Analysis of high energy charge particle in the Heliosphere

B. K. Tiwari[1], B.R.Ghormare [2]

[1.]Department of Physics,A.P.S.University, Rewa(M.P.)
[2.] Department of Physics, Rewa Engineering College, Rewa(M.P.)

Abstract

Data-driven analysis of the temporal dependence in the Galactic Cosmic Rays flux is performed over the Solar Cycle 23-24. Solar wind disturbances and magnetic turbulence inside the heliosphere are affected GCRs, which effect is known as Solar Modulation . To investigate this event, GCR data collected with a global statistical inference on monthly basis, determined the dependence of the GCR diffusion parameters upon rigidity and time . In this paper, we discuss their interpretation in terms of basic processes of particle transport and their relations with the heliospheric plasma dynamics . The observation based on for solar- interplanetary activity through Omniweb data centre and monthly mean count rate of CRI data from neutron monitors (Moscow, Oulu,) for the this period . We observed high values of CR intensity with low values of solar-interplanetary activity indices during minimum phase of solar cycle 23-24. Statistical techniques are used to correlate data of CRI and solar- interplanetary indices , these were opposite correlated with solar activity indices.

Keywords- , Solar Activity (SA), Galactic Cosmic Rays (GCRs), Coronal Mass Ejections (CME), Heliospheric magnetic Field (HMF)

