SH4.1-10

CUMULATIVE EFFECT OF FORBUSH DECREASES IN THE HELIO-SPHERIC MODULATION DURING THE PRESENT SOLAR CYCLE

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ABSTRACT

We generate a monthly Forbush decrease index (Fd-I) and compare it with the observed long-term changes in the cosmic ray intensity near earth at energies $\geq$ 1 Gev over 1976-83. Significant correlation is observed between the two except for 1978. Such an effect is also seen in the correlation plot between the solar flare index (SFI) and Fd-I.

1. Introduction. Characteristics of the long term variation of cosmic ray intensity have been obtained in the past using neutron monitor data (e.g. Lockwood and Webber, 1984). Recent studies from spacecraft have determined the radial gradient of cosmic ray intensity to a distance of up to 30 AU (e.g. Venkatesan et al., 1984; Van Allen and Randall, 1985). Furthermore specific cosmic ray intensity changes such as Forbush decreases have also been studied to large heliospheric radial distances (Van Allen, 1979; and references therein). The purpose of this paper is to explore the role of the short-term cosmic ray intensity decreases in generating the profile of the cosmic ray long-term variation.

2. Analysis and Results. The percent deviation has been calculated for each month for the interval 1976-83, using the cosmic ray intensity maximum for the months of Sept.-Nov. 1976 as 100%. The Forbush decrease index (Fd-I) is computed from the hourly data of Deep River neutron monitor after examining the plots of a number of stations as well. The magnitude of each Fd is added to form a cumulative total of all the Fd's observed in a month; such a total is the index, Fd-I. Similarly, the solar flare index (SFI) has been computed by using all solar flares (importance $\geq$ 1) and by assigning a weight according to the numerical importance of the flare and the relative brightness of each solar flare. Such objective criteria give proper weight to the energetic flares, which generally produce much larger decreases in cosmic ray intensity (Shukla et al., 1978).

The long-term modulation has been reported to be a direct consequence of large number of solar flares (e.g. Hatton, 1980; Agrawal, 1983; and references therein). Similarly, the Fd effects are also the consequence of energetic solar flares (Shukla et al., 1978). We therefore suggest that the long term modulation is the cumulative effect of large number of small and big Fd's, the validity for which is examined in Figure 1. Note that the cosmic ray intensity reaches a maximum in 1976, and a minimum in 1982. However, the Fd-I changes very abruptly, with a very large peak in 1978, and with a conspicuous minimum in 1980. The anomalous behaviour of low Fd activity during 1980 is being investigated separately in a paper (SH 5.1-15). Moreover, the peak value of Fd-I in 1978, is of considerable interest, and will be discussed further.

Note from Fig. 1 that both R_z and SFI are still increasing during 1978, while Fd-I shows a very large peak in 1978. Geomagnetic disturbance index Ap also shows moderately low values till 1981, after which it increases, (probably associated with the dominating effect of coronal holes).

The correlation between the long term cosmic ray variations and the Forbush decrease index, is investigated by a cross-plot (Fig. 2) using monthly values for the two quantities during 1976-83. Note that in spite of significant correlation, many points lie close to X-axis. Opposite is true for the year 1978, when most of the points lie close to y-axis, indicating large Fd-I without any associated cosmic ray decreases. Nevertheless, correlated changes observed during other periods show that the long term modulation of cosmic ray intensity can be understood in terms of the cumulative effect of Fd's. We believe that the exception during 1978 of Fd-I on %-deviation of cosmic rays is perhaps attributable to the faster recovery of cosmic rays during 1978. This needs further investigation as also why during certain months of high solar activity no Forbush decreases are seen.

The correlation between Fd-I and percent cosmic ray deviations, with SFI during 1976-83, is shown in Figure 3(a) and (b). Note again that large Fd-I's are associated with small SFI during 1978. Reverse is true for certain months in 1980. The correlation is poor in 1980 and during the recovery of cosmic ray intensity in 1983, when large cosmic ray intensity deviations are observed for low values of SFI. Nevertheless, Figure 3(a) indicates a correlated variation in the cosmic ray intensity with the observed changes in SFI. Thus, from Fig. 3(a) and 3(b), we observe the effect of SFI on both Fd-I and cosmic ray intensity (except for certain specific periods mentioned earlier), which also in turn justify the correlation shown in Fig. 2. It is therefore, reasonable to presume that the long term cosmic ray variation is generated by the cumulative effect of Forbush decreases, and the departure is quite significant during 1978 and 1980, in the present sunspot cycle.

