Effect of CME Events of Geomagnetic Field at Indian Station Alibag and Pondicherry

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Abstract: ***Space weather activity CMEs, and solar energetic particles from the Sun are carried out into space along with the solar wind. The wind speed sweeps toward the Earth at super sonic speed ranging from 300-1000 km/sec and distorts the Earth's magnetic field. CMEs are the main cause of major geomagnetic storms. Geomagnetic storms are identified by using indices like Kp, Dst . According to the Richardson the most intense storms at both solar minimum and solar maximum are almost associated with CMEs. They occur when a sufficiently strong negative southward vertical component of the interplanetary magnetic field (IMF) Bz interacts with the Earth's magnetosphere, when the dynamic pressure of solar wind is enchanced. The solar flare, CMEs and predominatly large magnitude of the IMF are the dominant phenomena during the high solar activity conditions. We have taken only 5 CME events out of 28 in year 2003 and all these events are Halo CMEs events. To study the effects of these CME events on geomagnetic field we have selected two stations, Alibag and Pondicherry with Geomagnetic Latitude and longitude (18.64N, 72.87E); (11.92N, 79.92E) respectively. The CME events were considered on 29 October 2003, 23 July 2003, 01 Nov.2003, and 28 October 2003. The data has been taken from Alibag and Pondicherry Geophysical Observatory. Three days have been taken during each event, one day before the event and one day after the event with the help of geomagnetic field Variations we can enlighten the effect of the CME on Earth. The severe event or epoch event of 29 october 2003 has IMF, Bz ≈-58nTwhich is very high value and produce large effect on the geomagnetic storm occur when solar wind long duration southward IMF impact Earth's magnetosphere. During the geomagnetic storms southward IMF reconnect with Earth's geomagnetic field at the dayside magnetopause, resulting a chain of events leading to the dramatic increase of ring current westward. The high speed CME affects more the geomagnetic field than the lesser one. According to the latitudinal variation the variation at Pondicherry is high as compare to the Alibag station with respect to their declination angle. As higher the declination angle lesser will be the variation.***

Keywords: Solar Flare, CME, Plasma Density and geomagnetic Field

1. Introduction

Space weather is a consequence of the behaviour of the Sun, the nature of the Earth's magnetic field and our location in the Solar system. The space weather events occur in the Sun –Earth system provides a chance to study various universal processes. Space weather events occur over a wide range of time scales: the Earth's magnetosphere respond to solar-originated disturbances within few minutes. Enhanced fluxes of energetic particles in radiation belts decay in time scales of days, months and ever longer. Space weather activity Coronal mass ejections (CMEs) and solar energetic particles from the Sun are carried out into space along with the solar wind. The wind speed sweeps toward the Earth at super sonic speed ranging from 300-1000 km/sec and distorts the Earth's magnetic field. CME is massive expulsions of magnetised plasma from the solar atmosphere. CMEs are the main cause of major geomagnetic storms. Geomagnetic storms are identified by using indices like Kp, Dst . According to the [Richardson et al. 2002] the most intense storms at both solar minimum and solar maximum are almost associated with CMEs. They occur when a sufficiently strong negative southward vertical component of the interplanetary magnetic field (IMF) Bz interacts with the Earth's magnetosphere, when the dynamic pressure of solar wind is enchanced. The solar flare, CMEs and predominatly large magnitude of the IMF are the dominant phenomena during the high solar activity conditions. There is the interaction between coronal ejecta, characterised belong period's southward orientation of the IMF and the Earth's magnetosphere while southward IMF conditions are associated with major geomagnetic storms. A geomagnetic storm is a temporary disturbance of the Earth's magnetosphere, associated with CME, solar flares and is caused by a solar wind shock wave which typically strikes the Earth's magnetic field from 24 to 36 hours after the event. This only happens if the shock wave travels in a direction toward the Earth. The maximum speed of HALO CME is found to be as large as 4000 km/sec., We have also found that HALO CME is the main cause to produce large geomagnetic storms. During coronal mass ejections large amount of matter expel out (about 1 to 10 billion tons of material) in the form of a large cloud of charged particles from the sun's outer atmosphere. Because the sun can eject matter in any direction, only some of the CMEs are actually directed towards earth. CMEs originating from regions close to the central meridian of the sun and directed towards the earth are of immediate concern because they are likely to be geoeffective. Numerous models have been used to study CME propagation in the inner heliosphere [Riley et al., 2003; Odstrcil et al., 2002]. For a few large ICMEs, the ejecta or preceding shocks have been traced from the inner (Earth and/or Ulysses) to outer heliosphere [Paularena et al., 2001; Wang et al., 2001a, 2001b; Zank et al., 2001; Wang and Richardson, 2002; Richardson et al., 2002].

