VARIABILITY IN COSMIC RAY DIURNAL ANISOTROPY TOGETHER WITH SOLAR AND GEOMAGNETIC PARAMETERS

[1]Arvind Dubey, [2]Santosh Kumar, [3]Sushil Kumar Dubey

[1]Assistant professor, [2]Professor, [3] professor
[1]Department of Physics,Seva Sadan College, Burhanpur - 450331 (M.P.), India
[1]Seva Sadan College, Burhanpur - 450331 (M.P.), India

***Abstract :* We have analysed the cosmic ray diurnal amplitude on annual basis with the Sunspot Number (R_z), Solar flare index, geomagnetic activity index (Ap) and disturbance storm time index (Dst) for the period of 1986-2017; i.e., covering solar cycle 22, 23 and major part of cycle 24, we have used neutron monitor data from Kiel and Moscow Neutron monitoring stations. The diurnal amplitude (%) of both the stations shows a positive correlation with sunspot number, solar flare index and geomagnetic index. Correlation with Disturbance storm time index Dst shows a negative value with the diurnal amplitude.**

***IndexTerms* - Cosmic Ray Daily Variation, Sunspot Number, Geomagnetic activity Index Ap, Disturbance storm time index Dst.**

I. INTRODUCTION

Cosmic Rays undergo large changes through their path from their source to the earth before being recorded by the instruments. Incident angle and pattern of variability evidently are different for radiations arriving from different sources and different passage having different magnetic conditions. They get affected during this process; in terms of trajectories and thus the energy acquired through acceleration under the field prevailing through the trajectories. The variability of cosmic ray is one of the most interesting challenges because of their impact on geophysical environment. The daily variations reflecting in cosmic rays intensity is a consequence of complex effects owing to multiple parameters in interplanetary magnetic field (IMF) and geomagnetic field. The short term and long term modulation in cosmic ray flux have been studied taking different parameters into account; by many researchers involved in cosmic ray comprehensive study of time variation of intensity and they have critically analysed various aspects of modulation [9,8,10,1,16,2,3,15,7,13,11 and 12]. The diurnal variation of Cosmic Rays is studied by working out the amplitude and the time of maximum on the earth based neutron monitoring stations.
These modulation analyses are complimentary studies to the 'insitu' measurements for providing a complete understanding of the various processes or mechanisms working in the interplanetary space.

As an established fact, the variability of cosmic rays features is resulted from multiple heliosphere phenomena and no single factor may be held responsible for these variations. Many groups of workers and individuals have proposed various empirical relation to predict & explain the cosmic ray modulation as an effect of multiple solar features such as solar wind velocity, solar flares, sunspot numbers etc. [4].

Their statistical relationship with various potential drivers has also been investigated. The physical mechanisms of solar flares and the relationship between flare activity and sunspot activity have become the hottest and biggest problem in the field of solar physics [6].

In this work Considering the Solar cycles 22, 23 and major part of cycle 24 for the present studies (year 1986-2017) the first harmonic of the daily variability have been taken and the amplitude have been analysed together with multiple solar features.

II. DATA ANALYSIS

During the period 1986 to 2017, covering the major portion of solar cycles 22, 23 and 24 the amplitudes of the first (diurnal) harmonics of the daily variation of high energy cosmic rays have been obtained on a day-to-day basis by using the pressure corrected hourly data of neutron monitors. These observational results for first harmonic have been compared with the solar and geomagnetic activity parameters. The hourly pressure corrected cosmic ray neutron monitor data of Kiel and Moscow neutron monitoring stations have been obtained from the website from Kiel neutron monitor http://cr0.izmiran.ru/kiel/main.htm and Moscow neutron monitor http://cr0.izmiran.ru/mosc/. The amplitudes of the anisotropic variation of cosmic rays have been derived from these data by harmonic analysis using Fourier technique.
Table 1. shows the details of neutron monitor which are used for study.

Table 1

Neutron monitor station	Geographic Latitude(Deg.)	Geographic Longitude(Deg,)	Cutoff Rigidity
Kiel (KIL)	54.3	10.1	2.36
Moscow	55.4	37.3	2.39

In the present study, we have used the yearly mean of SSN & SFI as solar activity parameters and Ap & Dst as geomagnetic parameters. SSNs, Dst and Ap are available through the https://omniweb.gsfc.nasa.gov/form/dx1.html, while SFI has been taken from the website https://www.ngdc.noaa.gov/stp/solar/solarflares. html for the period 1986–2017.

