frontiers in Astronomy and Space Sciences

EDITORIAL
published: 15 February 2022
doi: 10.3389/fspas.2022.853925

Editorial: Magnetic Connectivity of the Earth and Planetary Environments to the Sun in Space Weather Studies

Daniele Telloni[1]*, *Zoltan Vörös*[2], *Emiliya Yordanova*[3] *and Raffaella D'Amicis*[4]

[1]National Institute for Astrophysics, Astrophysical Observatory of Torino, Pino Torinese, Italy, [2]Space Research Institute, Austrian Academy of Sciences, Graz, Austria, [3]Swedish Institute for Space Physics, Uppsala, Sweden, [4]National Institute for Astrophysics, Institute for Space Astrophysics and Planetology, Roma, Italy

Keywords: space weather, Sun, interplanetary medium, planetary systems, magnetohydrodynamics (MHD)

Editorial on the Research Topic

Magnetic Connectivity of the Earth and Planetary Environments to the Sun in Space Weather Studies

Understanding how the Sun's activity regulates the response of the Earth's and other planets' atmospheres and/or magnetospheres has attracted great interest from the scientific community over the last few years. Planetary Space Weather is the general term referring to the science devoted to the study of the interaction between the Sun and the environment of a Solar System body (e.g., Lilensten et al., 2014). Although the solar activity is naturally the main driver for any planetary (or satellite) disturbance, it is worth reminding that in the outer Solar System, other interplanetary drivers (e.g., galactic cosmic rays and interstellar pick-up ions, which can alter the composition and properties of the solar wind) may play some role in the variability of planetary environments. It follows that both solar and non-solar impinging plasma/radiation are different actors at different locations in the Solar System and should be thus both considered in Planetary Space Weather. It turns out that Planetary Space Weather is a cross-discipline that spans planetology, heliophysics, and aeronomy, at the interface between fundamental science and applications. The fleet of solar and planetary space missions significantly advances our understanding of space weather phenomena in the Solar System and greatly supports theoretical models. This kind of missions enables a large variety of plasma and magnetic field observations, both with remote-sensing and in-situ instruments and dedicated to different bodies in the heliosphere. With the recent launches in the last 4 years of Parker Solar Probe (Fox et al., 2016), Solar Orbiter (Müller et al., 2020), and BepiColombo (Benkhoff et al., 2010) for the study of the Sun and Mercury, respectively, the insertion of the Juno mission into orbit around Jupiter in 2016 (Bolton et al., 2017) and the upcoming launch of JUpiter ICy moons Explorer (JUICE, Grasset et al., 2013) scheduled in 2023 for the exploration of the largest Solar System planet and three of its Galilean moons (Ganymede, Callisto, and Europa), we have entered what is universally recognized as the golden age of the heliophysics and planetology. This unprecedented observational capability will be allowing scientists to investigate in great detail the relationship between solar and terrestrial/planetary environments, with particular reference to the magnetic connectivity between these environments and the solar corona, the outer layer of the solar atmosphere, where the solar wind originates permeating the whole heliosphere.

This Research Topic collects six original research papers (both observational and modeling), one perspective article, and one review, all of them addressing space weather science and space weather awareness related to the chain of phenomena at the base of the onset and propagation of disturbances (both transient, such as Coronal Mass Ejections—CMEs—or shocks, or advected by the solar wind as turbulence and flux ropes) from the Sun into the inner heliosphere and their interaction with terrestrial/planetary environments, in particular highlighting how space weather phenomena are characterized by different intensities and morphologies across the entire Solar System.

OPEN ACCESS

Edited and reviewed by:
Joseph E. Borovsky,
Space Science Institute, United States

Correspondence:
Daniele Telloni
daniele.telloni@inaf.it

Specialty section:
This article was submitted to Space Physics, a section of the journal Frontiers in Astronomy and Space Sciences

Received: *13 January 2022*
Accepted: *24 January 2022*
Published: *15 February 2022*

Citation:
Telloni D, Vörös Z, Yordanova E and D'Amicis R (2022) Editorial: Magnetic Connectivity of the Earth and Planetary Environments to the Sun in Space Weather Studies. Front. Astron. Space Sci. 9:853925. doi: 10.3389/fspas.2022.853925

