Geomagnetic Storms In Relation With Halo and Partial Halo Coronal Mass Ejections and Disturbances in Solar Wind Plasma Parameters.

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Coronal mass ejections are most energetic solar events that eject huge amount of mass and magnetic fields into the heliosphere and are widely recognized as being responsible to generate measure disturbances in solar wind plasma parameters and geomagnetic storms in the magnetosphere of the earth. We have studied geomagnetic storms Dst < - 50nT observed during the period of 1997-2006, with halo and partial halo coronal mass ejections associated with X-ray solar flares of different categories. We have found that 74.61% 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 34.73% and 65.27% respectively. We have further determined that halo and partial halo coronal mass ejections, which are related to geomagnetic storms, majority of them are associated with M and C, class X-ray solar flares (77%). From the study of geomagnetic storms with disturbances in solar wind plasma parameters, we have determined weak positive correlation between maximum jump amplitude in solar wind plasma density and magnitude of geomagnetic storms and medium positive correlation between maximum jump amplitude in solar wind plasma temperature and magnitude of geomagnetic storms and maximum jump amplitude in solar wind plasma velocity and magnitude of geomagnetic storms.

Keywords: Geomagnetic storms. Halo coronal mass ejections. Partial halo coronal mass ejections. Disturbances in solar wind plasma temperature, density and velocity.

1. Introduction

Geomagnetic storms are the significant perturbations of the earth's magnetosphere that occur when the interplanetary magnetic field (IMF) turns southward (Bz<o) and remains so for a prolong period of time [1, 2]. The two classes of geomagnetic storms [3] recurrent and no recurrent have been studied by R. Londi and G. Moreno [4] with coronal mass ejection and they have concluded that CMEs which are associated with enhanced solar soft X ray emission, are responsible for large fraction of geomagnetic storms. Crooker and Cliver [5] have concluded that the non-recurrent geomagnetic storms are caused by coronal mass ejections and coronal holes / streamer, ensemble. I.G. Richardson et al [6] have determined that intense geomagnetic activity often associated with CME related structure and intense geomagnetic storms are produced by coronal mass ejection at any stage of the solar cycle. Wu. C.C. Lepping et al [7, 8] have studied geomagnetic storms with southward-directed magnetic field. They have found that intense geomagnetic storms are caused by intense southward-directed magnetic field. They have found high correlation between Bz and Dst index.

Ghang et al [9] have studied major geomagnetic storms for the period of 1996-2000with coronal mass ejections and concluded that 59% major geomagnetic storms are associated with front side halo (FS) HCMEs and 22%are associated with multiple FS-HCMEs, 15%events are found to be associated with partial halo gradual CMEs emerging from the east limb. They have also found an asymmetry in the longitudinal distribution of the solar source region for the CMEs responsible for major geomagnetic storms. In terms of latitude the most geoeffective CMEs originate within latitude strips +_30degree. Lyatsky.W and Tan. A[10] have studied geomagnetic storms .they have concluded that the averaged disturbances in solar wind ,responsible for generating geomagnetic storms are associated with compression of ambient solar wind plasma and interplanetary magnetic field ahead of a high speed plasma flow. The magnetic field strength and plasma density start to increase, several hours before geomagnetic storm onset; however, the negative IMFBz start to increase approximately 4or 5 hours after the maximum variation in plasma and IMF By. Michalek, G: Gopalswamy N, et al [11] have studied geomagnetic storms with properties of halo coronal mass ejections (H-CMEs) and concluded that only fast halo CMEs with space velocity higher than 1000 km/s and originating from the western hemisphere close to the solar center could cause intense geomagnetic storms. Gopalswamy.N.et al [12] have studied geoeffectiveness, speed, solar source, and flare association of a set of 378 halo coronal mass ejections (HCMEs) of solar cycle 23 (1996-2005). They have compiled the minimum Dst values occurring within 1 - 5 days after the CME onset. They have compared the distribution of such Dst values for the subset of halo CMEs: — disk halos, limb halos, and back side halos CMEs. Defining that a halo CME is geoeffective if it is followed Dst ≤ -50 nT, moderately geoeffective if -50nT < Dst < -100nT, and strongly geoeffective if Dst ≤ -100nT, they have found that the disk halos are followed by strong geomagnetic storms, limb halos are followed by moderate storms, and back side halos are not followed by significant storms. They have concluded that disk halos and limb halos CMEs are very much effective in producing geomagnetic storms. In this investigation an attempt has been made to know the role of H-CMEs, P-HCME and disturbances in solar wind plasma parameters in producing geomagnetic storms.

