Imperial Journal of Interdisciplinary Research (IJIR)
Vol-3, Issue-3, 2017
ISSN: 2454-1362, http://www.onlinejournal.in

Sawtooth Variation of Horizontal Component with Solar Wind Conditions at High-Latitude

Rajni Devi[1], Shailendra Saini[2], Ajay Dhar[3] and A.K.Gwal[4]
[1]Department of Physics, Sri Sai University, Palampur- 176061, India
[2] National Center for Antarctic & Ocean Research, (NCAOR), GOA Vasgo-degama-403804, India
[3] Indian Institutes of Geomagnetism, New Panval, Mumbai, India.
[4]Space Science Laboratory, Department of Physics, Barkatullah University, Bhopal-462026, India

Abstract: *- We have examined three well-defined events of sawtooth oscillations in solar wind and magnetic field at high-latitude. For this study we have taken data of H component collected from digital fluxgate magnetometer at localized region of "MAITRI" (geom. 62°S, 52.8°E), Antarctica during storms of August, October and November 2003. The observed H component variation is compared with the plasma parameters (proton density N and speed v) and vertical component of Interplanetary Magnetic Field (IMF), magnetic activity. Results show that before storm sudden commencement (SSC) time the magnitude of H component, auroral electrojet index, proton density and speed, IMF shows smooth variation but after SSC of first storm, these all parameters shows fluctuations and at 20:00UT it starts to increase, but during second storm occurred next day, the magnitude of H component indicates large fluctuations and it increases rapidly. During all three events, nearly simultaneous solar energetic particles, IMF enhancements and magnetic field variations occurred for each sawtooth cycle. Geomagnetic H component data at high latitude also show a global H increase simultaneously with solar wind particles, IMF and auroral elecrojet AE indices generally show increases at each sawtooth cycle. All these are what is expected if solar wind pressure enhancements impacted the magnetosphere at times appropriate to have caused the onset of each sawtooth cycle. Finally we are enabled the solar wind and IMF has been predicted swatooth variation of H component during magnetic storm cause intense geomagnetic storm.*

Keywords: *The solar wind, IMF, geomagnetic storm and substorms, swatooth variation of H component*
PACS No: *94.05. –a; 94.30.-d*

1 Introduction:-

The primary cause of magnetic storms is associated with interplanetary structures with intense, long-duration and southward magnetic fields (*Bs*) which interconnect with the earth's magnetic field and allow solar wind energy transport into the earth's magnetosphere[1]. The physical mechanism for solar wind energy transport into the magnetosphere is reasonably well understood. The coupling mechanism is magnetic reconnection between southwardly directed IMF and northward magnetopause fields[2]. Geomagnetic storms, as seen in *Dst*, commonly have three phases: a sudden commencement, a main phase, and a recovery. However, other than the fact that sudden commencements often precede the main phase, there is little relationship between them. Piddington [1963] noted that the size of sudden commencements was independent of the main phase minimum. Hirshberg [1963] found evidence for ring current enhancement without sudden commencements. Akasofu [1964], in addition, found that sudden commencements are not always followed by storm main phases or auroral activity.

Qualitatively, the relation between the various phases of a storm and the solar wind is becoming understood. It has generally been accepted that sudden commencements are associated with enhancements of solar wind dynamic pressure. Burlaga and Ogilvie [1969] found that sudden commencements were associated with hydromagnetic shocks in the solar wind. Empirically, the size of the sudden commencement was found to be proportional to the square root of the solar wind dynamic pressure [Siscoe et al., 1968; Ogilvie et al., 1968]. The Z component of the interplanetary magnetic field (IMF) has been associated with geomagnetic activity in general [Hirshberg and Colburn, 1969; Arnoldy, 1971; Foster et al., 1971] and the geomagnetic storm main phase in particular [Rostoker and Fälthammar, 1967; Russell et al., 1974]. Rostoker and Fälthammar [1967] found that the storm main phase was associated with a sustained southward B_z. Russell et al. [1974] found that the southward B_z had to exceed an apparent threshold level, possibly Dst-dependent, in order to trigger a storm main phase. Rostoker and Fälthammar [1967] also noted that the recovery phase was associated with a decrease or switching off of the southward B_z. Davis and Parthasarathy [19671 observed that the rate of recovery was related to the magnitude of Dst. Chapman and Rajarao (1965) showed that the seasonal variations of the range in H as well as in Z at the equatorial electrojet stations have strong semi-annual wave with maxima during equinoctial months. Rastogi (1993a) showed that the declination at Kodaikanal has remarkable regular daily, seasonal and solar cycle variations similar to H field and the two components are closely associated with each other. The studies of solar flare effects in H and D components at low latitude stations by Rastogi (1996a, 1999a) and Rastogi et al. (1999) have shown that the direction of magnetic field vectors on the horizontal plane due to solar flare remains practically the same as that of the pre-flare quiet-day solar daily variation vector (Sq). Thus, the meridional current during the flare producing the change of D flows in the same region of the ionosphere as the zonal current producing the change of H field.

Moos (1910) analyzed the data of the geomagnetic observatory at Colaba, India for an extended period 1846 to 1905. He identified well defined pattern in the so called “X disturbance” in the geomagnetic horizontal field (H), characterized by a sudden initial rise followed by a rapid decrease lasting a few hours and a slow recovery lasting 2 to 3 days. Chapman (1918) defined these disturbances as “ge-omagnetic storms” and the various phases of disturbance as sudden storm commencement (SSC), initial, main and recovery phase. Schmidt (1917) ascribed the decrease of H field during the main phase of geomagnetic storms to the effect of a westward current encircling the earth. Chapman and Ferraro (1931a, b, 1932a, b) suggested that geomagnetic storms are due to the impact on the earth of a ionized solar plasma bubble ejected from the sun. The decrease of H during main phase was suggested as due to the penetration of some of the plasma within the influence of the geomagnetic field forming a ring current around the earth. Singer (1957) suggested that the charged particle from the sun after penetrating earth’s geomagnetic field oscillate rapidly to and fro along the earth’s magnetic field between the mirror points in fairly high northern and southern latitudes. Due to nonuniformity of earth’s magnetic field along the path these particles drift around the earth, the protons moving westward and electrons eastward. These motions correspond to a westward equatorial ring current around the earth. Akasofu and Chapman (1961) evaluated the effects of a model radiation belt on the ring current and the geomagnetic disturbance. They suggested that, only axially aligned horizontal field needs to be used to define the world-wide storm-time effects. To derive the longitudinal symmetric and asymmetric components in H and Y fields during magnetic storm periods, Iyemori (1990) considered that the ring current flows parallel to the dipole equatorial plane. Since the realization of a continuous solar wind, the ring current is assumed to be present at all times, varying intensity depending on the storminess of the geomagnetic field. This cause the H field at any place on the earth to be decreased on geomagnetically disturbed days compared to quiet days. Sugiura (1964) standardized the procedure to derive the hourly means of Dst index for each day using the H data from eight well distributed low latitude observatories, which are not seriously affected by the currents in the ionosphere like the equatorial and auroral electrojet currents. The Dst index represents the strength of westward equatorial ring current at about 4–6 earth radii. Generally Dst index is negative and decreases (becomes more negative) with increasing storminess.

