Characterisation of the ionospheric environment at low latitudes, application to Biomass external calibration sites

Ionospheric Research for Biomass in South America (IRIS)

Executive Summary

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Monthly variation of the North-South TEC gradients (left) and their standard deviation (right) within the southern crest of EIA in Brazil. Top panels refer to 06 AM, bottom panels to 06 PM.

The picture illustrates the monthly variation of the North-South TEC gradients within the southern crest of the EIA in Brazil. Gradients and related variability (standard deviation) are larger at 06 PM than at 6 AM and maximize during the equinoxes (reaching up to about 0.05 TECu/km), especially around March-April. The figure is the operative tool to understand the extent of the TEC gradients variability and their quantification during the BIOMASS orbital passes.
Motivation:
BIOMASS is a polarimetric P-band (435 MHz) synthetic aperture radar (SAR) in a dawn-dusk low Earth orbit. Its principal objective is to measure biomass content and biomass change in all the Earth’s forests. The mission launch is envisaged around 2020, for five-year duration. The ionosphere introduces Faraday rotation and scintillations on every pulse emitted by low-frequency SAR, impacting the quality of the imaging. Some of these effects are due to Total Electron Content (TEC) and its gradients along the propagation path. To support the BIOMASS operations, an accurate assessment of the ionosphere morphology and dynamics is necessary, especially in the equatorial and tropical regions.

Methodology:
To support the BIOMASS operations, an accurate assessment of the ionosphere morphology and dynamics is necessary, especially in the equatorial and tropical regions. To the scope, we have conducted an in-depth investigation of the significant noise budget introduced by the southern crest and the trough of the Equatorial Ionospheric Anomaly (EIA) over Brazil. The work performed is characterized by a novel approach to conceive a SAR-oriented ionospheric assessment, aimed at detecting and identifying spatial and temporal TEC gradients, including scintillation effects, by means of GNSS ground-based monitoring stations. The assessment is supported by the characterization of the ionospheric features derived from ionosondes. The novelty of the adopted approach stands in the customization of the information about the ionospheric impact on SAR imaging as derived by local dense networks of ground instruments during the times of BIOMASS passes.

Results:
IRIS has provided to ESA operative tools to understand the extent of the TEC gradients variability and their quantification. In the specific, the analyses conducted within IRIS confirms that the choice of making BIOMASS pass at 06 AM and 06 PM is reasonable to minimize the effect of the ionosphere in Brazil. However, the presence of meaningful TEC gradients has been highlighted also in correspondence with the BIOMASS pass times, especially around 06 PM, which are however safer than others for what concerns the ionospheric impact. Within the southern EIA crest TEC gradients maximize along NS direction. Gradients maximize during the equinoxes (reaching up to about 0.05 TECu/km), especially between March and April. Such TEC gradients must be compensated in pairs of images before interferometric measurements could be made.

The climatological characterization of the ionospheric scintillation on L-band in IRIS shows also that BIOMASS dawn-dusk orbit avoids the post-sunset scintillation. However, the probability of scintillation (from weak to strong regime) at 06 AM and 06 PM is small, but not negligible. Even with small probability of occurrence, such scintillation induces defocussing resulting into limitations of the performance of azimuth shift estimation. At P-band, scintillation effects are expected to be intensified, making correction more difficult.

Publications:
Preliminary results of the study were submitted to the 14th European Space Weather Week (ESWW), organised in Ostend (Belgium) on November 27 – December 1, 2017. The work has been accepted for oral presentation. A paper summarizing the main results from IRIS and IBisCo has been finalized. It will be likely submitted to the ESWW Special Issue on Space Weather and Space Climate Journal (https://www.swsc-journal.org/). A presentation of some of the IRIS outcomes has been given at the 9th Multi-GNSS Asia Conference, Jakarta (Indonesia), on October 9-11, 2017.
Highlights:
Synergy between European and Brazilian institutions resulted in a consolidation of the understanding of ionosphere dynamics in the EIA southern crest and trough and in the assessment of possible impacts on BIOMASS mission. However, some infrastructural issues still remain in the region, which is unevenly covered by networks of GNSS receivers in the Amazonian area due to difficult access to the region. A network of GNSS and P-band receivers could be deployed for short measurement campaigns in strategic dip equatorial locations and until the EIA crest region, in collaboration with INPE and with support from Brazilian army and air force.