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Study Of Coronal Mass Ejections Associated With Radio Burst Related Geomagnetic Storms With Solar Wind Disturbances

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Abstract
In this manuscript we have studied radio bursts (RB) related geomagnetic storms (GMS) Dst ≤ -90nT for the period 1997 to 2012. From the data analysis, we have found total number of radio bursts related geomagnetic storms are 42. Out these 37(88.09%) are found to be associated with coronal mass ejections (CMEs). Out of 37, 25 (67.57%) are related to the halo coronal mass ejections, 12(32.43%) are found to be associated with partial halo coronal mass ejection. Positive co-relation with co-relation coefficient 0.28 has been found between magnitude of radio bursts related geomagnetic storms and speed of associated coronal mass ejections. Further we have concluded that associated CMEs are closely related to jump in solar wind plasma density (JSWD) and jump in solar wind plasma velocity (JSWV). Positive co-relation has been found between speed of CMEs and peak value of associated JSWD events with co-relation co-efficient 0.16, 0.26 between speed of CMEs and magnitude of associated JSWD events, 0.44 between speed of CMEs and peak value of associated JSWV events, 0.26 between speed of CMEs and magnitude of associated JSWV events.
Keywords: *- Coronal mass ejections, Solar wind disturbances, Geomagnetic storms, Radio burst.*

1- INTRODUCTION

Coronal mass ejections (CMEs) are a key aspect of coronal and interplanetary dynamics .They can eject large amounts of mass and magnetic field into the heliosphere causing major geomagnetic storms. The measured properties of CMEs include their occurrence rate, locations relative to the solar disk, angular widths, speeds and masses and energies (Webb, 2002, Gopalswamy et al .2003, Yashiro et al 2004). Halo CMEs which appear as expanding, circular brightening that completely surround the coronagraphs occulting disks. CMEs which have a larger apparent angular size than typical limb CMEs but do not appear as complete halos are called partial halo CMEs. Extensive observations from the Solar and Heliospheric Observatory (SOHO) mission's Large Angle and Spectrometric Coronagraphs (LASCO) have shown that full halos constitute ~3.6% of all CMEs, while CMEs with width ≥120° account for ~11% (Gopalswamy, 2004). Full halos have an apparent width (W) of 360°, while partial halos have 120° ≤ W < 360° Halo CMEs are said to be front sided if the site of eruption (also known as the solar source) can be identified on the visible disk usually identified as the location of H-alpha flares or filament eruptions. Disk halos are likely to arrive at Earth and cause geomagnetic storms, while limb halos only impact Earth with their flanks and hence are less geoeffective (Gopalswamy et al., 2007). It is generally believed that the occurrence of a geomagnetic storm depends upon the solar conditions, particularly the southward interplanetary magnetic field (IMF) component. Some researchers have suggested a relationship between geomagnetic storms and solar wind parameters (Weigel 2010). In this study we have studied coronal mass ejections associated with radio bursts related geomagnetic storms, (magnitude ≤-90nT) and associated disturbances in solar wind plasma parameters.

2- EXPERIMENTAL DATA

In this investigation hourly Dst indices of geomagnetic field have been used over the period 1997 to 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 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. 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/solardataservices. html.) have been used.

Table: - Association of CMEs with radio burst related geomagnetic storms and solar wind disturbances.

Geomagnetic Storms Dst≤-90nT			Coronal Mass Ejections			Solar wind Density		Solar wind Velocity	
S.No.	Date	Magnitude of GMS	Date	Type	Speed of CMEs in Km/S	Maximum jump in density	Magnitude of jump	Maximum jump in velocity	Magnitude of jump
1	10.04.1997	-102	07.04.1997	Halo	878	19.9	15.3	473	196
2	15.05.1997	-115	12.05.1997	Halo	464	21.6	8.6	521	250
3	02.05.1998	-203	29.04.1998	Halo	1374	35.4	33.6	651	255
4	25.06.1998	-111	na	na	na	20.7	17.6	496	97
5	19.10.1998	-111	15.10.1998	Halo	262	22.6	20.4	430	113
6	07.11.1998	-139	04.11.1998	Halo	523	13.6	8.8	639	256
7	13.11.1998	-132	10.11.1998	Partial	286	33.4	30.1	412	96
8	17.02.1999	-128	na	na	na	9.2	8	607	226
9	28.02.1999	-94	na	na	na	56	51.4	412	76
10	12.09.1999	-103	10.09.1999	Partial	1467	35	32.5	615	204
11	21.10.1999	-257	19.10.1999	Partial	753	18.2	12	678	342
12	22.01.2000	-98	18.01.2000	Halo	739	14.1	8.2	403	72
13	24.05.2000	-164	22.05.2000	Halo	649	17.5	13.3	684	174
14	15.07.2000	-308	14.07.2000	Halo	1674	26.6	21.7	1107	497
15	15.09.2000	-221	12.09.2000	Halo	1053	22.3	17.7	401	78
16	24.09.2000	-191	22.09.2000	Partial	378	8.2	7	570	192
17	13.10.2000	-100	11.10.2000	Partial	799	9	6.5	469	155
18	10.11.2000	-102	08.11.2000	Halo	474	21.7	11.6	925	512
19	23.03.2002	-107	22.03.2002	Halo	1750	15.1	12.9	504	114
20	17.04.2002	-149	15.04.2002	Halo	720	15.2	3.8	611	286

