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Association of cosmic ray Forbush decrease event of February 1999 with geomagnetic storm

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Abstract

Using the data from world grid of neutron monitoring stations we have obtained a large Forbush decrease during the recent epoch of maximum solar cycle 23. The onset of Forbush decrease took place on February 10, 1999 and attained its maxima on February 17. This cosmic ray storm coincides with a major geomagnetic storm. The geomagnetic storm is a worldwide disturbance of the geomagnetic field, which is distinct from the regular variation. We have done a systematic study to investigate the variation of cosmic ray intensity and geomagnetic activity during the period of a major geomagnetic storm. We observed a significant decrease in cosmic ray intensity as well as in geomagnetic field during the main phase of storm. Preliminary results suggest a strong relationship between geomagnetic activity and cosmic ray intensity decrease on short-term basis.

1. Introduction :

Transient and rapid decrease in cosmic ray intensity followed by a slow recovery is called Forbush decrease event in cosmic ray intensity. Earlier it was suggested that these events are produced by perturbation in interplanetary condition and that these perturbation originate from solar flares or from magnetic field structures associated with interplanetary solar wind streams [Parker 1963; Kadokora & Nishida, 1986, Kaushik & Shrivastava, 2000]. The perturbation would be produced from shock waves, coronal mass ejections, flare generated high solar wind streams [Cane and Rechardson 1995; Shrivastava and Shukla, 1993,94,96; Shrivastava 1997, 2001]. Iucci *et al.* (1984) reported the idea of spiral cone like region which extend along the interplanetary magnetic field. They have also determined the separate configuration of shock front and of the following magnetic perturbation to the amplitude of first and second step of Forbush decrease as a function of the associated solar flare longitudes.

In this work; we have studied the characteristics of Forbush decrease event in association with geomagnetic field variation. Main concern of this paper is the geomagnetic disturbances and the associated cosmic ray variations.

2. Observations and analysis of data :

A very intense geomagnetic storm, was observed in February 10, 1999 having just been proceeded by a series of four solar flares during the period of 12 to 21, February, 1999. Three of the solar flares are emarated from the some NOAA active region 8869. Only one flare of February, 12 in a different active region 8853. Two more geomagnetic storms were observed on 17 – 18 February, 1999. Table-1 shows about the details of solar flares which have occurred during 12 – 21 February, 1999. Dat of geomagnetic activity, solar activity and cosmic rays are taken from solar geophysical data book. Table-1 shows the details about solar flares which have occurred during February, 12–21, 1999.

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Table – 1

Event	Date	Start UT	End UT	Location (Active region)	Classification optical
1	12 Feb. 1999	0410	0505	N 26 W 23 – 8853	1 N
2	17 Feb. 1999	1845	1948	S 25 W 16 – 8669	1 B
3	19 Feb. 1999	1506	1732	S 19 W 42 – 8869	1 N
4	20 Feb. 1999	2344	404	S 25 W 43 – 8869	1 N
5	21 Feb. 99	2308	2347	S 19 W 78 – 8869	2 B

3. Results and Discussion :

Fig. 1 shows the Forbush decrease event of Feb. 10 to 23, 1999. Onset time of this event is Feb. 10 and it remains low during 18 and 19^{th} Feb. 1999. Two major solar flares on 15 and 16 on Noaa region of 8462 which may be affected to produce large decreases in cosmic ray intensity. We have noticed a major geomagnetic storm on Feb. 10, which coincides with cosmic ray decrease. Two geomagnetic storms are also observed on 17 and 18 February, which coincides with maximum decrease. One sudden storm commencement is observed on 17^{th} Feb. 99, which is an indicator of arrival of shock. The decrease in cosmic ray intensity started just after occurrence of SSC. The decrease in cosmic ray intensity is found to be in 6%, which take place in duration of 22 hours. Further the cosmic ray intensity recovers to its pre-storm average value in time span of four days. A significant "pre-increase" on early hours of 17^{th} February, 99, immediately prior to the onset of the fast decrease is seen for all the five neutron monitor location. A step like onset of the recovery phase of the Forbush decrease is reflected in the NM data of most locations as seen in neutron monitors Table-2, present the parameters of these stations. Last three stations have approximate cutoff rigidity of 2-5 GV but are located at different longitudes.

