Effects of Interplanetary Coronal Mass Ejections on cosmic ray intensity and geomagnetic field variation for solar cycle 23

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Abstract: Interplanetary Coronal Mass Ejections (ICMEs) are the interplanetary manifestation of coronal mass ejections observed by coronagraphs near the sun. In this analysis 101 events of ICMEs have been used to derive their effects on cosmic ray intensity for the period of 1996 to 2007, which cover the solar cycle 23. Daily values of Kiel neutron monitor have been taken in three analysis. Results of our analysis suggest that ICMEs produce short-term decreases in cosmic ray intensity. It has been also investigated that ICMEs produce increases in geomagnetic field variations.

Keywords: Cosmic rays, Interplanetary Coronal Mass Ejections, Geomagnetic activity.

1 Introduction

The concept of mass ejection from sun has been known from a long time, the phenomena of coronal mass ejection first time reported in 1971, using the seventh orbiting solar observatory. Currently interplanetary manifestation of CMEs are known as Interplanetary Coronal Mass Ejections. ICMEs are associated with many characteristics including the speed of ICMEs, almost majority of ICMEs includes abnormally low solar wind proton temperature. Solar wind ion change state and compositional anomalies, the generation of shock upstream of fast ICMEs which may be important accelerators of energetic particles. Forbusch decrease in cosmic ray intensity and generation of geomagnetic storms are caused by these anomalies.

CMEs are known as the causes of interplanetary magnetic field fluctuations and many scientists suggested that the solar cycle dependent modulation of galactic cosmic rays can be explained by the presence of CMEs related magnetic in homogeneities in the heliosphere [1-3]. They studied the effect of interplanetary Coronal Mass Ejections on cosmic ray intensity for the period of 1997 to 2002. Recently Shrivastava and Singh [4] suggested that ICMEs can produce geomagnetic activity with an increase geomagnetic Ap index and decrease in Dst values. In this work we examine the effect of ICMEs on cosmic rays and geomagnetic field variation for the period of solar cycle 23.

2 Data and method of analysis

Observations of ICMEs are taken from LASCO/SOHO, FIT/SOHO and GOES satellites. These data are taken from internet websites. 101 events of ICME have been taken for the period of 1996 to 2006, which cover the solar cycle 23. The present study investigate by the superpose epoch analysis. In order to evaluate the atmospheric response to ICME disturbances the daily values of geomagnetic planetary Ap index are taken from the solar geophysical data books. The present study investigate by means of super posed epoch analysis the changes in cosmic ray intensity as well as geomagnetic
field on a longer time scale (5 days before and 10 days after ICME onset)

2 Results and discussion

Earlier it was thought that solar flares and solar wind remain culprits in short-term decreases in cosmic ray intensity [5-6]. After the identification of CMEs in 1971 many cosmic ray researchers investigated the role of CMEs and ICMEs in the cosmic ray modulation processes in short-term as well as long-term basis [1.7].

Our aim of this study to verify the near earth ICME effects in short-term modulation of cosmic ray intensity as well as geomagnetic field variations. To observe the average behavior of cosmic ray intensity variation during the period of ICMEs the chree analysis for days -5 to 10 have been plotted in figure 1 as percent deviation of the data from the Kiel neutron monitor station. Zero day is corresponding to onset day of ICMEs. A maximum decrease is observed near zero epoch days (arrival date of CME at 1 AU) this study suggest that ICME occurrence is important for galactic cosmic ray modulation it is now expected that the shock disturbance in which the ICME driving the shock highly effective in stimulating geomagnetic disturbances as well as cosmic ray decreases.

Further, the analysis has been extended on short-term basis to draw the combined effect of these ICMEs on geomagnetic field, on adopting the Chree analysis of super epoch method. A significant increase in Ap values on Zero day (arrival date of CME at 1 AU) for the period of 1996 to 2006.

Figure 2 the results of Cree analysis for -5 to 10 days with respect to zero epoch days the variation of Ap values is shown in figure for the period of 1996 to 2007. Zero day correspond to the starting day of occurrence of ICME events.

Earlier, it has been reported that the speed of CME/ICMEs are also an effective parameters for controls the geoeffectiveness of very fast halo CMEs [4, 8]. To observe the relationship of ICME speed with geomagnetic activity, the ICME speeds have been correlated with Ap values, as shown in Figure 3. Annual mean values of ICMEs are cross plotted with annual mean values of Ap index. Scatter of points in figure 3 shows a significant positive correlation between these two interplanetary and geomagnetic parameters.

From this analysis it is inferred that ICME produces significant increases in geomagnetic disturbance index Ap values. It is now expected that shock disturbances in which the ICMEs driving the shock highly effective in stimulating geomagnetic disturbances.

Vol. 11, 207
3 Conclusions

(i) ICMEs produce distinctly different effect on cosmic ray intensity as well as on geomagnetic field.

(ii) ICMEs produce short-term transient decreases in cosmic ray intensity.

(iii) ICMEs produce enhancement in geomagnetic field on short-term basis.

(iv) Significant positive correlation has been found between ICME speed and geomagnetic disturbance index Ap.

References


Figure 2 Shows the cross plot between annual mean values of ICME speed and annual mean values of Geomagnetic Ap index for the period of 1996 to 2007.

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