International Journal of Science, Environment and Technology, Vol. 2, No 5, 2013, 903 – 910

ISSN 2278-3687 (O)

CORRELATIVE ANALYSIS OF LONG TERM COSMIC RAY MODULATION IN RELATION WITH SOLAR ACTIVITY FOR THE PERIOD 1986-2008

[1]Uma Pandey, [2]Mahendra Singh, [3]Pankaj K. Shrivastava and [4]Mukesh Jothe

[1,2]Department of Physics, MVM, Bhopal-462003 (M.P.), India

[3]Department of Physics Govt. Model Science College, Rewa-486001, (M.P.), India

[4]Department of Physics Govt. MGM College, Itarsi-461111, (M.P.), India

E-mail: [1]uma.pandey185@gmail.com

Abstract: In this paper we will make a detail study of the relationship between Cosmic ray Intensity (CRI) and Solar activity. For this we have taken the data of Sunspot number and Solar flux for the period 1986 to 2008 and detail study have been made to correlate the Cosmic ray intensity with these two solar parameters namely sunspot number and solar flux. Cosmic ray Intensity (CRI) data have been taken from various neutron monitor stations which are well maintained stations and provides reliable cosmic ray data for variation study. A detail correlative study has been done by running cross correlation method. The cosmic ray intensity shows high and negative correlation with solar parameters namely sunspot number and solar flux. These parameters show anti phase with Cosmic ray Intensity (CRI).

Keywords: Cosmic ray; Solar Cycle; Solar activity; Sunspot number; Solar Flux.

Introduction

Solar modulation of cosmic ray intensity has been extensively investigated in the past years by using the data of various ground based neutron monitor stations in relation with various solar parameters such as sunspot number, solar flares, solar flux etc. (Shrivastava et al., 1993; Herber et.al., 2006). Generally sunspot numbers are used as one of the reliable parameters to measure solar activity [1-10]. Sunspots are relatively dark areas on the radiating 'surface' (photosphere) of the Sun where intense magnetic activity inhibits convection and cools the photosphere. Faculae are slightly brighter areas that form around sunspot groups as the flow of energy to the photosphere is re-established and both the normal flow and the sunspot-blocked energy elevate the radiating 'surface' temperature. Scientists have speculated on possible relationships between sunspots and solar luminosity since the historical sunspot area record began in the17th century [1-2].

It has been well known for a long time that intensity as well as the energy spectrum of the galactic cosmic ray is modulated by solar activity. Because of the huge domain of the

*Received July 22, 2013 * Published October 2, 2013 * www.ijset.net*

heliosphere and diffusive /drift propagation of cosmic ray particles, there is a time- lag in correlation between sunspot number and cosmic ray intensity as well as the amplitude of modulation varies from cycle to cycle [3-5]. The cosmic ray intensity varies inversely with sunspot numbers, showing maximum intensity at time when solar activity is the minimum in the 11- year sunspot cycle (Forbush 1954, 1958). Forbush determined that the intensity of Galactic cosmic rays varies inversely with sunspot number [6-7]. Cosmic rays have their maximum intensity at the minimum of the 11 yr sunspot cycles. The cosmic-ray intensity curve also appears to 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 every 11 yr and curvature and gradient drifts in the large-scale magnetic field of the heliosphere [8-11]. The cosmic ray time profiles are more flat-topped (sharply peaked) around solar minimum when the interplanetary magnetic fields have a positive (negative) polarity in the northern hemisphere. This phenomenon is likely due to CR gradient, curvature and current sheet drift transport, which depends on the sign of the magnetic field polarity [12]. Solar flux, is also a good indicator of solar activity. The 10.7cm Solar Flux is the disk integrated emission from the sun at radio wavelength of 10.7cm (2800MHz). Measurements of this flux have been taken daily by the Canadian Solar Radio Monitoring Programme since 1946 [13].

METHOD OF ANALYSIS

In this paper we will find the correlation between Cosmic ray intensity and solar parameters sunspot number & solar Flux for the period 1986 to2008. For this, monthly mean values of sunspot number (Rz) and solar flux are taken from the Solar Geophysical Data books. The pressure corrected monthly mean value of cosmic ray data of Beijing, China (Cutoff Rigidity = 9.56GV.) neutron monitor station have been taken for analysis.

