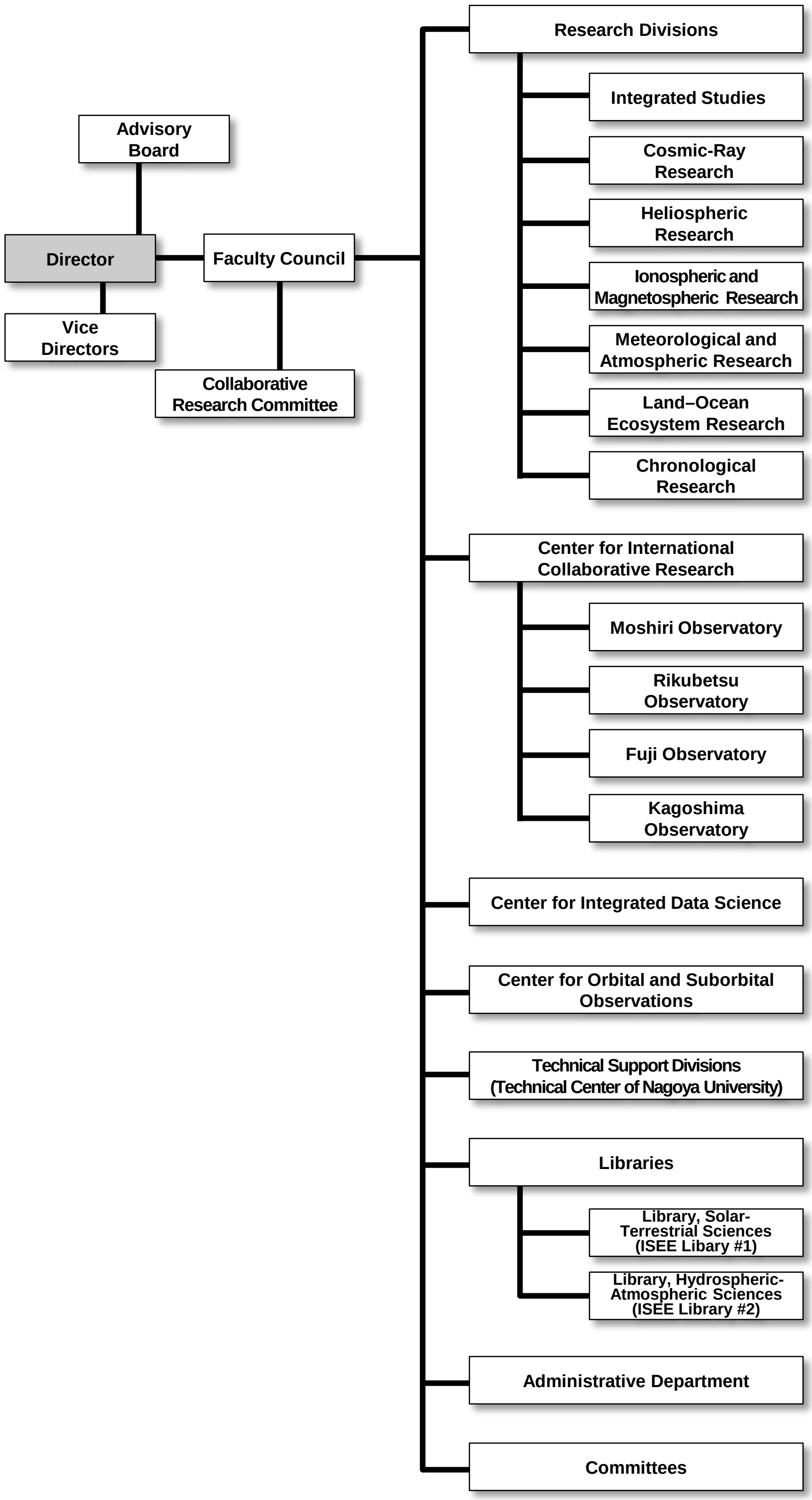
April, 2000
The Nagoya University Center for Chronological Research was organized.The CHIME dating system was transferred from the School of Science.

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, 2021–March 31, 2022
✱: Concurrent post
▲: Left the Institute in the 2021 academic year
○: Joined the Institute in the 2021 academic year
*: Belongs to Institute for Advanced Research Section

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Designated Assistant Professor	Takafumi Kaneko ▲
Designated Assistant Professor	Hisashi Hayakawa *
Research Institution Researcher	Sandeep Kumar

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Designated Assistant Professor	Sneha Yadav ▲

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Associate Professor	Shingo Kazama **
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Designated Technical Staff	Kinji Morikawa
Technical Assistant	Kazuhiro Huruta

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

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Associate Professor	Hirohiko Masunaga
Associate Professor	Taro Shinoda (✱)
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Assistant Professor	Taku Nakajima
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Researcher	Fumie Furuzawa
Researcher	Gemma Mizoguchi ○
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Research Institution Researcher	Ryusei Kuma ○
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Professor	Akira Mizuno (✱)
Professor	Masayo Minami (✱)
Professor	Michihiro Mochida (✱)
Designated Professor (Cross Appointment)	K. D. Leka
Designated Professor (Cross Appointment)	Lynn Marie Kistler
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Associate Professor	Claudia Martinez-Calderon
Associate Professor	Naoyuki Kurita (✱)
Associate Professor	Satonori Nozawa (✱)
Lecturer	Shinsuke Imada (✱)▲
Lecturer	Hatsuki Fujinami (✱)
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Designated Assistant Professor	Masafumi Shoji
Designated Assistant Professor	Sung-Hong Park ▲
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Designated Assistant Professor	Chae-Woo Jun
Designated Assistant Professor	YunHee Kang
Designated Assistant Professor	Atsuki Shinbori (✱)
Researcher	Masaya Kato
Researcher	Yoshiki Fukutomi
Designated Technical Staff	Mariko Kayaba
Designated Technical Staff	Asayo Maeda
Technical Assistant (Research Support Facilitator)	Nanako Hirata
Technical Assistant	Tomoyo Ogawa ○▲

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Professor	Kazuhisa Tsuboki (✱)
Professor	Masafumi Hirahara (✱)
Designated Professor	Masataka Murakami
Associate Professor	Taro Shinoda
Associate Professor	Hidenori Aiki (✱)
Designated Associate Professor	Kazutaka Yamaoka ***
Assistant Professor	Sho Ohata (✱)*
Designated Assistant Professor	Youko Yoshizumi ▲
Designated Assistant Professor	Takeharu Kouketsu

***2021.11.1～2022.3.31 Institute of Materials and Systems for Sustainability

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Visiting Professor	Yoshiya Kasahara
Visiting Professor	Tomo'omi Kumagai
Visiting Professor	Yoshikatsu Kuroda
Visiting Professor	Yoko Kokubu
Visiting Professor	Hiroyuki Shinagawa
Visiting Professor	Nobuo Sugimoto
Visiting Professor	Kanako Seki
Visiting Professor	Hidetaka Tanaka ○
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Visiting Associate Professor	Christian Leipe
Visiting Associate Professor	Yasunobu Ogawa
Visiting Associate Professor	Shinji Saito
Visiting Associate Professor	Daikou Shiota
Visiting Associate Professor	Iku Shinohara
Visiting Associate Professor	Toru Tamura
Visiting Associate Professor	Hiroshi Hayashi ○
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 ○

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	Mitsuyuki Hirokawa ▲
Specialist, General Affairs Section	Hideaki Yano
Section Head, General Affairs Section	Takamasa Sato ○
Section Head, General Affairs Section	Tomoko Mizutani ▲
Section Head, Personnel Affairs Section	Yohei Sato ○
Section Head, Budget Planning Section	Mirei Miyao
Leader, Personnel Affairs Section	Yoshikazu Akamatsu ○
Administrator	Junpei Okada
Administrator	Asana Goto
Administrator	Megumi Goto
Administrator	Hisako Watabe ▲
Designated Supervisor	Tadashi Tsuboi

Foreign Visiting Cooperation Researcher

2021.6.26－2022.6.25	Xiaolong Li
2021.9.11－2021.12.10	Aleksandr Rubtsov
2021.10.1－2021.12.21	Adhitya Pavithran
2021.11.13－2021.12.23	Daniel Izuikedinachi Okoh
2021.11.15－2022.2.23	Dejene Ambisa Terefe
2022.1.23－2022.2.11	HajiHossein Azizi

Toyokawa Branch

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

4. Committee of Other Organizations

Committee of Other Organizations

Contact Post	Job Title	Organizations	Name of Committee / Title
Joji Ishizaka	Professor	North Pacific Marine Science Organization (PICES)	Co-Chair of Advisory Panel for a CREAMS/PICES Program in East Asian Marginal Seas
Joji Ishizaka	Professor	North Pacific Marine Science Organization (PICES)	Member of Working Group 35: Third North Pacific Ecosystem Report
Joji Ishizaka	Professor	Northwest Pacific Action Plan (NOWPAP)	Focal Point of Center for Special Monitoring and Coastal Environmental Assessment Regional Active Center (CEARAC)
Yoshitaka Itow	Professor	Institute of Particle and Nuclear Studies, KEK	J-Parc Program Advisory Committee member
Hiroyuki Kitagawa	Professor	International Continental Scientific Drilling Program (ICDP), Dead Sea Deep Sea Drilling Project (DSDDP)	Principal Investigator
Hiroyuki Kitagawa	Professor	Geosciences	Editor
Kazuo Shiokawa	Professor	Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)	President
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
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
Hiroyasu Tajima	Professor	The Scientific World Journal	Editorial Board member
Tetsuya Hiyama	Professor	International Arctic Science Committee (IASC)	Terrestrial Working Group (TWG) member
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	EU-Horizon 2020: SafeSpace	Advisory Panel
Yoshizumi Miyoshi	Professor	Annales Geophysicae	Editor

Contact Post	Job Title	Organizations	Name of Committee / Title
Yoshizumi Miyoshi	Professor	Earth and Planetary Physics	Editor
Yoshizumi Miyoshi	Professor	Polar Research	Guest editor
Yoshizumi Miyoshi	Professor	Scientific Reports	Editorial Board member
Yoshizumi Miyoshi	Professor	Frontiers in Astronomy and Space Sciences	Associate Editor
Michihiro Mochida	Professor	International Commission on Atmospheric Chemistry and Global Pollution (iCACGP)	Commission member
Michihiro Mochida	Professor	Atmospheric Environment	Editorial Advisory Board member
Hidenori Aiki	Associate Professor	Journal of Physical Oceanography	Associate Editor
Hidenori Aiki	Associate Professor	Journal of Atmospheric and Oceanic Technology	Associate Editor
Yuichi Otsuka	Associate Professor	Journal of Astronomy and Space Sciences	Editor
Yuichi Otsuka	Associate Professor	Earth and Planetary Physics	Guest editor for the special issue of “Recent Advances in Equatorial Plasma Bubble and Ionospheric Scintillation”
Nozomu Nishitani	Associate Professor	Super Dual Auroral Radar Network (SuperDARN)	Vice chair of Executive Council
Nozomu Nishitani	Associate Professor	Polar Science	Guest editor for the special issue of “SuperDARN / Studies of Geospace Dynamics - Today and Future”
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
Satonori Nozawa	Associate Professor	EISCAT Scientific Association	Council member
Masahito Nosé	Associate Professor	International Association of Geomagnetism and Aeronomy (IAGA)	Division V Chair
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
Hirohiko Masunaga	Associate Professor	National Aeronautics and Space Administration (NASA)	ACCP Science Community Cohort
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
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

One of the major functions of the ISEE is to promote and conduct collaborative research on space–Earth environmental science together with researchers from universities and institutes outside the ISEE. On January 14, 2016, the ISEE was certified by MEXT of Japan as a joint usage/research center for the third medium-term goal/planning period (FY2016 to FY2021) of national universities. During this period, we promoted two projects: “Study of the coupling processes in the solar–terrestrial system using ground-based observation networks” and “Establishment of an international collaborative research hub to solve research issues in the global (terrestrial) environment and space applications based on comprehensive studies of the space–Sun–Earth system.” The former focuses on coupling processes in the solar–terrestrial system and the interactions of neutral and plasma components in the Earth’s atmosphere by establishing an international ground-based observation network ranging from low- to high-latitude regions, especially in Asia and Africa. While the latter aims to establish an international collaborative research hub for comprehensive studies of the space–Sun–Earth system, space applications, space weather forecasting, and environmental problems, such as global warming.

The following 12 categories of open-call joint research programs were prepared for application in FY2021. These collaborative research programs are executed using the instruments, software/databases, and facilities of the ISEE. Joint research programs. 01) to 03) are managed by the CICR; 07) and 08) are managed by the CIDAS; and 09) and 10) are managed by the Division for Chronological Research. In FY2021, we adopted 200 research projects based on proposals from researchers worldwide.

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

(*) Applicable only to foreign researchers

Due to the influence of COVID-19, as in FY2020, most of the international joint research programs and workshops were canceled or implemented by changing the scope, and most symposiums and research meetings were conducted online. The fourth ISEE symposium, which had to be postponed in FY2020, was held online March 1–3, 2022, entitled “International Conference on Heavy Rainfall and Tropical Cyclone in East Asia,” led by Professor Kazuhisa Tsuboki.

A community meeting was held online with researchers from inside and outside the institute on August 5, 2021. At the end of the third medium-term period, we surveyed to gather inputs from the community and received a variety of opinions and suggestions regarding our existing joint research programs and interdisciplinary research. We shared this information and discussed future joint research programs.

The year-end evaluation by MEXT stated that the ISEE is a unique research facility that integrates space and earth sciences and that the scale of joint usage/research programs is large, especially in international collaboration with related research institutions. As a result, the ISEE received an “S” rating, designating it as a “highly significant” institution. In the fourth medium-term goal/planning period (FY2022 to FY2027), we will add five categories of joint research programs and focus on fostering young researchers, promoting international joint usage/research, integrating different fields through interdisciplinary joint research, and developing new science related to the space–Sun–Earth system.

List of Accepted Proposals

■ ISEE International Joint Research Program

Proposer	Affiliation*	Job title*	Corresponding ISEE researcher	Title of the research program
Akala, Andrew Oke-‘Ovie	University of Lagos	Associate Professor	Otsuka, Y.	Investigation of the responses of global equatorial/low-latitude ionosphere to CIR-driven and CME-driven intense geomagnetic storms during solar cycle 24
Teh, Wai Leong	National University of Malaysia	lecturer	Umeda, T.	Understanding the Role of Magnetic Island in Plasma Acceleration and Energy Dissipation during Magnetic Reconnection
Berger, Thomas	University of Colorado at Boulder	Research Staff	Imada, S.	Investigation of Solar Polar Magnetic Fields using Hinode/SP and SDO/HMI Data
Santolík, Ondřej	Institute of Atmospheric Physics, Czech Academy of Sciences	Professor	Miyoshi, Y.	Investigation of electromagnetic waves in space
Buranapratheprat, Anukul	Burapha University	Assistant Professor	Ishizaka, J.	An investigation of Mekong River plume in the South China Sea influenced by dam construction and climate change: a numerical modeling approach
Poluianov, Stepan	University of Oulu	Senior Researcher	Kurita, N.	Solar and terrestrial effects in the 50-year long tritium record from Antarctica
Mohanty, Pravata Kumar	Tata Institute of Fundamental Research	Reader	Matsubara, Y.	Study of galactic cosmic rays in the near-Earth space by high resolution multi-directional muon telescopes
Spiegl, Tobias Christian	Freie Universität Berlin	Postdoctoral Researcher	Miyake, F.	Using cosmogenic isotopes to trace back large-scale atmospheric dynamics of the neutron monitor era
Okoh, Daniel Izuikedinachi	National Space Research and Development Agency	Researcher and Coordinator	Shiokawa, K.	Investigating Variations and Similarities between Consecutive Equatorial Plasma Bubble Occurrences and Propagation Speeds across Longitudinal Sections of the Globe
Welsch, Brian	University of Wisconsin -Green Bay	Associate Professor	Kusano, K.	Exploring Magnetic Energies to Understand and Predict CME Onset
Maurya, Ajeet Kumar	Doon University	Assistant Professor	Otsuka, Y.	Characterization of the gravity waves of the meteorological origin and their role in vertical atmosphere-ionosphere coupling
Lugaz, Noé	University of New Hampshire	Research Associate Professor	Kusano, K.	Sheaths of Coronal Mass Ejections and Their Effects on Earth’s Dayside Magnetosphere and Radiation Belts
Al-Haddad, Nada	University of New Hampshire	Research Assistant Professor	Kusano, K.	Magnetic Structures and Associated Flows of Coronal Mass Ejections
Fedun, Viktor	The University of Sheffield	Senior Lecturer	Kusano, K.	Comprehensive analysis of solar atmospheric dynamics driven by interacting vortex tubes
Zhang, Jie	George Mason University	Full Professor	Kusano, K.	Study the Origin of Solar Eruptions Using Homologous Events

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

■ ISEE/CICR International Workshop

Not adopted FY2021.

Lists of Collaboration Resources

■ Instruments

Name	Contact Person
Multi-Directional Cosmic Ray Muon Telescope (Nagoya)	Y. Matsubara
Multi-Station IPS Solar Wind Observation System (Toyokawa, Fuji, and Kiso)	M. Tokumaru
ELF/VLF Network	K. Shiokawa
ISEE Magnetometer Network	K. Shiokawa
ISEE Riometer Network	K. Shiokawa
Optical Mesosphere Thermosphere Imagers	K. Shiokawa
Sodium LIDAR (Tromsø)	S. Nozawa
MF Radar (Tromsø)	S. Nozawa
Five-Wavelength Photometer (Tromsø)	S. Nozawa
Meteor Radar (Alta)	S. Nozawa
SuperDARN Hokkaido Pair of (HOP) Radars (Rikubetsu)	N. Nishitani
Upper Air Sounding Systems (two sets)	K. Tsuboki
Polarimetric Radar Systems (two sets)	K. Tsuboki
Ka-Band Polarimetric Radar	K. Tsuboki
Hydrometeor Video Sonde (HYVIS) System	K. Tsuboki
Fourier Transform Infrared (FTIR) Spectrometer for Atmospheric Composition Measurement (Rikubetsu)	T. Nagahama
Sea Spray Aerosol Optical Particle Counter	H. Aiki
Low-Background Beta-Ray Counter	N. Kurita
Water Isotope Analyzer (Picarro L2130-i)	N. Kurita

■ Software/Databases

Name	Contact Person
Hinode Science Center, Nagoya University	K. Kusano
ERG Science Center	Y. Miyoshi
QL Plot Archive of Satellite Data for Integrated Studies	Y. Miyoshi
MHD Simulation on the Magnetospheric Environment	T. Umeda
Numerical Simulation Codes for Plasma Kinetics	T. Umeda
Cosmic Ray Intensity Database	Y. Matsubara
Interplanetary Scintillation Data	M. Tokumaru
Solar Wind Speed Data	M. Tokumaru
Remei Satellite Observation Database	M. Hirahara
Coordinated Magnetic Data Along 210° Magnetic Meridian (Moshiri, Rikubetsu, Kagoshima, and Overseas MM Stations)	K. Shiokawa
Database of the Optical Mesosphere Thermosphere Imagers	K. Shiokawa
ELF/VLF Wave Data	K. Shiokawa

Name	Contact Person
ISEE Riometer Network Database	K. Shiokawa
All-Sky Auroral Data (Canada, Alaska, and Siberia)	K. Shiokawa, Y. Miyoshi
VHF Radar/GPS Scintillation (Indonesia)	Y. Otsuka
EISCAT Database	S. Nozawa, S. Oyama
SuperDARN Hokkaido Pair of (HOP) Radars Database	N. Nishitani
Cloud Resolving Strom Simulator (CReSS)	K. Tsuboki
Atmospheric Composition Data by FT-IR Measurements (Moshiri and Rikubetsu)	T. Nagahama
NO_2 and O_3 Data by UV/Visible Spectrometer Measurements (Moshiri and Rikubetsu)	T. Nagahama
Satellite Data Simulator Unit (SDSU)	H. Masunaga
Energy Flux Diagnosis Code for Atmospheric and Oceanic Waves	H. Aiki

■ Facilities

Name	Contact Person
CIDAS System	S. Masuda, T. Umeda, Y. Miyoshi
Ion/Electron Beamline and Calibration Facility	M. Hirahara
Clean Room Facility for Instrument Development	M. Hirahara
CHN Analyzer, Isotope Ratio Mass Spectrometer	Y. Mino
Tandetron Accelerator Mass Spectrometry	H. Kitagawa, M. Minami
Electron Probe Microanalyzer (EPMA)	T. Kato
X-Ray Fluorescence Spectrometer (XRF)	T. Kato
X-Ray Diffractometer (XRD)	T. Kato
Facilities at Moshiri Observatory	A. Mizuno
Facilities at Rikubetsu Observatory	A. Mizuno
Facilities at Kiso Station	M. Tokumaru
Facilities at Fuji Observatory	M. Tokumaru
Facilities at Kagoshima Observatory	K. Shiokawa

6. Governance

As of March 31, 2022

Advisory Board

Masaki Fujimoto	Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency
Tohru Hada	Interdisciplinary Graduate School of Engineering Sciences, Kyushu University
Masahiro Hoshino	Graduate School of Science, The University of Tokyo
Hironobu Hyodo	Research Institute of Frontier Science and Technology, Okayama University of Science
Mamoru Ishii	Radio Propagation Research Center, Radio Research Institute, National Institute of Information and Communications Technology
Takaaki Kajita	Institute for Cosmic Ray Research, The University of Tokyo
Takeshi Kawano	Japan Agency for Marine-Earth Science and Technology
Takuji Nakamura	National Institute of Polar Research, Research Organization of Information and Systems
Nobuko Saigusa	Earth System Division, National Institute for Environmental Studies
Yukari N. Takayabu	Atmosphere and Ocean Research Institute, The University of Tokyo
Makoto Taniguchi	Research Institute for Humanity and Nature, National Institutes for the Humanities
Junichi Watanabe	National Astronomical Observatory of Japan, National Institutes of Natural Sciences
Mamoru Yamamoto	Research Institute for Sustainable Humanosphere, Kyoto University
Hisayoshi Yurimoto	Faculty of Science, Hokkaido University
Tatsuya Suzuki	Graduate School of Engineering, Nagoya University
Urumu Tsunogai	Graduate School of Environmental Studies, Nagoya University
Tomohiko Watanabe	Graduate School of Science, Nagoya University
Masafumi Hirahara	Institute for Space–Earth Environmental Research, Nagoya University
Tetsuya Hiyama	Institute for Space–Earth Environmental Research, Nagoya University
Yoshitaka Itow	Institute for Space–Earth Environmental Research, Nagoya University
Hiroyuki Kitagawa	Institute for Space–Earth Environmental Research, Nagoya University
Kazuo Shiokawa	Institute for Space–Earth Environmental Research, Nagoya University
Nobuhiro Takahashi	Institute for Space–Earth Environmental Research, Nagoya University
Munetoshi Tokumaru	Institute for Space–Earth Environmental Research, Nagoya University

Collaborative Research Committee

Yoichiro Hanaoka	National Astronomical Observatory of Japan, National Institutes of Natural Sciences
Atsushi Higuchi	Center for Environmental Remote Sensing, Chiba University
Akira Kadokura	Polar Environment Data Science Center, Joint Support-Center for Data Science Research, Research Organization of Information and Systems
Yoshiya Kasahara	Emerging Media Initiative, Kanazawa University
Chihiro Kato	Faculty of Science, Shinshu University
Kazuyuki Kita	College of Science, Ibaraki University
Yoko S. Kokubu	Tono Geoscience Center, Japan Atomic Energy Agency
Yuki Kubo	Radio Research Institute, National Institute of Information and Communications Technology
Takashi Minoshima	Research Institute for Value-Added-Information Generation, Japan Agency for Marine-Earth Science and Technology
Akihiko Morimoto	Center for Marine Environmental Studies, Ehime University
Takeshi Sakanoi	Graduate School of Science, Tohoku University
Kimikazu Sasa	Physics, Faculty of Pure and Applied Sciences, University of Tsukuba
Kanako Seki	Graduate School of Science, The University of Tokyo
Iku Shinohara	Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency
Hiroyuki Yamada	Faculty of Science, University of the Ryukyus
Hidenori Aiki	Institute for Space–Earth Environmental Research, Nagoya University
Takenori Kato	Institute for Space–Earth Environmental Research, Nagoya University
Kanya Kusano	Institute for Space–Earth Environmental Research, Nagoya University
Satoshi Masuda	Institute for Space–Earth Environmental Research, Nagoya University
Hirohiko Masunaga	Institute for Space–Earth Environmental Research, Nagoya University
Yutaka Matsubara	Institute for Space–Earth Environmental Research, Nagoya University
Masayo Minami	Institute for Space–Earth Environmental Research, Nagoya University
Masahito Nosé	Institute for Space–Earth Environmental Research, Nagoya University
Yuichi Otsuka	Institute for Space–Earth Environmental Research, Nagoya University
Taro Shinoda	Institute for Space–Earth Environmental Research, Nagoya University
Kazuo Shiokawa	Institute for Space–Earth Environmental Research, Nagoya University
Nobuhiro Takahashi	Institute for Space–Earth Environmental Research, Nagoya University
Munetoshi Tokumaru	Institute for Space–Earth Environmental Research, Nagoya University
Takayuki Umeda	Institute for Space–Earth Environmental Research, Nagoya University

