Flare Index of Solar activity and Global Geomagnetic Disturbances

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Abstract

The solar flare is a most spectacular short-lived phenomenon that occurs on the surface of the Sun and is responsible for solar energetic particles (SEPs) events and geomagnetic storms. Association of solar flares with geomagnetic storms have been discussed so far by many researchers. In the present work, we have analyse solar cycle dependence of flare index of solar activity and global geomagnetic disturbances, during solar cycle 22. We find that the flare index of solar activity on northern hemisphere, southern hemisphere and full disk on Sun shows close correspondence with 11-year sunspot cycle, while global geomagnetic disturbances does not show any clear association with 11-year sunspot cycle.

Introduction :

Various types of solar dynamic phenomena occur on the solar surface namely, solar flares, prominence eruptions and coronal mass ejections. The solar flare is a most important phenomenon for solar terrestrial relationship. The solar flares consist of several components, *viz.* flare loops, flare-ribbons, eruptive filaments, remote patches and flaring archs. These components can be distinguished on the basis of their mass motions, as each component exhibits a spatial and velocity pattern that is characteristics of its own. Solar flares transform magnetic energy into several forms. Large solar flares occur in magnetically complex regions where the field is often strong sheared. The mechanism of release of energy is associated with magnetic reconnection. There are two basic phenomena that occur during magnetic reconnection in the flare site. One of them is rapid heating of coronal and chromospheric material, which expands outward into interplanetary medium and produces interplanetary shocks that cause geomagnetic field disturbances and auroras. The other phenomenon is associated with particle acceleration, which represents the energy aspect of the solar flare.

Sunspots are the active regions, represent exceptionally strong concentration of magnetic flux on the average possess a well-known cyclic variation of 11-year sunspot cycle. The association of solar source activities and large geomagnetic disturbances with 11-year sunspot cycle have been reported by many authors and suggested that the different types of coronal transients and large geomagnetic disturbances are varies with 11-year sunspot cycle. During solar activity maximum years, the huge amount of solar energetic particles is released from the Sun and enters in the earth's magnetosphere that is found to be responsible in large number of geomagnetic storms, whereas, at solar activity minimum years, a very few number of geomagnetic storms are observed. Solar flare is also known as solar storm and a major cause of geomagnetic disturbances. Numbers of workers

(Akasofu & Yoshida, 1967; Lockwood, 1971; Pudovkin & Chertkov, 1976) have shown that the association of different types of geomagnetic storms with solar flares and suggested that solar flare of higher importance can produce large geomagnetic storms. We have also shown a good association of large geomagnetic storm with large solar flares during solar cycle 22 in our previous work (Dubey & Mishra, 1997). The total energy emitted by solar flare is represented by flare index of solar activity. The short-term changes (storm time variations) are actively follows with large scale coronal disturbances. So here a question arises as to what is relationship between average (global) geomagnetic disturbances and flare index of solar activity on long-term basis. In this paper, an attempt has been made to examine the association of flare index of solar activity and global geomagnetic disturbances with 11-year sunspot cycle, during the period (1986-96), which covers the whole period of solar cycle 22.

Data set and analysis :

For representation of total energy emitted by solar flares, (Kleczek, 1952) first introduce a relationship 'Q = i × t'. In this relation 'i' represents the intensity scale of importance of solar flare, 't' time duration (in minutes) of the solar flare and 'Q' denotes total energy emitted by solar flares, which is also known as flare index of solar activity. Recently, according to the occurrence of solar flares on northern hemisphere, southern hemisphere and full disk on Sun, flare index of solar activity were calculated and published by (Atac & Ozguc, 1997) in SGD bulletin (January, 1997) for the period January-1986 to October-1996. On the basis of these values, we have calculate the yearly mean value of flare index of solar activity on northern hemisphere, southern hemisphere and full disk on Sun, which are listed in table 1.

Table 1. Yearly mean value of flare index of solar activity on northern hemisphere, southern hemisphere and full disk on Sun.

Year	Northern hemisphere	Southern hemisphere	Full disk on Sun
1986	0.61	0.53	1.13
1987	0.86	1.79	2.26
1988	4.10	4.13	8.14
1989	9.90	8.30	17.39
1990	6.43	5.74	12.20
1991	5.57	9.58	15.16
1992	2.71	5.20	7.74
1993	1.99	2.29	4.23
1994	0.70	0.87	1.58
1995	0.30	0.56	0.86
1996	0.08	0.25	0.32

The long term behaviors of the geomagnetic field disturbances are available through measurements of A_p and K_p indices. For the long-term variations of geomagnetic field, we have used planetary index A_p, which represents the degree of global geomagnetic variability of each day. A_p index is compiled and distributed by the Institut fr Geophysik Gttingen, as a part of International Service of Geomagnetic Indices (ISGI). The annual means of A_p index have been estimated for the period, 1986-96. The data of SSN have been compiled from Solar Geophysical Data (SGD) bulletins.

