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STUDY OF SUPER GEOMAGNETIC STORM OBSERVED ON 17 MARCH 2015

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ABSTRACT

Halo-CMEs (Coronal mass ejections) and their associated solar flares play an important role in heliosphere and disrupt Earth and their environments. In this paper we have studied heliospheric disturbance of solar cycle 24 during the time period from 10 to 31 March 2015. We observed that a huge explosion of magnetic field and plasma from the Sun's corona on 15 March known as halo-CMEs (Coronal mass ejections) and their associated solar flares have been produced extremely powerful geomagnetic storm on 17 March 2015. We found that Disturbance storm time (Dst) value decreased to its minimum -223 nT and Forbush Decrease (FDs) 3.5% on 17 March 2015.

KEYWORDS: CMEs (Coronal Mass Ejections), FDs (Forbush Decreases), CRI (Cosmic Ray Intensity), Dst (Disturbance Storm Time), Solar Wind Velocity (V)

In the history of solar terrestrial relationships, CMEs are a very recent phenomenon, discovered only in the beginning of the 1970s. However, I show that CMEs were waiting to be discovered with some elements of CMEs were already known over the preceding decades. Solar cycle 24 has been the weakest in the space era as measured by the sunspot number (SSN). The sun is already in declining phase of cycle 24, but the paucity of high-energy solar energetic particle (SEP) events are associated with solar phenomenon. Earth-directed CMEs are the main drivers of major geomagnetic storm. Therefore, a good estimate of the disturbance arrival time at Earth is required for space weather predictions. Earth-directed CMEs are able to trigger geomagnetic storms when they hit Earth's magnetosphere, provided they contains southward magnetic field component. Previous studies on the cause's geomagnetic storms have established that major geomagnetic storms are mostly caused by CMEs or their sheath regions ahead of them (Gosling et al., 1990). Therefore, a good estimate of the CMEs and shock arrival time at the Earth is required in order to predict space weather conditions. In general CMEs launched near the centre of the solar disk arrive at Earth within 1 to 5 days. Various CMEs and shock propagation models have been suggested for space weather forecasting purposes. (Gopalswamy et al., 2001) presented an empirical model that attempts to take into account that during IP propagation CMEs speed converge towards solar wind speed and that the CMEs acceleration ceases before 1 AU. They applied this model to asset of 47 CMEs observed during December 1996 and July 2000 and found the average prediction error of the CMEs arrival time to be 10.7 hours. A similar CMEs propagation model that considers explicitly the effect of the drag force by the solar wind on the CMEs has been suggested (Vrsnak and Gopalswamy, 2002; Borgazzi et al., 2009). Studies using various methods to track the CMEs propagation have found evidence in support of the drag force model (Byrne et al., 2010; Mostl et al., 2014). However validation tests of the drag model have shown that the prediction error of the disturbance arrival time at Earth is around 10 hours (Owens and Cargill, 2004; Colaninno et al., 2013), which is comparable to the result by (Gopalswamy et al., 2001). More recently (Hess and Zhang, 2015) have been able to predict the arrival time of both ejecta and the preceding sheath with the MAE of 1.5 hours to 3.5 hours, respectively, using a Drag-based model.

DATA ANALYSIS

For this study we have taken hourly data of magnetic field (B), solar wind velocity (v) and Disturbance storm time (Dst) from OMNI Web as well as hourly data of Cosmic rays intensity from Moscow ground based neutron monitor having cut-off rigidity (Rc=2.42Gev) and location on the Earth is latitude 55.47N, longitude 37.32E during the time period from 10 to 31 March 2015. For CMEs data we have used CME catlog of NASA.

RESULTS AND DISCUSSION

Large eruption of magnetic plasma from the Sun's outer atmosphere, or corona, that propagates outward into interplanetary space. The CMEs is one of the main transient features of the Sun. When the CMEs inter into interplanetary space called interplanetary coronal mass ejections (ICMEs). On 15 March 2015 these Earth-directed CMEs explosions inter into interplanetary space disrupted the space weather. Interplanetary magnetic field (B) and interplanetary force field (VB) shows similar activity and good positive linear correlation during the