2. Data Selection and Methodology

In the present study the CME events are classified as severe ,moderate and minor depending upon Dst value as shown in the Table 1 which is extracted from NOAA site. The data of Dst have been taken from World Data Centre. The acceleration /deceleration has been taken from the Solar and Heliospheric Observatory (SOHO). In our analysis we have 28 events according to SOHO/LASCO. But we have taken only 3 CME events as major moderate and minor. To study the effects of these CME events on geomagnetic field we have selected two stations, Alibag and Pondicherry with Geomagnetic Latitude and longitude (18.64N, 72.87E); (11.92N, 79.92E) respectively. The CME events were considered on 29 October, 2003, 23 July, 2003 and 01 November, 2003. The data has been taken from Alibag and Pondicherry Geophysical Observatory. Three days have been taken during each event, one day before the event and one day after the event with the help of geomagnetic field Variations we can enlighten the effect of the CME on Earth. Space weather is greatly influenced by the speed and density of the solar wind and the interplanetary magnetic field (IMF) carried by solar wind plasma.

3. Observation and Result

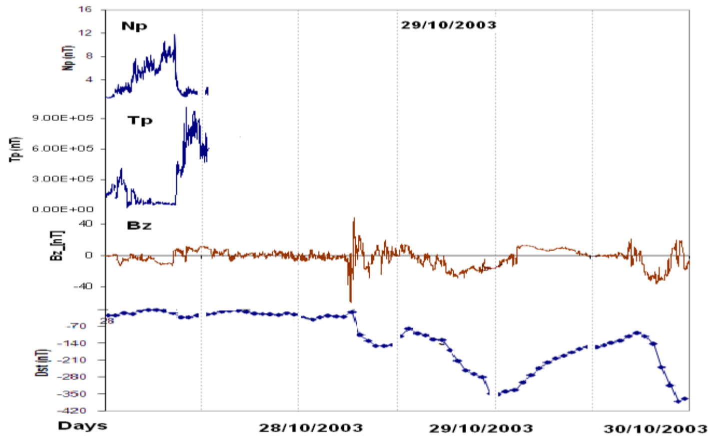
To depict the effect of CME on the geomagnetic field components we have taken Severe, moderate and Minor events occurs during the period 2000-2005 of 23 solar cycle. The categorization of geomagnetic storms depends upon the Dst value. For minor events, the value of Dst<60, for moderate the value Dst>60<100 and for Severe event the value of Dst>100. We have five events as severe, minor and moderate. The event on 29 Oct 2003 was severe; the events on the 16 June 2003 and 1 Nov 2003 were minor. All these CMEs were Halo CMEs with speed between 900 km/sec to 2500km/sec.

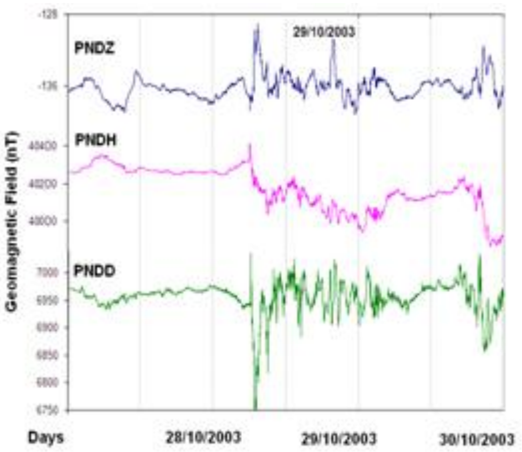
Table 1: Table of Duration of Southward IMF Bz, CME and Flare types

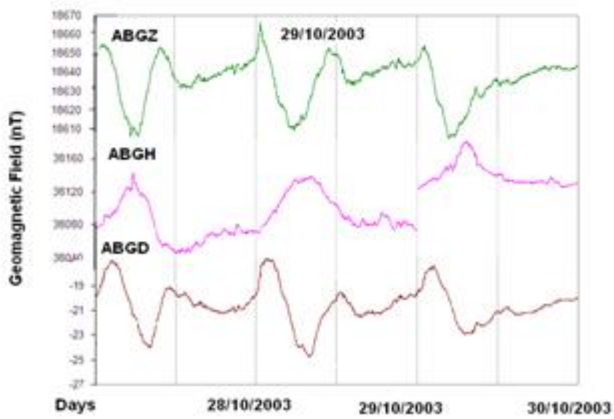
Year	Month	Storm day	CME type	Onset time UT	Speed Km/sec	Acceleration /Deceleration (m/sec^2)	Source Location	Southward IMF Bz (nT)	Category Of CME
2003	10	29	Halo	20:54:05	2029	-146.5	S15W02	-58.356	Severe
2003	07	23	Halo	00:42:05	2285	87	S13E72	-5.368	Minor
2003	11	01	Halo	22:55:00	899		S12W60	-21.845	Moderate