4. References.

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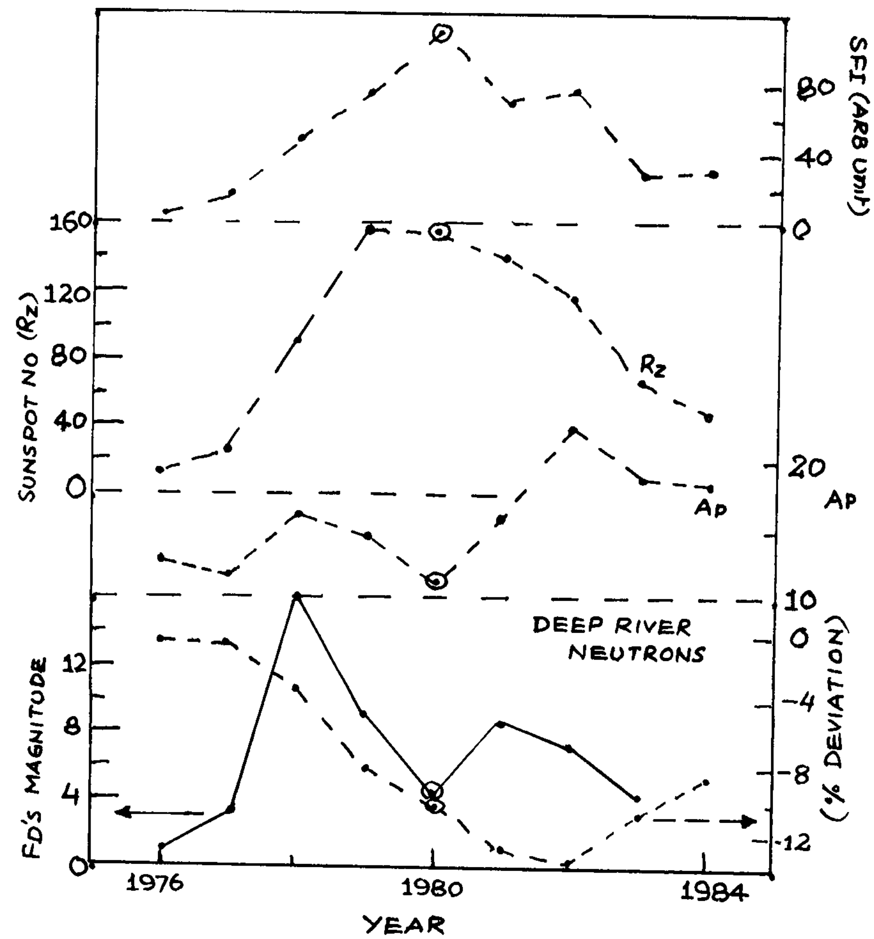
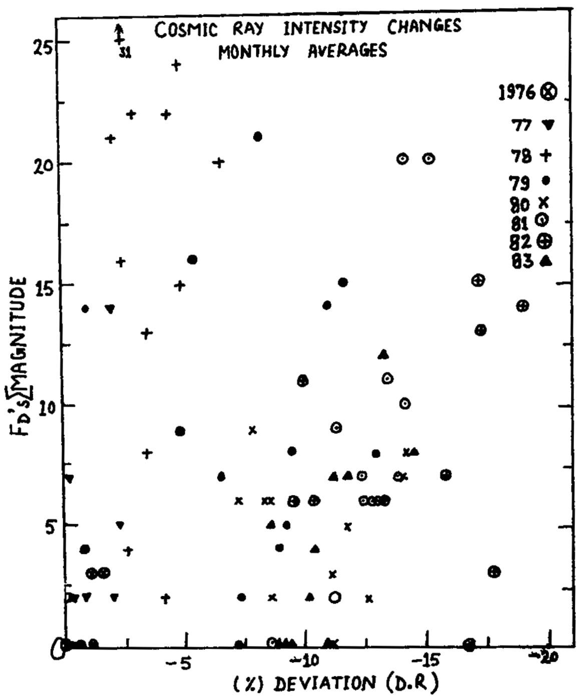


Figure 1 Yearly means of the solar flare index, sunspot number, Ap index, Forbush decrease index (Fd-I) and the cosmic ray intensity deviations from its maximum value, for 1976-84. The annual average values for 1984 are derived from limited number of monthly values. A large peak in Fd-I in 1978 is clearly evident.



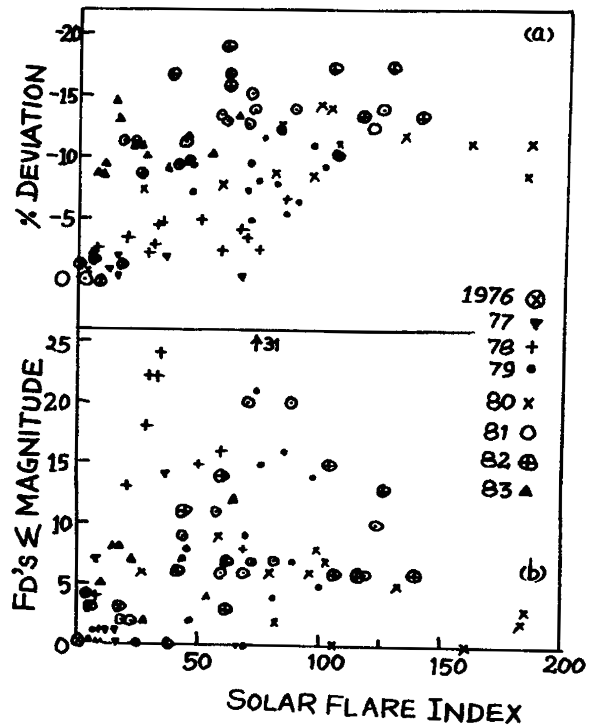


Figure 2 Cross-plot of monthly values of % deviation of cosmic ray intensity and Fd-I during 1976-83 with various symbols for different years.

Figure 3 (a,b) Crossplot of monthly values of SFI and (Fd-I)/percent deviation of cosmic rays during 1976-83. Symbols are the same as used in Figure 2.