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Study of VHF Ionospheric Scintillation During Geomagnetic Storms at Udaipur

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Abstract Space weather refers to the conditions on the sun and the solar wind, magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space-borne and ground technological systems and can endanger human life or health. In this paper VHF amplitude scintillation recorded during the period 1991 to 2001 at low latitude Udaipur (24.60 N, 73.70 E, Dip angle 35 degree) are analysed to study the behaviour of ionospheric irregularities during active solar periods and magnetic storms. During a geomagnetic storm, the Sun and the magnetosphere are connected, giving rise severe changes both in interplanetary space and terrestrial environment. In the present study an attempt is made to further understand some of the observed storm time effects in terms of scintillation index and solar disturbance. It opened up new ways because observations in the interaction between the solar wind - magnetosphere - ionospheres during magnetic storms have progressed greatly. An attempt is made to identify and delineate the effects of a) storms on scintillation occurrences during Pre and post Mid-night Hours b) the development of generation and inhabitation of storm due to ring currents and c) the disturbance dynamo electric fields based on Aaron's hypothesis.

Keywords Ionosphere (Ionospheric Irregularities), Radio Science (Ionosphere Propagation, Space & Satellite Communication), Magnetic Storm, Dst Index

1. Introduction

A geomagnetic storm is a temporary disturbance of the Earth's magnetosphere caused by a disturbance in the interplanetary medium. However, the under- standing of the magnetospheric response to the solar wind variations is still an open problem, as it involves different mechanisms of energy release and multi-scale coupling phenomena..A geomagnetic storm is a major component of space weather and provides the input for many other components of space weather. The primary cause of magnetic storm is associated with interplanetary structures with intense, long duration and southward magnetic field allows solar wind energy transport into the earth's magnetosphere. A geomagnetic storm is caused by a solar wind shock wave and cloud of magnetic field which interacts with the Earth's magnetic field. The increase in the solar wind pressure initially compresses the magnetosphere and the solar wind magnetic field will interact with the Earth's magnetic field and transfer an increased amount of energy into the magnetosphere[5]. Both interactions cause an increase in movement of plasma through the magnetosphere (driven by increased electric fields inside the magnetosphere) and an increase in electric current in the magnetosphere and ionosphere[50].

Sun is a driving factor for the climate on the earth and the structure of earth's magnetosphere thus determining and influencing the near earth space environment. Therefore, the study of solar territorial relations is of great importance for our modern telecommunication system both based on earth and in space. Sun is a ball of gas and plasma where two forces are acting: gravitational force acts inwards and pressure acts outward. Let us consider a shell inside a sun; the lower boundary is at r from the centre and the upper at $(r+\Delta r)$. ΔA is a surface element and p_{out} & p_{inner} denote the pressure at r and $(r+\Delta r)$. The resultant force on such a shell is:

And $F_p = (P_{outer} - P_{inner})\Delta A.$

$$F_p = \left(P(r) + \left(\frac{dp}{dr}\right)\Delta r - P_{inner} \right)\Delta A = \left(\frac{dP}{dr}\right)\Delta r \Delta A \quad (1)$$

By dividing the net force F_{net} by $-\Delta m = -\rho(r)\Delta r \Lambda A$, we find the equation of motion of the shell:

$$\frac{-d^2 r}{dt^2} = g(r) + \left[\frac{1}{\rho(r)}\right]\left(\frac{dP}{dr}\right) \quad (2)$$

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And $F_p = (P_{outer} - P_{inner})\Delta A.$

If the acceleration is set to zero, the hydrostatic equilibrium becomes;

$$\frac{dP}{dr} = \frac{GM(r)\rho(r)}{r^2} \quad (3)$$

Central pressure of the sun is given by

$$P_c = \frac{3}{4\pi}\frac{GM^2}{R^4} \quad (4)$$

The high solar wind pressure had an important impact on the magnetosphere during storms. In particular, a clear anti-correlation is observed between the non-storm component of D_{st} and the long –term variation of the solar-wind dynamic pressure. This means that in the long term, the D_{st} index tends to increase when the solar-wind dymiac pressure decreases. This anti-correlation as an indication of that the long-tem non-storm variation of D_{st} is influenced by the tail current variation. The relation can be summarized as follows

