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ROLE OF SOLAR FLARE INDEX IN LONG TERM MODULATION OF COSMIC RAY INTENSITY

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ABSTRACT

Recently, the importance of the occurrence of solar flares in the long-term modulation of cosmic ray intensity has been re-emphasized. For this purpose, the data of solar flares have been used from various publications, such as Solar Geophysical Data books, U.A.G. reports and Quarterly Bulletin Of Solar Activity. Our investigation, very clearly reveals that even the periodic changes in the solar flare observations, obtained from the four different data sources, for the same interval, differ significantly from one another; this is evident even on an average basis. Hence, in any study using solar flares, the importance of selecting a single compilation of the solar-flare data for the entire period of investigation is stressed.

1. Introduction. The study of the long term records of cosmic ray measurements, extending to energies beyond 100 Gev., have confirmed the eleven year solar cycle variation of cosmic ray intensity. Recent results (Hatton, 1980; Hatton and Bowe, 1981; Hatton and Bowe, 1983) using the number of solar flares, of importance ≥ 1, and the cosmic ray intensity deviations, have provided an empirical relation with better correlations for a time lag of ≈ 10 months. Such a time lag corresponds to a value of ≈ 70 A.U. for the solar modulating boundary. The goodness of fit has been shown to be quite satisfactory. The use of solar flares for such a correlation studies, often assumes that the total number and importance of solar flares would be the same, irrespective of the source of data of the solar flares. In this paper, we define a more realistic index for using the solar flare data, and then derive the monthly solar flare indices (SFI) for an extended period of time, from 1957-84, to compare it with the monthly averages of the cosmic ray intensity. During the course of investigation, we have found very significant difference in the solar flare indices, when derived from the tabulation of solar flares published in different data sources. These differences are quite large, hence need to be emphasized.

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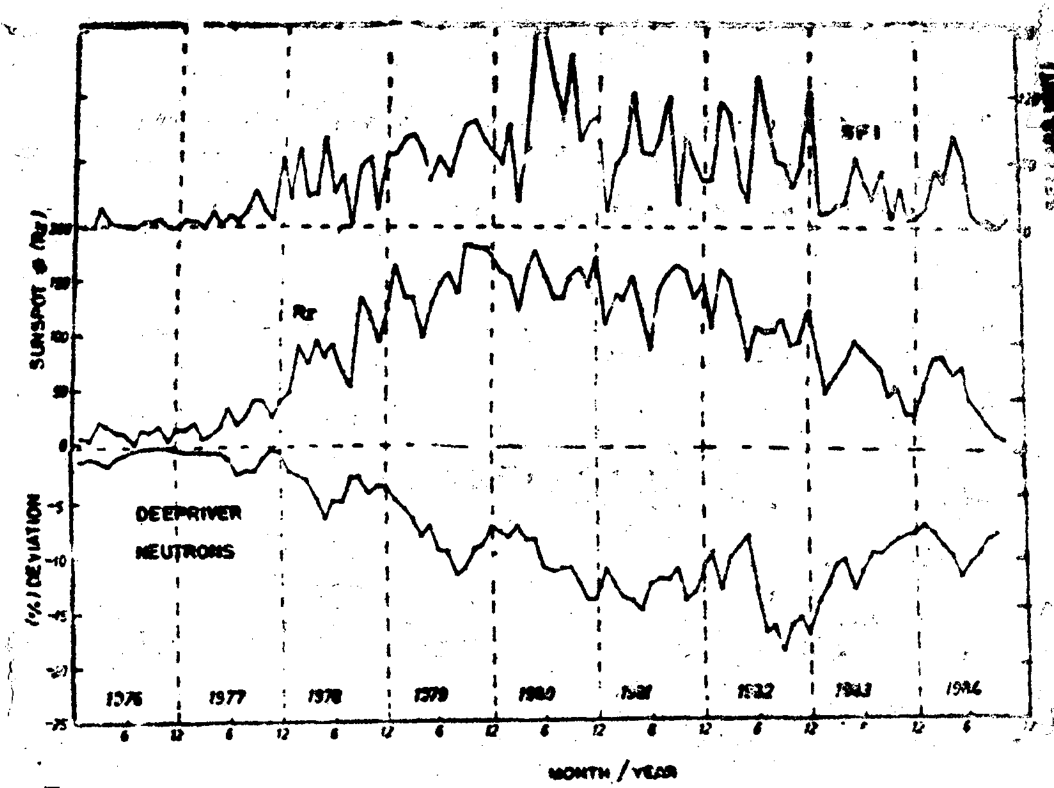
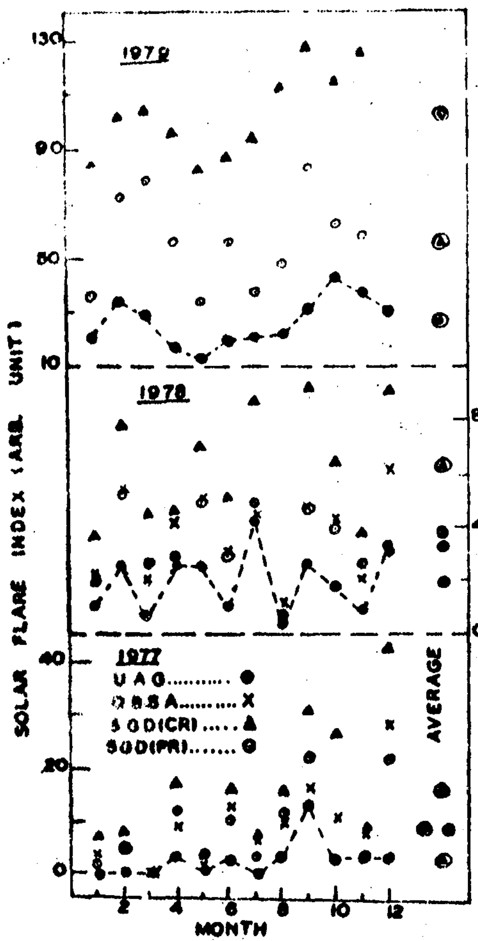


