

Analysis of coronal mass ejections and solar flares

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Abstract

The Sun is the most conspicuous element in our nearby planet group and contains around 98% of the all out planetary group mass. In this work we have selected those CME events which are having velocity ≥ 500 Km/s with an apparent width of 3600 during the period from 2008-2019 (SC24). Within this time frame we have observed 201 CME events and corresponding solar flare events were 183 of different categories most of the flares observed was C class flares (47.5%). Further we have observed that there were no CME events for the year 2008, 2009, 2018 and 2019. The peak of SC24 was observed on April 2014 with 23 months smoothed sunspot number 81.8. By extracting the data of CMEs and flare events from SOHO/LASCO catalog and NOAA and do the statistical analysis and find out the correlation between CMEs and solar flares of different categories. CME events with B class and C class flares not having any correlation but M class flares have positive correlation with correlation coefficient 0.38. Further CME events are moderately correlated with X class solar flares with correlation coefficient 0.45.

Keywords: - CMEs, Solar flares, Solar cycle.

1. Introduction

CME launch from the sun is one of the truly sun oriented quirks. The Earth-composed CMEs are indispensable, since they can convey geomagnetic storms. For the most part these CMEs are seen as Halo CMEs (Howard et al., 1982). Early assessments of the CMEs speeds have helped with moving appreciation we could decipher the actual cycles in the daylight based corona. CMEs include enormous designs containing plasma and magnetic fields that are removed from the Sun into the heliosphere. They are of interest for both scientific and technological reasons. Experimentally they are of interest since they dispose of created appealing energy and plasma from the sun situated crown (Low, 1996), and creatively they are of interest since they are responsible for the most over the top space weather patterns influences at Earth (Baker et al., 2008). CMEs now and again disturb the magnetosphere of the Earth, provoking pulverizing repercussions for satellites and correspondence systems (Clark 2006). Other hazardous events, known as solar flares, similarly occur in the sun controlled climate. These are portrayed as a surprising extension in electromagnetic radiation with a wide spectral range. The association among CMEs and sun controlled flares is a critical subject in sun based physical science. In any case, CMEs were seen as begun by gigantic flares (Lin and Hudson 1976). Nevertheless, Zhang et al. (2001) showed that CMEs are begun before the start of the connected flares. Bein et al. (2012) reported that 25% of CMEs were not related with sun controlled flares. It is moreover understood that flares without CMEs exist (Yashiro et al. 2006). Sun powered flares are for the most part organized into two sorts: eruptive flares (with CMEs) and restricted flares (without CMEs). In eruptive flares, the discharge of an alluring movement rope looks at to a CME and the warmed plasma achieved by the attractive reconnection is viewed as a flare (Shibata and Magara 2011). In this manuscript we have considered CME events having speed ≥ 500 Km/s during solar cycle (SC) 24 and obtain the association with solar flares during the prescribed time frame (SC24).

2. Data Sources and Selection of Events

We used 201 records of CMEs data (gained from CME index) saw by SOHO, during the period from 2008 to 2019. This CME data is open in the CDA site: https://cdaw.gsfc.nasa.gov/CME_list/. This index contains all CMEs physically perceived start around 1996 from the Large Angle and Spectrometric Coronagraph (LASCO) on board the Solar and Heliospheric Observatory (SOHO) mission. LASCO has three telescopes C1, C2, and C3. Regardless, just C2 and C3 data

are used for consistency considering the way that C1 was debilitated in June 1998. Without an ideal customized CME pointer program, the manual identification is at this point the best method for recognizing CMEs. This data base will go about as a sort of point of view to support customized conspicuous evidence projects being made. We furthermore used the X-beam flares data which assessed and given by Geostationary Operational Environmental Satellite (GEOS), during a comparative stretch (2008-2019) with records of 183 flare occasions.

3. Data Analysis, Results and Discussion

In this work we have selected those CMEs event which are having velocity ≥ 500 Km/s with an apparent width of 360° . During this period from 2008-2019, we have observed 201 CME events and corresponding solar flare events were 183 of different categories out of 183 solar flare events 34 B class, 87 C class, 42 M class and 20 X class flares was found shown in figure-1. For 18 CME events no associated flares were observed for SC24. Table-1 shows the flares distribution.

Table-1: Observed Solar Flares from 2008-2019.

Class of Flares	Number of Flares
B-Class	34
C-Class	87
M-Class	42
X-Class	20

We perform the statistical analysis using Karl's Pearson correlation formula and find out the correlation between CMEs and solar flares of different categories.

