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Geomagnetic Field Disturbances with Solar Features and Solar Wind Plasma Parameters During The Period of 2009-2012

KEYWORDS: Coronal mass ejections, X-ray solar flares, solar wind plasma parameters and geomagnetic storms.

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ABSTRACT *We have studied geomagnetic storms (Dst ≤ - 80nT) observed during the period of 2009-2012, with halo and partial halo coronal mass ejections ,X-ray solar flares ,interplanetary shocks and disturbances in solar wind plasma parameters . We have found that 81.25% geomagnetic storms are associated with halo and partial halo coronal mass ejections. The association rate of geomagnetic storms with halo and partial halo coronal mass ejections are found 61.54% and 38.46% respectively. We have found positive correlation with correlation coefficient 0.69 between magnitude of geomagnetic storms and speed of associated CMEs. Further we have observed that geomagnetic storms are also associated with X ray solar flares of different categories. The association rate of B-class, C-class and M-class X-ray solar flares are found 20.00%, 40.00% and 40.7% respectively. Majority of the geomagnetic storms 68.75% have been found to be associated with interplanetary shocks .From the study of geomagnetic storms with storms in solar wind plasma parameters we have determined positive co-relation between magnitude of geomagnetic storms and peak values of associated storm in solar wind plasma parameters with co-relation co-efficient, 0.72 between magnitude of geomagnetic storms and peak values of associated storms in interplanetary magnetic field, 0.28 between magnitude of geomagnetic storms and peak value of associated solar wind plasma temperature, 0.24 between magnitude of geomagnetic storms and peak value of associated solar wind plasma pressure.*

1-Introduction

The physical condition on the sun and in the heliosphere responsible for the production of appreciable geo-magnetic perturbations is still under investigation. They are commonly related to powerful non stationary process on the time scale from less than one hour to many hours in the solar corona and deeper layers of the solar atmosphere. It is generally believed that geomagnetic perturbations are produced by heliospheric magnetic fields and solar wind plasma streams related to the active regions, disappearing filaments and prominences, solar flares, coronal mass ejections (CMEs) and coronal holes (CH), and heliospheric current sheet (HCS). Impulsive and long duration solar flares, disappearing filaments, CMEs transient brightening and coronal holes, are the most popular solar signatures to date used for the study of geomagnetic storms .Since the beginning of the space age, the cause of geomagnetic activity has been sought in a number of correlative studies (Akasofu 1983). It is suggested that geomagnetic, activity is related to variety of interplanetary plasma/ field parameters, e.g. Solar wind velocity V, interplanetary magnetic field (IMF) B and Bz (Akasofu 1983, Joselyn and McIntosh1981,Gonzalez,et al 1994). Furthermore, the strong geomagnetic disturbance is associated with passage of magnetic cloud (Gonzalez, 1994), which causes intense and severe geomagnetic storms. (Weigel 2010). Wu & Lepping (2006) have investigated geomagnetic activity induced by interplanetary magnetic cloud (MC) during the past four solar cycles, 1965~1998 and found that the intensity of geomagnetic storms is more severe in a solar active period than in a solar quiet period. Borovsky & Denton (2006) have studied the coronal mass ejection (CME)-driven storms and co-rotating interaction region (CIR)-driven geomagnetic storms and showed that there are many differences between coronal mass ejection (CME)-driven storms and co-rotating interaction region (CIR)-driven storms. According to their findings, CME-driven storms have denser plasma sheets, stronger ring currents, disturbance storm time (Dst) perturbation, and solar energetic particle events, while CIR-driven storms have longer duration and hotter plasma sheets. On the other hand, many studies have examined the role of solar wind parameters in the development of geomagnetic storms. Some other scientists have reported that the properties of the earth-directed CMEs, such as the internal structure of the magnetic field, may determine whether or not a geomagnetic storm subsequently occurs (Burton et al. 1975; Cane et al.2000). Some other scientists have associated geomagnetic storms with coronal mass ejections (Caneet al., 2000; Cane and Richardson, 2003; Gopalswamy et al., 2007; Gopalswamy et al., 2007; Howard et al., 1982; St. Cyr et al., 2000; Webb et al., 2000; Zhao and Webb, 2003; Zhang et al., 2007,verma 2012) and all found good associations between front side halo CMEs and geomagnetic storms. Tsurutani (2001) concluded that that major geomagnetic storms are caused by solar wind structures that possess strong (>> 5 nT) southward components of the interplanetary magnetic field at 1 AU, which are usually, but not always at wind speeds higher than average. Gopalswamy (2009) studied geo-effectiveness 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 the Earth. Rather than halo coronal mass ejections. Michalek et al. (2005) 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. In this investigation we have studied geomagnetic storms (Dst ≤ - 80nT) observed during the period of 2009-2012 with coronal mass ejections X-ray solar flares and disturbances in solar wind plasma temperature, pressure and interplanetary magnetic fields to know the role of these parameters to generate geomagnetic storms.

