Research Journal of Physical Sciences ISSN 2320–4796
Vol. **2(5),** 8-11, September **(2014)** *Res. J. Physical Sci.*

Dependence of the Helioshphere and Cosmic ray (CR) Modulation on Solar activity

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Available online at: www.isca.in
Received 16th July 2014, revised 22nd August 2014, accepted 3rd September 2014

Abstract

Solar variability control the structure of the heliosphere and produce changes in cosmic ray intensity (CRI) both on short-term as well as on long–term basis through the level of solar activity. Based on the observation from Omniweb data centre for solar- interplanetary data activity and yearly mean count rate of cosmic ray intensity (CRI) variation data from Moscow neutron monitors (Rc=2.42 GV) during the period of 23/24. It is observed that sunspot number, 10.7 cm solar radio flux, velocity of solar wind and the strength and turbulence of the interplanetary magnetic field with count rate of cosmic ray intensity are inverse correlated.

Keywords Interplanetary magnetic field (IMF), cosmic ray intensity (CRI), interplanetary coronal mass ejections (ICMEs), solar activity.

Introduction

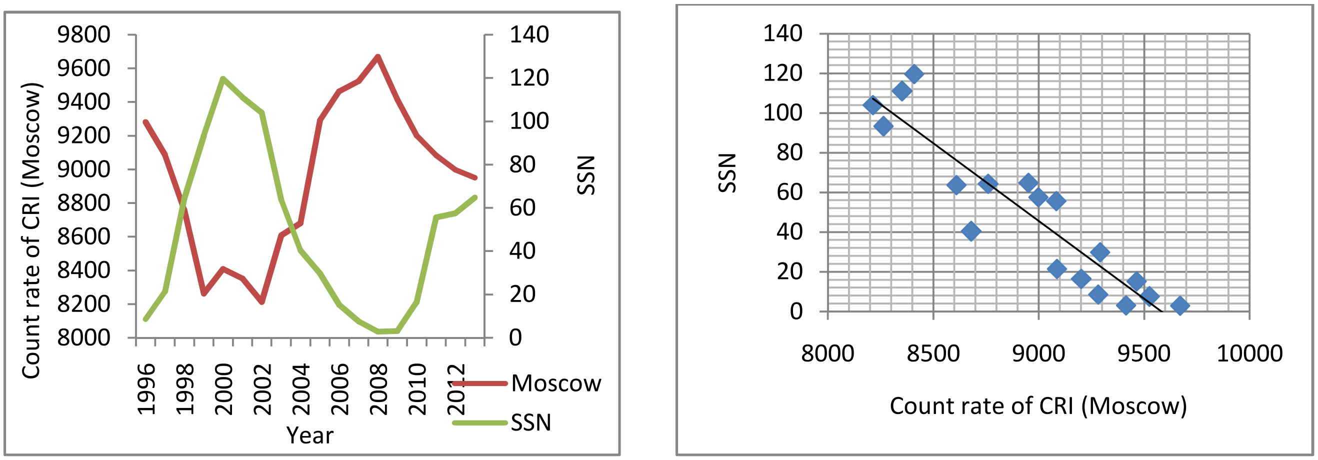
To study the dependendence of the helioshphere and cosmic ray (CR) modulation on solar activity supported by space and ground based experiments[1,2], during this period relationship between solar activity, heliosphere and cosmic ray modulation have been studied intensively. In order to study the cosmic ray modulation , in early times, when no direct measurements of cosmic ray were made only different proxies of cosmic ray intensity were used ,such as ^{14}C and ^{10}Be produced by cosmic rays in the earth's atmosphere are commonly used for this purpose. However anti-correlation between cosmic ray intensity and solar activity has been proven during this period of very low solar activity, sunspot activity nearly disappeared and solar magnetic field is reduced across the whole surface of the sun and the polar field are about half as those observed during the previous minimum period and the mean value of the strength B of the interplanetary magnetic field IMF between 2007-2009 was recorded low level (≈ 2.5nT) compared with previous (≈ 4 nT in 1985-1987 and ≈ 3.4 nT in 1995-1997). This decrease in IMF in this minimum 23/24, may be either due to less input from interplanetary coronal mass ejection (ICME) or a weaker input from the solar polar magnetic flux. Changes in solar wind plasma flow through the interplanetary medium which caused by weaker solar magnetic field and the tilt angle is widely used to characterize drift effect on GCR[3]. Observation near the earth orbit during the end phase of solar cycle 23, the IMF strength and solar wind density were about 30% lower than 22/23 and momentum flux was about 38% lower[4], where as solar wind speed remained unchanged[5,6].

