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Editorial: Earth-affecting Solar Transients

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This Topical Collection (TC) is devoted to the recent advancement in the study of Earth-affecting solar transients. Earth-affecting solar transients encompass a broad range of phenomena, including major solar flares, coronal mass ejections (CMEs), interplanetary CMEs (ICMEs), solar energetic particle (SEP) events, and corotating interaction regions (CIRs). In the past decade, nearly continuous observations of the Sun and the inner heliosphere

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with an unprecedented wide spatial coverage from a fleet of spacecraft, including the *Solar Terrestrial Relations Observatory Ahead/Behind* (STEREO A/B), the *Solar Dynamics Observatory* (SDO), the *Solar and Heliospheric Observatory* (SOHO), the *Mercury Surface, Space Environment, Geochemistry, and Ranging* (MESSENGER) spacecraft, *Venus Express* (VEX), the *Advance Composition Explorer* (ACE), and *Wind*, in combination with a significant development and improvement of global magnetohydrodynamics (MHD) numerical simulations and theoretical analyses, have greatly improved our understanding of solar transients and the prediction of their potential impact on Earth. This TC includes articles that address, but are not limited to, the following questions: (1) How do various geoeffective phenomena originate on the Sun? (2) How do they propagate and evolve in the inner heliosphere? (3) How can we reconcile *in situ* and remote-sensing data on transients? (4) How can we predict the probability of arrival, time of arrival, and geoeffectiveness of these phenomena? (5) Which type of solar wind transients are geoeffective, and why?

This Topical Collection is based on the International Study of Earth-affecting Solar Transients (ISEST) project, initially launched in 2013 to bring together scientists from many countries to join efforts on studying solar transients. ISEST became one of the four research projects of the Variability of the Sun and Its Terrestrial Impact (VarSITI)) program, sponsored by the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) for the period of 2014 – 2018. The overarching goal of the ISEST project is to understand the origin, propagation, and evolution of solar transients through the space between the Sun and the Earth, and develop the prediction capability of space weather. Toward this goal, the ISEST project has organized three workshops in three different geographic locations across the globe: 17 – 20 June 2013 in Hvar, Croatia, 26 – 30 October 2015 in Mexico City, Mexico, and 18 – 22 September 2017 in Jeju, South Korea. Several smaller but more focused workshops were also organized in convenient locations, *e.g.* as part of international meetings. The ISEST project maintains a standing website for hosting events catalogs, data, and presentations, and offers a forum for discussion at http://solar.gmu.edu/heliophysics/index.php/.

This Topical Collection contains 34 articles covering a broad range of scientific topics relevant to solar transients that can be separated into six large groups, which we summarize in the following six paragraphs.

In creating event catalogs, Hess and Zhang (2017) compiled a catalog of 70 Earth-affecting ICMEs in Solar Cycle 24 and tracked these events back to the sources of the eruptions in the low corona; the tracking was made possible possible through the complete Sun-to-Earth coverage of STEREO observations. These authors additionally made a statistical study of the properties of these events, including the source regions. Using more than 20 years of *Wind* observations, Nieves-Chinchilla *et al.* (2018) compiled a comprehensive database of ICMEs through three solar cycles and studied the asymmetry of the magnetic field strength profiles of these events. Ameri and Valtonen (2017) studied the occurrence and characteristics of geomagnetic storms associated with 66 disk-center full-halo CMEs from 1996 to 2015, of which 50% were deduced to be the cause of 30 geomagnetic storms with Dst ≤ -50 nT. There are two review articles in this TC. Lugaz *et al.* (2017) presented a review of the different aspects associated with the interaction of successive CMEs in the corona and inner heliosphere, focusing on the initiation of series of CMEs, their interaction in the heliosphere, the particle acceleration associated with successive CMEs, and the effect of compound events on Earth's magnetosphere. Shen *et al.* (2017) reviewed the collision nature of two CMEs and pointed out that these collisions can have a different nature, *i.e.* inelastic, elastic, and super-elastic processes, depending on their initial kinematic characteristics.

In relation to the evolution of transients near the Sun, Kay *et al.* (2017) studied the deflection and rotation of seven CMEs, which originated from active region (AR) 11158 between

13 and 16 February 2011, and found good agreement between observations and the Forecasting a CME's Altered Trajectory (ForeCAT) model. Nitta and Mulligan (2017) studied the origin of CMEs that were not accompanied by obvious low coronal signatures (LCSs), the so-called stealth CMEs, but were responsible for appreciable disturbances at 1 AU. These authors found that all these CMEs typically started slowly. Kim *et al.* (2017) investigated the relation of CME speed and magnetic helicity in CME source regions during the early phases of Solar Cycles 23 and 24. Ichimoto *et al.* (2017) presented a new solar imaging system for observing high-speed eruptions, the *Solar Dynamics Doppler Imager* (SDDI), whose great dynamic range in line-of-sight velocity measurements in Hα allows determining the motion of erupting filaments in 3D space.

