Earth, Planets and Space

International CAWSES-II Symposium

EUVI 171, 11-Apr-2013 02:14:00









Society of Geomagnetism and Earth, Planetary and Space Sciences (SGEPSS) The Seismological Society of Japan The Volcanological Society of Japan The Geodetic Society of Japan The Japanese Society for Planetary Sciences



Editorial Board (Mar. 2016)

Editor-in-Chief

Yasuo Ogawa, Tokyo Institute of Technology, Japan

Editorial Board

Yosuke Aoki, University of Tokyo, Japan Mitsuhiro Nakagawa, Hokkaido University, Japan Nanan Balan, University of Sheffield, United Junichi Nakajima, Tokyo Institute of Technology, Kingdom Japan Stephen Bannister, GNS Science, New Zealand Yasuhiro Nariyuki, University of Toyama, Japan Benjamin Fong Chao, Academia Sinica, Taiwan Nozomu Nishitani, Nagoya University, Japan Shanaka de Silva, Oregon State University, U.S.A. Azusa Nishizawa, Japan Coast Guard, Japan Koji Fukuma, Doshisha University, Japan Keiji Ohtsuki, Kobe University, Japan Nobuo Geshi, Geological Survey of Japan, AIST, Taku Ozawa, National Research Institute for Earth Science and Disaster Prevention, Japan Japan Lin-Ni Hau, National Central University, Taiwan Takeshi Sakanoi, Tohoku University, Japan Hauke Hussmann, German Aerospace Center, Martha K. Savage, Victoria University of Wellington, New Zealand Germany Hiroo Kanamori, California Institute of Benoit Taisne, Nanyang Technological University, Technology, U.S.A. Singapore Attila Komjathy, National Aeronautics and Space Hiroshi Takenaka, Okayama University, Japan Hiroaki Toh, Kyoto University, Japan Administration, U.S.A. Alexey Kuvshinov, Swiss Federal Institute of Yih-Min Wu, National Taiwan University, Taiwan Technology Zurich, Switzerland Zhongliang Wu, China Earthquake Administration, Takuto Maeda, University of Tokyo, Japan China Koji Matsumoto, National Astronomical Toshitsugu Yamazaki, University of Tokyo, Japan Observatory, Japan Akimasa Yoshikawa, Kyushu University, Japan

Journal Scope

Earth, Planets and Space (EPS) is the official journal of the Society of Geomagnetism and Earth, Planetary and Space Sciences, The Seismological Society of Japan, The Volcanological Society of Japan, The Geodetic Society of Japan, and The Japanese Society for Planetary Sciences.

EPS is a peer-reviewed, open-access journal published under SpringerOpen. It is an international journal covering scientific articles in the entire field of earth and planetary sciences, particularly geomagnetism, aeronomy, space science, seismology, volcanology, geodesy, and planetary science. EPS also welcomes articles in new and interdisciplinary subjects, and technical reports on instrumentation and software.

The journal was launched in 1998 and has since published over 2700 articles. All of them are available for free on SpringerLink:

http://link.springer.com/journal/40623

More information about the journal, its article collections, and the submission process is available on the journal homepage:

http://www.earth-planets-space.com/

Submit your next research article to Earth, Planets and Space via: <u>https://www.editorialmanager.com/epsp</u>

Yours sincerely,

Prof. Yasuo Ogawa Editor-in-Chief, *Earth, Planets and Space* editor-in-chief@earth-planets-space.org

PREFACE

Open Access

Special issue "International CAWSES-II Symposium"



Mamoru Yamamoto^{1*}, Kazuo Shiokawa², Takuji Nakamura³ and Nat Gopalswamy⁴

Abstract

This special issue gathered papers from the International CAWSES-II Symposium (November 18–22, 2013 at Nagoya University, Japan). Climate and Weather of the Sun-Earth System II (CAWSES-II) is an international scientific program sponsored by Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) that continued from 2009 to 2013. The program was established with the aim of significantly enhancing our understanding of the space environment and its impacts on life and society. The International CAWSES-II Symposium was successful with 388 presentations; and from that, 38 papers were published in this special issue. In this preface, we briefly discuss the contents of the special issue as well as the CAWSES-II review papers published in Progress in Earth and Planetary Science (PEPS) in 2014–2015.

Keywords: Sun-Earth system, Solar-terrestrial physics, International program, CAWSES-II, SCOSTEP

Introduction

Climate and Weather of the Sun-Earth System II (CAWSES-II), an international program sponsored by Scientific Committee on Solar-Terrestrial Physics (SCOSTEP), was established with an aim of significantly enhancing our understanding of the space environment and its impacts on life and society. This program was conducted from 2009 to 2013 to follow the CAWSES program that continued from 2004 to 2008. In contrast to a very low solar activity during the CAWSES period, CAWSES-II was conducted during the earlier stage of the recent solar cycle 24. The project was then subtitled "Towards solar maximum." During November 18-22, 2013, the International CAWSES-II Symposium was held at Nagoya University in Japan in order to provide an excellent opportunity to discuss the scientific accomplishments of CAWSES-II near the end of its 5-year period and look forward to SCOSTEP's future programs. The symposium was very successful with 320 participants from 33 countries/areas, and 388 papers were presented. This special issue, published in 2014-2015, gathered 38 excellent papers from this symposium. In addition to this special issue, reviews of all aspects of CAWSES-II were published in Progress in Earth and

* Correspondence: yamamoto@rish.kyoto-u.ac.jp

¹Research Institute for Sustainable Humanosphere (RISH), Kyoto University, Gokasho, Uji, Kyoto 611-0011, Japan

Full list of author information is available at the end of the article



Planetary Science (PEPS) during the same period. These are two important activities to summarize the scientific program of CAWSES-II. In this preface, we will highlight the papers from our special issue together with the reviews in PEPS. We also note that these publications were recently compiled in a book entitled "Selected publications from the SCOSTEP/CAWSES II project" (ISBN 978-4-904090-15-2 C3044).

Contents of the special issue CAWSES-II program

The overall review of CAWSES-II was given in Tsuda et al. (2015). It stated that "The CAWSES program was aimed at improving the understanding of the coupled solar-terrestrial system, with special emphasis placed on the short-term (weather) and long-term (climate) variability of solar activities and their effects on and responses of geospace and Earth's environment" with "time-scale ranging from minutes to millennia." CAWSES-II pursued this goal by establishing four task groups, which were identified by the key questions of research fields as shown below.

- Task group 1 (TG1): What are the solar influences on climate?
- Task group 2 (TG2): How will geospace respond to an altered climate?

© 2016 Yamamoto et al. **Open Access** This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

- Task group 3 (TG3): How does short-term solar variability affect the geospace environment?
- Task group 4 (TG4): What is the geospace response to variable inputs from the lower atmosphere?

In addition to these task groups, CAWSES-II put significant effort into "capacity building" and "E-science and Informatics," both of which are important for future development of the research field. In the following, we categorize papers from our special issue by task groups and E-science and also refer to the related review papers in PEPS.

Task group 1

Task group 1 (TG1) of CAWSES-II tackled the key question "What are the solar influences on climate?" Seppälä et al. (2014) reviewed the research activities of TG1. They showed different aspects of solar forcing from solar irradiance and demonstrated proposed mechanisms by which solar variation could influence the Earth's climate. Major questions in TG1 were as follows: What is the importance of spectral variations to solar influences on climate? What is the effect of energetic particle forcing on the whole atmosphere and what are the implications for climate? How well do models reproduce and predict solar irradiance and energetic particle influences on the atmosphere and climate? Through CAWSES-II, solar influence on climate is now accepted as an important contribution to climate variability particularly on regional scales. Also, ionization rates and chemical changes by the energetic particle precipitation are now better understood. For climate models which include effect of the solar cycle, however, more efforts are needed (Seppälä et al. 2014).

In our special issue, four papers were published for TG1. Elias et al. (2014) studied the effect of solar cycle 23 in critical frequency (foF2) trend estimation, in which they used ionosonde and model data to estimate the long-term decreasing trend of foF2. The result of the study was consistent with those expected from the greenhouse gas effect. Kozai et al. (2014) studied the spatial density gradient of galactic cosmic rays and their solar cycle variation observed with the Global Muon Detector Network (GMDN). The authors compared the threedimensional (3D) anisotropy of approximately 60 GV galactic cosmic rays (GCRs) from the data observed with the GMDN with conventional analysis with a single muon detector at Nagoya in Japan. They found that both results were fairly consistent as far as the yearly mean value was concerned. Smirnov (2014) studied the reaction of the electric and the meteorological states of the near-ground atmosphere during a geomagnetic storm on April 5, 2010. It was found that air electro-conductivity began to decrease 4 hours before the storm, which lasted for 20 hours. The storm's sudden commencement caused potential gradient oscillations with amplitudes up to 300 V/m. Muraki et al. (2015) studied regional climate patterns over 2000 years as estimated from the annual tree rings of Yaku cedar trees from Yakushima, Japan. They discovered an 11-year periodicity in the meteorological daylight-hour data in the month of June from 1938 to 2013 and a 24-year periodicity in July. The growth rate of the tree rings may be affected by the variation in the daylight hours.

Task group 2

The key question of task group 2 (TG2) was "How will geospace respond to an altered climate?" Laštovička et al. (2014) reviewed the research activities of the task group. It was stated that long-term trends in the mesosphere, thermosphere, and ionosphere are areas of research of increasing importance, both because they are sensitive indicators of climatic change and because they affect satellitebased technologies that are increasingly important to modern life. During the CAWSES-II period, significant progress was achieved in several areas, such as understanding and quantifying the role of stratospheric ozone changes in trends in the upper atmosphere, reaching reasonable agreement between observed and simulated trends in mesospheric temperatures and polar mesospheric clouds, and understanding why the thermospheric density trends are much stronger under solar cycle minimum conditions (Laštovička et al. 2014).

In our special issue, six papers are categorized in TG2. Pertsev et al. (2014) studied long-term ground observations of the noctilucent clouds and found that the occurrence of the noctilucent clouds was correlated to the humidity of the mesosphere that corresponded to the saturated or supersaturated water vapor. However, there was no statistically significant long-term trend in either the occurrence or brightness of the noctilucent cloud when a weather correction was applied. Gan et al. (2014) studied the climatology of the diurnal tides from the extended Canadian Middle Atmosphere Model (eCMAM) run in a nudged mode using reanalysis data of the ground to 1 hPa for the period of January 1979 to June 2010 and the satellite data from Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) in the period from January 2002 to December 2013. The diurnal tidal spectra and their relative strengths compared very well between eCMAM30 and SABER. A variation with a period of 25 to 26 months was found, which indicates the modulation of the diurnal tides by the stratospheric quasi-biennial oscillation (QBO). Elias (2014) studied the foF2 long-term trend that was linked to the anthropogenic effects. It was found that 90 % of the foF2 variation is owing to the solar variability. It is recommended that the F10.7 index should be used for the filtering process, as it is better proxy to the solar EUV compared with the

Zurich relative sunspot number (Rz). Gordiyenko et al. (2014) studied long-term trends in the foF2 as observed at Alma-Ata ionosonde station from 1957 to 2012. The F10.7 and Ap indexes were used to remove shorter variability of the parameter. Results of the analysis showed a long-term trend of -0.0075 MHz/year for the annual mean foF2, which was consistent with the results by Elias (2014). Bychkov et al. (2014) investigated the correlation of 532-nm lidar returns at Kamchatka with the night ionospheric F2 layer and found the role of excited nitrogen ions in the formation of lidar signals. Shinbori et al. (2014) investigated characteristics of the long-term variation in the amplitude of solar quiet (Sq) geomagnetic field daily variation by using 1-h geomagnetic field data obtained from 69 geomagnetic observation stations within the period of 1947 to 2013. They showed clear dependence of the Sq amplitude on the solar activity. The long-term trend of the Sq amplitude was generally negative over a wide region. The authors showed that the relationship between the magnetic field intensity and residual Sq amplitude was an anticorrelation for about 71 % of the geomagnetic stations and implied that there was a movement of the equatorial electrojet due to secular variation of the ambient magnetic field.

Task group 3

The key question of task group 3 (TG3) was "How does short-term solar variability affect the geospace environment?" Gopalswamy et al. (2015) reviewed the scientific achievements of TG3 during CAWSES-II. In particular, after a deep minimum following cycle 23, the Sun climbed to a very weak maximum in terms of the sunspot number in cycle 24, so that many of the results referred to this weak activity in comparison with cycle 23. There were many studies of the short-term variability, manifested as solar eruptions from closed-field regions and high-speed streams from coronal holes, which have immediate consequence to the Earth and the geospace. In addition, there was a progress of studies of extreme space weather events prompted by the July 23, 2012 superstorm event (Gopalswamy et al. 2015).

In our special issue, 12 papers were categorized in TG3. Gopalswamy et al. (2014) reported on all major solar eruptions that occurred on the front side of the Sun during the rise to the peak phase of cycle 24 in order to understand the key factors affecting the occurrence of large solar energetic particle (SEP) events and ground level enhancement (GLE) events. The authors examined the reason for the paucity of GLE events during the period. Most of the eruptions with high coronal mass ejection (CME) speed (>2000 km/s) had poor connection to the Earth, so the highest-energy particles may not have reached the Earth even though they may have been accelerated. There were a few eruptions with high CME speed and good connection, yet they lacked GLEs. Many well-connected SEP

events also did not have GLEs, mainly because of the lower CME speed. Sasai et al. (2014) reported a new project of observing solar neutrons at Mt. Sierra Negra in Mexico. The project is named SciBar Cosmic Ray Telescope (SciCRT) and aims to study the mechanism of ion acceleration on the surface of the Sun and to monitor the anisotropy of galactic cosmic-ray muons. The system was installed in April 2013, and its detection performance was reported. Iwai et al. (2014) studied the coronal magnetic field and the plasma beta (plasma pressure/magnetic pressure). They utilized radio free-free emission data from the Nobeyama Radioheliograph (NoRH) and multiple lineof-sight extreme ultraviolet (EUV) light observations from the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) and the EUV imager onboard the Solar Terrestrial Relations Observatory (STEREO) and achieved more accurate estimations of the coronal parameters than have ever previously been derived. Lopez and Matsubara (2015) studied solar neutrons at Mt. Chacaltaya associated with M- and X-class flares during the rising period of solar cycle 24 in order to better understand the acceleration mechanism of high-energy particles that are driven by solar flares. They found that no statistically significant solar neutron signals were found from the sample, which consisted of 28 M-class and 3 X-class flares. Also, an estimation of the upper limit for solar neutrons to arrive at Mt. Chacaltaya was suggested as 1.07×10^{27} /MeV/sr on the Sun.

