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Sunspot number and Coronal Mass Ejection correlation during solar cycle 24th and on going

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ABSTRACT: In this study indicated that the correlation between Coronal Mass Ejection and Sunspot Number(SSN)during the period 2008-2019 for the solar cycle 24th and so on. Thecorrelation between Coronal Mass Ejection number from observations made by the Large Angle and spectrometric, coronagraph (ASCO) on board the Solar and Heliospheric Observatory mission (SOHO) while SSN number was extracted from Sunspot Index and Long term Solar observations (SILSO) .In this present period correlation between them is positive and also found that the total number of CME is greater than the total number of SSN and also found two peaks in CMEs and only one peak in SSN during the period and going on. The result indicate that the average speed of Halo CMEs is almost faster than the average speed of partial Halo CMEs. The test of the annual correlation between SSN and CMEs are simple and can be represented by a linear regression equation.

Keywords: Coronal Mass Ejection, Sunspot Number, Halo CMEs, Partial CMEs,Solar cycle and Angular width.

I. INTRODUCTION:

Solar atmospheric phenomena gained increasing scientific interest during the past Century mainly because of their accepted effect on climate of the earth as well as radio communication stability. these phenomena possess important clues about solar structure and internal reactions.

A key parameter in these research Coronal Mass Ejection are the most energetic phenomena in the solar atmosphere. CMEs originate from closed magnetic field region and quiescent filament reason. Active region on the sun containing Sun spots and places are the primary source of CMEs. Closed magnetic field reason such as quiescent filament region is the secondary source of CMEs. These secondary source regions can occur at all latitude but during the solar maximum, they occur prominently at high latitude.

Our sun is the huge ball of electrically charged hot gas. This charged gas move generating powerful magnetic field. The sun's magnetic field goes through a cycle called the solar cycle. Over the 11 year the sun magnetic field completely flips. This means that the sun's switch the North and South pole then it takes about another 11 years are the sun's North and South poles to flip back again. One way to track solar cycle is by counting the number of sunspots. The beginning of solar cycle is solar maximumor when the sun has the least Sunspot over time, solar activity and the number of sunspots increasing. the middle of the solar cycle is the solarmaximum or when the sun has the most Sun spots. As the cycle ends it fades back to the solar minimum and then a new cycle begins as shown in Fig.1

