



The analysis of GPS loss of lock over Brazil during the 24th solar cycle

Juliana G. Damaceno^{(1,2)*}, Karl Bolmgren⁽³⁾, Jon Bruno⁽³⁾, Giorgiana De Franceschi⁽¹⁾, Cathryn Mitchell⁽³⁾, Massimo Cafaro⁽²⁾

(1) Istituto Nazionale di Geofisica e Vulcanologia, Via di Vigna Murata, 605, 00143 Roma, Italy, e-mail: juliana.damaceno@ingv.it

(2) Department of Engineering for Innovation, University of Salento, Piazza Tancredi, 7, 73100 Lecce, Italy.

(3) Department of Electronic and Electrical Engineering, University of Bath, North Rd, BA2 7AY Bath, UK.

A statistical analysis of Loss of Lock (LoL) over Brazil has been performed throughout the 24th solar cycle, the weakest of the last century. Four geodetic GPS dual-frequency (L1, L2) receivers, deployed at different geographic latitudes ranging from about 25° to 2° South in the eastern part of the country, are used to investigate the LoL dependence on time of the day, season, solar and geomagnetic activity [1, 2]. The results of the analysis show that LoL is most likely in the post-sunset hours during summer and equinox, especially within the southern crest of the Equatorial Ionospheric Anomaly (EIA), in a region between about 10°S and 25°S of geographic latitude, matching the typical behaviour of scintillation over Brazil. Moreover, the LoL preferred azimuth direction in the North sector (NW-NE) further support a relationship between LoL and scintillation, as it indicates LoL occurrence along the magnetic meridian where the signal propagation path segments align with plasma bubbles. The relative occurrence of LoL (LoL (%)) for given solar and geomagnetic indices (F10.7, AE, Dst, respectively) show some correlation with increasing the severity of the of geospatial conditions. This correlation is strongest in the area of the southern crest of the EIA, while there is little to no apparent impact closer to the equator, depending on the index. LoL (%) increases with increasing geomagnetic disturbances, varying between ~1% and ~10% for AE ranged between 400 and 1200 nT, and exceeding 3% when Dst is around -100 nT, both related to moderate-severely disturbed conditions. A simple exponential function is found to express empirically LoL (%) as a function of solar and geomagnetic indices (F10.7, AE, Dst). This simple empirical function may be further tested and improved as a function of different latitude and longitude sectors and geomagnetic conditions making use of the available IGS network along with different solar cycles, possibly opening to the opportunity of using LoL as a proxy indicator of scintillation.

References

- [1] Damaceno, J., Bruno, J., Bolmgren, K., De Franceschi, G., Mitchell, C. and Cafaro, M., GPS Loss of Lock statistics over Brazil during the 24th solar cycle. Submitted to ASR in December 2019.
- [2] Liu, Y., Fu, L., Wang, J., & Zhang, C., 2017. Study of GNSS loss of lock characteristics under ionosphere scintillation with GNSS data at Weipa (Australia) during solar maximum phase. *Sensors (Switzerland)* 17, 1–15. <http://dx.doi.org/10.3390/s17102205>