The Influance of High speed Solar Wind Streems on the Cosmic Ray Intensity Modulation

I. Sabbah
Department of Science, Faculty of Basic Education, Kuwait

Abstract
We have studied the behavior of cosmic rays observed by three stations during the time of high speed solar wind (HSSW) events. These stations cover the median rigidity range 16GV-164GV. Our analysis covers the period 1967-1986. The cosmic ray intensity depression is rigidity dependent. Low energy cosmic rays suffer more intensity depression. The cosmic ray spectrum depend upon the phase of solar cycle. It is sharp during 1979-1980 . The power exponent is dependent upon the magnetic state of the solar cycle. This confirms the predications of the drift model.

1 Introduction:

Galactic cosmic rays are continuously modulated by various solar, interplanetary and geophysical parameters during their propagation to Earth. The effect of high speed solar wind streams is one of the major processes for the modulation. Understanding short-term cosmic ray intensity (CRI) modulation is very important since accumulation of many short term effects leads to the long-term solar modulation (e.g., 11-year solar cycle, 22-year solar magnetic cycle, etc.). This short-term modulation is strongly correlated with various solar, interplanetary and geophysical parameters. It is well known that there are two types of high-speed solar wind streams (HSSW) streams: long-lasting HSSW streams emitted by coronal hole (CH) and the others associated with strong active regions emitting solar flares (SF) generated streams. These two origins were classified considerably the bulk velocity, proton density, temperature and magnetic field in the interplanetary medium (Mavromichalaki et al., 1988; Lindblad et al. 1989). These streams produce geomagnetic disturbances, which in turn changes in the level of cosmic ray (CR) density. The influence of the two types of HSSW streams on cosmic ray intensity has been studied using neutron monitor and muon data during different short periods (Yadav et al., 1994; Shrivastava and Shukla, 1994).

In this paper we investigate the behavior of the galactic cosmic ray intensity modulated by their interaction with HSSW streams ejected from solar active regions during solar flares (SF) and those coming from coronal holes (CH), through their passages in the heliosphere during the period 1967-1986.

2 Variations of Cosmic Ray Intensity:

In order to examine the effect of each type of HSSW streams on CRI, we find the average behavior of CRI for neutron monitor (NM) located near mid latitude at Deep River (DR) with median primary rigidity R_m= 16 GV and that near equator at Huancayo (HU) with R_m= 46 GV and underground muon telescope (UMT) at Mawson (31 m.w.e) with R_m=164 GV. Days with Forbush decreases with magnitude $\geq$4% as seen by Deep River NM have been eliminated to avoid their influence on CRI. We have calculated the mean CRI for 13 days of each event (from -3 day to +9 day with respect to the event day) and then deduce the percent deviation for each of these days. Finally we perform the superposed-epoch analysis for SF as well as for CH related streams separably from the percent deviation of each epoch day.

Figure 1 shows the effect of SF related streams on CRI during descending (1972-1974), minimum (1975-1976), ascending (1977-1978) and maximum (1979-1980) phases of solar activity. We see from Figure 1 that CRI dropped to a minimum (at the zero-epoch day) more faster during minimum and ascending phases of solar activity in (b&c). It recovers more faster as well. The largest intensity depression occurs during ascending and

