Statistical Analysis of Ionospheric GPS vTEC and Gradient Estimates based on A Full Solar Cycle of Data from the Brazilian Network for Continuous Monitoring

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The Global Positioning System (GPS) has an increasing role in Air Traffic Control. However, ionospheric delays and scintillation cause positioning error that degrades the accuracy, performance and availability of associated operations, particularly in the equatorial and low-latitude regions. Different techniques and auxiliary systems have been developed to meet the safety requirements of aviation. For example, Ground Based Augmentation Systems (GBAS) provide higher accuracy for differential corrections.

To simulate ionospheric effects on GBAS in the future, the variability of estimated vertical Total Electron Content (vTEC) at associated 400-km ionospheric pierce point (IPP) is studied through a statistical analysis of dual-frequency GPS data from the Brazilian Network for Continuous Monitoring (RBMC). The IPP positions are determined from those of the RBMC stations and every satellite, using the GPS Precise Orbit Files in the SP3 format from the International GNSS Service (IGS), provided at every 15 minutes and trigonometrically interpolated to the RBMC 15-second intervals. The positions of the RBMC stations and the corresponding IPPs at a particular epoch are shown in Figure 1. The slant TEC time series obtained from the RBMC data are corrected for cycle slips, as well as satellite and ground receiver biases (G. Ma and T. Maruyama, Ann. Geophys., 21, pp. 2083–2093, 2003), before being mapped into vTEC, through its product by a slant factor that depends on the zenith angle of the corresponding ray path and the altitude of the associated IPP.

The ionospheric delay gradient is another important parameter for the correction of medium effect on GBAS. The present work determines ionospheric delay gradients g^s (mm/km) and g^t (mm/km) by the station-pair and time-step methods, as shown in Equations (1) and (2), respectively, which map vTEC into excess path length l_{rs} or l_{rt} (mm) values:

$$g^s = \frac{|l_{rs_1} - l_{rs_2}|}{DIST_{IPP(rs_1, rs_2)}} \quad (1)$$

$$g^t = \frac{|l_{rt_1} - l_{rt_2}|}{DIST_{IPP(rt_1, rt_2)}} \quad (2)$$

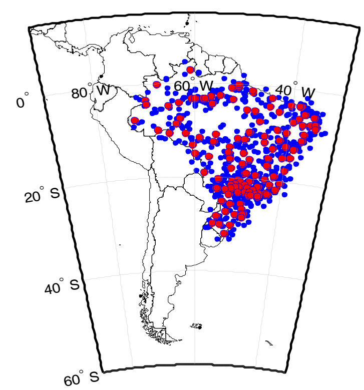

Figure 1. Positions of the ground-based RBMC stations (red) and the 400-km IPPs (blue) at 21:30:00 UT on 21 October 2015.

This contribution will present and discuss statistical distributions of vTEC values and ionospheric gradients, as well as of their residuals relative to the ones provided by the latest version of the International Reference Ionosphere (IRI). This analysis will consider different combinations of ranges the following geophysical parameters: (i) solar activity, represented by the F10.7 index; (ii) geomagnetic activity, represented by the Kp index ; (iii) geomagnetic latitude; (iv) local time; and (v) season.