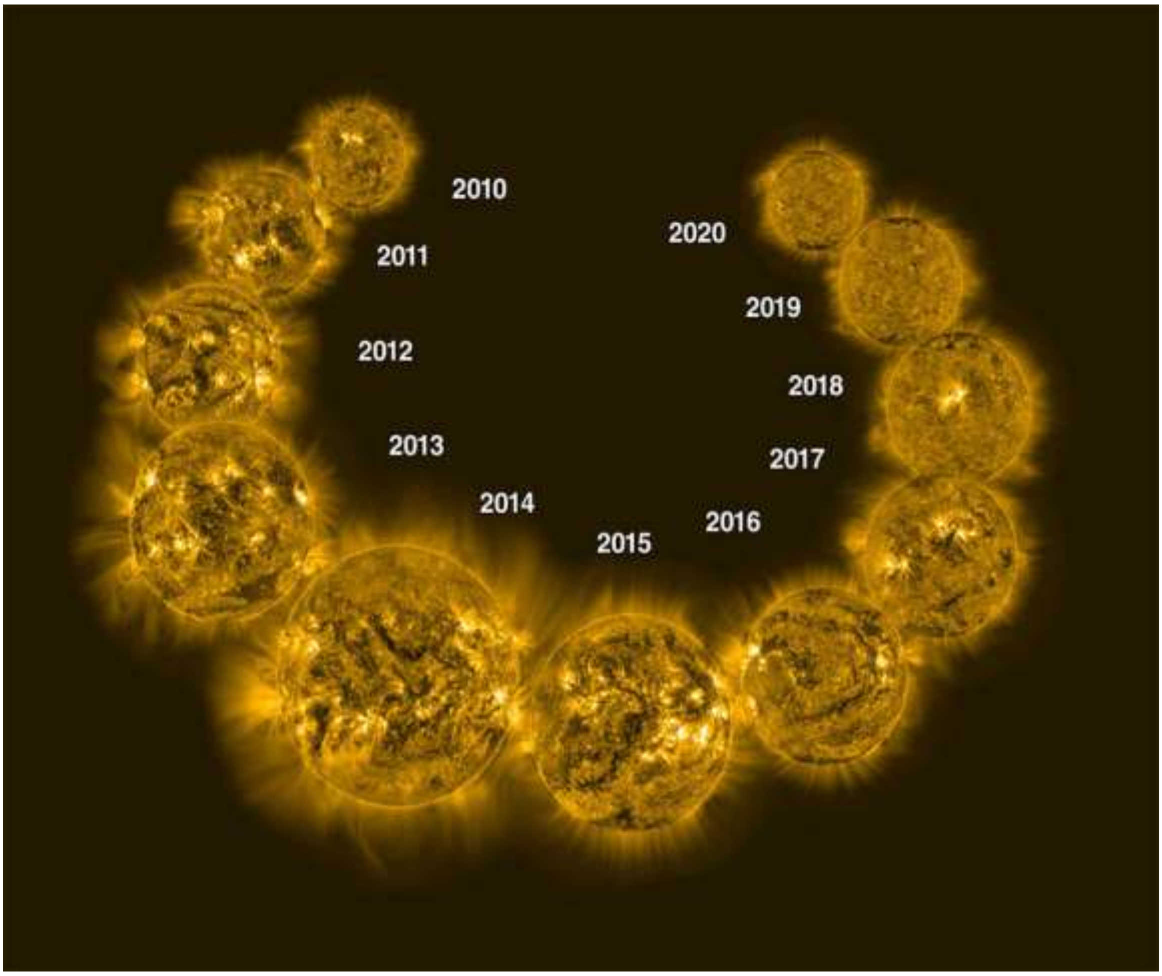

Fig.1 Shows the solar cycle during the period 24.

Giant eruption on the sun, such as solar flares and coronal mass ejection, also increase during the solar cycle these eruptions send powerful bursts of energy and material into space. These activities can have effects on earth. For example, eruptions can cause light in the sky called aurora, or impact radio communication. Extreme eruptions can even affect electrically grid on earth.

From the calculation SSN, which was considered to be the smallest number since the beginning of the space age, the solar cycle 24 was relatively weak but comparable longer than the near cycle. It is thought to be due to the measured low polar magnetic field strength in solar cycle 23. According to the Christensen- Lassen theory. That behavior of the solar cycle 24 affect the solar cycle 25 by making the sun with lesser irradiance.

A classical CMEs carries away some 10^{15g} of coronal mass and liberate energies of 10^{23-} 10^{25}j(Howard etal.1985, vourlida etal. 20020).CMEs speed can varies from 10kms^{-1}- to more than 3300kms^{-1}(Gopalaswamy2004;yashiro etal.2004; Mittal et al.2009).

Gopalswamy et al. (2002) Suggested that only fast and wide CMEs have important role in the production of large solar energetic particle (SEPs). Whereas (kahleret.al.(2001)) reported that some impulsive SEP event were also associated with fast but narrow CMEs. Narrow CMEs may also have an important role in impulsivesolar energetic particle(SEPs) production orpropagation into the interplanetary medium.

II. DATA SELECTION:

The SSN data were obtained from sunspot index and Longterm solar observation(SILSO) which is supported by international council for science world data system. while the data of CMEs and hello CMEs where are downloaded from the Coordinated Data Analysis Workshop(CWAW). During the period from January 2008 to December 2019 through solar cycle 24 and ongoing.

