02）ISEE International Joint Research Program List

Affiliation and Department displayed are current as of March 2022.

（注1）：Cancelled due to COVID-19

2021年度　15件

研究代表者 Principal Investigator	所属機関 Affiliation	所属部局 Department	職名 Position	研究課題名 Project Title	頁 Page	備考 Remarks
AKALA ANDREW OKE-OVIE	UNIVERSITY OF LAGOS, LAGOS, NIGERIA	PHYSICS	Associate Professor	Investigation of the responses of global equatorial/low-latitude ionosphere to CIR-driven and CME-driven intense geomagnetic storms during solar cycle 24	48	
The Wai-Leong	Universiti Kebangsaan Malaysia	Institute of Climate Change	Lecturer	Understanding the Role of Magnetic Island in Plasma Acceleration and Energy Dissipation during Magnetic Reconnection	50	
Berger Thomas	University of Colorado at Boulder	College of Engineering and Applied Sciences	Research Staff	Investigation of Solar Polar Magnetic Fields using Hinode/SP and SDO/HMI Data	51	
Santolik Ondrej	Institute of Atmospheric Physics	Department of Space Physics	Professor	Investigation of electromagnetic waves in space	52	
Buranapratheprat Anukul	Burapha University	Aquatic Science, Faculty of Science	Assistant Professor	An investigation of Mekong River plume in the South China Sea influenced by dam construction and climate change: a numerical modeling approach	54	
Poluianov Stepan	University of Oulu	Sodankylä Geophysical Observatory; Space Physics and Astronomy Research Unit	Senior Researcher	Solar and terrestrial effects in the 50-year long tritium record from Antarctica	56	
Mohanty Pravata Kumar	Tata Institute of Fundamental Research	Department of High Energy Physics	Leader	Study of galactic cosmic rays in the near-Earth space by high resolution multi-directional muon telescopes	57	（注1）
Spiegl Tobias Christian	Freie Universität Berlin	Institute of Meteorology	Postdoc Researcher	Using cosmogenic isotopes to trace back large-scale atmospheric dynamics of the neutron monitor era.	58	
Okoh Daniel Izuikedinachi	Centre for Atmospheric Research, National Space Research and Development Agency	Space Environment Research Facility	Researcher & Coordinator	Investigating Variations and Similarities between Consecutive Equatorial Plasma Bubble Occurrences and Propagation Speeds across Longitudinal Sections of the Globe	60	
Welsch Brian	University of Wisconsin - Green Bay	Physics	Associate Professor	Exploring Magnetic Energies to Understand and Predict CME Onset	62	（注1）
Maurya Ajeet Kumar	Doon University	Physics	Assistant Professor	Characterization of the gravity waves of the meteorological origin and their role in vertical atmosphere-ionosphere coupling	63	
Lugaz Noé	University of New Hampshire	University of New Hampshire	Research Associate Professor	Sheaths of Coronal Mass Ejections and Their Effects on Earth’s Dayside Magnetosphere and Radiation Belts	65	（注1）
Al-Haddad Nada	University of New Hampshire	Space Science Center	Research Assistant Professor	Magnetic Structures and Associated Flows of Coronal Mass Ejections	66	（注1）

研究代表者 Principal Investigator	所属機関 Affiliation	所属部局 Department	職名 Position	研究課題名 Project Title	頁 Page	備考 Remarks
Fedun Viktor	The University of Sheffield	Department of Automatic Control and Systems Engineering	Senior Lecturer	Comprehensive analysis of solar atmospheric dynamics driven by interacting vortex tubes	67	
Zhang Jie	George Mason University	Department of Physics and Astronomy	Full Professor	Study the Origin of Solar Eruptions Using Homologous Events	69	（注1）

(Form 2-2)

Investigation of responses of global equatorial/low-latitude ionosphere to geomagnetic storms of solar cycle 24

PI: **Andrew Akala** (University of Lagos, Nigeria)

Research Summary

Purpose of Project

Occurrences of geomagnetic storms are known to pose threats to Global Navigation Satellite System (GNSS) dependent services, with huge socio-economic consequences under severe conditions. This project investigated the responses of global equatorial/low-latitude ionospheric TEC and irregularities to CIR-driven and CME-driven intense geomagnetic storms of solar cycle 24.

Methods

A Multi-instruments approach was adopted to acquire data. Solar events data that caused each geomagnetic storm were obtained from the Solar Dynamics Observatory. Interplanetary Magnetic Field (IMF) and solar wind plasma data were obtained from the Advanced Composition Explorer (ACE) satellite at https//omniweb.gsfc.nasa.gov/hw/hmtl. PPEF data were obtained from the Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado's PPEF model platform at http://geomag.colorado.edu/real-time-model-of-the-ionosphericelectric-fields.html. We obtained O/N2 data from Global Ultraviolet Imager (GUVI) at http://guvitimed.jhuapl.edu/data_on2_info. GNSS observatory data were obtained from the University NAVSTAR Consortium (UNAVCO), SONEL, and International GNSS Service, IGS websites. Disturbance storm time (Dst) were obtained from the World Data Center for terrestrial Geomagnetism, Kyoto University, Japan (http://wdc.kugi.kyoto-u.ac.jp/DSTdir). The Rate Of change of TEC Index (ROTI) was used as proxy for ionospheric irregularities. An irregularities threshold of 0.5 TECU/min was set for all visible satellite at a cut off elevation of 30°.

