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VARIATION OF LOW LATITUDE TEC DURING GEOMAGNETIC STORMS OF AUGUST 24, 2005

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Abstract. We present a case study concerning an interplanetary event that occurred on August 24, 2005 and effect thereof on the low latitude ionosphere. The effect of the prompt penetration electric field has been evidenced in the low latitude TEC data obtained from Udaipur, India, situated near the crest of the equatorial ionization anomaly (EIA). We observe a positive ionospheric storm during the local daytime of August 24, 2005. The enhancements in TEC have been attributed to local uplifting of the F region as well as to reinforcement of the equatorial plasma fountain.

1 INTRODUCTION

Rapid fluctuations in the intensity and phase of radio occultation signals can indicate the presence of small scale electron density irregularities along the radio propagation path. Instruments onboard several low Earth orbiting satellites routinely collect radio occultation observations using signals transmitted by the GPS constellation of satellites, providing a rich source of information about the occurrence and morphology of ionospheric scintillation. Nevertheless, the relatively longer propagation path of a radio occultation signal through the ionosphere, as compared to through the lower neutral atmosphere, makes it challenging to determine the geographic location and horizontal extent of the ionospheric irregularities responsible for the scintillation. In this paper, we use the multiple phase screen method1,2 to simulate the forward-scatter of radio occultation signals by irregularities in the equatorial ionosphere, and explore spectral techniques for geolocating these irregularities along the radio occultation raypath. We validate the results of our phase screen simulations and analysis using radio occultation measurements from the CORISS instrument onboard the C/NOFS satellite.

2 METHODOLOGY

Ionospheric disturbances during geomagnetically active periods in the low and equatorial latitudes are mainly due to the combined effect of relatively short lived prompt penetration and longer lasting ionospheric disturbance dynamo electric fields. The dynamic solar wind parameters have a direct bearing on the generation of these electric fields. Due to the southward (northward) turning of z- component of the interplanetary magnetic field (IMF Bz) from steady northward (southward) configuration, under shielding (over-shielding) condition creates and thus produced a dawn-dusk (dusk-dawn) electric field at high latitudes, which penetrates instantaneously up to the equator[1,2,3,4]. This paper concerns with the effect of prompt penetration electric field in ionospheric total electron content over Udaipur (Geog. latitude 24.58^o N, Geog. longitude 73.7^o E, Geomagnetic latitude 16.20^o N) during August 24, 2005 geomagnetic storm.

3 RESULTS AND DISCUSSION

Due to the combined effects of the CMEs that occurred from the active regions AR0798 and AR0798 on August 22, 2005 at 0131 UT (S11W54) and 1730 UT (S12W60), respectively a geomagnetic storm was triggered on August 24, 2005[5]. These CMEs were associated with M2.6 class and M5.6 class x-ray flares, respectively. Figure 1 presents, the solar wind parameters, viz., proton density, temperature, solar wind velocity, and IMF Bz in the top four panels. From the solar wind parameters, the zonal component of the interplanetary electric field (IEF Ey) have been computed using Ey = -V Bz and is shown in fifth panel of figure 1. The sixth plot contains SYM-H index, which gives information about strength of the symmetric ring currents.

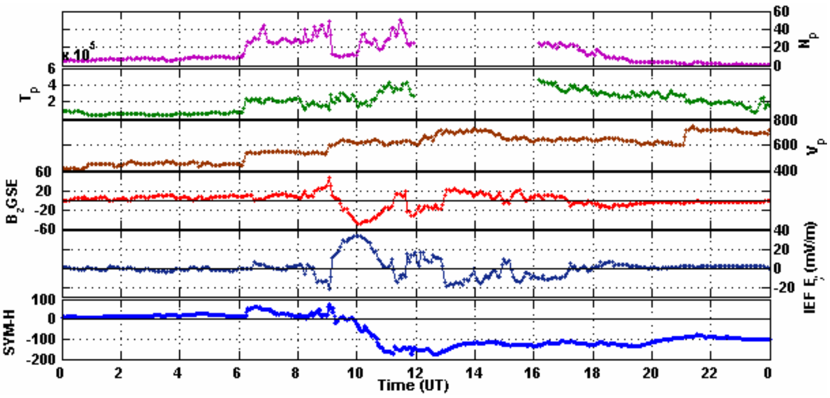

Figure 1: The solar wind and geomagnetic parameters for August 24, 2005. Four panels from top are the solar wind (proton) density, the proton temperature, the proton speed, and the IMF-Bz as measured by ACE spacecraft. In the fifth panel computed IEF Ey and SYM-H index in sixth panel.

The figure 1 reveals that the solar wind speed VSW, increased suddenly from about 440 km/s to about 540 km/s at 0613 UT. A similar sudden variation is also seen in solar wind temperature and density. However, no noticeable change in IMF Bz has been seen at this time, but SYM-H index shows an increase of about 35nT and reached around 50nT. It is conjectured that these changes are due to the first CME that occurred at 0113 UT on August 22, 2005. But this did not cause a geomagnetic storm. Then around 0900 UT, VSW is seen to rise abruptly up to 600 km/s. All the other solar wind parameters (T_P, N_P and IMF Bz) and SYM-H also show a sharp increase at the same time. This shock, observed at 0900 UT, may be due to the combined effect of both the CMEs, or due to the second CME alone, and resulted in the southward turning of the IMF Bz, accompanied by a sharp decrease in SYM-H index, which is an indication of the commencement of the main phase of the geomagnetic storm. For better comparison, the solar wind parameters have been shifted in time by 35 minute, in accordance with the SSC as observed in SYM-H index to account for the shock arrival time from ACE satellite to the magnetopause.