Table – 2
List of Neutron Monitor stations

S.No.	Station Name	Geographic		Cut off Rigidity
		Latitude	Longitude	
1.	Calgary	51.08	245.91	1.09
2.	Goose Bay	53.33	299.58	0.61
3.	Climax	39.37	253.82	2.95
4.	Moscow	55.47	37.32	2.41
5.	Kiel	54.33	10.13	2.23

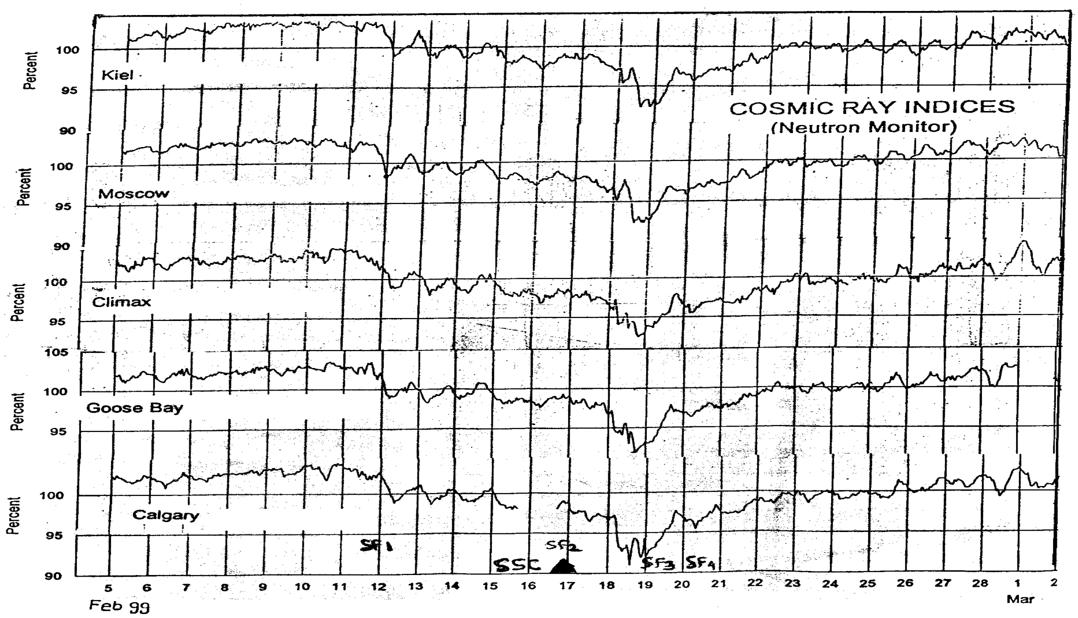

Fig. 1 : Shows the Forbush decrease event of Feb. 99 at different stations.

Further to correlate the geomagnetic activity with cosmic ray intensity, near – earth interplanetary medium, we have plotted the daily values of geomagnetic Dst index for the event period of Forbush decrease as illustrated in Figure 2 (a). The Dst index is representation of the magnetic effect at low latitude. The signature of geomagnetic storm as indicated by Dst is seen in figure 2 (a). The geomagnetic field which showed only slight activity prior to 17 Feb. 99 was disturbed by arrival of interplanetary shock as reported by SSC on Feb. 17. Primary effect of magnetic storm is a reduction in the strength of the horizontal magnetic field ΔH as illustrated in figure 2(b). The pattern of horizonal magnetic disturbance caused by a magnetic storm is roughly that of uniform arial field projected on the earth surface. This pattern suggest that the source of the magnetic disturbance is a ring current circuling the earth in the equatorial plane. A large decrease in Dst – index as shown in Fig. 2(a) for the period of Feb. 15 to 23 concides with main phase of Forbush decrease event of Feb. 99. The value of Dst – index shows significant decrease in similar pattern as that of Forbush decrease. The geomagnetic disturbance index Dst recorded at low latitude which comes from the outward blowing zonal current system called the ring current. It is assumed that the massive compression of the magnetosphere and anormous identification of the large scale magnetospheric current system reflected in Dst lead to a significant geomagnetic effect on cosmic rays measurement near the earth.

