Radio Bursts Related Geomagnetic Storms with Coronal Mass Ejections, X-ray Solar Flares

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Abstract
For this study, we have to consider radio bursts (RB) related geomagnetic storms of magnitude ≤-90nT for the period 1997-2012 with coronal mass ejections (CMEs). For this period we have found the total number of geomagnetic storms is 42. Out of these 37 geomagnetic storms are found to be associated with coronal mass ejections (CMEs). Majority of geomagnetic storms are related to halo coronal mass ejections. Out of 37 geomagnetic storms 25 geomagnetic storms are related to the halo coronal mass ejections and 12 geomagnetic storms are found to be associated with partial halo coronal mass ejection. Again all the geomagnetic storms are associated with Solar X-ray flares of different categories. Majority of the geomagnetic storms are associated with M class Solar X-ray flares. We find the weak positive correlation with correlation coefficient 0.28 between the magnitude of radio bursts related geomagnetic storms and speed of associated CMEs
Keywords: - *Coronal mass ejections, Solar flares, RB related Geomagnetic storm*

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 and interplanetary shocks. The measured properties of CMEs include their occurrence rate, locations relative to the solar disk, angular widths, speed sand masses and energies (Webb, 2002, Gopalswamy et al .2003Yashiro et al. 2004). Halo CMEs which appear as expanding, circular brightening that completely surrounds the coronagraphs occulting disks This suggests that these are normal CMEs seen in projection (Burkepile et al. 2004) to be moving outward either toward or away from the earth .CMEs which have a larger apparent angular size than typical limb CMEs but do not appear as complete halos are called partial halo CMEs. Coronal mass ejections (CMEs) that appear to surround the occulting disk of the observing coronagraphs in sky plane projection are known as halo CMEs (Howard et al., 1982). Halo CMEs are fast and wide on the average and are associated with flares of greater X-ray importance because only energetic CMEs expand rapidly to appear above the occulting disk early in the event (Gopalswamy et al., 2007)

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, the 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 dataset, 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 Solar X-ray 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-1 Association of RB related geomagnetic storms with CMEs and Solar flares.

Geomagnetic Storms Dst≤-90nT			Solar flare		Coronal Mass Ejections	
S.No.	Date	Magnitude of GMS	Date	Type	Date	Type
1	10.04.1997	-102	07.04.1997	C	07.04.1997	Halo
2	15.05.1997	-115	12.05.1997	B	12.05.1997	Halo
3	02.05.1998	-203	30.04.1998	C	29.04.1998	Halo
4	25.06.1998	-111	22.06.1998	C	na	na
5	19.10.1998	-111	18.10.1998	M	15.10.1998	Halo
6	07.11.1998	-139	05.11.1998	M	04.11.1998	Halo
7	13.11.1998	-132	11.11.1998	M	10.11.1998	Partial
8	17.02.1999	-128	14.02.1999	M	na	na
9	28.02.1999	-94	25.02.1999	B	na	na
10	12.09.1999	-103	10.09.1999	B	10.09.1999	Partial
11	21.10.1999	-257	20.10.1999	M	19.10.1999	Partial
12	22.01.2000	-98	18.01.2000	M	18.01.2000	Halo
13	24.05.2000	-164	21.05.2000	C	22.05.2000	Halo
14	15.07.2000	-308	14.07.2000	X	14.07.2000	Halo
15	15.09.2000	-221	12.09.2000	M	12.09.2000	Halo
16	24.09.2000	-191	21.09.2000	C	22.09.2000	Partial
17	13.10.2000	-100	12.10.2000	M	11.10.2000	Partial
18	10.11.2000	-102	08.11.2000	M	08.11.2000	Halo
19	23.03.2002	-107	22.03.2002	M	22.03.2002	Halo
20	17.04.2002	-149	14.04.2002	M	15.04.2002	Halo
21	11.05.2002	-103	09.05.2002	B	08.05.2002	Halo
22	23.05.2002	-172	20.05.2002	X	21.05.2002	Partial
23	01.08.2002	-98	29.07.2002	M	29.07.2002	Partial
24	04.09.2002	-179	01.09.2002	C	na	na
25	30.09.2002	-179	27.09.2002	M	26.09.2002	Partial
26	16.06.2003	-152	15.06.2003	X	14.06.2003	Partial
27	10.07.2003	-128	09.07.2003	M	na	na
28	28.10.2003	-382	26.10.2003	X	27.10.2003	Partial
29	20.11.2003	-417	17.11.2003	M	18.11.2003	Halo

