Validation of Global Ionospheric Total Electron Content Mapping Using a Multi-Shell Approach

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Abstract

Dual-frequency transmissions from GPS satellites have been used for many years to measure and map ionospheric total electron content (TEC) on global scales. Global Ionospheric Mapping (GIM) software developed at the NASA Jet Propulsion Laboratoty (JPL) uses observations from about 100 GPS sites, an extended shell model, and Kalman filtering to compute global maps of vertical TEC with 15-minute time resolution and about 5-degree spatial resolution. Recently, the GIM algorithms have been enhanced to solve for parameters on a multi-shell grid, instead of using a single grid at a fixed ionospheric centroid height. Such multi-parameter models are designed to improve the accuracy of slant TEC retrievals and the ability to calibrate slant TEC measurements for arbitrary propagation paths. The extra parameters allow GIM to better model horizontal gradients and variations in peak height, while still retaining a simple, constrained fitting model as compared to a full tomographic density solution which is vastly underdetermined using only ground GPS data.

We will present two methods to validate the multi-shell approach: missing site and missing satellite tests. The missing site approach uses a global network of dual-frequency GPS stations but excludes a handful as validation sites. The line-of-sight TEC at these "missing" sites is predicted, using the GIM coefficients along with estimated satellite and receiver differential biases, and then validated against the actual line-of-sight TEC observations. A similar approach can be used for individual GPS satellite tracks in which line-of-sight TEC is predicted using only data from other GPS satellites and then validated against the observations. A series of comparisons using several days of data will be presented using both the conventional single-layer and the new multi-shell approaches. It is expected that the multi-shell approach will provide better slant TEC accuracy at low elevation angles along with more consistent bias solutions. Several versions of the multi-shell approach which use shells at different altitudes will be examined to see which one yields the best slant TEC prediction accuracy.