Hysteresis Effect on Solar and Interplanetary Activity

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Abstract:

The hysteresis effect has been studied sequentially to observe the features of cosmic ray intensity (CRI) for the year 1996-2018, covering two consecutive solar cycles 23 and 24. The regular changes in the hysteresis curve of cosmic ray modulation for different phases of sunspot cycle (Stoker., 1971), gives an inference of propagation of shocks through interplanetary medium, which in turn is the main player to produce regular changes (Moraal.,1986). This envisages that solar parameters are originate from wide range of altitudes ,in case of often similar hysteresis models, while small difference can be ruled out.

Keywords: Cosmic Ray Intensity, Sunspot Number, Interplanetary Magnetic Field

Introduction:

The most obvious feature of the disturbed surface of the photosphere, are the sunspots, which are generated as pores between the granules. The darkest central part of sunspot is known as umbra, surrounded by a less dark region with a filament-like appearance known as the penumbra. The clearest visible given of solar activity are the sunspots. The interplanetary magnetic field (IMF) is an integral part of the solar wind and is carried out of the photosphere field extended out ward by the expansion of solar wind plasma. According to Parker (1958), the frozen in magnetic field configuration of the interplanetary space, i.e. the field lines are constrained to move with the plasma flow. These magnetic field lines generally obey the equation

$$E + (V/C) \times B = O$$

The Archimedean spiral configuration of the IMF is generated because of the solar rotation (average period 27 days.).

The cosmic rays in turn provide indirect integral measurements of global heliosphere configuration, since they sample large volume of the hemisphere in a very short time before they are detected. This aspect can be understood through the study of time and spatial cosmic ray variations in the three dimensional hemisphere. The connection between solar activity and the

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regulation of cosmic ray intensity (CRI) is clear from the neutron monitors estimation, accessible in the ground based indicators. The neutron monitors is an overall system of identifiers that measures the quality of neutron arriving at Earth's surface. The counter relationship between cosmic ray intensity and the solar activity has an influence at solar maximum, there is minimum of cosmic ray intensity, while at solar minimum there is maximum of the cosmic ray intensity. CRI is dominated by geomagnetic cut-off, when it arrives in the Earth's atmosphere. Modulation in CRI was observed generally of two types. The first one corresponds to slow increase in terms of count rate which can be understood in terms of steady state cosmic ray transport equation, which involves scattering convection energy change and drift mechanism particularly for long periods. While the second one corresponds to instantaneous transit changes in the counting of neutron monitor (Webber et.al., 1981). Transit changes occur due to interference from solar wind, which in turn can be elucidated on the bases of time lag effects on CRI at variable long distance in the hemisphere usually calculated as heliocentric distance (McDonald et.al., 1981).

Results and Discussion

On the basis of results and discussion, we have summarized important results derived from the analysis of the Sunspot Number, Interplanetary Magnetic Field and Cosmic Ray Intensity. Figure 1.1 shows hysteresis loops of CRI (Kiel) and SSN for solar cycle 23 and 24. The loops are different for solar cycle 23 and 24. In has been observed that hysteresis loop of CRI and SSN is wide in solar cycle 24 and in solar cycle 23 the hysteresis loop is narrow. In solar cycle 23 the hysteresis loop shows positive polar magnetic parameter from year 1996 to 2001 and shows negative polar magnetic field from year 2002 to 2008.The solar cycle 24 show positive polar magnetic parameters from year 2009 to 2014 and negative polar magnetic parameter from year 2015 to 2018. From figures 1.2 shows hysteresis loop of CRI (Moscow) versus IMF for solar cycle 23 and 24. The hysteresis loop is different for both the solar cycles. In solar cycle 23 the hysteresis loop is narrow in solar and interplanetary parameters and in solar cycle 24 the hysteresis loop is wide.