30	22.07.2004	-115	20.07.2004	M	20.07.2004	Halo
31	24.07.2004	-201	22.07.2004	M	22.07.2004	Partial
32	07.11.2004	-415	04.11.2004	M	04.11.2004	Halo
33	07.01.2005	-94	04.01.2005	B	05.01.2005	Halo
34	16.01.2005	-117	14.01.2005	M	15.01.2005	Halo
35	07.05.2005	-275	06.05.2005	M	05.05.2005	Halo
36	28.05.2005	-155	27.05.2005	M	26.05.2005	Halo
37	10.07.2005	-100	07.07.2005	M	09.07.2005	Halo
38	24.08.2005	-248	22.08.2005	M	22.08.2005	Halo
39	14.12.2006	-155	13.12.2006	X	13.12.2006	Halo
40	07.03.2012	-140	04.03.2012	M	05.03.2012	Halo
41	4/23/2012	-119	20.04.2012	C	19.04.2012	Partial
42	17.06.2012	-151	14.06.2012	M	14.06.2012	Halo

Data Analysis and Results

1- From the data analysis of RB related geomagnetic storms with coronal mass ejections and Solar X-ray flares listed in table-1. We find the total geomagnetic storms are 42 for the period 1997-2012, out of these 37(88.09%) geomagnetic storms are found to be associated with coronal mass ejections (CMEs). We have further analyzed that the majority of geomagnetic storms are related to halo CMEs. We have 37 geomagnetic storms, which are associated with coronal mass ejections out of which 25(67.57%) geomagnetic storms are related to the halo coronal mass ejections. Out of 37, 12(32.43%) geomagnetic storms are found to be associated with partial halo coronal mass ejection.

To know the possible statistical behavior between radio bursts related geomagnetic storms and speed of associated CMEs, a scatter plot has been plotted between the magnitude of radio bursts related geomagnetic storms and speed of associated CMEs and resulting plot is shown in figure-1.The trend line of the figure shows a weak positive correlation between the 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 magnitudes of radio bursts related geomagnetic storms and speed of associated coronal mass ejections by a statistical method

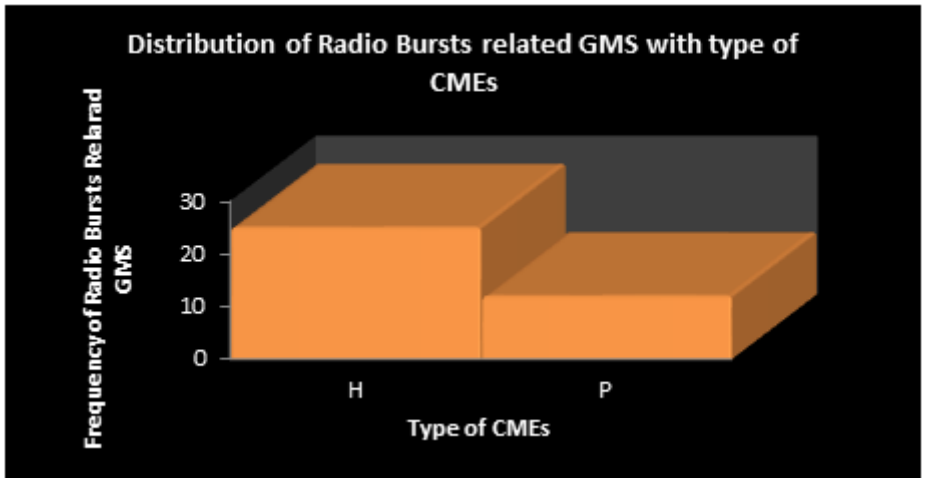

Figure-1 -Distribution of radio bursts related geomagnetic storms with coronal mass ejections.

