Study Of High/Low Amplitude Anisotropic Wave Train Events During 1991–94

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Abstract

The high/low amplitude anisotropic wave train events (HAE/LAE) in cosmic ray (CR) intensity have been investigated during the period 1991–94 using the neutron monitor data for different latitudes. In all, 16 HAE and 13 LAE cases have been studied. An inter-comparison of the first three harmonics during these events has been made so as to understand the basic reason causing the occurrence of these types of events. The interplanetary magnetic field (IMF) and solar wind plasma (SWP) parameters during these events are also investigated.

1. Introduction

Solar diurnal variation of cosmic ray (CR) intensity shows a large day-to-day variability. This variability is a reflection of the continually changing conditions in the interplanetary space [1]. The average diurnal anisotropy of cosmic radiation has generally been explained in terms of azimuthal corotation [2 and references therein]. The systematic and significant deviations of amplitude as well as phase for diurnal/semi-diurnal anisotropies from the average values are known to occur in association with strong geomagnetic activity [3]. The enhanced diurnal variation of high amplitude anisotropic events (HAEs) exhibits a maximum intensity in space around the anti-garden hose direction and a minimum intensity around the garden hose direction. A number of HAEs and low amplitude anisotropic events (LAEs) have been observed with a significant shift towards later or earlier hours [4, 5, 6]. The changes have also been observed in the amplitude and phase during the high speed solar wind streams (HSSWS) coming from coronal holes [7, 8]. The diurnal variation might be influenced by the polarity of the magnetic field [9], so that the largest diurnal variation is observed during the days when the daily average magnetic field is directed outward from the Sun. An inter-comparison of diurnal/semi-diurnal/tri-diurnal anisotropy during 1991–94 for HAE/LAE has been presented in this paper to investigate the basic reason causing the occurrence of these types of unusual events.

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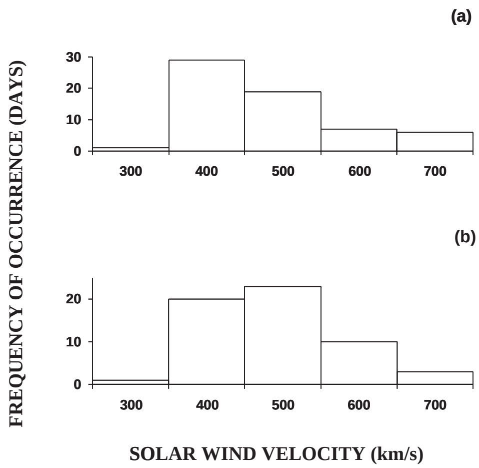

Fig. 1. Frequency histogram of solar wind velocity for all the (a) HAE and (b) LAE events during 1991–94.

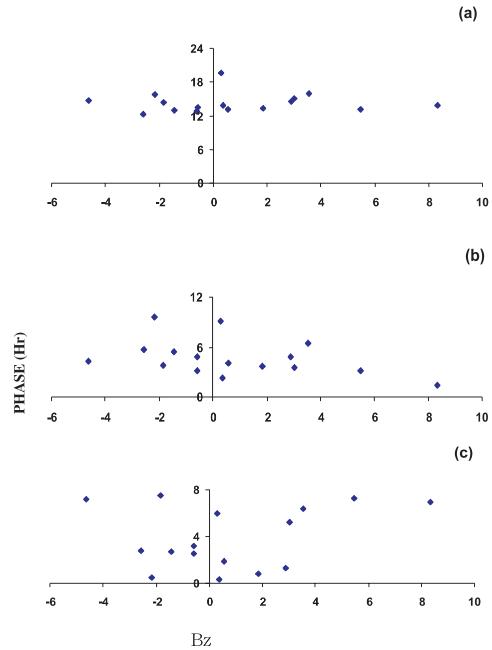

Fig. 2. The phase of (a) Diurnal, (b) Semi-diurnal and (c) Tri-diurnal anisotropy for all the HAE events with the variation in associated values of Bz during 1991–94

2. Data Analysis

The anisotropic events are identified using the hourly plots of cosmic ray intensity recorded at ground based neutron monitoring stations and selected 16 unusually high amplitude anisotropic wave train events (HAEs) and 13 unusually low amplitude anisotropic wave train events (LAEs) during the period 1991–94. The days having abnormally high/low amplitude for five or more consecutive number of days have been selected as HAE/LAE. The pressure corrected hourly neutron monitor data after applying trend correction are harmonically analysed to have amplitude (%) and phase (Hr) of the diurnal, semi-diurnal and tri-diurnal anisotropies of cosmic ray intensity for HAE and LAE. The data related with interplanetary magnetic field and solar wind plasma parameters have also been investigated.

