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Association between Geomagnetic Storms and Forbush Decreases

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Abstract

In the present work we have chosen 78 Coronal Mass Ejections (CMEs) events from 1999 to 2005.We have done a comparative study to investigate the variation of Cosmic Ray (CR) intensity and geomagnetic activity during the period of seven years. Here we used Disturbance storm time index (Dst) as a measure of geomagnetic disturbance. We observed a significant variation in CR intensity in 2000, 2004 and 2005. We found that halo CMEs and fast Interplanetary Coronal Mass Ejections (ICMEs) are more geo-effective than non-halo CMEs and slower ICMEs but slower ICMEs are found to be more effective in causing FDs in CRs.

Keyword Coronal Mass Ejection · Geomagnetic Storm · Disturbance storm time index Forbush Decrease

Introduction

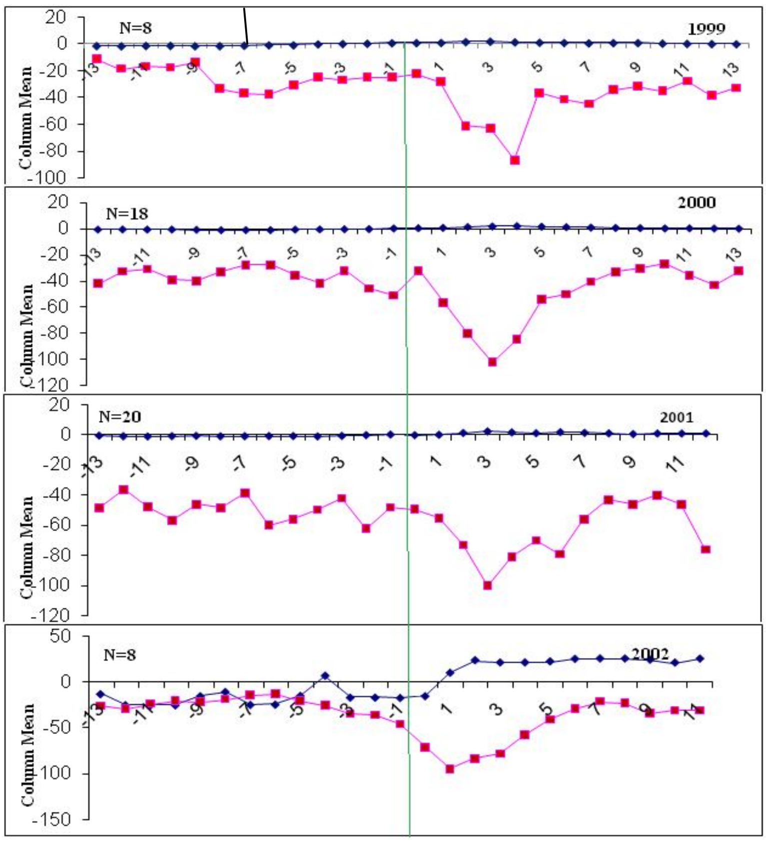
CMEs produce large disturbances in the solar wind. These disturbances are the primary cause of Geomagnetic Storms (GSs) and Forbush Decreases (FDs). CMEs are the source of major disturbances in the interplanetary medium, which further produce sudden changes in the the earth’s magnetic field and cause GSs. The existences of GSs are temporary disturbances in the geo-magnetosphere. The Dst is the conventional measure of ring current intensity and energy observed at earth's surface over low and moderate latitudes. It is the best indicator of ring current intensity and a very sensitive index to measure the degree of solar wind disturbances. FDs are transient decreases in the counting rate of GCRs that last typically for about a week. FDs are the Heliospheric phenomenon caused in CRs by solar wind disturbances mainly the structure within the shocks and sheath preceding the interplanetary CMEs

(Ifedili, 2001, 2004). CMEs are known as the by the presence of CMEs related magnetic inhomogeneities in the hemisphere (Lara et al, 2005; Shrivastava, 2005).Though GSs and FDs have a common origin in interplanetary space but the magnitudes of GSs and FDs are not proportional to each other. The Dst variation depends on the local characteristics of solar wind flowing around the earth magnetosphere whereas FDs depends on condition of whole interplanetary space(Kane, 1977).

In this paper we investigate the relationship among CMEs, FDs and GSs for the time interval 1999-2005. The present study investigates by means of superposed epoch analysis the intensity of cosmic rays on a large time scale (days: 13days before and 13days after the CME onset).

