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Geomagnetic Storm Events and Associated Phenomena During the Ascending Phase of Solar Cycle-24

Balendra Pratap Singh[1*], Achyut Pandeya[2], P. K. Srivastava[2], Devendra Kumar Bajpai[3], Kamlesh Pd. Jaiswal[4]

[1]Research Scholar, Govt. P. G. Science College, Rewa, M.P. (India)
[2]Deptt. of Physics, Govt. P. G. Science College, Rewa, M.P. (India)
[3]Research Scholar, P. S. N. S. Govt. P. G. College, Sahdhol, M.P. (India)
[4]Deptt. of Physics, Govt. Tulsi Degree College, Anuppur, M.P. (India)

[1]E. Mail: balendra1982@yahoo.com

www.isroset.org

Abstract- We have listed out the geomagnetic storms of the ascending phase of solar cycle-24 (covering the period January 2008 to December 2011). Since, our analysis interval is low activity period, so that the geomagnetic storms occurred during this time of interval, are not very large but they have the average Dst values between -50nT to -75nT. We have also find out the associated phenomena to these geomagnetic storms like solar flares, CMEs, interplanetary (IP) shocks and magnetic cloud (as shown in table no. 1).

Keywords: Coronal Mass Ejection (CME), Interplanetary (IP) Shocks, Solar Flares, Magnetic Cloud, Disturbance Storm Time (Dst), Geomagnetic Storm.

INTRODUCTION

A geomagnetic storm is a temporary disturbance of the Earth's magnetosphere caused by a solar wind shock wave associated with CMEs or solar flares which typically strikes the Earth's magnetic field 24 to 36 hours after the event (Mishra et al. 2010).

Gosling (1993, 1994) basically combined the published and generally accepted results from a variety of interplanetary observations into "The flare myth". Most in the interplanetary community were well aware that CMEs, not flares cause the dominant near-earth phenomena of relevance to solar-terrestrial studies. Except for the "sudden ionospheric disturbances" caused directly by photons, flares are not "geo-effective".

Geomagnetic storms can occur when magnetic field of the interplanetary feature engulfing the earth has a strong southward component Bz and a good correlation is obtained between Dst and Vsw*Bz product (Wang et al., 2003). Another researcher Vatsa (2006), reported the effect of high speed solar wind on the geomagnetic conditions, and he concluded the most of severe geomagnetic storm of 23-solar cycle occurred when z-component of IMF B was positive. Gonzalez et al., (1999), have discussed in detail, the possible interplanetary mechanism for the creation of very intense geomagnetic storm.

A magnetic cloud is a transient ejection in the solar wind defined by relatively strong magnetic fields, a large and smooth rotation of the magnetic field direction over approximately 0.25AU at 1AU, and a low proton temperature. Magnetic clouds are ideal objects for solar-terrestrial studies because of their simplicity and their extended intervals of southward and northward magnetic fields [Burlaga et al., 1990].

We have analyzed the all events on the basis of hourly data for about fourteen days, so that the events day exists in middle on graph plotting of the geomagnetic storms.

DATA DETECTION AND METHOD OF ANALYSIS

In the present study we have considered the hourly data of geomagnetic parameter Dst, from Omni web data explorer to study the geomagnetic storm event ocuurred on the ascending phase of solar cycle-24. The associated phenomena to this event like solar flares, CMEs, interplanetary (IP) shock and magnetic cloud etc., we have compiled the solar flares data from *ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SGD_PDFversion/* and data for CMEs are taken from SOHO/LASCO CME catalog via *cdaw.gsfc.nasa.gov/CME_list/*. The interplanetary (IP) shocks are compiled from the website *umtof.umd.edu/pm/FIGS.html* and *www.ssg.sr.unh.edu/mag/ace/ACElists/obs_list.html#shocks*. Data for *Magnetic cloud is observed from www.ssg.sr.unh.edu/mag/ace/ACElists/obs_list.html.*

The observed phenomenona (as shown in table no. 1) are then studied along with the geomagnetic storm events occurred on the ascending phase of solar cycle-24 (for the period 2008 to 2011) covering the first four year of the solar cycle-24.