29th October 2003

The CME event of 29th October comes under the severe event. It is a Halo CME with onset time of 20:54:05 UT. The speed and deceleration of this Halo CME were 2029 Km/sec and 146.5 m/sec^2. This CME occurs on 29th October 2003 with active region NOAA 10486 at source location S15W02.On 29th October a geomagnetic storm is observed with maximum proton density Np (6.871nT) , temperature Tp (9.29E +04) and southward vertical component of IMF Bz (-5.434). To evaluate the effect of this Halo CME on the geomagnetic field we have taken two stations Alibag and Pondicherry. At station Alibag (Abg.) with latitude and longitude (18.64N, 72. 87E) , the geomagnetic component H , D and Z are 38175.5nT , -10.45nT and 18809.4 nT respectively. Also at station Pondicherry with latitude and longitude 11.92N and 79.92E res. , the geomagnetic components H , D and Z are 40411.2 nT , -129.08 nT and 7035.2 nT.



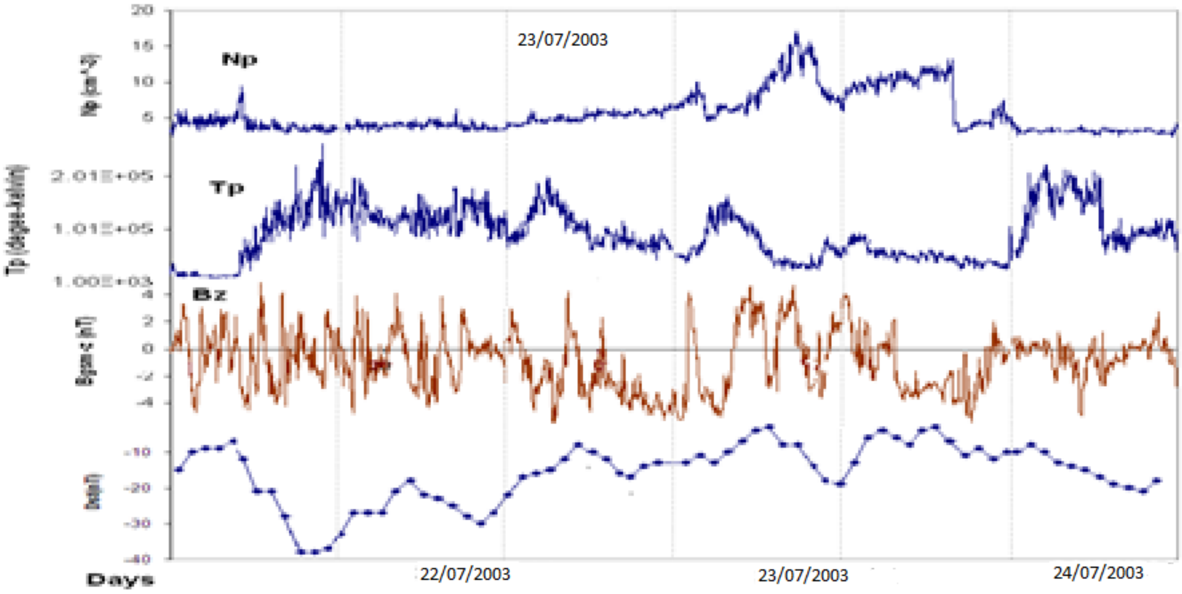


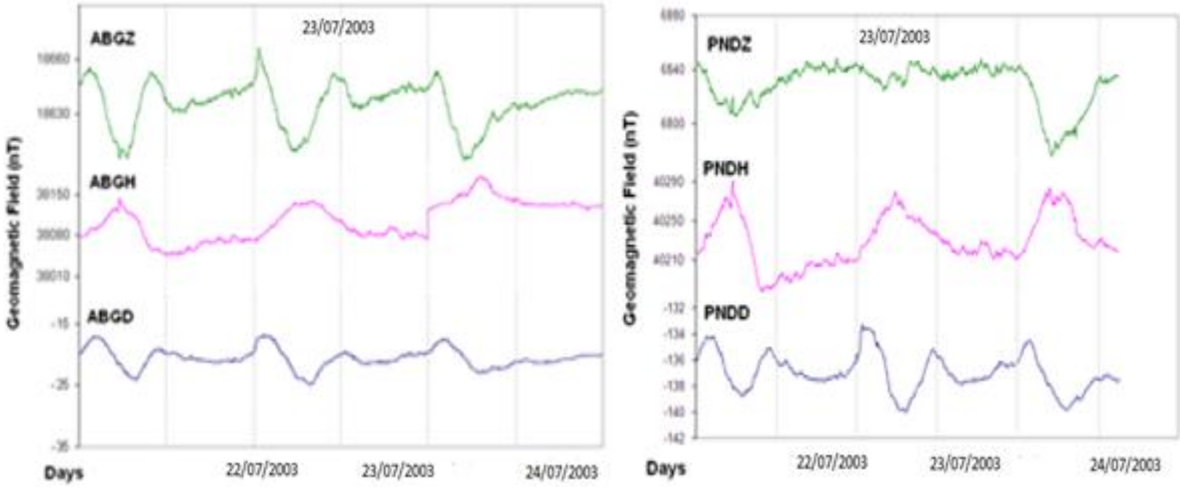


The variations of Proton density (Np), Temperature (Tp) , IMF Bz(nT) and Dst and H-, Z-, D- Components of Geomagnetic Field for two stations Alibag and Pondicherry

23th July 2003

This CME event comes under the Minor event. It is one Halo CME with onset time of 00:42:00 UT. The speed and acceleration of this halo CME were 2285 Km/sec and 87 m/sec^2. The active region for this event was NOAA 10039 at source location S13E72. The maximum value for Southward vertical component of IMF and disturbed storm time were 4.726 nT and -22/-38. The observed maximum value for proton density (Np) , temperature (Tp) were 19.306 nT 2.75E + 05 deg. kelvin. To check the influence of this Halo CME on the geomagnetic field we have taken two stations Alibag and Pondicherry. At station Alibag (Abg.) with latitude and longitude (18.64N, 72.87E) , the geomagnetic component H , D and Z are 38180.4nT, -16.91nT and 18664.4 nT respectively. Also at station Pondicherry with latitude and longitude 11.92N and 79.92E res., the geomagnetic components H , D and Z are 40290.4 nT, -133.34 nT and 6848nT.





The variations of H-, Z-, D- Components of Geomagnetic Field for two stations Alibag and Pondicherry The variations of Proton density (Np), Temperature (Tp) , IMF Bz(nT) and Dst on 23 July 2003.

1st Nov 2003

This CME event comes under the moderate event. It is a Halo CME with onset time of 22:55:00 UT. The speed of this halo CME was 899 Km/sec. This CME occurs on this day at source location S12W60. The maximum value for Southward vertical component of IMF (Bz) and disturbed storm time were 34.438 nT and -69/307. The observed maximum value for proton density (Np) and temperature (Tp) were -862.53 nT and 1.60E + 06 deg. kelvin.

To check the influence of this Halo CME on the geomagnetic field we have taken two stations Alibag and Pondicherry. At station Alibag (Abg.) with latitude and longitude (18.64N, 72. 87E) , the geomagnetic component H , D and Z are 38175.5nT , -15.97 nT and 18792.7 nT respectively. Also at station Pondicherry with latitude and longitude 11.92N and 79.92E res. , the geomagnetic components H , D and Z are 40379.9 nT , -134.25 nT and 7161.1 nT.