Joint Research Technical Committee

Integrated Studies Technical Committee

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

Heliospheric and Cosmic-Ray Research Technical Committee

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

Ionospheric and Magnetospheric Research Technical Committee

Yoshiya Kasahara	Emerging Media Initiative, Kanazawa University
Hiroyuki Nakata	Graduate School of Engineering, Chiba University
Shin Suzuki	Faculty of Regional Policy, Aichi University
Fuminori Tsuchiya	Graduate School of Science, Tohoku University
Masahito Nosé	Institute for Space–Earth Environmental Research, Nagoya University
Satonori Nozawa	Institute for Space–Earth Environmental Research, Nagoya University
Yuichi Otsuka	Institute for Space–Earth Environmental Research, Nagoya University

Meteorological, Atmospheric and Land-Ocean Ecosystem Research Technical Committee

Daisuke Goto	Center for Regional Environmental Research, National Institute for Environmental Studies
Atsushi Higuchi	Center for Environmental Remote Sensing, Chiba University
Masafumi Hirose	Faculty of Science and Technology, Meijo University
Akihiko Morimoto	Center for Marine Environmental Studies, Ehime University
Kenshi Takahashi	Research Institute for Sustainable Humanosphere, Kyoto University
Hidenori Aiki	Institute for Space–Earth Environmental Research, Nagoya University
Hirohiko Masunaga	Institute for Space–Earth Environmental Research, Nagoya University
Akira Mizuno	Institute for Space–Earth Environmental Research, Nagoya University
Tomoo Nagahama	Institute for Space–Earth Environmental Research, Nagoya University

Chronological Research Technical Committee

Seiji Kadowaki	Nagoya University Museum
Yoko S. Kokubu	Tono Geoscience Center, Japan Atomic Energy Agency
Katsuyoshi Michibayashi	Graduate School of Environmental Studies, Nagoya University
Kimikazu Sasa	Physics, Faculty of Pure and Applied Sciences, University of Tsukuba
Motohiro Tsuboi	School of Biological and Environmental Sciences, Kwansei Gakuin University
Hiromi Yamazawa	Graduate School of Engineering, Nagoya University
Takenori Kato	Institute for Space–Earth Environmental Research, Nagoya University
Hiroyuki Kitagawa	Institute for Space–Earth Environmental Research, Nagoya University
Masayo Minami	Institute for Space–Earth Environmental Research, Nagoya University
Fusa Miyake	Institute for Space–Earth Environmental Research, Nagoya University

Airplane Usage Technical Committee

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

Steering Committee of the Center for International Collaborative Research

Yoichiro Hanaoka	National Astronomical Observatory of Japan, National Institutes of Natural Sciences
Akihiko Morimoto	Center for Marine Environmental Studies, Ehime University
Akinori Saito	Graduate School of Science, Kyoto University.
Wallis Simon	Graduate School of Science, The University of Tokyo
Joji Isizaka	Institute for Space–Earth Environmental Research, Nagoya University
Nozomu Nishitani	Institute for Space–Earth Environmental Research, Nagoya University
Kazuo Shiokawa	Institute for Space–Earth Environmental Research, Nagoya University

Steering Committee of the Center for Integrated Data Science

Hiroshi Hidaka	Graduate School of Environmental Studies, Nagoya University
Masahiro Hoshino	Graduate School of Science, The University of Tokyo
Ichiro Ide	Mathematical and Data Science Center, Nagoya University
Yoshifumi Saito	Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency
Shin-ichiro Shima	Graduate School of Information Science. University of Hyogo
Junichi Watanabe	National Astronomical Observatory of Japan, National Institutes of Natural Sciences
Akimasa Yoshikawa	Faculty of Science, Kyushu University
Takenori Kato	Institute for Space–Earth Environmental Research, Nagoya University
Kanya Kusano	Institute for Space–Earth Environmental Research, Nagoya University
Yoshizumi Miyoshi	Institute for Space–Earth Environmental Research, Nagoya University
Kazuhisa Tsuboki	Institute for Space–Earth Environmental Research, Nagoya University
Takayuki Umeda	Institute for Space–Earth Environmental Research, Nagoya University

Steering Committee of the Center for Orbital and Suborbital Research

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

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	2,860,000
Grant-in-Aid for Scientific Research (S)	3	115,440,000
Grant-in-Aid for Scientific Research (A)	8	79,040,000
Grant-in-Aid for Scientific Research (B)	10	43,940,000
Grant-in-Aid for Scientific Research (C)	5	6,890,000
Grant-in-Aid for Challenging Research (Exploratory)	10	24,050,000
Grant-in-Aid for Early-Career Scientists	6	7,800,000
Grant-in-Aid for Research Activity Start-up	3	4,160,000
Fund for the Promotion of Joint International Research (Fostering Joint International Research (B))	4	15,470,000
Grant-in-Aid for JSPS Fellows	1	1,690,000
Total	51	301,340,000

- Fifty-one research subjects listed in the table were supported by the JSPS Kakenhi.
- Twenty-five research subjects received total 143,896,264 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.
- Four research subjects received total 50,191,345 JPY of donation.

Libraries

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

Books

Japanese	3,026
Foreign	11,136

Journals

Japanese	47
Foreign	207

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

Books

Japanese	4,463
Foreign	8,863

Journals

Japanese	273
Foreign	249

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
Sugadaira Station	3,300	0	Nagano
Kiso Station	6,240	66	Nagano
Total	272,241	10,922	

8. Research Topics

The mission of the ISEE is to understand the mechanisms and interactions of diverse processes occurring in the integrated space–Sun–Earth system to deal with global environmental problems and to contribute to human society in the space age. To develop this new research field, four projects of Interdisciplinary Research were studied with seven research divisions: Divisions for Integrated Studies, Cosmic Ray Research, Heliospheric Research, Ionospheric and Magnetospheric Research, Meteorological and Atmospheric Research, Land–Ocean Ecosystem Research, and Chronological Research.

1) **The Project for Space–Earth Environmental Prediction** aims to develop our understanding and predictive capabilities of the influence of solar dynamics and atmosphere–ocean activities on the global environment.
2) **The Project for the Interaction of Neutral and Plasma Atmospheres** aims to improve our understanding of the relationship between Earth's atmosphere and space using a global observation network of interactions between the upper plasma and middle atmosphere.
3) **The Project for Solar–Terrestrial Climate Research** aims to observe the long-term variability in solar activity over more than several thousands of years through radioisotopes and to examine the influence of solar activity on the atmosphere using observations and models to understand the influence of solar activity on global climate variability.
4) **The Project for Aerosol and Cloud Formation** aims to understand the processes that form cloud and precipitation particles by considering the influence of cosmic rays and the processes of scattering and absorption of radiation by clouds and aerosol particles using experiments, field observations, and simulations.

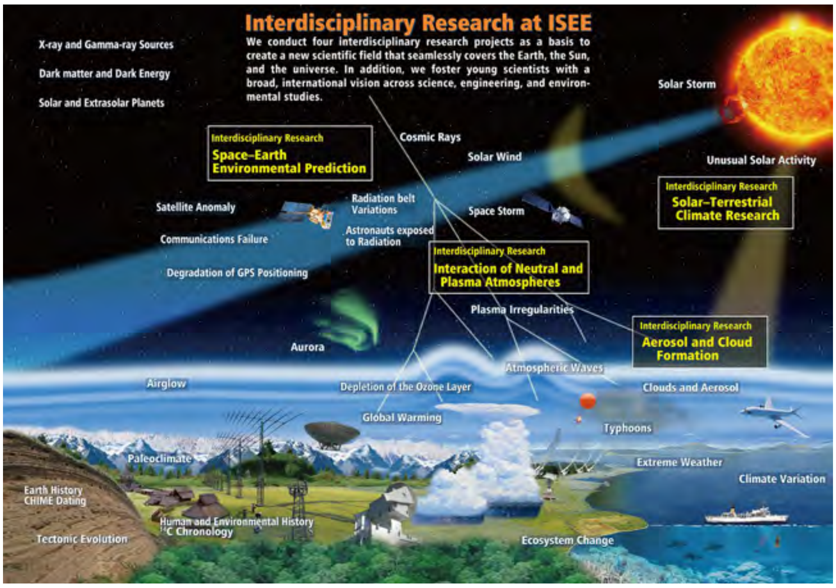
The main results of these interdisciplinary studies carried out during the period of the 3rd medium-term goal period (six years from 2016 to 2021) are summarized in "8.3 Interdisciplinary Research."

In addition, to develop new interdisciplinary research, in 2021, the Institute started the following research projects based on proposals from faculty members, using the Director's Leadership Funds.

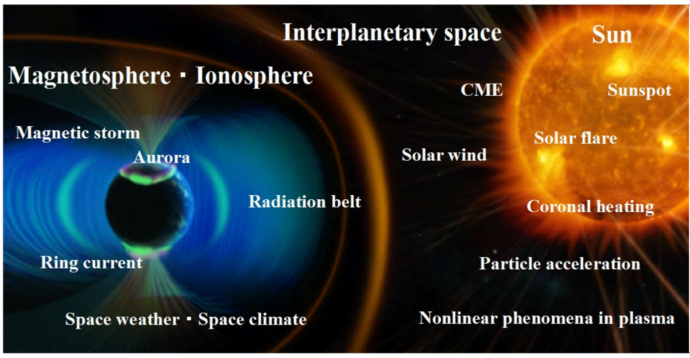
1) **Energetic Particle Chain -Effects on the middle/lower atmosphere from energetic particle precipitations-**
2) **Direct Search for Dark Matter with Paleo-detector**
3) **Data Rescues of the Analog Observational Records for the Past Solar-Terrestrial Environment**
4) **Changes in Surface Temperature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

More information on these research projects can be found in "8.4 FY2021 Interdisciplinary Research Projects".

The ISEE also has three research centers that contribute to national and international research development of the relevant disciplines in cooperation with the research divisions. The Center for International Collaborative Research (CICR) conducts extensive observations with four domestic observatories (Moshiri, Rikubetsu, Fuji, and Kagoshima) and a global observation network to enhance collaboration and joint research between domestic and international researchers and institutions. The Center for Integrated Data Science (CIDAS) develops 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) conducts 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."



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 FY2021

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

Analog records and historical documents are of vital importance to chronologically extend our scientific knowledge of the extremity of the solar-terrestrial environment. Our team exploited historical records of solar storms and long-term solar variability. In the fiscal year 2021, we quantitatively analyzed and reconstructed the solar storms in September 1859, March 1940, and the International Geophysical Year (1957–1958) based on reports on solar eruptions, geomagnetic disturbances, and low-latitude aurorae. For the long-term solar variability, we analyzed the sunspot observations of Prantner in the Dalton Minimum and those of Fogelius, Siverus, and Müller around the Maunder Minimum (Hayakawa et al., *MNRAS*, 2021 and 2022; *GDJ*, 2022; *ApJ*, 2021 and 2022; *PASJ*, 2021; *Solar Physics*, 2021).

The solar differential rotation was reproduced for the first time with the highest resolution simulation with supercomputer “Fugaku”

Associate Professor Hideyuki Hotta (Graduate School of Science, Chiba University) and Professor Kanya Kusano (ISEE) succeeded in precisely reproducing the thermal convection and the magnetic field in the solar interior in the super high-resolution calculation on supercomputer “Fugaku.” As a result, the basic structure of the solar differential rotation, that is, the equatorial region rotates faster than the polar region, was reproduced based on the first principle of magnetohydrodynamics without any artificial manipulation. The powerful computational ability of “Fugaku” enabled us to resolve the Sun with 5.4 billion grid points and reproduce the differential rotation on the computer. Because the differential rotation of the interior of the Sun is believed to be the main cause of sunspot formation, this result will be a big step toward solving the mystery of the 11-year solar cycle (Schwabe cycle), which is one of the biggest problems in astronomy (Hotta and Kusano, *Nature Astronomy*, 2021).

New numerical method to model the energy loss from solar corona

Most of the energy of the solar corona is lost in the atmospheric layer, which is known as the transition region. The transition region tends to be extremely thin owing to the sharp temperature dependence of thermal conduction and radiative cooling. A large number of grid points are required to fully resolve this thin layer and accurately model the energy loss from the solar corona. We proposed a new numerical method to model the energy loss from a solar corona. In this method, the transition region was numerically broadened while maintaining the energy balance between thermal conduction and radiative cooling. This method enabled us to model the transition region with a grid size of 50–100 km, which is approximately 1000 times larger than the physical requirement. In other words, we can reduce the computational cost of the 3-D atmospheric model by a factor of 1 trillion (Iijima and Imada, *ApJ*, 2021).

Study of coronal heating mechanism based on statistical analysis of occurrence frequency distributions of solar flares

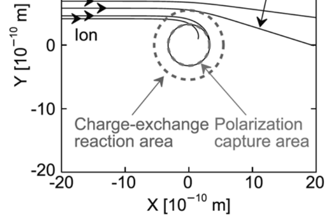
In conventional corona heating research, the contribution of nanoflares, which cannot be identified by observation, is not sufficiently considered and energy other than thermal energy is not considered when estimating the amount of flare release energy. To overcome these problems, we developed and researched a new analytical method that combined satellite observation data and numerical calculations. The results supported the validity of the nanoflare hypothesis in the active region (Kawai and Imada, *ApJ*, 2021a, 2021b, Kawai, PhD thesis, Nagoya University, 2022).

Magnetic helicity as a tool for understanding the flaring activity of the Sun

Observations of various features in the solar atmosphere revealed an interesting tendency for more left-handed helical structures in the northern hemisphere and right-handed structures in the southern hemisphere. This is the so-called hemispheric sign preference (HSP) for magnetic helicity. Recently, we examined what the HSP tells us about the long-term flaring activity of the Sun, using the solar magnetic field data observed by NASA's Solar Dynamics Observatories (SDO). As a result, we found a specific heliographic region in the Carrington coordinates correlating with the solar surface that shows an extremely low degree (approximately 40%) of HSP compliance. Interestingly, this heliographic region showed the highest flaring activity over solar cycle 24. This association of the lower HSP compliance with the higher flaring activity needs to be further examined with more AR samples and different solar cycles to understand the early formation and development of flaring active regions even in the deeper convection zone (Park et al., *ApJ*, 2021).

Curved trajectory effect on charge-exchange collision at ionospheric temperatures

Collisions between ions and neutral particles are an essential characteristic of the Earth's ionosphere. This ion-neutral collision is usually caused by the polarization of neutral particles. This collision can also be caused by charge exchange if the particle pair is parental, such as atomic oxygen and its ion. The total collision frequency is not the sum of the polarization and charge-exchange components but is essentially equal to the dominant component. The total is enhanced only around the classic transition temperature, which is near the ionospheric temperature range (typically, 200–2000 K). However, the magnitude of this enhancement differs in previous studies; the maximum enhancement has been reported to be 41% and 11% without physical explanation. In this study, the contribution of the polarization force to the charge-exchange collision was expressed as a simple curved particle trajectory effect. Consequently, the maximum enhancement was 22%. The enhancement has been neglected in classic ionospheric



Collision between an ion and parent neutral particle. The polarization collision couples with the charge-exchange collision, resulting in an enhancement of the total momentum-transfer cross section up to 25%.

studies, partly due to confusion with the glancing particle contribution, which adds 10.5% to the polarization component. This enhancement has presumably been neglected because there is no functional form to express it. This expression was derived in this study (Ieda, *JGR*, 2022).

Ozone depletion caused by high-energy electron Precipitation: Arase and EISCAT Observations

During a magnetic storm in March 2017, simultaneous European Incoherent Scatter Scientific Association (EISCAT) and optical campaign observations detected precipitation of relativistic electrons to ~3 MeV with pulsating auroras associated with omega bands. During this time interval, strong chorus waves were observed on the magnetosphere side by the Arase satellite. Simulations based on Arase observations reproduced the high-energy electron precipitation observed by the EISCAT. Furthermore, computer simulations of atmospheric chemistry showed that energetic electrons precipitated into the atmosphere cause strong ionization in the mesosphere, destroying more than 10% of mesospheric ozone. This result indicated that interactions between chorus and magnetospheric electrons cause coupling between the magnetosphere and atmosphere through the precipitation of energetic electrons (Miyoshi et al., *Scientific Reports*, 2021).

Contribution of electron pressure to ring current and ground magnetic depression using RAM-SCB simulations and Arase observations during 7–8 November 2017 magnetic storm

Geomagnetic storms are among the most important phenomena affecting Earth's space weather. Intense geomagnetic storms can cause severe damage to satellites, communication, and power transmission lines. Geomagnetic storms are primarily caused by the enhancement of the ring current. The storm time distribution of ring current particles in the inner magnetosphere depends strongly on their transport in evolving electric and magnetic fields, along with particle acceleration and loss. In this study, we investigated ring current particle variations using observations and simulations. We compared the ion (H^+, He^+, and O^+), electron flux, and plasma pressure variations from Arase observations with the self-consistent inner magnetosphere model: Ring current Atmosphere interactions Model with Self Consistent magnetic field (RAM-SCB) during the 7–8 November, 2017, geomagnetic storm. We investigated the contribution of different species (ions and electrons) to the magnetic field deformation observed at ground magnetic stations (09°–45° CGM Lat.) using the RAM-SCB simulations. The results showed that ions are the major contributor (~88 %) and electrons contribute ~12% to the total ring current pressure. It was also found that the electron contribution was non-negligible (~18%) to the ring current on the dawn side during the main phase of the storm. These results indicate that the electron contribution to the storm -time ring current is important and should not be neglected (Kumar et al., *JGR*, 2021).

Analyses of drift echo holes using the Arase satellite and ground-based observations

We analyzed "drift echo holes," in which only electrons above several hundred keV are lost from the magnetosphere owing to localized and sporadic Electromagnetic ion cyclotron (EMIC) waves. Because the drift period depends on the electron energy, the echo hole shows a clear energy dispersion and diffuses and disappears several times around Earth. A single drift echo corresponds to a localized decrease of approximately 30% in the particle flux. After the echoes were repeated, the flux of the entire radiation belt decreased by approximately 10% (Nakamura et al., *GRL*, 2022).

Statistical study of EMIC waves and related proton distributions observed by the Arase satellite

EMIC waves are considered to play an important role in controlling magnetospheric plasma dynamics. In particular, EMIC wave-particle interactions can cause the loss of energetic protons and relativistic electrons in the Earth's magnetosphere, and the scattered particles precipitate into the ionosphere, creating isolated proton auroras at subauroral latitudes (55–65 geomagnetic latitudes). To understand the coupling of EMIC waves with energetic protons in the inner magnetosphere, we performed a statistical study of proton distributions associated with EMIC waves using a 4-year *in-situ* observation obtained by the Arase satellite. We found four significantly different regions of EMIC waves with different characteristics of the energetic proton distributions, and the minimum resonance energies were different. We found that EMIC waves near the threshold of the proton cyclotron instability have left-handed polarization at the magnetic equator and the generated waves propagate to higher magnetic latitudes. Furthermore, the observed pitch-angle scattering energy range coincides with the computed minimum proton resonance energy. These observational results provide new insights into the spatial distribution of the EMIC waves.

Error estimation of electron fluxes measured by HEP instrument onboard the Arase satellite

An error estimation method for the energetic electron flux was measured using a high-energy electron experiment (HEP) instrument onboard the Arase satellite. While counting statistics are assumed for the uncertainty of raw electron counts, the count-to-flux conversion for HEP data must include deconvolution using counts taken by all energy channels. In our method, the same deconvolution was applied to the electron counts to correctly deduce the error of the measured electron flux. The results showed that the flux-to-error ratio worsened for higher energy and pitch angles closer to 0° or 180°, indicating that a longer (~ several minutes) integration time is necessary to achieve a reasonable level of flux uncertainty.

Impact of subsurface convective flows on the formation of flare-productive sunspots and energy buildup

Solar flares are caused by the release of magnetic free energy stored in sunspots. This study aimed to reveal the impact of convective flows in the convection zone on the formation and evolution of sunspot magnetic fields. We simulated the transport of magnetic flux tubes in the convection zone and sunspot formation in the photosphere using the radiative magnetohydrodynamic code R2D2 and the supercomputer Fugaku. We performed 93 simulations by allocating flux tubes to 93 different positions in the convection zone. We found a strong correlation between the distribution of magnetic free energy in the photosphere and the position of the downflow plume in the convection zone. The results suggested that high free energy regions can be predicted even before the magnetic flux appears on the solar surface by detecting the downflow profile in the convection zone (Kaneko et al., *MNRAS*, in press).

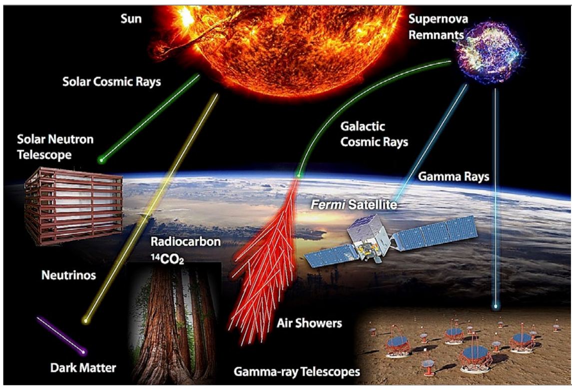
Investigation of spatiotemporal evolution of erupted solar magnetic flux rope in the inner heliosphere using multi-point spacecraft measurements

The global structure of the magnetic flux rope inside the CME plays a key role in triggering geomagnetic storms and their cascade of effects. Thus, it is important to understand how the magnetic flux rope that erupts from the Sun evolves spatially and temporally as it propagates in the inner heliosphere. We developed an analysis tool to implement 1D (or 2D) flux rope model fitting on solar eruptive magnetic flux rope events observed by multiple spacecraft to reconstruct their global topologies. We started to analyze a magnetic flux rope event observed by Venus Express (orbited Venus), WIND (upstream of Earth), MAVEN (cruise to Mars), and Mars Express (orbited Mars) in 2014 April, using the analysis tools.

Database construction of Toyokawa Radio Polarimeters

Historical data from 1958 to 1978 taken by Toyokawa Radio Polarimeters (1, 2, 3.75, and 9.4 GHz) were recorded in microfilms. All have been scanned and restored in digital image form. This database is very useful for various types of research, such as the size estimation of a solar flare in the era before GOES soft X-ray observations began and the study of the characteristics of solar flares in the old solar cycle.

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
- Widefield transient survey using an optical telescope

Cosmic rays (CRs), which are mostly protons with small amounts of charged particles such as electrons or nuclei, and neutral particles, such as gamma rays or neutrinos, are produced in space and propagate through interstellar and 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 cores.

Main Activities in FY2021

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

Cosmic gamma rays are produced through interactions of dark matter, CRs, and the interstellar medium. Therefore, gamma rays are useful probes to search for dark matter and investigate the properties and distribution of CRs and the interstellar medium.

We are developing a next-generation gamma-ray observatory, CTA, to observe cosmic gamma rays in an energy range from well below 100 GeV to above 100 TeV. We oversee the development, procurement, and calibration of silicon photomultipliers (SiPMs) for small-sized telescopes in CTA. One advantage of the SiPM is its ability to operate under moonlight, which can increase the observation time by a factor of two. We studied the behavior of the SiPM under intense background light. Under intense background light, the SiPM current increases, the voltage drops across the series resistor of the bias circuit, and the drift of the breakdown voltage due to the temperature rise are expected to reduce the pulse amplitude. In addition, the pulse amplitude of the SiPM output signal can be reduced if the SiPM detects photons while recovering from detecting previous photons owing to the background light. When the series resistor is at a minimum, the pulse amplitude drop is measured to be approximately 7%, with a background light intensity equivalent to that of the full moon. We found that the temperature increase had the largest effect on the pulse amplitude at 4%, whereas the effect of the voltage drop across the series resistor was 1.5%. These two effects accounted for 5.5% and 7% of the measured amplitude reduction, respectively. The simulation of pulse overlap during the recovery time indicates that this effect can fully explain the remaining 1.5%.

The CTA is now considering employing the SiPM for the large-sized telescope to take advantage of the higher photon detection efficiency, smaller pixel size, and ability to operate under moonlight. However, the SiPM suffers from higher background light owing to better photon detection efficiencies in the red region, where the background light is bright. We proposed the application of a red filter on the surface of a light concentrator to reduce background light. We developed a prototype light concentrator and verified its characteristics. We also performed simulation studies on the gamma-ray detection efficiencies and found that the red filter improved the efficiency by more than 20% at a gamma-ray energy of 20 GeV. By reducing the pixel size by half, the improvement can be as much as 30%.

Acceleration mechanism of solar energetic particles

We studied the acceleration mechanism of energetic solar particles by observing solar neutrons with energies greater than 100 MeV on the ground. Energetic solar particles are accelerated in association with energetic solar flares. These accelerated ions produce neutrons through their interactions with the solar atmosphere. It is expected that observing neutrons is better for understanding the acceleration mechanism of solar energetic particles rather than observing accelerated ions directly because neutrons are not reflected by the interplanetary magnetic field. Neutrons are attenuated in the Earth's atmosphere. Therefore, the ISEE has developed a worldwide network of solar neutron detectors at high mountains of different longitudes.

