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New Methods of Characterizing Traveling Ionospheric Disturbances using GNSS Measurements

Abstract:
Recently, there has been a renewed interest in the coupling between atmospheric gravity waves (AGWs) and the ionospheric electron density response to AGWs, known as traveling ionospheric disturbances (TIDs). There are several good scientific reasons for this renewed interest. In particular, recent research has revealed that there is a much greater importance and coupling of mesospheric-thermospheric waves upon the ionosphere system than previously thought; that both the neutral and ionized wave fields are present at all times and at all geographic regions, and have a wide distribution of periods and wavelengths. Current research efforts include improved understanding of the altitude dependence of filtering and dissipation effects on AGWs, how the ionospheric wave response varies with altitude, wavelength and period and how these variations in ionospheric electron density, velocity and temperatures can effect the overall large scale bulk properties of the ionosphere. In addition to scientific inquiries, ionospheric TIDS can severely impact and effect various types of RF propagation, most notably bi-static HF propagation links. Since the HF propagation is necessarily non-linear, small changes in electron density can make large changes in propagation characteristics.

This paper will focus on new techniques methods of analysis, and modeling to improve the ability to accurately characterize three-dimensional time-evolving TIDs using GNSS ground receiver total electron content (TEC) observations. The new methods discussed include improved filtering of the data, improved estimation of basic TID parameters, and full 3D time-evolving tomographic imaging of TIDS. Results will include a discussion of intrinsic limitations to the GNSS estimation methods, including dependence upon wavelength and period, satellite motion distortion effects upon the estimation, and sensitivity to AGWs/TIDS that dissipate prior to propagating well into the F2 and topside of the ionosphere. Finally we will explore the impact of AGW produced TIDS in the bottom-side on HF propagation.