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Study of variation in Cosmic ray Intensity due to Solar-Interplanetary activity between 1996-2013

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Abstract

Solar outputs and their variations are responsible to produce changes in cosmic ray intensity (CRI) both on short-term as well as on long–term basis. 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. Moreover, coronal mass ejections are associated with a variety of interplanetary plasma and field disturbances. Based on the observation from Omniweb data centre for solar- interplanetary data activity and monthly mean count rate of cosmic ray intensity (CRI) variation data from neutron monitors (Moscow, Oulu, Keil) during the period of 1996-2013.We observed a record high value of cosmic ray intensity with low values of solar interplanetary activity parameters during minimum of solar cycle 23 and ascending phase of 24. Statistical techniques are used to correlate data of solar interplanetary and count rate of cosmic ray intensity i.e. better anti-correlated with solar activity parameters.

Keywords: Heliospheric magnetic field (HMF), Galactic cosmic ray (GCR), Magnetic clouds (MCs), Coronal mass ejections (CMEs).

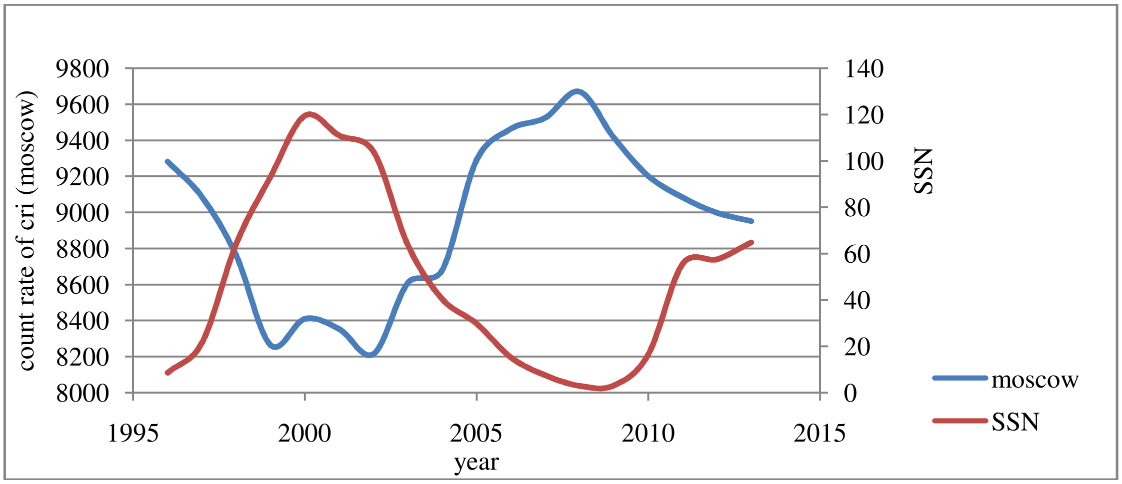
Introduction

The intensity of galactic cosmic rays is subjected to heliospheric modulation under the influence of solar outputs and their variations. Cosmic rays (charge particles) 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. Variation in cosmic ray is 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[1] and the sunspot cycle (~11 years) in GCRs 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)[2] . During high solar activity magnitude of the HMF increases due to larger number of CMEs ejected from the sun (which occurs each~ 11- years sunspot cycle), therefore solar magnetic field more effective at sweeping GCRs out of the inner heliosphere which causes a strong reduction in GCR flux and reproduce the~ 22 years GCR modulation using a time-dependent modulation model. In the interplanetary space GCR can be modulated by sporadic emission of clouds of magnetized plasma and produce terrestrial geomagnetic storms[3, 4,] . 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[5]. The interplanetary magnetic field 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[6].

