EFFECT OF GEOMAGNETIC STORMS ON VHF SCINTILLATIONS OVER NEAR EQUATORIAL STATION ANANTAPUR

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ABSTRACT

The dynamics and composition of the neutral thermosphere controlled by the difference sources of energy, some fundamental properties of the Geo-magnetic storms and their effects on the F-region ionization are discussed in this paper. The ionospheric electric fields and currents during both SC and GC types of geomagnetic storms and their importance are also presented in this paper. In the present study the scintillation data obtained from FLEETSAT radio beacon signal at 250.649MHz at near equatorial station, Anantapur (14.7° N, 77.7° E, and Dip 15.4 ° N) India, during some specific storm periods of varying strengths have been examined in association with the occurrence of maximum negative excursion of equatorial DST. The DST index, which is a measure of the ring current at low latitudes, has been used as a measure of the magnetic activity. The occurrence of maximum negative excursions in DST during the local pre-midnight and post-midnight hours is also presented in this paper.

Keywords: Geomagnetic storms, ionization, ring-current, magnetic activity

1 INTRODUCTION

The earth’s ionosphere can cause serious problems for many radio applications such as navigation systems, communication systems, and radio astronomy etc. The importance of "Space Weather" research in the scientific community is increasing widely. Thus the studies of geomagnetic storms have recently revived. The main objective of the programme is to understand the causes of magnetic storms in the Sun with the storm from the Sun to the Earth's upper atmosphere.

In addition to the ionospheric response to solar UV and EUV radiation during geomagnetic storms, the upper atmosphere receives energy and momentum from the solar wind through the magnetosphere, in the form of precipitating particles and electric fields. [3] reported that during magnetic storms, when the solar wind-magnetospheric interactions are enhanced, large-scale dynamical processes are set-in due to heating at high latitudes.

The thermosphere and ionospheric storms are the consequences of an increased level of geomagnetic activity. The general features of ionospheric storms, in particular F-region storms, have been reviewed by [5]. It is now well recognized that the ionospheric storm in low and mid latitudes is a manifestation of the changes occurring in the composition and dynamics of the thermosphere during geomagnetic disturbances. However, during certain times, the contributions due to protonospheric-fluxes and electric fields are also important, for example, during the initial phase of a storm the magnetospheric electric field penetrates to mid and low latitudes.

The solar wind energy dissipation at high latitudes causes a temperature increase, which in turn leads to expansion of atmospheric gases. This expansion produces vertical winds, which transport mass and energy to higher altitudes. A bulge in the density and temperature occurs above the region, where the energy was initially deposited, and sets up pressure gradients. Both mass and energy are transported by advection towards lower latitudes by
means of horizontal winds. A return flow exists in the lower regions to complete the circulation [4]. The upwelling of air tends to decrease the ratio of light gas to heavy gas concentrations and the down welling to increase it. Thus the observed composition changes have been thought of arising due to large-scale circulation [5]. The dynamics, composition and energy budget of the neutral thermosphere are controlled by six main external sources of energy (i) Solar UV and X-radiation (ii) Tidal energy propagated upwards from below (iii) Magnetospheric large-scale convection electric field that maps into the high latitude ionosphere (iv) Sub storm associated electric fields and ionospheric electric currents (v) Disturbance dynamo effects and (vi) Particle precipitation.

In the following sections, the magnetosphere and its associated disturbances such as magnetic storms are briefly discussed. The earth resides in a vast magnetic cavity, called the magnetosphere. The magnetospheric cavity is created by the electrodynamics interaction between the solar wind (a gas of charged particles continuously flowing from sun) and the earth’s magnetic field. The solar wind originates from the continuous hydrodynamic expansion of the solar corona and has a velocity of 400 km/sec and a density of 1-10 atoms/cm$^3$ at the orbit of the earth during quiet days. On active days, the density of the solar wind for a period of 10 hours or more may go as high as 30 atoms/ cm$^3$ and velocity as high as 1000 km/sec. The solar wind carries with it the interplanetary magnetic field (IMF) an extension of the general solar field, which takes up a spiral pattern in interplanetary space. Now it is well recognized that it is the arrival of the solar magnetic field which with an orientation anti-parallel to the earth’s day side magnetic field that causes the magnetic storms.

