J. Mountain Res. P-ISSN: 0974-3030, E-ISSN: 2582-5011 DOI: https://doi.org/10.51220/jmr.v19-i2.53
Vol. 19(2), (2024), 519-525

Variation of CRI with Solar Wind Speed for Solar Cycles 23

Chandrasekhar Bhoj[1*] • Lalan Prasad[1]

DBS Global University, Selaqui, Dehradun Uttarakhand, India – 248011

[*]Corresponding author. E-mail: csbphysics@gmail.com

Received: 20.07.2024; Revised: 23.11.2024; Accepted: 25.12.2024

Abstract: In this research paper we investigated the relationship between Cosmic ray intensity (CRI) with Solar wind speeds for our study we choose two types of Solar Winds i.e. Slow speed solar winds and High speed solar winds for Solar Cycle 23. As we Know Solar wind is one of the most important parameters which can Modulate CRI. From our study we found that CRI varies inversely with both Slow speed solar winds (SSSWs) and High speed solar wind (HSSWs) also we investigated that the correlation coefficient between HSSWs and CRI is comparatively high than that of SSSWs so based on that we can conclude that HSSWs are the prominent parameter to modulation The Cosmic Ray Intensity.

Keywords. Solar wind speed • Cosmic ray intensity • Solar cycle

Introduction

A stream of charged particle heading towards earth known as Solar Wind. According to their speed Solar Winds are Further divided into two parts HSSWs and SSSWs. HSSWs is further divided into two categories flare-generated solar wind which results a decrease in cosmic rays' intensity and other one is corotating interaction regions, which produce Forbush decreases (Belcher & Davis 1971; Badruddin 1996).

Cosmic Rays is the high energy particle which mostly originated from the outer galaxies which consists of hydrogen nuclei high energy photos electrons etc. Cosmic ray divided into three categories Galactic Cosmic ray which originated from supernova or energetic event that take place in our galaxy, Extragalactic cosmic rays are originated from the outer galaxies in event like Quasar and Active galactic nuclei, and the last one is Solar cosmic ray which produces during solar activities. When these high-speed cosmic ray's particles interact with upper atmospheric particle it breaks into smaller particles known as secondary cosmic rays. The decrease in CRI is identical correspond to HSSWs and SSSWs (Shrivastava and Jaiswal 2003). The variation in CRI and Solar activities can significantly impact the earth atmosphere, researchers also observed different type of pattern in the variation of CRI related to solar wind (Leamon et al 2022) as Solar magnetic field get weak more and more Cosmic Rays penetrated to the inner heliosphere (Oludehinwa et al 2018).

The interaction between cosmic rays and solar wind is a highly dynamic process, totally driven by the activity of the Sun and its magnetic field. The magnetic field of solar wind deflected and slowed down the low-energy cosmic rays. During the solar maximum, the high solar wind intensity decreases the cosmic ray intensity close to Earth, also known as solar modulation. A sudden drop in the cosmic ray intensity which can be induced due to the passage of solar wind disturbance like CMEs. The puffed-up solar wind blows heliosphere as a shield to the galactic cosmic rays. This shielding is effective in proportion to the Sun's activity and the solar cycle.Shock waves from CMEs could accelerate cosmic rays and solar particles to

high energies, playing a significant role in space weather phenomena.

Methodology and Data analysis

We use Chree analysis by the superposed epoch method to find the variation of CRI with solar wind speeds, the zero day correspond to value of SSSWS (300 km/s ≤ Vsw < 450 km s−1) and for HSSWS (450 km/s ≤ Vsw < 800 km s−1). We took the daily mean data of CRI from the Moscow Neutron Monitor Station (cro.izmiran.rssi.ru/mosc/main.htm) which is an open access data base centre. And the daily mean data for Solar wind speed we took from ominiweb data centre (omniweb.gsfc.nasa.gov/form/dx1.html). in our study the 6 above value correspond to zero day are −1, −2, −3, −4, −5, −6 days. Similarly the lower 6 values are considered as +1, +2, +3, +4, +5, +6 days. Than for each corresponding year we find the average values for each day and we plot the graph between these two parameters for every year. We also calculate the correlation coefficient for HSSSWs & CRI and HSSWs & CRI. In order to calculate the correlation coefficient between these parameters.