Results and Discussion :

In this communication, we have shown the association of flare index of solar activity on northern hemisphere, southern hemisphere, full disk on Sun and global geomagnetic field disturbances with 11-year sunspot cycle for afore-said period, are plotted in figure 1. From this plot, we have found that the yearly mean value of flare index of solar activity on northern hemisphere, southern hemisphere and full disk on Sun shows close correspondence with 11-year sunspot cycle. Actually occurrence of solar transients varies with sunspot cycles. Similarly flare index of solar activities vary with 11-year sunspot cycle. During the solar cycle 22, it is also seen that the average flare index of solar activity on southern hemisphere is higher in comparison to northern hemisphere. So we conclude that the southern hemisphere of solar disk is more active for producing solar flares during solar cycle 22.

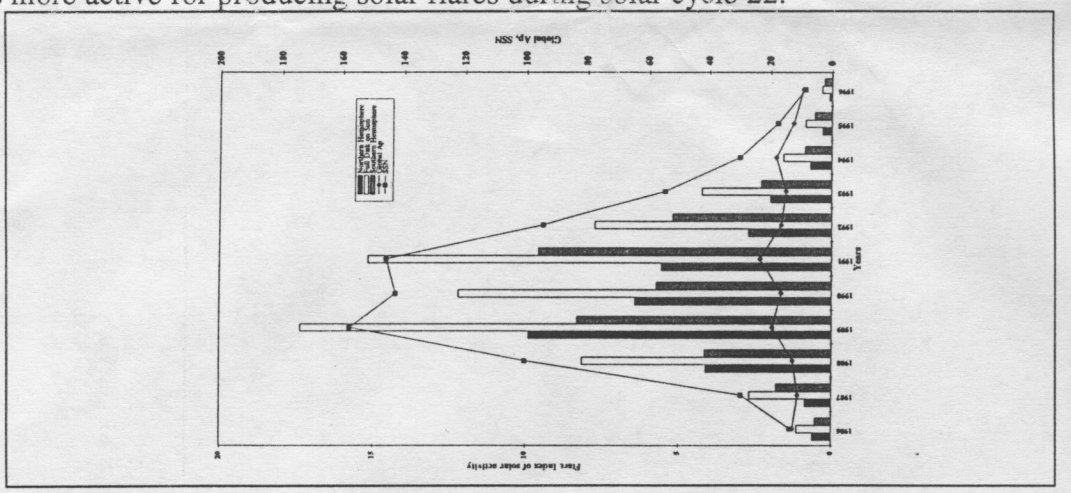

Figure 1 : Variation of yearly mean flare index of solar activity on northern hemisphere, full disk on Sun, southern hemisphere and global A_p with 11-year sunspot cycle, during the period (1986-96).

Flare index of solar activity actively follows the solar cycle, but the relationship between global A_p and annual sunspot number is not straightforward and shows almost similar trend of A_p variation reported for earlier solar cycles. Actually there are many coronal transients are processed on the solar surface. During the maximum phase of solar activity, many closed field regions are more active for producing solar plasma and field, whereas near the minimum phase of solar activity, coronal holes are most prominent for these effects. It is also implied

that two types of solar wind streams and their occurrence in minimum and maximum phases are responsible for this. During solar maximum, the maximum number of large geomagnetic disturbances are caused by transient disturbances in solar wind streams whereas near solar minimum, maximum number of large geomagnetic disturbances are caused by corotating flows in solar wind streams. The velocity of transient disturbances is relatively less than the velocity of corotating flows. So the overall effects of coronal transients and solar wind streams does not show major changes in the global geomagnetic field disturbances, during solar maximum period. In the present analysis, it is found that the average value of global geomagnetic field disturbances are maximum during the solar maximum year (1989-91) in comparision to solar minimum period (1986-88 and 1992-96). Actually, solar cycle 22 is exceptional among other 21 solar cycles, containing two peaks and large duration for solar maximum period. So we find that the average geomagnetic disturbances is higher during the maximum phase in comparision to solar minimum period for solar cycle 22.

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