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Cosmic Rays Intensity Related to Geomagnetic Disturbances

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Abstract

The relation between yearly average value of cosmic ray intensity (CRI) observed at Moscow super neutron monitor during the period of 1996-2019 with yearly average values of Geomagnetic parameter Ap index and Kp index has been studied. It is noticed that the yearly average value of cosmic ray intensity is inversely correlated with the yearly average values of Ap index and Kp index. A negative correlation between the yearly average values of cosmic ray intensity (CRI) and the yearly average values of geomagnetic parameter Ap index and Kp index for the period of 1996-2019 has been found. Also, a strong negative correlation with the correlation coefficient -0.85 has been found between yearly average values of cosmic ray intensity (CRI) and Ap- index. Finally, there is a high negative correlation between the yearly average values of cosmic ray intensity (CRI) and Kp-index with the correlation coefficient -0.78.
Keywords: - Cosmic Ray Intensity (CRI), Geomagnetic Parameter Ap Index and Kp Index.

1. Introduction

Cosmic rays are assumed to be produced by a range of sources, including the remains of supernovae, neutron stars, and black holes, as well as more exotic stuff from the sun and stars and the upper radio galaxies (Firoz et al. 2010, Horowitz, et al. 2019, Diehl et al. 2022). The effects of solar variations on cosmic rays and geomagnetism have been previously studied using data from ground-based detectors (mainly the global grid of ultraneutron monitors) in combination with other solar geophysical factors. (Ables et al. 1965, Agrawal et al. 1980, Usoskin et al 1998 Jaroslav et al 2021). Long-term changes in galactic cosmic rays, as well as short-term variations in CRI (cosmic ray intensity), remain an open problem in cosmic ray research. Various studies show that the cosmic ray flux is modulated by the 11-year solar cycle of sunspot activity, reaching a maximum during the stationary phase of the solar cycle and a minimum near the peak of the solar cycle, i.e., near the peak of the solar cycle. The intensity of cosmic ray's changes with a time lag of 1-2 years depending on the solar cycle. Lockwood (1971) found out that the count rate of a neutron monitor is intrinsically related to the tilt angle of the neutron current plate at the start of the current modulation cycle. Kota and Jokipii (1991) studied the modification of cosmic rays by co-rotating interaction zones in a paradigm involving both drift and diffusion. Agrawal et al. (1993) used the spherical harmonics of the solar magnetic field to improve the correlation between the cosmic ray intensity and solar activity. Forbush (1954) showed that the mean intensity of cosmic rays has an apparent anti correlation period of 11 years with solar activity. The continuous recording of cosmic ray intensity by neutron shielding techniques has greatly inspired his work on the characteristics of the 11-year variability over the past decades. Correlative analysis between the CRI and SA parameters SSN, GSF, and Ap have been performed for low and medium cut-off rigidity stations (Hatton 1980, 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 (Chattopadhaya et al. 2003). The Correlatives analysis of long-term modulation of Cosmic Ray Intensity (CRI) variations with solar active parameters such as CMEs, sunspot numbers (SSN), solar flare index (SFT) and interplanetary magnetic field (IMF) and from the correlative studies indicated there is inverse or anti co-relation between Cosmic Ray Intensity (CRI) with sunspot numbers (SSN), solar flare index (SFT) and interplanetary magnetic field (IMF) (Singh et al., 2022, Patel et al.,2013).

2. Data Analysis

For the study of cosmic rays, the pressure-corrected data (yearly mean) have been taken from Moscow Neutron Monitor Station (http://cro.izmiran.rssi.ru/mosc/main.htm) while the data for geomagnetic indices Ap index and Kp index were obtained from the Omniweb data center (http://omniweb.gsfc.nasa.gov/cgi/nx1.cgi). The correlation coefficient of Cosmic Ray Intensity with geomagnetic indices Ap index and Kp index has been calculated using the method of "minimizing correlation coefficient method".

