Statistical Relation of CMEs Related Geomagnetic Storms With Interplanetary Magnetic Fields

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Abstract
We have studied geomagnetic storm (Dst≤-150 nT), associated with Coronal Mass Ejections (CMEs), observed during the period of 2000-2011 with Interplanetary Magnetic Fields. It is observed that coronal mass ejections (CMEs) related geomagnetic storms are found to be association rates of halo and partial halo CMEs are 18(90%) and 02(10%) respectively. From the further analysis, positive co-relation has been found between magnitude of CMEs related geomagnetic storms and speed of coronal mass ejections (CMEs), with correlation coefficient 0.50. Positive co-relation has been found between magnitude of CMEs related geomagnetic storms and magnitude of change in interplanetary magnetic fields, with correlation coefficient 0.55, positive co-relation has been found between magnitude of CMEs related geomagnetic storms and peak value of change in interplanetary magnetic fields, with correlation coefficient 0.56.
Keywords– Geomagnetic Storms, Coronal Mass Ejection and Interplanetary Magnetic Fields.

1. Introduction

Coronal mass ejections (CMEs) are the energetic solar events in which huge amount of solar plasma materials are ejected into the heliosphere from the sun and generate large disturbances in solar wind plasma parameters and geomagnetic storms in geomagnetic field (St. Cyr, 2000; Webb, 2000; Cane, 2000; Gopalswamy, 2006; Manoharan 2006; Verma et al, 2009; Verma 2012). It is believed that the main cause of intense geomagnetic storms is the large IMF structure which has an intense and long duration southward magnetic field component, Bz (Tsurutani, et al., 1988; Echer, et. al. 2004). They interact with the earth's magnetic field and facilitate the transport of energy into the earth's atmosphere through the reconnection process. Correiaa and De Souza (2005) have presented the identification of solar coronal mass ejection (CME) sources for selected major geomagnetic storms in the geomagnetic field of geomagnetosphere. They have inferred that full halo CMEs originating from active regions associated with X-ray solar flares and propagating in the western hemisphere, cause strong geomagnetic storms.

Michalek G. et. al. (2006) have concluded that halo coronal mass ejections (HCMEs) originating from regions close to the center of the sun are likely to be geoeffective. They have showed that, only fast halo CMEs (with space velocities higher than ~1000 km/s) and originating from the Western Hemisphere close to the solar center could cause intense geomagnetic storms. Gopalswamy (2009) have studied geoeffectiviness of halo and partial halo coronal mass ejections and concluded that the geoeffectiveness of partial halo CMEs is lower because they are of low speed and likely to make a glancing impact on earth rather than halo coronal mass ejections. Veronica et al (2010) have concluded on average, the most intense geomagnetic storms are caused by sheaths, followed by sheath-ICME combinations and by ICMEs. They have obtained the correlation coefficients between the intensity of each geomagnetic storm (minimum Dst) and several solar wind parameters. Gonzalez, et al (2011) have presented a review on the interplanetary causes of intense geomagnetic storms (Dst≤-100 nT), that occurred during solar cycle 23 (1997-2005). They have reported that the most common interplanetary structures leading to the development of intense storm were: magnetic clouds, sheath fields, sheath fields followed by a magnetic cloud and corotating interaction regions at the leading fronts of high speed streams.

2. Experimental Data

In this investigation hourly Dst indices of geomagnetic field have been used over the period 2000 to 2011 to determine onset time, maximum depression time, magnitude of geomagnetic storms. This data has been taken from the NSSDC Omni web data system which been created in late 1994 for enhanced access to the near earth solar wind, magnetic field and plasma data of Omni data set, which consists of one hour resolution near earth, solar wind magnetic field and plasma data, energetic proton fluxes and geomagnetic and solar activity indices. The data of coronal mass ejections (CMEs) have been taken from SOHO – large angle spectrometric, coronagraph (SOHO / LASCO) and extreme ultraviolet imaging telescope (SOHO/EIT) data. To determine disturbances in interplanetary magnetic, hourly data of average interplanetary magnetic field have been used, these data has also been taken from Omni web data (http;//omniweb.gsfc.nasa.gov/form/dxi.html)).