Prikryl et al. (2014) studied high-latitude Global Positioning System (GPS) phase scintillation and cycle slips during high-speed solar wind streams and CMEs by superposed epoch (SPE) analysis. The occurrence of scintillation peaked on days with high-speed solar wind streams (HSS) or with CME impacts at the Earth's magnetosphere. They tapered off a few days later, which is similar to the day-to-day variability of geomagnetic activity and riometer absorption at high latitudes. The SPE analysis results were used to obtain cumulative probability distribution functions for the phase scintillation occurrence that could be employed in probabilistic forecasts of phase scintillation at high latitudes. Kumar and Kumar (2014) studied the effects of the solar flares and the geomagnetic storms during December 2006 to 2008 by the investigation of very low frequency (VLF) signals received at Suva in Fiji. The enhancement in the amplitude and phase of VLF signals by solar flares was due to the increase in the D-region electron density by the solar flareproduced extra ionization. Uwamahoro and Habarulema (2014) studied empirical modeling of the storm time geomagnetic indices. They used a neural network to predict Kp index and the local K index from geomagnetic field data from Hermanus, South Africa, with inputs of the solar wind particle density; the solar wind velocity; the interplanetary magnetic field (IMF); the total average field,

Bt; and the IMF Bz component. The model gave good predictability of the Hermanus storm time K index with a correlation coefficient of 0.8. Jun et al. (2014) studied Pc1 pearl structures observed at ground stations in Russia, Japan, and Canada. They selected two Pc1 pulsations. In case 1, Pc1 pearl structures were slightly different during some time intervals at different stations, and their polarization angles varied depending on the frequencies. In case 2, Pc1 pearl structures were similar at different stations, and their polarization angle was independent of frequency. Case 1 was explained by the beating of Pc1 pearl structures in the ionosphere, while case 2 was explained by magnetospheric effects. Kondoh and Shimizu (2014) investigated tailward flow in the near-Earth plasma sheet associated with a rebound of the earthward bursty bulk flow (BBF) by using 3D magnetohydrodynamic simulations of magnetic reconnection in the magnetotail on the basis of the spontaneous fast reconnection model. It was found that, as a result of the rebound of the earthward flow, the accumulation of the plasma density and the plasma pressure was observed at any position in the plasma sheet during the interval between the BBF and the reverse flow. Mandrikova et al. (2014) studied methods of analysis of geomagnetic field variations and cosmic ray data. They proposed a wavelet-based method of describing variations in the Earth's magnetic field, such as the horizontal component of the geomagnetic field, in addition to methods for evaluating changes in the energy characteristics of the field and for isolating the periods of increased geomagnetic activity. The analysis showed that in periods of increased geomagnetic activity, the developed methods allowed the recording of the onset of geomagnetic disturbances and quantitative estimates of the power of the geomagnetic field disturbance. Cherniak et al. (2014) studied the influence of ionospheric irregularities on Global Navigation Satellite System (GNSS) applications. They used data from the permanent GNSS network to develop an empirical model of the ionospheric irregularities over the northern hemisphere. The rate of total electron content (TEC) index (ROTI) maps was used for the estimation of the overall fluctuation activity and the auroral oval evolution. They also showed the correlations between the Kp index and parameters that characterized the activity of the ionosphere irregularities from 2010 to 2013. Martinez-Calderon et al. (2015) conducted polarization analysis of VLF/extremely low frequency (ELF) waves at subauroral latitudes based on the VLF Campaign observation with the High-resolution Aurora Imaging Network (VLF-CHAIN) from February 17 to 25, 2012. Among the naturally occurring VLF and ELF radiations, chorus wave emissions are one of the most intense phenomena. The authors observed several types of VLF/ELF emissions, including chorus, and found that the polarization angle of several emissions depended on both frequency and time. It was suggested that the frequencydependent events, which usually last several tens of minutes, might be the consequence of the broadening of the ray path that the waves follow from their generation region to the ground.

Task group 4

Task group 4 (TG4) of CAWSES-II aimed to answer the key question: "What is the geospace response to variable inputs from the lower atmosphere?" Oberheide et al. (2015) reviewed the achievements of TG4 during CAWSES-II. They identified the progress of the research as the advent of new satellite missions, ground-based instrumentation networks, and the development of whole atmosphere models over the past decade. This resulted in a paradigm shift in the understanding of the variability of geospace, that is, the region of the atmosphere between the stratosphere and several thousand kilometers above ground where atmosphere-ionosphere-magnetosphere interactions occur. The progress made during the CAWSES-II time period is reviewed emphasizing the role of gravity waves, planetary waves and tides, and their ionospheric impacts (Oberheide et al. 2015).

In this category, there are 16 papers in our special issue. Fytterer et al. (2014) studied the global distribution of the migrating terdiurnal tide in the sporadic E occurrence frequencies based on a GPS radio occultation experiment with FORMOSAT-3/COSMIC satellites. Using 6-year averages from December 2006 to November 2012, a global distribution of the terdiurnal oscillation in the occurrence frequency of sporadic E was obtained from 60° S to 60° N. The authors found two peaks above 100 km during the solstice with one maximum at low and midlatitudes in each hemisphere. Comparisons with the neutral wind behavior from simulation and satellite observations showed good agreement for data above 100 km. Gavrilov and Kshevetskii (2014) studied the 3D numerical simulation of nonlinear acoustic-gravity wave (AGW) propagation from the troposphere to the thermosphere. Horizontally moving periodical structures of vertical velocity on the Earth's surface were used as AGW sources in the model. The numerical simulation covered altitudes from the ground up to 500 km. It was found that, in a few minutes, atmospheric waves can propagate to high altitudes above 100 km after activation of the surface wave force. AGWs may transport amplitude modulation of atmospheric wave sources in horizontal directions up to very high levels. Laskar et al. (2014) studied vertical coupling of atmospheres depending on the strength of sudden stratospheric warming (SSW) and solar activity. The equatorial electrojet (EEJ) strength and the TEC data from low latitudes over Indian longitudes during the mid-winter season in the years 2005 to 2013 were used. The authors concluded that the vertical coupling of atmospheres in terms of the

strength of the spectral amplitude was found to be dependent on the strength of SSW, the solar activity, and the interaction between tides and planetary waves. Ren et al. (2014) studied the influence of DE3 tides on the equinoctial asymmetry of the zonal mean ionospheric electron density by using the Global Coupled Ionosphere-Thermosphere-Electrodynamics Model, Institute of Geology and Geophysics, Chinese Academy of Sciences (GCITEM-IGGCAS). The authors showed that the results varied with latitude, altitude, and solar activity level. Compared with the density driven by the September DE3 tide, the March DE3 tide mainly decreased the lower ionospheric zonal mean electron density and mainly increased the electron density at higher ionosphere. It is also reported that DE3 tides drive an equatorial ionization anomaly (EIA) structure at higher ionosphere in the relative difference of zonal mean electron density. This suggests that DE3 tides affect the longitudinal mean equatorial vertical E × B plasma drifts. Truskowski et al. (2014) and Forbes et al. (2014) conducted a two-part study of thermosphere tides. Truskowski et al. (2014), in part 1, investigated TIMED/SABER temperature measurements at 110 km and between ±50° latitude from 2002 through 2010 and revealed the tidal spectrum entering the ionosphere-thermosphere system. The tidal spectrum obtained by the analysis was especially relevant to the dynamo generation of electric fields, which then imposed the tidal variability on the overlying F-region ionosphere. Forbes et al. (2014), as part two of the study, presented multi-year and 72-day mean seasonal-latitudinal tidal structures in exospheric temperature derived from the joint analysis of CHAMP and GRACE accelerometer measurements. With the aid of theory and a simulation model, the authors presented data consistent with those observed at 110 km and presented in part 1. The aggregate sum of all of the tidal components was shown to impose considerable longitude and month-to-month variability on the exosphere temperature tidal spectrum. Hamid et al. (2014) studied the relationship between the EEJ and global Sq currents at the dip equator region. They examined the EEJ-Sq relationship by using observations at six stations in the south American, Indian, and southeast Asian sectors. A weak positive correlation between the EEJ and Sq was obtained in the southeast Asian sector, while weak negative correlations were obtained in the south American and Indian sectors. These results demonstrated that the southeast Asian sector is different from the Indian and south American sectors, which was indicative of a unique physical processes related to the electro-dynamo. Su et al. (2014) studied the seeding mechanism of ionospheric irregularity occurrences by correlating the global monthly/latitudinal distributions of irregularity occurrences and the deep atmospheric convection in the intertropical convergence zone (ITCZ) indicated by the outgoing longwave radiation (OLR)

measurements. The results indicated that good correlations existed only in the south American sector and to some extent in the African sector, which implied that the gravity wave induced in the ITCZ cannot be the sole seeding agent for the Rayleigh-Taylor (RT) instability in the global irregularity occurrences every season. The authors suspected that the post-sunset ionospheric electrodynamic perturbations could be the prevailing seeds for the year-long RT instability globally. Narayanan et al. (2014) investigated ionosonde observations made at 5-min intervals at the Indian dip equatorial station from March 2008 to February 2009 and studied the interlink between equatorial spread F (ESF) and satellite traces (STs), which are assumed to represent tilts in the bottomside isoelectron density surfaces probably caused by largescale wave-like structures (LSWS). They found that nearly half of the ESF events were preceded by ST. Following the first occurrence of ST, the ESF onset was delayed by about 30 min on the average, suggesting that ST may be used as a precursor of ESF. Pre-reversal enhancement (PRE) of upward plasma drift was found to be insignificant during the period of study. Abdu et al. (2015) investigated the role of eastward and upward propagating fast (FK) and ultrafast Kelvin (UFK) waves in the day-to-day variability of equatorial evening PRE and post-sunset generation of ESF. The vertical drift oscillations were found to cause significant modulation in ESF development. The overall results highlighted the role of FK/UFK waves in the day-today variability of ESF in its occurrence season. Shpynev et al. (2015) investigated the impact of dynamic processes in the neutral atmosphere on the high-midlatitude ionosphere during two SSW events. In the case from January 2009, the authors found a negative effect in foF2 and a positive effect in F2 layer maximum (hmF2) above the border of a stratospheric cyclone and an anticyclone with northward flow direction. In January 2013, they found a positive effect in foF2 up to approximately 2.5 MHz and a negative effect in hmF2 at approximately 10 km above the center of the stratospheric cyclone. It was concluded that these effects were caused by the upward transport of molecular gas to the lower thermosphere for the first case and a pulldown forcing of molecular species above the low-pressure zone inside the cyclone for the second case. Oinats et al. (2015) conducted a statistical study of medium-scale traveling ionospheric disturbances (MSTID) using SuperDARN Hokkaido ground backscatter data for 2011. They found four peaks with a distinct diurnal and seasonal dependence in the MSTID azimuth occurrence rate distributions. Shiokawa et al. (2015) reported the first observation of the disappearance of ESF over geomagnetically conjugate points with data from airglow imagers at Darwin, Australia, and Sata, Japan, on August 8, 2002. It is reported that ESF observed in 630-nm airglow images from 1530 (0030 LT) to 1800 UT (0300 LT) disappeared

toward the equator at 1800 to 1900 UT (0300 to 0400 LT) in the field of view. At Darwin, the F-layer virtual height suddenly increased, but it did not increase over the conjugate point at Yamagawa. The authors explained this event by indicating that a polarized electric field associated with this equatorward neutral wind drove a plasma drift across the magnetic field line to cause the observed ESF disappearance. Abadi et al. (2015) investigated the effects of the F region bottomside altitude (h'F), the maximum upward $E \times B$ drift velocity, the duration of PRE, and the integral of upward E × B drifts on the latitudinal extension of ESF in the southeast Asian sector by using GPS receivers and ionosondes. They found that ESF reached magnetic latitudes of 10°-20° in the following conditions: (1) the peak value of h'F was greater than 250–450 km, (2) the maximum upward $E \times B$ drift was greater than 10-70 m/s, and (3) the integral of upward $E \times B$ drift was greater than 50–250 m/s.

E-science

Fox and Kozyra (2015) reviewed E-science and Informatics in CAWSES-II. The authors stated that the effort had the goal of promoting an international virtual institute and several virtual observatories in order to advance system-level science investigations aligned with the four CAWSES-II task groups. They examined what was adopted for CAWSES-II and highlighted the successes and challenges of the effort. They evaluated that the degree of effectiveness of E-science and Informatics efforts varied widely across the CAWSES-II activities, but generally was limited. However, there was a subcommunity that embraced newer forms of collaboration, such as MediaWiki, in what appeared to be a very effective way. They encouraged future international science programs to consider the benefits and resource costs of enhancing the virtual participation opportunities (Fox and Kozyra 2015).

In our special issue, there are two technical reports published in relation to this category. Abe et al. (2014) reported on Progress of the Inter-university Upper Atmosphere Global Observation NETwork (IUGONET) project, which aimed to establish a metadata database of various ground-based observation data covering a wide region from the Sun to the Earth. For archiving purposes, the metadata database system for cross-searching various data distributed across many institutions was developed based on the existing repository software called DSpace as the core component and the Space Physics Archive Search and Extract (SPASE) data model as the metadata format. Yatagai et al. (2015) gave an overview of the capacity-building activities and science-enabling services related to IUGONET. They regularly facilitated training seminars for Japanese students and also in developing countries. IUGONET prepared various tools for users that included the IUGONET data analysis tool and a geographical display tool that uses Google Earth (KML file). In addition, the study by Shinbori et al. (2014) was based on the IUGONET data and its data analysis tool.

Summary

The main functions of CAWSES-II were to help coordinate international activities in observations, modeling, and applications crucial to achieving an understanding of the Sun-Earth system, to involve scientists in both developed and developing countries, and to provide educational opportunities for students of all levels. The International CAWSES-II Symposium in November 2013 gathered a large number of scientists from around the world, and 388 papers were presented. This special issue from the symposium is composed of 38 excellent papers from the symposium. Also, the achievements of CAWSES-II were reviewed by the leaders of the four task groups and the E-science component of the project. The overall success of CAWSES-II can be summarized as follows:

- Study of the geospace environment was one of most important issues in CAWSES-II. The most intense variability of the geospace originates from the Sun, but through studies in CAWSES-II, it is now understood that similarly important influences come from the lower atmosphere through wave dynamics. This suggests the necessity for a deeper understanding of the Sun-Earth coupling processes.
- The understanding of a variety of solar variabilities was greatly enhanced during CAWSES-II. The solar minimum between cycles 23 and 24 was the weakest among recent solar cycles and became an important study area in the field. We also obtained a deeper understanding on the mechanisms of how short-term variability of the Sun affects the Earth. For example, reliable computer simulations are becoming available for space-weather nowcasting/forecasting.
- For studying the long-term variability of the geospace, a careful investigation of the relationship with the Earth's climate is necessary. Great effort was expended in this area during the period of CAWSES-II. The study of the Earth's climate change in response to the solar variability is also rapidly progressing. Better understanding of the long-term Sun-Earth coupling is an important achievement of CAWSES-II.
- E-science and Informatics was a new element in CAWSES-II. This movement is still under progress during the program period, partly because the understanding and computer/network skill of the participating researchers did not reach the level the leaders had expected. However, there were some achievements regarding the virtual poster

activities and database developments shown in the review paper and the special issue papers.

In addition, CAWSES-II paid much attention to the capacity building for young scientists and researchers from Asian and African countries. This movement was not largely reported in the reviews, but we can find its success in the fact that many young scientists have written papers in the special issue, and some papers are from Asian and African countries.