21	11.05.2002	-103	08.05.2002	Halo	614	57.2	48.2	522	181
22	23.05.2002	-172	21.05.2002	Partial	853	0.2	0	871	473
23	01.08.2002	-98	29.07.2002	Partial	360	13.8	12.4	524	157
24	04.09.2002	-179	na	na	na	17.1	6.6	461	121
25	30.09.2002	-179	26.09.2002	Partial	178	30	18.3	370	80
26	16.06.2003	-152	14.06.2003	Partial	875	6.5	5.9	533	86
27	10.07.2003	-128	na	na	na	22.1	20.1	390	56
28	28.10.2003	-382	27.10.2003	Partial	1322	7.5	6.7	809	373
29	20.11.2003	-417	18.11.2003	Halo	1660	21.7	19.3	703	262
30	22.07.2004	-115	20.07.2004	Halo	710	13.9	11.9	672	312
31	24.07.2004	-201	22.07.2004	Partial	899	17.5	16.9	600	110
32	07.11.2004	-415	04.11.2004	Halo	653	1.7	0.8	730	418
33	07.01.2005	-94	05.01.2005	Halo	735	31.9	28.4	577	84
34	16.01.2005	-117	15.01.2005	Halo	2049	55.4	52.5	780	286
35	07.05.2005	-275	05.05.2005	Halo	1180	47	34.6	821	472
36	28.05.2005	-155	26.05.2005	Halo	586	10.4	3.7	464	185
37	10.07.2005	-100	09.07.2005	Halo	1540	14.1	12.3	474	148
38	24.08.2005	-248	22.08.2005	Halo	2378	27.9	23.5	721	309
39	14.12.2006	-155	13.12.2006	Halo	1774	8.6	7.3	896	333
40	07.03.2012	-140	05.03.2012	Halo	1531	24.4	20.2	592	231
41	4/23/2012	-119	19.04.2012	Partial	540	41.5	35.7	501	205
42	17.06.2012	-151	14.06.2012	Halo	987	54.4	39.2	519	222

3- RESULT ANALYSIS AND DISCUSSION

- From the data analysis given in table above, we have found total number of radio bursts related geomagnetic storms of magnitude ≤-90nT, observed during the period of 1997-2012 are 42. Out of 42 geomagnetic storms 88.09% geomagnetic storms are found to be associated with coronal mass ejections CMEs. We have further observed that the majority of geomagnetic storms are related to halo CMEs. We have found 37 geomagnetic storms, which are associated with coronal mass ejections out of which 25 geomagnetic storms (67.57%) are related to the halo coronal mass ejections and 12 (32.43%) geomagnetic storms are found to be associated with partial halo coronal mass ejection (Fig.-1)
- To know the possible statistical behavior between radio bursts related geomagnetic storms and speed of associated CMEs, a scatter plot has been plotted between magnitude of radio bursts related geomagnetic storms and speed of associated CMEs and resulting plot is shown in figure-2. The trend line of the figure shows weak positive correlation between magnitude of radio bursts related geomagnetic storms and speed of associated CMEs. Positive co-relation with co-relation coefficient 0.28 has been found between them.

