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Editorial

Special issue of SCOSTEP's 15th Quadrennial Solar-Terrestrial Physics Symposium (STP-15)

1. Introduction

The Scientific Committee on Solar-Terrestrial Physics (SCOSTEP, https://scostep.org/) runs the program of Predictability of the variable Solar-Terrestrial Coupling (PRESTO) in 2020–2024. The PRESTO program (https://scostep.org/presto/, Daglis et al., 2021) identifies predictability of the variable solar-terrestrial coupling performance metrics through modeling, measurements, and data analysis and to strengthen the communication between scientists and users. SCOSTEP's 15th Quadrennial Solar-Terrestrial Physics Symposium (STP-15) was organized during February 21–25, 2022, via full online format by the host, the Indian Institute of Geomagnetism, India. Eminent scientists from solar, magnetospheric, ionospheric, thermospheric and atmospheric physics communities gathered to discuss and deliberate on the cutting-edge sciences pertaining to STP that are being pursued, especially the coupling across disciplines to understand predictability of variable solar-terrestrial coupling. The symposium had three sessions corresponding to the three PRESTO Pillars, i.e., Pillar 1: Sun, interplanetary space and geospace, Pillar 2: Space weather and the Earth's atmosphere, Pillar 3: Solar activity and its influence on the climate of the Earth System. The symposium also covered overarching topics in the Sun-Earth connection, space weather prediction and implementation, modelling, database, data analysis tools, new ground and space-based initiatives for solar-terrestrial physics. A special session on geomagnetism - the connecting link between Sun and Earth was also held. A total of 4 keynote talks, 29 invited papers and 313 contributed papers were presented orally in STP-15, making it the largest among SCOSTEP's STP symposia. This special issue includes the following 24 papers on all these topics of solar-terrestrial physics and PRESTO achievements.

2. PRESTO Pillar 1-related papers: Sun, interplanetary space and geospace

Gopalswamy et al. (2024) report on a study of the Multiview Observatory for Solar Terrestrial Science (MOST) mission that will provide comprehensive imagery and time series data needed to understand the magnetic connection between the solar interior and the solar atmosphere/inner heliosphere. The MOST mission consists of 2 pairs of spacecraft located in the vicinity of Sun-Earth Lagrange points L4 (MOST1, MOST3) and L5 (MOST2 and MOST4).

Kumar et al. (2023) study propagation of magnetoacoustic waves in the sun using photospheric and chromospheric Dopplergrams based on observations by the HMI instrument onboard SDO spacecraft and the Multi-Application Solar Telescope (MAST) operational at the Udaipur Solar Observatory. They show that the wavelet power spectrum over photospheric and chromospheric velocity signals show a one-to-one correspondence between the presence of power in the 2.5–4 mHz band, and suggest that the leakage of photospheric oscillations into the higher atmosphere is not a continuous process.

Shanmugaraju et al. (2023) study solar active region magnetic parameters and their relationship with the properties of halo coronal mass ejections (CMEs). They found a moderate to strong correlation value for flare flux and halo CME kinematic properties (like linear speed, space speed and kinetic energy). They suggested that the most complex active regions are feasible sources of strong flare-associated halo CME productivity.

Telloni et al. (2023) review radial spacecraft alignments of the Parker Solar Probe, BepiColombo, and Solar Orbiter missions in the three-year period 2018–2020, describing the diagnostics adopted and discussing the most important achievements in the field of solar wind turbulence evolution.

Xie et al. (2023) report two case studies of magnetic flux rope (MFR) structures in CME associated with filament channels. Both cases show that the post-eruption flux rope has a lower twist at the core and a higher twist at the edge of the flux rope. They also find that the magnetic clouds may deviate from a force-free state at the edge of flux rope.