Based on this vast range of achievements from CAWSES-II, SCSOTEP launched the next international project named "Variability of the Sun and Its Terrestrial Impact (VarSITI)" in January 2014. VarSITI is a 5-year program to understand the variability of solar activity and its consequences for the Earth. It will cover various time scales, from the order of thousands of years to milliseconds, and various locations and their connection from the solar interior to the Earth's atmosphere (http://www.varsiti.org/). We continue to investigate further challenges in order to develop a better understanding of the Sun-Earth system.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

All authors of this article worked as the conveners of the International CAWSES-II Symposium and served as guest editors for this special issue. This preface was prepared by Mamoru Yamamoto, revised by Kazuo Shiokawa and Nat Gopalswamy, and agreed upon by all authors. All authors read and approved the final manuscript.

Acknowledgements

We thank all of the participants of the International CAWSES-II Symposium and give special acknowledgement to all of the authors of the papers in our special issue. We highly appreciate all referees who served in evaluating the papers and giving the authors helpful comments and suggestions.

Author details

¹Research Institute for Sustainable Humanosphere (RISH), Kyoto University, Gokasho, Uji, Kyoto 611-0011, Japan. ²Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8601, Japan. ³National Institute of Polar Research, 10-3, Midori-cho, Tachikawa-shi, Tokyo 190-8518, Japan. ⁴Solar Physics Laboratory, Code 671, Heliophysics Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA.

Received: 22 January 2016 Accepted: 23 January 2016 Published online: 19 February 2016

References

- Abadi P, Otsuka Y, Tsugawa T (2015) Effects of pre-reversal enhancement of EXB drift on the latitudinal extension of plasma bubble in Southeast Asia. Earth Planets Space 67:74. doi:10.1186/s40623-015-0246-7
- Abdu MA, Brum CGM, Batista PP, Gurubaran S, Pancheva D, Bageston JV, Batista IS, Takahashi H (2015) Fast and ultrafast Kelvin wave modulations of the equatorial evening F region vertical drift and spread F development. Earth Planets Space 67:1. doi:10.1186/s40623-014-0143-5
- Abe S, Umemura N, Koyama Y, Tanaka Y, Yagi M, Yatagai A, Shinbori A, UeNo S, Sato Y, Kaneda N (2014) Progress of the IUGONET system—metadata database for upper atmosphere ground-based observation data. Earth Planets Space 66:133. doi:10.1186/1880-5981-66-133

- Bychkov W, Nepomnyashchiy YA, Perezhogin AS, Shevtsov BM (2014) Lidar returns from the upper atmosphere of Kamchatka for 2008 to 2014 observations. Earth Planets Space 66:150. doi:10.1186/s40623-014-0150-6
- Cherniak I, Zakharenkova I, Krankowski A (2014) Approaches for modeling ionosphere irregularities based on the TEC rate index. Earth Planets Space 66:165. doi:10.1186/s40623-014-0165-z
- Elias AG (2014) Filtering ionosphere parameters to detect trends linked to anthropogenic effects. Earth Planets Space 66:113. doi:10.1186/1880-5981-66-113
- Elias AG, de Haro Barbas BF, Shibasaki K, Souza JR (2014) Effect of solar cycle 23 in foF2 trend estimation. Earth Planets Space 66:111. doi:10.1186/1880-5981-66-111
- Forbes JM, Zhang X, Bruinsma SL (2014) New perspectives on thermosphere tides: 2. Penetration to the upper thermosphere. Earth Planets Space 66:122. doi:10.1186/1880-5981-66-122
- Fox P, Kozyra J (2015) eScience and Informatics for international science programs. Prog Earth Planet Sci 2(12):2015. doi:10.1186/s40645-015-0042-9
- Fytterer T, Arras C, Hoffmann P, Jacobi C (2014) Global distribution of the migrating terdiurnal tide seen in sporadic E occurrence frequencies obtained from GPS radio occultations. Earth Planets Space 66:79. doi:10.1186/1880-5981-66-79
- Gan Q, Du J, Ward WE, Beagley SR, Fomichev VI, Zhang S (2014) Climatology of the diurnal tides from eCMAM30 (1979 to 2010) and its comparison with SABER. Earth Planets Space 66:103. doi:10.1186/1880-5981-66-103
- Gavrilov NM, Kshevetskii SP (2014) Three-dimensional numerical simulation of nonlinear acoustic-gravity wave propagation from the troposphere to the thermosphere. Earth Planets Space 66:88. doi:10.1186/1880-5981-66-88
- Gopalswamy N, Xie H, Akiyama S, Mäkelä PA, Yashiro S (2014) Major solar eruptions and high-energy particle events during solar cycle 24. Earth Planets Space 66:104. doi:10.1186/1880-5981-66-104
- Gopalswamy N, Tsurutani B, Yan Y (2015) Short-term variability of the Sun-Earth system: an overview of progress made during the CAWSES-II period. Prog Earth Planet Sci 2:13. doi:10.1186/s40645-015-0043-8
- Gordiyenko GI, Vodyannikov VV, Yakovets AF, Litvinov YG (2014) A long-term trend in the F2-layer critical frequency as observed at Alma-Ata ionosonde station. Earth Planets Space 66:125. doi:10.1186/1880-5981-66-125
- Hamid NSA, Liu H, Uozumi T, Yumoto K, Veenadhari B, Yoshikawa A, Sanchez JA (2014) Relationship between the equatorial electrojet and global Sq currents at the dip equator region. Earth Planets Space 66:146. doi:10.1186/s40623-014-0146-2
- Iwai K, Shibasaki K, Nozawa S, Takahashi T, Sawada S, Kitagawa J, Miyawaki S, Kashiwagi H (2014) Coronal magnetic field and the plasma beta determined from radio and multiple satellite observations. Earth Planets Space 66:149. doi:10.1186/s40623-014-0149-z
- Jun C-W, Shiokawa K, Connors M, Schofield I, Poddelsky I, Shevtsov B (2014) Study of Pc1 pearl structures observed at multi-point ground stations in Russia, Japan, and Canada. Earth Planets Space 66:140. doi:10.1186/s40623-014-0140-8
- Kondoh K, Shimizu T (2014) Study of plasma flow reversal in the near-Earth plasma sheet using numerical computations. Earth Planets Space 66:147. doi:10.1186/s40623-014-0147-1
- Kozai M, Munakata K, Kato C, Kuwabara T, Bieber JW, Evenson P, Rockenbach M, Lago AD, Schuch NJ, Tokumaru M, Duldig ML, Humble JE, Sabbah I, Al Jassar HK, Sharma MM, Kota J (2014) The spatial density gradient of galactic cosmic rays and its solar cycle variation observed with the Global Muon Detector Network. Earth Planets Space 66:15. doi:10.1186/s40623-014-0151-5
- Kumar A, Kumar S (2014) Space weather effects on the low latitude D-region ionosphere during solar minimum. Earth Planets Space 66:76. doi:10.1186/ 1880-5981-66-76
- Laskar FI, Pallamraju D, Veenadhari B (2014) Vertical coupling of atmospheres: dependence on strength of sudden stratospheric warming and solar activity. Earth Planets Space 66:94. doi:10.1186/1880-5981-66-94
- Laštovička J, Beig G, Marsh DR (2014) Response of the mesosphere-thermosphereionosphere system to global change—CAWSES-II contribution. Prog Earth Planet Sci 1:21. doi:10.1186/s40645-014-0021-6
- Lopez D, Matsubara Y (2015) Search for solar neutrons at Mount Chacaltaya associated with M- and X-class flares during the rising period of solar cycle 24. Earth Planets Space 67:54. doi:10.1186/s40623-015-0222-2
- Mandrikova OV, Solovev IS, Zalyaev TL (2014) Methods of analysis of geomagnetic field variations and cosmic ray data. Earth Planets Space 66:148. doi:10.1186/ s40623-014-0148-0
- Martinez-Calderon C, Shiokawa K, Miyoshi Y, Ozaki M, Schofield I, Connors M (2015) Polarization analysis of VLF/ELF waves observed at subauroral latitudes during the VLF-CHAIN campaign. Earth Planets Space 67:21. doi:10.1186/s40623-014-0178-7

- Muraki Y, Mitsutani T, Shibata S, Kuramata S, Masuda K, Nagaya K (2015) Regional climate pattern during two millennia estimated from annual tree rings of Yaku cedar trees: a hint for solar variability? Earth Planets Space 67:31. doi:10. 1186/s40623-015-0198-y
- Narayanan VL, Sau S, Gurubaran S, Shiokawa K, Balan N, Emperumal K, Sripathi S (2014) A statistical study of satellite traces and evolution of equatorial spread F. Earth Planets Space 66:160. doi:10.1186/s40623-014-0160-4
- Oberheide J, Shiokawa K, Gurubaran S, Ward WE, Fujiwara H, Kosch MJ, Makela JJ, Takahashi H (2015) The geospace response to variable inputs from the lower atmosphere: a review of the progress made by Task Group 4 of CAWSES-II. Prog Earth Planet Sci 2:2. doi:10.1186/s40645-014-0031-4
- Oinats AV, Kurkin VI, Nishitani N (2015) Statistical study of medium-scale traveling ionospheric disturbances using SuperDARN Hokkaido ground backscatter data for 2011. Earth Planets Space 67:22. doi:10.1186/s40623-015-0192-4
- Pertsev N, Dalin P, Perminov V, Romejko V, Dubietis A, Balčiunas R, Černis K, Zalcik M (2014) Noctilucent clouds observed from the ground: sensitivity to mesospheric parameters and long-term time series. Earth Planets Space 66:98. doi:10.1186/1880-5981-66-98
- Prikryl P, Jayachandran PT, Mushini SC, Richardson IG (2014) High-latitude GPS phase scintillation and cycle slips during high-speed solar wind streams and interplanetary coronal mass ejections: a superposed epoch analysis. Earth Planets Space 66:62. doi:10.1186/1880-5981-66-62
- Ren Z, Wan W, Xiong J, Liu L (2014) Influence of DE3 tide on the equinoctial asymmetry of the zonal mean ionospheric electron density. Earth Planets Space 66:117. doi:10.1186/1880-5981-66-117
- Sasai Y, Nagai Y, Itow Y, Matsubara Y, Sako T, Lopez D, Itow T, Munakata K, Kato C, Kozai M, Miyazaki T, Shibata S, Oshima A, Kojima H, Tsuchiya H, Watanabe K, Koi T, Valdes-Galicia JF, González LX, Ortiz E, Musalem O, Hurtado A, Garcia R, Anzorena M (2014) Performance of the SciBar cosmic ray telescope (SciCRT) toward the detection of high-energy solar neutrons in solar cycle 24. Earth Planets Space 66:130. doi:10.1186/1880-5981-66-130
- Seppälä A, Matthes K, Randall CE, Mironova IA (2014) What is the solar influence on climate? Overview of activities during CAWSES-II. Prog Earth Planet Sci 1:24. doi:10.1186/s40645-014-0024-3
- Shinbori A, Koyama Y, Nose M, Hori T, Otsuka Y, Yatagai A (2014) Long-term variation in the upper atmosphere as seen in the geomagnetic solar quiet daily variation. Earth Planets Space 66:155. doi:10.1186/s40623-014-0155-1
- Shiokawa K, Otsuka Y, Lynn KJ, Wilkinson P, Tsugawa T (2015) Airglow-imaging observation of plasma bubble disappearance at geomagnetically conjugate points. Earth Planets Space 67:43. doi:10.1186/s40623-015-0202-6
- Shpynev BG, Kurkin VI, Ratovsky KG, Chernigovskaya MA, Belinskaya AY, Grigorieva SA, Stepanov AE, Bychkov W, Pancheva D, Mukhtarov P (2015) High-midlatitude ionosphere response to major stratospheric warming. Earth Planets Space 67:18. doi:10.1186/s40623-015-0187-1
- Smirnov S (2014) Reaction of electric and meteorological states of the near-ground atmosphere during a geomagnetic storm on 5 April 2010. Earth Planets Space 66:154. doi:10.1186/s40623-014-0154-2
- Su S-Y, Wu CL, Liu CH (2014) Correlation between the global occurrences of ionospheric irregularities and deep atmospheric convective clouds in the intertropical convergence zone (ITCZ). Earth Planets Space 66:134. doi:10. 1186/1880-5981-66-134
- Truskowski AO, Forbes JM, Zhang X, Palo SE (2014) New perspectives on thermosphere tides: 1. Lower thermosphere spectra and seasonal-latitudinal structures. Earth Planets Space 66:136. doi:10.1186/s40623-014-0136-4
- Tsuda T, Shepherd M, Gopalswamy N (2015) Advancing the understanding of the Sun-Earth interaction—the Climate and Weather of the Sun-Earth System (CAWSES) II program. Prog Earth Planet Sci 2:28. doi:10.1186/s40645-015-0059-0
- Uwamahoro J, Habarulema JB (2014) Empirical modeling of the storm time geomagnetic indices: a comparison between the local K and global Kp indices. Earth Planets Space 66:95. doi:10.1186/1880-5981-66-95
- Yatagai A, Sato Y, Shinbori A, Abe S, Ueno S, IUGONET project team (2015) The capacity-building and science-enabling activities of the IUGONET for the solar-terrestrial research community. Earth Planets Space 67:2. doi:10.1186/ s40623-014-0170-2

Correlation between the global occurrences of ionospheric irregularities and deep atmospheric convective clouds in the intertropical convergence zone (ITCZ)

Shin-Yi Su*, Chung Lung Wu and Chao Han Liu

Earth, Planets and Space 2014, **66**:134 doi:10.1186/1880-5981-66-134 Received: 4 March 2014, Accepted: 24 September 2014, Published: 6 November 2014

Abstract

To study the seeding mechanism of ionospheric irregularity occurrences, a correlation study has been carried out between the global monthly/latitudinal (m/l) distributions of irregularity occurrences and the deep atmospheric convective clouds in the intertropical convergence zone (ITCZ) indicated by the outgoing longwave radiation (OLR) measurements. Seven longitude sectors - the African, Indian, West Pacific, Central Pacific, East Pacific, South American, and Atlantic sectors - are selected to study the correlations between the two distributions. The results indicate that good correlations exist only in the South American sector and to some extent in the African sector. For the other five sectors, no correlations are found in the m/l distributions between the irregularities and OLRs. This implies that the gravity wave induced in the ITCZ cannot be the sole seeding agent for the Rayleigh-Taylor (RT) instability in the global irregularity occurrences every season. We suspect that the post-sunset ionospheric electrodynamic perturbations could be the prevailing seeds for the RT instability globally year long. Together with the favorable post-sunset ionospheric condition, the global m/l distributions of irregularity occurrences could be adequately explained.