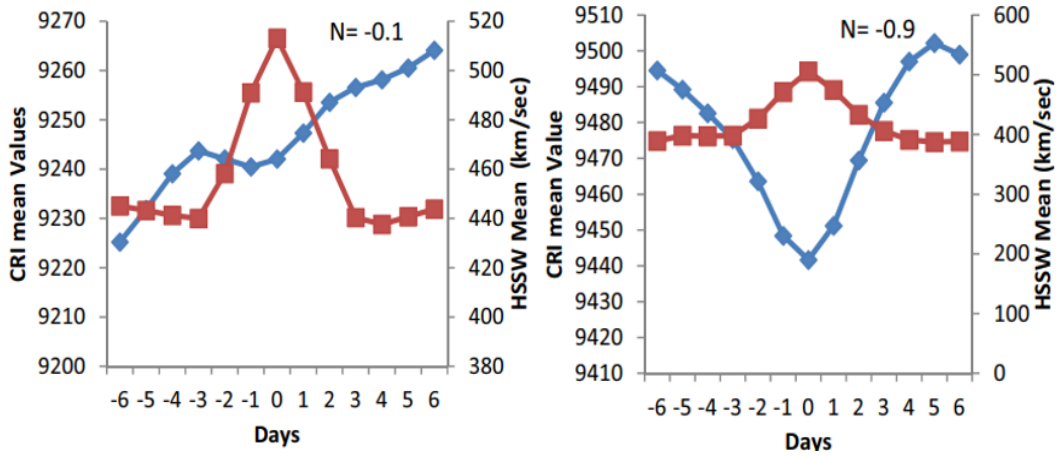
Results and discussion

CRI Variation with HSSWs (450 km s−1 ≤ Vsw< 800 km s−1)

If the velocity of Solar wind speed varies from 450 km/s to 800 km/s Known as HSSWs Gosling & Pizzo (1999) and Bame et al (1976). From our study we get a negative correlation between CRI and HSSWs for most of the years and the average correlation coefficient is about -0.54 which is in good correlation with the pervious study done by Pokharia et al (2017), for those years in which the correlation coefficient is stronger a symmetric shape is observed nears zero day. Also, the peak is observed near zero epoch day while CRI exhibits a minimum around the same time, subsequently entering recover phase CRI recovers stepwise over the following days from the zero epoch, as would be expected from the dissipation of solar wind disturbances.

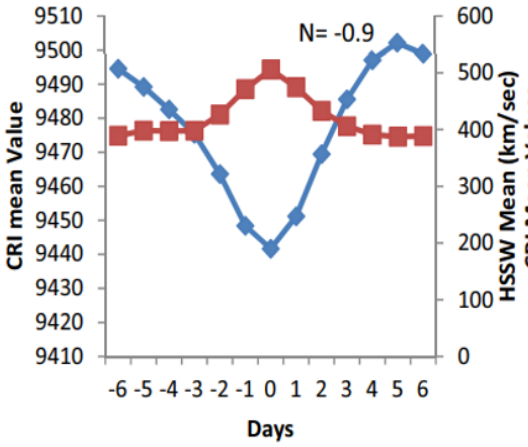
CRI and SSSWs Variation for SC 23

There is no consistent relationship between CRI and SSSW during the rising phase of solar cycle 23, but a symmetrical V-shaped pattern of SSSW is observed after 1997, excluding 2006. Across the graph, there is a noticeable pattern when the variable One increases, the other decreases, showing the opposite relationship. This is especially true near day 0, where the two curves tend to intersect. The size and timing of the crossover near day 0 is consistent from year to year. This may indicate a repeating event affecting both variables. In 2006, unusual behavior was shown. Also, the average correlation coefficient (-0.51) between the above parameters.

