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Challenges to observe ionospheric Storm-Enhanced Density and Tongue-of-Ionization structures in South American sector during strong geomagnetic storms

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Abstract

During geomagnetic storms, large ionospheric plasma density enhancements can occur at middle and polar latitudes. One of the most dramatical phenomena that can affect the midlatitude ionosphere is so called Storm-Enhanced Density (SED)—a localized plume of largely enhanced total electron content (TEC) that moves poleward and sunward from lower latitudes toward higher latitudes. Sharp plasma density gradients (> 10x) can be found at the edges of the SED plume and they can lead to intense scintillations of the received GNSS signals and to performance degradation of GNSS-based systems even at midlatitudes. When SED plume enters into the polar cap near noon, it transforms into a large-scale polar Tongue of Ionization (TOI) structure. In polar cap, the electron density within TOI can be 2-10 times larger than the background values. Most SED structures have been observed and reported in the American longitudinal sector, namely over continental North America, using dense networks of GNSS receivers. Model simulations show that SED/TOI structures may occur symmetrically in both hemispheres. However, in the Southern Hemisphere, we have a very limited global coverage of GNSS receivers at middle and high latitudes. The largest spatial coverage is provided by several regional networks of GNSS receivers in South America. On several representative cases of geomagnetic storms, we present results of observations the SED/TOI structures in this region of the Southern Hemisphere on the base of existing ground-based GNSS observations and multi-instrumental measurements onboard ESA's Swarm satellites. We will discuss the observational problems and challenges on existing data coverage by GNSS and ionosondes in the southern part of South America and Antarctica. Advancements in these areas could provide a better understanding of space weather effects in the Southern Hemisphere and globally.