Thus far, more than 10 solar neutron events have been reported. The energy spectra of neutrons at the solar surface can be obtained if we assume that neutrons are produced simultaneously with electromagnetic waves produced in association with the same solar flares. The obtained spectra indicate that stochastic acceleration occurs when energetic neutrons are produced at the Sun. To derive a conclusive understanding of the acceleration mechanism, we must observe a solar neutron event in which the energy spectrum of the neutrons can be determined without assuming the production time of the neutrons. The sensitivity to neutrons and the energy resolution of the solar neutron detectors used in the worldwide network are not sufficient to determine the acceleration mechanism of solar energetic particles.

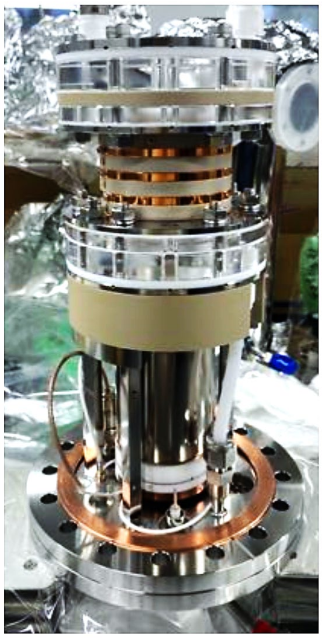
A new solar neutron telescope was installed at the top of Sierra Negra (4,580 m above sea level) in Mexico. The new detector is called the SciBar Cosmic Ray Telescope (SciCRT). SciBar was used in the accelerator experiments and this installation was realized with support from Kyoto University, the High Energy Accelerator Research Organization (KEK), the National Autonomous University of Mexico, and the National Institute for Astrophysics, Optics, and Electronics in Mexico. SciCRT uses 15,000 scintillator bars to measure particle tracks, providing much better sensitivity to neutrons, energy resolution, and particle discrimination. The performance of SciCRT was investigated using Monte Carlo simulation and we can discriminate the production time of neutrons, whether instantaneous or continuous for more than 5 min, while discriminating between shock acceleration and stochastic acceleration. At the same time as the observation of solar neutrons, the variation in the intensity of cosmic rays from various directions was monitored using SciCRT.

SciCRT has been maintained by scientists in Mexico City. Unfortunately, starting in the fiscal year 2020, people in Mexico City could not visit Sierra Negra due to the COVID-19 pandemic and the stable operation of SciCRT was not possible. In February 2022, scientists in Mexico City could once again reach Sierra Negra and cosmic ray intensities were monitored from February 2022. It was not possible to start the observation of solar neutrons in the fiscal year 2021 owing to some minor technical problems. The operation of solar neutron observation is planned to start early in the fiscal year 2022.

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

Study of neutrinos and dark matter in underground experiments

Neutrinos are elementary particles with almost no mass, are neutral, and interact only through weak interactions. Neutrino oscillations caused by the mixing of three flavors of neutrino allow us to probe neutrino properties, such as neutrino masses or the mixing matrix. The Cosmic Ray Research Division conducts neutrino research at the Super-Kamiokande experiment in the Kamioka underground observatory and promotes the Hyper-Kamiokande experiment, a future water Cherenkov detector with a fiducial volume eight times larger than that of the Super-Kamiokande. In 2022 , the performance of a new 50 cm photomultiplier tube with a box-and-line-type dynode was studied for the construction of the Hyper-Kamiokande. In addition to the signal test of the delivered PMT at the Kamioka site, a test bench was set up in the laboratory to evaluate the signal stability. We also developed a new atmospheric neutrino simulation based on the Honda code, utilizing existing hadron production data from accelerator experiments.



Developing a 0.1 L prototype liquid xenon chamber with a hermetic quartz vessel inside.

Dark matter is yet-undiscovered heavy neutral particles that are difficult to observe owing to their weak interactions. Many experiments are currently underway to detect these particles. We directly searched for dark matter in the XENONnT experiment using a double-phase xenon time-projection chamber (TPC) at the Gran Sasso underground laboratory in Italy. This year, we analyzed the data currently being acquired for the first time. We also measured the environmental tritium at the site, which may be a background source for the recently claimed excess of electron recoil events by XENON1T. In addition, for the future liquid xenon dark matter experiment DARWIN, we are developing a hermetic liquid xenon detector using a quartz chamber and built a 0.1 L prototype to verify its radon shielding capability. In addition, we measured the photoelectric efficiency of metal surfaces under ultraviolet light and developed a hybrid photomultiplier tube using SiPM for photoelectron amplification.

Historic CR intensity variation with cosmogenic radioisotopes

CRs that fall on Earth interact with the atmosphere and produce various secondary particles. Among them, long-lived cosmogenic nuclides, such as ^{14}C and ^{10}Be, have been used as excellent proxies for CR intensities in the past. We measured ^{14}C concentrations in tree rings and ^{10}Be and ^{36}Cl concentrations in ice cores to investigate past CR variations. From such analyses of cosmogenic nuclides, we found increased CR events at 774/775 CE, 993/994 CE, and ~660 BCE. Possible causes of these CR events are solar energetic particle (SEP) events and the scale of these SEP events is estimated to be tens of times larger than the largest event recorded. Such large-scale SEP events pose a major threat to the current space-exploration era. We aimed to search for 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 reported a new CR event in 5410 BCE detected by ^{14}C analyses using tree samples from the U.S., Finland, and Switzerland (Miyake et al., 2021). The origin of the 5410 BCE event may be also an extreme SEP event because the ^{14}C variations are very similar between the 5410 BCE event and other reported SEP-driven events. We also confirmed a regional difference in ^{14}C data, that is, higher latitudes trees show higher ^{14}C concentrations, which has been reported in previous studies.

We performed quasi-annual analyses of ^{10}Be and ^{36}Cl concentrations using the Antarctic Dome Fuji ice core around 5480 BCE and investigated the causes of the CR increase event reported at approximately 5480 BCE by comparing the results with the ^{10}Be and ^{36}Cl variations around the 775 CE event. The results showed that the cosmogenic nuclide data around 5480 BCE can be explained by a variation in galactic CRs (Kanzawa et al., 2021). An extreme grand solar minimum can be considered as a possible cause. Further investigation using ^{10}Be and ^{36}Cl data from other ice cores is important.

CR interaction-focused accelerator experiments

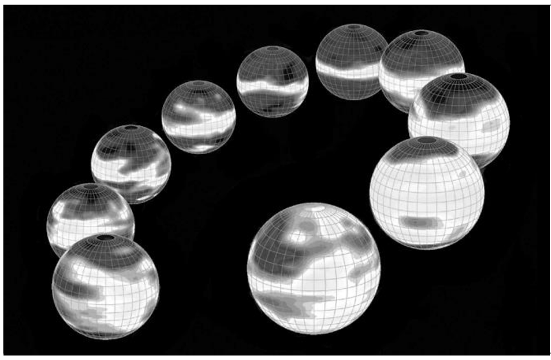
To understand where and how CR particles accelerate to higher energies, many observations and studies on CRs have been conducted worldwide. CRs are observed using the air shower technique, which involves observing particle cascades caused by interactions between CRs and atmospheric atomic nuclei using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

Beam test of the LHCf detectors at CERN−SPS.

We performed LHCf and RHICf experiments to observe the energetic photons and neutrons produced in the very forward region of proton-proton collisions in LHC and RHIC. Both experiments were conducted internationally. This year, we analyzed the data obtained with proton-proton collisions at the center-of-mass energy of 510 GeV at RHIC in 2017 and published the results of production cross-section measurements for very forward photons. The spectra were compared with the results of the LHCf experiment at 7 and 13 TeV and we confirmed the collision-energy scaling law, the so-called Feynman scaling, within the experimental error.

Both the LHCf and RHICf plan their next operations in the coming years. The LHCf will have an operation in September 2022, and we are accelerating the preparation. One of the milestones is the beam test of the detectors at CERN-SPS to test the aging effect of the detectors, new read-out system, and performance of joint operation with the ATLAS-ZDC detector. The test was completed in September, although there were some difficulties due to COVID-19.

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 FY2021

Solar wind observations using the IPS system

We have been performing remote-sensing observations of the solar wind since the 1980s using a multi-station interplanetary scintillation (IPS) system. Tomographic analysis 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, where *in-situ* observations are currently unavailable. The IPS system currently consists of three large antennas in Toyokawa, Fuji, and Kiso. The Toyokawa antenna (called the Solar Wind Imaging Facility Telescope: SWIFT) has the largest aperture and highest sensitivity among the three antennas and started daily observations in 2008. The Fuji and Kiso antennas were upgraded in 2013–2014 by installing new receivers, which significantly improved their sensitivity. These two antennas are in mountainous areas and are not used for observations during winter owing to heavy snowfall. Hence, the solar wind speed data from three-station observations were unavailable during winter. Instead, the 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 various international collaborations. In this fiscal year, three-station IPS observations were conducted between early April and early December using Toyokawa, Fuji, and Kiso antennas. Observations with the Fuji antenna were frequently interrupted owing to failure of the driving system from late June to early August and late November to early December. In addition, the Sugadaira antenna, which had been out of order due to snow damage, was removed from this fiscal year.

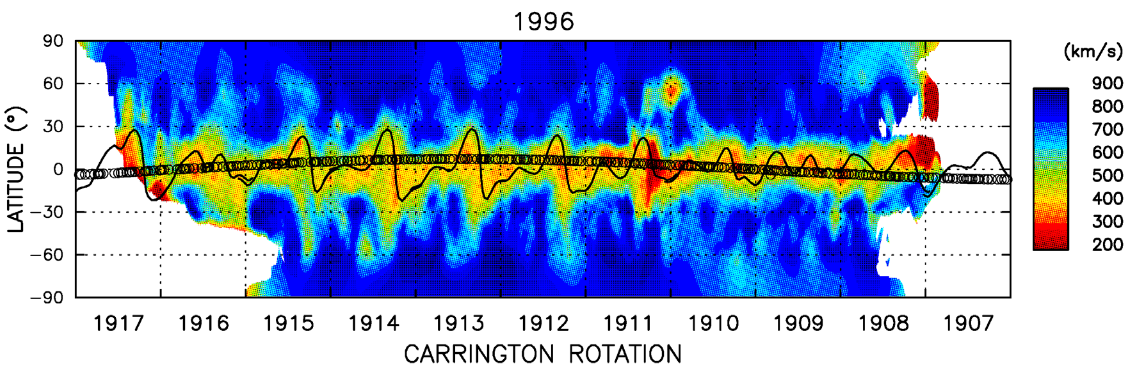
International collaboration for space weather forecast

We have performed collaborative research with Dr. B. V. Jackson and his colleagues at the University of California, San Diego (UCSD) since 1996 on the 3-dimensional reconstruction of the time-varying heliosphere using tomographic analysis of IPS observations. A time-dependent tomographic (TDT) program was developed through this collaborative study. Furthermore, a combined analysis system using IPS observations and the ENLIL solar wind model was developed to improve space weather forecasting through collaborations. These programs are now available on the NASA Community Coordinated Modeling Center web server and are running in real time at the Korean Space Weather Center (KSWC) to predict the solar wind reaching the Earth.

With growing awareness of the utility of IPS observations for space weather forecasting, an increasing number of IPS observations have been conducted globally. In Japan, Russia, and India, where IPS observations have been conducted 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 conducted on a campaign basis. In this fiscal year, the integrated analysis of IPS data from ISEE, LoFAR, and Russia was performed using the TDT program for three periods (Orbit 1–3) when the Parker Solar Probe approached the Sun. TDT analysis was compared with PSP in situ measurements and discrepancies between them were found in the solar wind speed and density. The cause for these discrepancies is currently under investigation and we will compare the IPS and PSP observations for the periods after Orbit 3.

Improvement of IPS tomography and long-term change in solar wind turbulence

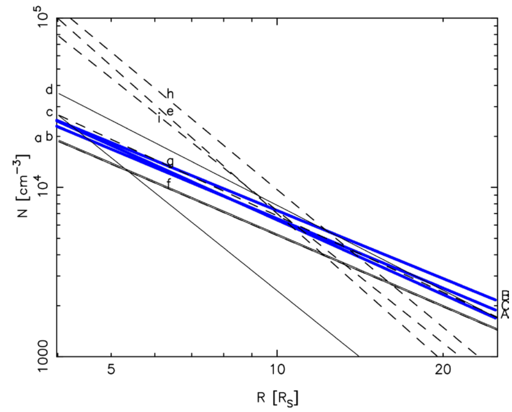
In performing the tomographic analysis of solar wind speeds obtained from IPS observations, information on the spatial distribution of density fluctuations (ΔN_e) along the line of sight is required. Previous studies have shown that the following relationship exists between ΔN_e and speed V: $\Delta N \propto V^{\alpha}$, $\alpha = -0.5$. The tomographic analysis with this relation yielded solar wind speeds that showed good agreement with *in situ* measurements (such as OMNI data and Ulysses observations) for Solar Cycle 23 (SC23). However, the comparison between IPS and *in situ* measurements for Solar Cycle 24 (SC24) revealed a systematic discrepancy between them; the speeds from the tomographic analysis were higher than those from *in situ* measurements by 50–100 km/s. We examined the possible causes for this discrepancy and found that it can be improved by changing the value of the index α. The optimal value for α to produce the best agreement between the tomographic analysis and *in situ* measurements was +0.5. According to a recent theoretical study, ΔN_e is a key parameter for controlling the efficiency of solar wind acceleration, and the results obtained from this study suggest that acceleration efficiency varies with the solar cycle. The solar wind speed data obtained in this study were used in collaboration with Dr. Bzowski (Poland) to develop a global model of solar wind density that covers a long period.



Synoptic map of solar wind speed derived from tomographic analysis of IPS observations for 1996. The solid line indicates the magnetic neutral line determined from magnetographic observations at the Wilcox Solar Observatory. Open circles indicate the locations of Earth, that is, where OMNI data were collected (Tokumaru et al., 2021).

Coronal density measurements using giant radio pulses of the Crab pulsar

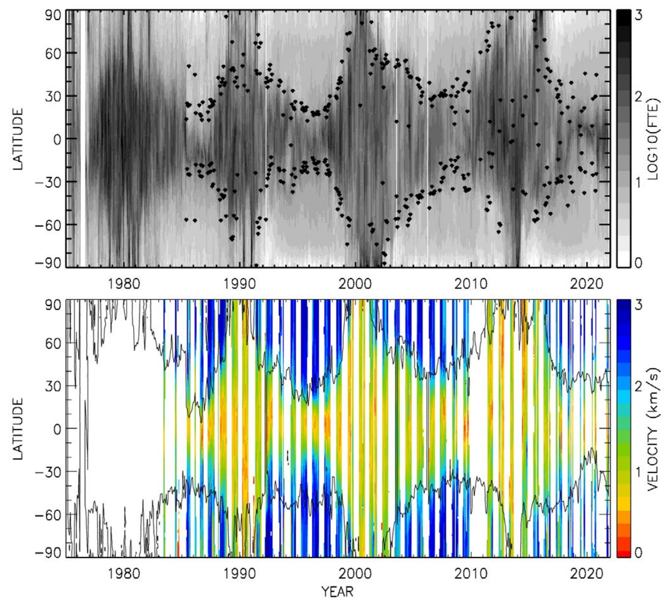
Crab pulsar observations have been carried out using the Toyokawa antenna since 2017 to examine the coronal plasma density. The radio waves from a pulsar are delayed upon arrival owing to the effect of plasma intervening between the source and observer. The line-of-sight integration of the plasma density (dispersion measure, DM) can be estimated by measuring this delay. The line of sight for the Crab pulsar approaches the Sun every June, up to a distance of five solar radii. If the DMs for the Crab pulsar are measured during the closest approach to the Sun, the coronal density can be estimated from the excess in the DM compared to those when the Crab pulsar is in opposition to the Sun. In addition, the Crab pulsar sporadically emits strong radio waves (giant radio pulses, GRPs), and the DMs can be accurately determined in a short time using GRPs. In this study, we analyzed the DM data collected in 2018 and 2019 (SC24/25 minimum) from Crab pulsar observations at Toyokawa to develop a model of coronal plasma density between 5 and 60 solar radii. The density model obtained in this study agreed with those in the low-activity periods of the past solar cycles within the margin of error. A significant drop in the solar wind density was reported for the previous (SC23/24) minimum. The results of this study suggest the recovery of the solar wind density at this minimum to the level of past minima.



Coronal density models obtained from Crab pulsar observations at Toyokawa for 2018 and 2019 (Thick lines A-C). The density models obtained in the low and high activity periods of the past solar cycles are indicated by thin solid (a-d) and bashed (e-i) lines, respectively (Tokumaru et al., 2022).

Reconstruction of the global structure of the solar wind during 1975–1985

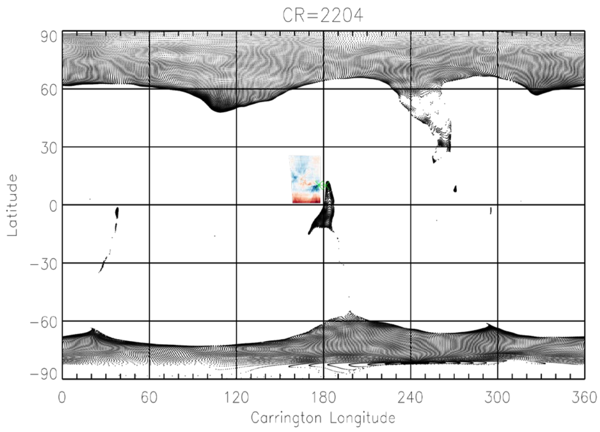
It is well known that solar winds consist of low-latitude slow winds (<450 km/s) and high-latitude fast winds (~800 km/s) except during the maximum. Because the boundary latitude between fast and slow solar winds is highly dependent on the solar activity cycle, it is expected to be used as a foothold for understanding the solar cycle in solar wind. We previously clarified the distribution of coronal holes, which are the origin of the solar wind, and revealed that their distribution resembles a sunspot butterfly diagram. In 2021, we compared IPS observations with the magnetic flux tube expansion factor (FTE) calculated from potential field source surface (PFSS) analysis. First, we derived the average of FTEs at the boundary latitudes in each Carrington rotation, which was found to be log10(FTE)=0.97±0.56 (see upper panel). Next, we plotted the latitudes at log10(FTE)=0.97 on the solar wind structure (see the lower panel). As a result, we found that latitudes at log10(FTE)=0.97 generally coincided with the velocity boundary latitudes obtained from the IPS observations. The contour can be extrapolated to the past, which has allowed us to estimate the global structure of solar wind since 1975.



Upper panel: FTE distribution on the source surface (2.5Rs) and latitudinal boundary (black dots) obtained from IPS observations. Lower panel: IPS observations and contour of log10(FTE)=0.97 (black curves).

Investigation of plasma upflow and slow solar wind using Hinode/EIS and IPS observations

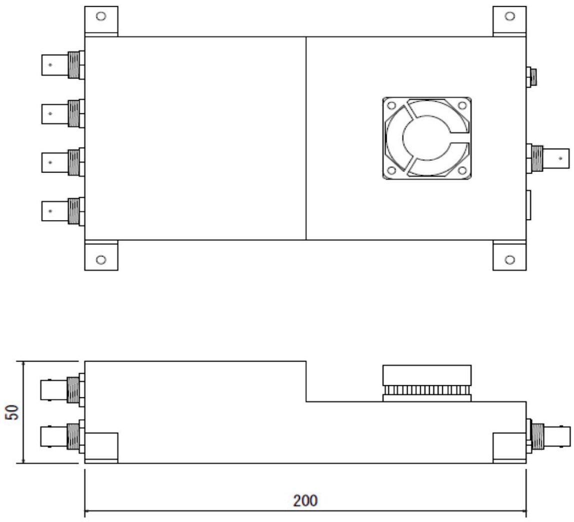
We studied plasma upflow in the solar active region. Plasma upflow was detected using an extreme ultraviolet imaging spectrometer (EIS) onboard the Hinode satellite. The elemental composition of the plasma upflow was similar to that of slow solar wind, suggesting that it was the source of the slow solar wind. We studied the relationship between plasma upflow and the open magnetic field by comparing EIS observations with photospheric magnetic fields calculated using the potential field source surface (PFSS) model. As a result, it was found that plasma upflow can be classified into two patterns: one is located near an open magnetic field and the other is located near an open magnetic field. Furthermore, by comparing the PFSS model with the IPS data, we found a correlation between the active region where the upflow exists and the location of the slow solar wind.



The EIS observation data (boxed area in the center) and the footprint in the photosphere of the open magnetic field lines determined by PFSS are superimposed. It can be seen that the open magnetic field lines exist near the plasma upflow.

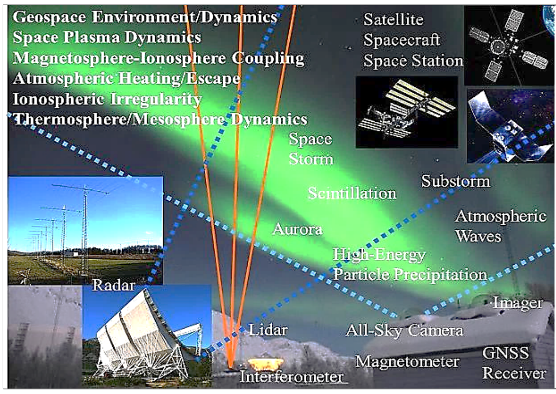
Next generation IPS observation system

We promoted the next-generation solar wind observation system to dramatically improve IPS observations at the Division for Heliospheric Research. In FY2021, we decided to submit a proposal to Master Plan 2023. We received hearings of the proposal as a middle-scale plan (B) from the astronomy and astrophysics community and as a middle-scale plan from the Earth and planetary science community. Although the Master Plan itself covers larger-scale plans than our plan, the hearings this fiscal year also include milled scale plans of billions-yen scale to look into the future of the research fields, which made it possible for our plan to be proposed as well. Although Master Plan 2023 itself was not summarized, it made great progress in advertising our plan to each community. In addition, we applied for Specially Promoted Research of the Grants-in-Aid for Scientific Research (KAKENHI) and submitted proposals for the budget requests of ISEE. In FY2021, a Grant-in-Aid for Scientific Research (A) was adopted and construction of a core array that has a scale of 5% of the total for the Fuji station was started. We completed the system design of 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. Unfortunately, delivery of the system was postponed until FY2022 due to the worldwide shortage of semiconductors. However, there has been significant progress in completing the system design of the backend.



AD module of the next generation solar wind observation system.

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 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 FY2021

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

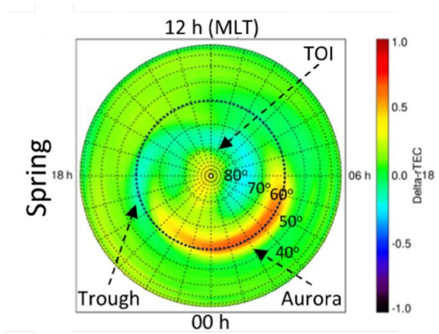
Aurora/airglow imagers and electromagnetic wave receivers have been involved in the PWING project at eight stations around the North Pole, at MLATs of approximately 60° (in Canada, Russia, Alaska, Finland, and Iceland) since 2016. They were used to investigate the plasma and wave dynamics in the inner magnetosphere. Many new results were obtained in FY2021. For example, the plasma and field characteristics in the source region of medium-scale traveling ionospheric disturbances (MSTIDs) in the inner magnetosphere were first revealed based on conjugate measurements by the Arase satellite and at Athabasca, Canada. Other conjugate measurements of isolated proton auroras associated with Pc1 geomagnetic pulsations and an equatorward-detached arc from the auroral oval have been reported using ground airglow/aurora imagers and the Arase Satellite.

Upper atmosphere imaging using the OMTIs

The optical mesosphere thermosphere imagers (OMTIs) consist of five sky-scanning Fabry-Perot interferometers, 21 all-sky charge-coupled device imagers, three tilting photometers, and three airglow temperature photometers, which are used to investigate the dynamics of the mesosphere, thermosphere, and ionosphere. Several new results were obtained from the OMTI measurements in FY2021. For example, we compared the zonal drift speed of equatorial plasma bubbles and zonal wind in the thermosphere over Indonesia and Africa to reveal the F-region dynamo effect on bubble drift. In addition, new observations were made by the PWING project described above at the subauroral latitudes.

Ionospheric disturbances observed by GNSS networks

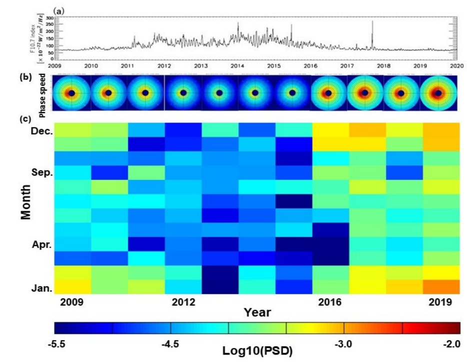
We developed a database that provides global 2-dimensional maps of total electron content (TEC) with high temporal and spatial resolutions for more than 20 years. TEC data have been obtained from more than 9000 GNSS receivers worldwide. Using the TEC database, we statistically studied the ionospheric response to magnetic storms, especially seasonal variations in TEC enhancements related to the tongue of ionization (TOI), auroral oval, and storm-enhanced density (SED) plume, as well as the spatial structure of the mid-latitude trough in the nighttime sector. The geomagnetic activity dependence of equatorial plasma bubbles was also studied.



