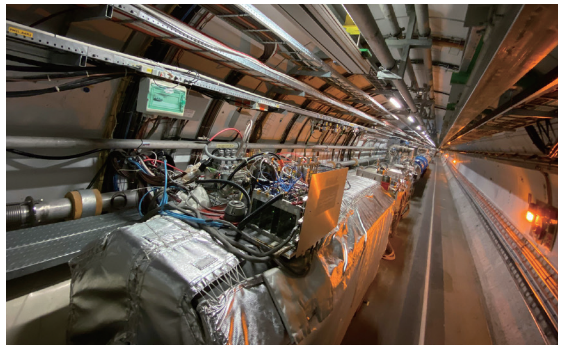
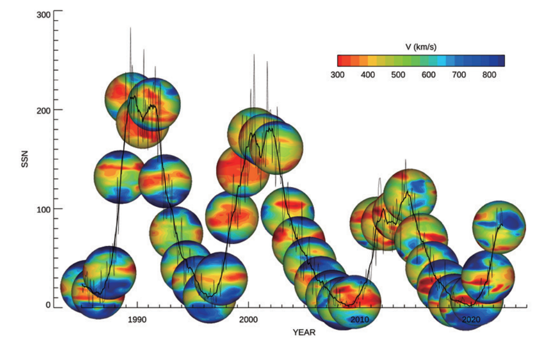
ISEE Award ceremony and commemorative lecture were held on Nov. 16, 2022

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



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

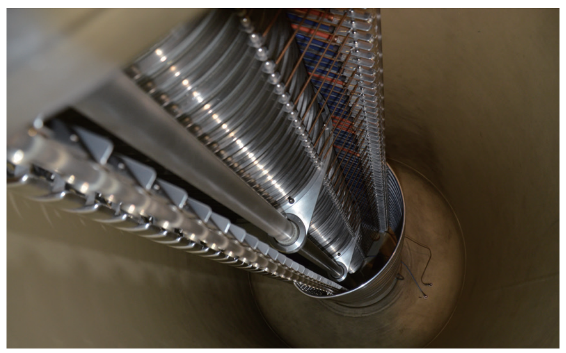


Solar wind structure from 1985 to 2022

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

Collaborative radar observation at Yonaguni Island in the summer season

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



Accelerator tube mentanance of ISEE AMS

Institute for Space–Earth Environmental Research, Nagoya University

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

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

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

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

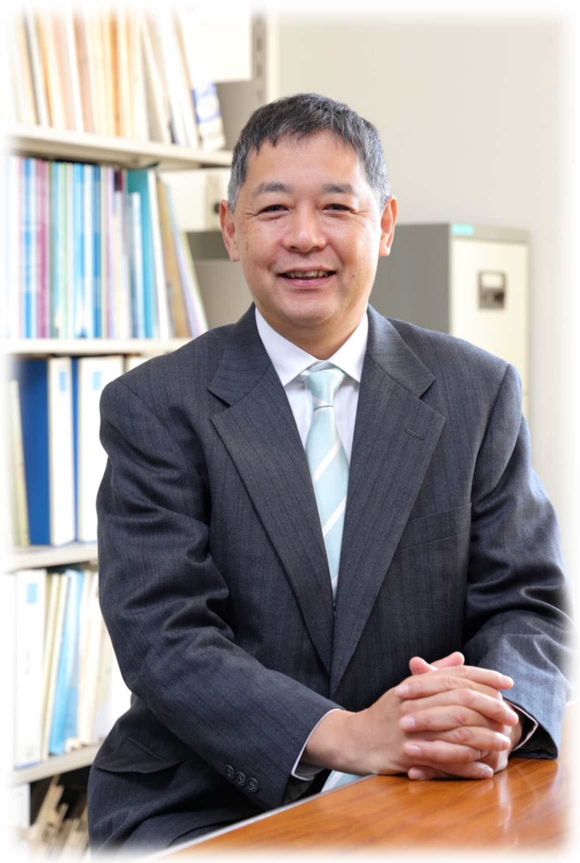
FY2022

Institute for Space–Earth Environmental Research Nagoya University

Annual Report

April 2022–March 2023

Foreword



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

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

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

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

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

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

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

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

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Kazuo Shiokawa
Director

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

The 4th ISEE Award

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

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

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

ISEE Award 2022

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

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

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

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

Fig.1

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

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

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

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

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

Fig. 2

Fig. 3

Fig. 4

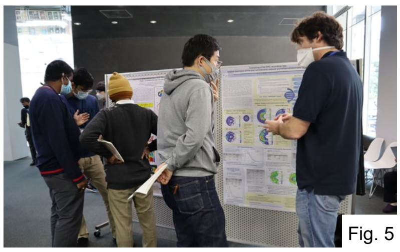

Fig. 5

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

Fig.1

Sounding Rocket Hits the Pulsating Aurora!

