

Swarm FAST data processing chain

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Abstract:

After 10 years in Space, Swarm ESA's Earth Explorer mission is still in excellent shape and continues to contribute to a wide range of scientific studies, from the core of our planet, via the mantle and the lithosphere, to the ionosphere and interactions with Solar wind. Its highly accurate observations of electromagnetic and atmospheric parameters of the near-Earth space environment, and the peculiar mission constellation design, make Swarm eligible for developing novel Space Weather products and applications. In April 2023 a "FAST" processing chain has been transferred to operations, providing Swarm L1B products with a minimum delay respect to the acquisition. These Fast data products add significant value in monitoring present Space Weather phenomena and help modelling and nowcasting the evolution of several geomagnetic and ionospheric events. This work presents the set-up of the Swarm "FAST" data processing chain, current status and plans for future improvements and applications.

Swarm L1B FAST chain setup

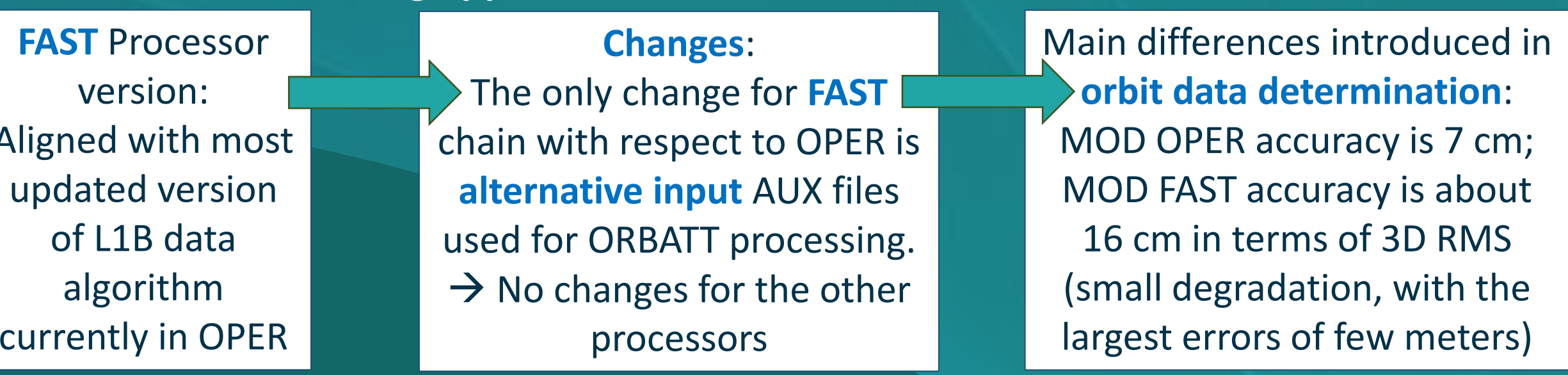
Implementation plan:

PHASE I - Analysis	PHASE II - Feasibility	PHASE III - Demo	PHASE IV - Routine
<ul style="list-style-type: none"> Retrieve alternative Auxiliary Data 3-days L1B TDS, QC & validation Characterise possible errors Identify potential users 	<ul style="list-style-type: none"> Integrate modified IPF into a parallel chain 1 year L1B TDS, QC & validation Provide TDS to selected users and collect feedback 	<ul style="list-style-type: none"> Demonstration Datasets: TDS for all S/Cs disseminate to selected users Collect feedback 	<ul style="list-style-type: none"> Systematic Fast L1b Data production for all S/Cs Revised dump approach Extend to selected L2 products

