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The aspect of time lag and hystersis in long-term cosmic ray modulation.

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Abstract

In this study we have explained the characteristics of long-term cosmic ray intensity variation during the ascending and descending phases of sunspot cycles 19 to 22. The pressure corrected monthly mean values of cosmic ray intensity of low ,middle and high energy range are taken for correlative study. The mean values of sun spot numbers has been taken as solar parameter to derive the correlation coefficient considering different time lag . All the phases have been further divided into two parts (first & second) on the basis of sun spot numbers. The analysis has been done for considering the time lag up to nineteen months. Analysis indicates higher correlation between cosmic rays and sun spot numbers during second parts of ascending phases of each sun spot cycles in comparison to first part. Phase lag analysis between two neutron monitors data of different energy range have been also done. It is found that the hystersis is seen only during the minimum solar activity period .

1.Introduction

Inverse correlation between monthly mean cosmic ray intensity on neutron monitor energies and the solar activity has been known for along time (Venkatesan & Badruddin,1990; Shrivastava,1990,93). On the other hand cosmic ray particles of different energy range show different behavior during the low and high solar activity periods (Stoker & Moraal,1986 ; Singh, Nigam & Shrivastava 1997). In this work ,two aspects have been taken to explain the long-term modulation of cosmic rays. These are known as time-lag and phase-lag analysis, which performed during different phases of solar sun spot cycles.

2.Data and Method of analysis.

The pressure corrected monthly mean values of cosmic rays obtained from the data of Climax (2.9Gev),Huancayo (12.9 Gev) and Deep river (1.1 Gev) for the period of 1965 to 1994. To derive aspect of time-lag in long-term cosmic ray modulation we have adopted the techniques of k-series (Shea & Smart 1985)

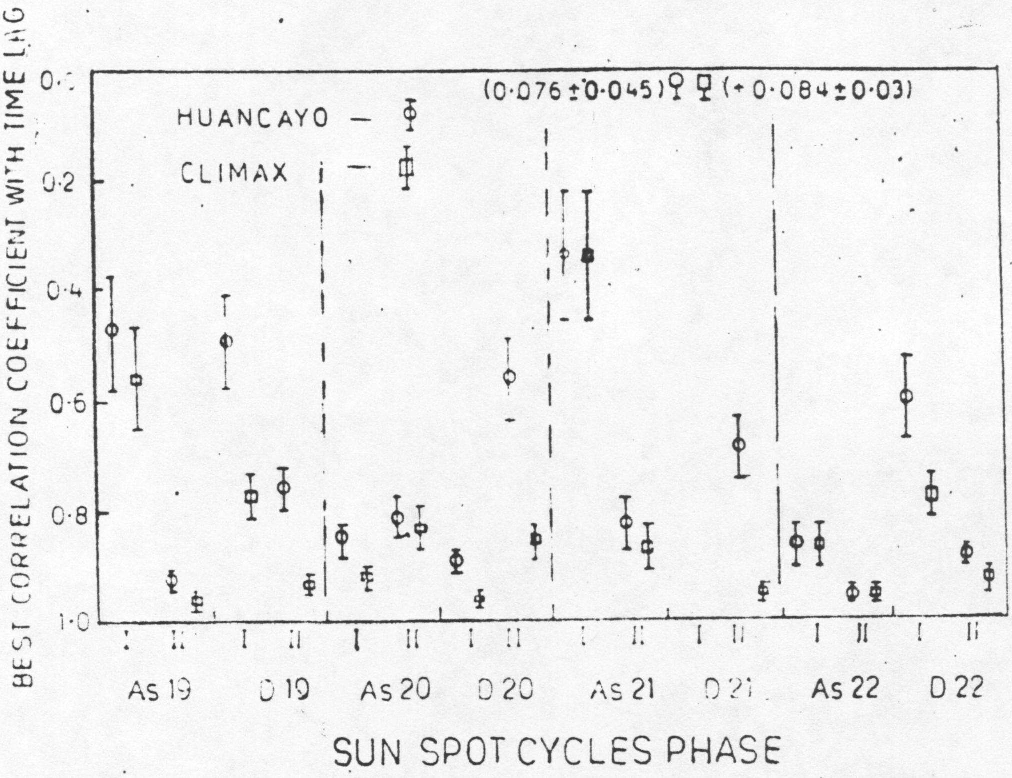

Figure 1.Shows the values of correlation coefficients between Rz and cosmic Rays for considering the time lag. Coefficients are plotted for ascending Phase I and II, descending phase I and II, covering the four successive solar cycles 19 to 22.