Fig. 1 Shows the percent deviation of monthly mean cosmic ray intensity observed by Deep River Neutron monitoring station. The 100% level is taken as the average for the month, Sept.-Nov. 1976. The monthly values of sunspot number (Rz) and solar flare index (SFI; see text for details for computing SFI) are also plotted for the year 1976-84.

2. Solar flare index. The occurrence of the solar flares are routinely published in solar Geophysical Data, both in the prompt reports as well as in the comprehensive reports. The solar flares are also listed in the quarterly Bulletin of solar Activity as well as in a slightly modified form in the UAG reports of World Data Centre-A. From these listing, various investigators have used the information of the occurrence of solar flares for comparison, with other observations. Usually, for most of the studies the solar flares of importance ≥ 1 are selected (as was done by Hatton, 1980; for Cosmic ray investigations). In these studies the number of solar flares were added without giving any weight either to the importance of the flares or to their brightness. The solar flare brightness is usually represented by B, N and F, whereas the flare-importance is represented by numerical numbers 1, 2, 3 and rarely also 4. We have therefore, generated a



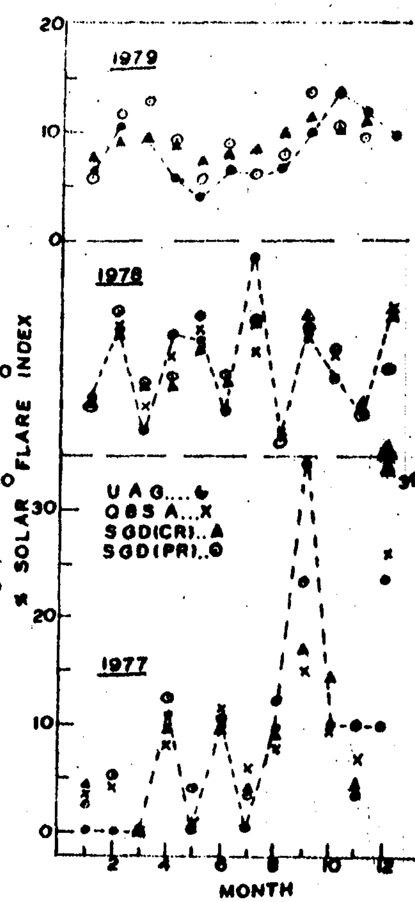


Fig.2 Shows the solar flare index for each month for the three years of high solar activity period 1977,78,79,for four different data sources, which are routinely published. The month to month changes are distinguished by joining the line for the solar flare computed from UAG report. The averages are shown in the right most part of the figure.

Fig.3 Shows the normalised values of solar flare index for all the monthly data sets and the time interval shown in figure 2. In each case the yearly sums are normalised to 100, to derive the percent solar flare index for each month.

Solar Flare Index (SFI) for each flare, for the interval for which the solar flare data from various sources (mentioned earlier) are available. In generating the new flare index (SFI) the reported importance of the solar flare is used as a numerical weight i.e. the SFI increases with the importance of the flare. Moreover, the brightness level, F, N, and B (Faint, Normal and Bright) are used to additionally weight the numeric value of the importance of the solar flares, by adding to it - 0.3, 0 and + 0.3 respectively. Such a solar flare index (SFI) has been computed for each solar flare of importance ≥ 1. These are then added to form monthly solar flare indices.

3. Results and Discussion. By the method described earlier, we have computed the solar flare index (SFI) using the data of solar flares published in the prompt report of the Solar Geophysical Data (SGD). By using the average of 3 monthly (Sept.-Nov.,1976) values of cosmic ray intensity (when the maximum intensity for the solar cycle occurred), the percent deviations for each month has been obtained for the period 1976-84. These are plotted in fig. 1, along with Rz and SFI (obtained from prompt reports) for 1976-84. In general, from this figure we observe an anti-correlation of both Rz and SFI with percent deviation of Deep River neutrons. However, the significant departure during the year 1980, is clearly evident in the figure.

The solar flare data are also published in the comprehensive reports (C.R.) of SGD. Therefore, the value of SFI calculated from comprehensive reports have been compared with the values of SFI computed earlier from the prompt reports (PR) for the same interval. From this comparison, we notice very significant differences, both in their absolute magnitude as well as in the variations observed from one month to another. Similar differences are noted when we make use of the solar flare listings from other two sources, viz. Quarterly Bulletin of solar Activity and UAG report. Figure 2 shows the monthly values of SFI derived from four different data sources. The annual averages are also marked, to show the difference in their absolute values. It is apparent from the figure that the changes from one month to another are not always similar. As mentioned earlier, if one uses different data sources to compute SFI for different periods, it is necessary to normalise the indices. This has been done for each year by using the yearly sums which are each normalised to 100. The percent solar flare index for each month, has been computed and plotted in figure 3, by using the absolute values plotted in figure 2. From this figure, the large differences in % SFI, from one month to another, comes out in a very significant manner. We conclude therefore, that the solar flare indices generated by either giving weight or otherwise, one should use only one type of data source.

4. References.

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