Program and Abstracts for

the 5th ISEE Symposium

Toward the Future of Space–Earth Environmental Research

Date: November 15 to 17 (Tuesday to Thursday), 2022

Venue: Sakata–Hirata Hall, Nagoya University (Higashiyama campus, Nagoya city, Japan)

This symposium is a hybrid conference with both in-person and online attendance options.

Host: Institute for Space–Earth Environmental Research (ISEE), Nagoya University

Web page: http://www.isee.nagoya-u.ac.jp/symposium05

Important Dates

20 July, 2022: Open the registration and abstract submission site

29 September, 2022: Deadline for abstract submission and early-bird registration

15 October, 2022: Deadline for registration

Free Registration

Registration and submission of abstracts for this symposium are both free.

ISEE Award Ceremony (11:40–12:50 JST on Wednesday, November 16th)

Aiming to develop space–Earth environmental research, promote interdisciplinary research, and explore the new discipline of space–Earth environmental research, we present the ISEE Award each year to a prominent research activity based on the ISEE Joint Research Program. The 2022 ISEE Award Ceremony will be held during this symposium.

Contact: kyodo-isee@isee.nagoya-u.ac.jp

Scientific Organizing Committee (SOC):

K. Kusano (Chair of SOC, the director of ISEE)

Y. Kasahara (Kanazawa University)

Y. Kokubu (Japan Atomic Energy Agency)

M. Koike (The University of Tokyo)

Y. Miyoshi, T. Hiyama, K. Shiokawa, N. Takahashi, K. Iwai, F. Miyake (ISEE)

Local Organizing Committee (LOC):

H. Aiki (Chair of LOC, ISEE)

S. Masuda, Y. Otsuka, M. Nose, T. Nagahama, T. Kato, T. Shinoda, M. Minami (ISEE)

Preface for the 5th ISEE Symposium

We are pleased to hold the 5th ISEE symposium – *Toward the Future of Space–Earth Environmental Research* –. The ISEE Symposium, which is a large international workshop held once a year as a flagship symposium of collaborative research with ISEE, intends to promote the space-Earth environmental research. The scope of this symposium covers all research subjects on the space–Earth environment including deepening of a specific research subject, interdisciplinary research across different fields, prospects and plans for a new research subject.

In 2022, this symposium aims to share space–Earth environmental research's present status and prospects through interdisciplinary discussion from various aspects. The symposium is especially focused on (1) discussions on plans for each field related to ISEE, and the possibility of new interdisciplinary research over the next 10 years, and (2) concept to make ISEE an International Joint Usage/Research Center and WPI. The symposium also covers topics on space–Earth sciences and new approaches to multidisciplinary collaboration, including the discussion also for the capacity building of young scientists.

Feature of the 5th ISEE Symposium

The symposium consists of six topical sessions and panel discussions on the future challenge of space–Earth environmental research. Each topical session is about 2 hours, consisting of the invited keynote (30 min), solicited (20 min), and contributed poster presentations. Each session contains a discussion on the plan of ISEE as well as the capacity building of young scientists (10–20 min).

JST	Tuesday, Nov 15	Wednesday, Nov 16	Thursday, Nov 17	GMT	MST
9				0	17
	Opening	Session 3 Next-generation computational science in space–Earth environmental research: Advanced simulation, integrated modeling, machine learning, and data science	Session 5 International collaborations for space–Earth environmental research from present to future		
10	Session 1 Climate variations in space–Earth environment: paleoclimate, global warming, and space climate			1	18
11				2	19
		Break	Lunch		
12	Lunch	ISEE Award ceremony		3	20
			Poster time 2 associated with Sessions 4–6		
13	Poster time 1 associated with Sessions 1–3	Lunch		4	21
	Session 2	Session 4	Session 6		
14	Prediction and mitigation of disaster in space–Earth environment: typhoon, torrential rain, space weather disaster prevention, and forecasting technology	Next-generation observation of space–Earth environmental research: future planning of satellite missions, aircraft, ground observation, and measurement technology	Interdisciplinary fusion in space–Earth environmental research: possibilities and challenges of fusion of Earth science, space science, anthropology, and history	5	22
15				6	23
		Break	Break		
16	Break	Panel Discussion Theme II Next-generation observation and computation for space–Earth environmental research	Panel Discussion Theme III International and interdisciplinary collaboration for space–Earth environmental research	7	0
	Panel Discussion Theme I Climate variability and disaster mitigation in the space–Earth environment				
17			Closing	8	1

The symposium expects to attract about 70 in-person attendees and another 140 online. The symposium features 1 award commemorative lecture, 8 keynote talks, 18 solicited talks, 14 panel-discussion talks, and 91 online posters.

Instruction for Poster Presenters

Necessary PDF file

Upload your poster PDF file to LOC using the attendees' page of the symposium.

Posters should be uploaded between Oct 21 and Nov 9.

The content of the poster should be enough to explain within 8 minutes.

The dimension of the PDF file is A0 (W=84cm, H=119cm, portrait) on a single page.

The file size should be less than 30 MB.

The file name should be in the format of [Presentation number]-[Last name]-version.pdf.

Each author sets the session of the poster by reporting it to the Where is Who List.

Optional Printed poster for in-person

On-site poster time 1 is on Tuesday, Nov 15 from 12:40 to 13:50.

On-site poster time 2 is on Thursday, Nov 17 from 12:30 to 13:50.

The number of poster boards at Nagoya Univ. is limited to 30 for each day, with priorities being given to younger presenters.

The author may choose Tuesday for Sessions 1–3 and Thursday for Sessions 4–6 and report it to the Where is Who List if one wishes to present in-person.

The size of the printed poster should be A0 (W=84cm, H=119cm, portrait).

Printed posters for Tuesday may be put up from 9:00 a.m. They must be removed by 12:00 a.m. the following day.

Printed posters for Thursday may be put up from 1:00 p.m. on the day before.

Optional Presentation video file for on-demand viewing

Make an 8-min presentation video for the poster.

This presentation may be done using PPT slides, as far as the content of them is the same as that of the poster.

Upload it to a file-sharing site of each author's preference, such as YouTube / Google Drive allowing access to all who know the address of the video.

Provide a link to your presentation video file in the Where is Who List for on-demand viewing.

These should be done between Oct 21 and Nov 14.

Instruction for All Oral Presenters

Zoom Conference Topic: 5th ISEE Symposium Meeting ID: XXX XXXX XXXX Participant Name: Presentation No. Last Name Passcode: YYYYYY Please keep your Zoom camera on from the previous presenter's time.

	1st ring	2nd ring end of presentation	3rd ring end of discussion
Keynote (30 min)	15 min	23 min	28 min
Solicited (20 min)	10 min	15 min	19 min
Short presentation (5 min)	4 min	5 min	6 min
Introduction (10 min)	9 min	10 min	11 min

Instruction for In-person Oral Presenters

Please connect your computer to the network in the following priority order

(1) Eduroam, (2) University guest WiFi, (3) Pocket WiFi, and (4) LOC router

If you happen to use the Pocket WiFi, please deactivate it after the presentation as there is a limit to the number of simultaneous connections. Please turn off (mute) the Zoom microphone until the end of the presentation. Please turn off all speakers on your computer. When at the presentation table, please keep the microphone tip of the stand as close to your mouth as possible.

Instruction for Chairs

Please make the following announcements before the start of the first presentation or during breaks.

When giving a question, whether local or online, say your name and then state what you are asking. Repeat. When giving a question, whether local or online, please say your name first and then state your question.

Instruction for All In-person Attendees

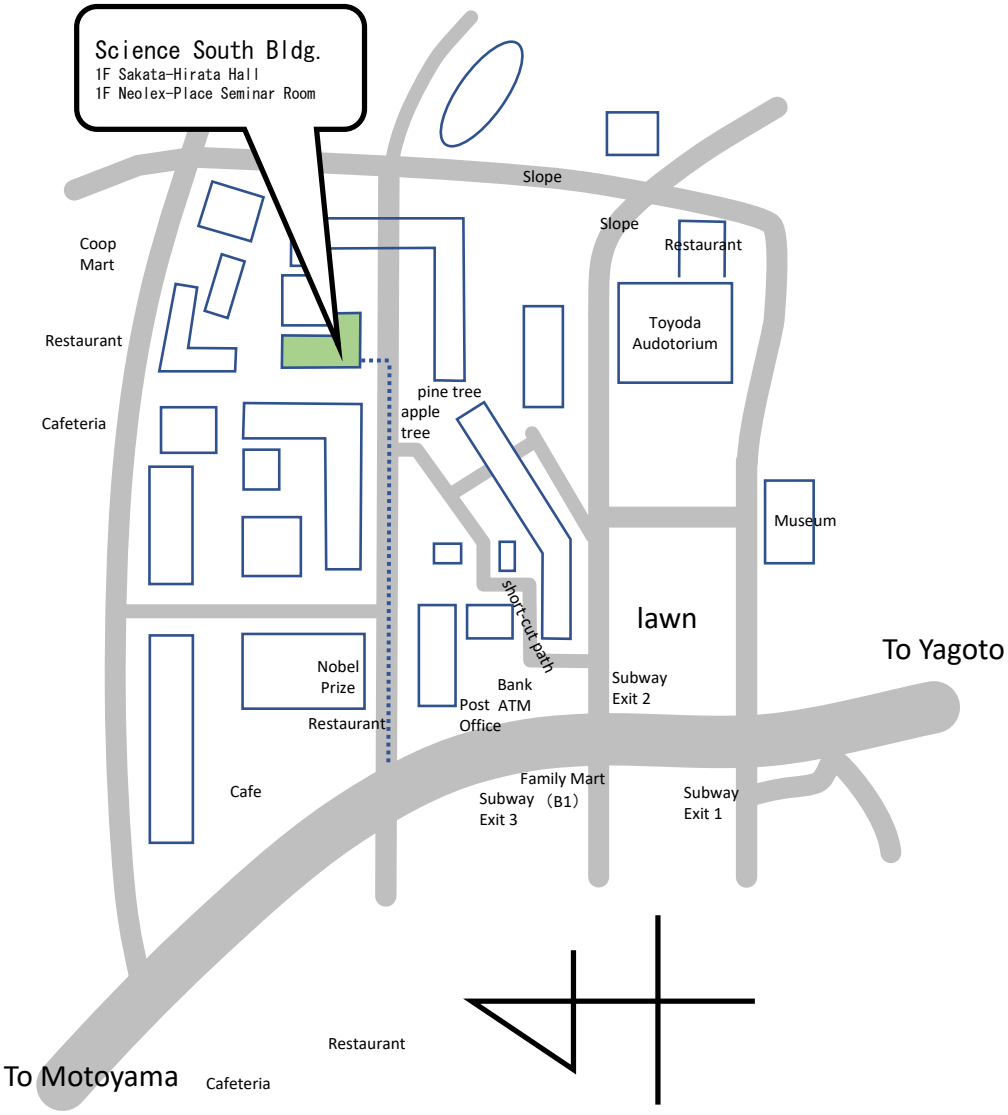
Directions to Nagoya University

From Nagoya Station: Take the Subway Higashiyama Line to Motoyama Sta. (15 minutes), then transfer to the Subway Meijo Line to Nagoya Daigaku Sta. (Higashiyama Campus is just off the subway exit.).

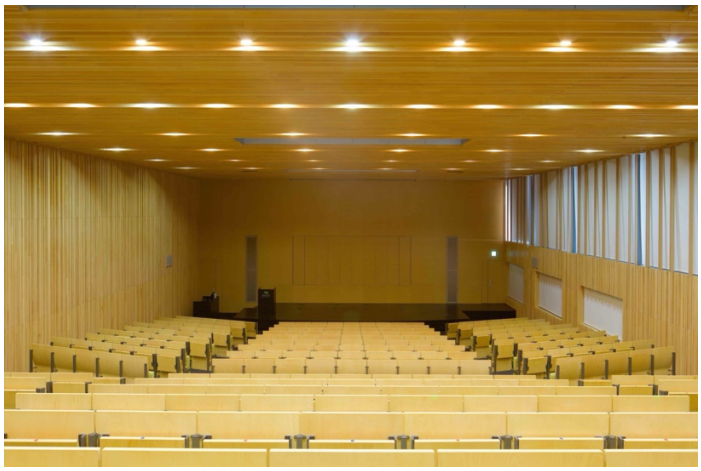
From Centrair (Central Japan International Airport): Take the Meitetsu Line to Kanayama Sta. (30 min.), then transfer to the Subway Meijyo Line to Nagoya Daigaku Sta. (21 min.).

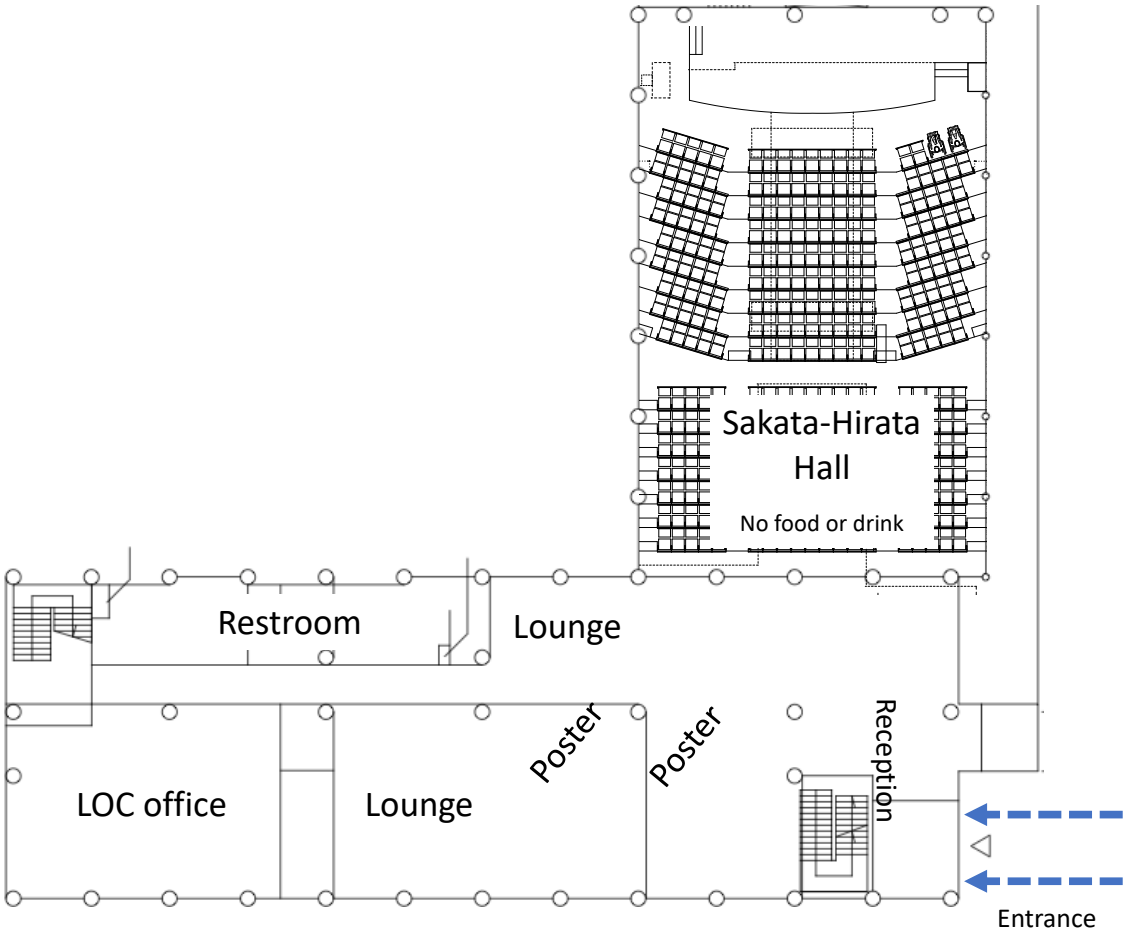
Sakata-Hirata Hall, Nagoya University (Higashiyama campus, Nagoya city)

Campus map is here. Sakata-Hirata Hall is in building **D2-7**.



Map for the hill side of the Higashiyama-Campus, Nagoya Univ.





Science South Building in the Higashiyama-Campus, Nagoya Univ.

Tuesday, November 15th: AM

Opening (9:30–9:40 JST)

Kanya Kusano (ISEE)

Session 1: Climate variations in space–Earth environment: paleoclimate, global warming, and space climate

9:40–11:40, Chairs: Tetsuya Hiyama and Tomoo Nagahama

Introduction

9:40–9:50 Tetsuya Hiyama (ISEE) 15AM-01L

Keynote presentation

9:50–10:20 Go Iwahana (Univ. of Alaska Fairbanks) 15AM-02K

Permafrost changes and its potential usage for paleo-environmental reconstruction

Solicited presentation

10:20–10:40 Hiroko Miyahara (Musashino Art Univ.) 15AM-03S

Influence of solar and cosmic-ray variations on climate and weather: current status and future prospects

10:40–11:00 Toru Tamura (The National Institute of Advanced Industrial Science and Technology) 15AM-04S

Geoscience of coastal lowlands in a changing world

11:00–11:20 Hisashi Hayakawa (ISEE) 15AM-05S

Archival reanalyses for the Carrington event: case studies

11:20–11:40 Discussion

Lunch (11:40–12:40)

Tuesday, November 15th: PM

Poster time 1 (12:40–13:50)

P01–P91 associated with Sessions 1–3

Session 2: Prediction and mitigation of disaster in space–Earth environment: typhoon, torrential rain, space weather disaster prevention, and forecasting technology

13:50–16:00, Chairs: Yoshizumi Miyoshi, Yoshiya Kasahara, and Taro Shinoda

Introduction

13:50–14:00 Yoshizumi Miyoshi (ISEE) 15PM-01L

Keynote presentation

14:00–14:30 Mamoru Ishii (National Institute of Information and Communications Technology) 15PM-02K

Space Weather as a critical natural disaster

Solicited presentation

14:30–14:50 KD Leka (NorthWest Research Associates / ISEE) 15PM-03S

Forecasting impactful Space Weather: Today's successes and tomorrow's challenges

14:50–15:10 Bruce Tsurutani (JPL) 15PM-04S

Magnetic storm predictability, are we close to being able to do this?

15:10–15:30 Takemasa Miyoshi (Riken) 15PM-05S

Big data assimilation: Real-time 30-s-update torrential rain forecast using Fugaku in Tokyo in 2021

15:30–15:50 Chun-Chieh Wu (National Taiwan Univ.) 15PM-06S

Targeted observations in DOTSTAR and beyond

15:50–16:00 Discussion

Break (16:00–16:15)

Tuesday, November 15th: PD

Panel Discussion Theme I: Climate variability and disaster mitigation in the space–Earth environment

16:15–17:25, Chairs: Tetsuya Hiyama and Yoshizumi Miyoshi

Introduction

16:15–16:25 Tetsuya Hiyama and Yoshizumi Miyoshi (ISEE) 15PD-01L

Solicited presentation

16:25–16:45 José Vaquero (Univ. of Extremadura) 15PD-02S
Past, present, and future of Sun-Climate relationships: a personal viewpoint

Short presentation

16:45–16:50 Go Iwahana (Univ. of Alaska Fairbanks) 15PD-03D

16:50–16:55 Mamoru Ishii (National Institute of Information and Communications Technology) 15PD-04D

16:55–17:00 Hiroko Miyahara (Musashino Art Univ.) 15PD-05D

17:00–17:05 Kazuhisa Tsuboki (ISEE) 15PD-06D

17:05–17:25 Discussion

Wednesday, November 16th: AM

Session 3: Next-generation computational science in space–Earth environmental research: Advanced simulation, integrated modeling, machine learning, and data science

9:30–11:30, Chairs: Kanya Kusano and Hidenori Aiki

Introduction
9:30–9:40 Takayuki Umeda (ISEE) 16AM-01L

Keynote presentation
9:40–10:10 Hideyuki Hotta (Chiba Univ.) 16AM-02K
Current and next-generation simulations in solar physics
10:10–10:40 Takeshi Enomoto (Kyoto Univ.) 16AM-03K
Digital twins of Earth-like planets

Solicited presentation:
10:40–11:00 Hidekatsu Jin (National Institute of Information and Communications Technology) 16AM-04S
Future challenges of whole atmosphere-ionosphere modeling
11:00–11:20 Prabir K. Patra (Japan Agency for Marine-Earth Science and Technology) 16AM-05S
Global carbon budget analysis using inverse modelling of regional sources and sinks

11:20–11:30 Discussion (10 min)

Break (11:30–11:40)

ISEE Award ceremony (11:40–12:50)
Satoshi Kasahara (The University of Tokyo) 16AC-01A
One solar cycle with the ERG (ARASE) mission

Lunch (12:50–13:50)

Wednesday, November 16th: PM

Session 4: Next-generation observation of space–Earth environmental research: future planning of satellite missions, aircraft, ground observation, and measurement technology

13:50–15:50, Chairs: Nobuhiro Takahashi, Makoto Koike, Yuichi Otsuka, and Masahiro Nose

Introduction

13:50–14:00 Nobuhiro Takahashi (ISEE) 16PM-01L

Keynote presentation

14:00–14:30 James Crawford (NASA) 16PM-02K
Advancing towards an Integrated Observing System for Atmospheric Chemistry

Solicited presentation

14:30–14:50 Yoshifumi Saito (JAXA) 16PM-03S
Future heliospheric system science exploration and the enabling technical development status in Japan

14:50–15:10 Craig Heinselman (European Incoherent Scatter Scientific Association) 16PM-04S
EISCAT_3D: new research infrastructure for Geospace studies

15:10–15:30 Tomoo Ushio (Osaka Univ.) 16PM-05S
Next-generation technologies for the observation of thunderstorm and lightning

15:30–15:50 Discussion

Break (15:50–16:05)

Wednesday, November 16th: PD

Panel Discussion Theme II: Next-generation observation and computation for space–Earth environmental research

16:05–17:05, Chairs: Kanya Kusano and Nobuhiro Takahashi

Introduction

16:05–16:15 Kanya Kusano and Nobuhiro Takahashi (ISEE) 16PD-01L

Short presentation

16:15–16:20 James Crawford (NASA) 16PD-02D

16:20–16:25 Hideyuki Hotta (Chiba Univ.) 16PD-03D

16:25–16:30 Takeshi Enomoto (Kyoto Univ.) 16PD-04D

16:30–16:35 Kazumasa Iwai (ISEE) 16PD-05D

16:35–17:05 Discussion

Thursday, November 17th: AM

Session 5: International collaborations for space–Earth environmental research from present to future

9:30–11:30, Chairs: Kazuo Shiokawa, Masayo Minami, and Kazumasa Iwai

Introduction (10 min)
9:30–9:40 Kazuo Shiokawa (ISEE) 17AM-01L

Keynote presentation
9:40–10:10 Nat Gopalswamy (NASA) 17AM-02K
International collaborations for space–Earth environmental research

Solicited presentation
10:10–10:30 Seung-Gu Lee (Korea Institute of Geoscience and Mineral Resources) 17AM-03S
What impact did the international research exchange for rare earth element geochemistry have on me?
10:30–10:50 Masayuki Kondo (ISEE) 17AM-04S
Decadal carbon budget assessment of Southeast Asia
10:50–11:10 Rumi Nakamura (Univ. of Graz) 17AM-05S
Towards an International Geospace Systems Program (IGSP) and opportunities for new multi-point spacecraft collaborations

11:10–11:30 Discussion

Lunch (11:30–12:30)

Thursday, November 17th: PM

Poster time 2 (12:30–13:50)

P01–P91 associated with Sessions 4–6

Session 6: Interdisciplinary fusion in space–Earth environmental research: possibilities and challenges of fusion of Earth science, space science, anthropology, and history

13:50–15:50, Chairs: Takenori Kato, Fusa Miyake, Satoshi Masuda, and Yoko Kokubu

Introduction

13:50–14:00 Kanya Kusano (ISEE) 17PM-01L

Keynote presentation

14:00–14:30 Ilya Usoskin (Univ. of Oulu) 17PM-02K

Solar extreme eruptions: Black swans or dragon kings?

