

Study of geomagnetic storms with interplanetary Parameters

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Abstract

In this correlative analysis, we have taken daily value and yearly mean value of total interplanetary magnetic field B, Solar wind speed V, Geomagnetic Index, (Ap), Electro magnetic field V*B, Sunspot number (Rz) with equatorial disturbance storm time (Dst \leq -50 nT) index for the solar cycle 22 to ascending phase of recent solar cycle 24, (years 1986 – 3 June 2013), 577 geomagnetic storms are identified and a correlative study has been preformed. It has been found that the anti- correlation between total interplanetary magnetic field B, Solar wind speed V, Geomagnetic Index (Ap), Electro magnetic field (V*B), with geomagnetic storms (Dst \leq -50 nT) index and Ap Index are also found to be positive correlated with B, Solar wind speed V, Electro magnetic field (EMF) V*B, which clearly indicate a good positive correlation $r = 0.947$ (Ap with V*B), $r = 0.901$ (Ap with B), and negative correlation coefficient between geomagnetic storms (Dst \leq -50 nT) with V*B, $r = -0.947$ and $r = -0.947$ (Dst \leq -50 nT) with B. The study of solar, interplanetary and geomagnetic parameters make possible to know the disturbances and impact on space weather interaction in the interplanetary magnetic field. In the present papers, we have analyzed the effect of interplanetary parameters on geomagnetic-sphere.

Key words : Geomagnetic Storms, Interplanetary magnetic field, solar wind speed, Solar Cycle.

1. Introduction

The Sun has been continuously

observed by using ground based detectors which are important measuring devices to study the sun and its continuously varying

outputs, which modulate cosmic rays as well as produce disturbances in geomagnetic field may lead to cause the occurrence of geomagnetic storms at various locations of the earth. In fact continuous measurement of the solar variability has been found to be of great importance. Actually, in the last few decades, different parameters have been standardized representing various facets of the solar activity occurring on the various layers of sun surface *i.e.* photosphere, chromospheres, corona and geomagnetic activity^{12,15,19}. Many other researchers have also reported such relationship, mostly involving solar wind speed (V), interplanetary magnetic field (B) as well as the southward component of IMF, to study the effect on geomagnetic field represented by Parameters Kp, Ap, Dst and AE. Later on, more significant relationship have been obtained for B, and in Particular for the Product of V and B. Sabbah I, 2000 has shown that instead of V, or for that matter B alone, is not sufficient to depict the geomagnetic disturbances or cosmic ray variations. Dwivedi *et. al.*³, also reported the relationship between the interplanetary parameters and geomagnetic disturbance index Ap for a long periods (1965-2007). Similar conclusions have reported in some of the other recent publications^{4,10,11,9,16,21}.

These are SSNs, solar flares, coronal hole, V, B geomagnetic indices Ap, Kp, Dst *etc.* The level of magnetic disturbance or geomagnetic activity is measured by these geomagnetic indices. Geomagnetic activity can be divided into two main categories, Namely storms and substorms. Storms, the main contributors to space weather, are initiated when enhanced energy transfer from the solar wind and

interplanetary magnetic field into the magnetosphere leads into intensification of ring current. The ring current development can be monitored with the Dst index^{7,2,6}.

The intense and super intense GMSs during the period 1999 to 2002, based on disturbance storm time Dst Index, has been identified. The intense GMSs have been designated by $-100 \text{ nT} > \text{Dst} \geq 200 \text{ nT}$ whereas, super intense GMSs by $\text{Dst} < -200 \text{ nT}$ following^{6,13,20}. Which is different from Loewe and Prolss¹⁴.

Geomagnetic storms defined by changes in the Dst (disturbance storms time) index. The Dst index estimates the globally averaged change of the horizontal component of the earth's magnetic field at the magnetic equator based on measurements from a few magnetometer stations Firoz *et. al.*,⁵. Crooker *et. al.*,¹, shows that long-term averages of correlation between geomagnetic activity and solar wind velocity are indeed very striking.

