URSI GASS 2021, Rome, Italy,28 August- 4September 2021

Impact of equatorial and low latitude ionospheric irregularities observed across a broad spectrum of frequencies

A. Paul*, T. Das and S. Goswami
(1) Institute of Radio Physics and Electronics, University of Calcutta, India, e-mail: ap.rpe@caluniv.ac.in; stanmaydas@gmail.com; samiddha.goswami@gmail.com

Equatorial and low latitude ionospheric irregularities impact transionospheric radio signals over a wide spectrum of frequencies ranging from HF to L-band and sometimes even S-band. Since these frequency bands host majority of satellite-based communication and navigation links and other systems, impairment of these signals implies partial or sometimes complete outage of associated services to a vast panoply of modern society. Characterization and diagnostics of such effects are necessary for advancement of the present understanding of the basic physics of ionospheric irregularity dynamics and its applications.

Institute of Radio Physics and Electronics, University of Calcutta operates a number of active and passive radio systems around the northern crest of Equatorial Ionization Anomaly (EIA) in the Indian longitude sector. During 2011-12, intense VHF amplitude scintillations were observed on geostationary link (73°E) at 250MHz, with S_4 indices being greater than 0.8 on several cases during post-sunset hours. Associated irregularity zonal drift and characteristic velocities showed a progressive decrease in values from early evening hours to midnight and sometimes even post-midnight periods [1]. During this time, GPS signals showed intense fluctuations in carrier-to-noise (C/N_o) ratios with S_4~0.6-1.0 and associated position deviations were found to be several meters. Interrelating the VHF and L-band observations showed that periods of high characteristic velocities measured at VHF were correlated with intense S_4 and high receiver position deviations for GPS in a non-linear fashion. Decorrelation times and distances at VHF were also found to be inversely proportional to S_4 at GPS L1 frequency.

With the availability of multi-frequency multi-constellation GNSS signals (GPS, GLONASS, Galileo), the spatially distributed configuration was found to effectively provide diagnostics for satellite signal outages during scintillation events by applying the principles of spatial diversity while the inter-frequency signal decorrelation, even across L-band, was found to be effective as a tool for mitigation of the effects of scintillation. Based on observations during March 2014, the different satellite navigation constellations were also found to differ in terms of their signal outages and robustness during periods of intense amplitude scintillations. In addition, periods of loss of lock and cycle slips also differed on different GNSS signals, indicating the important role of the associated signal codes towards relative robustness [2].

Effects of ionospheric irregularities in terms of ionization density depletions and TEC bite-outs were found on 150 and 400MHz beacon transmissions received from LEO satellites during equinoxes as well as local summer months (June, July) of 2015-2016 from this station. Few isolated cases of TEC fluctuations were also noted on the dual L1 and S-band (2492.5MHz) transmission of IRNSS during March-April 2017 from Calcutta.

During the summer months of 2019 (July-August), radar backscattered signals from ionospheric irregularities were observed on the 53MHz active phased-array radar operational at this station. The backscattered signals were found during the daytime from heights of 90-120km while the nighttime echoes were received from heights around 130-140km.

Hence, it could conclusively be established that equatorial and low-latitude ionosphere is subject to perturbations from irregularities over a wide spectrum of frequencies as observed from Calcutta at 53MHz (radar), 150/400MHz (LEO), 250MHz (GEO), L-band (GNSS) and even S-band (IRNSS). Further these observations were made under geomagnetic quiet conditions implying that geomagnetic disturbed conditions may impose an additional metric to the already deeply involved dynamic geophysics of this region.

References

[1] Das, T., Roy, B. and Paul, A. (2014). Effects of transionospheric signal decorrelation on GNSS performance studied from irregularity dynamics around the northern crest of the EIA, *Radio Sci.* http://dx.doi.org/10.1002/2014RS005406.

[2] Biswas, T., Ghosh, S., Paul, A. and Sarkar, S. (2019). Interfrequency performance characterization of GPS during signal outages from an anomaly crest location. *Space Weather*, https://doi.org/10.1029/2018SW002105.