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DISTURBANCES IN SOLAR WIND PLASMA PARAMETERS IN RELATION WITH X AND M CLASS X- RAY SOLAR FLARE RELATED INTENSE GEOMAGNETIC STORMS

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Abstract

We have studied X and M-Class X -Ray solar flares related intense geomagnetic storms observed during the period of 2000-2006 with halo and partial halo coronal mass ejections, solar radio bursts and disturbances in solar wind plasma parameters. We have found that 82.45% X and M-Class X-Ray solar flare related intense geomagnetic storms are associated with halo and partial halo coronal mass ejections. The association rate of halo and partial halo coronal mass ejections are found 78.72 % and 21.27 % respectively. Further we have observed that 73.68% X and M-Class X-Ray solar flare related intense geomagnetic storms are associated with solar radio bursts. The association rate of type IV and type II radio bursts have been found 59.52 % and 40.47% respectively. From the study of X and M-Class X-Ray solar flare related intense geomagnetic storms with disturbances in solar wind plasma parameters ,we have determined positive co-relation with co-relation co-efficient, 0.71 between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak values of associated jump in interplanetary magnetic field, 0.69 between magnitude of X and M-class X-Ray solar flare related intense geomagnetic storms and magnitude of jump in interplanetary magnetic fields .0.30 between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak value of associated jump in solar wind plasma temperature, 0.35 between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and magnitude of associated jump in solar wind plasma temperature 0.43 between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak value of associated jump in solar wind plasma velocity, 0.30 between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak value of associated jump in solar wind plasma pressure.

Keywords *–Disturbances in Solar Wind Plasma Parameters, Coronal Mass Ejections, X-Ray Solar Flares, Radio Bursts, Intense Geomagnetic Storms.*

Introduction

The geospheric en-vironment is highly affected by the solar active regions associated solar features and interplanetary parameters such as solar flare (SFs), active prominences disappearing filaments (APDFs), coronal holes, magnetic clouds , coronal mass ejections (CMEs), radio bursts interplanetary shocks and disturbances in solar wind plasma parameters . The active regions and related major classes of solar activity tend to track the sunspot number during the cycle, including, radio burst, calcium plages, solar flares, filaments, and coronal mass ejections (CMEs) (Webb and Howard, 1994). Several scientist have investigated relation between solar features and interplanetary parameters (Leamon et al. 2004, Bothmer and Schwenn 1994, Marubashi 1997, Zhao and Hoeksema 1998, Crooker 2000, McAllister and Martin 2000, Yurchyshyn et al. 2001, Luhmann et al. 2002 and Zhao and Webb 2003) and suggested that there is a straightforward relationship between the solar features and interplanetary parameters and it is inferred that geomagnetosphere is highly effected by solar active regions associated solar features and interplanetary parameters. Earth-directed CMEs are likely to impact the magnetosphere to cause geomagnetic storms in geomagnetosphere (N Gopalswamy, 2006, Manoharan 2006). The intensity of geomagnetic storms is primarily decided by the speed of CME and strength of magnetic field it contains (Gopalswamy, 2002, Cane, et al 2000), whereas according to Manoharan(,2006), primary factors determining the geoeffectiveness are the direction of propagation of CMEs, its speed, size, density, orientation and strength of the magnetic field at the near earth space. Intense geomagnetic storms are found to be mainly caused by CMEs (Landi and Moreno et al 1998, Zhang, et al 2003, Gopalswamy 2002, Cid, et al 2004, Gopalswamy, 2007, Michalek G.et al 2006, Correiaa, and de Souzaa 2005 , Gopalswamy et al. 2008 , Gopalswamy 2009). Tsurutani,et al 1988 and Echer,et al 2004 have studied geomagnetic storms with interplanetary magnetic fields and inferred 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* .They interact with the earth's magetic field and facilitate the transport of energy into the earth's atmosphere through the reconnection process.

Zhang et al (2007) have studied, 88 major geomagnetic storms ($Dst < -100$ nT) that occurred during 1996-2005. They have found that 53 (60%),) S-type, in which the storm is associated with a single ICME and a single CME at the Sun ,24 (27%), M-type, in which the storm is associated with a complex solar wind flow produced by multiple interacting ICMEs arising from multiple halo CMEs launched from the Sun in a short period; and 11 (13%), C-type, in which the storm is associated with a CIR formed at the leading edge of a high-speed stream originating from a solar coronal hole (CH).Echer, E et al (2004) have analyzed plasma and magnetic field parameter variations across fast forward interplanetary shocks during the last solar cycle minimum (1995 1996, 15 shocks), and maximum year 2000 .They have observed that the solar wind velocity and magnetic field strength variation across the shocks are the parameters better correlated with Dst. They have also observed that during solar maximum, 36% of interplanetary shocks are followed by intense ($Dst \leq -100$ nT) and 28% by moderate ($-50 \leq Dst < -100$ nT) geomagnetic activity. During solar minimum, 13% and 33% of the shocks are followed by intense and moderate geomagnetic activity, respectively .Chao Yuea nd Qiugang Zong (2011) have investigated interplanetary shocks associated with coronal mass ejections (CMEs) with geomagnetic storms and concluded that interplanetary shocks associated with coronal mass ejections (CMEs have very profound effects on geomagnetic storms. C. Oprea1 et al (2013) have studied solar and interplanetary parameters and found that the superposed epoch analysis revealed the strong dependence of the geomagnetic storm intensity on the southward component of the interplanetary magnetic field, Bz, which leads to magnetic reconnection between the IP structures and Earth’s front-side magnetic field. This strong dependence between the storm intensity and Bz has been well established by the past studies (Wu and Lepping, 2002; Srivastava and Venkatakrishnan, 2004; Echer et al., 2008).In this investigation X and M class solar flare related intense geomagnetic storms observed during the period of 2000-2006 have been studied with coronal mass ejections, radio bursts and disturbances in solar wind plasma parameters to know the physical process mainly responsible generate intense geomagnetic storms .