Data collection and analysis

We used Chree analysis by the super epoch method. The daily mean value of CRs intensity is taken from Moscow and Beijing have been used for the period 1999-2005. The CMEs from 1999 to 2005 causing GSs(Dst≥-50 nT)have been identified from Cane and Richardson ICME list 2008. The values of Dst index and CR intensity are taken from the websites http://wdc.kugi.kyotou.ac.jp/dst_final/195712/index.html and http://www.ngdc.noaa.gov/stp/solar/cosmic.html. respectively. We excluded those events whose onset time are not given in the list.



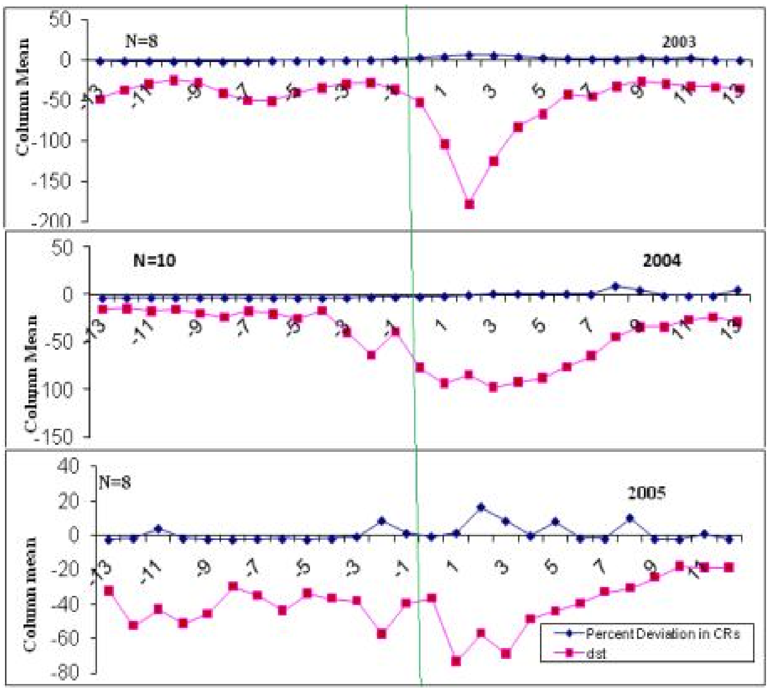


Figure 1. The result of chree analysis from -13 to +13 days with respect to zero epoch days. The variation of mean Dst value and mean value of percent deviation in CR intensity. Zero days corresponds to the starting day of occurrence of the CME event during 2000-2005.

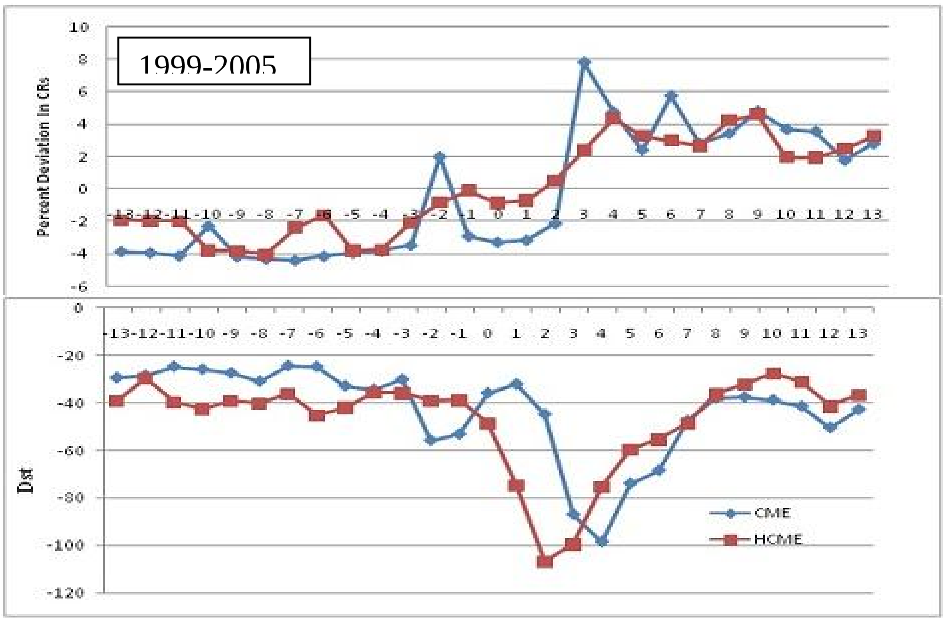


Figure 2. Shows the average picture of CR intensity and Dst under the influence of halo CMEs and non halo CMEs depicted by different symbols.

