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Effects of interplanetary transient disturbances on cosmic ray intensity in relation with solar wind plasma parameters

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Abstract. Two types of interplanetary disturbances namely magnetic cloud events (MCE's) and bidirectional events (BDE's) are taken to study the short term change in solar wind plasma components as well as in cosmic ray intensity. These two types of disturbances are again separated into two categories : (i) coronal hole associated events (MCE's & BDE's), and (ii) without coronal hole associated events (MCE's & BDE's). Analysis of this research work indicates distinctly different effects on solar wind plasma velocity and cosmic ray intensity. Coronal holes associated BDE's are found significantly responsible for enhanced plasma velocity. Both disturbances in either of the category produce short-term decrease in cosmic ray intensity.

Key words : interplanetary disturbance - cosmic ray - solar wind parameters

1. Introduction

Interplanetary disturbances with a shock wave at 1 AU are classified into two categories : first in which the shock wave is accompanied by a magnetic cloud known as magnetic cloud event (MCE), the second type of event where the shock wave is followed by a plasma region with bidirectional solar wind electron heat flux (BEHF) is termed as bidirectional event (BDE). It has been found that the plasma and magnetic field characteristics of these two types of transient disturbances are distinguished markedly. If magnetic cloud and BEHF are truly fast magnetised plasmoids moving away from the Sun into interplanetary space, then the interplanetary magnetic field must drape around them (Fainshtein et al., 1996). Gosling and McComas (1987) treated the field line draping around BEHF as a likely source of the out-of-the ecliptic magnetic fields at 1AU. IMF draping was thought of as being the possible cause of the characteristic eastward deflection of BEHF at the Earth's orbit. This provides insight into the physical nature of these two interplanetary transients.

In this paper a systematic study has been performed to draw the relationship of magnetic field characteristics of MCE and BDE with various interplanetary / geomagnetic phenomena as well as also with cosmic ray intensity.

2. Data and method of analysis

MCE and BDE events data with an accuracy of 1 hour from the period 1978-1982 are taken from IMP 8 and ISEE 3 observations (Couzens and King, 1986). The shock wave in the solar wind is generally identified in high time resolution plots of solar wind plasma and magnetic field data as abrupt and simultaneous increases in bulk flow speed V, particle density Np, proton temperature Tp and magnetic field B (Borrini et al., 1982). Solar wind components values are taken from interplanetary medium data book (kind 1977, 1986). For cosmic rays we have taken the daily mean temperature and pressure corrected values of Calgary neutron monitor.

3. Results and discussion

It is a well established fact that magnetic clouds events (MCE's) and bidirectional events (BDE's) consist of different plasma and magnetic field characteristics. Such disturbances in interplanetary medium certainly produce influences on energetic particles of galactic cosmic rays as well as the distrubances in Earth's magnetic field. Coronal holes are the regions on the outer surface of Sun, which propagate high speed solar wind stream into interplanetary medium. We have divided both MCE and BDE into two classes : one which is associated with coronal holes and another which is not associated with coronal holes and then explicitly analysing their influences.

Figure 1 shows the results of Chree analysis for BDE and MCE events with solar wind components, such as bulk flow speed, ion density and proton temperature on left and right panels respectively. These two events are associated with coronal holes. Zero day on the time scale corresponds to the beginning of the event. Coronal holes associated BDE's show significant increase in solar wind velocity and proton temperature. Both show transient enhancements lasting six to seven days after the zero day. Ion density decreases immediately after the occurrence of the event. However on the other hand results of Chree analysis of coronal hole associated MCE's show different effects on solar wind velocity as shown in figure 1 (right panel). An enhanced bulk solar wind velocity and ion density on the onset of event day is evident. Proton temperature does not provide any meaningful result except a sharp decrease on the first day after the event day. Hence it is concluded that the bidirectional events (BDE's) are more effective to produce increase in solar wind velocity as well as for transient fluctuations in ion temperature than the events of magnetic clouds (MCE's).