Table-1, Shows the selected Geomagnetic Storm events during the ascending phase of solar cycle-23 and associated phenomena:

Geomagnetic Storm Day	**Dst (avg.)**	**Solar Flare**	**CMEs**	**IP Shocks**	**Magnetic Cloud**
6th April 2010	-61 nT	3 April at 0904 UT, B7.4, N16W63, AR 11057	3 April, Full-Halo, at 1033 UT, with speed, 668 km/sec.	5 April at 0759 UT, Forward IP shock	No
4th Aug. 2010	-50 nT	1 Aug. at 0755 UT, C3.2, N20E36, AR 11092	1 Aug., Full-Halo, at 1342 UT, with speed, 850 km/sec.	3 Aug. 1651 UT, Forward IP shock	Yes
11th March 2011	-61 nT	7 March at 1430 UT, M 1.9, N10E18, AR 11166. Second flare 7 March at 2000 UT, M3.7, N31W53, AR 11164	7 March, Full-Halo, at 2000 UT, with high speed, 2125 km/sec.	10 March at 0545 UT, Forward IP shock, travel time 58 hour.	No
28th May 2011	-52 nT	28 May at ? M 1.1, ?	26 May, 1912 UT Partial halo (359^0), with 519 km/sec.	No	Yes
6th Aug. 2011	-68 nT	3 Aug. at 1317 UT, M6.3, AR 1261. 4 Aug. at 0341 UT, M9.3, AR ?	3 Aug. Full-Halo at 1400 UT, 610 km/s. 4 Aug. Full-Halo at 0412 UT, 1351 km/s	5 Aug. at 1723 UT and 1832 UT & 4 Aug. 2110 UT, travel time 64 hour.	No
25th Oct. 2011	-75 nT	22 Oct. at 0115 UT,? 22 Oct. at 1315 UT, M1.3, N05W79, AR 11319	22 Oct. at1024 UT, with speed 1005 km/sec.	24 Oct. at 1750 UT, Forward IP shock	Yes

ANALYSIS AND DISSCUSSION

1. Geomagnetic Storm of 6th April 2010:

We have plotted the graph for geomagnetic storm of 6th April 2010, Dst-index variation from 1st April to 14th April 2010 on hourly data basis as shown in fig. 1. The average value of Dst-idex on 6th April is -61nT.

An x-ray flare B7.4 was observed by GOES at 0904 UT on 3rd April 2010 in AR 11057 (N16W63), and SOHO/LASCO observed a full-halo CME at 1033 UT on 3rd April with a speed of 668 km/sec. A forward interplanetary (IP) shock was observed by ACE spacecraft at 0759 UT on 5th April.

2. Geomagnetic Storm event of 4th August 2010:

The disturbance storm time index (Dst) value for the geomagnetic storm of 4th Aug. 2010, is -50nT, which is plotted in fig. 2 in terms of hourly variation of Dst-index.

GOES observed a C3.2 class solar flare at 0755 UT on 1st August 2010 in AR 11092 (N20E36) region. SOHO/LASCO observed a full-halo CME at 1342 UT on 1st Aug. with a speed of 850 km/sec. and type II burst/wave is also predicted by WIND spacecraft on 1st August at 0920 UT. A forward IP shock was observed by ACE spacecraft at 1651 UT on 3rd August. This event is associated with two magnetic clouds, first cloud starts on 4th Aug. at 0315 UT and ends at 0820 UT on 4th August and second magnetic cloud starts at 1125 UT on 4th Aug. and end on 5th Aug. at 0135 UT.