The geomagnetic disturbance effects at any particular station include variations related to both universal time and local solar time. The mean daily variations of geomagnetic field component on international quiet (IQ) days of the month and international disturbed (ID) days of the month are represented by Sq and Sd respectively, and then Sd-Sq designates the additional daily variations due to disturbances. It is called Disturbance Daily variations and is denoted as SD. In case of individual magnetic storm, the first impulse in magnetogram is indicative of SSC and is generally positive in the H field. The SSC effects in declination seemed to be absent (Akasofu, 1961). Subtracting the Sq variations from the geomagnetic field components on three days following the SSC and arranging these Sd-Sq values with UT beginning with the hours of SSC gives the storm-time variations of the components at the stations, denoted as Dst (H) and Dst (Y) variations. Vestine et al. (1947) studied the Sq and Sd variations of X, Y and Z fields at a number of stations. Obayashi and Jacobs (1957) studied the global morphology of SSC in the three components of the geomagnetic field, and identified an extra-terrestrial as well as an ionospheric component in the SSC. Simultaneous changes in D and H fields during a SSC were examined by Wilson and Sugiura (1961) and by Sano (1963) from the rapid run magnetograms taken during the IGY. Tsunomura (1998) has studied the characteristics of SSC in H and D components of the geomagnetic field at a number of middle and low latitude stations. He identified a negative impulse of SSC in H field superposed on the main impulse of SSC in H field just after its onset during daytime hours. He suggested this negative impulse as due to the polar originated ionospheric current system. Rastogi

(1999b) has described a comprehensive study of the SSC impulses in H, Y and Z fields at Indian observatories. The SSC in D at Alibag was shown to be westward for any time of the day or night. Magnetospheric storms and substorms are indicators of geomagnetic activity[2]. While many studies assert that during magnetic storm, the inner magnetosphere ring current response is a function of the solar wind electric field only[4], other have proposed that substorms and hence internal magnetotail dynamic play also a role in the process[2]. The question is significant both our understanding of the plasma environment of the Earth and for space weather predictions, which require detailed knowledge of the magnetosphere response to a given driver[5]. In other words, each cycle of periodic substorms has all well known characteristics of isolated substorms. The multiscale expansions and contractions of the magnetosphere create magnetic storms and substorms. They had been studied the evolution of the magnetospheric current systems during storms of varying intensity, specifically, addressed the long-standing issue of the relative contributions of the tail and ring currents during storms[6-8]. It was demonstrated that during moderate magnetic storms the tail current intensification is a major contributor to the Dst-enhancement. Interestingly, the energy input and output to and fro the magnetosphere were in balance such that the Dst index remained almost constant at the level of near -150 nT over a 24-hour period[8].

The effects of solar flares on the geomagnetic field records, vertical incidence pulsed ionosphere sounding records and earth current records all at an equatorial station Huancayo were first described by McNish (1937). He showed that the flare disturbance vectors in H were similar in direction to that of the pre-flare Sq (H) vectors. Rastogi et al. (1975) showed that some of the abnormal features of SFE in H were due to a partial counter electrojet at the start time of the solar flare. Rastogi (1996a) described the results of an extensive study of SFE in H and D at the equatorial station Annamalainagar over the period 1967±1976. During the normal electrojet period a solar flare produced a positive change in H, a negative change in Y and a negative change in Z.

Successively occurring enhancements in energetic particle fluxes and concurrent magnetic field changes are often observed at geosynchronous orbit during intervals of sustained southward IMF (Interplanetary Magnetic Field), such as geomagnetic storms and steady magnetospheric convection periods. These changes have become known as sawtooth oscillations, and they are currently a key issue in storm-substorm related research. Reeves et al. (2004) examined a sawtooth event on 4 October 2000 and suggested that the sawtooth oscillations were a sequence of storm-time substorms, which, together with the quasi-steady convection electric field, contribute to the storm development. Huang (2002) and Huang et al. (2003) studied several sawtooth events. They also suggested that sawtooth oscillations were a sequence of substorms and suggested that they had an intrinsic occurrence periodicity of 2–3 hours. They further argued that the impact of a solar wind pressure enhancement could trigger the onset of sawtooth oscillations, but, following the initial pressure impact, the remaining cycles of the sawtooth oscillations were determined by the intrinsic nature of the periodic occurrence of substorms.

Recently, we have found that solar wind pressure enhancements during southward IMF cause depolarization like changes of geosynchronous magnetic field on the nightside. These changes were found to occur nearly simultaneously with magnetic field compression on the dayside, with geosynchronous energetic particle enhancements observed on the nightside and dayside, and with global increases in the low-latitude H component of ground magnetic field. We thus argued that the solar wind pressure driven geosynchronous dipolarization is part of the global direct response to solar wind pressure enhancements, rather than part of the more localized response to a substorm (Lee and Lyons, 2004).

Taking advantage of this, we aim here to focus on some of the aspects of an solar wind particles and associated SSC and their related changes in the ionospheric conductivities and electric fields.

In this paper we discuss the H component variations of Earth's magnetic field at high latitude station "Maitri" during intense magnetic storms of August, October and November 2003 which were associated with solar wind, solar flare/CMEs. H component variation is compared with the plasma parameters (proton density N and speed ν) and vertical component of Interplanetary Magnetic Field (IMF) and magnetic activity (AE and Dst). We have found that the solar wind speed, density and temperature play a significant role in the modification of earth's magnetic field during disturbed conditions.