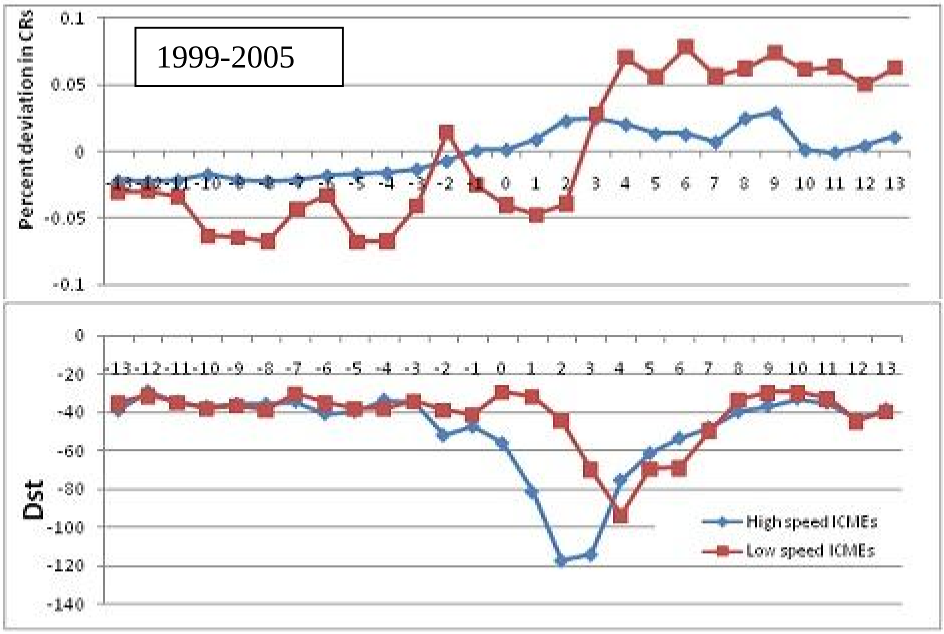


Figure 3. Shows the average picture of CR intensity and Dst under the influence of high speed ICMEs and low speed ICMEs depicted by different symbols.

Result and Discussion

We have plotted daily mean values of CR intensity and the Dst index as illustrated in Figure 1.It is clear from the figure that the maximum decrease in Dst(GS) takes place within 5 day after the occurrence of an event. Also, the average behavior of Dst shows more variation in 1999, 2000, 2001 and 2005. Since in solar cycle 23 the smoothed maximum are 1999, 2000 and 2001 so due to high solar activity the Dst shows more variation. But in case of CRs, the percent deviation in CR intensity shows more variation in 2002 and 2005. Where 2005 is the year of high solar activity. Thus the average behavior of Dst somewhat affected by solar cycle but FDs behavior doesn’t follow the solar activity cycle. It ia assumed that in GSs the key role is played by the sign of the Bz component of Interplanetary Magnetic Field(IMF) which generally does not affect FDs magnitude.

In figure 2 halo CME are responsible for more intense GSs in comparison with non halo CMEs. We have selected 78 CME events during 1999 to 2005. Out of 78 CMEs 52 are halo CMEs and 26 are non halo CMEs. We observed that Halo CMEs are more effective in causing GSs rather than non-halo CMEs. But in case of FDs, halo CME seems to be not so important because not all halo CMEs give rise to interplanetary shocks and sheath behind the shocks that may be effective in CR modulation.

In Figure 3 we found that ICMEs having high speed (speed≥500km/s) are geo-effective more than low speed ICMEs (speed□500km/s) because the sheath of solar wind plasma upstream is compressed by fast ICMEs moving behind it, contains large fluctuation which further may produce large negative value of GSM z component of magnetic field, which when combined with increased density in the compressed sheath, can make this region highly geo-effective. In case of CRs, low speed ICMEs are the cause to create more variation in CRs in comparison with high speed ICMEs because of more possibility of low speed ICMEs to interact with other ICMEs coming behind and form multiple ejecta.Vesques et al.(2001) showed that ICMEs contains multiple ejecta contains topological boundaries between different plasma regions having a tangential discontinuity within the boundaries where energetic particle diffusion coefficients are much lower. This discontinuity dramatically reduces particle diffusion within ICME sheath region and makes it effective in causing FDs in CRs.

Conclusion

Thus we found that

1. GSs occur within 5 days after the onset of CMEs and variation in geomagnetic disturbances generally follows the phase of the solar cycle.
2. Halo CMEs are geo-effective more than non halo CMEs.
3. Fast ICMEs are geo-effective more than slower ICMEs whereas slower ICMEs are CR effective more than fast ICMEs.

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