Experimental data

In this study geomagnetic storms associated with X and M class X-ray solar flares have been studied with coronal mass ejections, radio bursts, and disturbances in solar wind plasma parameters observed during the period of 2000-2006. To determine geomagnetic storms and disturbances in solar wind plasma parameters, solar wind plasma velocity, hourly data of Dst index and solar wind plasma parameters has been used and these data has been taken from Omni web data (http;//omniweb.gsfc.nasa.gov/form/dxi.html). 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. The data of solar radio bursts and X-ray solar flares are taken from STP solar data (http://www.ngdc.noaa.gov/stp/solar/solardataservices.html).

Table -1

	X and M Class Related Intense Geomagnetic storms , Associated Solar Features and IMF									
	Geomagnetic storms			**IMF**			**CMEs**		**SF**	**Radio bursts**
S. NO.	Date	Onset time in dd(hh)	Magnitude in nT	Start time in dd(hh)	Maximum IMF	Magnitude in nT	types H/P	Speeds km/sec.	Class	Type
1	11.02.00	11(07)	-132	11(23)	20.6	14.3	H	1079	M-13	II
2	06.04.00	06(16)	-282	06(10)	31.4	26.5	H	1188	M-10	II
3	24.05.00	24(00)	-151	23(15)	32.1	24.8	H	649	M13	IV
4	15.07.00	15(15)	-308	15(08)	51.9	45.2	H	1674	X-57	II
5	12.08.00	12(01)	-214	11(17)	33.6	24.1	H	702	M11	II
6	17.09.00	17(20)	-197	17(14)	39.5	34.1	H	1215	M-59	IV
7	03.10.00	03(23)	-156	03(00)	18.4	12.9	P	703	M-10	II
8	13.10.00	13(14)	-100	12(19)	18	12	H	798	M15	II
9	28.10.00	28(21)	-126	28(18)	18.8	10.1	H	770	M11	II
10	05.11.00	05(10)	-150	04(23)	14.2	4.8	H	291	C-32	na
11	10.11.00	10(07)	-102	10(05)	17.8	8.2	H	474	M74	IV
12	26.11.00	26(22)	-127	26(08)	27.7	24.2	H	1254	X-23	II
13	19.03.01	19(11)	-150	19(09)	21.5	15.2	H	752	M11	II
14	31.03.01	31(04)	-379	30(21)	47.1	43.8	H	427	M-17	IV
15	11.04.01	11(15)	-269	11(09)	34.5	30.1	H	1192	M-79	IV
16	18.04.01	18(01)	-106	17(23)	23.8	18.9	P	1199	X-144	IV
17	22.04.01	22(00)	-106	21(21)	15.1	9.6	P	1160	M41	na
18	17.08.01	17(17)	-102	17(07)	32.1	28	H	1575	M10	II
19	21.10.01	21(16)	-178	21(13)	28.4	21.7	H	558	X-16	II
20	28.10.01	28(01)	-142	27(22)	19.5	12.8	H	1092	X-13	IV
21	31.10.01	31(14)	-104	31(18)	13.9	7.8	P	1005	M30	IV
22	05.11.01	05(19)	-297	05(12)	65.6	51.2	H	1810	X-10	IV
23	24.11.01	24(06)	-223	24(04)	56.9	51.2	H	1443	M-38	II
24	17.04.02	17(11)	-149	17(07)	30.4	23.2	H	720	M-12	IV
25	11.05.02	11(13)	-103	11(05)	19.4	13.3	H	614	M14	na
26	01.08.02	01(23)	-105	01(01)	14.4	7.4	P	360	M12	IV
27	18.08.02	18(22)	-110	18(18)	13.8	9.1	H	1585	M-52	II
28	04.09.02	04(02)	-102	03(07)	18.9	9.1	na	na	M10	na
29	06.09.02	06(09)	-159	na	na	na	P	513	M10	II
30	01.10.02	01(04)	-156	01(06)	24.8	4	na	na	M31	na
31	21.11.02	21(02)	-122	20(22)	32	22.2	P	938	M14	na
32	27.05.03	27(23)	-118	27(04)	12	3.5	na	na	M14	na
33	16.06.03	16(10)	-136	15(17)	14.4	5	P	1215	M-15	IV
34	11.07.03	11(00)	-109	11(03)	12.8	3.5	na	na	M20	na