3.1. CMEs with B Class Flares

To know the statistical behavior of CME events with B class solar flares during 2008-2019. With the analysis of CME events and B class flares found that they have weak positive correlation with correlation coefficient 0.12. The trend line of figure-2 shows the weak positive correlation between these two events.



Figure-1 Distribution of different solar flares.

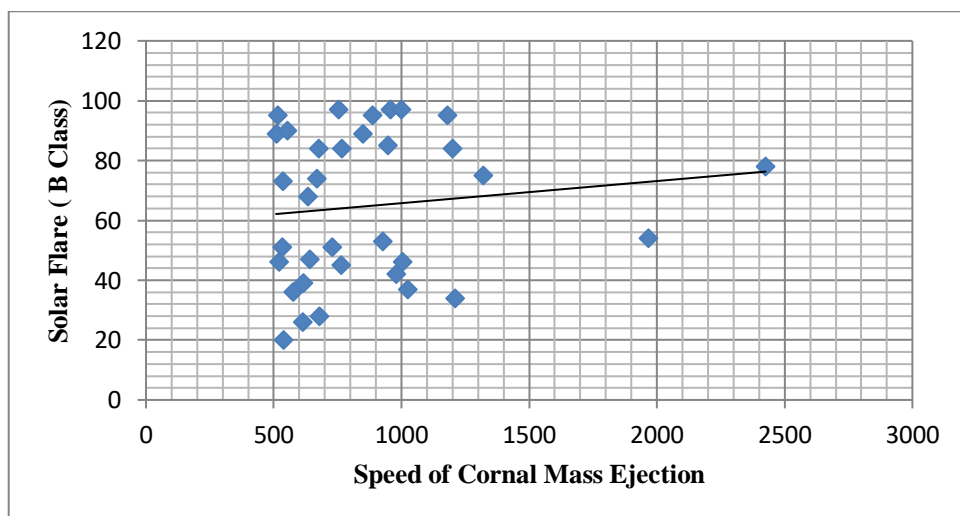


Figure-2 Correlation between CMEs and B class flare during 2008-2019.

3.2. CMEs with C Class Flares

Further we perform statistical analysis between CME events and C class flares. With the analysis we have found that they are not having any correlation with correlation coefficient -0.01, see figure-3.

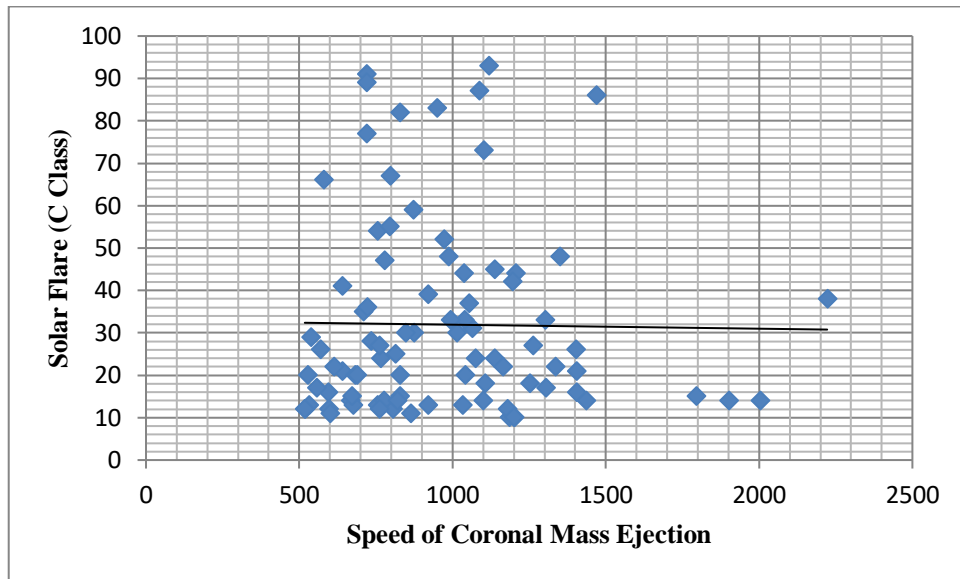


Figure-3 Correlation between CMEs and C class flare during 2008-2019.

3.3. CMEs with M Class Flares

Further we perform statistical analysis between CME events and M class flares and found that they are moderately correlated with each other. Gour et al. 2021 also showed that these two events are correlated. Scatter plot shown in figure-4 tells that these two events have moderate positive correlation having correlation coefficient 0.38 between these two events.