3. Geomagnetic Storm of 11th March 2011:

Fig. 3, shows the geomagnetic storm event of 11/03/ 2011 having average Dst-index value -61nT, from 6th to 19th of March 2011 in terms of hourly data variation.

GOES observed two solar flares before this event of storm, first flare observed of the class M1.9 on 7th March at 1430 UT in the region AR 11166 (N10E18) and second flare class is M3.7 on 7th March at 2000 UT in AR 11164 (N31W53). SOHO/LASCO, observed a full-halo CME at 2000 UT on 7th March with a very high speed of 2125 km/sec. ACE spacecraft observed a forward IP shock with travel time of about 58-hours on 10th March at 0545 UT.

4. Event of Geomagnetic Storm of 28th May 2011:

Geomagnetic storm event of 28th May 2011 (average Dst value = -52nT) is shown in fig. 4, from 24 May to 6th of June 2011 on short-term basis.

A partial Halo CME having angular width ~3590 was observed by SOHO/LASCO on 26 May 2011 at 1912 UT with a speed of 519 km/sec. A solar flare of class M1.1 is observed by GOES on 28 May 2011, whose source area is not predicted**.** No any IP shock was observed by ACE spacecraft, but this event is associated with magnetic cloud starts at 0610 UT on 28th May and ends at 2145 UT on 28 May 2011.

5. Geomagnetic Storm of 6th August 2011:

Fig. 5, shows the hourly variation of Dst- from 1st Aug. to 14th Aug. 2011, for the plot of geomagnetic storm of 6th Aug. 2011.

GOES observed two solar flares before the geomagnetic storm event of 6th 2011. First flare of class M6.3 on 3rd August at 1317 UT in AR 1261 with 2B optical flare at (N16W30), and second flare having class M9.3 on 4th August 2011 at 0341 UT, whose source area is not predicted.

SOHO/LASCO observed two full-halo CMEs before the storm event of 6th Aug. 2011. First CME was observed on 3rd Aug. at 1400 UT with a speed of 610 km/sec. and second CME at 0412 UT on 4th of Aug. 2011 with a speed of 1351 km/sec. ACE spacecraft observed the three forward IP shocks before this the event of storm. First IP shock was observed at 2110 UT on 4th Aug. with travel time of shock about 64-hours, and left two IP shocks was observed on 5th Aug. at 1723 UT and 1832 UT with travel time of about 52-hours and 39-hours respectively.

6. Geomagnetic Storm event of 25th October 2011:

GOES observed a solar flare of class M1.3 on 22nd Oct. at 1315 UT in AR 11319 (N05W79) region. SOHO/LASCO observed a full-halo CME on 22nd Oct. at 1024 UT with a high speed of 1005 km/sec. A forward IP shock is also observed by ACE spacecraft on 24th Oct. at 1750 UT. This geomagnetic storm event is associated with magnetic cloud starts at 0120 UT and ends on 25th Oct. at 1540 UT.

The geomagnetic storm event of 25th October 2011 is shown in fig. 6 in terms of Dst-index on short-term (hourly data) basis from 20 October to 2nd November 2011.