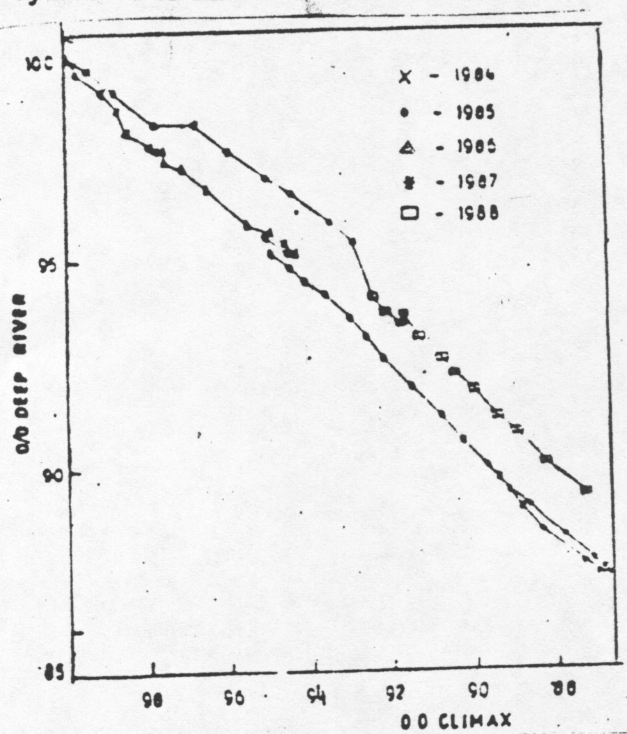

Figure 2. Five monthly sliding average & normalized counting rates of neutron Monitor at Deep river (1.1Gev) plotted against the counting rates of Climax (3.01) from 1984 to 1988. Percent deviation of cosmic ray Intensity are calculated from the taking the cosmic ray counts during the Solar minimum period of oct.1978.

3.Results and Discussion.

To derive the long-term relation ship between solar activity measured by the observed mean sun spot numbers and cosmic ray intensity for four solar cycles 19 to 22.Values of correlation coefficient between these two parameters have been obtained . All the sun spots cycles are divided in four parts as ascending parts I &II, descending part I & II. These division have been done on the basis of the sun spot numbers and duration of the period from one minimum to next maximum and vise versa. Recently ,a significant relationship has been reported between cosmic rays and Rz in different phases of sun spot cycles ,which is always found r > -0.4 (Singh, Nigam & Shrivastava 1998). To look in more detail into problem , the correlation coefficient have been derived between monthly mean values of cosmic rays and Rz considering a lag between these two parameters on the basis of k-series analysis. In this process ,monthly mean values of cosmic ray data for the k-th month has been correlated against the two months averages of Rz for months k and k-1 and similarly three months averages of Rz k, k-1 & k-2 ,etc up to nineteen months. Results of time lag analysis has been shown in figure 1. It is apparent from the figure 1 that correlation are significantly higher (r > -0.9) for all the second parts of the ascending phases in comparison to all the other phases of solar cycles 19 to 22.