$$D_{st}^* = D_{st} - b\sqrt{P_c} + c \quad (5)$$

Where D_{st}^* represents the pure magnetic-storm disturbance due to the ring current and the tail current, and P_c denotes the dynamic pressure of the solar wind. The temporal evolution of pure magnetic storm effect D_{st}^* can then be modeled as follows:

$$\frac{D_{st}^*}{\Delta t} = Q - \frac{D_{st}^*}{\tau} \quad (6)$$

Based on the study of Burton et al., the values of the parameters in Equation (5) and (6) have revised in several studies. For example, according to Xie et al.(2008), the parameters b and c in above equation are given as:

$$b\left[\frac{nT}{nPa^{1/2}}\right] = 4.2 + 3.5\exp\left[-R(E)\right] \quad (7)$$

$$c[nT] = 10.8 \quad (8)$$

Where E denotes solar wind electric field and R is the Ramp function given as

$$R(x) = \begin{cases} x & if \quad x \geq 0 \\ 0 & other\ wise \end{cases} \quad (9)$$

The solar-wind electric field E is given as $E = vB_s$, where v is the solar wind speed, and B_s is the southward component of the solar-wind magnetic field in the geocentric solar magnetospheric coordinate system. The parameter Q, which represents the evolution of D_{st}^*, can be given as follows as:

$$Q\left[\frac{nT}{h}\right] = -4.4\left(\frac{P_c}{3}\right)^{0.5} R\left[E - 0.49\right] \quad (10)$$

Finally τ is given as follows as:

$$\tau(hours) = \begin{cases} 2.4 \quad \exp\left[\frac{9.74}{(4.69+E)}\right] & if \quad E > 0 \\ 8.7 \quad \exp\left[\frac{6.66}{(6.04+P_C)}\right] & if\ otherwise \end{cases} \quad (11)$$

In 2012 Nakano et.al introduced a method which decompose the variation of D_{st} into three components as

$$D_{st} = D_{RC} - D_{MPC} + D_{base} \quad (12)$$

Where D_{RC} denotes the ring-current effect on D_{st}, D_{MPC} denotes the magnetopause-current effect, and D_{base} denotes a non-storm long-term components that is related to neither the storm-time ring-current nor the magnetopause current.

The magnetic polarity of the leading spot changes every 11 year there is a 22 years magnetic cycle. Spots appear as a magnetic flux tubes rises and intersects with the photosphere. The magnitude of the magnetic induction of 0.3T in the umbra and 0.15 T in the penumbra. The number of sunspots changes are related to sunspots and thus to magnetic activity. To measure the solar activity the sunspot number are related as shown below

$$R = k(\log g + f)$$

Here g denotes the number of sunspot groups and f the number of spots. The factor k is a correction which takes into account for the different instruments used for the determination of R. The sun loses continuously mass and this mass loss is called solar wind. The existence of the solar wind was first suggested to understand magnetic storms on the earth. During magnetic storm, the properties of the earth's ionosphere are modifies and radio communication can seriously become disrupted for some time after the observation ofsome violent activity on the suns such as solar flare. Such a perturbation cannot be caused by electromagnetic radiation form the sun because takes 8 minutes to reach the earth.

Solar wind also arose from observation of comet tails. These are produced when comets are close enough to the sumand the rails always point away from the sun. Originally, it was believed that radiation pressure produces the tails. If small particles in the comet absorb radiation from the sun they take up energy and momentum. If they subsequently emit radiation, this emission is isotropic into all directions and this will carry off no momentum- the matter will be pushed away from the sun and thus the dust tails are produced. But observations showed that there is also a plasma tail consisting of ionized gas. If sun emits a continuous stream of plasma, the ionized solar gas would collide with atoms-momentum is transferred and charge exchange reaction occur; an electron will be exchanged between the incoming charged particles and a neutral cometay particles which produced the plasma tail. Since the charged particles move around magnetic field lines, the plasma tail aligned with the local interplanetary field [47].

The solar wind varies in strength through the solar activity. It has an average speed at the earth of about 400km/s. the total mass loss is a few $10^{-14} M / year$. This is about 1 million tons of solar material flung out into space every second. The solar wind flows along the open magnetic field lines which pass through coronal holes. Additionally to the solar wind, the sun also losses mass by coronal mass ejections.

