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Correlative study of partial and halo CMEs with sunspots number during the solar cycle 24

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Abstract

Sunspots and CMEs is one of the most important activities in the sun. The Number of Sunspots (SSNs) are interesting aspects of the sun. In this study we found that solar cycle rises with the SSNs increases and the solar cycle decelerates with the SSNs decreases. The solar cycle 24 had a rising face from 2008 to 2014 while the declining face from 2014 to 2019. Number of SSNs increased by 49.5 to 1363.3 in rising face while the number SSNs reduced from 1363.3 to 84.1 in declining face. The CMEs are powerful eruptions on the sun's surface. In this study the angular width of 360° was considered for full Halo CMEs while 121°-359° was considered partial Halo CMEs. During rising face number of Halo CMEs increases from 1-69 and partial Halo CMEs increases from 12-265 while in declining face Halo CMEs reduced from 69 to 01 and partial Halo CMEs reduced from 265 to 03 and also, we have found that good correlation ship between CMEs and SSNs.

Keywords: - Coronal Mass Ejections (CMEs), Sunspots Numbers (SSNs), Solar Cycle, Halo CMEs, Partial CMEs.

1. Introduction

A Coronal Mass Ejection (or CME) is one of the most spectacular phenomena produced by the Sun. A Coronal Mass Ejections (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. A CME contains particle radiation (mostly protons and electrons) and powerful magnetic fields. These blasts originate in magnetically disturbed regions of the corona, the Sun's upper atmosphere - hence the name. A CME is best observed using an instrument called a coronagraph which simulates a solar eclipse by blocking out the main disk of the Sun. This brings the Sun's corona out into sharp relief. One way to picture this is by trying to imagine the light of a match in the bright glare of a car's headlight: block out the headlight with your hand or a book and the match becomes quite visible. This is how a coronagraph works. When the CME occurs, a large mass of ionized gas (or plasma) is ejected and we see it as a spectacular eruption. Important CME parameters used in analysis are size, speed, and direction. These properties are inferred from orbital satellites' coronagraph imagery by SWPC forecasters to determine any Earth-impact likelihood. The NASA Solar and Heliospheric Observatory (SOHO) carries a coronagraph – known as the Large Angle and Spectrometric Coronagraph (LASCO). This instrument has two ranges for optical imaging of the Sun's corona: C2 (covers distance range of 1.5 to 6 solar radii) and C3 (range of 3 to 32 solar radii). The LASCO instrument is currently the primary means used by forecasters to analyze and categorize CMEs; however, another coronagraph is on the NASA STEREO-A spacecraft as an additional source.

Imminent CME arrival is first observed by the Deep Space Climate Observatory (DSCOVR) satellite, located at the L1 orbital area. Sudden increases in density, total interplanetary magnetic field (IMF) strength, and solar wind speed at the DSCOVR spacecraft indicate arrival of the CME-associated interplanetary shock ahead of the magnetic cloud. This can often provide 15 to 60 minutes advanced warning of shock arrival at Earth – and any possible sudden impulse or sudden storm commencement; as registered by Earth-based magnetometers.

2. Data Selection

Data selection is defined as the process of determining the appropriate data type and source, as well as suitable instruments to collect data. The Sunspots Number (SSN) data were obtained from Sunspots index and Long-term 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 (CDAW). During the period of 2008 to 2020 through solar cycle 24 and running.

3. Results and Discussions

In this Study, we discus partial and halo CMEs with the number of sunspots rising and declining face during the period of 2008 to 2020 through solar cycle 24 and 25. Although the solar cycle 24 started in December 2008 while the solar cycle 25 is the current solar cycle started from December 2019. In this research, we found that in 2008, where the number of SSN was only 14.9, it increased to 1363.3 in 2014, then this number started decreasing from 2014 and decreased to 43 in 2019, then in 2020 this number started increasing again and in 2020 increased to 105.5. On the basis of prediction, it can be said that in 2025 again the number of sunspots will increase to peak thus increasing the number of sunspots phenomenon occurs as a cycle when it increases (from 2008 to 2014) then it occurs in rising face whereas from 2014 to 2019, when the number of sunspots decreases then it happens in declining face when the number of SSN is maximum then sun activity also increases whose effect is also visible on earth especially northern and southern hemisphere. Also, the number of auroras increases in the hemisphere, the risk of damage to the communication systems and electronic equipment on Earth increases. The angular width of 3600 was considered for full halo CMEs, while 1210 -3590 was considered for partial halo CMEs. Other size of angular width could be narrow (~5-1200) or spike (less than ~50); and CMEs with these widths were not considered in the present research. During the period of 2008 to 2020 the total number of sunspots was 6684.9 found and these period the total coronal mass ejections received 17536. The full coronal mass ejections were received 328 whose angular width is 3600 and partial halo CMEs were received 1056 whose angular width is from 1210-3590. There are 207 CMEs whose speed was more than 1000 km/sec achieved.

