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Session 2A Paper 2

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Characterizing traveling ionospheric disturbances using passive HF observations from lightning sources

Mathematical data assimilation algorithms (MIDAS, IDA) have been used for over 15 years to retrieve accurate three dimensional (3D) time evolving maps of the large scale, slowly varying global ionospheric electron density distribution. However, data assimilative techniques to retrieve accurate 3D time evolving maps of the electron density distribution due to traveling ionospheric disturbances (TIDS) have only recently been developed. The most accurate methods of estimating the 3D time evolving maps of bottom-side TIDS make use of multiple known HF transmitters. The observations available for analysis are angles of arrival (AoAs), group delay (GD) and Doppler. While these methods have shown great promise, the requirement of having known transmitters as well as a receive array available limits their usefulness for both scientific studies and operational applications.

Purely passive methods of characterizing TIDS would be useful for a variety of reasons. One passive source of data, which is ubiquitous and found over most of the globe, is RF Lightning data. New methods of registering the coordinates of lightning events are available to the research and applied communities in near real-time, making the use of lightning observations as a source to characterize TIDS an attractive option.

This paper takes a comprehensive approach to determining the feasibility of using low earth orbiting (LEO) and geostationary (GEO) satellites with broadband HF receivers capable of receiving lightning signals to characterize bottom-side TIDS. A computer simulation of a TID-rich bottom-side ionosphere is generated. The TID parameters are derived from previous work estimating TID parameters from bottom-side HF observations, and thus represent a realistic TID environment. Then using realistic satellite-lightning link geometry derived from the fast onboard recording of transient events (FORTE) satellite observations, we simulate HF time delay versus frequency observations at the satellite.

We use these simulations to investigate the feasibility of the system by studying different possible system configurations, and their impact upon the ability to first detect the presence of bottom-side TIDS and then reliably estimate wave parameters. The system configurations to be studied include: configuration of the satellite orbit; HF/VHF frequency range, number of frequencies and frequency resolutions; trade-off between bandwidth and resolution of time-of-arrival measurements; and number of lightning events per minute.

In addition to satellite space-based methods, it is also possible to use ground broadband HF receivers to collect lightning signals via skywave propagation paths. The same TID simulations will be used to investigate the capability of detecting and characterizing TIDS using passive ground-based broadband HF receivers.

We will close by first discussing instrumentation challenges that would be necessary to understand for any practical realization of satellite or ground based passive lightning based system to estimate bottom-side TIDS.

Reliable passive measurement techniques that can accurately retrieve 3D time evolving TIDS on the bottom-side F-region is of great interest to both the basic scientific community and the applied community.