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

Ionospheric environment characterization for Biomass Calibration over South East Asia (IBisCo)

Executive Summary

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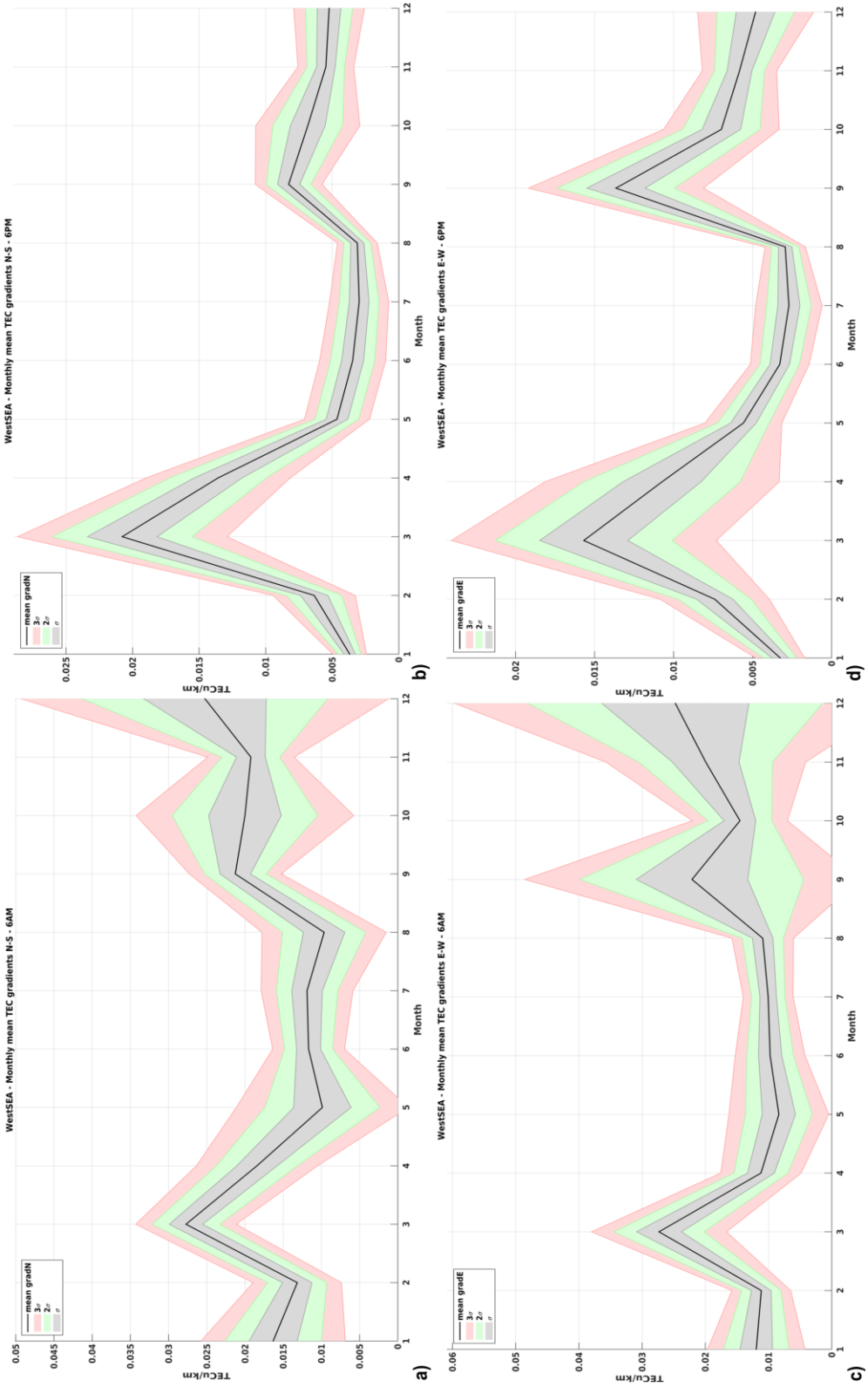
Picture:



Monthly variation of the hourly mean absolute value of the TEC gradients over West SEA in the North-South direction (panels a and b) and in the East-West direction (panels c and d). Panels a and c refer to 06 AM, panels b and d to 06 PM.

The picture illustrates the monthly variation of the mean absolute value of the TEC gradients in both North-South (a,b) and East-West (c,d) directions for the West SEA (longitudinal sector between 90°E and 118°E). Plots on panels a and c of the figure refer to 6 AM, while plots on panels b and d refer to 6 PM. East SEA presents the same behavior and similar (or even smaller) values of the gradients. Gradients are larger at 6 AM than at 6 PM and maximize during the equinoxes (reaching up to about 0.05 TECu/km) and in December (East-West gradient reaches up to 0.06 TECu/km). The figure**Errore. L'origine riferimento non è stata trovata.** is the operative tool to understand the extent of the TEC gradients variability and their quantification.

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 accurately assess the ionosphere morphology and dynamics in the equatorial and tropical regions of interest, we have conducted an in-depth investigation of the significant noise budget introduced by the two crests of the Equatorial Ionospheric Anomaly (EIA) over South-East Asia. 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:

IBisCo 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 IBisCo confirms that the choice of making Biomass pass at 06 am and 06 pm is reasonable to minimize the effect of the ionosphere also in SEA region. However, some *caveat* arose from the study that must be considered for the deployment of the Biomass calibration sites. Above all, the presence of meaningful TEC gradients has been highlighted also in correspondence with the Biomass pass times, which are however safer than others for what concerns the ionospheric impact. In both West and East part of SEA, TEC gradients along EW and NS directions are of the same order of magnitude and are generally larger at 06 am than at 06 pm. Gradients maximize during the equinoxes (reaching up to about 0.05 TECu/km) and in December (EW gradient reaches up to 0.06 TECu/km). 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 IBisCo 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, organised in Ostend (Belgium) on November 27 – December 1, 2017. The work has been accepted for oral presentation.

A presentation of some of the IBisCo outcomes has been given at the 9th Multi-GNSS Asia Conference, Jakarta (Indonesia), held on October 9-11, 2017.

A paper summarizing the main results from IBisCo and IRIS will be likely submitted to the ESWW Special Issue on Space Weather and Space Climate Journal (https://www.swsc-journal.org/).

Highlights:

Synergy between European and Asian institutions resulted in a good understanding of ionosphere dynamics in the South East Asian region 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 and other relevant equipment. Laws and regulations in some countries can impact on data availability, but within IBisCo, direct contacts relevant departments and institutions have been undertaken to pave the way to ESA for future possible openings on this issue.