Space Weather data and products in support of high-precision applications in South America

Monitoring Ionosphere Over South America to support high precision applications (MImOSA2)

Executive Summary

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Motivation:

Scope of the MImOSA2 (Monitoring Ionosphere Over South America to support high precision applications) study was to support high-precision GNSS based applications in South America, analysing, through an original method, GNSS data acquired by a dense network of 50 Hz receivers to assess possible improvements on positioning accuracy when ionospheric degradation is taken into account.

Methodology:

The MImOSA2 team used new algorithms, developed by UoN and UNESP, to evaluate the improvement of positioning capability on long baseline RTK and NRTK (VRS approach) solutions in the considered region, achieved using ad hoc local IONEX maps instead of IGS maps and other global products. The proposed local maps have been constructed using GPS, GLONASS and GALILEO satellite signals to reach a very fine spatial and temporal resolution to take into account the effects caused by the electron density irregularities.

Moreover, the effects of anthropogenic interference on GNSS signals, on one of the station installed in Presidente Prudente, have been studied to evaluate the effects of environmental disturbances on GNSS derived TEC measurements. The activity has been realized in close collaboration with UNESP (Brazil), with recognized expertise in the field and excellent links with the interested stakeholders.

Results:

The comparative analysis on the positioning techniques have showed a general improvement of the performance when local TEC maps are used to feed the algorithms. In particular, Figure 1 summarizes the results on positioning when VRS approach is used to generate RINEX for a virtual station. Blue bars, representing 3D RMS when IGS TEC maps are used, show the inadequacy of such TEC maps in describing the local ionosphere. From the analysis, the natural neighbour interpolation results to be the more effective.
Figure 2 describes the performance of the RTK algorithm in terms of 3D RMS when fed with IGS and Local TEC maps. A general improvement of the positioning accuracy is obtained adopting local TEC except for few cases in which IGS TEC performs better. In particular, local TEC maps seem to give a better accuracy under strong scintillation conditions.

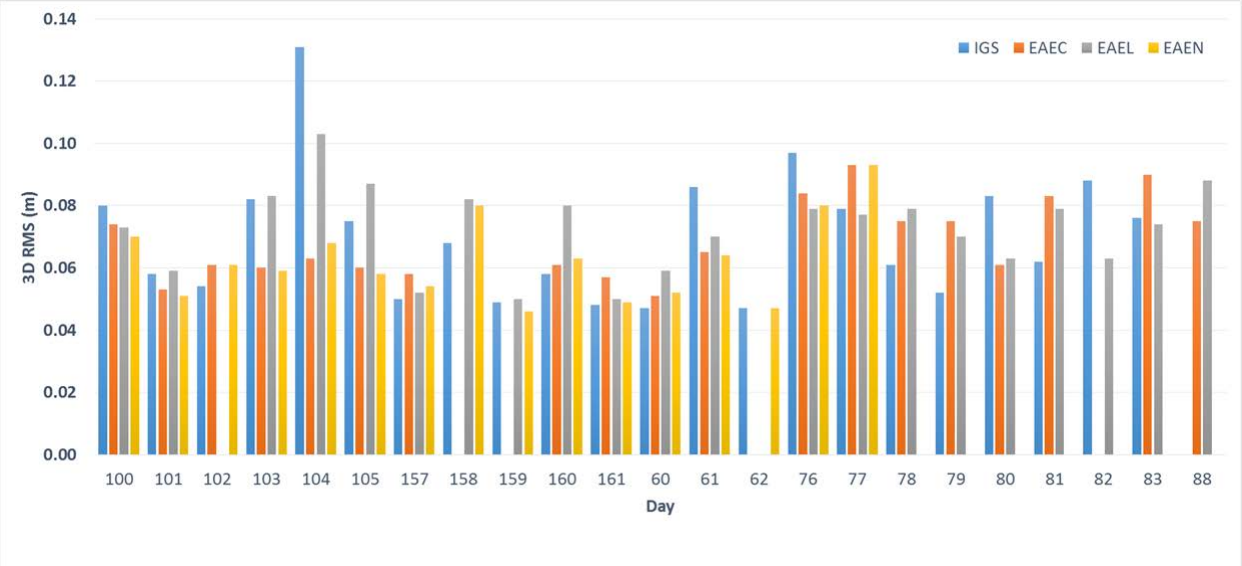

Figure 1. Summary of the results for the PPP positioning technique in terms of 3D RMS.

