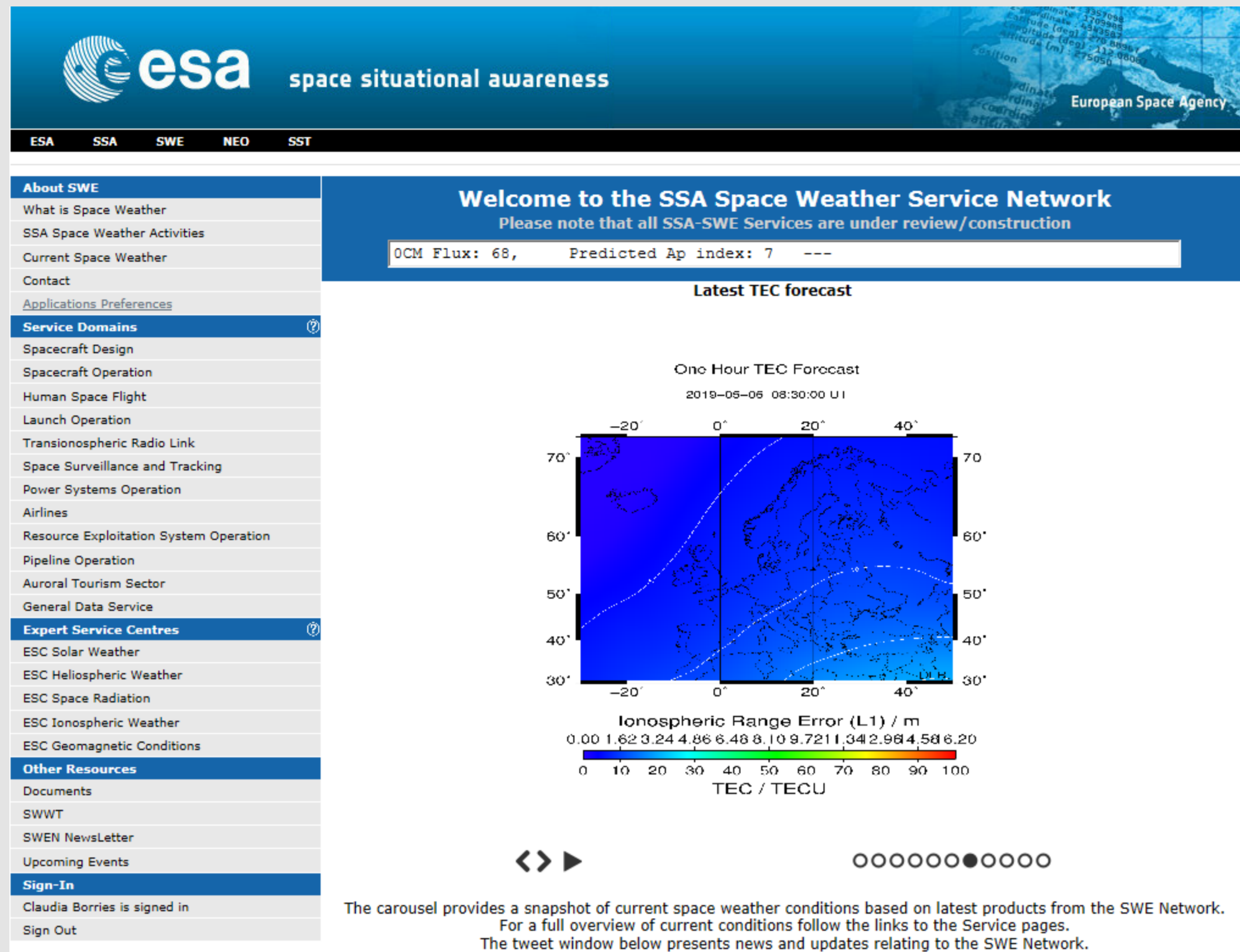


Contributions of Low Earth Orbit (LEO) satellite missions to the provision of space weather services in the ESA Space Weather Network

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ESA Space Situation Awareness Space Weather (SSA SWE) Portal: <http://swe.ssa.esa.int/>

ESA SSA SWE Network

The European Space Agency's (ESA) Space Situational Awareness (SSA) Programme aims to develop space weather (SWE) products that will help to predict the severe SWE events, which can have devastating effects on critical infrastructures in Europe, such as communication and navigation systems, power grids, aviation, etc. Currently, a comprehensive system to monitor, predict and disseminate SWE information and alerts is in development, which will help to reduce costs and improve the reliability of these infrastructures. The fundament of the ESA SSA SWE Network is five Expert Service Centres (ESCs), each focusing on different SWE topics.

