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EFFECT OF CORONAL MASS EJECTION ON THE EARTH'S MAGNETIC FIELD DURING THE ASCENDING AND DESCENDING PHASE OF SOLAR CYCLES-24

Physics

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ABSTRACT

In this paper we analyzed the coronal mass ejection (CMEs) in angular widths wise and linear speed wise and geomagnetic disturbance storm time (Dst) index during ascending and descending phase of solar cycles-24. Total CME's divided by two phase – angular widths wise and linear speed wise for the ascending period 2007-2012 and descending period 2013-2017. We have found that the widths of 79% CME's are narrow and 2% are Halo for the ascending phase of solar cycles-24, and 71% CME's are narrow and 2% are Halo for the descending phase of solar cycles-24. The linear speed distribution of 87% CME's has speed <=500 km/sec and 1%CME's have speed >1000 km/sec for ascending phase of solar cycles-24, and 85% CMEs has speed <=500 km/sec and 1% CMEs has speed >1000 km/sec for descending phase of solar cycles-24. We also describe the coefficient of correlation between disturbance storm time (Dst) and coronal mass ejection (CMEs) for ascending and descending phase of solar cycles-24, and we conclude that the ascending phase of solar cycles-24 is strong as compare to descending phase of solar cycles-24

KEYWORDS

Coronal mass ejection (CMEs), disturbance storm time (Dst), Halo CMEs, Fast CMEs

INTRODUCTION

Coronal mass ejection (CMEs) are a topic of comprehensive study. Coronal mass ejection (CMEs) have very importance in the complement of interplanetary and geomagnetic activity. [1][2][3]. The disturbance storm time index (Dst) is an estimate of geomagnetic activity used to assess the magnetic storm and it is affected by solar output. The relation between CMEs and geomagnetic storm has been examined by many researchers. [4][5][6][7]. For establishing a physical relationship between the solar origin and the final geomagnetic effect, it is therefore required to monitor the CMEs right from the solar surface through the interplanetary medium till they reach the earth. More recently , with the launch of solar and Heliospheric observatory (SOHO), it has become possible to track a CME from the solar surface using extreme ultraviolet telescope (EIT) image , generally in 19.5 nm [8] to the outer corona in white light with the Large angle spectrometric coronagraphs LASCO-C2 and C3 [9] which have a combined field of view ranging from 2 to 30 R. coronal mass ejection (CMEs) with strong magnetic field generate geomagnetic storms [10].

Coronal mass ejection (CMEs) travels typically three range speed – Low (~100 km/sec.), Fast (~483 km/sec.), Faster (~3000 km/sec.) [11][12]. The lowest CMEs erupt from small sunspot quit regions, powered by the inactive magnetic field concentrations on the sun. On the other hand, the fastest CMEs erupt from large sunspot effective regions, powered by the active magnetic field concentrations on the sun. Low CMEs can reach earth in a long time but fast CMEs can reach earth in a little time. And caused major geomagnetic storms. It is notable that the most solar cycles show a double peak due to the out of phase activity in the two hemispheres [13]. The double peak in SSN during solar cycle 24 is the second peak is larger than the first on by ~20% such a behavior was observed only a few times since the 1800s [14].

To study geomagnetic storms, Halo CMEs have most important role which is first observed by Howard [15]. Halo CMEs, expand rapidly and appear to surround the occulting disk of the observing coronagraph. Halo CMEs create only ~3% of all CMEs and produce an energetic community because most of the CMEs that production large solar energetic particle (SEP) events and major geomagnetic storms are Halos. [16]. There only 11 CMEs that caused major storms during cycle 24 until the end of period 2014 [17]. CMEs number shows a double peak and similar to see in sunspot number [18].

In this paper, we evaluate the correlation between Dst and CMEs (Fast and Halo) during the ascending and descending phase of solar cycles-24. We also describe the variation of Dst and CMEs (speed and widths wise) for the selected period.

DATA DETECTION AND METHOD OF ANALYSIS

We have taken CMEs and Dst data during the ascending and descending phase of solar cycle-24. We know that 11 year produce a solar cycle. We have selected the first 6 years in ascending phase and 5 years in descending phase. The time duration of ascending phase 2007 to 2012 and time duration of descending phase 2013 to 2017. In the present study, we have selected CMEs events data on the basis of angular width wise and speed wise from SOHO/LASCO (cdaw.gsfc.nasa.gov. / CME_list/). In this paper, we have distributed CMEs events in Narrow (width <=60^0), Moderate (width 61^0~120^0), Partial Halo (width 121^0~359^0) and Halo (width =360^0) and speed distribution we have classified CMEs in such categories as <=500 km/sec , >500~1000 km/sec , and >1000km/sec. The values of the annual average of geomagnetic disturbance storms time index (Dst) (based on daily data) is taken from the omni web (https://omniweb.gsfc.nasa.gov./from/dx1.html).