Polar maps of averaged TEC in the Northern Hemisphere at the epoch time of Dst-index minimum as a function of geomagnetic latitude and local time during the main phase of moderate geomagnetic storms in winter. The TEC is shown as deviation from the geomagnetically quiet condition (Shinbori et al., 2022).

SuperDARN Hokkaido HF radars

Using the SuperDARN Hokkaido HF East and West radars at Rikubetsu, Hokkaido, and other SuperDARN radars, we studied the statistical occurrence characteristics of nighttime medium-scale traveling ionospheric disturbances (MSTIDs) using a 3D-FFT data analysis algorithm. We found that the nighttime MSTIDs occurrence rate was negatively correlated with solar activity. We also statistically studied the ion outflow enhancement associated with the sub-auroral polarization streams using SuperDARN and Arase spacecraft data. Furthermore, we obtained funding for the imaging receiver system at the Hokkaido East Radar. Implementation will begin next fiscal year.



Solar activity (F10.7 index) and seasonal dependence of power spectral density of nighttime MSTIDs. (Hazeyama et al., 2022). (a) F10.7 index. (b) Yearly power spectral density of nighttime MSTID. (c) Monthly averaged PSD. The horizontal axis represents the year and the vertical axis represents the month.

FACTORS initiative as the next space exploration mission realizing *in-situ* observations by formation flight in the space–Earth coupling system

The new space exploration mission, FACTORS, which is next to the ERG (Arase) satellite mission led by our institute, has been promoted for simultaneous *in-situ* observations of the space-Earth coupling physical mechanisms using multi-satellite formation flight. It is planned that satellite separation distances of 1–50 km in the polar orbit at altitudes ranging from 350–3500 km are maintained with two types of formation flight operations using a conventional chemical propulsion method and a newly proposed aerodynamics method with precise satellite attitude controls near the perigee. This fiscal year, we made a detailed design of an on-board propulsion system including a fuel tank, four thrusters, valves, and plumbing. In addition, a new type of data/command-handling circuit system was investigated as a space-qualified application for huge mission data management in space.

Development of a hemispherical FOV electrostatic analyzer suitable for future exploration satellite plans and foil experiments for TOF mass spectrometer

We have developed a hemispherical field-of-view (FOV) double-shell electrostatic energy analyzer that enables the measurement of ion/electron energies and flight directions using one sensor head on a three-axis stabilized satellite. By obtaining the sensor characteristics through numerical simulation and comparing them with the calibration test results, it was confirmed that the performance was close to the numerical calculation results and that the required specifications were satisfied. To establish the design of a time-of-flight (TOF)-type mass spectrometer that analyzes the mass of ions, a fundamental foil test was conducted to confirm the characteristics of the transmitted particles (angular scattering, energy degradation, particle neutralization, etc.), which are caused by the ultrathin carbon foil widely used in analyzers.

Experiments on floating-mode APD using a beam line, electron guns, and hybrid detector using APD and MCP

We conducted 1) fundamental experiments for the floating-mode avalanche photodiode (APD) accelerating electrons by applying a floating voltage to the APD and 2) development of a hybrid detector combining APD and microchannel plate (MCP). The purpose of the floating mode is to reduce the lowermost energy of electron energy analyzers equipped with APD as detectors. We could detect electrons at 2 keV lower than in previous research. However, the hybrid detector is expected to detect a wide energy band (1 eV –100 keV). We confirmed that the total charge of the electron clouds ejected from the MCP increased as the operation voltage increased.

Promotion of EISCAT and EISCAT_3D projects

We proceeded with the EISCAT project in collaboration with National Institute of Polar Research (NIPR): (1) we performed 11 EISCAT SP experiments with Japanese colleagues; (2) we proceeded with the EISCAT_3D project; and (3) we had a special session for the Master Plan 2020 in JpGU2021. We have also operated a photometer and an MF radar in Tromsø, and a meteor radar in Alta, northern Norway, and collaborated with Japanese and foreign colleagues in studies on turbopause altitude, atmospheric tomography, and sporadic sodium layers in the MLT region. Furthermore, we have been conducting statistical studies of the polar lower thermosphere wind (93–118 km) using EISCAT radar data and of the atmospheric stability of the polar winter upper mesosphere (80–100 km) region using sodium LIDAR data obtained at Tromsø.

Field-aligned low-energy O^+ Ion in the inner magnetosphere

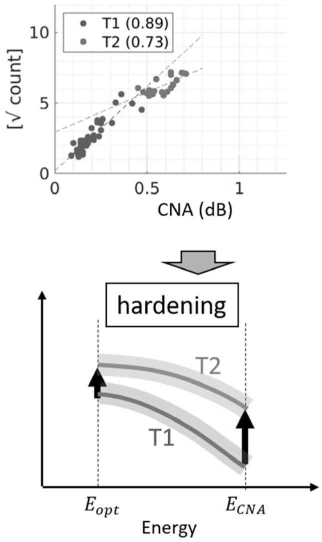
We found that flux enhancements of field-aligned low-energy O^+ ions (FALEO) were simultaneously observed by Arase and Van Allen Probes A and B in the nightside inner magnetosphere during 05–07 UT on September 22, 2018. FALEO has an energy-dispersion signature ranging from a few keV to ~10 eV, only in the direction parallel/antiparallel to the magnetic field. From a numerical simulation to trace the trajectories of test O^+ ions in a model magnetosphere, we revealed that FALEOs originate from ionospheric O^+ ions that are extracted from the upper ionosphere at substorm onset and flow along the magnetic field toward the geomagnetic equator. It was also revealed that 3–9 h after their launch, test O^+ ions less than 400 eV have a spatial distribution in the inner magnetosphere, which is similar to those of the warm plasma cloak and the oxygen torus. Therefore, we conclude that FALEO is a source of these cold ion populations. This result was published in *Journal of Geophysical Research* (Nosé et al., 2022).

Development of a low-cost magnetometer using a MI sensor

The magneto-impedance (MI) effect was discovered approximately 25 years ago, and a microsized magnetic sensor that utilizes this effect has now become commercially available. We made some modifications to the commercially available MI sensors, as they cover the range of the geomagnetic field (±80000 nT). We developed an instrument for ground measurements, including MI sensors, a Raspberry Pi-based data logger, and an A/D converter, which is only ~1/10 of the usual cost of a fluxgate magnetometer. Experimental observations showed that MI sensors can detect geomagnetic variations, such as Sq variations, geomagnetic storms, and geomagnetic pulsations. This instrument can be used for continuous field measurements over several months. We also developed a magnetometer using an MI sensor onboard a sounding rocket that was launched from Alaska on March 5, 2022.

Japan-Russia bilateral project

Several universities and institutes in Japan, including ISEE, Nagoya University have deployed optical and radio wave instruments in northern Scandinavia to collaborate with magnetospheric satellites such as the Arase satellite. We promoted a Japan-Russia bilateral project with the Polar Geophysical Institute (PGI) in Apatity (Murmansk, Russia) to expand the collaborative observation region and encourage cooperation with Magnetosphere-Ionosphere researchers in Russia using the Japan Society for the Promotion of Science budget. The bilateral project extended the ground-based observation network to further eastward of Scandinavia and met with many conjunctions with the Arase Satellite. Thirteen researchers from Japan, including students and 10 researchers from Russia participated in the project. A remote workshop (March 2022) was held, and several papers were published based on discussions during the workshops. For example, latitudinal dependencies of the auroral electron precipitation spectrum were found in high-speed camera and riometer observations during the pulsating auroral patch formation. This finding was published in the *Journal of Geophysical Research Space Physics* (Miyamoto et al., 2021).



(Upper) Relationship between the auroral intensity and mesospheric ionization intensity during a pulsating aurora. There is a difference in the slope of the fitted line before (steeper slope) and after (gentler slope) auroral patch formation. (Lower) Estimated shift in the auroral particle precipitation spectrum to satisfy the slope change.

SDI-3D project

The scanning Doppler imager (SDI) is a ground-based Fabry-Perot Doppler spectrometer operating in an all-sky imaging mode with a separation scanned etalon to resolve Doppler spectra at heights of 90–400 km. A single station can estimate the horizontal wind vector and temperature on the horizontal plane with a diameter of 1000 km. We established an international team in 2018 with researchers from Japan, Scandinavian countries, and the U.S. 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. To progress this project, in 2018, an international exchange program (or a cross-appointment system) was concluded between Nagoya University and the University of Oulu (Finland) as the first case in Nagoya University, and a faculty member will stay in Oulu for three months in 2022. The development of the SDI has progressed satisfactorily, based on the budget awarded by the National Science Foundation in the U.S. Stations to deploy the SDIs were decided, with two in Finland and one in Sweden. An etalon system for SDI was delivered from Japan to the U.S.

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

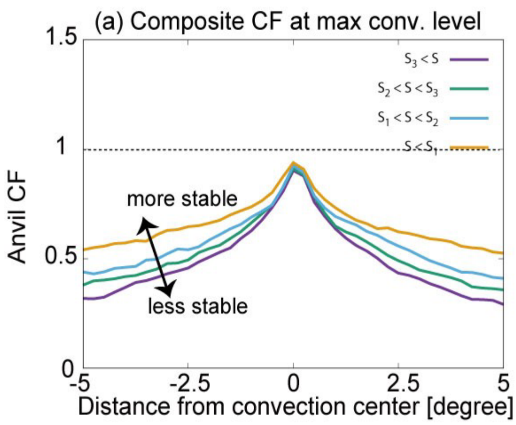
- Precipitation measurements by advanced polarimetric radars and hydrometeor videosondes
- Development of new instrumental technology
- Clouds and precipitation observed by multiple satellites
- Millimeter-wave/infrared spectroscopy of green house gases and ozone-depleting substances
- Measurements and 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 FY2021

Process-level assessment of the Iris effect over tropical oceans

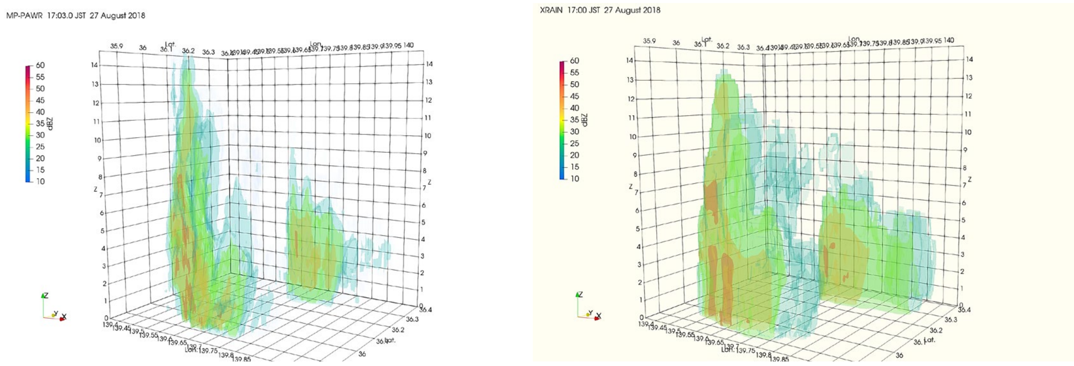
The iris hypothesis suggests a cloud feedback mechanism in which a reduction in the tropical anvil cloud fraction (CF) in a warmer climate may act to mitigate warming by enhanced outgoing longwave radiation. Two different physical processes, one involving precipitation efficiency and the other focusing on upper-tropospheric stability, have been argued to be responsible for the iris effect. In this study, A-Train observations and reanalysis data were analyzed to assess these two processes. The major findings were as follows: (1) the anvil CF changes evidently with upper-tropospheric stability, as expected from the stability iris theory (see Figure); (2) precipitation efficiency is unlikely to have control of the anvil CF but is related to mid- and low-level CFs; and (3) the day and nighttime cloud radiative effects are expected to largely cancel out when integrated over a diurnal cycle, suggesting a neutral cloud feedback.



Composite anvil CF for different quartiles of 200-hPa stability.

Calibration of MP-PAWR

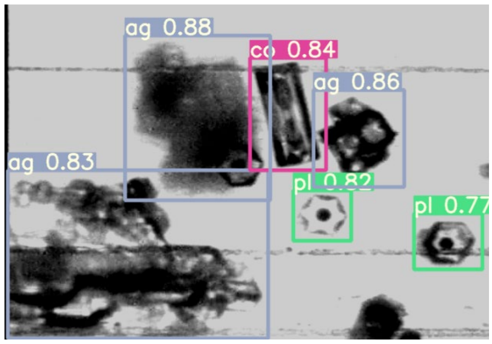
The state-of-the-art radar technology, multi-parameter phased array weather radar (MP-PAWR), transmits with a fan beam and receives with a pencil beam; therefore, its calibration must be performed at all elevation angles. This is different from the conventional radar, which can be calibrated at a single elevation angle. The relationship between the ratio of the specific phase shift between the two polarizations (KDP) to the radar reflectivity factor (Z) and differential reflectivity (ZDR) was used because of its small dependence on the raindrop particle size distribution. The ZDR was calibrated by assuming a Marshall-Palmer type raindrop size distribution and, at the same time, by determining the Z bias that satisfies the relationship between KDP/Z and ZDR. The results showed that ZDR bias jumps appeared at the elevation angle of transmitter fan beam switching. This calibration was evaluated by comparison with a well-calibrated radar system.



3D structure of Z from MP-PAWR (left) and XRAIN (right) on August 27, 2018, at 17:00 JST. The 3D structure of XRAIN is broadened by integrating 4 different radars for 5 minutes.

Objective classification of solid hydrometeor images using deep learning

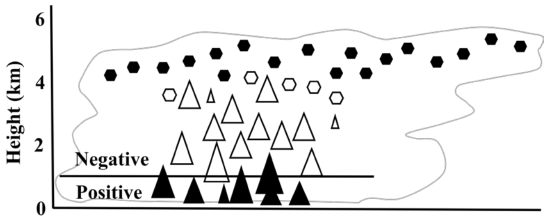
A balloon-borne "hydrometeor videosonde (HYVIS)" equipped with a microscope camera was used to observe the cloud particles in various clouds. As HYVIS observations can obtain a large number of particle images, it is very difficult for an analyzer to conduct quantitative and statistical analyses, that is, to objectively identify their categories, such as plate-, column-, and dendric-type ice crystals. Thus, we developed an image analysis method using deep learning. The figure shows an example of the particles identified by this method. Solid particles in actual clouds are not six-fold symmetric dendritic- and column-type crystals but are dominated by diverse, complex, and asymmetric crystals. As the classification method can objectively identify particle categories in a very short time, statistical analyses of cloud particles should be performed. This method is highly novel because the engineering method can be applied to meteorological research. It is expected to contribute not only to advancing our knowledge of cloud microphysics but also to improving parameterizations of cloud-resolving models.



An example of deep-learning objective classification of solid hydrometeors observed by an HYVIS in a cloud. The particles surrounded by a square are identified particles, where "ag", "co", and "pl" show identified categories as "aggregate", "column", and "plate" particles.

Hypothesis on the mechanism of gamma-ray glow events inferred from a meteorological perspective

Recently, gamma-ray glows from active convective clouds have been observed on the ground in the Hokuriku region during the winter season. Gamma-ray glows typically last a few seconds to several minutes and are considered to originate from relativistic runaway electron avalanches (RREAs) in strong electric fields owing to charged hydrometeor particles. This study aimed to confirm that the inner structure of precipitation clouds brought about gamma-ray glows using an X-band

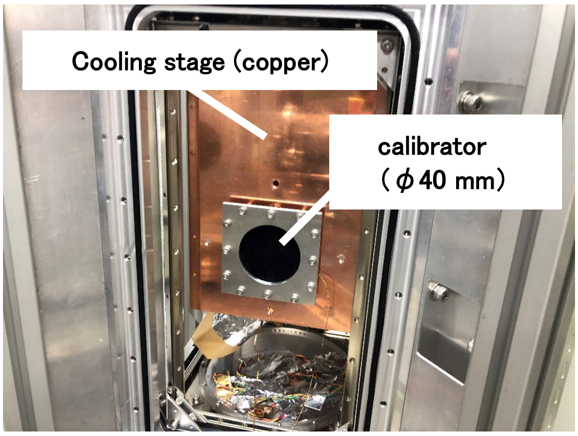


Conceptual model of precipitation particles and their charge distributions during the gamma-ray glow event. Black (white) triangles (hexagons) indicate the presence of positively (negatively) charged graupel particles (ice crystals).

polarimetric radar. Eleven gamma-ray glow events were analyzed during the five winter seasons. The time series of reflectivity shows that both heights of maximum reflectivity and 35-dBZ echo-top, which is a proxy for the existence of graupel particles, clearly decreased before and after the time when the gamma-ray glows were observed. This indicates that the convective cell is in the dissipating stage of its life cycle. As a result, updraft and riming electrification should hardly exist at this stage. Thus, dense graupel particles and the boundary between a positively charged region formed by graupel particles below a height of −10 °C and a negatively charged region above the height move downward and approach the ground surface. If the boundary between the positive and negative charge regions has sufficient intensity for the RREAs and reaches close to the surface, gamma-ray glows should be observed at the surface.

Development of a new calibrator for the millimeter-wave atmospheric radiometer

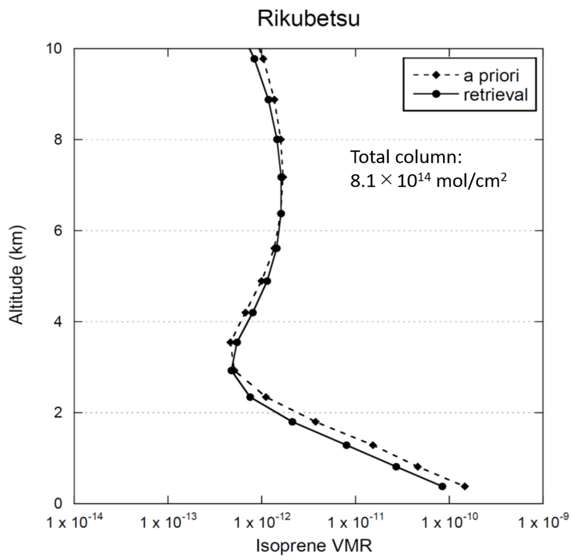
A calibrator composed of blackbody radiation sources was used for calibrating the signal intensity of a millimeter-wave atmospheric radiometer. The existing calibrator is cooled by liquid nitrogen but must always generate, supply, and store it during observation, which is not suitable for long-term unmanned observation at remote sites. In this year, we developed a new mechanical cooled calibrator using a cryogenic refrigerator which is primarily used for cooling the superconducting detector in an observation system, in collaboration with Kyoto University. We designed a calibrator with the characteristics of reflection coefficient, observation frequency, and size of the receiver, and carried out cooling tests. It was found that the temperature was stably controlled at approximately 76 K, which is almost the same as the temperature of liquid nitrogen. This suggests that this new cooling method can be adopted in our radiometer system



New calibrator installed on the cooling stage of the receiver cryostat.

Monitoring atmospheric minor constituents with a high-resolution infrared spectrometer

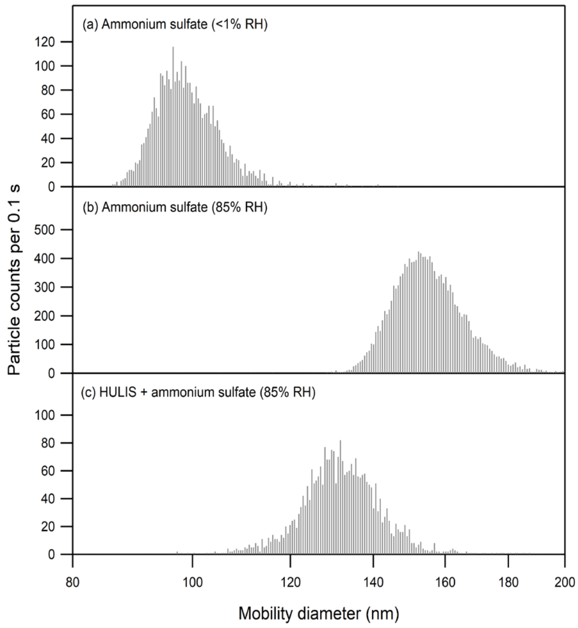
Monitoring observations of solar absorption spectra using high-resolution Fourier transform infrared spectroscopy (FTIR) at Rikubetsu Observatory have continued in cooperation with the National Institute for Environmental Studies (NIES). The total column amounts and vertical profiles of the 17 molecular species, including O_3, CH_4, and CO, were retrieved from the spectrum. In this year, we newly attempted to derive the column amount of isoprene, the major biogenic volatile organic compound. After a preliminary analysis of the vertical distribution of CO_2 and H_2O from the observed spectra, the column amount of isoprene was determined simultaneously with CFC-12, HCFC-142b, NH_3, and HNO_3. The isoprene column amount observed in 2020 was estimated to be $(2–8)\times10^{14}$ mol/cm^2, which was significantly lower in winter.



Vertical distribution of isoprene, with a solid line representing observed values and a broken line representing an initial guess.

Analyses of the hygroscopicity and light-absorption property of atmospheric aerosol

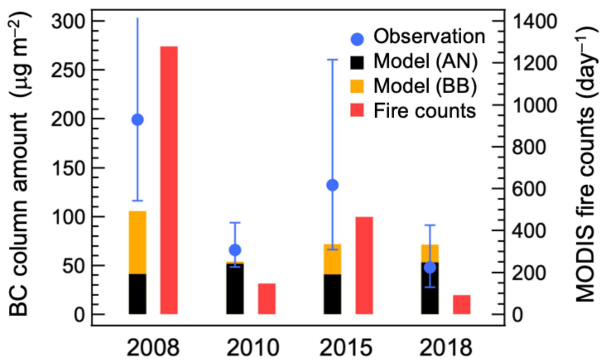
Atmospheric aerosols affect the radiative balance of Earth, and the properties regulating this effect include hygroscopicity and light-absorption properties. The hygroscopicity of aerosols is generally represented by the assumption of additivity of the hygroscopicity parameter of the chemical components. However, its appropriateness has not been tentatively assessed. In this study, particles composed of humic-like substances (HULIS) extracted from atmospheric aerosol samples and ammonium sulfate were generated and the relationship between the proportions of the two components and hygroscopic growth was investigated. The relationship of κ values with chemical composition (proportions of organics and inorganics) was then determined. Regarding the light-absorption property of atmospheric aerosol, the contribution of light-absorptive organics is not well understood. The light absorption properties were analyzed for organic fractions from atmospheric aerosol samples collected in urban and forest environments. For future analysis of aerosol hygroscopicity, aerosol sampling was performed at the Hyytiälä Forestry Field Station in Finland, under the support of the University of Helsinki.



Examples of data from the hygroscopic growth measurements of particles using an HTDMA. (a,b) Particle counts versus diameter for ammonium sulfate particles under (a) dry and (b) humidified conditions. (c) Particle counts versus diameter for particles composed of the mixture of HULIS and ammonium sulfate under the humidified condition. The relative humidity of the humidified condition was 85%. The horizontal axis uses a logarithmic scale.

Evaluation of the methods to measure water-insoluble aerosols and observations

Water-insoluble aerosols, such as black carbon (BC) and mineral dust, can influence the climate through their light-absorption and ice-nucleating properties. However, their atmospheric behavior is poorly understood owing to the limited number of observations and the lack of established measurement methods. In this study, data obtained from aircraft-based observations conducted in the Arctic region from March–April 2018 were analyzed. We showed that the year-to-year variations in BC column amounts in the Arctic spring were strongly correlated with magnitudes of biomass burning in the mid-latitudes and that current numerical models significantly underestimated the contribution of BC from biomass burning. Moreover, we evaluated a new method for measuring the number concentrations of water-insoluble particles collected on filters, where the particles were dispersed in water and optically detected. For analysis using this method, intensive aerosol sampling was conducted in Nagoya and Ny-Ålesund in the Arctic.



Spring BC column amounts for different years in the Arctic. Observations and numerical model simulations for anthropogenic BC and biomass burning BC are shown. MODIS-derived average fire counts at latitudes north of 50ºN are also shown.

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 FY2021

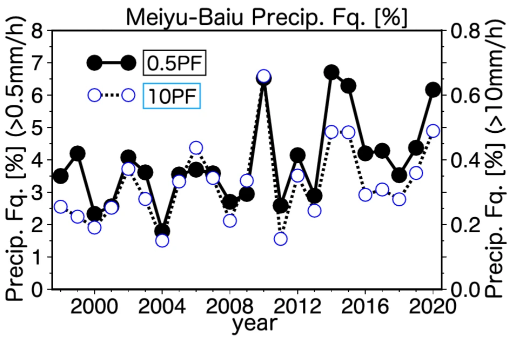
Impact of Arctic warming and abnormally high precipitation on vegetation activity of Siberian larch forests

The fate of a boreal forest may depend on the trend in its normalized difference vegetation index (NDVI), such as whether NDVI has been increasing significantly over the past few decades. We analyzed the responses of two Siberian larch forests at Spasskaya Pad and Elgeeii in eastern Siberia to various waterlogging-induced disturbances using satellite-based NDVI and meteorological data for the period 2000–2019. The forest at Spasskaya Pad experienced waterlogging (i.e., flooding events caused by abnormal precipitation) during 2005–2008, which damaged canopy-forming larch trees and increased the abundance of water-resistant understory vegetation. In contrast, the forest at Elgeeii did not experience any remarkable disturbances, such as tree dieback or changes in the vegetation community. Significant increasing NDVI trends were found in May and June–August in Elgeeii, whereas no significant trends were found in Spasskaya Pad. NDVI anomalies in May and June–August at Elgeeii were significantly associated with precipitation or temperature, depending on the season, whereas no significant relationships were found at Spasskaya Pad. Thus, the 20-year NDVI trend and the NDVI–temperature–precipitation relationship differed between the two larch forests, although no significant trends in temperature or precipitation were observed. These findings indicate that non-significant NDVI trends for Siberian larch forests may reflect waterlogging-induced dieback of larch trees with a concomitant increase in water-resistant understory vegetation.