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

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

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

Fig.2

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

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

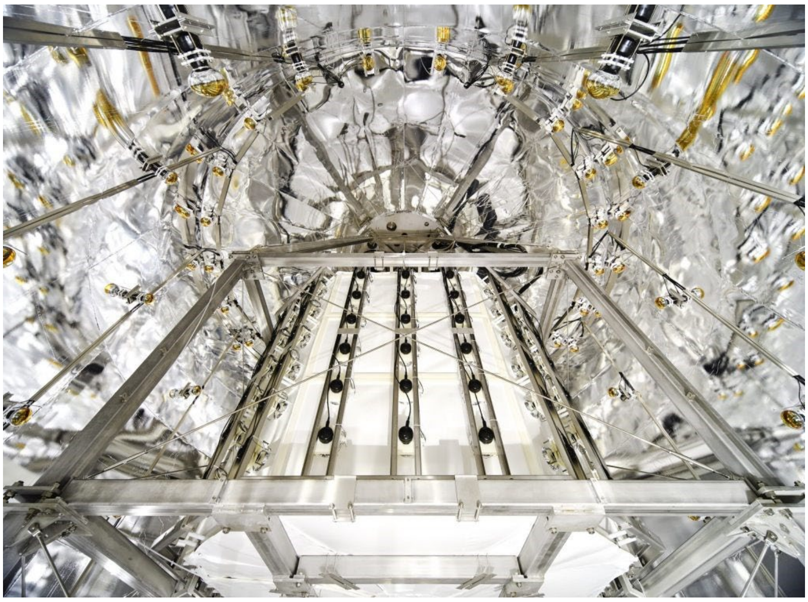

Fig.1

Search for New Physics in Electronic Recoil Data from XENONnT

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

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

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

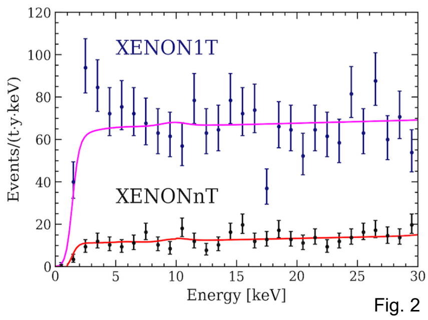

Fig. 2

Paper information

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

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

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

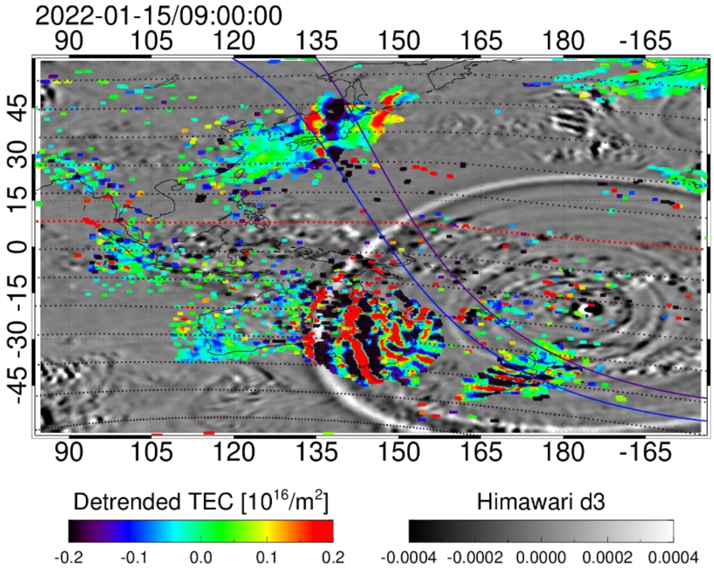

Fig.1

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

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

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

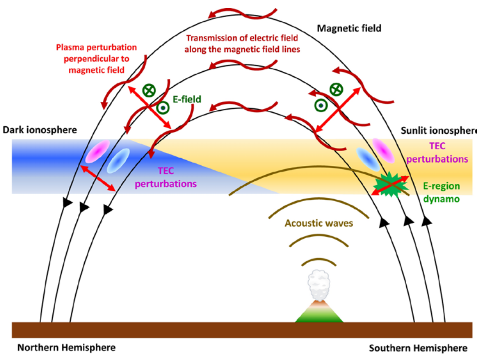

Fig.2

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

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

Paper information

Journal： *Earth Planets Space*, 74, 106, 2022
Authors： Shinbori, A., Y. Otsuka, T. Sori, M. Nishioka, S. Perwitasari, T. Tsuda, and N. Nishitani
Title：Electromagnetic conjugacy of ionospheric disturbances after the 2022 Hunga Tonga-Hunga Ha'apai volcanic eruption as seen in GNSS-TEC and SuperDARN Hokkaido pair of radars observations
DOI： 10.1186/s40623-022-01665-8

