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Correlative Analysis of Long Term Cosmic Ray Variation in Relation with Sunspot Number

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Abstract
In this paper we will study about the relation between Cosmic ray Intensity(CRI) and Sunspot Number for solar cycle 22, 23 and 24.For this we have taken the data of cosmic ray intensity from various neutron Monitor stations .These neutron monitor stations are well maintained stations and provide reliable cosmic ray data for variation study. A detail correlative study have been done by running cross correlation method. The cosmic ray intensity and sunspot number shows high and negative correlation among themselves. Sunspot number shows anti phase with Cosmic ray Intensity (CRI).
Keywords:- Cosmic –ray; Solar Cycle; Solar activity; Sunspot number

Introduction

In the past a lot of work has been done to correlate the solar parameters with cosmic ray intensity on long term basis. In the recent past two ideas have motivated much to modulation research.The first originally proposed by Lockwood (1960), is that the long term modulation of cosmic ray intensity i.e. 11 year variation result from pileup of individual intensity decreases caused by shock's and other disturbance in solar wind. The second major idea is that gradient end curvature drifts, long neglected in theories of modulation may be significant and in some cases dominant in governing the modulation of cosmic rays [1-3]. Generally sunspot numbers have been used as a representative of solar activity index for various studies. Solar terrestrial relationships provide an important factor to explain the aspects of the 11 and 22 year variation of galactic cosmic ray.The 11 year variation in Cosmic ray Intensity observed on the earth is anti-correlated with sunspot number[4-5]. The Cosmic ray Intensity curve follow a 22 year cycle with alternate maxima being flat topped and peaked as predicted by models of Cosmic ray modulation based on the observed reversal of the sun's magnetic field polarity after every 11 year and curvature and gradient drifts in the large scale magnetic field of the heliosphere[6-10]..In this paper we have made an attempt to derive the correlation between Sunspot number and Cosmic ray Intensity for solar cycle22, 23 and 24.The solar cycle 22 have been started in the September 1986 and ended in the year 1996(May). The solar cycle 23 lasted in 12.6 years, beginning in May 1996 and ending in December 2008. The maximum smoothed sunspot number (monthly number of sunspots averaged over a twelve-month period) observed during the solar cycle 23 was 120.8, and the minimum was 1.7. There were a total of 805 days with no sunspots during this cycle.[11]

METHOD OF ANALYSIS

In this paper we will find the correlation between Cosmic ray intensity and solar parameter sunspot number for solar cycle22, 23 and 24(incomplete) .For this monthly mean values of sunspot number (Rz) are taken from the Solar Geophysical Data books. The pressure corrected monthly mean value of cosmic ray data of Moscow, Russia (Cutoff Rigidity=2.42GV) neutron monitor station have been taken for analysis. In this paper we will also make comparative study of solar cycle 22, 23 and 24.

RESULTS AND DISCUSSION

Solar activity rises and falls with a period of about 11 years .The number of sunspots indicates the level of solar activity. The emissions of matter and electromagnetic fields from the sun increases during high solar activity, making it harder for Galactic Cosmic Ray to reach the earth. Cosmic ray intensity is lower when solar activity is high and vice versa. The long term modulation of cosmic ray intensity has been studied by several scholars in relation with sunspot number, and a high negative correlation is found between them. The fig.3 shows correlation between sunspot number and Cosmic ray intensity(CRI) for solar cycle 22, 23 and 24(incomplete).

Figure 1 & 2 shows the linear plot of Sunspot number and Cosmic ray intensity with year. From fig.3&4 it is clear that sunspot number and CRI are anti- correlated. Following conclusions can be drawn:

1) The solar 22 started in September 1986 and ended in May 1996.The total length of cycle 22 is 9.7 years. The solar cycle 23 started in May 1996 and ended in December 2008 and total length of cycle is 12.6 yrs. Thus solar cycle 23 is longer than solar cycle 22.The solar cycle 24 has started in the year 2008(December) and is incomplete.

2) The solar activity of solar cycle 22 shows increasing phase from 1986 to 1989 and then decreasing phase from 1989 to 1996.At the same time Cosmic ray intensity(CRI)decreases for the period 1986-1991 and shows increasing phase from 1991 to 1996.Thus from the figure it is clear that as sunspot activity increases ,at the same time Cosmic ray intensity (CRI) decreases. Thus both sunspot number and cosmic ray intensity shows anti-phase with each other.

3) The solar activity of solar cycle 23 shows increasing phase from 1996 to 2000 and then decreasing phase from 2000 to 2008.At the same time CRI decreases for the period 1996-2000 and shows increasing phase from 2000 to 2008.Thus it is clear from fig 3. that for cycle 23 also sunspot activity and Cosmic ray intensity(CRI) are anti-correlated.

