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LOW-AMPLITUDE ANISOTROPIC WAVE TRAIN EVENTS DURING PASSAGE OF INTERPLANETARY MAGNETIC CLOUDS

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The work presents a continuation in the series related to the long-term space observations made by ground-based neutron monitoring stations. The cosmic ray intensity variation is considered as affected by interplanetary magnetic clouds during low-amplitude anisotropic wave train (LAAWT) events. It was observed that the solar wind velocity is higher than normal (> 300 km/s) while the interplanetary magnetic field (IMF) strength is lower than normal on the arrival of magnetic cloud during LAAWT events. The proton density is found to remain significantly low at high solar-wind velocity, which was expected. The north/south component of interplanetary magnetic field turns southward one day before the arrival of cloud and remains in this direction after that. The cosmic ray intensity is found to increase with the solar wind velocity. It is noteworthy that the cosmic ray intensity significantly increases before and 90 h after the arrival of such a cloud, and decreases gradually after its passage. The north/south component of IMF (Bz) is found to significantly correlate with latitude angle (Θ) and disturbance storm time index D_{st}, whereas the geomagnetic activity index (A_p) significantly anti-correlates with these parameters, decreasing with (Θ) and D_{st} increasing on the arrival of interplanetary magnetic cloud during LAAWT events.

Key words: *solar wind, interplanetary magnetic field, magnetic cloud.*

1. INTRODUCTION

Earlier, many low amplitude anisotropic wave train (LAAWT) events were observed with a significant shift in the diurnal time of maximum to the co-rotational direction or in later hours [1]. Agrawal and Bercovitch [2] have shown that the direction of the 22-year component is perpendicular to the diurnal anisotropy vector and is along line 162 east of the Sun-Earth line; they have attributed the 11-year component to variation in the cut-off rigidity. A significant increase is observed in the amplitude of first three harmonics (diurnal/semi-diurnal/tri-diurnal) during the passage of high speed solar wind stream, whereas the direction of the anisotropy have no time-variation characteristics associated with solar wind velocity and north/south component of interplanetary magnetic field for three neutron monitoring stations located at different geomagnetic cut-off rigidities and altitudes [3].

Interplanetary magnetic clouds belong to one of several classes of transient flows in the solar wind. Magnetic clouds as ideal force-free objects (cylinders or spheres) are ejected near the Sun and followed beyond the Earth's orbit. It is found that the decrease in the cosmic ray intensity associated with a magnetic cloud preceded by a shock, is very significant and starts several days before the arrival of the cloud at the Earth. From the study of the relevant time profile it is found that the onset time of a Forbush type decrease produced by a shock-associated cloud starts nearly at the time of arrival of the shock front at the Earth [4, 5] and the recovery is almost complete within a week. The Forbush decreases of the type are caused by the magnetic field variations associated with interplanetary disturbances [5].

2. DATA AND ANALYSIS

The pressure-corrected data of the Deep River Neutron Monitor (NM) station (http:// spidr. ngdc. noaa.gov/ NeutronMonitor) were subjected to Fourier's analysis for the period 1981–1994 after de-trending. While performing the analysis, the days having more than three continuous hours of data missing were discarded.

Using the long-term plots of the cosmic-ray intensity data as well as the amplitudes derived from the cosmic-ray pressure-corrected hourly neutron monitor data using harmonic analysis, the LAAWT events were selected.

Based on the above selection criteria, we selected 28 LAAWT events during the period 1981–1994, and investigated the hourly cosmic-ray intensity data from Deep River NM station [Geog. Lat. 46.10º, Geog. Long. 282.50º, Vertical cut-off rigidity 1.02 (GV)].

3. RESULTS AND DISCUSSION

The cosmic ray intensity, interplanetary magnetic field and solar wind plasma parameters along with disturbance storm time index D_{st} values are plotted in Fig. 1 to exemplify the interplanetary positive magnetic cloud (i.e. with the magnetic field directed northward) without shock occurred on April 20, 1981 at 2300 UT during these events.

As seen from the plot, the solar wind velocity (V) remains higher than normal (> 300 km/s) and the interplanetary magnetic field (IMF) strength B remains lower than normal during this period. It is also evident that the proton density (N) remains significantly lower at high solar wind velocity, which was expected. The north/south IMF component (B_z) turns southward one day before the arrival of cloud and remains in this direction after that. The cosmic ray intensity is found to increase with the solar wind velocity.

To further find out a possible correlation between these parameters on the arrival of magnetic cloud, we constructed scattered plots (for significant and good correlation only, not shown here) and calculated the correlation coefficient between them. It is observed that the cosmic ray intensity increases with D_{st} and shows a good positive correlation with it (r = 0.65). The B_z component significantly increases with the latitude angle (Θ) and D_{st} index and shows significant positive correlation, r = 0.86 and r = 0.80, respectively. The geomagnetic activity index (A_p)

