Study the effect of great magnetic storms impact on equatorial and low latitude F-region Ionosphere during 2003 and 2004.

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For detailed study of geomagnetic activity impact on equatorial and low latitude F-region, the ionospheric response features are analyzed by using the data obtained from a modern digital Ionosonde IPS-71 operated at Delhi and IPS-41 operated at Thumba (Trivendrum) during the periods of three recent and great magnetic storm events of the present solar cycle. The F-layer h 'F and foF2 data, from Trivandrum an equatorial station and Delhi a low latitude location, are examined during the two great magnetospheric storm events that occurred in October 2003 and November 2003 with minimum Dst indexes -347 and -429 nT, respectively. While only Delhi data is analyzed for the recent storm of November 2004 having minimum Dst index -383 nT. During this study, it is clearly observed that there is an enhancement in height of F-region, at both equator and low latitude, with collapsing of ionization at midnight during maximum negative excursion on Dst values, which is followed by an enhancement at low latitude during recovery phase of the storm. During the main phase of the storm, at low latitude, an enhancement of F-region ionization with increase in h'F is observed while in equatorial region, ionization collapses with increase in h'F especially after sunset hours.

DATA

The data used for the present study are hourly data of the various ionospheric parameter obtained from the digital ionosonde operated in New Delhi (low latitude) and Thumba, Trivendrum (equatorial) respectively during the specific time period when the magnetic storms were occurred. The Dst and Kp-index values during the specific storm periods are obtained from World Data Center.

RESULTS

Due to the occurrence of three severe sudden commencement (SC) type magnetic storms having Kp index 9 during the current solar cycle number 23, the months of October, November of the year 2003 and November 2004 has a great importance for study of ionosphere. The maximum negative excursion of Dst for these three storms generally varied between 325 and 450. In this paper the study is restricted mainly to F-region parameters, namely foF2 (F–layer critical frequency) and h'F (base layer height of F- region).

A severe magnetic storm starts at 1143 LT on October 29, 2003 with a maximum negative excursion in Dst value -308 nT at 500 LT on October 30, and then it starts recovering which continue till late evening of 30th October and then another severe storm sets in with a maximum negative excursion of 347 nT at 300 LT on October 31, 2003. The fig.-1 shows the hourly value deviations in foF2 and h'F from the quite day values of the two locations along with Dst variation during the period of 28 October 2003 to 1 November 2003. From the figure it is clearly observed that, at Delhi, an enhancement was observed in foF2 and h'F from the quite day values and remain higher till midnight and then there was a sudden increases in h'F with sudden fall in foF2 observed, till about sunrise time which was contrary to day time behavior. During the recovery phase of storm, the daytime foF2 and h'F values shows sinusoidal variation like that of traveling ionospheric disturbances (TID's) While at trivendrum, the value of h'F decreases during the evening hours and become normal till the main phase was over and then a sudden enhancement was observed with the start of recovery period and become normal at sunrise hours but the value of foF2 starts collapsing with main phase and starts recovering with the recovery period of the storm. But before the full recovery of this storm another severe magnetic storm sets at 2200 LT when Dst value again falls to – 347 nT at 300 LT. During the main phase of storm a sudden increases in h'F without any significant change on foF2 was observed on Delhi data but a collapse on trivendrum foF2 was observed without any change in h'F value.

With start of the recovery phase the h'F value of Trivendrum starts increasing with fall in Delhi h'F data and become normal at both the station on same time.

Another severe storm occurred at around 1333 LT on 20 November 2003 with maximum negative excursion of Dst observed 429 nT around at mid-night hours on Nov. 20-21,2003. In fig.-2, top panel shows the variation in Dst value while middle and bottom panel shows corresponding deviations of h'F and foF2 from the quite day values of Delhi and Trivandrum. Similar to previous one an enhancement in foF2 observed from afternoon to sunset hours without any noticeable change in h'F but after sunset a simultaneous and sudden rise observed on both h'F and fof2 which then falls simultaneously just before midnight. After that again a sharp rise was observed in h'F value without any significant change in foF2 value, which coincides with maximum fall time in Dst value on Delhi data. But during the recovery phase, a large enhancement was again observed in foF2 values at Delhi from sunrise to sunset and then it becomes normal after sunset hours. In contrast to Delhi data, Trivandrum foF2 data shows an opposite behavior and showing corresponding decreases in foF2 values from the quit day values. It was observed that the variation in h'F at Delhi and Trivandrum has a sharp periodic increase and decrease from sunset to morning hours of Nov. 20-21 2003. In equatorial region only two peaks (enhancements) are observed just before and after the midnight hour (see fig.- 2).

