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Evaluating Different GPS Calibration Techniques in the Equatorial Ionization Anomaly Region

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Extended Abstract

The total electron content (TEC) obtained by the many Global Navigation Satellite Systems (GNSS) now in operation has become a very important data source not only for scientific analysis but also for the validation of other ground and space measurements and of theoretical and empirical models of the ionosphere and plasmasphere. When using slant TEC (sTEC) and vertical TEC (vTEC) from GNSS satellites, one has to keep in mind that these are not direct measurements but quantities derived from the raw data involving several data analysis steps and calibration methods that vary from data analysis group to data analysis group. These calibration steps have to account for receiver and transmitter biases, multi-path corrections, slant-to-vertical transformation, and other error sources. We have used simulated RINEX files that were generated using NeQuick [1] to calculated slant TEC data to test three different GNSS calibration schemes. The Azpilicueta-Brunini calibration scheme was developed as part of LPIM (La Plata Ionospheric Model) [2,3]. It is based on the geometry-free combination (L4) carrier-phase leveled to code and the assumption of constant calibration terms for at least one day. The slant TEC is mapped with the standard mapping function and the vertical TEC is geographically modeled with polynomial functions or spherical harmonics. The temporal variations of the coefficients are modeled with periodic functions. The method of Seemala and Valladares [4] uses the combination of both phase and code values at L1 and L2 frequencies to eliminate the effect of clock errors and tropospheric water vapor to calculate absolute values of slant TEC. The differential satellite bias corrections published by University of Bern are used. The receiver bias is calculated by minimizing the TEC variability between 0200 and 0600 LT (when spatial variability is less) or for the entire data of day (depending on data length). The resultant slant TEC is converted to vertical TEC using the single shell mapping function assuming 350 km altitude for the centroid of the ionosphere. The Single-Station Arc-Offset method of Ciraolo et al.[5] forms the geometry-free combination L4 is for each arc from the observations in the RINEX files. L4 gives TEC, which is expanded by a Vertical Equivalent 2-D function of time and horizontal coordinates, plus an arc unknown offset. Standard Least Square methods are used to estimate the unknown coefficients of VEQ expansion and the arc offsets. The data were simulated for the three African GPS ground stations located at Dakar (Senegal), Toro (Nigeria), and Libreville (Gabon). These stations were chosen considering that they are under the effect of the Ionospheric Equatorial Anomaly, a critical region of the ionosphere dominated by significant temporal and spatial gradients. Each team used their calibration method with the provided simulated data and their sTEC results were then compared back to the NeQuick reference data. Our presentation will discuss the results of this validation exercise.

References

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