ESC Ionospheric Weather

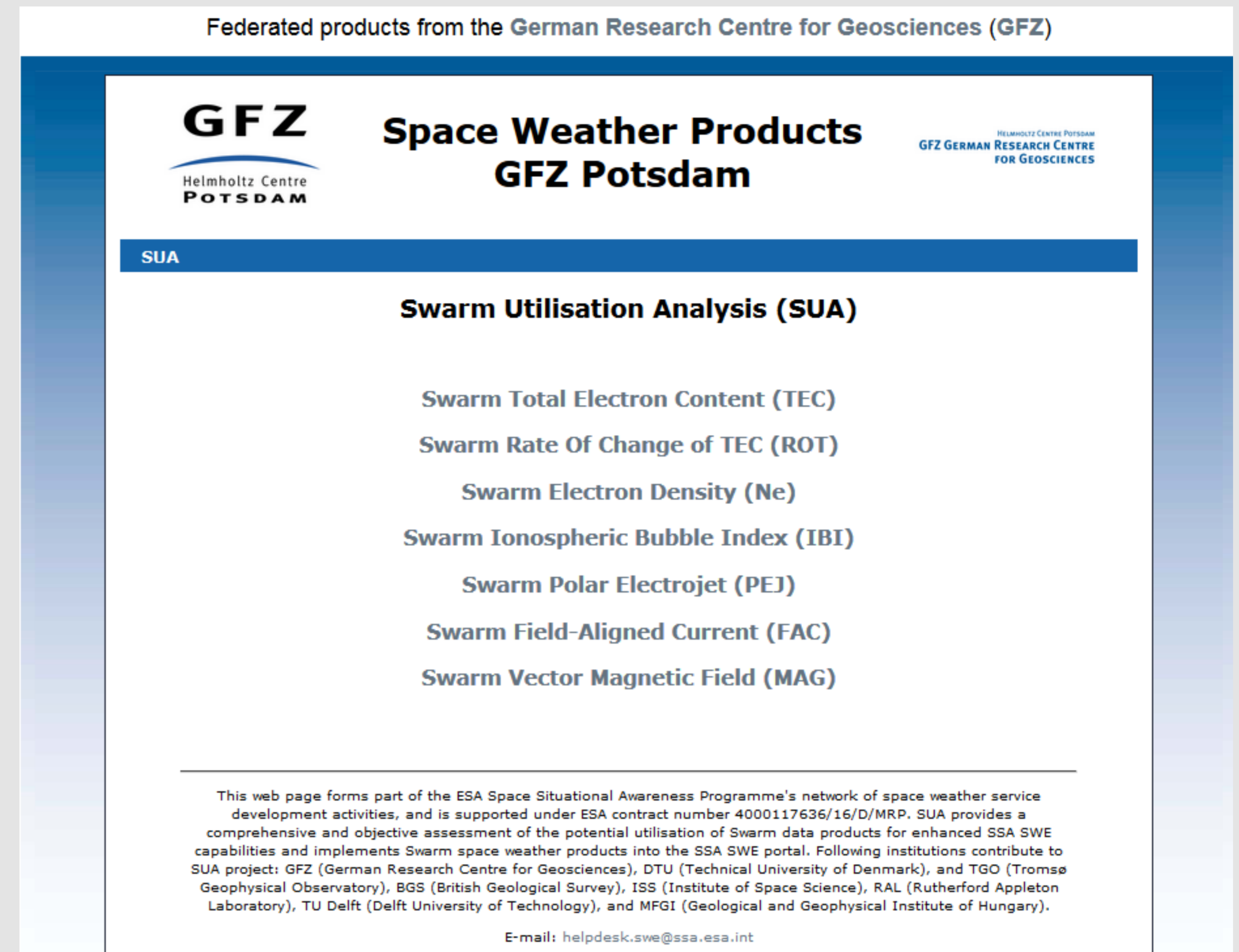
The mission of the Ionospheric Weather ESC (I-ESC) is to provide and develop the functionalities, capabilities and expertise in the domain of ionosphere and upper Atmosphere that are needed within the ESA SSA SWE network to achieve as a collaborative enterprise its mission of demonstrating and assessing the influences of Space Weather and informing and supporting end users through the provision of accurate, reliable and timely products and (pre-)operational services, tailored to their requirements. The I-ESC thus provides, implements and supports the Ionospheric and upper Atmosphere Weather products and capabilities of the ESA SSA SWE network, including the observation, monitoring, interpretation, modelling and forecasting of ionosphere and upper atmosphere weather conditions. It provides products and services that are tailored to the needs of communication and navigation system users, which rely on the transmission of radio signals and operators in the space surveillance and tracking domain who need space weather information, e.g. for proper satellite drag calculation.