3. Data analysis and results

Table-1 Association of CMEs related Geomagnetic Storms (Dst≤-150nT) with Interplanetary Magnetic Fields (IMF) parameters observed during the period of 2000-2011.There are no any data associated in the period of 2006-2011 (in the criteria of Dst≤-150 nT).

Geomagnetic Storms				CMEs			IMF		
S.No.	Date	Onset time in dd(hh)	Magnitude in nT	Start time in dd(hh)	types H/P	Speeds km/sec.	Start time in dd(hh)	Magnitude in nT	Peak value in nT
1	06.04.00	06(16)	-282	04(16.32)	H	1188	06(10)	26.5	31.4
2	24.05.00	24(00)	-151	22(01.50)	H	649	23(15)	24.8	32.1
3	15.07.00	15(15)	-308	14(10.54)	H	1674	15(08)	45.2	51.9
4	12.08.00	12(01)	-214	09(16.30)	H	702	11(17)	24.1	33.6
5	17.09.00	17(20)	-197	16(05.18)	H	1215	17(14)	34.1	39.5
6	03.10.00	03(23)	-156	30(18.06)	P	703	03(00)	12.9	18.4
7	05.11.00	05(10)	-150	03(18.26)	H	291	04(23)	4.8	14.2
8	19.03.01	19(11)	-150	18(02.26)	H	752	19(09)	15.2	21.5
9	31.03.01	31(04)	-379	28(01.27)	H	427	30(21)	43.8	47.1
10	11.04.01	11(15)	-269	09(15.54)	H	1192	11(09)	30.1	34.5
11	21.10.01	21(16)	-178	19(01.27)	H	558	21(13)	21.7	28.4
12	05.11.01	05(19)	-297	04(16.35)	H	1810	05(12)	51.2	65.6
13	24.11.01	24(06)	-223	22(20.30)	H	1443	24(04)	51.2	56.9
14	17.08.03	17(17)	-171	14(20.06)	H	378	17(00)	16.5	22.2
15	28.10.03	28(06)	-384	27(08.30)	P	1322	28(01)	9.6	19.2
16	20.11.03	20(02)	-461	18(08.05)	H	1660	20(05)	48.1	55
17	07.11.04	07(20)	-376	04(09.54)	H	653	07(12)	38.8	47.8
18	15.05.05	15(05)	-293	13(17.12)	H	1689	15(01)	48.4	54.2
19	29.05.05	29(22)	-150	26(15.06)	H	586	29(01)	9.1	19.2
20	24.08.05	24(08)	-219	22(01.31)	H	1194	24(04)	43.1	52.2

The coronal mass ejections related Geomagnetic Storms and associated Interplanetary Magnetic Fields (IMF) for the period of 2000-2011 are given in the table-1. From the data analysis we have identified 20 CMEs related geomagnetic storms (Dst ≤-150 nT) during the period of 2000-2011. Out of 20 associated CMEs related geomagnetic storms 18(90%) geomagnetic storms are found to be associated with halo coronal mass ejections and 02(10%) geomagnetic storms are found to be associated with partial halo. From the fig.1, shows the positive co-relation has been found between magnitudes of CMEs related geomagnetic storms and speed of coronal mass ejections (CMEs), with correlation coefficient 0.50. From the data analysis of CMEs related geomagnetic and associated disturbances in interplanetary magnetic field, we have observed that all the CMEs related geomagnetic storms are associated with change in interplanetary magnetic field (IMF) events. To see how the magnitude of CMEs related geomagnetic storms are correlated with the magnitude of change in IMF events, we have plotted a scatter diagram between the magnitude of CMEs related geomagnetic storms and change in IMF events in fig. 2 and fig. 3. From the fig.2 and fig.3, it is clear that maximum CMEs related geomagnetic storms which have large magnitude are associated with change in IMF events which have relatively large magnitude and large peak value. Positive co-relation has been found between magnitude of CMEs related geomagnetic storms and magnitude of change in interplanetary magnetic fields. Statistically calculated co-relation co-efficient is 0.55 between these two events. Positive co-relation has been found between magnitude of CMEs related geomagnetic storms and peak value of change in interplanetary magnetic fields. Statistically calculated co-relation co-efficient is 0.56 between these two events.

