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Coronal Holes in Relation to High Speed Solar Wind Stream and Cosmic Ray Intensity Variations

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The long lived High Speed Solar Wind Stream (HSWS) are generally associated with the long lived coronal holes, located in both the hemisphere of the Sun. Solar parameters such as sunspot number groups, solar flares, coronal holes and some others solar parameters have also been extensively used to study their relationships with the cosmic ray intensity. We have studied HSWS in different phases of previous solar cycle 22 and upto the declining phase of solar cycle 23. We have tried to study the relation and interrelationship between HSWS and cosmic ray intensity at different latitudes and have tried to have established the relationship with coronal hole intensity and locations. An anomalous situation has been found during the declining phase of solar activity cycle 23, in the year of 2003, where the longest duration streams have been detected. These anomalous streams have produced one of the longest and large values of geomagnetic disturbance index.

1. Introduction

It has been well established that the solar wind is one of the main factor which determine the modulation of cosmic rays due to the convections–diffusion approximation to the transport equation. High Speed Solar Wind Streams (HSWS) are also responsible for cosmic ray modulation. HSWS are classified into two categories which originate from two different sources [1]. One type is associated with the solar flares whereas another type is from coronal holes [2-4]. It has been reported before that flares generated streams produce large decreases in cosmic ray intensity [5-6]. During the long term analysis of HSWS, for complete two solar cycles 22, 23, we have found the year 2003 with remarkable increase in HSWS. It is interesting to see that the number of streams of HSWS is very high for duration greater than 12 days.

We have tried to see HSWS relation with long lived coronal holes because It is seen that HSWS arise from long lived coronal holes which are located in both the hemisphere of the sun. As such we have tried to locate its 27 day recurrence in the occurrence of the HSWS [7-8] and coronal holes as well as C9 index.

2. Discussion

We have separated two types of High Speed Solar Wind Speed (HSWS) on the basis of criteria earlier [1]. We have divided Ap in five groups 1st 0–8, 2nd 9–17, 3rd 8–26, 4th 27–53, 5th $\geq$ 54 and plotted the yearly values on the basis for each group individually. We have performed harmonic analysis to get the amplitude and phase of 1st harmonic.

Many authors have studied High Speed Solar Wind Streams (HSWS) and have come to the conclusion that the flares generated streams are more effective to produce decreases in cosmic ray intensity and it has been also reported that the solar flare generated High Speed Streams are more in high solar activity period producing Forbush type decreases [2, 9] in cosmic ray intensity.