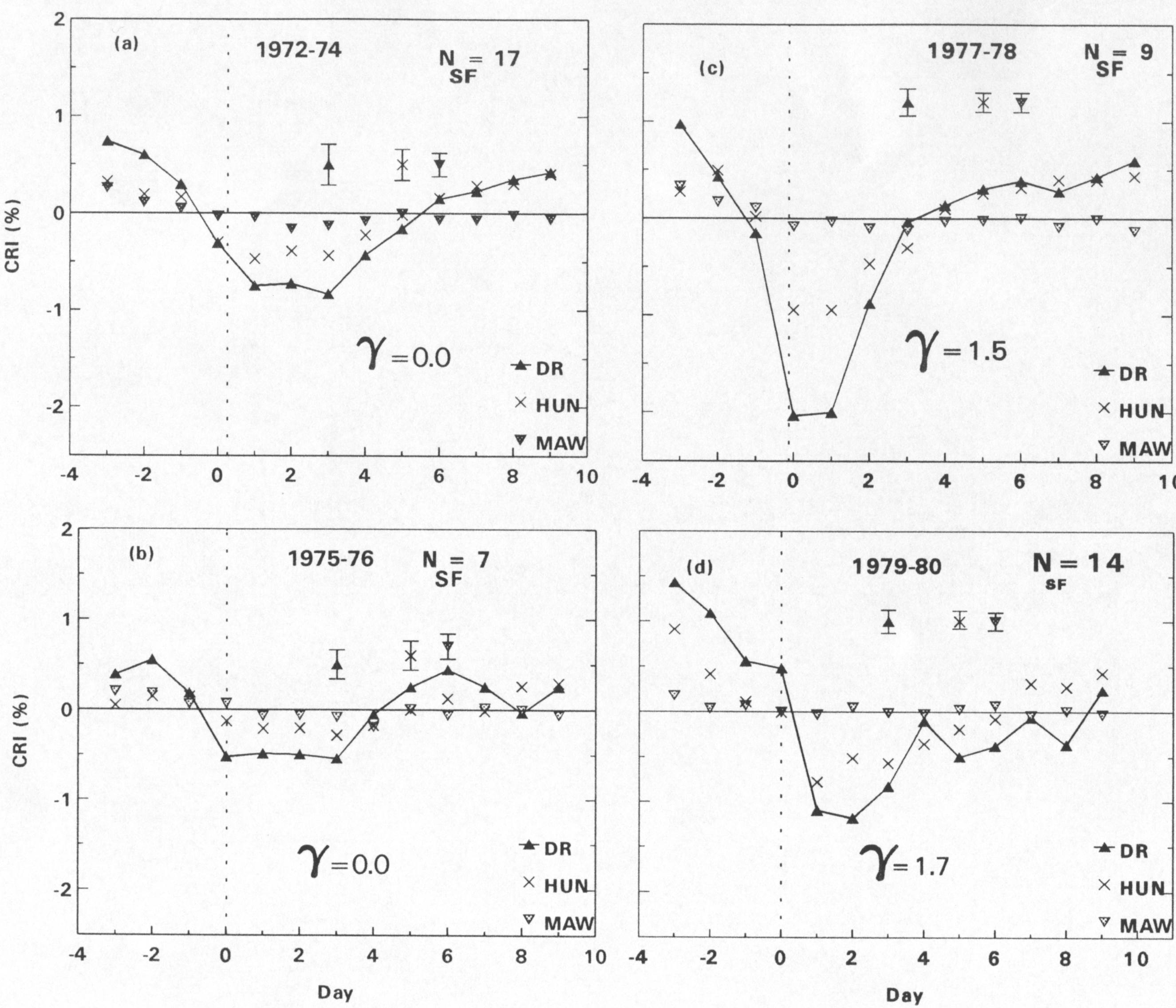

Figure 1: Superposed epoch analysis results of CRI deviations observed by DR, HU and Mawson with respect to SF related streams during descending (a), minimum (b), ascending © and maximum (d) phases of solar activity.

