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DIRECT BEARING OF PP ELECTRIC FIELD ON TEC IN LOW LATITUDES: DECOUPLING LOW LATITUDE TEC ENHANCEMENTS FROM EQUATORIAL FOUNTAIN

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Abstract. This paper shows observations which entail direct response of low latitude ionosphere to TEC during two major geomagnetic storms of May 15, and August24, 2005.

1 INTRODUCTION

The effect of prompt penetration electric field (PPEF) of high latitude origin on ionospheric total electron content (TEC) has been a subject of considerable recent interest. The generation and transmission of high latitude PPEF due to solar wind-magnetosphere interaction (Kikuchi and Arakai, 1979) is quantitatively better understood than the electrodynamic response of equatorial and low latitude ionosphere to the same. Although, the PPEF directly bear equatorial electric fields and currents due to maximum ionospheric conductivity in the region, the prompt effects of the PPEF on low latitude ionosphere are less understood due to complex temporal and spatial interplay of various geophysical processes like EEJ (equatorial electro-jet) and development of EIA (equatorial ionization anomaly). We present evidence of direct bearing of high latitude PPEF on low latitude ionosphere though GPS-TEC variations vis--vis ionosonde observations.

2 OBSERVATIONS

2.1 CASE 1: MAY 15, 2005

Variations in solar wind parameters as obtained from ACE and in the SYM-H index indicate that the storm commenced on May 15, 2005 at 0239 UT. The main phase of the storm commenced at 0600 UT on 15 May with sudden southward turning of the Z-component of interplanetary magnetic field (IMF-Bz) and subsequent decrease in SYM-H index. The dawn-to-dusk convection electric field of high latitude origin penetrated to low and equatorial latitudes simultaneously as corroborated by the magnetometer data from the Indian zone. Subsequent northward turning of the IMF-Bz and the penetration of the dusk-to-dawn electric field over the dip equator is also discernible. Response of the low latitude ionosphere for this storm may be characterized in terms of (i) enhanced background level of VTEC as compared to the mean VTEC, (ii) peaks in VTEC and foF2 within two hours of prompt penetration of electric field and (iii) wave-like modulations in VTEC and sudden enhancement in hmF2 within 4-5 hours in to the storm. These features have been explained in terms of the modified fountain effect, local low latitude electrodynamic response to penetration electric field and the TIDs, respectively. The study reveals a strong positive ionospheric storm in the Indian zone on May 15, 2005. Consequences of such major ionospheric storms on the systems that use satellite based navigation solutions, in low latitudes are also discussed.

2.2 CASE 2: AUGUST 24, 2005

Another interplanetary event of August 24, 2005 has been analyzed as a case study to delineate the response of low latitude TEC and equatorial fountain. The temporal development of the event in the Indian longitude sector has been demonstrated by utilizing the interplanetary data from ACE satellite for solar wind bulk speed, solar wind proton density and IMF-Bz, SYM-H data from world data centre, Kyoto and measurements of horizontal magnetic field intensity from Indian sector. The sudden positive excursion in SYM-H index at 0630 UT and minimum excursion of -180nT at about 1100UT (IST=UT+05:30 Hrs) entail the sudden commencement and occurrence of a major geomagnetic storm on daytime of the August 24, 2005 in the Indian longitudes, respectively. Excursions in the IMF-Bz and solar wind speed (V) do signify the effect of the geomagnetic storm in terms of interplanetary electric field (E=-VxB) that penetrated to high latitudes. The multiple excursions in EEJ strength from Indian sector show both polarities of the convection electric field over the dip equator. The dawn-to-dusk and then sudden dusk-to-dawn electric field variations directly affect the low altitude TEC, forming the sharp peaks in VTEC. Although, it was evening local time in Indian sector, very large enhancement in VTEC is seen due to presence of such PP fields in low altitudes.

3 RESULTS

The data from multiple GPS receivers (about 15) from Indian longitude sector has been analyzed to characterize the response of TEC. The data analysis has been restricted to first four hours into the storm after commencement of the main phase for each storm respectively. Strikingly similar results have been obtained in terms of response of TEC in Indian zone for both the cases. Both storms commenced in daytime and large peak structures in TEC are seen starting from the main phase of the storm. We found that this peak occurs at the same time in different longitude sectors separated by 5 degrees apart. This relates the source mechanism to be common for generation of this peak. We demonstrate that the dawn-to-dusk prompt penetration (PP) electric field during main phase of storm was operative in low latitudes during daytime. The response in TEC as a peak was generated through uplift (ExB) of low latitude F- layer in response to the eastward PP electric field. While the production continues in lower f regions, the uplifted ionization contributes to the sudden TEC enhancement structures.
Another confirmation stems from the fact that, once the effect of pp field over low latitude was over (i.e. within two hours), the low latitude TEC fell back to background levels. The equatorial fountain, which might have responded to the eastward directed pp electric field, has contributed to the TEC in low latitudes only after two hours. The TEC increased by about 200% in daytime in effect of modified fountain effect, wherein, the extra ionization was transported from equatorial to low altitudes. We also found that the crest of EIA moved pole- ward on the storm day as compared to quiet day.

4 CONCLUSIONS

- The dawn-to-dusk PP electric fields directly control the vertical component of the ExB drift of ionization in low latitudes. The response of low latitude F region to suddenly enhanced vertical drift produces enhanced TEC just after the main phase of the storm commences.
- The enhancement followed by decrements in TEC form the peaks in TEC as seen in time series of GSP data.
- The peaks in TEC are formed almost at the same time over a given latitude belt, suggesting a common mechanism behind their synchronized existence.
- After two hours into the storm, the travelling atmospheric disturbances (TADs) and enhance equatorial fountain compete to form next peaks in TEC in low altitudes.
- To delineate the contribution of dusk-to-dawn PP field and sudden reversals in that, with other electrodynamical responses in low latitudes, we have taken a modeling study, which uses the SAMI2 model. First such results would be shown.