RESULTS AND DISCUSSION

The long term modulation of cosmic ray intensity has been studied by several scholars in relation with solar activity, and a high negative correlation is found between them. Fig.7 & 9 show correlation graph between Sunspot number Vs Cosmic ray intensity (CRI) and Solar Flux Vs Cosmic ray intensity (CRI) for the period 1986 to 2008 respectively. From fig.7&9 it is clear that sunspot number and solar flux are anti-correlated with Cosmic ray intensity (CRI). The period 1986 to 2008 comprises of two solar cycle 22 and 23. The solar cycle 22 started in September 1986 and ended in May 1996 and the solar cycle 23 started in May 1996

and ended in December 2008. Thus solar cycle 23 is longer than solar cycle 22. Following conclusions can be drawn from the figures:

1) Fig.4 shows the correlation between two solar parameters sunspot number and solar flux for the period 1986 to 2008. From the figure 4 & 5 it is clear that sunspot number and solar flux shows strong and positive correlation with each other. The correlation coefficient between sunspot number and solar flux is found to be R = 0.98913.

2) For solar cycle 22, sunspot number shows increasing phase from 1986 to 1989 and then decreasing phase from 1991 to 1996. At the same time cosmic ray intensity (CRI) decreases for the period 1986 to1989 and then shows increasing phase from1991to1996. Thus from the fig.6 it is clear that as Solar activity increases, at the same time Cosmic ray intensity (CRI) decreases. Thus both show anti-phase with each other.

3) For solar cycle 22 solar flux shows increasing phase from 1986 to 1989 and then decreasing phase from 1991 to 1996. At the same time cosmic ray intensity (CRI) decreases for the period 1986-1989 and then shows increasing phase from 1991 to 1996. Thus from the fig. 8 it is clear that Solar Flux & Cosmic ray intensity (CRI) are anti correlated.

4) For solar cycle 23, the sunspot number shows increasing phase from 1996 to 2000 and then decreasing phase from 2001 to 2008. At the same time cosmic ray intensity (CRI) decreases for the period 1996-2001 and then shows increasing phase from 2001 to 2008. Thus it is clear from fig. 6 that for cycle 23 also Sunspot activity and Cosmic ray intensity (CRI) are anti-correlated.

5) For solar cycle 23, the solar flux shows increasing phase from 1996 to 2001 and then decreasing phase from 2001 to 2008.At the same time cosmic ray intensity (CRI) decreases for the period 1997-2000 and shows increasing phase from 2003 to 2008. Thus it is clear from fig. 3 that for cycle 23 also solar flux and Cosmic ray intensity (CRI) are anti-correlated.

6) The correlation coefficient between Sunspot number and Cosmic ray intensity (CRI) for the period 1986-2008 is found to be -0.9233 which is highly negative correlated.

7) The correlation coefficient between Solar flux and Cosmic ray intensity (CRI) for the period 1986-2008 is found to be -0.9220 which is highly negative correlated.