14:30–15:00 Seiji Kadowaki (Nagoya Univ.) 17PM-03K

Challenges in dating and reconstructing cultural dynamics during the global expansions of anatomically modern humans and agriculture

Solicited presentation

15:00–15:20 Haji Hossein Azizi (Kurdistan Univ.) 17PM-04S

Magmatic activities related to the oceanic crust subduction and recycling of the deep sediments based on the 10Be cosmic isotope, NW Iran

15:20–15:40 Takeshi Nakatsuka (Nagoya Univ.) 17PM-05S

Multi-decadal climate variability as a driver of human history

15:40–15:50 Discussion

Break (15:50–16:05)

Thursday, November 17th: PD

Panel Discussion Theme III: International and interdisciplinary collaboration for space–Earth environmental research

16:05–17:05, Chairs: Kazuo Shiokawa and Masayo Minami

Intoroduction
16:05–16:15 Kazuo Shiokawa and Masayo Minami (ISEE) 17PD-01L
Short presentation
16:15–16:20 Nat Gopalswamy (NASA) 17PD-02D
16:20–16:25 Ilya Usoskin (Univ. of Oulu) 17PD-03D
16:25–16:30 Seiji Kadowaki (Nagoya Univ.) 17PD-04D
16:30–16:35 Takenori Kato (ISEE) 17PD-05D
16:35–16:40 Tac Nakajima (ISEE) 17PD-06D
16:40–16:45 Craig Heinselman (European Incoherent Scatter Scientific Association) 17PD-07D
16:45–17:05 Discussion (20 min)

Closing (17:05–17:15)
Kanya Kusano (ISEE)

The 5th ISEE Symposium is followed by the ISEE Community Meeting 2022 on Friday, November 18th, announed at https://www.isee.nagoya-u.ac.jp/co-re/meeting.html

15AM-02K keynote

Permafrost changes and its potential usage for paleo-environmental reconstruction

Go Iwahana

Permafrost is the ground with its temperature below 0 °C for at least two consecutive years. Permafrost developed during ice ages, mostly in the land mass exposed to the cold air without thick ice or snow covers, such as glaciers and ice sheets. It is natural that we observe permafrost warming and thawing under warmer climates in the interglacial period than in the glacial period. However, we experience intense permafrost degradation at an unprecedently rapid rate in the monitoring history. Firstly, this keynote presentation introduces recent observations of changing permafrost. In Alaska, formations of “Talik (unfrozen zone in the near-surface ground layer in permafrost regions)” drastically increased in the last decade which alters regional hydrology significantly. The degradation includes permafrost temperature increase, landform deformation due to the massive ground ice melting, and thawing of saline permafrost in the coastal regions. The landform destruction due to ground ice loss is called “thermokarst” and is considered a slow-onset disaster in the cold regions because it is an irreversible geomorphological change and it damages infrastructure built on the frozen ground. The probable impacts of permafrost degradation on local communities and the carbon cycle will be discussed. Secondly, this talk will focus on recent advances in permafrost age control that have suffered from old carbon contamination. In the regions where those surface ice covers are not available, permafrost may provide alternative paleo-environmental proxies because it contains water and organic matter, which preserve information from the moment of freezing. However, it has been recognized that radiocarbon dating of permafrost using macro plant remains provides significantly older ages. This is because the organic matter used for the measurement is often influenced by reworks of the surrounding old permafrost sediments, known as the old carbon problem. In collaborative research with ISEE researchers, I conducted an extensive comparison of the radiocarbon ages from different carbon sources stored in permafrost samples to more accurately measure the timing of sedimentation and freezing of the permafrost. With our new findings as to radiocarbon age control, I will address the potential usage of permafrost for paleo-environmental studies and links to other science fields, including planetary science.

15AM-03S solicited

Influence of solar and cosmic-ray variations on climate and weather: current status and future prospects

Hiroko Miyahara

Correlations between solar activity and climate have been observed over a wide range of time scales; however, the mechanisms behind the link are not yet resolved. The most straightforward explanation is through the heating by solar radiations; however, it requires significant positive feedback to explain the observed temperature variations as the variability of total solar irradiance is as small as 0.1 %. Other possibilities are through the impact of solar UV and the galactic cosmic rays modulated by solar magnetic field. However, it is difficult to evaluate the exact role of each parameter as they vary in complete correspondence at most time scales. A possible strategy is to concentrate on the timescales decadal or shorter. This talk presents the current status and the future prospects of the research on the Sun-Climate/Sun-Weather connections at such relatively short time scales.

15AM-04S solicited

Geoscience of coastal lowlands in a changing world

Toru Tamura

Coastal lowlands are low-lying plains on the coast and typically formed by accumulation of unconsolidated sediments over the last thousands of years. While coastal lowlands are one of the most valuable areas on the earth with concentrated population, they are vulnerable to global warming and associated sea-level rise, and human-induced impacts. Geoscience of coastal lowlands has thus attracted growing interests. The accelerated sea-level rise after the Industrial Revolution is highlighted by the geological sea-level reconstruction over the past 1,000 years beyond instrumental records. This reconstruction is based on microfossil assemblages and chronology of the sediment stratigraphy in coastal lowlands. Earth big data, such as satellite images and bathymetry that cover the globe, enables global assessments of coastal flooding and erosion in response to the sea-level rise expected in the next decades, warning uneven impacts on developing countries and the extinction of almost half of the world's sandy beaches. Many regional studies indicate that the coastal flooding and erosion are deteriorated by deficits in river sediment supply to the coast owing to river dam construction and fluvial mining, the ground-water pumping, and the potential intensification of coastal storms in response to climate changes. Paleoenvironment studies with aids of appropriate geochronology play supplementary, or sometime critical roles for comprehensive understanding of coastal environments. Long-term reconstruction of coastal environments provides a baseline scenario with much less human-induced impacts, helping understanding of the present status and better anticipation of the future. Some past geological events may provide implications for future changes. For example, the mangrove evolution in response to the postglacial sea-level rise that were rapid and then decelerated in the last 10,000 years empirically tells threshold rate of the sea-level rise that allows its sustainable development. Outputs of geoscientific research of coastal lowlands should be more comprehensive and reliably considered for decision making given improvements of the quality and amount of dataset used, such as the global digital elevation model, the refinement of model of coastal processes, sustained monitoring, and numerical modeling of various factors.

15AM-05S solicited

Archival reanalyses for the Carrington event: case studies

Hisashi Hayakawa

Solar eruptions occasionally launch geo-effective interplanetary coronal mass ejections (ICMEs) to cause geomagnetic storms and extend auroral ovals. The Carrington storm in September 1859 has been considered one of their benchmarks in terms of its flare magnitude, ICME velocity, geomagnetic disturbance, and equatorward auroral extension. However, the limited data availability has made the actual magnitudes and temporal evolutions have remained somewhat controversial. Here, we aim at overcoming these difficulties following archival investigations especially in the British archival records for oprtical observations and geomagnetic measurements (partially on the basis of: Hayakawa et al., 2022, ApJ, 928, 32). This presentation aims at revising magnitudes and time series of the source solar flare and the resultant geomagnetic disturbances on their basis. Our result will form a ground bases for future discussions on the Carrington event and extreme space weather events.

15PM-02K keynote

Space Weather as a critical natural disaster

Mamoru Ishii, Takuya Tsugawa and Yuki Kubo

Japanese government finally published a report for future space weather services in June 2022. Extreme space weather occurs much rare but once it occurs, the social impact can be huge which is almost equivalent to Tohoku Earthquake in 2011. Some countries, for example US and UK, have been discussing the preparedness against such big space weather events. Also in UN, UN/DDR assigned severe space weather as one of the critical disasters in 2022. The most impacted social fields are electricity and aviation. For aviation, ICAO started the space weather information service for civil aviation since 2019 for avoiding risks of communication and satellite positioning troubles. For electricity, countries in high latitude region have significant activities for preparedness against GIC. In this session, we will present the status of social preparedness against space weather disasters in recent years, and introduce the needs for scientific communities.

15PM-03S solicited

Forecasting Impactful Space Weather: Today's Successes and Tomorrow's Challenges

KD Leka

Space Weather is a very broad topic, covering an almost overwhelmingly large and diverse set of physical systems for which, to produce successful forecasts, unfortunately all of the "small details" become important. Yet in many ways, our ability to predict impactful space weather phenomena has come impressively far, given the very short period of time over which intense research has been performed. In this talk I will outline our progress in understanding the Space Weather system from "Sun to Mud", in particular the recent advances in understanding and forecasting across the physical regimes that span orders of magnitude in the relevant physical regimes. Space Weather research and operational forecasting in particular faces the peculiar challenge of simultaneously being "data-flooded" and "data-starved". I will examine this riddle and discuss its impact on our future ability to improve the forecasts of space weather events.

15PM-04S solicited

Magnetic Storm Predictability, Are We Close to Being Able to Do This?

1Bruce T. Tsurutani, 2Gurbax S. Lakhina, 3Rajkumar Hajra, 4Xing Meng
1Retired, Pasadena, CA, USA; 2Indian Institute for Geomagnetism, Navi Mumbai, India; 3Indian Institute of Technology Indore, Simrol, Indore, India; 4Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

Major power outages occur during magnetic storms. Magnetic storms occur when intense southwardly directed interplanetary magnetic fields hit the Earth's magnetosphere and through the process of magnetic reconnection (Dungey, 1961), solar wind energy is transferred to the magnetosphere. How can we predict when such intense southward magnetic fields will occur at Earth?

Our current knowledge is that these intense southward magnetic fields occur in the magnetic cloud (MC) portion of coronal mass ejections (CMEs), and if we can predict the direction of these fields and the trajectory of the CMEs, we can predict the occurrence of magnetic storms. Currently we have spacecraft measurements ~0.01 au upstream of the Earth, so ~30 min warnings are possible. With Parker Solar Probe and Solar Orbiter, even greater (12 hrs to days) warning times could be established. Solar active region modeling is the ultimate goal for giving consistent advanced "alerts".

However there is an even more difficult problem that has not been addressed. Meng, Tsurutani and Mannucci (JGR, 2019) have studied all superstorms (SYM-H < -250 nT) occurring in the space age up to 2019 and found that most events were caused by intense southward magnetic fields in the sheaths upstream of the CMEs and not by CME fields themselves. The sheath plasma is shocked/compressed slow solar wind plasma which come from a different source from the Sun.

15PM-05S solicited

Big Data Assimilation: Real-time 30-s-update Torrential Rain Forecast Using Fugaku in Tokyo in 2021

Takemasa Miyoshi, Arata Amemiya, Takumi Honda, Shigenori Otsuka, Yasumitsu Maejima, James Taylor, Hirofumi Tomita, Seiya Nishizawa, Kenta Sueki, Tsuyoshi Yamaura, Yutaka Ishikawa, Shinsuke Satoh, Tomoo Ushio, Kana Koike

The Japan's Big Data Assimilation (BDA) project started in October 2013 and ended its 5.5-year period in March 2019. Here, we developed a novel numerical weather prediction (NWP) system at 100-m resolution updated every 30 seconds for precise prediction of individual convective clouds. This system was designed to fully take advantage of the phased array weather radar (PAWR) which observes reflectivity and Doppler velocity at 30-second frequency for 100 elevation angles at 100-m range resolution. By the end of the 5.5-year project period, we achieved less than 30-second computational time using the Japan's flagship K computer for past cases with all input data such as boundary conditions and observation data being ready to use. The direct follow-on project started in April 2019 for three years until March 2022. We continued the development and achieved real-time operations of this novel 30-second-update NWP system for demonstration at 500-m resolution during July 31 and August 7, 2020, using the supercomputer Oakforest-PACS operated jointly by the Tsukuba University and the University of Tokyo. In 2021, we performed real-time experiments during two periods corresponding to the Tokyo Olympic and Paralympic games, i.e., July 20-August 8 and August 24-September 5, with an enhanced system using the new Japan's flagship supercomputer Fugaku. Taking advantage of the computing power, we increased the ensemble size from 50 to 1000 for the local ensemble transform Kalman filter (LETKF). This presentation will summarize the real-time demonstration in 2021 and discuss future perspectives based on the 8.5-year-long project efforts.

15PM-06S solicited

Targeted Observations in DOTSTAR and Beyond

Chun-Chieh Wu
(Department of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan)

The DOTSTAR (Dropwindsonde Observations for Typhoon Surveillance near the Taiwan Region) is an international research program conducted by scientists in Taiwan, partnered with scientists at the Hurricane Research Division (HRD) and the National Centers for Environmental Prediction (NCEP) of the National Oceanic and Atmospheric Administration (NOAA), Meteorological Research Institute/Japan Meteorological Agency (MRI/JMA), and Naval Research Laboratory. This project marked the beginning of a new era for the aircraft surveillance of typhoons in the western North Pacific. Built upon work pioneered at NOAA's HRD, the key to the project is the use of airborne sensors -- dropwindsondes, which are released from jet aircraft flying above 42,000 feet in the environment of a tropical cyclone (TC). These sensors gather temperature, humidity, pressure, and wind velocity information as they fall to the surface. Information from the surveillance flights is transmitted in near real-time to the Central Weather Bureau (CWB) of Taiwan, as well as to the NCEP, FNMOC, and JMA. The data are immediately assimilated into the numerical models of CWB, NCEP (AVN/GFDL), FNMOC (NOGAPS/COAMPS/GFDN), UKMET, and JMA. DOTSTAR provides valuable data which can improve TC analysis and track forecasts, assess the impact of the data on numerical models, evaluate the strategies for adaptive/targeted observations, validate/calibrate the remote-sensing data, and improve our understanding on TC dynamics, especially over the TC's boundary layer. In total, 85 surveillance DOTSTAR missions have been conducted for 69 TCs, with 441 flight hours and 1303 dropsondes deployed. An average 20% improvement for the 12-72h track forecasts over the NCEP-GFS, FNMOC-NOGAPS, JMA-GSM, their ensembles, and the WRF model has been demonstrated (Wu et al. 2007a). Multiple techniques have been employed to help design the flight path for the targeted observations in DOTSTAR. A new targeted method (Wu et al. 2007b) was proposed to identify the sensitive area for the targeted observations of TCs based on the adjoint model. By appropriately defining the response functions to represent typhoon's steering flow at the verifying time, a unique new parameter, the Adjoint-Derived Sensitivity Steering Vector (ADSSV) was designed to better demonstrate the sensitivity locations at the observing time. An inter-comparison study (Wu et al. 2009) was conducted to examine the common features and differences among all different targeting techniques. DOTSTAR participated the international THORPEX/PARC (T-PARC) initiative under World Meteorological Organization, in collaboration with the Japanese program, Typhoon Hunting 2008, TH08, as well as the project of Tropical Cyclone Structure 2008, TCS-08. Joint flights among DOTSTAR, Falcon (DLR), P3 (NRL) and C130 (USAF) for Typhoons Nuri, Sinlaku, Hagupit, and Jangmi had been successfully conducted during T-PARC in the summer of 2008. The unprecedented data obtained provided a great opportunity for the advance of the research on TC genesis, structure change, targeted observation, recurvature, and extratropical transition. In particular, a new mechanism for secondary eyewall formation was proposed (Wu et al. 2002 and Huang et al. 2002) based on numerical simulations of Typhoon Sinlaku (2008) with flight and dropwindsonde data assimilated. In 2010, DOTSTAR joined the field program of ITOP (D'Asaro et al. 2014), and provided a unique new dataset to investigate the interaction of typhoons and ocean (Wu et al. 2016). Since 2018, DOTSTAR has been collaborating with T-PARCII (Ito et al. 2018) for jointly conducting airborne typhoon observations in the northwestern Pacific region (Chang et al. 2022).

15PD-02S solicited

Past, present, and future of Sun-Climate relationships: a personal viewpoint

José Manuel Vaquero

The study of Sun-Climate relationships has been one of the main tasks of the scientists throughout history. These studies have often been controversial due to the non-linear nature of the behavior of the systems involved (Sun, Earth's atmosphere) and the physical laws that govern this interaction. I will review here the most important contributions in this field. Moreover, I will show some actual problems (including data recovery and data analysis) presenting some works made by my research team. I will emphasize the work carried out to recover early meteorological data from various areas of the Earth. Finally, a personal point of view of the future work for the development of this field will be presented.

16AM-02K keynote

Current and next-generation simulations in solar physics

Hideyuki Hotta

In this keynote talk, we review our achievements in the last decade in numerical simulations in the solar physics field. Numerical simulations have had essential roles in the solar physics field in almost all domains, from the interior through the photosphere to corona and solar wind. While the maturity of the simulation still depends on the layer, these calculations have been significantly developed in the last decade. We have reproduced the global-scale flow structure in the interior, detailed sunspot feature at the photosphere, and 1 MK corona, flares, and solar wind in the upper atmosphere. These achievements, especially done by the speaker's group, are reviewed. In addition, future perspectives of the next-generation numerical simulations in the post-Fugaku era and the expected role of ISEE in this field are also discussed.

16AM-03K keynote

Digital twins of Earth-like planets

Takeshi Enomoto, Yoshi-Yuki Hayashi, and Masato Shiotani

Earth is located in a habitable zone in the solar system and has an ocean and atmosphere. Venus and Mars are not suitable for human beings, but have a solid surface and atmosphere. Comparisons of the atmospheres of the three Earth-like planets provide insights into the dynamics of fluid on a rotating planet and phenomena that appear. To enhance our understanding of the planetary atmosphere and let us reflect upon our environment we live in, a challenging plan to build digital twins of the three planets is proposed. Digital twins of Earth are being built, for example in Europe. Upon rich experience in modeling and data assimilation and history of supercomputers including the Earth Simulator, K Computer and Fugaku, our community in atmospheric and oceanic sciences in Japan have and have a potential to build replicas of these planets. Such a system should be validated against operational weather forecasts, e.g. from the Japan Meteorological Agency (JMA). Therefore, we begin by archiving the JMA forecast data, in a platform named Atmospheric and Hydrospheric Science Archive Platform (AHSAP) and will conduct numerical experiments, data analysis, data assimilation, and machine learning studies. The modeling of Venusian and Martian atmosphere is maturing and preliminary data assimilation products are being constructed. The experience with an Earth twin should be useful in developing Venus and Mars twins to produce useful information for future explorations. The data on AHSAP will be curated and can be utilized for educational purposes to train students in geosciences, especially those who are interested in becoming teachers in secondary education and for reaching citizens to build a society resilient against natural disasters.

16AM-04S solicited

future challenges of whole atmosphere-ionosphere modeling

Hidekatsu Jin

A whole atmosphere-ionosphere model called GAIA has been developed to address scientific issues related regional coupling processes and to develop numerical prediction system of the ionosphere and thermosphere. We introduce recent updates including studies of solar and magnetospheric storm influences and discuss future challenges.

16AM-05S solicited

Global carbon budget analysis using inverse modelling of regional sources and sinks

Prabir K. Patra, Naveen Chandra, Masayuki Kondo

Carbon dioxide (CO2) has risen to more than 415 ppm globally in the recent years due to a significant increase in anthropogenic emissions since the pre-industrial times, circa 1850. The CO2 growth rates are about 2.2 ppm/yr in the most recent decade compared to less than 1 ppm/yr in the 1960s. Anthropogenic emissions are consisted of fossil fuel consumption and cement manufacturing (FFC), and land-use/land-use-change (LULUC). There are two natural CO2 sinks by the terrestrial ecosystem uptakes and storage in the deep ocean. We study the global and regional sources and sinks of CO2 using inverse modelling where atmospheric observations and transport models are employed in order to refine known a priori emissions in a Bayesian framework. Our inverse model estimates net sources/sinks corrections at regional scales (54 land and 30 ocean divisions) at monthly-mean time intervals, say for a period 2000-2020 (Chandra et al., 2022). The inversion fluxes can be tested using independent CO2 measurements and/or regional flux assessments, such as those produced under the REgional Carbon Cycle Assessment and Processes (RECCAP) or global budgets in IPCC 6th Assessment Report and the Global Carbon Project (Poulter at al., 2022; Canadell et al., 2021; Le Quere et al., 2018). Our major interests are focused on the science of climate-carbon feedback using historical sources/sinks variability in relation with the El Niño Southern Oscillation (ENSO) and the other modes of natural climate variability. The link of warm and dry climate to an increased loss of carbon from the terrestrial ecosystem suggests a positive (dangerous) climate feedback to increased CO2 and thus a warmer global temperature in the future. The study of regional sensitivity to carbon-climate nexus with water cycle is another potential area of study in order to make effective policies for limiting global warming under the Kyoto Protocol and through the nationally determined contributions (NDCs) as per the Paris Agreement.

16AC-01A ISEE Award Commemorative Lecture

One solar cycle with the ERG (ARASE) mission

Satoshi Kasahara

The ERG (ARASE) spacecraft was launched in December 2016 aiming at exploring the dynamic evolution of Earth's radiation belt and revealing plasma physics behind it. The spacecraft is equipped with 9 scientific instruments to cover the broad ranges of particle energy and wave frequency. Our team developed 2 instruments among them: medium-energy particle experiments – electron analyser (MEP-e) and medium-energy particle experiments – ion mass analyser (MEP-i), with extensive use of a laboratory at ISEE for calibration. The flight data have been processed also at ISEE and distributed to the international community, producing a wide range of scientific results. The mission will cover this solar cycle as long as it survives in the harsh radiation environment. Here I review some unique results related to these instruments, with special emphasis on wave-particle interaction.

16PM-02K keynote

Advancing towards an Integrated Observing System for Atmospheric Chemistry

James Crawford

Much attention is given to satellite observations of atmospheric composition. Satellite images are excellent for communicating the distribution and breadth of impacts that human activity have on atmospheric conditions and air quality. Surface observations, however, continue to be the standard for assessing exposure and monitoring progress in achieving air quality goals. Both satellite observations and ground monitoring tend to focus on a few key constituents, while the underlying chemistry governing the pathway between emissions and air quality outcomes involves myriad compounds. Targeted field studies using aircraft and expanded ground and ship-based observations offer the opportunity to observe the complexity of atmospheric chemistry and dynamics needed for a process-level understanding. These details lead to better interpretation and integration of satellite and surface observations as well as improved models needed to both forecast air quality and develop mitigation strategies. Examples of multi-perspective observations (surface, airborne, and satellite) and the robust information they provide when used in combination will be discussed.

16PM-03S solicited

Future heliospheric system science exploration and the enabling technical development status in Japan

Yoshifumi Saito

Toward the inner heliospheric system exploration in the late 2020s, ISAS/JAXA is currently operating the Arase, BepiColombo/Mio, Hinode, and Akatsuki satellites, and Solar-C EUVST is scheduled for launch in the near future. These satellites will be linked with overseas satellites such as Solar-Orbiter, Solar Parker Probe, Cluster, THEMIS, MMS, and other satellites around the Earth to realize exploration of the inner heliosphere. In the 2030s, Japan is considering the FACTORS formation-flight satellite mission that will make observation in the magnetosphere-ionosphere interaction region, as well as a formation-flight magnetospheric satellite mission under consideration further in the future. In Europe, Plasma Observatory, which will cover multiple scales with seven satellites have been proposed. In the United States, magnetospheric constellation mission will be proposed in the future. The future heliospheric system science exploration will be conducted by further expanding its observation area while improving the performance of individual satellite missions. In order to realize these future heliospheric system science exploration exploration, it is necessary for us to significantly miniaturize and improve the performance of onboard science instruments in order to realize formation-flying satellites using the relatively small Epsilon launch vehicle. I will introduce the current status of the technological development in Japan, especially for enabling the future heliospheric system science exploration through in-situ observations.

16PM-04S solicited

EISCAT_3D: new research infrastructure for Geospace studies

Craig Heinselman

Incoherent scatter radars have, over the past decades, provided some of the most comprehensive measurements of the ionospheric state in the regions they probe. Progress in the field has been driven by innovations in the technologies employed, advances in software sophistication and speed, collaboration with other measurement modalities, and advanced modeling of the near-earth space environment. The systems themselves represent major investments and, as such, they also act as magnets for collaborations of both research communities and instrumentation.

EISCAT_3D is a major upgrade to the suite of systems operated in northern Fenno-Scandinavia by the EISCAT Scientific Association. It received development funds via European Commission projects (notably under ESFRI) and, when ready, implementation funds from EISCAT member nations. EISCAT_3D is also now one of a small number of ESFRI Landmark projects.

Stage 1 of the EISCAT_3D implementation is now under way, with hardware being delivered to the three field sites. Once completed, these three sites will provide unique measurements of the auroral plasma, and other phemonema, including fully resolved ion velocity vectors as functions of space and time. The system sensitivity will also support measurements at nearly unprecedented time scales in support of basic Geospace research.