Minta et al. (2023) present an artificial neural network model for forecasting the transit times of Earth-directed halo CMEs This model uses inputs based on implementation of the Graduated Cylindrical Shell (GCS) forward-modeling technique on these CMEs. They validate the efficiency of the GCS model for studying the 3D kinematics of CMEs and emphasized the essence of utilizing the projected speeds in machine learning frameworks as a better alternative for fast, reliable, and accurate CME arrival (transit) time predictions.

Mishev (2023) report application of the global neutron monitor (NM) network on the assessment of spectra and anisotropy and related terrestrial effects of strong solar energetic particles (SEPs). They present an example study of two ground-level enhancements (GLEs), namely, their SEP energy/rigidity spectra derived using records from the global NM network and models for quantification of the atmospheric ionization and exposure to radiation at flight altitudes (ambient dose) during the considered events.

3. PRESTO Pillar 2-related papers: Space weather and the Earth's atmosphere

Balan et al. (2024) review recent efforts on how to identify and forecast severe space weather (SvSW) events from solar wind data. They show that if one can estimate ΔVBz at the Sun-Earth L1 point based on observations such as from the Advanced Composition Explorer (ACE)

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satellite, it is possible to forecast an SvSW event with an advance warning time of about half an hour.

Hariharan et al. (2023) show probing solar storms with GRAPES-3 muon telescope in Ooty, India. The telescope detected a 2-h burst of cosmic ray muons on 22 June 2015 upon the arrival of a strong CME which triggered a G4 class geomagnetic storm. They discuss the relevance of their results to the space weather prediction.

Kleimenova et al. (2023) investigate 254 “polar” substorms on a contracted auroral oval recorded at the Scandinavian IMAGE magnetometer chain during the winter seasons of 2010–2020, which tend to occur in the late evening (~19–23 MLT) (a bit earlier than the “normal” substorms (22–24 MLT)). They claim that “polar” substorms exhibited the properties, typical for “normal” substorms, so, they could be referred as a specific type of substorms developing under rather quiet space weather conditions.

Based on the statistical analysis of the plasma density data obtained by the Arase satellite, Rubtsov et al. (2023) found an Alfvén velocity increase by a factor of 1.65 or more within a radial distance of 0.5 R_E to be a threshold that corresponds to the classic plasmapause definition that is the electron density drop by a factor of 5 or more within a radial distance of 0.5 R_E.

Gordiyenko (2023) studies ionospheric effects over the five Middle Asian ionospheric stations to the major space weather event of the May 25–26, 1967 geomagnetic storm with the Dst-index of −387 nT based on ionosonde measurements that were not previously considered. The observations indicate a major (≥50%) and long lasting (>28 h) negative ionospheric disturbance appeared during night- and daytime.

Mohamed et al. (2023) report delayed response of low latitudes total electron content (TEC) from the onset of sudden storm commencement (SSC) of thirty-six geomagnetic storms from 2014 to 2017, at American, African, and Asian longitude sectors. They observed both positive and negative ionospheric storms with an average response time of about 27.2 h.

Borries et al. (2023) report a new index for statistical analyses and prediction of travelling ionospheric disturbances (TIDs) using Global Navigation Satellite Systems (GNSS) stations. Using the derived new index, they showed from correlation analysis that large-scale TID magnitudes at mid-latitudes are well correlated with solar wind derived parameters, like the Kan-Lee merging electric field (EKL), the intermediate function (EWAV) and the modified version of the Akasofu’s epsilon parameter.

Otsuka et al. (2023) show equinoctial asymmetry of plasma bubble occurrence and electric field at evening based on the GPS and ionosonde measurements in Southeast Asia. They found that the upward drift velocity at post-sunset is larger in March equinox than September equinox and that solar activity dependence of the zonal and vertical drift velocities is more clearly seen in March equinox than in Septemb equinox. They suggest that in March. equinox, due to high electron density, intense electric field could be generated through the F-region dynamo so that plasma bubble likely occurs.