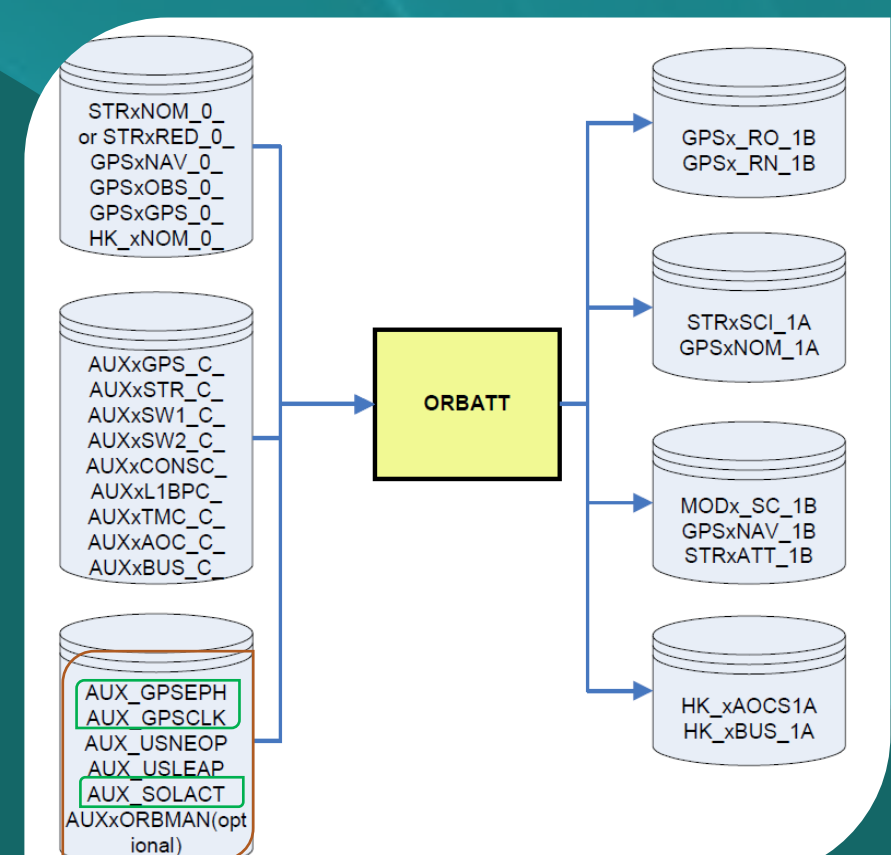
Activities timeline:



FAST Data Processing approach:



- Same product types
- Same time resolution
- Different latency:
 - 4 days for OPER
 - ~12 h for FAST (see below)