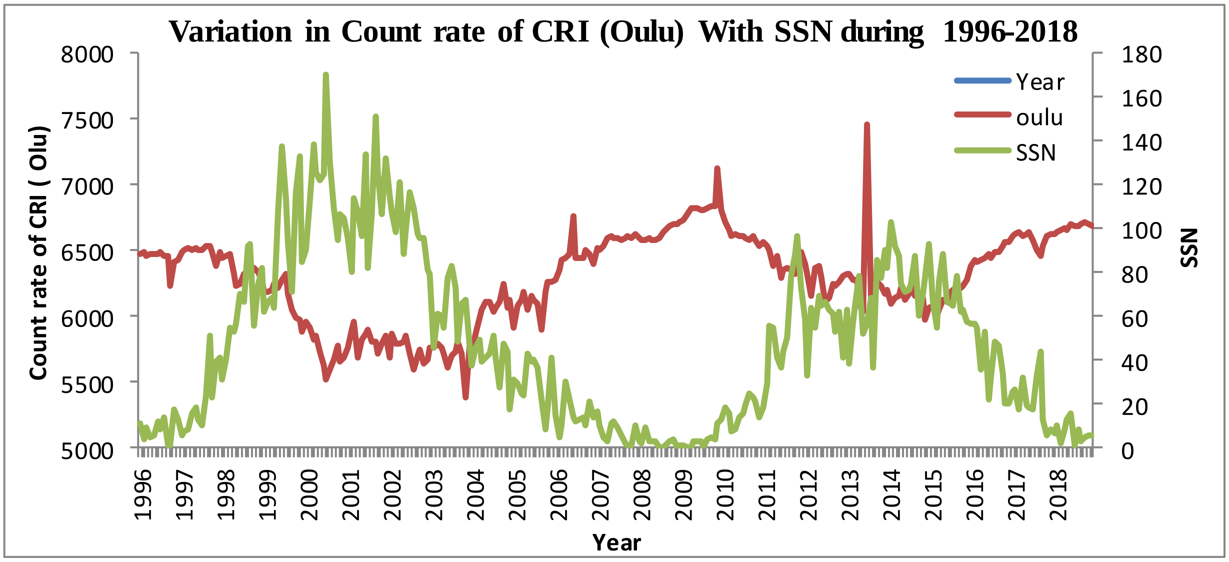
Introduction

Short-term as well as on long-term variations in Cosmic ray intensity are produced by Solar outputs and their modulation[1,2] .Galactic Cosmic Rays modulation in Long-term basics were compared with the behavior of various solar activity indices and helioshperic parameters. It is observed that SSN, 10.7 cm Solar radio flux (SRF), Solar flares and CMEs are the causal link of Solar activity . Moreover, interplanetary plasma and field disturbances are associated with a variety of CMEs . Irregularities in the heliospheric magnetic field structure scattered Cosmic rays and , convection and adiabatic deceleration undergoes in the expanding solar wind changes in the heliospheric conditions as produced by the solar activity (SA)[3,4] . Modulation in the cosmic ray is usually caused by transient interplanetary phenomenon , which are related to CMEs. The intensity of GCRs is subjected to changes in heliospheric conditions under the influence of Solar outputs and their variations. Scott.Forbush established the correlation between Geomagnetic storm and world-wide decreases in CRI [5]. The Sunspot cycle (~ 11 years) in GCRs intensity and its variation are opposite in phase with Sunspot number and the transport of GCRs understood through the model of heliospheric magnetic field [6] . HMF magnitudes increases during high Solar activity due to larger number of CMEs ejected from the Sun (which occurs each ~11- years sunspot cycle). Therefore Solar Magnetic Field (SMF) more effective at sweeping Cosmic rays out of the inner heliosphere which causes a strong reduction in Cosmic rays fluxes and reproduce ~ 22 years Galactic Cosmic Rays modulation . The GCR modulated by sporadic emission of clouds of magnetized plasma in the Interplanetary space and produces terrestrial geomagnetic storms [7]. Large decreases are associated with that MCs are preceding by shocks where as small decreases in GCRs are associated with Magnetic clouds (MCs) are not preceded by Shocks [8,9] .

The IMF emanated from the Sun changes with changing variations in speed of particle, process of transport , such as convection, diffusion drift and adiabatic deceleration[10]. Pressure and strength of Interplanetary Magnetic Field (IMF) and Solar wind (SW) density all are their lowest values and measured a record high GCR intensity and was associated with the relative decrease in anomalous cosmic rays, with energy about zero for low latitudes neutron monitors(NMs) during minimum phase of Solar cycle 23/24 [11] . This period is interesting for the study of CRI modulation with Solar and Heliospheric conditions. Solar activity indices and Heliospheric parameters as, SSN and strength of the HMF was exceptionally low between minimum period of Solar cycle 23/24. Solar interplanetary activity parameters where significant different from the previous Solar minimum[12,13] . This anomalous period shows unusual features in the GCR intensity are excess of the maximum intensity during 2009-2010.Heliospheric magnetic field was weaker, the Sun was much quieter, and observed higher CR diffusion coefficient, allows an increase in GCR intensity[14,15,16].

Data analysis

To study the long-term modulation in GCRs intensity between periods of Solar cycle 23-24 , monthly mean count rates of Cosmic Rays data were used by neutron monitors (NMs) Moscow and Oulu http://www.nmdb.in with their cutoff rigidities ; Moscow (Rc=2.35GV) and Oulu (Rc=0.80GV). we analyzed solar interplanetary data from Omniweb data centre http://www.omniweb.gsfc.nasa.gov.in . and we also used data of monthly mean Sunspot Numbers (SSN) and 10.7 Solar Flare Index (SFI) through National Geographical Data Centre (NGDC) .