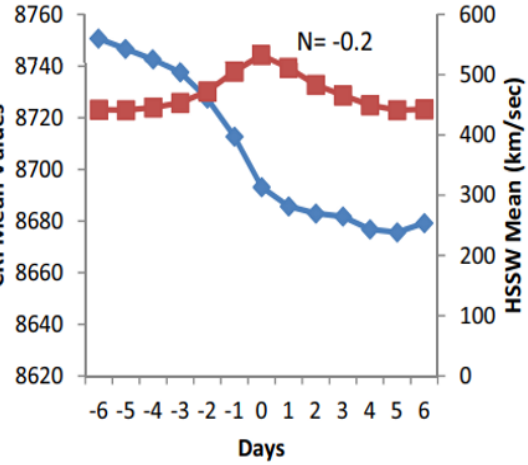


1996

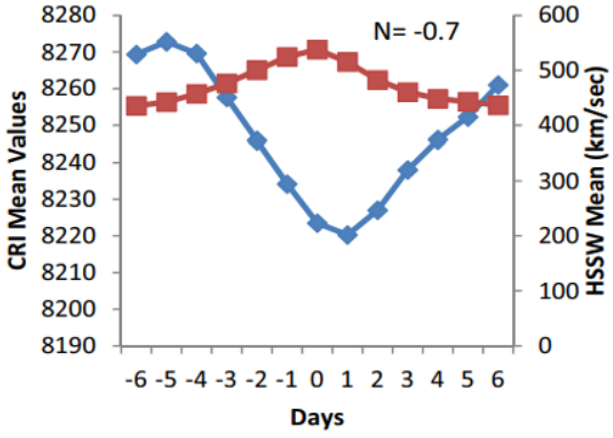
1997



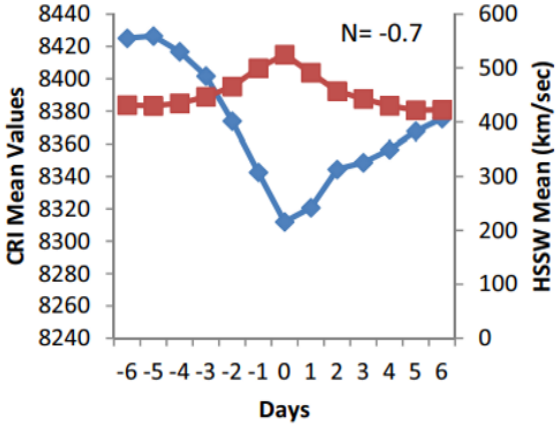
1998



1999



2000



2001

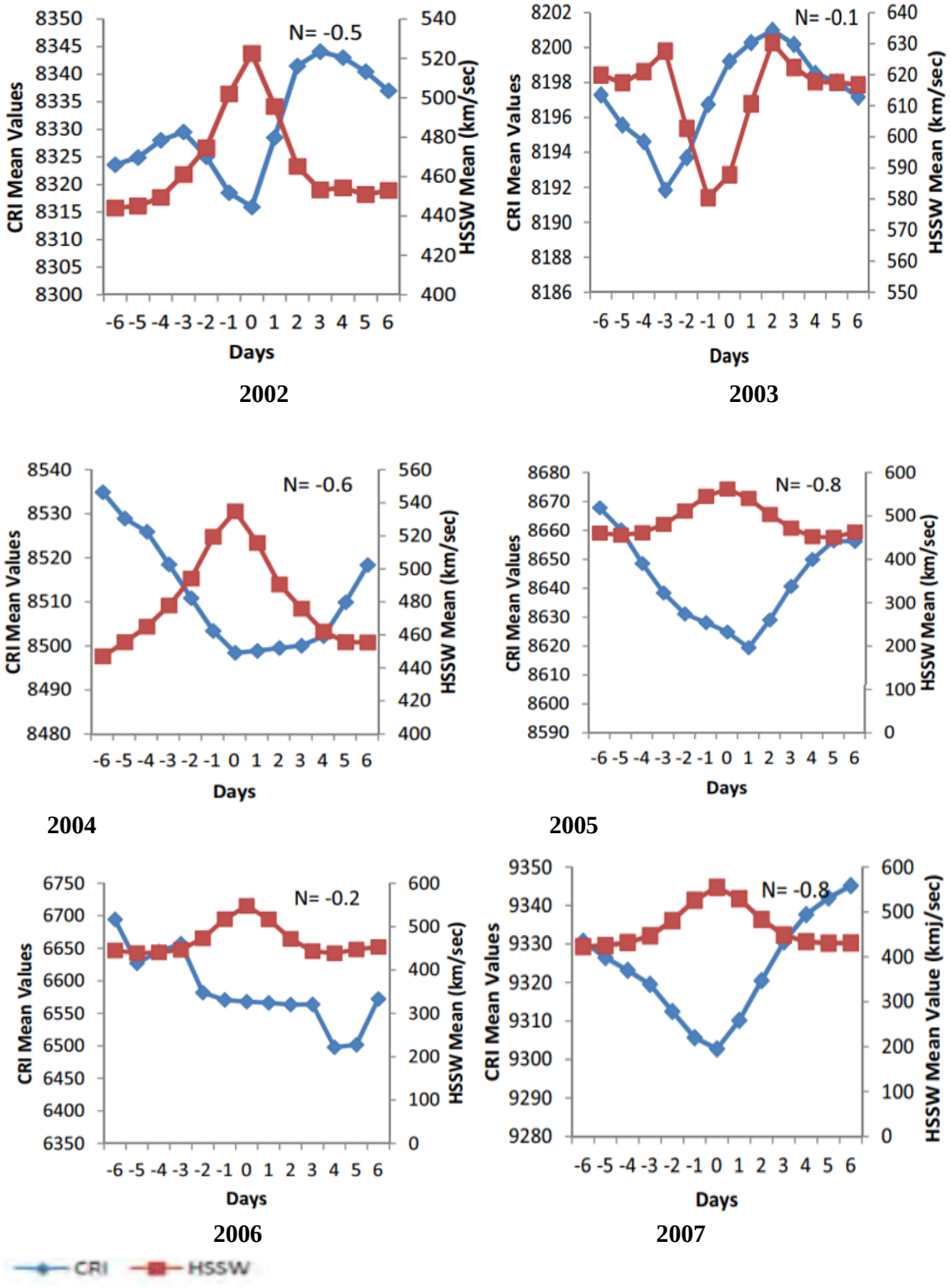
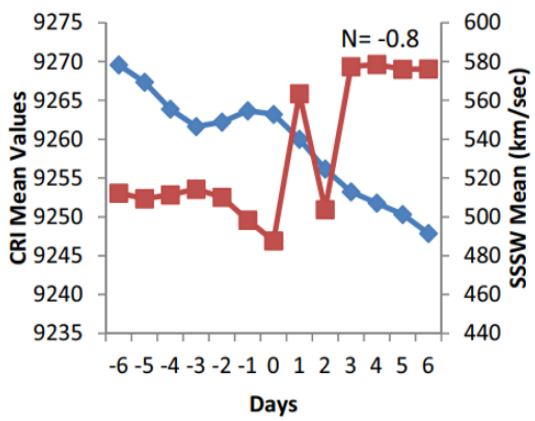
