Variability ofTEC and scintillation near the northern EIA crest under the extreme space weather event

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ABSTRACT

1. Introduction

The study of variability in ambient ionization and occurrence of scintillation during the period of geomagnetically disturbed condition is an important aspect of space weather scenario. Though much studies have been made on the storm time variability of the stated ionospheric parameters-more investigations are needed to develop a comprehensive model of space time variability of ambient ionization and scintillationboth on the regional as well as global basis under varying space weather conditions. The study is motivated by the fact that each storm has its own class, quite different from the others. Storm time variability of the ionosphere in the equatorial low latitude region is primarily driven by the electric fields of magnetosphere and disturbance dynamo origin having different space time climatological pattern of variations. The disturbed time fields are identified as i) prompt penetration (PP) and ii) disturbance dynamo (DD) fields having respective temporal evolution pattern. The present observations pertaining to super storm event of March 17-19, 2015 reveals that inspite of persistence of all the geo-effective condition to dictate prompt penetration of eastward electric field,variability of ambient ionization and occurrence of density irregularities as revealed through scintillation around the post sunset period exhibits opposite pattern of variability within a very narrow longitudinal span.

2. Data

Transionospheric signals at GNSS frequencies (L1,L2) along with VHF signal at 250 MHz from satellite FleetSatCom (FSC) (72.5°E) recorded at Raja Peary Mohan College (RPMC)(geographic: 22.65°N, 88.36°E; geomagnetic: 13.12°N, 161.69°E) are used for the present studies. The station is situated near the northern EIA crest of Indian longitudes sector.The slant TEC obtained from the GNSS receiver is converted to vertical TEC (VTEC) using a mapping function and incorporating corrections due to satellite and receiver biases.For tracking GNSS amplitude signal elevation mask angle greater than 20^0 and azimuth angle in the range 100^0-220^0 are selected to avoid multipath effect as well as

contamination by local time effect. The magnetometer data available in the website of Intermagnet are used to indicate the electric field condition near the equator during disturbed period. Dst index, AE index, solar wind pressure and solar wind velocity, interplanetary magnetic field and electric field dataused for the present study are downloaded from the website of Omniweb and srl-caltec.

3. Results

The superstorm events commenced at 4:45 UT. The main phase initiated around 5UT (10:30 IST) on 17th March, 2015 and continued upto 23UT (4:30 IST on 18th March, 2015). The maximum negative excursion ds_tvalue is reported to be -217 nT. The diurnal variation of ambient ionization as dictated by the TEC values on 17th March 2015 at two longitudes sector 85°E & 90°E are shown in fig.1 (a). A remarkable opposite phase in the variability of TEC around the post sunset period is reflected (shown within circle in fig 1.a). While diurnal TEC around 85^0E shows enhancement the same around 90^0E exhibits decreasing trend. The opposite nature is reflected in the occurrence pattern of GNSS scintillation also. While the longitude range around the 85°E are interspersed by the footprint of density irregularities as revealed through scintillation (fig.1.b shown by red color track) both at VHF(250 MHz) and GNSS frequencies- no scintillation is evident around the longitude of 90°E. The presence/absence of density irregularities are also reflected through the wavelet analysis of the TEC deviation data at the two longitude sectors. During the main phase of local dusk sector estimated $\frac{dDst}{dt}$ =-25 nT/h, AE attained a value > 1200 nT, Bz remains southward for 11 hours with maximum value -18 nT and solar wind pressure recorded to be >10 nPa for more than 6 hours.