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same period of time which have shown in figure 2 and 5. Interplanetary force field plays an important role in heliosphere and operates a force on moving charge particle into interplanetary space. Table 1 shows the SOHO/LASCO, HALO-CMEs (Coronal mass ejections) their associated solar flare events during the time period from 10 to 31 March 2015. Solar flares produce high energy particles and radiation that are dangerous to living organisms. However, at the surface of the Earth's we are well protected from the effects of solar flares and other solar activity by the Earth's magnetic field and atmosphere. The most dangerous emissions from flares are energetic charged particles (primarily high energy protons) and electromagnetic radiation (primarily X- rays). The X-rays from flares are stopped by our atmosphere well above the Earth's surface. They also disturb the Earth's ionosphere, however, which in turn disturb some radio communications. Along with energetic ultraviolet radiation, they heat the Earth's outer atmosphere, causing it to expand. This increases the drag on Earth-orbiting satellites, reducing their lifetime in orbit. Also, both intense radio emission from flares and these changes in the atmosphere can degrade the precision of global positioning system (GPS) measurements. The energetic particles produced at the Sun in flares seldom reach the Earth. When they do, the Earth's magnetic field prevents almost all of them from reaching the Earth's surface. The small number of very high energy particles that does reach the surface does not significantly increase the level of radiation that we experience every day. The most serious effect on human activity occurs during major geomagnetic storms are usually associated with solar flares and plasma clouds of halo-CMEs (Coronal mass ejections) but sometimes no flares are associated with halo-CMEs observed when they occur. Solar wind may be viewed as an extension of the outer atmosphere of the Sun (the Corona) into interplanetary space. Solar wind contains roughly equal number of electrons and protons, along with a few heavier ions and blows continuously from the surface of the Sun at an average velocity of about 400 Km/second, this is remarkable velocity. The Solar wind escape primarily through the coronal holes, which are predominantly near the Sun's pole. In figure 3 shows the flow of solar wind speed during the time period from 10 to 31 March 2015. The solar wind can have a large influence on our planet, particularly in times of the active Sun (near sunspot maximum) when the solar wind is strong and can contain bursts corresponding to flares and coronal mass ejections from the Sun. The solar winds have a significant influence on our ionosphere, the Earth's magnetic field, on our Earth's auroras and on telecommunication system. When these halo-CMEs and their associated solar flares on 15 March reached near the Earth's magnetosphere they modulated the Galactic cosmic rays that coming from interstellar medium and a super geomagnetic storm observed on 17 March shown in figure 4. Therefore, nearly 3.5% Forbush decrease occurred on 17 March 2015. On 15 March 2015 same day halo-CMEs and solar flares strike on the Earth's magnetosphere therefore Disturbance storm time (Dst) decreased to its minimum -223 nT.

Table 1: SOHO/LASCO, HALO-CMEs and Solar flare events during time period from 10 to 31 March 2015.

First C2 Appearance Date Time [UT]		Apparent Speed [km/s]	Space Speed [km/s]	Accel. [m/s^2]	MPA [deg]	Source Location	X-ray Importance	Flare onset [UT]
10/03/2015	00:00:50	955	1081	-10.2	107	S18E45	M5.8	23:29
10/03/2015	03:36:05	1040	---	-20.4	71	N15E40	M5.1	03:19
15/03/2015	01:48:05	719	932	-9.0	240	N22W25	C9.1	01:15
24/03/2015	8:24:05	1794	1794	-34.4	255	Blimb-SW	---	08:03

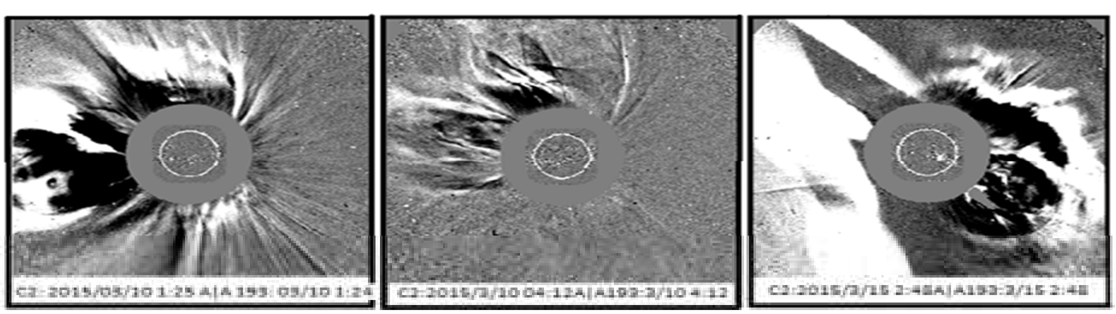


Figure 1: Image has been recorded by (SOHO/LASCO) C2 Coronagraph on 10 and 15 March 2015.

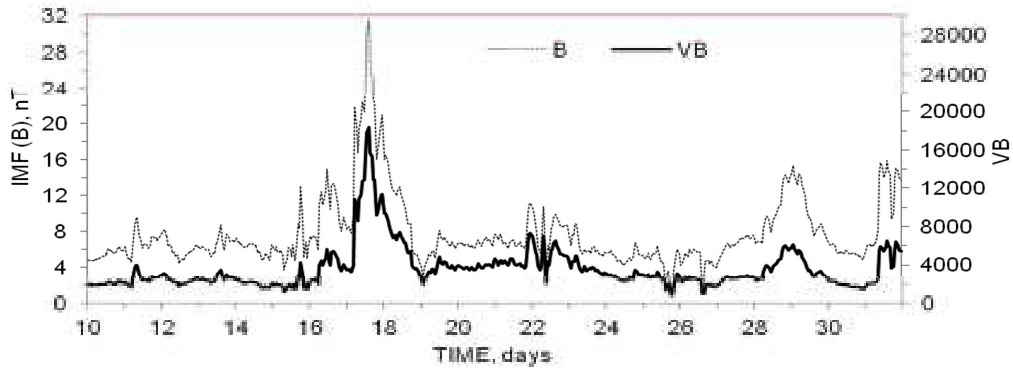


Figure 2: Time profile of IMF (B) and interplanetary force field (VB) during the time period from 10 to 31 March 2015.

