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Stormtime Variation of TEC over Waltair

D NRU, P V S RAMA RAO, K NIRANJAN & M SRIRAMA RAO
Department of Physics, Andhra University, Waltair 530 003

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TEC measurements made at Waltair (17·7°N; 83·3°E) using the telemetry signal from the ETS-II geostationary satellite at 136·1123 MHz are used to study the stormtime variation of total electron content (TEC) during 21 SC type of geomagnetic storms pertaining to the period Mar. 1978—Feb. 1979. It is found, from these measurements, that the effect of a geomagnetic storm on TEC is to increase in the case of daytime storms and decrease in the case of nighttime storms. The percentage increase is proportional to the main phase magnitude. During winter the increase in TEC is more and during summer the increase is less and delayed.

1. Introduction

It has been established that geomagnetic storm produces appreciable changes in the maximum ionization density of the F2 layer.[1,2] It has also been found that the variation of N_mF2 during magnetic storms depends on the latitude of observation. At high latitudes the results show an increase followed by a decrease, and at low latitudes and equatorial stations the results show only an increase in N_mF2 followed by a gradual recovery. However, Matshushita[3] has reported that, for a latitudinal belt of $\pm 10°$, there is a decrease in the values of N_mF2 during the first six hours and then it increases above the average values. He has also reported that, for weak storms, the decrease is less and lasts for a period of two hours. Rajaram and Rastogi[2] showed that the prestorm N_mF2 values are mostly above average and the post-storm values show a seasonal dependence with maximum enhancements in winter.

Kane[1] observed that there is a local time dependence of the storm commencement on the changes of N_mF2. From his results for low latitude stations it is observed that there is an increase in N_mF2 for the daytime storms, and that there is either a decrease or an inconsistent behaviour in the N_mF2 values for the nighttime storms. Thomas and Venables[4] have studied the storm effects, by setting the main phase onset (MPO) time as the zero hour, and showed that the N_mF2 values are either above or below the normal values depending on whether the MPO occurs during daytime or nighttime.

The effect of magnetic storms on the ionospheric total electron content (TEC) has also been studied using the radio signals from orbiting as well as geostationary satellites. From the measurements made at Auckland (New Zealand), a midlatitude station, Thitheridge and Andrews[5] noticed an increase in the TEC value during the first day of the storm followed by a sharp decrease during the next two to three days, attaining the average normal value on the fifth day. From a study of 28 magnetic storms pertaining to the period 1967–70 at a midlatitude station, Mendillo[6] showed that the changes in TEC measurements correlate better with the local measurements of the total geomagnetic field (*F*). From the analysis of the data of two low latitude stations (Hongkong and Manila) Walker[7] found that the effect of a geomagnetic storm on TEC is less compared to that on N_mF2. From the TEC measurements made in Indian subcontinent Jain *et al.*[8] and Basu *et al.*[9] found an increase in TEC during first day of the storm followed by a decrease. They have also observed a seasonal dependence of the stormtime changes of TEC, the first day increase being more during winter months.

In this paper we report the results of our investigations on the stormtime changes in TEC observed at Waltair during 21 SC type of geomagnetic storms.

2. Method of Analysis

Faraday rotation data obtained on a continuous basis at Waltair (geomag. lat. 7·3°N), a low latitude station, by recording the VHF signal (136·1123 MHz) from the ETS-II Japanese geostationary satellite for the period Mar. 1978-Feb. 1979 were used for the present study. Storm data of Hyderabad, a station nearby to Waltair, were taken from the *Solar Geophysical Data Bulletin* published by NOAA every month from Boulder, USA. In all, 21 sudden commencement (SC) type of storms pertaining to the said period were chosen for the present study. Although many storms have occurred during this period these 21 storms were found to be independently free from the overlapping of a second storm. In order to study the effect of a geomagnetic storm on TEC (N_T) the average value of TEC for five quiet days ($A_p \leq 6$) for the month concerned was obtained and superposed over the diurnal variation of TEC during the entire period of the storm, i.e. from the time of SC to the recovery of the storm, which generally takes 3 days. Then these stormtime TEC values are subtracted from quiet day TEC values to get the stormtime deviations ($\Delta N_T = N_T - \bar{N}_T$). These deviations are studied as a function of local time and duration of the storm. Further, the seasonal dependence of these deviations are also studied.

