*Research Journal of Physical Sciences* _____ ISSN 2320–4796
Vol. 2**(2),** 9-12, May **(2014)** *Res. J. Physical Sci.*

# Modulation in Cosmic ray During the Declining and Minimum Solar Activity Period of Solar Cycle 23

**B. K. Tiwari[1], B.R.Ghormare[2], P.K.Shrivastava[3] and D.P. Tiwari[4]**
[1]Department of Physics, Jawahar Lal Nehru college of Technology, Rewa MP, INDIA
[2]Department of Physics, Rewa Engineering College, Rewa MP, INDIA
[3]Department of Physics, Model Science College, Rewa MP, INDIA
[4]Department of Physics, A.P.S. University, Rewa, MP, INDIA

**Available online at: www.isca.in**
Received 16th March 2014, revised 30th April 2014, accepted 3rd May 2014

## Abstract

*We study modulation in galactic cosmic rays (GCRs) during the declining and minimum solar activity period, of solar cycle 23. We study the simultaneously relation between variation in cosmic ray intensity recorded by neutron monitors (Moscow and Oulu) and solar interplanetary parameters from omniweb data centre during this period. We observe a record high GCR intensity with low values of solar activity indices such as interplanetary magnetic field (IMF), sunspot number (SSN), solar wind velocity 10.7cm solar radio flux and also find co-relation between GCR intensity and SSN, is weak and better with solar wind velocity and interplanetary magnetic field.*

**Keywords:** Interplanetary magnetic field (IMF), solar wind velocity (V), galactic cosmic rays (GCR), heliospheric current sheet (HCS), sunspot number (SSN).

## Introduction

The cosmic ray intensity variations under different condition of solar interplanetary activity is useful tool to understand the physics of interaction between charged particles and shape and dynamics of the heliospheric current sheet, the heliolatitudinal distribution of solar wind velocity boundaries between fast and slow solar wind streams, role of the termination shock and the heliopause responsible for their variations[1, 2]. Galactic cosmic rays (GCRs) are subjected to heliospheric modulation under the influence of solar output and its variations. The 11-year galactic cosmic ray modulations has been correlated with several different solar activity indices and anti-correlated with solar activity was first studied[3].

During solar minimum the sun's magnetic field resembles with closed loops near the equator and open field lines near the poles where as during solar maxima solar activity increased such as maximum sunspots are seen on the photosphere of the sun and, solar flares and CMEs are frequently occurred. Sun's magnetic field carries by the solar wind throughout the heliosphere known as IMF has spiral shape (parker spiral) because of the sun's rotations .The polarity of IMF changes periodically alternate positive (away from the sun) and negative (towards the sun). Solar magnetic field variation causes cosmic ray modulation are subjected to four distinct transport effects (convection, drift, diffusion, adiabatic energy changes), during solar minimum of solar cycle 23 drift may play an important role in the transport of cosmic rays.

The decaling phase of solar cycle 23 has been unusually long and quiet period was characterised by low magnetic flux emergence at the photosphere, low coronal mass ejection (CMEs) and flare activity in the corona[4]. During most of the time period in the cycle 23 minimum, solar and heliospheric condition are minimum therefore sunspots are low or almost absent and slow solar wind stream as regards the interplanetary parameters (B and V) was low, although the cosmic ray intensity was much higher than in the previous solar cycle .This minimum had an extra ordinary effect on the properties of the magnetic structure shielding the earth to allow such an increase in GCR intensity[5].

Solar cycle 23was a more interesting cycle as it was a lot of extreme solar events in declining phase and It had an extraordinary and extended minimum with duration more than three years. In this solar minimum, the cosmic ray intensity was much higher than in previous solar cycle[6,7] .This solar minima were unusual in several ways, including greatly reduced IMF, strength and a prolonged decrease in the interplanetary turbulence level[8]. During this minimum, solar activity was low and the heliospheric magnetic field was ≈28% weaker than the other recent minima. Both these parameters (lower solar activity and weaker magnetic field) imply higher cosmic ray diffusion coefficients; this gives records high galactic cosmic ray intensities that were observed[9].

**Data and method of analysis:** In this study we have data of the mean monthly sunspots number (SSN) taken from the National Geophysical data centre and intensity of

interplanetary magnetic field (IMF), is obtained from the OMNI data base and to study the long term modulation, monthly values cosmic ray as observed by a neutron monitors (Moscow and Oulu) were used and then statistical technique use to correlate them.

