COSMIC RAY INTENSITY DISTRIBUTION PERPENDICULAR TO SOLAR EQUATORIAL PLANE AT 1 A.U. DURING 1978-83.

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ABSTRACT

The distribution of cosmic ray intensity perpendicular to solar equatorial plane, has been investigated by using its yearly variation with respect to the helio-latitudinal position of the earth, for the two intervals 1978-80 and 1981-83. The monthly mean values of two high latitude stations along with the solar and geomagnetic indices are used to derive the cosmic ray intensity distribution free from the changes due to variation in solar activity. The correction is found to be significant only during the interval 1978-80. The results indicate a significant linear increase in cosmic ray intensity from north to south of solar equator, contrary to that observed during 1973-75. No symmetrical gradients are found during the period of study, in agreement with earlier results.

1. Introduction.

The helio-latitude of the earth changes by $\pm 7.25^{\circ}$ with respect to solar equatorial plane during the period September to March each year. Any cosmic ray density gradient perpendicular to the solar equatorial plane will therefore, cause yearly variation in cosmic ray intensity. Earlier results, using high latitude neutron monitor data have failed to provide any evidence of the presence of symmetrical cosmic ray density gradients perpendicular to the solar equatorial plane, which are predicted to explain

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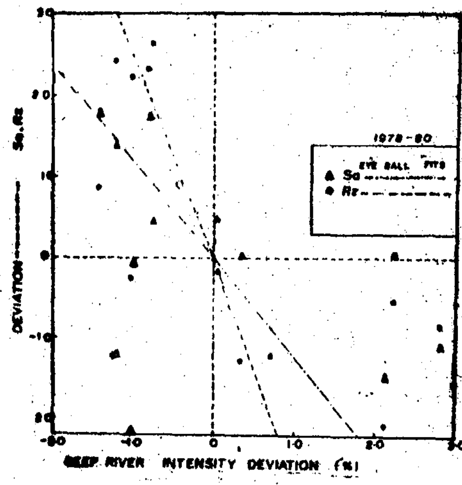

Fig. 1 Cross-plot between the average percent deviation of the cosmic ray intensity, with mean deviation of sunspot number (Rz), and solar radio flux (Sa) for the interval 1978-80. Eye-ball linear fits for Sa and Rz are also drawn.

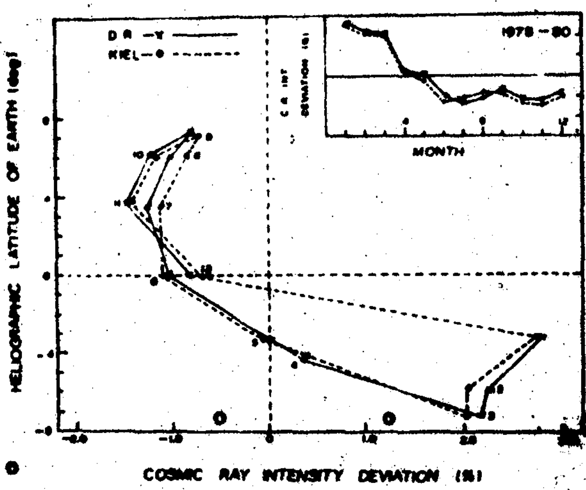

Fig. 2 (a) Cross-plot between the observed average percent deviation of cosmic ray intensity for 1978-80 for two stations and helio-latitudinal position of earth. The inset shows the linear time-intensity plot of cosmic ray intensity for the 12 month period.

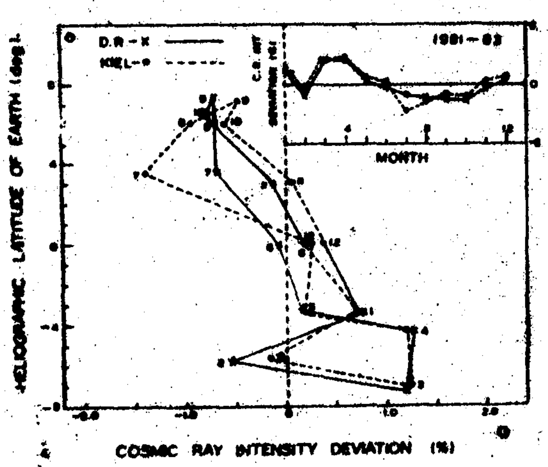

Fig. 2 (b) Same as in figure 2a, for the interval 1981-83.