3. Results and Discussion

From an examination of the TEC pertaining to the total period of the 21 storms, it is observed that there is an increase in TEC values soon after the main phase onset of the storm in the case of 17 storms and a decrease in the case of the remaining 4 storms. Further, the SC times of these 17 storms fall during daytime hours while for the remaining 4 storms the SC time falls during nighttime hours. This suggests that there is a local time dependence on the stormtime variation of TEC. Similar result has also been reported by Kane[1] from a stormtime study of N_mF2 variations in low latitudes.

Fig. 1 shows diurnal variation of (a) the TEC for the three day period 21–24 Feb. 1979 (solid curve) along with the average quiet day TEC (dotted curve), (b) the stormtime deviations of TEC ($\Delta N_T = N_T - \bar{N}_T$) for the above period and (c) the hourly equatorial Dst (in H) values during the above period relating to a typical daytime storm of 21 Feb. 1979. It is observed from Fig. 1 that there is a decrease in the values of TEC, by about 5 to 10%, soon after the main phase onset of the storm. In fact this increase is found to be conspicuous and sudden for all the storms reported here and lasts for only 2 to 3 hr. The observed delay in the starting time of this depletion and the time of main phase onset varied from a minimum of a few minutes to a maximum of about an hour in the case of the 17 daytime storms studied. This phenomenon is followed by an increase in TEC within a duration of about 3 to 4 hr. This increase is observed to persist for a period of 3 to 4 days after the commencement of the storm, reaching its peak value within 24 hr. This increase is found to be about 24% on the average, varying from a maximum of 53% in the case of a typical daytime storm to a minimum of 4% in

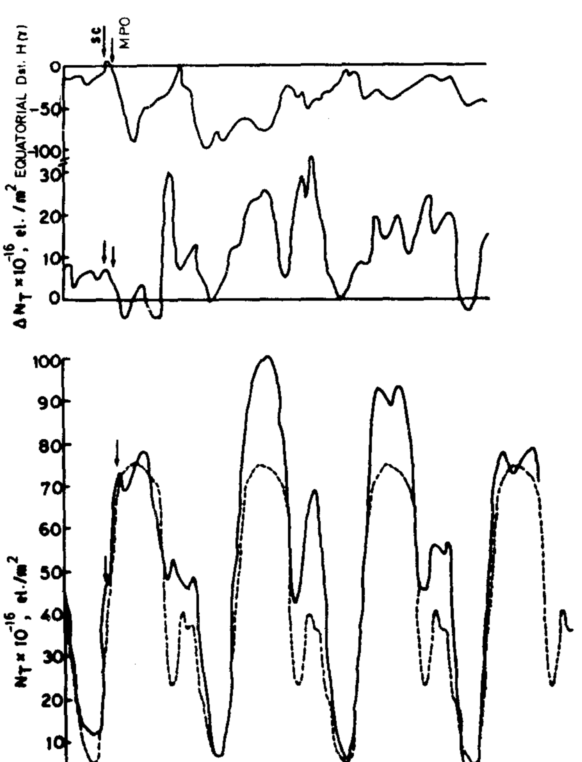

Fig. 1—Diurnal variation of N_T (solid line), $\bar{N}_T$ (dotted line), ΔN_T and equatorial Dst $H(\gamma)$ value during a typical daytime storm which occurred on 21 Feb. 1979

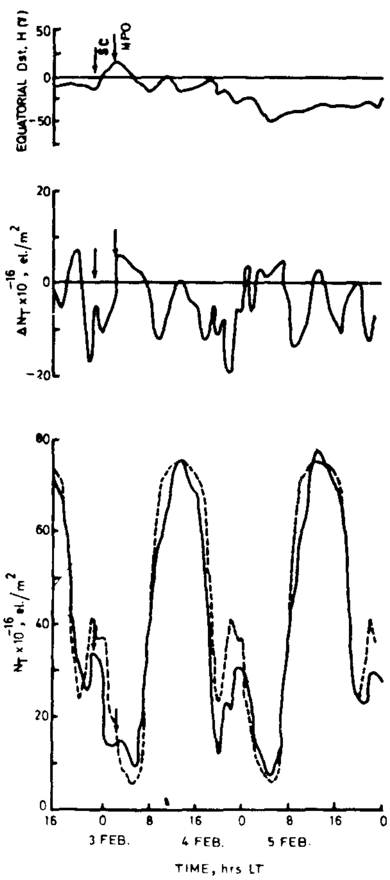

Fig. 2—Diurnal variation of N_T, $\bar{N}_T$, ΔN_T and equatorial Dst $H(\gamma)$ values during a typical nighttime storm which occurred on 3 Feb. 1979