Geomagnetic storms have been classified into two groups, they are
- Storm sudden commencements (SSC’s) type
- Storm Gradual commencements (SGC’s) type

1.1 Storm sudden commencements (SSC’S)

The starting of the sudden commencement storms is characterized by a sudden increase in the horizontal component of the earth’s magnetic field (H), in the low and middle latitude magnetograms, due to a sudden increase in the usual quiet day compression of the geomagnetic field. The increase in compression propagates into the surface of the earth as an elastic or hydro magnetic wave and is known as the storm sudden commencement (SSC). The increase in H is typically 20-30 $\gamma$ although it may occasionally be as high as 50 – 200 $\gamma$. The sudden increase has a rise time of about 1-6 minutes. After this sudden commencement the storm shows typical time variations as initial, main and recovery phases before the end of the storm.

1.1.1 Initial phase

The continuation of the solar wind at a high level after the sudden commencement maintains the increased compression of the field, which is known as the initial phase of the storm. The initial phase lasts for about 2 to 6 hours.

1.1.2 Main phase

The initial phase is then followed by the main phase, which is characterized by a decrease of the mean value of H attained during the initial phase of the storm. A typical value of the main phase decrease may be in the order of 50-200 $\gamma$ although larger decreases occur in extreme cases and may last for 12 to 24 hours. This main phase decrease is caused by the flow of a westward current encircling round the earth at an altitude of about 3-4 earth’s radii during disturbance times and is known as the ring current. The available ground measurements of the disturbance field (DR) are recorded DST values [8]. The DST value is a sum of the disturbance field produced by the ring current, the tail current and the magnetopause boundary current (DCF). The occurrence of electric currents DR, DCF and tail currents is a consequence of the interaction of solar wind with the geomagnetic field. The boundary current enhances the earth’s main field and the enhanced field depends on the size of the magnetosphere. On the other hand, the ring current and the tail current reduce the earth’s magnetic field.

1.1.3 Recovery phase

After attaining a minimum value of H during the main phase, there is a slow recovery towards the initial undisturbed value with a characteristic time of about 24-36 hours.

1.2 Gradual commencement storms (GCS)

Geomagnetic storms of the second type namely the Gradual Commencement (GC) type show no clear indication of the onset and hence they are called gradual commencement storms which are characterized by the main phase only. Two types of disturbance fields, the field caused by the compression of the magnetosphere and the field produced by the ring current characterize these storms. The variability observed in the development of geomagnetic storms can be interpreted as due to a combination of these two fields in different ratios.
and with different growth and decay rates. This is possible only when the two fields are almost independent of each other. Magnetic disturbances such as magnetic storms and their associated effects on the ionized and the neutral plasma of the ionospheric F-region remains one of the interesting topics of study, the upper atmospheric physics.

These disturbances have profound influence on the global morphology of the upper atmosphere and they constitute one of the important links in understanding the complex solar terrestrial relations, since the energy is supplied by the solar wind. The study of solar-terrestrial relation is also of practical importance as the trans-ionospheric radio communications and satellite ephemeris predictions are severely degraded during these disturbances. Magnetic storms are important dynamical and electro-dynamical changes in the ionosphere resulting from the solar wind-magnetospheric interactions.

Although many experimental observations and their statistical results are available regarding the average behavior of storm phenomena, still there exist some scientific interest in the short term (transients) and long term ionospheric effects during individual storm events [1].

1.2.1 Magnetic Indices

The magnetic storms produces magnetic disturbances throughout the world are generally characterized by using various magnetic indices like $K_p$, $A_p$ and DST indices. The $K_p$ index will have a value between 0 and 9 assigned to a certain level of disturbance according to the observed global fluctuations in the magnetic field during a 3 hour interval of universal time (UT). The $K_p$ index is based on a quasi-logarithmic scale described in detail by [7].