(Reference: Nagano, H., A. Kotani, H. Mizuochi, K. Ichii, H. Kanamori, and T. Hiyama (2022): Contrasting 20-year trends in NDVI at two Siberian larch forests with and without multiyear waterlogging-induced disturbances. *Environmental Research Letters*, 17, 025003, doi:10.1088/1748-9326/ac4884)

Recent decadal enhancement of Meiyu–Baiu heavy rainfall

We investigated recent decadal trends in Meiyu–Baiu rainfall over the last two decades using 23-year satellite precipitation radar (TRMM-PR and GPM-DPR) data. We also explored the variability of atmospheric circulation, such as water vapor transport and uppertropospheric circulations, related to the trend using the JRA-55 reanalysis. The frequency of heavy precipitation along the Meiyu–Baiu front has increased over the past 22 years. In particular, heavy precipitation (10 mm/h) increased by 24% between 1998 and 2008 and 2009–2019, which likely led to the recent enhancement in Meiyu–Baiu heavy rainfall. The decadal enhancement of the Meiyu–Baiu rainfall is associated with both tropical and mid-latitudinal influences. Along with the westward expansion of the western North Pacific subtropical high, more water vapor was transported to the Meiyu–Baiu front. Simultaneously, the upper-level trough over the East China Sea, associated with wave trains along the subtropical jet, intensifies the transport of water vapor and upward flow. These changes in atmospheric circulation are physically consistent with the increase in rainfall at the Meiyu–Baiu front.



Interannual variations in the frequency of Meiyu–Baiu band precipitation.

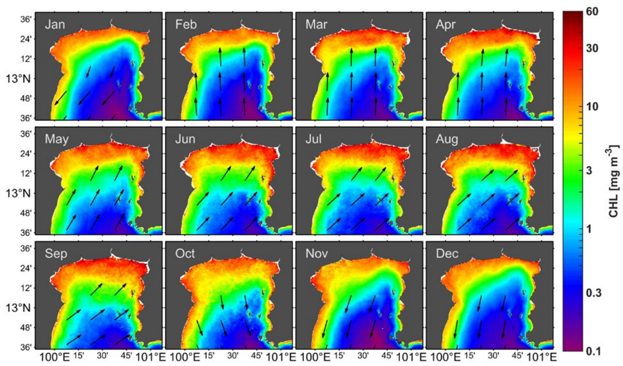
(Reference: Takahashi, H. G. and H. Fujinami, (2021): Recent decadal enhancement of Meiyu–Baiu heavy rainfall over East Asia. *Scientific Reports*, 11, 13665, doi:10.1038/s41598-021-93006-0)

Calibration of the surface temperature measurement biases on the Antarctic Plateau

Near-surface air temperature measurements over the Antarctic Plateau (AP) are important for climate change monitoring and model validation. Owing to their remoteness and harsh environment, automatic weather stations (AWSs) were installed on the AP. However, it is difficult to obtain accurate temperatures because most temperature measurements are subject to systematic errors owing to solar radiative heating. Owing to the shortage of power supplies, naturally ventilated (NV) sensors are often used in Antarctica instead of mechanically force-ventilated (FV) sensors. When ventilation is inadequate to remove the influence of radiative heating, NV temperature measurements result in higher values than FV measurements. In this study, we examined the radiative heating error of NV measurements on the East Antarctic Plateau using both the newly installed AWSs at NDF and Relay Station and the existing AWSs at Relay Station and Dome Fuji. In austral summer, the temperature bias between the FV and NV sensors never reached zero owing to continuous sunlight. The hourly mean temperature errors reached 8 °C at noon on a sunny day with weak wind conditions. The errors increased linearly with increasing reflected shortwave radiation and decreased nonlinearly with increasing wind speed. These features are consistent with those reported in previous studies. Thus, to quantify radiative errors, we applied an existing correction model based on the regression approach. We found that this approach successfully reduced radiative biases by up to 70%. This indicates that we can use the corrected temperature data instead of quality-controlled data, which removes the warm bias during weak winds in inland Antarctica.

(Reference: Morino, S., N. Kurita, N. Hirasawa, H. Motoyama, K. Sugiura, M. A. Lazzara, D. Mikolajczyk, L. Welhouse, L. Keller, and G. Weidner (2021): Comparison of ventilated and unventilated air temperature measurements in inland Dronning Maud Land on the East Antarctic Plateau. *J. Atmos. Oceanic Technol.*, 38, 2061–2070, doi:10.1175/JTECH-D-21-0107.1)

Seasonal and interannual variations of chlorophyll-a in the upper Gulf of Thailand



Mean MODIS Chl-a (2003–2017) and wind distributions of upper Gulf of Thailand.

Seasonal and interannual variations in the total phytoplankton biomass in the upper Gulf of Thailand (uGoT) from 2003–2017 were investigated using the chlorophyll-a (Chl-a) of the Moderate Resolution Imaging Spectroradiometer (MODIS) on Aqua. The accuracy of Chla was first verified and improved by the local tuning of the empirical algorithm. The seasonal variation was mostly related to the monsoon variability, the non-monsoon (NOM), southwest-monsoon (SWM), and northeast-monsoon (NEM) seasons, of the environmental parameters. High and low Chl-a corresponded with high and low precipitation and river discharge during the SWM and NEM, respectively. Chl-a was generally low during NOM because of the low precipitation. Chl-a was generally higher in the north where the river discharge was high, especially from the Chao Phraya and Tha Chin Rivers. The high Chl-a area was shifted to the east and west and was related to the wind direction, resulting in the current and probable freshwater distribution during SWM and NEM, respectively. Interannual variations in Chl-a were related to variations in precipitation, river discharge, and wind patterns caused by El Niño-Southern Oscillation rather than the Indian Ocean Dipole. Positive and negative SWM Chl-a anomalies corresponded to high and low precipitation and river discharge during La Niña and El Niño, respectively. Positive and negative NEM Chl-a anomalies corresponded to high and low river discharge and strong and weak winds during La Niña/El Niño. A positive NOM Chl-a anomaly appears to be related to the higher wind speed and precipitation during El Niño.

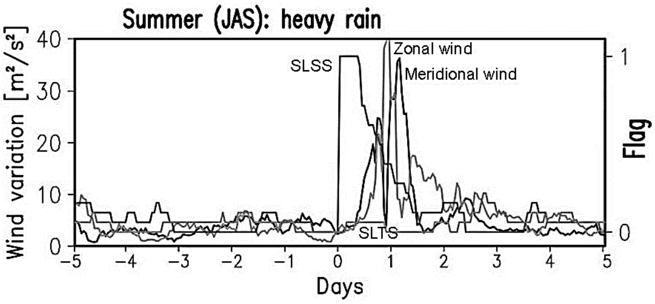
(References: Luang-on, J., J. Ishizaka, A. Buranapratheprat, J. Phaksopa, J. I. Goes, H. Kobayashi, M. Hayashi, E. R. Maúre, and S. Matsumura (2021): Seasonal and interannual variations of MODIS Aqua chlorophyll-a (2003–2017) in the Upper Gulf of Thailand influenced by Asian monsoons. *J. Oceanogr.*, doi:10.1007/s10872-021-00625-2)

High-resolution vertical observations of phytoplankton groups derived from an *in-situ* multiple excitation fluorometer in the East China Sea and Tsushima Strait

Few studies have used multiple excitation fluorometers to understand the variability in coastal phytoplankton groups. We used a multiple excitation fluorometer to understand the high-resolution vertical distributions of phytoplankton composition in the East China Sea (ECS) and Tsushima Strait (TS) where the Changjiang River diluted water (CDW), Kuroshio water (KW), and Tsushima water (TW) during the summers of 2011, 2012, and 2014. The multiple excitation fluorometer was calibrated with phytoplankton group data derived from high-performance liquid chromatography (HPLC) analysis of the water samples. We found clear differences in the distribution of phytoplankton in CDW, KW, and TW. Brown algae were generally dominant (~60%) in the CDW, although cyanobacteria (>40%) and green algae plus cryptophytes (>40%) were abundant above and below the subsurface chlorophyll maximum, respectively. Brown algae were also dominant in the water column (>60%), including the subsurface chlorophyll maximum (>80%) of TW, and cyanobacteria were dominant in the surface water. Cyanobacteria were abundant (>40%) at the surface while brown and green algae dominated (>60%) below 40 m in the KW. These results are related to the nutrient distributions in these areas. A multiple excitation fluorometer, which was calibrated using phytoplankton group data derived from HPLC analysis of some water samples, can efficiently supply high-resolution vertical distribution of phytoplankton group distribution.

(References: Xu, Q., S. Wang, C. Sukigara, J. I. Goes, H. d. R. Gomes, T. Matsuno, Y. Zhu, Y. Xu, J. Luang-on, Y. Watanabe, S. Yoo, and J. Ishizaka (2022): High-Resolution Vertical Observations of Phytoplankton Groups Derived from an *in-situ* Fluorometer in the East China Sea and Tsushima Strait. *Front. Mar. Sci.*, 8, 756180, doi: 10.3389/fmars.2021.756180)

Statistical analysis of the impact of typhoons and other strong wind precipitation events on the oceanic mixed layer



Composite time series of SLSS flag, sporadic low-temperature signal flag, and wind variance for 18 SLSS events in summer with heavy rainfall.

The Kuroshio Extension Observatory (KEO) buoy has been measuring air-sea interaction quantities since 2004. The KEO buoy records contain sporadic low-salinity signals (SLSSs) in the mixed layer when using, for example, the tropical cyclone approach. SLSSs cannot be reproduced by one-dimensional turbulence closure models, which have been used as a part of three-dimensional ocean circulation models in previous studies. In the western North Pacific, precipitation is substantial in both the Baiu and autumn front seasons, around June and November, respectively. SLSS events can be terminated by entrainment of saltier subsurface water parcels to the mixed layer in response to storms (Figure). The discovery of wind velocity subdiurnal variation peaks following SLSS commencement is the reason the present study adopted a time scale of 1-day wind velocity analysis. The present study illustrates how to extract the features of marine weather events that produce SLSSs in the oceanic mixed layer. This new and concise approach will be useful for identifying SLSS events in other regions of the global ocean to provide the necessary information for improving air-sea flux formulations.

(References: Kameyama et al. (2022): Sporadic low salinity signals in the oceanic mixed layer observed by the Kuroshio Extension Observatory buoy. *Front. Clim.*, 4, 820490, doi:10.3389/fclim.2022.820490)

Enhanced oxygen consumption results in summertime hypoxia in Mikawa Bay, Japan

The spread of coastal hypoxia (“dead zones”), whose occurrence has increased rapidly since the latter half of the 20th century, is having a serious impact on ecosystem functions. Six shipboard observations were conducted in Mikawa Bay from May to August 2014 to investigate the spatiotemporal variation in the oxygen consumption rate (OCR) of the bottom layer. The OCR was determined from the dark incubation of sample waters using an optical oxygen sensor, which showed a range of 5.7–38.3 μM d^{-1}. A high OCR was observed at the inner-most station, where higher concentrations of nutrients and chlorophyll a than at the other stations were found and bottom hypoxic water appeared during the observation period after late June. These OCRs can deplete the oxygen dissolved in water within a week. Overall, OCR showed a highly significant positive correlation with particulate organic carbon concentrations in the bottom water. Considering the relatively low carbon-to-nitrogen mole ratio (6.4~7.6) and high carbon isotope ratio (between −20.2‰ and −18.8‰) of particulate organic matter at the stations, the supply of fresh organic matter produced in the bay as opposed to land may have affected the OCR by acting as a substrate for microbial aerobic respiration. High temporal resolution data from two automated observation buoys near the bay mouth and the inner area captured increases in Chl-a a at both sites in response to typhoon events, along with the subsequent appearance of bottom hypoxic water at the inner site and its expansion at the mouth. This supports our hypothesis that enhanced organic matter production due to nutrient input to the surface layer through vertical mixing would increase the bottom OCR, resulting in hypoxia. The apparent oxygen decline in the bottom layer from the buoy data was consistent with incubation-based OCRs during the observation period. Therefore, it is essential to properly model the OCR in numerical simulations of hypoxia, to which the variability characteristics that we revealed make a significant contribution.

(References: Sukigara, S., Y. Mino, A. Yasuda, A. Morimoto, A. Buranapratheprat, and J. Ishizaka (2021): Measurement of oxygenconcentrations and oxygen consumption rates using an optical oxygen sensor, and its application in hypoxia-related research in highly eutrophic coastal regions. *Cont. Shelf Res.*, 229, 104551, doi:10.1016/j.csr.2021.104551)

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 FY2021

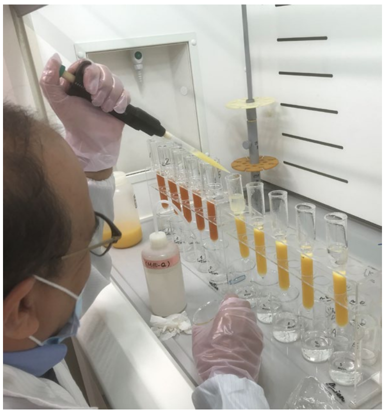
Development of carbon-14 detection technique by PIMS

Carbon positive-ion mass spectrometry (C-PIMS) is an effective method for detecting radiocarbons at low concentrations. In this new radiocarbon detection technology, an electron cyclotron resonance ion source (ECRIS) is used to generate highly charged positive ions (e.g., C^{2+}), which are converted into negative ions (C-) in a charge exchange cell. The development of high-performance ECRIS is important for the practical application of C-PIMS. At the ISEE, we are conducting theoretical and experimental studies on whether a small ECR ion source using a solid-state 2.45-GHz microwave generator is a viable option for the practical application of C-PIMS. Theoretical estimates predict that the generation of a 40-keV C^{2+} ion beam of approximately 40 mA will enable the detection of natural radiocarbons.

Beam injection system of PIMS.

Model construction of long- and short-term structural evolution of Zagros orogenic belt

Understanding the igneous activity and formation process of the Zagros orogenic belt in Western Asia, which is part of the Alpine–Himalayan orogenic belt, is important for understanding the formation of the Earth's continental crust and for analyzing the formation process of resource deposits. This year, we invited Prof. Azizi from the University of Kurdistan, Iran to Nagoya University for three months, from November 2021 to February 2022, to research the long-term evolution of long-lived radioisotopes (Sr-Nd-Hf) (Azizi *et al*., 2021, *Journal of Petrology*; Daneshvar *et al.,* 2021, *Minerals*; Nouri *et al.,* 2021, *Lithos*; Gholipour *et al*., 2021, *Lithos*). We also initiated an effort to develop a new structural development history model by adding a short time series of light elements such as Li and Be. The relatively short-lived cosmic ray-produced nuclide ^{10}Be can be useful for clarifying isotope recycling in subduction zones and post-impact systems. In 2021, we set up columns of cation and anion exchange resins for Be separation and conducted Be extraction from 40 rock samples, for which chemical and Sr-Nd-Hf isotopic ratio data were obtained.



Column separation of rock samples for extraction of Be fraction.

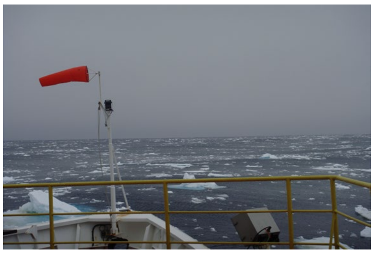
Formation process of gigantic whale bone concretions in the Oga Peninsula, Akita Prefecture, Japan

More than 100 gigantic spherical carbonate concretions containing whale bone are exposed in the Unozaki coast of the Oga Peninsula in Akita Prefecture, Japan. This study examined the formation mechanism of these concretions, which has not been elucidated before, using field surveys and geochemical analyses. The results suggested that these gigantic whale bone concretions were formed by the rapid burial of the whale bone on the seafloor during wave storms and the decomposition of its carbon component by benthic organisms. The observation of the primary dolomite suggests that gigantic concretions may have formed in a reducing environment. Subsequently, gigantic spherical carbonate concretions were formed by growth of calcite. (This research was supported by the 2021 Akita Geopark Research Grant and was conducted with the cooperation of the Culture and Sports Division of Oga City and the Oga Peninsula–Oogata Geopark Association.)

Giant whalebone concretion in the Oga Peninsula, Akita Prefecture, Japan.

Relationship between Antarctic primary productivity and sea ice changes with sub-decadal-scale climate variability during the last 11,400 years

The marine margin of Antarctica plays an important role in the global carbon cycle through the formation of Antarctic bottom water and primary productivity. An international joint research team that included researchers from the University of Tokyo, Nagoya University, Victoria University of Wellington, and Stanford University investigated a 170-m-long sediment core recovered from the Adélie Basin along the Wilkes Land margin of East Antarctica. The

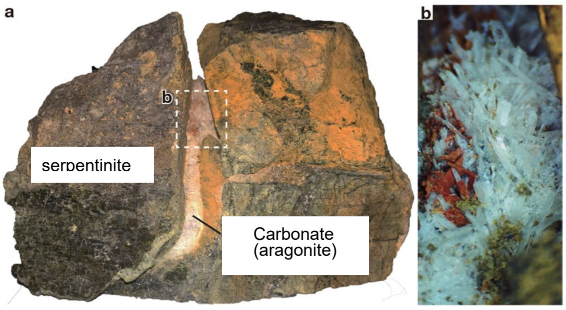


Off the coast of Wilkes Land, East Antarctica.

study revealed that sea ice variations off the coast of East Antarctica have been closely linked to sub-decadal-scale climate modes (for example, the El Niño–Southern Oscillation, Southern Annular Mode, and Indian Ocean Dipole) during the past ~11,400 years (Johnson *et al*., 2021). The study findings can be used to improve models for predicting the global carbon and marine biogeochemical cycles.

Carbon cycle processes in shallow subduction zones

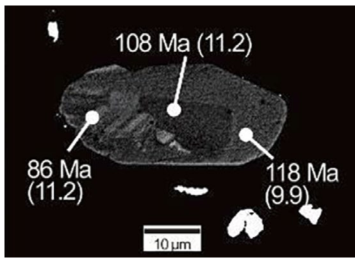
Carbon in the Earth's surface layer is brought to the Earth's depths as plates are subducted and then returned to the surface in a cyclic process. The importance of the shallow carbon cycle process, in which subducted carbon returns to the Earth's surface from relatively shallow areas, has long been highlighted; however, the time scale of this cycle is not well understood. In this study, carbonate (aragonite) mineral veins in forearc mantle rocks collected from Kaigamekaiyama (6,400-m depth) in the Izu–Ogasawara Trench were analyzed and found to have stable carbon isotope ratios similar to those of deep-sea water and low ^{14}C concentrations. This indicates that carbonates that originated from carbon in old seawater and were transported into the Earth's interior remained in the fore-arc mantle of the upper plate for tens of thousands of years or more. This finding is important and advances our understanding of the global carbon cycle by adding a new indicator, ^{14}C, to rocks that have been studied geologically and mineralogically. This research was conducted in collaboration with the Japan Agency for Marine-Earth Science and Technology, Tohoku University, Niigata University, and the National Institute of Advanced Industrial Science and Technology and was supported by the ISEE Joint Research Program (Accelerator Mass Spectrometry Analysis) (Oyanagi *et al*., 2021, *Communications Earth & Environment*).



(a) Carbonate (aragonite) produced by precipitation in a fracture of altered mantle rock (serpentinite). (b) Enlarged view of the area enclosed by the white dotted line in (a). Aragonite is needle-shaped.

Geochronological study of the Pingze–Dongshan metamorphic belt, Fujian, China

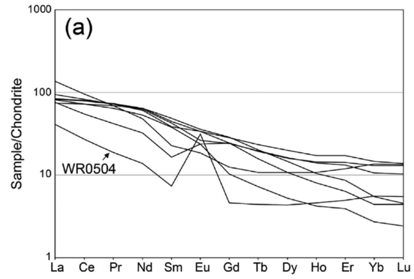
Geochronological studies of the Pingze–Dongshan metamorphic belt in Fujian Province, China are important for understanding the late Mesozoic tectonic development history of the continental margin in South China. Therefore, we measured the ages of monazite and zircon in mica schist and intrusive granite in this region. U-Pb isotopic ages were determined by LA-ICP-MS at National Taiwan University and NanoSIMS at the University of Tokyo and U-Th-Pb CHIME ages were determined by EPMA at ISEE. The results indicated that the age of peak metamorphism of the mica schist reached its metamorphic peak at approximately 100 Ma. One group of zircons had a simple age cluster (145–30 Ma) while the other showed a wide age spectrum of two populations (c. 1.8 Ga and c. 190 Ma) that are uncommon in this region (Lin *et al*., 2021, *Journal of Asian Earth Sciences*).



Backscattered electron image and CHIME ages of monazite (from Lin *et al*., 2021)

Structural developmental history of Hida and Yoengnam belts based on zircon ages and Hf isotopic ratios

Integrated zircon U-Pb chronology and Hf isotope geochemistry of igneous and metamorphic rocks from the Hida Belt, southwest Japan, have led to a new understanding of the evolution of the arc system. The igneous parts of zircon in basic-medium orthogneisses from the Tateyama and Tsunokawa areas yielded Permian $^{206}Pb/^{238}U$ ages. The overgrown parts are 250–240 Ma in age and have a relatively high Th/U ratio (> 0.2). These parts may have been formed by a thermal event caused by the intrusion of the Hida granitoids. Based on the whole rock chemistry, Sr-Nd isotopic ratios, Hf isotopic ratios, and zircon ages, the Hida Belt was an island–arc system that formed along the North China Craton with the Yeongnam Belt in the Paleozoic–Mesozoic (Cho *et al.*, 2021, *Geoscience Frontiers*).



Rare earth element patterns in Hida gneiss (From Cho et al., 2021, under CC BY-NC-ND license).

Isotope Ratio Meeting 2021

The Isotope Ratio Meeting of the Mass Spectrometry Society of Japan is held annually to allow researchers and students in Japan to use isotope analysis as their main research tool to exchange information on current problems in both hardware and software and to develop isotope ratio measurements and applied research fields. This is the only meeting in Japan that provides a forum for the exchange of isotope research using mass spectrometry as a research method.

This year, the ISEE took the lead in holding the online meeting on November 10–12, 2021, in collaboration with the Graduate School of Environmental Studies of Nagoya University. The meeting was attended by 94 participants, including 29 students. Two special scientific lectures, three invited lectures (one of which was given by Associate Professor Fusa Miyake of ISEE on "Investigation of past extreme solar events using cosmic ray-produced nuclides"), and seven live video introductions from the laboratories were given. In the laboratory introductions, the analytical equipment was demonstrated and the audience was able to catch a glimpse of the laboratories, making it a meaningful opportunity for exchange among isotope researchers.

Poster for Isotope Ratio Meeting 2021.

Regional Contribution Program 2021 of Nagoya University "Let's Learn about Radiation from the Natural World"

The Regional Contribution Program 2021 of Nagoya University, "Let's Learn about Radiation from the Natural World," was conducted as a hands-on learning experience for upper elementary school students. The purpose of this program was to understand the nature of radiation and how humans are constantly exposed to radiation from the natural world. We have been considering ways to implement the "hands-on" learning program for COVID-19. We decided to send students educational materials for simple experiments that could be done safely at home, and to conduct experiments and discussions that would be difficult to perform at home in an online format. We distributed simple radiation measurement instruments and radiation sources to the students and asked them to measure the radiation levels in the samples and their surroundings. The results were discussed in an online format. Additionally, a fog-box experiment was conducted online. This allowed the participants to observe radiation emitted from minerals and the atmosphere, as well as radiation from outer space. Although the online format limited the number of possible experiments, it had the advantage of allowing participation from outside the Nagoya area. Participants from the Kansai area were able to examine differences in natural radiation doses that were thought to be due to geological differences.

Poster for 2021 Regional Contribution Program of Nagoya University.

