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PREFACE Open Access

Special issue "International CAWSES-II Symposium"

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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 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).

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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?

– 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 three-dimensional (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 satellite-based 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 line-of-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 flare-produced 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 frequency-dependent 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 $E \times B$ 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 bottom-side isoelectron density surfaces probably caused by large-scale 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-to-day 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 $E \times B$ 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.

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