Variation of Diurnal Anisotropy During 1964–95

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Abstract

The Amplitude and the Phase of the diurnal anisotropy of cosmic ray (CR) intensity; on 60 geo-magnetically quietest days (QD), have been investigated together with other solar features. The diurnal phase has remained statistically constant in co-rotational direction during 1987–1992, which is analogous to the constant phase during the period of 1965–1970. The phase shift towards earlier hours is pronounced in the years 1971, 1973 and1975; which reaches to its maximum during 1976. This could not be explained on the basis of lower values of cutoff rigidity; because the change is more pronounced for higher primary rigidity. The phase has recovered its usual co-rotational (18 Hr) direction during 1980. Further, it remained constant from 1980 onwards till 1992. Again, from 1993 and onwards it has shown a tendency of shifting towards earlier hours. The maximum shift to earlier hours has been reported during 1953–54; i.e. the period of minimum solar activity, is repeated during the period 1975–76 and once again as it approaches to the period of minimum solar activity of solar cycle-22.

1. Introduction

Long term variation of the CR diurnal anisotropy has been examined using neutron and muon monitor data for all days (Bieber and Evenson, 1997; Riker and Ahluwalia, 1987)[3,8] for geomagnetically QD in a year (Badruddin et al, 1985; Dubey et al, 2001)[2,4]. The diurnal anisotropy of might posses two modulating components related to $\sim$ 22-year and $\sim$ 11-year solar magnetic cycles (Sharma and Yadav, 1998)[10]. Ahluwalia and Sabbah (1993) [1] have reported that the annual anisotropy vector shows a long term change. Kudo and Mori (1990)[5] have confirmed the 22-year periodicity in the phase modulation. Further, the phase shift in diurnal anisotropy during solar polarity reversal has attracted attention (Sabbah,1999; Kumar et al 1998) [9,6]. This investigation is an attempt to explore the trend of variation on a long term basis on geomagnetically consistent periods.

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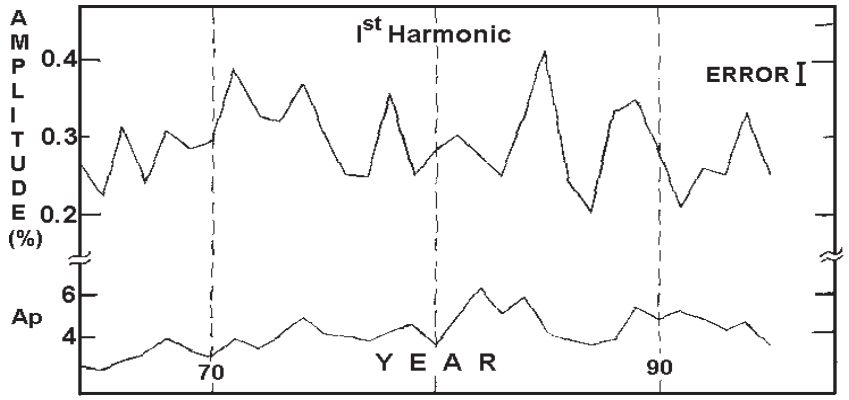

Fig. 1. Amplitude of the Diurnal Anisotropy and average values of Ap-Index On Quiet Days during 1964–1995 for Deep River Neutron Monitor

2. Data Analysis

The cosmic ray intensity data for Deep River Neutron Monitoring station has been used for the present work. Five most quiet days in a month, selected on the basis of index Ap; have been considered for harmonic analysis in this study. Thus, 60 quietest days for each year are investigated on yearly average basis, for a period of more than 3 decades i.e., 1964–95.

3. Results and Discussion

The amplitude of the diurnal anisotropy (DA) in CR intensity alongwith average values of Ap-index on 60 QD have been depicted in Fig. 1, which shows large variations in the amplitude of the DA with the changing values of yearly average values of Ap. The diurnal amplitude has been almost constant during 1964–70 except for lower values of DA during 1964–65, which has been attributed to the decrease in the upper cut-off rigidity. The amplitude of the diurnal anisotropy does not remain constant after 1970. It varies quite dramatically. During1971, there is a sharp increase in the value of the diurnal amplitude on QD in association with the phase shift early hours. Later to 1971, the diurnal amplitude decreases continuously till 1976, which is the year of minimum solar activity, except for 1974.