Keywords: Ionospheric density irregularity; Gravity wave; OLR; ITCZ



*Corresponding author: Shin-Yi Su, sysu@jupiter.ss.ncu.edu.tw

FRONTIER LETTER

Open Access

Coronal magnetic field and the plasma beta determined from radio and multiple satellite observations

Kazumasa Iwai*, Kiyoto Shibasaki, Satoshi Nozawa, Takuya Takahashi, Shinpei Sawada, Jun Kitagawa, Shun Miyawaki and Hirotaka Kashiwagi

Earth, Planets and Space 2014, **66**:149 doi:10.1186/s40623-014-0149-z Received: 3 March 2014, Accepted: 29 October 2014, Published: 14 November 2014

Abstract

We derived the coronal magnetic field, plasma density, and temperature from the observation of polarization and intensity of radio thermal free-free emission using the Nobeyama Radioheliograph (NoRH) and extreme ultraviolet (EUV) observations. We observed a post-flare loop on the west limb on 11 April 2013. The line-of-sight magnetic field was derived from the circularly polarized free-free emission observed by NoRH. The emission measure and temperature were derived from the *Atmospheric Imaging Assembly* (AIA) onboard *Solar Dynamics Observatory* (SDO). The derived temperature was used to estimate the emission measure from the NoRH radio free-free emission observations. The derived density from NoRH was larger than that determined using AIA, which can be explained by the fact that the low-temperature plasma is not within the temperature coverage of the AIA filters used in this study. We also discuss the other observation of the post-flare loops by the EUV Imager onboard the Solar Terrestrial Relations Observatory (STEREO), which can be used in future studies to reconstruct the coronal magnetic field strength. The derived plasma parameters and magnetic field were used to derive the plasma beta, which is a ratio between the magnetic pressure and the plasma pressure. The derived plasma beta is about 5.7×10^{-4} to 7.6×10^{-4} at the loop top region.

Keywords: Sun: Corona; Sun: Magnetic fields; Sun: Radio radiation; Methods: Data analysis



Figure 1

*Corresponding author: Kazumasa Iwai, kazumasa.iwai@nao.ac.jp

High-latitude GPS phase scintillation and cycle slips during high-speed solar wind streams and interplanetary coronal mass ejections: a superposed epoch analysis

Paul Prikryl*, P Thayyil Jayachandran, Sajan C Mushini and Ian G Richardson

Earth, Planets and Space 2014, 66:62 doi:10.1186/1880-5981-66-62 Received: 12 March 2014, Accepted: 12 May 2014, Published: 30 June 2014

Abstract

Results of a superposed epoch (SPE) analysis of occurrence of phase scintillation and cycle slips at high latitudes keyed by arrival times of high-speed solar wind streams (HSS) and interplanetary coronal mass ejections (ICME) for years 2008 to 2012 are presented. Phase scintillation index σ_{ϕ} is obtained in real time from L1 signal recorded at the rate of 50 Hz by specialized at the rate of 50 Hz by specialized solar wind streams (GDE) is no and with the real time from L1 signal recorded at the rate of 50 Hz by specialized solar wind streams (GDE) is no and total be stream at total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the rate of 50 Hz by specialized solar wind streams (GDE) is no and total black the r

global positioning system (GPS) ionospheric scintillation and total electron content (TEC) monitors (GISTMs) deployed as a part of the Canadian High Arctic Ionospheric Network (CHAIN). The phase scintillation, mapped as a function of magnetic latitude and magnetic local time, occurs predominantly on the dayside in the cusp and in the nightside auroral oval. The scintillation occurrence peaks on days of HSS or ICME impacts at the Earth's magnetosphere and tapers off a few days later, which is similar to day-to-day variability of geomagnetic activity and riometer absorption at high latitudes. ICMEs that are identified as magnetic clouds are significantly more geoeffective than HSSs and ICMEs with no or weak magnetic cloud characteristics. On their arrival day, magnetic clouds result in higher occurrence, and thus probability, of scintillation in the nightside auroral zone. The SPE analysis results are used to obtain cumulative probability distribution functions for the phase scintillation at high latitudes.

Keywords: Ionosphere; Ionospheric irregularities; GPS scintillation; Solar wind disturbances; Space weather forecasting

*Corresponding author: Paul Prikryl, paul.prikryl@nrcan.gc.ca

FULL PAPER

Open Access

Space weather effects on the low latitude D-region ionosphere during solar minimum

Abhikesh Kumar* and Sushil Kumar

Earth, Planets and Space 2014, **66**:76 doi:10.1186/1880-5981-66-76 Received: 13 March 2014, Accepted: 15 July 2014, Published: 24 July 2014

Abstract

The effects of the solar flares and the geomagnetic storms (disturbance storm time (*Dst*) < -50 nT) during December 2006 to 2008, a period during the unprecedented solar minimum of solar cycles 23 and 24, have been examined on sub-ionospheric very low frequency (VLF) signals from NWC (19.8 kHz), NPM (21.4 kHz), VTX (18.2 kHz), and NLK (24.8 kHz) transmitters monitored at Suva (18.2° S, 178.4° E), Fiji. Apart from the higher class solar flares (C to X), a solar flare of class B8.5 also produced enhancements both on the amplitude and phase. The amplitude enhancements in NLK, NPM, and NWC signals as a function of peak solar flare X-ray flux in decibel (dB; relative to 1 μ W/m²) shows that the relationship curve is steeper and quite linear between the flare power levels of 0 to 15 dB; below 0 dB, the curve gets less steep and flattens towards –5 dB flare power level, while it also gets less steep above 15 dB and almost flattens above 20 dB. In general, the level of amplitude enhancement for NLK signal is higher than that for NPM and NWC signals for all solar flares. The enhancement in the amplitude and phase is due to the increase in the D-region electron density by the solar flare-produced extra ionization. The modeling of VLF perturbations produced by B8.5 and C1.5 classes of solar flares on 29 January

2007 using LWPC (Long Wave Propagation Capability) V2.1 codes show that reflection height (*H'*) was reduced by 0.6 and 1.2 km and the exponential sharpness factor (β) was raised by 0.010 and 0.005 km⁻¹, respectively. Out of seven storms with Dst < -50 nT, only the intense storm of 14 to 16 December 2006 with a minimum Dst of -145 nT has shown a clear reduction in the signal strength of NWC and NPM sub-ionospheric signals due to storm-induced reduction in the D-region electron density.

Keywords: VLF perturbations; Solar flares; Geomagnetic storms; D-region ionosphere



*Corresponding author: Abhikesh Kumar, kumar_ab@usp.ac.fj



Global distribution of the migrating terdiurnal tide seen in sporadic E occurrence frequencies obtained from GPS radio occultations

Tilo Fytterer*, Christina Arras, Peter Hoffmann and Christoph Jacobi *Earth, Planets and Space* 2014, **66**:79 doi:10.1186/1880-5981-66-79 Received: 30 March 2014, Accepted: 9 July 2014, Published: 28 July 2014

Abstract

Global Positioning System radio occultation measurements by FORMOsa SATellite mission-3/Constellation Observing System for Meteorology, Ionosphere and Climate satellites were used to analyse the characteristics of the 8-h oscillation in sporadic E (E_s) layers. Six-year averages based on the 3-monthly mean zonal means from December 2006 to November 2012 were constructed for the amplitude of the terdiurnal oscillation in the occurrence frequency of E_s . A global distribution from 60° S to 60° N is given, revealing two peaks above 100 km during solstice with one maximum at low and midlatitudes (approximately 10° to 40°) in each hemisphere. During equinox, the global distribution is marked by two dominant peaks centred at midlatitudes, while an additional weak maximum is located at very low southern latitudes. The seasonal characteristics around 110 km reveal large values during equinox at low and midlatitudes (<40° N), while further peaks occur

in April at >40° S and in July near 30° S. The pattern around 90 km is dominated by a broad peak between 20° and 30° S from March to September. Comparisons with the terdiurnal oscillation in the neutral atmosphere derived from zonal wind and vertical zonal wind shear simulated with a circulation model of the middle atmosphere, as well as with satellite observations of the terdiurnal tide in temperature, fit quite well for the results above 100 km, but do not show agreement for lower altitudes.

Keywords: Sporadic E layer; Terdiurnal tide; Wind shear theory; GPS radio occultation



*Corresponding author: Tilo Fytterer, tilo.fytterer@kit.edu

FULL PAPER

Open Access

Vertical coupling of atmospheres: dependence on strength of sudden stratospheric warming and solar activity

Fazlul I Laskar*, Duggirala Pallamraju and Bhaskara Veenadhari

Earth, Planets and Space 2014, **66**:94 doi:10.1186/1880-5981-66-94 Received: 30 April 2014, Accepted: 7 August 2014, Published: 18 August 2014

Abstract

Comprehensive behavior of the low-latitude upper atmosphere during sudden stratospheric warming (SSW) events at varying levels of solar activity has been investigated. The equatorial electrojet (EEJ) strength and the total electron content (TEC) data from low latitudes over Indian longitudes during the mid-winter season in the years 2005 to 2013 are used in this study. Five major and three minor SSW events occurred in the observation duration, wherein the solar activity had varied from minimum (almost no sunspots) to mini-maximum (approximately 50 sunspots of the solar cycle 24). Spectral powers of the large-scale planetary wave (PW) features in the EEJ and the TEC have been found to be varying with solar activity and SSW strengths. Specially, the spectral powers of quasi-16-day wave variations during the three very strong SSW events in the years 2006, 2009, and 2013 were found to be very high in comparison with those of other years. For these major events, the amplitudes of

the semi-diurnal tides and quasi-16-day waves were found to be highly correlated and were maximum around the peak of SSW, suggesting a strong interaction between the two waves. However, this correlation was poor and the quasi-16-day spectral power was low for the minor events. A strong coupling of atmospheres was noted during a relatively high solar activity epoch of 2013 SSW, which was, however, explained to be due to the occurrence of a strong SSW event. These results suggest that the vertical coupling of atmospheres is stronger during strong major SSW events and these events play an important role in enabling the coupling even during high solar activity.

Keywords: Sudden stratospheric warming; Planetary waves; Atmospheric tides; Total electron content; Sun-Earth interaction; Vertical coupling; Upper atmosphere; Ionosphere; Thermosphere



*Corresponding author: Fazlul I Laskar, fazlul84@gmail.com

Empirical modeling of the storm time geomagnetic indices: a comparison between the local *K* and global *Kp* indices

Jean Uwamahoro* and John Bosco Habarulema

Earth, Planets and Space 2014, **66**:95 doi:10.1186/1880-5981-66-95 Received: 1 April 2014, Accepted: 6 August 2014, Published: 20 August 2014

Abstract

This paper describes a neural network-based model developed to predict geomagnetic storms time *K* index as measured at a magnetic observatory located in Hermanus (34°25 S; 19°13 E), South Africa. The parameters used as inputs to the neural network were the solar wind particle density *N*, the solar wind velocity *V*, the interplanetary magnetic field (IMF) total average field B_t as well as the IMF B_z component. Averaged hourly OMNI-2 data comprising storm periods extracted from solar cycle 23 (SC23) were used to train the neural network. The prediction performance of this model was tested on some moderate to severe storms (with $K \ge 5$) that were not included in the training data set and the results are compared to the prediction of the global geomagnetic *Kp* index. The model results show a good predictability of the

Hermanus storm time *K* index with a correlation coefficient of 0.8.



*Corresponding author: Jean Uwamahoro, mahorojpacis@gmail.com

FULL PAPER

Open Access

K-index measurements: Magnetic storm on 3-4 /08/2010

Climatology of the diurnal tides from eCMAM30 (1979 to 2010) and its comparison with SABER

Quan Gan*, Jian Du, William E Ward, Stephen R Beagley, Victor I Fomichev and Shaodong Zhang

Earth, Planets and Space 2014, **66**:103 doi:10.1186/1880-5981-66-103 Received: 31 March 2014, Accepted: 16 August 2014, Published: 28 August 2014

Abstract

The extended Canadian Middle Atmosphere Model (eCMAM) was recently run in a nudged mode using reanalysis data from the ground to 1 hPa for the period of January 1979 to June 2010 (hence the name eCMAM30). In this paper, eCMAM30 temperature is used to examine the background mean temperature, the spectrum of the diurnal tides, and the climatology of the migrating diurnal tide Dw1 and three nonmigrating diurnal tides De3, Dw2, and Ds0 in the stratosphere, mesosphere, and lower thermosphere. The model results are then compared to the diurnal tidal climatology derived from Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) observations between 40 to 110 km and 50° S to 50° N from January 2002 to December 2013. The model reproduces the latitudinal background mean temperature gradients well except that the cold mesopause temperature in eCMAM30 is 10 to 20 K colder than SABER. The diurnal tidal spectra and their relative strengths compare very well between eCMAM30 and SABER. The altitude-latitude structures for the four diurnal tidal components (Dw1, De3, Dw2, and Ds0) from the two datasets are also in very good agreement even for structures in the stratosphere with a weaker amplitude. The largest discrepancy between the model and SABER is associated with the seasonal variation of De3. In addition to the Northern Hemisphere (NH) summer maximum, a secondary maximum occurs during NH winter (December-February) in the model but is absent in SABER. The seasonal variations of the other three diurnal tidal

components are in good agreement. Interannual time series of Dw1 and De3 from both eCMAM30 and SABER reveal variability with a period of 25 to 26 months, which indicates the modulation of the diurnal tides by the stratospheric quasi-biennial oscillation (QBO).

Keywords: Diurnal tides; Migrating; Nonmigrating; eCMAM30; SABER; QBO



*Corresponding author: Quan Gan, quan.gan@louisville.edu

Major solar eruptions and high-energy particle events during solar cycle 24

Nat Gopalswamy*, Hong Xie, Sachiko Akiyama, Pertti A Mäkelä and Seiji Yashiro *Earth, Planets and Space* 2014, **66**:104 doi:10.1186/1880-5981-66-104 Received: 10 April 2014, Accepted: 14 August 2014, Published: 1 September 2014

Abstract

We report on a study of all major solar eruptions that occurred on the frontside of the Sun during the rise to peak phase of cycle 24 (first 62 months) in order to understand the key factors affecting the occurrence of large solar energetic particle events (SEPs) and ground level enhancement (GLE) events. The eruptions involve major flares with soft X-ray peak flux \geq 5.0 x10⁻⁵ Wm⁻² (i.e., flare size \geq M5.0) and accompanying coronal mass ejections (CMEs). The selection criterion was based on the fact that the only front-side GLE in cycle 24 (GLE 71) had a flare size of M5.1. Only approximately 37% of the major eruptions from the western hemisphere resulted in large SEP events. Almost the same number of large SEP events was produced in weaker eruptions (flare size < M5.0), suggesting that the soft X-ray flare is not a good indicator of SEP or GLE events. On the other hand, the CME speed is a good indicator of SEP and GLE events because it is consistently high supporting the shock acceleration mechanism. We found the CME speed, magnetic connectivity to Earth (in longitude and latitude), and ambient conditions as the main factors that contribute to the lack of high-energy particle events during cycle 24. Several eruptions poorly connected to Earth (eastern-hemisphere or behind-the-west-limb events) resulted in very large SEP events detected by the Solar Terrestrial Relations Observatory (STEREO) spacecraft. Some very fast CMEs, likely to have accelerated particles to GeV energies, did not result in a GLE event because of poor

latitudinal connectivity. The stringent latitudinal requirement suggests that the highestenergy particles are likely accelerated in the nose part of shocks, while the lower energy particles are accelerated at all parts. There were also well-connected fast CMEs, which did not seem to have accelerated high-energy particles due to possible unfavorable ambient conditions (high Alfven speed, overall reduction in acceleration efficiency in cycle 24).