35	17.08.03	17(17)	-171	17(00)	22.2	16.5	H	378	M12	na
36	28.10.03	28(06)	-384	28(01)	19.2	9.6	P	1322	M-27	IV
37	20.11.03	20(02)	-461	20(05)	55	48.1	H	1660	M-45	IV
38	22.01.04	22(05)	-144	21(21)	25	19.7	H	965	M-61	II
39	11.02.04	11(10)	-107	11(09)	21.2	13.6	na	na	M12	na
40	03.04.04	03(14)	-113	03(23)	18.3	10.1	na	na	M15	na
41	22.07.04	22(00)	-106	22(14)	18.9	10.4	H	710	M-86	IV
42	24.07.04	24(11)	-198	24(05)	21.9	16.3	na	na	M22	na
43	30.08.04	30(02)	-119	29(23)	15	5.9	na	na	M14	na
44	07.11.04	07(20)	-376	07(12)	47.8	38.8	H	653	M93	IV
45	16.01.05	16(20)	-117	17(07)	35.3	31.1	H	2049	M-86	IV
46	21.01.05	21(19)	-103	21(15)	29.5	24.8	H	2020	X-13	IV
47	07.05.05	07(20)	-126	07(12)	16.6	10.7	H	1180	M13	II
48	15.05.05	15(05)	-293	15(01)	54.2	48.4	H	1689	M-80	IV
49	20.05.05	20(04)	-101	20(06)	15	5.7	P	405	M18	IV
50	29.05.05	29(22)	-150	29(01)	19.2	9.1	H	586	M11	IV
51	12.06.05	12(17)	-109	12(07)	24.2	18.6	na	na	M10	na
52	10.07.05	10(11)	-100	10(02)	25.2	15.7	H	683	M-49	IV
53	24.08.05	24(08)	-219	24(04)	52.2	43.1	H	1194	M-26	IV
54	31.08.05	31(12)	-138	31(03)	18.6	10.8	H	1600	M16	na
55	11.09.05	11(02)	-127	10(21)	18.2	13	H	2257	X-62	IV
56	14.04.06	14(10)	-111	13(14)	19.8	10.9	na	na	M12	na
57	14.12.06	14(21)	-143	14(11)	17.9	13.9	H	1774	X-34	IV

Table -2

	X and M Class X-Ray Solar Related Geomagnetic storms and Associated Disturbances in Solar wind Plasma Parameters									
	Geomagnetic storms			Solar wind temperature			Solar wind velocity		Solar wind pressure	
S. NO.	Date	Onset time in dd(hh)	Magnitude in nT	Start time in dd(hh)	Maximum Temperature in degree Kelvin	Jump Magnitude in Degree kelvin	Start time in dd(hh)	Maximum velocity in Km/s	Start time in dd(hh)	Maximum Pressure npa
1	11.02.00	11(07)	-132	11(01)	256885	157720	11(02)	505	11(01)	4.36
2	06.04.00	06(16)	-282	06(15)	345986	325941	06(15)	589	06(12)	19.6
3	24.05.00	24(00)	-151	23(20)	468151	413126	23(16)	631	23(16)	27.97
4	15.07.00	15(15)	-308	15(08)	1501458	1452345	15(13)	1010	15(12)	30.15
5	12.08.00	12(01)	-214	11(18)	400136	651965	11(16)	671	11(20)	10.34
6	17.09.00	17(20)	-197	17(13)	920518	803820	17(15)	839	17(13)	25.54
7	03.10.00	03(23)	-156	03(14)	29535	15645	02(23)	461	03(16)	4.09
8	13.10.00	13(14)	-100	13(02)	265699	173385	12(21)	469	13(06)	11.05
9	28.10.00	28(21)	-126	28(13)	157899	102142	28(05)	415	28(18)	11.35
10	05.11.00	05(10)	-150	04(17)	487233	303563	04(11)	594	04(18)	3.66
11	10.11.00	10(07)	-102	10(05)	2228444	1925089	09(23)	910	10(05)	28.49
12	26.11.00	26(22)	-127	26(08)	631551	552597	26(03)	623	26(11)	23.61
13	19.03.01	19(11)	-150	na	na	na	19(08)	490	na	na
14	31.03.01	31(04)	-379	30(22)	704151	666839	30(19)	716	31(02)	38.76
15	11.04.01	11(15)	-269	11(10)	849339	729729	11(12)	732	11(10)	24.47
16	18.04.01	18(01)	-106	17(22)	301239	272566	17(23)	518	17(22)	14.38
17	22.04.01	22(00)	-106	21(13)	70688	54930	21(15)	388	21(15)	7.18
18	17.08.01	17(17)	-102	17(08)	316649	299070	17(09)	599	17(10)	21.8
19	21.10.01	21(16)	-178	21(15)	529177	422395	21(10)	676	21(13)	26.9
20	28.10.01	28(01)	-142	28(00)	190892	178222	28(01)	502	27(23)	5.29
21	31.10.01	31(14)	-104	31(08)	66992	63658	31(12)	387	31(10)	8.42