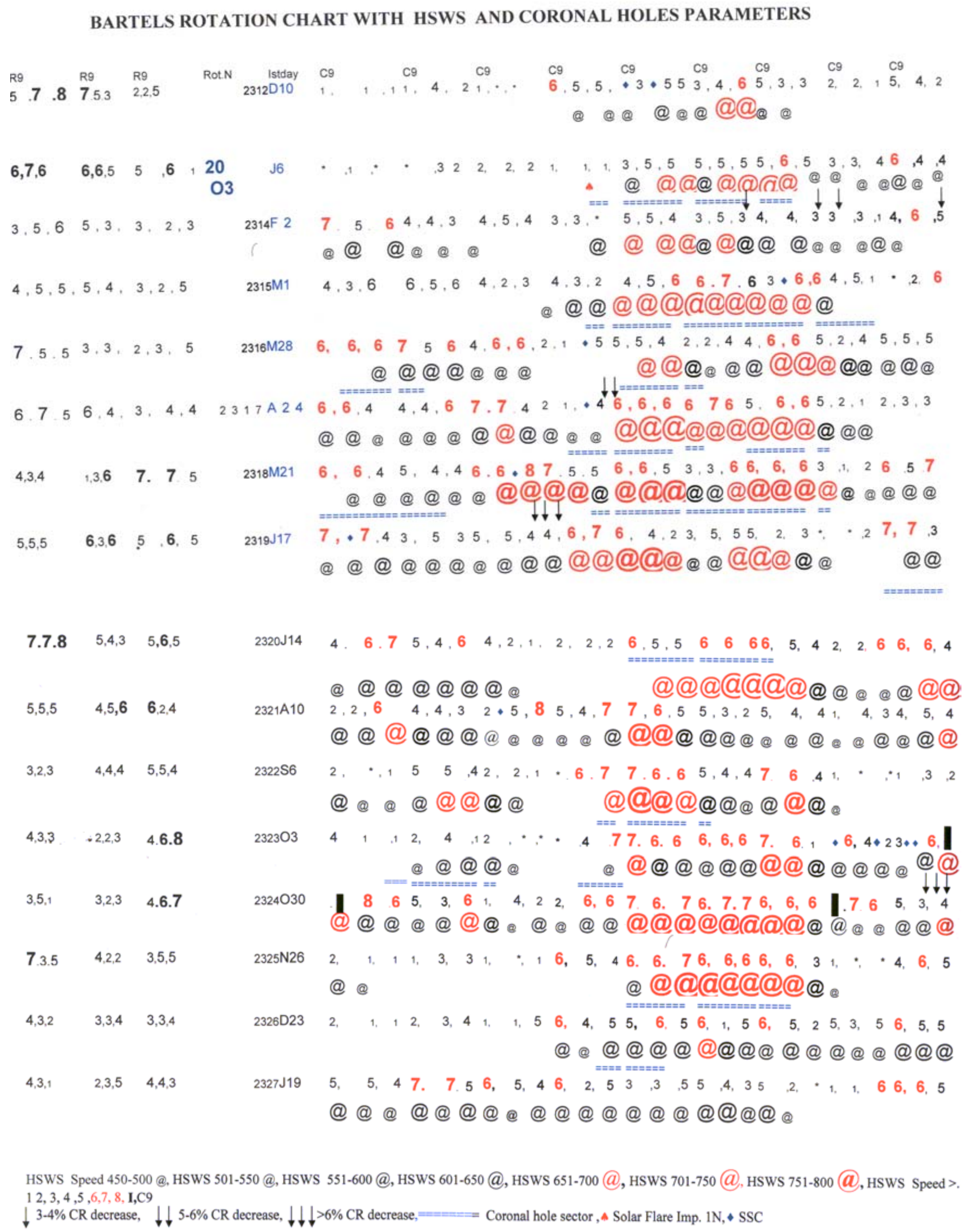

Figure 1. Shows the C9 Index, High Speed Solar Wind Stream, Coronal Hole, Solar Flares, SSC, Cosmic Ray Intensity Decreases for the period Bartels rotation number 2312 to 2327.

Here, we have tried to study the 27 day recurrence of C9 index, cosmic ray decreases coronal holes, HSWS solar flares and geomagnetic disturbances. We have classified HSWS into eight groups based on their speed. From Figure1, we can see 27 day recurrence of HSWS in association with coronal holes, as well as higher value of C9 index. Also one can observe from this chart that some of the HSWS are also producing significant cosmic ray decreases even utpo 15%, without the occurrence of any major solar flares (N). It is interesting to see much higher number of high speed solar wind streams, producing cosmic ray decreases in the absence of major solar flares in the declining phase of solar cycle 23.

The high speed solar wind streams in the year 2003 are found to be of very much longer durations. (≈ 50 day), some time producing cosmic ray decreases, as well as some months are very much disturbed in terms of fluctuations in (July, August, September, and December) the overall CR intensity. Average of Ap in the year 2003 (Figure 2) is also very high (21.7). Harmonics phase in the year 2003 is at about 13 hrs (Figure3). The reasons for such long duration HSWS in the declining phase of solar cycle producing CR decreases is not understood and are a matter of further investigation.

