Statistical Analysis of Nighttime TEC Depletions and GPS Loss of Lock in the Crest of Anomaly Region

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Extended Abstract

Depletions in nighttime total electron content (TEC) near the crest of equatorial ionization anomaly (EIA), Bhopal (Geog. 23.2° N, 77.4° E, and MLAT 14.2° N) has been statistically studied for the solar minimum period 2005-06. TEC data is recorded by dual frequency GPS receiver which was installed at Space Science Laboratory, Bhopal. Observations suggest the presence of large depletions in TEC which are always accompanied with fast increase in the scintillation index. Rate of change of TEC index (ROTI) has been used as an irregularity index. Losses of lock occur during the encounter of the irregularity. It is observed thatnighttime depletions in TEC are more frequent in winter, less during equinox and least in summer months. These irregularities can cause significant errors in GPS positioning.These irregularities are also seen from in situ density fluctuations measured by the DEMETER satellite. The Langmuir Probe experiment and Plasma Analyzer onboard DEMETER measure the electron and ion densities respectively. It is interesting to note that in situ density fluctuations observed on magnetic flux tubes that pass over equatorial and anomaly region, can be used as indicator of ionospheric scintillations at that site.Many cases of density fluctuations and associated scintillations have been observed during descending low solar activity period. The strength of equatorial electrojet is compared with the density fluctuations and scintillations and a good correspondence between the two parameters have been found.

1. Introduction

Disturbances in the ionosphere cause significant impact on satellite signals for communication and navigation, which are dependent on the signal frequency and the ionospheric electron content. Equatorial ionosphere is highly dynamical, unpredictable and is characterized by the existence of intense equatorial plasma bubble associated irregularities. In this paper we have presented the first observations of nighttime TEC depletions (Plasma bubbles) at Bhopal (23.2°N, 77.4°E), a station near the northern crest of EIA using GPS derived TEC, for the period of low solar activity from January 2005 to December 2006. The statistics of nighttime TEC depletions have also been presented. We also study two parameters associated with scintillations on GPS signals. First parameter is the in situ electron density and ion density fluctuations in the region between trough and crest of the equatorial anomaly region using DEMETER satellite

measurements. Second parameter is the calculation of the diurnal maximum of the strength of the equatorial electrojet, which can serve as precursor to ionospheric scintillations in the anomaly region. Both these parameters are correlated with the GPS L band scintillations observed at a station near the northern crest of equatorial anomaly, Bhopal.

2. Methodology

Scintillation and TEC data recorded during 2005 to 2006 by a GPS Ionospheric Scintillation and TEC monitor system (GISTM); GSV4004A installed at Department of Physics,Barkatullah University, Bhopal (23.2°N, 77.4°E, Geomagnetic 14.2°N) has been used to study the occurrence of nighttime depletions and associated scintillations. Study of loss of lock of GPS signals has also been studied.TEC depletions and associated scintillations including loss of lock events during the low solar activity period 2005-2006 are presented and discussed in this paper. During this period we observed TEC depletions in 59 events in individual PRNs. Only those cases are considered in which maximum TEC depletion was larger than 1 TECU relative to the background TEC.

3. Results

The presence of large depletions (plasma bubbles) is always accompanied with very fast increase in the S4 index (S4).The ROTI value shows the strength of irregularity this is confirmed by the suddenTEC depletion and increase in the S4 value.Hence ROTI can alone be used as the irregularity index.The losses of lock occur during the encounterof the irregularity and the signal strength degrades during the passes of the irregularity.It is confirmed that north-south satellite trajectories show scintillations over a long period with transition from intense scintillation to no scintillations corresponding to crossing over the northern edge of the irregularity cloud.The occurrence of depletion in TEC is found maximum in winter and minimum in summer.Maximum cases of depletions are reported during pre-midnight hours in winter. This leads to the belief that the depletions in TEC are connected with the equatorial spread F. The scintillation events corresponded well with irregularity structures present on the DEMETER observations and can be attributed to plasma bubble activity.

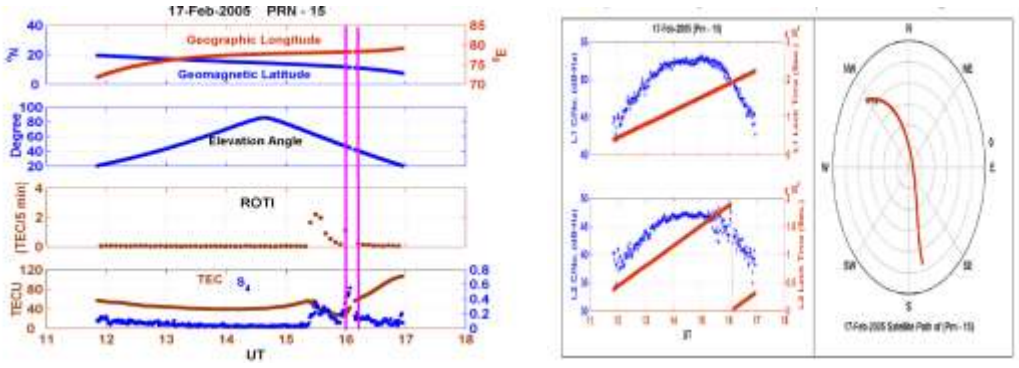

Figure: TEC depletions and loss of lock event observed by GPS receiver