Results

Storms with daytime onset time enhanced TEC and intensified fountain effect, while storms with nighttime onset time reduced TEC and caused reversed fountain effect. Three physical processes, namely, PPEF, thermospheric composition changes, and DDEF, generated in response of ionospheric dynamo to thermospheric composition changes drove low-latitude ionospheric electrodynamics. PPEF is dominant around storm's onset, but after several hours, the three processes; either acting individually or collectively, controls low-latitude ionospheric electron density.

Periods of Stay in ISEE, Nagoya University

Unfortunately, due the COVID-19 pandemic and the travel restriction announced by the government of Japan by December, 2021 which was prolonged to February, 2022, I was unable to visit ISEE, Nagoya University during the period of the project. My travel plans for second week of January to first week of March, 2022 was concluded before the travel restriction was announced, although, data processing and analyses had already kick-started in Nigeria since March, 2021.

Publications

Two manuscripts are in the final stage of preparation. When they are ready, they will be submitted to top-rated space science journals. Furthermore, I am in constant discussion with my co-investigator, Yuichi Otsuka on the need to expand the scope of the project to include MSTIDs modeling.

(Form 2-2)

Understanding the Role of Magnetic Island in Plasma Acceleration and Energy Dissipation during Magnetic Reconnection

Wai-Leong Teh (Universiti Kebangsaan Malaysia)

The total budget of the 2021 ISEE project planned for traveling expanses has been fully returned to ISEE due to COVID-19 pandemic. Although we cannot meet in the ISEE, we had a virtual meeting to discuss the analysis results every three months. We are achieving some convincing results. Based on the 2-D simulation results, it is found that the energy conversion occurs more intensively in the secondary magnetic flux rope than in the primary one, and also in the early stage of the secondary flux rope than in the later stage.

(Form 2-2)

Investigation of Solar Polar Magnetic Fields using Hinode/SP and SDO/HMI Data

Dr. Thomas Berger (University of Colorado at Boulder)

Research Summary:

Last year, I couldn't go to Nagoya University ISEE due to the influence of COVID-19, so we couldn't compare the polar observation data of Hinode / SP and SDO / HMI that was originally proposed.

On the other hand, the team in Japan has organized the data so that the polar magnetic field observation data of Hinode / SP can be published on the ISEE website. Obtaining the three components of the magnetic field from the Hinode / SP data is difficult for beginners and requires specialized calculations, and we have compiled the data especially for polar data.

The Japanese team is ready to publish the polar data observed by Hinode / SP so far. As soon as COVID-19 restrictions are lifted, I am prepared to travel to ISEE to begin the work to compare the polar observation data of Hinode / SP with the SDO / HMI data.

(Form 2-2)

Investigation of electromagnetic waves in space

Ondrej Santolik (IAP Prague)

This project aimed at innovative joint research of electromagnetic waves in the plasma environment of the Earth proposed by scientists form the Institute of Atmospheric Physics of the Czech Academy of Sciences in cooperation with colleagues from the Nagoya University. We proposed a one-day visit in Nagoya aiming at Analysis and interpretation of Arase data with a special attention to chorus waves, equatorial noise waves, and lightning whistlers. Comparison with measurements of CLUSTER and Van Allen Probes, initial discussions about a common publication, and drafting a manuscript of a common publication.

The planned personal meeting in Nagoya unfortunately was not possible because of the continuing pandemic restrictions and we communicated and discussed only via Internet.

We worked together on inter-calibration of measurements of intense whistlers by Arase and Van Allen Probes can be given. This work has been recently published in Journal of Geophysical Research: Space Physics. Inter-calibration of data from different spacecraft missions is necessary for combining their measurements in empirical models or in case studies. We showed results collected during a close conjunction of the Van Allen Probes and Arase spacecraft. The inter-calibration was based on a fortuitous case of common observations of strong whistlers at frequencies between a few hundred hertz and 10 kHz, which were generated by the same lightning strokes and which propagated along very similar paths to the two spacecraft. Measured amplitudes of the magnetic field fluctuations were the same within ~14% precision of our analysis, corresponding to 1.2 dB. Electric field measurements showed twice larger amplitudes on Arase compared to Van Allen Probes but they started to match within ~33% precision (2.5 dB) once the newest results on the interface of the antennas to the surrounding plasma were included in the calibration procedures. Ray tracing simulations helped us to build a consistent scenario of wave propagation to both spacecraft. We thus successfully inter-calibrated the polarization and propagation parameters obtained from multicomponent measurements. We also succeed in linking the spacecraft observations to localizations of lightning return strokes by two different ground based networks which independently verified the correctness of the Universal Time tags of waveform measurements by both spacecraft missions, with an uncertainty better than 10 ms.