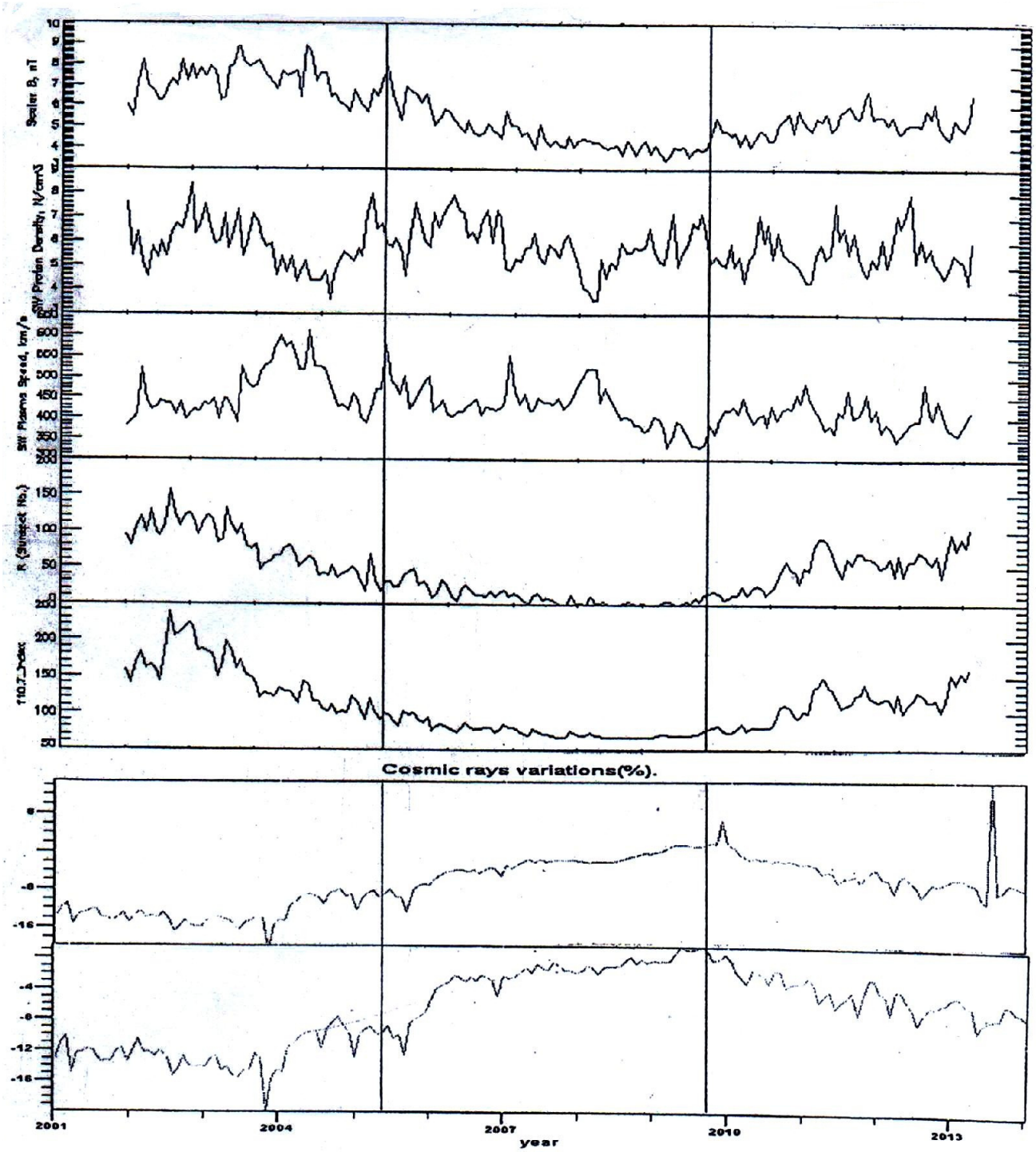


**Figure-1**

**Simultaneous variation in Solar ( SSN and 10.7 cm solar flux) and interplanetary (V and B) parameters with cosmic ray intensity variation observed at Oulu (above) and Moscow (below) neutron monitor during declining and minimum solar activity period of solar cycle 23 and ascending phase of solar cycle 24**