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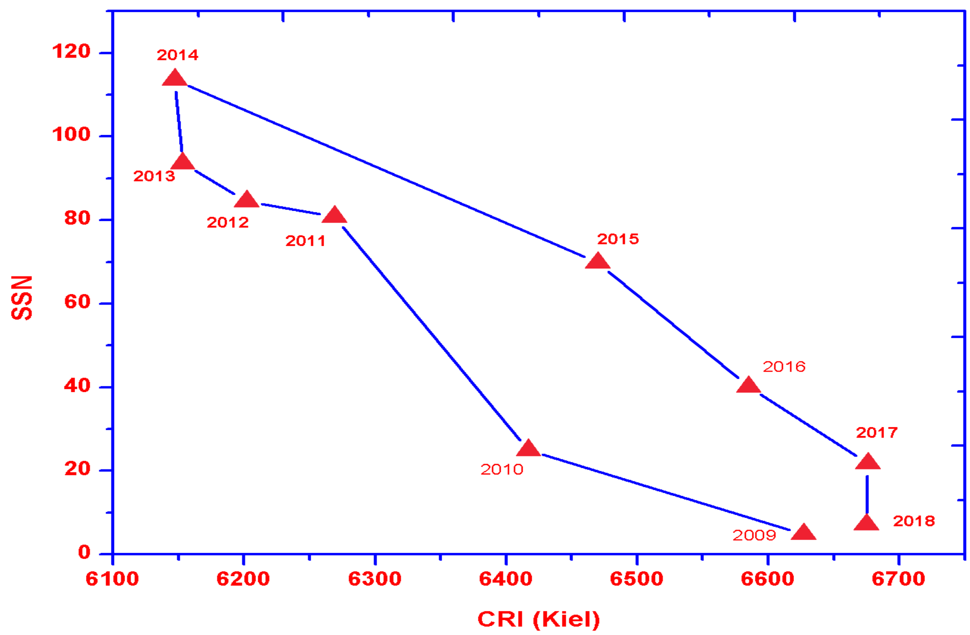

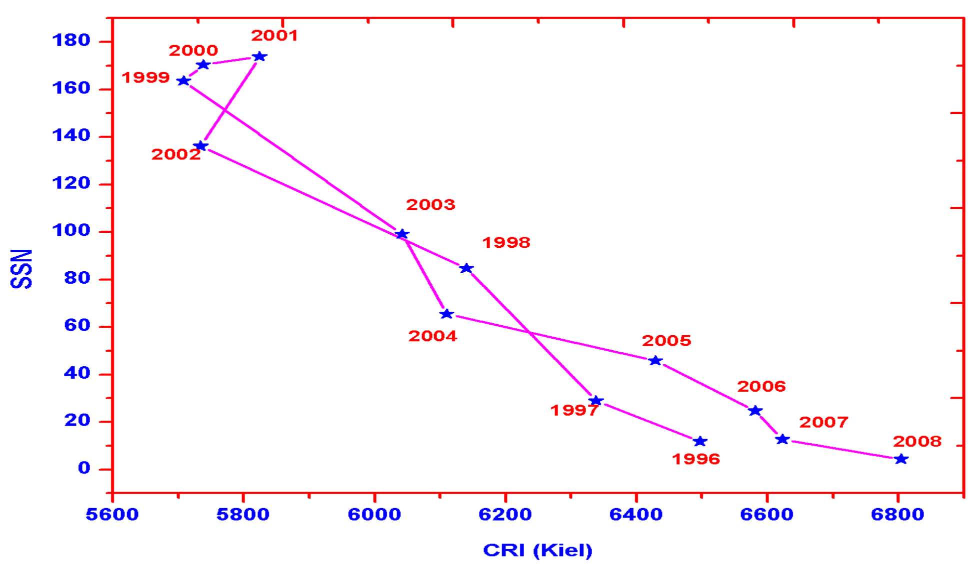

Figure 1.1 Hysteresis loop of CRI (Kiel) and SSN for solar cycle 23 (Upper) and for solar cycle 24 (Bottom).