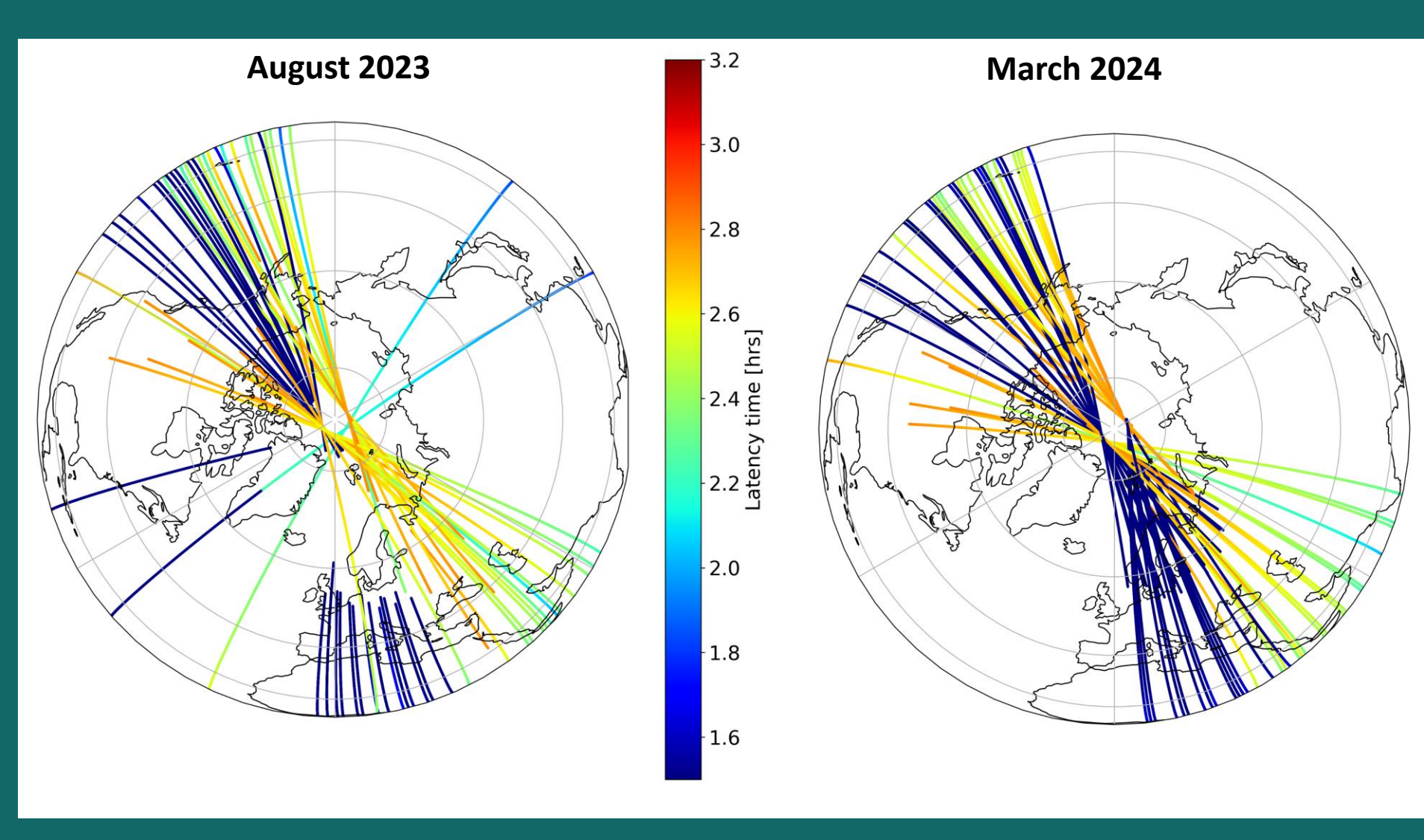
Latency and Coverage improvements



Latency after downlink and distribution is mainly related to archival and processing time. ORBATT, ACCELE and PLASMA data are available after ~1h 20m. MAGNET processor is the most time-consuming, taking ~30min more in average. Processor optimization, to further improve the latency, can be applied in the future.

Users' community recommended to improve pass strategy to provide a more uniform pass distribution and a more efficient utilisation of the FAST data. The optimization has been defined, reflecting requirements and operational constraints, and applied: current strategy foresees 2 passes per day every ~12h (with a standard deviation of ~1:30-2h).

A further improvement involving the downlink approach, set up in March 2024, guarantees a better coverage and reduces latency over northern Europe.



