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Statistical Study Of Coronal Mass Ejections And Solar Flares

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Abstract
In this article we have reported the data of coronal mass ejections and solar flares of different categories during the period 2004-2013. By the analysis of data we have found 26 coronal mass ejections (CMEs) out of which 5 partial halo coronal mass ejections and 21 halo coronal mass ejections have been found. Out of 26 CMEs, 25 are associated with different categories of solar flares and the association rate is 48% are related to M class solar flare, 20% are related to B and C class solar flares and 12% are related to X class solar flares. By the analysis we have found the negative correlation between CMEs and B and C class solar flares with correlation coefficient -0.25 and -0.22 respectively. Again we have found the positive correlation between CMEs and M and X class solar flares with correlation coefficient 0.71 and 0.72 respectively. We have concluded that coronal mass ejections are strongly related to M class and X class solar flares statistically but most of the CMEs are associated with M class X-ray solar flares intensity.
***Keywords: -** Coronal mass ejections, Solar flares, Solar flare intensity.*

1- INTRODUCTION

The Coronal Mass Ejection (CMEs), large eruption of magnetized plasma from the sun's outer atmosphere or corona that propagates outward into interplanetary space. A coronal mass ejection (CMEs) is a significant release of plasma and accompanying magnetic field from the solar corona. They often follow solar flares and are normally present during a solar prominence eruption. The plasma is released into the solar wind, and can be observed in coronagraph imagery. (Christian, Eric R.(5 March 2012), Hathaway, David H.,). CMEs most often originate from active regions on the surface, such as grouping of sunspots associated with frequent flares near solar maxima, the sun produced about three CMEs every day, whereas near solar minima, there is about one CME every five days (Fox, Nicky). A coronal mass ejection (CME) is an explosive outburst of solar wind plasma from the sun. The blast of a CME typically carries roughly a billion tons of material outward from the sun at speeds on the order of hundreds of kilometers per second. These blasts originate in magnetically disturbed region of the corona, the sun's upper atmosphere- hence the name. CMEs are often associated with solar flare, another type of explosive "solar storm". However, CMEs and solar flare don't always go together, and scientists aren't completely sure how the two phenomena are related. CMEs are much more common during the "solar max" phase of the sunspot cycle, when sunspot and magnetic disturbances on the sun are plentiful.

Flare is a sudden flash, variation of intense brightness on the sun. Observed near its surface and in close proximity to a sunspot group, most powerful flares are often, accompanied by a coronal mass ejection. Solar flares are observed due to the sudden changes of strong magnetic field of corona in the sun. First Solar flares are observed by sept. 1859. The magnetic field lines near sunspots often tangles, cross and reorganize. This can cause a sudden explosion of energy called a solar flare.

2- DATA SOURCES

In this investigation 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 over the period 2004 through 2013. The data of X ray solar flares have been taken from 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.).

Table 1: Data of Coronal Mass Ejection and Solar Flares

S. No.	Date	Coronal Mass Ejections			Solar Flares	
		Date time dd(hh)	Type H/P	Speed Km/s	Date time dd(hh)	Class
1	07.01.04	06(06)	P	1469	06(06)	M-58
2	21.01.04	20(00)	H	1074	20(07)	M-61
3	26.07.04	23(16)	H	824	23(17)	M-22
4	07.11.04	07(17)	H	1759	07(16)	X-20
5	08.05.05	06(17)	H	1128	06(11)	M-13
6	15.05.05	13(17)	H	1689	13(16)	M-80
7	28.05.05	26(15)	H	586	27(12)	M-11
8	23.08.05	22(01)	H	1194	22(01)	M-26
9	11.09.05	09(20)	H	2257	09(19)	X-62
10	14.12.06	13(02)	H	1931	13(02)	X-34
11	21.05.07	na	na	na	19(12)	B-95
12	08.03.08	na	na	na	na	na
13	05.04.10	03(11)	H	668	03(09)	B-74
14	03.08.10	01(13)	H	1309	01(08)	C-32
15	18.02.11	14(18)	H	449	14(17)	M-22
16	05.04.11	03(10)	H	668	03(05)	C-12
17	23.06.11	21(03)	H	719	21(00)	C-77
18	10.07.11	09(07)	P	546	09(09)	B-42
19	05.08.11	04(04)	H	1315	04(04)	M-93
20	25.09.11	22(10)	H	1905	22(10)	X-14
21	24.10.11	22(01)	H	739	22(10)	M-13
22	01.11.11	na	na	na	31(14)	M-11
23	24.01.12	23(04)	H	2283	23(04)	M-87
24	07.03.12	04(11)	H	1473	04(10)	M-20
25	05.04.12	02(02)	P	350	02(02)	B-79
26	16.06.12	02(04)	P	1227	02(04)	C-14
27	14.07.12	12(16)	H	1092	12(16)	X-14
28	03.09.12	02(04)	H	538	02(02)	C-29
29	13.11.12	11(01)	P	1039	na	na
30	14.03.13	nd	nd	nd	12(22)	C-36
31	13.04.13	nd	nd	nd	11(06)	M-65
32	23.06.13	nd	nd	nd	21(02)	M-29