Common Publication:

Santolík, O., Miyoshi, Y., Kolmašová, I., Matsuda, S., Hospodarsky, G. B., Hartley, D. P., et al. (2021). Inter-calibrated measurements of intense whistlers by Arase and Van Allen Probes. Journal of Geophysical Research: Space Physics, 126, e2021JA029700. https://doi.org/10.1029/2021JA029700

Common Presentations:

I. Kolmasova and O. Santolik, (Invited) On the use of three-component ELF/VLF measurements of radio atmospherics in investigation of lightning related phenomena, The 3rd ISEE Symposium PWING-ERG conference and school on the inner magnetosphere, online conference (ISEE, Nagoya University, Japan)

O. Santolik , (Invited) Spacecraft measurements of whistler mode waves as a tool for investigation of the inner magnetosphere The 3rd ISEE Symposium PWING-ERG conference and school on the inner magnetosphere, online conference (ISEE, Nagoya University, Japan)

Ondrej Santolik, Yoshizumi Miyoshi, Ivana Kolmasova, Shoya Matsuda, George Hospodarsky, David Hartley, Yoshiya Kasahara, Hirotsugu Kojima, Ayako Matsuoka, Iku Shinohara, Aerospace William Kurth, Craig Kletzing, Inter-Calibration of Measurements of Electromagnetic Waves by Arase and Van Allen Probes, Oral presentation at the AGU hybrid meeting, New Orleans, USA

An investigation of Mekong River plume in the South China Sea influenced by dam construction and climate change: a numerical modeling approach

Anukul Buranapratheprat (Burapha University)

Purpose:

The Mekong River is one of the large rivers in Southeast Asia, providing nutrients and sediments to the South China Sea (SCS). Phases of the river plume are important to the marine biogeochemical process and biological productivities in the area influenced by discharged water. Seasonal variations of river plume expansion, modified by wind, current, and the amount of discharged water, can affect the marine ecosystem and productivity in the surrounding area. Changes in the hydrology of the Mekong River resulting from dam construction and global climate change also significantly contribute to the modification of river water influence on marine provinces, but they are not well understood. The numerical experiments were conducted to investigate:

(1) Seasonal variations of the Mekong River plume,

(2) The influences of dam construction and climate change on the river plume.

Methods:

The Princeton Ocean Model (POM) was used to simulate the monthly circulations and variations of the Mekong River plume using a passive tracer. The model domain covers the South China Sea area from latitude 1-24ºN and 98.99-121ºE with 0.166º spatial resolutions and 10 sigma layers. The monthly climatological data were used as driving forces including wind from ECMWF (2000-2020), net heat flux from J-OFURO (2000-2017), and river discharge from the Mekong River Commission. The open boundaries were vertically forced salinity and temperature by World Ocean Atlas 2018 and tidal elevation based on harmonic analysis, K1, O1, M2, S2, P1, Q1, N2, K2 tidal from TPXO8-atlas. The passive tracer model was coupled with POM to track the movement of a conservative dissolved substance placed near the Mekong River mouth. The variations of tracer were calculated by advection and diffusion from the POM. The tracer was released on the first day of the month until the last day of the last day was tracked.

Results:

The seasonal mean of surface currents in the SCS (Fig.1) was used to explain the variations of tracer distributions. In general, the surface currents varied by the monsoon winds. During the northeast monsoon (October to February), surface currents flow from the open ocean to the western coast. Strong southward flows along with the Vietnam coast and the Mekong River mouth to the mouth of the Gulf of Thailand were observed. The surface current near the Mekong River mouth became weak during non-monsoon (March to May) and separated into northeast and southwest directions from the river mouth. During the southwest monsoon (June to September), strong northward currents from the Malay Peninsula were observed. The surface current bent to the east and the northeast near the Mekong River mouth. The current flow crosses the center of the South China Sea to the Philippines at 12 ºN, approximately.

The spatial distribution of the region influenced by discharged water is shown in Figure 2. The contours are defined by 1% from the initial concentration at the initial points (Mekong River mouth). The simulated results indicate that the tracer is transported by seasonal circulations. During the northeast monsoon, the tracer is transported from the Mekong River mouth to the tip of the Indochina Peninsula. Within this season, tracer has spread by covering the largest area in January and the smallest area in October. During the non-monsoon, most of the tracer is located near the river mouth. The covered area is shifted from southwest to northeast of the river mouth from March to May. During the southwest monsoon, the area is expanded to the northeast of the river mouth by largest in July-August and lowest in September.

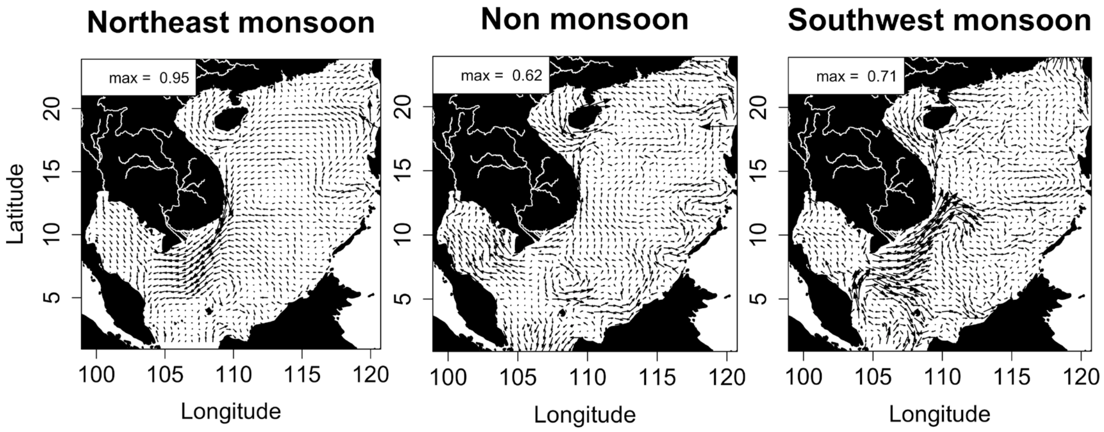

Figure 1 Seasonal surface currents in the SCS during non-monsoon (March-May), southwest monsoon (June-October), and northeast monsoon (November-February).