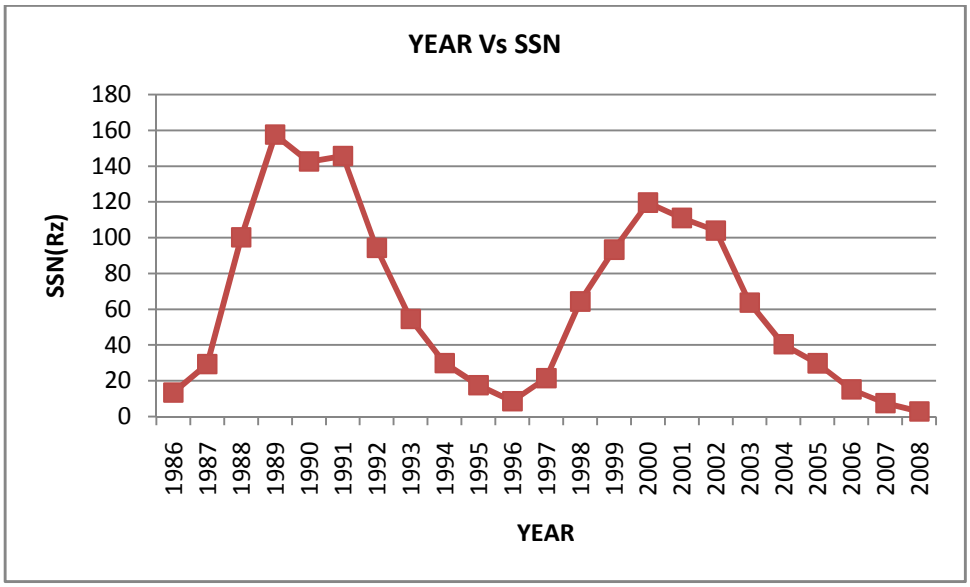

Fig: 1 Year Vs average yearly values of sunspot number (Rz) for the period 1986 to 2008