Let us consider the hot corona sits in static equilibrium on the top of solar atmosphere. In such a case the pressure gradient in the corona must be balanced by gravitation attraction of the sun;

$$\frac{dP}{dr} = \frac{GM(c)\rho(r)}{r^2} \tag{13}$$

We can also write

$$P = nkT_{kin} \quad \rho = mn \tag{14}$$

n is the number of particles per unit volume and m is the average particles mass and T_{kin} is the kinetic temperature of the corona which is far from thermodynamic equilibrium.

In the corona, conduction is important for energy transport if the k is the coefficient of heat conduction, then

$$k = k_0 T_{kin}^{\frac{5}{2}} \tag{15}$$

Where k_0 is constant. If there is no inertial release of heat in the corona, the outward flow of heat must be constant;

$$L_{cond} = -4\pi r^2 k_0 T_{kin}^{\frac{5}{2}} \left[\frac{dk_{kin}}{dr}\right] = cons\tan t \tag{16}$$

This equation can be integrated:

$$\frac{T_{kin}}{T_c} = \left(\frac{r_c}{r}\right)^{\frac{2}{7}} \tag{17}$$

Where r_c , T_c are radius and temperature at some point in the corona. Combining all four above equation one gets P and n as a function of r. when expanding this to the earth one gets a kinetic temperature of $5x10^5 K$ and a particle density of $4x10^8 m^{-3}$

If the material of the corona mover outward with a velocity v_r in the radial direction, then equation (4) together with (5) becomes

$$nmv_r\left[\frac{dv_r}{dr}\right] = \frac{d}{dr}\left[nkT_{kin}\right] - \frac{GnmM(c)}{r^2} \tag{18}$$

During coronal mass ejection large amount of solar material are propelled outward into interplanetary space, the interplanetary counterparts are the main cause of major interplanetary and geomagnetic disturbances [21, 22, 23, 25, and 26]. Gonzalez and Tsurutani[27]have empirically shown that a southward interplanetary magnetic field is the necessary condition in interplanetary space for the creation of an intense geomagnetic storm. Less intense storm require less duration southward IMF. In any case, a southward directed IMF is essential for the occurrence of a storm and the development of the ring current.

During the main phase of a geomagnetic storm, electric current in the magnetosphere create magnetic force which pushes out the boundary between the magnetosphere and the solar wind. The disturbance in the interplanetary medium which drives the geomagnetic storm may be due to a solar coronal mass ejection (CME) or a high speed stream of the solar wind originating from a region of weak magnetic field on the Sun's surface[37,47]. The frequency of geomagnetic storms increases and decreases with the sunspot cycle. CME driven storms are more common during the maximum of the solar cycle and CIR driven storms are more common during the minimum of the solar cycle[59].

During the geomagnetic storm, equatorial plasma irregularities and scintillations have been the subject of extensive investigations over the last several decades. These irregularities, which cover a very large range of scale sizes, often strongly affect the propagation of radio waves through the equatorial low latitude night-time ionosphere[46]. The generation mechanisms and the general morphology of these plasma irregularities and scintillations are now reasonably well understood. However, there is still considerable difficulty in the understanding of the large variability in their occurrence. The basic difficulty lies in the highly variable nature of the ionospheric electric field, which is the main instability driving mechanism. The low latitude and equatorial electric field exhibits strongest variations in the night-time sector and during geomagnetic storms [42, 43]. The effect of geomagnetic activity on the low-latitude ionospheric electric field and on the generation of plasma irregularities is season, solar cycle, and local time dependent. This dependence can only be understood by taking into account the storm-time dependent response of the ionospheric electric fields to magnetospheric disturbances. There have been many efforts to understand the ionospheric effects of solar weather events triggering the geomagnetic storms [17, 54].

