Comparative study of solar and geomagnetic indices for the solar cycle 22 and 23

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Abstract: The solar and geomagnetic indices for the interval 2000 to 2008 have been analyzed. The geomagnetic indices vary almost continuously with time period of minutes to days (short-term) and extending to 11 and 22 years (long-term). The yearly averages have been used to correlate understand the solar-terrestrial relationships. The analysis deals with the relation between long-term variation of solar parameters and geomagnetic parameters. The combined use of solar and geomagnetic parameters allows us to improve the long-term variability of both the parameters. The analysis of data for 2000 to 2008 has revealed a good correlation between the geomagnetic indices behavior during the period 2000 to 2008, spanning solar cycle 23 of solar activity.

Keywords: solar cycles, solar parameters, geomagnetic parameters

I. Introduction

The cosmic-ray nuclei suffer modulation due to the physical conditions, mainly electromagnetic, prevailing in the interplanetary space. Of the different variations, the eleven-year cycle of solar activity is of paramount significance in relating the energy spectra outside the interplanetary region to the one observed near earth. The variation of fluxes of heavy cosmic-ray nuclei during a solar cycle is observed to be small above energies of 600 MeV/nucl.

The modulation of the galactic and anomalous cosmic rays is a result of the energy loss cosmic rays suffer during their passage through the heliospheric magnetic and electric fields. By contrast with the years of quiet heliosphere, which can be described with a tilted dipole model that remains stable for several solar rotations, cosmic-ray modulation during the periods of the active Sun is thought to be dominated by transient events. Propagating disturbances forming global merged interaction regions (GMIRs) act as propagating barriers. The heliospheric current sheet (HCS) dividing the opposite polarities of the heliospheric magnetic field (HMF) becomes highly tilted and may contain a significant quadrupole component, leading to a warped current sheet with a profound north-south asymmetry.

The descending phase of the 23-rd solar cycle evolved into a quarry of extreme events on the bright manifestations of the Sun [1]. Two extreme magnetic storms were registered on the 24 th – 25 th of August and 11 th -14 th of September 2005. In the first case, Kp-index of geomagnetic activity reached the value 9- and Dst index fall down to -216 nT. The significant events on the Sun and in the heliosphere naturally modulated the galactic cosmic rays. Notably cosmic ray (CR) variations were observed during this time. In order to study these variations, the hourly characteristics of CR density and vector anisotropy derived by data of the neutron monitor network[2-7]. Among the numerous effects in CR during both cases, three Forbush decreases are noticeable: 24 th - 25 th August (amplitude 6.4% for CR with rigidity 10 GV), 11 th of September (12.1%) and 15 th of September (5.1%). Contradictory to the situation in July 2005 [8-11], when powerful flares occurred on the western limb or behind the limb, the events of this considered period turned out to be much more geoeffective. In all these cases very fast shocks arrived at the Earth and their mean velocity exceeded.

II. Data and Methods

A daily and half-day index of geomagnetic activity determined from the k indexes scaled at two nearly antipodal stations at invariant magnetic latitude 50 degrees (Hartland, England and Canberra, Australia). The aa values are in units of 1 nT. A 3-hourly ak index “equivalent amplitude” index of geomagnetic activity for a specific station or network of stations (represented generically here by k) expressing the range of disturbance in the horizontal magnetic field. “ak” is scaled from the 3-hourly K index. A daily index of geomagnetic activity for a specific station or network of stations (represented generically here by k) derived as the average of the eight 3-hourly ak indexes in a Universal Time day ap index. A mean, 3-hourly “equivalent amplitude” of magnetic activity based on K index data from a planetary network of 11 Northern and 2 Southern Hemisphere magnetic observations between the geomagnetic latitude of 46 degrees and 63 degrees by the Institut fur Geophysik at Gottingen, F. R. Germany; ap values. Formally the daily Ak index, determined from the eight daily ak indexes. However, for daily operational uses (since several weeks are required to collect the data and calculate the index), Air Force Space Forecast Center estimates the value of the Ap index by measuring the geomagnetic field in near-real time at several Western Hemisphere magnetometer stations and statistically weighting the data to represent the Gottingen Ap. Cp index a daily index of geomagnetic activity analogous to
the Ci index, obtained from the sum of the eight daily values of the ap index. Dst index is a measure of variation in the geomagnetic field due to the equatorial ring current. It is computed from the H-components at approximately four near-equatorial stations at hourly intervals. At a given time, the Dst index is the average of variation over all longitudes, the reference level is set so that Dst is sadistically disturbance, and an index of − 200 or deeper is associated with middle-latitude auroras Kp index is a 3-hourly planetary index of geomagnetic activity calculated by the Institut fur Geophysik der Gottingen Universitat, F. R. Germany, from the K indexes observed at 13 stations primarily in the Northern Hemisphere.

