Assimilative Model for Ionospheric Dynamics Driven by TEC-related data from Beacon Satellites as well as by Skywave HF propagation Data from Multiple HF Channels

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ABSTRACT

We describe development of HF data assimilation capabilities for our ionospheric inversion algorithm called GPSII (GPS Ionospheric Inversion). This algorithm is able to assimilate GPS/LEO TEC data, leading edges of HF backscatter ionograms, as well as propagation delay, Doppler, and angle of arrival measurements collected over multiple HF channels. The resulting ionospheric model is consistent with all assimilated measurements. Previously the measure of goodness of fit in GPSII was the weighed mean-square discrepancy between measured and simulated data. We have now addressed the issue of uniformity of the data fit statistics. This is necessary because we observed that in configurations where both TEC and HF data were employed to drive a GPSII solution, GPSII tended to under-fit the HF data while maintaining an excessively tight fit to the TEC data, so that the overall normalized mean-square error maintained a satisfactory value. In order to alleviate this undesirable phenomenon of non-uniform data fitting, we partition the vector of measurements into sub-vectors representing distinct categories of measured data and impose data matching constraints for each of the categories. A strategy that tends to uniformly match data across all data categories is substantiated and tested. Details of the GPSII technique for assimilating TEC data simultaneously with HF data are also discussed.

The key theoretical element for assimilating HF data is the ray path response operator (RPRO) which describes response of ray path parameters to infinitesimal variations of electron density in the ionosphere. We construct the RPRO out of the fundamental solution of linearized ray-tracing equations. We demonstrate performance and internal consistency of the algorithm using propagation delay, direction of arrival, and Doppler measurements from various types of HF channels.