A New Ionospheric Model for Wide Area Differential GPS: The Multiple Shell Approach

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To provide accurate delay corrections for single frequency GPS users, wide area differential GPS systems (WADGPS) must broadcast ionospheric delay estimates derived from reference networks of dual-frequency GPS receivers. Global receiver networks have been used for many years to measure and map ionospheric total electron content (TEC) on global scales. In particular, Global Ionospheric Mapping (GIM) software developed at the NASA Jet Propulsion Laboratory uses observations from about 100 GPS sites to compute global maps of vertical TEC with 15-minute time resolution and about 5-degree spatial resolution. The vertical variation of the ionospheric electron density is represented by a simplified, predetermined form consisting of a constant density slab at fixed height with exponential tails.

GIM algorithms have been recently enhanced to solve for electron content distributions on multiple horizontal grids distributed vertically (multiple shell), instead of using a single grid at a fixed height (single shell). We are assessing this new ionospheric model for application in WADGPS systems over the coterminous United States (CONUS). The additional parameters from multiple vertical layers allow GIM to better model the height variation of ionospheric electron density along the GPS raypaths, and accommodate significant diurnal height variations of the ionosphere which are ignored in a fixed-height single layer approach. This new model is a conceptually simple extension of several existing WADGPS algorithms, that may offer benefits similar to various forms of ionospheric tomography. We compare solutions that model the ionosphere as a correlated random-walk stochastic process (the standard GIM approach), with a simpler strategy of performing least-squares fits to the data independently at every epoch.

We will present methods to validate the new multiple shell approach: the "missing" site and "missing" satellite tests. The missing site approach uses a network of dual-frequency GPS receivers within the CONUS but excludes a handful as validation sites. The line-of-sight TEC at these missing sites is predicted, using the GIM solutions, and then validated against the actual line-of-sight TEC observations (inter-frequency receiver biases for the missing sites are estimated in a separate run that includes all sites). 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, both quiet and disturbed, will be presented using both the single shell and the new multiple shell approaches. It is shown

that the multi-shell approach improves slant TEC accuracy and reduces systematic error in the GPS inter-frequency bias estimates.