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Feasibility Study for Reconstructing the Spatial-Temporal Structure of TIDs from High-Resolution Backscatter Ionograms

Abstract:
Over-the-Horizon radar (OTHR) utilizes the reflective “skywave” property of the ionosphere for High Frequency radiowaves to illuminate targets at ranges extending to several thousand kilometers. However, the ionospheric “mirror” is not static, but exhibits geographic, diurnal, seasonal, and solar cycle variations.

NorthWest Research Associates (NWRA) has developed an ionospheric data assimilation capability called Global Positioning Satellite Ionospheric Inversion (GPSII; pronounced “Gypsy”) that allows real-time modeling of the ionospheric structure for the purpose of accurate Coordinate Registration (CR; geolocating targets illuminated by HF skywave modes). However, the ionosphere is routinely subjected to wavelike perturbations known as Traveling Ionospheric Disturbances (TIDs), and the deflection of HF skywave signals by unmodeled TIDs remains a troubling source of CR errors (tens of kilometers). Traditional OTHR tools for ionospheric sounding (vertical and backscatter ionograms) do not resolve the fine spatial structure associated with TIDs.

It was demonstrated recently that it is possible to collect backscatter ionograms using the full aperture of the OTHR, thus providing enhanced resolution in radar steer in comparison with conventional OTHR backscatter soundings that utilize only a fraction of the OTHR receiver array. Leading edges of such backscatter ionograms demonstrate prominent spatial features associated with TIDs.

In this paper we investigate the feasibility of recovering TID perturbations of ionospheric electron density from high-resolution backscatter ionograms. We incorporated a model of naturally-occurring TIDs into a numerical ray tracing code that allows the generation of synthetic OTHR data. We augmented GPSII to be able to assimilate time series of full-aperture backscatter ionogram leading edge data.

Results of the simulation show that GPSII inversion is able to reproduce the true TID structure reasonably well.