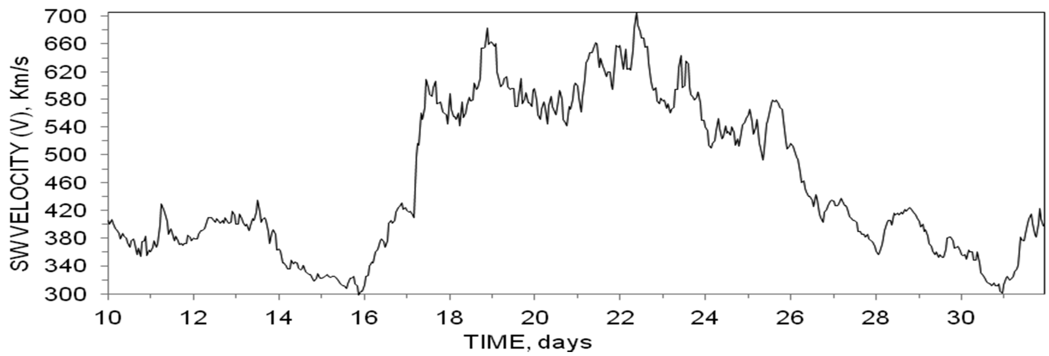
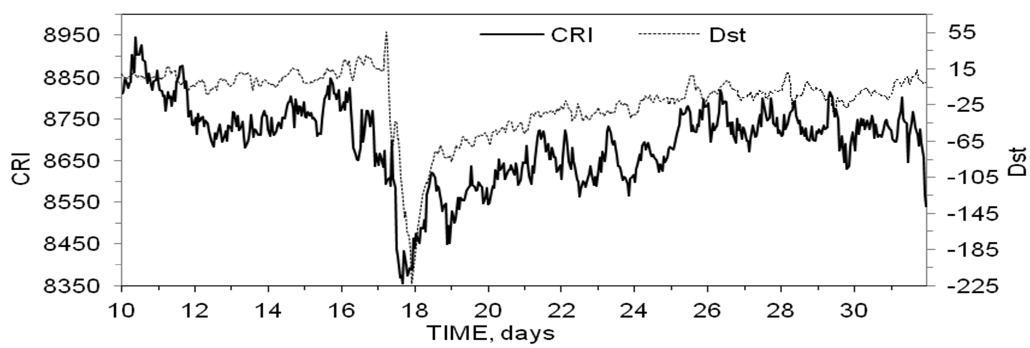


Figure 3: Time profile of Solar wind velocity (V) during the time period from 10 to 31 March 2015.



Figures 4: Time profile of Cosmic ray intensity (CRI) and Disturbance storm time (Dst) during the time period from 10 to 31 March 2015.

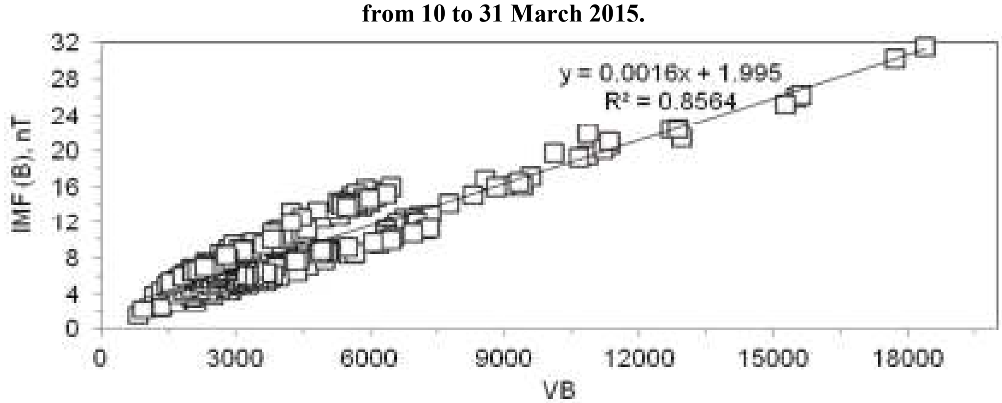


Figure 5: Cross plot between IMF (B) and VB during the time period from 10 to 31 March 2015.

CONCLUSION

On 15 March HALO-CMEs and their associated solar flares strikes to Earth's atmosphere it caused temporary disturbances on 17 March around planet's magnetic field. These storms would affect power grids, blacking out entire cities, radio communications and GPS navigation. So we should worry that an extreme CME on 15 March 2015 could cause a very powerful geomagnetic storm on 17 March 2015, resulting in global catastrophe and endanger able our lives. Its mean the Sun's violent activity and many unexpected and unpredictable events taking place on its surface suggest that we should prepare for worst.

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