Open Call for Ideas for

New data products, tools and services for Swarm

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Product Idea

Auto detection tool for small-scale traveling ionospheric disturbances

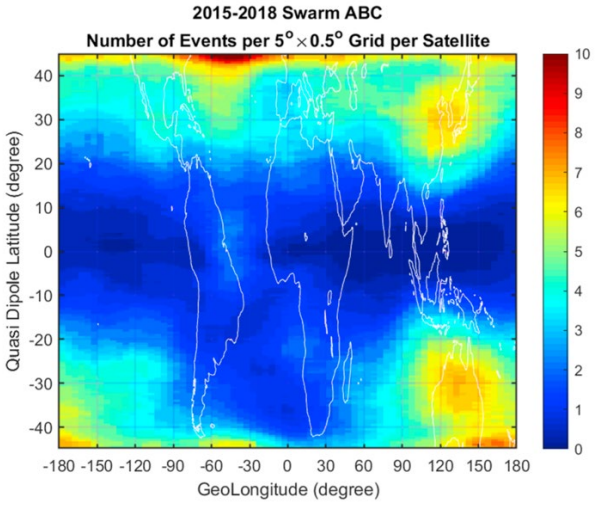
Product Description

Description of proposed product

The proposed product consists of a set of Python codes for detecting small-scale traveling ionospheric disturbances (SSTID) over middle and low latitudes, and the detected SSTID list over the past 10 years.

Description of current state of the art and level of maturity of proposed algorithm

Swarm Level 1b 50 Hz magnetic field vector data contain the information about small-scale (<10 km) electromagnetic fluctuations caused by various processes in the ionosphere. These fluctuations cannot be resolved by the standard 1 Hz data. Yin et al. (2019), exploring the Swarm 50 Hz magnetic field data over middle and low latitudes during 2015−2018, found that the small-scale magnetic fluctuations were partly due to equatorial plasma bubbles (EPB), and partly due to Pc1 magnetic pulsations. Even after removing EPB and PC1 events, approximately 30% of orbits was found to contain small-scale magnetic fluctuations, which have a distinct spatial distribution (see the figure below). They were attributed to SSTID. Adopting the methodology described by Yin et al. (2019), we create a set of Python codes for automatically detecting and listing SSTID events.



Spatial distribution of SSTID (Yin et al., 2019)

Data input needs

We will use the Swarm Level 1b 50 Hz magnetic field vector data (MAGX_HR_1B) given in the North-East-Center (NEC) coordinate system. Equatorward boundaries of small-scale field-aligned currents are given by Swarm Level 2 product PPI [1]. The data analysis will be limited to middle and low latitudes between the two boundaries. For the identification of EPB, we will use Swarm Level 2 product IBI [2].

Expected output

We will provide a set of Python codes, which use the Swarm Level 1b 50 Hz magnetic field vector data along with the Swarm Level 2 products PPI and IBI as inputs. It will provide the information about the detected SSTID events, i.e., magnitude of the disturbance, universal/local time, geographic/magnetic coordinates, and altitude, along with corresponding solar/geomagnetic activity indices.

Scientific benefits

SSTID is a frontier topic of ionospheric science. The origin and mechanism of SSTID are still to be identified. Larger-scale traveling ionospheric disturbances are generally associated with atmospheric disturbances caused by geomagnetic storms as well as gravity waves that are generated in the lower atmosphere (e.g., Jonah et al., 2018). Thus, studies of SSTID are important in terms of both solar-terrestrial coupling and vertical atmospheric coupling.

Expected user community

Main users of our product are expected to be scientific researchers in the field of the ionosphere (e.g., ionosphere-magnetosphere interactions, atmosphere-ionosphere interactions) and geomagnetism. For example, our SSTID list can be compared with the occurrence of larger-scale traveling ionospheric disturbances during geomagnetic storms as determined by ground-based total electron content data, or with the occurrence of atmospheric wave events following seismic or volcanic events. Our SSTID list can also benefit the researchers who wish to select “clean” geomagnetic data without any disturbances.

References

Jonah, O. F., Coster, A., Zhang, S., Goncharenko, L., Erickson, P. J., De Paula, E. R., & Kherani, E. A. (2018). TID observations and source analysis during the 2017 Memorial Day weekend geomagnetic storm over North America. Journal of Geophysical Research: Space Physics, 123(10), 8749-8765, https://doi.org/10.1029/2018JA025367

Yin, F., Lühr, H., Park, J., & Wang, L. (2019). Comprehensive analysis of the magnetic signatures of small-scale traveling ionospheric disturbances, as observed by Swarm. Journal of Geophysical Research: Space Physics, 124(12), 10794-10815, https://doi.org/10.1029/2019JA027523

[1] Swarm-PRISM Description of the Processing Algorithm, Doc. no: SW-DS-GFZ-GS-006, Rev: 2 (https://earth.esa.int/eogateway/documents/20142/37627/Swarm-PRISM-Description-of-the-algorithm.pdf)

[2] Swarm L2 IBI Product Description, Doc. no: SW-TR-GFZ-GS-0006, Rev: 2 (https://earth.esa.int/eogateway/documents/20142/37627/swarm-level-2-ibi-product-description.pdf)