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Study of cosmic ray intensity with solar activity parameters for the solar cycle 24

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Abstract

In this paper we have considered correlative study of Cosmic Ray Intensity (CRI) variations with solar activity parameters such as interplanetary magnetic field (IMF), sunspot numbers (SSN) and solar flare index (SFI) during the period of 2009-2019. From the correlative study we have found that negative co-relation between Cosmic Ray Intensity (CRI) with interplanetary magnetic field (IMF), sunspot numbers (SSN) and solar flare index (SFI), with: (i) Co-relation co-efficient -0.84 between Cosmic Ray Intensity and yearly average values of IMF, (ii) Co-relation co-efficient -0.94 between Cosmic Ray Intensity (CRI) and yearly average values of SSN, (iii) Co-relation co-efficient -0.95 between Cosmic Ray Intensity (CRI) and yearly average values of SFI.

Keywords: - Cosmic Ray Intensity (CRI), IMF, SSN and SFI.

1. Introduction

Cosmic rays are of galactic and extragalactic origin though small parts of cosmic rays (CR) are originated from sun as protons, alpha particles and heavier elements. Cosmic ray intensity (CRI) is almost constant outside the heliosphere but modulation happens during their passage through the heliosphere due to interplanetary magnetic field [Mavromichalaki et. al., 1988; Agarwal et. al., 1993]. Correlative analysis between the CRI and solar activity parameters SSN, GSF, and Ap have been performed for low and medium cut-off rigidity stations [Hatton 1980, Mavromichalaki & Petropoulos 1987, Mavromichalaki et. al., 1998]. Later on, other types of solar indices like 10.7-cm solar flux, grouped solar flares (GSF), solar flare index (SFI), sunspot area, grouped sunspot numbers, coronal index (CI), etc. have been used arbitrarily, mostly without assigning any physical reason for the choice of a particular index or the combination of indices [Mishra & Tiwari 2003, David et.al.,2002]. Solar flare index (SFI) has been shown to be a better index for the study of long-term variation of cosmic rays [Mishra & Tiwari, 2003]. The 11-year variation in Cosmic ray Intensity observed on the earth is anti-correlated with interplanetary magnetic field (IMFB), sunspot number (SSN) and index [Forbush, 1954]. The cosmic ray intensity varies inversely with interplanetary magnetic field (IMFB), sunspot numbers (SSN) and index, showing maximum intensity at time when solar activity is the minimum in the 11- year sunspot cycle [Forbush 1954, 1958]. In this paper we have investigated the correlations between cosmic ray intensity (CRI) with interplanetary magnetic field (IMF) sunspot number (SSN) and solar flare index (SFI) to explain the momentary behavior of cross correlation function with respect to solar activity parameters for the solar cycles 24.

2. Data and Analysis

Here we have taken yearly data of Cosmic Ray Intensity (CRI) variations from the Oulu Neutron Monitor. Also, we have taken interplanetary magnetic field (IMF), sunspot numbers (SSN) and Solar Flare Index (SFI) index data from Omni web data explorer (https://omniweb.gsfc.nasa.gov/form/dxi.html) during the period of 2009-2019. The correlation coefficient between Cosmic ray intensity and different solar activity parameters has also been calculated for the Said period using the method of “minimizing correlation coefficient method”. In this paper we will find the correlation between Cosmic ray intensity (CRI) and interplanetary magnetic field (IMF), sunspot numbers (SSN) and solar flare index (SFI) during the period of 2009-2019.