3. Results and discussion

The frequency histograms of solar wind velocity for HAE/LAE have been plotted in Figs 1a, b. It is observable from these Figs 1a, b that the majority of the HAE and LAE events have occurred when the solar wind velocity lies in the interval 400–500 km/s i.e. being nearly average. Usually, the velocity of high speed solar wind streams (HSSWSs) is 700 km/s [7]. Therefore it is quite apparent from Fig 1a, b that HAE/LAE events are not caused either by the HSSWS or by the sources on the Sun responsible for producing the HSSWS such as polar coronal holes (PCH) etc. Thus, we may infer that HAEs/LAEs are weakly dependent on solar wind velocity. Similar findings are reported by Munakata et al. [7] for LAEs.

The phases (Hr) of diurnal, semi-diurnal and tri-diurnal anisotropies for HAEs with the variations in the associated values of z-component of interplanetary magnetic field B, i.e. Bz have been plotted in Figs 2a, b, c during the period 1991–94. The similar plots are made for LAEs as well. It is deduced form these plots that phase of diurnal anisotropy is evenly aligned for both HAE and LAE; whereas, the phase of semi-diurnal anisotropy is more aligned for LAE as compared to HAE. Further, for tri-diurnal anisotropy the phase is more aligned for HAE as compared to LAE. On the basis of these anisotropic events for all the three harmonics, it is deduced that Bz remains lower for LAEs as compared to HAE events, which shows that when Bz attains higher values, the occurrence of HAEs is dominant and when Bz attains lower values the occurrence of LAEs is dominant. Kananen et al. [10] have found that for positive polarity of IMF the amplitude is high and phase shifts to early hours; whereas, for negative polarity of IMF the amplitude is lower and phase shifts to early hours as compared to corotational value.

The amplitude and phases of the diurnal, semi-diurnal and tri-diurnal anisotropies for each HAE/LAE events are plotted in Fig 3, 4 & 5 as a vector addition diagram. As depicted in Fig 3a the phase of the diurnal anisotropy shifts to earlier hours for most of the HAE events; whereas, the phase of the diurnal anisotropy remains in the corotation direction for most of the LAEs as shown in Fig 3b. For semi-diurnal anisotropy, the distribution of phase, as shown in Fig 4 is quite similar for both HAE/LAE cases. Further, the phase of tri-diurnal anisotropy, as depicted in Fig 5, is evenly distributed in all the quadrants for HAEs as well as for LAEs.

4. Conclusion

On the basis of present investigations the following conclusions have emerged:

1. HSSWSs do not play a significant role in causing the HAE/LAE.
2. The phase of diurnal anisotropy shifts towards earlier hours for HAEs; whereas, it remains in corotational direction for LAEs. For semi-diurnal anisotropy phase remains statistically the same for both HAE/LAE events while phase is distributed evenly in case of tri-diurnal anisotropy for both types of events.

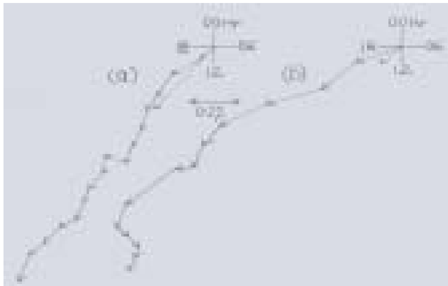

Fig. 3. The vector addition diagram of all the (a) HAE and (b) LAE events during 1991–94 for diurnal anisotropic events

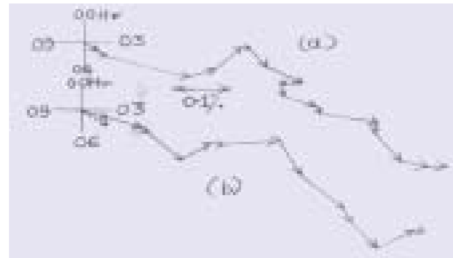

Fig. 4. The vector addition diagram of all the (a) HAE and (b) LAE events during 1991–94 for semi-diurnal anisotropic events

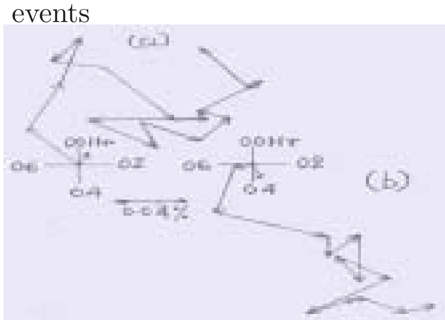

Fig. 5. The vector addition diagram of all the (a) HAE and (b) LAE events during 1991–94 for tri-diurnal anisotropic events

5. References

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