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Short Review Paper

Study of Anomalous Behaviour of Coronal Mass Ejections and Solar Flares and its Effect on the Earth's Environment

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Abstract

In this paper we have reported on a comparison between space weather events that occurred around two solar cycles i.e. during period of solar cycles 23 and solar cycle 24. The Space weather events that we have considered a large number of geomagnetic storms linked with halo-CMEs (coronal mass ejections) and solar flare events. We know that coronal mass ejections and solar flares disrupt interplanetary flow of solar wind plasma and magnetic field produces disturbance into space weather which impact on the Earth's magnetosphere resulting huge geomagnetic storms are created into space weather. We observed those occurrences of no. of halo-CMEs events and their associated solar flares into solar cycle 23 are more frequent and energetic than comparison to solar cycle 24 so their consequences occurrences of no .of geomagnetic storms of solar cycle 23 are more frequent and effective than comparison to solar cycle 24.

Keywords: CMEs (Coronal Mass Ejections), Solar Flares, Dst (Disturbance storm time). GIC (Geomagnetic Induced Current), SC (Solar Cycle).

Introduction

The Sun is emerging continuous flow of plasma and magnetic field into heliosphere. The solar plasma into interplanetary medium travels an average velocity up to 300 Km/s and affect all the interplanetary satellites, spacecrafts and astronauts which travelling around the orbits of the Sun and the Earth for a proper purpose. The solar plasma and magnetic field comes from outer atmosphere of the Sun's chromospheres i.e. called CMEs. Coronal holes are recognised in x-rays and uv-radiations of chronographs. Solar flares are a high energy particle that comes from the Sun's corona also. These flares mainly consists high energetic protons and radiations. When these radiations reach on outer atmosphere of the Earth they ionised all the atmospheric particles and gets an aurora.

Major disturbance on the Earth is by CMEs that give rise to enhanced aurora and geomagnetic storms. CMEs and Solar Flares originating from the Sun's corona are the big factor for generating space weather events or geomagnetic storms. Coronal mass ejections (CMEs) consists a large explosions of solar magnetic field and solar plasma from the Sun's corona on chromospheres. The first CME was observed on 14 December 1971 in white-light coronagraph onboard by NASA's OSO-7 satellite[1].

It is well known that CMEs are responsible for major geomagnetic storms leading to numerous effects in the Earth's magnetosphere, ionosphere, atmosphere, and on the ground[2]. The CMEs originate from solar corona have closed magnetic structures which are commonly observed in active regions on the Sun. During solar maxima, large number of active region (consisting of spot groups) appears. Sunspot groups on photosphere consists a large variety of shapes and sizes. Despite such a diversity of shapes and sizes sunspot, there have been at least three major attempts to classify morphological properties of sunspot groups. The Zurich classification of sunspot was first introduced by Waldmeier[3]. The sunspot group more recently classified by a new method that derived by McIntosh[4]. A classification of the active regions on the Sun and their magnetic properties was also developed by Scientist Smith and Howard[5]. The geomagnetic storms (Dst $\leq$ - 100 nT) causes by interplanetary disturbance during solar cycle 23 has been investigated by many authors[6-8].

CME produces disturbances in the solar wind preceded by a shock wave. Solar wind speed of solar plasma varies due to variation in solar cycles that variation link with CMEs and their associated phenomenon. Sometimes solar plasma and solar magnetic field accelerated and sometimes decelerated by interplanetary plasma and magnetic fields.

Data analysis

For this paper we have used daily mean value of Dst (Disturbance storm time) $\leq$ - 100 nT data from OMNI web of NASA from year 1997-2015 as well as for CMEs and Solar Flares we have used halo-CME catlog of NASA from year 1997-2015.

Results and Discussion

Coronal mass ejections consists magnetic field and plasma and their associated solar flares when inters into the interplanetary space, they disrupt the ionosphere and the Earth's magnetosphere. The CMEs and their associated solar flares have same activity during the same period of time i.e. have shown in figure-1a. The halo-CMEs and their associated solar flares both ionised the outer atmosphere of the Earth causes enhanced aurora around the North or South Polar Region i.e. the indicator of geomagnetic storms. Some solar charged particles inters into the Earth's atmosphere by the North or South Pole turn around the Earth magnetic field by force. Therefore, a creative magnetic field oppose the Earth's magnetic field resulting, anomalous changes on the Earth's magnetic field are caused of geomagnetic storms. Figure-1b have shown no. of geomagnetic storms during same period of time as well as halo-CMEs and their associated solar flares occurred have shown in figure-1a. Large geomagnetic storms are often link with interplanetary shocks that drive the CMEs and solar flares into the interplanetary space when its passes through the Earth's magnetosphere[9]. When CMEs reach into interplanetary space it's called ICMEs (Interplanetary Coronal Mass Ejections). ICMEs interacts with solar wind produces solar protons into interplanetary space called solar proton events.