22	05.11.01	05(19)	-297	05(10)	135790	105551	05(14)	426	05(17)	14.39
23	24.11.01	24(06)	-223	24(03)	2464027	2292789	24(03)	946	24(02)	70.02
24	17.04.02	17(11)	-149	17(08)	396426	353020	27(06)	611	17(09)	14.84
25	11.05.02	11(13)	-103	11(06)	224668	193268	11(08)	441	11(07)	21.33
26	01.08.02	01(23)	-105	01(03)	311710	292141	01(22)	524	01(16)	7.53
27	18.08.02	18(22)	-110	18(11)	571733	484987	18(16)	573	18(15)	8.97
28	04.09.02	04(02)	-102	04(00)	257857	226235	04(00)	442	na	na
29	06.09.02	06(09)	-159	06(03)	124893	26868	05(12)	457	05(12)	1.8
30	01.10.02	01(04)	-156	30(09)	112901	71897	01(00)	413	30(11)	10.73
31	21.11.02	21(02)	-122	21(01)	503038	401981	20(20)	727	20(21)	24.06
32	27.05.03	27(23)	-118	27(00)	320258	277056	27(17)	716	27(12)	4.3
33	16.06.03	16(10)	-136	15(13)	249171	100632	15(12)	594	16(02)	6.78
34	11.07.03	11(00)	-109	11(03)	529872	516059	10(16)	360	11(01)	6.04
35	17.08.03	17(17)	-171	17(09)	236723	224467	17(13)	530	17(12)	9.18
36	28.10.03	28(06)	-384	28(08)	1044292	979536	27(22)	809	27(22)	5.88
37	20.11.03	20(02)	-461	20(05)	534783	487107	20(02)	703	19(20)	16.26
38	22.01.04	22(05)	-144	22(00)	585976	501487	22(00)	666	22(00)	15.17
39	11.02.04	11(10)	-107	11(06)	100962	51108	11(13)	702	11(04)	6.35
40	03.04.04	03(14)	-113	03(07)	121421	80343	03(08)	504	03(08)	9.95
41	22.07.04	22(00)	-106	22(08)	981133	507727	22(09)	672	22(06)	6.33
42	24.07.04	24(11)	-198	24(00)	479820	472606	24(04)	600	23(22)	12.25
43	30.08.04	30(02)	-119	29(14)	59302	47028	29(06)	440	29(06)	5.19
44	07.11.04	07(20)	-376	07(10)	808505	786124	07(09)	730	07(17)	32.75
45	16.01.05	16(20)	-117	16(09)	184011	93358	16(09)	578	16(09)	11.8
46	21.01.05	21(19)	-103	21(04)	711877	640871	21(14)	950	21(11)	56.86
47	07.05.05	07(20)	-126	07(18)	918810	866682	07(17)	565	07(16)	12.92
48	15.05.05	15(05)	-293	15(02)	959643	883346	14(23)	959	14(22)	23.5
49	20.05.05	20(04)	-101	19(18)	54918	26401	19(16)	473	19(18)	8.84
50	29.05.05	29(22)	-150	29(12)	270337	247526	29(08)	540	29(09)	7.17
51	12.06.05	12(17)	-109	12(09)	474130	228070	12(02)	500	12(07)	12.6
52	10.07.05	10(11)	-100	10(00)	308733	290138	09(19)	466	10(03)	10.43
53	24.08.05	24(08)	-219	24(03)	456378	408410	24(00)	707	24(10)	21.3
54	31.08.05	31(12)	-138	31(18)	190393	145193	31(07)	414	31(08)	12.52
55	11.09.05	11(02)	-127	na	na	na	na	na	na	na
56	14.04.06	14(10)	-111	13(17)	367605	356943	14(01)	546	14(09)	8.59
57	14.12.06	14(21)	-143	14(03)	915015	779800	14(06)	896	14(09)	13.45

Data Analysis and Results

From data analysis of X and M class X-ray solar flare related intense geomagnetic storms and coronal mass ejections listed in Table 1 it is observed that most of the X and M class X-ray solar flare related intense geomagnetic storms are associated with halo and partial halo coronal mass ejections (CMEs) .We have 57 X and M class X-ray solar flare related intense geomagnetic storms in our list Out of which 47 are associated with coronal mass ejections (CMEs). The association rate of halo and partial halo coronal mass ejections are found 78.72 % and 21.27 % respectively. Further we have observed that 73.68% X and M-Class X-Ray solar flare related intense geomagnetic storms are associated with solar radio bursts. We have 57 X and M-Class X-Ray solar flare related intense geomagnetic storms out of which 41 are associated with type IV and type II solar radio bursts. The association rate of type IV and type II radio bursts have been found 59.52 % and 40.47% respectively.

From the data analysis of geomagnetic storms and associated disturbances in interplanetary magnetic fields listed in Table1,it is observed that most of the geomagnetic storms (98.24%) have been found to be associated with disturbances in interplanetary magnetic fields. We have 57 geomagnetic storms in our list out of which 56 are associated with jump in interplanetary magnetic fields.