The $A_p$ ranges give a representation of this index using a linear scale from 0 to 400 and the daily average calculated with respect to UT is the more commonly known $A_p$ index. $D_s t$ is the hourly measure of the globally averaged horizontal component of the earth’s magnetic field at low latitudes. Normally, $K_p$, and $A_p$ indices are more widely used than $D_s t$ because they are generally available in final form within a few weeks after the date of observation. According to the World Data Center in Boulder, Colorado the classification of magnetic storms DST values as shown in table 1.

<table>
<thead>
<tr>
<th>Type of storm</th>
<th>$K_p$</th>
<th>$A_p$</th>
<th>DST(nT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor</td>
<td>5</td>
<td>30-50</td>
<td>-30 to -50</td>
</tr>
<tr>
<td>Major</td>
<td>6</td>
<td>51-100</td>
<td>-50 to -100</td>
</tr>
<tr>
<td>Severe</td>
<td>7-9</td>
<td>&gt;100</td>
<td>-101 to 2005-06</td>
</tr>
</tbody>
</table>

Table 1. Classification of magnetic storms DST values

The remaining paper is organized as follows, section 2 deals with data and method of analysis, section 3 with results and discussion and section 4 and 5 deals with classification of a geomagnetic storms Aaron’s criteria and summary of results respectively.

2 DATA AND METHOD OF ANALYSIS

In order to investigate the effect of Geo-Magnetic Storms on F-layer irregularities and the resulting VHF scintillations, the data obtained from FLEETSAT Radio Beacon Signals (250.649 MHz) on a continuous basis at this low latitude near equatorial station Anantapur during the period from March 2005-February 06 covering all the seasons are used in the present study. The Storm data of Hyderabad (17.3° N, 78.5° E), Anantapur available from the Solar Geo-physical Data (SGD) on web site www.ngdc.noaa.gov.in is considered for the present study, since it is the closest location from Anantapur station.

A total of 50 magnetic storms of SC and other type occurred only pertaining to the period mentioned above are chosen for the present study. The maximum negative excursion of DST for these storms is varied between 2 and 262 nT. These storms are occurred 15 in Equinox, 23 in summer and 12 in winter. Though a large number of these storms occurred in the summer months, care has been taken to have adequate seasonal representation in the data sets chosen for the present study. The statistical classification of all the 50 storms at Anantapur, during 2005-06 is made as per the time of occurrence of maximum DST value. The storms selected are of varying intensities (weak, moderate and severe) belonging to different categories (I, II, III) occurring in different seasons (equinox, summer, and winter) during the period March 2005-February 2006incemt types (SC). The DST index, which is a measure of the ring current at low latitudes, is taken as an index of magnetic activity in the present analysis.

To investigate the influence of geomagnetic storms on the generation or inhibition of scintillations, 11 storm periods are selected for the present study. All the details of the storms selected for present study
are shown in table 2.

- Classification based on Intensity of the Storm: Out of these 11 storms selected, 2 storms are of moderate intensity, 5 storms are of severe intensity and 4 storms are of very severe intensity.
- Classification based on category of the Storm: Out of these 11 storms selected 5 belong to category-I, 5 belong to category-II and 1 belongs to Category-III.
- Classification based on Nature of Commencement of the Storm: Out of these 11 storms selected 6 come under sudden Commencement type remaining 5 are not specified under any type.
- Classification based on Season: Out of these 11 storms 3 are active during Equinox, 3 are active during winter and 5 are active during summer seasons.