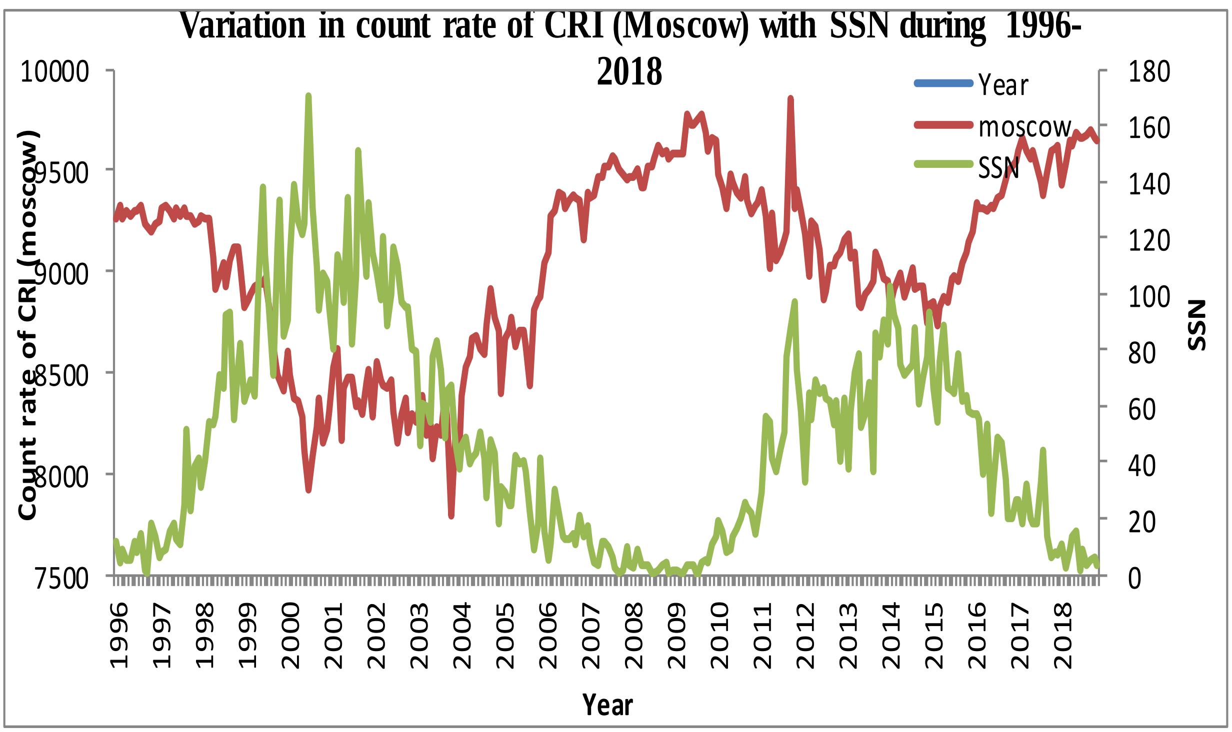
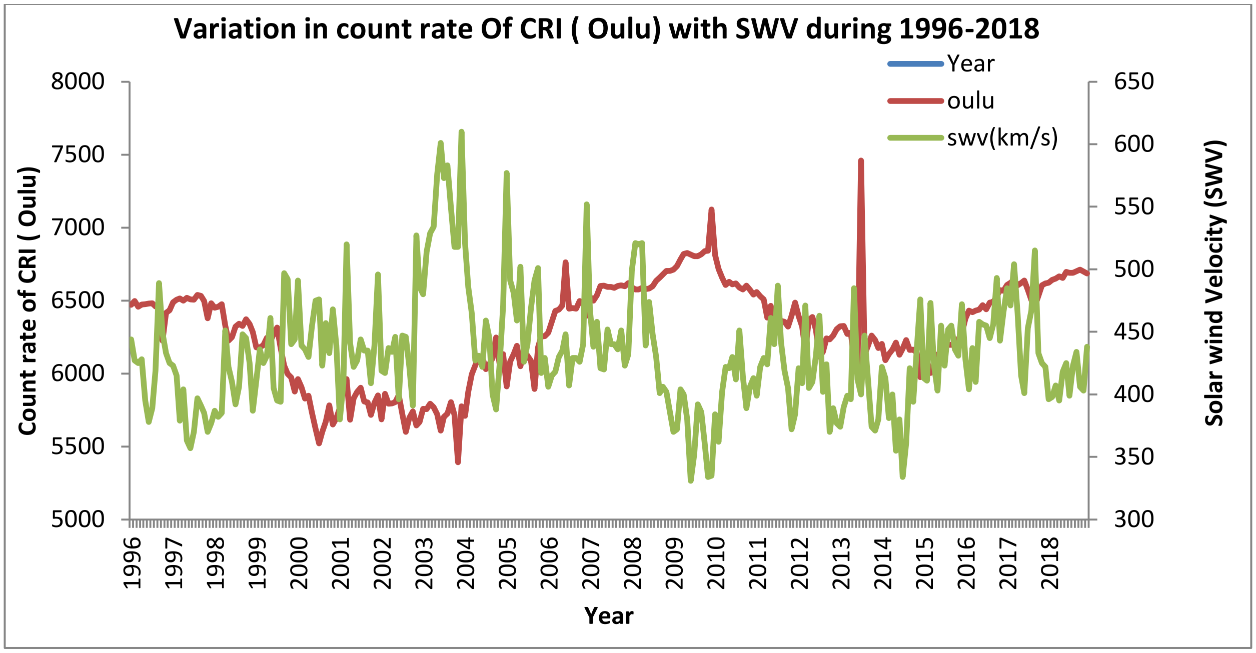