The fourth biggest magnetic storm (Dst –383 nT) was observed in the month of November 2004 during the current solar cycle, which started at 1100 LT on Nov. 7, 2004. Fig.- 3 shows the plots of Dst variations (top panel) and h'F (middle panel) and foF2 (bottom panel) deviations from the quite day values observed at low latitude station Delhi for November 6-11, 2004. In this case, equatorial station, Trivandrum data is not available. During the main phase of the storm, a sharp collapse was observed in foF2 value from afternoon to midnight hours. After that a sharp enhancement was observed in foF2 values during forenoon hours on Nov. 8, 2004. During the main and recovery phase of second storm, foF2 values show a considerable enhancement from the normal quite day values. While the rapid enhancement in h'F value was observed from 1400 to 0000 hours during the main phase of the first storm (see fig.-3). Again, during second storm on Nov. 9-10, 2004 night, a sharp rise in h'F was observed around the period of Dst maximum negative excursion. As seen from fig.-3, the observed rise in h'F value in second case was higher than that of first rise. It is noted that when the value of h'F falls after every rise, an increase in foF2 values is observed and this trend in foF2 and h'F variations at low latitude station Delhi is similar to that of other two storms discussed above.

DISCUSSION

It is noted that the storm impact on F-region ionosphere varies with latitude. Sometime it is observed that there was a simultaneous rise on h'F value on both the location. So, it is proposed that the simultaneous h'F rise at equatorial and low latitudinal region can be a combine effect of two factors i.e. 1) Due to the reversal in equatorial electric field direction from westward to eastward during night time and 2) Because of equator ward meridional winds during magnetic disturbances which is otherwise mainly pole ward (northward) during the night. The observed result can be divided into two parts for better understanding. 1) The variation of foF2 and h'F during pre-midnight of the storm period and 2) The variation of foF2 and h'F during post–midnight period. During the noontime to pre-midnight period, it is found that the foF2 and h'F values increases simultaneously as compared to quite day value at low latitude region while at equatorial region, the deviation in foF2 was just opposite to the deviation in h'F value. This might be due to ExB drift at equatorial region. During the second magnetic storm (fig. 2), the value of h'F at both locations was higher than the quite day values at pre midnight hours but at equatorial region the enhancement was higher than low latitudinal region with collapse in foF2 value at equator, which is a significant evidence of upward ExB drift due reversal of usual westward electric field to eastward direction for a short duration [1,2], during the night time. While the value of foF2 doesn't shows any significant increases at Delhi, which indicating that equatorial plasma did not reached up to Delhi but still deposited to lower latitudes. The results of fig. 1 are in good agreement with combine effects of ExB and that of meridional wind. The meridional wind are the cross-equatorial winds driven by joule heating which pushes the F region ionosphere to a higher altitudes along sloping magnetic field lines at low latitudes which results the increases in ionization due to low loss rates whereas decreasing the plasma at equatorial latitudes due to horizontal magnetic field lines and physically carry it to on the other side of the equator. Simultaneously, the upward ExB lift the F-region ionosphere at the equator and deposited to low latitude region causing the observed collapse of foF2 at equatorial location. At low latitudes, the forced migration due to meridonal winds depleted plasma cannot be replenished either from below or above because it is nighttime. Hence, over low latitude station Delhi, the base of the F-region is also subjected to this driven force, because of the ion neutral coupling at lower F- region. This will cause an increase in h'F at low latitudes. From figure-1, it is clearly observed that the height of F-region increases at both the location but higher at low latitude with slight collapse in ionization at low latitude while higher in equatorial region. This might be due to the effect of meridional wind. But the enhancement of h'F with higher collapse in ionization might be due to upward ExB drift at equator on post midnight period [3]. In the case of third magnetic storm only Delhi data is available but most of the h'F and foF2 variations, especially the enhancement in foF2 followed by h'F enhancement as well as post midnight increases in h'F over there can be explained on the basis of above results except the collapse of foF2 on Nov. 7, 2004 when main phase of the storm was in progress (fig.-3).

