Worldwide Monitoring of Ionospheric Scintillation based on Geodetic Receivers: from High End to Low Cost devices

Yu Yin, Guillermo González-Casado, Jose M. Juan, Cristhian C. Timoté, Jorge Garcia-Mateos and Raul Orus-Perez
gAGE/UPC Research group of Astronomy and Geomatics. Technical University of Catalonia, Barcelona Tech, Spain; e-mail: yu.yin@upc.edu

Radio signals crossing the ionosphere at high and low latitudes are regularly affected by ionospheric scintillation. Mid-latitudes may also be impacted during geomagnetic storm periods. Scintillation highly degrades precise positioning and Safety of Live (SoL) applications that rely on transionospheric links, causing disruptions in the services or misleading information from undetected cycle-slips or increased noise in the signals.

Currently, from GNSS signals scintillation is monitored using high-end special purpose devices (ISMR) equipped with stable clocks and using a 50 Hz sampling rate or higher. The cost of each device is large and few of them have been deployed. On the contrary, a world-wide network of geodetic ground receivers is freely available for more than one decade. This network can monitor ionospheric activity trough the Rate of TEC Index (ROTI) computed from GNSS measurements but there is not a straightforward relationship between ROTI and the actual scintillation. However, the receiver tracking design may lead to inaccurate estimates of ROTI values [1]. In order to overcome that limitation and expand the application of geodetic receivers, the postprocess Geodetic Detrending (GD) technique has been developed to accurately model GNSS signals using geodetic receivers operating at 1 Hz, being able to consistently measure scintillation and generate corresponding scintillation monitoring indexes at any GNSS frequency [2, 3].

In the framework of a recent Open Space Innovation Platform (OSIP) of the European Space Agency (ESA), a novel idea has been developed and implemented which applies the GD to obtain, in real-time and worldwide, genuine scintillation indexes based on the products from present/future real-time services such as the Galileo High Accuracy Service. The idea extends the currently localized amount of data from expensive ISMR receivers to a global scale with huge economical saving costs, since only data from existing public networks of permanent stations will be required. The main benefits are: real-time monitoring and warning of scintillation activity for precise positioning and SoL applications. Availability of extended data sets for worldwide climatological studies [4] and for testing global/regional models. Moreover, the possible extension to low-cost receivers is being studied, which will allow reducing even further the current cost for scintillation monitoring.

The different results being produced by the real-time tool implemented within ESA's Space Innovation Platform (OSIP) for the world-wide monitoring of ionospheric scintillation will be introduced and different results showing the performance of the tool will be presented.

[1] J.M. Juan, J. Sanz, G. González-Casado, A. Rovira-Garcia, C.C. Timoté, and R. Orús-Pérez R (2022) "Applying the geodetic detrending technique for investigating the consistency of GPS L2P(Y) in several receivers" Journal of Geodesy **96**, 11, 2022, A85, doi: 10.1007/s00190-022-01672-3.
[2] J.M. Juan, J.M., A. Aragon-Angel, J. Sanz, G. González-Casado, and A. Rovira-Garcia, “A method for scintillation characterization using geodetic receivers operating at 1 Hz”, Journal of Geodesy, **91**, 11, November 2017, pp. 1383–1397, doi: 10.1007/s00190-017-1031-0.
[3] V.K. Nguyen, A. Rovira-Garcia, J.M. Juan, J. Sanz, G. González-Casado, V. La-The, and T.H. Tung TH, “Measuring phase scintillation at different frequencies with conventional GNSS receivers operating at 1 Hz”, Journal of Geodesy, **93**, 10, 2019, pp. 1985-2001, doi: 10.1007/s00190-019-01297-z.
[4] A. Rovira-Garcia, G. González-Casado, J.M. Juan, J. Sanz, and R. Orús-Pérez, “Climatology of High and Low Latitude Scintillation in the Last Solar Cycle by Means of the Geodetic Detrending Technique”, Proceedings of the 2020 International Technical Meeting of The Institute of Navigation, San Diego, California, January 2020, pp. 920-933, doi: 10.33012/2020.17187.