III. RESULT AND DISCUSSION:

In this study,we discuss the statistical analysis and correlation between CMEs and SSN during the period from January 2008 to December 2019 through solar cycle 24. Although the solar cycle 24 started in December 2008, data were taken before that to increase sample number which give better statistics in the curve fitting. The angular width of 360^0 was considered for full halo CMEs, while 121^0-359^0 was considered for partial halo CMEs. Other size of angular width could be narrow (~5-120^0) or spike (less than ~5^0); and CMEs with these widths were not considered in the present research.

We found the total number of sunspots (SSN) to be 6579.4 and total number of coronal mass ejection (CMEs) to be16971 during the period January 2008 to December 2019 and ongoing. Out of these CMEs,326 were full halo CMEs and1051 were partial halo CMEs. This means that halo CMEs represented only about 2% of all CMEs, and partial halo represented only about 7% of all CMEs in this time period.

The total number of CMEs that had speed greater than or equal to 1000 kms^{-1} was 205. The yearly mean total number of occurred sunspots number in all the months in 2014, were 1363.3. The total number of CMEs found in all the months in 2014 were 2478.

The solar activity in 2014 was its maximum in 2014 therefore it is higher than other year in solar cycle 24. The highest percentage of halo CMEs were 3.9% and 2.8% recorded in 2012 and 2014 respectively.

The number of occurrences of CMEs slightly increase towards sunspots maximum and slightly decreases towards sunspots minimum.

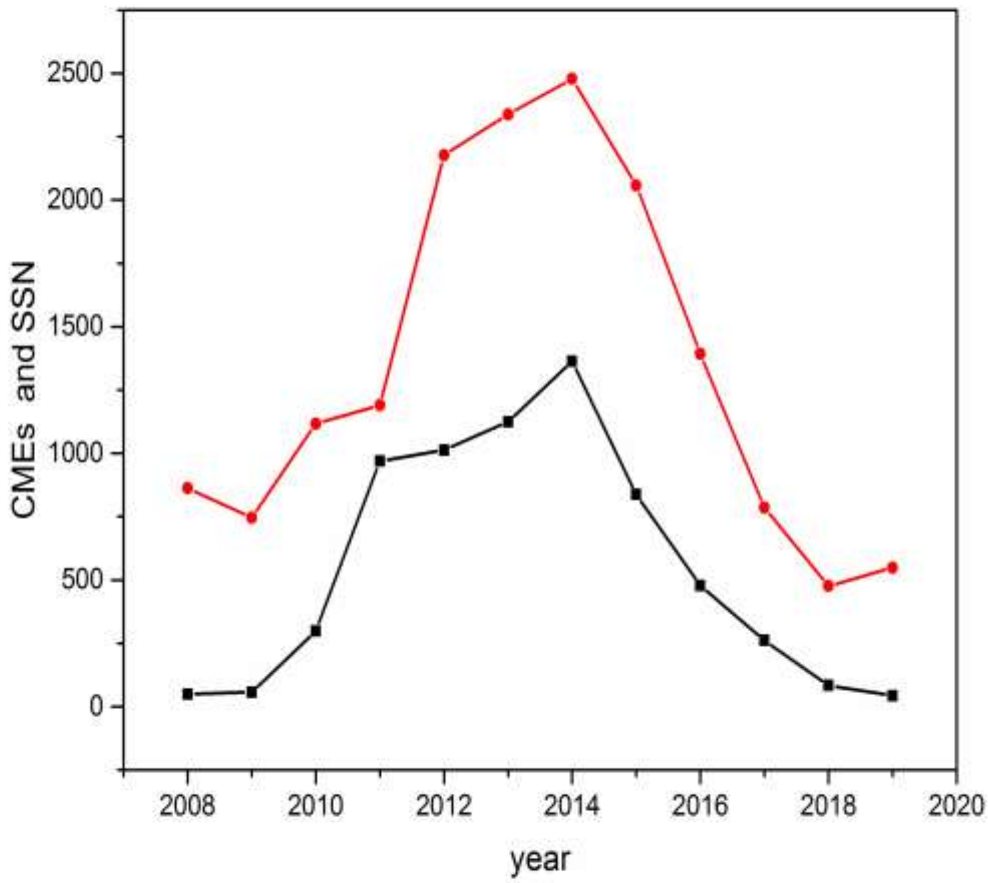

Fig.2 Linear plot for annual occurrence of CMEs and SSN during the period 2008-2019.