16PM-05S solicited

Next-generation technologies for the observation of thunderstorm and lightning

Tomoo Ushio and Yuuki Wada

Recent progress of information and communication technologies has been enabling us to realize a rapid scanning weather radar system. A single polarimetric Phased Array Radar (PAR) system at X band was developed and installed in Suita Campus, Osaka University in 2012, and then dual polarimetric PAR was also developed in 2017. These PAR systems can scan the whole sky within 30 seconds up to 80 km in radius over 100 elevation angles with digital beam forming technique, and the initial observation results demonstrate the unique capability of PAR. In addition to these radar system 3 dimensional lightning mapping system has been developed and installed near the radar site. Simultaneous observation of lightning and thunderstorm by radar shows how the lightning producing thunderstorm is charged and produces ground and cloud flashes with high temporal and spatial resolution.

Although the PAR observation of thunderstorm is impressive and clearly shows the process of heavy precipitation falling to ground, the observation is sometimes seriously contaminated by strong ground clutter through relatively high sidelobes at transmitting stage. To solve this problem, a new ground clutter mitigation algorithm from adaptive beam forming technique on Minimum Mean Square Error (MMSE) formulation was investigated, and succeeded in suppressing not only the ground clutter but also ghost echo from strong precipitation echo nearby. The results shows that the advantage of phased array method is not only the high spatio-temporal resolution but also the quality of the observation, leading the superior rainfall rate estimation to the parabolic type radar system.

17AM-02K keynote

International Collaborations for Space–Earth Environmental Research

Nat Gopalswamy

Humans and their ever-developing technology are in constant interaction with the space-earth environment. Therefore, the space–earth environmental research has both scientific and practical importance. Of particular importance is the short- and long-term variabilities of the space-earth environment termed as weather and climate. The international space science community had recognized the importance of space weather over the past couple of decades as evidenced by a number of international collaborative activities such as the International Space Weather Initiative (ISWI), SCOSTEP's scientific programs, the International Living with a Star (ILWS) program, and the COSPAR International Space Weather Action Teams (ISWAT). These programs have brought scientists together to tackle the scientific issues related to short and long term variability of the Sun and their consequences in the heliosphere. The scientific knowledge helps develop prediction schemes that are important in the advance warning of hazardous space weather events. Space weather is a global phenomenon that crosses geographical boundaries and hence a global response is necessary leading naturally to international collaboration. This talk highlights some salient examples of international collaboration that resulted in substantial progress in understanding the space-earth environment.

17AM-03S solicited

What impact did the international research exchange for rare earth element geochemistry have on me?

Seung-Gu Lee

We humans are very interested in the formation and evolution of the Earth and the universe. Since the Earth was formed about 4.56 billion years ago, numerous geological evolutionary processes have created the present continents and oceans. Geochemists study the evolutionary process of the Earth by using the content of various elements in the periodic table and their abundance of isotopes. Rare earth elements (REEs), which is composed of 14 elements from La to Lu, provides a powerful research method to understand the formation and evolution of the Earth and extra-terrestrial material.

In order to study the evolution history of the Northeast Asian continent, including Korea and Japan, and a unique geochemical feature of REEs in granite, called REE tetrad effect, I have been conducting joint-research with Nagoya University team. The research using abundances and isotopes of the REEs requires an advanced equipment called mass spectrometer. Therefore, since 2006, I have been continuously joint research using the mass spectrometers with the Geochemistry Lab Team of Nagoya University. As a result, a lot of information and research results related to the formation process of granite have been achieved. Hence, I would like to introduce the outputs obtained through such joint work at this conference. In addition, I could get the ideas for current and future research topics through exchanges with many fellow researchers in Japan. Moreover, it opened the way for me to collaborate with researchers from more diverse countries.

This tells us that international exchanges with researchers can become a forum for not only academic development but also a deeper understanding of each other.

17AM-04S solicited

Decadal carbon budget assessment of Southeast Asia

Masayuki Kondo, Prabir K. Patra

Southeast Asia is a complex geographical and geopolitical region. It has mainland and insular components dominated by tropical rainforest and cropland, with savanna woodlands in drier areas of the northeast. Forest cover constitutes 236 million ha, which corresponds to approximately 15% of the world's tropical forests. Most of Southeast Asia is considered a biodiversity hotspot because it harbors a high number of endemic species largely threatened by forest loss. home to the most extensive tropical peatlands in the world with 25 million ha and an estimated carbon pool of 69 Pg C and contains the greatest diversity of mangrove species. complexity and diversity of ecosystems, as well as the impact of climate and human disturbances on ecosystems, Southeast Asia is considered a region challenging to assess the net balance of greenhouse gases (a net exchange of uptake and release of gases).
In this study, we establish (1) the mean decadal budgets of greenhouse gases, including carbon dioxide (CO2) and methane (CH4), and Nitrous oxide (N2O), of Southeast Asia for the period 1980-2019, (2) its inter-annual and inter-decadal variability, and (3) the natural and human-driven attributions to the mean budget including net ecosystem exchange, fluxes from LULCC, fire emissions, and riverine transport into the ocean. For the LULCC component fluxes, we include all major land use change changes and the emissions from decomposition and transports from drained peatlands, which are significant and unique to the region. In addition to this budget attribution pertaining to the territorial carbon budget (carbon fluxes within the physical boundaries of Southeast Asia), we also report on (4) the non-territorial carbon emissions, i.e. emissions from the production of traded manufactured products and the physical carbon quantities contained in traded food and fossil fuels to and from Southeast Asia. We achieve the four objectives by combining and analyzing multiple top-down estimates of the net fluxes from atmospheric CO2, CH4, and N2O inversions, with multiple bottom-up flux estimates from various approaches to biogeochemical modeling of components of the net carbon balance, and trade statistics. Lastly, we discuss how emissions and uptake of GHG have changed over Southeast Asia, and the state of carbon neutrality aiming to mitigate climate change.

17AM-05S solicited

Towards an International Geospace Systems Program (IGSP) and opportunities for new multi-point spacecraft collaborations

Rumi Nakamura

The Earth's magnetosphere acts as a "System of Systems". Each magnetospheric system - the magnetotail, inner magnetosphere (itself a system of systems with plasmasphere, ring current, and radiation belts), magnetopause, magnetosheath, and ionosphere-thermosphere-mesosphere (another system of systems) - has its own dynamics and characteristics that can be, and have been, studied separately.There is a clear need to examine how these systems interact with each other - how magnetotail dynamics are connected to ring current enhancements; how ionospheric outflow modifies magnetospheric response; how meso- and macro-scale reconnection and boundary waves regulates the transfer of energy from the solar wind and foreshock into the magnetosphere. This cross-scale, system science currently relies on ad-hoc and chance alignments of largely uncoordinated missions. Such fortuitous conjunctions are not sufficient to address how these mesoscale dynamics (~1-3 RE in scale), that are both ubiquitous and central to magnetospheric dynamics, are driven and evolve. To address this "messenger scale" or "missing middle" of the mesoscales would involve multiple constellations of spacecraft in key regions, combined with remote imaging measurements, ground-based measurements, and advanced numerical modeling, all coordinated and working in concert to study Geospace holistically. This goes far beyond single instrument/observatory/mission or agency platforms, requiring broad international collaboration and coordination. To enable this vision, a new COSPAR Task Group on establishing an International Geospace Systems Program (IGSP) the output of which will be a COSPAR scientific roadmap. In this talk we will summarize the science questions that are motivating our desire to create such a program, and outline our approach (and challenges) towards building community support and stakeholder engagement. Examples of possible collaboration in future will be introduced.

17PM-02K keynote

Solar extreme eruptions: Black Swans or Dragon Kings?

Ilya Usoskin

Solar eruptive processes, such as flares and coronal mass ejections, release a large amount of energy. They are well known for the past decades using direct observations and measurements. However, the upper limit of the strength of such processes is not constrained by direct data because of a too short period of their observation and a narrow range of the observed energies. Additionally, extreme solar events are known to occur on the Sun over the last millennia, thanks to cosmogenic-proxy data, and also on sun-like stars, thanks to high-precision stellar photometry. However, the nature of extreme solar/stellar eruptive events remains unclear, and the question is still open whether they are similar to ‘normal’ solar flares but stronger, representing a tail of the distribution, the so-called ‘Black Swans’, or a new unknown type of solar events requiring new knowledge – the so-called ‘Dragon Kings’. Here I summarize the existing pieces of knowledge and try to make a distinction between the Black-swan and Dragon-king scenarios of the extreme events.

17PM-03K keynote

Challenges in dating and reconstructing cultural dynamics during the global expansions of anatomically modern humans and agriculture

Seiji Kadowaki

To explore directions of future interdisciplinary studies, I present several examples of collaborative studies between archaeology and earth sciences by focusing on my published and on-going studies on the topics of the dispersals of anatomically modern humans and agriculture. Considering the aim of the ISEE symposium, I will particularly discuss current status and future challenges in the chronological research in archaeology and paleoanthropology. In the study of human history, it is needless to say that radiocarbon dating is currently widespread and has become the major method to obtain absolute dates that delineate timings and paces of changes in human cultures and societies. In this respect, the Tandetron Accelerator Mass Spectrometer at Nagoya University has made great contributions to a wide variety of archaeological studies. The increased precision of radiocarbon dates has enabled comparisons of human cultures/histories among remote areas that do not have stratigraphic correlations. It has also encouraged many researchers to examine correlations between human activities and paleoclimate. From this viewpoint, it is expected that the Chronological Research Department of ISEE will continue to provide significant and fundamental contributions to archaeology.

Given this, I discuss a few possible directions that can lead to unique and distinctive contributions by ISEE. The first is the development of methods for increasing accuracy/precision of dates between 40 and 50 ky cal BP. This time period is near the limit of radiocarbon dating, but it is a critical period in human history. During this time period, our direct ancestors, i.e., anatomically modern humans, expanded their geographic range out of Africa where they initially emerged. At the same time, archaic humans like Neanderthals and Denisovans went to extinct, but they also interbred with anatomically modern humans. This topic has attracted much interdisciplinary attention, including archaeology, anthropology, earth sciences, and genetics, and also drawn interests from general public. The second is the increase of radiocarbon dating for high-resolution reconstructions of past human activities. Because of the accumulation of archaeological records, we are now able to examine changes in Jomon pottery-styles or early agricultural Neolithic settlements at the level of one to few generations if they are precisely dated. The resolution of these achievements depends on how many samples can be dated. In addition to chronological research, I will also present some of my archaeological studies using geochemical analyses as potential directions of future collaborations.

17PM-04S solicited

Magmatic activities related to the oceanic crust subduction and recycling of the deep sediments based on the 10Be cosmic isotope, NW Iran

Hossein Azizi

Magmatic activities have invaded the Iran Plateau from the north to south during the subducting of the Neotethys oceanic lithosphere beneath western Iran since the Cretaceous. The magmatic activities made a large potential for generation of the ore deposits such as gold, copper, and iron in the Iran Plateau. The relation of the ore deposits with their host magmatic rocks and the sources of the deposits are not well understood. Therefore, new methods and age determination are more important to elucidate the geodynamic and tectonic setting of magmatic activities. The chemical compositions and isotope ratios of young volcanic rocks in NW show the source rocks have been affected by the subducted oceanic flux. The important key to undertenant the recycling of pelagic sediments in the subduction zone is the Large Ion Lithophile elements such as Li, B, and Be. Actually, due to the high concentration of these elements in the continental crust, it would be difficult to know whether the enrichment of LILE in magma occurred by the filtrations of magma from the continental crust or by recycling of pelagic sediment in the subduction zone. 10Be is the key to solving this problem, especially for the young volcanic rocks with less than 10 Ma. 10Be is a cosmogenic isotope, formed in the Earth's atmosphere mainly by cosmic ray spallation of nitrogen and oxygen. This isotope is concentrated in the young pelagic sediments in the ocean. During the oceanic lithosphere subducting, due to the strong extensional regime, the horst and graben system develop near the trench zone and the grabens, which are more suitable to precipitate the young sediments rich in 10Be. The sediments are dragged down into the mantle beneath the continental crust, during the oceanic lithosphere subduction. To examine this process, we determined 10Be values for a large number of young volcanic rocks in NW Iran. The data show the different 10Be concentrations ranging from the very low to high value and it infers the involvement of pelagic sediments in the genesis of the young magmatic activities in NW Iran. Therefore, 10Be and 10Be/9Be ratios are expected to be prevailing factors in understanding the magmatic evolution in the active margins such as continental margin and Island arc tectonic regime in a subduction zone.

17PM-05S solicited

Multi-decadal climate variability as a driver of human history

Takeshi NAKATSUKA

Recently, oxygen isotopic studies on tree-ring cellulose in central Japan have elucidated past changes in summer climate over East Asia very precisely during last several millennia at annual time resolution. By comparing the paleoclimate time-series with numerous historical and archaeological evidence in Japan and surrounding countries, I have found remarkable relationships between climate variation and human history at various time scales from inter-annual to multi-centennial ones because summer climate directly influences yield of crops, such as rice, a main food of Japanese people from 3000 years ago. Especially when multi-decadal climate variability was enhanced, past human societies were suffering from many troubles, such as famines and wars, and obliged to change the social system to overcome the difficult condition, probably because the enhanced multi-decadal climate variation must have caused serious imbalance between human population and food production.

During last a few millennia, the multi-decadal climate variability was enhanced intermittently approximately at 400 years intervals, apparently resulting in political regime shifts in Japan and dynasty cycles in China, but the fundamental mechanisms why the multi-decadal variation is enhanced have not been clarified yet. Possible candidates are the changes in frequency of volcanic eruptions and the changes in solar cycles.

In this presentation, I will introduce the past climate-history relationship in Japan and world using up to date dendroclimatological datasets, with special foci on multi-decadal climate variations and societal responses against them and discuss the physical mechanisms underlying the intermittent enhancement of multi-decadal climate variability in order to forecast its possible occurrences and prevent its serious damages to societies in the nearest future.

P01 contributed

Influence of an interacting CME event on Earth and Mars constrained by remote sensing and in-situ observations

Shirsh Lata Soni, Ankush Bhaskar, Smitha Thampi, Satheesh Thampi

Detailed study of an interacting CME event occurred on 08/04/2014 is presented here. In the present study, simulation of ICME propagation parameters such as arrival time and signal amplitude of in situ measurements were carried out. The synergistic study of the ICME and solar energetic particle arrivals at Earth and Mars gives to have better predictions for the potentially hazardous space-weather.

P02 contributed

Periodicities in sunspot number and solar radio emissions during solar minimum and maximum of cycle 23

Mahender Aroori and Soumya Roy

We have performed the Lomb-Scargle periodogram and Date-compensated Discrete Fourier Transform (DCDFT) technique to study the periodic behavior of time-series data of solar radio emissions at different frequencies ranging from 245 –15400 MHz during different phases of the solar cycle 23.

P03 contributed

Estimation of Ionospheric vTEC using Multivariate Quadratic model over Bahir Dar, Ethiopia

Tsegaye Kassa and Kasech Gezahegne

The intention of the current work is to estimate and predict the low latitude ionospheric vertical Total Electron Content (vTEC) variations using multivariate quadratic model. The vTEC has showed daily variation that can be associated with the suppression of Earth's magnetic field due to particle or radiation storms originated from the sun. Both linear and non-linear variations of were analyzed.

P04 contributed

Connecting Astrobiology to the Space–Earth Environment: A Case Study in Membraneless Protocells

Tony Z. Jia

Astrobiology combines planetary science, geology, chemistry, and biology to study the origin of life on Earth or other planets. How does astrobiology connect with the space-Earth environment, equally broad in nature? Here, we present a case study in astrobiology on membraneless protocells to connect the Space-Earth environment research community with astrobiologists for future collaboration.

P05 contributed

Evidence of impact of earthquakes on geomagnetic and ionospheric activity during spotless Sun

Tamara Gulyaeva

The 1h geomagnetic index Hpo and the ionospheric Weq index are used for the comparisons with the daily peak earthquake Mw during 1810 Sun spotless days from 1994 to 2020. The ionosphere Weq index is derived at the EQ epicenter from JPL GIM-TEC map. The geomagnetic and ionospheric activities are dropped out daily at earthquake providing evidence on the Earth's impact on space weather.

P06 contributed

Terrestrial volcanic eruptions and their link with solar activity

Vasilieva I. and Zharkova V.

Frequencies of volcanic eruptions in the past three centuries are compared with the variations of solar activity and solar background magnetic field (SBMF) derived from the WSO synoptic magnetic maps. The frequency of volcanic eruptions in 1868 -1950 are established to have a well-defined period of 22 years, with maxima occurring in the cycles with the dominant southern polarity in SBMF.

P07 contributed

Space Environment Board in a CubeSat Laboratory

Sara Aziz , Mohmed Ibrahim , Safaa Ibrahim , Aya abosoud and Shymaa Sultan

In this paper, the first result obtained of the space environment board will be presented. The requirements for the concept, as well as assembly, integration and testing requirements to quantify the system will be discussed. . The main objective of this payload is to realize the risks of the space environment on the satellite structure and its components, and how to mitigate these hazards.

P08 contributed

Beryllium-10 in travertine deposits: A new proxy for the past solar and cosmic-ray variations

Hiroko Miyahara, Hongyang Xu, Kazuho Horiuchi, Limin Zhou, Hiroyuki Matsuzaki

Cosmogenic nuclides such as beryllium-10 and carbon-14 are powerful proxies for obtaining information on the history of solar activity and cosmic-ray variations. Ice cores are widely used to obtain the records of beryllium-10. However, the records of ice cores accompany a dating error of a few years; thus, it is sometimes difficult to derive accurate information on the short-term variations such as decadal-scale solar cycles. In addition, due to the thinning effect of ice, it is difficult to retrieve information on the decadal-scale variations from deep parts of ice cores. Therefore, it is desired to explore other possible archives to accurately reconstruct past solar and cosmic-ray variations. In this presentation, we show that beryllium-10 in travertines has a potential as a proxy of past solar and cosmic-ray variations. Travertines are terrestrial carbonates formed from spring water and sometimes preserve visible annual layers. They are found around limestone terrain, and several samples have been found to be dating back to about 1 Ma. We show that the inflow of beryllium-10 into travertines associated with precipitation events can be corrected based on the content of trace elements and that the signals of decadal solar cycles can be retrieved from travertines.

P09 contributed

Study and Modelling of the Brazilian low latitude ionosphere response to the occurrence of 22-23 June 2015 geomagnetic storm.

Oladayo O. Afolabi, Fabio . B. Guedes, Claudia M. N. Candido

In this research article, we study the response of the Brazilian low latitude ionosphere to the geomagnetic storm that occurred on 22-23 June 2015.

To understand the state of the interplanetary medium during the storm period, we analyzed interplanetary parameters such as interplanetary magnetic Bz component, Interplanetary electric field (IEF), and solar wind speed obtained from the National Aeronautics and Space Administration (https://omniweb.gsfc.nasa.gov) website. GPS Rinex File was downloaded at (https://www.ibge.gov.br/) and processed by using GPS-TEC analysis software by Gopi Seemala, and magnetometer data from Brazilian Study and Monitoring of Space Weather, and SAMBA-AMBER Magnetometers Data Center (Embrace: http://www2.inpe.br/climaespacial/portal/en/ and http://magnetometers.bc.edu) for equatorial and low latitude stations (Belem: dip latitude (-0.47, Alta Floresta: dip latitude (- 3.76), Cachoeira Paulista: dip latitude (-19.71)) were analyzed to examine the ionosphere response to the geomagnetic disturbance.

We also used a first principle physics base model (SAMI2) to simulate the ionospheric response to the geomagnetic storm during this period. We observed that there is no formation of the distinct crest and trough during the June month due to the suppression of the fountain effect.

On the dayside, Vertical Total Electron Content (VTEC) enhancement is due to the eastward prompt penetration of the magnetospheric convection electric field (PPEF). The nighttime VTEC enhancement in the Brazilian low latitude ionosphere is attributed to the effect of the eastward disturbance dynamo electric field (DDEF). DP2 current presents a large amplitude during the main phase on the dayside, but the eastward disturbance dynamo electric field dominates the nightside main phase of the geomagnetic storm. The counter electrojet current corresponds with the VTEC depletion that we observed during the recovery phase of the geomagnetic storm on the 23 of June 2015. Vertical drift velocity that we calculated from a ground-based magnetometer is used as one of the input parameters for the SAMI2 model to reproduce the effect of the 22-23 June geomagnetic storm on the Brazilian low latitude ionosphere and also to examine the role played by the zonal wind and the magnetic meridional wind in inhibition of the fountain effect as seen on the observation data.

KEYWORDS: Equatorial and Low Latitude Ionosphere, Geomagnetic Storm, Vertical Total Electron Content (VTEC), Prompt Penetration of Magnetospheric Convection Electric Field (PPEF), Disturbance Dynamo Electric Field (DDEF), Counter Electrojet (CEJ), SAMI2 model.

P10 contributed

Space weather relevance of solar eruptive phenomena: Recent results and the new Bulgarian-Egyptian initiative

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Recent results from the collaboration between Bulgarian and Egyptian scientists on the topic of space weather will be briefly outlined. These joint studies include statistical studies and the compilation of various catalogs: solar energetic particles (SEPs) - both protons and electrons, large solar flares, radio emission signatures in relevance to SEPs, and major geomagnetic storms. Selected space weather relevant topics will be explored during a new joint project under the interacademy cooperation program. The goal of this project is to strengthen the mutual collaboration focussing on the space weather effects from remote sensing observations of solar eruptive phenomena to the impacts on satellites in near Earth orbit.

P11 contributed

Cycle 25 Prediction Using Deep Learning Based Forecasting Algorithm

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For the present work, the 13- month smoothed sunspot number data downloaded from WDC-SILSO, Royal Observatory of Belgium Brussels has been used to estimate the strength and peak timing of solar cycle 25. The stacked Long Short-Term Memory (LSTM) deep learning based forecasting model has been employed to predict the upcoming cycle 25. Our investigation has demonstrated that the proposed model has the capability to capture long-term dependencies and trends present in the data. For demonstrating the robustness of the proposed LSTM model, we tried predicting the peak amplitude of solar cycles 20–24. The error between the predicted and observed peak values for cycles 20 and 21 are 2.3 and 0.7 respectively, whereas the peak prediction error is 1.47% and 0.30%., respectively. The root mean square error (RMSE) of the model in predicting solar cycles 20 and 21 is 3.97 and 4.34 respectively. The absolute error (AE) and relative error (RE) for cycle 22 are 4.6 and 2.16%, respectively, and the model's RMSE is 4.50. In case of solar cycle 23 and 24, the predicted peak amplitude using the proposed model has a RE of 1.75% and 1.99% respectively from the observed value while the RMSE is 3.4 for cycle 23 and 4.2 for cycle 24. Using the proposed stacked LSTM model, we suggest that cycle 25 will be weaker than cycle 23 but will be stronger 47% stronger than cycle 24. The solar cycle 25 will peak with sunspot number of 171.9 ± 3.4 during August 2023 ± 2 months.

P12 contributed

Global climate phenomena reflected in anomalies of winter lightning pattern in Northern Europe

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In this study, we use the World Wide Lightning Location Network data and investigate properties of more than ninety thousand lightning strokes which hit Northern Europe during an unusually stormy winter 2014/2015. Thunderstorm days with at least two strokes hitting an area of 0.5° x 0.5° occurred 5-13 times per month in the stormiest regions. Such frequency of thunderstorm days is about five times higher than a mean annual number calculated for the same region over winter months in 2008-2017. The number of individual winter lightning strokes was about four times larger than the long-term median calculated over the last decade. In colder months of December, January and February, the mean energy of detected strokes was by two order of magnitude larger than the global mean stroke energy of 1 kJ. We show for the first time that winter superbolts with radiated electromagnetic energies above one mega joule appeared at night and in the morning hours, while the diurnal distribution of all detected lightning was nearly uniform. The lightning strokes were concentrated above the ocean close to the western coastal areas. All these lightning characteristics suppose an anomalously efficient winter thundercloud charging in the eastern North Atlantic, especially at the sea-land boundary. We found that the resulting unusual production of lightning could not be explained solely by an anomalously warm sea surface caused by a positive phase of the North Atlantic Oscillation and by a starting super El Nino event. Increased updraft strengths, which are believed to accompany the cold to warm transition phase of El Nino, might have acted as another charging driver. We speculate that a combination of both these large-scale climatic events might have been needed to produce observed enormous amount of winter lightning in winter 2014/2015.