3. Results and Discussion

3.1. Correlative Study of Cosmic Ray Intensity (CRI) With Ap-Index

In this study there is a correlative analysis between the yearly average values of cosmic ray intensity (CRI) and the yearly average values of Ap-Index, during the period of 1996-2019. A liner graph between yearly average values of cosmic rays intensity (CRI) and yearly average values of Ap-Index, has been plotted, it is shown in fig. (3.1). From the figures, it is observed that an inverse correlation has been found between the yearly average values of cosmic ray intensity (CRI) and the yearly average value of Ap-Index. Also**,** the variation of higher values of cosmic ray intensity (CRI) with lower values of Ap-Index and the variation of lower values of cosmic ray intensity (CRI) with higher values of Ap-Index has been found. A scatter diagram has been plotted between the yearly average values of cosmic ray intensity (CRI) and the yearly average values of Ap-Index, during the period of 1996-2019 and the resulting diagram as shown in figure (3.2). From the figure, it is evident that the lower values of cosmic ray intensity (CRI) are associated with the higher values of Ap-Index and the higher values of cosmic ray intensity (CRI) are associated with the lower values of Ap-Index. A strong negative correlation between the yearly average values of cosmic ray intensity (CRI) and the yearly average values of Ap-Index, during the period of 1996-2019 with the correlation coefficient -0.85 has been found.

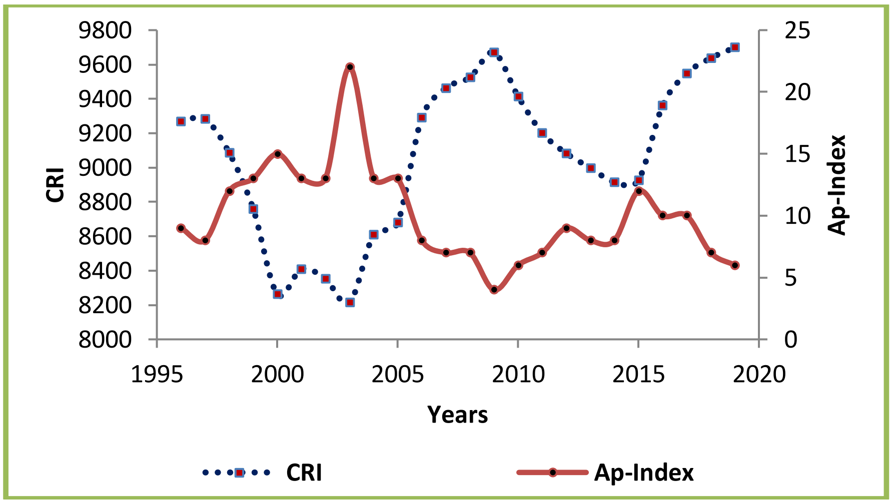

Figure-3.1 The linear diagram between the yearly average values of CRI and Ap-Index, during the period of 1996-2019.

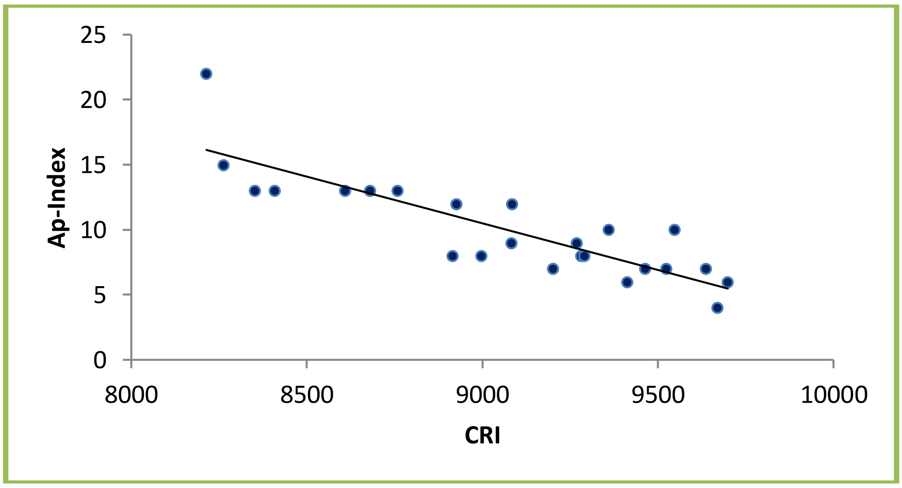

Figure-3.2 The scatter plot between the yearly average values of CRI and Ap-Index, during the period of 1996-2019 with Correlation coefficient -0.85.