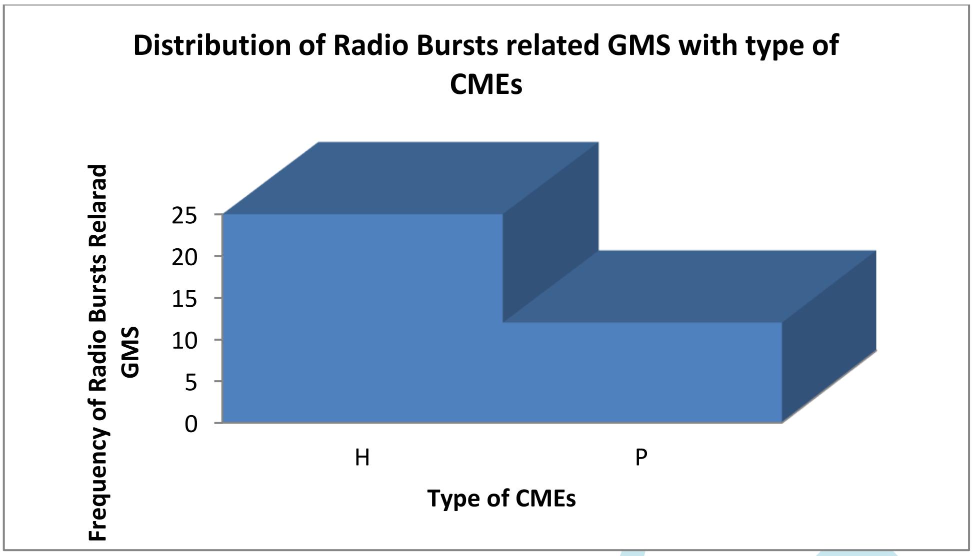

Figure-1 Distribution of radio bursts related geomagnetic storms with coronal mass ejections.

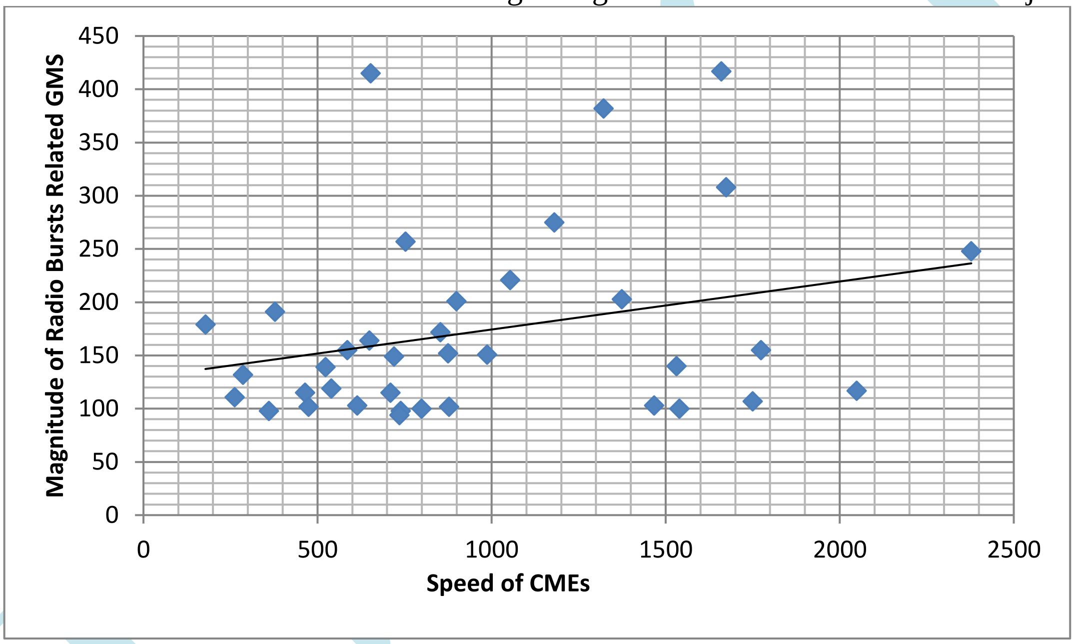

Figure-2 **S**catter plot between speed of CMEs and magnitude of radio bursts related geomagnetic storms.

- To see how the peak value of JSWD events are correlated with coronal mass ejections. We have plotted a scatter diagram between the speed of CMEs and peak value of associated JSWD events figure-3. The trend line of the fig shows weak positive correlation between these two events. Statistically calculated co-relation co-efficient is 0.16 between these two events.
- To see how the magnitudes of JSWD events are correlated with speed of CMEs, we have plotted a scatter diagram between magnitude of JSWD events and speed of associated CMES in figure-4. From the trend line of the scatter plot it is clear that there is weak positive correlation between magnitude of JSWD events and speed of associated CMEs. Positive co-relation has been found between magnitudes of JSWD events and speed of CMEs with correlation co-efficient 0.26.