2-Experimental Data

In this investigation hourly Dst indices of geomagnetic field have been used over the period 2002 through 2006 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

Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

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 – largeangle 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 has been used, these data has also been taken from omni webdata(http;//omniweb.gsfc.nasa.gov/form/dxi.html)). The data of X ray solar flares radio bursts, and other solar data, solar geophysical data report U.S. Department of commerce, NOAA

Monthly issue and solar STP data (http://www.ngdc.noaa.gov/stp/solar/solardatase rvices.html.) have been used. . Interplanetary shocks data are taken from the list of the shocks derived by PM group

Table-1-Geomagnetic storms and associated solar and solar wind plasma parameters during 2002-2006

	Geomagnetic Storms Dst≤-80			IMF	Temperature	Pressure	Solar flare	CMEs		Shocks
S.No.	Date	Onset time in dd(hh)	Magnitude in nT	Peak value in nT	Peak value in kelvin	Peak value in npa	Class	Speed in km/s	Type	Time in hours
1	22-07-09	22(00)	-84	16.6	225535	2.32	na	na	na	na
2	02-05-10	02(08)	-106	18.3	467969	10.86	C-22	na	na	908
3	28-05-10	28(20)	-105	14.3	102556	2.98	B-65	427	H	258
4	03-08-10	03(19)	-87	17	376618	10.07	C-32	850	H	1741
5	11-10-10	11(09)	-84	13.5	111218	9.12	B-16	282	P	na
6	04-02-11	04(16)	-80	21	530160	9.45	B-45	437	H	na
7	01-03-11	01(09)	-84	14	456448	7.84	C-42	na	na	na
8	27-05-11	27(15)	-81	13	267201	3.51	C-11	657	P	na
9	05-08-11	05(19)	-142	29.3	1024367	15.01	M-60	1315	H	2110
10	09-09-11	09(13)	-109	19.9	362200	13.65	M-67	924	P	1149
11	17-09-11	17(07)	-94	14.2	174729	15.13	C-92	530	P	305
12	26-09-11	26(13)	-136	33.3	502088	7.24	M-71	1915	H	1112
13	24-10-11	24(21)	-157	24.4	343148	13.25	M-13	1005	H	1750
14	07-03-12	07(00)	-140	17.1	364927	8.32	M-20	1531	H	347
15	23-04-12	23(15)	-119	15.5	327270	12.88	C-33	540	P	230
16	17-06-12	17(00)	-151	40.1	192576	4.4	M-19	987	H	1924

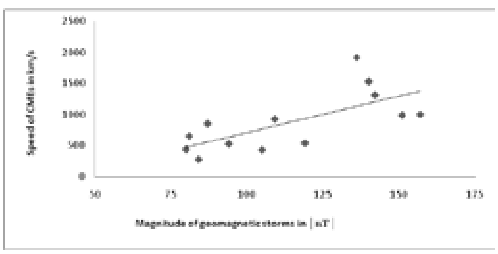

Fig-1-Scatter plot between magnitude of geomagnetic storms and speed of associated CMEs during the period of 2009-2012