Fig.1. (a) & (b) Long-term modulation in GCR intensity as observed by Oulu & Moscow Neutron Monitors with Sunspot number SSN during Solar Cycle 23/24



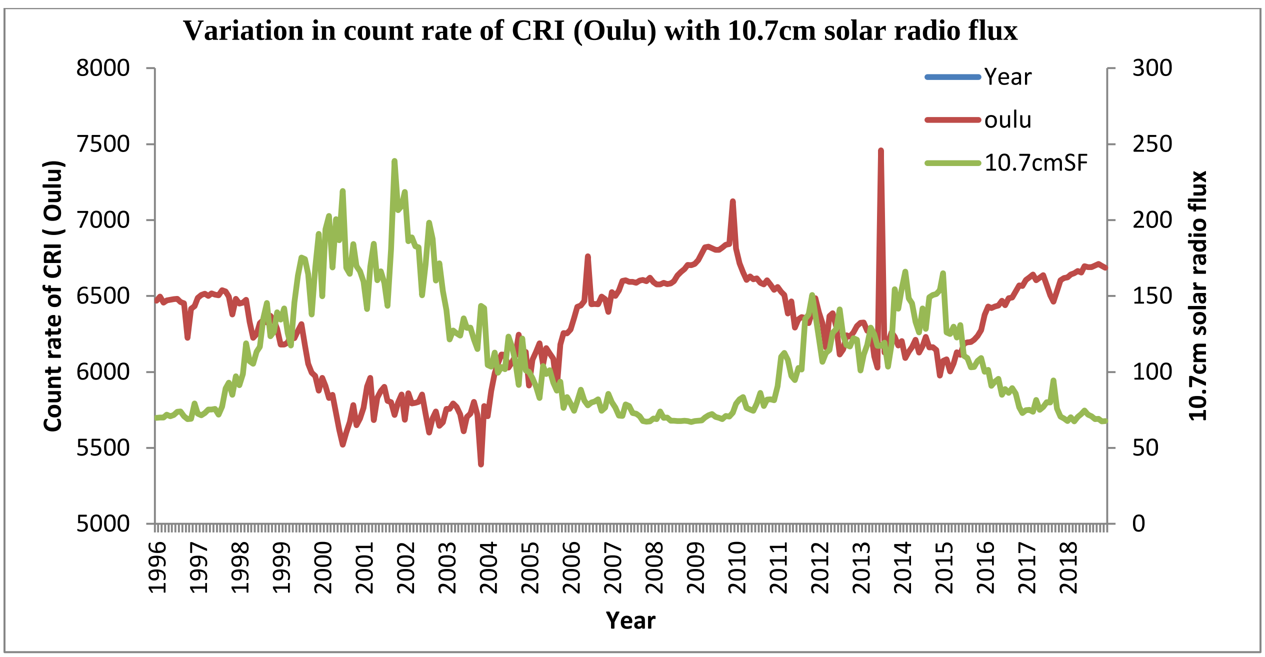
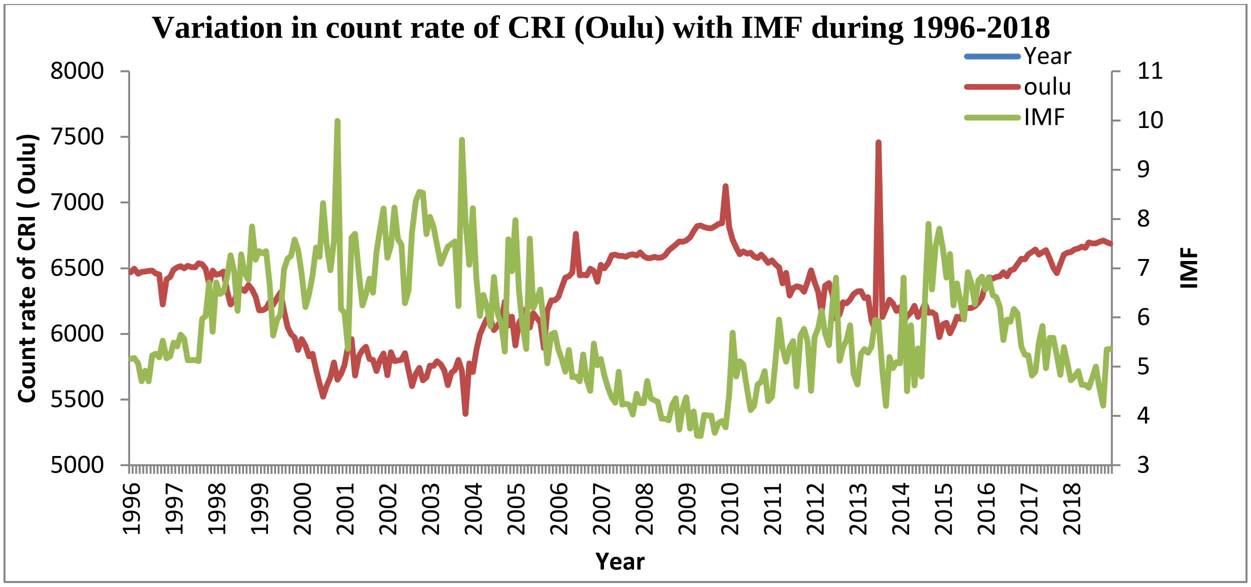