2. Data

In this investigation hourly Dst indices of geomagnetic field and solar wind plasma velocity, density and temperature have been used over the period 1997 through 2006 to determine onset time, maximum depression time, magnitude of geomagnetic storms and jump magnitude of solar wind plasma velocity, proton density and temperature. These data have been taken from the NSSDC omeni web system. The data of CMEs have been taken from SOHO, LASCO, CME catalogue, which consists all CMEs manually, identified since 1996 from large angle and spectrometric coronagraph (LASCO) on board the solar and heliospheric observatory mission (SOHO). We have observed 202 geomagnetic storms over the period 1997through 2006.The geomagnetic storms and associated coronal mass ejections, jump in solar wind velocity, density temperature are presented in table 1 and figure 1,2,3,4.

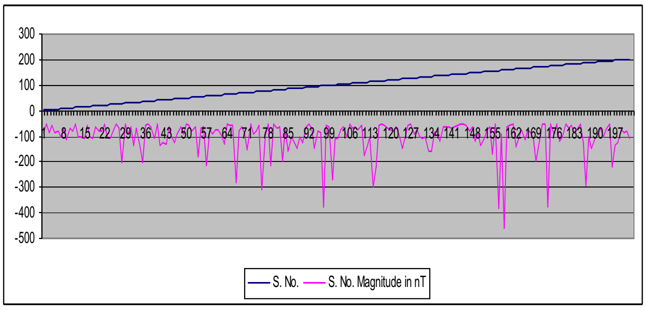

Figure 1 shows geomagnetic storms observed during the period of 1997to2006.

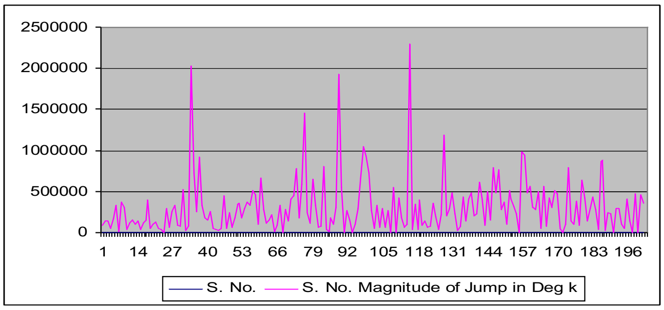

Figure 2 shows jump in solar wind plasma temperature associated with geomagnetic storms.

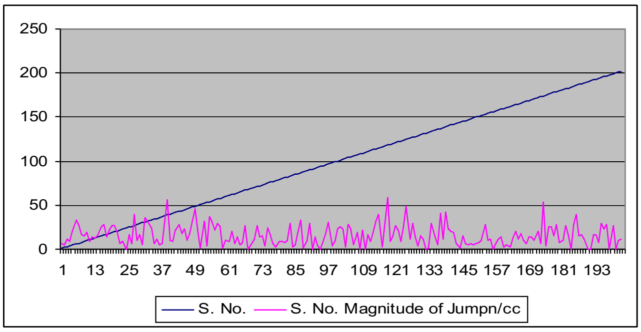

Figure 3 shows jump in solar wind plasma density associated with geomagnetic storms.