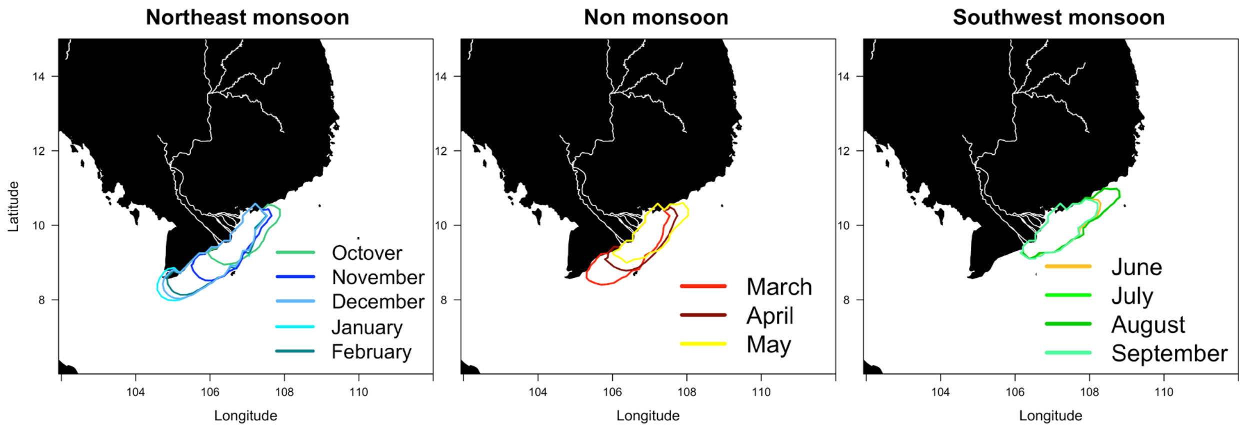

Figure 2 Simulated passive tracer from Mekong River during the northeast monsoon, non-monsoon, and southwest monsoon. The contours indicate a region influenced by discharged water.

We further investigated the influence of dam construction and climate change by decreasing the 50% of discharge water scenario by. The results show the percentage anomaly of tracer from the normal case in each season. Marine biogeochemical processes and biological productivities within these areas may be altered due to decreasing in discharge water.

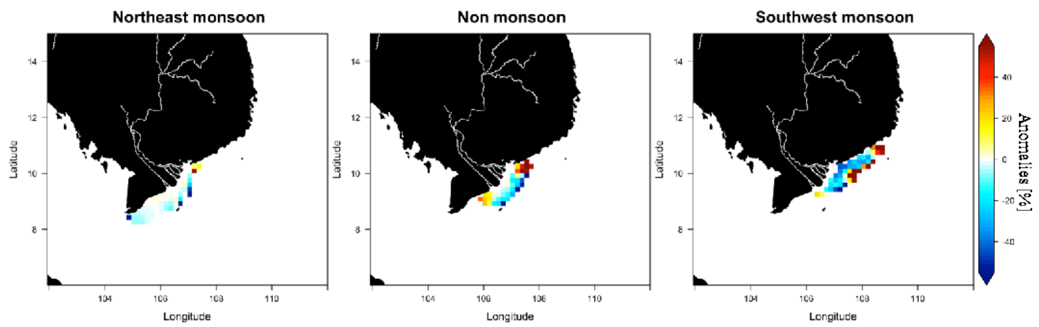

Figure 3 Percentage anomaly of tracer in three seasons.

Periods of stay in ISEE: It has been canceled due to the COVID19 outbreak.

List of publications: None

(Form 2-2)

Solar and terrestrial effects in the 50-year long tritium record from Antarctica

Principal Investigator: Stepn Poluianov (University of Oulu)

This study was carried out in collaboration with Naoyuki Kurita (Nagoya University). Oversea travel has been restricted due to the COVID-19 pandemic. As a result, we gave up on the proposed travel plan and just conducted a part of the project. Here we report the short summary of our study conducted in this fiscal year.

When energetic cosmic ray particles enter the atmosphere, they can initiate cascades of nuclear reactions with ambient air molecules such as nitrogen, oxygen and argon, leading to generation of tritium. After generation, they rapidly enter the global hydrological cycles and then a part of those precipitates on the surface. Thus, in polar region, the past records of tritium are preserved in snow/ice core samples and enable us to reconstruct past variability of cosmic rays reflecting solar activity. However, quantitative understanding of archived tritium in snow/ice cores is limited. In this joint research, we develop the tritium-enabled global water isotope model coupled with the production model of cosmogenic isotopes and challenge the quantitative understanding of the impact of solar variation to tritium signals archived in snow samples. In this year, since we had not conducted the face-to-face meeting at the ISEE, we gave up moving forward our model study and only carried out the preparation of validation dataset. We have measured tritium concentration in 5-m long snow pit samples collected at near Dome Fuji in East Antarctica. The results are shown in Fig. 1 together with solar activity. Since artificial tritium input to the atmosphere due to nuclear-weapon tests mask the variations of natural tritium production in the atmosphere, we focused only after the 1980s when the influence of the artificial tritium is limited. In another year joint research, we challenge the simulation of this observed data and the understanding how much variations of tritium production in associated with solar activity are recorded in snow in Antarctica.