Fig.2. (a) & (b) Long-term modulation in GCR intensity as observed by Oulu Neutron Monitors with Solar- activity indies[Solar wind velocity (Vsw) & 10.7 cm solar radio flux] during Solar Cycle 23/24.



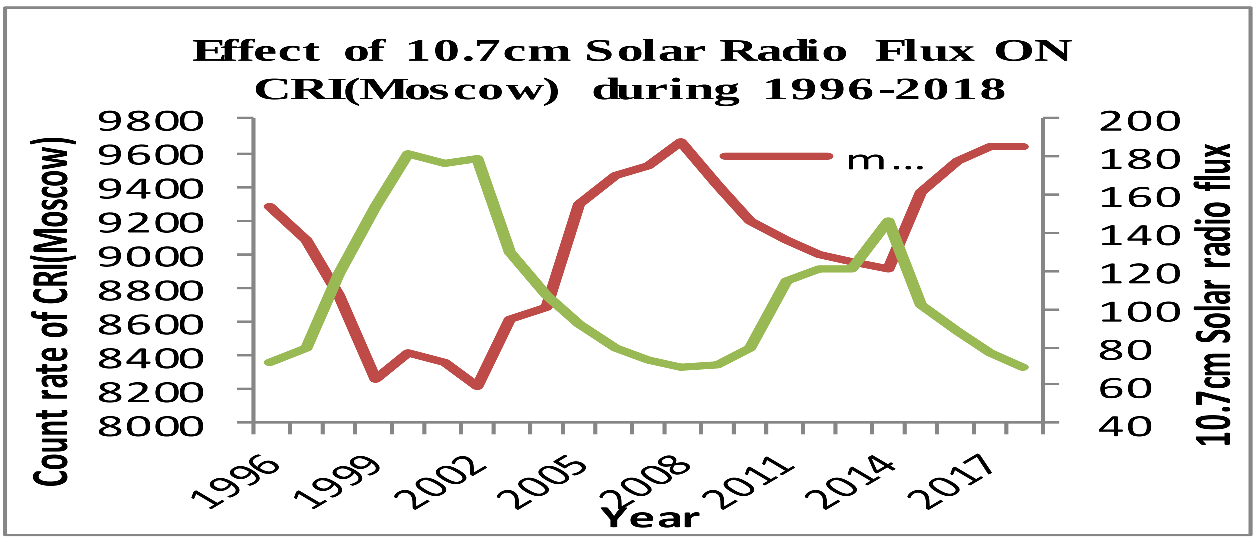


Fig.3. (a) & (c) Long-term modulation in GCR intensity as observed by Oulu Neutron Monitor with Solar-interplanetary activity indies (IMF) and (b) CRI (Moscow) with 10.7cm Solar Radio Fluxes (SRF) during Solar Cycle 23/24

