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Coronal mass ejections and Jump in solar wind plasma temperature in association with shock related geomagnetic storms

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Abstract

In this article we have considered the shock related geomagnetic storms of magnitude ≤-90nT, which are associated with coronal mass ejections (CMEs) and jump in solar wind plasma temperature (JSWT) events for the period 1997-2012. We have found 54 shock related geomagnetic storms of magnitude ≤-90nT. Out of these 54 geomagnetic storms, 48 geomagnetic storms are found to be associated with coronal mass ejections (CMEs). We observe the positive correlation between the magnitude of geomagnetic storms and speed of associated coronal mass ejections (CMEs) with correlation coefficient 0.26. Further we observe that all the shock related geomagnetic storms are associated with jump in solar wind plasma temperature (JSWT) events and studies these events with associated coronal mass ejections (CMEs). There is a positive correlation between peak value of jump in solar wind plasma temperature (JSWT) events and speed of coronal mass ejections (CMEs) with correlation coefficient 0.27. Again we have observed the positive correlation between the magnitudes of jump in solar wind plasma temperature (JSWT) events and speed of coronal mass ejections (CMEs), statistically calculated co-relation co-efficient is 0.26 between these two events.

INTRODUCTION

Coronal Mass Ejections (CMEs) are the drastic solar events in which huge amount of solar plasma materials are ejected into the heliosphere from the sun and are mainly responsible to generate large disturbances in solar wind plasma parameters and geomagnetic storms in geomagnetic field. CMEs from the Sun drive solar wind (SW) disturbances in terms of magnetic field, speed and density, which in turn cause geomagnetic disturbance in Earth [14]. It has been established by now the main cause of geomagnetic storms is believed to be the large IMF structure which has an intense and long duration southward magnetic field component, Bz [3, 10]. They interact with the Earth's magnetic field and facilitate the transport of energy into the Earth's atmosphere through the reconnection process. Several investigators have studied geomagnetic storms with various solar features, solar wind parameters and inferred that CMEs which are the energetic solar features and associated with active regions are responsible for the most geoeffective solar wind disturbances and, therefore, the largest storms and are well associated with geomagnetic storms [1,9,12,13] .Enhanced solar wind speeds and southward magnetic fields associated with interplanetary shocks and ejecta are known to be important causes of storms [4,10].

In this work we have studied shock related geomagnetic storms, (magnitude ≤-90nT) and associated disturbances in solar wind plasma parameters e.g. jump in solar wind plasma temperature (JSWT) and with coronal mass ejections.

Experimental Data

In this investigation, hourly Dst indices of geomagnetic field have been used over the period 1997 through 2012 to determine onset time, maximum depression time, magnitude of geomagnetic storms. This data has been taken from the NSSDC omni web data system which has 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 solar wind plasma parameters, hourly data of solar wind plasma temperature has been used and these data has also been taken from omni web data (http;//omniweb.gsfc.nasa.gov/form/dxi.html)).