P13 contributed

Polarization analysis of electric and magnetic signals onboard spacecraft

Ulrich Taubenschuss, Ondrej Santolik

An investigation of near-Earth space requires understanding of electromagnetic waves and plasma waves in general. Associated electric and magnetic fields are measured onboard spacecraft by appropriate antenna systems. We will discuss recent developments for the analysis of signals from tri-axial antenna systems mounted on spacecraft. A complete magnetic or electric spectral matrix enables us to obtain full information on the polarization of waves. This analysis is based on the singular value decomposition technique. The meaning of singular values and singular vectors will be discussed, and how this method aids with separating wave signals from the noise.

P14 contributed

Solar wind disturbances observed by interplanetary scintillation during 1997-2019

Munetoshi Tokumaru, Kne'ichi Fujiki and Kazumasa Iwai

Interplanetary scintillation (IPS) of cosmic radio sources serves as a useful ground-based method for detecting solar wind disturbances associated with coronal mass ejection (CME) or stream interaction region (SIR), which are known as the main drivers of space weather. IPS observations of the solar wind have been conducted for a long period over multiple solar cycles at the Institute for Space-Earth Environmental Research (ISEE) of Nagoya University using the 327MHz multi-station system. In this study, we determined IPS indices, which act as an indicator of the density disturbance level of the inner heliosphere, from the ISEE IPS observations for 1997-2019, and compared them with the solar wind density (N) and speed (V) from in situ observations at the Earth. As the result, weak but significant positive correlations were found between IPS indices and N and also between those and dV/dt at the time lag of 0 day. This suggests that increased IPS indices may represent the arrival of the compressed plasma leading the high-speed stream; i.e. solar wind disturbances, at the Earth. Meaningful correlations were found between IPS and Dst indices, although their magnitudes were weak. We determined the occurrence rates of solar wind disturbances for which the IPS indices increased above threshold values. The occurrence rates showed solar cycle dependence: two enhancements in the occurrence rate were observed at solar maximum and minimum, which are ascribed to the effects of CME and SIR, respectively. The smaller occurrence rates for 2010-2019 than for 1997-2009 are due to distinct reduction of the solar activity in the solar cycle 24. Thus, the IPS indices cane be used as a handy tool for addressing the long-term variation of solar wind disturbances.

P15 contributed

Development of a prototype for a PCA-NN model for TEC with space weather parameters as predictors

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A PCA-NN model for the total electron content (TEC) for the midlatitudinal region (Iberian Peninsula) is based on the decomposition of the observed TEC series using the principal component analysis (PCA) and the reconstruction of the TEC parameters (the daily mean TEC and amplitudes of the daily PCA modes) with neural networks (NN).

Different NN algorithms (feedforwards with weight backpropagation, convolutional, recurrent) were trained on 3.5 years of observational data (declined phase of the 24th solar cycle), and best sets of predictors (space weather parameters) were defined for each of the TEC parameters and for each of the NN algorithms.

A current stage of the development of a prototype for a PCA-NN model for TEC is discussed.

P16 contributed

SIGNIFICANT SUNSPOT MAGNETIC CLASSIFICATION RELATED TO SOLAR PARAMETERS AND SOLAR RADIO BURSTS ASSOCIATED WITH CORONAL MASS EJECTIONS (CMEs) EVENTS

Z.S. Hamidi, S.N.U.Sabri, N.N.M.Shariff , N. Mohamad Ansor, S.N.A. Syed Hamzah, W.M.A.W.Ismail, Nashwa,M.I, S.N.A.Shamsuddin & N.I.Johari

Sunspots are the darkest patches in the photosphere, and active regions are the concentrated magnetic fields. By using Mount Wilson (Mt Wilson) magnetic classification of sunspots, sunspot groups are classified based on their polarities and magnetic structures. Aside from that, this study identifies the pattern of sunspots and the structure of their magnetic classification during solar maximum in solar cycle 24. A correlation was also found between a sunspot number, solar radio flux, and interplanetary magnetic field, as well as the sunspot's highest magnetic classification. Thus, solar flares and CMEs can be triggered by sunspots with the highest magnetic classification, as well as the production of Type II and Type III bursts. Using Space Weather, Space Weather Live, and CALLISTO websites, the data were collected from 2012 to 2016, during the peak of solar cycle 24. In the past five years, Beta-Gamma sunspots, Beta-Gamma-Delta sunspots, Delta , and Beta-Delta sunspots have been most common magnetic classifications. There is a strong correlation between the progressions of solar cycles and Beta Delta and Beta Delta Gamma sunspots. The sunspot number of Beta Gamma sunspots can also be used to predict solar radio flux (SFU) using the linear equation y=0.4103x+89.95. With this equation, one can expect an increase of 0.4103 in solar radio flux (SFU) for every increase in sunspot number; however, the sunspot number is not reliable for predicting the magnetic field of a sunspot using the line equation y=-0.002858x+6.106. Our findings suggest that bipolar sunspots with a low degree of complexity, such as Beta Gamma sunspots capable of triggering solar flares and CMEs, can launch Type II bursts and Type III bursts toward the Earth. These findings demonstrate that solar flares and CMEs are not only initiated or produced by massive and complex AR structures such as Delta sunspots, Beta-Gamma-Delta sunspots, and Beta-Gamma sunspots. CMEs and solar flares are believed to be triggered by the instability of the magnetic field in the sunspot.

P17 contributed

SDI-3D project

S. Oyama and SDI-3D project members

The dynamics of terrestrial Thermosphere-Ionosphere system is governed by particle collisions between neutrals and plasmas. At high latitudes, external forces originated in the Magnetosphere accelerate ionospheric plasmas, and plasma kinetic energies are exchanged to kinetic and thermal energies of neutral particles. Since these energy transfer processes can be expressed by partial differential equations that incorporates numerous vector fields, it is essentially important to measure vector fields of the Ionosphere and Thermosphere in the common volume at the same time. European Incoherent Scatter (EISCAT) Scientific Association is now building a new international research infrastructure, EISCAT_3D, which adopts the phased-array system capable of conducting volumetric measurements of the ion velocity vector with the separated three radar systems in Norway, Sweden and Finland. The EISCAT_3D is the most powerful diagnostic to measure the ionosphere, but not suitable for measuring the Thermosphere or neutral particles. Then in 2018, a new scientific-oriented project of SDI-3D was established. SDI (Scanning Doppler Imager) is a passive optical instrument, which can measure 2D pattern of the thermospheric wind from the optical Doppler shift. The SDI-3D project has aimed for deploying three SDIs in the common volume of the EISCAT_3D in order to achieve spatiotemporally simultaneous observations of the Ionosphere and Thermosphere. A proposal including three SDIs was awarded in 2020, and we are now working for starting observation in 2023 with two SDIs in Finland and one in Sweden. This presentation will introduce the SDI-3D project.

P18 contributed

OBSERVING THE CORRELATION BETWEEN THE MECHANICS OF HALO CME WITH X-CLASS FLARES DURING THE CLIMAX OF SOLAR CYCLE 24

N. I. Johari, Z. S. Hamidi, N.N.M. Shariff

Solar flares and coronal mass ejections (CMEs) are two of the most important events from the Sun. Despite several theoretical and statistical analyses, the relationship between solar flares and CMEs has not been well understood. Many measurements are available from space and ground-based instruments, which are used in statistical approaches. It was possible to establish a relationship between the measured parameters of two events by charting them against each other. Halo CMEs are special CMEs in that they are directed at Earth and can therefore influence its atmosphere. We investigate the relationship between X-class solar flares and Halo CMEs in this paper. From 2012 to 2014, when solar cycle 24 was at its peak, the data sets were taken from credited websites. In order to determine which mechanical parameter best correlates with the intensity of X-class flares, Halo CME mechanics are divided into two categories: kinetics and kinematics. The strength of flare is highly correlated with the kinetic energy and speed of the Halo CME (a); the strength of flare is weakly correlated with the mass and acceleration of Halo CME (b); and the intensity of flares is strongly correlated with the kinetics and kinematics parameters of the CME.

P19 contributed

Curved trajectory effect on charge-exchange collision at ionospheric temperatures

Akimasa Ieda

Collision between ions and neutral particles is an essential characteristic of 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 has differed among previous studies; the maximum enhancement has been reported as 41% and 11% without physical explanation. In the present study, the contribution of the polarization force to the charge-exchange collision is expressed as a simple curved particle trajectory effect. As a result, the maximum enhancement is found to be 22%. It is discussed that the enhancement has been neglected in classic ionospheric studies partly due to confusion with the glancing particle contribution, which adds 10.5% to the polarization component. The enhancement has been neglected presumably also because there has been no functional form to express it. Such an expression is derived in this study.

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P20 contributed

Results and future plan of the Asia VLF observation network (AVON) toward an understanding of lightning and D-region ionosphere in Southeast Asia

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Asia VLF observation network (AVON) consists of five orthogonal loop antennas, three monopole antennas, and five dipole antennas. The AVON has been installed in Taiwan, Thailand, Indonesia, Philippines, and Vietnam in Southeast Asia. We have been observed wideband very low frequency (VLF)/extremely very low frequency (ELF) electromagnetic waves radiated from lightning discharges and manmade narrowband VLF/low frequency (LF) transmitter signals. In this presentation, we review results obtained by AVON, and discuss the future plan. For studies of the D-region ionosphere, the VLF/LF transmitter signals of the AVON have been used as an effective indicator of solar flares stronger than C-class (Suryana et al., Journal of Physics: Conference Series, 2021). During a solar eclipse of 22 July 2009, the D-region height increased by 5-6 km for the paths across the eclipse (JJY40kHz-Tainan (TNN), JJY60kHz-TNN, and BPC-TNN paths), and by 1-2 km for partial eclipse paths (Ohya et al., JGR, 2012). For studies of lightning, the AVON data have been used for short-term prediction for thunderstorm (0.5-1 hour) and typhoon (1-2 days), in addition to estimation of location for lightning (Takahashi et al., EGU General Assembly 2020). Occurrence number of lightning and maximum wind speed of major hurricanes with categories of more than 4 are significantly correlated with a correlation coefficient of 0.82 with the lag time ~30 h (Price et al., Nature Geoscience, 2009). Energy input of typhoons was estimated by counting the number lightning swept strokes from the AVON data (Purwadi et al., AGU Fall Meeting 2020). In this presentation, we will discuss the future plan of the AVON, and international cooperation based on ground-based and satellite observations.

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P21 contributed

Waveguide-to-Coplanar Waveguide Transition for Multi-Beam Millimeter-Wave Atmospheric Observation using a Planar-Integrated SIS Element

Akihiro Masukura 12, Wenlei Shan 1, Shohei Ezaki 1, Takafumi Kojima 1, Tac Nakajima 2 and Akira Mizuno 2
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2:Nagoya University

Our group has realized the ground-based multi-frequency millimeter-wave atmospheric observation using a Superconductor-Insulator-Superconductor (SIS) junction device. However, even with the low noise superconducting receiver, about 24-hour integration is required to measure trace molecules with weak intensity, such as nitric oxide. Receiver noise has already been suppressed to near the quantum limit, and dramatic improvement can no longer be expected by improving the receiver's performance. In this situation, taking independent data simultaneously with a multi-beam receiver and averaging them could reduce random noise or integration time, assuming that the air mass can be considered identical and uniform within the field of view of the beams. Therefore, we are currently studying a compact multi-beam receiver with a planar and miniaturized waveguide section by using MMIC-SIS with integrated functional circuits and SIS junctions on a silicon chip [Shan et al. 2019].

In the development of the receiver, since the radiation from the atmosphere and the local oscillator signals for heterodyne systems are provided by rectangular waveguides, the broadband and low loss of waveguide to co-planar waveguide (CPW) transition that converts these signals into CPW on MMIC-SIS is a crucial point. Using electromagnetic simulation software, we have successfully designed a transition with 70 % relative bandwidth of less than 0.5 dB insertion loss and 59 % relative bandwidth of more than 15 dB reflection loss in the target bandwidth of 125-211 GHz (without considering resistive loss and surface roughness). This was because of matching in a wide bandwidth by optimizing the waveguide size and the shape of the H-bend in the waveguide section, as well as adjusting the depth of the backshort and the scaling in the probe antenna section. This result indicates that the same level of performance as existing transitions can be achieved with twice the bandwidth.

We plan to measure the transitions placed back-to-back at cryogenic temperatures, which is the operating environment of the superconducting receiver. This will be the first direct measurement of the waveguide-to-CPW transition in the millimeter-wave at such low temperatures. This research is expected to establish measurement techniques in cryogenic domain techniques and provide test ports for other planar circuits used at cryogenic temperatures. This research will contribute not only to the broadening of MMIC-SIS itself but also to the enhancement of the functionality of MMIC-SIS by providing a test environment in which development can proceed while performing actual measurements of planar circuits at cryogenic temperatures.

P22 contributed

Forecasting of the EMIC occurrence rate: Relative importance of the solar wind dynamic pressure and enhanced geomagnetic activity

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Energetic particles driven by wave-particle interactions during strong geomagnetic storms can have a disastrous impact on spacecraft systems. The forecast of the wave activity, as ElectroMagnetic Ion Cyclotron (EMIC) waves, can help to prevent these outcomes. EMIC wave growth usually results from ion temperature anisotropy. In the sunward part of the magnetosphere this anisotropy can be consecutive to episodes of magnetospheric compressions resulting from impulses in the solar wind dynamic pressure (Pdyn). In the afternoon part of the magnetosphere following periods of enhanced geomagnetic activity (large values of Kp), temperature anisotropy can be observed in the energetic ion population convected from the magnetosphere nightside toward the dayside. Enhanced geomagnetic activity can be related to large magnetosphere compressions. However, when resulting from magnetosphere compression events, EMIC are observed almost immediately (less than an hour), whereas it takes longer to observe large Kp values (about one day or more). Recently we showed that in the dayside of the magnetosphere the distance to the magnetopause organizes the EMIC occurrence rate in a better way than the distance to Earth, confirming the role of the magnetopause compression.

This study gathers observations of EMIC waves observed by Cluster spacecraft and Van Allen Probes. Cluster has a high-inclination orbit and its apogee is at almost 20 Earth Radii (perigee above 4 Earth radii). Van Allen Probes orbits are designed to investigate the equatorial region of the inner magnetosphere (from about 2 to 6 Re). The same automatic detection procedure (adapted from Bortnik et al.) is applied to Cluster/FGM and Van Allen Probes/EMFISIS/FGM datasets in the Pc1 frequency range (0.1-2Hz) in order to detect narrowband emissions. We compare the influence of Kp and Pdyn on the EMIC occurrence rate in order to disentangle between the two EMIC populations that can overlap in space. A particular attention is put on the periods when large Kp and Pdyn are observed at the same time. Differences of wave properties (intensity, polarization, wave vector angle, …) related to the two different ion populations are also investigated.

P23 contributed

The Structure and Microstructure of Rising-Tone Chorus With Frequencies Crossing at f ~ 0.5 fce

Rui Chen, Bruce T. Tsurutani, Xinliang Gao, Quanming Lu, Huayue Chen, Gurbax S. Lakhina, and Rajkumar Hajra

Intense, midnight-to-dawn sector, near-equatorial, chorus rising tones which cross frequencies of ~0.5 fce have been analyzed to determine their structures and possible substructures. Upper band ($f \geq 0.5$ fce) chorus and "gap" ($f \sim 0.5$ fce) chorus are examined in detail for the first time. It is found that upper band chorus and gap chorus are composed of the same structure as lower band ($f \leq 0.5$ fce) chorus: they are composed of short-duration subelements, which are monochromatic with $\sigma \leq 1\%$. These findings have strong implications for the chorus element generation mechanism. Following Kennel and Petschek (1966) the overall chorus riser is most likely generated by anisotropic ($T\perp/T\,//\, > 1$) ~10-100 keV substorm-injected electrons. Assuming cyclotron resonance, the upper band chorus is generated by the low energy portion of the electron spectrum. The often-present gap at ~0.5 fce is related to Landau/cyclotron damping. This however is not the end of the story. There is another type of two-frequency chorus (called Type 2) for which the lower band is not well connected to the upper band. A Type 2 chorus reported previously by Fu et al. (2014) has also been studied in detail. Both the lower band and upper band are composed of subelements which are monochromatic. Such a similar fine structure for the different type of chorus may imply a similar generation mechanism, for which the difference between them is just the energy range of resonant energetic electrons. One mechanism discussed here, generation by phase bunched electrons, will be tested in the near future.

P24 contributed

Time variations of molecular ions in the inner magnetosphere observed by Arase

A. Nagatani, Y. Miyoshi, K. Asamura, S. Nakamura, M. Shoji, L. M. Kistler, Y. Ogawa, K. Seki, I. Shinohara

In the Earth's magnetosphere, there are several kinds of ions originated from both the solar wind and the ionosphere. Molecular ions in the magnetosphere are originated in the Earth's ionosphere. For example, statistical studies based on 20 years of Geotail/STICS data has indicated that the count rates of magnetospheric molecular ion are sensitive to geomagnetic activity [Christon+, 2020]. The Arase satellite has observed various kinds of ions since 2017 and two ion analyzers LEPi and MEPi cover energy range from 10 eV/q to 180 keV/q. Using the data from the MEPi instrument, variations of molecular ions to magnetic storms and solar wind conditions have been investigated, and molecular ions are observed in the inner magnetosphere even during small magnetic storms [Seki+, 2019]. However, observations about molecular ions are still not enough compared with other ion observations, and the mechanism of the outflow from the ionosphere as well as the long-term variations are not well known. In this study, we analyzed the time-of-flight (TOF) data from LEPi [Asamura+, 2018] onboard Arase to investigate variations of molecular ions in the inner magnetosphere and their dependence about magnetic activities and solar wind conditions. LEPi covers the energy range from 10 eV/q to 25 keV/q and counts as function of energy and TOF are obtained every 16 seconds. The TOF measurements of LEPi have been operated in the outbound pass every four revolutions around the Earth. In the analysis, we estimated counts of molecular ions by fitting the empirical functions onthe TOF profile using the non-linear least squares method. The estimated counts were calibrated by the time variations of efficiency of the LEPi instrument. Using this data set, we investigated relationships between molecular ion count and geomagnetic index and solar wind parameters. The results suggest that counts of molecular ions increase with solar wind speed as well as density. Also, we found that molecular ions appear in the magnetosphere during not only magnetic storms but also non-magnetic storms.

P25 contributed

Analyses of Spatiotemporal Variation of Mesospheric and Upper Stratospheric Ozone During Solar Eclipse Observed with AURA/MLS

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A solar eclipse is a natural phenomenon which offers a good view on the response of atmospheric physical-chemistry processes to a prompt blackout of solar radiation. Since ozone and ozone-depleting molecules in the upper stratosphere and mesosphere include production and loss processes caused by photochemical reactions, large changes in composition according to the portion of the eclipse are expected during a solar eclipse. Given that, however, the few observational limitations (e.g. Imai, et al. GRL, 2015) as well as the insufficient knowledge obtained for this field, in this research two of recorded eclipse events of July 22, 2009 and January 15, 2010, remarkable as the longest duration of total and annular eclipse in 21st century, respectively, are surveyed to work on the mechanism of middle atmospheric variation during an eclipse. For the 2009 event of total solar eclipse, significant ozone increment of up to 20% in the altitude range from 50 to 60 km was found and reach as much as that of nighttime up to 53 km while the increase of about 30% at altitudes near 58 km was found but only half of nighttime ozone concentration during the 2010 event of the annular solar eclipse. Both are in consistent with the previous studies on the mesospheric and upper stratospheric nighttime ozone trend, but the rate of increase is smaller. However, ozone concentrations observed by Aura/MLS are lack of high-resolution above 60 km.

In the presentation, we will report the results of the analysis of the short-term variation of ozone and ozone-depleting substances, and also discuss the factors of the short-term variation of ozone by altitude during solar eclipses.

P26 contributed

Precipitation of high-energy electrons into the mesosphere associated with pulsating aurorae: Arase and EISCAT conjugate observations

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Wave-particle interactions with LBC near the equator cause electron precipitations with energies of about 1-100 keV, and pulsating aurora (PsA) is caused by intermittent precipitations. On the other hand, recent studies have shown that sub-relativistic/relativistic electrons with energies of several hundred of keV to several MeV are scattered by chorus waves, propagating to high latitudes along the field line and precipitate into the mesosphere at an altitude of 60-80 km simultaneously with PsA (Miyoshi et al., 2015, 2020, 2021). In this study, we investigate the high-energy electron precipitations during PsA events that occurred at Tromsø, Norway, from 02:00 to 06:00 UT on March 12, 2022, using data from the Arase satellite and EISCAT radars. Using the plasma wave data observed by Arase, we derived the pitch angle diffusion coefficient of electrons through interactions with whistler mode waves. The result indicates that the observed LBC causes the pitch angle scattering of electrons with 10-15 keV near the magnetic equator. The EISCAT observation showed electron density enhancement at 68 km altitudes and higher, which suggests that energetic electrons of 200-400 keV were precipitated (Turunen et al., 2009). The analysis of the pitch angle diffusion coefficients shows that such high-energy electrons can be scattered by LBC around 30 magnetic latitudes. Considering these analysis, we suggest that the pitch angle scattering by LBC along the field line causes wide energy electron precipitations from a few keV to more than 100 keV during PsA.

P27 contributed

Investigation of coronal mass ejection at different heliospheric distances using Solar Orbiter, BepiColombo, and Wind data

Shirsh Lata Soni, R Selva Kumaran, Ankush Bhaskar, R Satheesh Thampi

This paper addresses the investigation of the ICMEs encountered by Solar Orbiter, BepiColombo and Wind spacecrafts on April 19-20, 2020, from both an observational and a modeling perspective. A coronal mass ejection (CME) was observed in situ by Solar Orbiter on April 19, 2020, at a heliocentric distance of nearly 0.8 AU. The CME was later detected in situ by the Wind and BepiColombo spacecrafts on April 20, while BepiColombo was quite near to Earth. Because the spacecraft were separated by less than 5° in longitude, this CME gives an excellent opportunity for a triple radial alignment investigation. The CME, which was initiated on April 15, was caused by an almost completely isolated streamer explosion. The event was remotely detected by the Solar Terrestrial Relations Observatory (STEREO)-A satellite from 75 longitude angle, which is an extremely well-suited perspective for heliospheric observing field of view of an Earth-directed CME.The four spacecraft's configuration provided an extraordinarily significant relationship between global imaging and in-situ investigations of the CME. To estimate the global structure of the CME and its evolution as it travelled through the inner heliosphere, we employed in situ measurements from Solar Orbiter, Wind, and BepiColombo, as well as distant observations from STEREO-A. When examination of magnetic field strength relationships indicates that the CME expansion is unlikely to be self-similar or cylindrically symmetric.Additionally, we compare in situ magnetic field measurements from distinct spacecraft, we observe that the influence of the highest magnetic field strength on heliocentric distance reduces.

P28 contributed

Deepening of radiation belt particles in South Atlantic Anomaly Region: A scenario over past 120 years

Pankaj Kumar Soni*, Bharati Kakad, Amar Kakad

The geomagnetic field has an unusual weak spot over South America and the South Atlantic Ocean, called South Atlantic Anomaly (SAA). We know that the magnetospheric particles trapped in the geomagnetic field move to the deeper altitudes over the SAA, resulting in the lower inner boundary of the radiation belt. However, over the past 400 years, the magnetic field in the SAA region has decreased consistently. In some recent studies, a rapid decrease of the magnetic field in the SAA region and the possibility of splitting of SAA have been reported. This weakened geomagnetic field has a bearing on the lower altitudinal reach (deepening) of the radiation belt particles. In this context, we performed simulations to examine and quantify the lowest altitudes encountered by the radiation belt particles over the SAA region. We found that particles of energies 100 keV-50 MeV, initially entering from an altitudes of 1–2 Earth radii are moving closer to the Earth at the rate of 3:8 4:7 km/year, which results in approximately 434 590 kms decrease in their altitude over the SAA region during 1900 to 2020. Furthermore, we noticed that the lowest altitude encountered by the particle in the SAA region is dependent on the initial longitude and independent of its initial local pitch angle corresponding to its entry in the Earth's magnetosphere.

