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Short–term influence of high speed solar wind streams on cosmic ray intensity variation during 1996–2002

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Cosmic ray intensity is affected by various sun oriented interplanetary phenomena such as Solar flares, Coronal Mass Ejections, Magnetic clouds and High Speed Solar Wind Stream (HSSWS). In this work, we have identified eighty-six events of HSSWS for the period of 1996 to 2002, using the space craft data near earth. Daily values of Kiel neutron monitor data have been used in chree analysis to derive the influence of HSSW Streams on cosmic ray intensity on short–term basis. It has been investigated that these streams produce transient decreases in cosmic ray intensity. Transient decreases are found much larger during the period of high solar activity. These streams in association with Sudden Storm Commencements (SSCs) are found to be more effective in producing large transient decreases in cosmic ray intensity.

1. Introduction

High Speed Solar Wind Streams (HSSWS) are known as a most dynamical feature in interplanetary medium. Solar wind is an ionised gas, which continuously emanates from the sun. When galactic cosmic rays enter our solar system, this solar wind impeds galactic cosmic rays reducing their energy ones from reaching earth. Previous studies in this field indicate a significant influence of solar wind streams on cosmic ray intensity variations [1-2]. On the basis of different physical features, two types of high speed solar wind streams have been identified [3]. One kind is associated with solar flares and other kind is coming from coronal holes are known as coronal hole associated or corotating streams. It was observed that the solar flare associated HSSW streams are dominant in high solar activity period and produce much larger decrease in cosmic ray intensity. On the other hand corotating streams are dominated during the low solar activity periods and produce smaller decrease [2]. The passage towards the earth of these two types of HSSWS leads to enhance the level of geomagnetic activity and in general a short–term changes in cosmic ray intensity [4].

Shrivastava and Shukla [5] investigated the effects of two categories of HSSWS (flare generated and corotating) on cosmic ray intensity for the period of 1980 to 1986. They reported that the flare generated streams produce significant decreases in cosmic ray intensity. These results are also reconfirmed for the extended period of 1979 to 1990 [6]. This trend is changed after 1990, when two types of these streams (FGS and CS) produced almost similar transient decreases in cosmic ray intensity for the period of 1991 to 1996 [7]. In this report high speed solar wind streams are identified and their influence on cosmic ray intensity are studied for the extended period 1996 to 2002.

2. Discussion

In this present study, we have defined a high speed solar wind stream as a period as one having a rapidly rising increase in the solar wind speed (v) over a short period ($\Delta V \geq 250$ kms^{-1} in ≤ 24 hr) reaching a maximum value of ≥ 450 kms^{-1} which persist at high values for at least 5 days after the increase. We have selected 86 HSSW streams satisfying the above conditions, starting from the year 1996 and continuing unto 2002. The velocity profile of HSSWS as well as solar wind data was obtained from the web site http://nsdc.gsfc.nasa.gov/omniweb/.

We have adopted the chree analysis of superpoch epoch to determine the average behaviour of cosmic ray intensity, using the daily mean of Kiel neutrons. (154º N, 114ºW cut off rigidity Re = 2.32 GV). The large forbush decreases of magnitude $\geq$ 3% in cosmic ray intensity and ground level enhancement have been excluded from the study to avoid their influence. Twenty two events are found to be associated with Fds, hence these events are excluded from the chree analysis.