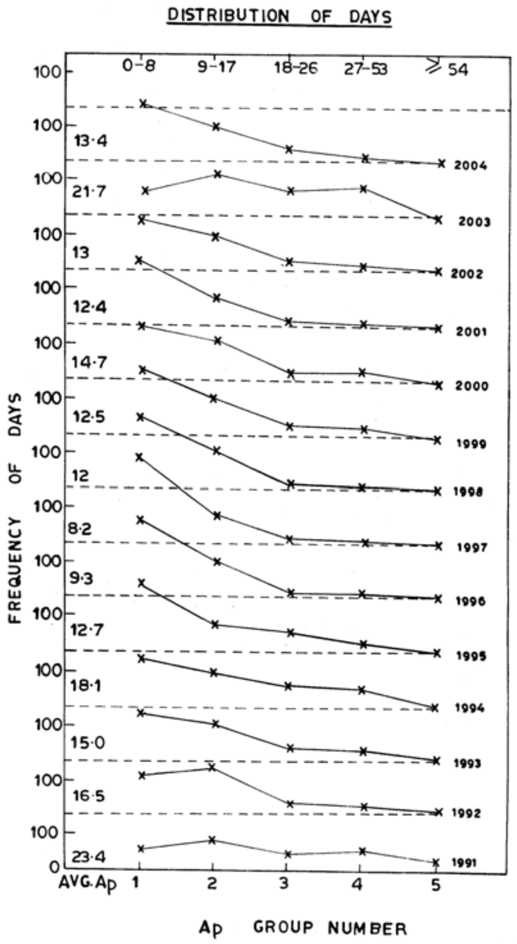

Figure 2. Shows the frequency distribution of days of Ap index for various groups indicated at the to 0 of the figure for each year from 1991 to 2004.

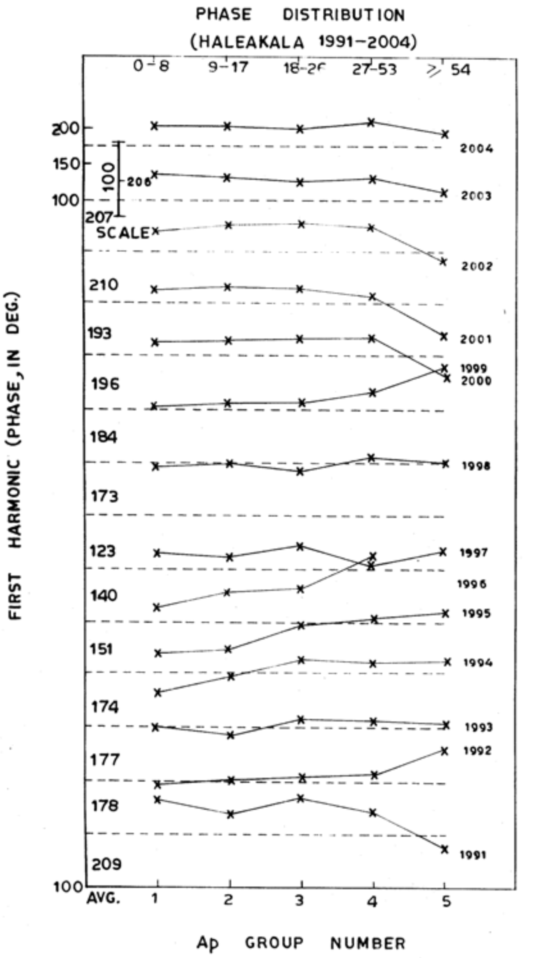

Figure 3. Shows the first harmonic distribution of phase for Halekala with Ap index for various groups for each year from 1991 to 2004.

3. Conclusions

The year 2003 is anomalous, firstly because of very high value of Ap (Ascending with normal values the adjoining years 2002 and 2004). In association the coronal hole associated HSWS are of much longer duration and occurring more frequently. The anomaly is also in effecting cosmic ray intensity producing large decreases, contrary to that reported earlier.

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References

[1] Mavromichalak H. et al., Solar Phys. 115, 345-65 (1988).
[2] Venkatesan D. et al., Solar Phys. 81, 375-381 (1982).
[3] Rao U.R. Space Science Rev. 12, 79-91 (1971).
[4] Mavromichalaki H. et al., Solar Phys. 122, 181-200 (1998).
[5] P.K. Shrivastava, Proc. 25th Int. Cos. Ray Conf. Durban (South Africa), 1, 429, 432 (1997).
[6] Anand Mashi et al., Vol. 16, 3, 309-312 (2004).
[7] Y. Munakata et al., Proc. 28th ICRC, 3925-3928 (2003).
[8] Munakata, Y. et al., Proc. 20th Int. Cosmic Ray Conf. 4, 39 (1987).
[9] Mishra, B.L. et al., Proc. 21st ICRC, Adelaide (Australia) 6, 299-302 (1990).