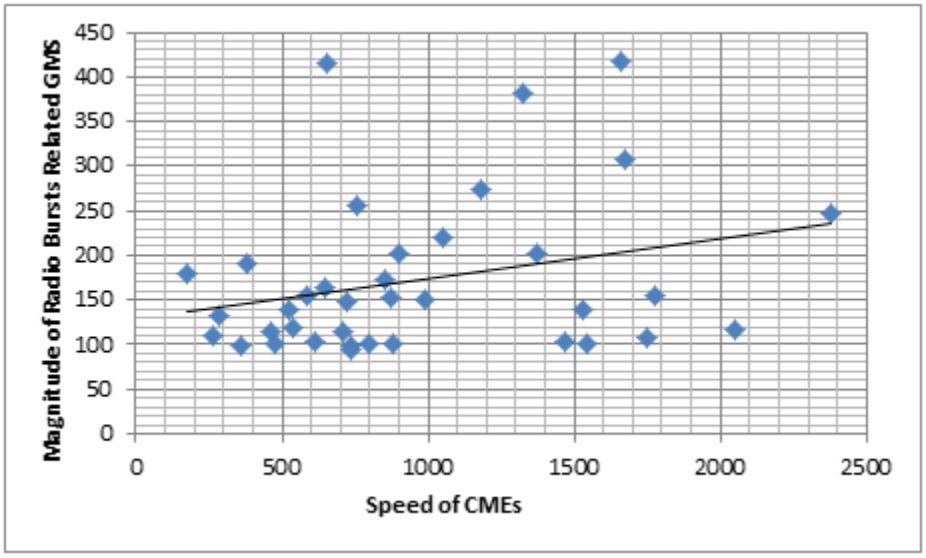

Figure-2-The figure shows scatter plot between the speed of CMEs and magnitude of radio bursts related geomagnetic storms.

2- We have analyzed radio bursts related geomagnetic storms of magnitude ≤-90nT with Solar X-ray flares of different categories From the analysis it is observed that 42 geomagnetic storms have been identified as being associated with radio bursts and all the geomagnetic storms have been found to be associated with Solar X-ray flares of different categories. Out of 42 geomagnetic storms, 05 (11.90 %) geomagnetic storms are found to be associated with X class X-ray solar flares. 25 (59.52%) geomagnetic storms are found to be associated with M class Solar X-ray flares, and 07(16.67%) geomagnetic storms are found to be associated with C class Solar X-ray flares. 05(11.90%) are found to be associated with B class Solar X-ray flares. From these results, it is concluded that radio bursts related geomagnetic storms are closely related to a solar flare.

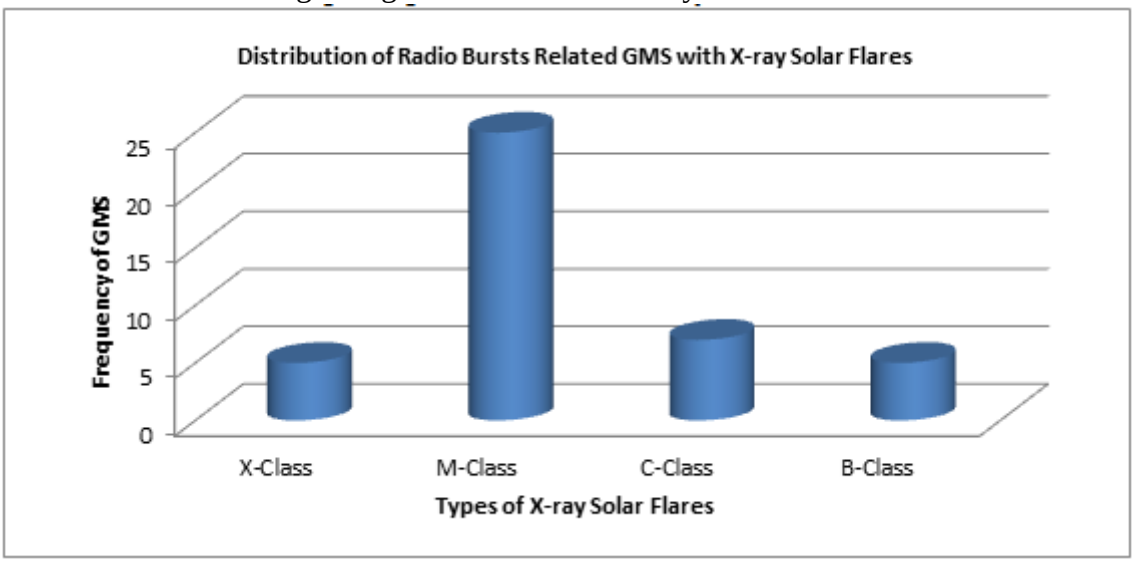

Figure-3-The figure shows the distribution of radio bursts related geomagnetic with Solar X-ray flares of different categories.

Conclusion

From our study 37 out of 42 geomagnetic storms < -90nT have been identified as being associated with coronal mass ejections (88.09%), 25 out of 37 have been identified as being associated with halo coronal mass ejections.

most of the halo CMEs related to radio burst related geomagnetic storms and associated with different types of Solar X-ray flares. Weak positive co-relation has been determined between the magnitude of radio bursts related geomagnetic storms and speed of associated CMEs. These results show that halo coronal mass ejections associated with Solar X-ray flares and radio bursts are very much effective in producing moderate, intense and severe geomagnetic storms.

Acknowledgment

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