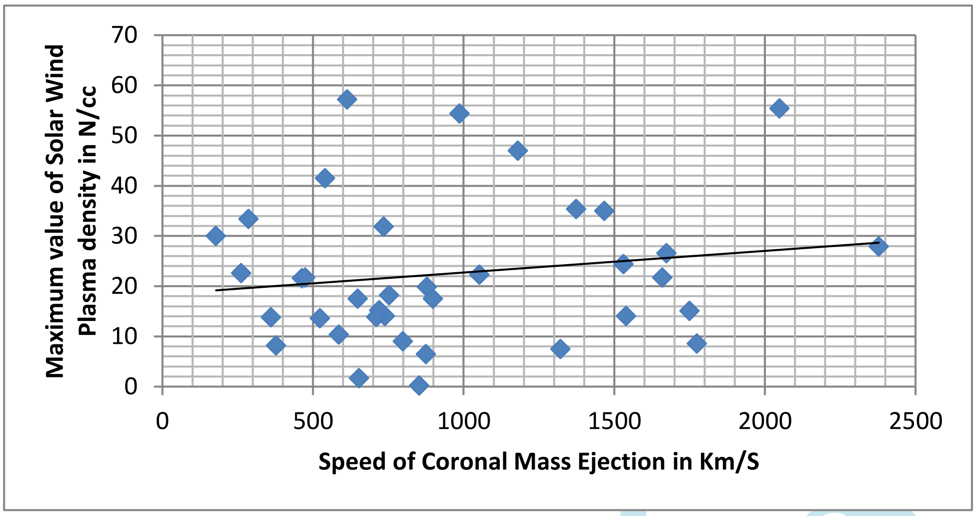

Figure-3 Scatter plot between speed of CMEs and peak value of JSWD events Associated with RB related GMS.

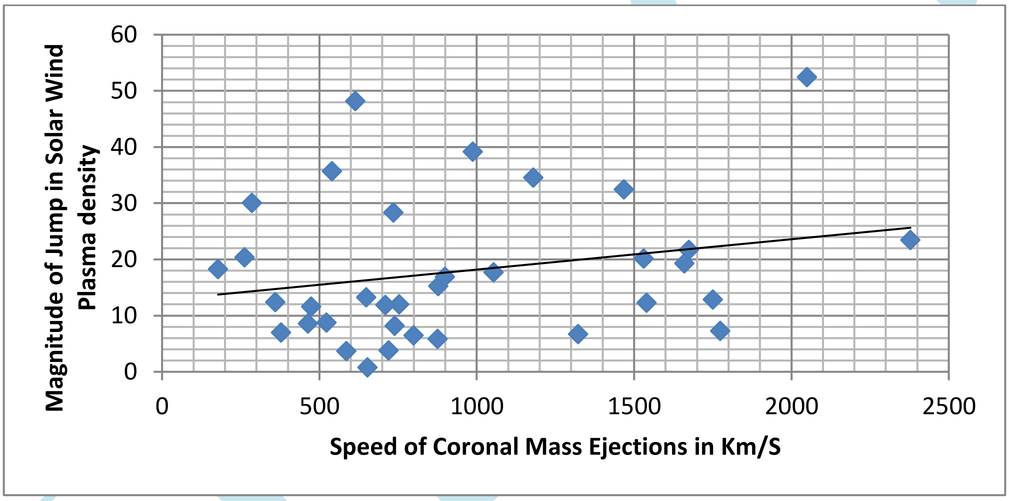

Figure-4 Scatter plot between magnitude of JSWD Associated with RB related GMS and speed of CMEs.

- In this section we have selected those jump in solar wind plasma velocity (JSWV) events which are associated with radio bursts related geomagnetic storms and studied statistical behavior of these events with coronal mass ejections .To see how the peak value of JSWV events are correlated with coronal mass ejections. We have plotted a scatter diagram between the speed of CMEs and peak value of associated JSWV events figure-5. The trend line of the scatter plot of these two events shows moderate positive correlation. Statistically calculated co-relation co-efficient is 0.44 between these two events.
- To see how the magnitudes of JSWV events are correlated with speed of CMEs we have plotted a scatter diagram between magnitude of JSWV events and speed of associated CMEs in figure-6. From the trend line of the scatter plot it is observed that there is weak positive correlation between the magnitude of JSWV events and speed of associated CMEs. Statistically calculated co-relation co-efficient is 0.26 between these two events.