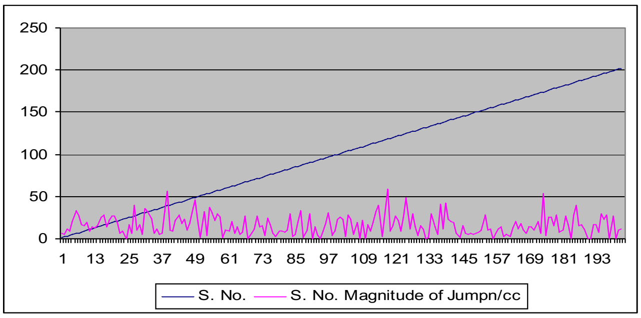

Figure 4 shows jump in solar wind plasma velocity associated with geomagnetic storms.

S.N.	Magnitude of GMS in nT	CME Type H/P	CME Speed km/s	Associated Solar Flares	S.N.	Magnitude of GMS in nT	CME Type H/P	CME Speed km/s	Associated Solar Flares	S.N.	Magnitude of GMS in nT	CME Type H/P	CME Speed km/s	Associated Solar Flares
1	-85	H	136	na	69	-61	na	na	na	137	-122	P	938	C-49
2	-55	H	490	na	70	-86	H	2604	C-28	138	-61	H	1077	C-64
3	-85	P	134	B-72	71	-151	H	649	C-63	139	-66	na	na	na
4	-58	na	na	na	72	-53	na	na	na	140	-62	H	1092	M-27
5	-88	H	878	C-68	73	-89	H	1119	X-23	141	-69	na	na	na
6	-79	na	na	na	74	-80	P	1617	M-19	142	-62	na	na	na
7	-101	na	na	na	75	-59	H	1078	X-19	143	-56	na	na	na
8	-68	H	255	na	76	-308	H	1078	X-19	144	-55	H	1042	X15
9	-113	H	464	C-13	77	-95	na	na	na	145	-55	na	na	na
10	-70	P	296	M-13	78	-51	H	267	C-14	146	-60	H	672	B
11	-81	na	na	na	79	-214	H	702	na	147	-78	P	89	na
12	-54	na	na	na	80	-53	P	518	M-14	148	-66	na	na	na
13	-103	H	371	B-55	81	-67	P	554	M-16	149	-118	P	370	M-10
14	-100	H	359	na	82	-62	H	1013	na	150	-85	H	1835	M-93
15	-109	P	293	na	83	-197	H	257	C-14	151	-136	P	2053	X13
16	-59	H	523	C-33	84	-67	H	587	B-81	152	-109	na	na	na
17	-105	H	785	X2.1	85	-156	H	525	C-44	153	-75	P	329	C-23
18	-106	na	na	na	86	-100	H	708	C-67	154	-66	H	699	M-13
19	-61	P	397	C-12	87	-126	H	770	C-40	155	-171	H	378	C-46
20	-80	P	197	C-20	88	-150	H	291	C-32	156	-53	P	320	C-33
21	-83	H	438	B-64	89	-102	H	474	C-52	157	-384	P	1322	M-27
22	-51	H	693	C-11	90	-127	H	492	C-54	158	-90	H	2036	M-10
23	-105	P	82	B-33	91	-64	H	510	C-70	159	-461	H	1660	M-39
24	-110	na	na	na	92	-53	H	1507	M-77	160	-66	na	na	
25	-76	P	636	C-12	93	-68	P	631	C-12	161	-60	P	1822	M-83
26	-54	na	na	na	94	-150	H	752	B-58	162	-54	P	406	C-17
27	-69	H	1618	M-23	95	-81	H	389	na	163	-144	H	762	C-12
28	-203	H	1374	M-68	96	-86	H	677	c-90	164	-107	na	na	na
29	-53	P	1223	M-14	97	-379	H	942	x17	165	-76	H	395	B-47
30	-92	nd	nd	nd	98	-57	H	1475	M-55	166	-113	P	436	B-61
31	-65	nd	nd	nd	99	-63	H	1270	X5.6	167	-77	na	na	na