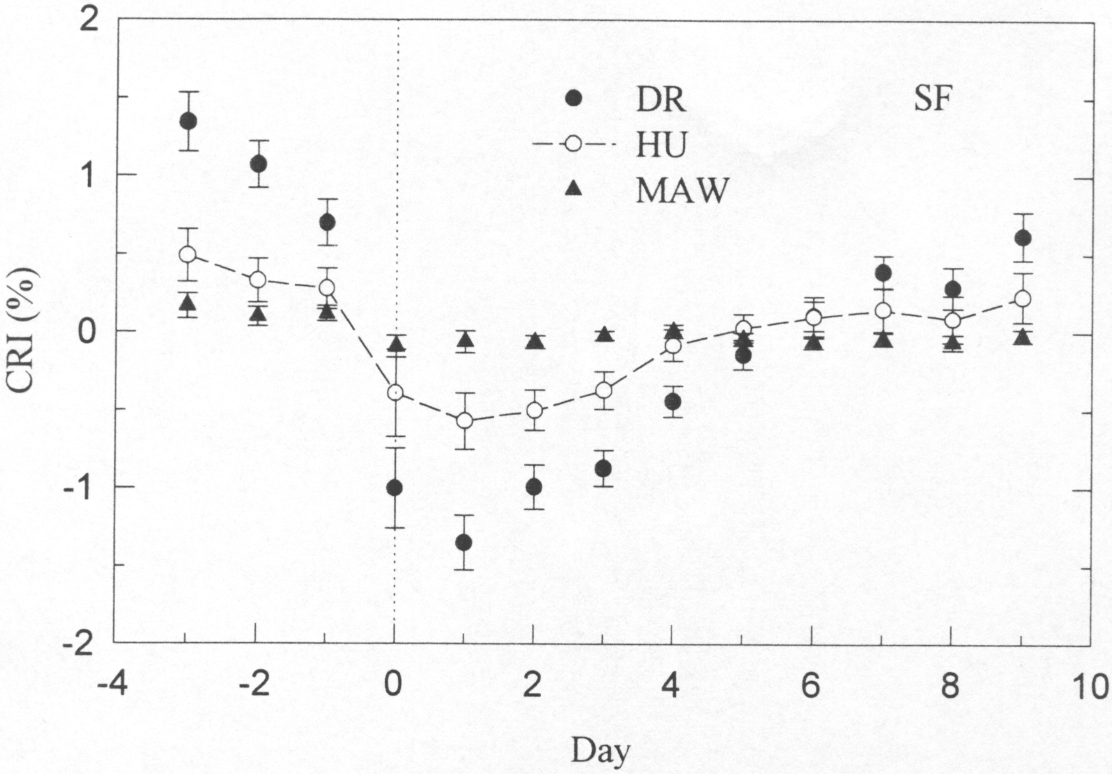

Figure 2: The average behaviors of CRI during the descending pahse (1982-84).

maximum phases of solar activity in (c&d), whereas the smallest depression occurs during minimum solar activity (Figure 1b). These depression are rigidity dependent during 1977-1980, with magnitude decreases with rigidity. The power exponent γ is shown in Figure 1 for each period. The spectra is flat during 1972-1975 which confirm the results obtained by Venkatesan et al. 1982. However our spectra is sharper during 1979-1980. We believe that the reason for this sharp depression in CRI observed by high latitude stations is due to the more scattering of low energy particles by geomagnetic activity and IMF lines and irregularities. Next we calculate the CRI spectrum during the descending phase the solar cycle (1982-1984) in order to check the effect of the IMF polarity after the solar field reversal in 1980. We got a sharp spectrum in Figure 2 with power exponent γ=1.5 in comparison with γ=0 during 1972-1974 before the reversal of the solar filed. This is consistent with the prediction of the drift model (Sabbah and Potgieter, 1995). Sabbah, 1999 obtained a very good correlation between the geomagnetic activity and HSSW for SF related streams. The CRI depressions during the time of SF is larger than during the time of CH. This is due to the larger values of the Kp index, IMF magnitude and fluctuation and number flux associated with SF related streams. IMF magnitude and fluctuation were high around solar activity maximum. This results in more scattering of cosmic rays particles on IMF lines and irregularities which produce maximum depression. The recovery time of the CRI depression is dependent on the level of solar activity. We obtain a power law rigidity dependence of the cosmic ray depression which varies with different phases of the solar cycle. It also varies with the reversal of the solar magnetic polarity which is consistant with the predictions of the drift model.

3 Acknowledgment:

I am also grateful to M. Duldig for Mawson data.

References

Lindblad, B. A., Lundstedt, H and Larsson, B. 1989, Solar Phys., 120, 145.

Mavromichalaki, H., Vassilaki, A., and Marmatsouri, E. 1988, Solar Phys., 115, 345.

Sabbah, I., and Potgieter, M.S. 1995 Proc. 24th ICRC, 4, 584.

Sabbah, I. 1999, Can. J. Phys., in press.

Shrivastava, P. K., and Shukla, R. P.1994, Solar Phys., 154, 177.

Venkatesan, D., Shukla, A. K., and Agrawal, S. P. 1982, Solar Phys., 81, 375.

Yadav, R. S., Sharma, N. K. and Badruddin.1994, Solar Phys., 151, 393.