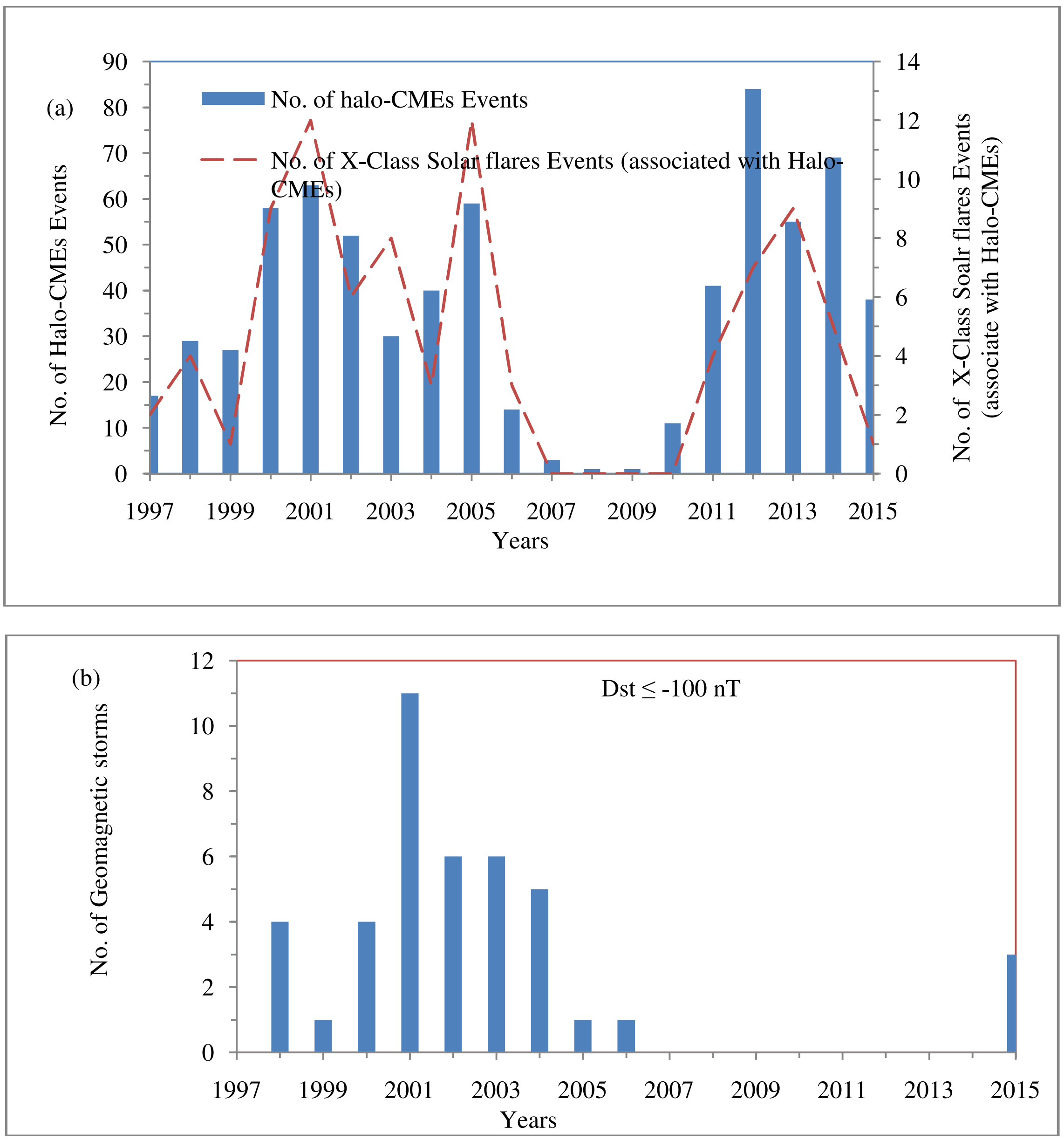

Figure-1

(a) shows the No. of halo-CMEs Events and No. of X-Class Solar Flares Events that linked with halo-CMEs during the period from year 1997-2015. (b) Shows the No. of Geomagnetic storms during the period from year 1997-2015