Table 2. Particulars of the Geomagnetic Storms selected for the present study

<table>
<thead>
<tr>
<th>No</th>
<th>Storms</th>
<th>Type</th>
<th>Commencement</th>
<th>Peak Time</th>
<th>SC</th>
<th>Intensity</th>
<th>Dist Absorption</th>
<th>Cal For</th>
<th>H(γ)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equinox</td>
<td>SC</td>
<td>0100 0150 0200</td>
<td>0200 0250 0300</td>
<td>0400 0450 0500</td>
<td>155</td>
<td>Severe</td>
<td>62</td>
<td>GI</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Equinox</td>
<td>SC</td>
<td>0200 0250 0300</td>
<td>0300 0350 0400</td>
<td>0450 0500 0550</td>
<td>114</td>
<td>Severe</td>
<td>86</td>
<td>II</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>Equinox</td>
<td>SC</td>
<td>0300 0350 0400</td>
<td>0400 0450 0500</td>
<td>0550 0600 0650</td>
<td>200</td>
<td>Severe</td>
<td>335</td>
<td>I</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>Equinox</td>
<td>SC</td>
<td>0400 0450 0500</td>
<td>0500 0550 0600</td>
<td>0650 0700 0750</td>
<td>131</td>
<td>Moderate</td>
<td>262</td>
<td>II</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>Equinox</td>
<td>SC</td>
<td>0500 0550 0600</td>
<td>0600 0650 0700</td>
<td>0750 0800 0850</td>
<td>151</td>
<td>Moderate</td>
<td>262</td>
<td>II</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>Equinox</td>
<td>SC</td>
<td>0600 0650 0700</td>
<td>0700 0750 0800</td>
<td>0850 0900 0950</td>
<td>109</td>
<td>Severe</td>
<td>335</td>
<td>I</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>Winter</td>
<td>SC</td>
<td>0700 0750 0800</td>
<td>0800 0850 0900</td>
<td>0950 1000 1050</td>
<td>151</td>
<td>Moderate</td>
<td>262</td>
<td>II</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>Winter</td>
<td>SC</td>
<td>0800 0850 0900</td>
<td>0900 0950 1000</td>
<td>0950 1000 1050</td>
<td>109</td>
<td>Severe</td>
<td>335</td>
<td>I</td>
<td>50</td>
</tr>
</tbody>
</table>

3 RESULTS AND DISCUSSION

The variation of equatorial DST values data and the associated VHF amplitude scintillation data obtained from the 250.649 MHz signal from FLEETSAT satellite at Anantapur (Geomagnetic Lat. 14.7°N, Long. 77.6°E and Dip 15.4° N) for Five Day Period centering the peak active day of the storm for each storm are considered for the present study.

To illustrate the ionospheric response to magnetic storms, seven typical storms observed during daytime and remaining are observed during nighttime during the three different seasons, equinox, winter and summer are discussed below. All these storms are not preceded by any other event and offer a clean background. It is generally observed from this study that the scintillations are observed occasionally in very few cases on the storm day and very much frequently on the subsequent days irrespective of the night or day time storms.

3.1 Magnetic Storm of 3 April 2005

The storm occurred on 3rd April 2005 with H (γ) value equal to 135 is a severe storm falls under category -III with sudden commencement at 2230 hrs LT and reached its recovery phase by around 1800 hrs LT on 4th April. The maximum DST negative excursion of 42 nT occurred around 2300 hrs LT on 5th April 2005. The variation of equatorial DST along with the corresponding scintillations is shown in Fig.3.1.

It is observed that on the storm day (3rd April) and also before and after the commencement of the storm day scintillations are observed. On the subsequent day (4th April) after the recovery phase of the storm, there are scintillations for about two hours during the pre-mid and post midnight hours (2130 – 0600 hrs LT). Further, it is also seen that day time scintillations are also observed for about 30 minutes (1130 hrs – 1200 hrs. LT) on 5th April two days after the occurrence of storm, and this storm ends on 6th April 05 at 930 hrs LT.
3.2 Magnetic Storm on 15 September 2005

The data of equatorial DST variations, the data of VHF scintillations at Anantapur for a five day period centering the storm day 15th September 05 is presented in Fig.3.2. It is a severe storm with $H(\gamma)$ value equal to 116 and reaches its recovery phase on 18th September 05 at 0200 hrs LT and it falls under category II. It is a sudden commencement type storm with commencement time at 14:03 hrs LT on 15th September 05 and has maximum negative excursion of DST value equal to 86nT occurred around 23:00hrs LT on storm day itself.

