DAILY VARIATION OF COSMIC RAY INTENSITY IN SOLAR CYCLE 22,23 AND 24

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Abstract : The diurnal anisotropy of cosmic ray intensity for the time period 1986 to 2017 is studied, covering the amplitude and phase of solar cycle 22,23 and 24 for entire period . Cosmic ray intensity data from 3 neutron monitor station (Inuvik, Kiel and Moscow) is used. The data is analyses by harmonic analyses and Fourier technique for entire period. It has been observed that the diurnal amplitude increases in maximum solar activities and decreasing minimum solar activates of these station . The phase of diurnal anisotropy is well correlated with solar cycle and the phase shifted to early hours.

IndexTerms - **Cosmic ray, solar activity ,solar cycle and diurnal anisotropy**.

I. INTRODUCTION

The spatial property of anisotropy the galactic cosmic radiation in the interplanetary medium is observed as the daily variation in cosmic ray (CR) intensity which is recorded by ground-based detectors. A detector on Earth scans the entire sky during a time period of 24 h, since the Earth completes one rotation around its own axis once in this time range [25]. Consequently, the detectors scan through different portions of the CR angular distribution with a l-day period. The projection of this anisotropy on the ecliptic plane may be observed as diurnal anisotropy [27]. As a result, the intensity of GCR recorded by ground-based neutron monitors (NMs) shows periodic and abrupt changes as a function of space, time, and energy (Oh et al., 2010). This phenomenon, which is known as the diurnal anisotropy of CR intensity, is a localtime short-term variation [23, 1].

The diurnal variation is due to complex phenomena, deriving from the convective-diffusive theory, which involves the radial convection of GCR flux by the solar wind and the inward diffusion along the interplanetary magnetic field (IMF) [20, 24,7, 26]. An energy-independent anisotropic flow of CR particles in the 18 h co-rotational direction is generated due to the equilibrium between the convection and diffusion mechanisms [9,24,16]. This can explain the long-term average, but not short-term variations in diurnal anisotropy [29]. The diurnal anisotropy is also modulated by the geographic coordinates and the altitude of the detectors' location on Earth [18]. The solar diurnal of the cosmic ray intensity is interpreted initially on the basis of an outward radial convection and an inward diffusion along the IMF. The balance between the convection and diffusion generates an energy independent anisotropy flow of cosmic ray particles from the 18 hour co-rotational direction. [14] studied long term behaviour of diurnal wave of cosmic ray anisotropy in relation with interplanetary magnetic field.

The diurnal amplitude follows the 11-year variation in the solar cycle (SC) [4] while the diurnal phase probably displays a correlation with the magnetic solar cycle (22-year variation). This is due to the reversal of the solar magnetic field (SMF) around solar maximum activity [1]. Consequently, a significant variability of the diurnal anisotropy vector is observed in terms of amplitude and time of maximum, when considered on a SC variation basis [15]. The average diurnal amplitude was calculated on the order of 0.6 % but sometimes can be as great as 1.5 % [7]. The continually changing conditions in the interplanetary space cause a large day-to-day variability in the solar diurnal variation in CR intensity. Phenomena related to solar and CR variations may also be affecting the diurnal anisotropy. Such phenomena include groundlevel enhancements (GLEs), Forbush decreases (FDs) and magnetospheric effects (MEs), which are not interpreted in the same way by every NM [5, 21]. The characteristics of diurnal anisotropy show a remarkable variation during these extreme events [27]. Latitudedinal and longitudinal dependence of the cosmic ray diurnal anisotropy well explain by [28]. In this work the diurnal anisotropy of the cosmic ray intensity recorded at selected neutron monitor stations.

II. DATA SOURES AND ANALYSIS

The present analysis has been performed by collected the records of diurnal amplitude and phase of cosmic ray diurnal anisotropy for the period 1986 – 2017.The values of cosmic ray intensity recorded at the neutron monitor stations of Inuvik (INV), Kiel (KIL) and Moscow (MSW) neutron monitor station. A list of these station with geographic coordinate, altitude and the cut-off rigidity are given in table 1. The data resource for Inuvik neutron monitor is http://cr0.izmiran.ru/invk/main.htm, Kiel neutron monitor http://cr0.izmiran.ru/kiel/main.htm and Moscow neutron monitor http://cr0.izmiran.ru/mosc/ the pressure corrected hourly neutron monitor data have been observed for this study. The pressure corrected neutron monitor data for diurnal anisotropy analysis by harmonic analysis and Fourier techniques to derive amplitude and phase for period 1986-2017. The entire period cover solar cycle 22,23 and 24 .