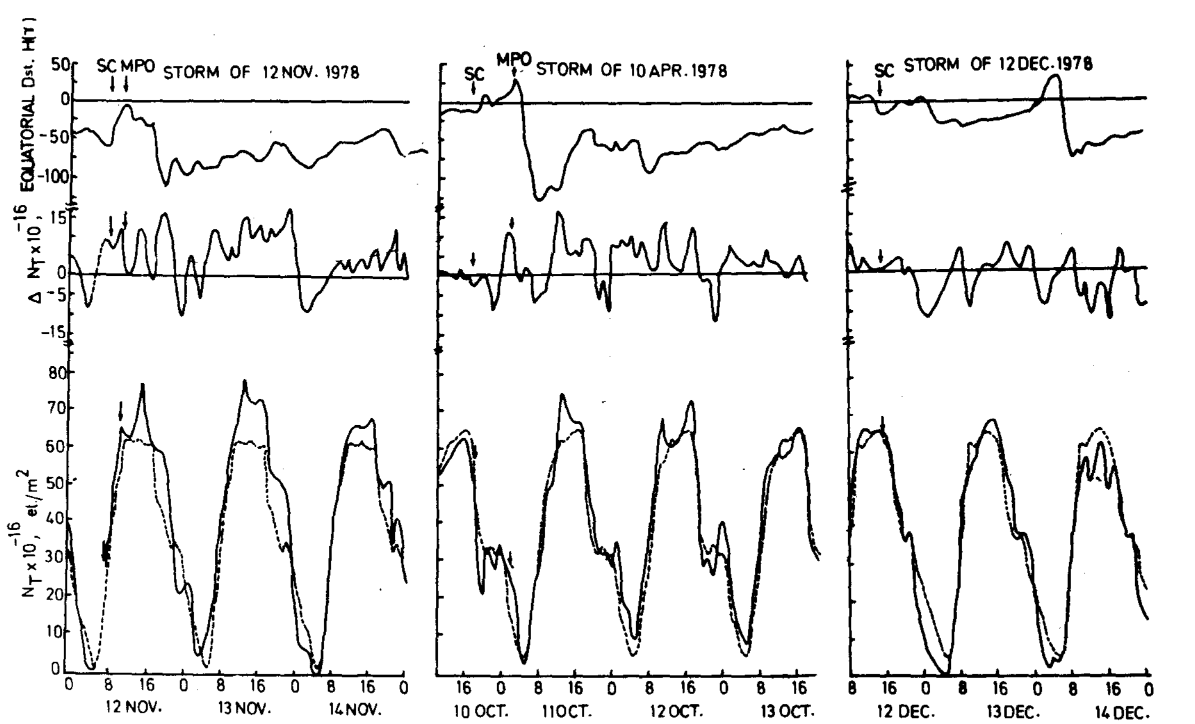

Fig. 3—Diurnal variation of N_T, $\bar{N}_T$, ΔN_T and equatorial *Dst* $H(\gamma)$ values during 3 different daytime storms with different main phase magnitudes

the case of a typical nighttime storm. A statistical measure of the day-to-day variation in the quiet day TEC, however, was found to be 5% on the average varying from a maximum of 8·2% to a minimum of 1·5%. Thus the observed stormtime deviations can be taken as significant. Further, this stormtime increase in TEC was found to be maximum during noontime hours and also during the nighttime hours when the enhancements are observed at this low station.

In Fig. 2 are presented (a) the diurnal variation of the TEC, (b) its deviation from the quiet day value and (c) the variation of the horizontal component of the earth's magnetic field for the period 3-5 Feb. 1979, corresponding to a nighttime storm which occurred at 2353 hrs on 3 Feb. 1979. It is observed from Fig. 2 that there is a decrease in the stormtime TEC (solid line) both during noontime hours and also during the nighttime hours when the enhancements in TEC are seen; while in the case of daytime storms the reverse (increase) is found to be true. This effect is also clearly seen in the ΔN_T graph [curve (b)], where the deviations are mostly towards the negative side of the X-axis.