32	-139	nd	nd	nd	100	-269	H	1192	M-79	168	-84	H	747	M-29
33	-68	nd	nd	nd	101	-106	P	1199	X14.4	169	-106	H	710	M-86
34	-143	nd	nd	nd	102	-106	H	2465	C-22	170	-198	H	824	M-22
35	-203	nd	nd	nd	103	-74	P	604	C-39	171	-119	na	na	na
36	-56	nd	nd	nd	104	-63	H	1701	C-22	172	-50	H	1328	M-32
37	-53	nd	nd	nd	105	-102	H	618	C-11	173	-54	na	na	na
38	-65	nd	nd	nd	106	-53	H	791	C-32	174	-376	na	na	na
39	-111	H	262	na	107	-71	H	436	C-41	175	-54	na	na	na
40	-55	P	661	C-44	108	-65	H	1537	C-20	176	-94	P	389	C-38
41	-139	H	523	C-1	109	-76	H	973	M-14	177	-50	P	256	na
42	-126	H	1118	M-84	110	-58	P	389	C-21	178	-117	P	335	C-68
43	-129	P	286	C-33	111	-178	H	558	X16	179	-103	H	882	X7.1
44	-63	na	na	na	112	-142	H	1092	X13	180	-55	P	711	na
45	-105	na	na	na	113	-104	P	759	C-60	181	-71	P	283	B-29
46	-125	na	na	na	114	-297	H	457	C-38	182	-56	na	na	na
47	-94	na	na	na	115	-223	H	1443	M-38	183	-86	na	na	na
48	-62	na	na	na	116	-60	na	na	na	184	-77	P	514	B-82
49	-90	na	na	na	117	-54	na	na	na	185	-52	P	351	B-23
50	-51	H	920	M-25	118	-57	H	2216	X3.4	186	-126	H	1180	C-78
51	-57	P	736	B-95	119	-71	H	1794	C-96	187	-293	H	1689	M-80
52	-78	P	1467	B-70	120	-77	na	na	na	188	-101	P	449	M-18
53	-64	P	761	C-20	121	-79	P	362	C-22	189	-150	H	586	B-75
54	-182	P	1144	C-49	122	-65	na	na	na	190	-109	P	377	C-10
55	-71	na	na	na	123	-91	H	1750	M-16	191	-92	na	na	na
56	-63	na	na	na	124	-149	H	720	M-12	192	-67	H	683	M-49
57	-214	P	753	C-29	125	-103	H	614	C-28	193	-100	H	683	M-49
58	-74	P	378	M-12	126	-57	na	na	na	194	-77	H	2115	X12
59	-89	na	na	na	127	-50	H	600	C-45	195	-52	H	1660	na
60	-77	P	359	C-24	128	-89	H	1557	C-50	196	-219	H	1194	M-26
61	-77	na	na	na	129	-73	P	1069	C-44	197	-138	H	1600	na
62	-96	H	739	M-39	130	-105	P	360	C-12	198	-127	H	2257	X6.2
63	-132	H	1079	M-13	131	-110	H	1585	M-52	199	-77	na	na	na
64	-52	P	nd	C-22	132	-102	na	na	na	200	-87	na	na	na
65	-57	H	949	C-27	133	-159	H	1748	C-52	201	-80	na	na	na
66	-59	H	542	M-20	134	-156	na	na	na	202	-111	H	174	na
67	-282	H	1188	C-97	135	-88	na	na	na					
68	-81	na	na	ns	136	-79	H	1185	C-29					