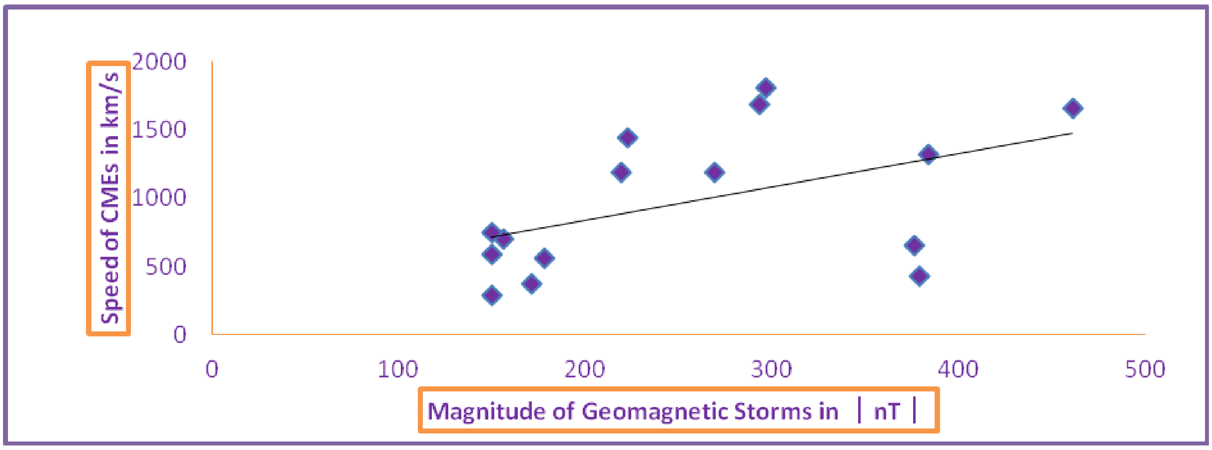

Figure-1 Shows scatter plot magnitude of CMEs related geomagnetic storms and speed of CMEs with correlation coefficient 0.50.

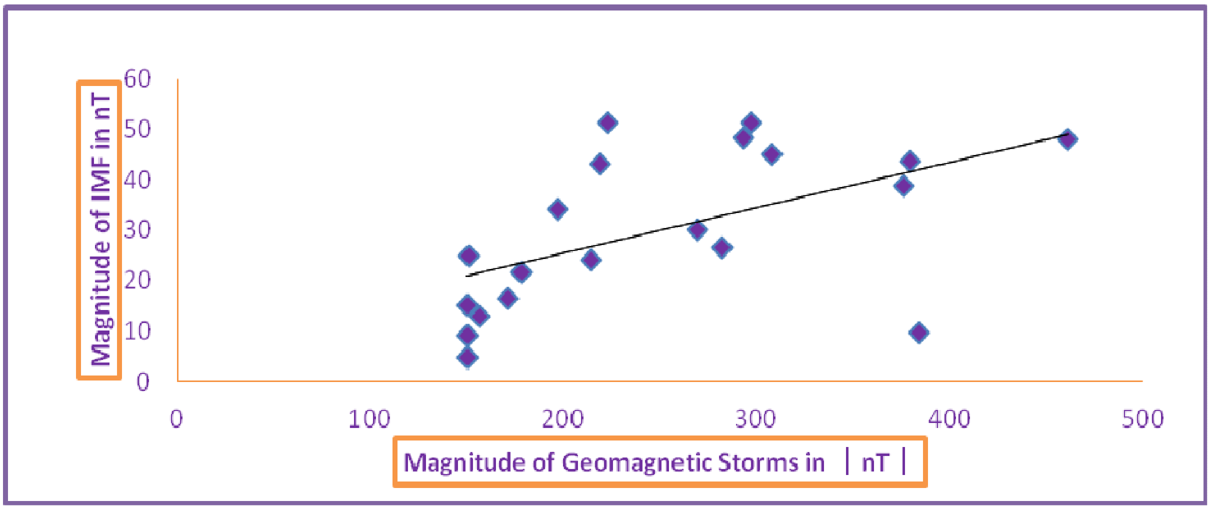

Figure-2 Shows scatter plot magnitude of CMEs related geomagnetic storms and magnitude of change in IMF events with correlation coefficient 0.55.