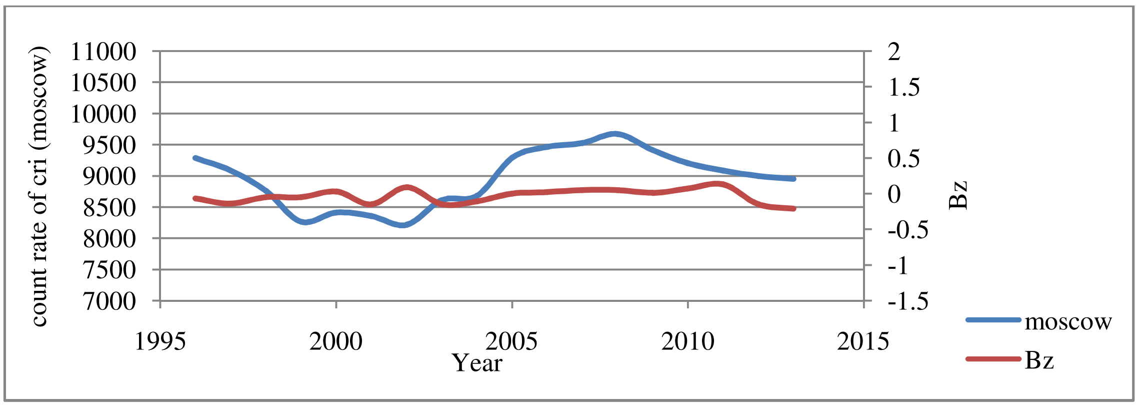
Solar wind (SW) density, pressure and strength of interplanetary magnetic field (IMF) all are their lowest values and measured a record excess GCR intensity was accompanied by the relative decrease of the anomalous cosmic rays (ACRs), quickly decreased with energy about zero for low latitudes neutron monitors during period between solar minimum of cycle 23 and ascending phase of 24. Solar and heliospheric conditions make this period interesting for the study of cosmic rays modulation with indices of solar activity and heliospheric parameters. Sunspots are low or absent, strength of the HMF was exceptionally low between cycle 23 and 24 minimum and solar interplanetary activity parameters where significant different from the previous solar minimum[7]. The main unusual features in the GCR intensity in this anomalous period are excess of the maximum intensity during 2009-2010, the sun was much quieter, the heliospheric magnetic field was weaker and observed higher cosmic ray diffusion coefficient allows an increase in GCR intensity[8,9,10].

Data analysis

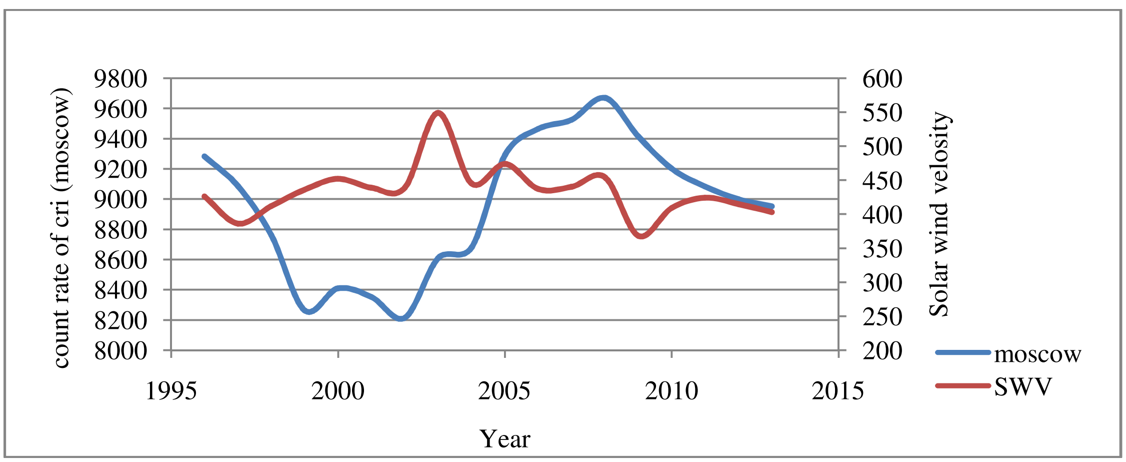
In order to study the long term variation in cosmic ray through the years 1996-2013 ,monthly mean values of cosmic rays data were used observed by neutron monitors http://www.nmdb.in (Moscow (Rc=2.32GV), Oulu (Rc=0.81GV) and Kiel (Rc=2.39GV). In this study we also used data of mean monthly sunspot numbers (SSN), monthly group solar flare index taken from National Geographical Data Centre (NGDC) and analyzed solar interplanetary data from Omniweb data base http://www.omniweb,gsfc.nasa.gov.in .