3. Results and Discussion

The sun and its outputs in the form of various interplanetary features such as interplanetary magnetic field (IMF), sunspot numbers (SSN) and solar flare index (SFI) are related to the disturbances in earth magnetic field. Figure [1] it shows the linear plot between yearly values of cosmic ray intensity (CRI) of Oulu Neutron monitor with interplanetary magnetic field (IMF) respectively. From the analysis it is clear that cosmic ray intensity (CRI) and interplanetary magnetic field (IMF) are anti-phase. It is clear from Figure [1] that Cosmic ray intensity (CRI) shows anti correlation with interplanetary magnetic fields (IMF) and correlation coefficient is found = -0.84 for the solar cycles 23 and 24. Similarly from Figure [2], it is clear that Cosmic ray intensity (CRI) shows anti-phase with sunspot numbers (SSN) and correlation coefficient between these two parameters is found = -0.94 for the solar cycles 24. Figure [3] shows linear plot between Cosmic ray intensity (CRI) with solar flare index (SFI). From Figures (3) it is clear that Cosmic ray intensity (CRI) also shows anti-correlation with solar flare index (SFI) and correlation coefficient is found = -0.95 for the solar cycles 24.

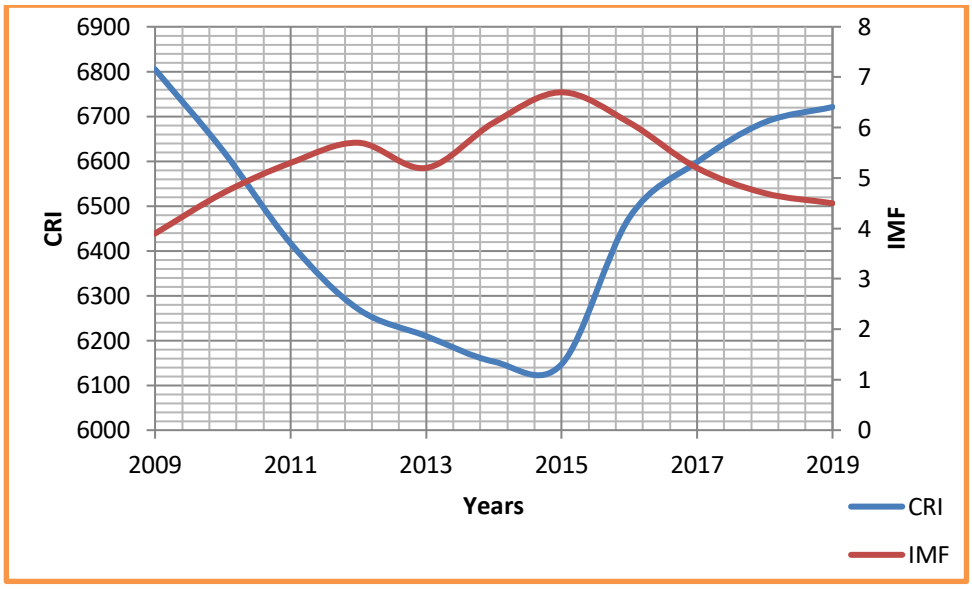

Figure.1. Shows yearly linear plot between Cosmic ray intensity (CRI) of Oulu Neutron Monitor and interplanetary magnetic field (IMF) during the period of 2009-2019.