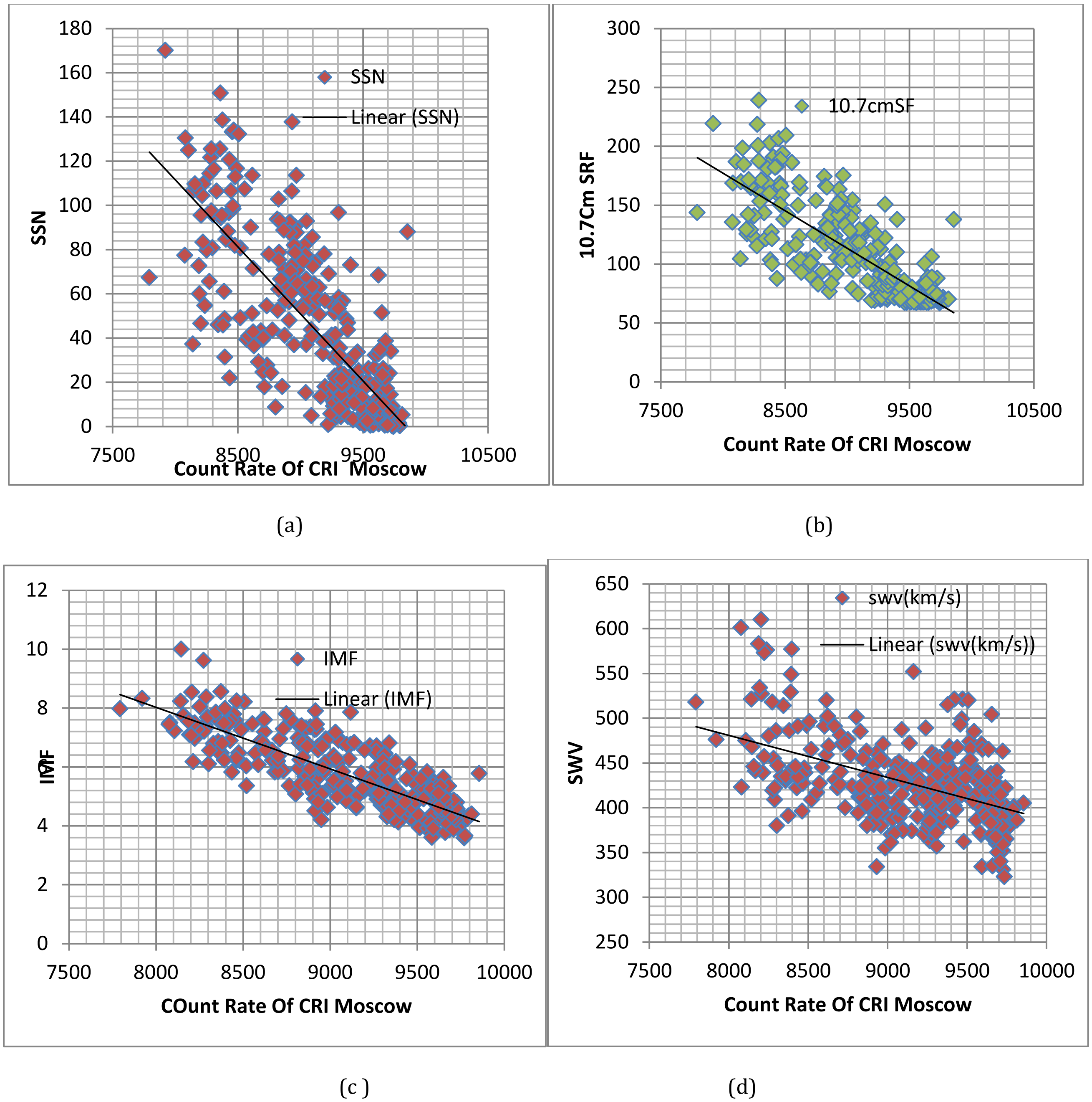


Fig.4. (a) & (b) Correlation between GCR intensity as observed by Moscow Neutron Monitor with Solar activity parameters [i.e. SSN & 10.7cm Solar Radio Flux] . Fig. (c) & (d) Correlation between GCR intensity as observed by Moscow Neutron Monitor with Solar-interplanetary activity indies (IMF) and Solar wind Velocity (Vsw) during Solar Cycle 23/24