Methodology

In this study yearly mean data of solar activity and heliosphere indices such as sunspot number, 10.7 cm solar radio flux, solar wind plasma density, interplanetary magnetic field and proton density with count rate of cosmic ray intensity as observed by Moscow (Rc=2.32GV) neutron monitors and data of sunspot numbers (SSN) taken from National Geographical Data Centre (NGDC), and analyzed solar-interplanetary data from Omni web data base http://www.omniweb,gsfc.nasa.gov.in data were used.

Result and Discussion

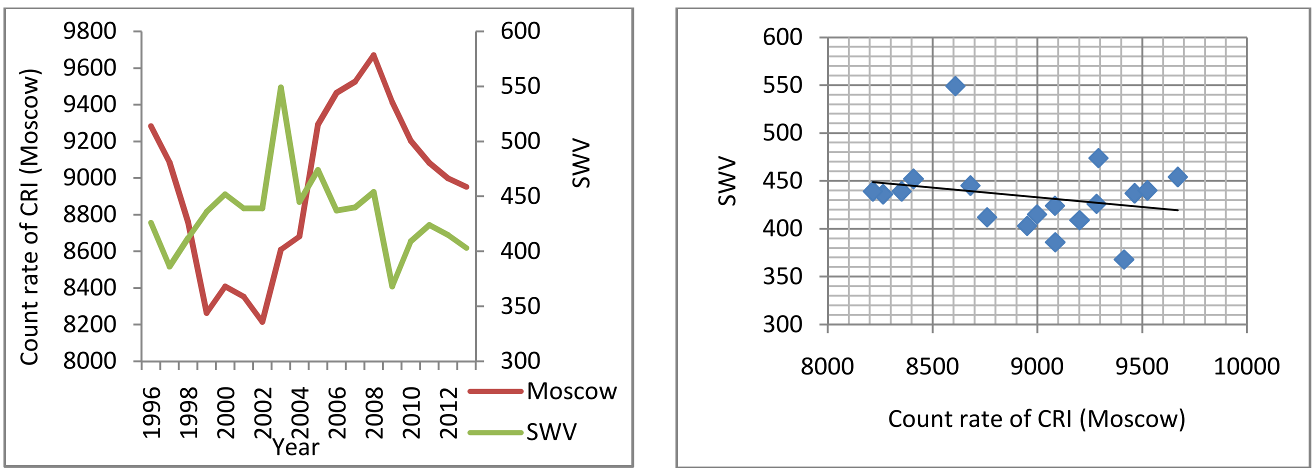
The variation cosmic ray intensity are inversely correlated with solar activity indices and these variations are produced by solar wind velocity (V) is related to convection, diffusion depends on the interplanetary field strength (B) and its fluctuations, and the tilt of the heliosphereic current sheet. Variation in cosmic ray intensity is a multi-valued function of the tilt of the heliosphereic current sheet for ascending and descending both phases of the solar cycle is due to inadequacy of the tilt angle as a parameters for drift modulation and it is single –valued function of solar wind B within a given polarity epoch.A record high cosmic ray intensities observed in 2009 due to reduction in B (from ~5.5nT to ~3.6 nT) and tilt angle (from ~20° to 14°) in comparison to 1986 and an unusually rapid rise in the tilt angle in 2010 is likely related to the weaker polar field .