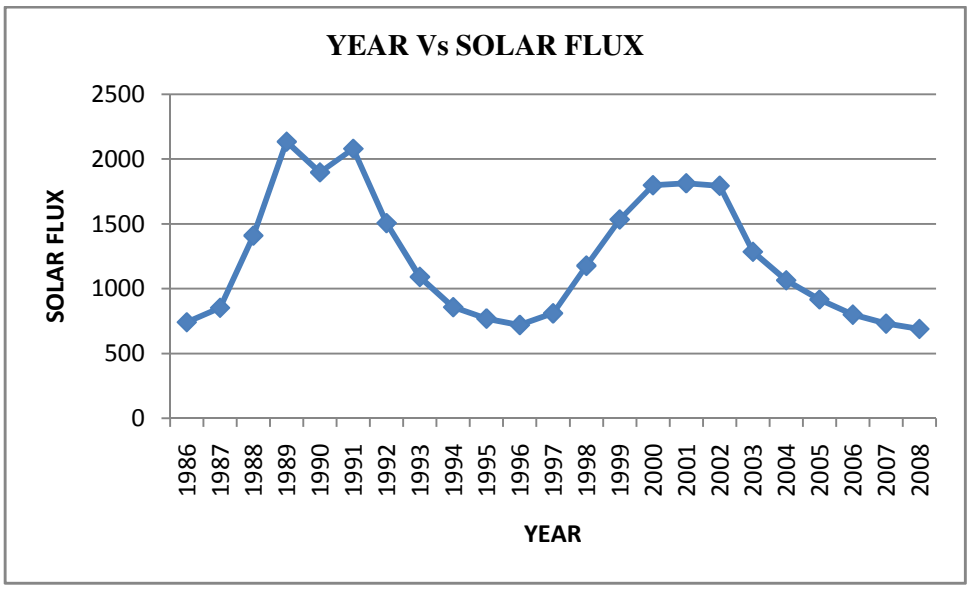

Fig: 2 Year Vs average yearly values of Solar Flux for the period 1986 to 2008

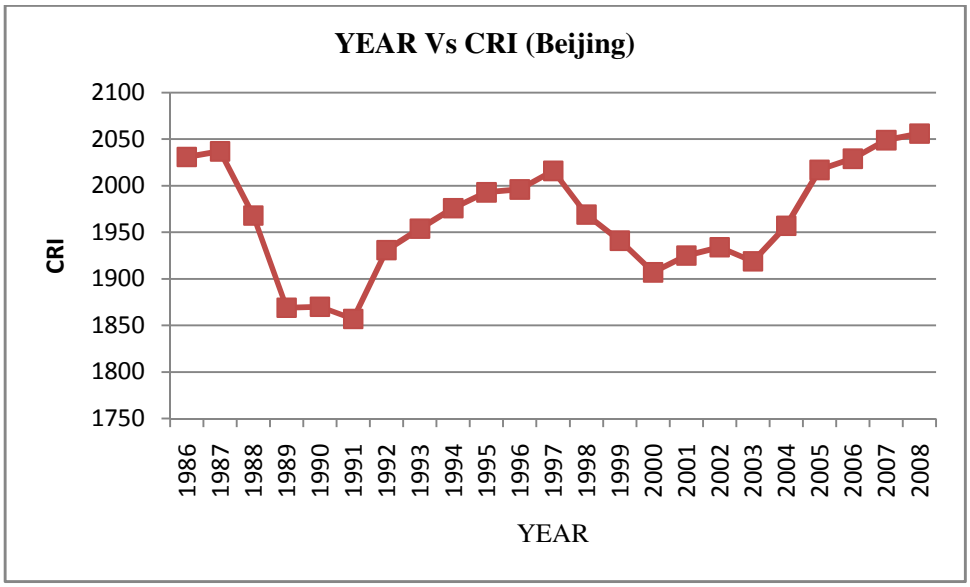

Fig: 3 Year Vs average yearly values of Cosmic Ray Intensity (Beijing Neutron Station) for the period 1986 to 2008

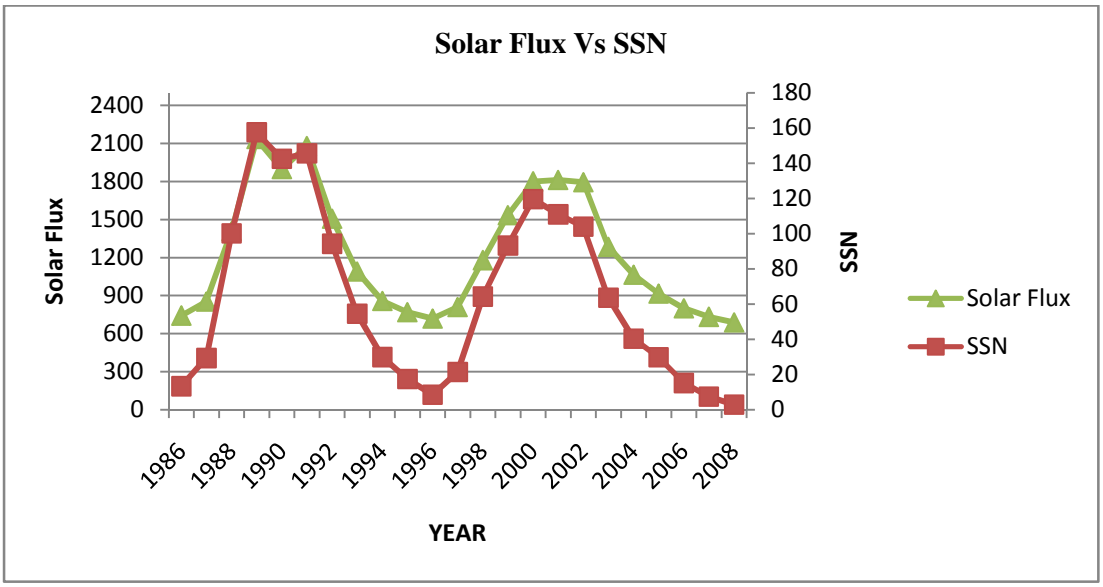

Fig: 4 Shows linear-plot curve between yearly values of sunspot number (Rz) and Solar Flux for the period 1986 to 2008