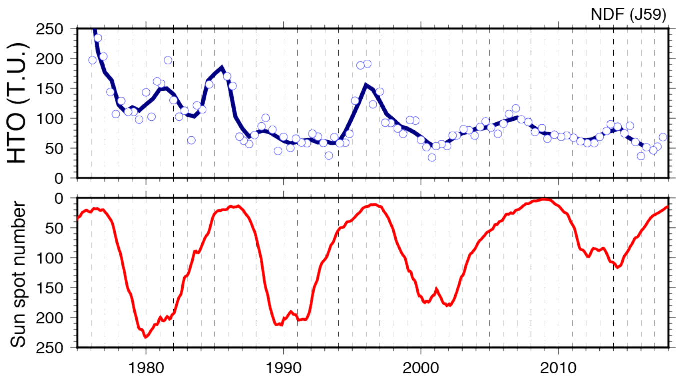

Fig1. Tritium variations of snow in Antarctica and sun spot number from 1975 to 2020.

(Form 2-2)

Study of galactic cosmic rays in the near-Earth space by high resolution multi-directional muon telescopes

Mohanty Pravata Kumar
Tata Institute of Fundamental Research
Department of High Energy Physics

Cancelled due to COVID-19

Using cosmogenic isotopes to trace back large-scale atmospheric dynamics of the neutron monitor era.

Dr. Tobias Spiegl (Institute of Meteorology, Free University of Berlin)

Summary

Due to the COVID-19 pandemic, an on-sight meeting at ISEE with all the international and domestic partners has not been possible. Thus, a two-day online meeting has been carried out to exchange ideas, deepen the collaboration between the domestic and international partners and plan subsequent steps. The scientific focus of the meeting was on the detection and modelling of extreme solar proton events (SPE) during the 8th and 10th century and on possible applications to use the cosmogenic isotopes to trace back the atmospheric dynamics of the neutron monitor era. The latter will be pushed forward as soon as in-person meetings become possible again. In the following, a summary of the workshop contributions from the individual project partners will be given.

Features of WASAVIES and PARMA: Estimation of SEP and GCR fluxes anywhere and anytime in the atmosphere (Tatsuhiko Sato)

The spatial and temporal variations of the initial cosmogenic nuclide yields are the fundamental information to be provided with the climate model. In this study, we calculated the monthly yields of ^{10}Be and ^{14}C during 2001-2020 using PHITS-based Analytical Radiation Model in the Atmosphere (PARMA) (https://phits.jaea.go.jp/expacs/) coupled with their production cross sections from atmospheric constitutions (^{14}N and ^{16}O) evaluated by Particle and Heavy Ion Transport code System PHITS (https://phits.jaea.go.jp/).

Update on modelling the extreme 8th century SPE with EMAC (Tobias Spiegl, Shigeo Yoden and Ulrike Langematz)

Prominent excursions in the amount of cosmogenic nuclides (e.g., ^{10}Be) around AD 774/775 document the most severe solar proton event (SPE) throughout the Holocene. Its manifestation in ice cores is valuable for geochronology, but also for solar-terrestrial physics and climate modeling. Using the ECHAM/MESSy Atmospheric Chemistry (EMAC) climate model in combination with the Warning System for Aviation Exposure to SEP (WASAVIES), we investigate the transport, mixing and deposition of the cosmogenic nuclide ^{10}Be produced by the AD 774/775 SPE. By comparing the model results to reconstructed ^{10}Be time series from four ice core records, we study the atmospheric pathways of ^{10}Be from its stratospheric source to its sink at Earth's surface.

Cosmogenic Proxies: Simulations of the Atmospheric Transport and Deposition of Cosmogenic Isotopes as Proxies of Solar Activity and Atmospheric Dynamics (COPROX) (Konstantin Schaar)

Investigation on the interplay of the production (SPE/GCR), transport and deposition of cosmogenic isotopes (e.g. Be-7/10 and C-14) using EMAC, with the purpose of simulating specific SPE (8./10. century) and GCR-born cosmogenic isotopes during the recent period (1950-2020). The results are compared with data from natural archives such as ice cores (e.g. Be-10) and tree rings (C-14) as well as daily Be-7 measurements from multiple CTBTO-stations around the globe. The project aims e.g. on a better understanding of (i) the role of different deposition mechanisms for cosmogenic isotopes, (ii) the impact of the seasonality of the atmosphere on the transport, (iii) the impact of man-made climate change on the transport and deposition of cosmogenic isotopes as well as the identification of various climate signals in simulated as well as empirical data on cosmogenic isotopes.

A thought on ensemble simulations in tracer transports, climate projections, and numerical weather predictions (Shigeo Yoden and Rattana Chhin)

Ensemble simulations in numerical weather predictions (NWPs) had started in the 1990s to deal with the growth of uncertainty included in an initial condition in simulations of chaotic atmospheric motions. Finite-time Lyapunov stability analysis is a standard tool to diagnose the tangent linear growth of the uncertainty, and ensemble NWPs became a standard tool to improve prediction skills and to predict prediction skills in the nonlinear phase. Ensemble projections are also becoming popular in probabilistic climate-change projections; multi-model ensembles, boundary condition (e.g., SST) perturbations, model parameter perturbations, etc. Chhin (2019) studied the selection of an optimal ensemble subset of CMIP5 models for specific metrics. Lagrangian chaos is another application of the concept of chaos in physical space to study trajectories of idealized fluid particles or passive tracers. An application to the real atmosphere is chaotic mixing and transport barriers in the winter stratosphere (e.g., Yoden, 1999; Mizuta and Yoden, 2001). An ensemble simulation approach to the ideal passive tracers 10Be (and 14C) in major solar proton events will be a new challenge on the chaotic transport in uncertain ensemble predictions, which could be applicable for interdisciplinary studies of solar-terrestrial physics, earth system modelling, and geochronology.