RESULT S AND DISCUSSION

Firstly, we describe the speed distribution, we have taken the ascending and descending phase of solar cycle-24. We have studied the interval 2007 to 2012 for ascending phase and 2013 to 2017 for descending phase. We have divided CMEs events in speed wise into three categories: - 1) CMEs with speed (<= 500 km/sec) 2) CMEs with speed (>500~1000 km/sec) 3) CMEs with speed (>1000 km/sec). figure 1 – shows the pie diagram for the distribution of CMEs according to above three categories for ascending and descending phase of solar cycle 24. According to Figure 1 we have noticed that the CMEs with speed <=500 km/sec for ascending phase is 87% and for descending phase is 85%. It is noted that the CMEs with speed <=500 are strong in ascending phase as compared to descending phase of solar cycle -24.

Figure 2(a) shows the annual occurrence of fast CMEs (>1000) during the ascending and descending phase of solar cycle -24. From figure 2(a) we found that the fast CMEs have double peaks in the ascending phase (2007 to 2012) and descending phase (2013 to 2017) of solar cycle 24. We have noticed that the interval for fast CMEs (>1000) between the first maximum to the second maximum is ~1 year during the ascending and descending phase of solar cycle 24. Fast CMEs are producing major geomagnetic storms (figure 2b). In figure(2b) we describe the scatter graph between fast CMEs and Dst index. The correlation coefficient between fast CMEs and Dst index for ascending phase is R = -0.467012 and for descending phase R = -0.2625. from figure (2b) we noted that the correlation coefficient between Dst and fast CMEs (>1000) is strong in ascending phase as compare to descending phase. we have reported that the solar activity is strong in ascending phase as compare to descending phase.

In figure (3) we describe the annual occurrence of total CMEs event for angular width wise. We have divided CMEs events in four categories for the ascending and descending phase – 1) Narrow (width <=60^0) 2) Moderate (width 61^0~120^0) 3) Partial Halo (width 121^0~359^0) 4) Full

Halo (width =360^0). From figure (3) we noted that the Narrow CMEs have the best percentage in total CMEs during the ascending phase and descending phase. In total, Halo CMEs are only 2% in both phases.

In figure (4a) we describe the annual occurrence of Halo CMEs, during ascending and descending phase of solar cycle 24. Halo CMEs has a double peak structure in solar cycle 24. From figure(4a) we noted that the interval for Halo CMEs (width =360^0) between the first maximum to second maximum is ~1 year during ascending and descending phase of solar cycle 24.

In figure(4b) we describe the scatter graph between Halo CMEs and Dst index during the ascending and descending phase of solar cycle 24. From figure(4b) we noted that the Halo CMEs is the strongest correlation with Dst during the ascending phase of solar cycle 24, for time duration 2007 to 2012. We have found correlation coefficient between Halo CMEs and Dst for ascending phase of solar cycle 24 is R=-0.479 and for descending phase of solar cycle 24 is R=-0.2612. we know that geomagnetic activity is depending on the CMEs during ascending phase of solar cycle. We noted that the correlation coefficient between Halo CMEs and Dst for ascending phase is strong as compare to descending phase.

In figure (5) we describe the annual average Dst. Dst is maximum for the ascending phase in the period 2012 and for descending phase in the period 2015. We noted that the maximum value of the annual average of Dst is produced in ascending phase as compared to descending phase. We have noticed that the annual average of Dst is maximum in the period 2009 during the ascending phase of solar cycle 24. It is observed that the Dst is depending on the CMEs during the study period [7].