Southward turning of the IMF Bz had dramatic effect in the equatorial and low latitude ionosphere is evidenced from figure 2 which presents the IEF Ey, and the SYM-H, horizontal component of the geomagnetic field at a low latitude station outside the electrojet at Alibagh, HABG and at an equatorial station, Tirunelveli HTIR, respectively, in the third and forth panel of figure 2. HABG has been plotted with a base line value of 37800 nT whereas for HTIR base line value is 39900 nT. The quiet time variations in the magnetic field at Alibag and Tirunalveli are also plotted in broken red curve for comparison. From figure 2 it is clearly seen that the changes in SYM-H mapped in HABG and HTIR. Sudden southward turning of IMF Bz at around 0900 UT caused the eastward excursion in IEF Ey of large magnitude. This was accompanied by a sharp increase in HABG and HTIR which has been a clear indication of the prompt penetration of the electric field, of high latitude origin, up to the equatorial ionosphere. But these fields are short lived, with a period $\sim$ 1 hour.

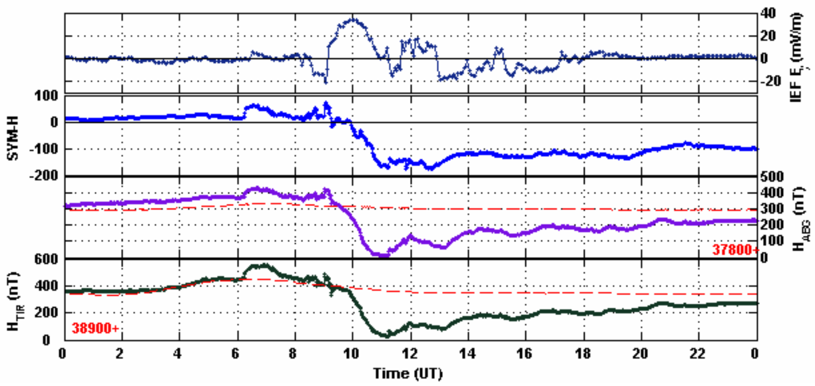

Figure 2: The interplanetary electric field Ey and SYM-H index for August 24, 2005 in top two panels. H component of the geomagnetic field at Alibagh and Tirunelveli, HABG and HTIR, respectively in last two panels, with base line 39900 nT and 37800 nT have been shown.

In order to see the effect of the prompt penetration electric fields associated with the geomagnetic storm of August 24, 2005 on the low latitude plasma, the vertical TEC (VTEC) obtained from all the satellites in view from 0900 UT to 1500 UT has been computed. The VTEC exhibits large enhancements during this period. As a sample example, variations of VTEC (in indigo-blue curve) from two satellites, PRN 8 and PRN 27, are shown in figure 3. Mean VTEC, which has been computed for international geomagnetic quiet days for the whole month, August 2005, has been used as reference VTEC, is also plotted as the black curve. The day to day variability in the VTEC has been shown as 1σ bars (standard deviation from the mean VTEC) on mean VTEC, in green. The mean VTEC exhibits a normal trend typical of a station near the anomaly crest. The normal anomaly peak is evident around 0900-1000 UT, corresponding to a local time of 1400-1500 LT. It can be seen from figure 3 that the VTEC variations for both the PRNs 8 and 27 on the storm day show two peaks, one around 1115 UT and the other around 1315 UT. The first peak in VTEC, observed at 1115 UT, may be a local effect, arising due to the uplifting of the F layer under the enhanced vertical drift, attributable to the prompt penetration electric field. The plasma from lower altitudes, when uplifted, survives longer due to reduced recombination rates at higher altitudes, and results in enhanced density. Whereas the second peak in VTEC, seen at 1315 UT may be a result of redevelopment of the equatorial ionization anomaly (EIA) arising due to reinforced plasma fountain effect at the equator. It is suggested that the prompt penetration electric fields, that reach the equator with a time delay on the order of an hour, coupled with the sluggish response of the ionosphere in the development of the ionization anomaly due to these fields, leads to observed second peak in VTEC at 1315 UT.

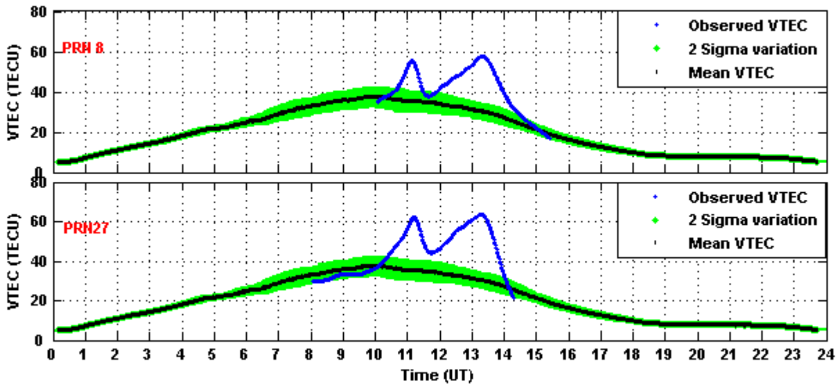

Figure 3: VTEC observations from Udaipur for PRN 8 and 27. The VTEC curve on August 24, 2005 (indigo-blue) is shown in comparison with the mean VTEC (black). Vertical bars (green) of 1 on mean VTEC curve represent the standard deviation for estimated mean.

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