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A study on continuous long-term monitoring of ionospheric irregularities in near-equatorial ionosphere enabled by geostationary BeiDou satellites

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The state of ionosphere is an important factor in various systems requiring long-range radio transmissions through the atmosphere. One of the widely used instruments for monitoring the ionosphere is GNSS remote sensing, where navigation satellites act as beacons used for atmospheric radio sounding using ground-based networks of receivers.

This work considers the new possibilities introduced with launches of additional geostationary navigation satellites in BeiDou constellations, as well as other systems. These geostationary satellites allow for long-term continuous survey of near-equatorial ionosphere. In this paper, BeiDou satellites are chosen due to their superior signal-noise ratio when compared to other geostationary satellite systems (as reported in other works), which makes total electron content (TEC) estimates much more precise, bringing them on almost the same level as GPS/GLONASS observations. Coupled with a stationary receiver, this allows for continuous and precise monitoring of TEC along a fixed line-of-sight between the satellite and the receiver as long as the line-of-sight is not too oblique, restricting the technique to near-equatorial regions.

First, modified geostationary ROTI index is used to study temporal variations caused by ionospheric disturbances, as well as provide a comparison with conventional GNSS ROTI index for African and South-East Asian sectors. It is shown that mean geoROTI values are generally smaller than conventionally computed ROTI, which is likely caused by spatial variability influence on conventional ROTI. This allows for estimating and excluding the influence of spatial variability along the satellite arc for conventional ROTI, and avoiding the pitfalls of using low-elevation data that contribute a lot of noisy input to ROTI calculations. GeoROTI successfully represents typical increase in small-scale irregularities after dusk, as well as considerable seasonal variations, corresponding to equatorial plasma bubbles occurrence statistics in studied regions.

Second, an automated technique for continuous monitoring of large-scale travelling ionospheric disturbances (LSTID) using geostationary TEC data is discussed. LSTID heading and velocity distributions are presented for different seasons and local times using stations located near Darwin, Australia. It is shown that the LSTIDs primarily travel westwards, which is consistent with solar terminator passing over the region. Non-negligible seasonal variations in heading and magnitude are shown.

The above results present the significant potential of geostationary BeiDou satellites for continuous survey of ionospheric irregularities of various temporal and spatial scales in the near- equatorial region.

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