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CORRELATIVE STUDY OF SOLAR TRANSIENT PARAMETERS ASSOCIATED WITH DST INDEX FOR SOLAR CYCLE 23 AND 24

Soumya Yadav, Priyank Srivastava, A.K. Singh

Physics Department, University of Lucknow, Lucknow-226007, India

Abstract

Geomagnetic storms and solar coronal mass ejections (CMEs) have been shown to be associated since the discovery of CMEs in solar activity (*Yurchyshyn et al.*, 2004). An intense geomagnetic storm can either be stemmed from a CME, or from a coronal hole. However, a great geomagnetic storm can only be sourced from a CME (*Le et al.*, 2012). The aim of this paper is to study the relation between the coronal mass ejections (CMEs), and their associated solar flares and correlate this with the Disturbance storm time (Dst) index. We have studied the count rate of soft X-rays class of X, M and C type through a histogram type plot for studying the number of X-rays of different class observed during solar cycle 23 and 24. We have also studied the angular width, speed of coronal mass ejections (CMEs) and disturbance storm time (Dst) index of solar cycle 23 and 24 for the whole cycle (*Pant et al.*, 2021).

1. Introduction

Coronal Mass Ejections (CMEs) are magnificent and dramatic solar atmosphere occurrences that have repercussion across the whole heliosphere. With the ability to affect the heliosphere, interplanetary space, and the atmosphere of Earth, coronal mass ejections are an important type of solar violent event that hurls massive volumes of magnetic flux and plasma out of the solar atmosphere (*Lamy et al.*, 2019). The angular width of CMEs typically refers to their projected, apparent span, in degree. The apparent angular width of CMEs ranges from a few degrees to 150º (*Bidhu et al.*, 2017). The study of the distribution of the angular width of CMEs offers crucial hints for comprehending the physical processes that cause the CMEs to grow.

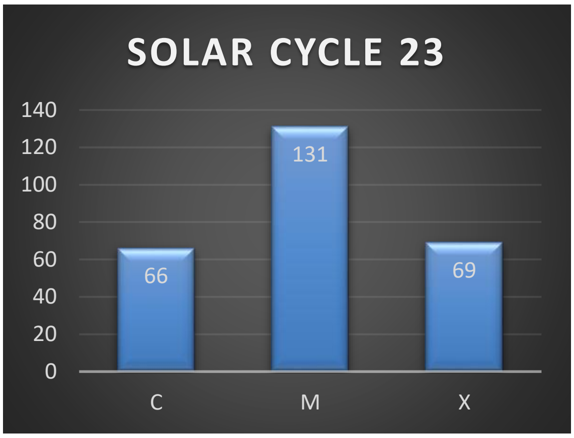
Geomagnetic storms are significant disruptions in the Earth's magnetosphere that occur when the interplanetary magnetic field (IMF) shifts southward and stays southern for an extended length of time. Geomagnetic storms and solar coronal mass ejections (CMEs) have been shown to be associated since the discovery of CMEs in solar activity (*Srivastava and Singh*, 2021). An intense geomagnetic storm can either be stemmed from a CME, or from a coronal hole. However, a great geomagnetic storm can only be sourced from a CME. The aim of this paper is to study the relation between the coronal mass ejections (CMEs), and their associated solar flares and correlate this with the Disturbance storm time (Dst) index (*Singh et al.*, 2021).

2. Data Sources

Since the LASCO has been continually studying CMEs since January 1996 (since the start of solar cycle 23), the data utilized in the current work for statistical analysis of angular width and speed are taken from the catalogue of SOHO's website (https://cdaw.gsfc.nasa.gov/CME_list/catalog_description.htm). Also, data for Dst are collected from OMNIWeb Data Explorer(https://omniweb.gsfc.nasa.gov/form/dx1.html). There have been a total of 12 observations of initial speed for solar cycle 23 and 9 for cycle 24, respectively.

3. Solar transient parameters and geomagnetic storm parameter, i.e., Dst

The solar transient parameters which are discussed here are angular width and speed. The geomagnetic storm parameter used is Dst. We have studied the count rate of soft X-rays class of X, M and C type through a histogram type plot shown in Figure 1 for studying the number of X-rays of different class observed during solar cycle 23 and 24. We have also studied the angular width, speed of coronal mass ejections (CMEs) and disturbance storm time (Dst) Index of solar cycle 23 and 24 for the whole cycle. The histogram clearly shows that the X-rays of class M are greater than those of classes X and C. M-class flares are considered mild, whereas X-class flares are the strongest. Thus, the graph indicates that the highest number of mild flares occurs in both solar cycles. However, in solar cycle 23, the quantity of X flares exceeds that of C-class flares. In solar cycle 24, the number of X flares is lower than the number of C-class flares. We may conclude that solar cycle 23 was more powerful than solar cycle 24.



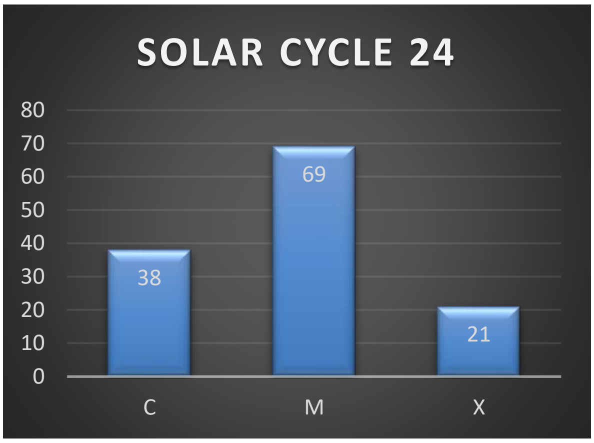


Figure 1. Histogram shows the count rate of soft X-rays class of X, M and C type observed during solar cycle 23 (1996-2008) and 24 (2008-2020).

