Study of Forbush Decrease Event and Associated Geomagnetic Field Variation During Space Radiation Storm

Sujeet K. Mishra,[1] Subhash C. Kaushik,[2]
(1) Department of Physics, A P S University, Rewa, M. P. 486 001, India
E-mail: sujeet_mishra2003@rediffmail.com
(2)Department of Physics, Government Art, Science and Commerce College, Rampurnaikin, M. P. 486 775, India
E-mail: subash_kaushik@rediffmail.com

1. Abstract

Transient decrease in cosmic ray intensity followed by a slow recovery typically lasting for several days is identified as Forbush decrease (Fd) event. Such Fd has been recorded by the world grid of neutron monitoring stations. The event was the result of a powerful explosion from sunspot region 9077, which sparked an X-5 class, one of the most powerful solar flare of the ascending phase of solar cycle 23. As a result the geomagentic index Dst decreased upto -300 nT, indicating a large geomagnetic storm and the % Fd decrease has gone to 16% giving rise a cosmic ray storm. Both events coincided with interplanetary conditions. Therefore, a systematic study has been performed to investigate the variation of cosmic ray intensity alongwith the interplanetary and geomagnetic disturbances. Results indicate a strong relationship between geomagnetic activity and Forbush decrease on short- term basis.

2. Introduction

Forbush decrease events (Fds) are transient and rapid decreases in cosmic ray intensity followed by a slow recovery typically lasting for several days. Soon after the discovery of such decreases in cosmic ray intensity by Forbush in 1938 [3], investigators have been searching for the cause of these decreases in the fields and flows emitted from the Sun, as well as their possible correlation with the geomagnetic activity [1,2,6]. It was reported that the high magnetic field regions (blobs) in the interplanetary space are associated with Forbush decrease [1]. Further it has been demonstrated that cosmic ray decreases are not related to the turbulence or random motions in the field, while only the regions of high field strength in interplanetary space are found responsible for causing Forbush decrease. These regions consist of interplanetary magnetic loops (or blobs)/ clouds of ordered field topology, ejected from active solar regions, interplanetary shocks having comparatively ordered field structure, the turbulent fields in the environ-

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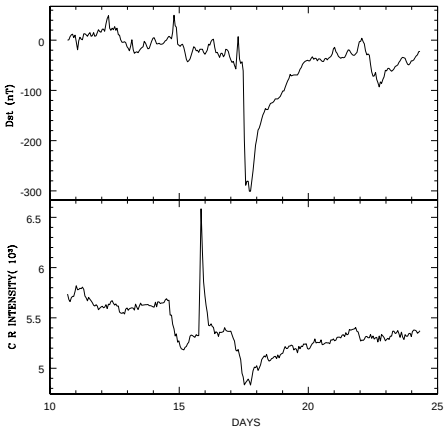

Fig. 1. Cosmic ray intensity and geomagnetic index Dst on day to day basis are shown in lower and upper panels respectively.

ment of shocks, corotating high speed streams or simply tangential discontinuties [3].

Various mechanism for the Forbush decrease have been proposed by the scientists, they identify the decrease as the reflection at the front of the the blast wave, the deflection of particles by extended structures of orderd field configuration [12], gradient B drift in the environment of shocks of rather ordered structures[1,9] and the scattering of particles in the turbulent field region between the shockfront and magnetic clouds [13]. This paper investigates the cosmic ray decrease and interplanetary disturbances that occurred during the period 13-15 July,2000. The particular aim is to find the possible correlation between Forbush decreaes and geomagnetic field variation.

3. Data and Method of Analysis

The Forbush decrease event is identified from the hourly plots of cosmic ray data. Daily mean temperature and pressure corrected values recorded by super neutron monitor at Oulu (lat. 65.05° N, long. 25.47° E) have been taken for this study. We have used hourly- averaged IMF components and solar wind plasma data at 1 AU obtained from satellite observations provided by National Space Science Data Center, in the present study to investigate the large Forbush decrease event during 13-15 July,2000 in relation with geomagnetic activity. Introduced in 1964, the ring current index Dst measures primarily the ring current magnetic field. Using which one can investigate the low latitude effects. Here Dst is used as an indicator of the geomagnetic activity to derive the possible relationship of cosmic rays with geomagnetic activity.

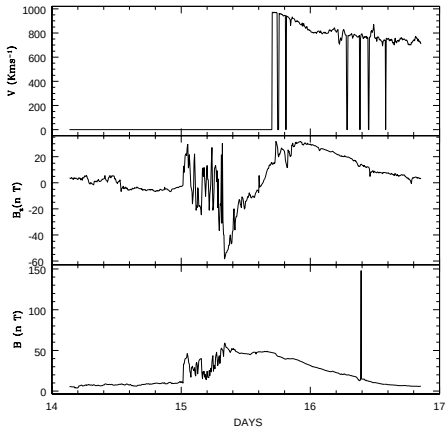

Fig. 2. It represents Interplanetary parameters and solarwind velocity during the event period on day to day basis. Lower panel depicts average field B, while Bz and SW velocity are shown in second and third panels respectively

4. Results and Discussion

As in the case of Forbush decrease the characteristic time is of the order of days [1], we have used the pressure corrected daily mean values of cosmic ray intensity from 10-20 July, 2000 as recorded by Oulu neutron monitor. Results are depicted in figure 1 on day to day basis. Lower panel of figure 1 shows the cosmic ray intensity variation, while the second panel represents the geomagnetic index Dst. Interplanetary features and solar wind velocity plots are shown in figure 2. Lower panel of figure 2 depicts the average magnetic field B, while the Bz component of magnetic field and solar wind velocity V are shown in second and third panels respectively. The transient decrease was detected during 13-15 July, 2000. The cosmic ray intensity was found to be 10% which took place on 13th July at 2100 hours. Further the minimum decrease 16% was observed on 15th July at 2200 hours after the transient enhancements observed at 1100 hrs. Both decreases coincides with two very strong X-class flares. Which were among the most strong flares of the ascending phase of solar cycle 23 and both originated from the NOAA active region 9077 (N 16.8°, E 0.21°), first flare on 12th July followed by a coronal mass ejection (CME) at 0342 UT. While the second flare from the same active region at 1024 UT on 14th July also followed by a full halo coronal mass ejection (CME) 1054 UT first visible at C2 camera of LASCO. This CME was moving out at a speed of 1800 km/s. As a result of these solar and interplanetary activities geomagnetic Dst index started decreasing at 0700 UT on 15 July and approached minimum value -301 nT after six hours, i.e. at 0100 UT on 16th July indicating a very strong geomagnetic storm.

Various investigators have established the fact that solar wind velocity plays an important role to produce short-term as well as long-term modulation of cosmic rays, and Fds are produced by perturbation in the interplanetary condition. These perturbations originate from shock waves, coronal mass ejections (CMEs), solar flares, high velocity solar wind streams [2,4]. Recently, Ifedili has pointed out that heliospheric propagation of galactic cosmic rays is independent of the polarity of heliospheric magnetic field [4].

5. Conclusions

In this paper Forbush decrease event has been analyzed.It is concluded from the observations that the value of Dst index shows a significant transient decrease in similar pattern as that of Forbush decrease. The massive compression of the magnetosphere and anormous intensification of the large scale magnetospheric current system reflected in Dst leads to a significant geomagnetic effect on cosmic ray measurement near the Earth.

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