III RESUTS AND DISCUSSION

The cosmic ray modulation is a consequence of complex mechanism prevailing all over the heliosphere and depends on many factors. No single solar index, however sophisticated, can account for cosmic ray variations [5]. The expression of long-term variation of the galactic CR intensity in terms of various solar indices and geophysical parameters; have been tried by many groups of researchers. In this paper, we have performed the study of variation in diurnal amplitude of cosmic ray intensity based on data recorded in Kiel and Moscow neutron monitor stations; together with sunspot number (Rz), solar flare index, geomagnetic activity index (Ap) and disturbance storm time index (Dst) for a period of 1986-2017. The period of study covers solar cycle 22, 23 and major part of cycle 24.

Crossplots between annual average values of diurnal amplitude and these parameters have been drawn and also looked into possible systematic statistical changes among them. The diurnal harmonic of daily variation was found to be maximum in the year 1989, 2000 and 2014 while the minimum values of these parameters were achieved in the years 1986, 1996 and 2008.

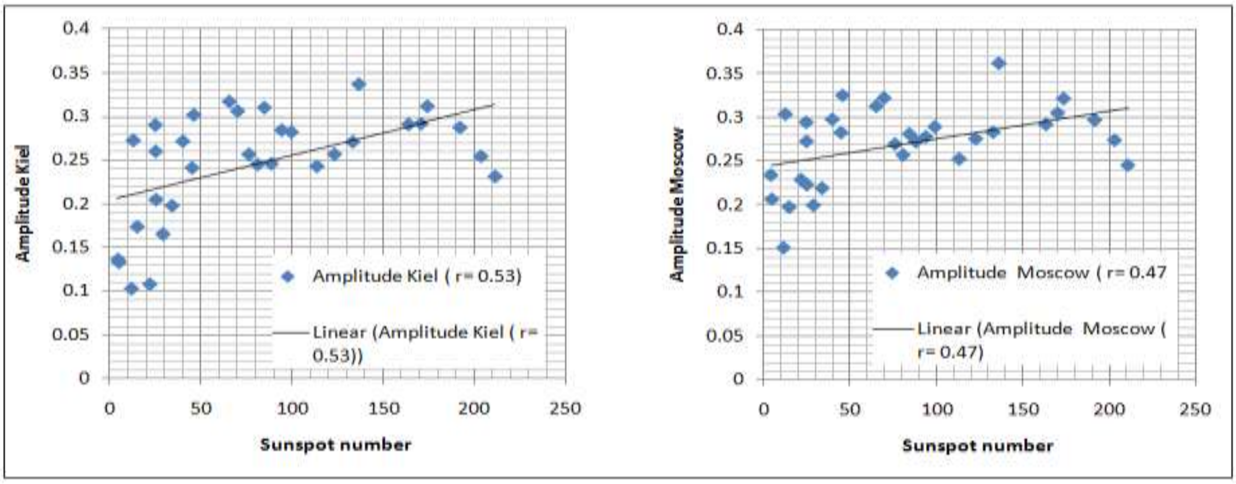

Figure 1. Shows the crossplot between the first harmonic (diurnal variation) annual average amplitude (for Kiel as well as for Moscow in %) with sunspot numbers for the interval 1986-2017. The best fit lines are also shown in both the figures.

It is observed that the Significant positive correlations of amplitude of diurnal variation for both the stations; sunspot number (Rz) have been found to have significant values. Annual average values of the first harmonic amplitudes for Kiel and Moscow neutron monitor data with the change in the annual average magnitudes of the sunspot number, for the interval 1986-2017, shows a significant positive correlations for both the stations. The correlation coefficient is r = 0.53 for Kiel and r = 0.47 for Moscow neutron monitor stations.