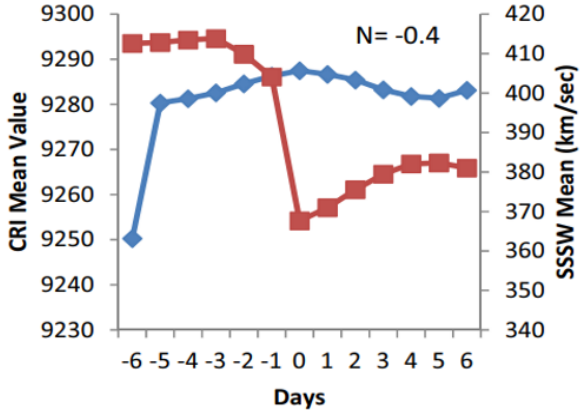


Figure 1. The variation between CRI and HSSWs.

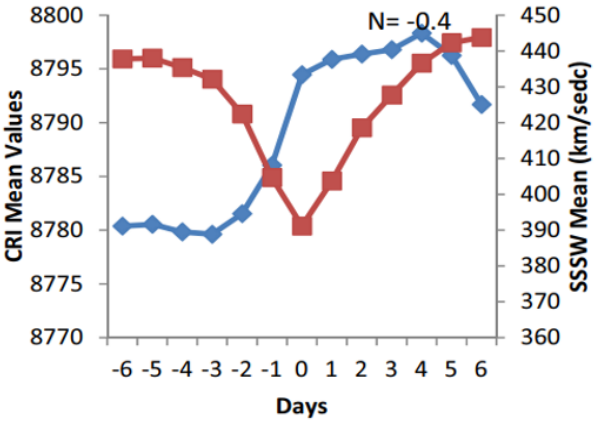
J. Mountain Res. P-ISSN: 0974-3030, E-ISSN: 2582-5011 DOI: https://doi.org/10.51220/jmr.v19-i2.53
Vol. 19(2), (2024), 519-525



