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Study of magnetic cloud events of 1996 in association with geomagnetic and cosmic ray intensity variation

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During the period of minimum solar activity, one of the major magnetic cloud events, which are a highly magnetised region with irregular variation in magnetic field, occurred on July 1–2, 1996. Beside this event, two other magnetic cloud events occurred on 26-27 May, 1996 and 7-8 August, 1996. All the interplanetary parameters are studied in association with the magnetic cloud events. Oulu neutron monitor data have been taken in our study. It is concluded from this analysis that the magnetic cloud events significantly produce changes in interplanetary features. A large decrease in CR intensity can be produced only by SSC associated magnetic cloud.

1. Introduction

The magnetic cloud (MC) is a large-scale interplanetary structure produced due to transient ejections in the ambient solar wind. Burlaga et al. [1] reported the characteristics of magnetic cloud. Peculiar type of interplanetary structure, named as magnetic cloud, has following properties.

1. The magnetic field direction rotates smoothly through a large angle during an interval of the order of one day.
2. The magnetic field strength is higher than average.
3. The temperature is lower than average.

All three of these criteria must be satisfied to identify any interplanetary event as a magnetic cloud. Several research investigations have been performed from time to time to derive effects of magnetic clouds on geomagnetic field as well as on cosmic ray modulation [2–3]. Burlaga et al. [1] and Badruddin et al. [4] have reported an associated decrease in cosmic ray intensity. On the other hand, Burlaga et al. [5] have reported the absence of CR decrease during the passage of magnetic clouds. The relationship between MC and CR is very complex and hence needs detailed studies. In the present study, we have taken three magnetic cloud events of 1996, a low solar activity year to derive their effects on interplanetary parameters, geomagnetic field as well as on cosmic ray intensity variation. The period of minimum activity is specifically suitable because of the expected presence of a very few events of transient variations in cosmic ray intensity.

2. Discussion

Figure-1 shows the plots for the magnetic cloud event (MC) of 1–2 July, 1996. Onset time of MC was 1700 UT on day 183. A SSC event was also noted at 1320 UT on 1 July 1996. As we know SSC is a signature of the arrival of interplanetary shock waves. Lower panel of Figure 1, shows the daily values of cosmic ray counts (Oulu neutrons) from 26 June to 7 July 1996, five days prior and post five days from the event. Daily values of geomagnetic Dst, IMF Bz, Solar wind velocity and density are also plotted in different panels of the figure. Cosmic ray intensity significantly decreases along with the increase of solar wind velocity and geomagnetic activity. Daily values of Dst index have been taken as a measure of the level of geomagnetic disturbances. As expected, proton density is significantly low during the period of high solar wind velocity. SW remains high 4-5 days after the onset of IMC event. Interplanetary magnetic field component Bz turns southward immediately after the MC event. Such a southward turning of IMF Bz produces large geomagnetic field variation, which reflects in Dst values. Similar analysis has been done for another two MC events of 1996. Figure 2 & 3 show the plots for similar analysis of 26-27 May, 1996 and 7-8 August, 1996, events respectively. Anomalously, Figure 2 does not show any decrease in CR intensity. However, IMF Bz turns to southward with enhancement in earth magnetic field. Cosmic ray increase seems to be associated with low solar wind velocity and high proton density. Increase in SW velocity prior to MC event produces decrease in cosmic ray intensity too early. We can see a southward turning of IMF Bz on 25th May, 1996 along with low proton density.

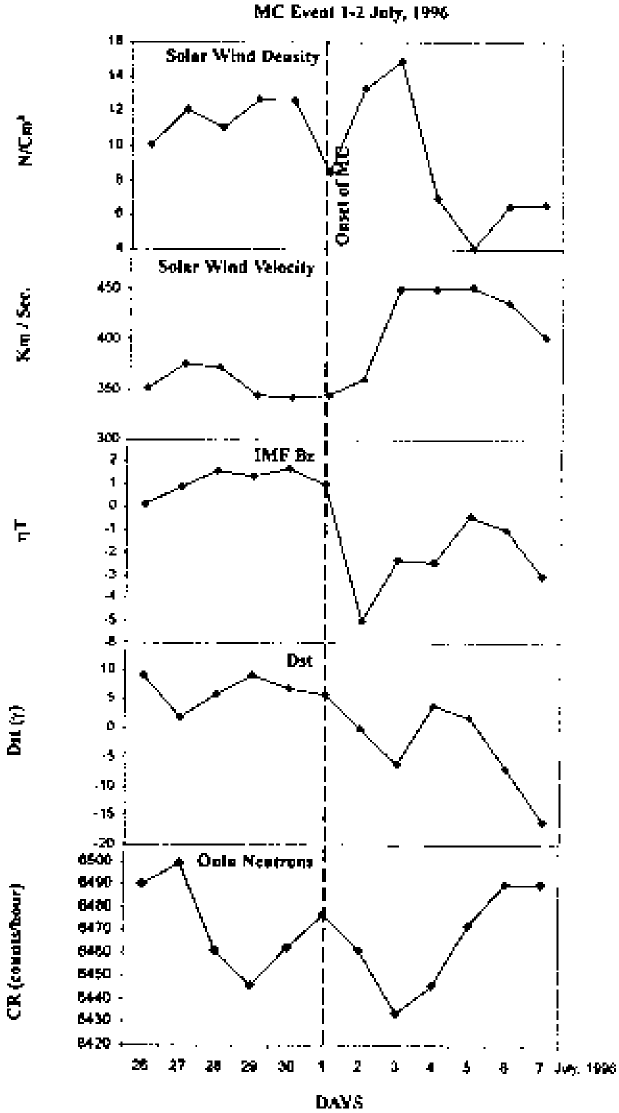

Figure 1. Plots of daily values of cosmic rays from –5 day to + 5 day for the magnetic cloud event of July 1–2, 1996. Daily values of Dst index, IMF Bz, Solar wind velocity and density are also plotted in different panels.