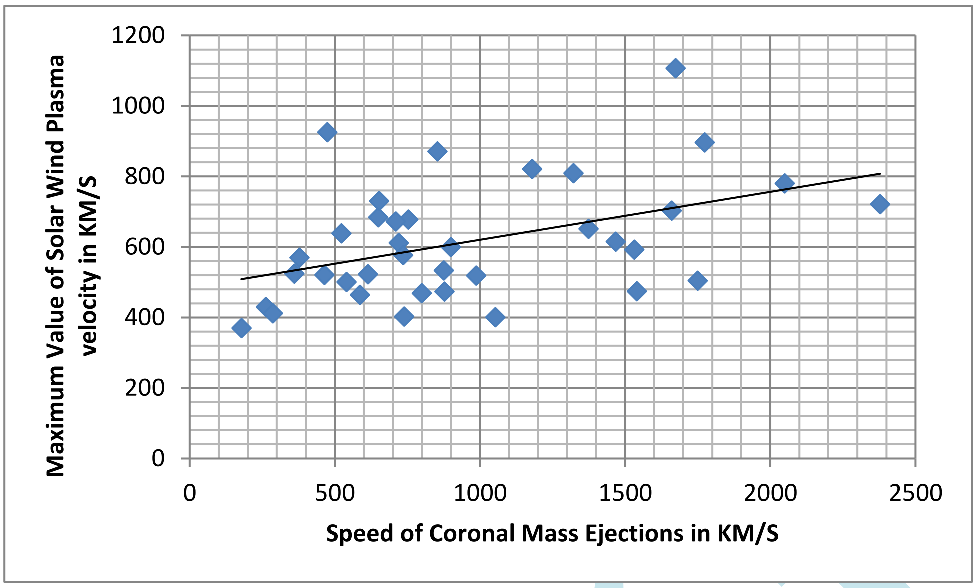

Figure-5 Scatter plot between speed of CMEs and peak value of JSWV events Associated with RB related GMS.

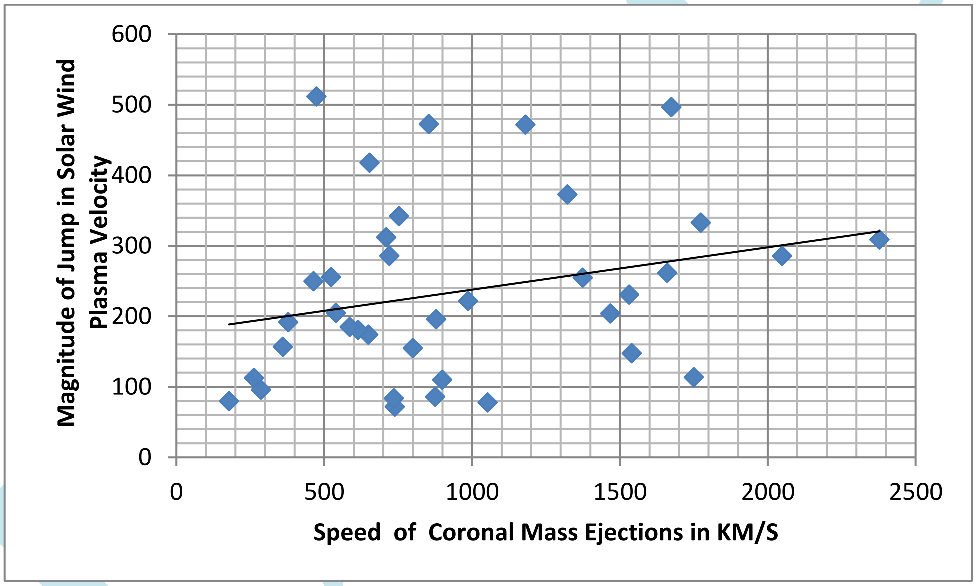

Figure-6 Scatter plot between magnitude of JSWV events Associated with RB related GMS and speed of CMEs.

4- ACKNOWLEDGEMENT

The authors are grateful to all databases for data used in the analysis.

5- CONCLUSION

In this article we have studied the relationship of coronal mass ejections which are associated with geomagnetic storms with the solar wind disturbances. We have found 37 geomagnetic storms are related to coronal mass ejections and the association rates of halo and partial halo coronal mass ejections are 67.57% and 32.43% respectively. Further we have found the coronal mass ejections are closely related to solar wind plasma parameters, i.e. jump in solar wind plasma density and jump in solar wind plasma velocity. There is a positive weak correlation between the speed of CMEs and solar wind plasma parameters.

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