3- RESULT AND DISCUSSION

In this article we have presented the analysis and results of selected solar and interplanetary parameters such as coronal mass ejections, X-ray solar flares during the period of 2004- 2013. to study the effects of coronal mass ejections on space weather particularly on the magnetosphere of the earth and find the correlation between these two parameters. By the analysis of data shown in table no.1, we have found the 26 CMEs for this duration. Out of these the association rate of halo and partial halo coronal mass ejections are 21(80.76%) and 5(19.23%) respectively (Fig.-3.1).

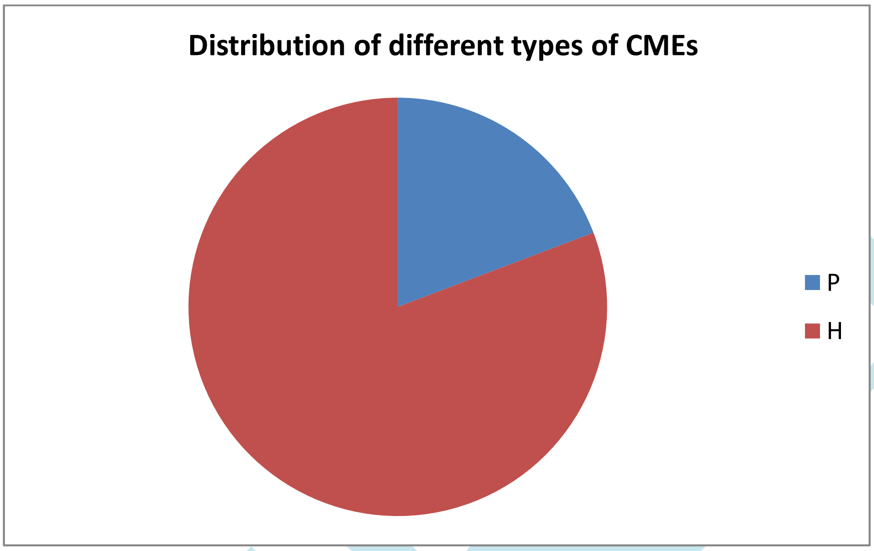

Fig.3.6 shows the different CMEs

Further we have found that out of 26 events, 25 CMEs events are associated with X-ray solar flares of different categories and the association rate is 12 (48.00%) to M-class x-ray solar flares, 5 (20.00%) to B and C class x-ray solar flares, 3 (12.00%) to X class x-ray solar flares shown in figure-3.2.