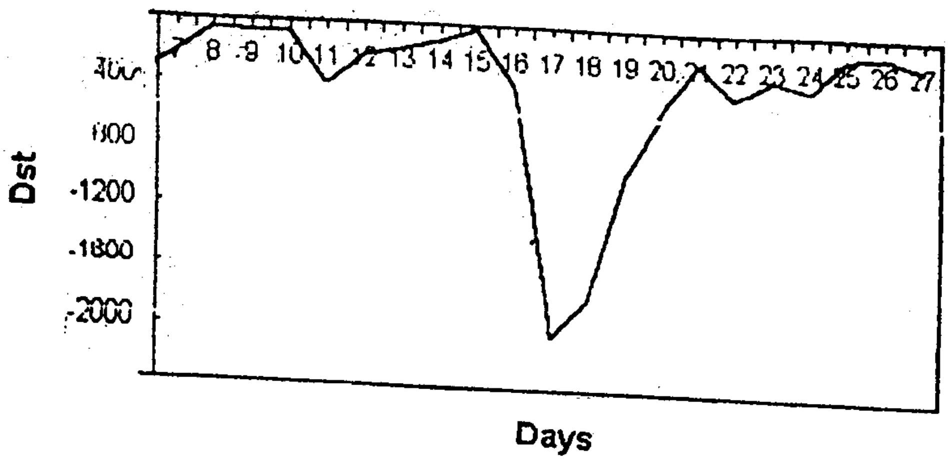

Fig. 2 (a) Shows the daily values of Dst index for the period of Feb. 7 to 27, 99.

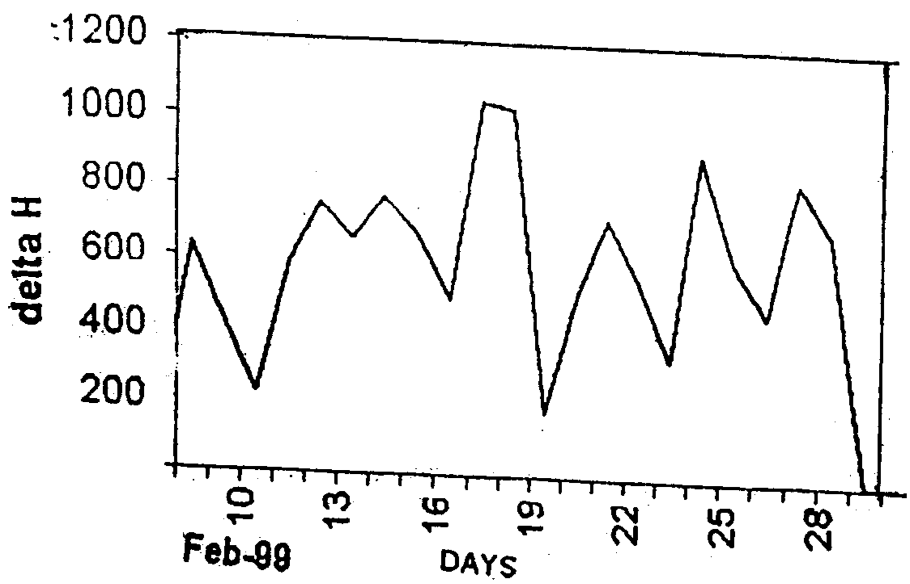

Fig. 2 (b) : Shows the daily values of earth magnetic component of ΔH at Trivenweli Geomagnetic Station.

High Ap values during Feb. 17 to 19 are also noticed, such a drastic change in Ap-index may be one of the contributing factor to the large cosmic ray decrease on Feb. 1999. Coronal mass ejections (CMEs) also play an important role in producing the Forbush decreases. However, because of the not availability of CMEs data, we could not investigate its contributions.

It is generally found that the CMEs is also associated with solar flares. In a number of previous studies it has been investigated that the occurrence of CME generally produced transient variation in cosmic ray intensity on short term basis. In a number of cases it has been also studied that the coronal mass ejections free from solar flares association also contribute in cosmic rays Forbush type decreases (Shrivastava, 2001). In this case we can expect a number of coronal mass ejections during the period of February 10 – 22, 1999.

Cosmic ray intensity shows a decrease during the low Dst values. This seems to be Forbush decrease in cosmic rays of the type observed during magnetic storm, because of neutrons are secondary products of collisons of cosmic ray energetic protons and heavy nuclei with air nuclei on the top of atmosphere. Forbush decrease itself is a consequence of the deflection of cosmic rays away from the earth by the enhanced interplanetary magnetic field associated with the energetic solar plasma which anvelopes the earth during disturbances.

4. Conclusions :

The large Forbush decrease event of Feb. 1999 as observed by the Neutron monitors clearly shows the effects of solar flares and shock waves on cosmic rays. Large scale magnetospheric current systems as reflected in Dst values support the concept of geomagnetic effects on cosmic ray intensity near earth.

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