



COMPARATIVE STUDY OF ODD-EVEN ASYMMETRY OF LONG-TERM VARIATION OF COSMIC RAY INTENSITY

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Abstract: To show the long-term cosmic ray intensity variation along with solar activity we have plotted the yearly mean values of the cosmic rays and solar parameter for the different solar cycles which cover the solar cycle 20 to 23. The effect of various solar activity parameters on the long-term variation of cosmic rays have been reported in literature by several investigators. Almost all have shown that the change in cosmic ray intensity lags behind the solar activity changes by a few months to years in different 11 - year solar cycles. Alternate cycles usually show similar behaviour. The larger slope means that the solar activity parameters produce much larger rate of change of cosmic ray intensity during the period 1986-2008.

Keywords: Cosmic rays, sunspot numbers

I. Introduction

Solar modulation of the cosmic ray has been an interested field since last four to five decades. The propagation and transport of high energy cosmic rays within the heliosphere and the surface of the earth studied since a long-time. Long-term cosmic ray modulation and its association with solar activity were studied by a number of cosmic ray researchers (Shea and Smart, 1985; Shrivastava *et al.* 1989, 1993; Venkatesan and Badruddin, 1990, Singh and Badruddin 2007, Dwivedi *et al.* 2009). It was understood that solar flares and Sunspots were the active regions responsible for sporadic variation in cosmic ray intensity. Several energy sources such as solar flares, coronal holes, solar wind, coronal mass ejection etc. As Sunspots are considered a reliable index of solar activity and key source of solar outputs as therefore, it is essential to find correlation between cosmic rays and Sunspot numbers.

II. Data and Method

In the present analysis, the days of large Forbush decreases type of variations have not been removed which if removed will give us a good comparative study. The other solar activity indices should also be used to obtain the best solar parameter for the period of our investigation.

III. Observational Results

To show the long-term cosmic ray intensity variation along with solar activity we have plotted the yearly mean values of the cosmic rays and solar parameter for the different solar cycles shown in figure 1.1, which cover the solar cycle 20 to 23. In figure 1.1 yearly mean values of Kiel NM cosmic ray counts rates are plotted against the yearly mean values of Sunspot numbers. We show the yearly average values of the cosmic ray intensity (I) for near about four solar cycles of Sunspots number (Rz). The 11 / 22 years cosmic ray intensity cycles in anti-relationship with Sunspot cycles are clearly seen for all the four successive solar cycles 20 to 23. From figure it is seen that solar cycle 20 has lots of differences from other solar cycle the mini and descending phase cycles are effective in solar cycle 20 which are seemingly occurred during the time of heliospheric neutrally flat sheet. The mini cycle existing within the declining phase cycle is the parts of causative solar activities related to additionally important research over cosmic ray anisotropic variations. In the mini cycle the highest upper cutoffs and also comparatively higher effective cutoffs undergo. Cycle 21 and 22 are also found different from other solar cycles where both maximum and minimum do not activity and inverse law of the summation of solar activity and cosmic ray intensity, the activities of solar parameters have different impacts on the ascending and descending phase of the same solar cycle

with differences in fluctuations of cutoff rigidities. There are rare events within solar cycles where the usual relations between cosmic ray intensity and solar activity indices are not obeyed.