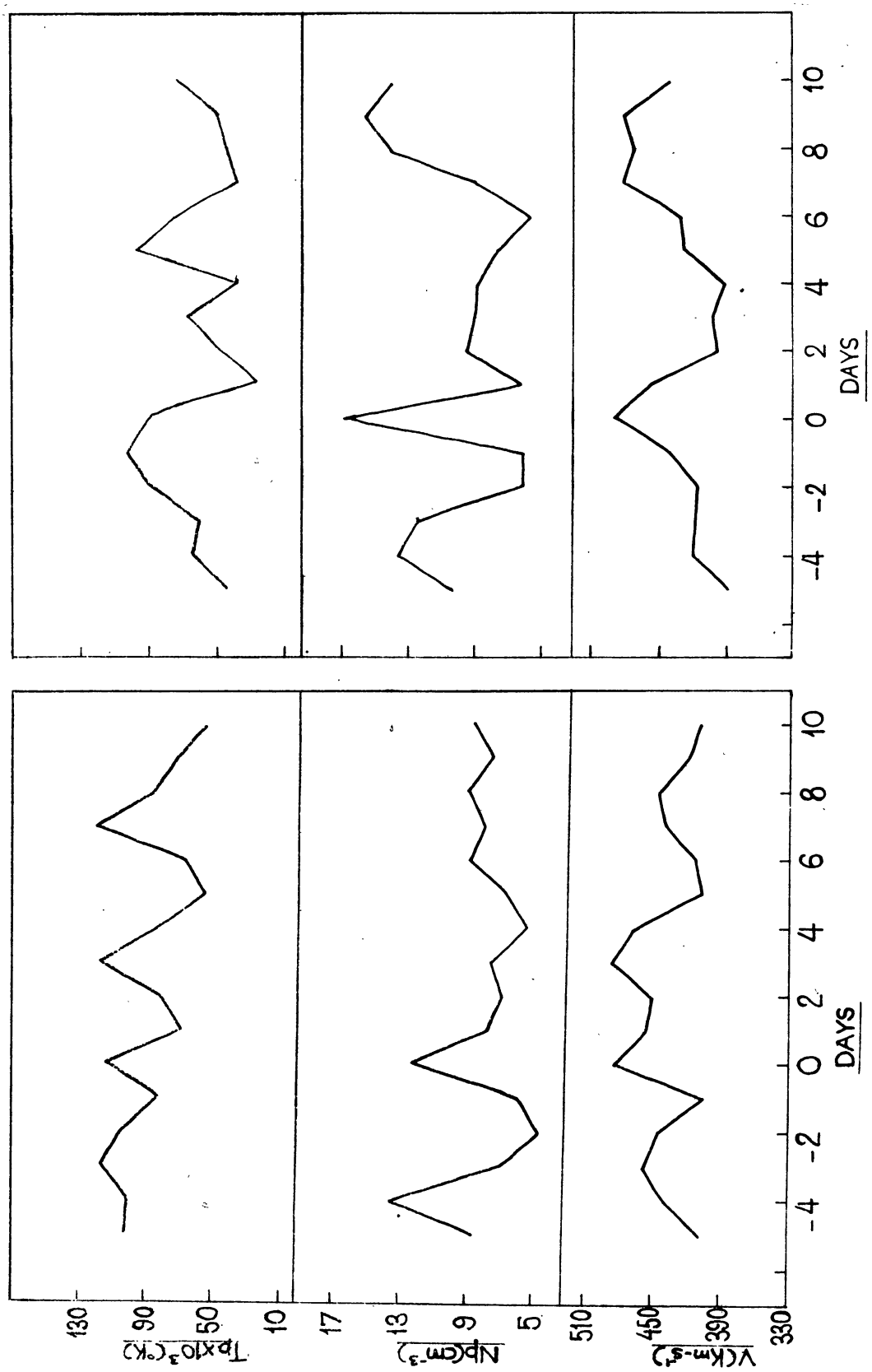

Figure 1. Superposed epoch analysis plots of the plasma parameters i.e. solar wind velocity V(km-s^{-1}) ion density Np (cm^{-3}), proton temperature Tpx10^3 (K^0) in transient disturbances of two types : BDE (left) and MCE (right) associated with coronal holes.

Further we have performed the Chree analysis to observe the effect of BDE's and MCE's which are not associated with coronal holes. Results are shown in figure 2. The BDE's show a maximum solar wind speed on the event day which starts increasing before 1 day of the event goes to maximum then decreases sharply taking 5 days on the time scale. Similarly the ion density and temperature starts increasing before one day and after having the maximum values on the event day decrease continuously for the following next day. Similar results for