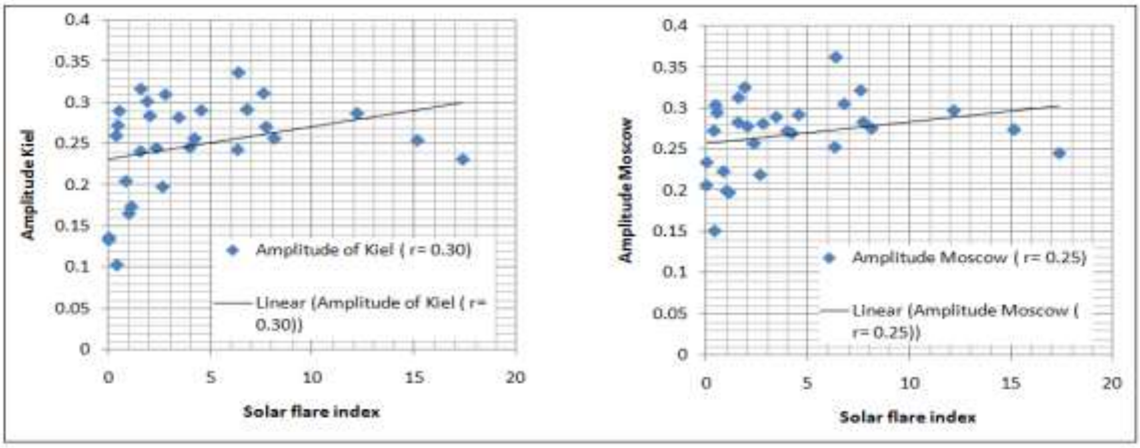

Figure 2. Shows the crossplot (with best fit lines) between the first harmonic (diurnal variation) annual average amplitude (for Kiel as well as Moscow in %) with Solar flare index for the interval 1986-2017.

It is observed that the diurnal amplitude shows a significant correlation with solar flare index for both the stations during the period of study. It shows a positive correlation (r = 0.30 for Kiel NM station; and r = 0.25 for Moscow NM station).

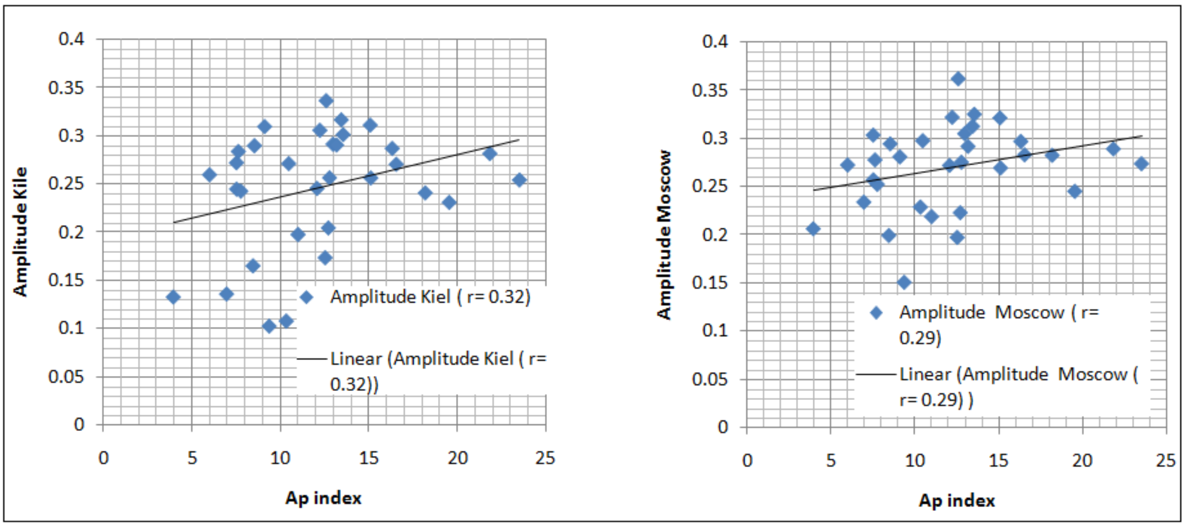

Figure 3. Shows the crossplot between the yearly mean Ap index vs. first harmonic (diurnal variation) annual average amplitude (%) for Kiel as well as for Moscow, for the period 1986-2017.

The yearly mean Ap vs first harmonic annual average amplitude for Kiel and for Moscow, are found to have a positive correlation between them (correlation coefficient r = 0.32 for Kiel station and r = 0.29 for Moscow station).