Table-1 Data of CMEs, geomagnetic storms and solar wind plasma temperature

	Geomagnetic Storms Dst≤-90nT					Coronal mass Ejections				Solar wind Temperature			
S. No.	DATE	Year	Day	Hour	Magnitude	Date	Time	Type	SPEED	Day	HourH Hour	Maximum jump in temp	Magnitude of jump
1	10.01.1997	1997	10	2	-101	06.01.1997	15:10:42	Halo	136	10	0	103125	83898
2	10.04.1997	1997	100	19	-102	07.04.1997	14:27:44	Halo	878	101	10	69 695175	682940
3	15.05.1997	1997	135	5	-115	12.05.1997	5:30:05	Halo	464	135	15	158816	149663
4	03.09.1997	1997	246	15	-108	30.08.1997	1:30:35	Halo	371	246	16	250517	228477
5	30.12.1997	1997	364	2	-95	26.12.1997	2:31:54	Partial	197	364	17	127484	110072
6	17.02.1998	1998	48	11	-114	na	na	na	NA	48	2	106475	88533
7	02.05.1998	1998	122	9	-203	29.04.1998	16:58:54	Halo	1374	121	19	420844	326112
8	07.11.1998	1998	311	11	-139	04.11.1998	7:54:06	Halo	523	312	1	223059	215560
9	28.02.1999	1999	59	17	-94	na	na	na	na	59	20	154621	131728
10	16.04.1999	1999	106	15	-156	na	na	na	na	106	7	94876	68434
11	12.09.1999	1999	255	7	-103	10.09.1999	7:54:05	Partial	1467	254	21	416852	369034
12	22.09.1999	1999	265	19	-191	20.09.1999	6:06:05	Halo	604	265	7	275183	250060
13	21.10.1999	1999	294	23	-257	19.10.1999	5:50:05	Partial	753	295	1	525759	511615
14	22.01.2000	2000	22	14	-98	18.01.2000	17:54:05	Halo	739	22	23	165657	153520
15	15.07.2000	2000	197	15	-308	14.07.2000	10:54:07	Halo	1674	197	3	352419	256112
16	15.09.2000	2000	259	19	-221	12.09.2000	17:30:05	Halo	1053	259	2	137342	117359
17	13.10.2000	2000	287	14	-100	11.10.2000	6:50:05	Partial	799	286	16	118307	90615
18	28.10.2000	2000	302	20	-142	25.10.2000	8:26:05	Halo	770	302	13	157899	102142
19	04.11.2000	2000	309	3	-194	01.11.2000	16:26:08	Halo	801	308	13	487233	465445
20	10.11.2000	2000	315	7	-102	08.11.2000	4:50:23	Halo	474	314	11	2228444	2189449
21	27.03.2001	2001	86	19	-123	25.03.2001	17:06:05	Halo	677	85	22	167582	136338
22	31.03.2001	2001	90	3	-413	29.03.2001	10:26:05	Halo	942	89	6	704151	690882
23	18.04.2001	2001	108	1	-106	15.04.2001	14:06:31	Partial	1199	107	18	393365	370482
24	17.08.2001	2001	229	12	-149	15.08.2001	23:54:05	Halo	1575	228	12	316649	299157
25	25.10.2001	2001	298	10	-162	22.10.2001	15:06:05	Halo	1336	298	5	153554	150823
26	05.11.2001	2001	309	18	-314	04.11.2001	16:35:06	Halo	1810	308	23	137590	121248
27	24.11.2001	2001	328	6	-223	22.11.2001	23:30:05	Halo	1437	327	16	147677	20239
28	29.12.2001	2001	363	22	-91	28.12.2001	20:30:05	Halo	2216	363	2	551297	543833
29	23.03.2002	2002	82	14	-107	22.03.2002	11:06:05	Halo	1750	82	9	116154	82810
30	17.04.2002	2002	107	11	-149	15.04.2002	3:50:05	Halo	720	107	1	56069	19374
31	11.05.2002	2002	131	13	-103	08.05.2002	13:50:05	Halo	614	131	6	262009	230600
32	23.05.2002	2002	143	11	-172	21.05.2002	21:50:05	Partial	853	142	19	1217894	1201690
33	8/1/2002	2002	213	10	-98	######	23:30:05	Partial	360	213	21	121706	110074
34	30.09.2002	2002	273	1	-179	26.09.2002	1:31:44	Partial	178	272	18	112901	98361
35	17.08.2003	2003	229	14	-175	14.08.2003	20:06:05	Halo	378	229	13	231036	216610
36	20.11.2003	2003	324	2	-417	18.11.2003	8:50:05	Halo	1660	324	5	505060	455915
37	03.04.2004	2004	94	14	-113	na	na	na	na	94	9	119293	71817
38	22.07.2004	2004	204	18	-115	20.07.2004	13:31:52	Halo	710	204	8	240584	167781
39	30.08.2004	2004	243	5	-116	na	na	na	na	243	12	81038	72912
40	07.11.2004	2004	312	19	-415	04.11.2004	9:54:05	Halo	653	312	12	750946	694860
41	28.05.2005	2005	148	11	-155	26.05.2005	15:06:05	Halo	586	148	3	210877	195777
42	12.06.2005	2005	163	16	-110	na	na	na	na	163	9	265471	218359
43	10.07.2005	2005	191	11	-100	09.07.2005	22:30:05	Halo	1540	191	0	297954	271207
44	24.08.2005	2005	236	6	-248	22.08.2005	17:30:05	Halo	2378	235	19	2666957	2640465
45	14.04.2006	2006	104	0	-111	10.04.2006	6:06:04	Partial	183	103	17	362684	350243
46	14.12.2006	2006	348	14	-155	13.12.2006	2:54:04	Halo	1774	349	6	213495	194741
47	05.08.2011	2011	217	19	-142	04.08.2011	4:12:05	Halo	1315	217	8	1024367	993166
48	09.09.2011	2011	252	13	-109	07.09.2011	18:48:05	Partial	924	252	6	362200	349740
49	17.09.2011	2011	260	7	-94	15.09.2011	0:00:06	Partial	530	260	2	174729	162941
50	26.09.2011	2011	269	13	-136	24.09.2011	12:48:07	Halo	1915	268	14	502088	474109
51	24.10.2011	2011	297	21	-157	22.10.2011	10:24:05	Halo	1005	296	21	343148	330159
52	07.03.2012	2012	67	0	-140	05.03.2012	4:00:05	Halo	1531	66	12	364927	353785
53	23.04.2012	2012	114	15	-119	19.04.2012	15:12:09	Partial	540	115	3	327270	307084
54	17.06.2012	2012	169	0	-151	14.06.2012	14:12:07	Halo	987	168	6	192576	156565

Analysis and Results

In this study we use statistical method association and correlation for data analysis of the observed, CMEs, geomagnetic storms and jump in solar wind plasma temperature (JSWT) events. The data of observed coronal mass ejections (CMEs), geomagnetic storms and solar wind plasma temperature are given in Table-1.