Fig.2 Shows the linear plot for the annual occurrence rate of CMEs and SSN during the period 2008-2019. The occurrence rate of CMEs increases with the active region measured by the SSN. It is clear that the maximum number of SSN and CMEs occurred in 2014.

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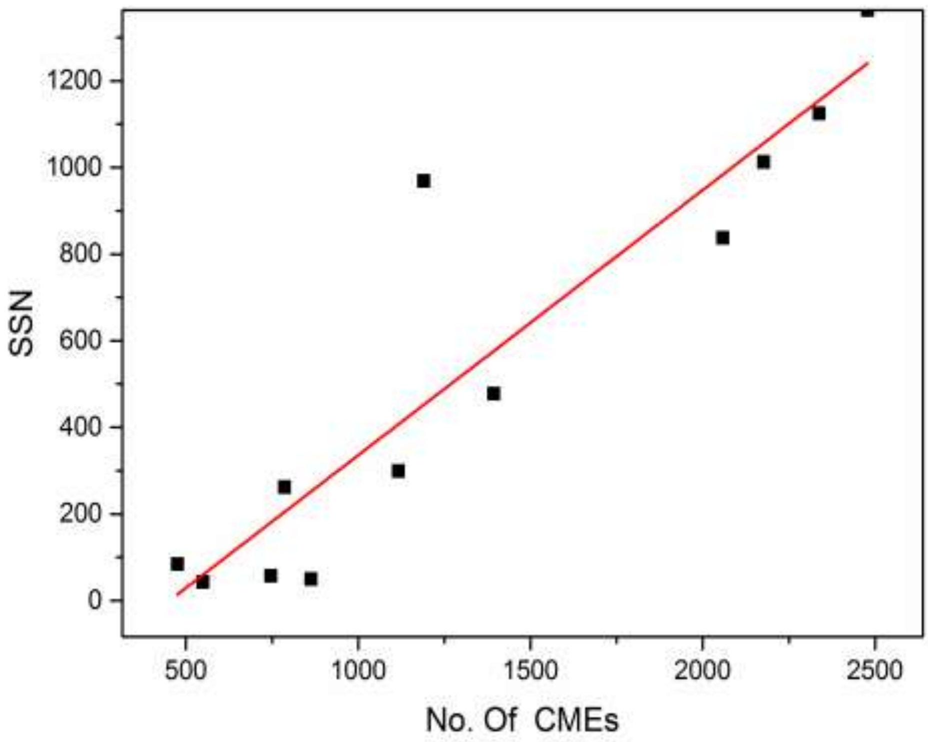

Fig.3 Linear regression fit between CMEs and SSN during the period 2008 to 2019.

Fig.2 shows the Linear regression fit betweenCMEs and SSN during the period 2008 to 2019. We find the Linear regression equation to be **y= -276.904+1.38495X** whoseintersect on y axis is -276.904 and slope is 1.384. Also we find that correlation coefficient is R =0.920. there is a good positive correlation between CMEs and SSN.

IV. CONCLUSION:

1. The solar cycle 24 was initially less active than solar cycle 23.
2. When SSN increases, the number of CMEs slightly increase.
3.The maximum number of halo CMEs occurred in 2012 and 2014.
4.The correlation coefficient between CMEs and SSN is 0.920.
5. Good relationship with a positive slope betweenSSN and the occurrence rate of CMEs.

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