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MODULATION IN COSMIC RAYS DUE TO SOLAR-INTERPLANETARY ACTIVITY

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ABSTRACT

The intensity of galactic cosmic rays (GCR) is subjected to heliospheric modulation under the influence of solar outputs and their variations. It is observed that sunspot number 10.7 cm solar radio flux, coronal mass ejections (CMEs) and solar flares are the causal link to solar activity. Based on the observation from Omniweb data Centre for solar- interplanetary activity data and monthly mean count rate of cosmic ray intensity (CRI) variation data from neutron monitor Oulu and Moscow (cutoff rigidity Rc=0.80 GV and cutoff rigidity Rc=2.43 GV) during the period of 23/24 solar cycle .We observed a record high value of galactic cosmic ray intensity with low values of solar - interplanetary activity parameters during this minimum period of solar activity and also correlate count rate of cosmic ray intensity with solar activity parameters i.e. better anti-correlated.

Key words- Cosmic rays (CRs), Magnetic clouds (MCs), Coronal mass ejections (CMEs), Interplanetary magnetic field (IMF)

INTRODUCTION

Solar outputs and their variations are responsible to produce changes in cosmic ray intensity. Cosmic rays are scattered by irregularities in the structure of heliospheric magnetic field and undergo convection and adiabatic deceleration in the expanding solar wind changes in the heliospheric conditions as produced by the solar activity. The changes in cosmic ray intensity are usually caused by transient interplanetary events, which are related to coronal mass ejections (CMEs).Scott.Forbush established the correlation between world-wide decreases in cosmic ray intensity and geomagnetic storms (Forbush,1937) and the sunspot cycle (~11 years) in CR intensity i.e., its variation in the opposite phase with sunspot number and which can be understood by the transport of GCRs through the model of heliospheric magnetic field (HMF) (Parker,1965) . During high solar activity magnitude of the HMF increases due to larger number of CMEs ejected from the sun, therefore solar magnetic field more effective at sweeping cosmic rays out of the inner heliosphere which causes a strong reduction in Cosmic rays flux and reproduce CRI modulation. Sporadic emission of clouds of magnetized plasma produced CRI modulation in the interplanetary space and terrestrial geomagnetic storms (Burlaga,et.,al., 1988). Small decreases in galactic cosmic rays are associated with magnetic clouds (MCs) are not preceded by shocks where as large decreases are associated with that MCs are preceding by shocks (Tiwari, et.,al., 2014, Potgieter,2010).The interplanetary magnetic field (IMF) emanated from the Sun changes with the solar activity cycle, changing variations in speed of particle transport process such as convection, diffusion, drift and adiabatic deceleration. Solar wind (SW) density, pressure and strength of interplanetary magnetic field (IMF) all are their lowest values and record excess cosmic ray intensity was accompanied by the relative decrease in the anomalous cosmic rays, with quickly decreased energy about zero for low latitudes neutron monitors during this period.

Solar and heliospheric conditions make this period interesting for the study of cosmic rays modulation with indices of solar activity and heliospheric parameters. the sun was much quieter, the heliospheric magnetic field was weaker and observed higher cosmic ray diffusion coefficient allows an increase in cosmic ray intensity (Ahluwalia et.,al.,2010, Tiwari,et.,al., 2014). Sunspots are low (or absent), strength of the HMF was exceptionally low and solar-interplanetary activity parameters where significant different from the previous solar minimum (Burlaga,et.,al., 1981, Potgieter,2008). The main unusual features in the GCR intensity in this anomalous period are excess of the maximum intensity during 2009-2010.

DATA ANALYSIS

In order to study the long term variation in cosmic ray through the years 1996-2013 ,monthly mean values of cosmic rays data were used observed by neutron monitors http://www.nmdb.in Oulu (Rc=0.81GV) .In this study we also used data of monthly mean sunspot numbers (SSN) ,and solar flare index were taken from National Geographical Data Centre (NGDC) and analyzed solar interplanetary data from Omniweb data base http://www.omniweb,gsfc.nasa.gov.in .

