Interplanetary Transient Plasma Signatures and Associated Cosmic Ray Intensity Variation

Subhash C. Kaushik
Department of Physics, Government Art, Science and Commerce College, Rampurnaikin, M. P. 486 775, India
E-mail: subash_kaushik@rediffmail.com

Abstract

Two types of interplanetary (IP) transient disturbances, namely magnetic cloud events (MCEs) and bidirectional events (BDEs) are analyzed to study the short- term changes in the solar wind (SW) plasma components as well as in cosmic ray intensity. Thses disturbances are divided in to two categories: coronal holes (CH) associated events and without CH associated events to analyze their influences explicitly. Study reveal distinctly different effects on SW plasma velocity and cosmic ray intensity. The BDEs associated with CH are found significantly responsible for enhanced plasma velocity. Both disturbances (MCEs and BDEs) produce decrease in cosmic ray intensity, but lesser decrease and fast recoveries are evident in case of events associated with CH.

1. Introduction

Interplanetary (IP) disturbances with a shock wave at 1 AU, generally have distinct plasma and field signatures by which they can be easily distinguished from the ordinary solar wind [6]. These transient disturbances represent a wide range of IP phenomena in the heliosphere. Few of them are coronal ejecta driving the shock waves, helium abundance enhancements, anomalously low proton and electron temperatures, anomalous ionization states, high magnetic field strength with low field variance, magentic clouds (MC's), low energy proton bidirectional anisotropies and regions with bidirectional solar wind electron heat flux (BEHF) [1,8,13]. Magnetic cloud events (MCEs) present a descriptive image of a coronal mass ejection (CME) caused IP disturbances. The cloud carries an intrinsic field, often with the characteristics of a flux rope [3,12]. It interacts with other SW structures and with the ambient medium. BDEs are interpreted as population of electrons travelling along IMF lines which either are rooted at both ends in the Sun or else are on closed loops entirely disconnected from the Sun [7]. Theories have predicted that MC and BEHF are truly fast magnetized plasmoids moving away from the Sun into IP space and IMF might be draping around them [6,7] and this IMF draping is the possible cause of the characteristic eastward deflection

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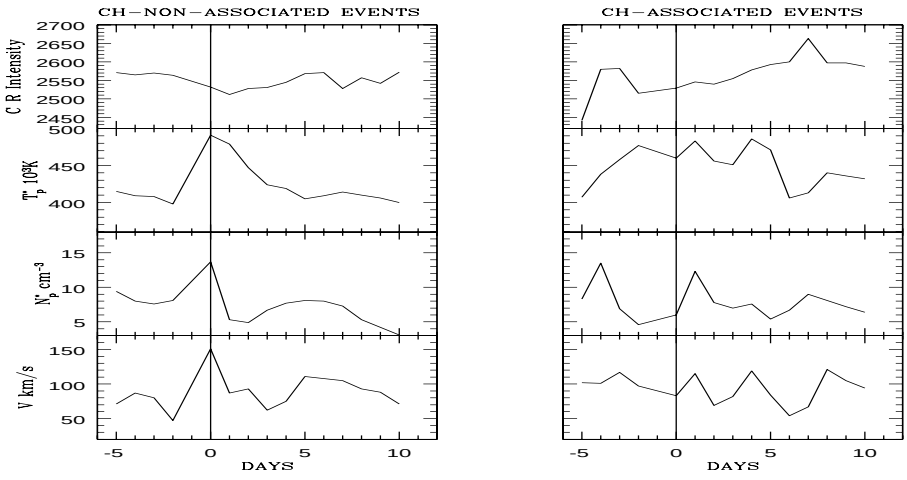

Fig. 1. Chree analysis plots depicting the solar wind plasma components and cosmic ray intensity for bidirectional events (BDEs). Left and right panels show CH-NON associated and CH- associated events respectively. 0 on X-axis indicates the event day.

of BEHF at the earth's orbit. This provides insight into the physical nature of these two IP transients. With a particular interest in the structures including MCs and regions with bidirectional solar wind electron heat flux (BEHF), termed as bidirectional events (BDEs), the aim of this study is to investigate the effects of these transient variations associated with or without CH, on CR intensity.

