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Session 2A Paper 5
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Realistic ionospheric specifications in support of a TID warning system

During the passage of traveling ionospheric disturbances (TIDs), HF skywave signals exhibit ~15-100 min oscillations of their properties, namely the angle of arrival, Doppler frequency, and time of flight, as confirmed by Huang et al. [2016]. A network of modern ionosondes like the DPS4D [Reinisch et al., 2009] can measure the time variations of these signal parameters, from which the TID wave characteristics, amplitude, wavelength, phase velocity, and direction of propagation are calculated in real time using the Doppler-Frequency-Angular-Sounding (FAS) technique [Beley et al., 1995; Paznukhov et al., 2012]. Bistatic Digisonde-to-Digisonde (D2D) skymap measurements in Europe were used for the NetTide pilot project [Belehaki et al., 2015], making 20-s skymaps measurement every 5 min. Usually a multitude of signals is observed with each skymap measurement, caused by the existing multipath propagation conditions (E-mode, F1 mode, etc.) and ionospheric electron density irregularities. An intelligent system for signal "clustering" on each skymap, and "tracking" from skymap to skymap was therefore developed that can follow each "consistent signal" for ~100 min (20 skymaps). The intelligent system detects and sorts strong RF signatures into clusters of the same propagation path, represents each found cluster with a set of the signal properties, and then processes the resulting signal pattern assemble.

A working prototype of the new signal processor has been successfully tested at the Net-TIDE network for a TID warning system in Europe [Reinisch et al., 2017]. It includes (a) a custom hierarchical bottom-up clustering algorithm, (b) a signal tracker based on the ANNAE (Artificial Neural Network pre-Attentive Eye) vision model, previously used in the ARTIST-5 software for ionogram autoscaling [Galkin et al., 2008] , and (c) an expert identification system that interprets the extracted tracks using simulation data from the RayTRIX algorithm suite (Ray-Tracing through Realistic Ionosphere eXplorer), operated by the Global Ionosphere Radio Observatory (GIRO) [Reinisch and Galkin, 2011]. The RayTRIX suite includes the HR2006 raytracing technique [Huang and Reinisch, 2006] and a Realistic Ionosphere Nowcast provided by the 3D IRI-based Real Time Assimilative Model (IRTAM) [Galkin et al., 2012], which assimilates real-time GIRO data streams from the global network of vertical incidence ionosondes.

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