Fig. 2 illustrates the phase variation of the diurnal anisotropy on QDs with the Polarity of Solar Poloidal Magnetic Field (SPMF). The nature of the diurnal phase as observed on QD from the Fig. 2, during 1964–70; is in agreement with the time invariant hypothesis on yearly average basis for the period 1957–70. However, significant variations have been reported in the high energy detectors

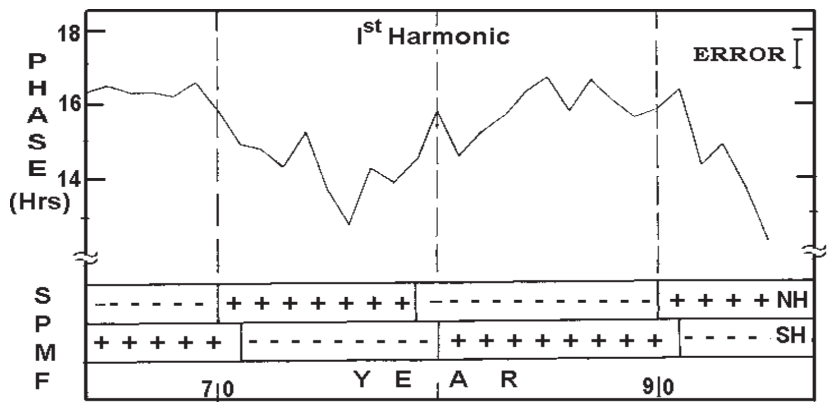

Fig. 2. Phase of the Diurnal anisotropy on Quiet Days during 1964–95 for Deep River Neutron Monitoring Station with the Polarity of Solar Poloidal Magnetic Field

during the same period i.e., 1957–70. Further, the phase of the diurnal anisotropy has started to shift towards early hours in 1971 and continue to remain in early hours till 1976; though it has shown an increase in its value towards corotational direction in 1974. The phase shift to early hours has also been reported during the earlier period i.e. 1953–54 as well.

During 1974, a typical behaviour in both phase and amplitude of the diurnal anisotropy has been observed. The phase has shifted towards corotational direction and the amplitude has increased; whereas, the phase has shifted to earlier hours with the decreasing amplitude right from the instance of change of polarity of IMF; i.e., from 1971 and onwards. A continuous decrease in the amplitude and a shift of phase, towards early hours in the diurnal anisotropy are also observable during the periods 1971–73 and 1974–76.

The shift to the earlier hours in the phase of diurnal anisotropy on QD is maximum during 1976, which is the year of solar minimum, as compared to its direction during the period from 1964–70. Later to 1976, a recovery in the phase; shifting to its usual corotational/ azimuthal/ 18-hour direction has been observed. It has recovered completely to its usual corotational direction during the year 1980. A further shift towards early hours in 1981; is noticeable from the plot. It remained statistically constant during the period 1984–91 (Kumar et al, 2002)[7] and then once again shows a very systematic trend of shifting to early hours during the year 1992 and onwards, except for the year 1993; where it has shifted partly towards corotational direction.

The maximum shift to early hours in the phase, prior to the period of investigation, has been reported to occur in 1954. Thus, shift in phase to early hours during 1953–54, 1975–76 and once again in 1995 and possibly onwards; as approaching to minimum solar activity period, confirms once again a 22-year

periodicity in the diurnal phase of the CR intensity recorded with neutron monitor on quiet days.

4. Conclusions

The phase of diurnal anisotropy on quiet days, remains in the corotational direction during period 1964–65 and 1986–87; Solar Poloidal Magnetic Field (SPMF) being negative in Northern Hemisphere (NH). It shifts to early hours during 1971 (polarity inversion from negative to positive in NH) and onwards till 1975–76 and likewise during 1992, 1995 and possibly onwards as it approaching to minimum solar activity period of the present solar cycle.

5. References

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