4. Result and Discussion

For our analysis, we took the Dst index value for the specific day of year based on the maximum initial speed for each year in the relevant solar cycle, as shown in Tables 1 and 2. The graph in Figure 2 shows that there is a linear relationship between the geomagnetic storm parameter, Dst, and the starting speed of CMEs during solar cycle 23. Similarly, we found a relationship for solar cycle 24, as seen in the graph in Figure 3. Because of linear regression, both graphs have a negative slope, which indicates that when the initial speed declines, so does the Dst value. We must remember that a greater negative value of Dst indicates stronger geomagnetic storms. However, we may deduce that Dst increases when the initial speed increases and vice versa. Although there is a substantial association between Dst and initial speed in solar cycle 24, the linear intensity of the correlation is smaller than it was in solar cycle 23. In addition, solar cycle 23 has a steeper slope than solar cycle 24 indicating a higher rate of change. It is clear from this that solar cycle 23 was stronger than cycle 24.

Dst (nT)	Initial speed (km/s)
-24	1556
-43	2231
10	2230
-15	2604
-71	2505
-50	2393
-33	2657
-176	3387
-27	2861
-6	1994
-4	1367
1	1103

Table 1.

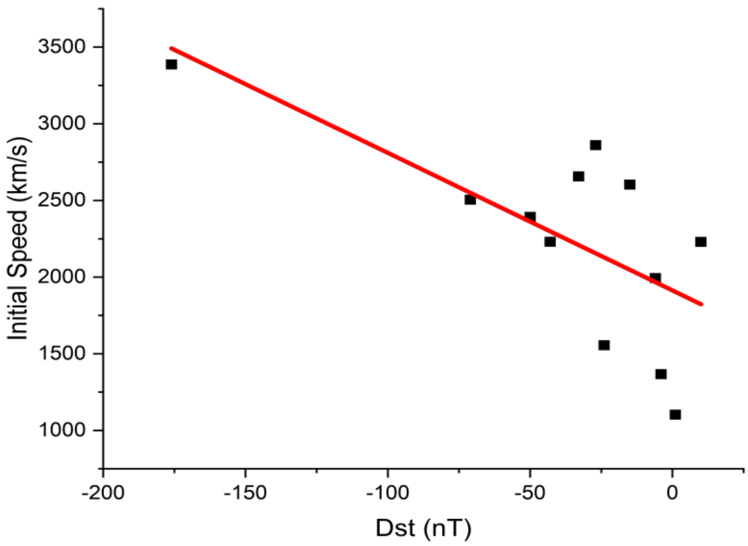


Figure 2. Graph shows linear correlation of Dst with speed of CMEs for the solar cycle 23.

Dst (nT)	Initial speed (km/s)
-7	1471
-3	2425
-98	2684
-2	2625
-29	2222
-33	1794
-26	1730
-24	3163
-9	692

Table 2.

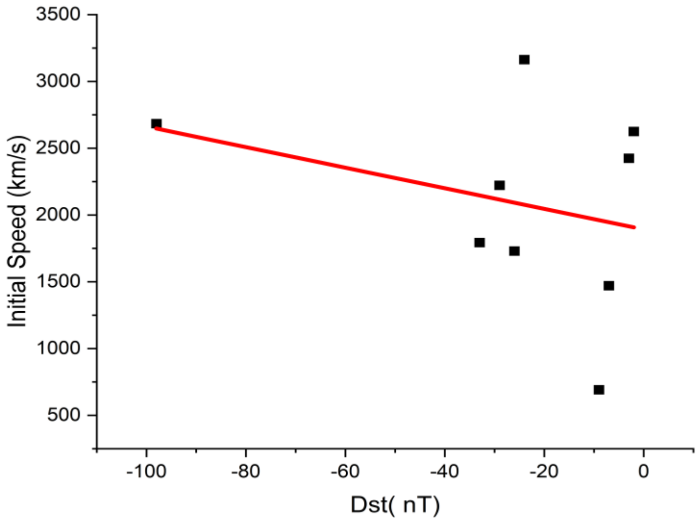


Figure 3. Graph shows linear correlation of Dst with speed of CMEs for the solar cycle 24.

5. Conclusion

As part of the current effort, we have investigated soft X-rays, the initial speed of CMEs, and the accompanying geomagnetic storm parameter, Dst, throughout solar cycles 23 and 24 between 1996 and 2020.The following are some of the most important conclusions from this statistical analysis:

- From our analysis, we can conclude that no. of M class soft X-rays is greater than that of X and C type for both solar cycles i.e., solar cycle 23 and 24. However, for solar cycle 23, there are more X-class flares than C-class, and for solar cycle 24, there are fewer X-class flares than C-class.
- There is significant relation between Dst and initial speed but the linear correlation here is less compared to solar cycle 23. The linear corelation of initial speed with Dst shows a strong negative correlation for solar cycle 23 as compared to solar cycle 24.
- Solar cycle 23 is stronger than solar cycle 24.
- From our analysis, we can say that solar transients affect the geomagnetic activity to some extent. The overall analysis shows that more the correlation stronger the solar cycle.

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