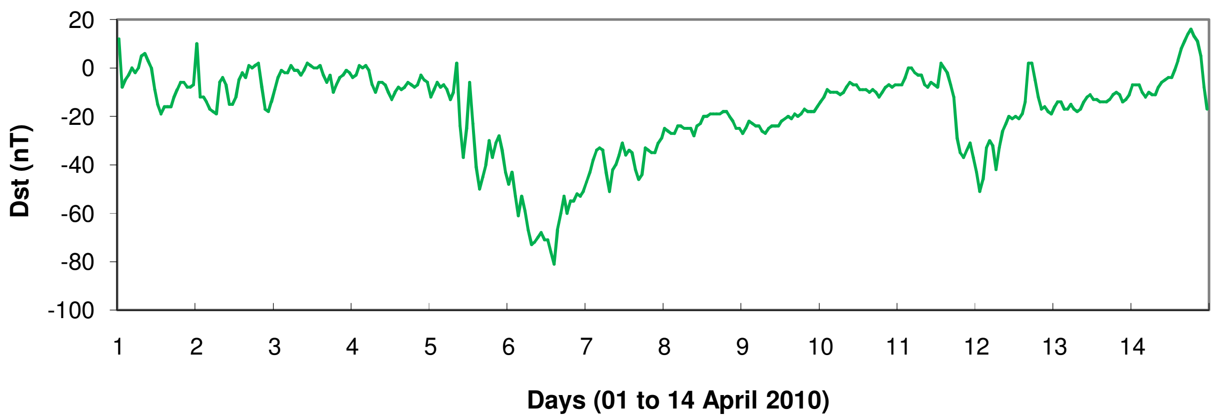

Fig. 1, shows the hourly variation of Dst-index for April 01 to 14th of 2010, for geomagnetic storm of 6th April 2010.

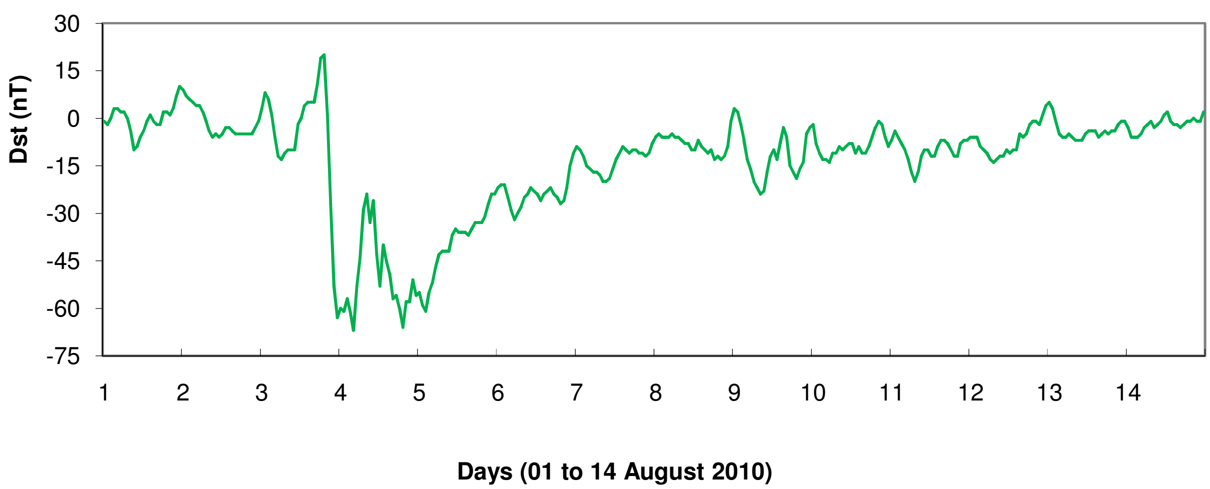

Fig. 2, shows the hourly variation of Dst-index for August 01 to 14th of 2010, for geomagnetic storm of 4th August 2010.