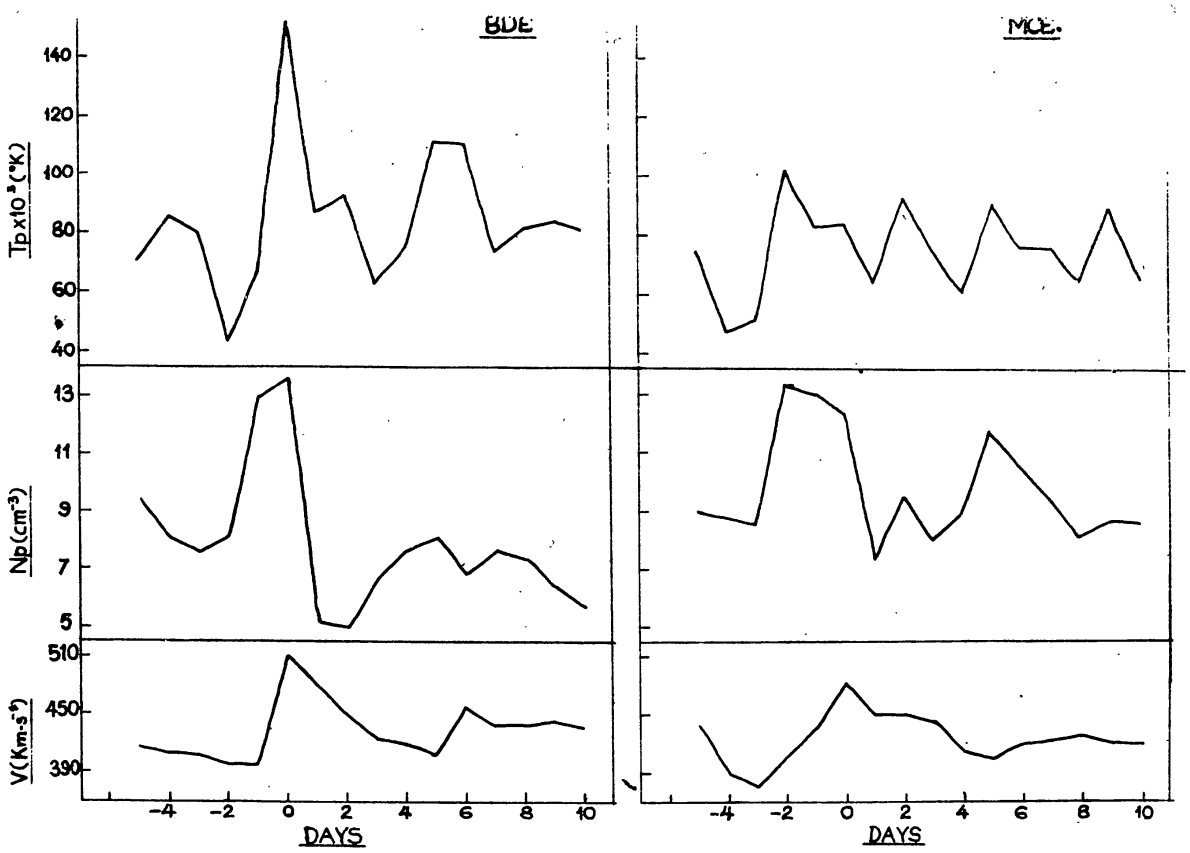

Figure 2. Superposed epoch analysis plots of the plasma parameters i.e. solar wind velocity V(km-s^{-1}) ion density Np (cm^{-3}), proton temperature Tp×10^3 (K^0) in transient disturbances of two types : BDE (left) and MCE (right) not associated with coronal holes.

solar wind velocity are observed for MCE's without coronal hole associated events. However density values are found minimum up to four days after the zero epoch day. Fluctuations are seen for the proton temperature. Here we can conclude that only coronal holes associated magnetic cloud events are found responsible to produce significant decrease in the solar wind velocity on short-term basis.

Figure 3 shows the effects of these two types of transient variations on cosmic ray intensity on short-term basis. Slight decreases are evident in the Chree analysis plots for both the categories of BDE's and MCE's. From critical examination it can be said that the bidirectional