Cosmogenic data (Fusa Miyake)

In the presentation of F. Miyake, a review of recent studies of extreme SEP events using cosmogenic nuclides were introduced. At the time of the workshop, three extreme SEP events have been confirmed by multiple cosmogenic nuclides data (14C in tree rings, 10Be & 36Cl in ice cores) in 774 CE, 993 CE, and ~660 BCE. Also, other candidates of extreme SEP events have been reported as 14C spikes by recent studies. Details of newly detected 14C spikes in 5410 BCE using tree samples from the US, Switzerland, and Finland were introduced in the presentation.

Radionuclides produced by large solar storms: theory vs proxy data (Florian Mekhaldi)

The threat that poses solar particle storms to our modern society is difficult to accurately quantify due to uncertainties regarding the recurrence and magnitude of the most extreme events. This is largely due to our limited observations of the sun that date back to the advent of satellites in the 1970s and neutron monitors in the 1950s. To extend our perspective on extreme solar storms, we can however rely on cosmogenic radionuclides (e.g., ^{10}Be, ^{14}C, and ^{36}Cl) that are generated in the atmosphere as the byproduct of the interactions between cosmic rays and atmospheric constituents. Here, we will show how state-of-the-art production models compare to empirical data, namely ^{10}Be and ^{36}Cl from ice cores and discuss the role of atmospheric transport in the signal. Considering this, we will compare seasonal 10Be data around one ancient event that was discovered.

(Form 2-2)

An Investigation of Equatorial Plasma Bubbles Intensities across Longitudinal Sectors of the Globe using GNSS Observations

Dr Daniel Okoh (Space Environment Research Laboratory, Centre for Atmospheric Research, National Space Research and Development Agency, Abuja - Nigeria)

Research Summary

Introduction

Equatorial plasma bubbles (EPBs) are important space weather phenomena that usually occur in the nighttime equatorial ionosphere. EPBs have significant effects on space-based radio communication technologies such as the GNSS (Global Navigation Satellite System). As a result, there has been increased effort to expand understanding of EPB occurrence, their evolution, and propagation. Most of these studies are however directed at understanding EPB variability in relation to seasons, magnetic and solar activities. The present study is the first to investigate intensities of EPBs across longitudinal sectors of the globe using the GNSS.

Purpose

The purpose of the study is to investigate intensities of EPBs across longitudinal sectors of the globe. The study therefore expands our understanding of EPB features on a global scale by revealing variations of the EPB intensities at different longitudinal sections of the globe.

Data and Methods

GNSS TEC data was used for detecting EPB occurrence, and for deriving the intensities of the EPBs. Calibrated GNSS TEC data was obtained from the Calibrated GNSS TEC Service of the International Centre for Theoretical Physics (ICTP; website: https://arplsrv.ictp.it/). TEC Data from stations in the Service within ±20 degrees of the geomagnetic equator were used. These stations are as shown by the black dots in Figure 1.

As shown in Figure 1, we divided the globe into six longitudinal regions, namely: Pacific, American, Atlantic, African, Asian, and Australian (starting from longitude -180 to 180 degrees in steps of 60 degrees), as indicated by the black longitudinal lines in the figure.

Detection of EPBs was done using computations of ROTI and criteria detailed in Nishioka et al. (2008). To measure EPB intensities, we defined a parameter known as the SRT (Standard deviation of Residual TEC) that represents a measure of the variance in the magnitude of ionospheric ionization (TEC, to be precise) during EPB occurrence. The SRT was computed as follows. For each satellite, we first computed the moving background TEC, which is the running mean of sTEC on a 5-minute window (only observations from satellites having elevation angles greater than 45 degrees were considered). The residual TEC is then computed for each sTEC value as the sTEC value minus the moving background TEC. The purpose of this subtraction is to nullify/reduce the effects of monotonous changes in TEC such as variations connected with changing elevation angles and times of the day. The SRT is then computed for each satellite as the standard deviation of the residual TEC in 5-minute bins.

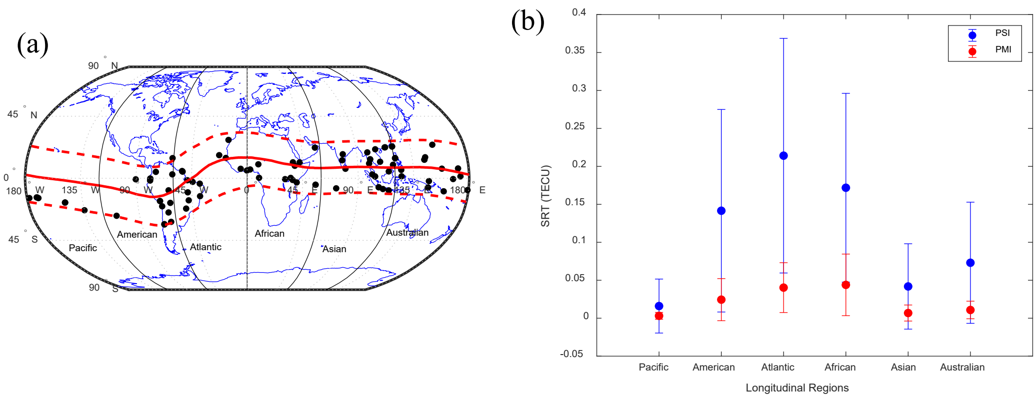

Figure 1. (a) Global map showing locations of the GNSS receiver stations used in this study. The continuous red line represents the geomagnetic equator flanked ±20 degrees by the red dash lines. (b) Annual mean of SRTs for post-sunset intensity (PSI) and post-midnight intensity (PMI) during all occurrences of EPBs in year 2014 at the various longitudinal regions. The lengths of the error bars indicate the standard deviations for the respective regions.