Swarm satellite mission in I-ESC

Swarm is the ESA's first constellation mission for Earth Observation and consists of the three identical satellites. A Swarm Utilisation Analysis (SUA) has been performed in 2016-2017. Seven Swarm derived ionosphere and geomagnetic products are the first LEO satellite measurements provided in different services on the SSA SWE Portal <http://swe.ssa.esa.int/>. The ionosphere products are in-situ electron densities, Total Electron Content (TEC), Rate Of change of TEC (ROT) and the Ionosphere Bubble Index (IBI). These products are excellent for research and validation of ground-based products.

After deployment, it was found that the applicability for end-users in the transionospheric radiolink and space surveillance and tracking domains is rather low. Limitations in the simultaneous spatial-temporal coverage of the given region and the timeliness of the data (it is provided several days after the observation – significant funds are required to improve that) were identified as critical points.

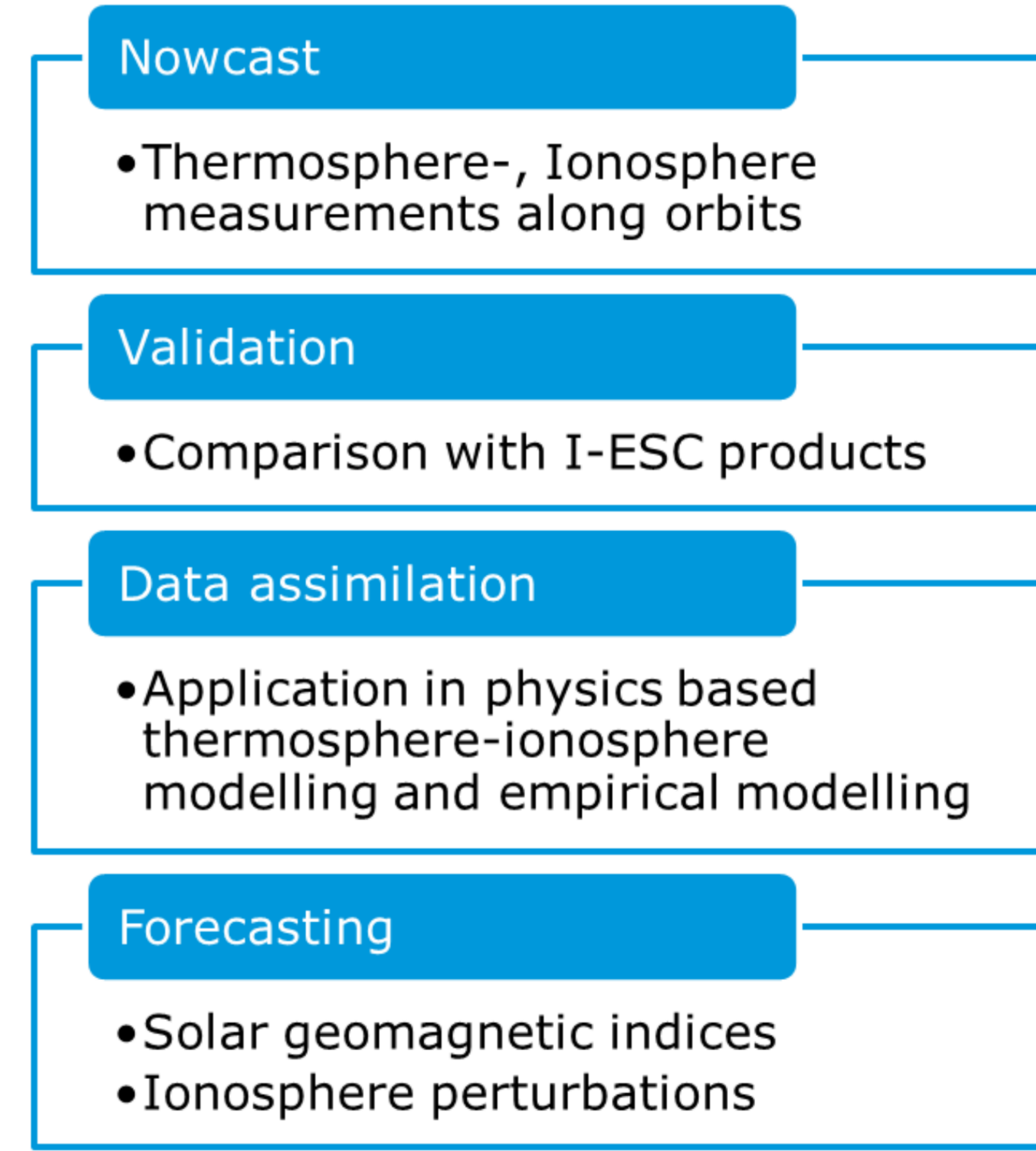
Still, the SUA products are considered valuable for the SSA SWE Network, because Swarm products are the only opportunity to check space weather conditions in satellite orbit altitudes. Also, model development and validation, which is an important fundament for the SSA SWE network, requires in-situ ionosphere-thermosphere data (like Swarm). Data assimilation in post-event studies is another important application of the Swarm data.