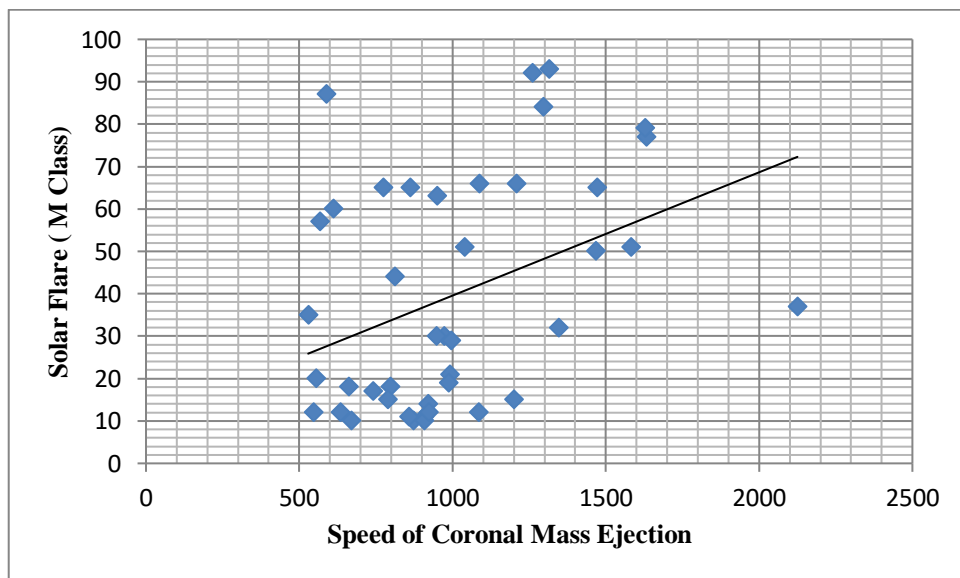


Figure-4 Correlation between CMEs and M class flare during 2008-2019.

3.4. CMEs with X Class Flares

Further we perform statistical analysis to know the behavior between CME events and X class flares and we have found that they are moderately correlated with each other. It means X class flares can cause the CMEs event more effectively irrespective of M class flares. Scatter plot shown in figure-5 tells that these two events have moderate positive correlation with correlation coefficient 0.45 between these two events.

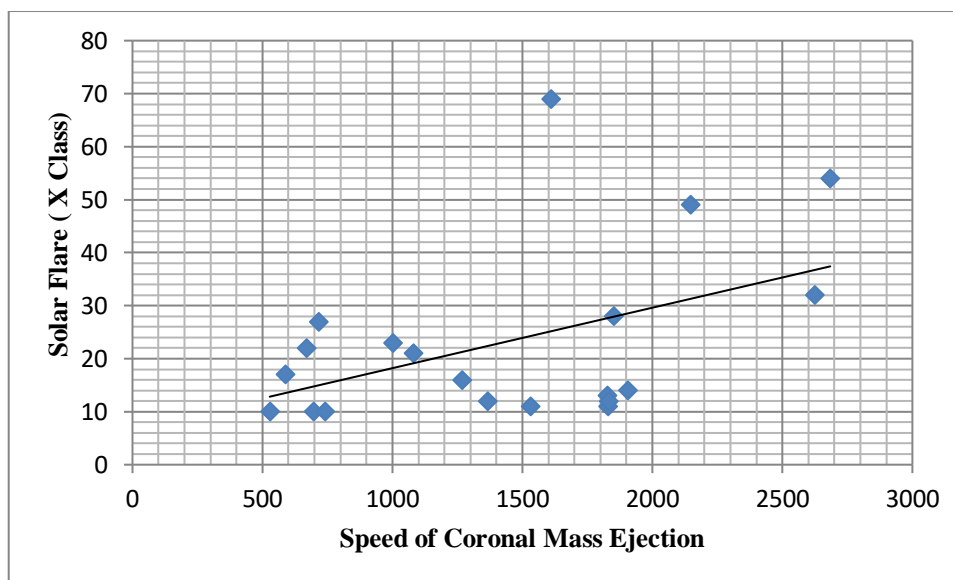


Figure-5 Correlation between CMEs and X class flare during 2008-2019.

4. Conclusion

In this work we have taken solar activities like CMEs, SF, and find out perform the correlative analysis during SC24. At last we inferred that CME events are related with flares explicitly X class flare. We found that the CME alliance speed of the 183 picked CME-Flare events is winning for X-beam flare events. We saw that the CME energies are more associated with the X-beam flux of their connected flares during the hour of high sun situated activity. Further we concluded that CMEs are not mainly responsible for the interplanetary phenomenon some other activities like flares and energetic particles may also be responsible for interplanetary disturbances. In further study we recommended that we can see the flares events with IMF B_z and find out the main cause of interplanetary disturbances.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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