Setsko et al. (2023) report geomagnetically induced currents (GICs) on Karelian-Kola power line and Finnish gas pipeline during September 12–13, 2017. They show that the increase in GIC amplitudes at different latitudes was associated with the poleward movement of the westward electrojet during the expansion phase of the substorm, while the source of the GICs at the recovery phase appeared to be a short pulse of Pc5 pulsations.

Ravindra et al. (2023) study atmospheric waves by ground-based observations of OH(3–1) emissions and rotational temperature using PRL airglow InfraRed Spectrograph (PAIRS). They showed that the PAIRS derived rotational temperatures for 28 nights of observations show good correspondence with the temperatures obtained from SABER for the passes close to the observational station, indicating that PAIRS provides an opportunity for the detailed investigation of tides and GWs, in general, and short timescale nocturnal MLT dynamics, in particular.

Saha and Pallamraju (2022) report latitudinal movement of the crest of the equatorial ionization anomaly (EIA) in both poleward in the evening and equatorward in the night based on OI 630 nm airglow observations at Mt. Abu, India. They propose that the EIA reversal speed derived from optical nightglow measurements can serve as a proxy for the determination of westward electric field over equator for the Indian longitude sector.

Pallamraju et al. (2023) described a portable CCD-based Daytime Airglow Photometer (CDAP) for investigations of ionosphere-thermosphere phenomena. A Fabry-Perot etalon is used as a high spectral resolution filter to obtain the dayglow signal with a spectral resolution of 0.026 nm at 630.0 nm, which is sufficient to separate the signal and the background from the neighbouring spectral regions.

4. PRESTO Pillar 3-related papers: Solar activity and its influence on the climate of the Earth System

Jiang et al. (2023) review a comparison of physics-based prediction models of solar cycle 25, i.e., flux transport dynamo (FTD) models, surface flux transport (SFT) models, and a combination of the two kinds of models. They suggest that uncertainties in both initial magnetograms and sunspot emergence should be included in such physics-based predictions because of their large effects on the results. They emphasize more on what we can learn from different predictions, rather than an assessment of prediction results.

Nandy et al. (2023) review causality in heliophysics, particularly the solar magnetic fields as a bridge between the Sun’s interior and the Earth’s space environment. Based on their research on the solar–terrestrial system and extant scientific literature, they illuminate processes related to the genesis of solar magnetic fields in the Sun’s interior, their emergence and evolution, their manifestation as solar eruptive events, and their eventual impact on the geospace environment mediated via solar winds and storms.

Chatzistergos et al. (2023) review recent efforts and advances aiming at improving long-term solar irradiance reconstructions and at reducing the existing uncertainty in the magnitude of the long-term variability. By employing state-of-the-art 3D magnetohydrodynamical simulations, an upper limit of 2 ± 0.7 Wm^{-2} was set on the possible increase of Total Solar Irradiance (TSI) since the end of the Maunder minimum as compared to the 2019 minimum level.

Pramitha et al. (2023) investigated long-term variations of temperature, CO_2 concentration and associated cooling rates in the middle and upper atmosphere (30–110 km) using Sounding of Atmosphere by Broadband Emission Radiometry (SABER) on board the Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED) satellite observations during 2002–2021 and Specified Dynamics-Whole Atmosphere Community Climate Model (SD-WACCM) simulations during 2002–2017 over 50^0 N–50^0 S latitudes. They evaluate the SD-WACCM simulations of long-term variabilities in the thermal structure, CO_2 volume mixing ratio and associated cooling rates using two decades of observations.

Using a chemistry-climate model with an interactive ocean, Egorova et al. (2023) analyze the ozone and climate response to the solar irradiance changes caused by the switch of the Sun to higher activity mode which is characterized by the simultaneous decrease of the total and increase of the UV solar irradiance. They conclude that, in general, a possible switch of the Sun to a more active state can lead to a slightly cooler climate and some decrease in the surface UV, though these changes cannot be considered as catastrophic.

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