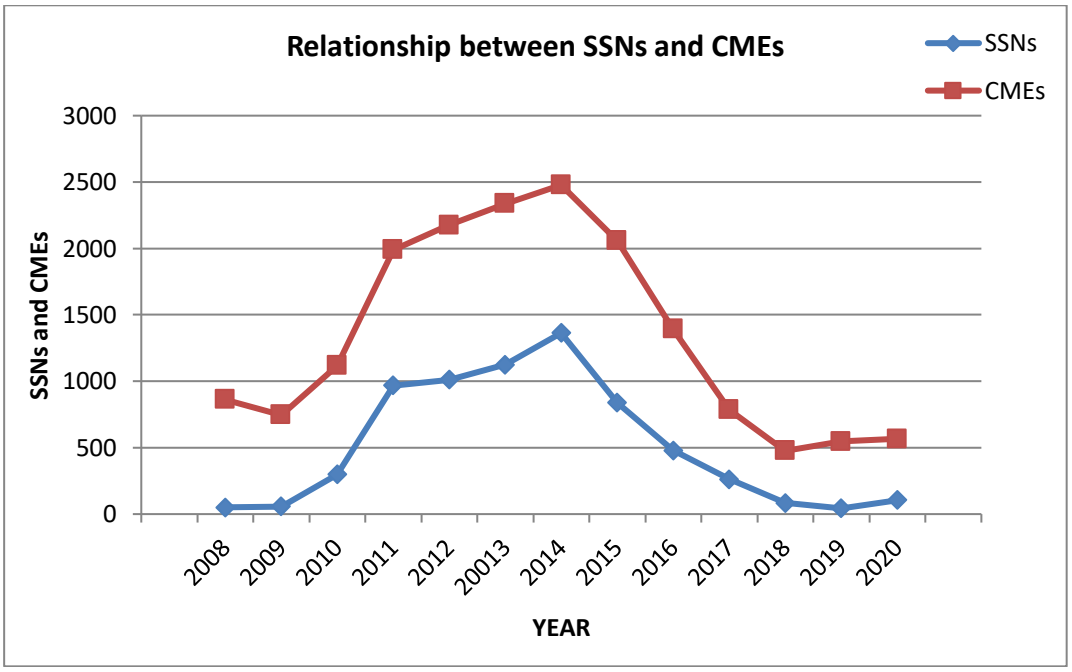

Figure-3 Shows linear plot for annual occurrence of CMEs and SSN during the period of 2008-2020.

Under the 24th solar cycle the number of sunspots and CMEs was the highest in the year 2014, the total number of sunspots 1363.3 and CMEs was 2478 in 2014. It is clear that from the obtained data and graph there is good positive correlation between SSNs and CMEs.

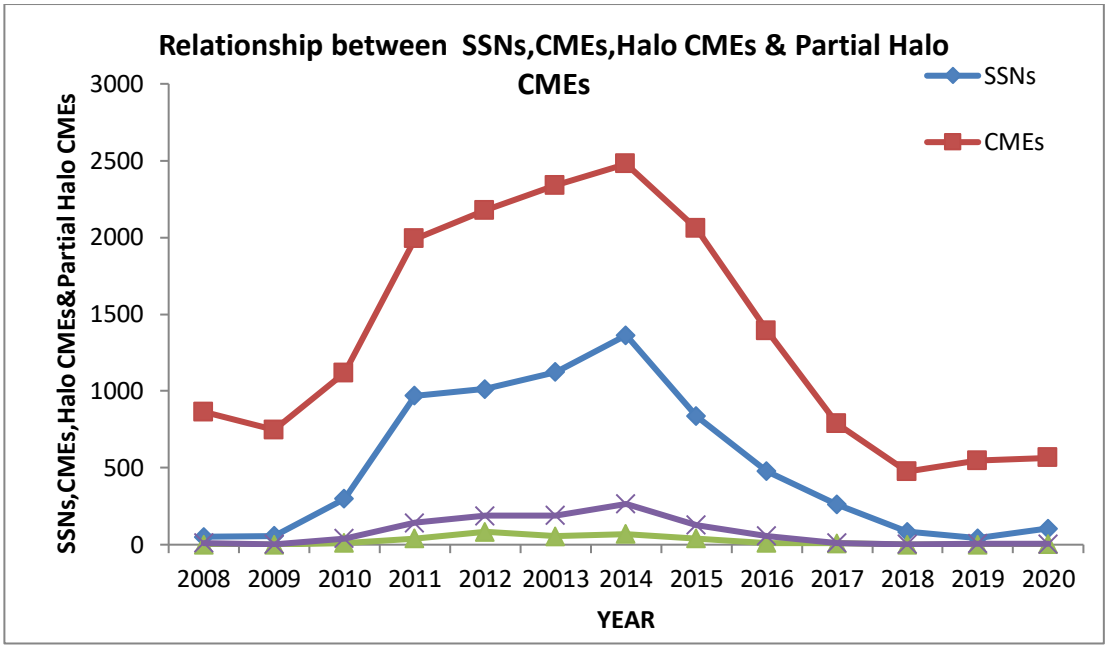

Figure-4 The figure shows that when the number of sunspots increases or decreases, then the number of all types of CMEs increases or decreases.

4. Conclusion

1. Positive correlation between CMEs & Partial Hallo CMEs is 0.965066.
2. There are also positive correlation between CMEs & Hallo CMEs is 0.9267.
3. The good and positive correlation between SSNs &CMEs is 0.9798.
4. The solar cycle 24 had a rising face from 2008 to 2014 while the declining faces from 2014 to 2019.

Conflict of Interest

The authors declares that no conflict of interest in the manuscript.

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