Ionosphere and geomagnetic products derived from Swarm measurements, provided on the SSA SWE Portal: <http://swe.ssa.esa.int/web/guest/gfz-sua-federated>

General perspective for the contribution of LEO mission measurements to the SSA SWE Network

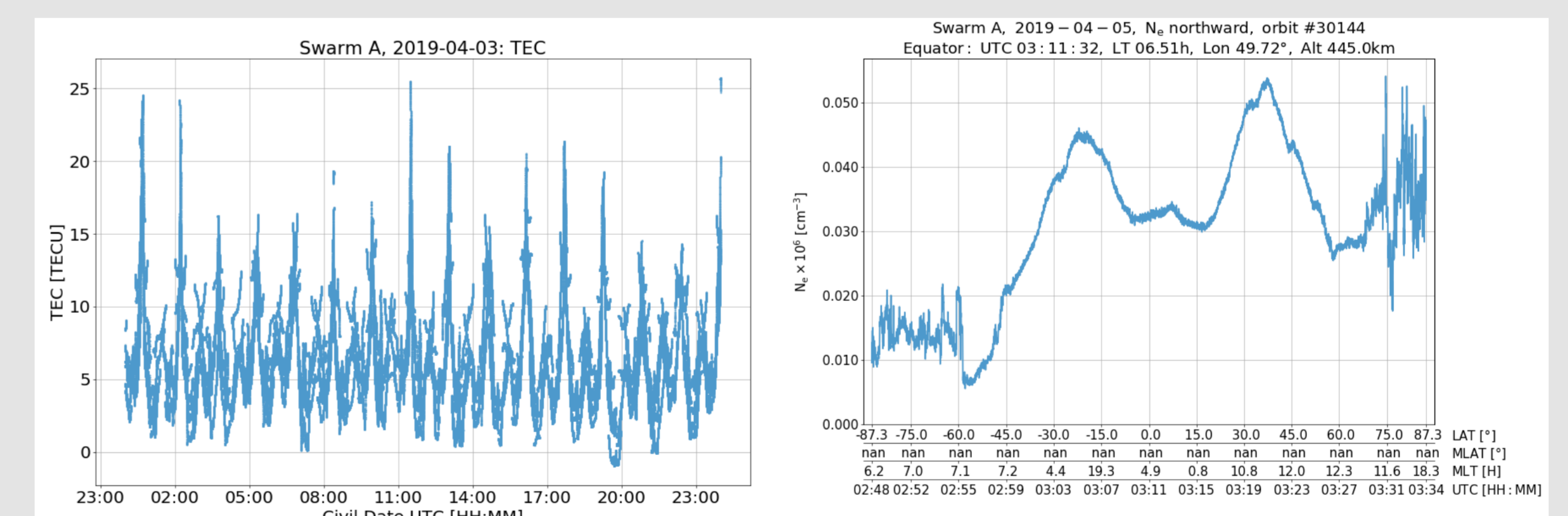
The SUA study showed that near real-time data provision is a rather important requirement for the application of satellite-based data in the SSA SWE network. It allows to provide and improve thermosphere-ionosphere-magnetosphere nowcast and forecast products. On the one hand, in-situ measurements along the orbits are useful and on the other hand, the in-situ measurements can enhance model results through data assimilation. Here, the in-situ measurements can also contribute to the improvement of ionosphere-thermosphere forecasts.



Following measurements are of high interest in the I-ESC:

- Neutral density in thermosphere (accelerometer, POD)
- Field aligned currents
- Electric fields and electron density (Langmuir probe)
- Thermosphere winds
- Thermosphere composition
- Solar wind/ IMF measurements, forecast

Even if satellite measurements are provided with a delay of a few days, the products can provide excellent and unique capabilities for product development and for enhancing SSA SWE services. This has been demonstrated with the SUA activity.



Two examples of Swarm (SUA) products deployed the the ESA SSA SWE Portal. Left: Total Electron Content (TEC) from Swarm A, Right: electron density from Swarm A.

Conclusion

Satellite-based measurements of thermosphere-ionosphere-magnetosphere conditions are a valuable contribution to the ESA SSA SWE Network. Its importance will raise in the near future particularly with the increasing utilisation of data assimilation techniques.