Table No1 Association of Geomagnetic Storm with CMEs

3. Analysis And Results

The statistical analysis of the association of geomagnetic storms with coronal mass ejections shows that majority 74.61% of the geomagnetic storms are associated with coronal mass ejections. We have 202 geomagnetic storms .The available data of CMEs for association are 193. Out of 193 geomagnetic storms, 144 geomagnetic storms have been found to be associated with CMEs.From the data analysis of geomagnetic storms and coronal mass ejections, we have found that out of 144 associated geomagnetic storms, 50 (34.72%) geomagnetic storms are found to be associated with partial halo CMEs where as 94 (65.27%) geomagnetic storms are found to be associated with full halo CMEs. Coronal mass ejections, which are related with geomagnetic storms, are also associated with solar flares of different categories. In this study 144 geomagnetic storms are found to be associated with CMEs in which 131 CMEs are associated with X-ray solar flares of different categories. 11.5% CMEs are associated with X class, 29.0% CMEs are associated with M class, 48.01% CMEs are associated with C class and 11.45% CMEs are found to be associated with B class X-ray solar flares. From the study of magnitude of geomagnetic storms and speed of associated coronal mass ejections, we have found weak positive correlation with correlation co-efficient .144 between magnitude of geomagnetic storms and speed of associated coronal mass ejections. From the study of geomagnetic storms with storm in solar wind plasma parameters i.e. jump in solar wind temperature (JSWT), jump in solar wind density (JSWD) and jump in solar wind velocity (JSWV), it is inferred that geomagnetic storms of higher magnitudes are found to be associated with such JSWT events, which have relatively higher jump magnitude. We have determined positive correlation between magnitude of geomagnetic storms and magnitude of associated JSWT events. Statistically calculated correlation co-efficient is .33 between these two events. Very weak positive correlation is found between magnitude of geomagnetic storms and magnitude of associated JSWD events. Geomagnetic storms of higher magnitudes are found to be associated with such JSWV, events which have relatively higher jump magnitude. Positive correlation has been found between magnitude of geomagnetic storms and magnitude of associated JSWV events, statistically calculated co-relation co-efficient has been found .36.

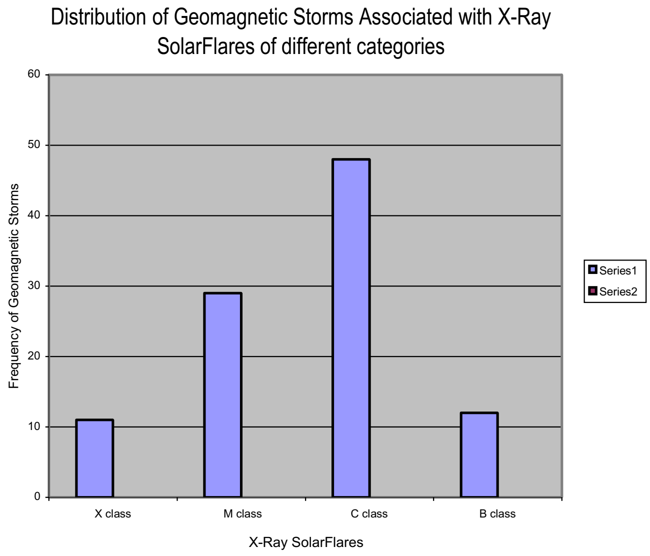

Figure 5 Shows distribution of geomagnetic storms with solar flares of different categories.

