



Relationship Between Daily Variation of CRI, Solar Activity and Interplanetary Conditions

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Abstract: The solar wind data available during 1965-2012 has been utilized to study the large scale features in interplanetary medium and their effect on the geomagnetic activity. The variation of amplitude of daily variation of cosmic ray intensity (CRI) is correlated with IMF B, solar wind velocity V and with product V.B, which show a very high and positive correlation for the ascending phase of the solar cycle variations. The similar analysis is carried out for the descending phase of the solar cycle for the same periods. The correlation is slightly lower in comparisons to the values for the ascending phase. For both ascending and descending phase of the solar cycle for the year 65-68, 87-89, 97-2000, 2009-2012, CRI is strongly anti correlated with the solar flux. The Ap values are also correlated with the amplitude of the first harmonic of daily variation, IMF B and solar wind velocity V and product V.B for the same period. From the analysis it is found that the correlation is positive and high among the parameters under consideration for both the ascending and descending phase of the solar cycles. The correlation for the solar flux with Ap is found to be strongly anti correlated for most of the solar cycles. The same analysis is performed between first harmonic amplitude, product V.B. and Ap values for the complete solar activity cycle (SC 20-SC 24), it is found that the product V.B and Ap values show almost similar correlation for the Solar cycles 20-24 with the first harmonic amplitude. We can conclude that V.B is a rather prominent and reliable indicator of the solar activity variations. It is also observed that the even solar cycles are strongly correlated (SC22, SC24) between first harmonic amplitude and V.B & Ap values in comparison to the odd solar cycles (SC21, SC23).

Keywords: Daily variation, Ap index, Interplanetary magnetic field, Solar wind velocity, V.B

I. Introduction

Cosmic ray ground observations are used to study the features of the variational primary energy spectrum of diurnal and eleven-year variations of neutron component of cosmic rays. When cosmic rays are subjected to heliospheric modulation with their intensity and spectrum changes during 11-year solar cycle, the diurnal variation amplitude is generally most sensitive to the interplanetary field direction and the solar wind velocity. The geomagnetic activity is mainly controlled by variations in the solar wind and interplanetary magnetic field (IMF) features. The direction of the field in the Sun's northern hemisphere is opposite to that of the field in the southern hemisphere and reverses at solar maximum. The strength of IMF and its fluctuations have also shown to be most important parameter affecting the geomagnetic field condition. South direction of IMF allows sufficient energy transfer from the solar wind into the Earth magnetosphere through magnetic reconnection. The solar wind is continuously emanating from the sun's outer corona and engulfs the entire heliosphere. The density and speed of this flow is highly variable and depends solely upon the conditions which has caused it to eject. The strength and orientation of IMF associated with solar wind depends up on its interaction between slow and fast solar wind originating from coronal holes and leads to create co-rotating interaction region.

The long-term variation of galactic cosmic ray intensity and its association with various solar, interplanetary and geophysical parameters have been studied by many authors.^{[1]-[6]} The systematic and significant deviations in the amplitude/phase of the diurnal/semi-diurnal anisotropy from the average values are known to occur in association with strong geomagnetic activity^{[7]-[12]}. The diurnal variation might be influenced by the polarity of the magnetic field, so that the largest diurnal variation is observed during the days when the daily average magnetic field is directed outward from the Sun. On days of high geomagnetic disturbance, the daily variation exhibits abrupt changes indicative of the source being situated at a distance shorter than the range of the geomagnetic field. The relation between diurnal variation and geomagnetic condition has been studied by many authors on long term basis and on short term basis for geomagnetic quiet days^{[13],[14]}. They have found that the Ap is best fit parameters on short term basis as well as long term basis to study the quiet condition of geomagnetic activity.

II. Data Analysis

For the study of Cosmic Ray Intensity (CRI) daily variation, we have used the pressure and temperature corrected hourly counts of Kiel neutron monitor station for the period 1965 to 2012, which cover the solar cycle 20- 24. We have received the data for sun spot number (Rz), geomagnetic activity parameter (Ap) and solar wind velocity (V) for the period of 1986-2010 from omini data centre. A computer program is being used to derive the amplitudes and phases of the first harmonics of daily variation. Harmonic analysis technique has been adopted to derive the various characteristics of anisotropic (daily variation) variation of cosmic ray intensity.