2 Data Selection and Methodology:-

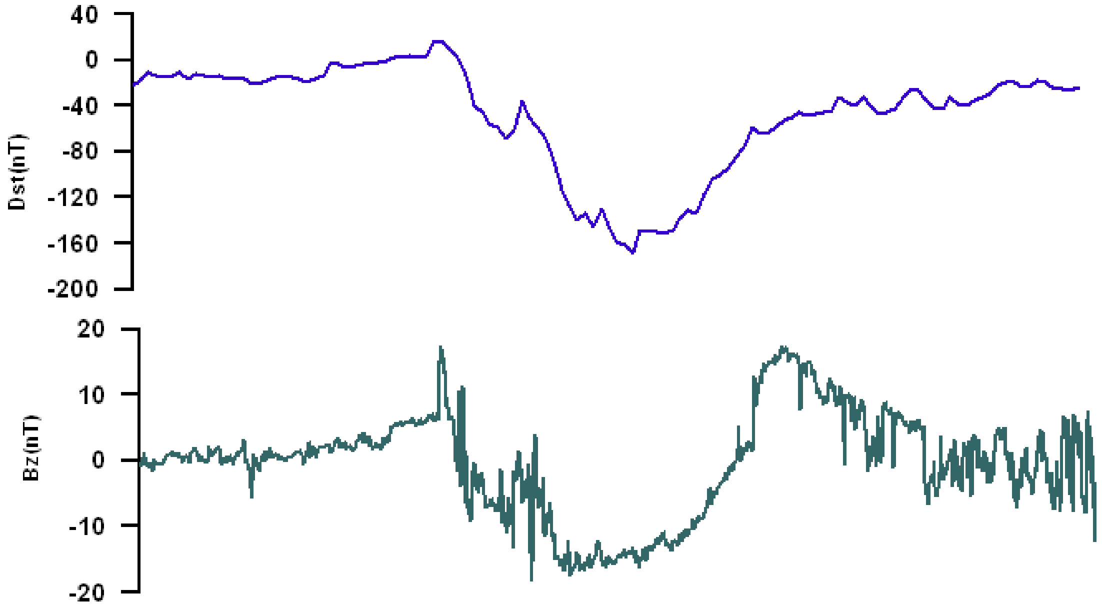
We studied three intense magnetic storms (Dst < -500 nT) that occurred during the years of 2003, we analyze a storm event of August 17-18, 2003 during which the Dst index was steady over an extended period of time. A ground base digital fluxgate magnetometer is used to collect the Earth's magnetic field at Southern Sub Auroral localized region "MAITRI" (geom. 62°S, 52.8°E). Global geomagnetic Dst and AE indices are taken from the World Data Center Service. Vertical component of Interplanetary Magnetic Field (IMF) and plasma parameters (solar proton density N and speed ν) values is taken from the Advance Composition

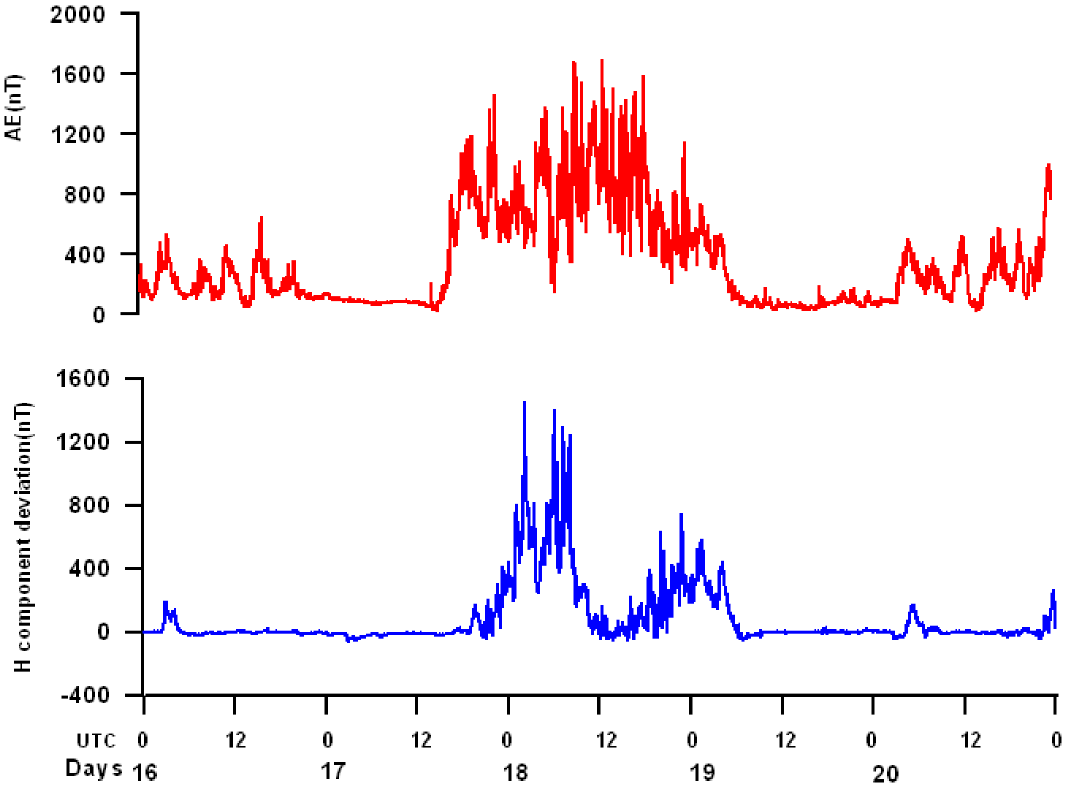
Explorer (ACE) Satellite Data Service of World Data Center. Days that are used for this work are storm days along with the preceding and succeeding days of equinox month of October, summer month of August and winter month of November of 2003.To study the H component deviation during storm time we have first calculated average of quite days H component as a reference of the storm month. With respect to that we have taken the deviation of H component, electrojet index (AE) of storm time and studied effect of vertical component of the Interplanetary Magnetic Field (IMF) and solar wind plasma parameters on it.

3 Observation and Results:-

16-21 August 2003:-

Figure 1 shows the variation of disturb storm time index with respect to Interplanetary Magnetic Field (IMF), proton density and speed, high-latitude magnetic activity auroral electrojet index (AE), H component deviation. There are eight panels in Figure 1 top panel shows the Dst of successive magnetic storm while second, third, forth, fifth, sixth, seventh and eighth panel has shown the variation in Interplanetary Magnetic Field, auroral electrojet index (AE), proton density and speed, H component deviation respectively. Graphs show the result of two magnetic storms dated 17 August and 19 August 2003. The upper panel of Fig1 shows the Dst variation for two magnetic storm. First storm begin at 14:21UT (19.51LT) on 17 August 2003, the second storm began at 17:20UT (22:50LT) on 19 August 2003. On 17 August at 18:00UT the main phase of storm is started at the same time when we observe IMF, proton density and speed, AE, H variation at "MATRI" we find that all the parameters show rapid fluctuation and this fluctuation is increased during main phase of storm. At 08:00UT on 18 August when disturb storm time (Dst), auroral electrojet index (AE), proton density and speed reached its maximum value of –150nT, -1700nT,10cm^{-3} and 400km/s H component shows maximum value of 1400nT and interplanetary magnetic field (IMF) move towards south and shows the value of -10nT. During the recovery phase of storm the auroral electrojet index (AE), proton density and speed , the magnitude of H component decreases and IMF move upward. After 23:00UT when these all parameters have smooth variations. But on 19 August 2003 at 07:00UT, all the other parameters return to their original condition at the instant interplanetary magnetic field (IMF) have small fluctuation in northward direction. Accompanying with this deviation in H component, auroral electrojet index (AE) and IMF shows that the fluctuation depends on the intensity of magnetic storm. Also the Earth's magnetic storm occurs when the auroral current intensity is very high in summer month. On 18 August H component shows sawtooth variations during main and disturbances is more due to high geomagnetic activity at high-latitude.





