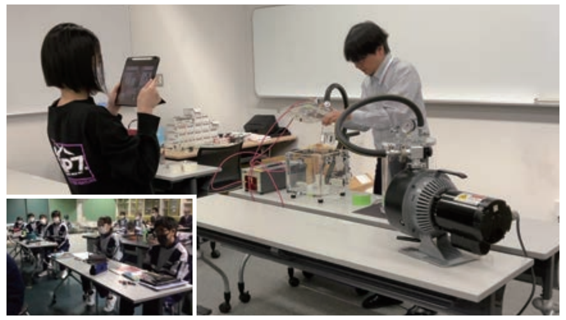
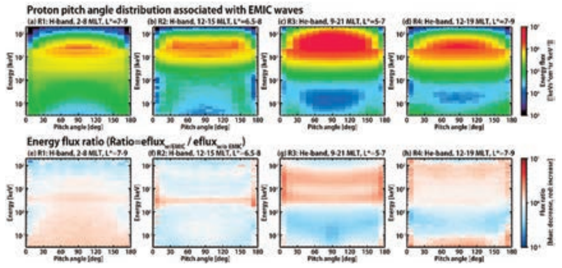
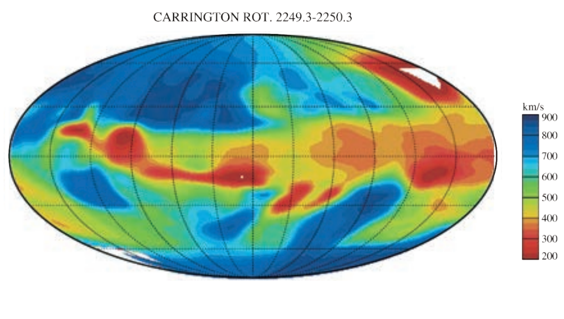


Photo of an online experimental demonstration using vacuum vessels and pumps in a live lesson for Rikubetsu junior high school in Hokkaido (November 5, 2021)



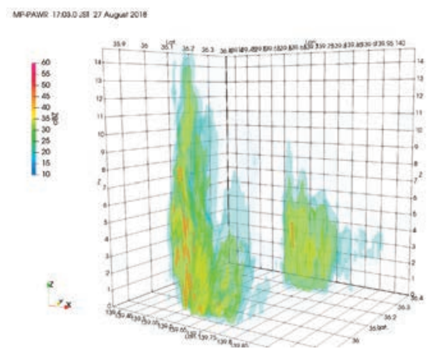
Top: Proton pitch-angle distribution associated with EMIC waves as a function of energy and pitch angle. Bottom: Energy flux ratio with and without EMIC waves at each peak occurrence region (see pp.32-33)

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

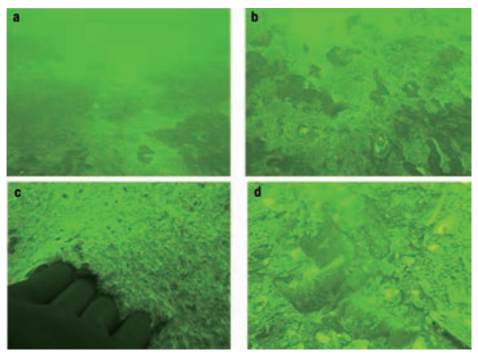


Global distribution of the solar wind on autumn 2021 derived from the IPS observation of ISEE

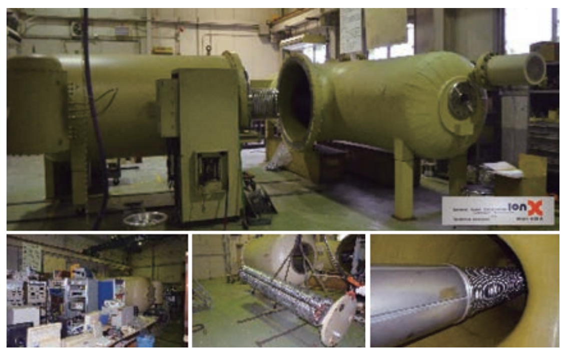
Installation of a magnetometer at Sata, Japan (October 2021)



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)

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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

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Institute for
Space–Earth Environmental Research
Nagoya University