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

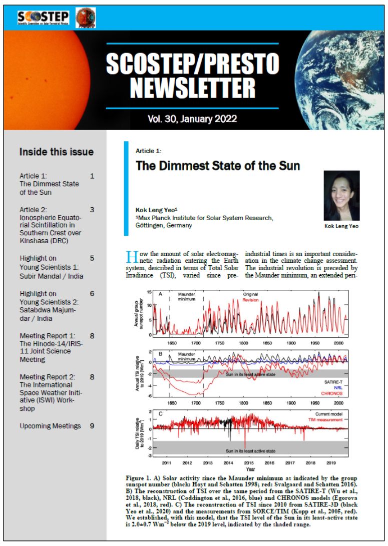
The Center for International Collaborative Research (CICR) provides leadership to promote international collaborative studies to understand the physical mechanisms of phenomena occurring in the space–Sun–Earth environmental system and their interactions. The CICR encourages programs to develop ground-based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

Main Activities in FY2021

In FY2021, the CICR conducted the following international collaborative research programs: 1) Joint Research Program (international, 23 projects); 2) ISEE International Joint Research Program, inviting 15 researchers from overseas; and 3) ISEE/CICR International Workshop, including two designated professors from overseas who were hired through a 5-year cross-appointment with US universities and institutions. Four English-speaking staff members were hired to provide administrative support. However, part of programs 2) and 3) were canceled due to COVID-19. Employment of the two designated professors continued after FY2022. In program 1), the CICR conducted research to understand coupling processes in the solar-terrestrial system by overseas observation using a wide range of ground-based multipoint networks. In collaboration with SCOSTEP, the CICR hosted five international online seminars and nine online lectures for students in FY2021. It also supported two graduate students in making presentations at an international online conference. In the PRESTO program (2020–2024), the CICR published four newsletters in FY2021 (April, July, October, and January). The CICR also supported two international schools in Nigeria and Portugal. A student from Russia was invited to the ISEE for collaborative research under the SCOSTEP Visiting Scholar program. Students from Ethiopia and India were invited to the ISEE under the JSPS Core-to-Core Program.



SCOSTEP/PRESTO Newsletter vol. 30 (January 2022).

The EISCAT radar project was undertaken in collaboration with an NIPR group, and eleven 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 newly 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.

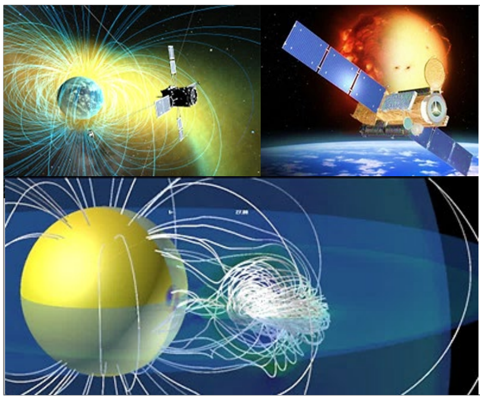
The four domestic observatories continued to operate in FY2021. The Moshiri Observatory became an unmanned observatory in FY2018, and it has continued to run electromagnetic instruments: an auroral photometer, magnetometers, and ELF/VLF receivers. Its fluxgate magnetometer and induction magnetometer were repaired in 2021. 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, the SuperDARN Hokkaido radars for ionospheric disturbances, and an ELF atmospheric receiver.

Multi-station IPS observations using Fuji, Kiso, and Toyokawa antennas were conducted between April and December 2021. The Sugadaira station, which was one of the solar wind observatories, was closed this fiscal year. A public lecture was held on September 18, 2021, at Kiso, in collaboration with the Kiso Observatory of the University of Tokyo.

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

Moshiri Observatory.

Center for Integrated Data Science (CIDAS)



- Hinode Science Center
- ERG Science Center
- Research and development of advanced simulations (SUSANOO, CReSS, Monte Carlo simulations for high-precision age calculations)
- 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.

Science centers for space missions: Hinode and ERG

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

Cooperative research program for database construction and supercomputing

CIDAS produces various databases for space–Earth environmental research and provides supercomputing facilities in collaboration with the Information Technology Center of Nagoya University and other universities and institutes. CIDAS mints DOIs for ISEE research data 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.

Main Activities in FY2021

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

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

Energy-consistent finite difference schemes for compressible (magneto-)hydrodynamics

When the magnetic or kinetic energies overwhelm the internal energy of the plasma, numerical simulations of the (magneto-)hydrodynamic equations become strongly unstable, sometimes causing unphysical solutions. Unfortunately, such situations can be found all over the universe, for example, in the solar atmosphere above sunspots. A new finite difference formulation has been proposed to overcome this difficulty, focusing on the consistency among the internal, kinetic, and magnetic energy equations in the discrete sense. Traditionally, the total energy equation is solved. The time variation of the internal energy was calculated by subtracting the kinetic and magnetic energies from the total energy. However, the resultant internal energy can be erroneous from the discretization error in stringent situations, such as the solar corona. In this study, the discrete versions of the product rule were effectively used to implicitly satisfy the internal, magnetic, and kinetic energy equations without directly solving them. The resultant formulation was implemented as spatial second- and fifth-order schemes. The numerical tests showed the extremely high robustness of these schemes for most stringent problems under high Mach number and low plasma beta conditions (Iijima, 2021, *Journal of Computational Physics*).

Activity of IUGONET

IUGONET has been promoting the use and application of upper atmospheric observation data by providing metadata databases and analysis tools in collaboration with other institutions (e.g., the Research Organization of Information and Systems) and has been developing a universal infrastructure to disclose and cite data. In FY2021, the IUGONET metadata schema was updated and metadata were recreated as they follow the international standard. IUGONET has held data analysis workshops in collaboration with international organizations, such as SCOSTEP and the World Data System affiliated with the ISC, and supported the construction of infrastructure for disclosing data and data integrity (http://www.iugonet.org/).

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 FY2021, 190 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)

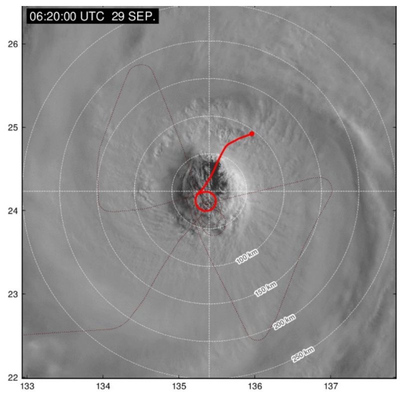
- Establishment of an aircraft observing system
- Aircraft observations of cloud, aerosol and typhoon
- Promotion of ERG mission
- Solar observation missions using micro satellites
- Study of the simultaneous development of multiple satellites for future space science
- Human resource development for space applications

Based on ISEE research objectives, which encompass natural phenomena ranging from the Earth's surface to outer space, COSO is expected to perform empirical and advanced research through observation, especially through 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 newly established to promote aircraft observation in Japan.

Main Activities in FY2021

Promotion of aircraft observations

Thanks to Nagoya University President's Discretionary Funds, we were able to install drop-sonde observation equipment on a new jet plane, Gulfstream IV (G-IV). Test flight and drop-sonde experiments were conducted, and the drop-sonde ejection was filmed using a high-speed camera from another jet tracking the G-IV to confirm that the drop-sonde was ejected correctly from the shooter of the G-IV. Typhoon Mindulle, which approached Japan on September 29, 2021, was observed using this drop-sonde observation system, and three penetrating observations of the eye were made in a butterfly pattern at an altitude of 45,000 feet to observe the inner core region. A total of 31 drop-sondes were dropped around the eye and eye wall clouds. In addition, a real-time data-transmission experiment at Nagoya University was successful. This observation system allowed us to observe the warm-core structure of the eye, in addition to the central pressure and maximum wind speed.



Meteorological satellite image of Typhoon Mindulle in 2021 overlaid with the path of the observation flight.

In preparation for an aircraft observation project under the Ministry of Land, Infrastructure, Transport and Tourism, we investigated aerosol measurement equipment, CCN counters, and ice nuclei counts for use in NASA/DC-8, such as modifications to the aircraft, including aerosol inlets, for use in high-altitude operations.

A research paper based on the data analysis of aircraft observations in Greenland in 2018 was published and preparations were made for simultaneous aircraft and ship observations off the east coast of Hokkaido in the summer of 2022.

Hydrospheric Atmospheric Research Laboratory

To prepare for joint observations with the U.S. and Taiwan on Baiu fronts and typhoons from June to August 2022, a Ka-band radar was installed on Yonaguni Island in 2020 and an X-band radar was transported to Yonaguni Island. An ISEE symposium titled “Heavy Rainfall and Tropical Cyclone in East Asia” was held in March. During this symposium, details of the joint observations were also discussed with researchers from other countries.

Investigations on in-parallel manufacturing and cluster launch configuration for multiple 150–200 kg-class satellites developed for future space exploration

In cooperation with a Japanese satellite manufacturer, NEC, qualified by numerous satellite development experts for space missions of more than 300 kg, we have been investigating new types of system specifications and in-parallel development for future satellite exploration missions. Assuming the application of space-qualified components supplied by Airbus for simultaneous development and launch for almost equivalent satellites with a weight of less than 200 kg, we discussed the satellite structure with deployed subcomponents, launch configuration and separation sequence by a single rocket, and operation tasks in this fiscal year. Assuming that the launch service for multiple satellites is based on the Epsilon-S system by IHI-Aerospace, we investigated detailed satellite structures and concrete launch configurations for a case of vertically stacked satellites, which has not been realized in Japan.

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. We plan to launch an engineering prototype in FY2022 and a satellite with scientific instruments in FY2024 or later, in time for the next solar maximum. In FY2021, we established signal processing and calibration procedures for a plastic scintillator used for neutron detection and energy measurements. We achieved an energy resolution of 15% (full width at half maximum, FWHM) and angular resolution of 11° (FWHM) for 46 MeV protons. This corresponds to a 23% energy resolution for 56 MeV neutrons, which satisfies the mission requirement.

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 processes. 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 72 applicants for the basic course and 42 for the advanced course. More than 80% of the applicants were from outside Nagoya University and approximately 40% of the applicants were from industries.

Promotion of observations using Earth-observing satellites

Activities were conducted to formulate a plan for Japanese Earth observation satellites under the TF remote sensing subcommittee. We contributed to the development of algorithms for spaceborne precipitation radar and studied future space-borne Doppler radars. We conducted validation activities for JAXA’s climate change mission (GCOM-C), validated the Northwest Pacific Action Plan (NOWPAP) marine eutrophication assessment protocol using satellite data, and studied the basic production of oligotrophic coastal areas in Japan. Quantity fluctuations were evaluated using Ise Bay as an example.

Project for Solar–Terrestrial Climate Research

In 1801, British astronomer William Herschel discovered a significant correlation between the number of sunspots and market value of wheat in London (published by the Royal Society). He concluded that a reduction in the number of sunspots affected a change in climate, which altered wheat yields and influenced the price of wheat. This study was the first to examine the correlations between the Sun, climate, and society (human life). Even now, correctly identifying the characteristic variations in solar activity and investigating their effects on climate change and modern society remain important research topics in academia and society.

Very few sunspots were observed between March 7 and March 20, 2017. The cycle of solar magnetic activity corresponding to the sunspot cycle was estimated to be approximately 14 years during the Maunder Minimum. The sunspot cycle in solar cycle 24, which began in 2008, grew to approximately 13 years, similar to that during the Maunder Minimum. Therefore, we are entering a period of low solar activity and cooling on a global scale may occur in the near future. To offer a qualified opinion on the likelihood of this prediction, we must examine diverse viewpoints on how solar activity affects the climate. The globally averaged surface temperature showed a clear upward trend after the latter half of the 20th century. However, it continued to increase by 0.03–0.05 ℃ per 10 years from 1998 to 2012 and the global warming pause is called the "global warming hiatus." Nonetheless, the atmospheric greenhouse gas concentration is increasing yearly; however, a clear rise is not observed in surface temperature observations. The topic "global warming hiatus" was taken up by Internet news and blogs, moved over the scientific community, and then had a considerable impact on the public. Based on a detailed analysis of the meteorological dataset from land and ocean temperatures and computer experiments with climate models, it was suggested that the global warming hiatus was caused by natural characteristics. Although we still cannot provide a sufficient explanation, decadal-centurial-time scale climate change is indirectly driven by secular variations in solar activity. Encouraging an understanding of the characteristics and mechanisms of short-term natural fluctuations appearing in the age of global warming will predict anthropogenic climate change more reliably. It is extremely important to develop environmental policies that influence human society.

Radiocarbon (^{14}C) and Beryllium-10 (^{10}Be), known as cosmogenic isotopes, are produced at a rate that varies based on the intensity of incoming cosmic rays (CRs) to Earth, which are in turn influenced by solar activity. Analyzing ^{14}C in tree rings and ^{10}Be in polar ice cores is an effective approach for studying the long-term variations in solar activity that go back tens of thousands of years. Analyses of ^{14}C and ^{10}Be suggested that episodes of declining solar activity resembling the Maunder Minimum have occurred 12 times throughout the Holocene, which spans the past ten thousand years. Comparing cosmogenic isotopes with paleoclimate data can improve the understanding of solar-driven climate change over a long timescale. We have accumulated evidence that will be effective for studying the mechanisms by which variations in solar activity affect climate and human society. The interdisciplinary project for Solar-Terrestrial Climate Research at the ISEE integrates the latest knowledge in solar physics, meteorology, climatology, environmental studies, paleoclimatology, space physics, and CR physics to better understand the variability in solar activity, foster an understanding of solar-driven Earth systems, and contribute to predicting future global environments.

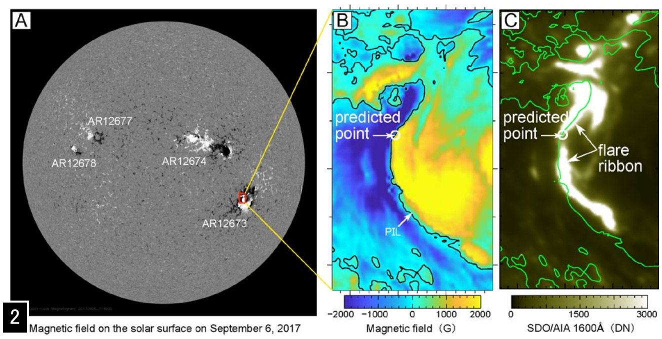
Main Activities

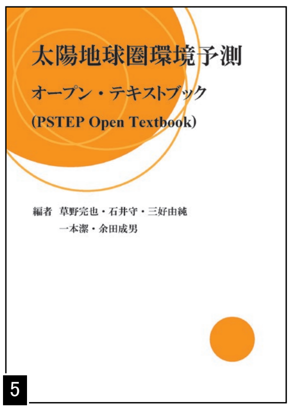
The ISEE operates a Tandetron ^{14}C AMS measurement system to trace the details of past ^{14}C changes caused by solar changes. To investigate the details of past solar changes and solar events, such as solar high-energy proton events (SPE), the accuracy and efficiency of AMS ^{14}C measurements have been improved. Some of our data obtained at the ISEE were used to develop an internationally used radiocarbon age calibration dataset (IntCal20) showing past ^{14}C changes in the atmosphere. On the other hand, we performed the accumulation of high temporal resolution paleoclimate datasets with the promotion of the International Continental Scientific Drilling Program (ICDP), Deep Sea Drilling Program, and the Suigetsu Varve Sediment Project. These efforts significantly contributed to the construction of the platform to promote "Solar-Terrestrial Climate Research" with researchers in solar physics, meteorology/climatology, environment, paleoclimatology, Earth magnetism, and cosmic ray physics.

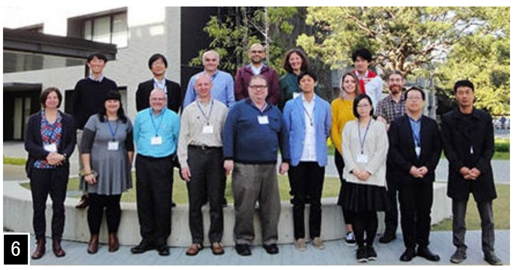
Project for Space–Earth Environmental Prediction

The solar activity and dynamics of the space environment can significantly impact human socio-economic systems and the global environment. For example, the giant solar flare observed by the British astronomer Richard Carrington in 1859 caused powerful magnetic storms, called the Carrington event. If such an event occurred in the modern era, power grids, satellites, aviation, and communication networks could be damaged globally. Moreover, analyses of the latest stellar observations and cosmogenic isotopes in tree rings suggest even larger solar flares. However, the onset mechanisms of solar flares and their subsequent processes have not yet been fully explained. Thus, modern society is at risk of severe space weather disturbances caused by such solar explosions, and understanding and predicting variations in the space–Earth environment is an important scientific subject and a crucial issue for modern society.

The Project for the Space-Earth Environmental Prediction was promoted during the third medium-term target period for the purpose to advance of synergistic development for predictive technology as scientific research and a social infrastructure via cooperation and interaction with experts in solar physics, geomagnetism, space sciences, meteorology/climatology, space engineering, and related fields. This project produced excellent research results shown in the figure below, based on ISEE Joint Usage/Research Programs and the support of a Grant-in-Aid for Scientific Research on Innovative Areas from MEXT.







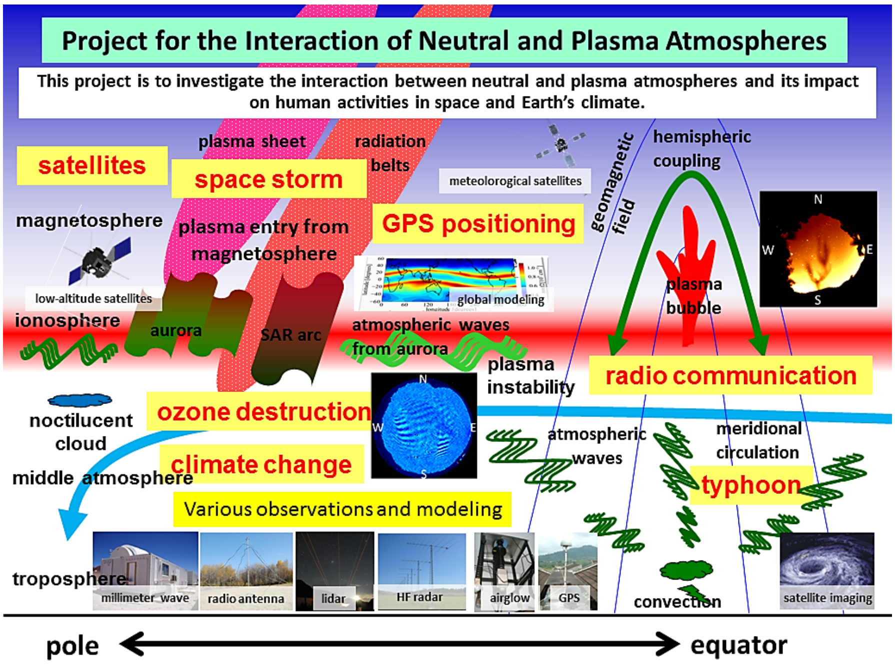
1: The 2nd ISEE Symposium “PSTEP-4: Toward the Solar-Terrestrial Environmental Prediction as Science and Social Infrastructure”, Jan. 2020, Nagoya University (http://www.pstep.jp/news/20200127.html) 2: Succeeded in developing the first physics-based model that can accurately predict imminent large solar flares (Kusano et al., 2020, Science, doi:10.1126/science.aaz2511) 3: ISEE/PSTEP International Workshop on the Solar Cycle 25 Prediction, Nov, 2017 4: PSTEP Summer School 2017 in Rikubetsu (https://www.isee.nagoya-u.ac.jp/pstep/news/20170704ss.html) 5: PSTEP Open Textbook (https://nagoya.repo.nii.ac.jp/records/2001522) 6: ISEE/PSTEP International Workshop on the Benchmarks for Operational Solar Flare Forecasts, Oct. 2017 7: Science Meeting on Modeling Study for Solar- Terrestrial Environment Prediction (2017–2021)

Project for the Interaction of Neutral and Plasma Atmospheres

The ionosphere is part of the Earth's upper atmosphere and is partly ionized by solar ultraviolet emissions. The peak altitudes of plasma density in the ionosphere are 300–400 km, where most low-altitude space vehicles fly. Thus, ionospheric plasma significantly affects human activities in space, such as radio communications and positioning by Global Navigation Satellite System (GNSS). The consequences of climate change are significant in the upper atmosphere and ionosphere. As shown in the figure below, neutral–plasma interaction processes in the upper atmosphere and ionosphere can be observed as various phenomena occurring from high to low latitudes. The aurora in the polar regions is caused by the precipitation of high-energy plasma, which heats the upper atmosphere and generates atmospheric waves and disturbances that propagate toward low latitudes. However, ionospheric plasma instabilities, known as plasma bubbles, occur in the equatorial upper atmosphere, interfering with satellite–ground communication and GNSS positioning. These phenomena can be measured using various ground-based remote-sensing instruments, such as airglow imagers, magnetometers, radars, lidars, and millimeter-wave telescopes. This interdisciplinary project has investigated the interactions between the neutral and plasma components of the Earth's atmosphere, using various ground remote-sensing techniques and *in-situ* satellite measurements, and global and regional high-resolution modeling of neutral–plasma interactions. This project has contributed to the reliable use of space by humans and our understanding of possible plasma effects on Earth's climate change. From FY2016–2021, we conducted 69 international collaborative studies, 57 domestic collaborative projects, and 120 domestic meetings for the ISEE, as shown in the table. Various scientific results have been obtained through these collaborative projects.

	2016	2017	2018	2019	2020	2021	total
international collaborative projects	11	12	11	9	14	12	**69**
domestic collaborative projects	8	8	8	9	13	11	**57**
domestic meetings	18	22	21	20	22	17	**120**
total	**37**	**42**	**40**	**38**	**49**	**40**	**246**

The number of collaborative research projects related to the Project for the Interaction of Neutral and Plasma Atmospheres.



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

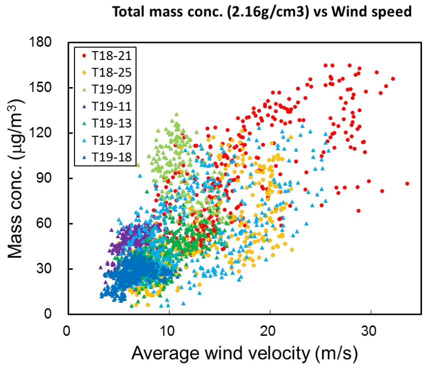
Project for Aerosol and Cloud Formation

Hydrometeors and aerosols interact closely in their generation and dissipation, and play important roles in atmospheric water circulation, the formation of convective clouds and typhoons, and the Earth's radiation budget. However, hydrometeors and cloud-precipitation systems have been studied at the Hydrospheric Atmospheric Research Center, and aerosols and related processes have been studied at the Solar-Terrestrial Environmental Laboratory. In a joint research program, researchers from both centers cooperated to study the interaction between aerosols and hydrometeors, and their variations in the formation of precipitation by field observations and numerical simulations.

Observational studies of hydrometeors and aerosols

Drone observation of sea spray particles: Sea sprays are sources of water vapor and aerosols in the atmosphere. They may influence development of convective clouds. We attempted drone observation of sea spray particles in August 2016 on Tarama Island, Okinawa. The cloud particle sonde was lifted by a drone 2 m above the sea level, and sea spray particles were observed. Although observations were made under weak wind conditions, sea spray particles were successfully observed.

Cloud and aerosol observations in the United Arab Emirates (UAE): Using an aircraft equipped with an aerosol-cloud-precipitation observation system, aerosol observations were conducted over the UAE to clarify the physical and chemical characteristics of aerosols. The effects of aerosols on clouds and precipitation were studied using the observed data. These data were also used to verify the aerosol activation process in the numerical model.



Relation of mass concentration of aerosol particles with diameters between 0.3 and 10 μm and wind speed during the passage of seven typhoons.

Observations of aerosol particles in Okinawa: Aerosol observations were conducted at the University of Ryukyus. We measured the size distribution of aerosol particles in the summer and autumn of 2018 and 2019 using an optical particle analyzer. For seven typhoons that passed near the site, the effect of wind speed on the mass concentration of aerosol particles with diameters between 0.3 and 10 μm was analyzed. The mass concentration was found to increase by 50 $\mu g/m^3$ as the wind speed increased by 10 m/s (Fig.). In addition, to study the concentrations of sea salt and dissolved organic carbon (DOC) in the aerosols, we collected bulk aerosols continuously since Sep. 2018, even during typhoons. The amount of sea salt in the aerosols showed a good positive correlation with wind speed. The DOC concentrations in aerosols collected under different wind speed conditions in this study and the fraction of sea salt in the aerosols suggest that oceanic DOC in actual atmospheric aerosols is approximately 700 times more concentrated.

Numerical studies of hydrometeors and aerosols

Super-Droplet Method with CReSS and impact experiments of aerosols on warm rain: The Super-Droplet Method (SDM) developed by Professor Shima of the University of Hyogo was coupled with the CReSS model and aerosol impact experiments were performed for warm rain. A significant difference was found in cloud and precipitation amounts according to the amount of aerosols. The maximum rainfall intensity exceeded 80 mm h^{-1} at a low aerosol density.

Numerical modeling of aerosol-cloud interaction: We developed CReSS-4ICE-AEROSOL, which implements aerosol-cloud-precipitation integrated microphysics parameterization with various aerosols in the atmosphere and hydrometeors as prognostic variables. Idealized experiments on cumulonimbus clouds with strong updrafts were conducted to investigate the effect of the amount of anthropogenic aerosols on the microphysical structure of the cloud. It has been shown that increasing anthropogenic aerosols by an order of magnitude increases the concentration and mixing ratio of cloud ice in the anvil associated with the cumulonimbus cloud several times. Furthermore, by providing aerosol information from the global aerosol model SPRINTARS as initial and boundary values, the actual cloud and aerosol processes can be simulated.

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

Research aims and background

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.