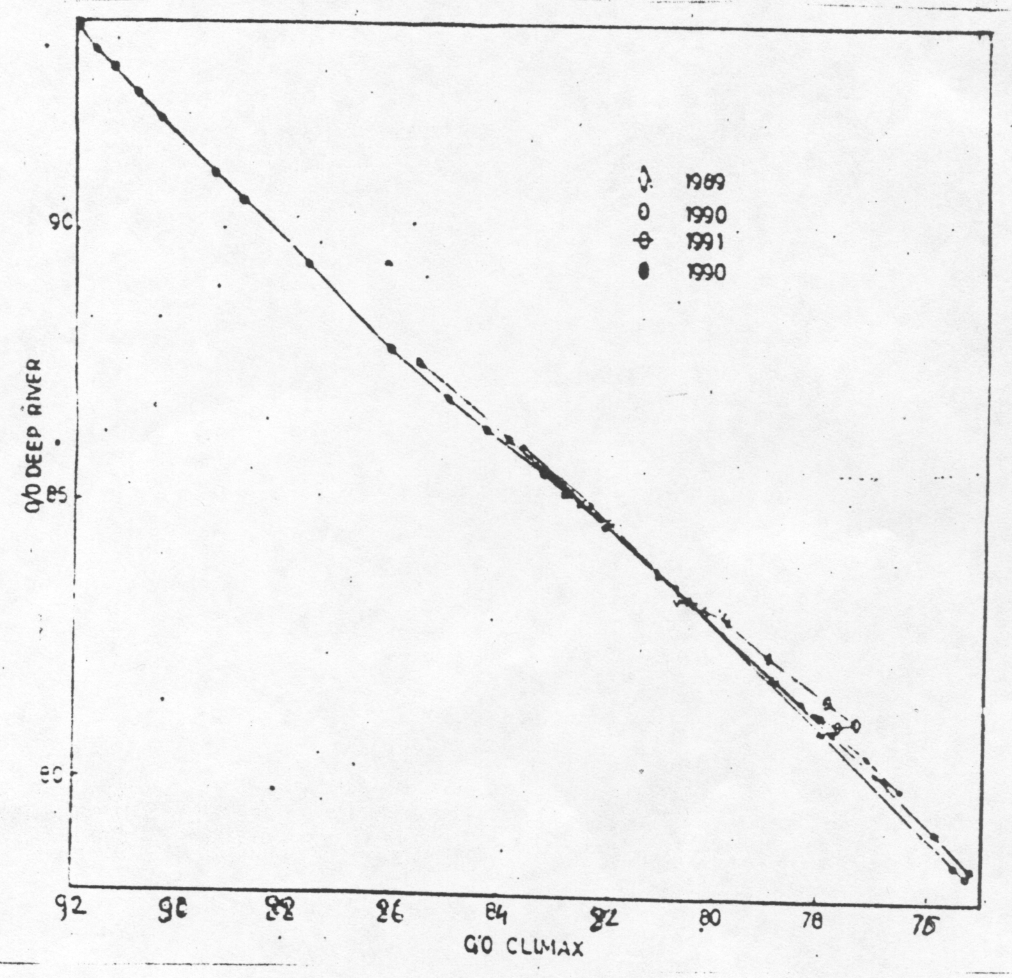

Figure 3.Same as figure 2,but for the period 1989 to 1992.

Further ,phase lag analysis has been also done for the solar. cycles 22. A phase lag between the modulation of low and high rigidity cosmic rays generally produce a loop like structures. Figure 2 shows the correlation plot of normalized count rates of deep river (1.1 Gev) against Climax (3.01 Gev) from 1984 to 1988 ,which cover almost minimum solar activity periods. A narrow loop is clearly seen in this diagram. Several step like changes are also seen due to the modulation effects of traveling shocks passing earth. Study have been further extended for the high solar activity period 1989 to 1992 for same pair of stations as shown in figure 3. Figure 3 shows rectangular curve with complete absence of hysteresis in regression plot between Deep river and Climax data for the maximum solar activity period of solar cycle 22.

4.Conclusions.

According to time lag analysis ,it is concluded from time lag analysis that the second part of the ascending of sun spot cycles are found more active in cosmic ray modulation. High negative correlation is noticed during the second part of all the sun spot cycles. Similarly the phase lag analysis between two cosmic ray data from tow different energy range produce hysteresis curve during minimum solar activity periods. On the other hand loop is not observed in high solar activity period.

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References.

Venkateson, D. & Badruddin 1990 Spce Sci. Rew. 52,121

Shrivastava, P.K. 1990 Proc. 21st.ICRC Adelaide,6,65.

Shrivastava, P.K. Shukla R. P. & Agrawal S.P. 1993 Proc. NAT.ACAD.SCI.INDIA 63(A) IV,663.

Stroker,P.H. & Moraal, H. 1986. J. Geophys. Res.(USA),91,1355

Shea,M, & Smart, D.F. 1985 Proc. 25th.ICRC Lajolla (USA) 4, 501

Singh,M., Nigam., S.K. & Shrivastava P.K. 1997,Proc.25th. ICRC Durban 2,33