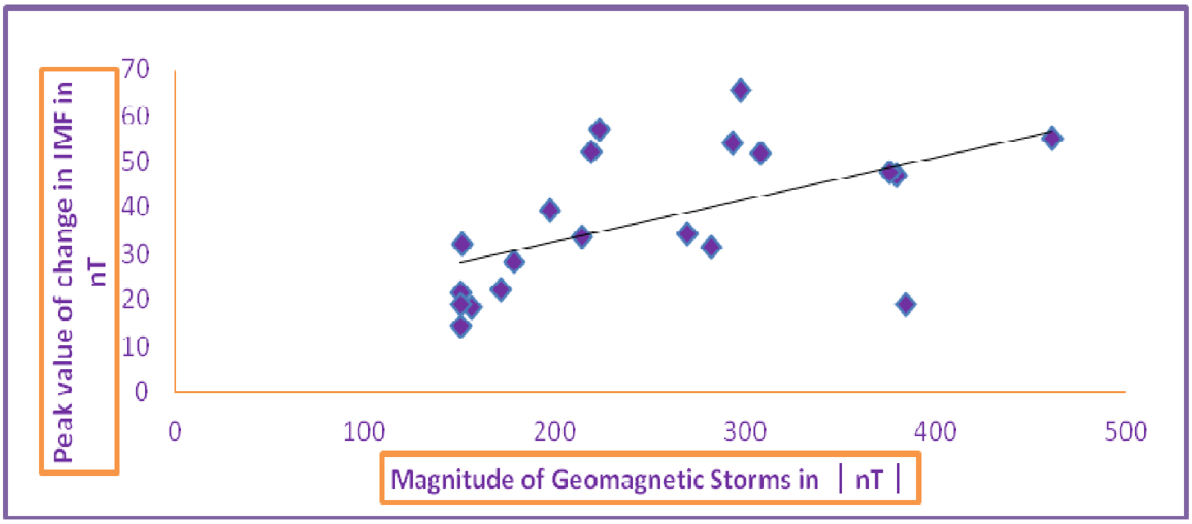

Figure-3 Shows scatter plot magnitude of CMEs related geomagnetic storms and peak value of change in IMF events with correlation coefficient 0.56.

4. Conclusion

As per the theoretically and from the study the geomagnetic storms out come from the CMEs and there is positive relationship between both such as CMEs is increase the geomagnetic storms is also increase and both have good relationship. From the study we have identified 20 CMEs related geomagnetic storms (Dst ≤-150 nT) during the period of 2000-2011. Out of 20 associated CMEs related geomagnetic storms 18(90%) geomagnetic storms are found to be associated with halo coronal mass ejections and 02(10%) geomagnetic storms are found to be associated with partial halo. Positive co-relation has been found between magnitude of CMEs related geomagnetic storms and speed of coronal mass ejections (CMEs), with correlation coefficient 0.50. Further, it is clear that maximum CMEs related geomagnetic storms which have large magnitude are associated with change in IMF events which have relatively large magnitude and large peak value. Positive co-relation has been found between magnitude of CMEs related geomagnetic storms and magnitude of change in interplanetary magnetic fields with correlation coefficient 0.55 between these two events. Positive co-relation has been found between magnitudes of CMEs related geomagnetic storms and peak value of change in interplanetary magnetic fields with correlation coefficient 0.56 between these two events. It is concluded that geomagnetic storms are mainly caused by coronal mass ejections (CMEs) associated with interplanetary magnetic fields (IMF). Thus the dynamics of all these parameters in solar atmosphere seems to be complicated and need further detailed scrutiny. So this research may be interest for future study.

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