2. Data analysis :

In our analysis, the daily values of Dst, interplanetary parameters (V, B and V*B) and annual average sunspot number (Rz) have been used over the period 1986 to 3 June 2013, covering solar cycles 22 to ascending phase of current solar cycle 24 (Years 1986 to 3 June 2013). This data has been taken from the website www.omniweb.gsfc.nasa.gov. Similarly, the geomagnetic index (AP) have been downloaded from www.ngdc.noaa.gov. The disturbance storm time index (Dst) is the conventional measure of ring current intensity

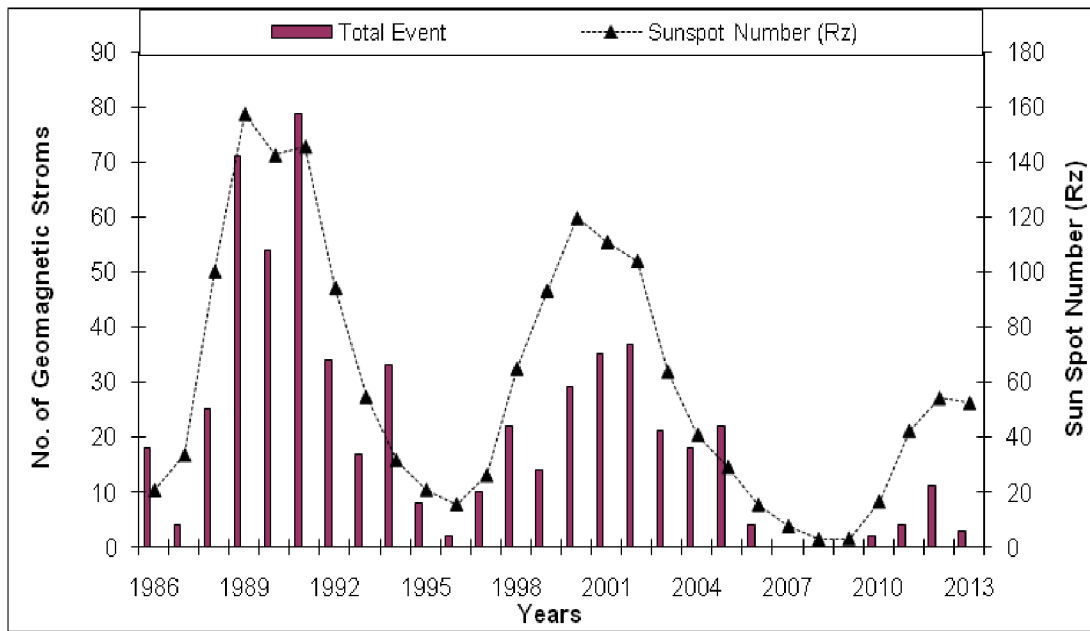


Figure1 : Shows the curve between annual average of sunspot number and number of geomagnetic storms (GMSs) during solar cycles 22 to ascending phase of solar cycle 24 (1986 – 3 June 2013)

and energy observed at earth's surface over low and moderate latitudes. It is the best indicator of ring current intensity and a very sensitive index to represent the degree of solar disturbances. In the present study we have detect geomagnetic storms ($Dst \leq 50$ nT) with respect to their Dst magnitude. On the basis of this criteria that 577 storms occurred during⁸ solar cycle, 22 to ascending phase of solar cycle 24 (From year 1986 to 3 June 2013).

3. Results and Discussion

Jurac and Recharadson, 2001 use the Ap and Dst indices as a measure for the level of geomagnetic disturbance and find that correlation of plasma density, IBI, Bz and By

are about 0.85 for the most geo effective events. Sabbah 2000 reported that the magnitude of the product V.B rather than either solar wind speed or IMF strength B that directly modulate geomagnetic activity. The Sun and its output inform of Various interplanetary features such as Solar plasma, interplanetary magnetic field are related to the disturbance in earth magnetic filed. Using the daily value of $Dst \leq -50$ nT, IMF(B), SWS (V Km/Sec), EMF ($V*B$), Ap index and annual mean value of sunspot number (Rz) are calculated for the solar cycle 22 to ascending phase of recent solar cycles 24, which is occurred during 1986 to 3 June 2013, based on 577 geomagnetic storms ($Dst \leq -50$ nT). In figure 1, we shows the frequency