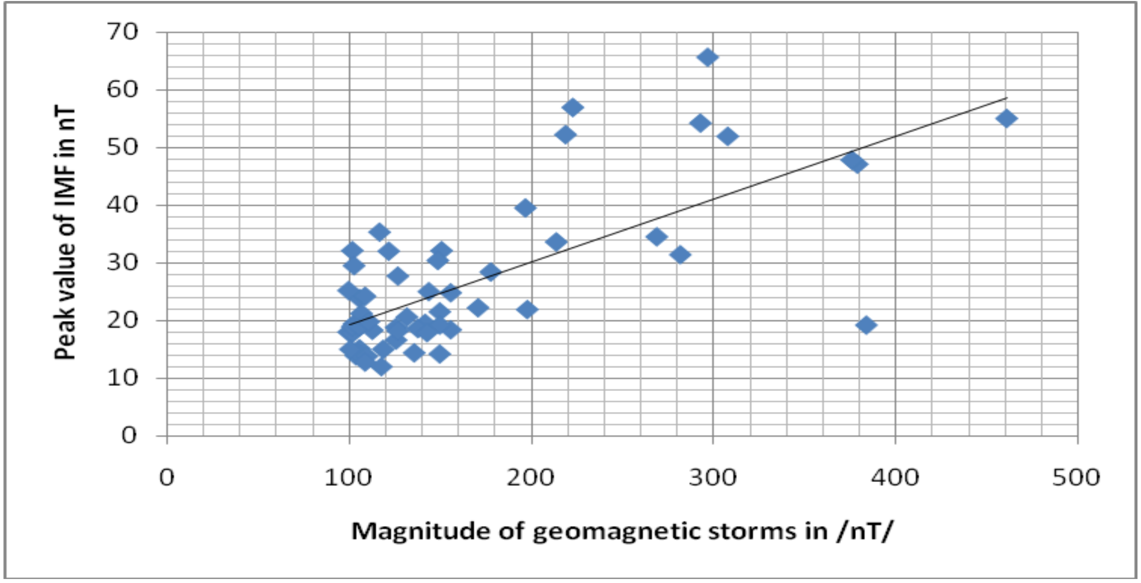

Figure-1-Scatter plot between magnitude of geomagnetic storms and peak value of IMF showing positive correlation with correlation coefficient 0.71.

To know the statistical behavior of geomagnetic storms and peak value of associated JIMF events a scatter plot has been plotted between magnitude of geomagnetic storms and peak value of associated JIMF events and the resulting plot is shown in Figure 1. From the Figure it is inferred that, most of geomagnetic storms having higher magnitude are associated with such JIMF which have relatively higher peak value but these two events do not have any fixed proportion, We have found some geomagnetic storms which have higher magnitude but they are associated with such JIMF events which have lower values of peak IMF and vice versa. Positive correlation has been found between magnitude of geomagnetic storms and peak value of IMF of associated JIMF events. Statistically calculated co-relation co-efficient is 0.71 between these two events.

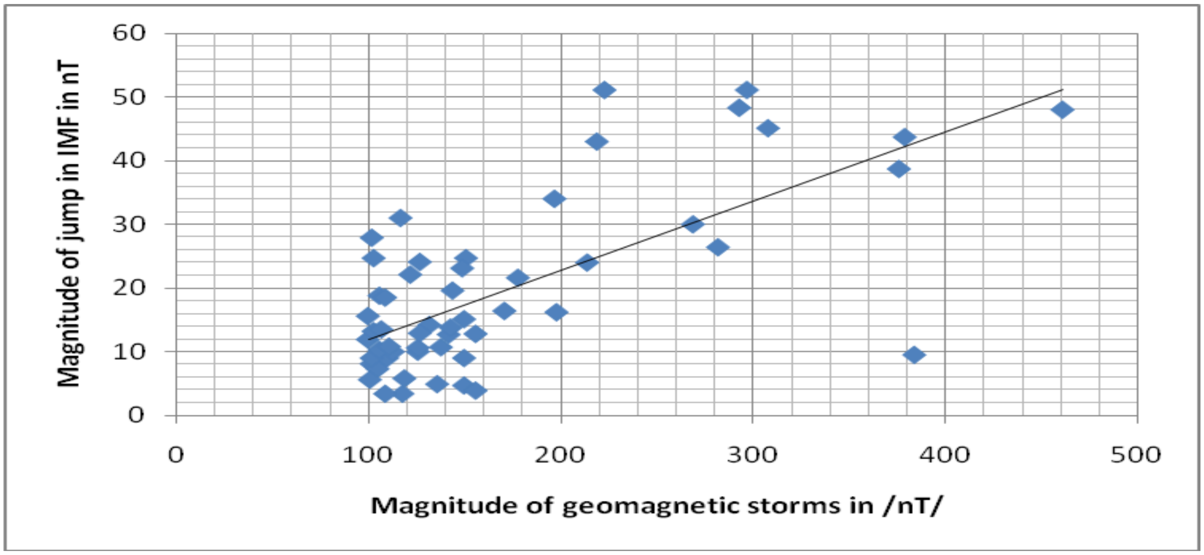

Figure-2-Scatter plot between magnitude of geomagnetic storms and magnitude of jump in IMF showing positive correlation with correlation coefficient 0.69.

To know the statistical behavior of geomagnetic storms and magnitude of jump of associated JIMF events a scatter plot has been plotted between magnitude of geomagnetic storms and magnitude of jump of associated JIMF events and the resulting plot is shown in Figure 2. From the Figure it is inferred that, most of geomagnetic storms having higher magnitude are associated with such JIMF events which have relatively higher magnitude but these two events do not have any fixed proportion, We have found some geomagnetic storms which have higher magnitude but they are associated with such JIMF events which have lower magnitude of IMF and vice versa. Positive correlation has been found between magnitude of geomagnetic storms and magnitude of associated JIMF events. Statistically calculated co-relation co-efficient is 0.69 between these two events.

From the data analysis of geomagnetic storms and associated disturbances in solar wind plasma temperature listed in Table 2 , it is observed that most of the geomagnetic storms (96.49%) have been found to be associated with disturbances in solar wind plasma temperature. We have 57 geomagnetic storms in our list out of which 55 are associated with jump in solar wind plasma temperature.

