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A warning system for travelling ionospheric disturbances using skywave Doppler frequency and angle-of-arrival measurements

Anna Belehaki (1), Bodo Reinisch (2,3), Ivan Galkin (3), and the The Net-TIDE project group Team

(1) National Observatory of Athens, Institute of Space Applications and Remote Sensing, Palea Penteli, Greece (belehaki@noa.gr), (2) Lowell Digisonde International, LLC, Lowell, MA USA, (3) University of Massachusetts Lowell, Space Science Laboratory, Lowell, MA USA

Travelling ionospheric disturbances (TIDs) constitute a threat for operational systems using groundbased HF and trans-ionospheric VHF-UHF radiowave propagation. TIDs can impose disturbances with amplitudes of up to $\sim$20% of the ambient electron density, and a Doppler frequency shifts of the order of 0.5 Hz on HF signals. Therefore their identification and tracking is important for the reliable operation of critical systems using the ionosphere as an essential part or for systems for which the ionosphere is fundamentally a nuisance. The Net-TIDE project has developed a warning system for real-time identification of TIDs using skywave Doppler frequency and angle-of-arrival measurements. Data are collected from network-coordinated HF sounding between pairs of European DPS4D and processed in real-time for the calculation of the angles-of-arrival and Doppler frequencies of ionospherically reflected high-frequency (HF) radio signals. The outcome is provided in real-time to the users to characterise TID activity over Europe based on the measured signal parameters. Complementary methodologies based on the analysis of vertical sounding parameters are currently exploited as verification means to improve the confidence level of the warnings. The resulting map of TID activity is updated every 5 minutes to enable the end-users enabling them to put into action specific mitigation techniques to protect their systems.