Figure 1

Keywords: Coronal mass ejections; Flares; Ground level enhancement events; Solar energetic particle events

*Corresponding author: Nat Gopalswamy, nat.gopalswamy@nasa.gov

FULL PAPER

Effect of solar cycle 23 in foF2 trend estimation

Ana G Elias*, Blas F de Haro Barbas, Kiyoto Shibasaki and Jonas R Souza

Earth, Planets and Space 2014, **66**:111 doi:10.1186/1880-5981-66-111 Received: 27 April 2014, Accepted: 22 August 2014, Published: 10 September 2014

Abstract

The effect of including solar cycle 23 in foF2 trend estimation is assessed using experimental values for Slough (51.5°N, 359.4°E) and Kokobunji (35.7°N, 139.5°E), and values obtained from two models: (1) the Sheffield University Plasmaspherelonosphere model, SUPIM, and (2) the International Reference lonosphere, IRI. The dominant influence on the F2 layer is solar extreme ultraviolet (EUV) radiation, evinced by the almost 90% variance of its parameters explained by solar EUV proxies such as the solar activity indices Rz and F10.7. This makes necessary to filter out solar activity effects prior to long-term trend estimation. Solar cycle 23 seems to have had an EUV emission different from that deduced from traditional solar EUV proxies. During maximum and descending phase of the cycle, Rz and F10.7 seem to underestimate EUV solar radiation, while during minimum, they overestimate EUV levels. Including this solar cycle in trend estimations then, and using traditional filtering techniques, may induce some spurious results. In the present work, filtering is done in the usual way considering the residuals of the linear regression between foF2 and F10.7, for both experimental and modeled values. foF2 trends become less negative as we include years after 2000, since foF2

values. foF2 trends become less negative as we include years after 2000, since foF2 systematically exceeds the values predicted by a linear fit between foF2 and F10.7. Trends become more negative again when solar cycle 23 minimum is included, since for this period, foF2 is systematically lower than values predicted by the linear fit. foF2 trends assessed with modeled foF2 values are less strong than those obtained with experimental foF2 values and more stable as solar cycle 23 is included in the trend estimation. Modeled trends may be thought of as a 'zero level' trend due to the assumptions made in the process of trend estimation considering also that we are not dealing with ideal conditions or infinite time series.

Keywords: Ionospheric trends; Solar cycle 23; EUV proxies



*Corresponding author: Ana G Elias, anagelias@yahoo.com

Filtering ionosphere parameters to detect trends linked to anthropogenic effects

Ana G Elias

Earth, Planets and Space 2014, **66**:113 doi:10.1186/1880-5981-66-113 Received: 8 April 2014, Accepted: 22 August 2014, Published: 10 September 2014

Abstract

The great concern about the global warming observed in the troposphere has generated a large interest in the study of long-term trends in the ionosphere since the early 1990s, which has now become a significant topic in global change investigations. Some research works link ionosphere trends to anthropogenic sources such as the increase in greenhouse gas concentration, and others to natural causes such as solar and geomagnetic activity long-term changes, and secular variations in the Earth's main magnetic field. In all the cases, in order to analyze ionospheric trends, solar activity effect must be filtered out first since around 90% of ionosphere parameter variance is due to solar variations. The filtering process can generate 'spurious' trends in the filtered data series which may lead to erroneous conclusions. foF2 data series which include solar cycle 23 are analyzed in the present work in order to detect the effect of different filtering procedures on the determination of long-term trends. In particular, solar cycle 23 seems to have had an extreme ultraviolet (EUV) emission greater than that deduced from traditional solar EUV proxies during the maximum epoch and lower during the minimum epoch. When solar activity is filtered assessing the residuals of

a linear regression between foF2 and Rz, or between foF2 and F10.7, this fact may bias trend values especially because it is at the end of the time series. The length of the period considered for trend assessment, the saturation and hysteresis effect of some ionosphere parameters, and the solar EUV proxy used are also considered in this study in order to quantify a possible spurious trend that may result as a by-product of a filtering process. Since trends expected as a consequence of anthropogenic effects are relatively small, these spurious effects may surely mask, or enhance, trends expected from anthropogenic origins.



Open Access

Keywords: Long-term trends; lonosphere; foF2; Solar EUV proxy; Greenhouse effect

Corresponding author: Ana G Elias, anagelias@yahoo.com

FULL PAPER

New perspectives on thermosphere tides: 2. Penetration to the upper thermosphere

Jeffrey M Forbes*, Xiaoli Zhang and Sean L Bruinsma

Earth, Planets and Space 2014, **66**:122 doi:10.1186/1880-5981-66-122 Received: 1 April 2014, Accepted: 16 August 2014, Published: 25 September 2014

Abstract

In this paper, we present new multi-year and 72-day mean seasonal-latitudinal tidal structures in exospheric temperature derived from joint analysis of CHAMP and GRACE accelerometer measurements. These results include diurnal tides DE3, DE2, D0, and DW2 and semidiurnal tides S0, SE1, SE2, SE3, SW4, and SW6. We also employ Hough mode extensions (HMEs) and the Climatological Model of Thermosphere Tides (CTMT) to ascertain whether the observed structures are consistent with those observed at 110 km and presented in part 1 of this study. The aggregate sum of all the tidal components is shown to impose considerable longitude and month-to-month variability on the exosphere temperature tidal spectrum. Please see related article: http://www.earth-planets-space.com/content/66/1/136.

Keywords: Tides; Thermosphere; Dynamics; Propagation



*Corresponding author: Jeffrey M Forbes, forbes@colorado.edu

A long-term trend in the F2-layer critical frequency as observed at Alma-Ata ionosonde station

Galina I Gordiyenko*, Victor V Vodyannikov, Artur F Yakovets and Yuriy G Litvinov *Earth, Planets and Space* 2014, **66**:125 doi:10.1186/1880-5981-66-125

Received: 31 March 2014, Accepted: 3 September 2014, Published: 17 October 2014

Abstract

In this study, we combine monthly median values for the *F2*-layer critical frequency (*foF2*), measured at Alma-Ata ionosonde station [43.25°N, 76.92°E] between 1000 and 1400 (local time), with historical data on the monthly mean values for solar radio flux at 10.7 cm (*F10.7*) and the geomagnetic activity index (*Ap*) (available at http://www.swpc.noaa.gov/), over the period from 1957 to 2012. These data are used to derive long-term trends in the upper ionosphere and to discuss their importance in the context of coupling between solar and geomagnetic activity in the ionosphere at middle latitudes.

Keywords: Upper ionosphere; Long-term changes (trends); Solar-ionosphere interactions



*Corresponding author: Galina I Gordiyenko, ggordiyenko@mail.ru

FULL PAPER

Open Access

Study of Pc1 pearl structures observed at multi-point ground stations in Russia, Japan, and Canada

Chae-Woo Jun*, Kazuo Shiokawa, Martin Connors, Ian Schofield, Igor Poddelsky and Boris Shevtsov

Earth, Planets and Space 2014, **66**:140 doi:10.1186/s40623-014-0140-8 Received: 28 March 2014, Accepted: 1 October 2014, Published: 23 October 2014

Abstract

We investigate possible generation mechanisms of Pc1 pearl structures using multi-point induction magnetometers in Athabasca in Canada, Magadan in Russia, and Moshiri in Japan. We selected two Pc1 pulsations that were simultaneously observed at the three stations and applied a polarization analysis. In case 1, on 8 April 2010, Pc1 pearl structures were slightly different in some time intervals at different stations, and their polarization angles varied depending on the frequencies at the three stations. Case 2, on 11 April 2010, showed Pc1 pearl structures that were similar at different stations, and their polarization angle was independent of frequency at all three stations. In order to understand these differences, we performed two simple model calculations of Pc1 pearl structures under different conditions. The first model assumes that Pc1 waves propagated from a latitudinally extended source with different frequencies at different latitudes to the observation points,

representing beating of these waves in the ionosphere. The second model considers Pc1 waves for which different frequencies are mixed at a point source to cause the beating at the source point, indicating that the Pc1 pearl structures are generated in the magnetosphere. The first model shows slightly different waveforms at different stations. In contrast, the second model shows identical waveforms at different stations. From these results, we conclude that, in case 1, Pc1 pearl structures were caused by beating in the ionosphere. On the other hand, in case 2, they were the result of magnetospheric effects. We suggest that beating processes in the ionosphere could be one of the generation mechanisms of Pc1 pearl structures.





*Corresponding author: Chae-Woo Jun, chae-woo@stelab.nagoya-u.ac.jp

New perspectives on thermosphere tides: 1. Lower thermosphere spectra and seasonal-latitudinal structures

Alexander O Truskowski, Jeffrey M Forbes*, Xiaoli Zhang and Scott E Palo Earth, Planets and Space 2014, 66:136 doi:10.1186/s40623-014-0136-4 Received: 1 April 2014, Accepted: 29 September 2014, Published: 30 October 2014

Abstract

Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics/Sounding of the Atmosphere using Broadband Emission Radiometry (TIMED/SABER) temperature measurements at 110 km and between ±50° latitude extending from 2002 through 2010 are analyzed to reveal the tidal spectrum entering the ionosphere-thermosphere (IT) system. Seasonal-latitudinal structures are presented for the most prominent spectral components which include DE3, DE2, D0, DW1, DW2, SE1 to SE4,

SW1 to SW4, SW6, TE1, TW4, TW5, and TW7. Referring to recent calculations of lower atmosphere heat sources as well as vertical structure characteristics of these waves anticipated from classical tidal theory, we analyze the likely origins of these waves and the nature of their seasonal-latitudinal structures. Several waves are likely to arise through nonlinear wave-wave interactions, and in some cases, this appears to be the sole viable mechanism leading to their existence. The tidal spectrum quantified here is especially relevant to the dynamo generation of electric fields which then impose the tidal variability on the overlying F-region ionosphere. Part 2 of this 2-part study examines penetration of the tidal spectrum to the upper thermosphere.

Please see related article: http://www.earth-planets-space.com/content/66/1/122.

Keywords: Tides; Thermosphere; Dynamics; Propagation



Open Access

*Corresponding author: Jeffrey M Forbes, forbes@colorado.edu

FULL PAPER

A statistical study of satellite traces and evolution of equatorial spread F

Viswanathan Lakshmi Narayanan*, Sukanta Sau, Subramanian Gurubaran, Kazuo Shiokawa, Nanan Balan, Kaliappan Emperumal and Samireddipalle Sripathi Earth, Planets and Space 2014, 66:160 doi:10.1186/s40623-014-0160-4

Received: 30 April 2014, Accepted: 14 November 2014, Published: 3 December 2014

Abstract

The ionosonde observations made at 5-min intervals at the Indian dip equatorial station Tirunelveli (8.7°N, 77.8°E geographic; 1.1°N dip latitude) from March 2008 to February 2009 during the extended solar minimum period are used to study the interlink between equatorial spread F (ESF) and satellite traces (STs) which are assumed to represent tilts in the bottomside iso-electron density surfaces probably caused by large-scale wave-like structures (LSWS). The data show different patterns of ESF onset in the bottomside F region, which are illustrated through examples. In addition, the statistics of occurrence of ST and its relation to the formation of ESF are studied. The results indicate that (1) the zonally drifting ESF 06 Oct 08 19:20 irregularities can be differentiated from those forming over the observing station. (2) Nearly half of the ESF events were preceded by ST. (3) In about 30% of the cases of occurrence of ST, ESF was not formed afterwards implying that LSWS may not always lead to ESF. (4) The 06 Oct 08 percentage of ESF following ST was high in summer and increased with the time of the 19:40 night. (5) Following the first occurrence of ST, the ESF onset was delayed by about 30 min on the average suggesting that ST may be used as a precursor of ESF. (6) Pre-reversal enhancement (PRE) of upward plasma drift was found insignificant during the period of 06 Oct 08 20:00 study. The trapping of high-frequency radio waves between the E and F regions during intense sporadic E is also illustrated.

Keywords: Ionosonde; Equatorial spread F; Plasma bubbles; Satellite traces; Large-scale wave-like structures



*Corresponding author: Viswanathan L Narayanan, narayananvlwins@gmail.com

Long-term variation in the upper atmosphere as seen in the geomagnetic solar quiet daily variation

Atsuki Shinbori*, Yukinobu Koyama, Masahito Nose, Tomoaki Hori, Yuichi Otsuka and Akiyo Yatagai

Earth, Planets and Space 2014, 66:155 doi:10.1186/s40623-014-0155-1

Received: 28 March 2014, Accepted: 11 November 2014, Published: 11 December 2014

Abstract

Characteristics of long-term variation in the amplitude of solar quiet (Sq) geomagnetic field daily variation have been investigated using 1-h geomagnetic field data obtained from 69 geomagnetic observation stations within the period of 1947 to 2013. The Sq amplitude observed at these geomagnetic stations showed a clear dependence on the 10- to 12-year solar activity cycle and tended to be enhanced during each solar maximum phase. The Sq amplitude was the smallest around the minimum of solar cycle 23/24 in 2008 to 2009. The relationship between the solar F10.7 index and Sq amplitude was approximately linear but about 53% of geomagnetic stations showed a weak nonlinear relation to the solar F10.7 index. In order to remove the effect of solar activity seen in the long-term variation of the Sq amplitude, we calculated a linear or second-order fitting curve between the solar F10.7 index and Sq amplitude during 1947 to 2013 and examined the residual Sq amplitude, which is defined as the deviation from the fitting curve. As a result, the majority of trends in the residual Sq amplitude that passed through a trend test showed negative values over a wide region. This tendency was relatively strong in

Europe, India, the eastern part of Canada, and New Zealand. The relationship between the magnetic field intensity at 100-km altitude and residual Sq amplitude showed an anti-correlation for about 71% of the geomagnetic stations. Furthermore, the residual Sq amplitude at the equatorial station (Addis Ababa) was anti-correlated with the absolute value of the magnetic field inclination. This implies movement of the equatorial electrojet due to the secular variation of the ambient magnetic field.