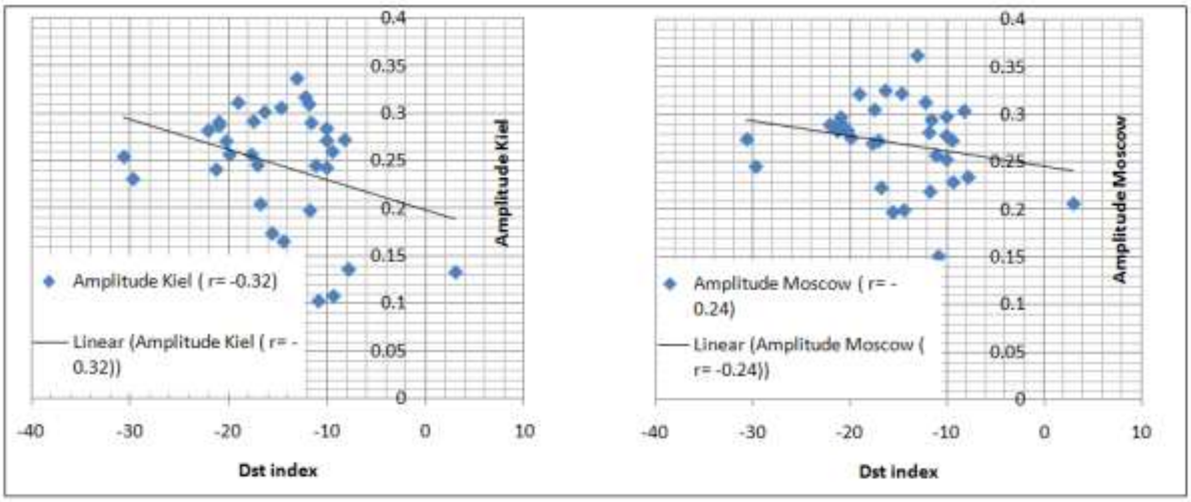

Figure 4. Shows the crossplot and best fit curve between the yearly mean Dst index vs. first harmonic (diurnal variation) annual average amplitude (%) for Kiel as well as for Moscow, for the period 1986-2017.

Disturbance storm time index (Dst) is negatively correlated with diurnal amplitude. A negative correlation coefficient between annual average amplitude and Dst index is found as, Correlation coefficient r = - 0.32, and r = - 0.24 for Kiel and Moscow neutron monitoring stations, respectively.

The amplitude of diurnal wave has been found to have an association together with sunspot number (Rz), solar flare index, geomagnetic activity index (Ap) and disturbance storm time index (Dst) during the period of study covering solar cycle 22, 23 and major part of cycle 24.

Acknowledgement

We thankfully acknowledge Kiel and Moscow neutron monitor stations to provide Cosmic ray intensity data. Authors are also thankful to OMNI and NGDC database centers for providing the data of sunspot number, solar flare, geomagnetic index and disturbed storm time index.

References

[1] Agrawal, S.P. 1981.J. Geophy. Res. (USA), 86, 10115.
[2] Ananth AG, Vankatesan D, Pillai S (1993 changes in cosmic ra). Solar Phys. 143:187-196.
[3] Bazilevskaya BA, Krainev MB, Makhmutov VS, Stozhkov YI, Svirzhevskaya AK, Svirzhevsky NS .1995. Adv. Space Res. 16(9):221-225.
[4] Belov,A.V., Gushchina, R.T., Yanke, V. G .1999. Proc. 26th int. cosmic conf. 7:175-178.
[5] Helen, M., Evangelos, P. 2012. Adv. in Astron. pp. 1-8.
[6] Hathaway, H. D. 2010, Solar Phys. 7,1.
[7] Kudela, K., Firoz, K.A., Langer, R.D., Kollir, V. 2008. Proc. 21st Eur. cosmic ray conf. 374-378.
[8] Lockwood, J.A.; 1971, Space Sci. Rev., 12, 658.
[9] Pomerantz, M. A. and Duggal, S.P. 1971. Space Sci. Rev., 12,75.
[10] Rao, U.R. 1972. Sp. Sci. Rev., 12,719.

[11] Singh, Y.P. and Badruddin. 2017. Plant. Space Sci.138,1-6.
[12] Singh, Y.P. and Badruddin. 2015. Space Sci. 359,60.
[13] Sabbah, I., Kudela, K. 2011. J. Geophys. Res. Space Phys. 116(A4):2156-2202.
[14] Thomas, S., Owens, M., Lockwood,M. and Owen, C.; 2017, Ann. Geophys., 35, 825-838.
[15] Usoskin. I. G., Kalevi. M. 2001. J. Geophys. Res. 106(A8):16039-16046.
[16] Venkatesan, D. and Badruddin. 1990. Space Sci. Rev., 52, 121.