International Beacon Satellite Symposium BSS-2016
Trieste, Italy

Monitoring the Occurrence Probability of Steep Ionospheric TEC Gradients Associated with Equatorial Plasma Bubbles using Network of GNSS Receivers in South America

Rezy Pradipta*[1] and Patricia H. Doherty[1]

[1] Boston College, Institute for Scientific Research, Chestnut Hill, MA, USA.
(E-mail: rezy.pradipta@bc.edu, patricia.doherty@bc.edu)

ABSTRACT

In comparison to the midlatitude region, ionospheric plasma distribution in the equatorial region is considerably more inhomogeneous and might therefore contain steeper ionospheric gradients. This highly inhomogeneous ionospheric plasma distribution in the low-latitude and equatorial regions is controlled by a number of contributing factors. First of all, the equatorial fountain effect during the daytime typically creates two crests of higher density plasma on both the northern and southern sides of the geomagnetic equator (forming the well-known characteristic pattern of equatorial ionospheric anomaly). On top of that, the development of equatorial plasma bubbles via the Rayleigh-Taylor instability during the post-sunset period also makes the equatorial ionosphere very inhomogeneous at night. The steep total electron content (TEC) gradients associated with these space/ionospheric plasma phenomena could pose some serious threats to the operation of SBAS/GBAS to support GNSS applications in aviation.

In this study, we used GPS-derived TEC data to monitor the spatial structures of equatorial plasma bubbles and investigated the statistical occurrence pattern of the corresponding ionospheric TEC gradients over a representative section of the Brazilian airspace in 2014/2015. The GPS TEC data in our analysis had been obtained from the RBMC network (operated by *Instituto Brasiliero de Geografia e Statistica* – IBGE), where we selected a chain of receiver stations located approximately along the southern crest of the equatorial ionospheric anomaly in this sector. More specifically, here we estimated the TEC gradient magnitudes using the single-station method (i.e. time-step method).

Based on our observations and analysis, we found that the side boundary wall(s) of equatorial plasma bubbles, as well as the plasma density irregularities in the interior of these bubbles, can have extremely large TEC gradients associated with them. The TEC gradients associated with the side walls of bubbles can be very large in magnitude (exceeding 600 mm/km at GPS L1 frequency). On the other hand, the TEC gradients associated with the plasma density irregularities usually are not very large in magnitude (typically 200-300 mm/km at GPS L1 frequency), but they are more prevalent and extensive spatially.

We have also determined that the overall probability distribution function of TEC gradient magnitudes over the Brazilian airspace follows a form of power law distribution, with a distinct break. This break (at ∼200 mm/km) marks a boundary between two separate regimes in the distribution function, with different power-law exponent in each regime. In the first regime (TEC gradient range of 50-150 mm/km), the exponent is n=-2.4; and in the second regime (TEC gradient range of 200-750 mm/km) the exponent is n=-4.0. Finally, the distribution function for TEC gradient magnitudes beyond 800 mm/km was found to be roughly flat containing mostly random noise.

Key words: Ionosphere, Total Electron Content, Scintillation, Equatorial Plasma Bubbles, GNSS, Turbulence.

Acknowledgements

This work was supported by FAA grant FAA 11-G-006 at Boston College. We would also like to thank the *Instituto Brasileiro de Geografia e Estatistica* (IBGE) for the GPS receiver data from the RBMC network.

References

[1] Rezy Pradipta, Patricia H. Doherty, Richard Cole, and Navin Mathur (2016), Observations and Analysis of the Occurrence Pattern of Large Ionospheric TEC Gradients Over the Brazilian Airspace, ION Precise Time and Time Interval Meeting, January 25-28, 2016, Monterey, CA

[2] Pradipta, R., and P.H. Doherty (2016), Assessing the Occurrence Pattern of Large Ionospheric TEC Gradients over the Brazilian Airspace, Navigation (accepted articles).