As VHF radio waves scintillation is extensively used to study the sub-kilometre scale size plasma density irregularities. Effect of magnetic and solar activities on ionospheric irregularities are studied so as to ascertain their role in the space weather of the near earth environment in space [14].The amplitude measurement of VHF satellite signal at 250 MHz transmission from the geostationary satellite at 73 degree east have been continuously monitored for the study of VHF Scintillation occurrences at Udaipur, a station situated right at crest of the equatorial anomaly region, since 1986. Extensive studies on the occurrences and intensity of night time ionopheric scintillation have been made and reported over several stations by various workers. The role of geomagnetic storms on occurrences of VHF ionospheric scintillation are studied by Aarons [2] and suggested the three categories based on the local time of the start, the recovery phase as observed from variations in Dst below -75nT and the strength of storm.The size of a geomagnetic storm is classified as moderate (-50 nT >minimum of Dst > -100 nT), intense (-100 nT > minimum Dst > -250 nT) or super-storm (minimum of Dst < -250 nT).

2. Data Analysis

It is known that the combination of the storm and sub stormcaused some unique and well-correlated phenomena in the magnetosphere and equatorial ionosphere [55]. Moreover, other studies also observed that the magnetic sub storm is the set of phenomena during which a reduction in topological complexity in the tail regions takes place [8, 11].

The percentage occurrence of ionospheric scintillation of above 1dB peak to peak and SI(dB) have been calculated for the night time data of winter and equinoxes months during the year 1992 to 1993 in the declining phase of solar activity and year 1998 to 2001 in ascending phase of the next solar cycle. To study the role of geomagnetic storm and geomagnetic activity dependence, the equatorial Dst- index is used to represent the storm time development that is in main phase, recovery and initial phase [47].

For the equatorial ionosphere in the years of high solar flux, the F-layer parameters are such that irregularities are produced every night in specified months. It is generally accepted that changes in the ring current due to the passage of an interplanetary structure through it is the main cause for the global decrease in the Earth's equator magnetic field. The constituents of the ring current are energetic magnetosphere particles, localized near Earth plasma sheet and out –flowing inospheric plasma, which flow around the earth form east to west. The storm ring current condition is thought to be a consequence of two accumulated effects; the injection of energetic mageospheric particles by frequent occurrence of gametospheric sub storms, and the enhanced magnetospheric convection. Both ring current stretching occur during the storm main phase. Afterwards, there was no increase in the current population. Ring current during magnetic storms appears to play a major role directly or indirectly in establishing the conditions necessary for equatorial F-layer irregularity generation and inhibition. The hypothesis advanced is that for particular ionospheric propagation intersection, the local time when the peak excursion of the ring current occurs (its decay from maximum negative values), affects the equatorial electric field and therefore the height of the F-layer [32]. If the maximum ring current energy as shown by DST occurred during the mid night to post mid night period irregularities were generated. If the maximum DST, the period before recovery sets in, occurred in the early afternoon, irregularities were inhibited. If the maximum DST occurred around sunset or shortly after sunset, then there was no effect on the generation or inhibition of irregularities the ring current in the generation or inhibition of equatorial F-layer irregularities during magnetic storms. He categorized the storms in to three different types as follows:

Category –I

If the recovery phase in the DST started during the local daytime hours (preferably between 10:00-16:00 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 10:00-16:00 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 (00:00-06:00 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 (00:00-06:00 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 (18:00- 00:00 hrs LT), the occurrence of usual night-time scintillation activity was found to be unaffected**.** That is if the maximum excursion of DST (peak of the magnetic storm) occurs after sunset - midnight (18:00 – 00:00 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 2.

2.1. Scintillation Activity During the Geomagnetic Storms

Storm 1: 17-18 December 1992 (Category II)

In Figure1, Dst value shows maximum at 00:45 LT with -60 nT on 17th December 1992 , Scintillation is observed at early morning 00:00-04:15 on 17th December 1992 LT According to Aarons (1991) this was a Category 1 storm. The inhibition of regularities and scintillations on the night 17-18 December 1992 is associated with proceeding strongly positive with Dst index. The initial phase of the storm and subsequent main phase decrease was generated by positive solar wind electric field with negative Dst index. This behavior is likely associated with the intensification of the fountain effect, due to the penetration of an eastward electric field into the equatorial ionosphere, which forced a large amount of plasma to be uplifted at the magnetic equator and subsequently diffused along the magnetic field line toward higher latitudes [54].