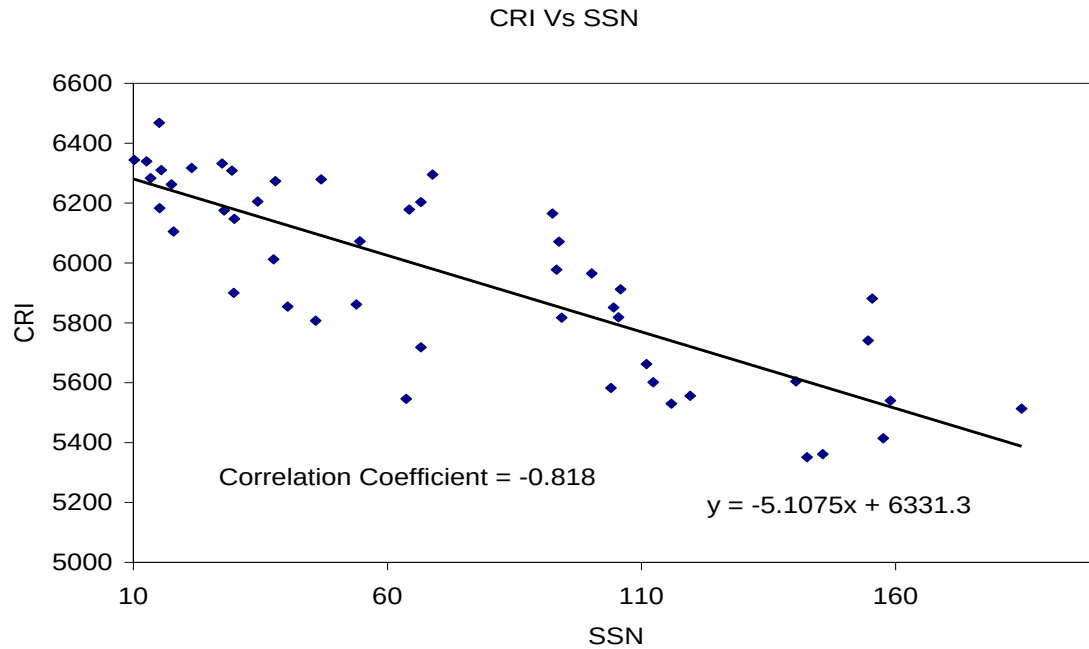


Figure 1.1 Shows the annual mean values of CR intensity and Rz.

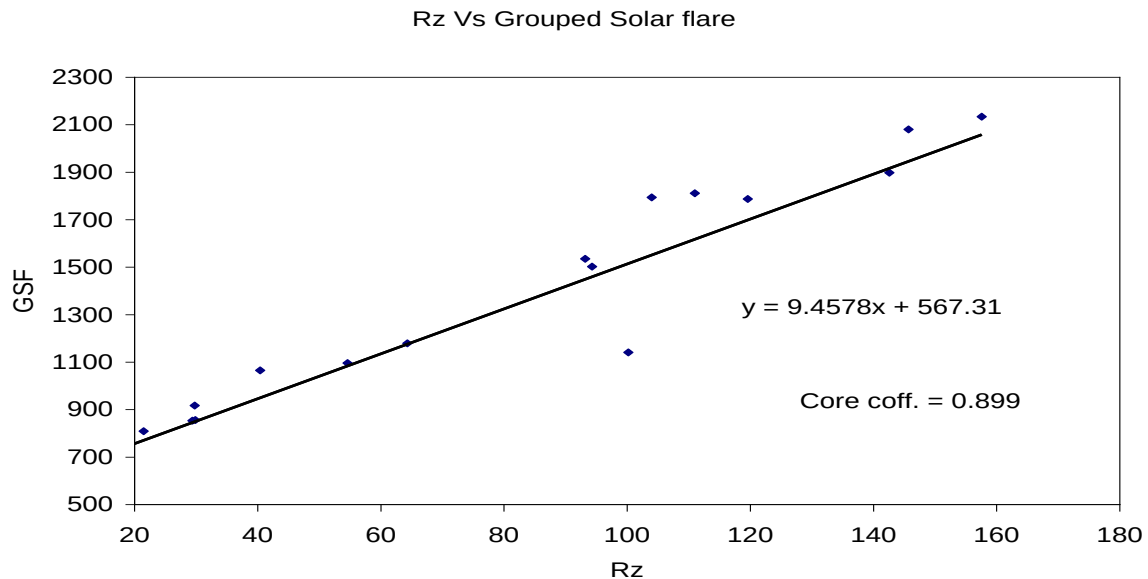


Figure 1.2 Shows the annual mean values of GSF and Rz for the period 1986 to 2008.

Figure 1.1 supports the odd-even hypothesis of cyclic variational pattern of cosmic ray intensity with sunspot number on long-term basis. Such a cyclic variation is not seen for the geomagnetic disturbance index Ap in combination with Rz. Therefore, it can be assumed that the annual mean values of Rz is not perfect parameter of solar activity to estimate geomagnetic field variation of Earth. Interestingly a peculiarities is seen during descending phases of sunspot solar cycle 20 (1965-1976), solar cycle 21 (1976-1986) solar cycle 22 (1981-1996) and solar cycle 23 (1996-2010) in which large cosmic rays depressions and high geomagnetic disturbances are observed in association of medium range of sunspot numbers. IT indicates a strong relationship between cosmic rays and geomagnetic activity, particularly for certain solar activity periods.

It is well known that if we plot yearly mean of cosmic ray intensity against sunspot number, it creates a loop-like structure. Nagapshima and Murishita 1979, have studied the loop like structure in detail and reported odd-even hypothesis in long-term cosmic ray modulation.