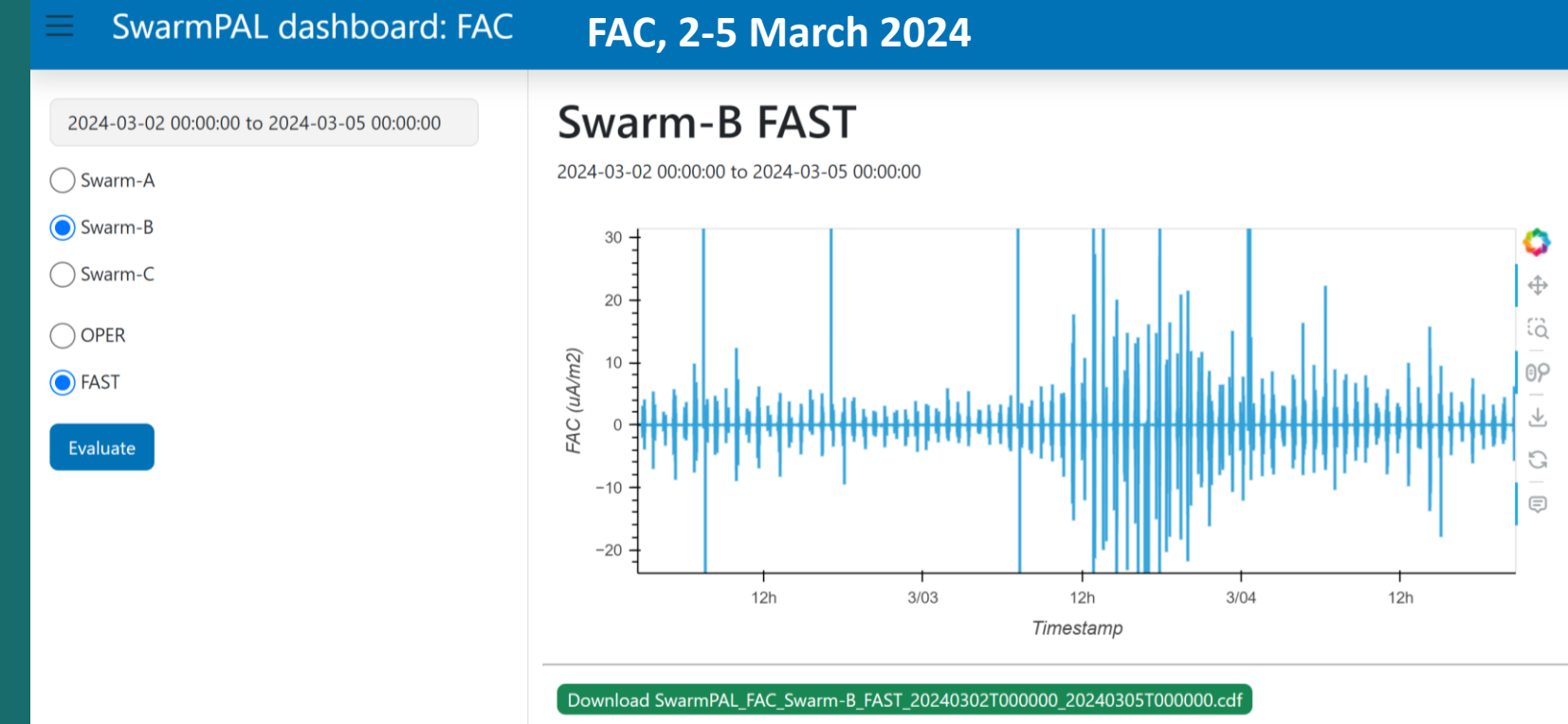
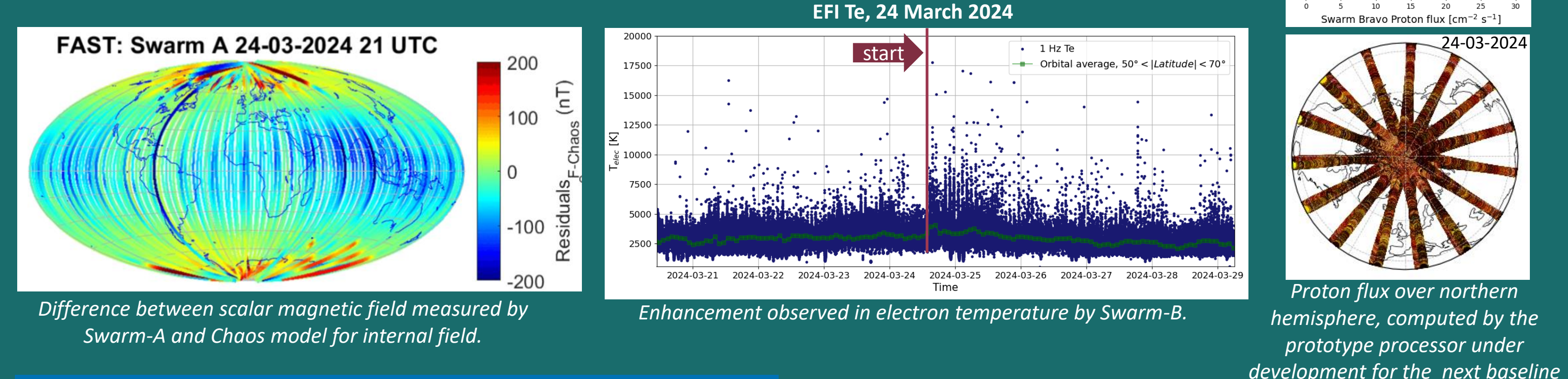
Impact of the change in the downlink approach for Swarm Alpha during a 15 days period.

Latency here is defined as difference between data acquisition time and data generation + distribution time.