Storm 2: 28 December 1992 (Category II)

The correlation between geomagnetic activity based on Dst index and scintillation occurrence has been investigated. From the figure we can see that scintillation occurrence is maul confined to periods of higher Dst index, and for periods with lower Dst index, there are nearly no scintillation occurrence. Figure 2 represent a case of scintillation activity during the daytime hours in correlation with Dst index. From about 08:00 LT on 28 December Dst value started decreasing and attained the lowest value of -120nT on the next day at 06:00 LT . It is seen from the figure that the scintillation occurred during the main phase as well as the recovery phase of the storm. During recovery phase of geomagnetic storms, the effect of disturbance dynamo fields could be discernible provided the wind circulation patterns are changed to the extent to produce fields of magnitude that are comparable to the ambient electric field at low and equatorial latitudes. Here the scintillation associated with a sharp decrease in Dst may be caused by a prompt penetration of the electric field into the equatorial ionosphere with a consequent sudden onset of irregularities [9]. These scintillations were associated with the southward Bz IMF. At this period the time delay was also more during the main phase of the storm than the recovery phase.From these results, it is suggested that the prompt penetration of westward electric fields into the equatorial latitudes drives strong vertical drifts, thereby lifting the F-layer to higher altitudes where the growth rate of the Rayleigh-Taykir instability maximizes. Consequently, this resulted in a sudden onset of VHF scintillations at Udaipur.

Storm3: 17-18 February 1993 (Category-I)

Here we present a case study of irregularities producing scintillations at Udaipur were triggered by a geomagnetic storm. The enhancements of vertical upward drifts due to the storm helped to create right conditions for irregularities to develop, and then induced the scintillations. In Figure3, Dst value shows maximum at 08:00 LT with 20 nT on 17th February 1992, 09:00 LT and minimum at 20 LT with -120 nT. According to [2] this was a Category 1 storm.

We can see from the figure that only on 17th February 1992, there was no scintillation activity observed up to 20:00LT but patches are created during 21:00LT to 03:30 LT. We found that the scintillation was collocated with the enhancement of the equatorial ionization anomaly (EIA); And coexistence of large and small scale irregularities at post midnight was also found.[2] have suggested that the occurrence of post midnight scintillation is enhanced if the recovery phase of storm starts at midnight down to the local time sector.

The results may be relevant regarding the influence of the equatorial ionospheric eastward electric field during geomagnetic storms. During the event VHF scintillation was strongly positive with Dst and a quiet recovery phase of the ring current [56, 57] .We can see from that the Dst index is associated with scintillation activity as the maximum variation occurred during the scintillation period. Thus, conditions for the generation of scintillation Influence of Magnetospheric and Ionospheric currents on radio wave scintillation during storm time activity during the storm recovery phase were not satisfied at this sector of the equatorial ionosphere.

Storm 4: 4-6 April 1993 (Category III)

In comparison to scintillation activity during above mentioned storm, maximum scintillation was observed but patchy nature during the storm that occurred on April 1993. First minimum for Dst value is 100nT which is observed at 00:45 LT on 4th of April. Then Dst drastically change to -160nT at 10:00LT then increased to -50nT at 03:00 LT.

Here also the suppression of scintillation was observed prior to maximum excursion of Dst, while enhanced activity occurred during the recovery phase of the storm. During the magnetospheric disturbances, coupling of the high latitude and the magnetospheric current systems with the equatorial electric fields possibly causes a direction reversal of the electric fields from westward to eastward[26,27]. This plays a significant role in the generation and growth of F-region irregularities and explains the magnetic storm induced post midnight scintillations extending into the daytime [9, 18, and 36]. The equatorial dynamo electric field is also disturbed during a magnetic storm and this also affects the irregularities. The behavior of the equatorial electric fields during a storm has been studied and attempts have been made to delineate the relative contributions of prompt penetration and disturbance dynamo electric fields [22, 23]. Influence of Magnetospheric and Ionospheric currents on radio wave scintillation during storm time condition.During Dst excursions in the premidnight period, the eastward electric field is enhanced and consequently, the F-layer along with the irregularities formed at the bottom of the Flayer are lifted upwards[24,35].