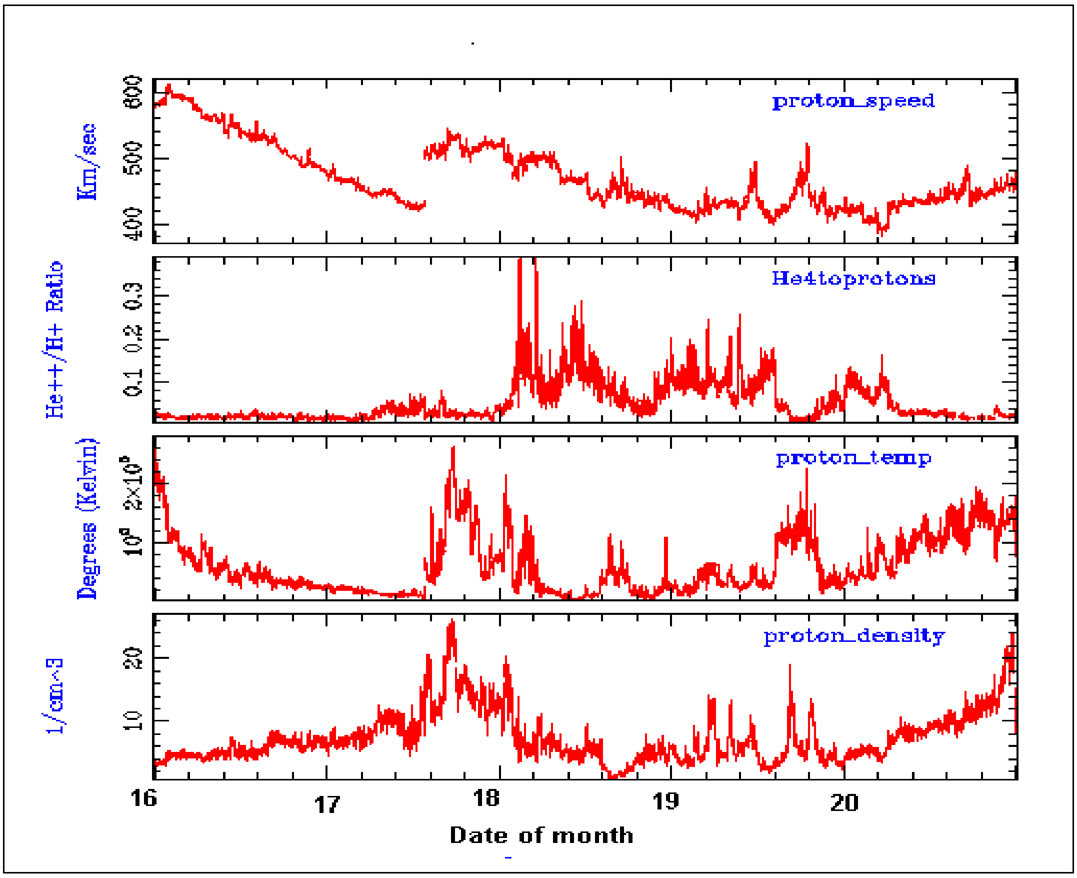
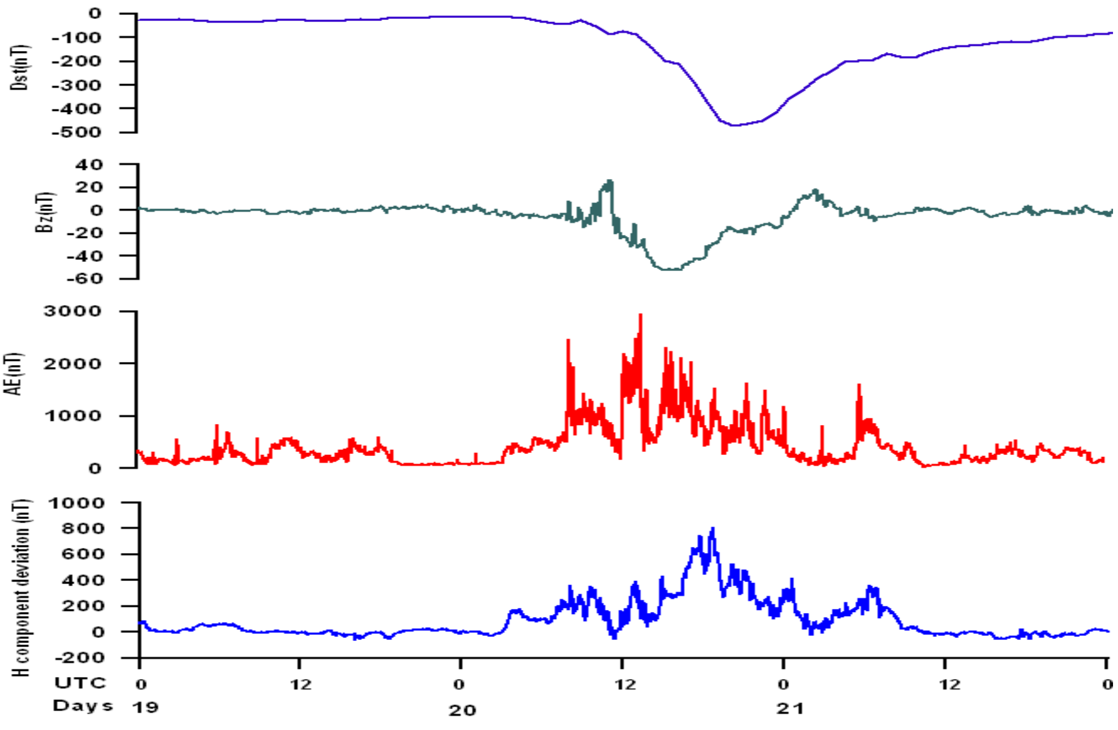


Figure 1: The eight panels (from top to bottom) successively show the Dst index, IMF_Bz, auroral electrojet index (AE), deviation of H component, plasma parameters (the proton density N (cm-3) and speed v (km/s)) on y-axis and time on x-axis in UTC which is common to all panels for the storm of 16-20 August 2003.

On 18 August H component shows sawtooth variations during main and recovery phase of magnetic storm these types of events are called sawtooth event and its oscillations is 02:00-04:00 hours respectively.