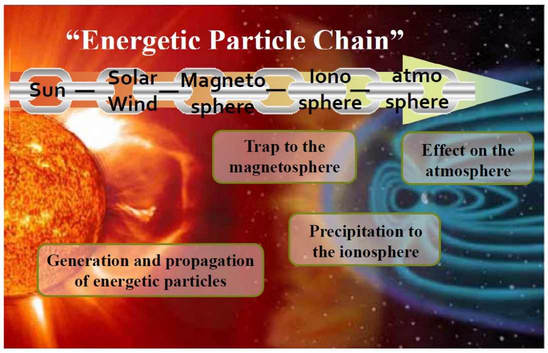


Fig.1: Image of a causal chain reaction system.

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.

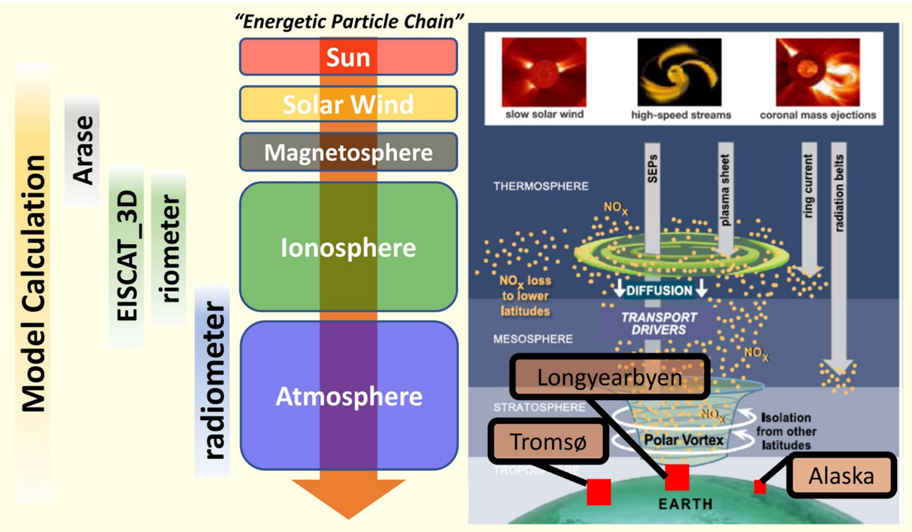


Fig.2: (left side) Observational region with each instrument and data fusion with simulation. (right side; modified from Marshall et al., 2020) Relationship between the energetic particle precipitations and new observation sites.

Results in FY2021

1. We developed a method to derive the downward energy flux and characteristic energy of aurora electrons from observations at two different wavelengths and applied the method to a pulsating aurora using camera data from Tromsø.
2. We studied pulsating auroral morphology and its precipitation electron energy flux by analyzing measurements from a high-speed sampling camera and riometers in Finland. Energy spectrum hardening and softening were detected at pulsating periods shorter and longer than 40 s, respectively, in association with pulsating auroral patch formation. Hardening was identified on the equatorward side of the pulsating aurora.
3. We developed a code that calculates the pitch angle scattering via both quasi-linear processes and non-linear processes. We also developed a code to calculate the height profile of the auroral emission at each wavelength and CNA absorption using the precipitating electrons.

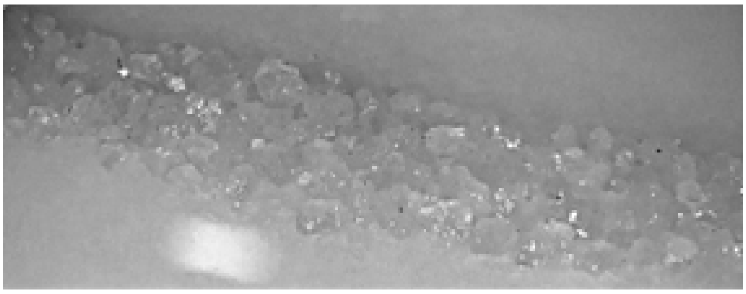
Direct Search for Dark Matter with Paleo-Detectors

Although dark matter constitutes about a quarter of the universe, it cannot be observed optically and its true nature remains a mystery. Several studies have been conducted to determine what this substance is. For example, the XENONnT project uses tons of liquid xenon in a direct search; in a direct search, the detection sensitivity is limited by the product of the mass of the detector and the experimental time. The time cannot be stretched indefinitely in experiments by humans, and methods using liquid xenon reach the limits of scale. Therefore, the method of using minerals as detectors and the 'paleo-detector' method are attracting attention. Minerals interact with dark matter on a geological scale of time; therefore, even small quantities of minerals have the potential to search for dark matter with sensitivity exceeding that of large-scale experiments. Our project combines petrology, geochronology, particle astrophysics, X-ray spectroscopy, electron microscopy, and analytical chemistry to directly search for dark matter and other unknown elementary particles using a paleo-detector. The method assumes that dark matter is a WIMP and reads the tracks produced by the interaction of dark matter with atoms in minerals, from which the scattering cross sections of dark matter and atoms are deduced.

Direct dark matter searches using paleo-detectors have a long history, and Snowden-Ifft et al. (1995) [1] observed mica etched with hydrofluoric acid using atomic force microscopy (AFM). However, no dark matter was detected. Drukier et al. [2] identified rock salt, epsomite, olivine, and nickelbischofite as candidates, with low uranium concentrations being a prerequisite for paleo-detectors. Edwards et al. [3] considered nchwaningite and sinjarite as candidates. Baum et al. [4] also submitted a letter of interest (LOI) on the direct search for dark matter by paleo-detectors during the Snowmass Process. Electron microscopy, ion-beam microscopy using helium, AFM, and synchrotron radiation have been proposed as possible read-out methods.

In our project, we are working toward proof of principle with the following considerations regarding the selection of minerals and the methods of reading the tracks. For the mineral samples, we decided to use olivine collected from the seabed and olivine from xenoliths in Quaternary basalts, considering the low noise due to cosmic rays and the possibility of preparing sufficient samples. For the readings of the tracks, we considered the optical readout method of the etched samples. First, olivine was measured by inductively coupled plasma mass spectrometry (ICP-MS) using a solution method to assess whether the uranium concentration was very low. The results showed that olivine was present in low concentrations, as assumed in theoretical studies [2][3][5]. A preliminary experiment using muscovite also revealed that tracks formed under conditions where nuclear inhibition was dominant could be easily identified. As white mica can be dated by the K-Ar method, its effectiveness as a paleo-detector will be investigated in the future.

In the future, the project will continue by trying out white mica, which was also used in the direct search for magnetic monopoles [6], and by considering the possibility of searching for dark matter and various unknown elementary particles.



Olivine in lherzolite from Mariana trench.

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

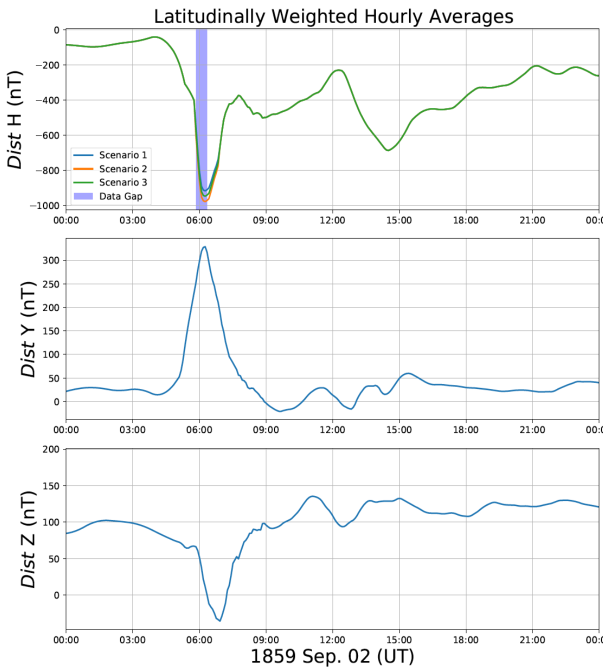
Variable solar-terrestrial environments are closely related to the humanosphere of modern civilizations. Solar eruptions and the resultant space weather disturbances often significantly impact modern human infrastructure. However, modern datasets frequently have limitations in their chronological coverage, especially when understanding the variability of such solar-terrestrial environments. It is only since the International Geophysical Year (1957–1958) that multiple observational record series have been systematically archived under international collaborations. In this context, analog records and historical documents have often benefitted studies on extreme space weather events. Therefore, our team investigated historical observations to survey, collect, and digitize their analog records. In this fiscal year, our team obtained significant results for the analog records for visual aurorae, sunspots, and geomagnetic measurements based on analog collections and yearbooks.

Our team collected and analyzed Japanese visual auroral reports around the International Geophysical Year (IGY:1957–1958), for which only the air overview and fragmental episodes are well known to the scientific community. We have published our results as Hayakawa et al. (2022, *Geosci. Data J.*, DOI:10.1002/gdj3.140) based on our archival investigations. On this basis, we confirmed the equatorward extension of the auroral oval in September 1957 and February 1958, at least down to over the Tsugaru Strait and Aomori, respectively. These results have been widely broadcast in Japanese newspapers such as Hokkaido Shinbun, Asahi Shinbun, and Chunichi Shinbun.

Furthermore, our team has also significantly developed our research on the Carrington storm of September 1859 (Hayakawa et al., 2022, *Astrophysical. J.*, 928, 32, DOI: 10.3847/1538-4357/ac2601), which is considered to be one of the greatest space weather events in the space weather community. Our team located copies of yearbooks for Bombay geomagnetic measurements in British India in several libraries, such as the British Library. Our team obtained these copies to find parallel measurement results in an hourly cadence and variable shorter cadence in 5–15 minutes, detect their apparent discrepancies around the Carrington peak in the geomagnetic horizontal component, newly derived variabilities of the eastward and vertical components, and reconstructed their diurnal variations and disturbance variations. These results directly benefit scientific discussions of their magnitude and temporal variations.

Our team has progressed in our analyses of sunspot records, especially based on Hitoshi Takuma's sunspot drawings in 1972–2013 at the Kawaguchi Science Museum following an international collaboration with the Kawaguchi Science Museum, the Royal Observatory of Belgium, and the National Astronomical Observatory of Japan. On this basis, we have revealed that Takuma's data are richer than previously known to the scientific community and one of the best data stability among the long-term sunspot observers known to the scientific community (Hayakawa et al., 2022, *Geosci. Data J.*, DOI:10.1002/gdj3.158). This result is important not only for the sunspot number recalibration itself but also for the confirmation of the scientific value of the long-term observers' individual sunspot observations in our country.

As such, past analog records allow us to develop several scientific discussions and analyses on the long-term variability and short-term space weather disturbances of solar-terrestrial environments. Our team is going to expand these studies to further archival materials to better understand solar-terrestrial environments for long-term variability and short-term eruptive events.



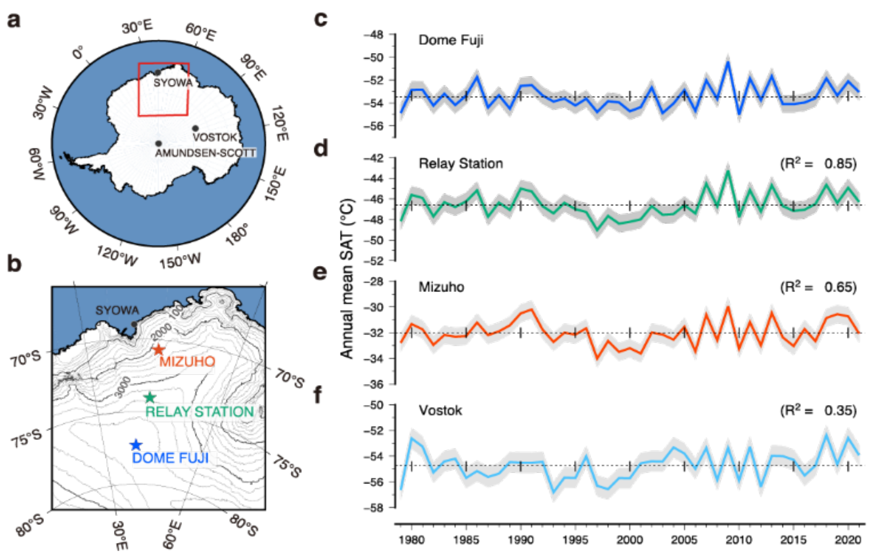
Temporal variations of the three geomagnetic components at Colaba during the Carrington storm (Hayakawa et al., 2022, *ApJ*, 928, 32).

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

Cosmogenic isotopes such as ^{10}Be and ^{3}HHO are mainly produced in the stratosphere by the interaction of cosmic rays. After production, these enter the atmospheric circulation in the troposphere and are then deposited on the ice sheet in Antarctica. Thus, the concentrations of cosmogenic isotopes preserved in ice cores from Antarctica can be used as a proxy for past cosmogenic records. However, they not only reflect the production rate in the stratosphere but are also influenced by transport and deposition processes in the troposphere. To translate isotopic records in ice cores into the stratosphere production rate, it is necessary to understand these influences on the variability of the production rate. Here, we aim to explore the temporal variations of the cosmogenic isotopes during the past 70 years by modeling their production and deposition and quantitatively analyzing the extent of the increase/decrease in the production rate in the upper atmosphere recorded in the ice cores in Antarctica. In this project, we will correct the snow samples accumulated after the 1950s in inland Antarctica and present high-resolution measurements of ^{10}Be and ^{3}HHO over the last 70 years. Thereafter, by comparing with the modeled temporal variability of the production rate, we will assess the impact of atmospheric processes.

This year is the first year of this project and we joined a field trip to the Dome Fuji site in East Antarctica as part of the Japanese Antarctic Research Expedition (JARE) and carried out snow sampling at Dome Fuji (77.31°S, 39.70°E, 3810 m als). We collected snow samples with a 3 cm depth resolution from the wall of the snow pit (5.3 m depth) drilled at Dome Fuji and shipped them to Japan.

In addition to fieldwork, we explored climate change over timescales of decades in the Dome Fuji region. Because long-term near-surface temperature observations are restricted to Dome Fuji in East Antarctica, we created a dataset of monthly mean near-surface temperatures for the interior of East Antarctica. Owing to harsh climate conditions, the observed data are fragmentary and far from near-continuous. Thus, in this study, we reconstructed continuous temperature records using adjusted temperature data from the 2-m temperature (T-2m) of ERA5 reanalysis data. Figure 1 shows the reconstructed temperature records at the four stations in the interior of East Antarctica. The year-to-year variability at the three stations in the Dome Fuji region was similar. The surface temperature from 1999 to 2021 experienced a statistically significant warming trend at all three stations. However, surface warming did not occur during any season. The strongest warming occurred in the austral spring (September, October, and November) followed by the austral summer (December, January, and February). Except for spring and summer seasons, there was no significant trend. Previous studies based on statistical methods to reconstruct temperature records have reported that statistical warming has not started in the interior of East Antarctica. However, in contrast to previous studies, we reported that significant warming has begun, particularly in the austral spring. This implies that the atmospheric circulation that transports cosmogenic isotopes from the upper atmosphere may be changed, which may significantly influence the temporal ^{10}Be and ^{3}HHO variations in the snow samples. In the fiscal year of 2023, we will explore the impact of climate change on the ^{10}Be and ^{3}HHO records in snow samples collected at Dome Fuji.



Time series of annual mean surface air temperature in the interior East Antarctica.

9. Publications and Presentations

Papers (in refereed Journals, April 2021–March 2022)

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Two more books were published in Japanese.

Publication of Proceedings (April 2021–March 2022)

Title	Date of Publication
PSTEP Open Textbook	Jul. 2021
iLEAPS-Japan2021 Workshop: Book of Abstracts	Dec. 2021
The Nagoya University Bulletin of Chronological Research Vol. 6	Mar. 31, 2022

Conference Presentations (April 2021–March 2022)

■ International Conferences

*Session Conveners

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staffs and PDs	Students	Total	Invited
EGU General Assembly 2021	Online	Apr. 19–30, 2021	0	2	2	4	0
14th International Conference on Mesoscale Convective System and High-Impact Weather in East Asia (ICMCS-XIV)	Hybrid Conference/ Nanjing, China	Apr. 28–30, 2021	0	3	0	3	2
Online Radio Heliophysics Catch-up	Online	May 10–13, 2021	0	1	0	1	0
SuperDARN 2021 Workshop	Online	May 24–28, 2021	0	1	2	3	0
4th PACES Open Science Meeting	Online	May 26–28, 2021	0	1	0	1	0
Japan Geoscience Union Meeting 2021	Online	May 30–Jun. 12, 2021	5*	52	31	83	4
The 28th International Conference on Weak Interactions and Neutrinos	Online	Jun. 7–12, 2021	1	0	0	0	0
International Workshop for Mid-latitude Air-Sea Interaction	Online	Jun. 8–14, 2021	0	1	0	1	0
Japan Open Science Summit 2021	Online	Jun. 14–18, 2021	0	1	0	1	0
The 16th Workshop on Antarctic Meteorology and Climate (WAMC)	Online	Jun. 21–23, 2021	0	0	1	1	0
3rd International Radiocarbon in the Environment Conference	Online	Jul. 5–9, 2021	1*	1	0	1	1
2021 RHIC/AGS Annual Users' Meeting	Online	Jul. 8–11, 2021	0	1	0	1	0
37th International Cosmic Ray Conference	Online	Jul. 12–23, 2021	0	3	0	3	0
18th Annual Meeting (AOGS2021)	Online	Aug. 1–6, 2021	2*	11	5	16	3
International Conference on Clouds and Precipitation 2021	Online	Aug. 2–6, 2021	0	1	0	1	0
ICEAA - IEEE APWC 2021	Hybrid Conference/ Honolulu, Hawaii	Aug. 9–13, 2021	0	1	0	1	1
IAGA-IASPEI 2021	Online	Aug. 21–27, 2021	8*	7	0	7	1
64th session of the of the Committee on the Peaceful Uses of Outer Space, United Nations	Online	Aug. 25–Sep. 3, 2021	0	1	0	1	0
URSI GASS 2021	Hybrid Conference/ Rome, Italy	Aug. 28–Sep. 3, 2021	0	3	0	3	1
The virtual DPG-Tagung (DPG Meeting) of the Matter and Cosmos Section (SMuK)	Online	Aug. 30–Sep. 3, 2021	0	1	0	1	1
The Fifth Convection-Permitting Modeling Workshop 2021 (CPM2021)	Online	Sep. 7–10, and Sep. 14, 2021	0	1	0	1	0
16th IGAC Scientific Conference	Online	Sep. 12–20, 2021	0	0	1	1	0
International Colloquium on Equatorial and Low-Latitude Ionosphere	Hybrid Conference/ Iwo, Nigeria	Sep. 13–18, 2021	1	3	0	3	3
LAPAN/BRIN - Kyoto University International Symposium for Equatorial Atmosphere /The 6th Asia Research Node Symposium on Humanosphere Science	Online	Sep. 20–22, 2021	0	2	0	2	0
Workshop on Laboratory Facilities for Cloud Research	Online	Sep. 24, 2021	0	1	0	1	1
General Incorporated Association Division of Plasma Physics Association of Asia Pacific Physical Societies (APPS-DPP) 5th Asia Pacific Conference on Plasma Physics	Online	Sep. 29–Oct. 1, 2021	0	1	0	1	1
Low-x 2021	Hybrid Conference/ Elba, Italy	Sep. 26–Oct. 1, 2021	0	1	0	1	0

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staffs and PDs	Students	Total	Invited
International Workshop on “Climate change impact on the natural ecosystems in the Arctic” within the framework of the III Northern Forum on Sustainable Development	Online	Sep. 27–30, 2021	0	1	0	1	0
12th International Conference: Solar-Terrestrial Relations and Physics of Earthquake Precursors	Hybrid Conference/ Kamchatka, Russia	Sep. 27–Oct. 1, 2021	1	1	0	1	0
International Heliophysics Data Environment Alliance	Online	Sep. 27–Oct. 1, 2021	1	2	0	2	1
International Space Science Institute SEESUP 2021	Hybrid Conference/ Bern, Switzerland	Sep. 27–Oct. 1, 2021	1	2	0	2	0
9th PRL Ka Amrut Vyakhyaan	Online	Sep. 29, 2021	0	1	0	1	1
Quadrennial Ozone Symposium (QOS 2021)	Online	Oct. 3–9, 2021	0	2	0	2	0
NASA PMM Science Team Meeting	Online	Oct. 18–22, 2021	0	1	0	1	0
SciDataCon21	Online	Sep. 18–28, 2021	0	1	0	1	1
First International Conference on Environmental Challenges: Climate change, disaster, and urban environment	Hybrid Conference/ Ulaanbaatar, Mongolia	Oct. 25, 2021	0	1	0	1	1
AOS Colloquium Series	Hybrid Conference/ Madison, WI, USA	Oct. 25, 2021	0	1	0	1	1
3rd Forward Physics Facility Meeting	Online	Oct. 25–26, 2021	0	1	0	1	1
17th European Space Weather Week	Hybrid Conference/ Glasgow, UK	Oct. 25–29, 2021	0	1	0	1	0
Asia-Oceania Group on Earth Observations (AOGEO) Task Group 3 Meeting：Carbon and Greenhouse Gases	Online	Oct. 27, 2021	0	1	0	1	0
Tropical Cyclone Trami Mini Workshop	Online	Oct. 29, 2021	0	1	0	1	0
The 2nd International Symposium on Space Science (ISSS 2021)	Online	Nov. 15, 2021	0	1	0	1	1
Workshop of Water Isotopes: from Weather to Climate	Online	Nov. 15–17, 2021	0	1	0	1	0
The 12th Symposium on Polar Science	Online	Nov. 15–18, 2021	0	3	4	7	0
The 15th International Conference on Accelerator Mass Spectrometry (AMS-15)	Online	Nov. 15–19, 2021	0	1	1	2	0
Particle Acceleration in Solar Flares and the Plasma Universe - Deciphering its features under magnetic reconnection	Online	Nov. 15–19, 2021	0	1	0	1	1
GEO Week 2021/ GEO-GEE Programme Side Event	Online	Nov. 22–26, 2021	0	1	0	1	0
7th International Conference on Space Science and Communication (IconSpace2021)	Online	Nov. 23–24, 2021	1	0	0	0	0
ISEE/ISAS Symposium on Inner Heliosphere Studies 2021	Online	Nov. 29–30, 2021	0	2	0	2	1
Linking the science of large interferometers in the 2030s	Online	Nov. 30–Dec. 1, 2021	0	1	0	1	1
AGU Fall Meeting 2021	Hybrid Conference/ Los Angeles, CA, USA	Dec. 13–17, 2021	0	14	9	23	1
GEE Training & The 9th Asian/18th Korea-Jaoan Workshop on Ocean Color 2021	Online	Dec. 20–22, 2021	1	1	1	2	0
Sodankyla Geophysical Observatory Days	Online	Jan. 10–14, 2022	0	1	0	1	0
1st Japan-Russia Bilateral Project Meeting (ISEE-IKFIA)	Online	Jan. 13, 2022	0	1	0	1	0
International Conference on Frontiers of Physics-2022	Hybrid Conference/ Katmandu, Nepal	Jan. 22–24, 2022	0	1	0	1	1
The 16th Vienna Conference on Instrumentation	Online	Feb. 21–25, 2022	1	0	0	0	0

Title	Venue	Date	Orga-nizers	Number of Presentations			
				Staffs and PDs	Students	Total	Invited
59th session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, United Nations	Online	Feb. 21–25, 2022	0	1	0	1	0
15th Quadrennial Solar-Terrestrial Physics symposium (STP-15)	Online	Feb. 21–25, 2022	1	13	11	24	1
ISEE Symposium International Conference on Heavy Rainfall and Tropical Cyclone in East Asia	Online	Mar. 1–2, 2022	1	2	0	2	0
International Symposium on “Pan-Arctic Water-Carbon Cycles and Terrestrial Changes in the Arctic: For resilient Arctic Communities”	Online	Mar. 8–11, 2022	1	4	0	4	0
Synergies at new frontiers at gamma-rays, neutrinos and gravitational waves	Online	Mar. 24–25, 2022	1*	1	0	1	1
Total			11 17*	168	68	236	33

■ Domestic Conferences

* Session Conveners

Number of Conferences	Organizers	Number of Presentations			
		Staffs and PDs	Students	Total	Invited
82	29 10*	164	92	256	15

■ Lectures for Researchers

Date	Title	Number of Paticipants
May 21, 2021 Jun. 8, 2021 Sep. 23, 2021 Nov. 30, 2021 Feb 10, 2022 JMar. 11, 2022	SCOSTEP/PRESTO Online Seminar (7st–12th)	114 159 121 83 155 48
Apr. 29, 2021 May 31, 2021 Jun. 28, 2021 Aug.19, 2021 Sep. 14, 2021 Oct. 21, 2021 Nov. 16, 2021 Jun. 27, 2022 Mar. 31, 2022	SCOSTEP Online Capacity Building Lecture (4th–12th)	52 108 114 49 90 40 35 53 39