To study the chain of events from the Sun to the Earth, Temmer *et al.* (2017) comprehensively examined the flare and CME event from 1 October 2011, covering the complete Sun-to-Earth chain of effects, including the evolution of the CME mass and the comparison of the magnetic flux inferred from remote-sensing and *in situ* observations. Using a large array of ground-based and satellite instruments, Piersanti *et al.* (2017) made a comprehensive analysis of the CME launched on 21 June 2015 and its specific effects on the magnetosphere, plasmasphere, and ionosphere. Rodkin *et al.* (2017) studied the kinematic and thermodynamic properties of the CMEs that occurred on 2 – 4 August 2011 and modeled their charge states to be consistent with *in situ* observations through estimating a probable heating rate of the CME plasma. Srivastava, Mishra, and Chakrabarty (2018) reported on the kinematics of two interacting CMEs observed on 13 and 14 June 2012 and found that the interaction of the two CMEs was inelastic in nature and led to the strongest sudden storm commencement (SSC) (≈ 150 nT) in the current Solar Cycle 24. Ojeda-González *et al.* (2017) used six different methods, including minimum variance analysis and Grad-Shafranov (GS) reconstruction, to evaluate the properties of the complex ejecta in the time series of solar wind data obtained on 19 – 22 March 2001. They found that the event was composed of two magnetic clouds (MCs). Aslam and Badruddin (2017) studied the similarities and differences in the geoeffectiveness and galactic cosmic-ray (GCR) responses of selected ISEST campaign events. Watari (2018) identified and studied two geomagnetic storms associated with coronal holes within the 19 intense geomagnetic storms that occurred in Cycle 24. Bocchialini *et al.* (2018) selected 32 SSC events during 2002 as a starting point and performed a multi-data analysis based on observations to associate them with their solar sources, identify their effects in the interplanetary medium, and analyzed the response of the terrestrial ionized and neutral environment.

In the context of magnetic properties of CMEs, Gopalswamy *et al.* (2017) reported a new method for computing the flare reconnection flux from post-eruption arcades and the underlying photospheric magnetic field. These authors found that the reconnection flux is correlated with the poloidal flux of the associated MC at 1 AU. Bothmer and Mrotzek (2018) made a comparison study of the 3D orientation of CMEs near the Sun and *in situ* and suggested that the kink in the near-Sun structure of the CMEs could explain the orientation differences. Sachdeva *et al.* (2017) analyzed the observed evolution of a set of 38 CMEs and found that the Lorentz forces acting on CMEs generally peak between 1.65 and 2.45 $R_\odot$. These forces become negligible in comparison to aerodynamic drag as early as 3.5 to 4 $R_\odot$ for fast CMEs and only from 12 – 50 $R_\odot$ for slow CMEs. Patsourakos and Georgoulis (2017) extended their earlier work on a helicity-based method to infer the CME magnetic field in both the Sun and the geospace through a generalization of the formalism to several possible flux rope configurations. These authors further discussed the implications for exoplanet habitability. Fitting several *in situ* CMEs with cylindrical and toroidal force-free flux rope models, Marubashi, Cho, and Ishibashi (2017) compared the orientation of these flux ropes with that of the magnetic polarity inversion lines (PILs) in their solar source regions. They argued that in most cases, the magnetic flux rope structure created in the corona is carried through interplanetary space and maintains its orientation. Hu (2017) developed an approach of the GS reconstruction for toroidal structures in space plasmas and made benchmark studies to demonstrate the performance of the GS solver. Based on 13 simple MC events with slow expansion speed and weak asymmetry, Al-Haddad *et al.* (2018) compared three reconstruction methods and suggested that attempts at reconciling *in situ* and remote-sensing views of CMEs must take into consideration the compatibility of different models with specific CME structures.

From *in situ* solar wind observations, Vršnak *et al.* (2017) examined CIRs during the declining phase of Solar Cycle 23 and found a generally weak correlation between solar wind plasma and magnetic field parameters and geomagnetic activity indices (the Dst, Ap, and AE indices and the Dst time derivative). Wu *et al.* (2017) examined a short-duration (35 min), but extremely dense (peak 94 cm^{-3}), pulse in the solar wind and suggested that the high-density pulse might be the result of the compression of the heliospheric plasma sheet by an interplanetary shock crossing or an interaction between an interplanetary shock and a CIR. Applying a double superposed epoch analysis method to a large number of transients in the solar wind from 1976 to 2000, Yermolaev *et al.* (2017) argued that the observed differences between MC and non-MC ejecta arise because the satellite passes farther from the nose in non-MC than in MC ejecta. Yang *et al.* (2018) reported a study of the correlation between the solar wind magnetic field, B, and plasma parameters (density, N, temperature, T, and velocity, V) and found that while the magnetic field does not appear to be correlated with any individual plasma parameter, the field correlates well with the combined parameters $\sqrt{NV^2}$ and $\sqrt{NT}$. Augusto *et al.* (2017) studied a muon excess event at sea level on 28 August 2015 and attributed the increase to the acceleration of particles by shock waves at the front of the high-speed stream and the focusing effect of the heliospheric current sheet crossing. Using both observations and MHD simulations, Alves *et al.* (2017) evaluated the ability of two different solar wind transient events to generate ultra-low-frequency (ULF) waves in the equatorial region of the inner magnetopshere, which lead to a dropout in the relativistic electron fluxes in the outer radiation belt. Nina *et al.* (2018) studied the relationship between the solar X-ray radiation intensity and the D-region electron density in the Earth's ionosphere.

In the field of space weather prediction, Dumbović *et al.* (2017) presented a validation of the Coronal Mass Ejections and Solar Energetic Particles (COMESEP) space weather alert system and pointed out that the success rate of the system in its current form is unacceptably low for realistic operation. These authors further discussed the implications of a possible improvement of the alert system. Using a set of well-selected events, Webb and Nitta (2017) highlighted the problems in forecasting ICMEs and their geoeffectiveness. They identified likely source CMEs and found that the related solar surface activity ranged from uncertain or weak to X-class flares, while the geoeffects ranged from none to severe. Chertok, Grechnev, and Abunin (2017) extended their previously developed tool for SOHO data to SDO data. This tool allows for the early diagnostics of the geoeffectiveness of solar eruptions based on the estimate of the total unsigned line-of-sight photospheric magnetic flux in accompanying EUV arcades and dimmings.

In short, the articles in this Topical Collection have addressed a broad range of subjects relevant to Earth-affecting solar transients. We hope that readers enjoy this TC and find it valuable for their own work.

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