29-31 October 2003:-

Figure 2 has the six panels top panel shows the Dst of magnetic storm while second, third, forth, fifth, and sixth bottom panel shows the interplanetary magnetic field, the auroral electrojet index (AE), plasma parameter (proton density and speed), H component deviation respectively. Graphs show the result of magnetic storm dated 29-31 October 2003. First storm begin at 15:25UT (20:55LT) on 24 October. Second and third storm started on 26 at 19:09UT (224:39LT) and 28 October at 02:06UT (07:36LT). Finally storm is started on 29 at 06:11UT (11:41LT) and at 10:29UT (15:59 LT) on 30 October 2003. Result shows before SSC deviation in H component, proton density and speed, Interplanetary Magnetic Field (IMF) shows smooth variations but at the onset of SSC of the storm of on 29 October 2003, three of the parameters shows sudden increase in its amplitude at 06:00UT which increases upto 3995nT, ± 40nT and 3995nT respectively but at this instant two of the solar parameters shows no data. After SSC IMF fluctuate towards southward and northward, solar parameters shows no data, also AE and H component shows fluctuation at 00:00 UT Dst=-350nT, but at 20:00 UT IMF starts to move southward, proton density and speed has no data, H component, AE increases upto maximum values 3980nT, 1500nT. After 18 hour interval IMF fluctuate towards northward, two of the parameters H component and AE show smooth variations. At the same time the second onset of SSC of the storm of 30 October 2003, the H component shows deviation and at 00:00 UT it increases up to 1750nT, the IMF fluctuate



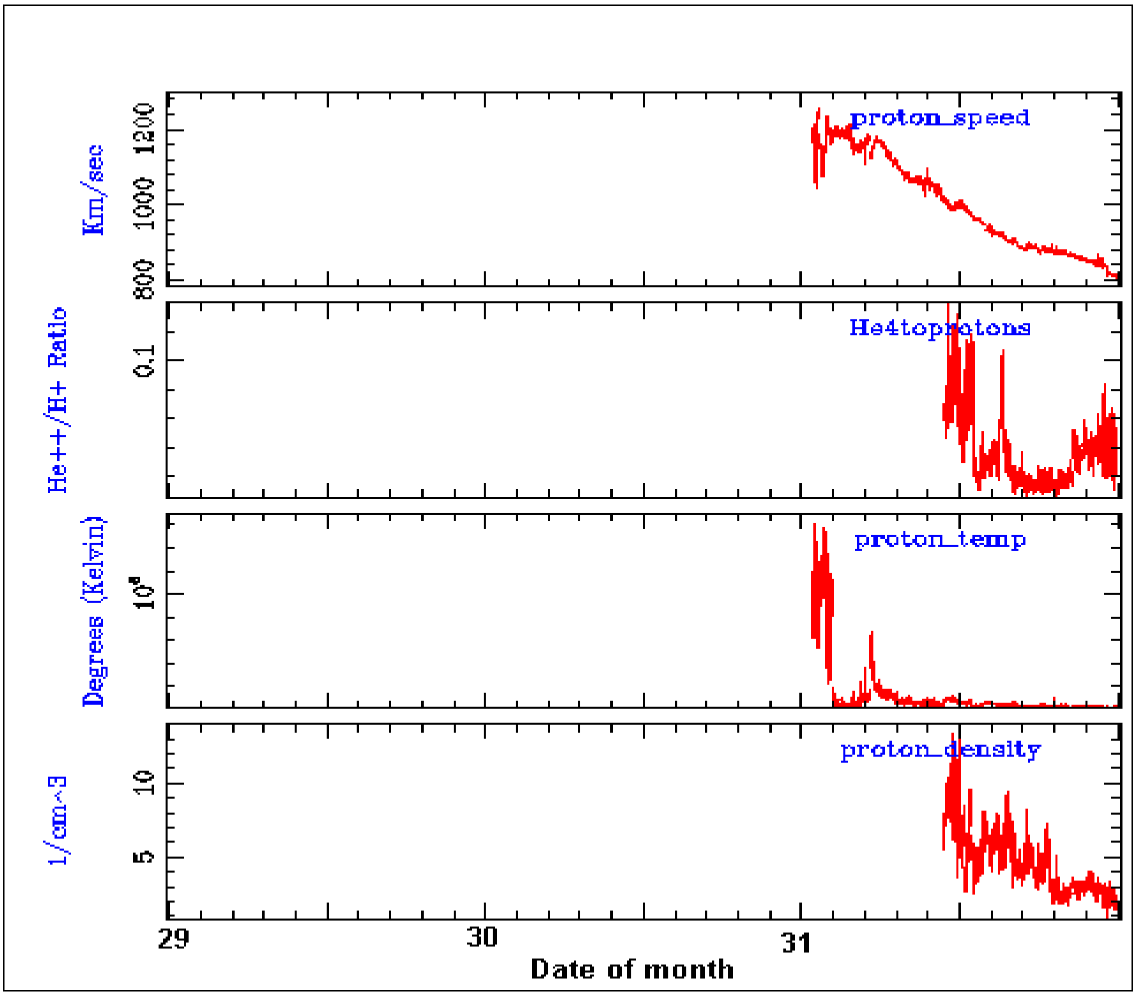
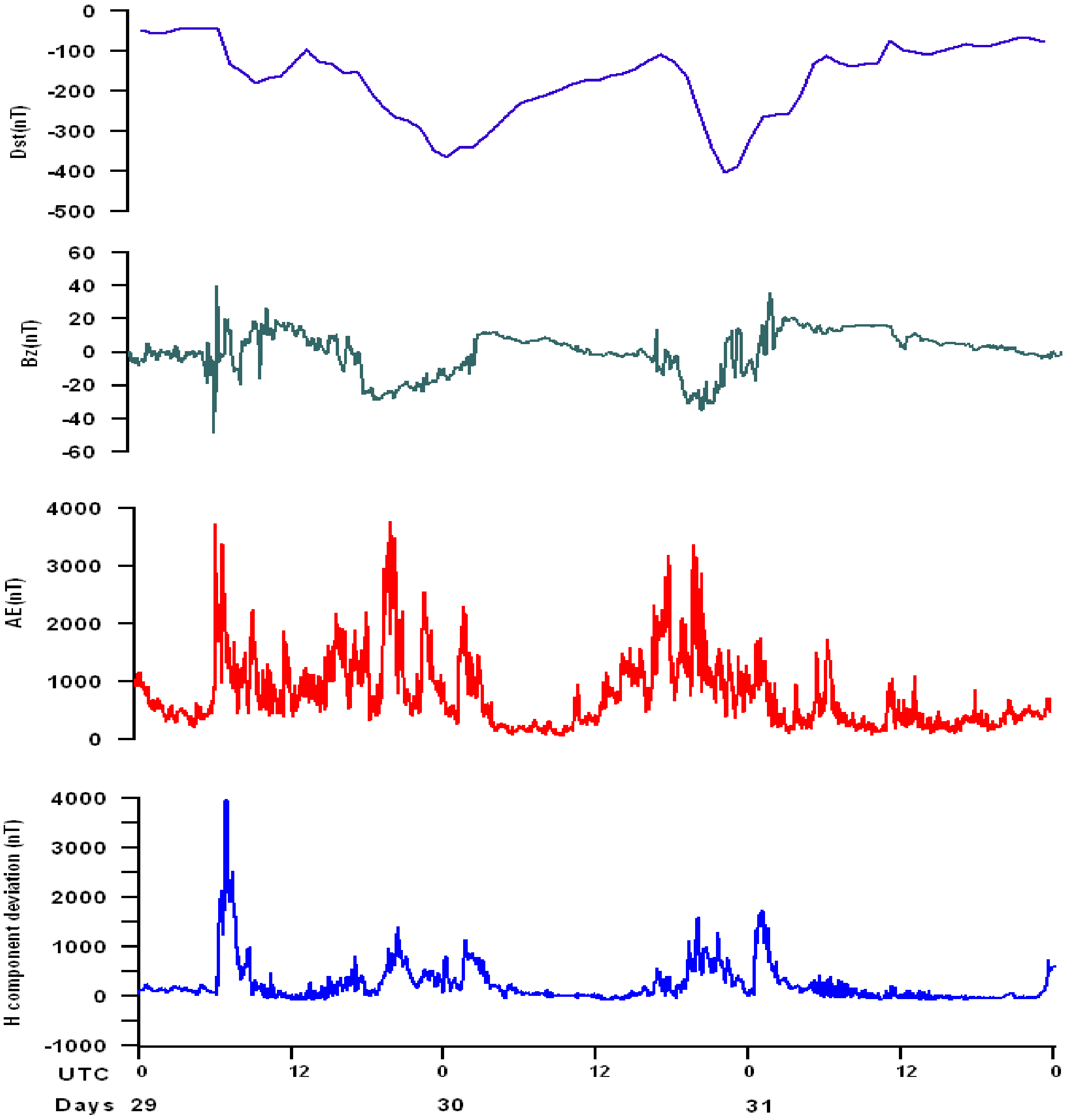