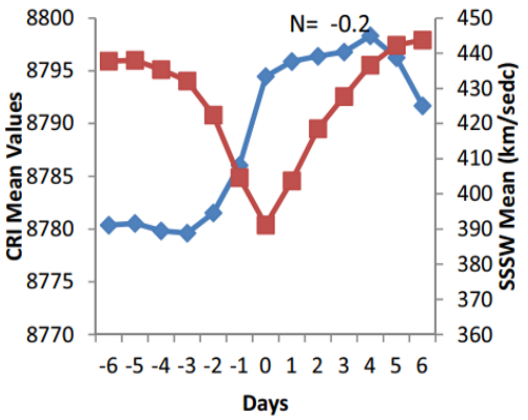
1996



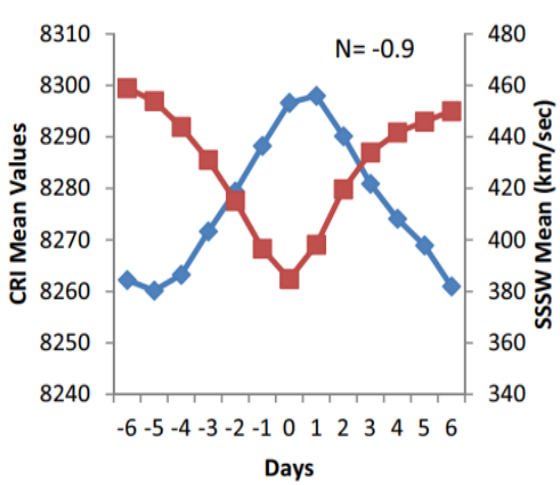
1997



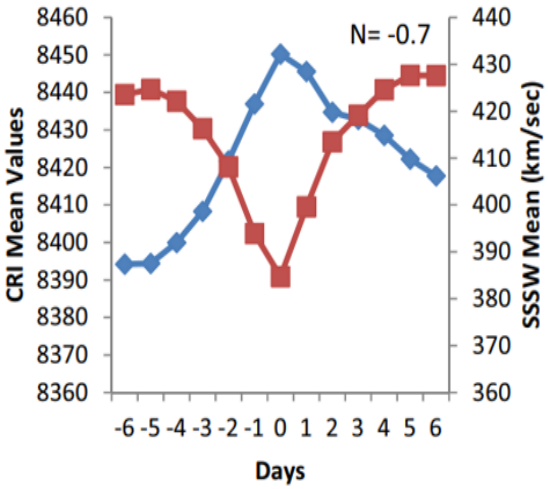
1998



1999



2000



2001

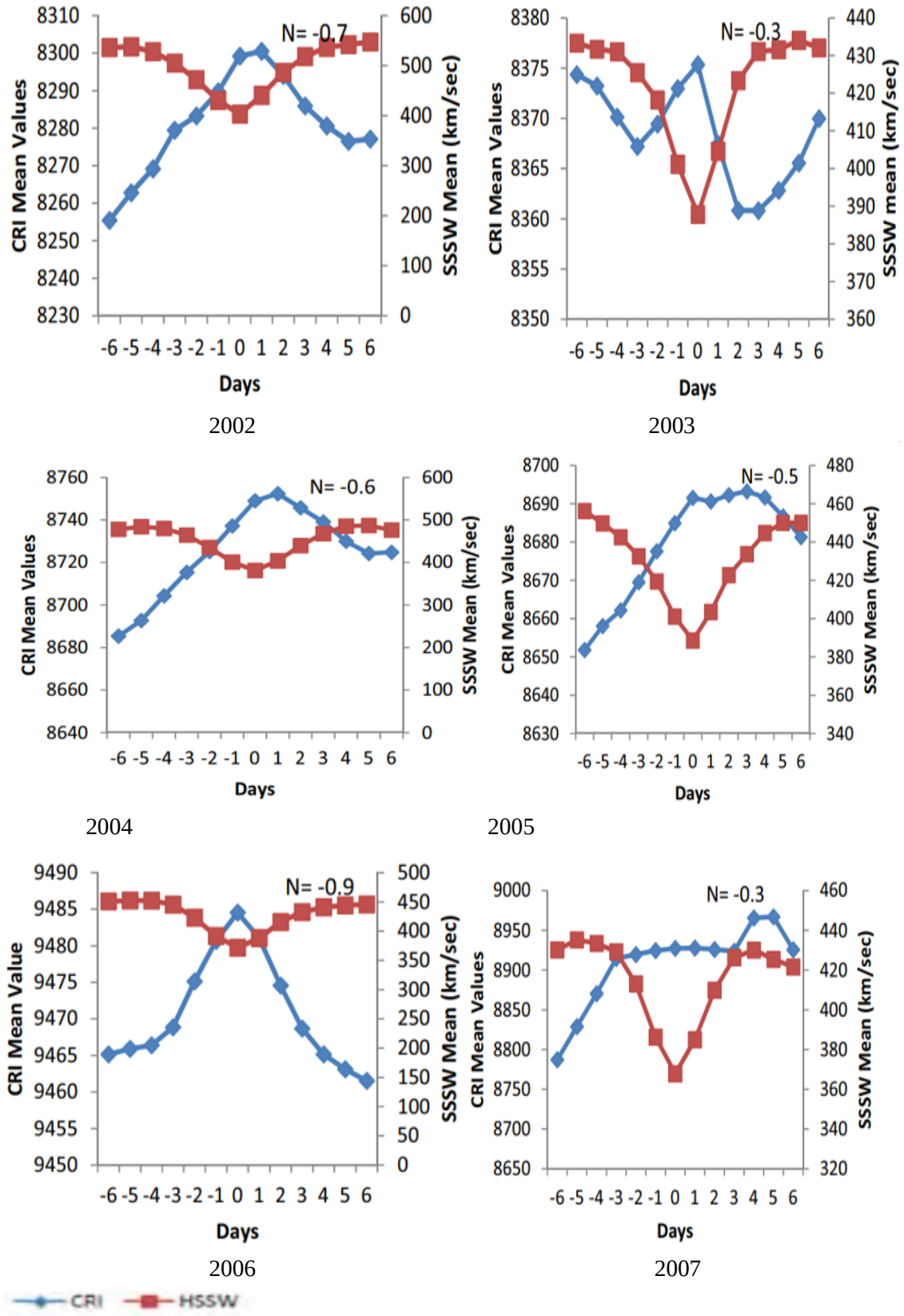


Figure 2 The variation between CRI and SSSWs.

Table 1. Table for Coefficient of Correlation between Different Parameters.

Parameters	Solar cycle −23
HSSWs and CRI	- 0.54
SSSWs and CRI	- 0.51

Conclusions

In this report we study variation of cosmic ray intensity (CRI) and solar wind speeds (high-speed solar wind (HSSW) and low-speed solar wind (SSSW), over a solar cycle 23 extending over 11 years. There is a strong anti-correlation between CRI and HSSW and SSSW, but it was stronger for HSSW with r = −0.54 than for SSSW with r = −0.51. This makes HSSW an even stronger control of CRI. The analysis shows that there is no statistically significant delay between the onset of HSSW and CRI within a few years. This supports the idea that HSSW directly affects CRI. The results may indicate how the dynamics of the solar wind affect the behaviour of cosmic rays. where cosmic rays originate from to increase the efficiency of the magnetic shield Faster winds cause more oppression. The results will provide deeper insights into the solar modulation of cosmic rays and their dynamic interactions in the solar system. It has an impact on space weather as well as the study of the atmosphere.