Table 1. show the details of three neutron monitor station used in our study.

Neutron monitor station	Geographic Latitude (Deg.)	Geographic Longitude (Deg.)	Cutoff Rigidity (GV)	Altitude (m)
Inuvik (INV)	68.35	226.28	0.18	21
Kiel (KIL)	54.3	10.1	2.36	54
Moscow(MSW)	55.4	37.3	2.39	200

III RESUTS AND DISCUSSION

The amplitude (%) and phase (Hr) of the diurnal anisotropy for three neutron monitor have been plotted against year in Fig.1 and Fig.2 . Figure1 shows the plot of annual diurnal variation in amplitude (%) and Figure 2 shows the annual diurnal variation in phase (Hr) . The [17,24] considering all the days in a year have found yearly mean diurnal amplitude and phase to be practically constant during the period 1957-70, except for the small though significant decrease in amplitude in the years of minimum solar activity. The decrease in diurnal amplitude in 1965 is attributed to a significant reduction of the upper cutoff rigidity. Later to 1970, a significant shift to early hours in the phase of diurnal anisotropy was noticed for the first The neutron time during 1971, [3] monitor observations have shown a significant reduction in the diurnal amplitude as well as large phase shift to earlier hours in the phase of diurnal anisotropy on quiet days on a day-to-day basis, , prior to 1957, the similar variations in the result have been observed again since 1971 [10].the interstation studied They further as dispersion for the yearly average values for geomagnetically most quiet days and noted that the dispersion is small as compared to the changes from one year to another [11]. They have also reported that during the period when the polarity of the solar poloidal magnetic field.

The association of phase shift with solar magnetic field cycle inversion has been interpreted theoretically by many workers [8,6,12,22,13] using the concept of invoking drift effects. During the 1960s and 1980s when the direction of the IMF is inward above the heliospheric current sheet, cosmic rays (positively charged nuclei) enter and diffuse predominantly in the inner heliosphere mainly through the ecliptic plane. The net inflow balances the net outflow in the ecliptic plane (convective component); this leads to an azimuthal diurnal variation and the observed anisotropy during these epochs is explained by the convection-diffusion model.

During the 1950s and 1970s, when the direction of the IMF is outward above the heliospheric current sheet, these particles enter the inner heliosphere mainly from polar regions. The net inflow of cosmic ray balances the net outflow in the ecliptic plane and this results in a relative increase in the radial component which leads to shift in the phase to earlier hours. The long term changes in the amplitude and phase of diurnal variation are established with sufficient precision to ensure a physically meaningful comparison with the predictions of theoretical models; eliminating the marginal models.

The Figure.1 RDVV, Jabalpur graph shows the 11 years variation of phase and we found that the graph of Inuvik, Kiel and Moscow are same till the year 2010 and the graph of Inuvik increase in the year 2011 & 2012.The Figure.2 RDVV, Jabalpur graph shows the 11 years variation of amplitude and increasing diurnal amplitude in maximum solar activities. Decreasing the diurnal amplitude in minimum solar activity.