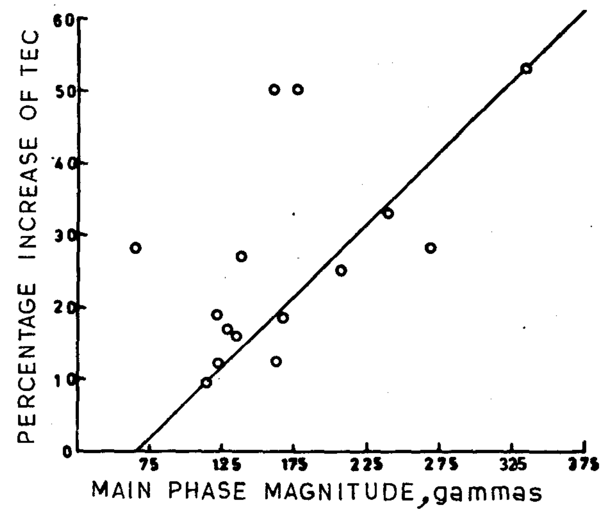

Fig. 4—Plot showing the relation between the main phase magitude and percentage increase in N_T during daytime storms

4. Relation between the Percentage Increase in TEC and the Main Phase Magnitude

In Fig. 3 are presented the data of three more daytime storms of different main phase magnitudes (strong, moderate and weak) with a view to study the extent of variation of TEC with the magnitude of the storm. It may be seen from Fig. 3 that the increase in TEC is proportional to the main phase magnitude of the storm. From a close examination of the deviations, ΔN_T, for the periods relating the 17 daytime storms studied, it is observed that the extent of deviation in N_T seems to have a dependence on the main phase magnitude of the storm. The maximum percentage increase in TEC [$(= \Delta N_{T\max}/N_{T\max}) \times 100$] observed in each of the 17 daytime storms is plotted as a function of the main phase magnitude and presented in Fig. 4. A best fit line drawn passing through these points suggests that there is a definite relation between the

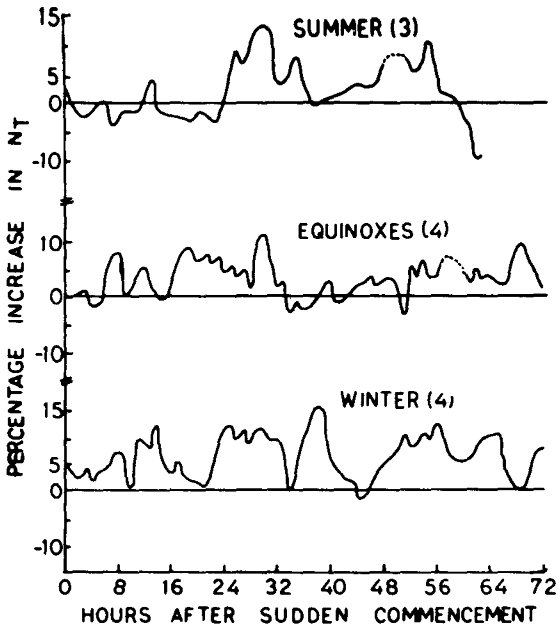

Fig. 5—Percentage variation of N_T during 72 hr after SC for 3 different seasons

above two parameters (ΔN_T% and main phase magnitude).

5. Seasonal Variation in the Stormtime Deviation of TEC

To study the stormtime behaviour of TEC during different seasons the data were separated into three different groups corresponding to the three different seasons, namely, winter, equinoxes and summer. The grouping of the different storms corresponding to the seasons was chosen in such a way that their sudden commencement times lie within a duration of 6 hr so that the effects, if any, due to local time dependence are eliminated. Thus, the number of storms useful for this study has come down to ten. Taking the sudden commencement time of the storm as the zero hour, the variation of ΔN_T, for a period of 72 hr, in three different seasons is computed and presented in Fig. 5. It may be seen from Fig. 5 that (a) the deviations in TEC (ΔN_T) are mostly positive in all the three seasons, (b) the enhancement is more significant during winter and (c) a significant enhancement starts only after 24 hr of the storm commencement during summer; whereas in winter the enhancement starts with the SC of the storm and it is delayed by a few hours (about 8 hr) in equinoxes. This result, however, needs further investigation with more data.

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