Acknowledgments

Authors are thankfully acknowledging The CSIR EMR-II, New Delhi of major research project No. 03/1491/2023.

Reference

Badruddin (1996). Cosmic Ray Modulation: Effects of High-Speed Solar Wind Streams. Astrophysics and pace Science, 246, 171-191.

Bame S J, Asbridge J R, Feldman W C, and Gosling J T (1976). The Astrophysical Journal, 207:977-980.

Belcher J W, Davis L Jr (1971). large amplitude alfven waves in the interplanetary medium. ii., J. Geophys. Res., 76, 3534.

Gosling J T, Pizzo V J (1999). Formation and Evolution of Corotating Interaction Regions and their Three-Dimensional Structure, Space Sci. Rev., 1, 21.

Leamon R J, McIntosh S W and Title A M (2022). Deciphering solar magnetic activity: The solar cycle clock. *Front. Astronomy Space Sci.* 9, 886670.

Meena P, Lalan Prasad, Mathpal C, Bhoj C, Kharayat H, Mathpal R (2017). Association Between the Solar Wind Speed, Interplanetary Magnetic Field and the Cosmic Ray Intensity for Solar Cycles 23 and 24, Journal of Astrophysics and Astronomy, Volume 38, Issue 4

Oludehinwa I A, Olusola O I, Bolaji O S and Odeyemi O (2018). Investigation of nonlinearity effect during storm time disturbance, Adv. Space. Res, 62, 440–456

Shrivastava P K, Jaiswal K L (2003). High-Speed Solar wind Streams and Cosmic-Ray Intensity Variations During 1991–1996, Solar Phys., 214, 195.