URSI AP-RASC, Sydney, Australia, 17-22 August 2025

NavIC for measuring Plasma Bubble Drifts

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Abstract

Equatorial Plasma Bubbles (EPBs) are localised regions of plasma depletion that occur in the low-latitude ionosphere, primarily after sunset. These irregularities arise due to the Rayleigh-Taylor instability mechanism, leading to turbulent plasma structures. These irregularities significantly impact transionospheric communication and satellite-based navigation by causing fluctuations in signal phase and amplitude.

The study of EPB dynamics, particularly their drift velocities, is crucial for understanding ionospheric variability and space weather effects. The plasma bubbles exhibit both zonal and vertical drifts, influenced by background electric fields, neutral winds, and geomagnetic activity. This study utilises NavIC, India's regional navigation system, to detect and characterise plasma bubbles and measure their zonal drift near the Equatorial Ionization Anomaly (EIA).

NavIC's unique constellation, consisting of geostationary (GEO) and geosynchronous (GSO) satellites, provides a distinct advantage over traditional GNSS systems, which require multiple ground-based receivers for plasma bubble velocity estimation. For a short period of time, NavIC satellites seem nearly static with respect to the receiver station. This provides us with continuous TEC and scintillation measurements in different lines of sites. The occurrence of TEC depletion or high scintillation has some time lag in different lines of sight, using the time lag plasma bubble drift was calculated between the IPPs.. In this study, we used the data for the equinoctial period of March-April 2022 from NavIC station near EIA's northern crest.

Plasma drifts measured with NavIC standalone receiver ranged 68-105m/s eastward. Our results demonstrate that a standalone NavIC receiver can independently estimate zonal drift, showing a strong correlation ($R^2 = 0.72$) with GAGAN and IGS-generated ROTI keograms.

The ability of NavIC to independently measure plasma bubble drifts, and scintillation events underscores its value as a powerful tool for ionospheric research in the Indian region. This study presents the first unconventional use of NavIC for plasma bubble drift estimation, demonstrating its potential for improving space weather monitoring and navigation system reliability.

References

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