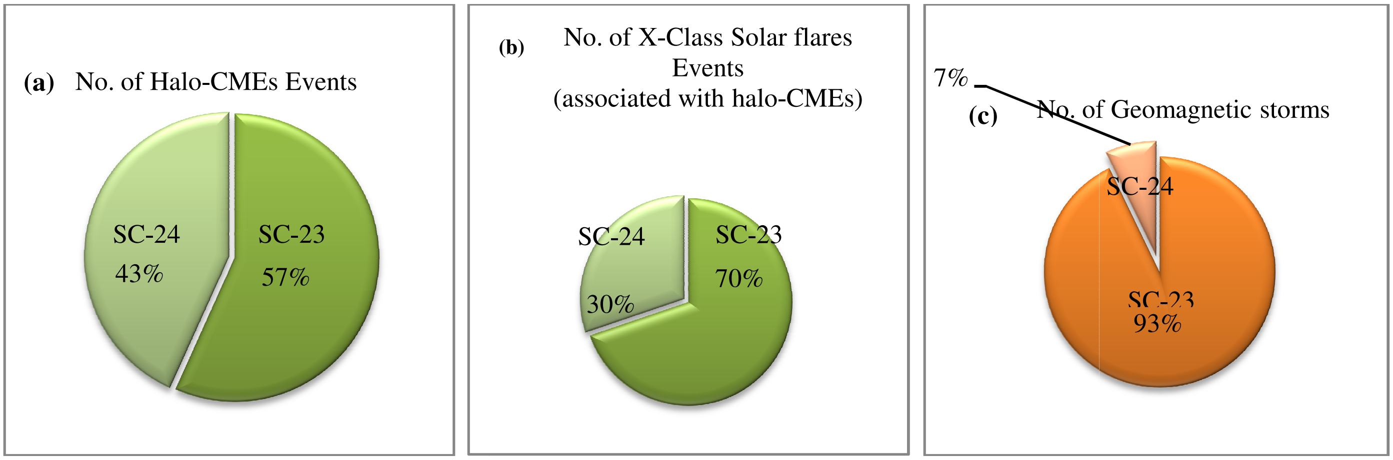

Figure-2

(a) shows the No. of halo-CMEs (in %) of solar cycles 23 to 24 during the period from year 1997-2015. (b) Shows the No. of X-Class Solar Flares that linked with halo-CMEs (in %) of solar cycles 23 to 24 during the period from year 1997-2015. (c) shows the No. of Geomagnetic storms (in %) of solar cycles 23 to 24 during the period from year 1997-2015, taking daily mean value of Dst ≤ - 100 nT

Solar proton interacts on the Earth's magnetosphere produces geomagnetic disturbances causes (GICs) Geomagnetic Induced Currents. When these interplanetary disturbances shocks reach the Earth's magnetosphere, they give rise to geomagnetic storms. The decrease in the equatorial magnetic field strength, measured by the Dst (Disturbance storm time) index, is directly related to the total kinetic energy of the ring current particles that moving around the Earth's magnetosphere; thus the Dst (Disturbance storm time) index is a good indicator that measure the solar energy by geomagnetic storm.

The substorms are built up when geomagnetic storms of Dst index decreases by ring currents around the Earth's magnetosphere[10]. For this analysis we observed that the geomagnetic storms are linked with halo-CMEs and Solar flares. Here we have calculated the percentage value of no. of halo-CMEs, no. of solar flares and no. of geomagnetic storms i.e. have shown in Figure 2 of (a, b and c). We found that no. of halo-CMEs and no. of Solar flares of solar cycle 23 have more geomagnetic storms in comparison to solar cycle 24. Its mean solar cycle 23 is more energetic than solar cycle 24. Therefore, solar cycle 23 have more no. of geomagnetic storms (Dst ≤ -100 nT) than solar cycle 24 i.e. have shown in Figure-2c.

The frequency of halo-CMEs and associated solar flares varies with the solar cycle. Coronal mass ejections can be geoeffective, because they can generate geomagnetic storms and they can bring to Earth strong southward magnetic fields at the dayside boundary of the magnetosphere, as a consequence allow solar wind energetic particles, momentum, and mass access to the magnetosphere. During geomagnetic storms, the currents in the Earth's ionosphere, as well as the energetic particles that interact into the ionosphere collect energy in the form of heat that can increase the density and distribution of particles in the upper atmosphere, causing extra drag on satellites goes to low-earth orbit. The local heating also generates strong horizontal variations in the in the ionospheric density that can modify the path of radio transmission signals and create errors in the positioning information provided by GPS (Global Positioning System). While geomagnetic storms create beautiful aurora around polar region of the Earth, they can also disturb navigation systems such as the Global Navigation Satellite System (GNSS) and create dangerous and harmful geomagnetic induced currents (GICs) in the power grid and pipelines.

Conclusion

For above long-term analysis we found that halo-CMEs and their associated solar flares are direct affect the Earth's magnetosphere so a large no. of enhanced aurora and GIC (Geomagnetic induced current) would developed into the polar region of Earth's magnetosphere during period from year 1997 to 2015. We know that this GIC (Geomagnetic induced current) affect the electric conductor, electric transmission grid and buried pipelines etc. These variations induced currents are called GIC (Geomagnetic induced current). GIC also affect the GPS (global position system) and Gas and Oil operation in the Sea. We found that – (1) solar cycle 23 is more energetic than solar cycle 24 because solar cycle 23 has more occurrences of no. of CMEs and solar flares than comparison to solar cycle 24. (2) Solar cycle 23 has more occurrences of no. of geomagnetic storms (Dst ≤ -100nT) than comparison to during solar cycle 24.

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