P29 contributed

Reconstruction of the global solar wind structure from 1975 to 2021

Ken'ichi Fujiki, Munetoshi Tokumaru, Kazumasa Iwai

The solar wind is an important piece of information in space weather, space climate, and heliophysics, however, we have not yet fully understood its origin and acceleration mechanism and its propagation in the heliosphere. Especially for the space climate, a variation of the global solar wind structure provides the key to understanding. Interplanetary scintillation (IPS) observation at the Institute for Space-Earth Environmental Research (ISEE) started routinely in 1985, and it allows us to reconstruct global solar wind velocity structure in each Carrington rotation (CR) without winter. Here, to derive long-term variations, ISEE-IPS data are converted into latitudinal velocity structure data such as sunspot butterfly maps. It is clearly seen that the solar wind is composed of two types of solar wind with about 400 km/s and 800 km/s, known as the bimodal solar wind, and their boundary latitudes depend highly on solar cycles. In this study, the bimodal boundary latitude is defined as the latitude at a longitudinally averaged solar wind velocity of 600 km/s. The solar wind is accelerated in the low plasma-beta corona; it is confined along a magnetic field open to the interplanetary space. The origin of the solar wind closely relates to the photospheric magnetic field distribution. Therefore, the solar wind origin can be estimated potentially by calculating the coronal magnetic field. We introduce the PFSS analysis which is known as one of the robust techniques to extrapolate the coronal magnetic field from the photosphere to interplanetary space, then, we estimate the distribution of the photospheric origin of the solar wind and compare solar wind velocities to various parameters of coronal magnetic structure from 1985 to 2021. As a result, we obtain the following results. 1) Solar wind origins distribute a similar pattern of photospheric magnetic butterflies. 2) A good correlation is found between the boundary latitudes and tile angles of the heliospheric current sheet. 3) A good correlation is found between the bimodal boundary latitudes and a parameter defined by using the PFSS spherical harmonics. 4) the solar wind structure is well reconstructed from a latitudinal structure of magnetic flux expansion rate, however, reproducibility of the bimodal boundary is reduced compared to 2 and 3. These results can be used to fill the winter gaps in ISEE-IPS observation and to extrapolate the global solar wind structure, and finally, we reconstruct the global solar wind structure back to 1975 when modern solar observations began.

P30 contributed

Magnetic field structure and non-thermal velocity in the plasma upflow region

Sora Nakada, Munetoshi Tokumaru, Kazumasa Iwai, Ken'ichi Fujiki, Shinsuke Imada

Plasma upflows have been detected by Hinode's Extreme Ultraviolet Imaging Spectrometer (EIS). They are usually observed in the transition regions or corona above the active region. Some studies have suggested that the upflow is the source of the slow solar wind. However, the relationship between upflows and the slow solar wind has not been understood. The global structure of the magnetic field associated with upflows, in particular, whether the magnetic field lines above the upflow are open or closed, will be an important point to investigate the relationship between the upflows and slow solar wind.

In this study, we analyzed EIS data obtained from Hinode observations to identify upflow events. We calibrated the EIS data using the eis_prep routine available in the Solar SoftWare (SSW) library and obtained Doppler velocity maps from a single Gaussian fit of the FeXIII 202.04 angstrom line with the eis_auto_fit routine. We also corrected the orbital variation using the eis_update_fitdata routine. We used potential field source surface (PFSS) extrapolation to study the configuration of the coronal magnetic field around the upflow region. The PFSS extrapolation was performed using the synoptic magnetogram of the ADAPT model 0. For comparison, we analyzed non-thermal velocities of the upflow regions connected to open/closed magnetic field lines. In this analysis, we chose AR 11271 (2011 Aug 21), AR 12685 (2017 Oct 26), and AR 12713 (2018 Jun 17), where both upflows associated with open and closed field lines are observed. Non-thermal velocity is a broadening of the spectral linewidth that cannot be explained by thermal or instrumental broadening, that can be an important observational constraint for coronal heating models based on nanoflares and wave dissipation (Brooks 2016).

Our analysis showed that only three of the thirteen upflows were connected to an open magnetic field line. This result is similar to that of Edward et al. 2016, where only one of the seven was connected to an open magnetic field line. This result indicates that not all upflows can be the source of solar wind. In addition to this result, our analysis shows that the open upflow regions had smaller line widths than the closed upflow regions. This result means that the thermal temperatures or non-thermal velocities are smaller in the open upflow regions. In the latter case, open and closed upflow may have different generation mechanisms.

P31 contributed

Long-term monitoring of atmospheric minor constituents using high-resolution FTIRs in ISEE

Tomoo Nagahama, Isao Murata, Isamu Morino and Hideaki Nakajima

Since 1995, ISEE has been monitoring the changes in the composition of atmospheric minor constituents from solar absorption spectrum observations using two high-resolution FTIRs operated in Hokkaido, Japan. Greenhouse gases, the ozone layer, its depleting substances, air pollutants related to forest fires, etc., which are deeply related to today's global environmental problems, have absorption spectra in the infrared region and can be observed with an infrared spectrometer. The data on trace constituents obtained from the observations have been released as fundamental data for studying long-term changes in the substances responsible for global environmental changes, and It is used for global monitoring of stratospheric and tropospheric air quality fluctuations of increasing importance, such as irregular trends in stratospheric chlorine loading, which is thought to be associated with long-term fluctuations in the Brewer-Dobson circulation; fluctuations in urban air quality, where pollution from human activities is a problem; and monitoring trends in methane and ethane increases due to recent extraction and utilization of natural gas resources. We are also preparing to install a high-resolution FTIR in Nagoya in 2022 to begin observations similar to those at other observatories. In addition to conducting monitoring of trace constituents in the stratosphere and troposphere, the project will also focus on air pollutants in the urban area and will monitor changes in air quality in Nagoya. In the presentation, the results of the long-term monitoring of compositional change to date and future monitoring plans will be reported in detail.

P32 contributed

Digitization of Toyokawa radio polarimeter plot data (1958-1978) and size estimation of past large solar flares

Satoshi Masuda, Keitaro Matsumoto, Hisashi Hayakawa (Nagoya University), and Masumi Shimojo (NAOJ)

Solar radio (1, 2, 3.75, 9.4 GHz) intensity/polarization data observed at the Research Institute of Atmospherics, Nagoya University (currently the Institute for Space-Earth Environmental Research) from 1958 to 1978 had been recorded in microfilms. We are carrying out a project to scan these records, and to store and publish them as a digital image database. All scanning has been completed in the fiscal year 2021, and the number and data volume of image files have finally reached up to ≈ 57,000 and ≈ 35GB, respectively. As soon as the data and related metadata are prepared, we plan to put them into a database with DOIs attached and release them to the community.

It is important to estimate the magnitude of past solar large flares that occurred before the 1980s, when soft X-ray monitoring by the GOES satellites was not conducted, for understanding sources of past space weather events such as magnetic storms and GLE. Thus, we investigated correlation between peak flux of 9,4 GHz and GOES X-ray peak flux. Using about 600 events observed at 9.4 GHz by the Toyokawa-Nobeyama radio polarimeter from 1990 to 2014 with soft X-ray observations by the GOES satellite, a correlation with a correlation coefficient of about 0.7 was obtained. This result indicates that it is possible to estimate the GOES X-ray class from the 9.4 GHz peak flux. On this basis, if the calibration of the instrument can be confirmed, the scan data of the Toyokawa radio polarimeter may be useful for estimating the size of past large solar flares in the future.

P33 contributed

Data-driven MHD simulation of both flux rope formation and an eruptive event in AR 11283

Yeongmin Kang, Takafumi Kaneko, KD Leka, Kanya Kusano

Solar eruptive events such as solar flares are caused by the release of magnetic energy accumulated in the solar atmosphere. To understand the physical mechanism of solar flares, the dynamics of magnetic fields in the solar corona must be studied. Unfortunately, the dominant mechanisms are still unclear due to lack of information about coronal magnetic fields. Numerical simulations based on magnetohydrodynamics (MHD) reproducing the dynamical evolution of solar corona can be a useful method to explore flare initiation. One approach to explore different mechanisms is a data-driven MHD simulation in which the time-series observational data of the photospheric magnetic field can be used as input data. We used a data-driven model (Kaneko et al. 2021) in which the time-series data of the observational photospheric magnetic field was introduced to the bottom boundary. The target of our simulation was solar active region 11283 (AR 11283) where several large flares occurred successively. The simulation was governed by zero-beta MHD, focusing on the long-term period from the formation of the highly-twisted flux rope to the M5.3 flare whose peak time was 2011 Sep, 6 01:59 UT. The simulation covered the period from 2011 Sep, 4 19:48 UT to Sep, 6 06:48 UT. We reproduced both the flux rope formation and the following eruptive event, both of which were consistent with observations. We found that the formation of highly-twisted flux ropes and the eruption were triggered by the magnetic reconnections between the field lines belonging to the flux rope themselves. Moreover, we explained the direction of eruption by introducing a new method to evaluate the decay index for MHD (torus) instability.

P34 contributed

Study on hydrometeor classification based on polarization radar measurements -Compare the clustering approach and HC techniques-

Zhu Chendi, Department of Earth and Environmental Sciences, Nagoya University
Nobuhiro Takahashi, ISEE, Nagoya University

Hydrometeor classification (HC) is the techniques that retrieve the dominant hydrometeor type within the given volume. Its inputs are usually the polarimetric radar parameters. However, these kinds of approaches have the limitations, especially on the ice-phase hydrometeors due to the complex geometries and melting process.

Recently, a clustering technique (agglomerative hierarchical clustering algorithm) is applied to a database of precipitation measurements collected by an X-band dual polarization Doppler radar and seven hydrometeor classes are identified in this research. Since this algorithm is high in time complexity, it is not suitable for large dataset. In this paper, we apply BIRCH (balanced iterative reducing and clustering using hierarchies), an algorithm used to achieve hierarchical clustering over particularly huge data-sets, to the hydrometeor classification in order to summarize the characteristics, and validate the results using the HC techniques, and try to find the feature of hail particles.

The radar reflectivity data is from the Multi-Parameter Phased Array Weather Radar (MP-PAWR) (N35.8615°, E139.6090°). The MP-PAWR can make 3-D observations up to 15 km with a maximum range of 60 km (75 m spatial resolution). A data set, consisting of 3000 observations(x^*={ZH, ZDR, Kdp, ρhv, Δz}) taken from 6 precipitation events, is manually selected as input to the cluster analysis. A fuzzy-logic-based HC method, which identifies hydro-meteor from eight categories is used in this paper for a comparison.

In this paper, we use Calinski-Harabasz index (CH) , one of the clustering algorithms evaluation measures to evaluate the goodness of the result. After calculating the combination of various parameters, the number of the clusters is selected to be 7, and threshold to be 0.2, corresponding to the largest Calinski-Harabasz score, which represents the best result.The results of the two methods are in high agreement below the melting layer.

The future work is to summarize and label each cluster of Birch. This result could be employed as a support to fuzzy-logic-based classification methods to improve or adapt the membership functions. We also try to use the entropy as a measure of uncertainty, which indicates a level of uncertainty with which a hydrometeor class is assigned to an observation.

P35 contributed

A compression method for Stokes I and V polarimetric parameters of solar spectral data accumulated by Hinode/SP

Jargalmaa Batmunkh (Niigata U.), Yusuke Iida (Niigata U.), Takayoshi Oba (NAOJ), Haruhisa Iijima (Nagoya U.)

Space weather plays a significant role in helping us to understand the Sun-Earth relationship. Challenging tasks of space weather forecasting, in particular, predicting hazardous phenomena driven by solar flare, are potential to be done by the state-of-the-art computational tools and approaches with the use of solar observational data, such as solar spectra which contain important physical information.

Spectro-polarimetry data has been accumulated by the Hinode satellite for more than a decade. However, it is difficult to process such a large amount of high dimensional data even with the latest methods of informatics, including machine learning techniques. To this end, we aim to obtain a compressed representation of solar spectral data which is an important step for further detailed analysis of the polarimetric spectra, such as flare prediction, automatic categorization of spectra, detection of anomalous spectra, and so on.

Solar Optical Telescope-Spectropolarimeter (SOT-SP) data was used in this study. The spectro-polarimeter (SP) covers a wavelength range between 630.1 and 630.3 nm, including the Fe I line pair at 630.15 nm and 630.25 nm. The observation date is 2021-08-03 and the field-of-view (FoV) of the 2D spatial spectro-polarimeter is 75.6"× 81.2" with a sampling slit of ~0.15". The data was selected by its capture near the disk center (not around the solar limb) and inclusion of both regular surface and sunspot regions.

We built an autoencoder for compressing Stokes I and V polarization parameters. The model gets polarization data as input and encodes and decodes it to output data, which should be as similar as possible to the input data. Output of the encoding part is our feature vector, namely the compressed representation of Stokes I and V parameters.

For the model training we constructed a customized loss function as the sum of mean absolute error (mae) of Stokes I and weighted mae of Stokes V. The weight value is determined as 0.1 which is the variance ratio of Stokes I and V continuum. We analyzed the model performance from the correlation between raw and reconstructed spectra. Our study resulted in standard deviation (std) of 2.71–3.16% at the line centers and less than 0.7% at the continuum for Stokes I, and 4.46–4.79% at the line cores for Stokes V. The result shows that by using the customized loss function our model performed with smaller std values for reconstruction of the Stokes parameters.

P36 contributed

Energetic Particle Chain -Effects on the middle/lower atmosphere from energetic particle precipitations-

Tac Nakajima, Tomoo Nagahama, Satonori Nozawa, Shin-ichiro Oyama, Yoshizumi Miyoshi, Akira Mizuno, and the EPC consortium members

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 (NOx) and odd hydrogen (HOx), which can affect the neutral chemistry of the middle atmosphere and the ozone (O3) 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 based on observations in each region and comprehensive simulations. In this context, we started a new research project called the "Energetic Particle Chain" in the Institute for Space-Earth Environmental Research, Nagoya University in 2021. This project plans to conduct multi-point and long-term observations using the Arase satellite for measuring trapped particles in the magnetosphere, the EISCAT_3D at North Europe, the Poker Flat Incoherent Scatter Radar at North America as well as riometers for measuring EEP-induced ionization in the ionosphere, and millimeter-wave spectroradiometers at polar cap and auroral regions for the monitoring of atmospheric minor molecules such as O3, NOx, and HOx from the lower thermosphere to the upper stratosphere. These measurement data will be used as inputs and constraints in modelling, 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. In this presentation, we will report a brief introduction and status of the project.

P37 contributed

Performance of cosmic ray observations with global networks of the ground-based neutron monitors and muon detectors

K. Munakata, M. Kozai, R. Kataoka, C. Kato

We demonstrate what we can deduce from cosmic ray observations using global networks of the ground-based neutron monitors and muon detectors. As an example, we analyze a Forbush event in November, 2021 observed simultaneously with 21 neutron monitors and 69 directional channels of muon detectors. Utilizing the difference between primary cosmic-ray rigidities monitored by neutron monitors and muon detectors, we deduce the rigidity spectra of the cosmic-ray density (or omnidirectional intensity) and the first- and second-order anisotropies separately, for each hour of data. A clear two-step decrease is seen in the cosmic-ray density with the first decrease after the interplanetary shock arrival followed by the second decrease inside the magnetic flux rope (MFR). Most strikingly, a large bidirectional streaming along the magnetic field is observed in the MFR with a peak amplitude comparable to the total density decrease inside the MFR. The bidirectional streaming could be explained by adiabatic deceleration and/or focusing in the expanding MFR, which have stronger effects for pitch angles near 90 degree, or by selective entry of GCRs along a leg of the MFR. The peak anisotropy and density depression in the flux rope both decrease with increasing rigidity. The spectra vary dynamically indicating that the temporal variations of density and anisotropy appear different in neutron monitor and muon detector data.

P38 contributed

Effectiveness of the aircraft observation for vertical profiles of water vapor

Taro Shinoda (ISEE), Masaya Kato (ISEE), Sachie Kanada (ISEE), Norio Nagahama (Meisei Electric Inc.), Kensaku Shimizu (Meisei Electric Inc.), Tadayasu Ohigashi (NIED), Soichiro Hirano (Univ. Ryukyus), Hiroyuki Yamada (Univ. Ryukyus), Satoki Tsujino (MRI, JMA), Kazuhisa Tsuboki (ISEE), Shingo Shimizu (NIED)

To perform quantitative precipitation forecasting (QPF), it is necessary to observe water vapor distribution on the windward side accurately. However, it is difficult to observe it in Japan, because Japan is surrounded by the ocean and has quite less ground-based sounding observation points over the ocean. The dropsonde observation using an aircraft is useful to observe vertical profiles of water vapor over the sea. We carried out dropsonde observations using a jet aircraft (Gulfstream-IV: G—IV) of Diamond Air Service Inc. in order to grasp the distributions of water vapor over the Pacific Ocean and East China Sea on July 5, 2022. At that day, Typhoon Aere (T2204) struck Kyusyu and passed along the southern coast of Shikoku Island. Numerical simulations showed large amount of water vapor intrusion in the eastern side of the typhoon and heavy rainfall around the southern coast of Japanese Islands. Outward flight in the morning was carried out from Nagoya to Shimojishima Airport (Okinawa Prefecture), and homeward one in the afternoon was vice versa. The G-IV flew at a speed of 450 knots (833 km/s) and at a height of 45,000 ft (13.7 km). Dropsonde observations were conducted every 5 min (approximately 70 km resolution) except for some restricted observation region, and were obtained temperature, relative humidity, wind direction and speed at each altitude (pressure level) at every 1 sec. Observed water vapor amount is quite lesser than the simulated one in the whole troposphere; that is, the observed mixing ratio of water vapor is 3-5 (1-2) g/kg lesser than the simulated one in the lower (middle) troposphere at the dropsonde observation points. Numerical simulation forecasted heavy rainfall in eastern Shikoku Island and Kii Peninsula in the morning and afternoon at that day, however, the heavy rainfall is not observed by the lack of water vapor in the lower and middle troposphere in the windward region shown by the dropsonde observations. Large discrepancies of water vapor amount are also confirmed in the parent global scale model provided from the Japan Meteorological Agency (JMA). To perform accurate QPF, we have to clarify the cause of discrepancies of water vapor distributions in the numerical simulation in comparison with the aircraft observations. This research should show the effectiveness of aircraft observations.

P39 contributed

Do pre-event conditions of the upper solar atmosphere differ for flare-imminent vs. flare-quiet active regions?

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Observational case studies of the solar chromosphere and corona reveal increased levels of magnetic reorganization, dynamics, and temperature variation prior to solar energetic events. Here, we investigate whether parameters describing these activities can differentiate a region that will imminently produce a solar flare from one that will not. We statistically analyze the coronal and chromospheric conditions prior to solar flares and during flare-quiet periods using a machine-learning ready dataset from the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) recently created by NWRA. The AIA Active-Region Patches dataset (AARPs; Dissauer et al. 2022, ApJ under review) consists of region-targeted extractions of AIA time-series data in (extreme-) ultraviolet, matched to the HMI active region patches (HARPs), for most of solar cycle 24. Down-selection in the spatial domain is solely from full-disk to active-region size; the native spatial sampling is retained. Down-selection in the temporal domain is more severe (13min time intervals per hour at 72s cadence for 15:48-21:48 UT daily) yet allows for both short-lived features and longer-term trends to be evaluated. We characterize the pre-event dynamics and heating of the upper solar atmosphere using moment analysis through the kurtosis of brightness images and running-difference images. The temporal behavior is captured by the slope and intercept of a linear fit over a 6hr time-series of each parameter.

The NWRA Classification Infrastructure (NCI), a well-established statistical classifier system based on Non-Parametric Discriminant Analysis, is applied to 32,000+ samples and four different flare-based event definitions to evaluate if parameters describing the pre-event conditions significantly differ for flare-imminent vs. flare-quiet populations (Leka et al. 2022, ApJ, under review). We find top Brier Skill Scores in the 0.07 – 0.33 range, True Skill Statistics in the 0.68 – 0.82 range (both depending on event definition), and Receiver Operating Characteristic Skill Scores above 0.8. Classification success using higher-order moments of running difference images indicates enhanced levels of short-lived brightenings in flare-imminent active regions. A high temperature ``memory'' of flare activity is also found. The 94 A filter data provides the most parameters with discriminating power with indications that it benefits from sampling multiple physical regimes.

This research was made possible by funding primarily from NASA/GI Grant 80NSSC19K0285 with some initial exploration through AFRL SBIR Phase-I contract FA8650-11-M-1147, and some final support from NASA/GI Grant 80NSSC21K0738 and NSF/AGS-ST Grant 2154653.

P40 contributed

Comparison of magnetic flux rope structures obtained by two analysis methods: Fitting to force-free model vs Grad-Shafranov reconstruction

K. Marubashi, D. Shiota, Y. Kubo, H. Hasegawa, and M. Tokumaru

The main target in the analysis of interplanetary magnetic flux ropes (IFRs) is to determine the 3-D geometries and the internal magnetic field structures. In such studies, the following two methods are commonly used: (1) fitting of observed magnetic fields to force-free models (FF method), and (2) reconstruction of IFRs based on the Grad-Shafranov equation (GS method). The GS method is attractive in that no assumption is needed for the shape of the IFR cross-section. However, it needs magnetic field distribution along the line which is used as a boundary condition for calculating the spatial structure of the IFR. This raises a difficulty in analyzing the observed IFRs, because the data obtained along the spacecraft orbit are generally combination of spatial and temporal variations. In this study, we first extend the GS method so as to be applicable to dynamic (expanding) IFRs. Then we apply it to the 15 July 2000 flux rope. The field variation shows strong asymmetry between inbound and outbound parts, which is taken as the evidence for the expansion of this IFR, together with the decrease of the solar wind speed observed within the IFR. Our extended GS method yields the internal field structure which is very close to the structure obtained from the FF method. We emphasize that the extended GS method is applicable to analysis of expanding IFRs, while such dynamic IFRs could not analyzed by the original (earlier) GS method. We expect that further comparison between results from the extended GS method and the FF method for many events can give us information about deformation effects on the IFR cross-section shapes.

P41 contributed

Wave amplitude dependence of the pulsating aurora emissions

Kazuteru Takahashi, Shinji Saito, Yoshizumi Miyoshi, Kazushi Asamura, Keisuke Hosokawa

The Pulsating aurora is a type of diffuse aurora, and pulsation periods are several seconds - several tens of seconds. The amplitudes of the optical emissions should be proportional to the downward energy flux inside the loss cone, so it is natural to consider that that optical emission increases when the wave amplitudes increase if we consider the quasi-liner process. Recent observations indicated that the non-linear wave-particle interactions are essential to cause the pulsating aurora, and it is expected that the relationship between the optical emissions and wave amplitude is not simple as expected from the quasi-linear theory. For example, the phase-trapping effect may suppress the precipitation flux if the wave amplitudes increase. In order to investigate how the precipitation flux changes with the wave amplitudes, we conduct a test-particle simulation about chorus wave-particle interactions using GEMSIS-RBW (Saito+, 2012). Besides non-linear wave-particle interaction processes, stochastic differential equations that is equivalent to the Fokker-Planck equation are included to realize stable precipitations as like the quasi-linear process. Using the simulated precipitating electron flux from the test-particle simulation, we calculate the optical emissions at different wavelength at the ionospheric altitudes. From the simulations, we found that both the intermittent precipitations by chorus wave particle interactions and steady precipitations by quasi-linear process are suppressed when chorus amplitude increases, which are not expected from the quasi-linear process.

P42 contributed

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

Yumi Bamba, Takuya Hara, Katsuhide Marubashi, Kazumasa Iwai, Daikou Shiota

The global structure of the magnetic flux rope embedded in the coronal mass ejection (CME) plays a key role in triggering geomagnetic storms and their cascade of effects. It is thus 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 reconstructed the global geometrical configuration through the 1D (or 2D) cylindrical fitting on solar eruptive magnetic flux rope events observed by multiple spacecraft including BepiColombo (0.33AU), Solar Orbiter (0.68AU), STEREO-A (0.96AU), and Advanced Composition Explorer (ACE, 1AU) in October 2021. We also analyzed the source region of the flux rope eruption on the solar surface observed by Solar Dynamics Observatory (SDO). Based on the analysis results, we discuss the radial evolution of the magnetic flux rope, i.e., from that formed and erupted on the solar surface to that propagating through the inner heliosphere.