Although our physics-based understanding of solar-wind/magnetosphere coupling is still far from being satisfactory (Borovsky), the papers collected in this Research Topic will help advance our knowledge in tracing propagation of solar events through the Solar System, detecting and predicting planetary events driven by the Sun's activity, and finally forecasting the effectiveness of interplanetary disturbances on planetary magnetospheres and atmospheres. Specifically, based on a statistical study on 79 CMEs, Kilpua et al. clearly show that the fluctuation properties in CME sheath regions are very different from those generally observed within planetary magnetosheaths and that CME-driven shocks do not reset the solar wind turbulence at a similar extent than planetary bow shocks, thus advancing our understanding of the role of shocked solar-wind plasma in modulating geomagnetic activity and magnetospheric evolution. Interesting in the context of magnetic connectivity studies, Borovsky assesses the possibility of using the electron strahl as an indicator of the magnetic connection between the solar corona and the near-Earth environment. This study complements and is somehow supported by observational evidence that the magnetic-flux-tube structure of the solar wind can be mapped by measuring density and temperature of the core-electron population (Borovsky et al.). Magnetic connections from the Sun to the lunar nightside are explored by Borovsky and Delzanno as being very important in space weather science for identifying the pathways for impulsive Solar-Energetic-Electron (SEE) events, which may pose hazards for space objects orbiting around the Moon in the form of damaging radiation. Riley and Issan provide the interplanetary scientific community with a refined technique dedicated to Planetary Space Weather for magnetically connecting different regions of the inner heliosphere to their source regions at the Sun. This represents a breakthrough in understanding how coronal structures propagate and evolve from the Sun into the heliosphere, shaping the structure of the solar wind through dynamic stream-stream interactions. More accurate estimates of magnetic connectivities require the use of Carrington synoptic maps built from white-light observations (Poirier et al.) against which the different coronal and heliospheric models should be compared to rank their performance, e.g., in inferring the shape of the magnetic sector structure. Finally, as if to conceptually link in a rather comprehensive view all the results collected in this Research Topic, Beedle et al. briefly review the main solar-wind drivers governing the magnetosphere-ionosphere system, emphasizing the crucial roles played by magnetic topology and connectivity. The authors thus provide a concise though exhaustive description of the magnetically connected space weather system, intended for a growing cross-disciplinary audience interested in applied aspects of modern space weather research and forecasting.

AUTHOR CONTRIBUTIONS

All authors listed were guest Associate Editors of the Research Topic and made a substantial, direct and intellectual contribution in conveying the Research Topic. In particular, the Editorial was written by DT with the input and critical feedback of ZV, EY, and RD.

FUNDING

DT was partially supported by the Italian Space Agency (ASI) under contract 2018-30-HH.0. ZV was supported by the Austrian FWF under contract P28764-N27. EY was supported by Swedish Contingencies Agency (grant 2016–2102) and the Swedish National Space Agency (Grant 145/18).

ACKNOWLEDGMENTS

We thank authors of the papers published in this Research Topic for their valuable contributions and the referees for their rigorous reviews. We also thank the editorial board of the Space Physics, Plasma Physics, and Stellar and Solar Physics sections for their support. The contribution of the Associated Editor for the Space Physics section Marian Lazar, who acted as Editor for one paper in the Research Topic, is finally acknowledged.

REFERENCES

Benkhoff, J., van Casteren, J., Hayakawa, H., Fujimoto, M., Laakso, H., Novara, M., et al. (2010). BepiColombo-Comprehensive Exploration of Mercury: Mission Overview and Science Goals. *Planet. Space Sci.* 58, 2–20. doi:10.1016/j.pss.2009.09.020

Bolton, S. J., Lunine, J., Stevenson, D., Connerney, J. E. P., Levin, S., Owen, T. C., et al. (2017). The Juno Mission. *Space Sci. Rev.* 213, 5–37. doi:10.1007/s11214-017-0429-6

Fox, N. J., Velli, M. C., Bale, S. D., Decker, R., Driesman, A., Howard, R. A., et al. (2016). The Solar Probe Plus Mission: Humanity's First Visit to Our Star. *Space Sci. Rev.* 204, 7–48. doi:10.1007/s11214-015-0211-6

Grasset, O., Dougherty, M. K., Coustenis, A., Bunce, E. J., Erd, C., Titov, D., et al. (2013). JUpiter ICy Moons Explorer (JUICE): An ESA mission to Orbit Ganymede and to Characterise the Jupiter System. *Planet. Space Sci.* 78, 1–21. doi:10.1016/j.pss.2012.12.002

Lilensten, J., Coates, A. J., Dehant, V., Dudok de Wit, T., Horne, R. B., Leblanc, F., et al. (2014). What Characterizes Planetary Space Weather? *Astron. Astrophys. Rev.* 22, 79. doi:10.1007/s00159-014-0079-6

Müller, D., St. Cyr, O. C., Zouganelis, I., Gilbert, H. R., Marsden, R., Nieves-Chinchilla, T., et al. (2020). The Solar Orbiter Mission. Science Overview. *Astron. Astrophys.* 642, A1. doi:10.1051/0004-6361/202038467

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.