4) The solar cycle 24 has started in the year 2008(Dec) and is incomplete. But it seems to be that solar cycle 24 is weaker in solar activity as comparison to cycle 22 and 23.

5)From fig.4 the correlation coefficient between sunspot number and Cosmic ray intensity (CRI) for solar cycle 22,23 and 24 is found to be -0.90057 which is highly negative correlated.

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Graphs:

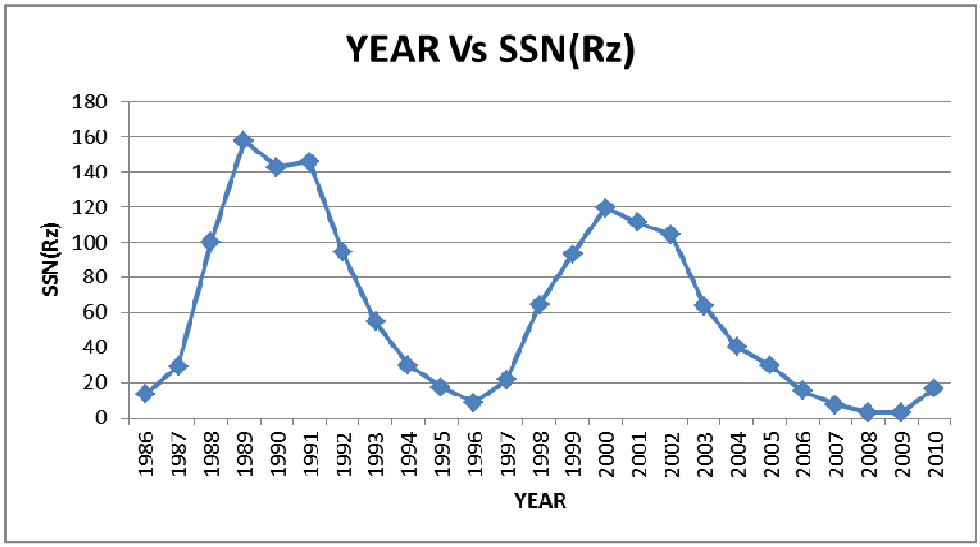

Fig:1 Year Vs average yearly values of sunspot number(Rz) for solar cycle 22,23 and 24

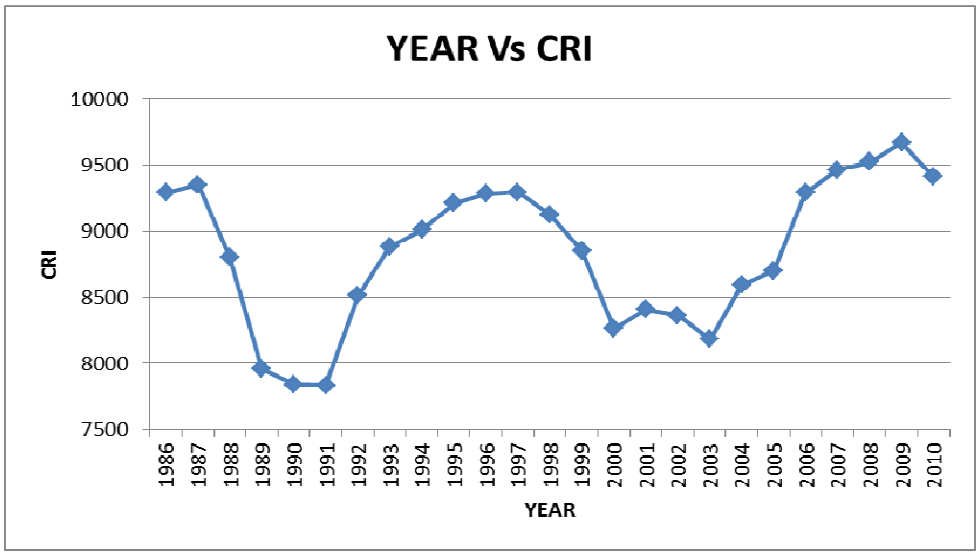

Fig:2 Year Vs average yearly values of Cosmic Ray Intensity(Moscow Neutron Station) for solar cycle 22,23 and24