The scintillations activity was observed two days before the storm on 13th September 05 during post-midnight scintillations of about two hours duration of 1900 to 2100 hrs LT and day time Scintillations around 1000 to 1400 hrs LT are observed. The pre and post midnight Scintillations are observed on the storm day also and the scintillation activity is extended further on subsequent 2days 16th and 17th September 05. Hence the storm has not inhibited the occurrence of scintillation and ends on 17th September 05 at 0530 hrs LT.

3.3 Magnetic Storm of 30 October 05

Fig.3.3 depicts the variation of equatorial DST and Scintillation activity for the storm occurred on 30th October 05 with commencement time at 1030 hrs LT and it is a severe storm with $H(\gamma)$ = 158 and it reaches its recovery phase by around 1600 hrs LT on 31st October 05 and it falls under category II. The negative maximum excursion of DST value of 262 has occurred at 1500 hrs LT on the same day and it reaches its recovery phase on 19th may 05 at 0430 hrs LT and falls under category II. Fig.3.1.4 shows the variations of equatorial DST and the corresponding scintillation activity.

It may be noticed that post-midnight scintillations from 0000 to 0600 hrs LT and day-time scintillations from 0600 to 0800 hrs LT and pre-midnight scintillations from 1830 to 1900 hrs LT are found and the scintillation activity is extended on subsequent days after the storm day during the post-midnight, day-time and pre-midnight on 16th and 17th may 05 and the storm ends on 16th may 05 at 2330 hrs LT.

3.4 Magnetic Storm on 15 May 05

The storm occurred on daytime hours of 15th May 05 at 0809 hrs LT is of severe commencement type storm with $H(\gamma)$ =374. The negative maximum excursion of DST value of 262 has occurred at 1500 hrs LT on the same day and it reaches its recovery phase on 19th may 05 at 0430 hrs LT and falls under category II. Fig.3.1.4 shows the variations of equatorial DST and the corresponding scintillation activity.

It may be observed that day time and pre-midnight scintillations are occurred two days before the commencement of storm that is 28th and 29th October 05.

The scintillation are observed on the storm day during pre-midnight from 1915 to 2000 hrs LT, on the subsequent days after the commencement of the storm 31st October 05 and 1st November 05 also pre and post-midnight scintillation activity is observed.
0400 hrs LT on 11<sup>th</sup> July 05, reaches its recovery phase by around 1400 hrs LT on 11<sup>th</sup> July 05 and it belongs to category I. The variation of equatorial DST along with the scintillations are presented in Fig.3.6, and noticed that the scintillation activity not found two days before the commencement of the storm on 8<sup>th</sup> and 9<sup>th</sup> July 05 and also on the storm day.

Figure 3.5. DST variation and occurrence of VHF scintillation data at Anantapur of the storm day of 14<sup>th</sup> June 2005

3.6 Magnetic Storm of 10 July 2005

The storm has occurred on 10<sup>th</sup> July 05 with sudden commencement at 0905 hrs LT has $H(\gamma) = 207$. It is a very severe type storm with maximum negative excursion DST of 88nT occurred around

On subsequent two days after the sudden commencement of the storm pre-midnight scintillation are observed 2245 to 2315 hrs LT and 2045 to 21 hrs LT on 11<sup>th</sup> and 12<sup>th</sup> July 05 respectively. Hence the storm has generated scintillation activity after its commencement.

3.7 Magnetic Storm of 24 January 06

The variation of equatorial DST values and occurrence of scintillation of the storm occurred on 24<sup>th</sup> Jan 06 0300hrs LT are presented in fig.3.7. the negative maximum excursion of DST 43nT occurs on 26<sup>th</sup> Jan 06 at 1000hr and it reaches its recovery phase on the same day at 1600 hrs LT and it falls under category I. it is a moderate storm with $H(\gamma) = 63$ and ends on 27<sup>th</sup> Jan 06 at 0430 hrs LT. No scintillation activity is present for two days before the commencement of storm.