Figure 2: The eight panels (from top to bottom) successively show the Dst index, IMF_Bz, auroral electrojet index, deviation of H component, solar wind plasma parameters (the proton density N, and speed v) on y-axis and time on x-axis in UTC for the storm of 29-31 October 2003.

upto -10nT, then magnetic index Dst =- 425nT, solar parameters shows no data. But at onset time auroral electrojet current intensity increases upto 3000nT on the 30 October 2003. So the 31 October 2003 storm was a sever magnetic storm of the year. Accompanying with this deviation in magnetic field H component, auroral electrojet index (AE) and IMF also observed in the storm and its intensity is depend on magnetic storm. The main phase of storm is started on 29 October at 06:00 UT at the same time when we observe IMF, AE, proton density and speed, H component variation at high latitude "MATRI" we find that two parameters show rapid fluctuation and this fluctuation increases during main phase of storm but third parameter increases values 3995nT but two solar parameters has no data. Recovery phase started at 00:00UT on 30 October 2003 it continue upto 18 hour interval find IMF turns to the northward and two of the parameters shows to its original conditions. The second main phase of storm is started on 30 October at 18:00 UT at the same time when we observe IMF and H variation at high latitude "MATRI" Antactica we find that there two the parameters show rapid fluctuation, solar two parameters shows no data and this fluctuation is increases during main phase of storm but third parameter increases values 3000nT at onset. On 31 October 00:00 UT when Dst reached its maximum value of -425nT, auroral electrojet index (AE), H component shows variation upto the value of 1500nT, 1750nT and interplanetary magnetic field (IMF) fluctuate north-south direction and shows the value of -20nT at that instant no data has found in solar parameters. During the recovery phase of storm the magnitude of H component, AE decreases and IMF northward direction. After 12:00UT when Dst, auroral electrojet index (AE) and H component shows smooth variation whereas IMF moves towards northward. Accompanying with this deviation in H component, IMF shows that fluctuation depends on the intensity of magnetic storm which do not relate with the auroral electrojet index (AE). Also magnetic storm intensity depends upon geomagnetic activity which is very high in equinox month due to polar ionospheric conductivity. On 29, 30 October 2003, H component shows sawtooth variations during magnetic storm and these type of event is called sawtooth event, its variations is 02:00-04:00 hours respectively. The event of 29, 30 October is sever magnetic event in the year of 2003. Also we observed that CMEs/shock, flares are also responsible to occurs the magnetic storms.

19-21 November 2003:-

The event of 20 November storm was one of the sever magnetic storm of the year 2003. Figure 3 shows six panel of the three magnetic storm of 04, 15, 19-21 November 2003. The top panel shows the Dst of magnetic storm while second, third, fourth, fifth and sixth bottom panel shows the variation in Interplanetary Magnetic Field (IMF) high latitude auroral electrojet (AE), solar plasma paramerers (proton density and speed), H component deviation respectively. First storm begin at 06:26UT (11:56LT), then the second storm began at 05:50UT (11:20LT) and finally at 08:03UT (13:53LT) on 20 November 2003. Before Ist Storm Sudden Commencement (SSC), magnitude of H component deviation, AE, proton density and speed and IMF shows smooth variation but after SSC when Dst start decreases the magnitude of H component deviation, IMF also shows fluctuation but high latitude magnetic activity auroral electrojet index, proton density and speed increases upto -2400nT, 30cm^{-3} and 700km/s at onset of the storm. On 20 November at 09:00 UT the main phase of storm is stated at the same time when we observe IMF and H variations, auroral electrojet at "MATRI" we find that