P43 contributed

U-NET WITH BATCH NORMALIZATION LAYERS FOR PRECIPITATION NOWCASTING BASED ON XRAIN DATA

Ding Jiyuan and Noburiho Takahashi

Precipitation nowcasting is important for people's social and economic activities because precipitation changes rapidly. In this study, we use U-net, a deep convolutional neural network, with batch normalization (BN) layers for precipitation nowcasting based on eXtended Radar Information Network (XRAIN) data. U-net is a deep learning neural networks which is simple, efficient, and also shows its potential in precipitation nowcasting. Batch Normalization is an effective way to accelerate the training of deep learning and achieve better performance especially on the model that lack normalization. In this study, the model takes 4 successive precipitation distributions from XRAIN as separate input channels (t-15, t-10, t-5 min, and t, where t is the time of the nowcast) to produce a nowcast at time t+5 min. the target area is set around Nagoya, Japan, and the dataset has 480×480 pixels and the time series are chosen as 5 min intervals from XRAIN. The data from June to October 2018-2021 were chosen in this experiment. To test the effect of U-net with BN layers, we compared the performance of U-net without BN layers and tried to analyze the effect of the convolutional cores on the model by adjusting the number of convolutional kernels. In this experiment, we tested the performance of the model with the number of convolutional kernels of 16 and 64, respectively. To evaluate the performance of precipitation nowcasting, I use three metrics for model verification: the critical success index (CSI), false alarm ratio (FAR), and probability of detection (POD). The values of them are all between 0 and 1. The closer the CSI and POD are to 1, while the closer the FAR is to 0, the more powerful forecasting ability the model has. For the experiment, U-net was trained to predict continuous precipitation intensities at a lead time of 5 min, results show that U-net performed better with batch normalization layers.

P44 contributed

A study on the influence of energetic particle precipitation by using a new multi-frequency mm-wave spectrometer at Syowa Station

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Energetic particle precipitations (EPPs) triggered by solar activity increase NOx and HOx in the polar mesosphere through ion chemical reactions and reduce ozone (O3) in the stratosphere as the NOx is transported downward. It has been suggested that such ozone depletion changes the radiation budget and temperature distribution, possibly causing a change of atmospheric circulation in global scale (e.g., Semeniuk et al. 2011).

In order to observe these effects, we have conducted continuous mm-wave observations of nitric oxide (NO) and ozone (O3) over Syowa Station since 2012. The NO observations revealed that energetic electrons have a greater influence on the NO enhancement than solar proton over Syowa Station located in the auroral region (e.g., Isono et al. 2014). However, due to the limitation of the instantaneous bandwidth of the spectrometer, we had to observe NO and O3 alternately by changing the receiver setting. To overcome this situation, we began upgrading the mm-wave spectrometer to a multi-frequency receiver system using a waveguide multiplexer since 2020. After tentative operation in 2021, further improvements including a superconducting filter and a 2.5 GHz FFT signal processor were applied in 2022 to achieve full-specification. Finally, the installation and adjustment were completed in June 2022, and after some tests of the simultaneous observations of NO, O3, CO, HO2, and NO2, we started regular operation in mid-July. Only one emission line at 250.796 GHz (2Π1/2 F=7/2-5/2) was observed for NO before the upgrade. Now five additional hyperfine structure lines of NO between 250.44 GHz and 250.82 GHz can be observed and the S/N ratio is expected to be improved. The frequency switching method with small dead time is applied for high observation efficiency. As a preliminary result, we detected enhancement of NO with a column density exceeding 1×1015 cm-2 due to the precipitation of energetic electron during 4 - 8 August and 4 - 7 September.

In the presentation, I will report the specifications of the new system and further analytic results of the relationship between the molecules and the energetic particles.

[Acknowledgement]
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P45 contributed

Next generation solar wind observation system of ISEE

Kazumasa Iwai, Munetoshi Tokumaru, Ken'ichi Fujiki (ISEE, Nagoya University)

Solar wind is a plasma flow from the Sun with its velocity from around 300 km/s to around 800 km/s, that forms the heliosphere. The acceleration mechanism of the solar wind is not well understood and is being actively studied as a major problem in solar physics and space physics. In addition, the solar wind often significantly disturbs the Earth's surrounding environment. This disturbance can seriously damage social infrastructure including communication failure and troubles in artificial satellites. Interplanetary scintillation (IPS) is a radio scattering phenomenon caused by the disturbances in the solar wind. The IPS observation using ground-based radio telescopes has been an important technique to investigate the global structure of the solar wind in the heliosphere. ISEE, Nagoya University have observed the solar wind velocity and density irregularities for several decades using IPS dedicated large radio telescopes at 327 MHz.

In the next generation project, we will develop new ground-based radio observation systems at 327 MHz by constructing a 2D flat phased-array antenna system consisting of multiple dipole antennas, and installing digital beam forming devices. The scopes of this project are (1) to elucidate the acceleration mechanisms of the solar wind and (2) improve the forecasting accuracy of the solar wind arrival to the Earth. The multidirectional simultaneous radio scintillation observation using this system enables the solar wind observation 10 times as much as the conventional radio instruments have been done. This observation data will enable us to clarify the source region of the solar wind with an enough spatial resolution to distinguish the solar wind acceleration processes. In addition, the real-time data provided by the new instruments will be assimilated to the global MHD simulation of the heliosphere to improve the accuracy of the arrival-time of the solar wind disturbances to the Earth.

P46 contributed

Towards operational coronal modelling for space-weather applications

Barbara Perri, Allan Sacha Brun, Antoine Strugarek, Stefaan Poedts, Andrea Lani, Michaela Brchnelova, Tinatin Baratashvili, Blazej Kuzma, Fan Zhang, Peter Leitner, Andrey Kochanov, Evangelia Samara

The anticipation of eruptive events and their impact on Earth has become a top priority for space weather at an international scale. But to do so, it is necessary to understand in details the interplanetary medium in which these events propagate in order to estimate properly their time of arrival and strength. This is made difficult by the complexity of the heliosphere, modulated on short time scales by the solar wind originating from the hot solar corona, and on long time scales by the dynamo-generated magnetic field taking the form of the Parker spiral and depending on the phase of the 11-year solar cycle. The question of the modelling of the heating is thus extremely crucial. Most solar wind MHD models oscillate between simple approximations such as polytropic heating, which yield fast but simplistic results, and detailed heating models coupling Alfvén waves, radiations and thermal conduction, which yield realistic but slow solution.

We will present two different approaches used to reach an operational coronal model for space-weather forecasting. The first one is the implicit model COCONUT, where numerical methods allow for speed and accuracy. We will present its benchmarking procedure and discuss its performances in regard to other explicit models. We also suggest a middle-ground with the model WP-AW-hyb that uses both polytropic and Alfvén waves heating in order to reproduce the bimodal distribution of the solar wind. We will present a parametric study on a simple dipole case to explain the interaction between these two heating terms, before presenting more realistic cases in 2.5D and 3D applied to real solar configurations. Finally, we will discuss the interface between models and observations : we will quantify the impact of the input synoptic map provider on our results, and discuss how to best use observations to validate the coronal forecast.

P47 contributed

Development of a receiving system using a frequency-modulated local oscillator to improve the efficiency of atmospheric ozone observation

Takumi Hikosaka, Taku Nakajima, Akio Taniguchi, Masato Hagimoto, Tomoo Nagahama, Kenichi Harada, Masato Fujii, Koichiro Shimoyama, Kosuke Takezawa

A new observation method with a frequency-modulating local oscillator (FMLO), which can significantly improve the observation efficiencies in single-dish spectroscopic observations by modulating the frequency (FM) of the local oscillator (LO) of a heterodyne receiver has been proposed (Taniguchi et al. 2020). This method has the advantage that it does not need to acquire the OFF point, which was necessary with the conventional method of position-switching observations. On the other hand, it has the problem that the emission line of atmosphere is also detected at the same time. We have taken this in reverse and devised an application of FMLO for atmospheric observations. In the FMLO method, spectroscopic data are acquired while modulating the LO frequency at a high frequency (10 Hz) and then statistically analyzed. This separates discrete molecular emission lines and correlated quasi-continuous wave components in the time series spectrum. However, it is difficult to correctly acquired the spectral shape of ozone emission lines of atmosphere because their line widths (a base width of ~1 GHz) are broader than those from common interstellar molecules. Therefore, it is important to study the best modulation pattern for atmospheric observations.

We first made pseudo-observations of the model spectrum of ozone using the FMLO method on the simulation to verify whether the original spectrum can be recovered. The recovered spectrum with various modulation parameters were compared with the model spectrum, and the results showed that it can be recovered by frequency modulation over the emission line width (1 GHz). Next, a digital spectrometer with a frequency bandwidth of 0.1-4 GHz and a frequency resolution of 75 kHz was developed to allow modulation over a wide frequency range of about 1 GHz. This spectrometer had a 10 Hz trigger signal that was output simultaneously with the start of data integration. By using this feature, the timing of spectrometer integration and LO frequency modulation could be synchronized with an accuracy of less than 1 ms without requiring other control devices. We have demonstrated the operation of FMLO by inputting a test signal using a signal generator into a receiver as a simulated molecular emission line signal in the laboratory and confirmed that frequency-modulated and demodulated spectral data can be acquired.

P48 contributed

Variation of energetic ions during magnetic storm and substorm time: ERG (Arase) and Van Allen Probe Observations.

B. Veenadhari, Yoshizumi Miyoshi, Megha Pandya, Trunali Shan,Y. Ebihara,, T. Hori, K. Asamura, S. Yokota, S. Kasahara, K. Keika, A. Matsuoka and I. Shinohara

The energetic ions, O+, H+ and He+ (10 to 100 of keV) are rapidly enhanced in the inner magnetosphere, which is responsible for the main contribution to the ring current enhancement associated with the geomagnetic storms and substorms. The ring current is the subset of innermagnetosphere particle populations, which carries the majority plasma pressure. The open drift paths through dusk result in a strong partial ring current, during main phase of magnetic storm. The ring current is a highly variable region, and understanding the energization processes provides information into how substorm-ring current coupling may contribute to the generation of storm conditions. Recent case studies provide the H+, O+ ion dynamics of the ring current and how their pressure ratio enhance during the main phase of the storm and understanding the source and loss processes by the knowledge of their pitch angle distributions (PAD) using CRRES, AMPTE/CCE, Polar and Van Allen Probes (VAP) observations. In this study, we analyse O+, H+ and He+ data from Radiation Belt Storm Probes Ion Composition Experiment (RBSPICE)and Helium Oxygen Electron ion flux (HOPE) onboard of VAP for some number of magnetic storms and substorms intervals. The relationship between the ion flow in the plasma sheet and fresh ion plasma injections into the ring current region will be examined during substorm intervals. The latest exploration of energization and Radiation in Geospace(ERG) satellite observations will also be analyzed for the same events. The characteristics of energetic ions will be quantitatively analyzed for variations at different energy, L-value and MLT and the evolution of the PADs during different phases of the magnetic storm will be investigated.

P49 contributed

Computer simulation on the structure of double layer in the auroral acceleration region

Ryouta Ikeba, Takayuki Umeda and Yoshizumi miyoshi

The existence of electric fields in the auroral region was predicted by Alfven (1957). Rocket observations of aurora in 1960's showed the precipitation of high energy electrons, possible due to electric fields in the acceleration region (McIlwain 1960). Evans (1974) reproduced the result of rocket observation by a model calculation, which demonstrated the existence of the auroral acceleration region. Electric fields due to the electric double layers in the auroral acceleration region were first observed by spacecrafts in 1970's (Mozer et al. 1977). The FAST observation showed detailed multi-dimensional structures of the auroral double layer (Ergun et al. 2001). The previous one-dimensional Vlasov-Poisson simulation of a current-carrying plasma showed that a double layer was generated by a strong density depression (Newman et al. 2001). However, multi-dimensional kinetic simulations have not been performed yet due to both computational resources and computational techniques. In the present study, we first perform a two-dimensional particle-in-cell simulation of a current-carrying plasma with a density depression. It is demonstrated that a double layer is driven generated in the two-dimensional system with a weak ambient magnetic field. An electrostatic wave is excited inside the double layer at the frequency around the ion plasma frequency and at the phase velocity around the ion acoustic speed, which propagates in the direction oblique to the ambient magneto field.

P50 contributed

Relaxation of the Courant Condition in the Explicit Finite-Difference Time-Domain Method with Higher-Degree Differential Terms

Harune Sekido, Takayuki Umeda, Yoshizumi Miyoshi

The Finite-Difference Time-Domain (FDTD) method (Yee 1966) is a numerical method for solving the time development of electromagnetic fields by approximating Maxwell's equations in both space and time with the finite difference of the second-order accuracy. A higher-order version of the FDTD method is known as FDTD(2,4), which uses the finite difference of the fourth-order spatial difference (Petropoulos 1994). However, the Courant condition of FDTD(2,4) is more restricted than that of the standard FDTD method. In the present study, a new explicit method is developed by using higher-order spatial difference terms. The new method relaxes the Courant condition and reduces the numerical error in the phase velocity of electromagnetic waves.

P51 contributed

Eleven-year, 22-year and ~90-year solar cycles discovered in nitrate concentrations in a Dome Fuji (Antarctica) ice core

Yuko Motizuki, Yoichi Nakai, Kazuya Takahashi, Takashi Imamura, and Hideaki Motoyama

Ice cores are known to yield information about astronomical phenomena as well as information about past climate. We report time series analyses of annually resolved nitrate variations in an ice core, drilled at the Dome Fuji station in East Antarctica, corresponding to the period from CE 1610 to 1904. Our analyses revealed clear evidence of ~11, ~22, and ~90 year periodicities, comparable to the respective periodicities of the well-known Schwabe, Hale, and Gleissberg solar cycles. Our results show for the first time that nitrate concentrations in an ice core can be used as a proxy for past solar activity on decadal to multidecadal time scales. Furthermore, 11-year and 22-year periodicities were detected in nitrate variations even during the Maunder Minimum (1645–1715), when sunspots were almost absent. This discovery may support cyclic behavior of the solar dynamo during the grand solar minimum.

P52 contributed

Recent results of the total electron content measurements for the ionospheric disturbances using global GNSS receiver networks

Yuichi Otsuka, Atsuki Shinbori, Takuya Sori, Michi Nishioka, and Septi Perwitasari

We developed a database that provides global 2-dimensional maps of the total electron content (TEC) with high temporal and spatial resolutions. The TEC data were obtained from more than 9000 GNSS receivers worldwide. In this presentation, we review some recent results obtained by the GNSS-TEC data. By analyzing the GNSS-TEC data statistically, the following results were obtained. Shinbori et al. (2021) have investigated relationship between the locations of the midlatitude trough minimum in the ionosphere and plasmapause in the inner magnetosphere by comparing electron density data obtained from the Arase satellite. Sori et al. (2021) and Shinbori et al. (2022a) have revealed plasma bubble occurrence and large-scale ionospheric disturbances during magnetic storms, respectively. Solar activity dependence of medium-scale traveling ionospheric disturbances (MSTIDs) is reported by Otsuka et al. (2021a). Case studies for plasma depletions lasting into daytime, plasma bubble occurrence during a magnetic storm, and traveling ionospheric disturbances induced by the 2022 after the 2022 Hunga Tonga Hunga Haapai volcanic eruption have been carried out by Otsuka et al. (2021b), Sori et al. (2022), and Shinbori et al. (2022b), respectively.

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Sori et al. (2022) https://doi.org/10.1029/2021JA030240

P53 contributed

Performance evaluation of Machine Learning methods for Identifications of Flares associated with CMEs

Hemapriya Raju; Saurabh Das

Coronal Mass ejections and flares are part of the continuous physical process that happens in the solar atmosphere. Though flares and CMEs don't drive each other, yet they have magnetic reconnection as an underlying physical process for eruptions. Forecasting such eruptions is necessary in this era of technology to avoid damages to satellites, blackouts to telecommunication systems. In this work, we evaluated the performance of 8 Machine Learning models (SVM,Linear Discriminant analysis, Random Forest, Decision Trees, Logistic Regression,Adaboost,Xgboost, Gradient Boost) in attempt of CME forecasting prior 8-48 hours of the actual event. SHARP features derived from HMI patches are utilized as input parameters for the prediction. The output is binary classification to forecast whether a flare will be accompanied by CMEs or not. Since the distribution of samples are biased towards the flare only class, we tried to address the class imbalance through different sampling techniques such as cost weight, Random Oversampling, Random undersampling, synthetic minority Sampling technique(SMOTE). We carefully separated the test set from sampling, and tested the model's performance by sampling the training data set. We evaluated the confidence score through cross validation. We found that for 36 hour time lag, SMOTE enhances the model performance of SVM and LDA. SVM with costweight fares True Skill Score(TSS) of 0.79±0.1, whereas with SVM with SMOTE sampling, tss score has improved to 0.84±0.04. LDA shows significant improvement in the Tss score of 0.8± 0.05 at 36th hour after ROS sampling. Additionally, we observe that the LDA model's TSS score increases significantly to 0.92 when change information i.e., the difference between 24 and 36 hour is included in the existing features. The change information of the features MEANPOT, MEANGBT, MEANALP plays a significant role in improving the prediction while analaysed using Wrapper method

P54 contributed

A Parametric Study of Performance of Two Solar Wind Velocity Forecasting Models During 2006–2011

Sandeep Kumar and Nandita Srivastava

There is an increasing need for the development of a robust space weather forecasting framework to study space–Earth environment. State-of-the-art MHD space weather forecasting frameworks are based upon the Potential Field Source Surface (PFSS) and Schatten Current Sheet (SCS) extrapolation models for the magnetic field using synoptic magnetograms. These models create a solar wind (SW) background for the simulations using empirical relations of Wang, Sheeley and Arge (WSA), at the inner boundary of the heliosphere and have been used to simulate coronal mass ejections for specific cases in previous studies. Besides these MHD frameworks, the Heliospheric Upwind eXtrapolation (HUX) technique can extrapolate SW from inner heliospheric boundaries to L1 and can give a reliable estimate of the SW velocity at L1 comparable to MHD models but in a short computational time. We carried out an extensive parametric study of the performance of the Model1 (PFSS+WSA+HUX) and Model2 (PFSS+SCS+WSA+HUX) for SW velocity prediction at L1. We implemented this framework on 60 Carrington Rotations from CR2047 to CR2107 during 2006–2011, covering the descending and deep minimum phase of the solar cycle (SC) 23, and the ascending phase of SC 24. Our results show an unexpected decrease in the performance of the framework during the deep minimum phase of cycle 23, which is attributed to the decrease in the observed coronal hole area. As SC 24 began, this decreasing trend vanished due to an increase in the coronal hole (CH) area at the low and mid-latitudes, suggesting a good correlation between the performance of the framework and the variation in the CH area.

P55 contributed

Toward an exploration of extreme SEP events for the past 10,000 years

F. Miyake, M. Hakozaki, R. Hantemirov, H. Hayakawa, S. Helama, K. Horiuchi, A.J. T. Jull, K. Kimura, H. Maehara, H. Miyahara, T. Moriya, M. Oinonen, I. P. Panyushkina, K. Sasa, M. Takeyama, F. Tokanai

Cosmogenic nuclides such as 14C, 10Be, and 36Cl are good proxy for past extreme solar energetic particle (SEP) events. After a finding of a signature of an extreme SEP event recorded in 14C data of tree-ring (Miyake et al. 2012), similar events have been reported, e.g., in 993 CE, 660 BCE, and 7176 BCE (Miyake et al. 2013, Park et al. 2017, Brehm et al. 2022). These candidates of extreme SEP events have also been confirmed in 10Be and 36Cl data in ice cores from Greenland and Antarctica (e.g., Mekhaldi et al. 2015). Since event scale of these SEP events were estimated as tens of times larger than the largest event in history of observation, it is important to investigate an occurrence rate and upper limit of such extreme events. We are proceeding a continuous 14C measurement with annual resolution for a comprehensive detection of extreme SEP events during past 10,000 years. We will introduce a current status of an exploration of past SEP events.

P56 contributed

Occurrence characteristics of ionospheric irregularities over African equatorial region

Ikani Ojochenemi, F.N Okeke, K.C Okpala, Dan Okoh, A.B Rabiu

We have studied the occurrence characteristics of ionospheric irregularities using GPS-TEC derived fluctuation indices (rate of change of TEC (ROT) and the average rate of change in TEC index (ROTIave)) from Global Positioning System (GPS) TEC data for the year 2014. The data were obtained from Nigerian GNSS Reference Network (NIGNET) stations. The observations revealed significant latitudinal differences for both quiet and disturbed conditions. The quiet-time observations indicate that irregularities were consistent across all the stations. The occurrence was strong and consistent at CLBR whose geomagnetic latitude is farther away from the geomagnetic equator (and closer to the southern anomaly crest) than those closer to the geomagnetic equator. During the disturbed periods, the occurrence of irregularities was inhibited in September equinox. An opposite pattern of occurrence was observed during the march equinox across all the stations. Two peaks of occurrence were observed: one in March and the other in September respectively. For most of the time, the strength of ionospheric irregularities in March equinox were greater than those during September equinox. Generally, irregularities activity is more pronounced during pre-midnight hours.

Keywords: Equatorial ionosphere; Ionospheric irregularities; TEC; ROTI.

P57 contributed

Search for the potential 14C excursions in the Intcal/SHcal curves and data raw atmospheric 14C time series

Jacek PAWLYTA and Andrzej Z. RAKOWSKI

Accuracy of radiocarbon dating depends both on uncertainty of radiocarbon concentration/radioactivity determination in the sample and quality of radiocarbon calibration curve. Radiocarbon calibration curves are sophisticated compositions of time series coming from different carbon reservoirs/environment. Time resolution of the Intcal20 and SHcal20 vary from one year to couples of ten years for different time periods. Precise radiocarbon dating, especially incorporating so-called wiggle matching approach requires high-resolution calibration curve. Miyake discovery of rapid 14C excursions in last millennia made obvious necessity of intensifying efforts to identify all the parts of calibration curve which may contain information about similar excursions. The identification should lead to the discoveries of other periods containing Miyake effect excursions, which will probably result in increased radiocarbon dating accuracy for time periods covering Miyake effects. Here we present results of automatic search for Miyake effect excursions in the all atmospheric 14C time series used for Intcal SHcal 2020 construction. We also propose a simple method of calibration curves analysis in order to find time periods suspected to contain hidden information about excursions.

P58 contributed

Statistical analyses on low energy ion heating by electromagnetic ion cyclotron waves via wave-particle interaction analyses: Arase observations

Masafumi Shoji, Yoshizumi Miyoshi, Lynn M Kistler, Kazushi Asamura, Yasumasa Kasaba, Ayako Matsuoka, Yoshiya Kasahara, Shoya Matsuda, Fuminori Tsuchiya, Atsushi Kumamoto, Satoko Nakamura, Chae-Woo Jun, Iku Shinohara

Electromagnetic ion cyclotron (EMIC) waves are generated through the cyclotron wave-particle interaction, affecting the plasma environment in the magnetosphere. Heating of the ions by EMIC waves in the inner magnetosphere has also been investigated by spacecraft observations by comparing variations of ion distribution and waves. The energy transfer between the plasma waves and ions can be quantitatively evaluated by calculating the inner product between the wave electric field vector and the ion velocity vector, so-called WPIA (wave-particle interaction analysis). We adapt the WPIA method to the Arase spacecraft data and investigate the spatial distribution of the positive qV・E region in the inner magnetosphere. Using 4.5 years data, we choose EMIC wave events associating proton or helium flux enhancements of which the WPIA analysis can be applied for the necessary data sets observed by the Arase satellite. The occurrence peaks of the proton heating events appear in the dayside and post noon regions. In the higher Kp case, we find the occurrence peaks of heating of both proton and helium close to the Earth, around L=3-4 while in the smaller Kp case, the peaks appear around the noon and dusk side.

P59 contributed

3 Professions Confronting Space Weather Hazard --Collaboration between Space Weather Researchers, Interpreters, and Casters--

Susumu Tamaoki, Satoshi Nozawa

Space weather means space environmental changes which can impact society. In recent years, it has been found that extreme space weather events may have serious consequences for aviation, electric power grids, and positioning. Since the beginning of 2022, the government and some Japanese industries began to seriously consider how to respond to extreme space weather events. Among them, the establishment of the space weather forecaster system is also being considered, and this is the first attempt in the world. The mission of the ABLab (Aerospace Business Laboratory) Space Weather Project in Japan is to foster active and ambitious persons who are enthusiastic and have a clear sense of purpose for Space Weather Casters and Space Weather Interpreters. Space Weather Caster would be a future profession extended from the current weather caster, who sends space weather information accurately and understandably for the public. Space weather interpreters, another future profession, would analyze space weather situation and give advice to avoid the space weather-originated damage to the societal infrastructure in advance. Space Weather Casters and Space Weather Interpreters would be included in the career of space weather forecasters. Space Weather Researchers, Interpreters, and Casters, 3 Professions confront space weather Hazard in near future.

