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T-FORS: a project to develop TID forecasting systems

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Travelling Ionospheric Disturbances (TIDs) are recognised as an important source of technology interruptions and failures. They present particular problems for HF-radio applications—such as over-the-horizon radar or geolocation of transmitters—as well as for high-precision GNSS-based navigation. Users of such technologies can have mitigation systems or operational procedures available to them to minimise impact of TIDs. However, the presence of TIDs is often not readily apparent from the performance of various technologies themselves. An external source of timely information of TID activity is required in order to employ available mitigation strategies effectively. The availability of information on TID activity has been identified as essential in the ESA SSA user requirements[1].

Over the last decade, significant progress has been made in development of methodologies for operationally detecting and characterising TIDs. There exist now operational systems for TID monitoring in near-real-time[2]. While this meets some users' requirements, there is also a need for at least short term forecasting of activity to avoid or minimise possible economic losses.

TIDs are known to be resulting from many different geophysical processes, including magnetospheric disturbances, mainly producing large scale TIDs, and bottomside drivers such as stratospheric and tropospheric weather, seismic activity, etc causing mostly medium scale TIDs. This variety of drivers, their overlapping activity, and the different types of TIDs make it difficult to conceive a design for a single forecasting system. Therefore, within the project T-FORS (Travelling ionospheric disturbances FORecasting System), a two-pronged approach is pursued. For the forecasting of large scale disturbances, a machine learning based system is being developed taking into account various heliospheric and geophysical parameters as inputs and producing TID activity alerts as output. Both ground-based data sources, e.g. magnetic activity in the auroral region, and space-based observations, e.g. in situ data from L_1, will be used to provide forecasts with different lead times.

Medium scale TIDs on the other hand will be forecasted in a probabilistic way, based on a statistical model of the climatology of TID activity. Such a climatological model will not be able to predict specific episodes of activity, but can predict activity stemming from most common sources in a stochastic way. For this purpose, a wide variety of drivers will be considered.

References

[1] European Space Agency, "Space Situational Awareness - Space Weather Customer Requirements Document," SWE-CRD-TIO-1636, 2011.

[2] A. Belehaki, I. Tsagouri, D. Altadill, *et al.*, "An overview of methodologies for real-time detection, characterisation and tracking of travelling ionospheric Disturbances developed in the TechTIDE project," *Journal of Space Weather and Space Climate*, **10**, A42, September 2020, doi:10.1051/swsc/2020043.