Keywords: Solar quiet geomagnetic field daily variation; Solar activity; Long-term trend; Secular variation; Upper atmosphere

*Corresponding author: Atsuki Shinbori, shinbori@rish.kyoto-u.ac.jp

FULL PAPER

Open Access

Fast and ultrafast Kelvin wave modulations of the equatorial evening F region vertical drift and spread F development

Mangalathayil A Abdu^{*}, Christiano GM Brum, Paulo P Batista, Subramanian Gurubaran, Dora Pancheva, Jose V Bageston, Inez S Batista and Hisao Takahashi

Earth, Planets and Space 2015, **67**:1 doi:10.1186/s40623-014-0143-5 Received: 29 April 2014, Accepted: 14 October 2014, Published: 6 January 2015

Abstract

In this paper, we investigate the role of eastward and upward propagating fast (FK) and ultrafast Kelvin (UFK) waves in the day-to-day variability of equatorial evening prereversal vertical drift and post sunset generation of spread F/plasma bubble irregularities. Meteor wind data from Cariri and Cachoeira Paulista (Brazil) and medium frequency (MF) radar wind data from Tirunelveli (India) are analyzed together with Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics/Sounding of the Atmosphere using Broadband Emission Radiometry (TIMED/SABER) temperature in the 40- to 100-km region to characterize the zonal and vertical propagations of these waves. Also analyzed are the F region evening vertical drift and spread F (ESF) development features as diagnosed by Digisonde (Lowell Digisonde International, LLC, Lowell, MA, USA) operated at Fortaleza and Sao Luis in Brazil. The SABER temperature data permitted determination of the upward propagation characteristics of the FK (E1) waves with propagation speed in the range of 4 km/day. The radar mesosphere and lower thermosphere (MLT) winds in the widely separated longitude sectors have yielded the eastward phase velocity of both the FK and UFK waves. The vertical propagation of these waves cause strong oscillation in the F region evening prereversal vertical drift, observed for the first time at both FK and UFK periodicities. A delay of a few

(approximately 10) days is observed in the F region vertical drift perturbation with respect to the corresponding FK/UFK zonal wind oscillations, or temperature oscillations in the MLT region, which has permitted a direct identification of the sunset electrodynamic coupling process as being responsible for the generation of the FK/UFK-induced vertical drift oscillation. The vertical drift oscillations are found to cause significant modulation in the spread F/plasma bubble irregularity development. The overall results highlight the role of FK/UFK waves in the day-to-day variability of the ESF in its occurrence season.



*Corresponding author: Mangalathayil A Abdu, ma.abdu@inpe.br

Polarization analysis of VLF/ELF waves observed at subauroral latitudes during the VLF-CHAIN campaign

Claudia Martinez-Calderon*, Kazuo Shiokawa, Yoshizumi Miyoshi, Mitsunori Ozaki, Ian Schofield and Martin Connors Earth, Planets and Space 2015, 67:21 doi:10.1186/s40623-014-0178-7 Received: 28 March 2014, Accepted: 25 November 2014, Published: 11 February 2015

Abstract

Chorus wave emissions are one of the most intense naturally occurring phenomena in the very low (VLF) and extremely low frequency (ELF) ranges. They are believed to be one of the major contributors to acceleration and loss of electrons in the radiation belts. During the VLF Campaign observation with High-resolution Aurora Imaging Network (VLF-CHAIN) from 17 to 25 February 2012, several types of VLF/ELF emissions, including chorus, were observed at subauroral latitudes in Athabasca, Canada. To our knowledge, there has not been any comprehensive study of the physical properties of such emissions at these latitudes. In this study, we calculate spectral and polarization parameters of VLF/ELF waves with high temporal resolution. We found that the polarization angle of several emissions depended on both frequency and time. We suggest that the frequencydependent events, which usually last several tens of minutes, might be the consequence of the broadening of the ray path that the waves follow from their generation region to the ground. Furthermore, time-dependent events, also lasting tens of minutes, have a polarization angle that changes from negative to positive values (or vice versa) every few minutes. We suggest that this could be due to variations of the wave duct, either near the generation region or along the wave propagation path. Using another ground station in Fort Vermillion, Canada, about 450 km northwest of Athabasca, we tracked the movements of the ionospheric exit point of three chorus Fort Vermillion (58.38°N, 243.99°E MI AT=64.5°N emissions observed simultaneously at both stations. Although we found that movement of the ionospheric exit point does not follow a general direction, it is subject to hovering motion, suggesting that the exit point can be affected by small-

Keywords: Chorus; Polarization; VLF; ELF; Ionospheric source

*Corresponding author: Claudia Martinez-Calderon, claudia@stelab.nagoya-u.ac.jp

FULL PAPER

scale plasma processes.

Open Access

Airglow-imaging observation of plasma bubble disappearance at geomagnetically conjugate points

Kazuo Shiokawa*, Yuichi Otsuka, Kenneth JW Lynn, Philip Wilkinson and Takuya Tsugawa

Earth, Planets and Space 2015, 67:43 doi:10.1186/s40623-015-0202-6 Received: 29 March 2014, Accepted: 3 February 2015, Published: 26 March 2015

Abstract

We report the first observation of the disappearance of a plasma bubble over geomagnetically conjugate points. It was observed by airglow imagers at Darwin, Australia (magnetic latitude: -22°N) and Sata, Japan (21°N) on 8 August 2002. The plasma bubble was observed in 630-nm airglow images from 1530 (0030 LT) to 1800 UT (0300 LT) and disappeared equatorward at 1800 to 1900 UT (0300 to 0400 LT) in the field of view. The ionograms at Darwin and Yamagawa (20 km north of Sata) show strong spread-F signatures at approximately 16 to 21 UT. At Darwin, the F-layer virtual height suddenly increased from approximately 200 to approximately 260 km at the time of bubble disappearance. However, a similar F-layer height increase was not observed over the conjugate point at Yamagawa, indicating that this F-layer rise was caused not by an

eastward electric field but by enhancement of the equatorward thermospheric wind over Darwin. We think that this enhancement of the equatorward neutral wind was caused by an equatorward-propagating large-scale traveling ionospheric disturbance, which was identified in the north-south keogram of 630-nm airglow images. We speculate that polarization electric field associated with this equatorward neutral wind drive plasma drift across the magnetic field line to cause the observed bubble disappearance.

Keywords: Plasma bubble disappearance; Conjugate observation; Airglow imaging



Figure 1

*Corresponding author: Kazuo Shiokawa, shiokawa@stelab.nagoya-u.ac.jp



Effects of pre-reversal enhancement of E×B drift on the latitudinal extension of plasma bubble in Southeast Asia

Prayitno Abadi*, Yuichi Otsuka and Takuya Tsugawa

Earth, Planets and Space 2015, 67:74 doi:10.1186/s40623-015-0246-7 Received: 5 June 2014, Accepted: 12 May 2015, Published: 27 May 2015

Abstract

We investigated the effects of the F region bottomside altitude (h'F), maximum upward E×B drift velocity, duration of pre-reversal enhancement and the integral of upward E×B drift on the latitudinal extension of equatorial plasma bubbles in the Southeast Asian sector using the observations recorded by three GPS receivers and two ionosondes. The GPS receivers are installed at Kototabang (0.2°S, 100.3°E; 9.9°S magnetic latitude), Pontianak (0.02°S, 109.3°E; 9.8°S magnetic latitude) and Bandung (6.9°S, 107.6°E; 16.7°S magnetic latitude) in Indonesia. The ionosondes are installed at magnetically equatorial stations, Chumphon (10.7°N, 99.4°E; 0.86°N magnetic latitude) in Thailand and Bac Lieu (9.3°N, 105.7°E; 0.62°N magnetic latitude) in Vietnam. We analysed those observations acquired in the equinoctial months (March, April, September and October) in 2010–2012, when the solar activity index F_{107} was in the range from 75 to 150. Assuming that plasma bubbles are the major source of scintillations, the latitudinal extension of the bubbles was determined according to the S4 index. We have found that the peak of h'F, maximum upward E×B drift and the integral of upward $E \times B$ drift during the pre-reversal enhancement period are positively correlated with the maximum latitude extension of plasma bubbles, but that duration of pre-reversal enhancement does not show correlation. The plasma bubbles reached magnetic latitudes of 10°-20° in the following conditions: (1) the peak value of h'F is greater than 250-450 km, (2) the maximum upward E×B drift is greater than 10–70 m/s and (3) the integral of upward E×B drift is greater than 50-250 m/s. These results suggest that the latitudinal extension of plasma bubbles is controlled mainly by the magnitude of pre-reversal enhancement and the peak value of h'F at the initial phase of development of plasma bubbles (or equatorial spread F) rather than by the duration of pre-reversal enhancement.

Keywords: Equatorial ionosphere; Plasma bubble; Pre-reversal enhancement; Scintillation

*Corresponding author: Prayitno Abadi, prayabadi@bdg.lapan.go.id

LETTER

Open Access

Three-dimensional numerical simulation of nonlinear acoustic-gravity wave propagation from the troposphere to the thermosphere

Nikolai M Gavrilov* and Sergey P Kshevetskii*

Earth, Planets and Space 2014, 66:88 doi:10.1186/1880-5981-66-88 Received: 22 January 2014, Accepted: 22 July 2014, Published: 6 August 2014

Abstract

Three-dimensional nonlinear breaking acoustic-gravity waves (AGWs) propagating from the Earth's surface to the upper atmosphere are simulated numerically. Horizontally moving periodical structures of vertical velocity on the Earth's surface are used as AGW sources in the model. The 3D algorithm for hydrodynamic equation solution uses finite-difference analogues of basic conservation laws. This approach allows us to select physically correct generalized wave solutions of hydrodynamic equations. The numerical simulation covers altitudes from the ground up to 500 km. Vertical profiles of the mean temperature,

density, molecular viscosity, and thermal conductivity are specified from standard models of the atmosphere. Atmospheric waves in a few minutes can propagate to high altitudes above 100 km after activation of the surface wave forcing. Surfaces of constant phases are quasi-vertical first, and then become inclined to the horizon below about 100 km after some transition time interval. Vertical wavelengths decrease with time and tend to theoretically predicted values after times longer than several periods of the wave forcing. Decrease in vertical wavelengths and increase in AGW amplitudes can lead to wave instabilities, accelerations of the mean flow and wave-induced jet streams at altitudes above 100 km. AGWs may transport amplitude modulation of atmospheric wave sources in horizontal directions up to very high levels. Low wave amplitudes in the beginning of transition processes after activation of atmospheric wave sources could be additional reasons for slower amplitude grows with height compared to the nondissipative exponential growth predicted for stationary linear AGWs. Production of wave-induced mean jets and their superposition with nonlinear unstable dissipative AGWs can produce strong narrow peaks of horizontal speed in the upper atmosphere. This may increase the role of transient nonstationary waves in effective energy transport and variations of atmospheric parameters and gas admixtures in a broad altitude range.



*Corresponding authors: Nikolai M Gavrilov, n.gavrilov@spbu.ru; Sergey P Kshevetskii, renger@mail.ru



*Corresponding author: Zhipeng Ren, zpren@mail.iggcas.ac.cn

Noctilucent clouds observed from the ground: sensitivity to mesospheric parameters and long-term time series

Nikolay Pertsev*, Peter Dalin, Vladimir Perminov, Vitaly Romejko, Audrius Dubietis, Ričardas Balčiunas, Kazimieras Černis and Mark Zalcik

Earth, Planets and Space 2014, **66**:98 doi:10.1186/1880-5981-66-98 Received: 29 March 2014, Accepted: 16 August 2014, Published: 26 August 2014

Abstract

LETTER

Long-term systematic observations of noctilucent clouds in the regions of Moscow (Russia), Vilnius (Lithuania), and La Ronge (Canada) are considered. Variables, describing the seasonal activity of noctilucent clouds, are discussed. It is shown that there are no statistically significant trends within time intervals of several recent decades. This result is compared to other known findings on trends in mesospheric clouds. Based on the data of the modern ground-based noctilucent cloud observing network in the northern hemisphere and simultaneous satellite data on mesospheric temperature and humidity, we estimate

sensitivity of noctilucent clouds to the relative humidity of the upper mesosphere. Such an approach allows us to discuss possible changes of the upper-mesospheric relative humidity, which are consistent with a zero secular trend in noctilucent cloud activity.

Keywords: Noctilucent clouds; Midlatitude mesosphere; Long-term trends; Mesospheric temperature; Mesospheric humidity

LETTER

Influence of DE3 tide on the equinoctial asymmetry of the zonal mean ionospheric electron density

Zhipeng Ren*, Weixing Wan, Jiangang Xiong and Libo Liu

Earth, Planets and Space 2014, **66**:117 doi:10.1186/1880-5981-66-117 Received: 29 March 2014, Accepted: 4 September 2014, Published: 17 September 2014

Abstract

Through respectively adding September DE3 tide and March DE3 tide at the low boundary of Global Coupled Ionosphere-Thermosphere-Electrodynamics Model, Institute of Geology and Geophysics, Chinese Academy of Sciences (GCITEM-IGGCAS), we simulate the influence of DE3 tide on the equinoctial asymmetry of the zonal mean ionospheric electron density. The influence of DE3 tide on the equinoctial asymmetry of the zonal mean electron density varies with latitude, altitude, and solar activity level. Compared with the density driven by the September DE3 tide, the March DE3 tide mainly decreases the lower ionospheric zonal mean electron density and mainly increases the electron density at higher ionosphere. In the low-latitude ionosphere, DE3 tide drives an equatorial ionization anomaly (EIA) structure at higher ionosphere in the relative difference of zonal mean electron density, which suggests that DE3 tide affects the longitudinal mean equatorial vertical E×B plasma drifts. Although the lower ionospheric equinoctial asymmetry driven by DE3 tide mainly decreases with the increase of solar activity, the asymmetry at higher ionosphere mainly increases with solar activity. However,

EIA in equinoctial asymmetry mainly decreases with the increase of solar activity.