Awards

■ Staffs and PDs

Award Winners	Date	Awards	Title
Satoko Nakamura	Apr. 23, 2021	Sasakawa Scientific Research Encouragement Prize 2020	A Preliminary Risk Assessment of Geomagnetically Induced Currents on Japanese Power Grids in Severe Space Storms
Nozomu Nishitani Tomoaki Hori	May 17, 2021	PEPS Most Cited Paper Award 2021	Nishitani, N., J. M. Ruohoniemi, M. Lester, J. B. H. Baker, A. V. Koustov, S. G. Shepherd, G. Chisham, T. Hori et al., Review of the accomplishments of mid-latitude Super Dual Auroral Radar Network (SuperDARN) HF radars. Prog Earth Planet Sci, 6, 27, 2019 (10.1186/s40645-019-0270-5)
Masayo Minami	Sep. 9, 2021	Top Leaders Awards for Female Faculty Members, Nagoya University	Commendation of particularly outstanding female researcher (who not only excels in research achievements and competence but is also expected to play an active role as a university director or manager in the near future)
Hironobu Takahashi (F.A. Shinta Seto)	Dec. 1, 2021	JMSJ Award	Seto, S., T. Iguchi, R. Meneghini, J. Awaka, T. Kubota, T. Masaki, and N. Takahashi: The Precipitation rate retrieval algorithms for the GPM Dual-frequency Precipitation Radar. J. *Meteor. Soc. Japan*, 99(2), 205–237, 2021 (10.2151/jmsj.2021-011)
Masataka Murakami	Jan. 5, 2022	STAC-Level Awards for 2022/ STAC Distinguished Scientific/ Technological Accomplishment Award	For leading the field of weather modification research by inventing novel approaches for lab and field work and numerical modeling

■ Students

Award Winners	Date	Awards	Title
Yoshiki Ito	Jun. 3, 2021	Society of Geomagnetism and Earth, Planetary and Space Sciences (SGEPSS) Student Presentation Award (Aurora Medal)	Computer simulations of precipitating electrons through chorus-wave particle interactions
Toshiki Kawai	Jun. 7, 2021	JpGU Meeting 2021 Outstanding Student Presentation Award	Contribution of small-scale flares to coronal heating estimated by a spectroscopic observation of Hinode
Ken Ohashi	Oct. 9, 2021	Student Presentation Award of the Physical Society of Japan	Analysis of forward neutrons with the LHCf-ATLAS detectors (III)

10. Education

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

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

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

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

Number of Students supervised by ISEE Staff

(April 1, 2021–March 31, 2022)

	M1	M2	D1	D2	D3	Undergraduate Students	Non-regular students	Total
Graduate School of Science	11	11	0	3	4	-	0	29
Graduate School of Engineering	12	11	0	0	0	-	0	23
Graduate School of Environmental Studies	11	13	2	3	4	-	5 *	38
School of Science	-	-	-	-	-	8	0	8
School of Engineering	-	-	-	-	-	9	0	9
ISEE	-	-	-	-	-	-	2*	2
Total	34	35	2	6	8	17	7	109

Cumulative total in FY 2021 * Research Student

Faculty Members

(April 1, 2021–March 31, 2022)

■ Division of Particle and Astrophysical Science, Graduate School of Science

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

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

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

* Left the Institute at August 31, 2021

■ 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 2021 Academic Year, The Following Courses were offered;

- Astrophysics and Space Science
- Astrophysics III
- Earth and Planetary Science Seminar I
- Electric Circuits with Exercise
- Electromagnetic Wave Engineering
- Environmental Chemistry
- Experimental Physics
- Experiments in Physics - Advanced Course
- Field work
- First Year Seminar A
- Frontier of Earth and Planetary Sciences
- Geochemical Analysis II and Experiments
- Geology Experiments
- Graduation Thesis A・B
- Introduction to Physics I
- Introduction to Physics II
- Laboratory in Physics
- Mathematics I and Tutorial A
- Mathematics I and Tutorial B
- Mathematics II and Tutorial
- Meteorology
- Physics Experiments I
- Physics Experiments 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

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

Visitor : 1／Going Abroad : 0

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

Research Projects

■ Major International Collaborative Projects

(86 in total)

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Study of the Onset Mechanism of Solar Eruptions	K. Kusano	Germany	1	University of Potsdam
Observational Study of the Onset Mechanism of Solar Eruptions	K. Kusano	U.S.A. China	2	New Jersey Institute of Technology University of Science and Technology of China
Study of Modeling of Solar Eruptions	K. Kusano	U.S.A.	1	Harvard-Smithsonian Center for Astrophysics
Study of Triggering Mechanism of Solar Flares	K. Kusano	U.K.	1	UCL Mullard Space Science Laboratory
Study of Magnetic Reconnection	K. Kusano	U.K.	1	University of Manchester
Modeling Study of Inner Magnetosphere	Y. Miyoshi	U.S.A.	1	Los Alamos National Laboratory
Collaborative Study on ERG Project	Y. Miyoshi	Taiwan	1	Academia Sinica Institute of Astronomy and Astrophysics
International Heliophysics Data Environment Alliance	Y. Miyoshi	U.S.A. Europe (Member States of ESA)	23	NASA (SPDF, SDAC, HPDE, SPASE, CCMC) European Space Agency (ESA), Centre National d'Études Spatiales
Collaborative Researches Based on Solar Radio Observations with MUSER	S. 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	S. 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	Y. Itow	U.S.A. Canada U.K. Spain Korea China Poland	7	Boston University, Brookhaven National Laboratory, UCI, Duke University, George Mason University, University of Hawaii, Indiana University, Los Alamos National Laboratory, University of Maryland, State University of New York, University of Washington University of British Columbia, University of Toronto, TRIUMF Queen Mary University of London, Imperial College London, University of Liverpool, University of Oxford, University of Sheffield Complutense University of Madrid Chonnam National University, Seoul National University, Sungkyunkwan University Tsinghua University University of Warsaw
Study in Interaction of Very High Energy Cosmic Rays by using Large Hadron Collider	Y. Itow	Italy France Switzerland U.S.A.	4	University of Florence, Catania University École Polytechnique CERN Lawrence Berkeley National Laboratory

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Study in Interaction of Very High Energy Cosmic Rays by using Relativistic Heavy Ion Collider	Y. Itow	Italy U.S.A.	2	University of Florence, Catania University Brookhaven National Laboratory
Study of Dark Matter and Solar Neutrinos using a Liquid Xenon Detector	Y. Itow	Korea	1	Seoul National University, Sejong University, Korea Research Institute of standards and Science
Research and Development for the Next Generation Water Cherenkov Detector, Hyper-Kamiokande	Y. Itow	U.S.A. Korea China U.K. Italy France Switzerland Spain Poland Brazil *Canada, Russia* *Portugal*	13	Boston University, Brookhaven National Laboratory, UCI, Duke University, George Mason University, Indiana University, University of Hawaii, Los Alamos National Laboratory, University of Maryland, State University of New York, University of Washington Chonnam National University, Seoul National University, Sungkyunkwan University Tsinghua University Imperial College London, Lancaster University, University of Oxford, Queen Mary University of London, University of Sheffield, Rutherford Appleton Laboratory INFN Sezione di Bari, INFN Sezione di Napoli, INFN Sezione di Padova, INFN Sezione di Roma CEA Saclay, École Polytechnique University of Bern, Swiss Federal Institute of Technology Zurich Autonomous University of Madrid University of Warsaw University of São Paulo *and other Institutions*
Study of Dark Matter and Solar Neutrinos using a 2-Phase Liquid Xenon TPC Detector	Y. Itow	Germany Italy Switzerland U.S.A. Sweden Israel Portugal *France, UAE, Netherlands*	10	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*
A Search for Dark Objects using the Gravitational Microlensing Effect	Y. Itow	New Zealand U.S.A.	2	University of Auckland, University of Canterbury, Victoria University of Wellington, Massey University University of Maryland, NASA
Research on Origin of Cosmic Rays with Fermi Satellite	H. Tajima	U.S.A. France Italy Sweden	4	Stanford University, SLAC National Accelerator Laboratory, GSFC/NASA, U.S. Naval Research Laboratory, UCSC, Sonoma State University, University of Washington, Purdue University, University of Denver CENS, CNRS, École Polytechnique INFN, Italian Space Agency, IFSI Royal Institute of Technology, Stockholm University

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Research on Origin of Cosmic Rays with CTA (Cherenkov Telescope Array)	H. Tajima	Germany France Italy Spain Switzerland U.K. U.S.A. *Brazil, Argentina, Poland, Armenia, Australia, Czech, Bulgaria, Croatia, Finland, Greece, Sweden, Slovenia, India, Ireland, South Africa*	22	Deutsches Elektronen-Synchrotron, Max-Planck-Institut, Heidelberg University CENS, École Polytechnique, University of Paris INFN, IFSI University of Barcelona, Complutense University 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*
Solar Flare Research with Hard X-Ray Spectral Imaging Observations	H. Tajima	U.S.A.	1	UCB, MSFC/NASA, Air Force Research Laboratory
Solar Flare Research with Gamma-Ray Spectral Imaging Observations with Polarimetry	H. Tajima	U.S.A.	1	UCB, Lawrence Berkeley National Laboratory, GSFC/NASA
Study of Solar Neutrons	Y. Matsubara	Bolivia Armenia China Mexico	4	Research Institute of Physics, University of San Andrés Yerevan Physics Institute Institute of High Energy Physics, Chinese Academy of Sciences National Autonomous University of Mexico
Search for Cosmic-Ray Excursions in the Past by Single-Year Measurements of ^{14}C in Tree Rings	F. Miyake	U.S.A. Switzerland	2	The University of Arizona Swiss Federal Institute of Technology Zürich
Observations of Interplanetary Disturbances using the International IPS Network	M. Tokumaru	U.K. Russia India Mexico Australia	5	LOFAR-UK Lebedev Physical Institute Tata Institute of Fundamental Research National Autonomous University of Mexico Murchison Widefield Array
Study of 3-D Solar Wind Structure and Dynamics Using Heliospheric Tomography	M. Tokumaru	U.S.A.	1	CASS/UCSD
Study on the Application of Interplanetary Scintillation Observations to Space Weather Forecast	M. Tokumaru	Korea	1	Korean Space Weather Center
Study of the Heliospheric Boundary Region using Observations of Interplanetary Scintillation	M. Tokumaru	U.S.A.	1	Interstellar Boundary Explorer, IMAP
Research and Development of the Plasma/Particle Instrument Suite for the Mercury Magnetospheric Exploration Mission	M. Hirahara	France Sweden U.K. U.S.A. Switzerland	5	CESR-CNRS, CETP-IPSL Institute for Solar Physics of the Royal Swedish Academy of Sciences Rutherford Appleton Laboratory Boston University University of Bern
Future Satellite Mission for the Terrestrial Magnetosphere-Ionosphere-Thermosphere Explorations by Formation Flight Observations and its Feasibility Study and Collaboration of the Satellite and Ground-Based Observations	M. Hirahara	Sweden	1	Swedish Institute of Space Physics, Swedish National Space Board

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Study on Science Subjects and Developmental Techniques of Observational Instruments toward Future Spacecraft Exploration Missions for the Space-Earth Coupling System	M. Hirahara	Sweden	1	Swedish Institute of Space Physics
PRESTO（Predictability of Variable Solar-Terrestrial Coupling）	K. 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	K. Shiokawa	U.S.A. Canada	2	University of California, Augsburg College, Virginia Polytechnic Institute and State University University of Calgary, Athabasca University
Magnetic Conjugate Observations of Midlatitude Thermospheric Disturbances	K. Shiokawa	Australia	1	IPS Radio and Space Service
Comparison of Dynamical Variations of the Mesosphere, Thermosphere, and Ionosphere between Asian and Brazilian Longitudes	K. Shiokawa	Brazil	1	INPE
Ground and Satellite Measurements of Geospace Environment in the Far-Eastern Russia	K. Shiokawa	Russia	1	Institute of Cosmophysical Research and Radiowave Propagation, Far Eastern Branch, RAS
Observations of the Equatorial Ionosphere in South-East Asia and West Africa	K. Shiokawa	Nigeria	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	K. 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	K. Shiokawa	Egypt Ethiopia	2	Egypt-Japan University of Science and Technology (E-JUST) Bahir Dar University
Study of the middle latitude ionosphere at Ukraine	K. Shiokawa	Ukraine	1	Institute of ionosphere (IION)
Collaborative Research and Operation in the Field of Space Weather Observations	Y. Otsuka	Indonesia	1	LAPAN
Observations and Researches of Ionosphere and Upper Atmosphere in Thailand	Y. Otsuka	Thailand	1	Chiang Mai University, King Mongkut's Institute of Technology Ladkrabang
Study on the Occurrence Characteristics of Ionospheric Irregularity and its Day-to-Day Variability over Southern China and Southeast Asia Regions	Y. Otsuka	China Indonesia Thailand	3	Institute of Geology and Geophysics Chinese Academy of Sciences LAPAN King Mongkut's Institute of Technology Ladkrabang
Study of the Polar Upper Atmosphere using the EISCAT Radars and Other Instruments	S. Nozawa	Norway Sweden, Finland, Germany, U.K., China	6	UiT The Arctic University of Norway EISCAT Scientific Association
Derivation of Substorm Index from Low-Latitude Geomagnetic Field Data	M. Nosé	Australia Turkey Germany Spain Denmark U.S.A.	6	Geoscience Australia Boğaziçi University Ludwig-Maximilians-Universität München Universitat Ramon Llull Technical University of Denmark United States Geological Survey
Experiment of geomagnetic field with sounding rocket LAMP	M. Nosé	U.S.A.	1	NASA
Study of high-frequency geomagnetic field variations with low-latitude induction magnetometer network	M. Nosé	Australia New Zealand	2	Geoscience Australia Dr. Peter Jaquiery

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Study of the Polar/Midlatitude Ionosphere and Magnetosphere using the SuparDARN HF Radar Network	N. Nishitani	U.S.A. U.K. France South Africa Australia Canada Italy Russia China	9	JHUAPL, Virginia Polytechnic Institute and State University University of Leicester LPC2E/CNRS University of KwaZulu-Natal La Trobe University University of Saskatchewan IFSI ISTP/SB RAS Polar Research Institute of China
SDI-3D Project: Development of SDI	S. Oyama	U.S.A. Finland Sweden	3	Geophysical Institute 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	S. 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	A. 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	A. Mizuno	U.S.A. Norway Sweden	3	University of Colorado Boulder, UCLA, University of Arizona UiT The Arctic University of Norway EISCAT Scientific Association
Source Apportionment of Organic Aerosols in Beijing	M. Mochida	China	1	Tianjin University
Characterizing Organics and Aerosol Loading over Australia (COALA)	M. Mochida S. Ohata	Australia U.S.A. U.K.	3	University of Wollongong, 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	M. Mochida S. Ohata	Finland	1	University of Helsinki
Global Precipitation Measurement Mission (GPM)	H. Masunaga N. Takahashi	U.S.A.	1	NASA
Tropical Cyclones-Pacific Asian Research Campaign for Improvement of Intensity Estimations/Forecasts (T-PARCII)	K. Tsuboki T. Shinoda N. Takahashi	Taiwan U.S.A.	2	National Taiwan University Atmospheric Sciences Colorado State University
Observational Study on Convective Self-Aggregation	H. Masunaga	U.K.	1	University of Reading
Satellite Algorithm Development for Tracking Precipitating Clouds	H. Masunaga	U.S.A.	1	NASA Jet Propulsion Laboratory
Development and Validation of a Satellite-Based Scheme to Estimate In-Cloud Vertical Velocity	H. Masunaga	U.S.A.	1	City University of New York

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Long-Term Observation of Black Carbon Aerosols in the Arctic	S. Ohata	Norway U.S.A. Canada Finland	4	Norwegian Polar Institute National Oceanic and Atmospheric Administration Government of Canada Finnish Meteorological Institute
Energetic Particle Chain -Effects on the middle/lower atmosphere from energetic particle precipitations-	T. Nakajima	Finland	1	University of Oule Finnish Meteorological Institute
High Aerosol High Ice Water Content project	M. Murakiami	U.S.A.	1	Federal Aviation Administration, NASA
Continuous Observation of Methane at a Paddy Field in Northern India	Y. Matsumi	India	1	University of Delhi
Observation of PM2.5 in Ulan Bator	Y. Matsumi	Mongolia	1	National University of Mongolia
Observation of PM2.5 in Hanoi	Y. Matsumi	Vietnam	1	Hanoi University of Science and Technology
Validation of GOCI Products and Application to Environmental Monitoring of Japanese Coastal Waters	J. 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	J. Ishizaka	U.S.A.	1	Columbia University
Collection of Validation Dataset of GCOM-C Coastal Products	J. Ishizaka	Korea U.S.A. Taiwan Thailand China Estonia	6	Korea Institute of Ocean Science and Technology Columbia University, East Carolina University National Cheng Kung University Burapha University First Institute of Oceanography, Nanjing, University of Science and Technology University of Tartu
Validation of Ocean Color Products in the Western North Pacific and Japanese Coastal Waters: Collaboration with JAXA GCOM-C Project	J. Ishizaka	Member States of EUMETSAT: Germany, U.K., France, Italy, Spain, Netherlands *and others countries*	30	European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)
Investigating the Optical Characteristics of Red Tides in the Upper Gulf of Thailand	J. Ishizaka	Thailand	1	University of Burapa, Kasetsart University
Integrated Land Ecosystem - Atmosphere Processes Study (iLEAPS), one of the Global Research Projects (GRPs) of the Future Earth	T. Hiyama	U.K., India, Finland, New Zealand, China, Koria *and others countries*	6	iLEAPS/Future Earth
Observational Study of Vegetation, Energy and Water in Eastern Siberia Towards Elucidation of Climate and Carbon Cycle Changes	T. Hiyama	Russia	1	Institute for Biological Problems of Cryolithozone/SB RAS
Arctic Challenge for Sustainability II (ArCS II) Project	T. Hiyama	U.S.A.	1	International Arctic Research Center of the University of Alaska Fairbanks
Estimating Permafrost Groundwater Age in Central Mongolia	T. Hiyama	Mongol	1	Institute of Geography and Geoecology of the Mongolian Academy of Sciences
Study of Methane Flux Observation in Eastern Siberia and the Obtained Data Analysis	T. Hiyama	Russia	1	Institute for Natural Science, North Eastern Federal University
An International Study on Precipitation Variability in High-Altitude Areas of the Himalayas in Nepal	H. Fujinami	Nepal	1	Kathmandu University, Nepal Academy of Science and Technology, International Centre for Integrated Mountain Development

Research Project	ISEE Representative	Collaborating Country/Region		Collaborating Organization
Asian Precipitation Experiment (AsiaPEX)	H. Fujinami	India Nepal China Korea Bangladesh	5	India Meteorological Department, Indian Institute of Tropical Meteorology, University of Rajasthan International Centre for Integrated Mountain Development, Nepal Academy of Science and Technology, Kathmandu University Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Tsinghua University Pusan National University *and other institutions*
International Continental Scientific Drilling Program - Dead Sea Deep Drilling Project (ICDP-DSDDP)	H. 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	H. Kitagawa	Vietnam	1	Vietnam Academy of Science and Technology
Climate Reconstruction using Travertine from Takht-e-Soleyman Area in Kurdistan, Iran	M. 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	M. 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	M. Minami	Poland	1	Silesian University of Technology
Measurements of Cosmic-Ray-Produced ^{14}C in Iron Meteorites	M. Minami	U.S.A.	1	UCB
Geochronological Research on the Basement Rocks in Japan and Korea	T. Kato	Korea	1	Korea Institute of Geoscience and Mineral Resources
Development of New Analytical Techniques and Accurate Quantification of Electron Microprobe Analysis	T. Kato	Korea	1	Pusan National University
International Ocean Discovery Program (IODP) Expedition 379: Amundsen Sea West Antarctic Ice Sheet History	M. 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, 2021–March 31, 2022)

Country/Region			
Asia	India	1	4
	Korea	1	
	China	2	
Europe (Including New Independent States)	Russia	1	1
Middle East	Iran	1	1
Africa	Ethiopia	1	2
	Nigeria	1	
Total	7	8	

Funding Source	
Japan Society for the Promotion of Science	2
Nagoya University	4
Self-funding	1
Government	1
Total	8

Purpose	
Joint Research	8
Total	8

Overseas Business Trips of Faculty

(April 1, 2021–March 31, 2022)

Country/Region			
North America	U.S.A.	3	3
Europe (Including New Independent States)	U.K.	1	3
	Switzerland	1	
	Norway	1	
Toal	4	6	

Online Seminars by Foreign Scientists

(16 in total)

Date	Name	Affiliation	Title	Number of Participant
Apr. 29, 2021	Alphonse C. Sterling	NASA Marshall Space Flight Center, U.S.A.	4th SCOSTEP Online Capacity Building Lecture/ An overview of the Sun's structure, and a closer look at solar magnetism and activity	52
May 21, 2021	Franz-Josef Lübken	Leibniz-Institute of Atmospheric Physics, Germany	7th SCOSTEP/PRESTO Online Seminar/ Physics at the edge between Earth's atmosphere and space	114
May 31, 2021	Esa Turunen	Sodankylä Geophysical Observatory, Finland	5th SCOSTEP Online Capacity Building Lecture/ The variable geospace environment and our radio wave based modern society: basic concepts of ionosphere and recent research problems at high latitudes	108
Jun. 8, 2021	Kristof Petrovay	ELTE Eotvos Lorand University, Hungary	8th SCOSTEP/PRESTO Online Seminar/ The Sun making history. The mechanism behind the varying amplitude of the solar cycle	159
Aug. 19, 2021	Craig Rodger	University of Otago, New Zealand	7th SCOSTEP Online Capacity Building Lecture/ Energetic electron precipitation from the radiation belts: How plasma waves in space kill atmospheric ozone	49
Sep. 14, 2021	Dibyendu Nandi	Indian Institute of Science Education and Research, India	8th SCOSTEP Online Capacity Building Lecture/ Solar magnetic fields: Their origin and predictability	90
Sep. 23, 2021	Richard Eastes	University of Colorado Boulder, U.S.A.	9th SCOSTEP/PRESTO Online Seminar/ Space weather in the thermosphere-ionosphere system - observation and Insights from the GOLD (Global-scale Observations of the Limb and Disk) * mission	121
Oct. 21, 2021	Sarah Gibson	High Altitude Observatory at NCAR, U.S.A.	9th SCOSTEP Online Capacity Building Lecture/ Whole Heliosphere and Planetary Interactions (WHPI): Connecting Sun to solar wind to planets during "quiet" times of the solar cycle	40
Nov. 16, 2021	Samuel Schonfeld	Boston College, U.S.A.	10th SCOSTEP Online Capacity Building Lecture/ F10.7 and solar spectral irradiance: drivers of ionosphere models	35
Nov. 30, 2021	Tibor Török	Predictive Science Inc., U.S.A.	10th SCOSTEP/PRESTO Online Seminar/ Understanding and modeling solar eruptions: Where do we stand?	83
Dec. 2, 2021	Aleksandr Rubstov	Institute of Solar-Terrestrial Physics SB RAS, Russia	Division for Ionospheric and Magnetospheric Research Seminar/ Characteristics of Pc4-5 waves in the magnetosphere by satellites measurements	25
Dec. 16, 2021	Adhitya Pavithran	Indian Institute of Geomagnetism, India	Division for Ionospheric and Magnetospheric Research Seminar/ The study of ionospheric Alfven resonator (IAR) at low latitude	25
Jan. 27, 2022	Michael Kosch	South African National Space Agency, South Africa	11th SCOSTEP Online Capacity Building Lecture/ The energetics of sprites: New results from South Africa	53
Feb. 10, 2022	Cora Randall	University of Colorado, U.S.A.	11th SCOSTEP/PRESTO Online Seminar/ Solar-terrestrial coupling via energetic particle precipitation	155
Feb. 17, 2022	KD Leka*	NorthWest Research Associates, U.S.A.	ISEE Solar Seminar/ The Sun is Not Divergence Free! (Not Yet)	17
Mar. 31, 2022	Martin Connors	Athabasca University, Canada	12th SCOSTEP Online Capacity Building Lecture/ Space weather geoelectromagnetic effects	39

* Foreign Visiting Staff

＜Abbreviations＞

AS CR:	Academy of Sciences of the Czech Republic
CASS:	Center for Astrophysics and Space Sciences
CCMC:	Community Coordinated Modeling Center
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
GSFC:	Goddard Space Flight Center
HPDE:	Heliophysics Data Environment
IBEX:	Interstellar Boundary Explorer
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
RAS	Russian Academy of Sciences
IPS:	Ionospheric Prediction Services
IPSL:	Institut Pierre-Simon Laplace
JHUAPL:	Johns Hopkins University Applied Physics Laboratory
KASI:	Korea Astronomy and Space Science Institute
LAPAN:	Lembaga Penerbangan dan Antariksa Nasional, National Institute of Aeronautics and Space
LOFAR:	Low Frequency Array
LPC2E:	Laboratoire de Physique et Chimie de l'Environnement et de l'Espace
MSFC:	Marshall Space Flight Center
MWA:	Murchison Widefield Array
NASA:	National Aeronautics and Space Administration
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
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 a variety of outreach events and activities. In continuation from FY2020, some events were canceled in FY2021 because of the COVID-19 pandemic, but many events and activities were still conducted online or in a hybrid format. Some were also conducted in-person. Specifically, seven visiting lectures, 12 online or hybrid lectures, two high-school student visits, two online open laboratory events, two online training courses for young researchers, and one virtual tour for university students, one online workshop for children were organized.

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/).

Latest issues of the Japanese booklet series "50 questions".

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