Annual Report

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

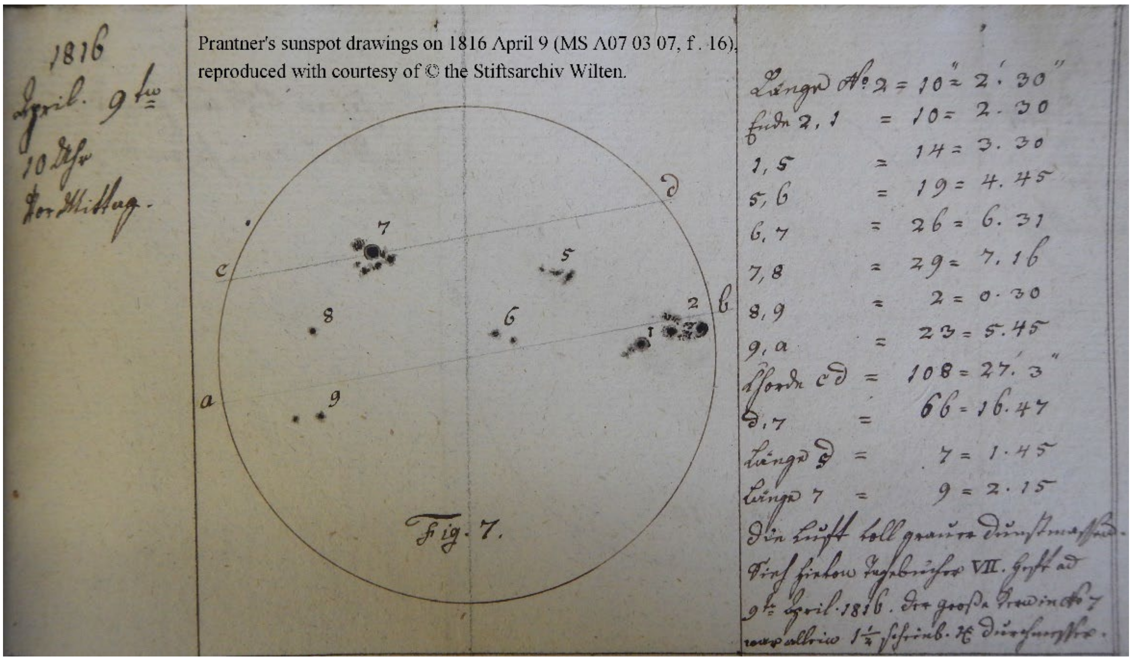

Fig.1

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'.

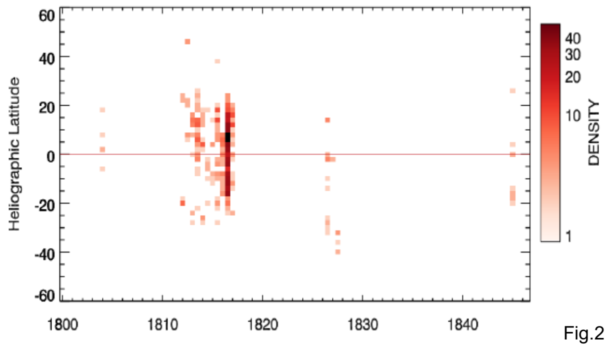

Fig.2

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

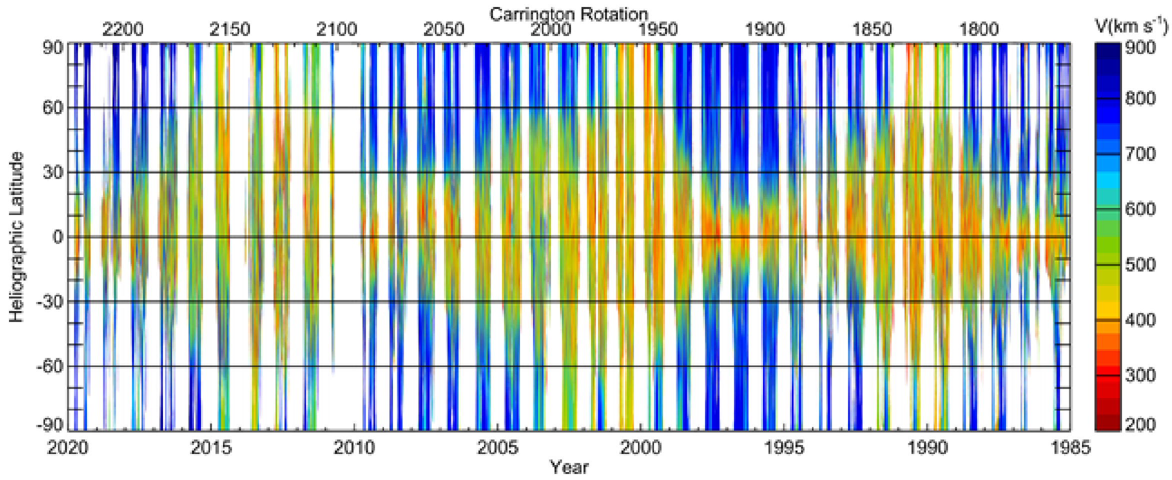

Fig.1

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.

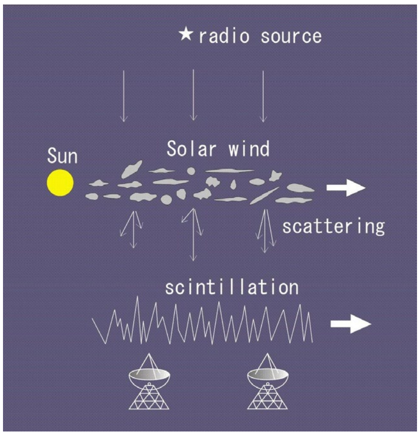

Fig. 2

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.