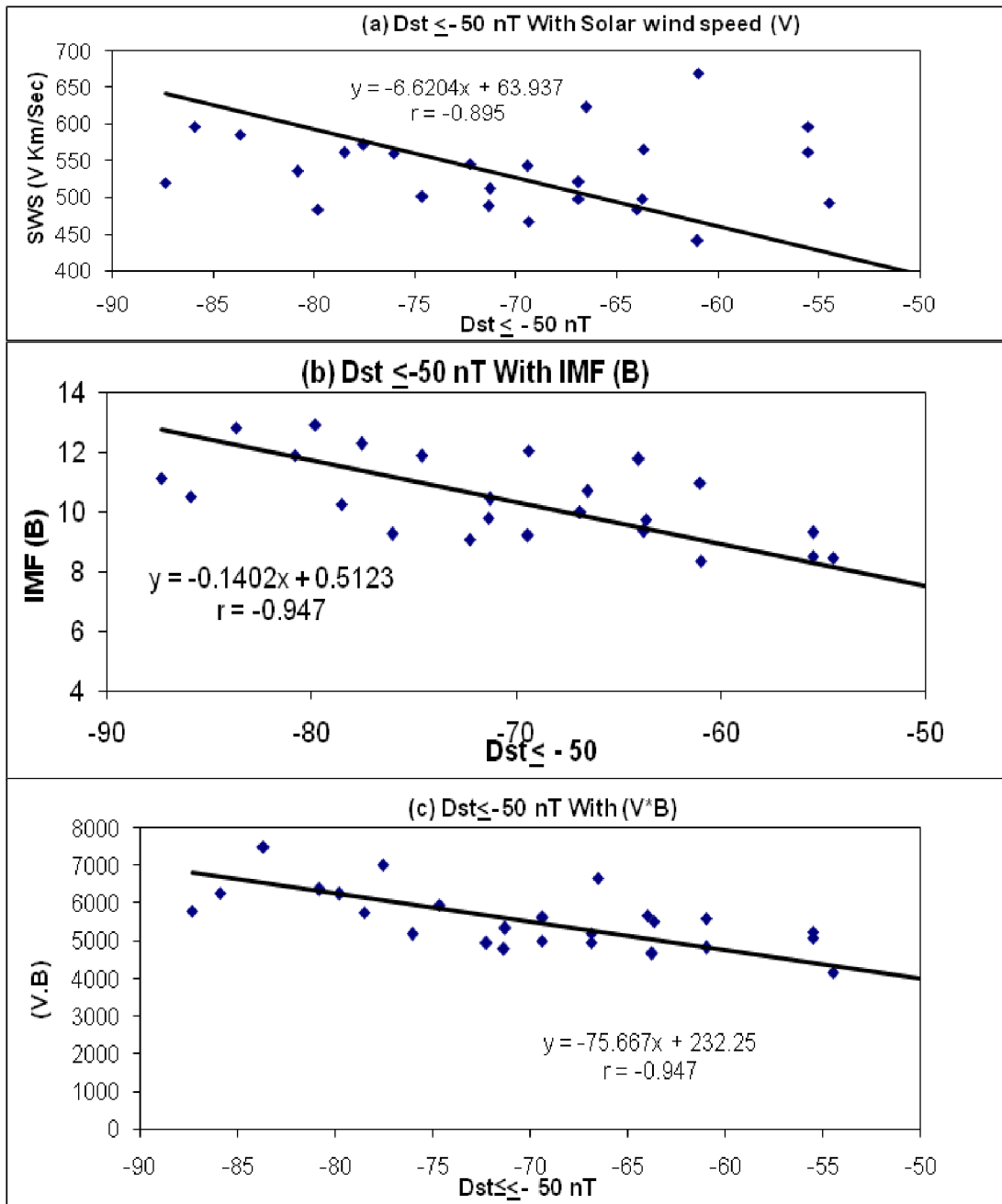


Figure 2. Shows the cross plot between Geomagnetic storm (Dst \leq -50 nt) with annual average value of V, B and V.B during event period for the interval (1986 –3 June 2013).