Figure 3.6. DST variation and occurrence of VHF scintillation data at Anantapur of the storm day of 10<sup>th</sup> July 2005

Figure 3.7. DST variation and occurrence of VHF scintillation data at Anantapur of the storm day of 24<sup>th</sup> January 06

3.5 Magnetic Storm of 14 June 2005

The storm occurred on 14<sup>th</sup> June 05 at 0006 hrs LT is SC type and severe storm with $H(\gamma) = 151$. The negative maximum excursion of DST of 58 nT occurred around 2000 hrs LT on 15<sup>th</sup> June 05. It reaches its recovery phase around 2100 hrs LT on 15<sup>th</sup> June 05 ending on 17<sup>th</sup> June 05 at 0530 hrs LT and it belongs to Category-II. The variation of equatorial DST and presence of scintillation activity is as shown in Fig. 3.5 it is observed that pre and post-midnight and day-time scintillation are occurred from 2215 to 0000 hrs LT and 0600 to 1000 hrs LT on 12<sup>th</sup> and 13<sup>th</sup> June 05 respectively two days before the commencement of the storm. But on 14<sup>th</sup> June 05 after the sudden commencement of the storm the scintillation are inhibited.

Figure 3.4. DST variation and occurrence of VHF scintillation data at Anantapur of the storm day of 15<sup>th</sup> May 2005

3.6 Magnetic Storm of 10 July 2005

The storm has occurred on 10<sup>th</sup> July 05 with sudden commencement at 0905 hrs LT has $H(\gamma) = 207$. It is a very severe type storm having maximum negative excursion DST of 88nT occurred around
Aarons hypothesized three basic effects of the ring current in the generation or inhibition of equatorial F-layer irregularities during magnetic storms. He categorized the storms into three different types as follows:

- **Category-I:** If the recovery phase in the DST started during the local daytime hours (preferably between 1000-1600 hrs LT), both scintillation and spread-F activities were found to be inhibited (suppressed) completely or partially on the following night, depending on the magnitude of maximum negative excursion of the DST. That is, if the maximum negative excursion of DST (peak of the magnetic storm) occurs during daytime hours preferably between 1000-1600 hrs LT) and well before sunset, the normal height rise of the F layer gets disturbed and hence the irregularities are inhibited on the following night.

- **Category-II:** If the recovery phase in the DST started during the midnight-dawn (0000-0600 hrs LT), strong post-midnight scintillations extending usually well beyond sunrise hours were observed at locations from 84° E to 122°E longitudes over a wide latitudinal belt up to 21° N. That is if the maximum negative excursion of DST (peak of the magnetic storm) occurs during the midnight-dawn (0000-0600 hrs LT), the F-layer height first rises and then falls which generates irregularities.

- **Category-III:** If the recovery phase in the DST occurs during sunset-midnight (1800-0000 hrs LT), the occurrence of usual nighttime scintillation activity was found to be unaffected. That is if the maximum excursion of DST (peak of the magnetic storm) occurs after sunset - midnight (1800-0000 hrs LT), the F-layer height is not disturbed, and hence the irregularities occur as they do on an undisturbed night. However, it is found that the scintillation activity remains unaffected during the main-phase of the magnetic storm.

The classification on the percentage of these storms satisfying Aarons Criteria (Aarons, 1991) in generation or inhibition of scintillation activity are given in Table 4.
TABLE 4.1 Classification of Geomagnetic storms satisfying Aaron’s criteria For the years 2005-06

<table>
<thead>
<tr>
<th>Type of the storms</th>
<th>No. of SC and other type of storms</th>
<th>Storms satisfying Aaron’s criteria</th>
<th>% of storms satisfying Aaron’s criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>15</td>
<td>9</td>
<td>60.0%</td>
</tr>
<tr>
<td>II</td>
<td>17</td>
<td>8</td>
<td>47.0%</td>
</tr>
<tr>
<td>III</td>
<td>18</td>
<td>10</td>
<td>55.5%</td>
</tr>
</tbody>
</table>

4.1 Magnetic Storm on 23 January 06

Fig.4.1 shows the variations of equatorial values of Dst scintillation activity from 21st to 25th Jan 06. The commencement of the storm occurred on day-time during 0730 hrs LT on 23rd Jan 06. With H (γ) =81 is a moderate storm. At about 1100 hrs LT the Dst value started decreasing and attained maximum negative excursion of 20 nT around 1700 hrs LT and no scintillations have been observed on two days before the commencement of the storm 21st Jan 06 and 22 Jan 06 and also on storm day 23rd Jan 06.