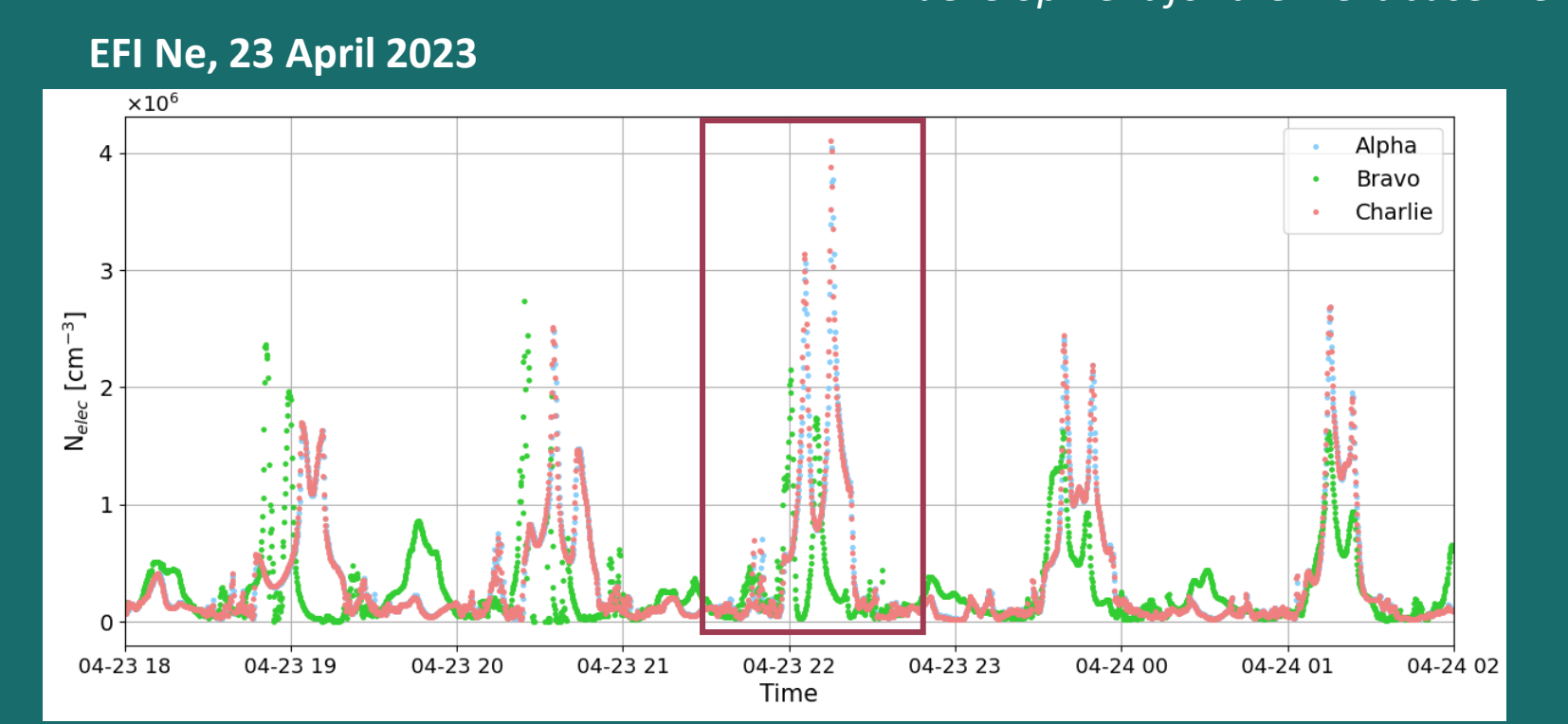
Swarm FAST data for Space Weather

Space Weather events observed with Swarm FAST data:

With a minimum delay with respect to the sensing time, Swarm FAST data are suitable for Space Weather applications. Several events of Solar Cycle #25 have been already observed and analysed with Swarm FAST data, allowing the scientific community to promptly monitor Magnetic and Electric field variations. As a representative example, the strongest event of Cycle #25 so far (a severe G4 class storm) and its impact on external magnetic field and plasma environment has been analysed with Swarm few hours after the interaction:



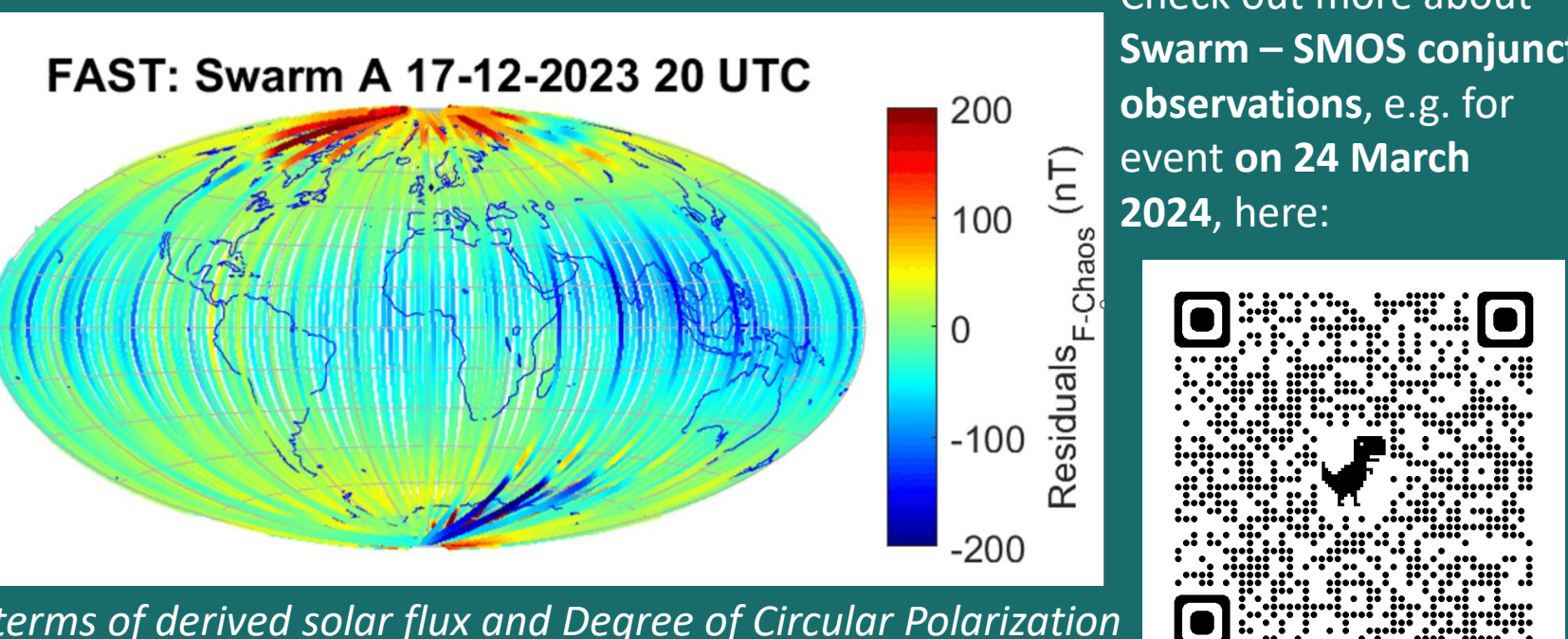
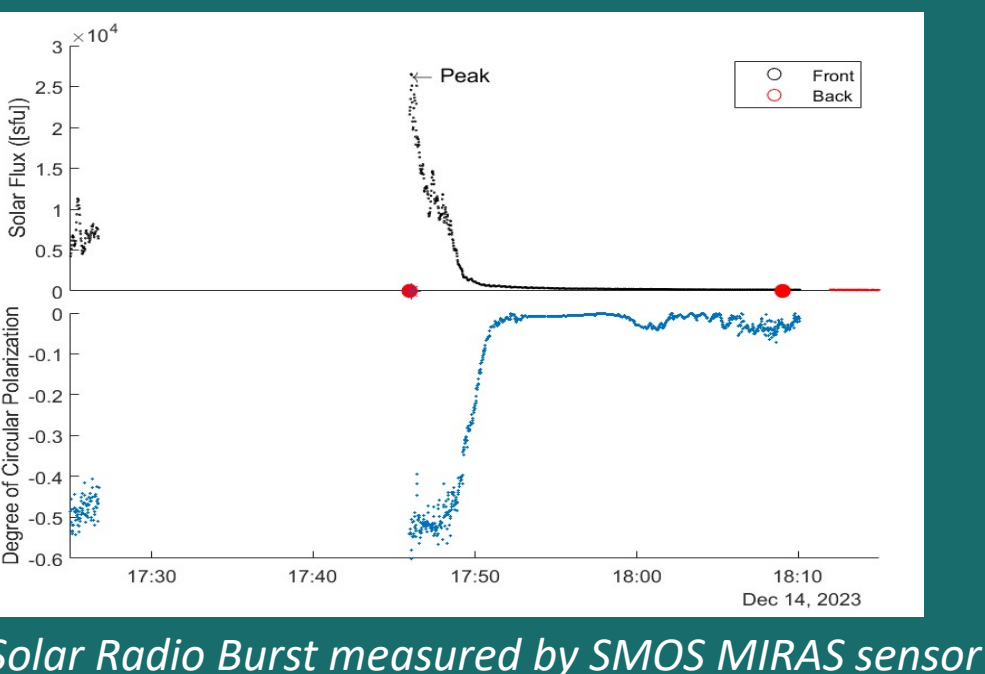
Swarm L2 FAC measured during G1 storm on 3 March 2024. Developed by A. Smith from University of Edinburgh, this dashboard incorporates a prototype FAST processing allowing a quick look of the FAC for all Swarm spacecraft from both the operational and FAST production.