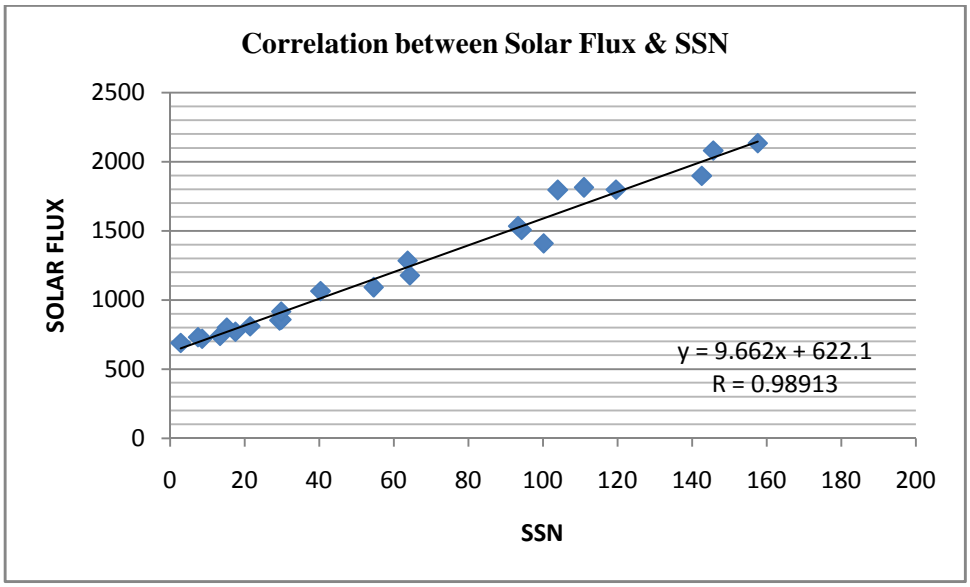

Fig: 5 Shows Correlation curve between yearly value of sunspot number (Rz) and Solar Flux for the period 1986 to 2008

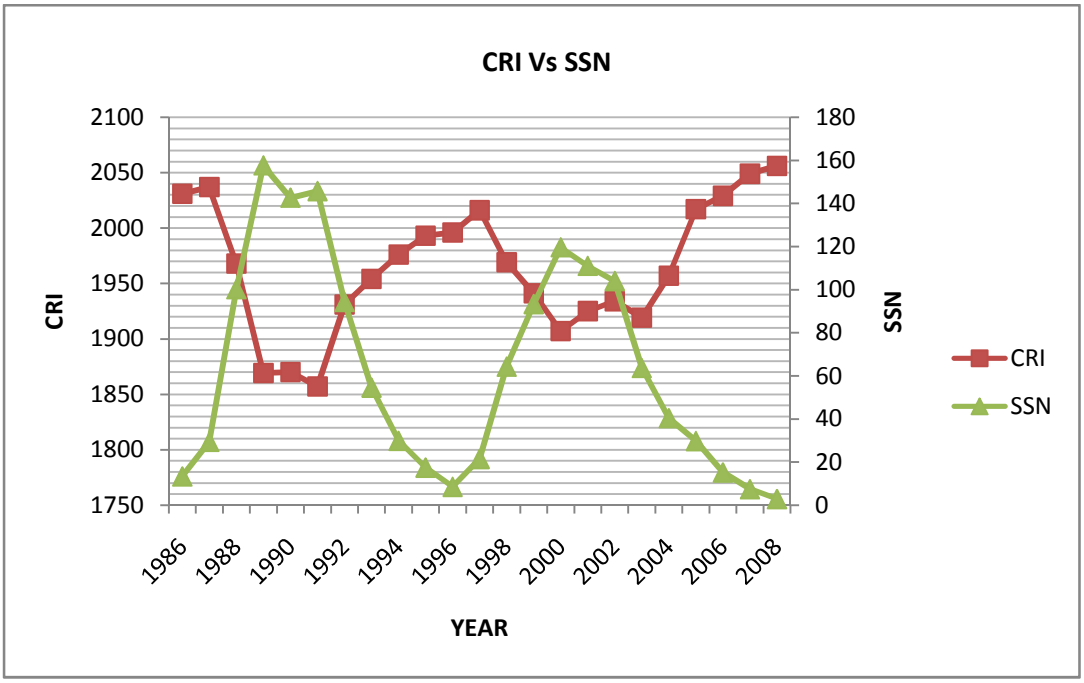

Fig: 6 Shows linear-plot curve between yearly value of sunspot number (Rz) and Cosmic Ray Intensity (CRI) for the period 1986 to 2008