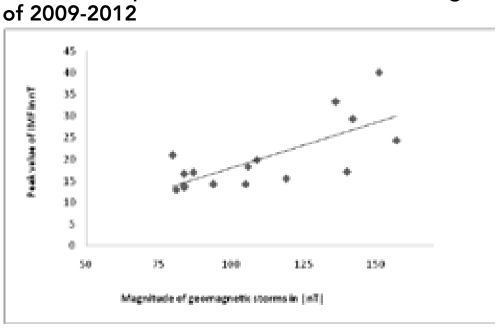

Fig-2-Scatter plot between magnitude of geomagnetic storm speak values of associated jump in interplanetary magnetic fields during the period of 2009-2012

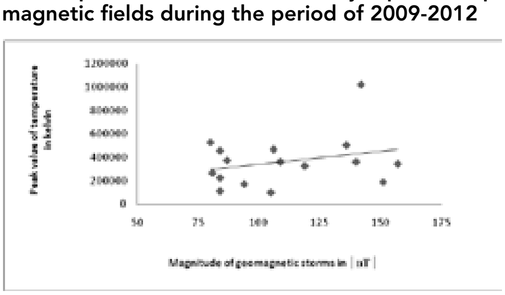

Fig-3-Scatter plot between magnitude of geomagnetic storms peak values of associated jump in solar wind plasma temperature during the period of 2009-2012

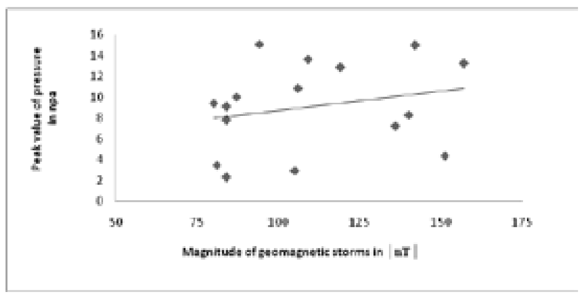

Fig-4-Scatter plot between magnitudes of geomagnetic storms peak values of associated jump in solar wind plasma pressure during the period of 2009-2012

3-Results

The association between geomagnetic storms (Dst < –80nT) and coronal mass ejections (CMEs), interplanetary shocks, disturbances in solar wind plasma parameters for the period 2009-2012 are given in Table No.1. From the data analysis it is observed that 13 out of 16(81.25%) geomagnetic storms are found to be associated with halo and partial halo coronal mass ejections. The association rate of halo and partial halo coronal mass ejections have been found 61.54% and 38.46% respectively. We have found positive correlation with correlation coefficient 0.69 between magnitude of geomagnetic storms and speed of associated CMEs[Fig-1].We have also determined 15 out of 16 geomagnetic storms, are related to the X-ray solar flares of different categories. 06(40.00%),M class, 06(40.00%)C-class and 03 (20.00%) B-class .From further analysis it is observed that majority of these geomagnetic storms are associated with interplanetary shocks and the related shocks are forward shocks. We have 16 geomagnetic storms in our list in which 11 geomagnetic storms (68.75%) have been found to be associated with interplanetary shocks. From the study of geomagnetic storms with solar wind plasma parameters i.e. Jump in solar wind temperature (JSWT) jump in solar wind pressure(JSWP) , jump in interplanetary magnetic field(JIMF) ,we have determined positive co-relation between magnitude of geomagnetic storms and peak values of associated storm in solar wind plasma parameters

Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

with correlation co-efficient 0.28 between magnitude of geomagnetic storms and peak values of associated jump in solar wind plasma temperature[Fig-3] , 0.72 between magnitude of geomagnetic storms and peak values of associated jump in interplanetary magnetic field[Fig2], 0.24 between magnitude of geomagnetic storms and peak value of associated jump in solar wind plasma pressure[Fig-4].

4-Cconclusion

From our study 13 out of 16 geomagnetic storms < -80nT have been identified as being associated with coronal mass ejections ,15out of 16 have been identified as being associated with solar flares 11out of 16 have been identified as being associated with interplanetary shocks.. These results are suggesting that the coronal mass ejections associated with X-ray solar and associated with interplanetary shocks are very much effective in producing major geomagnetic storms. The positive correlation between magnitude of geomagnetic storms and peak values of solar wind temperature, pressure and interplanetary magnetic fields suggest that disturbances in solar wind parameters play crucial role in producing geomagnetic storms.

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