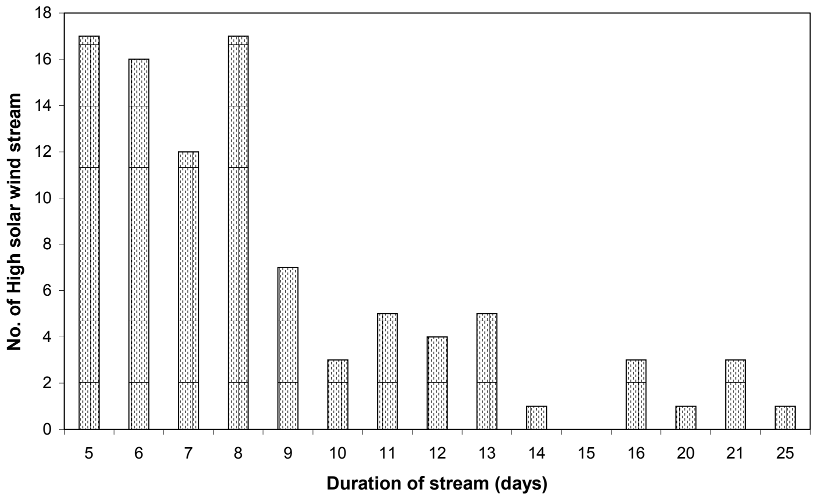

Figure 1. The time duration of high speed solar wind streams for the period of 1996 to 2002.

In Figure.1 histograms show the duration of the total number of HSSW streams in days during the period of 1996 to 2002, which cover the solar cycle 22 and ascending phase of solar cycle 23. It is noteworthy that the distribution of solar wind stream durations shows a maximum around 5 to 8 days. It has been investigated in a recent study that the medium range HSSWS (5 to 6 days) are found to be most effective in producing transient decreases in cosmic ray intensity [8]. It is believed that these HSSWS, which are dominated during 1996 to 2002, may be found very useful for cosmic ray modulation studies. The results of chree analysis for days – 5 to 10 days have been plotted in Figure.2, as a percent deviation of the data from the Kiel neutron monitor station. Deviations for each year are obtained from the overall average of the 16 days. Zero day (epoch day) correspond to the starting day of high speed solar wind streams. The number of events studied during each year is given in brackets besides the years. Figure.2 shows the average time profiles of cosmic ray intensity for each year starting from 1996 to 2002. Transient decreases in cosmic ray intensity are evident for the most of the years. The decrease starts from –1 day and reaches to maximum on +3 to +7 days. The deviations have been found much larger during the 1999 to 2001, which represent the years of high sunspots. However, some increases are also seen for the years of 1996 and 2002. It may be expected due to dominance of corotating streams during these two years [4]. The results presented here therefore confirm the earlier findings, which reports the larger decrease in cosmic ray intensity during high solar activity period and dominance of flare generated streams during high solar activity period [9]. We have shown in Figure.3, that HSSWS associated with Sudden Storm Commencements (SSCs) are responsible for large forbush type decrease in cosmic ray intensity. Analysis has been done separately for the two intervals (i) 1996 to 1999 and (ii) 2000-2002, which represent the ascending and high solar activity phases of solar cycle 23. It is noteworthy that HSSW streams in association of SSC also produce large decrease in cosmic ray intensity during the period of high solar activity. Large decrease is expected due to influence of shock waves. As we know the SSC, is a signature of arrival of shock waves. Our observational results supporting mechanism that scattering of energetic cosmic ray particles during high solar activity periods, accompanied by enhanced fluctuations in magnetic field are responsible for the cosmic ray transient decrease.

