(Form11-1)

Analysis of different techniques used to estimate impact of Equatorial Plasma Bubbles on Global Navigation Satellite System (GNSS) signals.

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Research summary:

In satellite-based navigation and positioning, ionospheric delay is regarded as a critical error source. Receivers on ground station with the help of satellite are used to determine the position, velocity and time information independently. In low latitudes, ionospheric variability significantly impacts positioning accuracy of GNSS signal. This necessitated the enhancement of precision and integration of many available satellite navigation systems.

Purpose: The existence of ionospheric abnormalities that may prevent continuous GNSS functioning, particularly in the Global positioning system (GPS) L2 frequency, is one of the primary issues in ionospheric modelling since, signals transmitted at L2 frequency are more susceptible to ionospheric delays compared to L1 frequency. Different estimation techniques have been developed over the time. Each of these techniques provides different aspect to ionosphere-radio frequency interaction. The main goal of this work is to analyse various estimation techniques to better understand the impact of ionospheric anomaly on GNSS signals.

Methods:

We have used two stations closely located in India as Base Station: LCK3 (26.9121° N , 80.9556° E) & Rover station: LCK4 (26.9140° N, 80.9588° E) for this event. Then we selected an event where Plasma bubble is detected (15^{th} Jan 2022). To analyze this plasma bubble we have plotted Rate of Change TEC Index (ROTI) of that day and to analyze GNSS signal we used RTKLIB software.

RTKLIB: Among many GNSS data processing software, RTKLIB is an open-source program for GNSS positioning. Numerous common data formats, including RINEX OBS/NAV, BINEX, ANTEX, and IONEX, are supported by RTKLIB. RTKPLOT is used to visualize the solutions; it can display the number of satellites utilized in the computation, the position, and the ground track of the observation points. There are differences in the GNSS data utilized for post processing. First, a RINEX observation file from a GNSS receiver that serves as a base station and has a ".o" extension is used. The position of the rover station, which is made up of additional observation data, must be calculated. GNSS sites offer navigation files in addition to observation data. An output file ending in “.pos" is what RTKPOST produces. The positioning mode, statistically predicted accuracy, and various computational limitations are all detailed in the output file.

ROTI: Total electron content (TEC) is one of the most often utilized GNSS-based measures defining the ionospheric plasma density. We calculated ROTI using a running window for 5-min sets of ROT observations.

Results:

Quite Day (13 Jan 2022) Event Day (15 Jan 2022)

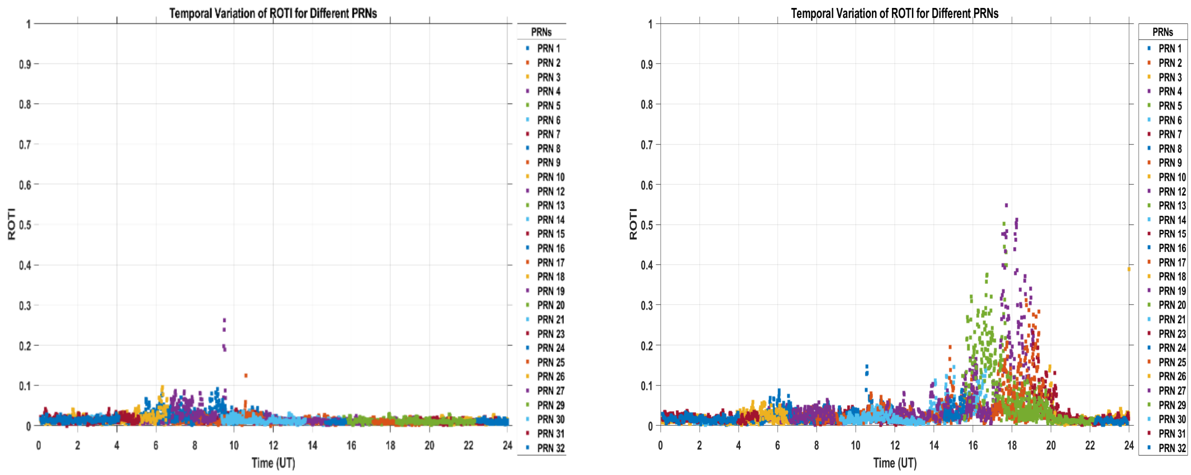

Fig.1 ROTI plot of base station LCK3 on quiet and event day.

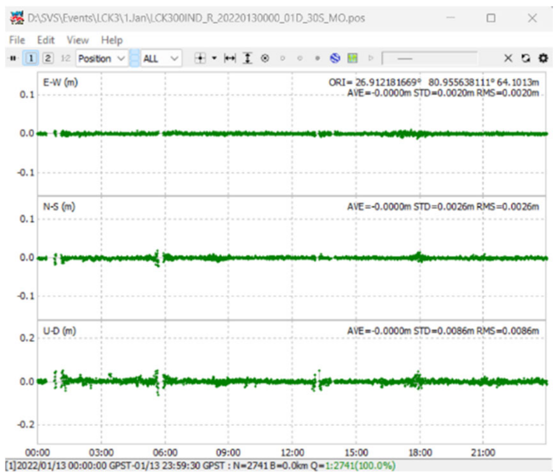

Fig. 2 shows variation in GNSS signal using DGNSS technique.

Our results shows that DGNSS (Code - based differential GNSS) provide best output for error detection in GNSS signal due to plasma bubble activity. We observed that after the occurrence of plasma bubble there is slight positioning error in GNSS signal. It also shows that meridional variation in positioning is slightly higher than that of zonal variation in positioning. But the error shows in this method is very minimum and it can be caused by other parameters. Hence to establish a solid relation multiple events at multiple station needs to be studied.