Plasma density peak observed at mid-latitudes by Swarm in correspondence of the G4-class geomagnetic storm on 23 April 2023. This event has been characterized by auroras observed at lower latitudes (e.g. in central Europe).

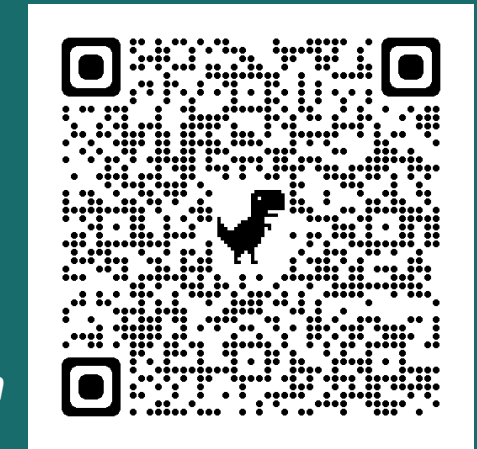
Swarm – SMOS Multi-mission synergies for Space Weather:

ESA SMOS mission, dedicated to Soil moisture and salinity measurements, captures a signal from the Sun that allows to derive the Solar Flux in L-band, with its polarization component. A combined observation of SMOS solar flux and Swarm measurements reveals new possible applications!



Solar Radio Burst measured by SMOS MIRAS sensor in terms of derived solar flux and Degree of Circular Polarization component on 14-12-2023 (left); variations of external magnetic field measured by Swarm few days later (right).

Check out more about Swarm – SMOS conjunct observations, e.g. for event on 24 March 2024, here:



What's coming next?

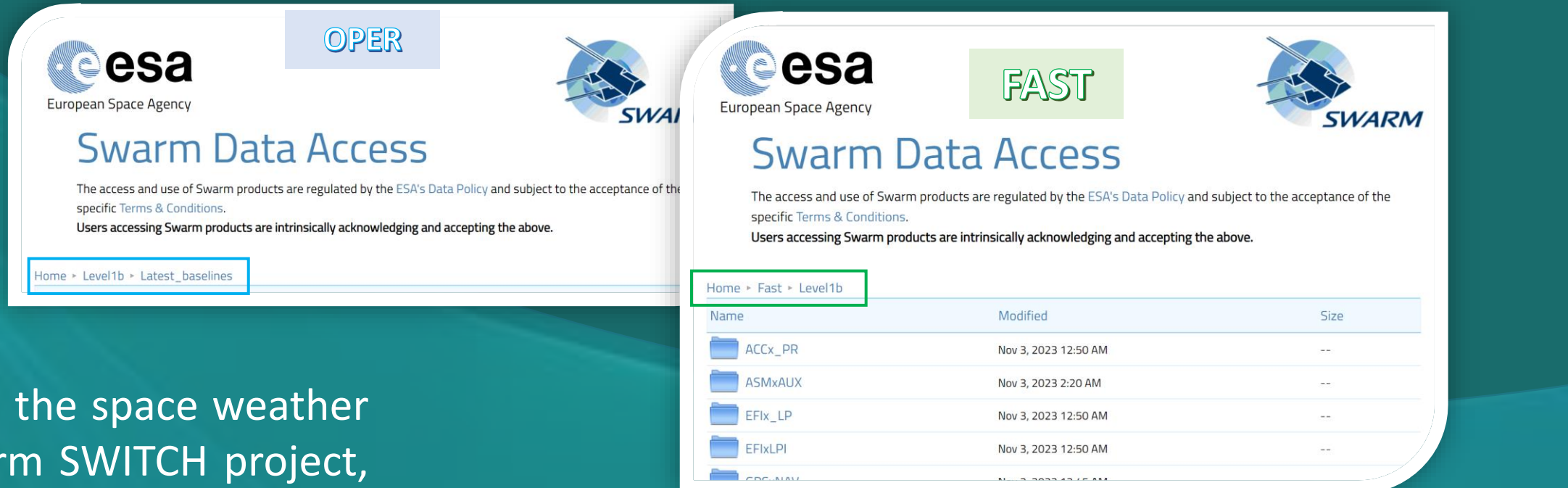
FAST processing data quality is continuously under monitoring and frequently used by Swarm community. Feedbacks and recommendations are collected and applied to the future improvements plan.