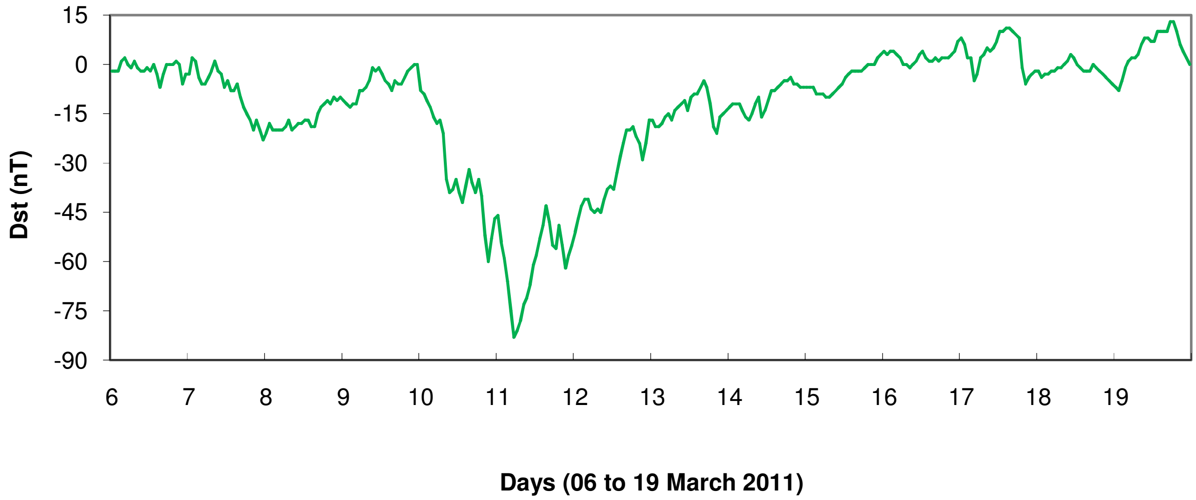

Fig. 3, shows the hourly variation of Dst-index for March 06 to 19th of 2011, for geomagnetic storm of 11th March 2011.

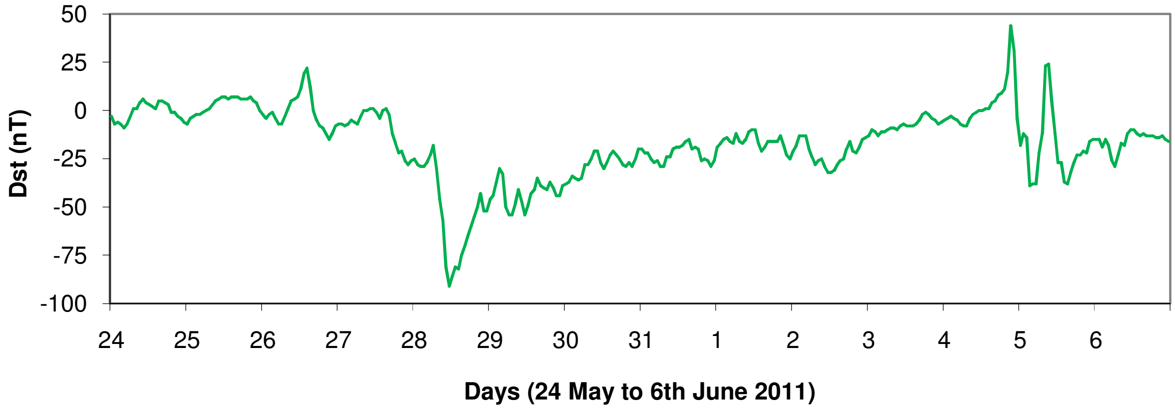

Fig. 4, shows the hourly variation of Dst-index for May 24 to 6th of June 2011, for Geomagnetic Storm of 28th May 2011.

