Numerical modeling of TEC gradients using the new Ionosphere-Plasmasphere-Electrodynamics (IPE) model

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It has been understood that Total Electron Content (TEC) gradients compromise integrity of aviation navigation. Generation of TEC gradients can be attributed to a combination of various ionospheric drivers involving electric field, neutral wind, and neutral compositions during geomagnetically active conditions. It is very important to improve our understanding of the formation mechanisms for an accurate prediction of temporal and spatial evolution of TEC gradients.

The Ionosphere-Plasmasphere-Electrodynamics (IPE) model is a new, time dependent, three-dimensional model of Ionosphere and Plasmasphere recently developed, in order to improve our prediction of the ionospheric weather with high temporal and spatial resolutions. The IPE model provides time dependent, global, three dimensional plasma densities for nine ion species, electron and ion temperatures, both parallel and perpendicular velocities of ionosphere and plasmasphere. The parallel plasma transport is based on the Field Line Interhemispheric Plasma (FLIP) Model [Richards et al., 1990]. A realistic model of Earth's magnetic field is implemented by using the APEX coordinate system [Richmond, 1995]. Global, seamless plasma transport perpendicular to the magnetic field has been included all the way from the equator to the poles. The electrodynamics solver based on the TIEGCM [Richmond and Maute, 2014] calculates the global electric field self-consistently.

In this paper, we will show the IPE global modeling of the ionosphere with a special emphasis on modeling steep gradients at boundaries, such as those associated with Storm Enhanced Densities (SEDs). The area of enhanced density is surrounded by steep density gradients and appears to progress rapidly through mid-latitudes and into the polar regions. Their formation mechanisms will be addressed; in particular, the relative roles will be examined between the various drivers. Furthermore, the paper will discuss how the gradients impact radio wave propagation, and how radio science measurements are used for physics based model development, verification, and testing.