III. Result and Discussion

It is well known that cosmic ray intensities are modulated by solar activity cycles. We have done a correlative analysis between the first harmonics amplitude of the CR intensity variation and various other interplanetary parameters.

The variation of amplitude of daily variation is correlated with IMF B, solar wind velocity V and with product V.B which show a very high and positive correlation for the ascending phase of the solar cycle variations. The similar analysis is carried out for the descending phase of the solar cycle for the same periods. The correlation is slightly lower in comparisons to the values for the ascending phase. For both ascending and descending phase of the solar cycle for the year 65-68, 87-89, 97-2000, 2009-2012, CRI is strongly anti correlated with the solar flux as shown in Table 1.

The Ap values are also correlated with the Solar flux, IMF B and solar wind velocity V and product V.B for the same period. From the analysis it is found that the correlation is positive and high among the parameter under consideration for both the ascending and descending phase of the solar cycles. The correlation for the solar flux with Ap is found to be strongly anti correlated for most of the solar cycle as shown in Table 2.

The same analysis is performed between first harmonic amplitude, product V.B, and Ap values for the complete solar activity cycle (SC's 20-24), it is found that the product V.B and Ap values show almost similar correlation for the Solar cycles 20-24 with the first harmonic amplitude. (As shown in the fig. 1 and fig. 2). We can conclude that V.B is a rather prominent and reliable indicator of the solar activity variations. It is also observed that the even solar cycles are strongly correlated (SC22,SC24) between first harmonic amplitude and V.B & Ap values in comparison to the odd solar cycles (SC21,SC23)

Solar wind speed V and IMF parameters are responsible for the transport and anisotropy of energetic cosmic ray particles in the interplanetary space. The high velocity solar wind fluxes associated with coronal holes give rise to both isotropic and anisotropic variations in cosmic ray intensity. The IMF magnitude and fluctuations are responsible for the depression of cosmic ray intensity during high-speed solar wind events^{[14]-[16]}. The strong correlation between cosmic ray intensity and solar wind velocity is found, especially in the period of the maximum solar activity. The relation of cosmic ray intensity to solar wind velocity depends on the physical conditions in the interplanetary space varying with the solar activity and also on the disturbances coming from the intergalactic regions. The present analysis will be extended for the phase of the first harmonic and for higher harmonics of CRI with the solar activity and geomagnetic activity parameters.

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V. References

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Table 1: The correlation coefficients between first harmonic of daily variation and different solar & geomagnetic activity parameters for the ascending and descending phase of the solar cycles

Ascending Phase					
Years	Amp VS B	Amp VS V	Amp VS. Solar flux	Amp VS V.B	Amp VS Ap
65-68	0.89	0.77	-0.87	0.97	0.86
77-79	0.89	0.74	-1.00	0.95	0.97
87-89	0.99	0.83	-0.74	0.97	0.90
97-2000	0.91	0.97	-0.73	0.96	0.89
2009-2012	0.96	0.93	-0.63	0.98	0.95
Descending Phase					
Year	Amp VS B	Amp VS V	Amp VS. Solar flux	Amp VS V.B	Amp VS Ap
69-76	0.49	-0.02	-0.58	0.22	-0.04
80-86	0.44	0.14	-0.24	0.44	0.44
90-96	0.77	0.44	-0.50	0.83	0.83
2001-2008	0.67	0.06	-0.28	0.56	0.50

Table 2: The correlation coefficients between Ap values and different solar & interplanetary parameters for the ascending and descending phase of the solar cycles

Ascending Phase				
Years	Ap VS B	Ap VS V	Ap VS Solar flux	Ap VS V.B
65-68	0.80	0.83	-0.89	0.94
77-79	0.76	0.87	-0.97	0.85
87-89	0.95	0.99	-0.37	0.98
97-2000	0.95	0.94	-0.59	0.97
2009-2012	0.99	0.78	-0.83	0.97
Descending Phase				
Years	Ap VS B	Ap VS V	Ap VS Solar flux	Ap VS V.B
69-76	0.56	0.88	0.67	0.95
80-86	0.85	0.60	-0.52	0.97
90-96	0.85	0.56	-0.34	0.96
2001-2008	0.85	0.80	-0.86	0.97