Keywords: Ionospheric equinoctial asymmetry; DE3 tide; Ionosphere-atmosphere coupling





Open Access

^{*}Corresponding author: Nikolay Pertsev, n.pertsev@bk.ru

Performance of the SciBar cosmic ray telescope (SciCRT) toward the detection of high-energy solar neutrons in solar cycle 24

Yoshinori Sasai^{*}, Yuya Nagai, Yoshitaka Itow, Yutaka Matsubara, Takashi Sako, Diego Lopez, Tsukasa Itow, Kazuoki Munakata, Chihiro Kato, Masayoshi Kozai, Takahiro Miyazaki, Shoichi Shibata, Akitoshi Oshima, Hiroshi Kojima, Harufumi Tsuchiya, Kyoko Watanabe, Tatsumi Koi, Jose Francisco Valdés-Galicia, Luis Xavier González, Ernesto Ortiz, Octavio Musalem, Alejandro Hurtado, Rocio Garcia and Marcos Anzorena

Earth, Planets and Space 2014, **66**:130 doi:10.1186/1880-5981-66-130 Received: 2 May 2014, Accepted: 17 September 2014, Published: 30 September 2014

Abstract

We plan to observe solar neutrons at Mt. Sierra Negra (4,600 m above sea level) in Mexico using the SciBar detector. This project is named the SciBar Cosmic Ray Telescope (SciCRT). The main aims of the SciCRT project are to observe solar neutrons to study the mechanism of ion acceleration on the surface of the sun and to monitor the anisotropy of galactic cosmic-ray muons. The SciBar detector, a fully active tracker, is composed of 14,848 scintillator bars, whose dimension is 300 cm \times 2.5 cm \times 1.3 cm. The structure of the detector enables us to obtain the particle trajectory and its total deposited energy. This information is useful for the energy Solar neutron reconstruction of primary neutrons and particle identification. The total volume of the Scintillator ba detector is 3.0 m \times 3.0 m \times 1.7 m. Since this volume is much larger than the solar neutron telescope (SNT) in Mexico, the detection efficiency of the SciCRT for neutrons is highly enhanced. We performed the calibration of the SciCRT at Instituto Nacional de Astrofisica, Optica y Electronica (INAOE) located at 2,150 m above sea level in Mexico in 2012. We installed the SciCRT at Mt. Sierra Negra in April 2013 and calibrated this detector in May and August 2013. We started continuous observation in March 2014. In this paper, we report the detector performance as a solar neutron telescope and the current status of MAPMT the SciCRT. Wave length 3m

Keywords: Cosmic-ray; Solar neutron; Scintillator bar

*Corresponding author: Yoshinori Sasai, sasaiyoshinori@stelab.nagoya-u.ac.jp

Open Access

Relationship between the equatorial electrojet and global Sq currents at the dip equator region

Nurul Shazana Abdul Hamid*, Huixin Liu*, Teiji Uozumi, Kiyohumi Yumoto, Bhaskara Veenadhari, Akimasa Yoshikawa and Jairo Avendaño Sanchez

Earth, Planets and Space 2014, **66**:146 doi:10.1186/s40623-014-0146-2 Received: 31 March 2014, Accepted: 16 October 2014, Published: 29 October 2014

Abstract

LETTER

The equatorial electrojet (EEJ) is a strong eastward ionospheric current flowing in a narrow band along the dip equator. In this study, we examined the EEJ-Sq relationship by using observations at six stations in the South American, Indian, and Southeast Asian sectors. The analysis was carried out with data on geomagnetically quiet days with $Kp \leq 3$ from 2005 to 2011. A normalization approach was used because it yields more accurate results by overcoming the uncertainties due to latitudinal variation of the EEJ and Sq. A weak positive correlation between the EEJ and Sq was obtained in the Southeast Asian sector, while weak negative correlations were obtained in the South American and Indian sectors. EEJ-Sq relationship is found to be independent of the hemispheric configuration of stations used to calculate their magnetic perturbations, and it also only changed slightly during low and moderate solar activity levels. These results demonstrate that the Southeast Asian sector is indeed different from the Indian and South American sectors, which is indicative of unique physical processes particularly related to the electro-dynamo. Furthermore, we also demonstrate that the definition of the EEJ, that is, the total current or enhanced current, can significantly affect the conclusions drawn from EEJ-Sq correlations.

Keywords: *H* component; Equatorial electrojet; Sq current; Longitudinal dependence



shifting fiber

Figure 1

*Corresponding authors: Nurul SA Hamid, shazana.ukm@gmail.com; Huixin Liu, huixin@serc.kyushu-u.ac.jp

Study of plasma flow reversal in the near-Earth plasma sheet using numerical computations

Koji Kondoh* and Tohru Shimizu

Earth, Planets and Space 2014, **66**:147 doi:10.1186/s40623-014-0147-1 Received: 31 March 2014, Accepted: 15 August 2014, Published: 29 October 2014

Abstract

Tailward flow in the near-Earth plasma sheet associated with a rebound of the earthward bursty bulk flow (BBF) is investigated using three-dimensional magnetohydrodynamics simulations of magnetic reconnection in the magnetotail on the basis of the spontaneous fast reconnection model. In order to investigate the properties of this tailward flow, virtual satellites are located at different positions in the plasma sheet within the simulation region, so that we can directly observe the temporal variations of plasma quantities in accordance with the growth and preceding the flow reversal associated with the magnetic reconnection. The time profile of the plasma flow velocity in the course of the BBF depends on the satellite position. Furthermore, the time profile of the magnetic field strength in the course of the reverse flow depends on the satellite position in the dawn-dusk direction. As a result of the rebound of the earthward flow, the accumulation of the plasma density and the plasma pressure is observed at any position in the plasma sheet during the interval between the BBF and the reverse flow.

Keywords: Magnetic reconnection; Bursty bulk flow; Flow reversal; MHD simulation



*Corresponding author: Koji Kondoh, kondo@cosmos.ehime-u.ac.jp

LETTER

Lidar returns from the upper atmosphere of Kamchatka for 2008 to 2014 observations

Vasily V Bychkov*, Yuri A Nepomnyashchiy, Andrey S Perezhogin and Boris M Shevtsov

Earth, Planets and Space 2014, **66**:150 doi:10.1186/s40623-014-0150-6 Received: 30 March 2014, Accepted: 29 October 2014, Published: 14 November 2014

Abstract

The correlation of lidar returns at a wavelength of 532 nm at altitudes of 150 to 300 km is investigated with the parameters of the night ionospheric F2 layer. Moreover, the role of excited ions of the nitrogen atoms in the formation of lidar signals is discussed.



*Corresponding author: Vasily V Bychkov, vasily.v.bychkov@gmail.com

The spatial density gradient of galactic cosmic rays and its solar cycle variation observed with the Global Muon Detector Network

Masayoshi Kozai*, Kazuoki Munakata, Chihiro Kato, Takao Kuwabara, John W Bieber, Paul Evenson, Marlos Rockenbach, Alisson Dal Lago, Nelson J Schuch, Munetoshi Tokumaru, Marcus L Duldig, John E Humble, Ismail Sabbah, Hala K Al Jassar, Madan M Sharma and Jozsef Kóta

Earth, Planets and Space 2014, 66:151 doi:10.1186/s40623-014-0151-5 Received: 31 March 2014, Accepted: 29 October 2014, Published: 14 November 2014

Abstract

We derive the long-term variation of the three-dimensional (3D) anisotropy of approximately 60 GV galactic cosmic rays (GCRs) from the data observed with the Global Muon Detector Network (GMDN) on an hourly basis and compare it with the variation deduced from a conventional analysis of the data recorded by a single muon detector at Nagoya in Japan. The conventional analysis uses a north-south (NS) component responsive to slightly higher rigidity (approximately 80 GV) GCRs and an ecliptic component responsive to the same rigidity as the GMDN. In contrast, the GMDN provides all components at the same rigidity simultaneously. It is confirmed that the temporal variations of the 3D anisotropy vectors including the NS component derived from two analyses are fairly consistent with each other as far as the yearly mean value is concerned. We particularly compare the NS anisotropies deduced from two analyses statistically by analyzing the distributions of the NS anisotropy on hourly and daily bases. It is found that the hourly mean NS anisotropy observed by Nagoya shows a larger spread than the daily mean due to the local time-dependent contribution from the ecliptic anisotropy. The NS anisotropy derived from the GMDN, on the other hand, shows similar distribution on both the daily and hourly bases, indicating that the NS anisotropy is successfully observed by the GMDN, free from the contribution of the ecliptic anisotropy. By analyzing the NS anisotropy deduced from neutron monitor (NM) data responding to lower rigidity (approximately 17 GV) GCRs, we qualitatively confirm the rigidity dependence of the NS anisotropy in which the GMDN has an intermediate rigidity response between NMs and Nagoya. From the 3D anisotropy vector (corrected for the solar wind convection and the Compton-Getting effect arising from the Earth's orbital motion around the Sun), we deduce the variation of each modulation parameter, i.e., the radial and latitudinal density gradients and the parallel mean free path for the pitch angle scattering of GCRs in the turbulent interplanetary magnetic field. We show the derived density gradient and mean free path varying with the solar activity and magnetic cycles. Keywords: Diurnal anisotropy; North-south anisotropy; Heliospheric modulation of galactic cosmic rays; Solar cycle variation of the cosmic ray density gradient

*Corresponding author: Masayoshi Kozai, 13st303f@shinshu-u.ac.jp



Open Access

LETTER

Methods of analysis of geomagnetic field variations and cosmic ray data

Oksana V Mandrikova*, Igor S Solovev and Timur L Zalyaev

Earth, Planets and Space 2014, 66:148 doi:10.1186/s40623-014-0148-0 Received: 31 March 2014, Accepted: 29 October 2014, Published: 21 November 2014

Abstract

In the present paper, we propose a wavelet-based method of describing variations in the Earth's magnetic field, such as the horizontal component of the geomagnetic field, in addition to methods for evaluating changes in the energy characteristics of the field and for isolating the periods of increased geomagnetic activity. Based on a combination of multiresolution wavelet decompositions with neural networks, we propose a method of approximation of the cosmic ray time course and the allocation of anomalous variations (Forbush effects) that occur during periods of high solar activity. During the realization of the method, an algorithm was created for selecting the level of the wavelet decomposition and adaptive construction of the neural network. By using the proposed methods, we performed a joint analysis of the geomagnetic field and cosmic rays during periods of strong magnetic storms. The strongest geomagnetic field perturbations were observed in periods of

abnormal changes in cosmic ray level. Assessment of the intensity of geomagnetic disturbances on the eve of and during magnetic storm development allowed us to highlight local increases in intensity of the geomagnetic field occurring at different frequency ranges prior to the development of the storm's main phase. Implementation of the proposed method with theoretical tools in combination with other methods will improve the estimation accuracy of the geomagnetic field state during space weather forecasting.

Keywords: Geomagnetic field; Cosmic rays; Wavelet transform; Neural networks; Magnetic storms



*Corresponding author: Oksana V Mandrikova, oksanam1@mail.ru

Reaction of electric and meteorological states of the near-ground atmosphere during a geomagnetic storm on 5 April 2010

Sergey Smirnov

Earth, Planets and Space 2014, **66**:154 doi:10.1186/s40623-014-0154-2 Received: 30 March 2014, Accepted: 8 November 2014, Published: 26 November 2014

Abstract

The effects of a geomagnetic storm on 5 April 2010 on electric parameters of the atmospheric near-ground layer in Kamchatka have been investigated. Three processes over the course of the storm were identified. Air electroconductivity began to decrease 4 h before the storm, and this lasted for 20 h. The storm's sudden commencement caused potential gradient oscillations with amplitudes up to 300 V/m. During the stages of the storm, a significant increase in the atmosphere ion content unipolarity coefficient occurred.



Open Access

Corresponding author: Sergey Smirnov, sergey@ikir.ru

LETTER

Approaches for modeling ionosphere irregularities based on the TEC rate index

Iurii Cherniak*, Irina Zakharenkova and Andrzej Krankowski

Earth, Planets and Space 2014, **66**:165 doi:10.1186/s40623-014-0165-z Received: 30 April 2014, Accepted: 30 November 2014, Published: 12 December 2014

Abstract

The ionosphere plays an important role in GNSS applications because it influences radio wave propagation. The ionospheric delay is the biggest error source for satellite navigation signals, but it can be directly measured and mitigated using dual-frequency GNSS receivers. However, the GNSS signal fades because of electron density gradients and irregularities in the ionosphere, decreasing the operational performance of navigation systems. Recently, several models were developed to reproduce the ionospheric fluctuations and scintillation activity under different

geophysical conditions, but these models were calibrated with data sets without GNSSderived experimental total electron content (TEC) data. There is a great demand for a proper model of ionospheric irregularity specification based on GNSS TEC measurements. In this work, we use data from the permanent GNSS network to develop the empirical model of the ionospheric irregularities over the Northern Hemisphere. As initial data, we used the daily dependences of the rate of TEC index (ROTI) as a function of geomagnetic local time on the specific grid. The ROTI maps allow us to estimate the overall fluctuation activity and the auroral oval evolution. The irregularities of the southern oval border were determined with the ROTI. This paper presents the correlation between the Kp geomagnetic index and parameters that characterized the activity of the ionosphere irregularities in 2010 to 2013.

Keywords: Ionosphere; TEC fluctuations; Irregularities oval; Empirical model; Space weather



*Corresponding author: Iurii Cherniak, tcherniak@ukr.net

High-midlatitude ionosphere response to major stratospheric warming

Boris G Shpynev*, Vladimir I Kurkin, Konstantin G Ratovsky, Marina A Chernigovskaya, Anastasiya Yu Belinskaya, Svetlana A Grigorieva, Alexander E Stepanov, Vasily V Bychkov, Dora Pancheva and Plamen Mukhtarov

Earth, Planets and Space 2015, **67**:18 doi:10.1186/s40623-015-0187-1 Received: 28 April 2014, Accepted: 15 January 2015, Published: 11 February 2015

Abstract

This study investigates the impact of dynamical processes in the neutral atmosphere on the high-midlatitude ionosphere during two sudden stratospheric warming (SSW) events. For this purpose, the reanalysis meteorological data of the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) and UK Met Office (UKMO) were used in addition to that from the high-midlatitude chain of Russian ionosonde stations. The results show that the ionospheric response to the SSW events at high-midlatitudes depends on the position of the ionosonde stations relative to the stratospheric circulation pattern. Two well-pronounced effects were detected in this study. The first effect, observed in January 2009, was a negative effect in critical frequency (f_0F2) and a positive effect in F2 layer maximum (h_mF2) above the border of a stratospheric cyclone and an anticyclone with northward flow direction. During a 6-day period, the ionosphere exhibited a sharply inhomogeneous longitudinal structure when ionosondes, displaced at a longitude of approximately 20°, showed differences of approximately 1 MHz in f_0F2 and more than 50 km in h_mF2 . The second feature, which was clearly observed in January 2013, implied a

positive effect in f_0F2 up to approximately 2.5 MHz and a negative effect in h_mF2 at approximately 10 km above the center of the stratospheric cyclone. We conclude that these effects were caused by upward transport of molecular gas to the lower thermosphere for the first case and a pulldown forcing of molecular species above the low-pressure zone inside the cyclone for the second case. Changes in the O⁺/N₂ ratio in the lower thermosphere altered the O⁺ recombination rate and the corresponding variations of ionosphere parameters.



Keywords: Sudden stratospheric warming; Atmosphere-ionosphere coupling; Ground-based ionosonde measurements

*Corresponding author: Boris G Shpynev, shpynev@iszf.irk.ru

LETTER

Open Access

Statistical study of medium-scale traveling ionospheric disturbances using SuperDARN Hokkaido ground backscatter data for 2011

Alexey V Oinats*, Vladimir I Kurkin and Nozomu Nishitani

Earth, Planets and Space 2015, **67**:22 doi:10.1186/s40623-015-0192-4 Received: 30 April 2014, Accepted: 23 January 2015, Published: 15 February 2015

Abstract

We describe an automated technique to determine parameters of traveling ionospheric disturbances (TIDs) using the Super Dual Auroral Radar Network (SuperDARN) high frequency (HF) radar data. The technique is based on the analysis of minimum ground backscatter range variations corresponding to different radar beams. Using this technique, we processed the SuperDARN Hokkaido radar data for 2011 and revealed statistical distributions of medium-scale TID (MSTID) azimuth and apparent horizontal velocity. We found four peaks with a distinct diurnal and seasonal dependence in the MSTID azimuth occurrence rate distributions. Northeast MSTID azimuths (20° to 50°) are typical of the summer and equinox morning hours; southeast azimuths (100° to 140°) prevail in the winter daytime; southwest azimuths (280° to 320°) are typical of the summer

daytime and evening. The apparent horizontal velocities are generally within the 100 to 160 m/s range. The obtained results agree well with earlier studies by other researchers. However, there are also certain differences. The summer daytime northwestward MSTIDs are not indicated in the earlier studies. The nighttime horizontal velocities are 1.5 to 2 times higher than those in the daytime. Furthermore, winter velocity values are about 1.5 times higher than those in other seasons. These differences might be associated with the peculiarities of the data recorded by different facilities, or the features of the processing techniques, and require further investigation for their interpretation.