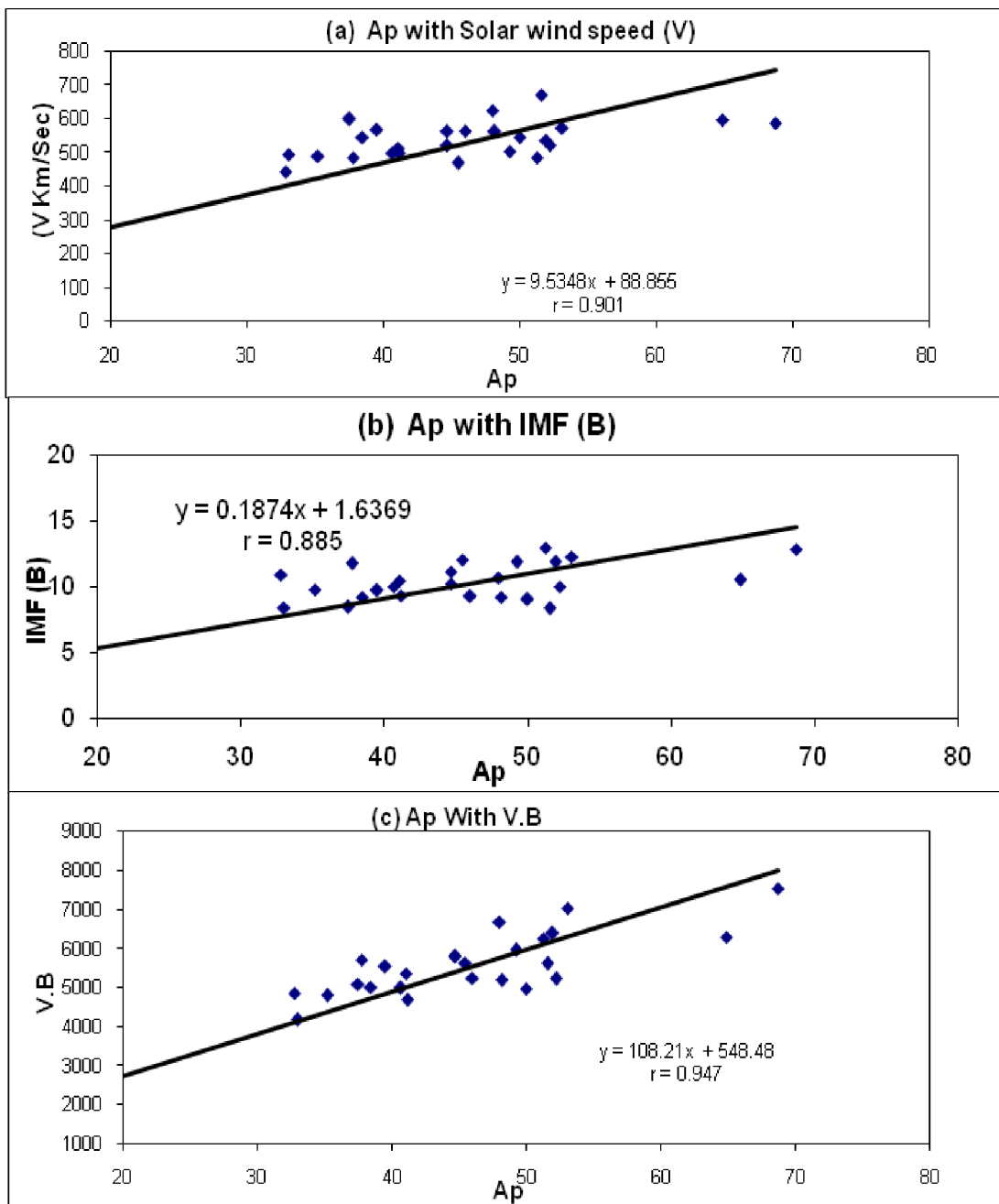


Figure 3. Shows cross plot between annual average of geomagnetic index (A_p) during event time with annual average value of V, B and V.B during event period for the interval (1986 –3 June 2013).

distribution of the Geomagnetic storm (GMSs) with annual average of sunspots numbers, for the period of 1986 to 3 June 2013 (Solar cycles 22 to ascending phase of Solar Cycle 24). Thus, we conclude that GMSs are highly correlated with sunspots numbers (Rz). Figure 1, shows the maximum number of Geomagnetic storm have occurred when sunspot number (Rz) are maximum, in ascending phase of solar cycle 24, number of Geomagnetic Strom (GMSs) less than compared to ascending phase of another solar cycle 22 and 23. In minimum periods of solar cycle 23 (Year 2007-2009) geomagnetic storms are absent. Figure 2, shows the cross plot between $Dst \leq 50$ nT with solar wind speed (V), Interplanetary magnetic field (B) and modulation parameter (V.B) during event period for interval 1986 to 3 June 2013. The cross correlation coefficient between $Dst \leq 50$ versus V' Dst versus B and Dst versus V.B have been found to be -0.895, -0.947 and -0.947 respectively. Thus, we conclude that Dst is highly negative correlated with interplanetary parameters (V,B and VB). Figure 3, shows the cross plat between annual average (during event time) of geomagnetic index (A_p) with annual average of interplanetary parameters (V,B and V.B during event time for the interval 1986 to 3 June 2013). The cross correlation coefficient between geomagnetic index (A_p) versus V, A_p Versus B and A_p versus V.B have been found to be 0.901, 0.885 and 0.947 respectively. Thus, we concluded that A_p is highly positive correlated with interplanetary parameters (V,B and V.B) during event time on annual average

basis^{17,18}.

4. Conclusions

- * Geomagnetic storms are highly correlated with sunspot numbers. It is maximum occurred during maximum activities years.
- * Number of GMSs are minimum during the ascending phase of solar cycle 24 as compare to another, ascending phase of solar cycle (Cycle 22 and 23). Hence Solar cycle 24, will be very weak compare to another solar cycle (Cycle 22 and 23).
- * Annual average of Dst (during event periods) highly negative correlated with annual average interplanetary magnetic field (B) and modulated parameters (V.B) (during event period).
- * During event periods annual average of geomagnetic index A_p with highly positive correlated with V, B and (V*B).

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