I **II**

Figure-1

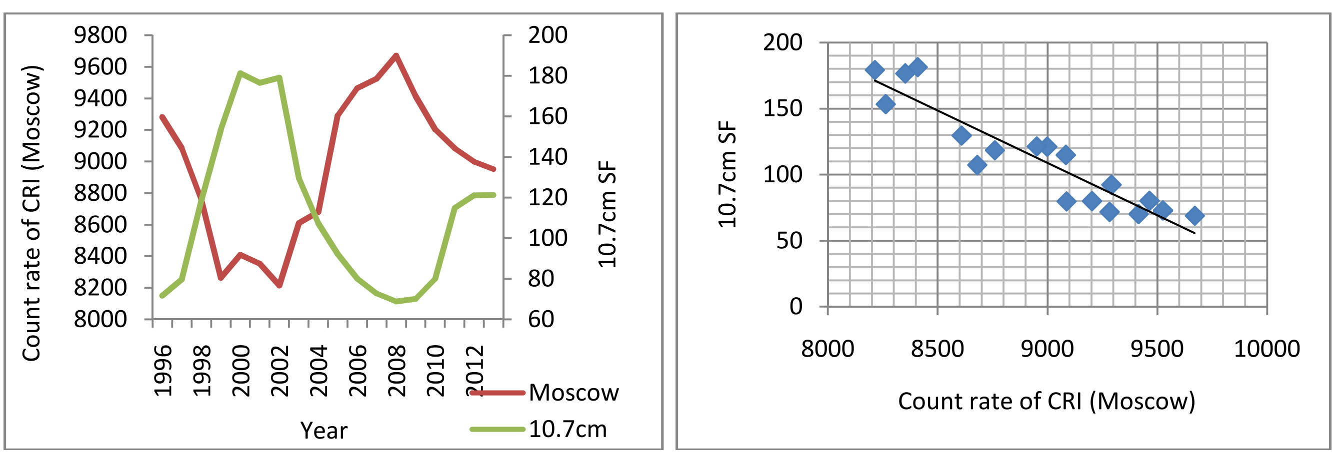
I,II Long-term count rate of cosmic ray intensity(Moscow) with sunspot number(SSN) of solar activity cycle 23/24



III **IV**

Figure-2

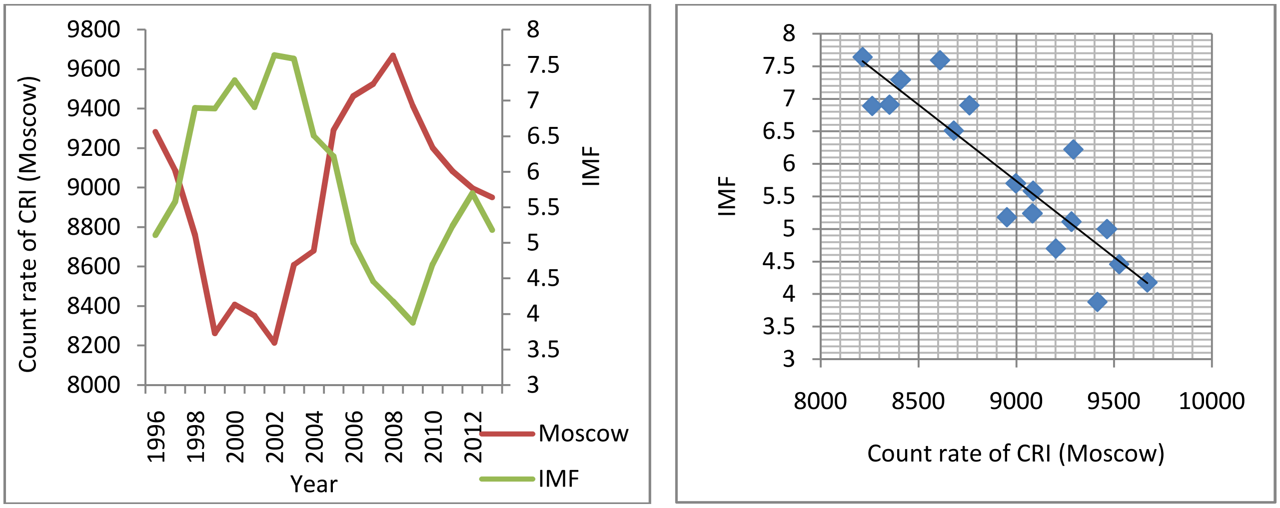
III, IV Long-term count rate of cosmic ray intensity(Moscow) with solar wind plasma velocity (SWV) of solar activity cycle 23/24