From data analysis it was observed that the number of geomagnetic storms during 1997 to 2012 is 54. Out of these 48 (88.09%) geomagnetic storms were found to be associated with CMEs. The majority of shock related geomagnetic storms are related to halo CMEs and the association rate is 75% (36) and the association rate with partial halo CMEs is 25% (12). Distribution of shock related geomagnetic storms with CMEs is shown in figure-1.

To know the statistical behavior of shock related geomagnetic storms and CMEs we have plotted a scatter plot between magnitude of geomagnetic storms and speed of CMEs and the resulting plot is shown in figure-2. The trend line of the plot shows weak positive correlation between magnitude of geomagnetic storms and speed of associated CMEs with co-relation coefficient 0.26.

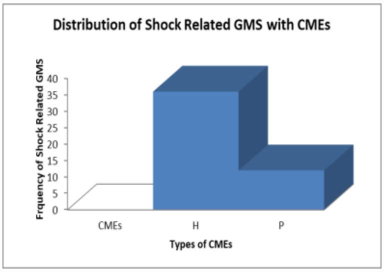

Figure- 1-Distribution of shock related geomagnetic storms with coronal mass ejections

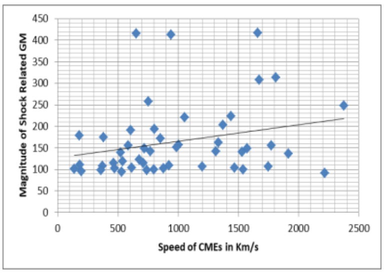

Figure -2 -The figure shows scatter plot between speed of CMEs and magnitude of shock related geomagnetic storms.

By the analysis we have selected those jumps in solar wind plasma temperature (JSWT) events which are associated with shock related geomagnetic storms and studied statistical behavior of these events with coronal mass ejections.

To see how the peak value of JSWT events are correlated with coronal mass ejections. We have plotted a scatter diagram between the speed of CMEs and peak value of associated JSWT events figure-3. From the fig it is clear that, most of the JSWT events having higher peak value are associated with such CMEs which have higher speed but these two events do not have any fixed proportion, We have found some JSWT events which have higher peak value but they are associated with such CMEs events which have relatively slow speed and vice versa. The trend line of the scatter plot positive co-relation has been found between speed of CMEs and peak temperature of jump in temperature. Statistically calculated co-relation co-efficient is 0.27 between these two events.

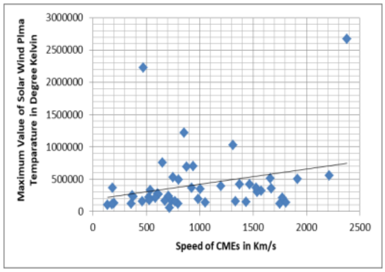

Figure-3 -The figure shows scatter plot between speed of CMEs and peak value of JSWT events associated with shock related GMS.

Furthermore we have found that the magnitudes of JSWT events are correlated with speed of CMEs, we have plotted a scatter diagram between magnitude of JSWT events and speed of associated CMES shown in figure-4. From the fig It is clear that, most of the JSWT events which have large magnitude are associated with such CMEs which have relatively higher speed but the magnitude of these two events do not have any fixed proportion, we have found some JSWT events which have large magnitude but they are associated with such CMEs which have slow speed and some JSWT events which have small amplitude but they are associated with CMEs having higher speed. The trend line of the scatter plot between these two parameters shows positive correlation with correlation co-efficient 0.26.

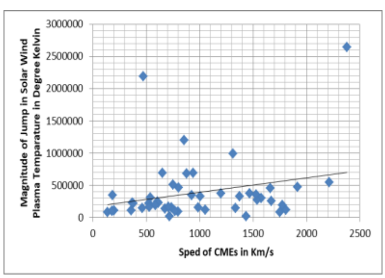

Figure-4 -The figure shows scatter plot between magnitude of JSWT associated with shock related GMS and speed of CMEs.

CONCLUSION

In this investigation we have studied shock related geomagnetic storms with coronal mass ejections (CMEs) and solar wins plasma parameters specifically with plasma temperature for the period 1997-2011 of magnitude ≤-90nT. We have observed that the geomagnetic storms which are related to shocks are 54 and out of these 48 are fund to be associated with coronal mass ejections (CMEs). These CMEs are associated with halo and partial halo coronal mass ejections and the association rate is 75% and 25% respectively. We have concluded that most of them are associated with halo CMEs. Again we observe that all the geomagnetic storms are associated with solar wind plasma temperature events and there is a positive correlation between plasma temperature events and coronal mass ejections. By the analysis of these results we have concluded that all the geomagnetic storms are related to coronal mass ejections and plasma parameters as well.

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