Keywords: Medium-scale traveling ionospheric disturbances; Atmospheric gravity waves; SuperDARN Hokkaido radar



*Corresponding author: Alexey V Oinats, oinats@iszf.irk.ru

Regional climate pattern during two millennia estimated from annual tree rings of Yaku cedar trees: a hint for solar variability?

Yasushi Muraki*, Takumi Mitsutani, Shoichi Shibata, Syuichi Kuramata, Kimiaki Masuda and Kentaro Nagaya

Earth, Planets and Space 2015, 67:31 doi:10.1186/s40623-015-0198-y

Received: 1 April 2014, Accepted: 27 January 2015, Published: 27 February 2015

Abstract

We analyzed trees that have survived on Yaku island (Yakushima) for 2,000 years. Quite surprisingly, the Fourier and wavelet analyses of the annual growth rate identified 2 cycles of periodicities of 11 and (24 ± 4) years during the Oort, Wolf, Spörer, Maunder, and Dalton minima. The 11-year periodicity originated from solar activity, while the (24 ± 4) -year periodicity may be related to the Pacific Decadal Oscillation (PDO). In particular, we have discovered an 11-year periodicity in the meteorological daylight-hour data from Yakushima in the month of June during 1938 to 2013 and a 24-year periodicity in July. The growth rate of the tree rings may be affected by the variation of the daylight hour.

Keywords: Sun-earth relation; Tree rings; Grand minima; Dendrochronology; Climate change



*Corresponding author: Yasushi Muraki, muraki@stelab.nagoya-u.ac.jp

LETTER

Open Access

Search for solar neutrons at Mount Chacaltaya associated with M- and X-class flares during the rising period of solar cycle 24

Diego Lopez* and Yutaka Matsubara

Earth, Planets and Space 2015, **67**:54 doi:10.1186/s40623-015-0222-2 Received: 2 May 2014, Accepted: 30 March 2015, Published: 23 April 2015

Abstract

To better understand the acceleration mechanism of high-energy particles that are driven by solar flares, we examined solar neutron signals. We have performed a statistical analysis by reviewing the data collected by a neutron monitor during the period of January 2010 to August 2013. This detector operates at Mount Chacaltaya in Bolivia at 5,200 m above sea level. Our aim is to search for solar neutron events in association with large solar flares observed by the GOES satellite. We report that our analysis did not yield any positive excess due to solar neutrons that are statistically significant. Hence, we calculated the upper limit of the number of solar neutrons for the X2.8-class solar flare which occurred on 13 May 2013. We performed a similar calculation with a solar neutron event that occurred on 7 September 2005. Our upper limit is seven times less than the one produced by the real signal.

Keywords: Solar neutrons; Neutron monitor



*Corresponding author: Diego Lopez, ndlopez@stelab.nagoya-u.ac.jp

TECHNICAL REPORT

Progress of the IUGONET system - metadata database for upper atmosphere ground-based observation data

Shuji Abe*, Norio Umemura, Yukinobu Koyama, Yoshimasa Tanaka, Manabu Yagi, Akiyo Yatagai, Atsuki Shinbori, Satoru UeNo, Yuka Sato and Naoki Kaneda

Earth, Planets and Space 2014, **66**:133 doi:10.1186/1880-5981-66-133 Received: 31 March 2014, Accepted: 24 September 2014, Published: 14 October 2014

Abstract

Background: The Interuniversity Upper atmosphere Global Observation NETwork (IUGONET) project is a 6-year research project which started in 2009. The objective of this project is to establish a metadata database of various ground-based observation data covering a wide region from the Sun to the Earth; this will encourage more studies on the mechanisms of long-term variations in the upper atmosphere.

Findings: For archiving purposes, the metadata database system for cross-searching various data distributed across many universities and institute was developed based on the existing repository software called DSpace as the core component and the Space Physics Archive Search and Extract (SPASE) data model as the metadata format. The IUGONET metadata database is still in operation since it was released in March 2012. The system is continuously examined, tested, and updated to improve its quality. The OpenSearch interface in the IUGONET metadata database allows the user to use external applications easily for exchanging metadata and/or for analyzing data.

Conclusions: We conducted self-examination of our product, which was added for planning future directions of the IUGONET project.

Keywords: Metadata database; Analysis software; Upper atmospheric physics; Earth and planetary sciences; Ground-based observation



*Corresponding author: Shuji Abe, abeshu@icswse.kyushu-u.ac.jp

TECHNICAL REPORT

Open Access

The capacity-building and science-enabling activities of the IUGONET for the solar-terrestrial research community

Akiyo Yatagai*, Yuka Sato, Atsuki Shinbori, Shuji Abe, Satoru UeNo and IUGONET project team

Earth, Planets and Space 2015, **67**:2 doi:10.1186/s40623-014-0170-2 Received: 15 November 2014, Accepted: 10 December 2014, Published: 8 January 2015

Abstract

Background: This paper presents an overview of the capacity-building activities and science-enabling services of the Inter-university Upper atmosphere Global Observation NETwork (IUGONET) project. This Japanese program, which started in 2009, is building a metadata database (MDDB) of ground-based observations and is developing an analysis software to handle the data linked to the MDDB system for use by the solar-terrestrial physics community. Because the institutional members of the IUGONET are mainly universities in Japan, we explore tools that can contribute to advanced education as well as promote research activities.

Findings: In this paper, we describe the utilities of the IUGONET for education, including our capacity-building activities in developing countries. We have regularly facilitated training seminars for Japanese students on the use of our tools (IUGONET MDDB and the software), and we have held capacity-building seminars for young scientists in developing countries. In addition to the MDDB, we have prepared various 'gateway' tools for users who are unfamiliar with 'keywords' to search for data. One of these is a geographical display tool that uses Google

Earth (KML file), which is included as supplemental material to this paper. The usefulness of the IUGONET has been proven over its first 5 years of operation by the increasing number of its users, which has led to the production of approximately 500 scientific papers, including 42 thesis papers.

Conclusions: The IUGONET community collaborates with the Scientific Committee on Solar-Terrestrial Physics program, not only in its scientific activities, but also in the establishment of E-infrastructure and capacity building.

Keywords: Ground-based observation; Solar-terrestrial physics (STP); Database; Metadata; Interdisciplinary studies; Capacity building; E-infrastructure



*Corresponding author: Akiyo Yatagai, akiyoyatagai@stelab.nagoya-u.ac.jp

Information for Contributors

General

- 1. Manuscripts should be submitted through the journal's Editorial Manager system (https://www.editorialmanager.com/epsp/default.aspx).
- 2. Only papers not previously published will be accepted, and the emphasis is on the originality of concept or observation.
- 3. Four varieties of article types are available.
 - 3.1 "Full papers" without word limit.
 - 3.2 "Letters" have a limit of 11,000 words including legends for figures and tables. One figure or table not exceeding one A4 page is counted as 500 words.
 - 3.3 "Frontier Letters" can be submitted upon invitation by the Editor-in-Chief.
 - 3.4 "Technical reports" describe the technical development of instrument or software.
- 4. Authors retain the copyright, and distribution of articles is free under cc-by license.

Technical

- 1. Manuscripts should be written in English with double spacing.
- Each manuscript should be organized in the following order: title, authors' names, affiliations, abstract, key words, main text, acknowledgement, appendix, references, and supplementary materials.
- 3. The corresponding author should be clearly indicated.
- 4. The abstract is limited to 300 words and should be informative and include principal findings and conclusions. Please avoid abbreviations.
- 5. The main text can have multiple free headings.
- 6. High-resolution figures should be provided in the following format; PDF (preferred format for diagrams), PNG (preferred format for photos or images), EPS ,TIFF, JPEG, BMP.
- 7. References must follow the Springer Basic style.

Correspondence

If you have any questions, please contact editorial@earth-planets-space.com.

© EPS Steering Committee 2016 All rights reserved.

A Grant-in-Aid for Publication of Scientific Research Results (251001) from Japan Society for the Promotion of Science is used for printing.

Continued from back cover

The spatial density gradient of galactic cosmic rays and its solar cycle variation observed with the Global Muon Detector Network	
Paul Evenson, Marlos Rockenbach, Alisson Dal Lago, Nelson J Schuch, Munetoshi Tokumaru,	
Marcus L Duldig, John E Humble, Ismail Sabbah, Hala K Al Jassar, Madan M Sharma and Jozsef Kóta	23
Methods of analysis of geomagnetic field variations and cosmic ray data	
Oksana V Mandrikova, Igor S Solovev and Timur L Zalvaev	23
Reaction of electric and meteorological states of the near-ground atmosphere during a geomagnetic storm on 5 April	
2010Sergey Smirnov	24
Approaches for modeling ionosphere irregularities based on the TEC rate index	
Iurii Cherniak, Irina Zakharenkova and Andrzej Krankowski	24
High-midlatitude ionosphere response to major stratospheric warming	
Svetlana A Grigorieva, Alexander E Stepanov, Vasily V Bychkov, Dora Pancheva and Plamen Mukhtarov	25
Statistical study of medium-scale traveling ionospheric disturbances using SuperDARN Hokkaido ground backscatter	
data for 2011 Alexev V Qinats Vladimir I Kurkin and Nozomu Nishitani	25
Regional climate nattern during two millennia estimated from annual tree rings of Vaku cedar trees: a hint for solar	25
voriability?	
Variability:	26
Kimiaki Masuda and Kentaro Nagaya	20
Search for solar neutrons at Mount Chacaltaya associated with M- and X-class flares during the rising period of solar	
cycle 24Diego Lopez and Yutaka Matsubara	26
Progress of the IUGONET system - metadata database for upper atmosphere ground-based observation data	
Shuji Abe, Norio Umemura, Yukinobu Koyama, Yoshimasa Tanaka, Manabu Yagi, Akiyo Yatagai,	
Atsuki Shinbori, Satoru UeNo, Yuka Sato and Naoki Kaneda	27
The capacity-building and science-enabling activities of the IUGONET for the solar-terrestrial research community	
Akiyo Yatagai, Yuka Sato, Atsuki Shinbori, Shuji Abe, Satoru UeNo and IUGONET project team	27

Contents

Special issue "International CAWSES-II Symposium"	
Correlation between the global occurrences of ionospheric irregularities and deep atmospheric convective clouds in	1
Coronal magnetic field and the plasma beta determined from radio and multiple satellite observations 	9
Jun Kitagawa, Shun Miyawaki and Hirotaka Kashiwagi High-latitude GPS phase scintillation and cycle slips during high-speed solar wind streams and interplanetary coronal	9
mass ejections: a superposed epoch analysisPaul Prikryl, P Thayyil Jayachandran, Sajan C Mushini and Ian G Richardson Space weather effects on the low latitude D-region ionosphere during solar minimum	10
Global distribution of the migrating terdiurnal tide seen in sporadic E occurrence frequencies obtained from GPS radio	10
occultations	11
Empirical modeling of the storm time geomagnetic indices: a comparison between the local <i>K</i> and global <i>Kp</i> indices	11
Climatology of the diurnal tides from eCMAM30 (1979 to 2010) and its comparison with SABER	12
Major solar eruptions and high-energy particle events during solar cycle 24	12
Nat Gopalswamy, Hong Xie, Sachiko Akiyama, Pertti A Mäkelä and Seiji Yashiro	13
Effect of solar cycle 23 in foF2 trend estimationAna G Elias, Blas F de Haro Barbas, Kiyoto Shibasaki and Jonas R Souza	13
Filtering ionosphere parameters to detect trends linked to anthropogenic effectsAna G Elias	14
New perspectives on thermosphere tides: 2. Penetration to the upper thermosphere	14
A long-term trend in the F2-layer critical frequency as observed at Alma-Ata ionosonde station	14
Galina I Gordivenko, Victor V Vodyannikov, Artur F Yakovets and Yuriy G Litvinov	15
Study of Pc1 pearl structures observed at multi-point ground stations in Russia, Japan, and Canada	
Chae-Woo Jun, Kazuo Shiokawa, Martin Connors, Ian Schofield, Igor Poddelsky and Boris Shevtsov	15
New perspectives on thermosphere tides: 1. Lower thermosphere spectra and seasonal-latitudinal structures	16
A statistical study of satellite traces and evolution of equatorial spread F	
Viswanathan Lakshmi Narayanan, Sukanta Sau, Subramanian Gurubaran, Kazuo Shiokawa, Nanan Balan, Kaliappan Emperumal and Samireddipalle Sripathi	16
Long-term variation in the upper atmosphere as seen in the geomagnetic solar quiet daily variation	47
East and ultrafact Kolvin wave modulations of the equatorial evening E region vertical drift and spread E development	17
	17
Polarization analysis of VLF/ELF waves observed at subauroral latitudes during the VLF-CHAIN campaign	
Claudia Martinez-Calderon, Kazuo Shiokawa, Yoshizumi Miyoshi, Mitsunori Ozaki, Ian Schofield and Martin Connors	18
Airglow-imaging observation of plasma bubble disappearance at geomagnetically conjugate points	10
Effects of pre-reversal enhancement of Ex B drift on the latitudinal extension of plasma hubble in Southeast Asia	10
Prayitno Abadi, Yuichi Otsuka and Takuya Tsugawa	19
thermosphere	10
Noctilucent clouds observed from the ground: sensitivity to mesospheric parameters and long-term time series	19
Nikolay Pertsev, Peter Dalin, Vladimir Perminov, vitaly Romejko, Audrius Dubletis, Ričardas Balčiupas, Kazimieras Černis and Mark Zalcik	20
Influence of DE3 tide on the equinoctial asymmetry of the zonal mean inconspheric electric electric density	20
Performance of the SciBar cosmic ray telescope (SciCBT) toward the detection of high-energy solar neutrons in	20
solar cycle 24	
Hiroshi kojima, Harufumi Isuchiya, Kyoko Watanabe, Tatsumi Koi, Jose Francisco Valdes-Galicia, Luis Xavier González, Ernesto Ortiz, Octavio Musalem, Alejandro Hurtado, Rocio Garcia and Marcos Anzorena	21
Relationship between the equatorial electrojet and global Sq currents at the dip equator region	
Bhaskara Veenadhari, Akimasa Yoshikawa and Jairo Avendaño Sanchez Study of plasma flow reversal in the near-Earth plasma sheet using numerical computations	21
	22
Lidar returns from the upper atmosphere of Kamchatka for 2008 to 2014 observations	
Vasily V Bychkov, Yuri A Nepomnyashchiy, Andrey S Perezhogin and Boris M Shevtsov	22