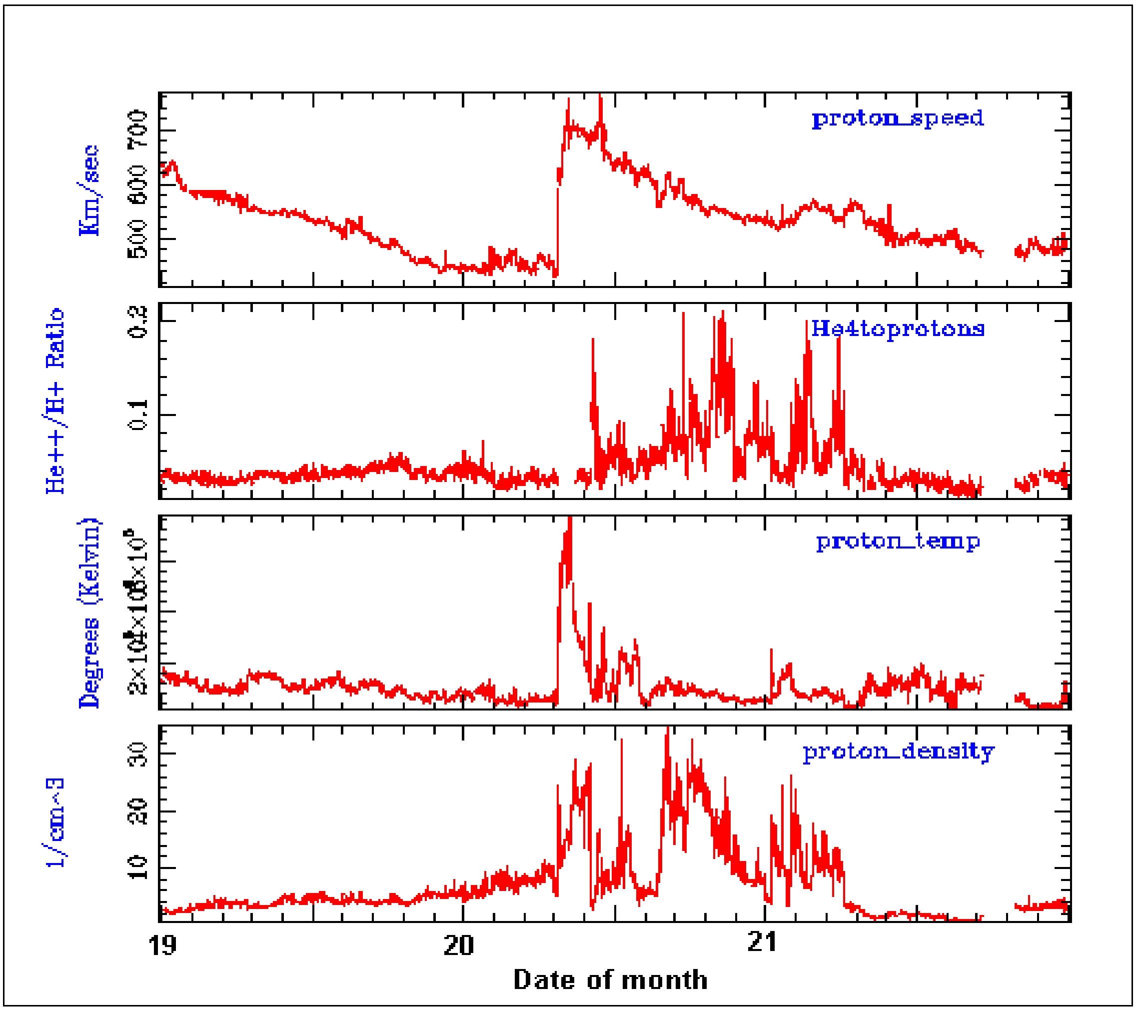


Figure 3: The eight panels (from top to bottom) successively show the Dst index, IMF_Bz, auroral electrojet index, deviation of H component, solar wind plasma parameters (the proton density N(cm^{-3}) and speed v (km/s) on y-axis and time on x-axis in UTC for the storm of 19-21 November 2003.

five of the parameter shows rapid fluctuation and this fluctuation increases during main phase of storm. On 20 November Dst shows its maximum negative excursion of -475nT at 19:00UT. At the same time the Magnitude of H component deviation, proton density and speed reached upto 600nT, 30cm-3 and 600km/s auroral electrojet (AE) shows the value of 1000nT and interplanetary magnetic field (IMF) move towards south and shows the value of -20nT. After 12:00UT on 20 November recovery phase starts and after 15:00UT Dst shows smooth variation. During the recovery phase of storm the magnitude of H component, plasma parameters decreases and IMF move upward. After 15:00UT when Dst shows smooth variation H component and IMF also show smooth variation at the same time magnitude of H component deviation Bz does not shows any fluctuations. From this result we concluded that the storm was sever in the winter month on 20 November 2003. Accompanying with this deviation in magnetic field the IMF,AE, solar parameters which follow storms and its intensity is depend on magnetic storm.