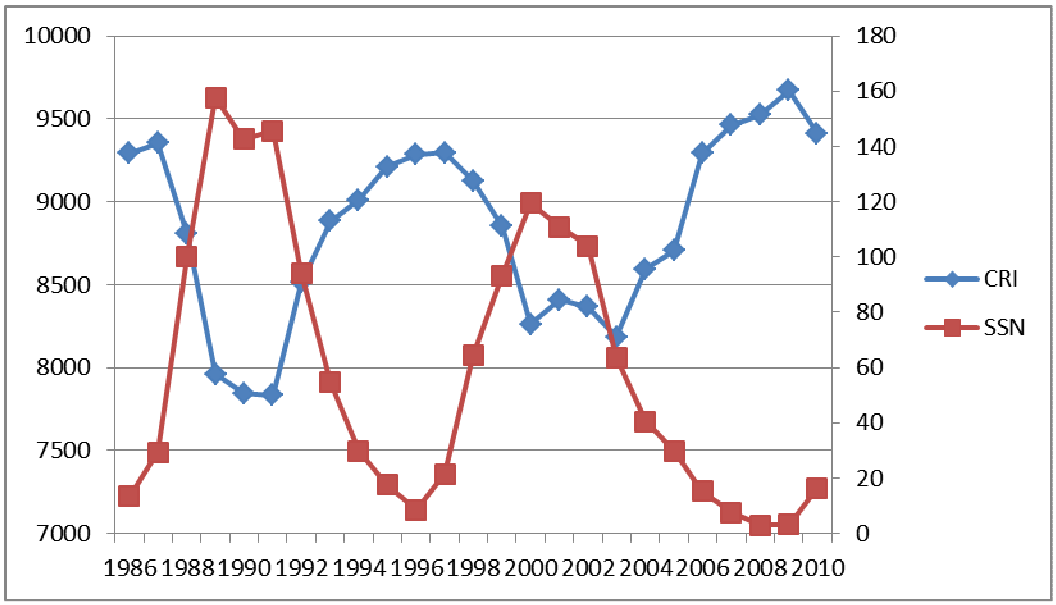

Fig:3 Shows cross-plot curve between yearly value of sunspot number(Rz) and Cosmic Ray Intensity (Moscow Neutron Station) for solar cycle 22,23 and24

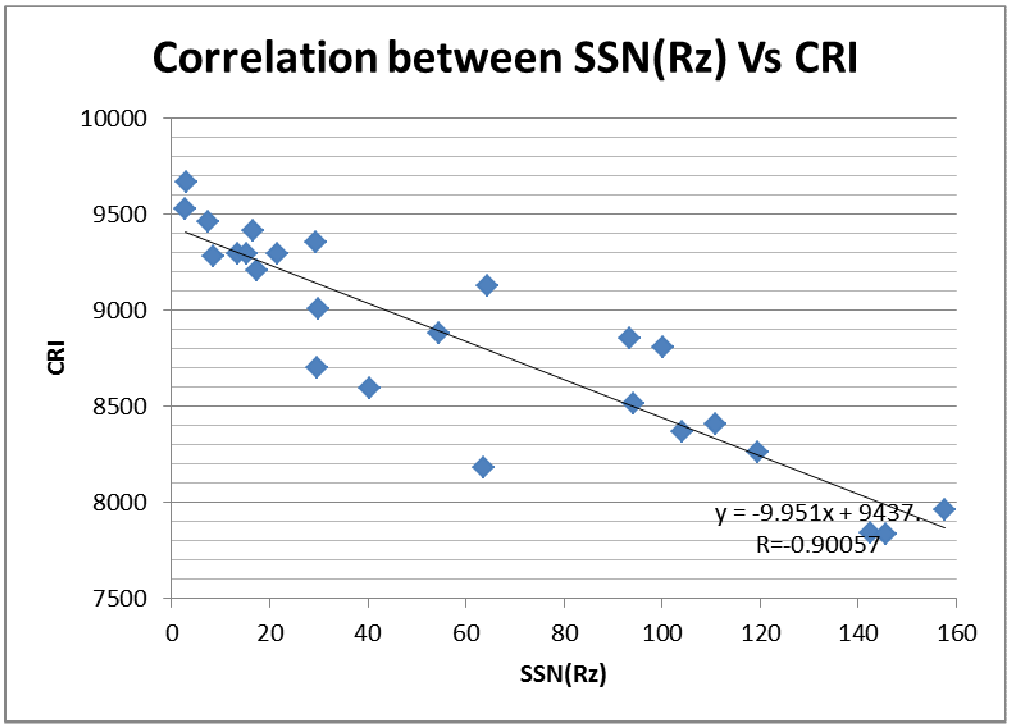

Fig:4 Shows Correlation curve between yearly value of sunspot number(Rz) and Cosmic Ray Intensity(CRI) for solar cycle 22,23 and24