P60 contributed

Ionospheric scintillation climatology over Ethiopia during the raising phase of Solar Cycle 24

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Abstract:

We characterize the climatology of ionospheric scintillation and total electron content (TEC) over Ethiopia during the ascending phase of solar cycle 24. To the scope, seven years data (2008–2014) of Total Electron Content and amplitude scintillation (S4 index) recorded from two SCINDA (Scintillation Network and Decision Aid) GPS receivers installed at Addis Ababa (9.034°N, 38.67°E, geomagnetic 0.9°N, 110.5°E) and Bahr Dar (11.37°N, 37.10°E, geomagnetic 2.64°N, 108.94°E) were used. We arranged the data into long term hourly mean, diurnal mean, seasonal and yearly mean scales. The long term seasonal data grouped into D- season (January, February, November and December), E- season (March, April, September and October) and J-season (May, June, July and August). The long term hourly mean scintillation values in Addis Ababa and Bahr Dar has similar trend of occurrences during the Post-Sunset hours, i.e. 16:00 - 22:00UT (LT = UT+3 hour) , with a peaking activity localized between 19:00 and 20:00 UT. In most observations of this study, the peak values of long term hourly mean (2008-2014) of TEC was exhibited at 10:00 -14:00 UT, as a result of the ionospheric photo ionization process. We have classified the seven years data into seasonal mean during low solar activity (2008-2010) and high solar activity period (2011-2014); we observed that both TEC and scintillation occurrence during solar maxima was doubled to the values during solar minima period. This study revealed that climatological amplitude scintillations in East African equatorial region were appeared at post sunset events and decrease around local midnight, with heighten activities in the months of March, April, October and September. In both stations the peak seasonal TEC values were observed during E-season followed by D-season and least TEC values were observed during J-season. Equinoctial asymmetry in scintillation occurs with higher occurrence during March and April than in September and October. We have found that, the instant fluctuation and slight enhancement of TEC during nighttime leads to the peak

P61 contributed

Analysis of the seasonal variation of the trends in foF2 linked to long-term variations in geomagnetic activity and secular variations of the Earth's magnetic field

Trinidad Duran, Blas F. de Haro Barbas, Ana G. Elias, Fernando S. Buezas

Since the early 1990s, the analysis of long-term trends in the upper atmosphere has gained great importance. The attribution of causes to these long-term variations continues to be a problem of real interest and complexity, still far from being resolved. It is argued that the Earth magnetic field, as well as geomagnetic activity vary over the solar cycle and also presents long-term variations. The upper atmosphere is strongly influenced by changes in these activity levels (in addition to CO2 long-term trend that is another possible mechanism causing atmospheric trends). Especially the ionosphere-thermosphere system responds strongly to changes in geomagnetic and solar activity, therefore any long-term changes in these could cause a long-term trend in atmospheric parameters, for example, affecting the height of the F2 layer peak, hmF2, and the maximum electron concentration estimated by the critical frequency of the F2 layer, foF2.

As a contribution to this topic, this work analyzes the seasonal variation of long-term trends in foF2, based on experimental data from mid latitude stations. The trends were estimated from the residuals of the multiple regression between foF2, different proxies of the solar EUV flux and geomagnetic disturbance index values, inferring that the frequencies are sensitive to the proxy considered, the phases of the solar activity cycle and the variation of geomagnetic activity. The seasonal variation of both, values and sign, of the trends, in this case, provides information about the relative roles of what would be its main driving factors. It seems that the increase in the concentration of greenhouse gases, long-term variations in geomagnetic activity and secular variations of the Earth’s magnetic field may be able to explain some seasonal and daily variation patterns in trend values.

P62 contributed

Solar Flare effects on the High Latitude Electrodynamics

S. Chakraborty, N. Nishitani, J. Baker, P. Ponomarenko, J. M. Ruohoniemi, K. Hosokawa, X. Shi, and B. Kunduri

A solar flare is a space weather event that causes a transient in the ionospheric system at sub-auroral, middle, and lower latitudes, commonly known as the solar flare effect (SFE). However, flare peaking beyond X-class or higher can impact current systems at auroral and polar latitudes. Using ground-based radars and magnetometers located in high latitude North American sectors, we conducted an event study on the X9.3 flare on 6 September 2017. We found: (i) SuperDARN radar located at Saskatoon (auroral latitude, dawn sector) observed a sudden appearance of ionospheric scatter following the flare; (ii) SuperDARN Inuvik radar, located at polar latitude, recorded a sudden reduction in plasma flow velocity; (iii) significant enhancement in geomagnetic field intensity observed by ground magnetometers, which lasted about 3-hours; (iv) several SuperDARN radars located at the nightside also recorded a change in plasma convection. Apparently, the sudden appearance of ionospheric irregularity structures near auroral latitudes-dawn sector and the change in nightside ionospheric plasma flow at auroral latitudes are related to a change in the ionospheric Hall/Pederson conductivity and current system. In addition, the longer lasting intense geomagnetic field variations detected by the magnetometer stations suggest a change in the day-night ionospheric current system. Finally, the reduction in plasma flow velocity observed by a polar latitude radar is predominantly driven by the reduction in efficiency of mechanical energy conversion in the dayside solar wind-magnetosphere-ionosphere (SW-M-I) interaction. This work demonstrates flare effects on auroral currents, nightside effects, and a reconfiguration of MI coupling morphology.

P63 contributed

Application of magneto-impedance (MI) sensor to geomagnetic field measurements

Masahito Nosé, Takeshi Kawano, and Hitoshi Aoyama

The magneto-impedance (MI) effect was discovered about 30 years ago and a micro-size magnetic sensor utilizing this effect has become commercially available. We make some modifications to the commercially available MI sensors to cover the dynamic range of the geomagnetic field. The total cost of three MI sensors for the two horizontal and one vertical components including the modification is approximately 1/3 of the standard price of triaxial fluxgate magnetometer sensors. For the period of March 30 to April 27, 2018, we conducted experimental observations of geomagnetic field variations with the MI sensor magnetometer (MIM) at the Mineyama observatory, which is located about 100 km north-west of Kyoto, Japan. Data obtained with the MIM are compared with those from the fluxgate magnetometer (FGM) that has been working at the observatory. Results show that the MIM can record geomagnetic field variations such as geomagnetic storm, solar quiet (Sq) variations, low-latitude positive bays, storm sudden commencement (SSC), and long-period geomagnetic pulsations with a peak-to-peak amplitude of < 1 nT that are also detected with the FGM. Power spectra of the geomagnetic field variations measured with the MIM and FGM are almost the same. It is found that the MIM has a larger temperature drift than the FGM. The present study reveals that the MIM is comparable to the FGM in measuring the geomagnetic field variations in a period from a few tens of seconds to a few hours, and is useful for researches in upper atmospheric physics or space physics.

P64 contributed

Probability Distribution Functions of Solar and Stellar Flare Energies

Takashi Sakurai (NAOJ)

We studied the soft X-ray data of solar flares and found that the distribution functions of flare fluence are successfully modeled by tapered power law or gamma function distributions whose power exponent is slightly smaller than 2, indicating that the total energy of the flare populations is mostly contributed from a small number of large flares. The largest possible solar flares in 1000 years are predicted to be around X70 in terms of the GOES flare class. We also studied superflares (more energetic than solar flares) from solar-type stars, and found that their power exponent found in the gamma distribution fit is around 1.05, much flatter than solar flares. The distribution function of stellar flare energy extrapolated downward does not connect to the distribution function of solar flare energy.

P65 contributed

Study of ion composition in lunar plasma environment with the KAGUYA satellites

Yamauchi, D., M. Nosé, Y. Harada, and S. Yokota

Currently, lunar exploration is being planned by many countries. Among them, NASA plans to build a near-lunar manned base “Gateway” as part of a lunar exploration program called the Artemis Program. One of the main objectives of the Gateway is to elucidate the ion composition around the Moon. In this study, prior to the launch of the Gateway, we investigate the ion composition around the Moon using data from the lunar orbiter KAGUYA, which was launched in Japan in 2007. The results will be useful for a future analysis of the Gateway data. From the KAGUYA data analysis, Terada et al. [2017] reported that O+ ions with energies of 1–10 keV, which are considered to be accelerated ions of Earth origin, were abundant only when the Moon was located within the Earth's plasma sheet. O+ ions with energies below 1 keV were often observed when KAGUYA was positioned on the dayside of the Moon, and thus were assumed to be ions of lunar origin. However, this previous study focused on only one particular day (April 21, 2008) in detail and did not examine observations on other days when the Moon was located within the Earth's plasma sheet. In addition, it is possible that some O+ ions with energies below 1 keV are also of terrestrial origin. Therefore, in this study, we will use the whole mission data from KAGUYA between October 4, 2007 and June 11, 2009 and investigate the correlation between the Earth's magnetic activity and O+ ion counts with energies lower than 1 keV.

P66 contributed

Estimation of precipitating electron energy characteristics of the Omega band aurora by two-wavelength optical measurements

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The Omega band aurora is an auroral phenomenon that often occur from the late expansion phase to the recovery phase of substorm. The name comes from appearance with a shape similar to the inverse of the Greek letter ‘Ω’. The Omega band aurora tends to drift eastward, from midnight to dawn. The Omega band aurora has a latitudinal structure with discrete auroras appearing on the polar side and pulsating auroras on the equator side. Previous studies regarding the Omega band aurora indicates that the west side of the Omega band is clearly divided into two parts, one with pulsating auroras and the other is diffuse aurora. Since it has been considered that the Omega band aurora is related to a magnetospheric fast flow and its shear motion, clarification of the spatial-temporal variations of precipitating electron energy and its downward flux is important for understanding the processes in the magnetosphere that cause Omega band auroras. In this study, the Omega band aurora was simultaneously observed at two wavelengths, 427.8 nm and 844.6 nm, using two EMCCD cameras installed in Tromsø, Norway (69.6°N in geographic coordinate, 66.7°N in geomagnetic coordinate). The characteristic energy of precipitating electrons and downward energy flux of the Omega band aurora were estimated from the intensity ratio of the emission at two wavelengths. Two Omega band aurora events observed at 01:30-2:30 UT (around 04:00-05:00 MLT) on March 2, 2017 and at 01:00-3:00 UT (around 03:30-05:30 MLT) on Feb. 24, 2018 showed a presence of simultaneous pulsating and diffuse auroras as reported by the previous studies. The downward energy flux in the west side of the Omega band aurora is higher than that in the east side. In the north-south direction, discrete aurora, diffuse aurora, and pulsating aurora are present from the polar side. We also examine spatial distributions of characteristic energy and downward energy flux. There was no significant difference of characteristic energy between the diffuse and discrete auroral areas, but we found the pulsating auroral area has a slightly larger characteristic energy, than the other areas by approximately 30%. We found that the discrete auroral region has the largest downward energy flux while the pulsating auroral region has a larger downward energy flux than the diffuse auroral region. We discuss possible processes that cause such characteristics of the Omega band auroras.

P67 contributed

Formation process of biogenic gigantic dolomite concretions found in Oga peninsula, Japan

Ryusei Kuma (ISEE, Nagoya University), Shoji Nishimoto (Aichi University), Yusuke Muramiya (Fukada Geological Institute), Hidekazu Yoshida (Nagoya University Museum)

Carbonate concretions occur in sedimentary rocks of widely varying geological ages throughout the world. Previous studies focused on calcium carbonate concretions revealed that the concretions are formed by the rapid reaction of carbon associated with the decay of organic matter with calcium in seawater. However, it is still unclear the detailed formation process of a lot of dolomite concretions how they are grown in marine sediments. In this study, we focused on the recently identified more than 100 gigantic dolomite concretions of 1-9 m in diameter distributed in the Unosaki coast of Oga Peninsula, Akita Prefecture, Japan. We investigated the formation mechanism and depositional environment of these gigantic dolomite concretions, many of them are containing whale bone in the center of concretion.

In this study, microscopic observations and elemental mapping using X-rays were carried out on concretions. Stable carbon and oxygen isotope ratios, elemental and mineral compositions analysis were also conducted for the fossil body, concretion and matrix, respectively. Based on the field observation and mineralogical analysis, the gigantic dolomite concretions are found in the uppermost part of the Nishikurosawa Formation and the Onnagawa Formation. Especially, Lenticular, spindle-shaped, and spherical dolomite carbonate concretions were found in the carbonaceous sandstone beds. The carbonaceous sandstone and siltstone showed graded structures and parallel lamination, and some of them showed hummocky cross stratification indicating storm-driven flow. It is thought that storm-driven flow caused the remains of the whale to accumulate in separate parts and form the nucleus for the concretion. In the carbonaceous sandstone beds, various trace fossils were also found, and the internal structures were disturbed. Although the sedimentary structure in the concretions is unclear, small trace fossils of millimeters in scale were found by fluorescence microscopic observation. By considering the location of dolomite precipitation, it suggests that the concretions were formed in a reducing environment where sulfate ions were removed. Light $\delta^{13}C$ and heavy $\delta^{18}O$ of the dolomite carbonate from whale bones and concretions suggest that whale organic matter contributed to the formation process of them. The gigantic dolomite concretions were presumably formed by rapid burial of whale body and the decomposition by benthic and microbial activities.

P68 contributed

PREDICTION OF GEOMAGNETIC ACTIVITY OF SOLAR CYCLE 25 USING PAST DATA FROM YEAR 1964-2019 FOR THE RISING PHASE

Soumya Yadav, A. K. Singh

Geomagnetic storms are caused by variations in the solar wind, which cause significant changes in the currents, plasmas, and fields in the Earth's magnetosphere. The geomagnetic disturbances associated with space weather events may produce changes in the local magnetic field, leading to altitude determination problems with satellites and spacecrafts that use magnetic guidance. A worst-case solar storm may have an economic impact as well. The data of solar cycles 20-24 helps us in predicting the potential trend of geomagnetic storm for the present solar cycle which help us to check whether it has any severe impact on terrestrial environment as well as on the Earth’s environment. The parameters used here for discussion are Dst, kp, indices and SSN to distinguish between severe space weather that causes the reported electric power outages and/or telecommunication failures and normal space weather. The recent data of the geomagnetic indices and SSN shows rapid increase in geomagnetic activities and prediction from the data for the rising phase shows that it is going to increase in the upcoming months. The peak is expected to be in between the year 2024 and 2026, i.e., July 2025.

P69 contributed

Development of coronal hole detection method from LOS magnetograms with deep learning

Ryo Takebe, Yusuke Iida

We challenged the development of coronal hole detection method only from LOS magnetograms with deep learning. If this study succeeds, it is expected to be possible to predict the appearance of coronal holes in the space weather forecast.

Coronal holes are the source of the solar wind that can cause geomagnetic storms to affect the Earth's magnetosphere. It is possible to predict the geomagnetic storms from the area of the coronal hole area and hence the detection/prediction of coronal holes is one of the most important targets in the space weather field. Coronal holes appear as dark areas in extreme ultraviolet(EUV) images, which can be used for automatic detection. In addition to automatic detection methods with image processing in past studies, a detection method with deep learning also has been developed by Jarolim et al. (2021). On the other hand, these detection methods from EUV images are aimed at the detection of coronal holes that have already appeared, but it is desirable to predict them before they appear in the space weather forecast. For example, if it becomes possible to detect the coronal hole magnetic field area which has unipolarity, it may be possible to discover signatures of its appearance. In this study, we challenged the development of an accurate coronal hole detection method from only LOS magnetograms with deep learning.

We used U-Net for semantic segmentation. For the data set, we used LOS magnetograms taken by Helioseismic and Magnetic Imager (HMI) on board the Solar Dynamics Observatory (SDO). The data set contains a total of 2,167 LOS magnetograms for the time period between 2011-01-01 and 2016-12-31. For the coronal hole labels, we used segmentation images created from EUV images with the automatic detection method proposed by Garton et al. (2017).

It is observed that the detected areas are clustered or scattered by epochs. We attributed this behavior to the fact that the area of the coronal hole is not large relative to the entire solar disk and that the parameter optimization range is narrow in this case. Therefore, we changed categorical cross-entropy to weighted categorical cross-entropy in the loss function and added learning rate decay in the optimization method. Our U-Net model achieves 0.633 as TSS and 0.330 as IoU using only LOS magnetograms. These scores are higher than those in the previous study and it is now practically possible to detect coronal holes from magnetic field data alone.

P70 contributed

Holocene ostracod assemblages and paleo-water depth from a raised beach sediment in East Antarctica

Satoshi Sasaki (ISEE, Nagoya Univ.), Toshiaki Irizuki (Shimane Univ.), Koji Seto (EsReC, Shimane Univ.) and Yusuke Suganuma (NIPR)

Accelerated melting of the Antarctic ice sheet (AIS) is one of the major contributors to global sea-level rise. To better constrain future climatic and environmental consequences, it is important to understand the history and mechanisms of AIS melting and associated sea-level changes. Since the Last Glacial Maximum, regional sea-level reconstructions are a critical component of these efforts to resolve past fluctuations in ice sheets and global sea-level.

Regional sea-level reconstructions have previously been attempted across the Skarvsnes area of Lützow-Holm Bay, East Antarctica (e.g., Takano et al., 2012; Verleyen et al., 2017). However, the results were not consistent, making it difficult to provide firm constraints on the past AIS in this region. Therefore, this study examined for paleo-environment and paleo-water depth near Lake Suribachi-Ike, Skarvsnes, based on grain size, CNS (carbon, nitrogen, and sulfur) elemental, and microfossil (ostracod) analyses of an outcrop of the Holocene-raised beach which was excavated approximately 4 cm from the surface by the 46th Japanese Antarctic Research Expedition (JARE 46).

As a results, the 14C dating of an annelid tube collected from the same outcrop was also conducted using an accelerator mass spectrometry. The resultant age was estimated at approximately 5,800 cal. year BP. A total of 16 ostracod species belonging to 10 genera were identified for the first time from all study samples near Lake Suribachi-Ike, Lützow–Holm Bay, East Antarctica. The phytal species was discovered to be the most dominant, implying a rich seagrass and/or seaweeds environment at approximately 5,800 cal. yr BP. The paleoenvironment was estimated using the autecological method and the modern analog technique (MAT) on ostracod assemblages. The result from the MAT suggested that the paleo-water depth of approximately 30 m at that time is the most probable estimation, implying the glacial-isostatic uplift of approximately 30–40 m (5.1–6.8 mm/year) until sample date. It is concordant with the previous studies on the 14C ages of the marine shells collected from raised beach sediments near the present study site.

P71 contributed

Longitudinal variation of equatorial ionosphere long-term trends expected from the magnetic equator secular displacement

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The Earth's ionosphere at equatorial latitudes depends strongly on solar radiation, the geomagnetic field, and atmospheric conditions, all of which present variabilities in different time scales. In particular, long-term trends have been of interest since the pioneering study in 1989 by Roble and Dickinson, suggesting that the long-term increase of greenhouse gases concentration would produce a global cooling in the upper atmosphere. Even though anthropogenic forcing seems the main trend driver until now, there are also other trend forcings of natural origin, and among them is the secular variation of the Earth's magnetic field, which affects not only the electron density, but ionospheric conductivity and currents, and radio wave propagation, among others. The present field can be approximated by a geocentric magnetic dipole with its axis tilted ~11° with respect to Earth's rotational axis. This dipole, which accounts for ~80% of the magnetic field power at the Earth's surface, has been rapidly decreasing during the last decades. In fact, the intrinsic Earth's magnetic field has been decaying at a rate of ~5% per century since at least 1840. This has led to thinking of an undergoing reversal or excursion even though there is also the possibility of a recovery without the occurrence of an extreme event. In any case, the intensity of the global field will continue to decrease in the near future with its consequent changes in the ionosphere dynamics and the weakening of our planet's magnetic shield, among other effects. For space weather events, for example, the main impacts are expected from the rapid decay of the dipole field and the expansion of the South Atlantic Anomaly. In the equatorial ionosphere case, the shift in the magnetic equator may be of greater importance, and this is linked not to the dipole field decay, but to the dipolar axis orientation and its center position variation, together with the growth of multipolar components. These may induce more noticeable and significant changes through their effect over the magnetic equator. In this work, the consequent spatial pattern of trends noticed in several ionospheric features at equatorial latitudes, consisting of alternating bands of positive and negative values, with strong longitudinal gradients are analyzed based on a theoretical analysis. The geomagnetic field secular variation, through the effects induced by its equator displacement, may be currently the dominant trend source in the Atlantic region ionosphere.

P72 contributed

Analysis of 25 Years' Long-Term GNSS Ionospheric Total Electron Content Data Using Statistical Extreme Value Theory at a Grid Point Location in Japan

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Space weather events occur due to the disruptions caused by the Sun to aviation, communications, and navigation systems, which affect a variety of aspects in modern life and technology, disturbing the radio communication and navigation signals of Global Navigation Satellite Systems (GNSS) while degrading its positional accuracy. Because of this, consistent and continuous space weather updates are necessary to mitigate the risks for Safety-of-Life applications. Furthermore, total Electron Content (TEC) varies with the season and time of the solar cycle and may be enhanced or depleted due to solar activity. Taking this into consideration, International Civil Aviation Organization (ICAO) indicated ionospheric TEC thresholds for space weather activity of GNSS systems as 125 and 175 TECU for moderate and severe thresholds, respectively, for safe and secure aviation applications. The present study provides the statistical analysis of 25 years long-term (1997-2021) GNSS Earth Observation Network System (GEONET) data,operated by Geographical Survey Institute of Japan, at the grid point location of 34.95º N and 134.05º E. Statistical Extreme Value Theory (EVT) is being performed to estimate TEC extreme events and to make an assessment, how frequently the values of TEC can exceed the moderate and severe thresholds, as specified by ICAO, to develop risk mitigation strategies for GNSS systems and simultaneously increasing its operability for safer communication and navigation applications. The obtained results depict that the TEC values for the occurrence rate of one in 10, 100, and 200 years are 101, 126, and 131 TECU, respectively, indicating the moderate threshold level of activity for a return period of greater than 50 years.

P73 contributed

Comparison of the Solar Soft X-ray Images from Hinode/XRT with SOHO/MDI & SDO/HMI Magnetograms

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The magnetic field is the main source for all surface features of the Sun. Understanding the role of the photospheric magnetic field on the dynamics and the variability of the coronal features is very important in Solar Physics. Determining the magnetic flux of individual coronal features helps in understanding their irradiance variability.

To study the role of the photospheric magnetic field in relation to emission features observed in the solar corona, we used the Hinode/XRT full-disk images for the period: 2008 to 2021 (solar cycle 24), and magnetograms from both SOHO/MDI (2008-2010) and SDO/HMI (2010-2021). From our previous studies, the different coronal features (such as ARs, XBPs, BGs, and CHs) have been segmented from the full-disk intensity images and these intensity maps are overlaid on the magnetograms to determine the magnetic flux for each coronal feature.

Preliminary results from these analyses show that the magnetic field is associated with the emission features of the solar corona. The important results derived from these analyses will be discussed in this poster presentation.

P74 contributed

Magnetic reconnection and particle acceleration in the solar wind

Olga Khabarova

Magnetic reconnection is known to transform magnetic energy into other forms of energy in laboratory and space plasmas. Solar physics and physics of magnetosphere consider this mechanism as the main candidate for acceleration of charged particles to suprathermal energies at reconnecting current sheets. Meanwhile, the solar wind has been treated as a much simpler medium for a long time, and significant energization of particles has been thought to be impossible there because of too slow inflow speeds. Energetic particles observed at the Earth's orbit have been supposed to come either from the Sun or from shocks. It took scientists several decades to make the way from imaging magnetic reconnection as the simplest Petschek or Sweet-Parker mechanism operating at Harris-type current sheets to understanding it as a 3D turbulent/intermittent/stochastic process associated with far more effective particle acceleration and creation of flux ropes, secondary current sheets and waves in the solar wind.

Historical and modern views on magnetic reconnection and local particle acceleration in the heliosphere will be discussed in the presentation, with a focus on observations from past and recent heliospheric missions at different distances from the Sun.

