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LEO radio occultation measurements for ionosphere and plasmasphere specification

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Nowadays the Earth's ionosphere, together with the plasmasphere, is a medium where human space activity is taking place and is being developed. Space-based technologies have become integral to everyday life and present unprecedented opportunity for science and economies. But their operation depends on capability to monitor, detect, and mitigate space weather phenomena with effects in the Earth's ionosphere. Plasma around the ionosphere's maximum ionization impacts the space assets most significantly, causing degradation in sub and trans-ionospheric radio wave propagation, losses of satellite communication and errors in navigation. Also, correct representation of the topside ionosphere including plasmasphere is still an open question for both empirical and first principal ionospheric models due to the lack of data/measurements/observation within this huge volume of space that comprises the global topside ionosphere-plasmasphere geospace region.

The GNSS RO observations from LEO satellites have served as a resource for ionosphere specification for about 25 years. The COSMIC-1 mission during 2006–2020 provided up to 5 millions ionospheric electron density profiles (EDPs) and data about the topside ionosphere-plasmasphere electron content globally. The follow-on COSMIC-2 mission operates over the equatorial region and provides daily ~5000 RO EDPs below orbit and ~10000 arcs above satellite orbit.

In this paper, we present an overview that demonstrates advantages of RO techniques for global specification of ionosphere and plasmasphere climatological behavior. In particular, we are discussing results of combination of RO GPS COSMIC-1 measurements, which include RO EDPs observations and POD TEC measurements from the upward-looking GPS antenna, provides information about the electron density distribution (profile) below the satellite orbit and the integral electron content above the satellite orbit during representative periods at background of solar activity level from low to high.

Based on 4+ years of COSMIC-2 constellation operation, we examined the comprehensive dataset that covers periods of low, mid, and high (towards the 25th solar cycle maximum) solar activity levels to retrieve climatological features of ionosphere's peak parameters and topside ionosphere-plasmasphere redistribution around the equatorial region within the current solar cycle progress.

Apart from the COSMIC-2 equatorial climatological studies, which are naturally limited by equatorial and subequatorial regions due to 24-degree orbital inclination, we investigated an opportunity to augment COSMIC-2 for global ionosphere coverage considering GNSS RO data from commercial small satellites missions that operate at high-inclination orbits. We are discussing challenges of commercial missions GNSS RO data processing and evaluation in order to investigate performance of this new data source to be combined with COSMIC-2 for representation of ionosphere specification. The first results demonstrate a good performance of multi-satellite constellations RO observations for global ionosphere climatology applications and can cover ranges within ± 80° magnetic latitudes.