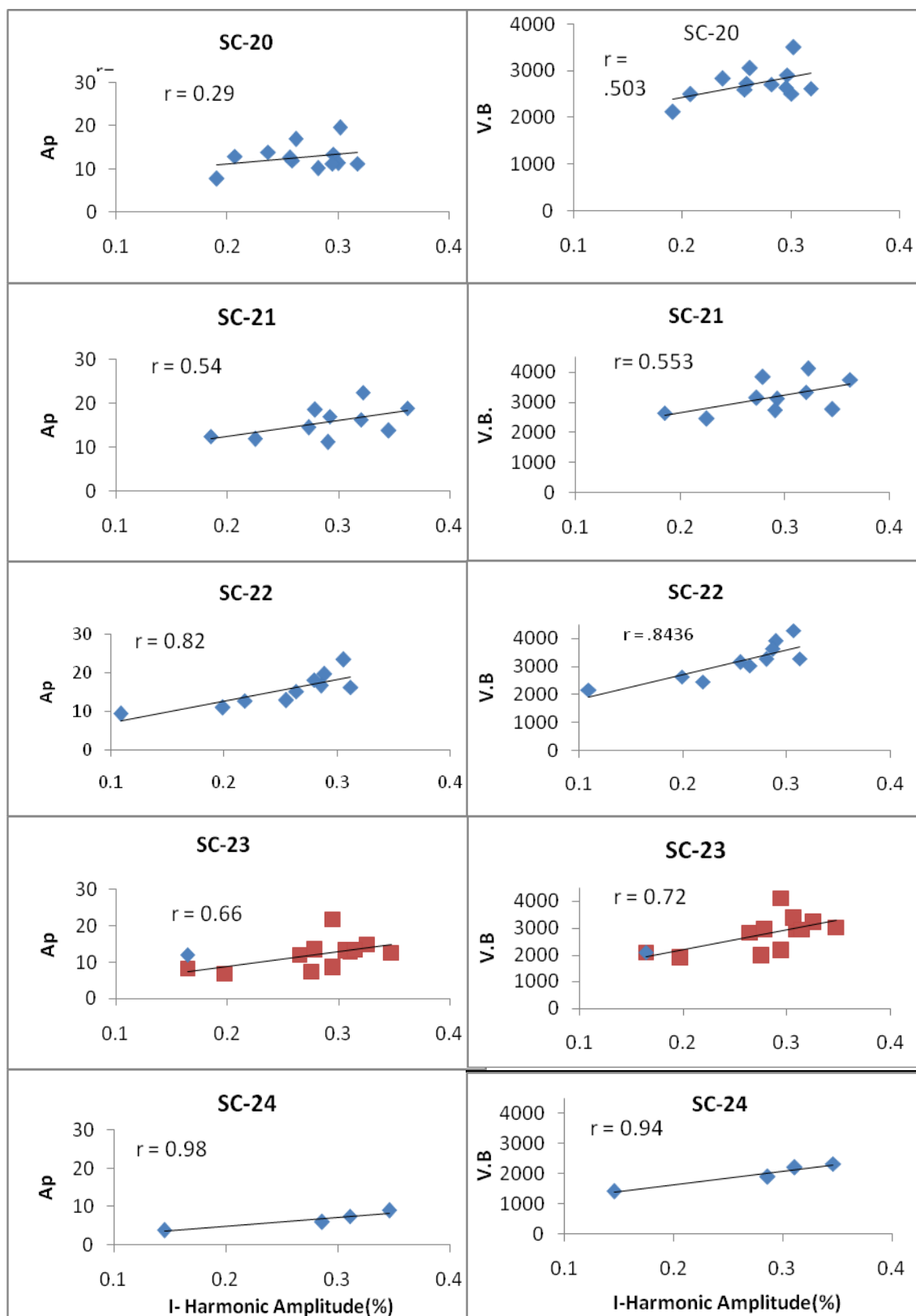


Fig.1: The correlation plot between the I-harmonic amplitude (%) and the geomagnetic activity parameters Ap for SC20-SC24

Fig.2: The correlation plot between the I-harmonic amplitude (%) and the product V.B for SC20-SC24