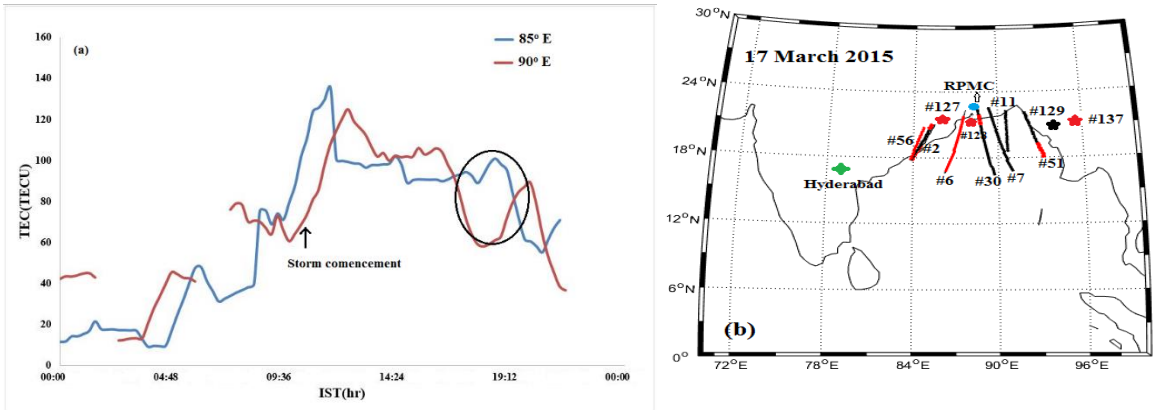

Figure 1. Plots of (a) Diurnal variation of TEC on 17th March, 2015 opposite phases of TEC variation are shown within black circle (b) Tracks of GNSS satellites in the post sunset period showing scintillation(red marks) and non-scintillation path, location of observing station and IPP of several SBAS are also shown.

One of the essential components for evolution of electron density irregularities in the post sunset period is the pre reversal enhancement (PRE) of eastward electric filed. The said field may be modified by prompt penetration electric field. The density perturbation scale length and corresponding nature may dictate the occurrence/nonoccurrence of scintillation but evolution of the opposite nature in TEC variability may seem to be related to the longitude confinement nature of PP field. Inspite of appearance of all the favorable geo-effective

condition in the dusk longitude sector of the main phase, as reported till date, the PP effects appears to be quite different within a narrow longitude belt.

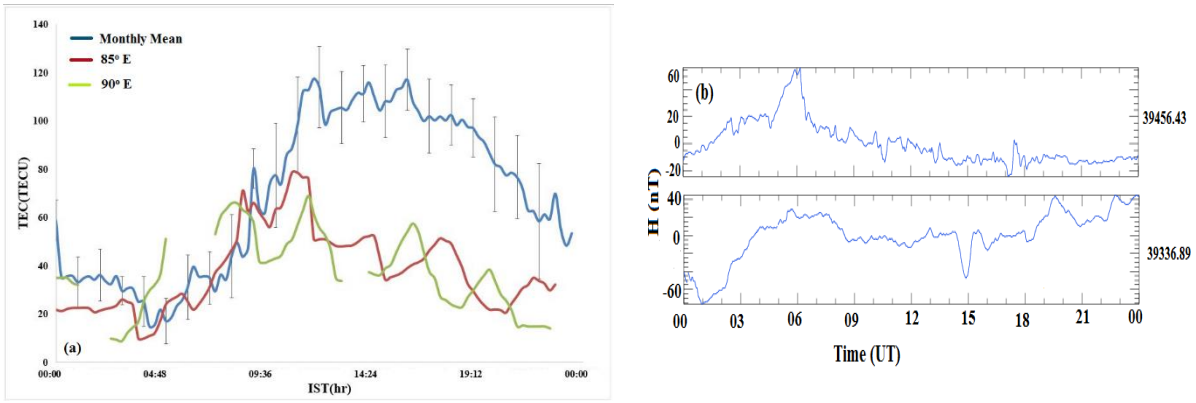

Figure 2. Plotsof (a) Diurnal variation of TEC over monthly mean on 18th March, 2015. Vertical bar indicates ±1σ (b) Variation of magnetometer data at Hyderabad (17.4°N, 78.6°E) on 16th March (upper panel, quiet day) &18th March (lower panel), 2015

On 18th March, 2015 the diurnal variation in TEC around the two longitude sector exhibitsextremely low values compared to the quiet time diurnal mean pattern. The TEC around EIA crest are mostly contributed, other than production, by transport effect as dictated by fountain mechanism, for which electric field around the magnetic equator is the prime contributor. The said field as revealed through the magnetometer data is found to be much low values in 18th March, 2015 compared to quiet day (fig2.b). PCA analysis of TEC data in conjunction with the magnetometer data suggest good correspondence between the two. The field related to disturbance dynamo (DD) having polarity opposite to quiet day pattern may be important contributor to dictate the lower TEC values around the two longitude sectors. The composition changes in the recovery phase may be another important agent to dictate the variability of ambient ionization. A comparative study of the O/N_2 map available around dayside with the GUVI website reflects a reduction in O/N_2 ratio around the 85°E-90°E longitude sector on 18th March, 2015 compared to geo-magnetically quiet day values.

4. Summary

Results of analysis of ionospheric scintillation and TEC data during the March 2105 super storm event reveal that inspite of persistence of all the geo-effective conditions, hitherto reported, field perturbation effect of magnetospheric origin in the main phase dusk sector may be quite different within a narrow longitude belt.
For the particular events studies much lower diurnal values in TEC in the recovery phase may be attributed to the field of disturbance dynamo origin as well as composition changes. The result may form an important data base for the ensuing space weather scenario.

5. Acknowledgement

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