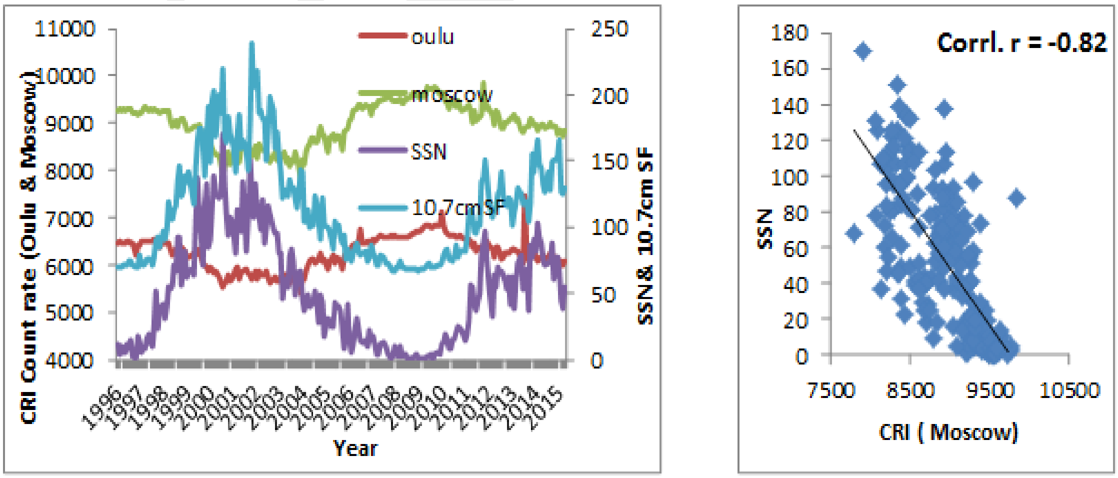
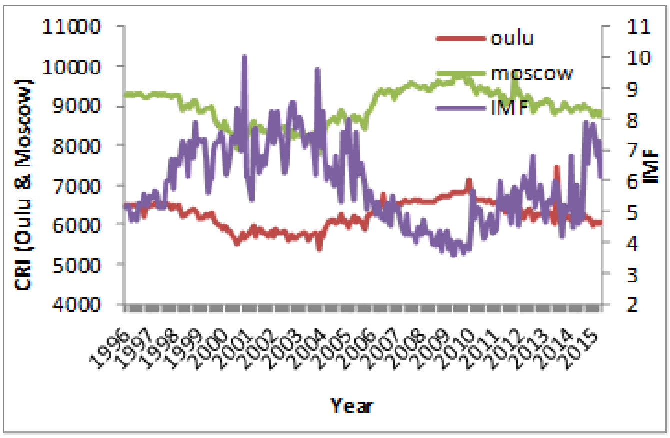


Fig 1- shows modulation in counts rate of CRI with Sunspot number and 10.7 cm solar radio flux (left) and correlation between count rate of CRI with sunspot number (SSN) (right).



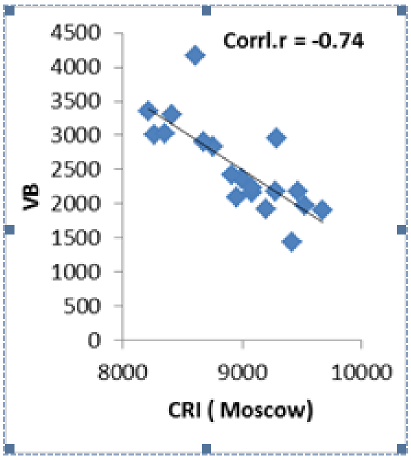
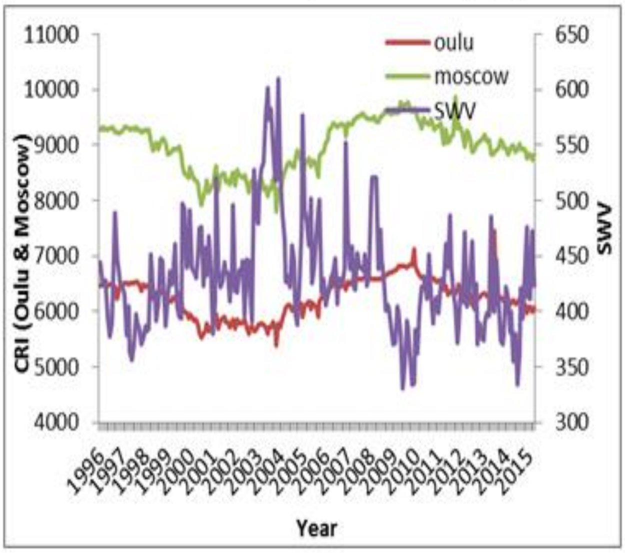


Fig 2- shows modulation in counts rate of CRI with Interplanetary Magnetic Field (IMF) (Left) and correlation between count rate of CRI with product of VB (Right).



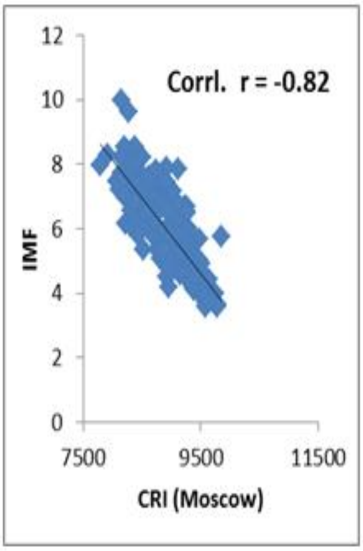


Fig 3- shows modulation in counts rate of CRI with Solar wind velocity (SWV)(Left) and Correlation between count rate of CRI with IMF (Right).

DISCUSSION AND CONCLUSIONS

Cosmic ray intensity variation are produced by the transient disturbance such as interplanetary shocks, are produced by coronal mass ejection. The large decreases in CRI are associated with MCs preceded by shocks, whereas, small decreases are associated with magnetic clouds are not preceded by shocks. Modulation in Cosmic ray intensity are high anti- correlated with solar activity parameters and these variations are produced by solar wind velocity is related to convection, diffusion and drifts, depends on the interplanetary field strength, its fluctuations and the tilt of the heliosphereic current sheet (HCS). The rate of decrease in cosmic ray intensity is faster with respect to increase in interplanetary magnetic field and solar wind velocity, although the correlations are poor.

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