Example of scintillation activity under the magnetic storm following the Dst minimum, Occurring in the premidnight period is presented in table 1 &2. No scintillation activity was observed during the main phase of the storm. Here also the suppression of scintillation was observed prior to maximum excursion of Dst, while enhanced activity occurred during the recovery phase of the storm.According to present view, the intensity of the electric fields and currents at the polar regions, as well as the magnetospheric ring current intensity, are strongly dependent on the variations of the interplanetary magnetic field. The magnetospheric ring current cannot directly penetrate the equatorial ionosphere and because of this difficulties emerge in explaining its relation to scintillation activity.

Table 1. Effect of storms on scintillation occurrences during Pre Mid-night Hours

Dst (max)-ve During LT	Aaron's Criteria category number	Total no. of storms	No of storms showing				% of storm satisfying Aaron's hypothesis
			Inhibition	Generation	No	Effect	
10-16	First	27	14	01	03	07	≈67%
00-06	Second	22	16	01	01	04	≈77%
18-22	Third	15	03	00	09	03	≈80%

Table 2. Effect of storms on scintillation occurrences during Post Mid-night Hours

Dst (max)-ve During LT	Aaron's Criteria category number	Total no. of storms	No of storms showing				% of storm satisfying Aaron's hypothesis
			Inhibition	Generation	No	Effect	
10-16	First	27	04	10	06	07	≈77%
00-06	Second	22	00	18	01	03	≈87%
18-22	Third	15	01	08	02	03	≈80%

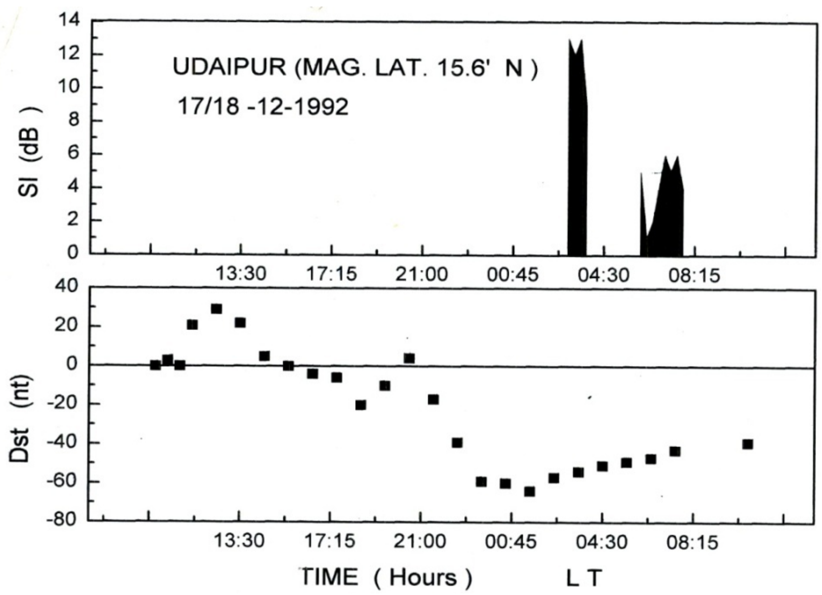

Figure 1. Temporal hourly Variation of SI(dB) along with Dst index observed during geomagnetic storm on over Udaipur (17-12-1992)