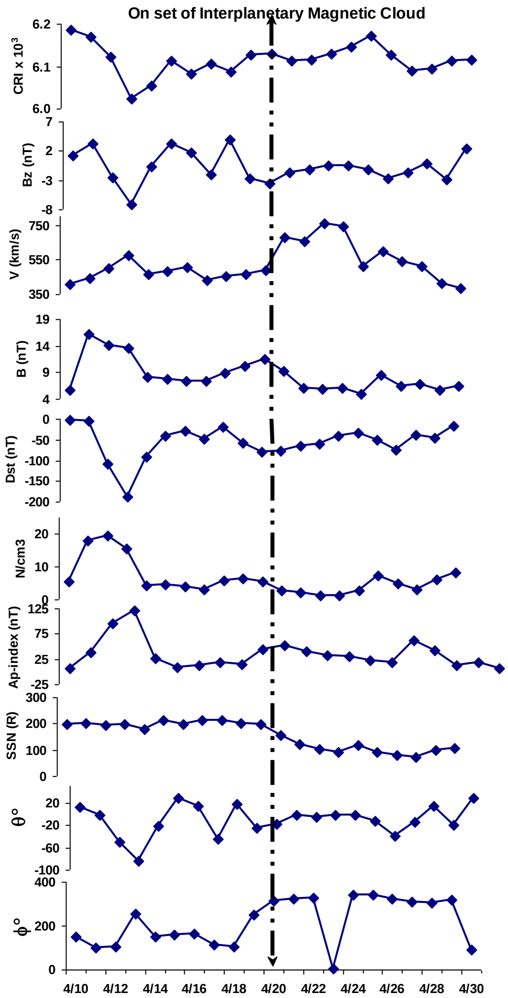

Fig. 1. Cosmic ray intensity records at Deep River NM station showing the occurrence of some low-amplitude anisotropic wave train events (NM count rates).

significantly decreases with the D_{st} and Θ, showing significant anti-correlation (r = –0.84, r = –0.83, respectively). At the same time, this value is found to significantly increase with IMF strength (B), and shows positive correlation with it (r = 0.70). The sunspot numbers (R) are seen to increase with the B value, showing a good positive correlation with it (r = 0.54). The latitude angle Θ is observed to increase with D_{st} and shows a significant positive correlation (r = 0.80), while the cosmic ray intensity increases gradually with D_{st}, also with good positive correlation (r = 0.65). As concerns the proton density (N), it increases with IMF strength (B) with a significant positive correlation (r = 0.84). The remaining parameters have no significant correlation with each other on the arrival of magnetic cloud during LAAWT events.

To study the effect of magnetic clouds on the cosmic ray intensity during LAAWT events, we have adopted the Chree analysis of superposed epoch for hours –141 to +121, and plotted in Fig. 2 as a percent deviation of cosmic ray hourly intensity data (along with statistical error bars) for Deep River NM station during the period 1981–1994.

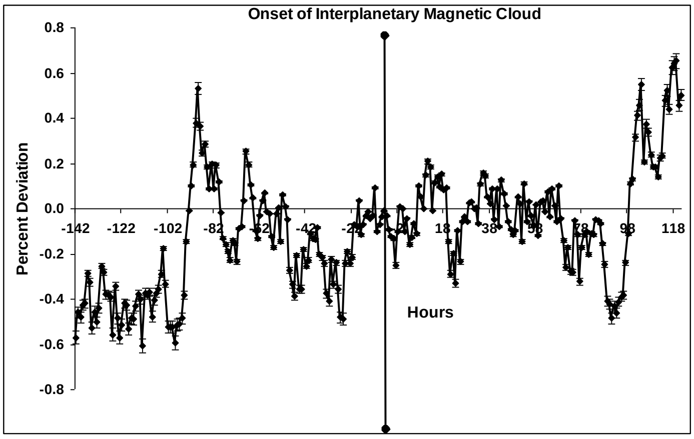

Fig. 2. Superposed epoch results of cosmic ray intensity due to interplanetary magnetic clouds during low-amplitude anisotropic wave train events (Deep River NM station, statistical error bars I).

As can be seen from this plot, the decrease in cosmic ray intensity starts not at the onset of cloud but after several hours. This intensity significantly increases before and 90 h after the arrival of the magnetic cloud and decreases gradually after its passage.

4. CONCLUSIONS

From the present investigations the following conclusions may be drawn:

1. The cosmic ray intensity significantly increases before and 90 h after the arrival of the magnetic cloud and decreases gradually after its passage.

2. The north/south component of IMF (B_z) significantly correlates with latitude angle (Θ) and disturbance storm time index D_{st}, whereas the geomagnetic activity index (A_p) significantly anti-correlates with these parameters, decreasing with Θ and D_{st} increasing on the arrival of interplanetary magnetic cloud during LAAWT events.

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MAZAS AMPLITŪDAS ANIZOTROPIJU VIĻŅU PARĀDĪBU SECĪBA STARPPLANĒTU MAGNĒTISKO MĀKOŅU RAŠANĀS LAIKĀ

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K o p s a v i l k u m s

Raksts ir turpinājums darbu sērijai par dažādām parādībām kosmosā, kas balstītas uz novērojumiem un datiem, iegūtiem dažādos laika periodos pasaules neitronu monitoringa stacijās (Deep River, Tokija, Maskava, u.c.).

Rakstā apskatītās kosmisko staru intensitātes izmaiņas tiek pamatotas ar starpplanētu magnētisko mākoņu parādīšanos. Tiek parādītas saules vēja, magnētiskā lauka spēka, vētru pertubāciju indeksa un citu parametru atkarība no magnētisko mākoņu parādīšanās. Tiek atzīmēts, ka kosmisko staru intensitāte strauji pieaug pirms mākoņu parādīšanās un 90 stundu laikā pēc tiem, un pakāpeniski samazinās pēc to aiziešanas.

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