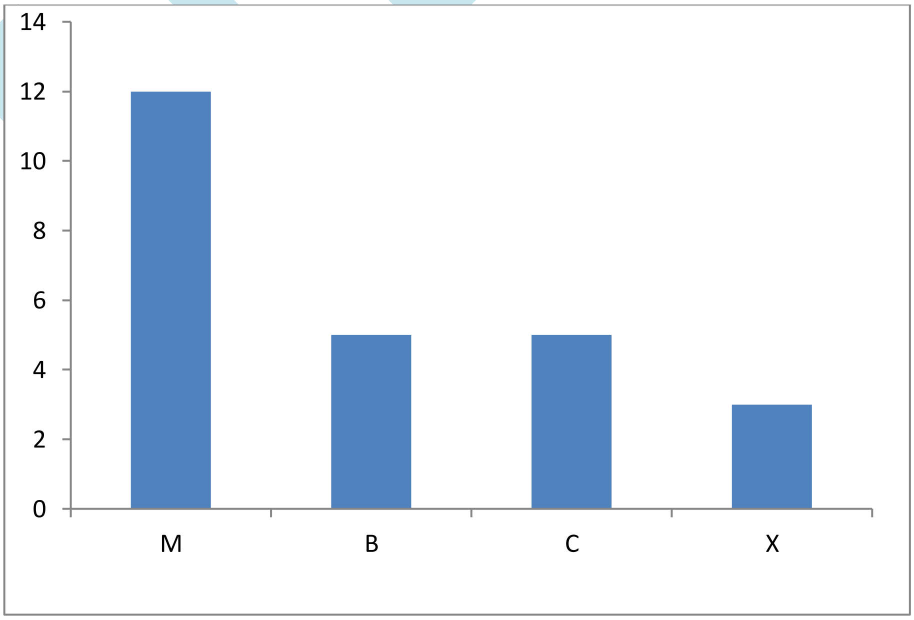

Fig.3.2 Distribution of Solar flares

Again we have studied the statistical correlation between coronal mass ejections speed and different flares intensity; there is a positive correlation between CMEs speed and M and X class solar flare intensity with correlation coefficient 0.71and 0.72 respectively (Fig.3.3& 3.4).

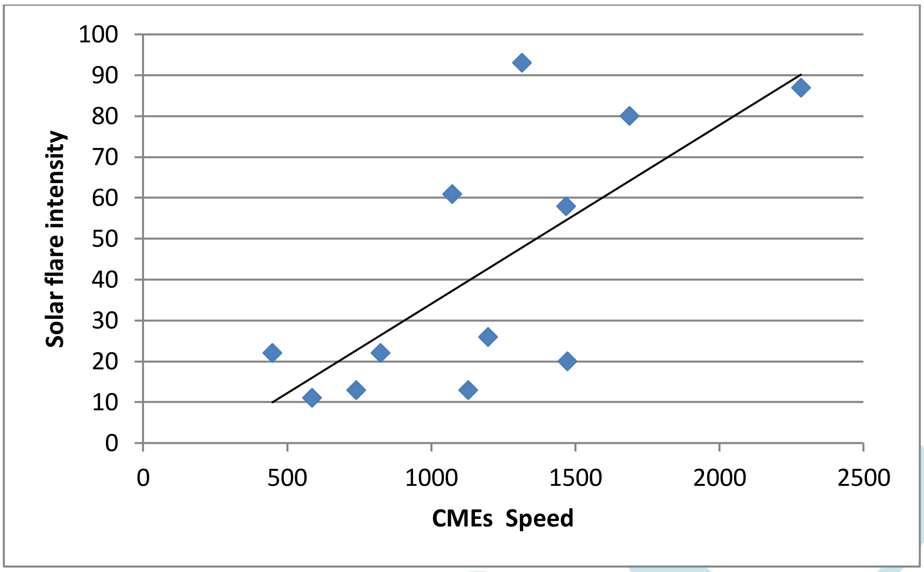

Fig.3.3 Shows correlation between CEMs Speed and Solar flare intensity of M class

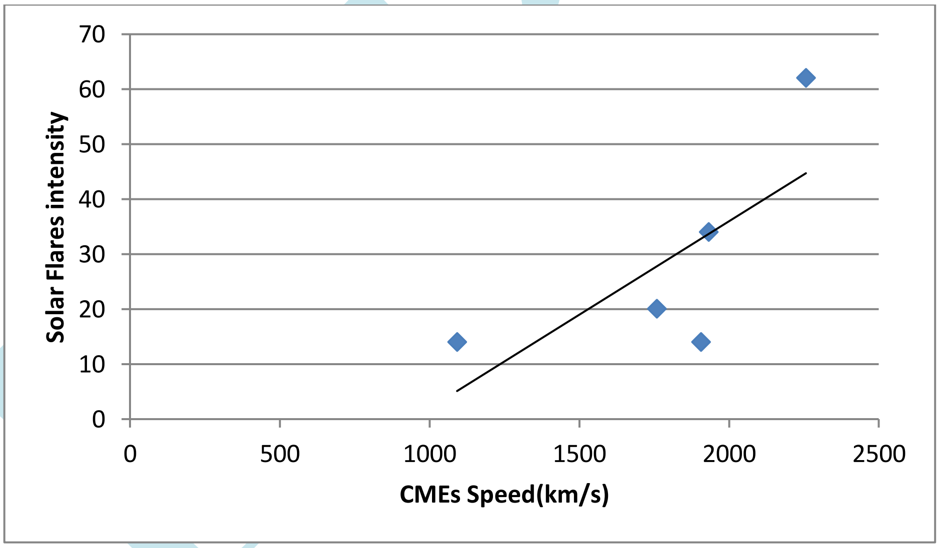

Fig. 3.4 Correlation between CEMs Speed and solar flare(X) intensity

Further we have observed the week negative correlation between CMEs speed and B and C class solar flare intensity with correlation coefficient -0.25 and -0.22 respectively between these two events (Fig. 3.5 & 3.6).