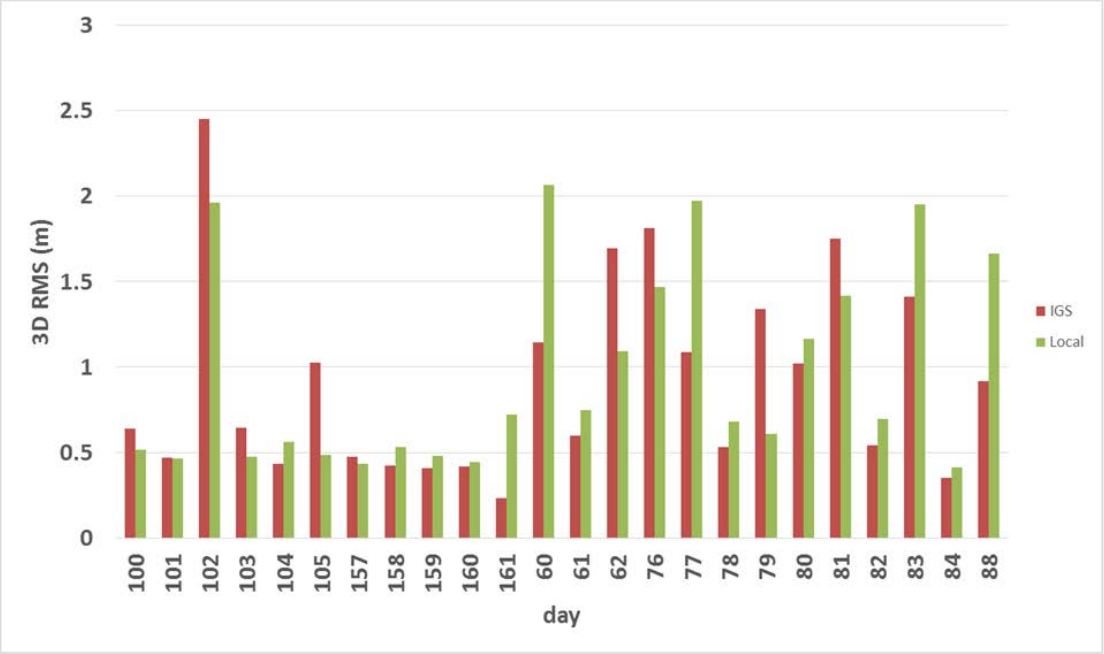

Figure 2. Summary of the results for the RTK results in terms of 3D RMS.

Additionally, we have tested the use of the IONEX files provided by the Agency to assess the improvement on positioning by using a multilayer description of the ionosphere. Our analysis did not identify any improvement, likely because our single layer approach is based on a regional network that allows to reach a very fine spatial resolution of the local ionospheric maps. This suggests how the availability of regional network can overcome the limitation introduced by the single layer model, reducing also the computational complexity.

The analysis performed on the SDR data have showed that, if not identified and properly mitigated, the interference can mislead the estimation of the TEC and scintillation indices. The use of

computation techniques. e.g. WPD, can help to identify and mitigate the interference impact on GNSS signals. The impact of the interference on positioning results to be significant, in terms of 3D rms.

Publications:

- C. Cesaroni, L.Alfonsi, R. Romero, N. Linty, F. Dovis, Sreeja Vaddake Veettil, Jihye Park, Daniele Barroca, Mayara Cobacho Ortega, Raul Orus Perez, "Monitoring Ionosphere over South America: the MImOSA and MImOSA2 projects", in the *Proceedings of the 2015 International Association of Institutes of Navigation World Congress*, Prague, Czech Republic, October 20-23, 2015, DOI 10.1109/IAIN.2015.7352226 IEEE Conference Publications.
- Cesaroni C., Alfonsi L., Park J., Veettil S., Romero R., Barroca D., Linty N. and Orus Perez R. "MImOSA2: Monitoring Ionosphere Over South America to support high precision applications", submitted to *2016 Beacon Satellite Symposium*, Trieste, Italy, June 27–July 1, 2016

Highlights:

The MImOSA2 results have identified the regional characterization as the most efficient way to understand deeply the impact on the precise positioning of the assumption on the ionospheric layer configuration, on the type of instrument to be used, and on the additional noise sources to account for. This confirms the usefulness of GBAS-like approach to correct and mitigate the ionospheric effects on positioning at low latitudes.

The exercise done within MImOSA2 suggests to establish a medium-long term funding action to boost the maintenance of the existing infrastructures, as regional networks, and the creation of new ones, to be able to provide a GBAS-like correction service. Our recommendation is to establish a bilateral agreement between Brazil (or any other Country interested in the Precision Agriculture) to train the next generation of specialists in the fields of ionospheric research and GNSS engineering development, favouring the collaboration of the involved Space Agencies.