(a) Variation in count rate of cri (moscow) with SSN during 1996-2013



(b) Variation of count rate of cri (moscow) and Bz during 1996-2013



(c) Effect of solar wind velosity on cri (moscow) during 1996-2013

Figure-1 (a,b,c,)

Long-term variation in cosmic ray intensity as observed by Moscow with solar-interplanetary activity indies (SSN,Bz,SWV) during 1996-2013

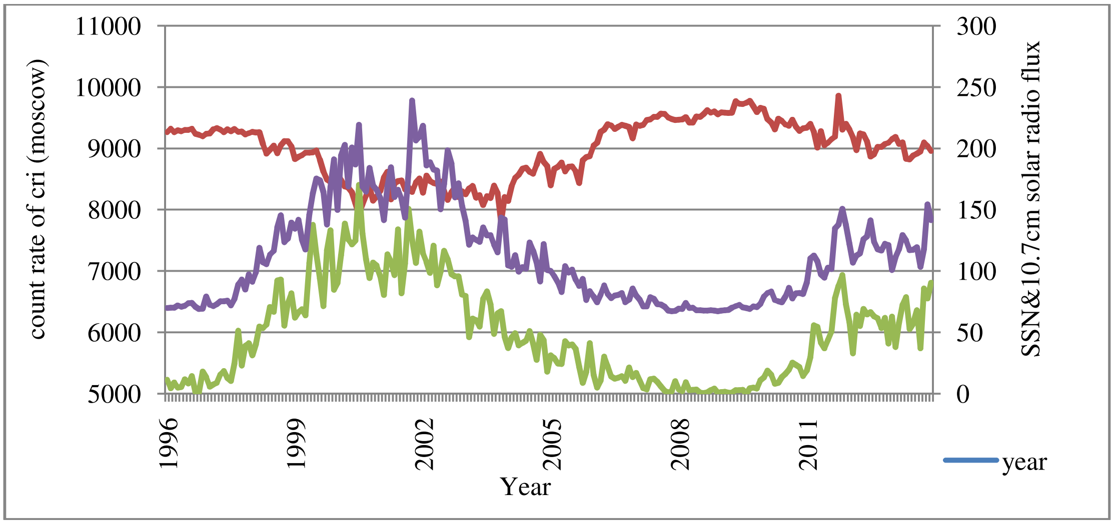


Figure-2 (d)

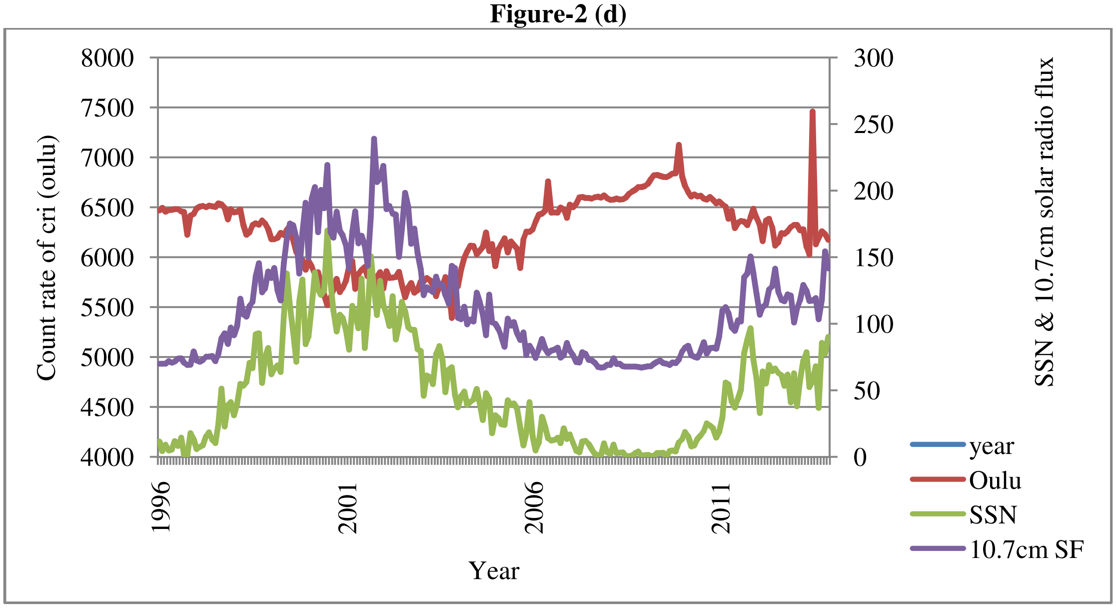


Figure-2(e)