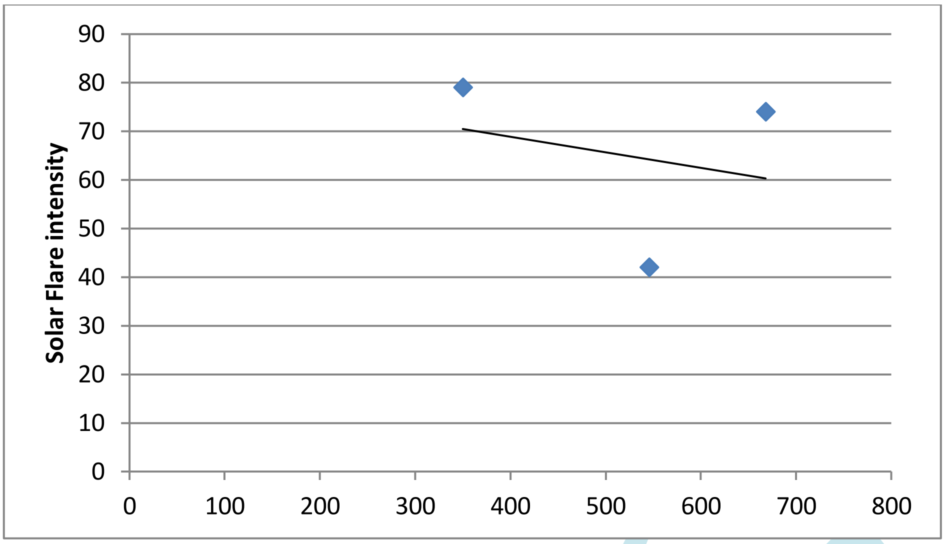

Fig.3.5 Shows correlation between CMEs Speed and Solar Flares (B) intensity

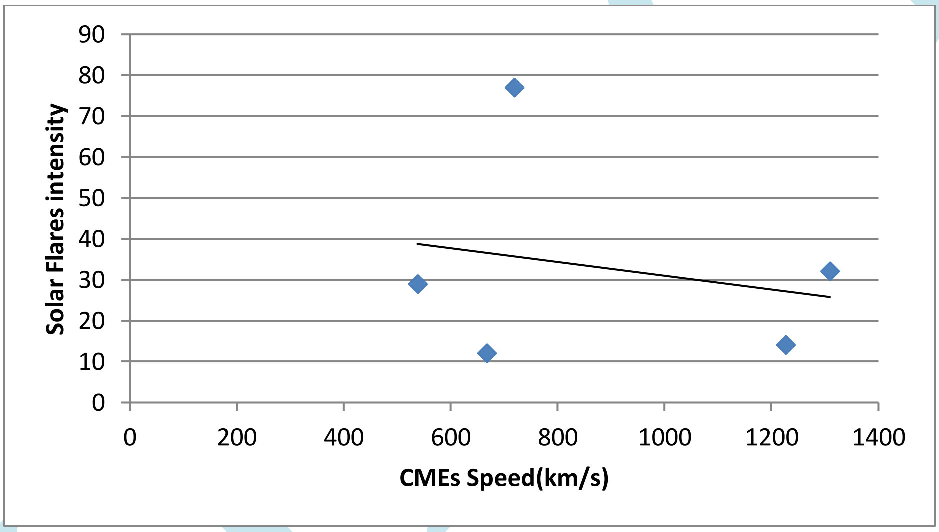

Fig.3.6 Correlation between CEMs Speed and Solar Flare(C) intensity

By this analysis finally we have concluded that the coronal mass ejections events are strongly associated with X and M class X-ray solar flares only and there is no correlation with other type of solar flare events. Coronal mass ejections are also responsible for the generation of geomagnetic storms and other solar and interplanetary parameters.

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