But on subsequent two days after the commencement of the storm pre-midnight scintillations observed during 1800 to 1900 hrs LT and 2245 to 2315 hrs LT on 24th Jan 06 and 2145 to 2300 hrs LT on 25th Jan 06 may be, due to the changes in height of the F-layer by the magnetic effect the storm.

4.2 Magnetic Storm on 07th May 05

The storm occurred on 7th May 05 at 0045 hrs LT is a very severe storm with H (γ) = 204. The variations of equatorial values of DST and associated scintillation activity from 05th to 09th May 06 are presented in fig 4.2.

The storm attained maximum value of 111nT on 09th May 05 after mid-night hours around 0200 hrs LT. no scintillation activity present during pre, post-midnight hrs LT 1845 to 2015 and 0000 to 0600 hrs LT on 8th May 05 and the post-midnight scintillation activity extended during the day time 0600 to 0800 hrs LT on 9th May 05 and pre-midnight scintillations observed on 9th May 05. This justifies Aarons Criteria II.

4.3 Magnetic Storm on 11th September 06

The occurrence of storm during 9th to 13th Sep 05 shown in fig 4.1.3. is an example of storm satisfying Aarons criteria III. The sudden commencement of the storm is at 0642 hrs LT on 11th Sep 05 is a very severe storm with H (γ) =207 and attains maximum Dst value of 85nT around 2300 hrs LT on same day. The time of maximum excursion of Dst, which took place between sunset and pre-midnight, no scintillations are observed on subsequent days after the occurrence of the storm.

A statistical classification of all the 50 storms at Anantapur during March 2005-February 2006 is made as per the time of occurrence of maximum Dst value. The classification on the percentage of these storms satisfying Aarons criteria [1] in generation or inhibition of scintillation activity are given in Table 4.1.
5. SUMMARY OF RESULTS

Studies on the magnetic storm time behavior of night time scintillations during the geomagnetic storms studied during the period 2005-2006 at the low latitude near equatorial station Anantapur has revealed the following features as per the Aaron’s criteria.

1) It is observed that the scintillations occur occasionally on the storm day and frequently on the subsequent on both sides of storm days irrespective of the SC of the storm type occurs during night or day time.

2) Scintillation activity is observed in the pre-midnight hours during the recovery phase of the storm if it starts in the midnight hours, whereas scintillation activity is suppressed if the recovery starts during daytime.

3) Out of 50 storms that are considered for the present study, three typical storms classified according to Aaron’s criteria are considered for the further study to investigate their association with the ionospheric scintillation activity and their occurrences revealed some interesting results, which are listed below.
   i) As per Aaron’s criteria of category - I type of storms, if the maximum excursion of DST occurs during day time hours and well before sunset irregularities are inhibited on that night (Fig.4.1.1) it may be due to no disturbance in the height of ionospheric layer.
   ii) As per Aarons criteria of category - II type of storms, if the large excursion of DST occurs in the midnight to post-midnight time period, the F-layer height rises and falls irregularities are generated (Fig. 4.1.2).
   iii) As per Aaron’s criteria of category - III type of storms, if the large excursion of the DST takes place after sunset and before midnight the ionospheric scintillations occur as if they occur on an undisturbed night (Fig.4.1.3).
   iv) Out of the total number of 50 SC type storms studied for the Aarons criteria as the basis nearly 55% of the storms have satisfied the categories I, II & III. However, in the rest of the 40 to 50% cases have no specific and consistent results are observed.

Thus there is a necessity for further in depth study of the effect of magnetic storms in the generation or inhibition of ionospheric irregularities particularly keeping in view the effect of ring current on the altitude changes of the ionospheric F-layer.
REFERENCES