III. Observational Results

In this analysis, we have used the yearly averages of sunspot number Rz and geomagnetic indices Ap and Cp for the period 2000 to 2008. Figure 1 allows us to estimate the both indices Ap and Cp decrease in the year 2001 and then increasing trend observed during the years 2004 and further decreasing trend of Ap and Cp is observed in the year 2006. The sudden increase in both the parameters have also been seen during the years 2007 and then again decreasing during the year 2008. The correlation coefficient (r = 0.75) between Ap and Cp have been calculated (figure 2).

Similarly figure 3 allows us to estimate Ap and aa decrease in the year 2001 and then increasing trend of both parameters have been observed during the year 2008. Further, decreasing trend of both these parameters has been observed in the year 2006. The sudden increase in Ap and aa have also seen during the year 2007 and then during the year 2008, again decrease in Ap and aa have been seen. The correlation coefficient of Ap and aa have been calculated (r = 0.57).

The association of geomagnetic index Cp and sunspot number Rz fig.4a estimate the Cp and Rz decrease in the year 2001 and then increasing trend have been observed attaining to peak value in the year 2004. Further decreasing trend is observed in the minimum solar activity period 2006. The Cp index increases sharply in the year 2007 and then decreases during the year 2008. The sunspot number smoothly decreased from 2004 to 2008. The correlation coefficient of Cp and Rz is r = 0.339 fig. 4b.

We have used the yearly averages of Rz and aa index for the period 2000 to 2008. Figure 5a revel that the aa and Rz decreases in the year 2001 then increasing trend of these parameters have been obtained attaining to peak value in 2004. Further decreasing trend of both these parameters have been seen in 2006 and sudden increase in aa have also seen during the year 2007 and then aa index decreases in the year 2008. Rz and aa indices are poorly correlated (r = 0.307 fig. 5b). The Ap and Rz decreases in the year 1997 then increasing to peak value in the year 2004 figure 6a. Further decreasing trend of Ap and Rz is observed in the year 2006. The sudden increase in Ap have also seen during the year 2007 and then Ap decreases in the year 2008. The correlation coefficient of Ap and Rz is (r = 0.079 figure 6b).

Figure 1 shows the relation between Ap and Cp indices

![Figure 1](image1)

Figure 2 shows the relation between Ap and Cp indices

![Figure 2](image2)
Figure 3 shows the relation between Ap and aa indices.

Figure 4a shows the relation between Cp and Rz indices.

Figure 4b shows the relation between Rz and Cp indices.

Figure 5a shows the relation between aa and Rz indices.
IV. Discussion

As we know that various solar outputs produce magnetic reconnection process in earth magnetosphere and impede magnetic energy into near the earth surface. Such activity produces geomagnetic disturbances. And in this way solar outputs directly and indirectly related with geomagnetic field variation. It also depends upon the propagation of solar emissions in heliosphere in different way in different epochs of solar magnetic cycles. Hence, the relationship between solar and geomagnetic activity in recent period provide as a new insight for us and also to study the cosmic ray modulation apart of solar terrestrial relationship. This study continues the series of work, where the sunspot numbers and other geomagnetic parameters are successfully used to describe long-term variations of solar and geomagnetic indices in the solar cycle 23.
V. References