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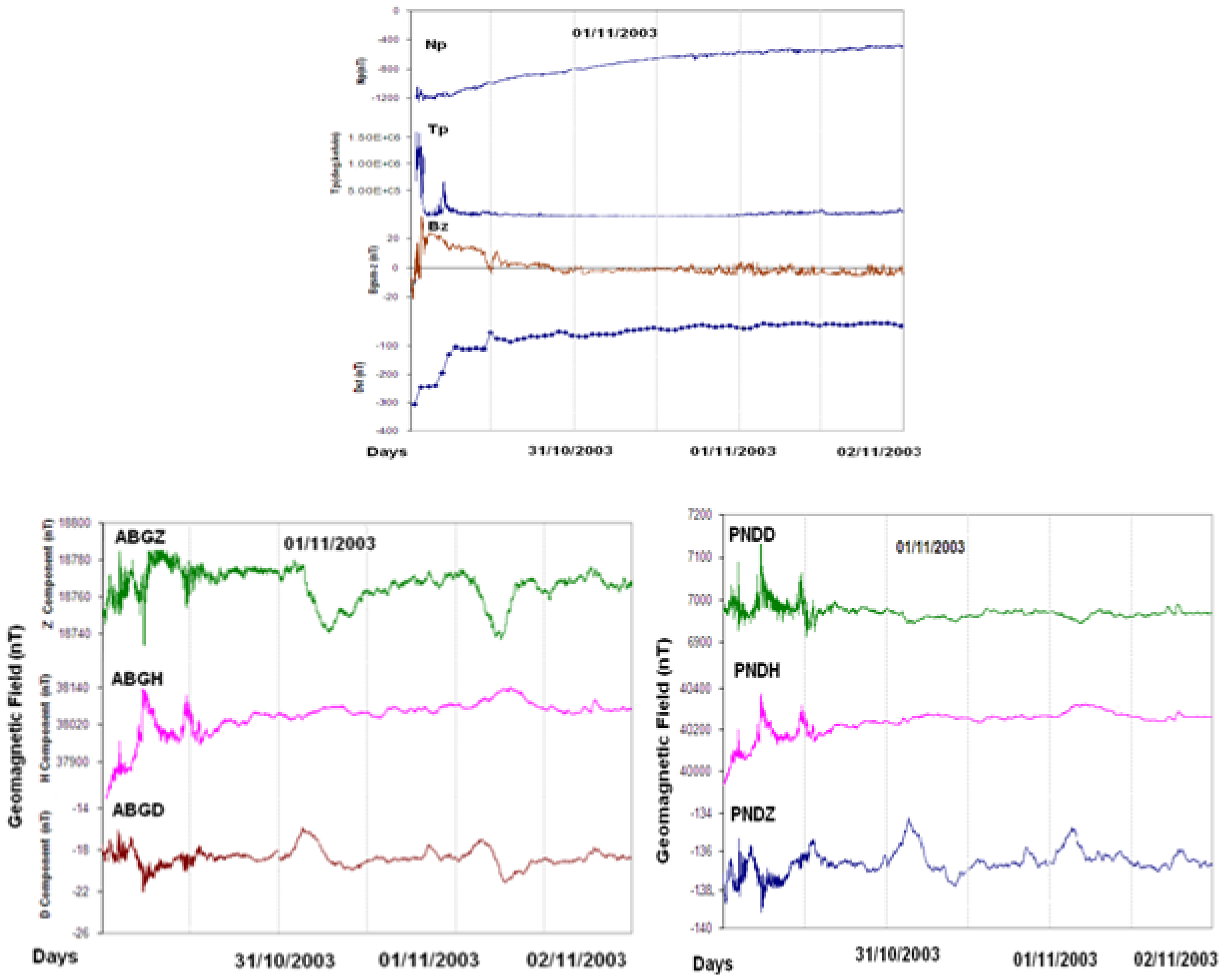

The variations of Proton density (Np), Temperature (Tp) , IMF Bz(nT) and Dst on 1 November 2003 and H-, Z-, D- Components of Geomagnetic Field for two stations Alibag and Pondicherry.

4. Discussion and Conclusion

As the solar disturbance reaches the Earth they can give rise to destructive disturbance on the Earth. During the geomagnetic storm; flares, CMEs and SEPs are produced which have abundance of high energy ions and electrons and also fluctuating magnetic fields. The production of ions depends upon the severity of the space weather as compare to the severe storm. The moderate storm has less effect on space weather as compare to the severe storm. The main solar phenomena responsible for the appearance of such conditions in the solar wind are CMEs. As in the present study we have shown the different categories of the geomagnetic storms depending upon Dst value. The severe storm of 29th October 2003 for which the Dst value was -350 and geomagnetic field component gives the more variations as compare to the other ones. The source region for CMEs are active regions which appears in solar disk. When the CMEs source region is located near the centre of the solar disk,then the CME is directed toward the Earth as an expending found the Halo around the Sun . Earth directed CMEs where the magnetic field has a southward component are capable to producing large geomagnetic storms [Gonzalez el.al.,1994; cane et al.,2000;pevtsov and canfield, 2001]. The event of 29 october 2003 has IMF, Bz ≈-58nTwhich is very high value and produce large effect on the geomagnetic storm occur when solar wind long duration southward IMF impact Earth's magnetosphere. During the geomagnetic storms southward IMF reconnect with Earth's geomagnetic field at the dayside magnetopause, resulting a chain of events leading to the dramatic increase of ring current westward. The high speed CME affect more the geomagnetic field than the lesser one. According to the latitudinal variation the variation at Pondicherry is high as compare to the Alibag station with respect to their declination angle. As higher the declination angle lesser will be the variation.

- The category of the geomagnetic storm depends upon the Dst value.
- The variation in the horizontal component of geomagnetic field at Pondicherry was Higher than Alibag.

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