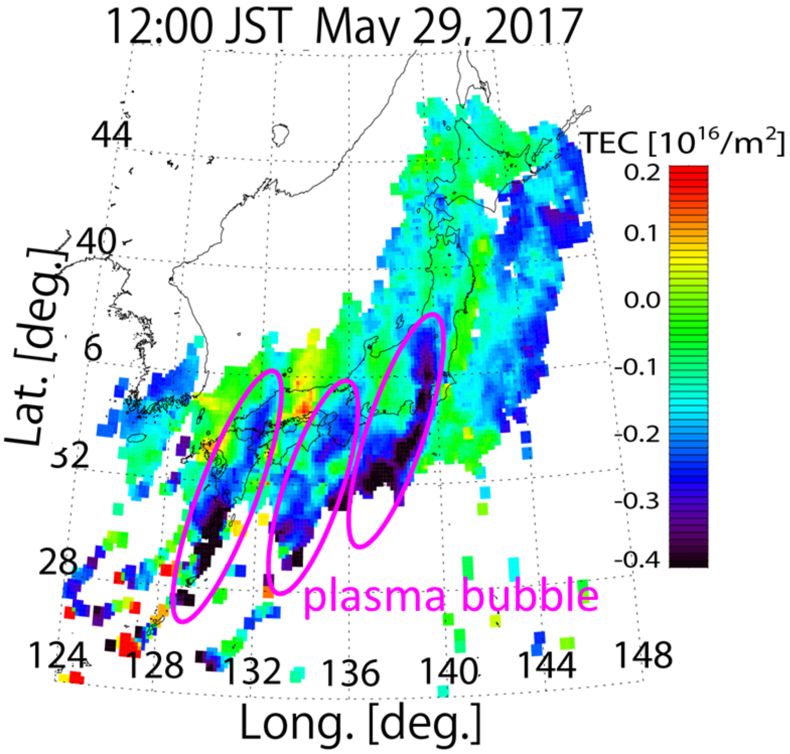

Fig.1

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.

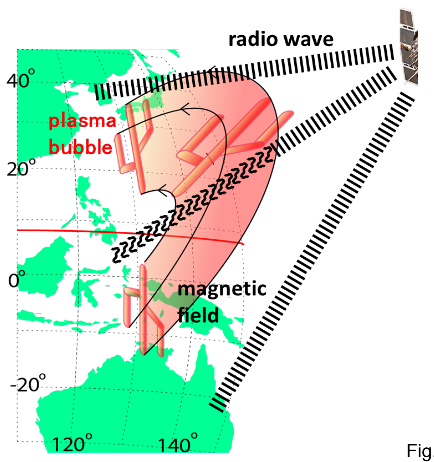

Fig.2

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)

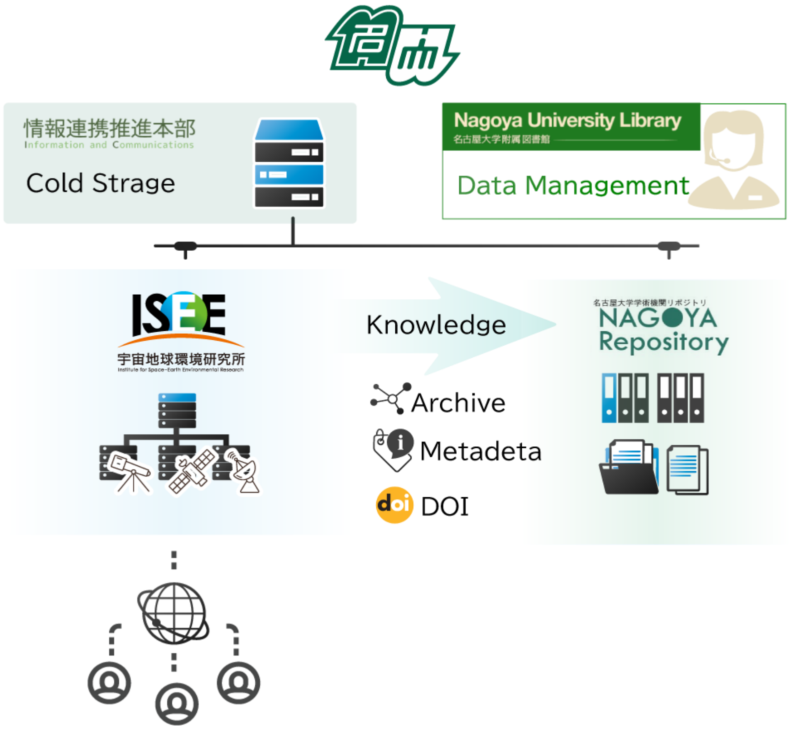

Fig.1

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