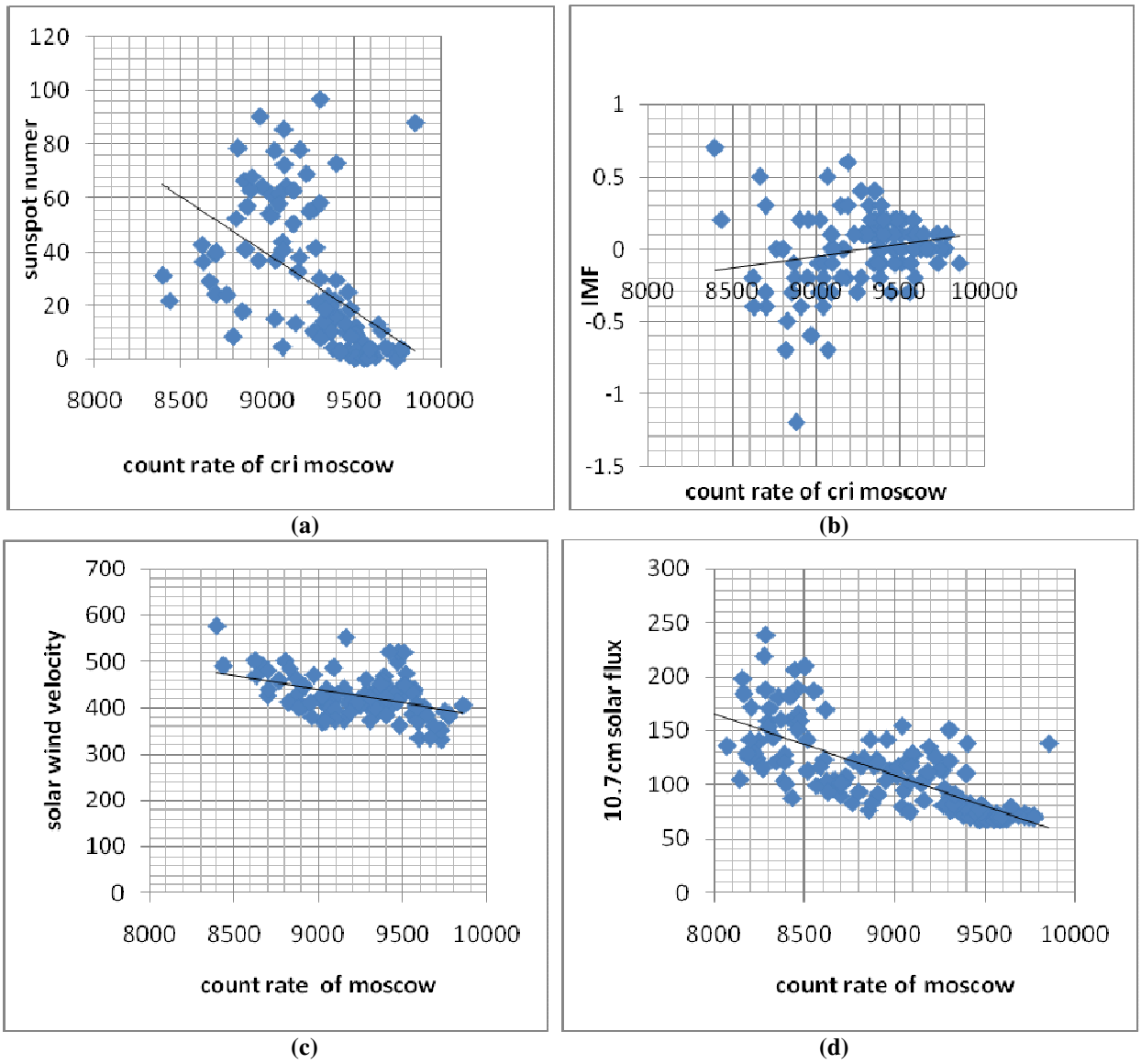


**Figure-2**
**(a) (b) (c) (d) Shows the correlation between count rates of Moscow vs. Sunspot number, IMF, Solar wind velocity and 10.7 cm solar flux**

## Result and Discussion

The cosmic ray modulation is a complex phenomenon which occurs all over the heliosphere and depends on many factors such as strength and velocity of solar wind, turbulence of interplanetary magnetic field, sunspot number (SSN) and 10.7 cm solar radio flux. The solar activity indices are, in general, anti -correlated with long term variation in cosmic ray intensity. Long-term variations in GCR, modulation processes are due to convection, diffusion and drifts. Strength of IMF characterised quantatively effect on cosmic ray. Solar indices with heliospheric variables (IMF, HCS, Ap, CMEs with width $>30^0$ andmean plasma velocity) were found to explain better, the cosmic ray modulation.

## Conclusion

Long term variation in cosmic ray based on solar and heliospheric indices, an increase of strength of IMF should lead to a decrease of transport path and the diffusion coefficient consequently, to an increase of the modulation in high energy Galactic cosmic ray intensity with earth atmosphere to produce secondary elementary particle that can be measured by ground based Neutron monitor.

## Reference

1. Cane H.V., *J .Geophys.Res.,* **98**, 3509 **(1993)**
2. Kudela K., *Acta Physica Slovaca,* **59**, 537 **(2009)**

**3.** Forbush S.E., *J .Geophys.Res.,* **63**, 651 **(1958)**

**4.** Anand Kumar and Badruddin 33rd ICRC Rio De Janeiro, **(2013)**

**5.** Tiwari B.K., Thesis Submitted to APSU Rewa, **(2010)**

**6.** Kane R.P., *Solar physics.,* **269(2),** 451-454, **(2011)**

**7.** Ahluwalia H.S. and Yghuhay R.C., AIP Conf. Proc., **1216**, 699 **(2010)**

**8.** Mewaldt R.A., Davis A.J., Lave K.A., leske R.A., Stone E.C. and Wiedenbeck M.E, *Astrophys.J.Lett.,* **723**, L1 **(2010)**

**9.** Moraal H. and Stoker P.H., *J .Geophys. Res.,* **115**, A12109, 1-9 **(2010)**