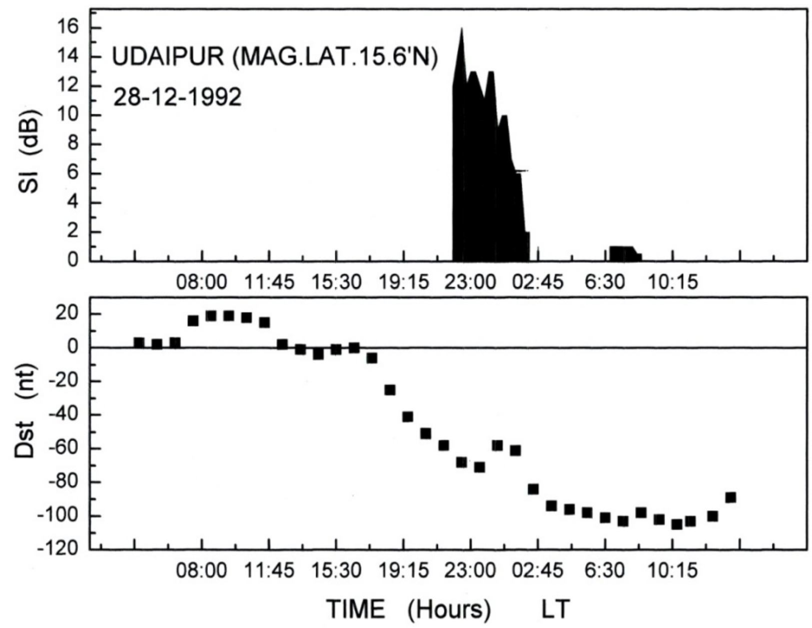

Figure 2. Temporal hourly Variation of SI(dB) along with Dst index observed during geomagnetic storm on over Udaipur (28-12-1992)

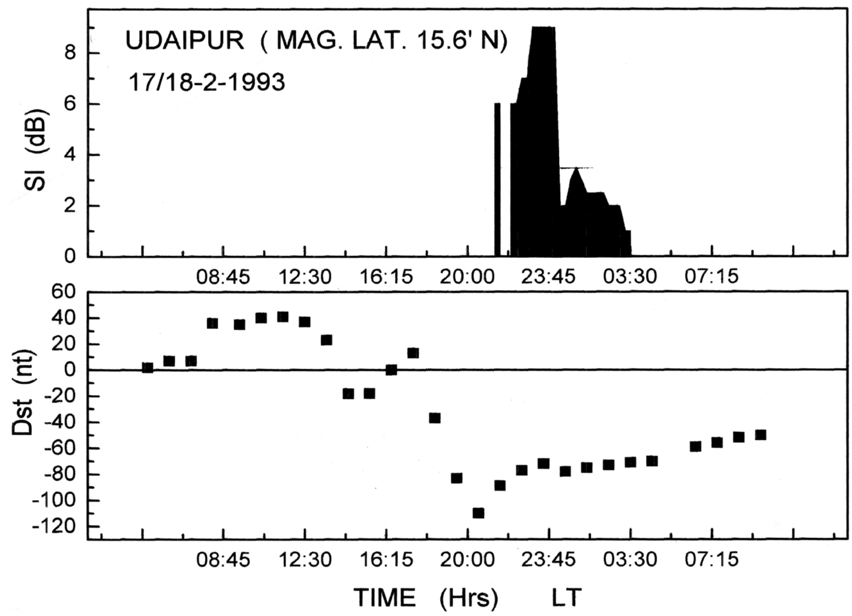

Figure 3. Temporal hourly Variation of SI(dB) along with Dst index observed during geomagnetic storm on over Udaipur (17-2-1993)

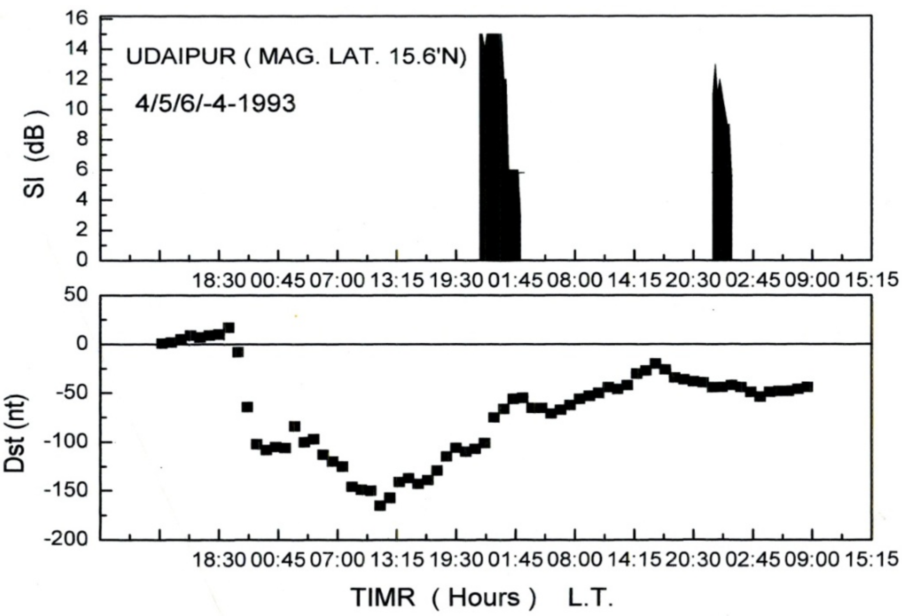

Figure 4. Temporal hourly Variation of SI(dB) along with Dst index observed during geomagnetic storm on over Udaipur (4-4-1993)

