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Editorial: Magnetosphere and ionosphere response to the solar wind transients

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Editorial on the Research Topic
Magnetosphere and ionosphere response to the solar wind transients

The uninterrupted stream of charged particles and magnetic fields that make up the solar wind dominates the interplanetary space. The solar wind is known to be highly variable and complex, consisting of different structures that vary in their spatial and temporal scales. When these transient structures from the solar wind interact with the Earth's magnetic field, they generate a range of dynamics within the magnetosphere-ionosphere system. Numerous studies, both observational and theoretical, have contributed valuable insights into the coupling of the solar wind with the magnetosphere and ionosphere during such events. The sudden changes in the magnetospheric and ionospheric currents, radiation belt particle fluxes, and magnetospheric waves due to the impact of the solar wind transients have been well-investigated However, recent advances in simulation capabilities and the availability of observations from state-of-the-art particle and field instruments on missions like Van Allen Probes, Magnetospheric Multiscale (MMS), Exploration of energization and radiation in geospace (ERG), Time History of Events and Macroscale Interactions during Substorms (THEMIS), and Cluster now enable comprehensive and systematic studies to address these questions in a better way. Therefore, this Research Topic "Magnetosphere and Ionosphere Response to the Solar Wind Transients" aims of integrating various studies pertaining to the response of the magnetosphere and ionosphere to transient solar wind structures to get an improved perspective of the basic underlying physical processes. The Research Topic has a total of five accepted manuscripts. Their topic of research spans from evaluating the impact of sudden commencement on ionospheric currents, solar wind pressure control of EMIC waves in the magnetosphere, sudden changes in the magnetosphere due to IMF By polarity changes, solar wind Mach number influence on Dst index, and magnetosphere interaction with isolated Co-rotating Interaction Regions over four consecutive solar rotations. Here we present a quick highlight of each manuscript to give an integrated overview of the Research Topic.

Kikuchi et al. presented a comprehensive article that aimed at a reporting consistent understanding of geomagnetic sudden commencement (SC). They presented an overview of the current understanding of SC based on observations, theoretical models, and simulation studies of the 12 May 2021 SC event. The study covers observations in the morning and afternoon local time sectors and high and middle latitudes in the northern and southern hemispheres. The observed characteristics of the SC, like the time scale, and polarity of the electric field were observed to be consistently explained by the simulations. Further, the associated preliminary impulse was recorded almost simultaneously (within a few seconds) in the southern and northern hemispheres indicating the validity of the TM0/TEM mode wave propagation model by Kikuchi and Araki (1979).

Upadhyay et al. investigated EMIC wave generation/occurrence modulation at the Indian Antarctica station due to solar wind dynamic pressure and substorms. They showed the effect of solar wind dynamic pressure and AE index on the local time occurrence of EMIC waves. Analysing the ground-based observations, EMIC waves were found to occur more frequently in the morning and afternoon-evening sectors. The larger AE index was seen to be associated with shifting the occurrence of EMIC waves in the dusk sector. Also, the EMIC waves occurring in the afternoon and evening time sectors were found to be associated with magnetospheric compression by enhanced solar wind dynamic pressure.

In the study by Gong et al., the authors used the Space Weather Modeling Framework (SWMF) to simulate the transient dynamics in the magnetosphere-ionosphere system when a sudden change in the IMF By having IMF Bz pointing northward impacted the magnetosphere-ionosphere system. Simulation results reveal that under northward IMF conditions, an abrupt change of the IMF By from duskward to dawnward induces geomagnetic field perturbation firstly in the cusp region and then in both the near-Earth and magnetotail regions. The ionosphere is seen to quickly responding to the changes of IMF By than the magnetosphere. The delay in the response is shown to be linear with downstream distance when $Bz < 0$, and not otherwise. This implies the differences in geomagnetic response for conditions when the magnetosphere is closed (Bz >0) and open Bz <0.

Bagheri and Lopez focused on the evaluation of the impact of low Mach number solar wind conditions on the magnetosphere-ionosphere system. They estimated the correlation between the Dst index and the energy dissipated in the ionosphere. They observed that for lower Mach numbers, this correlation was seen to decrease. Further, it is shown that for lower Mach numbers, ionospheric indices of the storms are less correlated to the geoeffectiveness of the solar wind during these storms. Thus implying that the Dst index is a not very accurate indicator of the ionospheric power for geomagnetic storms during low Mach number periods of solar wind.

Nasi et al. conducted a study on a series of Corotating Interaction Regions (CIRs) that affected the magnetosphere for four consecutive solar rotations. The study involved multiple spacecraft and focused on examining the acceleration processes occurring during the CIR-induced magnetospheric disturbances. The authors studied the seed, relativistic, and ultrarelativistic electron populations. The study reported a delay of several hours between the initial seed and the subsequent increase in the flux of relativistic and ultra-relativistic electrons. The population of 9.9 MeV electrons was found to be elevated before the population of 7.7 MeV electrons, which is indicative of different acceleration mechanism for each population. The phase space density profiles of electrons with near perpendicular pitch angles are most probably accelerated by chorus waves, while ultrarelativistic electrons are mostly accelerated by inward radial diffusion resulting from Pc 4-5 waves.

All the published works in this Research Topic advanced our understanding of how the magnetosphere responds to solar wind transients by utilizing ground and multi-spacecraft observations and improved simulation capabilities. The gained understanding will support future developments in space weather research and this also has implications for exploring the interaction of solar/stellar wind with other planetary and exoplanetary systems.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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