3.2. Correlative Study of Cosmic Ray Intensity (CRI) With Kp-Index

In this study, a correlative analysis between yearly average values of cosmic ray intensity (CRI) and yearly average values of Kp-Index, during the period of 1996-2019 has been conducted. A liner graph between yearly average values of cosmic rays intensity (CRI) and yearly average values of Kp-Index has been plotted, it is shown in fig. (3.3). From the figures, it is observed that an inverse correlation has been found between the yearly average values of cosmic ray intensity (CRI) and the yearly average value of Kp-Index**.** Also, the variation of the higher values of cosmic ray intensity (CRI) with the lower values of Kp-Index and the variation of the lower values of cosmic ray intensity (CRI) with the higher values of Kp-Index have been found.

Also, a scatter diagram between the yearly average values of cosmic ray intensity (CRI) and yearly average values of Kp-Index, during the period of 1996-2019 has been plotted and the resulting diagram is presented in figure (3.4). The figure indicates that the lower values of cosmic ray intensity (CRI) are associated with the higher values of Kp-Index and the higher values of cosmic ray intensity (CRI) are associated with the lower values of Kp-Index. Also, a strong negative correlation between the yearly average values of cosmic ray intensity (CRI) and the yearly average values of Kp-Index, during the period of 1996-2019 with the correlation coefficient -0.78 has been found.

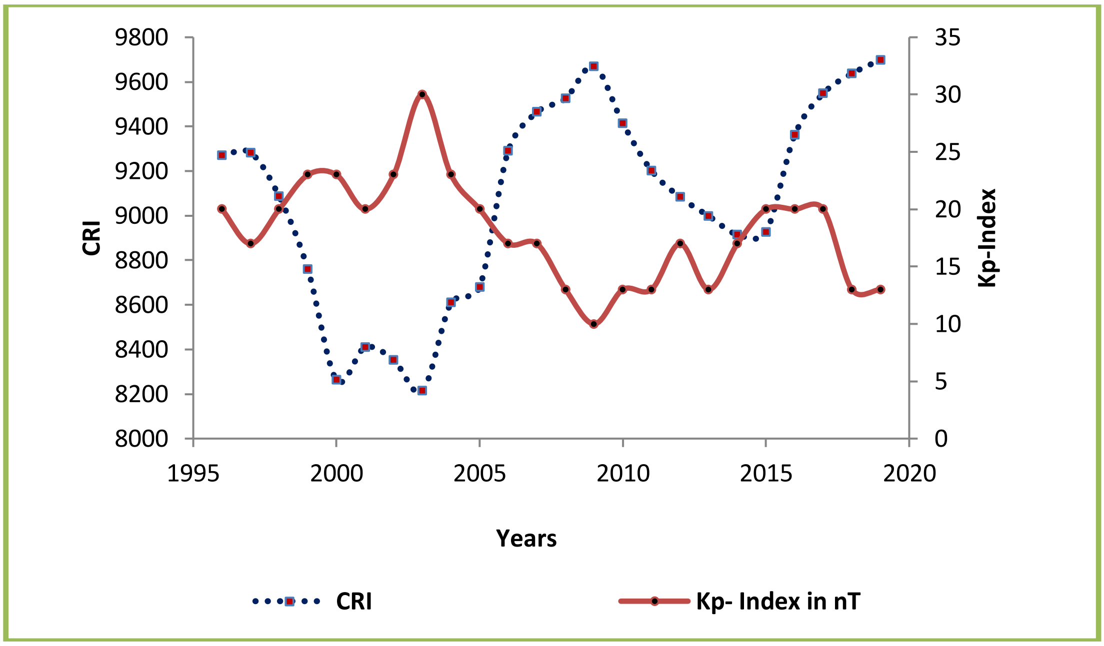

Figure-3.3 The linear diagram between the yearly average values of CRI and Kp-Index, during the period of 1996-2019.