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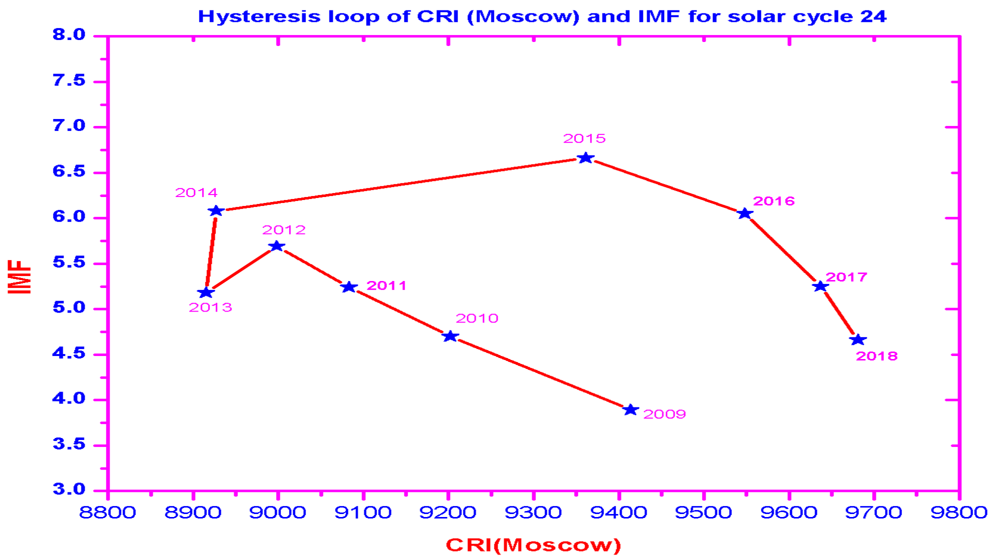

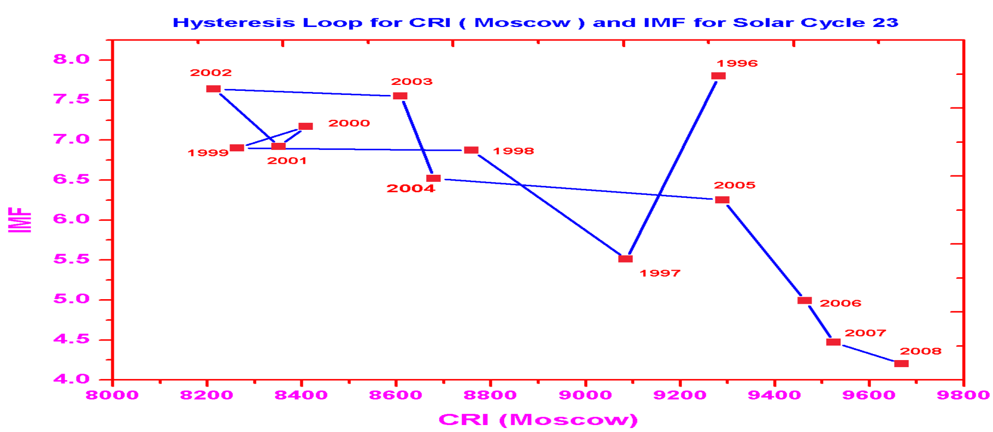

Figure 1.2 Hysteresis loop of CRI (Moscow) and IMF for solar cycle 23 (Upper) and for solar cycle 24 (Bottom).

Conclusion:

From this analysis we have concluded that the hysteresis loop is different for both the solar cycles. In solar cycle 23 the hysteresis loop is narrow in solar and interplanetary parameters and in solar cycle 24 the hysteresis loop is wide. In ascending phase of solar cycle the hysteresis plot shows positive polar magnetic parameter (A>0) and in descending phase the hysteresis plot shows negative polar magnetic parameter (A<0). Then the analysis shows that the hysteresis plot differs from odd and even solar cycles.

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