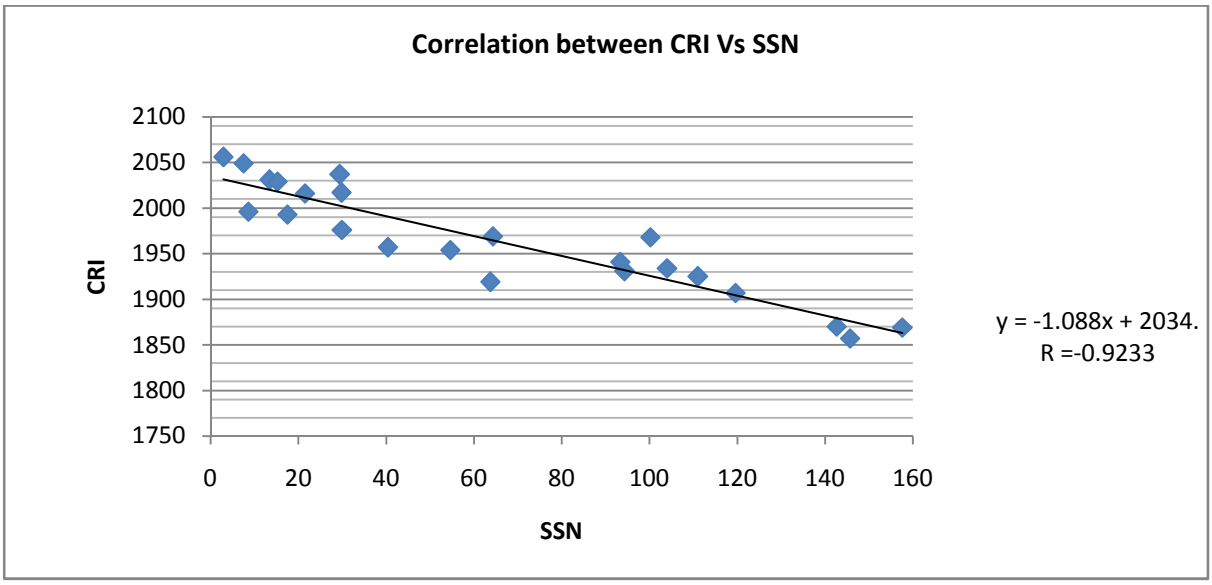

Fig: 7 Shows Correlation curve between yearly value of sunspot number (Rz) and Cosmic Ray Intensity (CRI) for the period 1986 to 2008

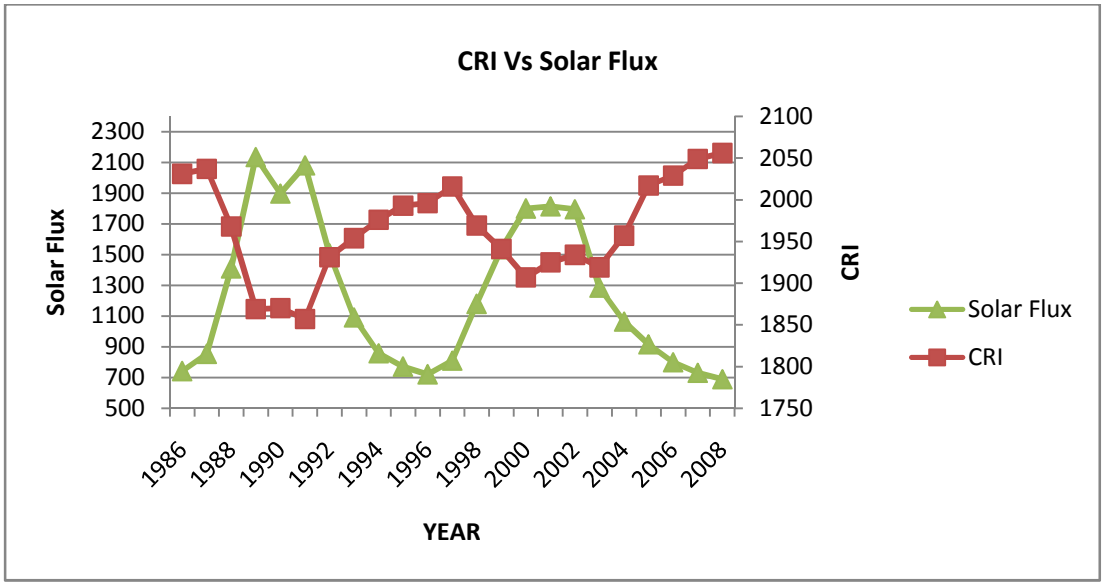

Fig: 8 Shows linear-plot curve between yearly values of Solar Flux and Cosmic Ray Intensity (CRI) for the period 1986 to 2008