- Short-term upgrades includes:
- Align L1B FAST processor with the upcoming L1B OPER processor version 3.25 (see poster #9, N. Comparetti et al.)
 - Implement L2 FAST production chain

FAST data distribution and visualization

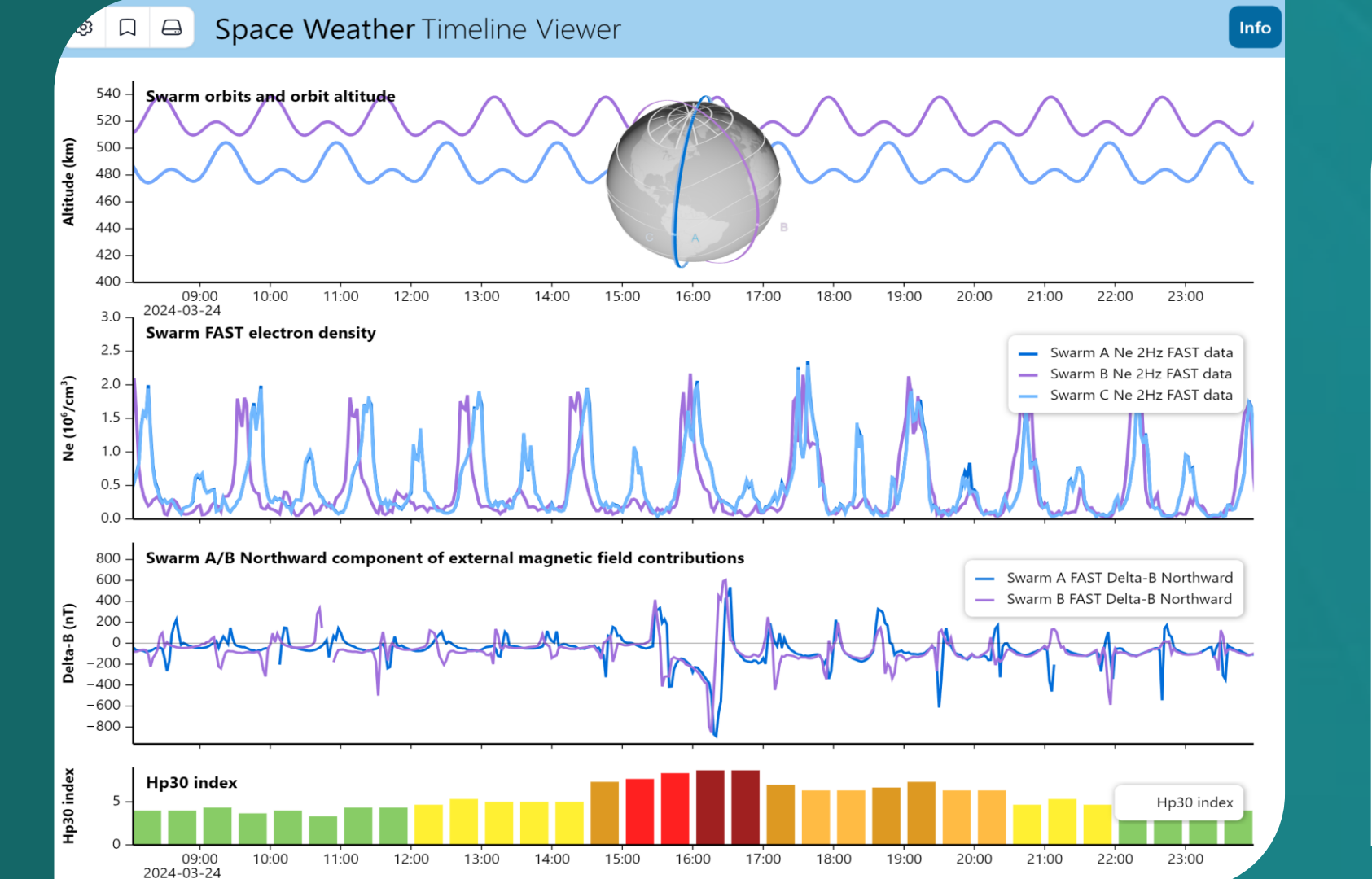
Data distribution:

Swarm FAST Data are distributed through the same dissemination server as OPER data: <https://swarm-diss.eo.esa.int/>



Data visualization:

HAPI timeline viewer, developed in the space weather group at KNMI as part of the Swarm SWITCH project, also includes visualization of Swarm FAST data:



Since Dec. 2023 Swarm FAST Data are accessible from VirES and VRE platforms, just like OPER data!