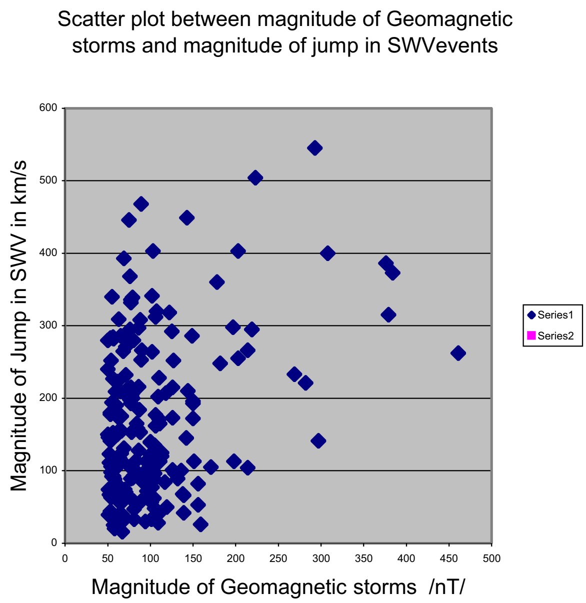

Figure 6. Shows scatter plot between magnitude of geomagnetic storms and magnitude of JSWV events showing positive correlation with correlation coefficient .36

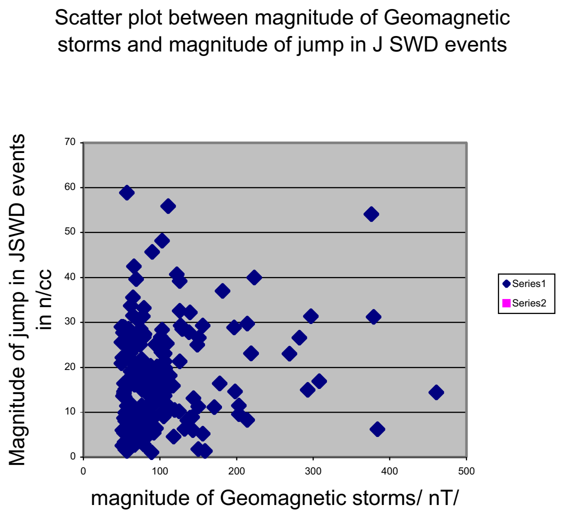

Figure7. Shows scatter plot between magnitude of geomagnetic storms and magnitude of JSWD events showing very weak positive correlation.

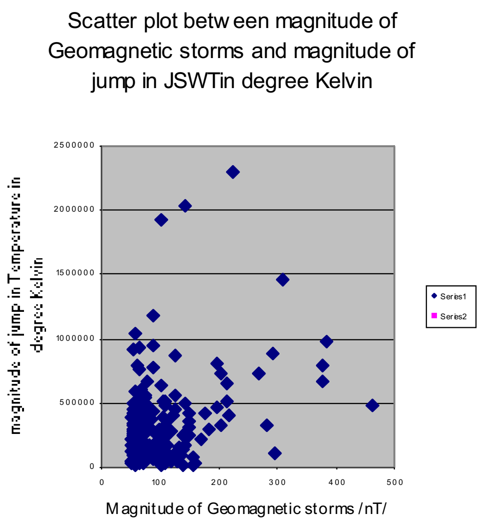

Figure 8 shows scatter plot between magnitude of geomagnetic storms and magnitude of JSWT events showing positive correlation with correlation coefficient .33

4. Conclusions

From our study, 144 out of 193 geomagnetic storms have been found to be associated with CMEs.Out of these 144 associated geomagnetic storms, 50 (34.72%) geomagnetic storms are found to be associated with partial halo CMEs where as 94 (65.27%) geomagnetic storms are found to be associated with full halo coronal mass ejections. The halo and partial halo CMEs are found to be related with X-ray solar flares of different categories. 131out of 144 CMEs are associated with X-ray solar flares, 11.5% CMEs are associated with X-class, 29.0% CMEs are associated with M- class, 48.01% CMEs are associated with C- class and 11.45% CMEs are found to be associated with B- class X-ray solar flares. From these results, it is concluded that halo coronal mass ejections and partial halo coronal mass ejections associated with strong X-ray solar flares are mainly responsible to generate geomagnetic storms in geomagnetic field. The positive correlation between magnitude of geomagnetic storms and magnitude of jump in solar wind temperature, density and velocity suggests that disturbances in solar wind parameters play also crucial role in producing geomagnetic storms

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