Open Call for Ideas for

New data products, tools and services for Swarm

Template

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Product/Tool/Service Idea

Swarm AE-Global, AE-North & AE-South indices

Product/Tool/Service Description (2 pages maximum)

- Description of proposed product/tool/service
  NOA has conducted a prototype study for the year 2015 (Papadimitriou et al., 2021) to demonstrate that Swarm-derived geomagnetic activity indices can monitor magnetic storms through the Swarm-based SYM-H index and magnetospheric substorms through the Swarm-based AE index at least as efficient as the standard ground-based activity indices SYM-H and AE (see also Balasis et al., 2019, 2023). More importantly, Swarm-based AE is of a more global character in comparison to AE, because the satellite index covers both hemispheres, while the ground index is derived with data from the northern hemisphere only, since magnetic observatories at auroral latitudes are very rare at the southern hemisphere. Additionally, Swarm observations offer us the possibility to derive separate indices for the northern hemisphere (Swarm-based AE-North) and southern hemisphere (Swarm-based AE-South), thus, enabling us to perform investigations of the North-South ionospheric asymmetry.
- Description of current state of the art and level of maturity of proposed algorithm
  Papadimitriou et al. (2021) and Balasis et al. (2019) showcased the feasibility of using Swarm data to produce indices of geomagnetic activity. These spaceborne indices can capture the same dynamic processes and exhibit the same behaviour as ground-based geomagnetic indices traditionally used to monitor magnetic storm (SYM-H index) and magnetospheric substorm (AE index) activity (Balasis et al., 2023). Since auroral indices (i.e., AE, AL, AU) are constructed from data recorded by ground-based stations located in the Northern hemisphere, it follows that all these indices are predominantly Northern; thus, any comparison against a global satellite-based index will be unavoidably biased. To mitigate this, specific versions of the Swarm AE index were produced, namely Swarm AE-North and Swarm AE-South for the year 2015. Even though the two localized indices generally agree with each other, focusing on specific small intervals, one can see small but significant differences between them, pointing to a clear North-South asymmetry.
- Data input needs (e.g. type of data from Swarm and/or other, frequency, auxiliary information)
  1. Swarm low-resolution vector magnetic field data (1 Hz) (SW_OPER_MAGX_LR_1B)
  2. Swarm low-resolution vector magnetic field data (1 Hz) from the near real time processing chain that produces data as soon as possible, namely the Swarm FAST product (SW_FAST_MAGX_LR_1B)
- Expected output (e.g. frequency of delivery, suggested strategy for data delivery)
  Indices will be produced for the entire life-time of the mission and saved in daily files. Possible choices for the file type are CDF (Common Data Format) files or simple, comma-separated ASCII files. Work will be performed to ensure the data are available through the client of the VIRES platform, while also data files will be delivered to ESA so that they can be included in the official Swarm FTP server as well.

The team will consider the possibility of making the methodology available through the Swarm PAL framework, and operational on FAST data, so that eager users can take advantage of the functionalities of Swarm-PAL and produce outputs in near-real time.

Types of Indices

- Swarm AE-Global (using data from both hemispheres)
- Swarm AE-North (using data from the northern hemisphere only)
- Swarm AE-South (using data from the southern hemisphere only)
- Swarm SYM-H, Swarm ap/Kp, Swarm PC (optional products)

- Scientific/application benefits, complementarity with other relevant ESA and non-ESA activities including opportunities for new scientific activities based on implementation of the proposed product / service.

  A Swarm-based family of novel geomagnetic-equivalent indices will be further developed, thoroughly tested and shared with the scientific community. These indices will characterize the recorded geomagnetic disturbance at the Swarm altitude, resembling the traditional AE index generated from ground-based magnetic observations. However, one distinctive feature lies in the ability to compute separate values for both hemispheres, mitigating the inherent constraint of the AE index, which relies just on Northern hemisphere observatory data. This innovation represents a significant step towards unravelling the genuine interhemispheric dissimilarities in ionospheric response to external perturbations.

  The proposed LEO-based indices can help also to identify space weather effects localized in MLT, e.g., driven by localized magnetospheric dynamics (like bursty bulk flows). Such effects can be missed by the sparse AE stations (also in the Northern hemisphere). Satellites like Swarm and others (e.g., Macau Science Satellites and NanoMagSat missions) can contribute to a better MLT coverage and a better chance to detect local space weather effects.

- Expected user community

  Geophysicists, Space physicists and Space weather experts would be interested in the proposed indices products of auroral electrojet. For instance, Geomagnetically Induced Currents (GIC) are sensitive to the variations of auroral electrojet (Beggan, 2015), while the AE index holds predictive capabilities for medium energy electron precipitation (Tyssøy et al., 2021).

  The proposed project is very timely given the increased geomagnetic activity that our planet is currently undergoing presumably associated with the maximum phase of solar cycle 25: on 11th of May 2024 a magnetic storm occurred with a minimum Dst index value of -412 nT, representing the strongest magnetic storm event over a period of 20 years (i.e., since the Halloween 2003 storm event). For this reason, it would be very interesting to attempt to derive the above-mentioned Swarm indices using the recently released Swarm FAST data for selected major geomagnetic disturbance events. This would highlight the usefulness of the Swarm mission as a space weather mission.

  In the longer run, the methodology applied to derive the AE family of indices from the Swarm mission could be easily adapted to derive corresponding indices from platform magnetometers and forthcoming missions, in particular the Macau Science Satellites and NanoMagSat missions.

References

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