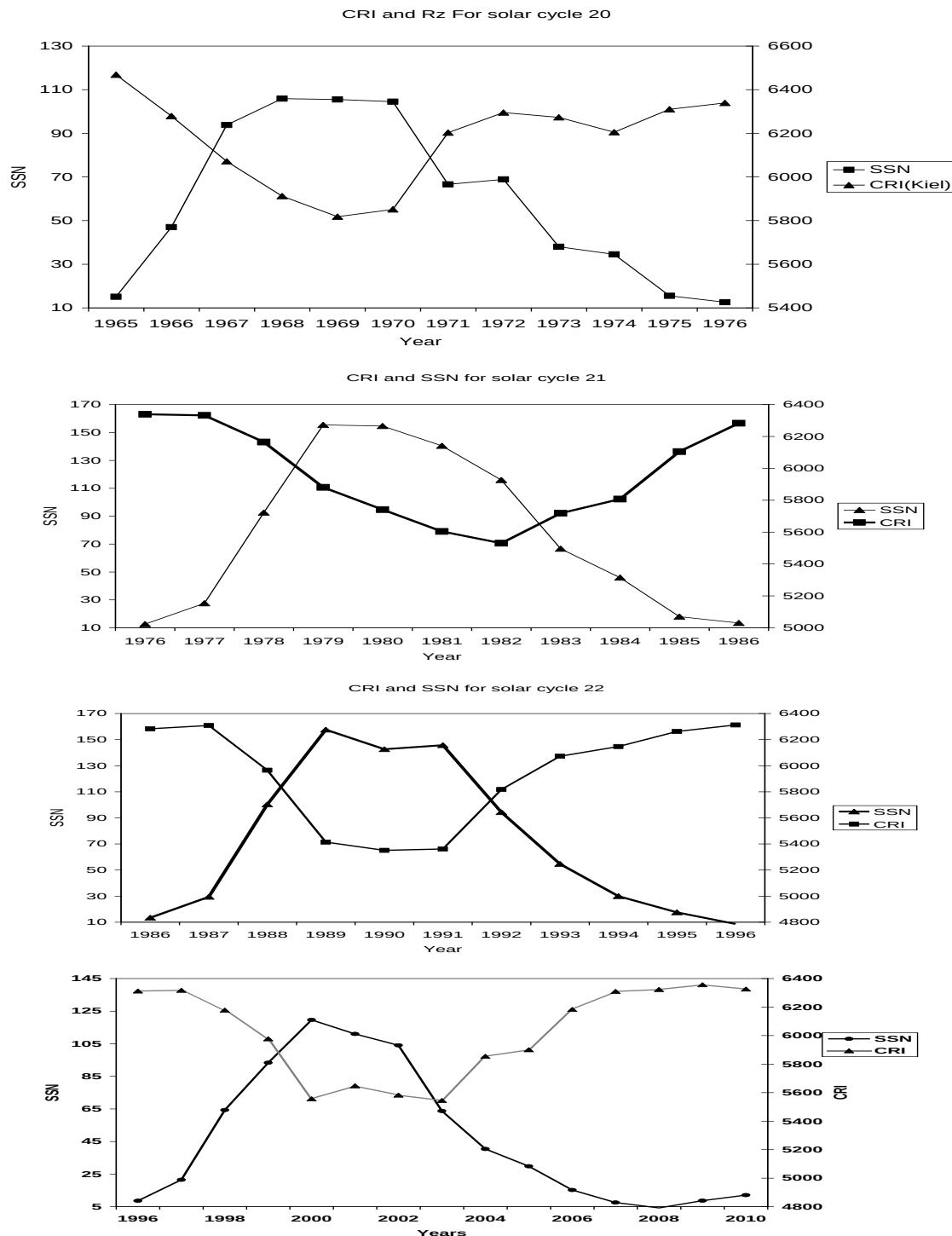


Figure 1.3 Shows the odd-even asymmetry of long-term variability of CRI and Solar activity parameters for the solar cycles 20 to solar cycle 23.

The 11 / 22 years cosmic ray intensity cycles in anti-relationship with Sunspot cycles are clearly seen for all the four successive solar cycles 20 to 23.

IV. Discussion

The cosmic ray particles are affected by the electromagnetic disturbances while transporting from galactic space to earth. It has been well known that cosmic ray intensities are modulated by solar activity cycle from one to another.

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