Khabarova et al. Current Sheets, Plasmoids and Flux Ropes in the Heliosphere. Part I. 2-D or not 2-D? General and Observational Aspects, Space Science Reviews, 217, 38 (2021). https://doi.org/10.1007/s11214-021-00814-x

P75 contributed

Using deep learning for automated detection of solar magnetic tornadoes

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Various neural networks (namely, fully connected, recurrent and convolutional networks) have increasingly become popular in many fields of physics involving data analysis and pattern recognition [Krizhevsky et al., 2012, NeurIPS]. Meanwhile, in solar physics, traditional algorithms relying on the pixel intensity, the optical flow, and other similar techniques are mainly used with few exceptions [e.g. Illarionov et al., 2018, MNRAS; Mackovjak et al., 2021, MNRAS]. We propose an automated detection algorithm of solar magnetic tornadoes, based on deep learning methods. We define magnetic tornadoes, independently of their origin, as magneto-plasma objects in the solar corona in which the magnetic field is twisted. Typically, a magnetic tornado rotates resembling tornadoes in the terrestrial atmosphere. Meanwhile, there are also tornadoes in which only plasma flows upward along the magnetic field spiral but the whole structure just shakes. The lack of identified tornadoes is one of many problems that prevent studying physics of magnetic tornadoes and processes associated with them. In particular, the filamentary rotating structures are well detectable only at the limb, while one can make suppositions about their presence at the solar disk. Our method relies on analyzing series of SDO/AIA images at 171 Å, to which we apply convolutional layers, inverted residual blocks, gated recurrent units, and fully connected layers. The new technique combines several approaches established in computer vision. Our method allows detecting structures with sufficient accuracy and recall. For training objects, we used magnetic tornadoes previously described in the literature as well as newfound ones. Our method made it possible to detect those structures, as well as to reveal previously unknown magnetic tornadoes.

P76 contributed

Solar magnetic tornadoes and neutral magnetic field lines at the Sun

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Magnetic tornadoes are long–lived prominences with the twisted magnetic field and plasma flowing upward along the spiral. These objects have recently been discovered at the Sun and their nature and mechanisms of their formation are actively discussed in the literature. Previously, we proposed a method for automated detection of these structures. One of the applications of our technique is to study properties and location patterns of tornadoes on the solar surface. In particular, we investigate a relationship between magnetic tornadoes and neutral magnetic field lines. Previously, the occurrence of the tornado chain at local neutral magnetic field lines has been noted [Wedemeyer et al. 2013, ApJ]. On the Wilcox Solar Observatory website, one can get information about the location of the large-scale neutral magnetic field lines at the photosphere, for example, the solar magnetic equator of the dipole magnetic field. Meanwhile, the accuracy of this method is limited since the resolution of the resulting images is low. We construct an inverse PFSS model that reconstructs the total magnetic field in the corona and at the photosphere with a better accuracy. Comparing the data on neutral lines at the photosphere with tornado images from SDO/AIA at 171 Å (the corona and the upper transition region), we conclude that solar magnetic tornadoes are related to neutral magnetic field lines. This provides a key to understanding physics of formation of stable rotating prominences in the solar atmosphere.

P77 contributed

Plasma – Wave interaction of multiple particles in solar wind plasma and the Earth's magnetospheric plasma systems

Priyank Srivastava, A.K. Singh

The Earth's magnetosphere and solar-wind systems are made up of numerous electron and ion populations, with interactions happening mostly through plasma waves [1]. Both the magnetosphere and the solar wind include numerous populations of ions and electrons that are co-located (i.e., exist on the same magnetic-field lines) and easily interact with one another [2]. The evolution of magnetized plasmas frequently results in anisotropies, which cause instabilities and wave-particle interactions: particle anisotropies in the magnetosphere arise from solar-wind-driven magnetospheric internal convection pushing particle populations into the strong magnetic field of the dipolar regions, and particle anisotropies in the solar wind arise from solar-wind expansion into weaker magnetic fields away from the Sun [3]. Wave-particle interactions work in two ways for any plasma-wave instability: pushing the waves and dispersing the waves. In this way, two distinct particle populations can interact with one another. We have examined 1) the Earth's magnetosphere, with ion and electron populations confined in closed flux tubes of the magnetic dipole, and 2) the solar wind, with ion and electron populations spreading away from the Sun in open magnetic flux tubes. Internal convection drives particle populations into stronger magnetic fields, resulting in particle anisotropies in the magnetosphere; expansion of the plasma away from the Sun leads in particle populations migrating into weaker magnetic fields, resulting in particle anisotropies in the solar wind. In both circumstances, the anisotropies of the various ion and electron populations cause kinetic instabilities, which result in the generation of various forms of plasma waves and wave-particle interactions.

P78 contributed

Sun-as-a-star Analyses of Various Active Events on the Sun Using H-alpha Spectral Images Taken by SMART/SDDI

Takato Otsu, Ayumi Asai, Kiyoshi Ichimoto, Takako T. Ishii (Kyoto University), Kosuke Namekata (NAOJ)

Superflares are known as explosive phenomena on stars releasing the energy more than 10^33 ergs. In recent years, superflares on Sun-like stars have been discovered (e.g., Maehara+ 2012). Moreover, it has been suggested that superflares may have also occurred on the past Sun from analyses of carbon-14 data (e.g., Miyake+ 2012). Then, do superflares occur on the current Sun? To answer this question, it is necessary to first gain a better understanding of stellar superflares, which are actually observed.

For interpreting stellar observations, comparison with spatially resolved data of the Sun is useful. In such a comparison, solar data are spatially integrated and this analysis is called “Sun-as-a-star analysis”. Namekata+ (2022a) carried out Sun-as-a-star analyses of Hαspectra for two solar flares accompanied by a filament eruption/surge to understand the Hαspectra for a superflare on a Sun-like star. From a resemblance between the solar and stellar data, the authors concluded that a stellar filament eruption associated the detected superflare. In addition to flares, other various active events are also observed on the Sun and Sun-as-a-star analyses for such solar events are required for advanced understandings of superflares.

Here we report results of Sun-as-a-star analyses of Hαspectra of various solar active events. We used full-disk solar Hα spectral images taken by SMART/SDDI at Hida observatory, Kyoto University (Ichimoto+ 2017). All the analyzed events show emission relative to the pre-event state and the changes in their Hα equivalent widths are all on the orders of 10^−4 Å. Sun-as-a-star Hα spectra exhibit various features: (i) Flares show emission at the Hα line center, together with red asymmetry and line broadening, as reported in a previous study (Namekata+ 2022c). (ii) Filament eruptions with and without flares show emission near the Hα line center, accompanied by blue- /red-shifted absorption. Notably, disappearance of dark filaments leads to the apparent enhancement of the Hα line center emission. (iii) Eruptions of off limb prominences show blue-/red-shifted emission. These spectral features enable us to identify the active phenomena on Sun-like stars. We have also found that even the filament eruptions showing red-shifted absorptions in Sun-as-a-star Hα spectra lead to coronal mass ejections (CMEs). This result suggests that even if the falling components of stellar filament eruptions are detected as red-shifted absorptions in Hα spectra, such stellar filament eruptions may also develop into CMEs.

P79 contributed

Evaluation of GPM DPR ice precipitation products

Yuya Kurosawa and Nobuhiro Takahashi

Measurement of ice precipitation is important for understanding the global water cycle, because ice precipitation has complex formation process as well as various types of particles. Satellite-based observation is one of the effective methods for global measurement. Dual-frequency radar (DPR) onboard the core observatory of the Global Precipitation Measurement (GPM) consists of a Ku- (KuPR) and a Ka-band radar (KaPR). Studies are actively being conducted to estimate the phase state and type of precipitation by using the difference in scattering and attenuation properties of liquid and solid precipitation at the two frequencies.

There are graupel and hail detection flag [flagGraupelHail] (flagGH), large solid precipitation detection flag [flagHeavyIcePrecip] (flagHIP) and multiple scattering detection index [MSindex] in the latest GPM DPR Level2 products (V07). The difference between two DPR measurements which called the measured dual-frequency ratio (DFRm) is commonly used for these products. The flagGH is calculated using the maximum measured radar reflectivity factor Zm(Ku) in the vertical profile, the storm top height and DFRm. The flagHIP is calculated using the maximum value of Zm and DFRm above the height of -10℃. The MSindex is calculated using the DFRm knee, which is mainly characterized by the vertical profile when multiple scattering occurs, and the slope of the received power at and near the ground surface echo.

In this study, global characteristics of three products, which are expected to be detected in well-developed convective systems, are compared. The detachabilities of three products are compared statistically; 60% (30%) of the pixels detected by flagGH or flagHIP are flagged by MSindex over land (ocean). In addition, only 50% of both flagGH and flagHIP are overlapped each other. The frequency distribution of solid precipitation over a three-month period in 2019 shows that MSindex and flagGH had similar structure, but unlike the other two, flagHIP was also distributed at higher latitudes on the winter hemisphere. Contoured frequency by altitude diagrams (CFAD) for Zm(Ku) and DFRm shows that the variation of the radar reflectivity factor was small at the altitudes referenced by the algorithm. A common characteristic of the three products was a higher frequency of strong precipitation above 30 dBZ below the 0°C altitude. The result of flagHIP had a unique peak near the -10℃ altitude. This peak was seen in stratiform precipitation and at high latitudes and was attributed to an increase in volume-weighted mean drop size (Dm) near the -10°C altitude.

P80 contributed

Changes in internal structure during life cycle of isolated cumulonimbus clouds using multi-parameter phased array weather radar data

Mana Miyairi , Nobuhiro Takahashi

The life cycle of cumulonimbus clouds has been studied by using aircraft and radar. However, cumulonimbus clouds change rapidly in a short period of time, and it has been difficult to capture their three-dimensional structure with the high temporal resolution to describe the life cycle. The Multi-Parameter Phased Array Weather Radar (MP-PAWR) is capable of high-speed, high-precision 3D precipitation observation, and is thought to be capable of providing more detailed information on the life cycle of cumulonimbus clouds.

The objective of this study is to use MP-PAWR data to reveal more detailed changes in structural characteristics and convective systems during the life cycle of cumulonimbus clouds. The analysis was performed on six isolated echoes observed in central Tokyo on August 2, 2018, at around 15:00 to 17:00.

The MP-PAWR covers a radius of 60 km and an altitude of 15 km in 30 seconds with 114 elevation and 300 azimuth angles of observation.

The analysis was conducted to identify individual cumulonimbus clouds and classify hydrometeor types as life cycle features. The characteristics of the appearance height of the first echo, the formation timing of the precipitation core, the timing of precipitation at the ground, and the wind field in the cloud were compared.

The six cases analyzed are designated as Case 1~6, respectively; Cases 1 and 2 occurred isolated, whereas Case 3 to 6 occurred continuously at almost the same location. Heavier precipitation was observed on the ground in Cases1 and 4 than in the other cases. In all cases, precipitation cores that defined as a region with a radar reflectivity factor of 30 dBZ or higher were detected, and precipitation peak on the ground was appeared when the core fell to near the ground. Hydrometeor classification results confirmed the basic structure of ice particles above the 0℃ altitude and rain below that altitude. In addition, there was a possibility that wet graupel was present in the region of strong reflectivity factor in the core. The Doppler velocity analysis showed that strong divergence near the ground surface occurred when radar echo reached at the ground surface in Cases 2, 3, 5, and 6. In contrast, Cases 1 and 4 showed strong divergence occurred when the strongest core region reached to the ground surface.

Further study is planned by using dual Doppler analysis to link these characteristics with dynamic processes.

P81 contributed

Low-cost magnetometers using magneto-impedance (MI) sensors

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Magneto-impedance (MI) effect was discovered about 25 years ago and a micro-size magnetic sensor that utilizes this effect becomes commercially available. We made some modifications to the commercially available MI sensors as they can cover the range of the geomagnetic field. For the period of March 30 to April 27, 2018, we conducted experimental observations of geomagnetic field variations with the MI sensors at Mineyama observation site, which is located about 100 km north-west of Kyoto. Data obtained with the MI sensors were compared with those from the fluxgate magnetometer that has been working at the site. Results showed that the MI sensor recorded geomagnetic variations with amplitudes of ~1 nT that were also detected with the fluxgate magnetometer. This suggests that MI sensors are useful for researches in geomagnetism or space physics, although they are much less expensive than fluxgate magnetometers.

Nomura [2021] developed a triaxial magnetometer which is composed of the MI sensors, Raspberry Pi, low-cost 24-bit A/D converters, and stable power supply circuits. This magnetometer is named MIM-Pi, and the cost of MIM-Pi is about one-tenth of that of fluxgate magnetometer. However, the result of the test at Inabu observation site in Japan showed that MIM-Pi had step noises with amplitudes of 2–3 nT which originated from an A/D converter. Therefore, we replaced the A/D converter with a new A/D conversion module (ADPi) and confirmed that modified MIM-Pi did not have such step noises. Long-term observation at Inabu with MIM-Pi has been performed since November 19, 2021 to January 14, 2022. Results shows that MIM-Pi can record Sq variations and geomagnetic pulsations with amplitudes of 1–2 nT that were also detected with the fluxgate magnetometer. We also performed long-term observation at Kakioka Magnetic Observatory and found that MIM-Pi can identify Pc4 pulsations. In order to install MIM-Pi in a field, we made a jig for MI sensors and a case for the controller. The continuous observation with MIM-Pi has been started at Kawatabi Observatory from September 9, 2022. In presentation, we will show the MIM-Pi data and initial analysis results, and discuss future deployment of MIM-Pi in field observations.

P82 contributed

Ionospheric TEC forecasting using Long Short-Term Memory deep learning approach at a low latitude Indian Location

Sampad Kumar Panda
Ram Kumar Vankadara

Ionospheric predictions are crucial for detecting space-weather anomalies. Ionospheric total electron content (TEC) from the global navigation satellite system (GNSS) plays a crucial role in monitoring the near-Earth space environment. In this paper, we used a deep learning neural network LSTM algorithm to forecast the TEC and scintillation indices. We used a deep learning neural network long short term memory (LSTM) model. The model is fed with solar and geomagnetic parameters like F10.7, Dst, and kP indices and hour of the day to consider the external factors affecting the ionosphere. The observation data (GPS) from May 2021 to April 2022 is taken from the Indian low latitude location recorded from a multi-frequency and multi-constellation GNSS receiver. The LSTM model is validated using the autoregressive moving average (ARIMA) time series model. The LSTM model performs well for all seasons compared to the ARIMA model forecast with a maximum root mean square error of 5.59 for the LSTM model and 6.20 for the ARIMA model and a maximum correlation coefficient of 0.98 for LSTM and 0.97 for the ARIMA model respectively. The model shows worthy performance in near forecasting the TEC that helps the ionospheric or GNSS community to provide suitable mitigation methods during adverse conditions.

P83 contributed

Observing climate change pattern during last four decades: a threat to society or mankind!

A. K. Singh

Since past few decades climate has shown various transference in its trend, but at present it has proved an obvious threat to society and mankind. As we know that the climate is a complex connection of natural elements like the Sun, the Earth, oceans, rain, snow, forests, deserts etc. and adding to the problem there are some anthropogenic factors which influenced the dynamics and the trends of climate change at longer time scale. There may be slight cooling effect due to extended La Nina event but still there is increase in global temperature. The IPCC report 2022 has revealed ~ 1.50C increment in global temperature during next few decades. In the present study, we have studied the pattern of climate in last few decades by analyzing forty years data of various climate parameters observed during the years 1978 to 2018. The parameters taken under consideration are the total solar irradiance (TSI), the ultra violet (UV) index, cloud cover, carbon dioxide (CO2) abundances, multivariate (ENSO) index, volcanic explosivity index (VEI), global surface temperature (GST) anomaly, global sea ice extent, global mean sea level and global precipitation anomaly. A proxy index has been constructed to study the quantitative measure of the climate change. In the process, these indicators were aggregated to a single proxy index as global climate index (GCI) which measures the strength of present climate change in approximation with the past natural variability. Our result has indicated that the strongest climate change has been occurred globally at present as comparison to late 1970's natural variability.

P84 contributed

Center for Heliospheric Science

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Heliospheric system science is one of the major directions of space science. Strong cooperation between solar physics and solar-terrestrial physics (STP) in Japan [Hinode, Geotail, Arase, Mio, and Solar-C (EUVST)], ground-based observations, and modeling contribute to a comprehensive understanding of the heliospheric system. In order to understand the system, a new research strategy that combines satellite and spacecraft missions with ground-based observations, numerical simulations, and modeling is essential. The Center for Heliopsheric Science (CHS) was launched by cooperation with ISEE, Nagoya University, ISAS/JAXA, and NAOJ to lead the heliospheric system science by interdisciplinary collaboration among different projects. The CHS has operated huge databases for various satellites which will be opened to the researchers with the common data format. The CHS has also provided the common data analysis environments to achieve integrated research using various types of datasets, In this presentation, we will present an overview of the CHS and future plan.

P85 contributed

Perturbations in the mid-latitude ionosphere to Severe Geomagnetic Storms

Razaman Atıcı, Selçuk Sağır

Geomagnetic storms that occur on Earth as a result of explosions in the sun can cause spatial and temporal variability of the earth's ionosphere. These variations can be detected through basic ionospheric parameters such as the total electron content (TEC), which refers to the number of electrons in the beam path between the receiver and satellite. This study focused on the analysis of ionospheric variations over a mid-latitude region using GPS-TEC forecasts during severe geomagnetic storms occurring in the 24th solar cycle. The research is based on the Differential TEC Ratio (DROT), a fast and automatic variability detection algorithm. The algorithm is tested using literature data. The obtained results show a very good agreement with the literature. DROT is applied to IONOLAB-TEC forecasts from Ankara (ANKR) Turkey National Permanent GPS Network (TNPGN Active) station over Turkey to detect wave-like oscillations and other irregularities. With the DROT algorithm, both small-scale and large-scale variability of the ionosphere during severe geomagnetic storms has been detected.

P86 contributed

Reconstruction of solar energetic particle spectra for extreme solar particle events

Sergey Koldobskiy, Florian Mekhaldi, Gennady Kovaltsov, Ilya Usoskin

Extreme solar particle events (ESPEs) are the most powerful known manifestations of solar activity. First discovered in 2012 by Fusa Miyake, ESPEs soon became a fastly rising field of research with important implications for climate, radiation hazards, etc. To date, 4 ESPE (774/5 AD, 993/4 AD, 660 BC, and 7176 BC) events are independently registered by three cosmogenic isotopes (radiocarbon, beryllium-10, and chlorine-36). In this presentation, we report the new multi-proxy reconstruction of ESPE integral fluxes. The reconstruction was made using the recent advances in the computation of cosmogenic isotope production in the atmosphere and consequent transport and deposition processes. We propose that the spectral form of ESPE integral flux can be similar to integral fluxes of ground-level enhancement (GLE) events registered by the network of neutron monitors. For GLE events we use recent combined NM and satellite reconstruction. We show that cosmogenic isotope data fit the hypothesis that ESPE integral fluxes can be described with GLE spectral form and evaluate the scaling between ESPEs and GLEs.

P87 contributed

Time of Flight analysis of accelerated electrons in solar flares by using Fermi Gamma-ray Space Telescope

Masaya Yakura, Satoshi Masuda

It is well known that particle acceleration occurs during a solar flare. However, the acceleration process has not been revealed yet. As for the acceleration site, using the so-called Time-of-Flight (ToF) analysis technique, it was concluded that the electron acceleration site is located slightly above the flare loop (Aschwanden et al. 1996). Although the time evolution of the acceleration site during a flare is important for understanding the acceleration process, there are no studies about it.

Thus, we try to solve this problem using a high time resolution X-ray instrument of observation such as Gamma-ray Burst Monitor(GBM) on board Fermi Gamma-ray Space Telescope. To derive a time evolution of the acceleration site, we must identify some spikes by time windows. Then ToF analysis should be done for each spike of multi-energy bands in each time window. A time-series of the time-lag might correspond to the time evolution of the acceleration site. We introduce the results of this study in this presentation.

P88 contributed

Hokkaido Pair of (HOP) radars and SuperDARN – overview, latest achievements and future perspectives

Nozomu Nishitani (ISEE, Nagoya University)

The Super Dual Auroral Radar Network (SuperDARN) is a network of high-frequency (HF) radars located in the high- and mid-latitude regions of both hemispheres. It is used to study the dynamics of the ionosphere and upper atmosphere on a global scale. As of 01 January 2022, there were 38 SuperDARN radars, 24 in the Northern Hemisphere and 14 in the Southern Hemisphere. In particular, the mid-latitude SuperDARN radars, which cover the geomagnetic latitudinal range as low as about 40 degrees, have been operational for more than 15 years. They have been yielding many scientific results on several topics, such as the Sub-Auroral Polarization Streams (SAPS), mid-latitude ionospheric flows at mid-latitudes during quiet and disturbed periods, Traveling ionospheric disturbances (TIDs), and Magnetohydrodynamics (MHD) waves. The Hokkaido Pair of (HOP) radars, i.e., Hokkaido East and West radars, are part of the mid-latitude SuperDARN radars operated by ISEE, Nagoya University. They are located at the lowest geomagnetic latitude and thus play essential roles in the functioning of the SuperDARN network. This paper will present the past scientific achievements, recent progress, and future perspectives of the HOP radars and SuperDARN.

P89 contributed

The Photospheric Imprints of Coronal Electric Currents: Aids to Flare & CME Prediction

Brian T. Welsch

The energy released in solar flares and eruptions (the latter referred to as coronal mass ejections, or CMEs) is stored in electric currents that flow in the solar corona (the Sun's outer atmosphere). Understanding of the nature of these currents would aid both scientific understanding about how flares and CMEs occur, as well as efforts to predict these events (which can drive "space weather" effects that harm Earth's technical systems). Present observational methods are not capable of directly measuring electric currents in the coronal volume. Measurements of the magnetic field vector over areas of the Sun's photosphere (its visible surface), however, are routinely made. These measurements are often used as inputs for models of coronal electric currents. Here, we apply Gauss's separation method, a technique with a long heritage in planetary magnetism recently introduced into the solar physics literature by Schuck et al. (2022), to magnetic fields associated with active regions (areas of relatively strong, coherent magnetic fields often associated with sunspots), enabling direct inferences about properties of coronal currents' structure. This information can be used to improve models of coronal electric currents, thereby aiding our understanding of solar flares and CMEs, and possibly leading to improved capabilities to predict these hazardous events.

P90 contributed

DOI minting and data citation promoted by ISEE

T. Hori, Y. Miyoshi, M. Nose', C.-W. Jun, S. Nakamura, M. Kitahara, A. Maeda, T. Segawa, F. Miyake, K. Hosokawa, S. Masuda, A. Shinbori, Y. Otsuka, K. Shiokawa, K. Iwai, S. Imada, H. Iijima, T. Kaneko, K. Tsuboki, and T. Kato

Since the Institute for Space-Earth Environmental Research (ISEE) of Nagoya University obtained a regular membership of the Japan Link Center (JaLC) in 2020, we have continued to register, and update if necessary, digital object identifiers (DOIs) for scientific data archived by the institute. A total of nearly 60 datasets have their citable DOIs so far and their online landing pages provide the essential information on the datasets including DOIs, basic metadata, and the direct links for accessing the online data repositories. As a result, an increasing number of journal papers and other literature have cited those "dataset DOIs", leading to a broad recognition of scientific data products distributed by ISEE and collaborating research institutes and universities. In the presentation, we report the status of our DOI and data citation activity and further discuss the best practices and lessons from it.

P91 contributed

The study of extended recovery phase of extreme geomagnetic storms

Komal Choraghe, Anil Raghav, Zubair Shaikh, Dibyendu Chakrabarty, Siddharth Kasthurirangan, Nitinkumar Bijewar.

Geomagnetic storms are severe space weather phenomena which affect communication, trasportation, navigation, power grid systems and satellite electronic systems. The temporal evolution of the storm is investigated using Dst or SymH index. The storm profile explicitly shows three phases i.e. initial, main, and recovery phases. Most of the extreme storms have distinguishable fast and slow recovery phases. Literature suggests that the Co-rotating Interaction Region (CIR) generated storms are weaker but have quite a longer recovery phase than Interplanetary Coronal Mass Ejection (ICME) generated stronger storm recovery phase. We demonstrate a case study of particular extreme geomagnetic storm caused by CME that exhibits a longer recovery phase than usual. Present study suggests that the Alfvenic fluctuations could be possible reason behind this longer recovery phase. Further, we have investigated the fast and slow recovery of extreme storms that occurred in the last three decades. We used exponential, hyperbolic, and linear decay functions to fit the fast and slow recovery of the storms. We observed that exponential and hyperbolic functions are well explained only for fast recovery while slow recovery is well explained by a linear function.

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