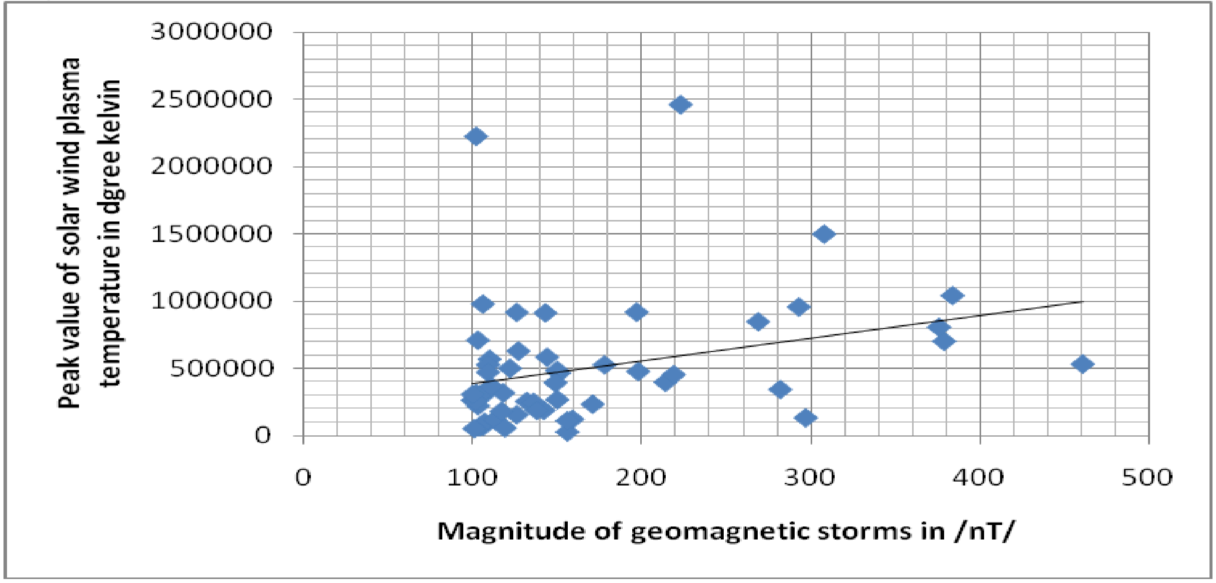

Figure-3-Scatter plot between magnitude of geomagnetic storms and peak value of solar wind plasma temperature showing positive correlation with correlation coefficient 0.30.

To know the statistical behavior of geomagnetic storms and peak value of associated JSWT events a scatter plot has been plotted between magnitude of geomagnetic storms and peak value of associated JSWT events and the resulting plot is shown in Figure 3. From the Figure it is inferred that, most of geomagnetic storms having higher magnitude are associated with such JSWT events which have relatively higher peak value of temperature but these two events do not have any fixed proportion, We have found some geomagnetic storms which have higher magnitude but they are associated with such JSWT events which have lower values of peak JSWT events and vice versa. Positive correlation has been found between magnitude of geomagnetic storms and peak value of temperature of associated JSWT events. Statistically calculated co-relation co-efficient is 0.30 between these two events.

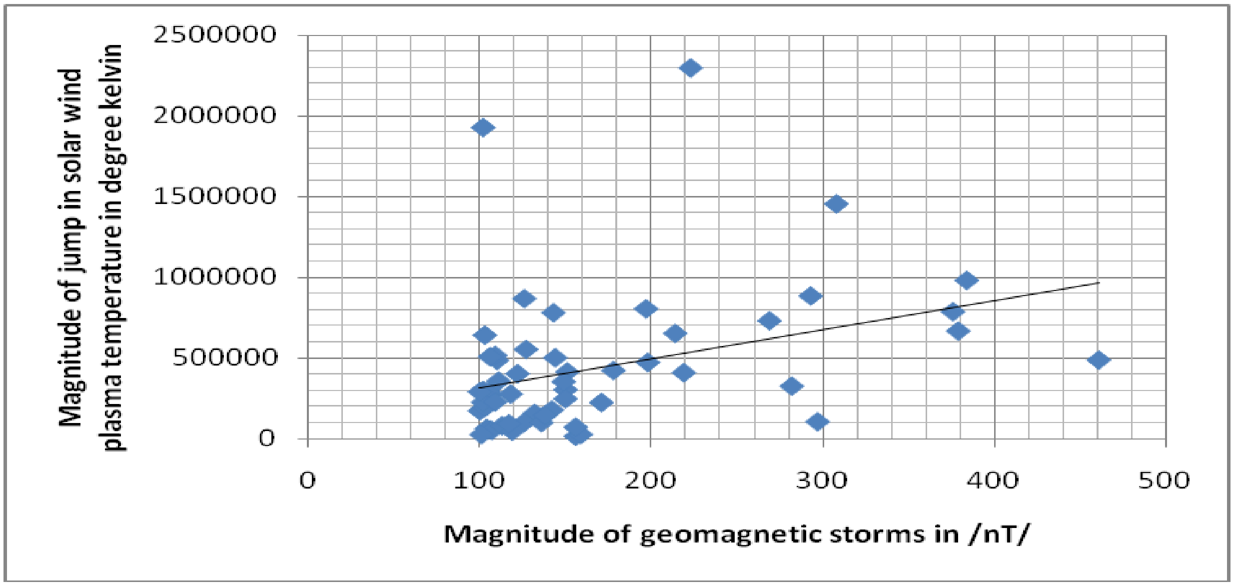

Figure-4-Scatter plot between magnitude of geomagnetic storms and magnitude of jump in solar wind plasma temperature showing positive correlation with correlation coefficient 0.35.