Investigation of ionosheric storms in connection with geomagnetic disturbances have been carried out for storms during the years 1993 until 2001.As to be seen in Table 1, during the chosen time period between 1991 and 2001 64 storms have been detected with above mentioned Aaron's criteria and are classified in to three types of magnetic storms. Category I and III satisfy the Aarons Criteria for about 72% and 82% satisfy the Aarons Criteria Category II, as evident from Table- 1 & 2. Night time VHF scintillation during different storms showed four different types of behaviours as observed from Table-1 & 2. The tables show that scintillation activity is found to be either inhibited or triggered during magnetic storms depending on the phase of the storms and its local time and also depending on the time of negative excursion of Dst index.The ionospheric scintillation activity is in general inhibited during pre-midnight hours during the various storms. However, the VHF ionospheric activity increases during the post mid night hours during the II category type of storms. Figures 1,2,3& 4 represent the typical example of variation of the Dst index and SI index with local time during magnetic storms. It is evident that during the recovery phase in post midnight to dawn local time hours, strong post mid night scintillation, which some time extends for several hours beyond the local sun rise. A pointed out by[25], during magnetic disturbances, large scale waves propagate efficiently form the remote high-latitude source region, and the strongest and most penetrating waves arise on the night side, where they are less hindered by drag from the low ion densities.

3. Discussion

In this paper, we performed a statistical study on specification of equatorial scintillation index during main phase of large magnetic storm. The generation or inhibition of irregularities during the main phase or recovery phase of a magnetic storm depends up on the location of the station and local time. If a storm occurs post-midnight, then scintillations are observed during main and recovery phase. On the other hand, when a storm occurs during the daytime no scintillation is observed during the night of the recovery phase. Weak scintillation observed during the recovery phase in some magnetic storms is attributed to freshly generated irregularities caused by disturbance dynamo effect. In the third case when a storm occurs after sunset and before midnight, the F-layer is disturbed but scintillations are observed only during the undisturbed night when Dst has recovered to the normal value. We have defined the phase of storm correspond to the three main categories. We fist illustrate inhibition, generation and effect of storm in connection with scintillation activity in equatorial region. It is well known that the eastward prompt penetration electric field becomes enhanced near sunset due to the day-to-night conductivity gradient. Such enhanced eastward electric field usually set off the Raleigh-Taylor plasma instability at F region depth and cause the formation of plasma bubbles and irregularities of electron density that give rise to scintillation of satellite signals. The combined effect of gravity and an east ward electric fields, in the presence of a vertical upward density gradient, can excite plasma instability in the night time F-region equatorial ionosphere. These instability generated density irregularities, which are commonly referred to as the equatorial spread F. During equatorial spread event, high plasma density magnetic flux tubes at the bottom side of the inospheric F region are thought to change places with lower density flux tubes form below in a situation analogous to R-T instability. This interchange of magnetic field creates a large-scale density perturbation locally, which rapidly penetrates through to the top side of the F-region due to the action perturbation electric fields that couples the ionosphere above the equation to lower altitudes, the electric fields of large scale irregularities are mapped along magnetic field lines, creating scintillation.

First we discuss individual magnetic storms that satisfy the Aaron's criteria. We then present a statistical study of with effect of storms on scintillation occurrences during pre mid night and post midnight hours and percentage of satisfying Aaron's hypothesis. The eastward prompt penetration of electric field at the magnetic equator during the main phase of storms becomes enhanced at dusk due to the conductivity gradient. Depending on the temporal and spatial variations, the neutral wind dynamo field that normally prevails at dusk near the magnetic equator may further enhance the east ward prompt penetration of electric field. Statistical analysis of Dst index and scintillation indices shows that most storms of the year have not triggered the scintillation occurrence at Udaipur.

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