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# Behaviour of Cosmic Ray Intensity with Solar and Geomagnetic Disturbances for Solar Cycle 24

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**ABSTRACT:** The purpose of this study to investigate the behaviour of cosmic ray intensity with solar and geomagnetic indices. The long-term relationship between solar activity features (sunspot number, solar flare index 10.7), geomagnetic indices (Dst and Ap) and CRI (Moscow neutron monitor) are considered. Simultaneous investigations have been made to evaluate the identical relationship between solar and geomagnetic disturbances with CRI variation. We have found that solar activity has eleven-year periodicity, while geomagnetic indices follow different periodicity. It has been found that Dst is in opposite phase with Ap index, while SSN and SFI are in the same phase. We observed that CRI provides inverse and high correlation with SSN ( $r=-0.95$ ), SFI ( $-0.97$ ), Dst (0.82), and average correlation along with Ap ( $-0.50$ ). Large anomalies are observed in Ap index rather than SSN, SFI and Dst index. The frequency of solar flare and coronal mass ejection is directly linked with SSN, SFI, Dst and Ap index. Thus, the present study will help to analyze the X-rays classification and also their impact on Earth's climate with solar activity, cosmic ray intensity and geomagnetic indices.

**KEYWORDS:** Cosmic ray intensity — solar activity — geomagnetic indices.

## I. INTRODUCTION

Geomagnetic field is a significant element of solar terrestrial research. The interaction between solar wind and interplanetary magnetic field causes a disturbance in magnetosphere called geomagnetic disturbance. For a short time, scale of space weather the geomagnetic field can be considered constant while for long time scale when space weather climate is taken into account change in geomagnetic field appears. Some indices are used to characterize the variation in geomagnetic field called geomagnetic indices. Dst, Kp, Ap and A.E are most commonly used geomagnetic indices [11]. The Dst index evaluated the globally averaged change of horizontal components of earth magnetic field at the equator based on measurement from few magnetometer stations Kp index is measures the magnetic radiation of solar particles and its value varies from quasi logarithmic integers 0-9 for each 3 h interval oh universal time day (UT). Its value is observed from 44° and 60° northern and southern geomagnetic latitudes. Kp index is converted into linear scale index called Ap. The variation of galactic cosmic rays is a complex combination of several mechanism. Cosmic ray intensity variation is a matter of interest which process and parameter are important for the modulation and variation in the heliosphere [2,5,8].

Investigating the relationship between cosmic ray intensity and solar activity is generally needed to understand the long-term behavior of cosmic ray intensity. The long-term behavior of cosmic ray intensity can be computed by using data of global network of neutron monitors having different cut off rigidities. In this analysis we have studied the cosmic ray intensity associated with solar and geomagnetic indices and their effect on cosmic ray intensity during solar cycle 24.

## II. DATA SOURCE AND METHOD

In order to study the long-term behaviour of cosmic ray intensity through the years 2008 to 2019, yearly mean values of cosmic rays' data were used observed by Moscow neutron monitor <http://cr0.izmiran.rssi.ru/mos/main.html> (cut of rigidity =2.39GV). In this study we also used monthly mean data of sunspot number, solar flare index, Dst and Ap taken from Omni web data base <http://omniweb.gsfc.nasa.gov/ow.html>.

In this paper an attempt is made to study the long-term behavior of CRI in association with solar and geomagnetic indices. The correlation coefficient has been calculated between cosmic ray intensity with various solar and geomagnetic parameters.



III. RESULT AND DISCUSSION

A detailed correlative analysis is done between cosmic ray intensity with solar and geomagnetic indices. The cosmic ray intensity in inner solar system is anti-correlated with the level of solar activity. We have presented the relationship between solar and geomagnetic activity with CRI for solar cycle 24.

Fig.1 show the time variation of average yearly value of CRI, SSN, SFI, Dst and Ap for the period 2008 to 2019 during solar cycle 24. We found that solar activity has eleven-year periodicity, while geomagnetic indices follow different periodicity. We examined that the strongest decrement occurs in CRI during 2014, SSN during 2019, SFI during 2009, Dst during 2012, Ap during 2009 and strongest increment occurs in CRI during 2019, SSN during 2014, SFI during 2014, Dst during 2009, Ap during 2015. We have also observed that the minima of SSN and SFI not coincide with each other. We also found that there is time lag between DST and Ap index.

Sunspot number is the trade mark of solar activity. Fig 2 (a) shows the association of CRI with SSN for the period 2008 to 2019. We have found that the maxima and minima of CRI is coincide with the minima and maxima of SSN. We have also calculated correlation coefficient between CRI and SSN with correlation coefficient  $r = -0.95$  (fig 3 a).