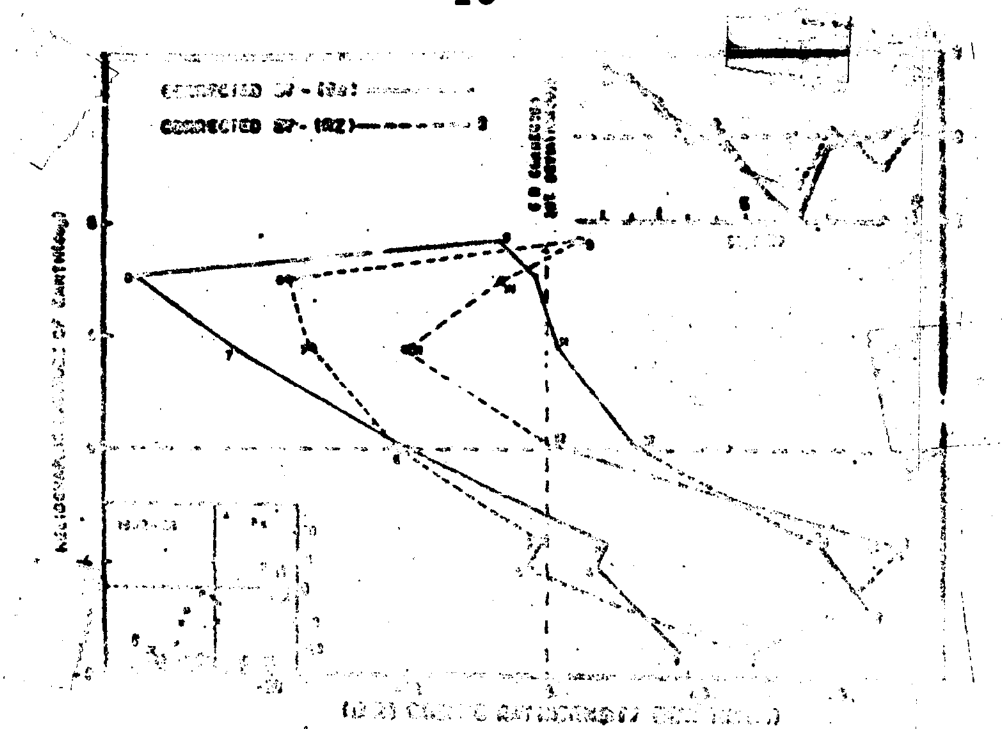

Fig.3 Cross-plot of the corrected average percent deviation of Deep River cosmic ray intensity for the interval 1978-80. The correction has been applied by using Sa & Rz separately.

the semi-diurnal anisotropy observations. In an earlier study (Pathak and Agrawal, 1982; and references there-in) for the interval 1973-75, during which the amplitude of semi-diurnal anisotropy was largest, no evidence was found for the presence of any symmetrical or linear cosmic ray gradients in the helio-latitude range $\pm 7.25^{\circ}$. Moreover, it is known that the semi-diurnal anisotropy exists during all the years of the sunspot cycle; the amplitude increases during the declining phase of the solar activity. In this paper, the analysis has been extended to include the period of maximum solar activity (1978-80) and the period of declining solar activity (1981-83), to derive the helio-latitudinal gradients by using the procedure adopted by Pathak and Agrawal (1982).

2. Method of analysis.

The corrected monthly average cosmic ray intensity values for two neutron monitor stations (Deep River and Kiel) have been used to determine the helio-latitudinal gradients, separately for the interval 1978-80 and 1981-83. Similar calculations have been performed for sunspot number (Rz), 2800 MHz solar radio flux (Sa), and for geo-magnetic field variability index (Ap), for both the intervals. The mean deviations have been obtained to derive the gradients after correcting the percent deviations of cosmicray intensity for variations in the solar indices.

3. Results and Discussion.

Earlier studies have shown significant correlation between the solar activity and the cosmic ray intensity during the 11-year period of a sunspot cycle, particularly on a long term basis (Rao, 1972). Therefore, to derive the gradient of cosmic ray intensity, it is necessary to remove the effect of solar activity from the observed cosmic ray intensity. Figure 1 shows the relationship between the percent deviation of cosmic ray intensity for Deep River neutron monitor and the deviations for Sa and Rz, for the interval 1978-80. The figure depicts significant correlation between the cosmic ray intensity and solar indices Sa and Rz. The lines drawn across them are the eye-ball fits, showing negative correlation. Such a fit has been used to correct for the effect of solar activity changes in the observed cosmic ray intensity deviations. However, a similar plot (not shown here), for interval 1981-83 does not show any relationship between these quantities; the points are observed to be randomly distributed. Therefore, no correction is applicable in the cosmic ray intensity deviations for the interval 1981-83. We have also investigated the effect of Ap on cosmic ray intensity deviations, which shows almost random changes, for both the intervals. Next we depict, the observed cosmic ray intensity deviations for both the intervals against the heliographic latitude of the earth for each month. Figures 2(a) and 2(b) show such a cross-plot, as well as the cosmic ray intensity deviations in a linear fashion. The observations indicate a rising density gradient from north to south with a small super-position of symmetrically rising density gradients with respect to solar equatorial plane. Nevertheless, the changes observed in the northern helio-latitudes are small. Moreover, these observations are affected by the changes in solar activity (see figure 1) and hence are re-plotted in figure 3, after correcting thecosmic ray intensity deviations for the effect of solar activity changes. The bottom inset shows the relationship between Sa and Rz in which months 8 and 11 do not show concurrent variability of Sa and Rz. This has resulted in two graphs in fig.3, for the corrected intensity for the same station Deep River. It is seen that the cosmic ray intensity in both the cases, is minimum in northern hemisphere, whereas it increases linearly with a maximum in southern hemisphere; the total percent change in cosmic ray intensity is $\approx 3\%$ during 1978-80, for the helio-graphic latitude of $\pm 7.25^{\circ}$. Similarly, the total change for the interval 1981-83 is $\approx 2\%$. The values of the linearly increasing gradient observed here are found to be quite significant and are much larger as compared to that reported earlier for intervals 1973-75. It is further noted that the smaller densities observed in northern hemisphere could be due to the presence of more abundant larger area solar polar coronal holes in the northern hemisphere as compared to southern hemisphere.

References.

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