2. Data and Method of Analysis

The data of MCE and BDE events with an accuracy of one hour for the period 1978-1982 are taken from IMP 8 and ISSE 3 satellite observations [11]. The shock wave in the solar wind is generally identified in high time resolution plots of SW plasma and magnetic field data, as abrupt and simultaneous increase in bulk flow speed V, particle density Np, proton temperature Tp and magnetic field B [2]. For cosmic rays the daily mean temperature and pressure corrected values recorded by super neutron monitor at Calgary (lat. 51.05° N, long. 114.08° W, cut off rigidity 1.09 GV) have been taken. We have applied the superposed epoch method to find the short- term effects.

3. Results and Discussion

It is well known fact that SW velocity plays an important role to produce short-term as well as long-term modulation of cosmic rays. MCEs and BDEs consist of different plasma and magnetic field characteristics. Such disturbances

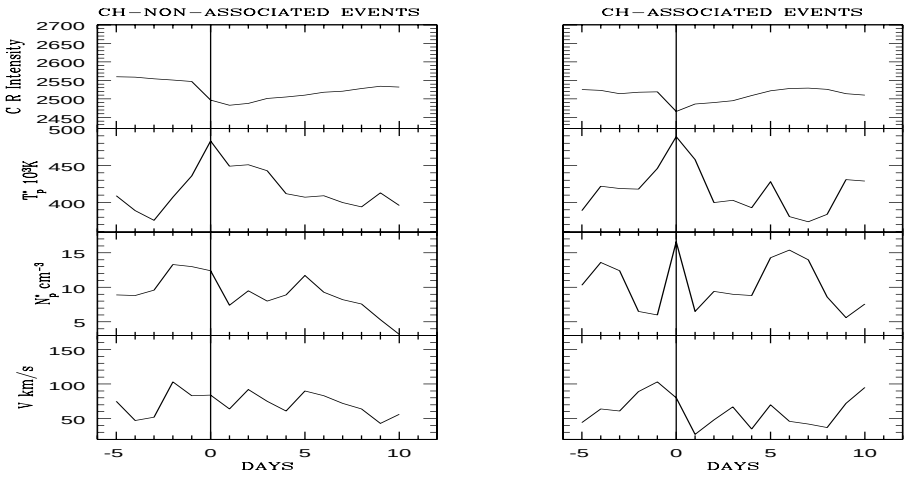

Fig. 2. Same as figure 1 but for magentic cloud events (MCEs).

in IP medium certainly produce influence on energetic particles of galactic cosmic rays. To analyze whether the terrestrial effects are primarily the results of high-speed solar wind associated with CH or they are the consequences of the interaction between differing SW flow, CH are taken to observe their effects on IP medium in relation with IP disturbances. As we know that CH are the regions on the outer surface of the Sun, which propagate high speed SW stream in to IP medium. Both MCE and BDE have been divided in to two categories -one which is associated with the CH and the other which is not associated with CH and then their influences have been explicitly analysed. Figure 1 depicts the results of Chree analysis for BDEs with SW components and cosmic rays. The left panel shows the CH- non associated events, while right panel represents CH associated events. Similar plots for MCEs are shown in figure 2. Both kind of disturbances produce decrease in cosmic rays, although CH associated MC events are found more effective comparing to other events. On comparing averaged relationship of plasma parameters for MCEs and BDEs from figures 1 and 2, it is found that the characteristics of these two types of transient disturbances in association with CH or without CH differ appreciably in plasma velocity and temperature. Increase in the SW plasma velocity in the BDEs associated with CH is about 50% larger than that for MCEs associated with CH. The MCEs and BDEs which are not associated with CH show slight differences in the proton temperature, where BDEs not associated with CH produce 40% larger decrease in comparision to MCEs. However, other investigators have reported different magnetic field characteristics in these transient disturbances [7]. Observational results indicate physical influence of coronal holes on solar wind and cosmic rays [9].

The propagation of these CH- associated streams into the IP medium significantly produce modulation in high energy particles as well as in magnetic field [7,10]. The modulation of galactic cosmic rays at neutron monitor energies varies year to year showing their dependence on solar sunspot cycles. It is expected to be so due to the variation of coronal holes area during sunspot maxima and minima. During sunspot maxima conditions, the coronal holes are small in area and concentrated near the poles. During solar minima conditions,the polar coronal holes are much larger in area dominating a larger fraction of the solar disk and greatly influencing the heliospheric condition in the ecliptic plane.

4. Conclusions

It is concluded from the present study that BDEs not associated with CH enhances the solar wind velocity on short- term basis. Both kind of events in either the category enhances the plasma temperatuer and produce decrease in cosmic ray intensity. However slight decreases and gradual recoveries are observed for the events not associated with coronal holes.

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