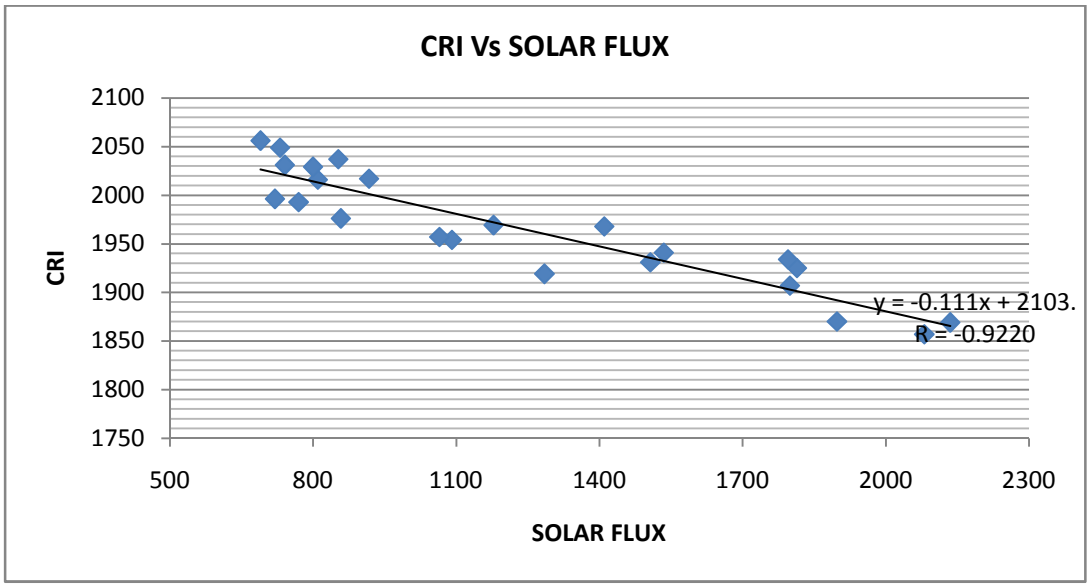

Fig: 9 Shows Correlation curve between yearly value of solar flux and Cosmic Ray Intensity (CRI) for the period 1986 to 2008

References

[1] Eddy, J.A., 1990, *Journal for the History of Astronomy* **21**: 111–20.

[2] Foukal, P.V.; Mack, P. E.; Vernazza, J. E. ,1977, *The Astrophysical Journal* **215**: 952.

[3] Dorman L I, 2001, *Adv space Res (USA)*, **27** (3)571.

[4] Dorman I V & Dorman L I, 1967, *J Geophys Res(USA)*, **72**,1513.

[5] Nagashima K & Morishitha I, 1979, *Proc of 16th ICRC, Tokyo, Japan*, Vol.**3**, p.325.

[6] Forbush, S.E. 1954, *J. Geophys. Res*., **59**, 525.

[7] Forbush, S.E. 1958, *J. Geophys. Res*., **63**, 651.

[8] Jokipii, J.R., Thomas, B.T. 1981, *Astrophys. J(USA)*, **243**,1115.

[9] Jokipii, J.R., Levy, E.H., Hubbard,W.B. 1977, *Astrophys. J*., **213**,861.

[10] Smith, E. J. 1990, *J. Geophys. Res*., **95**, 18,731.

[11] Smith, E. J., & Thomas, B. T. 1986, *J. Geophys. Res*., **91**, 2933.

[12] Potgieter, M. S. and Moraal H., 1985, *Astrophys. J*., **294,** 425.

[13] Tapping, K. F., and D. P. Charrois, 1994, *Solar Phys*., **150**, 305-315.