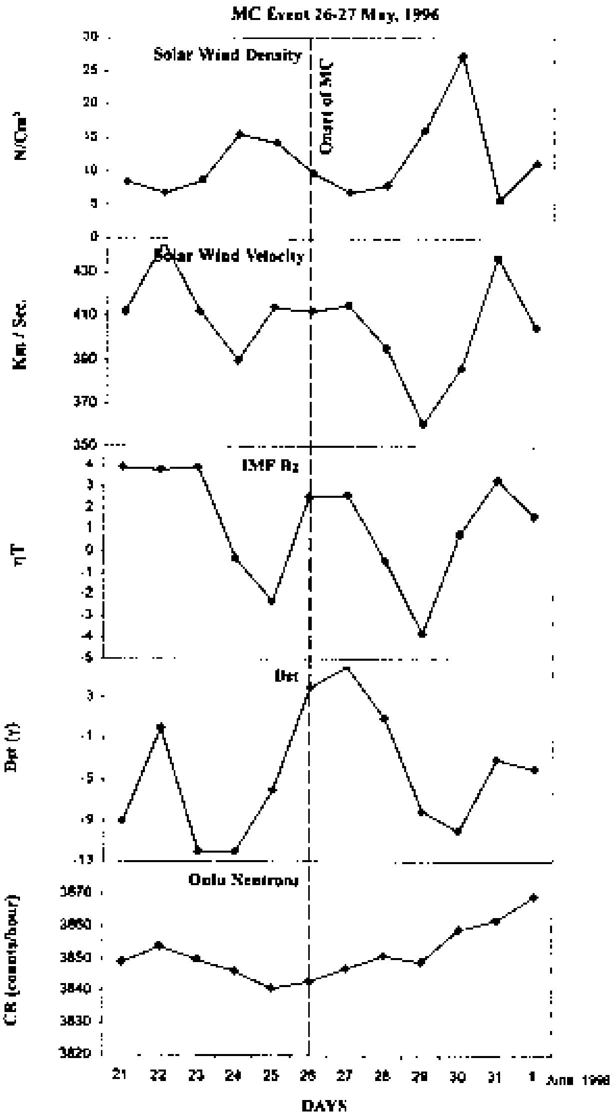

Figure 2. Plots of daily values of cosmic rays from –5 day to +5 day for the magnetic cloud event of May 26–27, 1996. Daily values of Dst index, IMF Bz, Solar wind velocity and density are also plotted in different panels.

Figure 3, shows the daily values of same parameters for the MC event of August 7-8, 1996. We can see a significant cosmic ray decrease in cosmic ray intensity. However, low SW velocity and Dst values are observed in association with magnetic cloud events. IMF Bz turns to northward after the onset of MC event.

As such, we observe from the behaviors of three MC events, that all the magnetic clouds are not related with the significant and large decrease of cosmic ray intensity and southward turning of Bz component of IMF. Large decreases of cosmic rays are associated with SSC associated magnetic clouds, perhaps caused by the turbulent sheet behind an interplanetary shock.

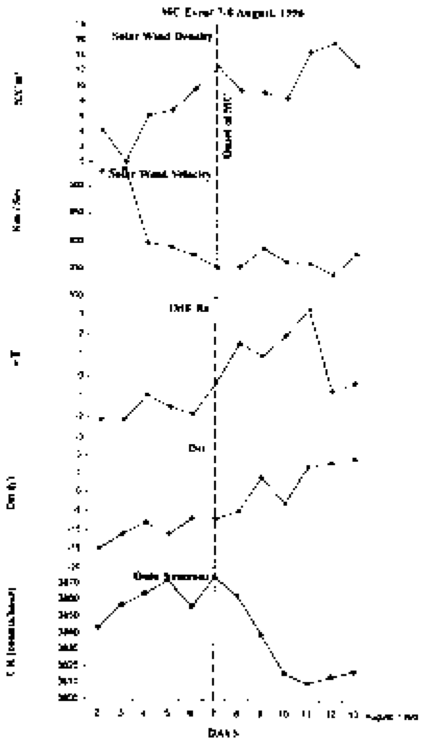

Figure 3. Plot of daily values of cosmic rays from –5 to +5 days for the MC event of 7–8 August, 1996. Daily values of Dst index IMF Bz, Solar wind velocity and density are plotted in different panels.

3. Conclusions

It is concluded from this analysis that magnetic cloud events significantly produce changes in interplanetary features, MC events in association with SSC event produce large decreases in cosmic ray intensity. MC events produce enhancement in geomagnetic disturbance level only when IMF Bz turns from northward to southward.

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