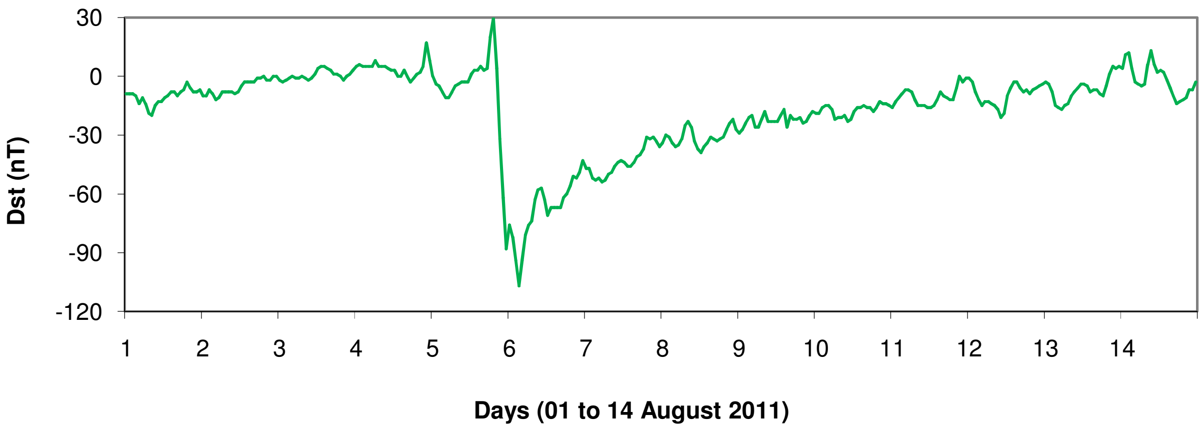

Fig. 5, shows the hourly variation of Dst-index for August 01 to 14th of 2011, for geomagnetic storm of 6th August 2011.

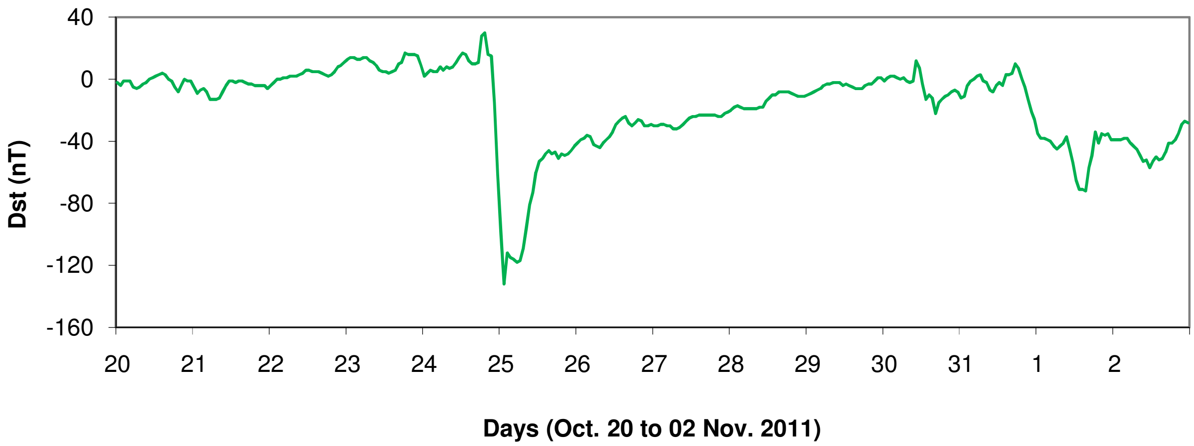

Fig. 6, shows the hourly variation of Dst-index for October-20 to 2nd November of 2011, for geomagnetic storm of 25th October 2011.

CONCLUSIONS

Based on the above discussion we have concluded that:

1. No any large geomagnetic storms (having value of Dst index -50 nT or more decreasing value) are observed in the year 2008 and 2009.
2. In our selected geomagnetic storm events, 100% events are associated with solar radio flares during the ascending phase of solar cycle-24.
3. 100% Geomagnetic Storms are associated with halo or partial halo CMEs, (83% geomagnetic storms are associated with full Halo CMEs; and only 17% storms are associated with partial Halo CMEs) during the ascending phase of cycle-24, and the speed of these CMEs lies between 519 km/sec to 2125 km/sec.
4. 83% of geomagnetic storm events are associated with interplanetary (IP) shocks and 17% storms are not associated with IP shocks during our analyzing period, the maximum travel time of any IP shocks is 64 hours (associated with the geomagnetic storm of 6th August 2011).
5. Only 50% geomagnetic storms are associated with magnetic cloud during our period of analysis.

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