Result and discussion

Variations in cosmic rays intensity on long -term basics and the tilt of the heliospheric current-sheet exists in all periods of the same heliomagnetoshperic polarity. CR intensity variation are produced by the transient disturbance like traveling interplanetary shocks, CMEs and events vary with solar activity at the different phases of the Sunspot Cycle. MCs preceded by shocks are associated large decreases in CRI **Fig 1 (a&b)** with , where as small decreases are associated magnetic clouds are not preceded by shocks. The modulation in CRI are anti- correlated **Fig.4b &Fig.4b** with Solar Activity indices **Fig.2b &Fig.3b**. Modulation in Cosmic rays are produced by Vsw is related to convection, diffusion depends on the IMF and its fluctuations,**Fig.2a & Fig.3a** and the tilt of the heliosphereic current sheet. Solar activity has been proven of very low Sunspot numbers nearly absent and solar magnetic field is reduced, are about half as those observed during the previous Solar minimum.Due to weaker in B, a high cosmic ray intensity observed in 2009 and there after an unusual rapid increase in the tilt angle is likely related to the weaker polar field. The decrease in IMF is due to either weaker input of solar polar magnetic flux which in turn reduces the GCRs entering the inner heliosphere .

Conclusion

The sector structure and local components of the solar magnetic field take part in the formation of the heliomagnetosphere and play an important role in GCR modulation. Modulation in GCR intensity are produced by the transient disturbance like traveling interplanetary shocks, CMEs and events vary with Solar Activity at the different phases of the Sunspot Cycle. Modulation in cosmic ray intensity are anti- correlated with solar activity indices . Modulations in GCRs are produced by solar wind velocity (Vsw) is related to diffusion & convection depends on the IMF strength (B) and its variation , and the tilt of the heliosphereic current sheet.

Refrences

1. W.S.,Smith, W.H.Matthaeus., and G.P. Zank, J .Geo.Res. 106, (**2001**),8253.
2. G.P. Zank, L.Adhikari, and P. Hunana, .Astrophys. J.835, **(2017),** 147.
3. P.Chawdhary, P.K., Kudela, and B.N. Dwivedi, Solar Physics 286, **(2013)** ,2.
4. L.L.Zhao, L. Adhikari, G.P. Zank, Q. Hu & X.S. Feng Astrophys.J. 856, **(2018)** 94.
5. Forbush , Physics Rev. **51**, (**1937**),1108-1109.
6. E.N.Parker. Planet.Space Sci,**13**,9-49,doi:10.1016/0032-0633(65),(**1965**),90131-5.
7. L.F. Burlaga, and G.J. Chang. Geophys. Res.**93**, (**1988**)2511-2518.
8. B.K.Tiwari, B.R.Ghormare, and P.K.Shrivastava Res. J. Physical Sci. Vol. **2(5),** (**2014**) 8-11.
9. L.F.Burlaga, E.Sitter, F.Mariani, R.Schwenn, J. Geophys. Res.**86**, (**1981**), 6673.
10. M.E.Potgieter, J.Atmos.Sci-Terr.Phys.**70**, (**2008**) , 207.
11. M.E.Potgieter, Plant.Space Res.**46**, (**2010**),402.
12. H.S.Ahluwalia and R.C. Yghuhay, AIP Conf. Proc.**1216**, (**2010**),699.
13. B.KTiwari., B.R.Ghormare., P.K.Shrivastava., D.P.Tiwari.Res. J. Physical Sci. Vol. 2(3), (**2014**),4-8.
14. R.Modzelewska.,M.V.Alania., Solar Phys, 286, (**2013**), 593-607.
15. H.Moraal , P.H.Stoker, J .Geophys.Res. **115**, (**2010**),A12109, 1-9 .
16. K.Nagashima and I. Morishitha., Planetary and space Sciences Vol.28 No.2, (**1980**)P- 117.
17. Y.Z.Ding.,G.Li.,X.J.Hu.,et al 2020,RAA,20,145
18. A.L.Upton And D.H.Hathaway.2018,GeoRL,45,8091