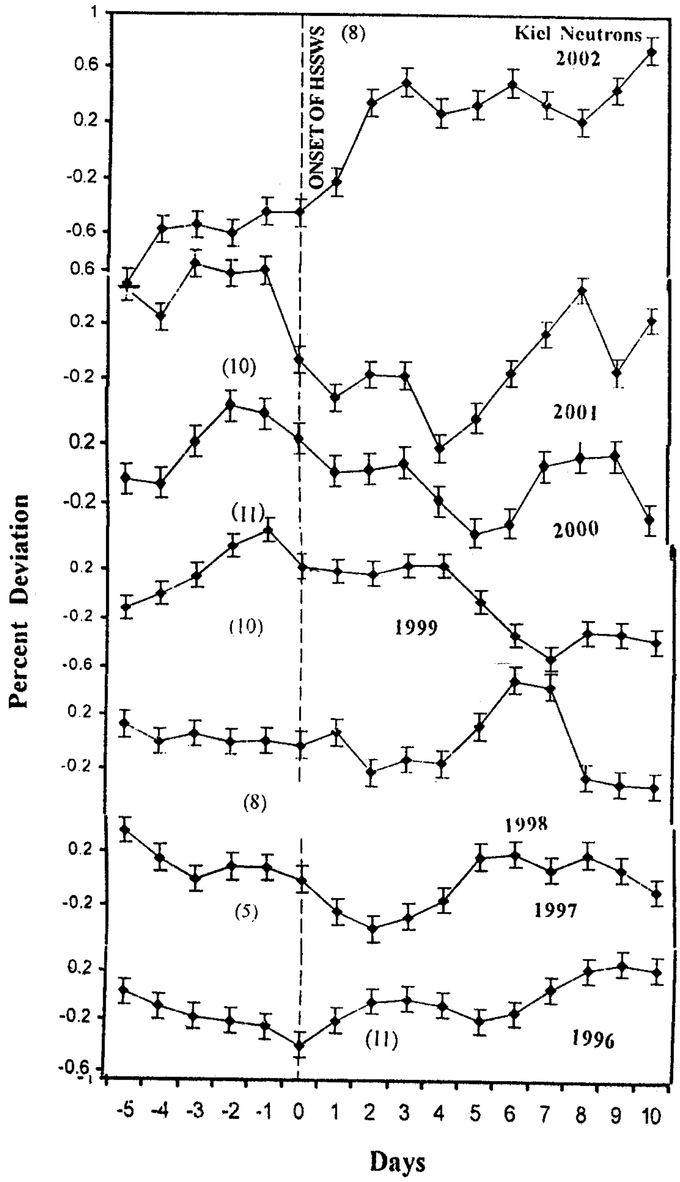

Figure 2. The results of chree analysis of superposed epoch from – 5 to 10 days with respect to zero epoch days for the period of 1996 to 2002. The percent deviation of daily mean cosmic ray intensity (Kiel neutrons) for a number of events (noted in parenthesis).

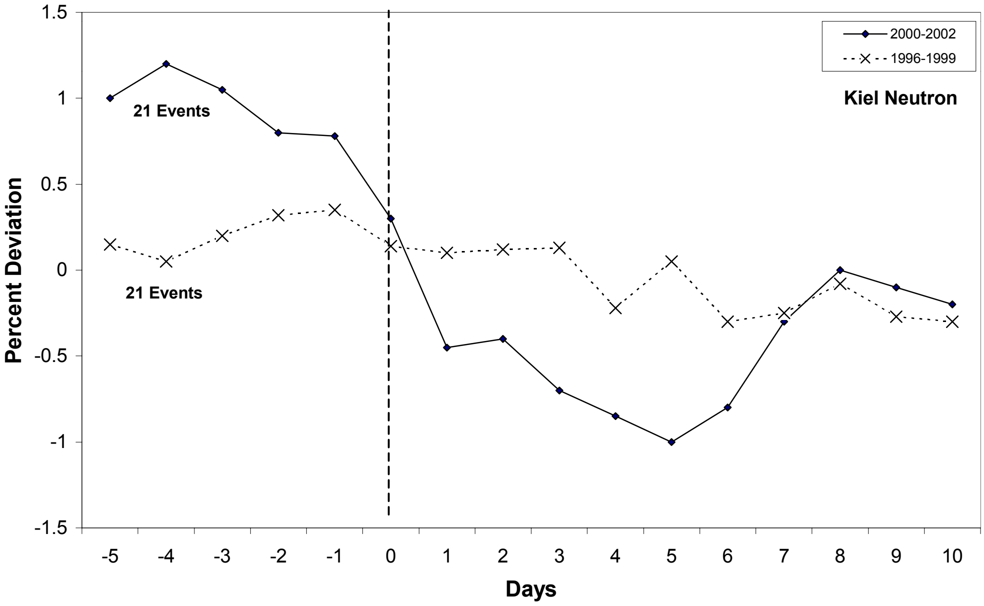

Figure 3. SSC associated high speed solar wind streams superposed with cosmic ray intensity.

3. Conclusions

It has been investigated that the high speed solar wind streams (HSSWS) generally produce transient decreases in cosmic ray intensity. Deviations have been found much larger during the period of high solar activity. However, some time these streams do not show any influence on cosmic rays. HSSWS in association with SSCs produce large transient decreases in cosmic rays on short–term basis.

4. Acknowledgements

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