4 Summary and Discussion:-

To understand the large increase in H component during magnetic storms, it is essential to discusses result of the three intense and SSC successive storms event monthly geomagnetic storms associated with solar wind, solar flare/CMEs and interplanetary magnetic field (IMF). Although the solar wind speed appears to be one of the key parameter. It determines the magnitude of the IMF, correlated well with an increase of the high latitude “Maitri” geomagnetic field H component. Thus the intensity of the storm, the duration of the southwardly directed Bz, and the solar wind the parameters i.e. velocity and density, also contribute to a storm. Thus bases on Figure 1, 2 and 3, we can concluded that solar wind speeds of 1200km/s or less are responsible for storms with a Dst index > -200 nT. Meanwhile, very fast solar wind (Vp > 1200km/s) are capable of causing extremely intense storms, when the Dst index decreases below- 300 nT. Further progress in our understanding of propagation of a CME in the interplanetary space may improve accuracy of the predictions of intense geomagnetic storms. We found the association between the solar wind particles speeds and the magnitude of IMF is most pronounced for very fast CMEs while it is less apparent in the case of slow ejecta. Relationship beween the magnitude of the southward IMF and Dst index supports. Findings, presented here, suggest that solar wind speeds of 1200km/s or less are responsible for storms with a Dst index > -200 nT, while the high speed solar wind (Vp > 1200km/s) are capable of cause of extremely intense storms. Here we compare the measured swatooth variation of H deviations, AE increases in growth phase, the solar wind proton speed, proton density and proton temperature starts to increases during periodic substorm means energy is stored and expansion phase H component decreases with all other plasma parameters with the prediction of Russell et al means energy is released with southward IMF. They show in growth phase directly relation with H component dipolarisation location near Earth neutral line release plasmoid, and in expansion phase AE ionospheric dissipation of energy in the form of ionospheric Joule heating, auroral precipitation, ring current particle injections and plasmoid release during substorms. Finally concluded substorms are most fundamental processes in the magnetosphere. The essential solar wind particles controlling the substorm are the southward IMF for the large scale magnetotail dynamics. Large IMF input produces current sheet disturbances close to the Earth, involves lower latitude region in the ionosphere. Dependence on dynamic pressure, on the other hand, is less apparent, at least for the near- Earth reconnection process. This could indicate some difference from a storm-type response of the tail, where the dynamic pressure plays a more active role. Yet, southward IMF is only a necessary condition for a large substorm, since southward IMF does not necessarily causes a substorm during periods of SMC or CMD. Furthermore, large scale magnetospheric response is likely controlled by the intrinsic condition of the magnetosphere, which is modified by modes of solar wind magnetosphere interaction other than soutward IMF reconnection. To explain substorm dynamics and to predict the magnetospheric response from the solar wind input it is important to understand both the internal current sheet instabilities leading to the large scale tail current sheet dissipation and the different modes of large scale solar wind-magnetosphere interaction. Before summarizing and discussing the observations of solar wind and sudden commencements on the horizontal (H) component of the geomagnetic field, it is essential to seek the origins of these phenomena. The SFE are associated with the arrival of a sudden increase of electromagnetic radiations from the Sun, which while traversing the ionosphere generate additional ionizations mainly in the E, partially in the D and sometimes in the F region. The SSC of a magnetic storm indicates the arrival of a dense plasma cloud consisting of charged particles from the Sun, generally a few tens of hours after the occurrence of the solar flare. These clouds are stopped at the magnetopause when the magnetic pressure of the Earth's magnetic field balances the dynamic pressure of the charged particles and the magnetosphere is compressed, causing a sudden increase in H at stations around the world on the dayside as well as the nightside. Substorms proceed in much shorter time scale than storms, lasting only a few hours. Three phases can be recognized during a substorm. We have studied the relationship between solar wind variations and periodic magnetospheric substorms during storm times. The sawtooth injections were well correlated with AE increases and auroral brightenings. The sawtooth substorm injections occurred during the main phase and initial recovery stage of magnetic storms with steadily southward IMF. This implies that continuous energy transfer from the solar wind with southward IMF to the magnetosphere is necessary to maintain the periodic substorms. We suggest that magnetospheric substorms have an intrinsic cycle time of 2–3 hours. We have performed ground H component of Earth's magnetic field and solar wind particles of periodic substorms. The periodic substorms always have a strong variation in H component of Earth's magnetic field peak at 2–3 hours, whether the IMF is continuously southward or rapidly fluctuating between southward and northward. If the IMF and Bz vary with periods of 2–3 hours, substorms may occur with similar periods. Substorms are most fundamental process in the magnetosphere. The essential solar wind parameter controlling the substorm is the southward IMF for the large scale magnetotail dynamic. Auroral breakup are the most reliable substorm indicator, whereas other commonly used onset identifiers may not always associated with substorms and are subjected to a propagation delay. Reconnection is a consequence of substorm expansion onset. Sudden compression of the magnetosphere by shock impact may lead to H component of magnetic bay-like activity but not to auroral breakups. After breakup, the expanded auroral bulge can move either westward or eastward. The auroral bulge dynamically maps to the magnetotail region where magnetic field become dipolarized. When the IMF is southward, positive east-west disturbances due to upward Field Aliened Current (FACs) are observed on the nightside. However, the positive disturbances are also often intensified by a substorm expansion especially in the post-midnight if the IMF is southward. The positive disturbances after substorm onsets exhibits essentially different behavior from the current wedge signature. These facts suggest that the upward Region 2 currents in the post-midnight are mainly controlled by the convection electric field and that they can be also intensified by a substorm expansion. The development of the upward currents at substorm onsets possibly results from the injection of energetic particles from the magnetospheric to the inner magnetosphere. (Kahler[10]) have shown that all E > 10 Mev solar proton events (SPE) are associated with the occurrence of CMEs and CME-solar flares. The value V×B directly modulates the geomagnetic activity. The product V×B is more important for geomagnetic activity rather than IMF alone[11].

Implicit in this discussion, of course, is the assumption that the ring current injection rate is linearly dependent on the merging rate. If it were not, the dependence of F(E) on E_y would in turn reflect this additional functional dependence. Another surprise is that the rectification of the interplanetary electric field appears to approximate that of a half-wave rectifier centered about a zero Y magnetospheric component. One expects merging to occur for even acute angles between the interplanetary and magnetospheric magnetic fields (Sonnerup, 1974). On the contrary, within the accuracy of this experiment this does not appear to be the case. Instead, the more common assumption about the nature of the solar wind interaction is supported (Arnoldy, 1971 - Russell and McPherron, 1973 a, b).

5 Conclusions: -

We observed most of the severe storms (Dst<-500 nT) in the month of August, October and November 2003 were also associated with SEP events, solar wind or solar flare/CMEs/Interplanetary shocks and generally more geoeffective CMEs originating from the western hemisphere of the Sun. The events associated with Bz are more likely to cause a super geomagnetic storm and were well correlated with AE increases and auroral brightenings. But it suggests that a change of the magnetospheric and ionospheric conditions would cause the development of the upward FACs. Result show that high latitude stations at “Maitri” sawtooth H component deviation is inversely proportional to intensity of storm. We divided the storm into three category depend on its Dst values, When severe storm is occurred the sawtooth oscillations of H component of Earth’s magnetic field shows the maximum deviation of up to 1750nT in the month of equinox. On the other hand IMF and AE show the maximum value of – 40nT, 3500nT and plasma parameters shows its maximum values. We evident the response of the magnetosphere-ionosphere system to solar wind driving has been studied during magnetic storm. The inner magnetosphere ring current response is a function of the solar wind electric field only, hence internal magnetotail dynamic play also a role in the process.

Acknowledgment:-

The authors are thankful to NCAOR, Goa for Antarctic visit and logistic support. One of the authors (Shailendra Saini) acknowledges CSIR, New Delhi, for awarding Senior Research Fellowship respectively.

References:-

1 Dungey J W, Physics Rev Lett, 6(1961)47.
2 Gonzalez W D, Joselyn J A, Kamide Y, Kroehl H W, Rostoker G, Tsurutani B T & Vasyliunas V M, J. Geophys Res 99(1994)5771-5792.
3 Chapman S & Bartels J, Oxford Univ. Press, New York, (1940).
4 Burton R K,. McPherron R L & Russel C T, J.Geophys Res, 80 (1975)4204.
5 Baker D N, Peterson W K, Eriksson S, Li X, and Blake J B, Geophys. Res Lett 29, (2002).
6 Skoug R M, J Geophys Res, 108(A6) (2003)1259.
7 Ganushkina N Y, Pulkkinen T I, Kubyshkina M V, Singer H J & Russell C T, Ann Geophys 22(2) (2004)1317.
8 Kalegaev V V, Ganushkina N Yu, Pulkkinen T I, Kuyshkina M V, Singer H J & Russell C T, Ann Geophysics, 23(2005)523.
9 Pulkkinen T I, Ganushkina N Yu, Donovan E, Li X, Reeves G D, Russell C T, Singer H J & Slavin J A Geophys Monogr Ser 155, edited by Pulkkinen T I, Tsyganenko N A & Friedel R H W, AGU(Washington, D. C,), 155(2005).
10 Kahler S W, Reams D V & Sheely N R, Jr., Proc. 21th ICRC 5, 183(1990).
11 Sabbah I, Geophysics. Res. Lett. 27, 13(2000).