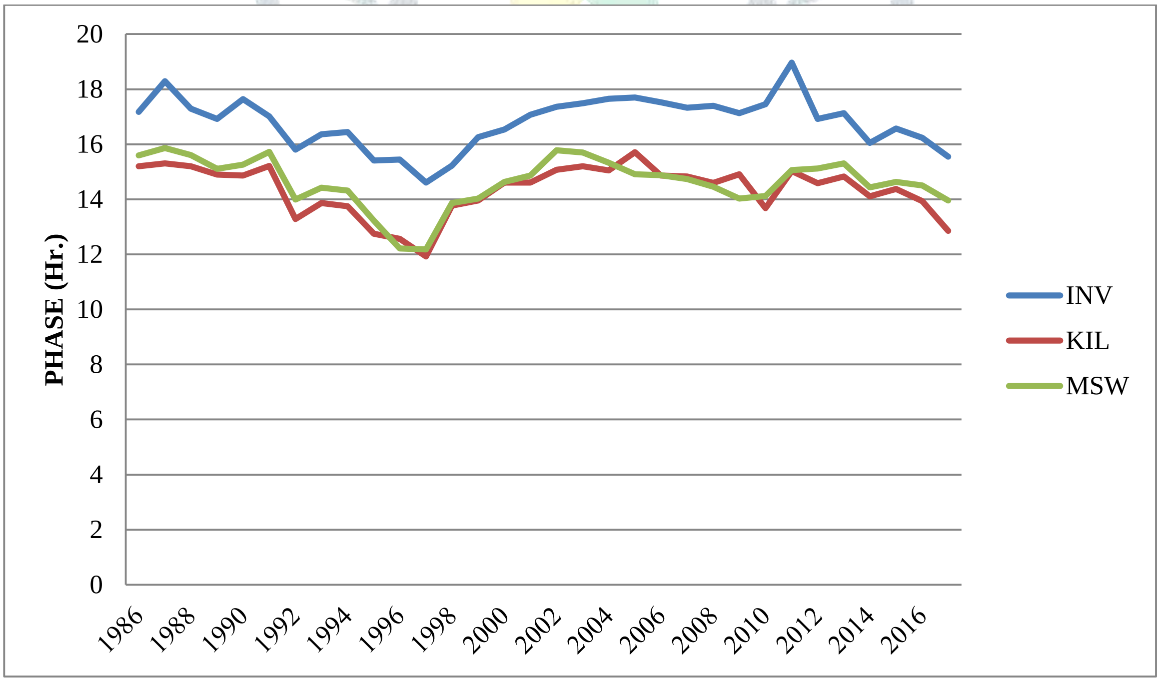

Fig. 1 – Phase (Hr.) for diurnal variation for Inuvik, Kiel and Moscow neutron monitors.

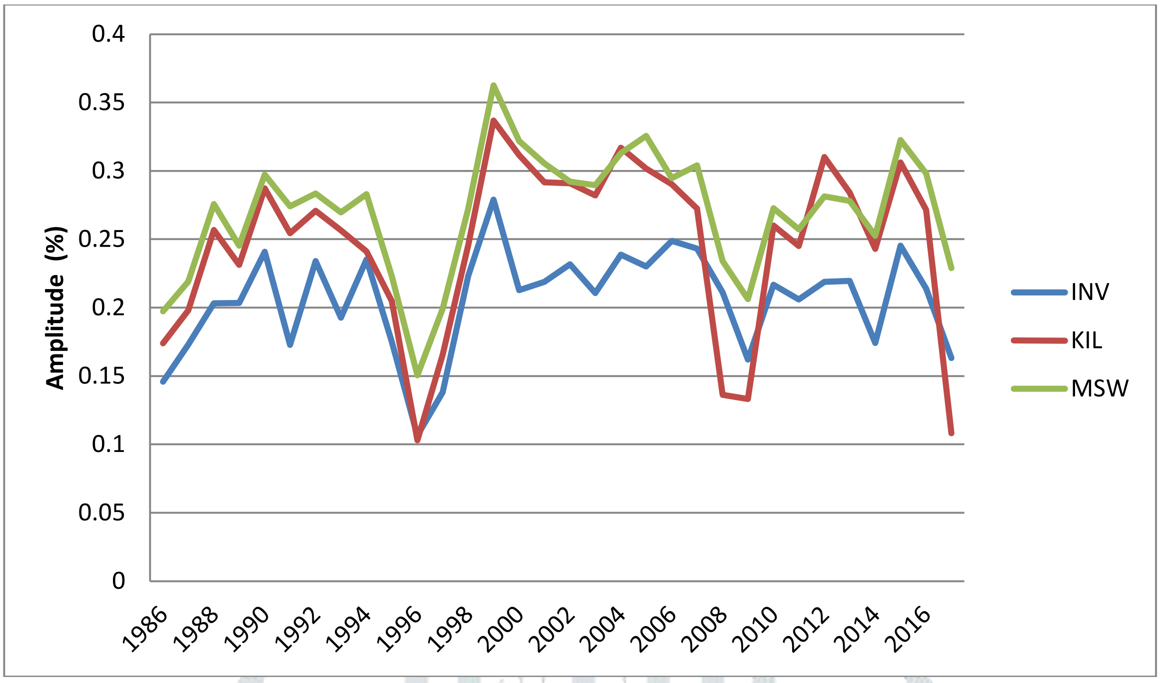

Fig.2 – Amplitude (%) for diurnal variation for Inuvik, Kiel and Moscow neutron monitors.

IV CONCLUSINON-

(I) Increasing diurnal amplitude of cosmic rays for three station observed 1998,2003,2012 in solar cycle 22,23 and 24 maximum solar activities.

(II) Decreasing the diurnal amplitude observed 86-87,95-96,09-10, and 16-17 solar cycle 22,23 and 24 minimum . solar activities.

(III) The phase shows a tendency to shift towards earlier hours from 1992 with a little increase towards corotational direction during 1993,2011 and again adopts a consistent treand of shifting towards early hours during later period.

(IV) With the comparative study of different station of diurnal variation on different geometric conditions for all days . it is observed that even though there are significant difference in INV neutron monitor compared to other two different monitor.

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