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MImOSA2: Monitoring Ionosphere Over South America to support high precision applications

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ABSTRACT

MImOSA2 (Monitoring Ionosphere Over South America to support high precision applications), a project funded by ESA in the framework of Alcantara scheme, aims to take advantage of the results achieved within the MImOSA project to move from the survey to the exploitation of GNSS data and infrastructures to support high-precision GNSS-based applications in South America [1].
The South American ionosphere is characterized by the presence of the Equatorial Ionospheric Anomaly that causes a complex configuration of the local ionospheric plasma even when the geospatial conditions are quiet. In this context, we have proposed to analyse, 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. Using new algorithms, developed by University of Nottingham (UoN) and Universidade Estadual Paulista in Brazil (UNESP), we have evaluated 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 and GLONASS satellite signals with 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, in 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, with recognized expertise in the field and excellent links with the interested stakeholders.

In this paper, we describe the results obtained in this project, discussing the main achievements in relation to the specific requirements of precision agriculture.

Data and method

The TEC data are retrieved by means of a calibration technique [2] starting from the data acquired by 5 PolaRxS receivers located in São Paulo state region that constitute the network of the FP7 CIGALA/CALIBRA projects (http://is-cigala-calibra.fct.unesp.br/is/). These receivers are maintained by UNESP for ionospheric monitoring.

In order to assess the performance of using calibrated TEC maps in support of long baseline RTK, a pair of stations in the São Paulo state has been selected based on the location of the stations and the data availability. A pair of GNSS stations from UNESP Real Time Kinematic Network (UNESP) is selected to perform the positioning experiments. One station of each pair contributed as a simulated rover for the long baseline RTK. The results, in terms of 3D RMS, are compared with the ones obtained using IGS TEC maps as input to the RTK algorithm. In addition, calibrated TEC maps are used to generate RINEX files for a virtual station (VRS) to be used in the NRTK. The performance of the VRS approach is evaluated by means of PPP technique.

The experiment to assess the impact of anthropogenic interference on TEC determination makes use of data collected during an ad hoc campaign performed within the project in Presidente Prudente. During the campaign we acquired GNSS raw data at intermediate frequency level (down-converted/unprocessed digital samples) by means of a GNSS front-end and software receiver designed by Politecnico di Torino [3]. The set-up consisted of two Universal Radio Software Peripherals (USRP) devices, one for each GNSS band (to record GPS L1 C/A and L2C signals), coupled with a high quality external Rubidium oscillator and connected to a PC for configuration control and to hard drives for data storage. Such system was set to work in parallel with one of the Septentrio PolaRxS receivers of the CIGALA/CALIBRA network (PRU2). Figure 1 presents a simplified diagram of the equipment installed.

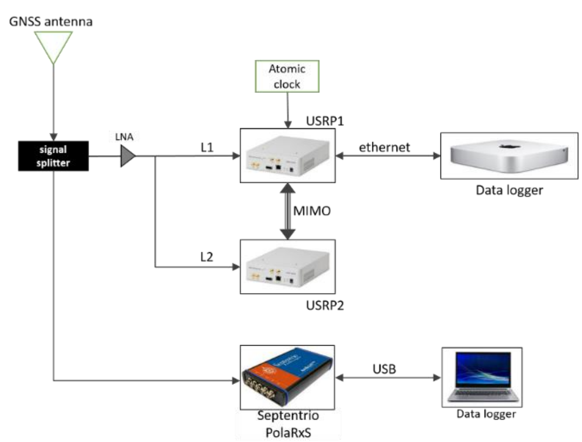

Figure 1. System set-up for recording GNSS raw samples installed at Presidente Prudente.

USRPs can also be used as transmitting devices, allowing to replay pre-recorded GNSS raw data by up-converting the digital samples to L-band Radio Frequencies (RF). Taking advantage of this capability, signals recorded during the ad-hoc campaign at Presidente Prudente were used to evaluate the impact of unintentional interferences from other telecommunication systems, by combining them in a controlled environment.

Results

As an example of the results obtained during the project, Figure 2 shows the performance of the long baseline RTK positioning algorithm during 15 April 2014 (moderate scintillations activity) in terms of error in North, East and Up component (red, green and blue lines respectively) and ambiguity resolution (bottom panel in figure 2). Left and right panels present the results when IGS TEC maps and calibrated TEC maps are used respectively. From the plots in figure 2 it is clear that the use of calibrated TEC maps dramatically improves the accuracy on positioning especially from 20 UT to 24 UT (post-sunset hours) when the scintillation activity increase.

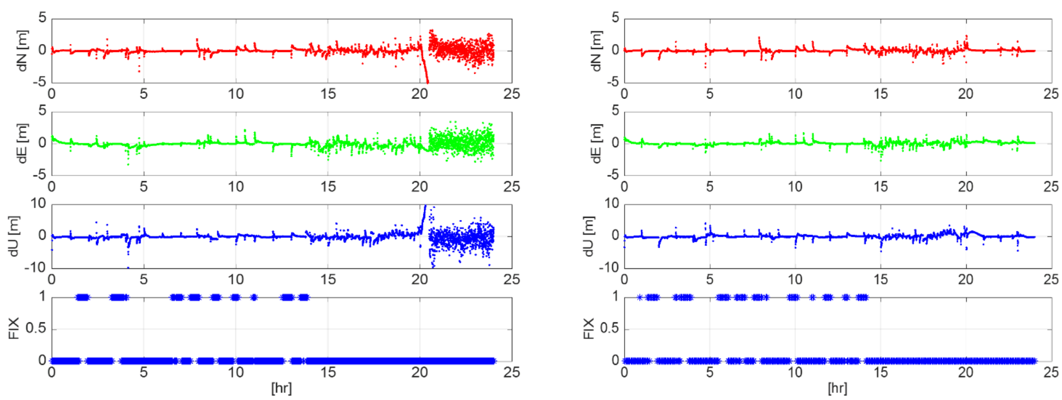

Figure 2. RTK result of SPAR-SJRP (URTKN) baseline using the GIM (left panel) and the local TEC model (right panel) on 15 April 2014 (time is in UT); Positioning error in north, east, and up components on the top three plots (dN, dE, dU) and the ambiguity resolution index on the bottom plot (0 – float, 1 – fixed).

Results of the VRS approach on precise positioning as well as on the impact of the anthropogenic interference on GNSS derived measurements will be presented in the paper.

Key words: Low latitude ionosphere, long-baseline RTK, VRS, SDR GNSS receiver.

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