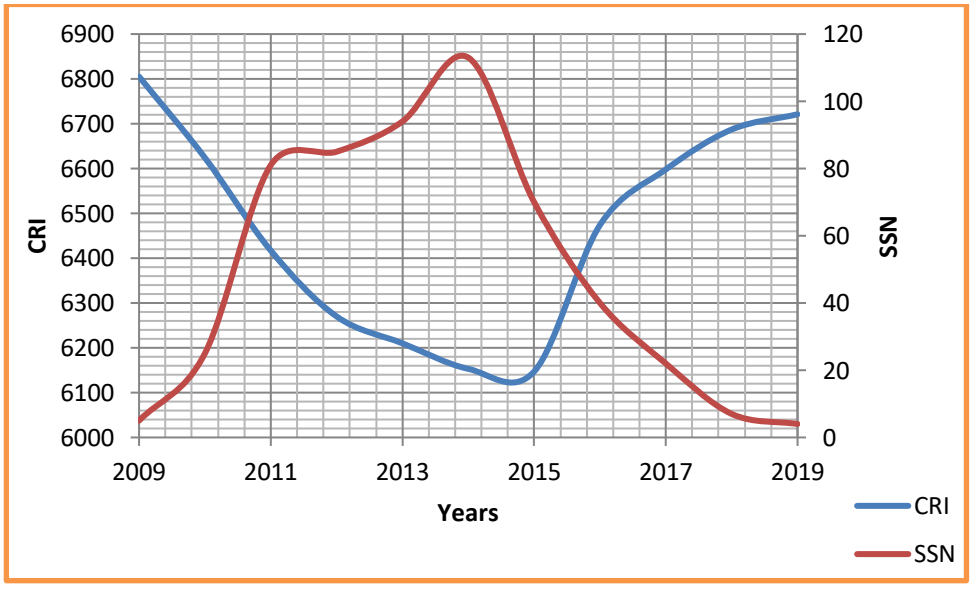

Figure.2. Shows yearly linear plot between Cosmic ray intensity (CRI) of Oulu Neutron Monitor and Sunspot number (SSN) during the period of 2009-2019.

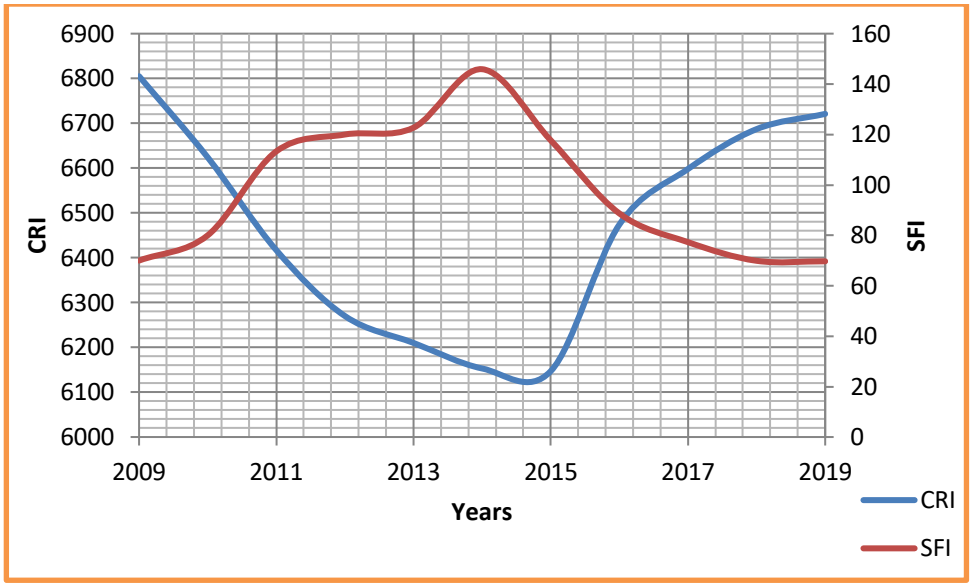

Figure.3. Shows yearly linear plot between Cosmic ray intensity (CRI) of Oulu Neutron Monitor and solar flare index (SFI) during the period of 2009-2019.

4. Conclusion

In this paper we have investigated the correlative study of cosmic ray intensity (CRI) with interplanetary magnetic field (IMF), sunspot number (SSN) and solar flare index (SFI) to explain the momentary behavior of cross correlation function with respect to solar activity parameters for the solar cycles 24. From the study we have found that negative co-relation between Cosmic Ray Intensity (CRI) with interplanetary magnetic field (IMF), sunspot numbers (SSN) and solar flare index (SFI). And we have found the anti-phase correlation between cosmic ray intensity (CRI) and solar activity parameters (IMF, SSN and SFI). The variations of cosmic ray intensity for the solar cycles give us information about the mechanism behind the ascending and descending phase of solar cycles. It is helpful for future studies in space weather forecasting and theoretical interest to understand why some cycles are very active in the declining phase and increasing phase.

Conflict of Interest

The authors declares that there is no conflict in this manuscript.

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