To know the statistical behavior of geomagnetic storms and magnitude of jump of associated JSWT events a scatter plot has been plotted between magnitude of geomagnetic storms and magnitude of jump of associated JSWT events and the resulting plot is shown in Figure4. From the Figure it is inferred that, most of geomagnetic storms having higher magnitude are associated with such JSWT which have relatively higher magnitude but these two events do not have any fixed proportion, We have found some geomagnetic storms which have higher magnitude but they are associated with such JSWT events which have lower magnitude of JSWT and vice versa. Positive correlation has been found between magnitude of geomagnetic storms and magnitude of jump of temperature of associated JSWT events. Statistically calculated co-relation co-efficient is 0.35 between these two events.

From the data analysis of geomagnetic storms and associated disturbances in solar wind plasma velocity listed in Table 2, it is observed that most of the geomagnetic storms (98.24%) have been found to be associated with disturbances in solar wind plasma velocity. We have 57 geomagnetic storms in our list out of which 56 are associated with jump in solar wind plasma velocity.

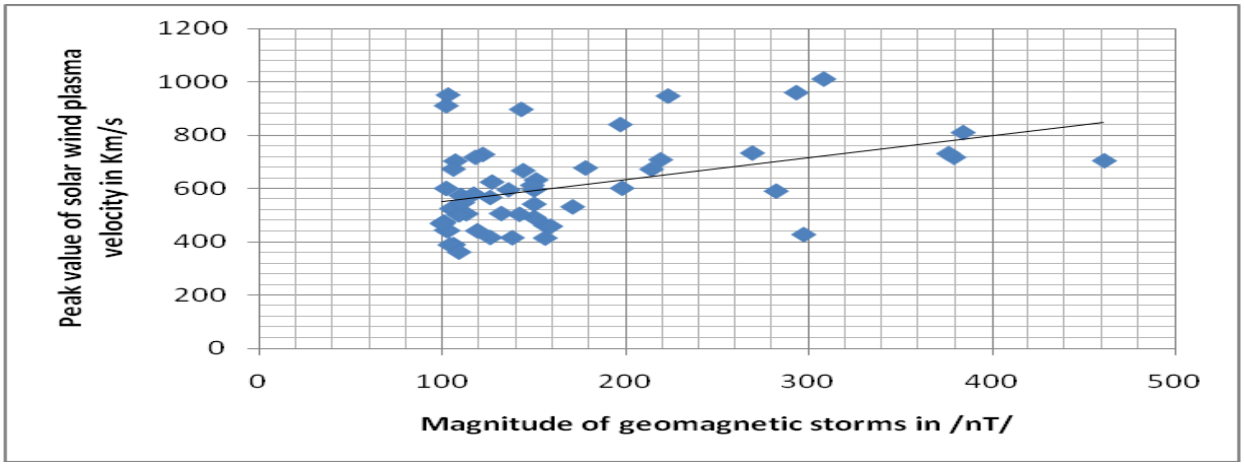

Figure-5-Scatter plot between magnitude of geomagnetic storms and peak value of solar wind plasma velocity showing positive correlation with correlation coefficient 0.42.

To know the statistical behavior of geomagnetic storms and peak value of associated JSWV events a scatter plot has been plotted between magnitude of geomagnetic storms and peak value of associated JSWV events and the resulting plot is shown in Figure 5. From the Figure it is inferred that, most of geomagnetic storms having higher magnitude are associated with such JSWV events which have relatively higher peak value but these two events do not have any fixed proportion, We have found some geomagnetic storms which have higher magnitude but they are associated with such JSWV events which have lower values of peak JSWV and vice versa. Positive correlation has been found between magnitude of geomagnetic storms and peak value of velocity of associated JSWV events. Statistically calculated co-relation co-efficient is 0.42 between these two events.

From the data analysis of geomagnetic storms and associated disturbances in solar wind plasma pressure listed in Table 2, it is observed that most of the geomagnetic storms (96.49%) have been found to be associated with disturbances in solar wind plasma pressure. We have 57 geomagnetic storms in our list out of which 55 are associated with jump in solar wind plasma pressure.