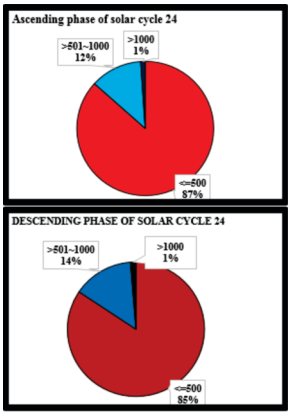
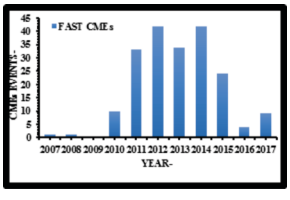
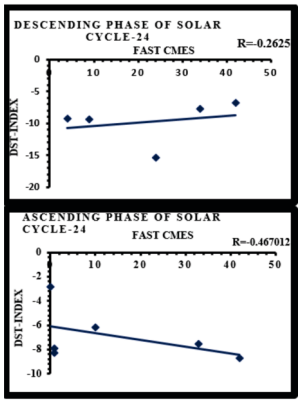


Figure 1. Shows the distribution of total CMEs according to CME's speed for ascending and descending phase of solar cycles- 24.



(a)



(b)

Figure 2. (a) Shows the graph of annual occurrence of fast CMEs during solar cycles- 24

(b) scatter graph between fast CMEs and Dst Index during ascending phase and descending phase of solar cycle-24.

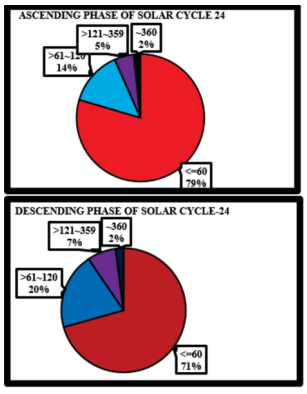
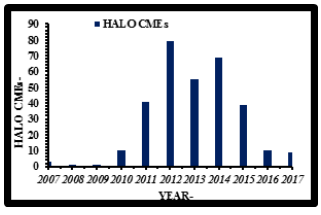
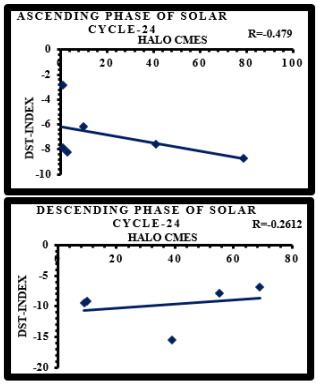


Figure 3. Shows the distribution of total CMEs according to Angular width for the ascending and descending phase of solar cycles-24.



(a)



(b)

Figure 4. (a) Shows the annual variation of Halo CME during solar cycles- 24 **(b)** Scatter graph between the annual value of Halo CMEs and Annual average value of Dst (nT) index for the ascending and descending phase of solar cycles-24.

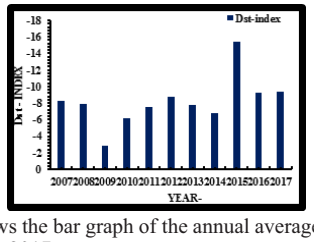


Figure 5. Shows the bar graph of the annual average of Dst Index for the year 2007 to 2017.

CONCLUSIONS

Our study base on the comparison of ascending phase of solar cycle 24 and descending phase of solar cycle-24 for the selected period by using fast CMEs, Halo CMEs, and Dst index. We Have summarized the main finding of this study as follows:

(1) We have found that the occurrence of Fast CMEs (>1000 km/sec) are only 1% in ascending and descending phase of solar cycle -24. Therefore, we have reported low solar activity in both phases.
(2) Fast CMEs have a double peak structure in solar cycle-24.
(3) The occurrence of Halo CMEs (=360^0) is 2% in both phases.
(4) Halo CMEs have a double peak structure in solar cycle -24.

(5) The correlation between Fast CMEs and Dst index is strong in ascending phase as compared to descending phase of solar cycle-24.
(6) The correlation coefficient between Halo CMEs and Dst index is strong in ascending phase as compared to descending phase of solar cycle-24. It is observed that the total number of Halo CMEs for ascending phase is less than as compared to descending phase. We know that the speed of CMEs with Fast and Halo are responsible for producing strong geomagnetic storms.
(7) By using correlation, the geo-effectiveness of CMEs events or earth directed to CMEs for descending phase are less than in ascending phase of solar cycle-24 for our selected period. In other hand we say that the total number of CMEs in descending phase is high as compare to ascending phase of solar cycle-24.

We have noted that the Fast CMEs and Halo CMEs with Dst are loose correlation during the ascending and descending phase of solar cycle-24. Therefore, we have concluded that in the above discussion the Dst (nT) have low negative value i.e. low geomagnetic storms are produced.

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