The SFI is considered a particularly good and simple parameter as an indicator of global activity, and the disk integrated emission from the Sun at the radio wavelength of 10.7 cm is affected to the earth climate. Fig.2 (b) show the association of average yearly value of CRI and SFI. We have observed that the minima of CRI and the maxima of SFI is coincide with each other, but the maxima of CRI and the minima of SFI is not coincide with each other. We have found that in the year 2013 both CRI and SFI decreases which shows the anomalous behaviour of SFI with CRI. We observed high and negative correlation coefficient between CRI and SFI with correlation coefficient  $r = -0.97$  (fig 3 b).

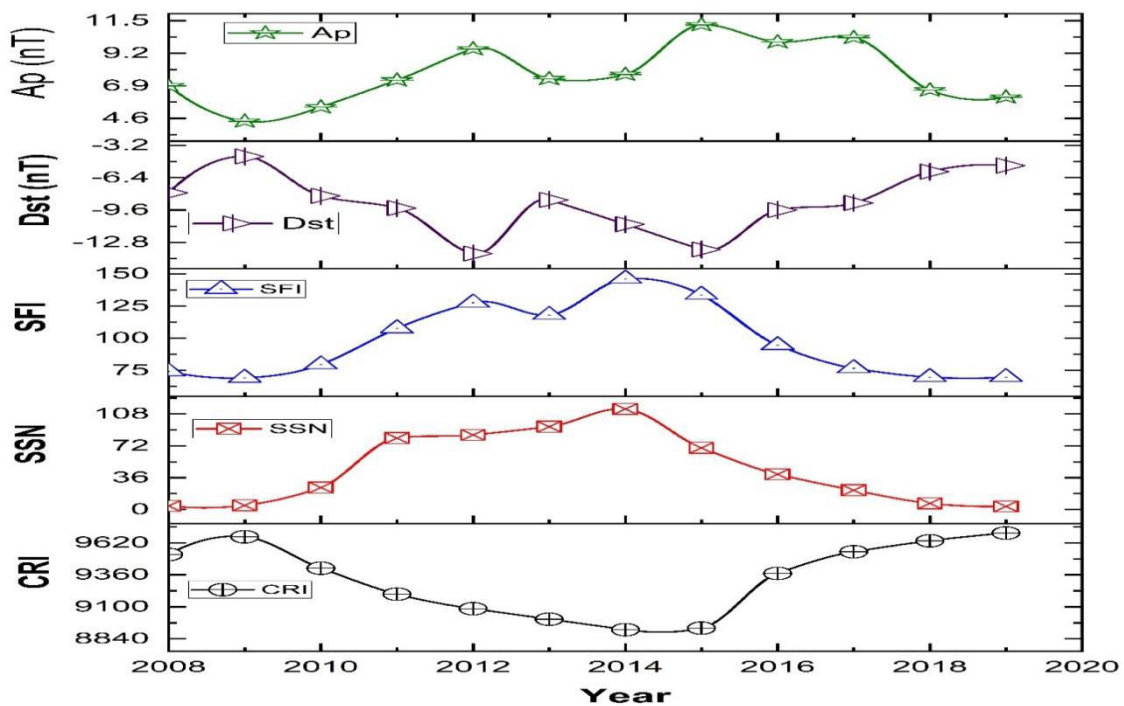


Figure 1. Yearly time profile of CRI, SSN, SFI, Dst and Ap for solar cycle 24

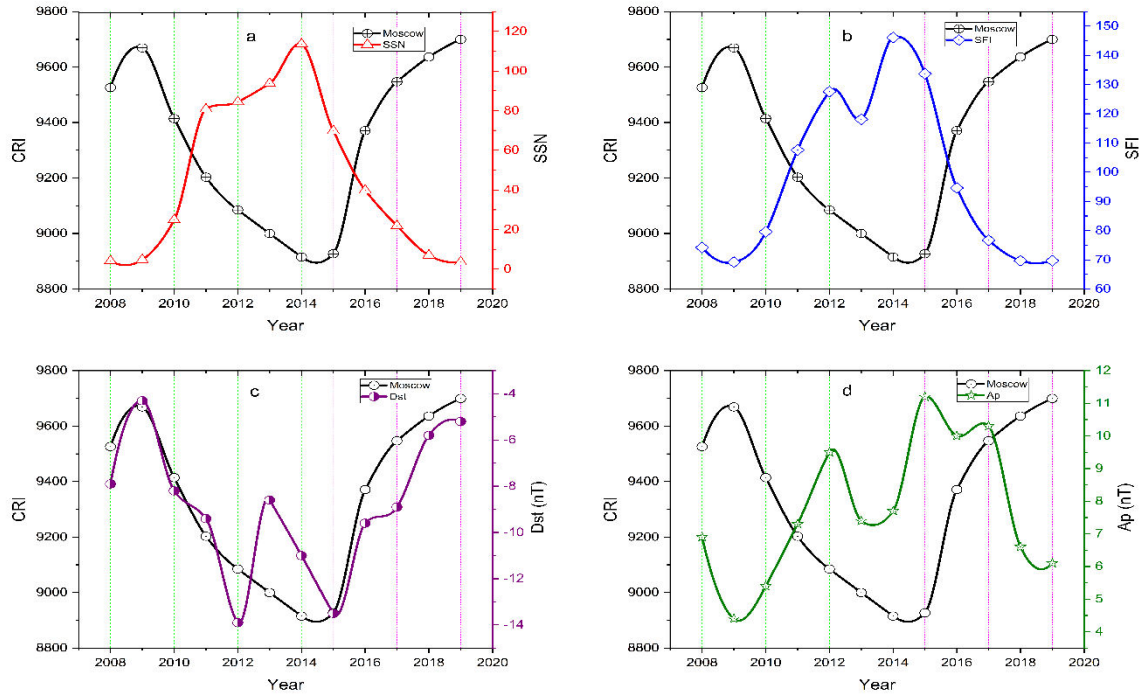


Figure 2 Association of CRI with (a) SSN (b) SFI (c) Dst (d) Ap during solar cycle 24

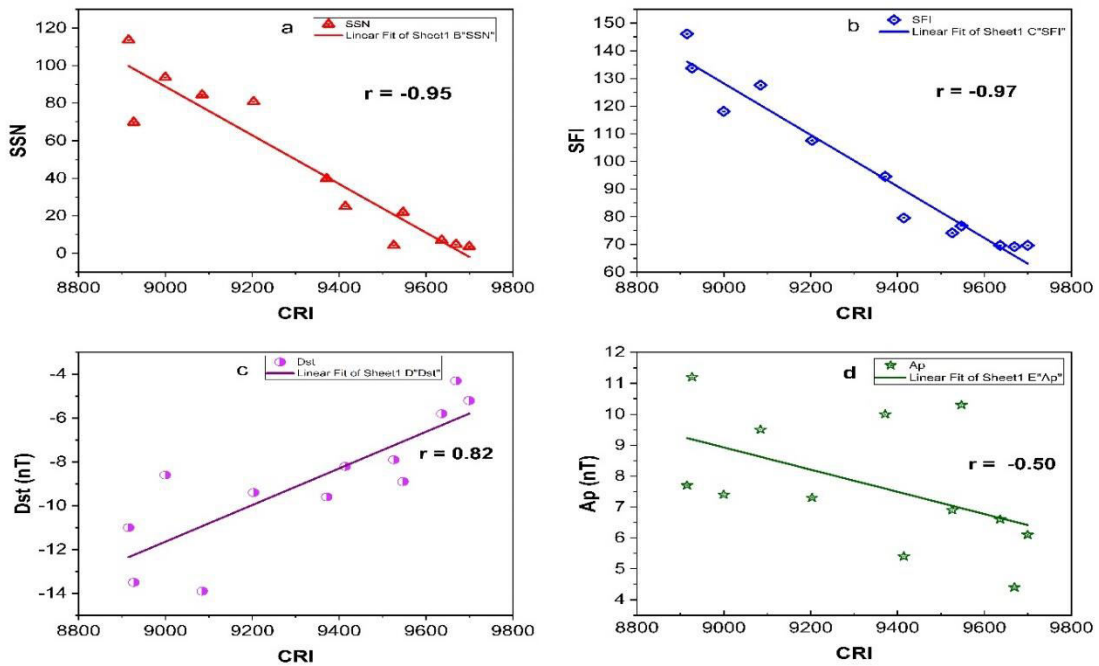


Figure 3. Correlation between CRI vs (a) SSN, (b) SFI, (c) Dst and (d) Ap



In the past a lot of work had been done to find the relationship of CRI with solar activity and geomagnetic activity for different solar cycle [7,8,10]. They have found negative and high correlation, of CRI with solar activity which varies randomly one year to another year to equally importance, X-ray and UV radiation emitted by solar flux. The change in earth climate has been associated with the variation of some solar activity indices, CRI and geomagnetic activity indices. Which is a good agreement with our result.

#### IV. CONCLUSION

The present study intends to examine the dependency of solar and geomagnetic activity on cosmic ray intensity. Our conclusions are as follows-

- We have found that solar activity (SSN and SFI) and geomagnetic index (Dst) are good correlation with CRI, while Ap show moderate correlation.
- We also found that the strongest decrement in CRI happens around the same time when SSN and SFI achieve their maxima.
- During the study of CRI vs SFI and Dst odd behavior is seen in year 2013, while with Ap odd behavior seen in year 2013,2015,2017.
- The correlation coefficient between CRI and SSN is observed to be -0.95 and with SFI is observed to be -0.97 and with Dst is observed to be 0.82 which is found to be high when compared to the correlation with Ap (-0.50).
- CRI is highly anti-correlated with SSN and SFI, while highly positive correlated with Dst.

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