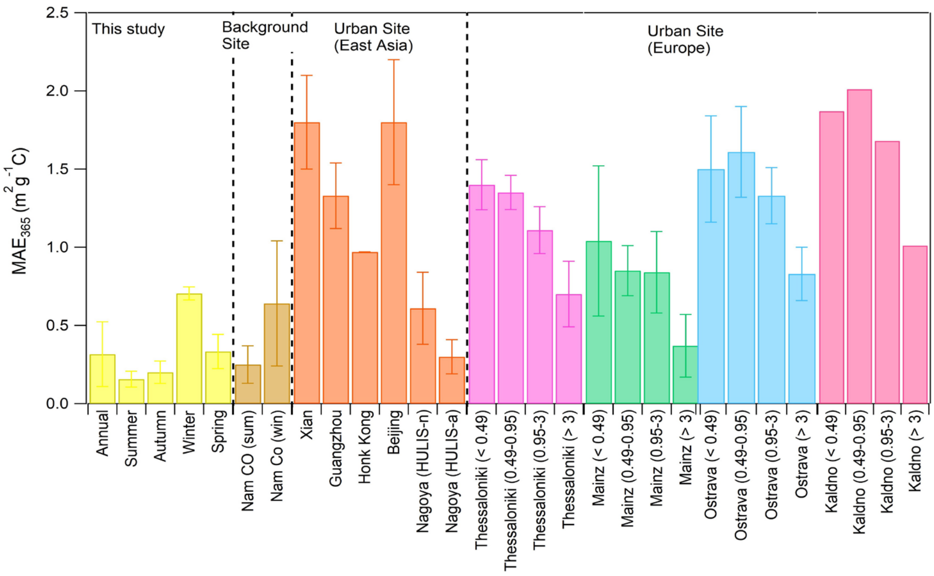

Fig.1

Weak Light Absorption Property of Biogenic Organic Aerosol Components

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

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

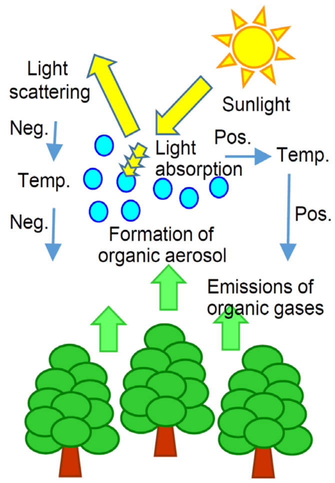

Fig. 2

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

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

Paper information

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

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

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

DOI： 10.1038/s41598-022-18201-z

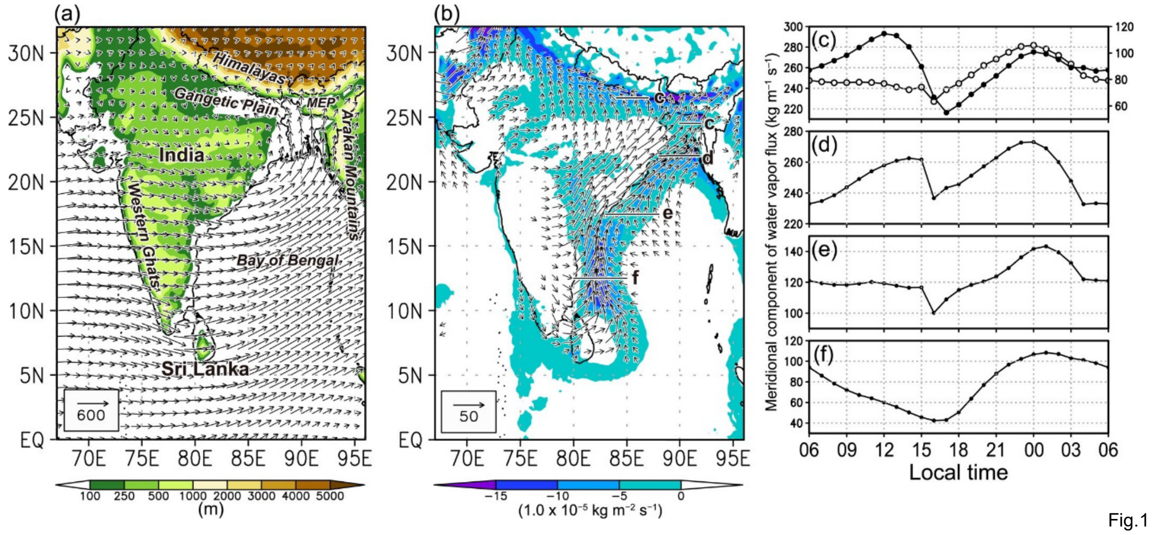

Fig.1

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

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

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

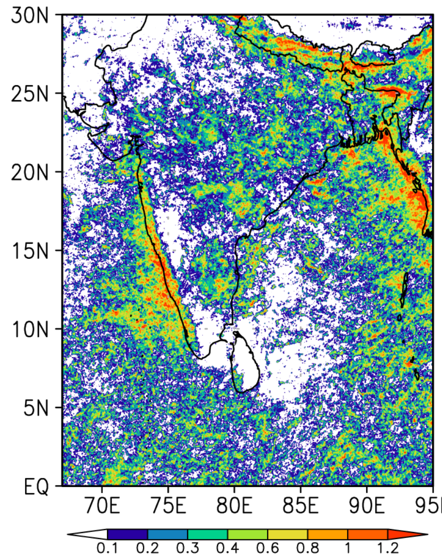

Fig.2

Paper information

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

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

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

Contents