V VI

Figure-3

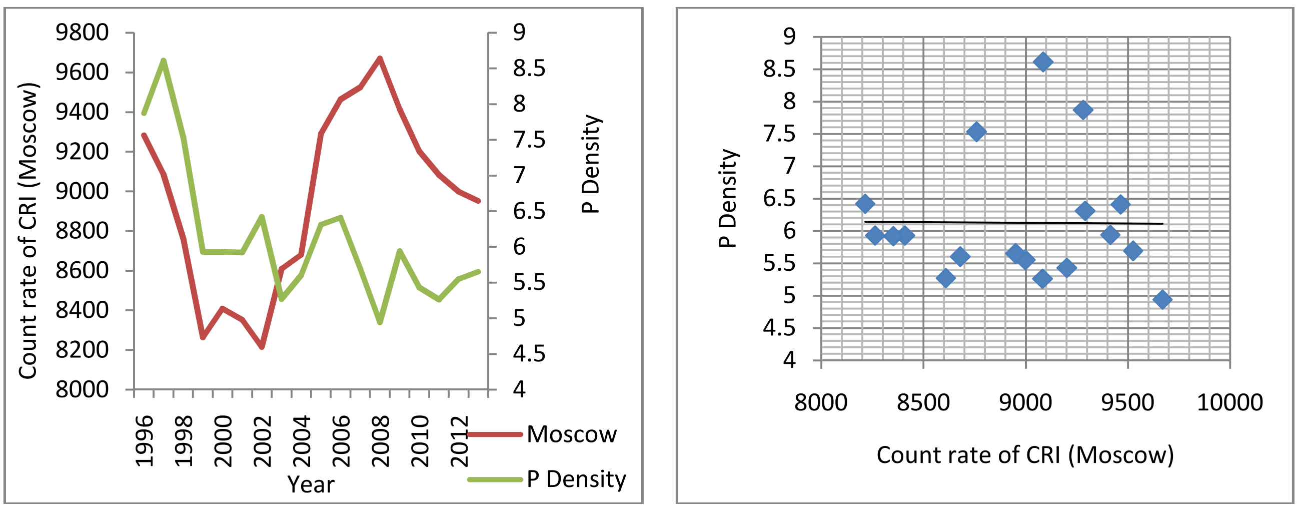
V, VI Long-term count rate of cosmic ray intensity(Moscow) with 10.7 cm solar radio flux of solar activity cycle 23/24



VII VIII

Figure-4

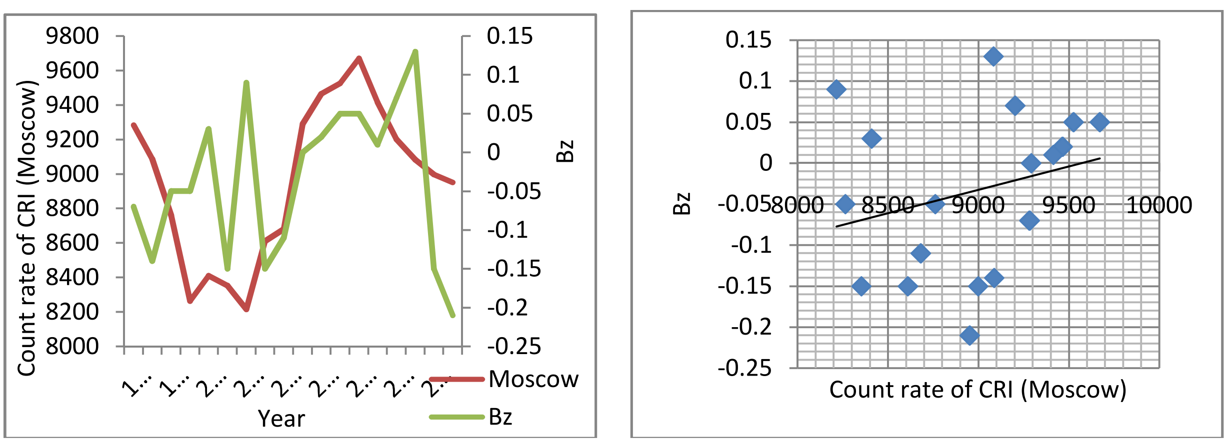
VII,VIII Long-term count rate of cosmic ray intensity(Moscow) with Interplanetary magnetic field (IMF) of solar activity cycle 23/24



IX X

Figure-5

XI, X Long-term count rate of cosmic ray intensity(Moscow) with Proton density of solar activity cycle 23/24



XI XII

Figure-6

XI, XII Long-term count rate of cosmic ray intensity(Moscow) with Bz of solar activity cycle 23/24

Conclusion

We have not found any features of interplanetary indices which could explain the unusual rigidity dependence of CR modulation in the solar minimum of solar cycle 23/24 however the duration of this minimum was unusually long deep and CR anomaly occurred after abrupt strong decrease in solar wind velocity and tilt angle. Solar- interplanetary indices, tilt of the heliosphereic current sheet and intensity variations of interplanetary magnetic field (IMF) caused modulation in CR. moreover the correlation coefficients are negative high, -0.75, -0.69, -0.77 with sunspot number 10.7cm solar radio flux and IMF respectively and negative medium correlation coefficient -0.52 with solar wind plasma velocity.

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