Results

Figure 1(b) shows results of the annual mean of SRTs, binned according to the six longitudinal regions, for year 2014. The mean SRTs are computed in two categories: Post-sunset intensity (PSI; after local sunset to local midnight), and Post-midnight intensity (PMI; after local midnight to local sunrise). The preliminary results show that the Atlantic region typically experiences the greatest post-sunset EPB intensities, followed by the African region, then the American, Australian, Asian, and Pacific regions in that order. The post-midnight intensities are however greatest in the African region, followed by the Atlantic, American, Australian, Asian, and Pacific regions in that order.

Periods of stay in ISEE:

13 Nov. - 22 Dec., 2021 (COVID-19 self-isolation in Narita: 29 Oct. – 13 Nov., 2021)

List of publications

Manuscript in preparation

(Form 2-2)

Exploring Magnetic Energies to Understand and Predict CME Onset

Welsch Brian
University of Wisconsin - Green Bay
Physics

Cancelled due to COVID-19

(Form 2-2)

Characterization of the gravity waves of the meteorological origin and their role in vertical atmosphere-ionosphere coupling

Principal Investigator Name (Affiliation)
Dr. Ajeet Kumar Maurya,
Department of Physics, Babasaheb Bhimrao Ambedkar University, Lucknow, India

Research summary,

Purpose: The proposed work is focused on the new understanding of the atmosphere-ionosphere (AI) coupling process through gravity waves. The sources of gravity waves considered in this work are of meteorological origin. The gravity waves generated from various sources in the troposphere. These waves are the important component of weather and climate and responsible for transporting energy and momentum from atmosphere to ionosphere. Because of this parameterization of gravity waves from various sources is necessary to improve the weather and climate models. Despite their important role, these waves remain poorly understood, mainly because of absence of continuous monitoring technique and propagation models. Thus, the main purpose of the work is to develop continuous monitoring technique using radio remote sensing method.

Method: The present work employs radio signals from Global positioning system derived total electron content and very low frequency (3-30kHz) navigational transmitter signals from various transmitter. Lightning, satellite and reanalysis data is also used as supporting data.

Results: We have first selected strong convection region using the infrared images from GOES satellite. The analysis started by selected VLF signals passing over these regions and showing wave like fluctuations. The wave fluctuations were dominant in two transmitter signal amplitudes. However, they occur at different times on these signals. we have applied power spectral analysis technique to bring out the spectral features of the wave like fluctuations. The Fast Fourier Transform (FFT) technique was applied to the VLF transmitter signal amplitude, which indicates a dominant period ~180 sec. The dominant period for other transmitters varies between ~160-200 sec, all of which are substantially less than the Brunt-Vaisala period at those heights (~300 seconds). Thus, these waves are most probably acoustic waves. Further, in order to understand atmosphere-ionosphere coupling and upward propagation of these waves, we have analyzed TEC data from various GPS stations located along the VLF transmitter receiver great circle path. The GPS TEC analysis provides vertical total electron content (VTEC) from the slant TEC (STEC). We have estimated differential VTEC (DVTEC) by fitting a 7^{th} order polynomial to the VTEC

data for each station. Thus, effectively removed the long periodic variations if any, and we are left with very short periodic modulations. As shown in the Figure 1, the DVTEC variation show similar wave like fluctuations as seen in the VLF signal. Further, the FFT analysis result of the DVTEC data show period of ~190 sec which is in the range of periodicity seen in the VLF signal analysis.