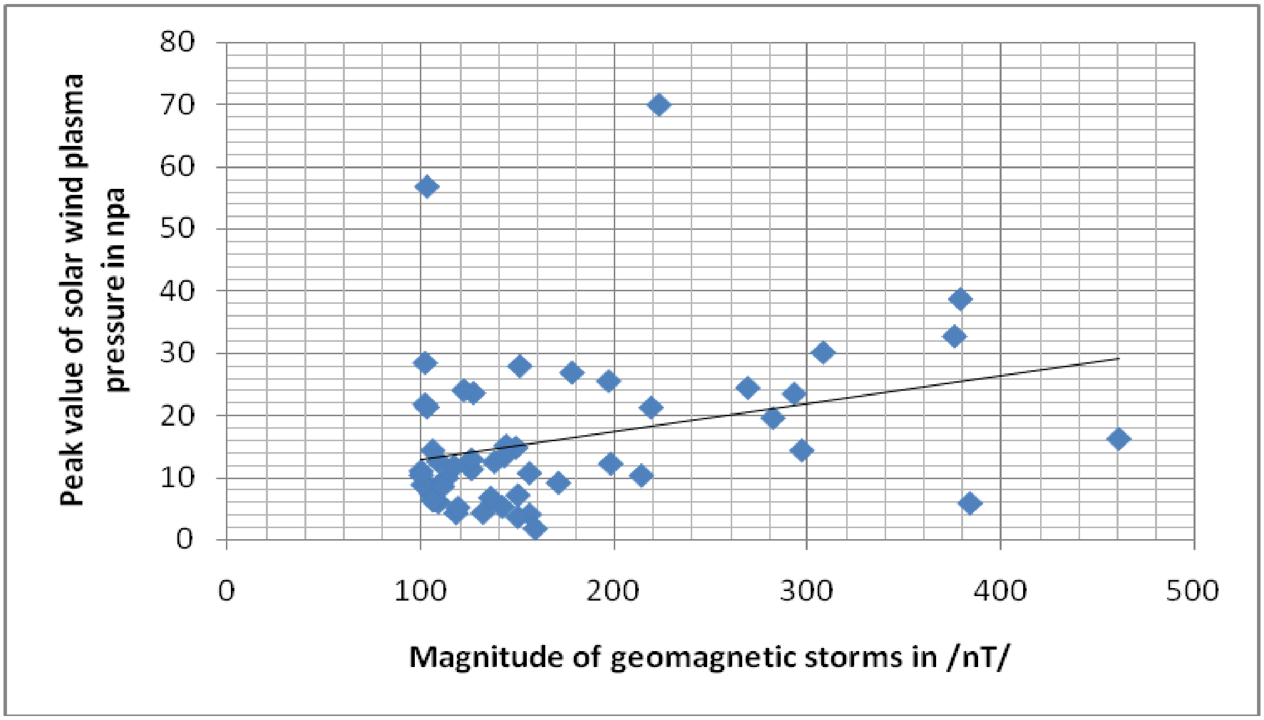

Figure-6-Scatter plot between magnitude of geomagnetic storms and peak value of solar wind plasma pressure showing positive correlation with correlation coefficient 0.30

To know the statistical behavior of geomagnetic storms and peak value of associated JSWP events a scatter plot has been plotted between magnitude of geomagnetic storms and peak value of associated JSWP events and the resulting plot is shown in Figure 6. From the Figure it is inferred that, most of geomagnetic storms having higher magnitude are associated with such JSWP events which have relatively higher peak value but these two events do not have any fixed proportion, We have found some geomagnetic storms which have higher magnitude but they are associated with such JSWP events which have lower values of peak JSWP and vice versa.

Positive correlation has been found between magnitude of geomagnetic storms and peak value of pressure of associated JSWP events. Statistically calculated co-relation co-efficient is 0.30 between these two events.

Main Results

Most of the X and M-Class X-Ray solar flare related intense geomagnetic storms (82.45%) have found to be associated with halo and partial halo coronal mass ejections. The association rate of halo and partial halo coronal mass ejections are found 78.72 % and 21.27 % respectively.

Majority of the X and M-Class X-Ray solar flare related intense geomagnetic storms (73.68%) have been found to be associated with type IV and type II solar radio bursts. The association rate of type IV and type II radio bursts have been found 59.52 % and 40.47% respectively.

Most of the X and M-Class X-Ray solar flare related intense geomagnetic storms (98.24%) have been found to be associated with disturbances in interplanetary magnetic fields.

Positive co-relation with co-relation co-efficient, 0.71has been determined between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak values of associated jump in interplanetary magnetic field.

Positive co-relation with co-relation co-efficient, 0.69 has been found between magnitude of X and M-class X-Ray solar flare related intense geomagnetic storms and magnitude of jump in interplanetary magnetic fields

Most of the X and M-Class X-Ray solar flare related intense geomagnetic storms (96.49%) have been found to be associated with disturbances in solar wind plasma temperature.

Positive co-relation with co-relation co-efficient,.0.30 has been obtained between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak value of associated jump in solar wind plasma temperature.

Positive co-relation with co-relation co-efficient,.0.35 has been obtained between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and magnitude of associated jump in solar wind plasma temperature.

Most of the X and M-Class X-Ray solar flare related intense geomagnetic storms (98.24%) have been found to be associated with disturbances in solar wind plasma velocity

Positive co-relation with co-relation co-efficient,. 0.43 has been determined between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak value of associated jump in solar wind plasma velocity.

Most of the X and M-Class X-Ray solar flare related intense geomagnetic storms (96.49%) have been found to be associated with disturbances in solar wind plasma pressure.

Positive co-relation with co-relation co-efficient, 0.30 has been determined between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak value of associated jump in solar wind plasma pressure.

Conclusion

From our study we have found that 82.45% X and M-Class X-Ray solar flare related intense geomagnetic storms are associated with halo and partial halo coronal mass ejections 73.68% X and M-Class X-Ray solar flare related intense geomagnetic storms are associated with solar radio bursts. From the study of X and M-Class X-Ray solar flare related intense geomagnetic storms with disturbances in solar wind plasma parameters ,large positive co-relation with co-relation co-efficient, 0.71 has been found between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak values of associated jump in interplanetary magnetic field, 0.69 between magnitude of X and M-class X-Ray solar flare related intense geomagnetic storms and magnitude of jump in interplanetary magnetic fields .0.30 between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak value of associated jump in solar wind plasma temperature, 0.35 between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and magnitude of associated jump in solar wind plasma temperature 0.43 between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak value of associated jump in solar wind plasma velocity, 0.30 between magnitude of X and M-Class X-Ray solar flare related intense geomagnetic storms and peak value of associated jump in solar wind plasma pressure. From these results it is concluded that coronal mass ejections, solar radio bursts and associated disturbances in solar wind plasma parameters are mainly responsible to generate X and M Class X-ray solar flare related intense geomagnetic storms.

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