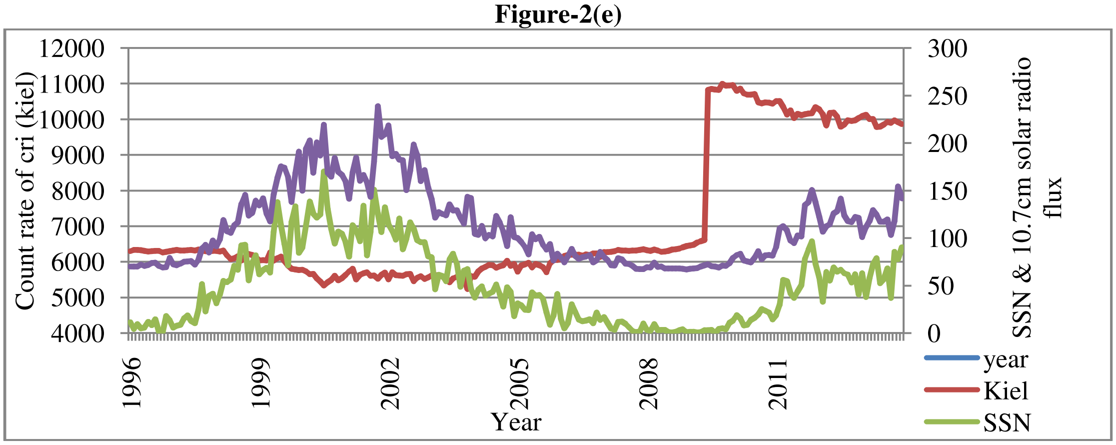


Figure-2(f)

Figure-2 (d,e,f,)

Long-term variation in cosmic ray intensity as observed by Moscow Oulu Keil with solar- activity indies (SSN,10.7 cm solar radio flux) during 1996-2013

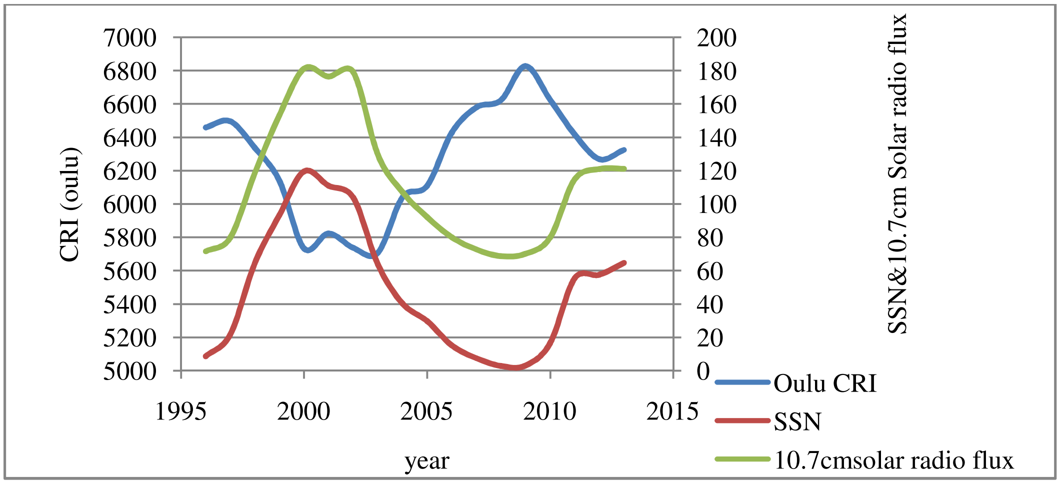


Figure-3(g)