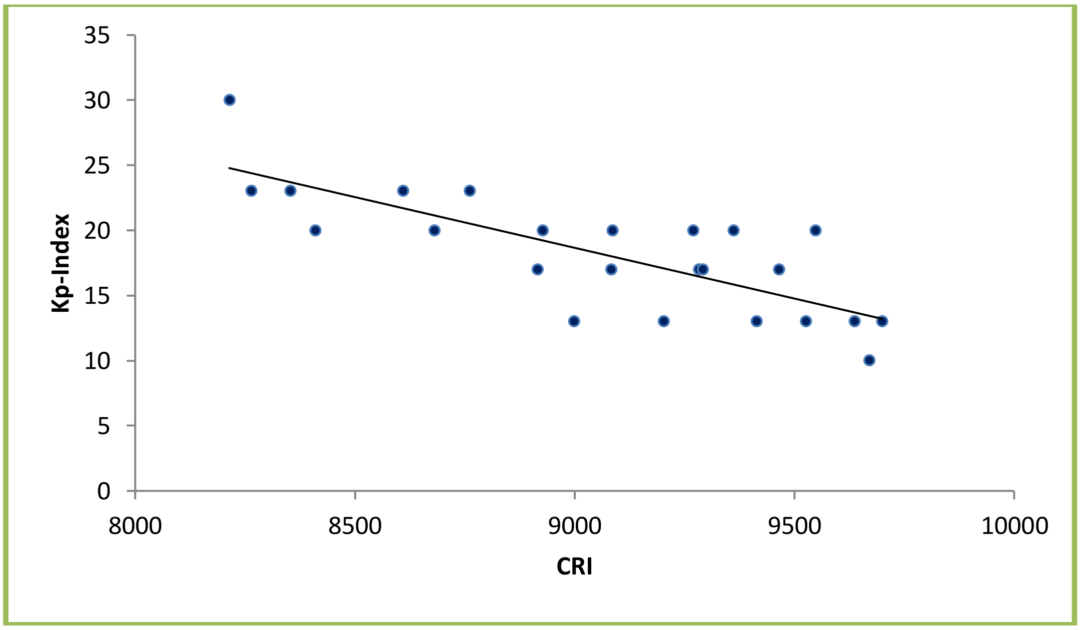

Figure-3.4 The scatter plot between the yearly average values of CRI and Kp-Index, during the period of 1996-2019 with Correlation coefficient -0.78.

4. Conclusions

From the study of the yearly average values of cosmic ray intensity observed during the period of 1996-2019 and the yearly average values of geomagnetic indices Ap and Kp index, it is seen that the yearly average values of cosmic ray intensity are inversely correlated with the yearly average values of geomagnetic indices Ap and Kp index. Also, a high and strong negative correlation between cosmic ray intensity and Ap and Kp index has been found.
Based on the various statistical and numerical calculated value and discussion, it is concluded that:

- There is a strong negative correlation of cosmic ray intensity (CRI) and Ap-index during the period of 1996-2019 with the correlation coefficient -0.85.
- There is a strong negative correlation between the cosmic ray intensity (CRI) and Kp-index during the period of 1996-2019 with the correlation coefficient -0.78.
- The yearly average values of cosmic ray intensity are inversely correlated with the yearly average values of geomagnetic indices Ap and Kp index. There is also a strong negative correlation between cosmic ray intensity Ap and Kp index.

Conflict of Interest

No conflict of interest in this manuscript.

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