3D Ionospheric Imaging for Space Weather Monitoring at Low-Latitudes

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Three-dimensional (3D) ionospheric imaging at Low-Latitudes is challenging due to the high ionospheric variability and dynamics in the region. The region is characterized by the presence of the Equatorial Ionization Anomaly (EIA), plasma bubbles, layered structures, and strong vertical drifts upwards during the evening pre-reversal enhancement. Aiming to better understand the ionosphere at low latitudes, this study shows the latest developments conducted by the authors to map the region with 3D inversion algorithms based on Global Navigation Satellite Systems (GNSS), ionosondes, GNSS radio-occultation, and empirical models, such as the International Reference Ionosphere (IRI). We address the capabilities of the developed 3D imaging methods to disclose the main morphologies and dynamics of the ionospheric electron density in the region. Limitations are also discussed since data assimilation schemes are still ill-conditioned for a complete 3D reconstruction. Based on the experiments conducted by the authors, the main conclusions have outlined that better 3D representation of the ionosphere in the region of particular interest requires three main improvements: 1) denser GNSS networks on ground and space; 2) better representation by empirical models to be used as background to the inversion technique, mainly to better represent the plasmasphere, topside ionosphere, and during the pre-reversal enhancements; and 3) dedicated signals for navigation transmitted by Low Earth Orbit (LEO) satellites.