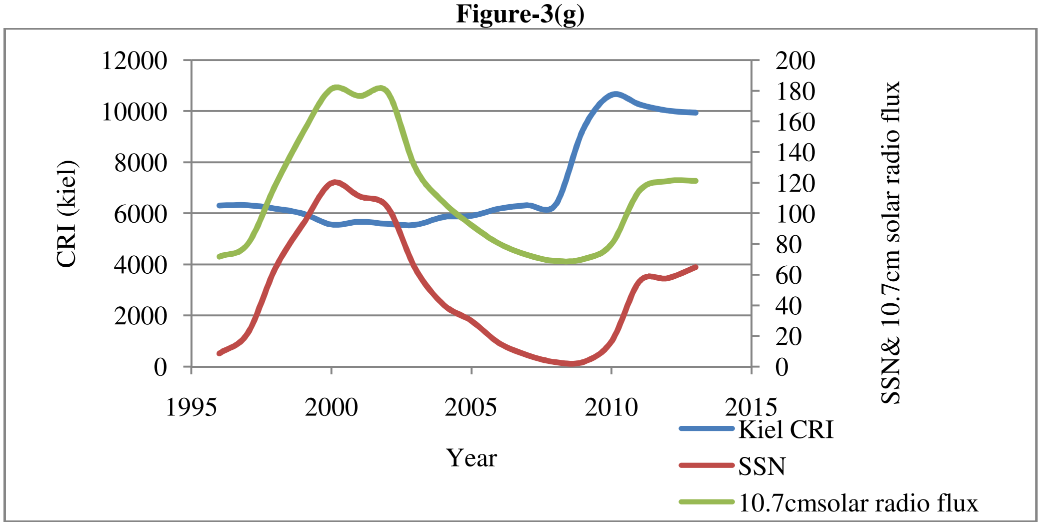


Figure-3(h)

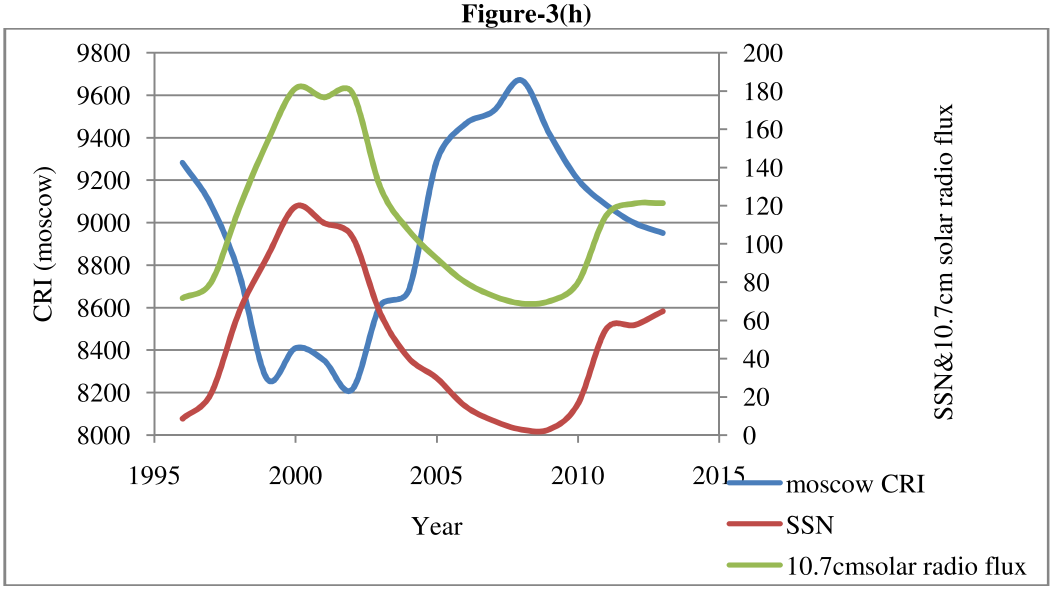


Figure-3(i)

Figure-3 (g,h,i,)

Long-term variation in cosmic ray intensity as observed by Oulu Keil Moscow with solar-interplanetary activity indies during 1996-2013

Result and Discussion

Cosmic ray intensity variation are produced by the transient disturbance like traveling interplanetary shocks, are produced by coronal mass ejection and events vary with solar activity at the different phases of the sun spot cycle. Large decreases in CRI are associated with MCs preceded by shocks where as small decreases are associated magnetic clouds are not preceded by shocks. 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.

Conclusion

Cosmic ray intensity variations based on variation with Solar and interplanetary indices as well as tilt of the heliosphereic current sheet and intensity variations of interplanetary magnetic field (IMF). Variation in CRI are closely related with halo CMEs associated with X-ray solar flares of different categories and interplanetary shocks .during the minimum solar activity phase decrease rate of cosmic ray intensity is faster with respect to increase in interplanetary magnetic field and solar wind velocity, although the correlation are poor.

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