PITHIA-NRF TNA Success story: **ASPIS** (Feasibility study of data-driven Autonomous Service for Prediction of Ionospheric Scintillations)

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The ionosphere is the most important atmospheric layer that affects the radio signal between space-based missions and ground-based stations. Disturbances that can rapidly modify the amplitude and phase of the radio waves are called ionospheric scintillations. They represent a high-risk effect for the signal from GNSS (Global Navigation Satellite System) used for high-precision calculation of position and time. The ASPIS activity is dedicated to study the feasibility of developing a data-driven service autonomously providing an assessment of ionospheric scintillation in a specific time ahead, based on available solar, space weather, geomagnetic, ionospheric, and thermospheric data for a particular location.

As part of ongoing studies to develop the ASPIS service, supported by European Space Agency (ESA) within the Program for European Coorporating States in Slovakia (PECS SK6-29), the objectives within the TNA program were to

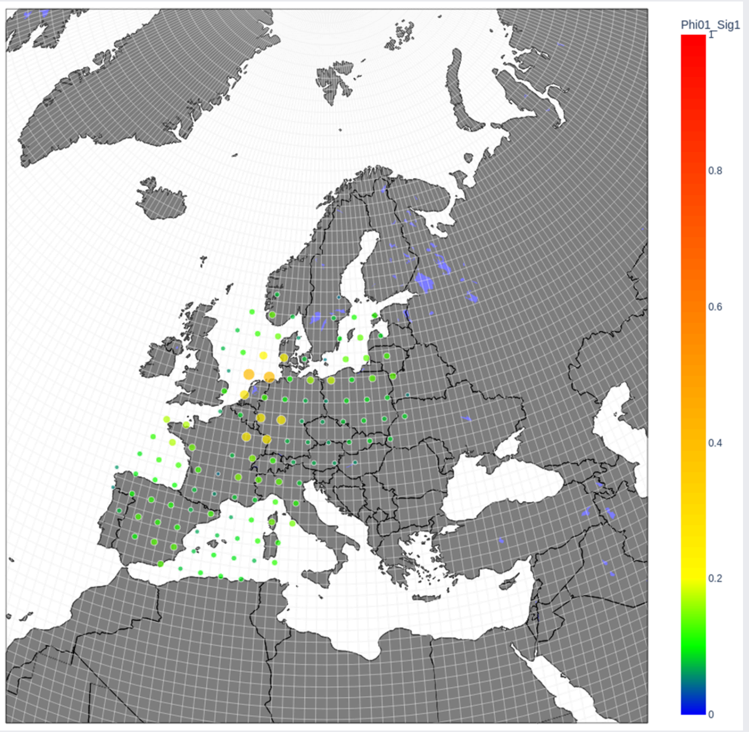
- become familiar with data of ionospheric scintillation (S4, $\sigma\phi$, ROTI) and other ionospheric parameters provided by DLR-SO;
- incorporate these data into an existing data-driven approach;
- investigate the performance of ASPIS in comparison with other current prediction models of ionospheric parameters;
- compile user needs and requirements for ionospheric prediction service for future demonstration purposes and for potential operation purposes.

At the start of the project, the DLR-SO node provided data of two years measurements for nine stations. The ionospheric scintillations parameters were then analysed. A clear understanding of the data and the physics of ionospheric scintillation is crucial for the successful progress of the ASPIS feasibility study. Some months later, the visit to the DLR-SO node allowed for very detailed discussions on the topic to answer open questions, specifically on

- the role of geometry for interpreting ionospheric data and the origin of ionospheric scintillations;
- GISM (Global Ionospheric Scintillation Model) and SWIGPAD (Space Weather Impact on GNSS Performance Application Development);
- the role of infrastructure development and its maintenance at example of DLR's IMPC (Ionosphere Monitoring and Prediction Center).

The know-how transfer had an inestimable value for the wider study, and the project continued with the employment of all obtained knowledge to incorporate the data. The analysis comprised

- removing systematic and gross errors as well as outliers on the phase scintillation parameter ($\sigma\phi$);
- projecting measured data to geographical coordinates based on the known location of the station and satellite;
- preparing the time series for the bins, representing the evolution of $\sigma\phi$ in tens of minutes around scintillation occurrence for usage as input for the machine learning model.



Projection of scintillation data provided by DLR-SO for Toulouse (France), Neustrelitz (Germany) and Kiruna (Sweden).

https://aspis.services/

The validated results were finally presented at the DLR-SO scientific seminar. The main advantage is that this input is self-consistent and has a straightforward temporal and spatial interpretation, in contrast to trying to put all raw data into the data-driven approach. All these aspects are known thanks to the TNA program and have not been considered before the start of ASPIS activity. The stay of the IEP SAS team in Neustrelitz was a key moment for the development of the data-driven solution, and the TNA program also accelerated the collaboration that might be very fruitful within ESA Space Safety Programme and/or EU Horizon Europe calls.

https://pithia-nrf.eu

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