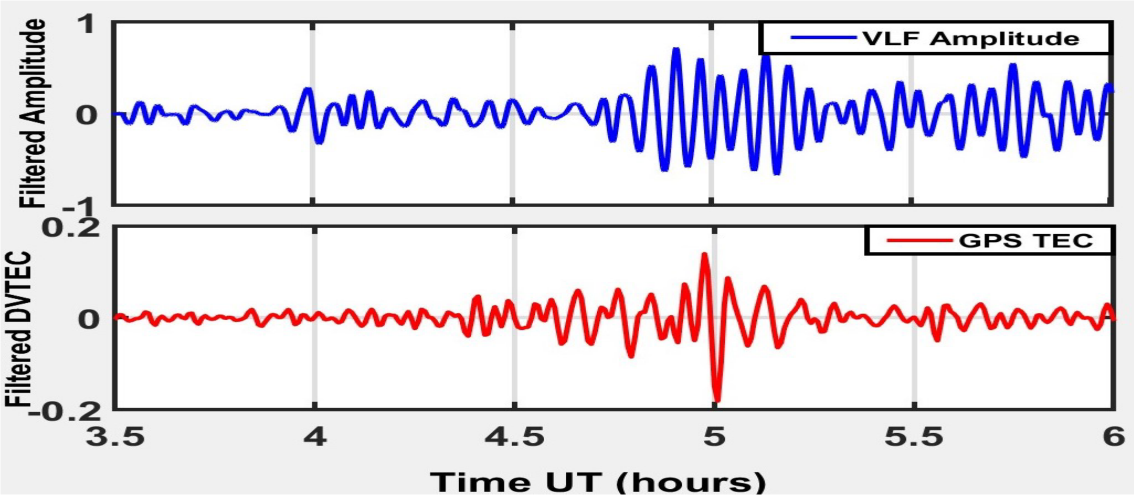

Figure 1: showing comparison of filtered VLF amplitude and GPS DVTEC signal

Possible explanation of observed wave like phenomenon in VLF and GPS data: The wave like fluctuations seen in the VLF signals are modulated by a perturbation in the lower ionosphere (75-85 km altitude), which is most probably triggered by a propagating neutral-density wave, possibly an acoustic gravity wave (AGWs). Further, the strong convection region followed by intense lighting activity during our observational period were present and could be a strong source for the triggering of AGWs. Furthermore, as the GPS estimated DVTEC also show similar kind of wave like signature and periodicity as seen in the VLF signal. Thus, it is possible that the waves observed in the lower ionosphere also seen in the upper ionospheric altitudes implying that there is strong dynamical coupling between the two regions due to high frequency gravity waves. These are our initial results and we are continue working to include modeling the AGWs propagation from source to the upper part of the ionosphere, to better understand AI coupling process.

Periods of stay in ISEE: Due to COVID, unfortunately, I could not travel to Japan and worked remotely. I would like to thank the Host researcher Prof. Yuichi Otsuka for all the support provided by him. He completed all the formalities for my visit and stay at Nagoya University, but due to COVID, my visit could not be materialized.

List of publications: None, work is still in progress

(Form 2-2)

Sheaths of Coronal Mass Ejections and Their Effects on Earth's Dayside Magnetosphere and Radiation Belts

Lugaz Noé
University of New Hampshire

Cancelled due to COVID-19

(Form 2-2)

Magnetic Structures and Associated Flows of Coronal Mass Ejections

Al-Haddad Nada
University of New Hampshire
Space Science Center

Cancelled due to COVID-19

(Form 2-2)

Comprehensive analysis of solar atmospheric dynamics driven by interacting vortex tubes

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One key aspect to understand the solar dynamo mechanism is to properly describe the emergence of solar active regions. In the work performed within the grant, we determine the true dynamics of photospheric flows (including vortex motions) during the formation of an active region. The Lagrangian analysis was applied of the lower photospheric flow topology prior, during and following the rise of a simulated active region formed by pores. The data for this study was obtained from R2D2 simulation which starts from zero-magnetic-field. Our results were obtained by means of the forward and backward Finite Time Lyapunov Exponent (FTLE), uncovering the repelling and attracting photospheric structures. It was shown that considerable global changes are present in granular and mesogranular scales for the converging and diverging flows in granular and mesogranular cells *30 hours prior the emergence of the magnetic field*. This is clearly indicated by a considerable reduction of the magnitude of FTLE fields as a function of time. Locally, the forward FTLE field present distinct features up to 12.67 hours before the emergence time at the location of AR appearance. The forward FTLE field also indicates that the strong concentration of magnetic field affects a region much greater than the actual pores, leading to strong diverging flows in the regions surrounding the pores. Our findings suggest that the FTLE is a powerful tool to describe the changes in the photospheric flows due to magnetic flux emergence. The results of the research (briefly described above) are the basis of the research paper (which is at the final stage of preparation) to be submitted to the Astrophysical Journal Letters. The further development of this study led to the new successful ISEE (International Joint Research Program, 2022/23) application.

Additionally, the new automated vortex detection algorithm (advanced Gamma method) as well as two new boundary detection algorithms dedicated to the analysis of the plasma vortical motion in the solar atmosphere were developed. Compared to the classical Gamma method, the new

algorithm: (1) is more computationally robust; (2) provides the vortex boundary with better accuracy.
The realistic velocity and magnetic field profiles as a function of r were identified in vortices after their identification in the magnetoconvection simulations (R2D2, Bifrost and MURaM). These profiles will be used for the modelling of MHD wave generation in MHS simulations of 3D magnetic/vortex tubes and the following analysis of modes generated with POD and DMD.

Due to COVID-19 it was not possible to visit Nagoya University during the grant duration. Therefore, in agreement with ISEE, the funding provided was spent on data storage (48 Tb in total), adapters, and visual equipment. All of this are in use and provide excellent support for the research conducted. For the same reason (i.e. due to COVID-19) the AOGS session organized by the PI and Co-PI "AOGS 19th Annual Meeting, 2022, ST04 – MHD Waves and Plasma Flows in the Solar Atmosphere" has been cancelled. Another session will be organized in 2023.

Publications

Silva, S.S.A., Lennard, M., Verth, G., Ballai, I., Rempel, E., Warnecke, J., Hotta, H., Ilijima, H., Park, S.-H., Kusano, K. and Fedun, V., Novel approach to forecasting photospheric emergence of active regions, The Astrophysical Journal Letters, 2022, (ready for submission)
Yuyang Yuan, Y., Fedun, V., Verth, G., Silva, S.S.A., Vortex detection by Advanced Γ Method in solar plasma, A&A, 2022 (at the final stage of preparation)

(Form 2-2)

Study the Origin of Solar Eruptions Using Homologous Events

Zhang Jie
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Department of Physics and Astronomy

Cancelled due to COVID-19