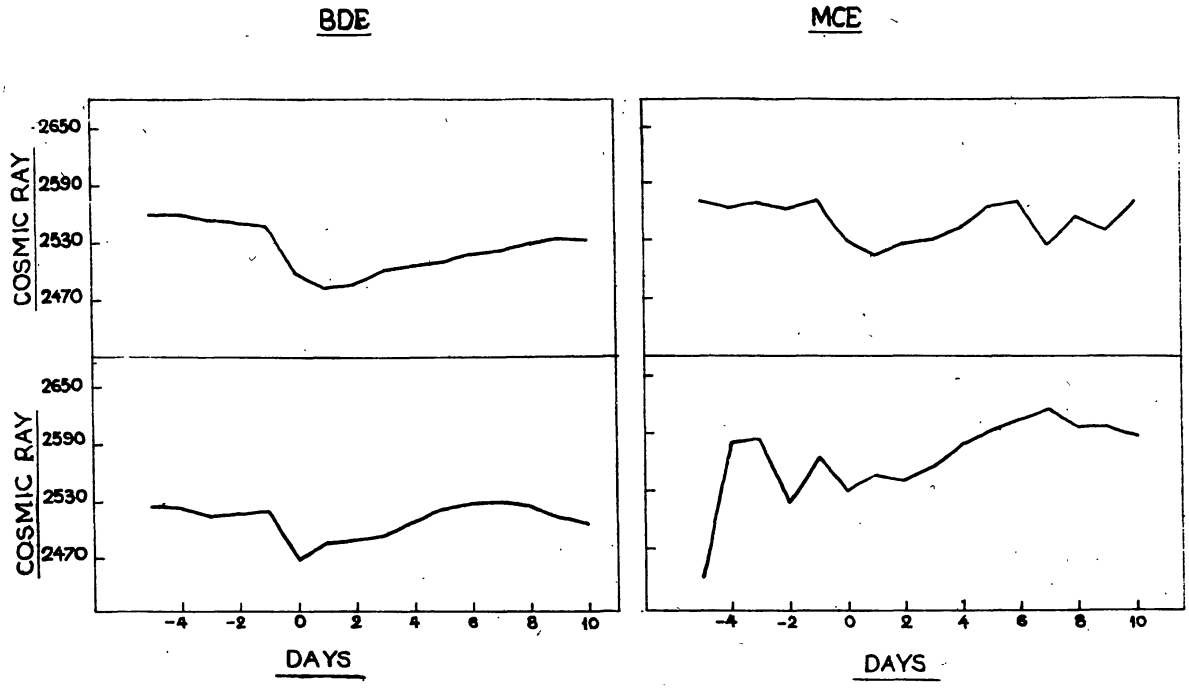

Figure 3. Superposed epoch analysis plots of cosmic ray intensity associated with transient distrubances (BDE & MCE). Left panel shows BDE associated with CH (bottom) and Without CH (top). Right panel represents MCE with CH (bottom) and without coronal holes events (top).

events with or without coronal holes produce larger decrease in cosmic ray intensity than the magnetic cloud events. Hence we can infer that coronal holes are not a prominent factor to produce decrease in cosmic ray intensity.

On comparing averaged relationship of plasma parameters for MCE and BDE from figures 1 and 2, it is found that the characteristics of these two types of transient disturbances in association with coronal holes or without coronal holes association differ appreciably in plasma velocity and temperature. Increases in the solar wind plasma velocity in the BDE with CH case is about 50% larger than those for MCE and CH case. MCE and BDE without CH only show slight differences in proton temperature where BDE without CH produce 40% large decrease in comparison to MCE without CH events. Fainstein et al., 1996 have reported different magnetic field characteristics in these two types of transient disturbances (BDE & MCE). The magnitude of the magnetic field in the sheath region in MCE increases as one approaches the MC boundary, while in BDE immediately in front of BEHF boundary the magnetic field decreases. Larger and varying magnetic field during the period of MCE's certainly produce decrease in solar wind plasma velocity as well as in the intensity of cosmic rays too. Therefore, increase in plasma velocity is associated with bidirectional events accompanied with coronal holes.

4. Conclusions

It has been concluded from the analysis that :

(1) Bidirectional events associated with coronal holes are found responsible for producing increase in solar wind plasma velocity on short-term basis.

(2) The magnetic cloud events do not produce any significant charge in plasma components.

(3) Both types of transient disturbances are found responsible factor in producing decrease in cosmic ray intensity on short-term basis.

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References

Borrini G., Gosling J. T., Bame S. J., Feldman W. C., 1982, J. Geophys. Res, 87, 4365.

Couzens D. A., King J. H., 1986, Interplanetary medium data book supplement 3, 1977-1985, N S S D C / W D C - A 86-04, Natl. Space Sci., Data centre, Greenbelt, Maryland.

Fainshtein V. G., Kaigorodov A. P., 1996, Planet. Space Sci., Vol. 44, No. 4, 387.

Gosling J. T., Mc Comas D. J., 1987, Geophys. Res. Lett., 14355.