CONCLUSIONS

The space weather effect at equatorial and low latitudinal F-region ionospheric parameters are studied in detail during three most severe magnetic storms of recent times, by using digital ionosonde data from two locations. During this study several striking features are observed but the most importantly the sudden collapse of ionization with increase of h'F in the post midnight hours at equatorial region and enhancement of ionization with increases of h'F during sunset to pre midnight hours at low latitude region. The results are explained on the basis of the reversal of westward electric field to eastward during midnight and post midnight hours, which enhance the upward E x B drift at equatorial location hours during the magnetic storm periods. The second possible reason is the equator ward maridonal winds, which drags the ionization from the lower side of the F-region causing the ionization decreases with increases in height due to drag of ionization.

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Figure-1

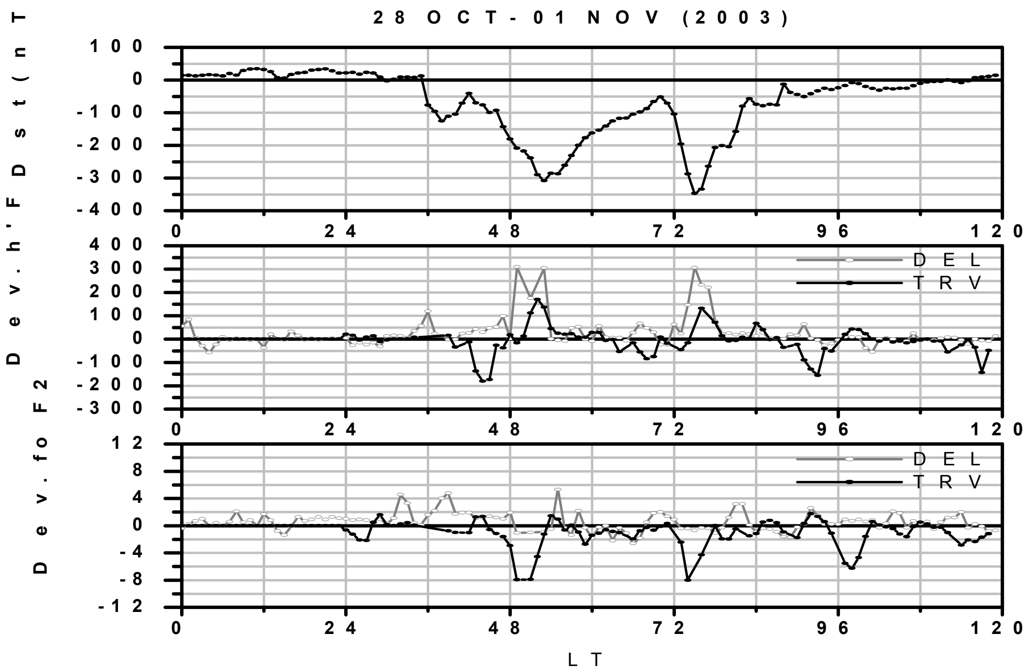


Figure-2

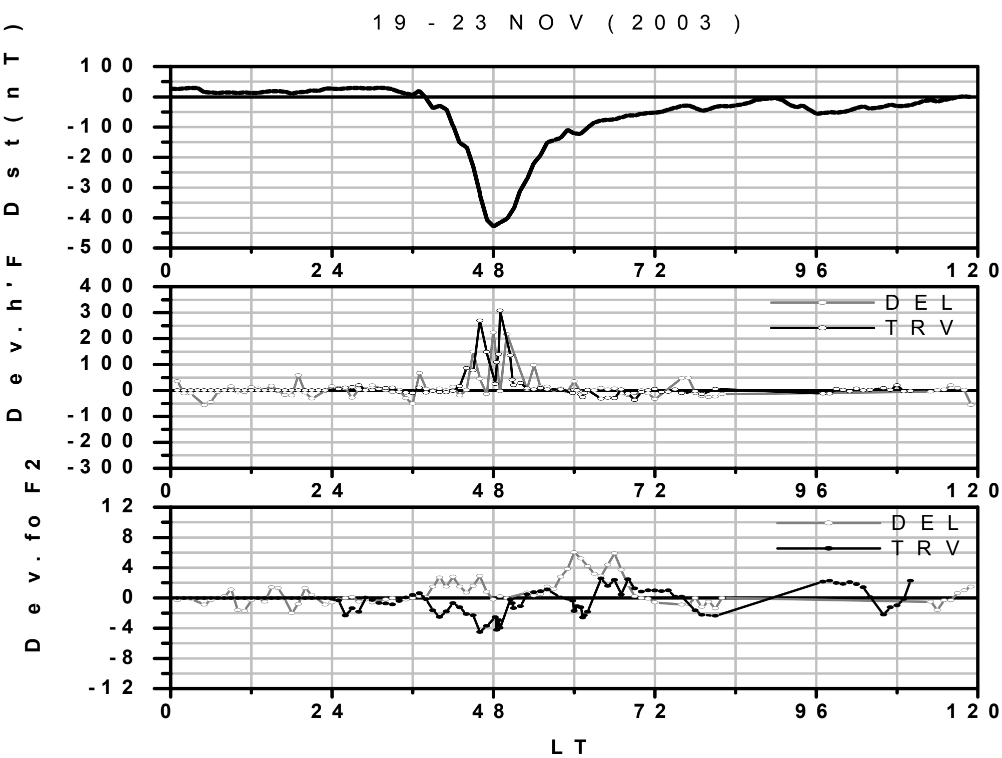
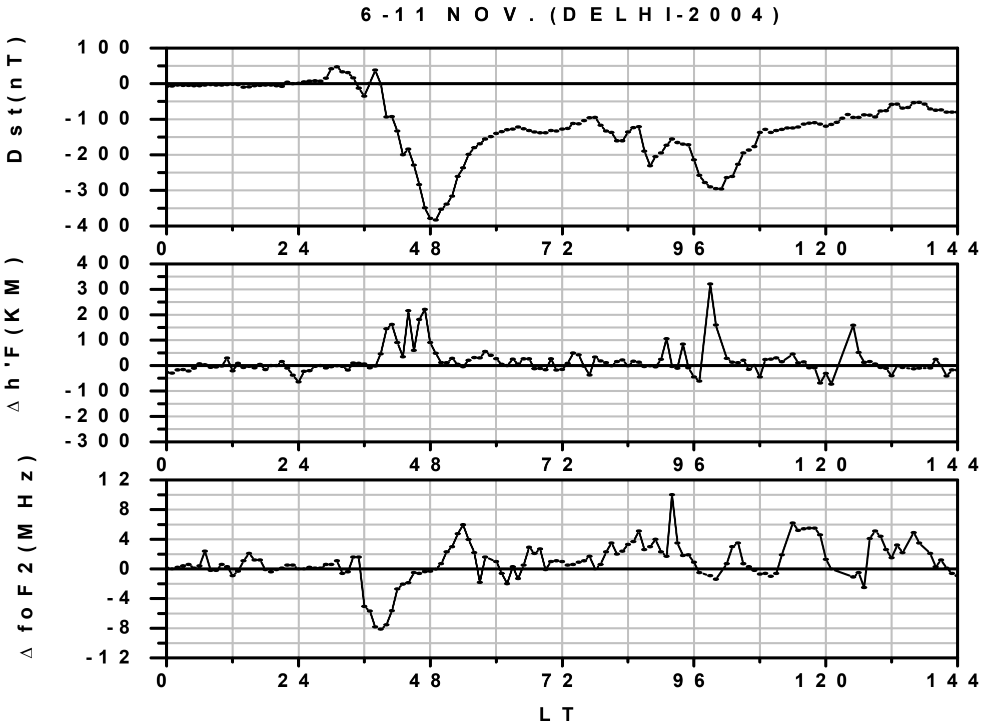


Figure-3



6-11 NOV. (DELHI-2004)
Dst(nT)
100
0
-100
-200
-300
-400
Δh'F(KM)
400
300
200
100
0
-100
-200
-300
ΔfoF2(MHz)
12
8
4
0
-4
-8
-12
0
24
48
72
96
120
144
LT