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Influnce of Solar and Interplanetary Parameters on Geomagnetic Storms During Solar Cycle 24

Physics

KEYWORDS : Geomagnetic storms (GMSs), Interplanetary magnetic field (IMF),Sunspot number (SSN),Disturbance time index (Dst).

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ABSTRACT

According to present study for the span of ascending and descending phases of solar cycle 24,we have seen that total 59 geomagnetic storms (GMSs) occurred, in which 42 moderate (GMSs),15 intense GMSs and only two sever GMSs occurred during the time of 2008 to May 2016 with disturbance time index (Dst). For this study we have discussed the association and correlation of GMSs with Solar source causes (Sunspot numbers, CMEs, Solar flares), interplanetary and geomagnetic parameters (B, Bz, Solar wind velocity, Proton density). A high positive correlation (r=0.72) have been observed between the yearly mean sunspot number (SSN) and yearly geomagnetic storms (GMSs) events of solar cycle 24. It has been found that intense GMSs are highly associated with the passage of interplanetary Coronal Mass Ejection and Solar Flare. The correlation between intensity of GMSs (Dst) and intensity of IMF Bz is higher(0.6518), as compared with solar wind velocity (r= -0.326) and ion density(r= -0.322),for intense GMS events of solar cycle 24 . Geomagnetic indices, Dst, Kp, ap are used to measure the intensity of geomagnetic storms. It has been verified that geomagnetic storm intensity is correlated well with the total magnetic indices Kp (r= -0.653) and ap (r= -0.658).

INTRODUCTION:

Geomagnetic storms (GMSs) generally occurred due to abnormal conditions in the interplanetary magnetic field (IMF) and solar wind plasma caused by various solar phenomena .Dst (Disturbance Storm Time) index was introduced in 1964 and is defined as the hourly average of the deviation of H (Horizontal) component of magnetic field measured in nanotesla (nT). It is suggested that geomagnetic, activity is related to variety of interplanetary plasma/ field parameters, e.g. Solar wind velocity V, interplanetary magnetic field (IMF) B and Bz (Akasofu 1983,Joselyn 1981,Gonzalez et.al. 1994,Parnahaj & kudela 2014). Comprehensive analysis of magnetic storm morphology have been made by Chapman 1935,Richardson 2013,Le et.el 2013.It is well established geomagnetic activity as measured by indices such as Kp (Menvielle & Berthelier 1991) and Dst (Sugiura 1964) is principally driven by the plasma and magnetic field conditions in the solar wind that encounters the Earth(O'Brien & Mcpherron 2000). Shrivastava and Schewenn,1999 presented an extensive study of a large number of halos and partial halos recorded by Lasco in conjunctions with their solar signature.

EXPERIMENTAL DATA ANALYSIS:

For the analyzed geomagnetic storms of solar cycle 24, we have used hourly data of disturbance time index (Dst). We have selected only those geomagnetic storms which magnitude (Dst) greater than -60nT. Identification of 17 intense geomagnetic storms (Dst<-100 nT), have been observed during 2008 to may 2016. For the above tasks the data is collected from the online sources provided by the World Data Center through its web (National Oceanic and Atmospheric Administration (NOAA): http:// www. noaa. gov/). We have used Interplanetary Magnetic Field (IMF) parameters B ,Bz, Solar Wind Velocity and geomagnetic indices, Kp, ap data from Omni web explorer (omni web.gsfc. nasa.gov). The study is made statistically between the Dst strength and the peak value obtained by solar wind plasma parameters and IMF Bz . To see the relation of these intense GMs with Solar Sources, we have taken CMEs and Solar Flares data. LASCO/SOHO data center and Solarham. com website have been used for associated CME and solar flare data. Table 1 and 2 are show detail information of GMSs during time interval 2008 to May 2016.

RESULT AND CONCLUSION:

The purpose of this work was to develop a catalog of Dst (-60 nt) from 2008 to May 2016. we have classified geomagnetic storms(GMSs) with respect to their Dst magnitude in different categories according to Loewe and Prolss [9], a geomagnetic storm can be weak (Dst > -50nT), moderate (-100nT < Dst ≤ -50nT), intense (Dst ≤ -100nT),severe (Dst ≤ -200 nT) and super storm(<-300nT) .Under the selection criteria from 59 GMSs,42 moderate GMSs, 15 intense GMSs ,2 severe GMS, and no any super storms have been observed during current solar cycle 24, which can be seen in fig.1.

In relation of GMSs with solar active regions in terms of sunspot number (SSN), It is believed that the majority of intense geomagnetic storms occur during the maximum phase of sunspot cycle because of many solar active regions.Figure-1, show a number of geomagnetic storms for each year along with the yearly average sunspot number. From this fig., we can observe that the periods 2008 & 2009 are the periods of minimum phase of solar activity, Only1,1 moderate GMS have occurred for both respective years, because sunspot activity during the ascending phase of solar cycle-24 was very less. While maximum number of geomagnetic storms have been occurred in descending phase in year 2015 with large intensity of GMSs (--223 nT) of current solar cycle 24. A highly positive correlation(r=0.72) have been observed between the yearly average sunspot number (SSN) and yearly geomagnetic storms (GMSs) events of solar cycle 24.

Influence of Solar and IMF parameters on intense GMSs (< -100 nT)

_In this work we have observed that almost all intense GMSs are correlated with CMEs (in which halo, partial halo CMEs, and other type CMEs included) as shown in fig. 2.We have found from the possible got data of CMEs and solar flare that 87% GMSs events associated with halo and partial halo CMEs, and only 13% GMSs events associated with poor CMEs. We have analyzed that halo CMEs has intense speed more than other type CME .For the study of association of Intense and sever GMSs with solar parameters; we took solar flare data also. It is found that x Class, M Class, and C Class, solar flares played significant equally role for occurrence of intense or sever GMSs of solar cycle 24.Interplanetary magnetic field (IMF)parameters are also play significant correlation with intense geomagnetic storms(GMSs) events. The Kp index represent the intensity of planetary magnetic activity as seen at subauroral latitude and is given for each 3-h interval. Fig.3. presents the scatter diagram between the maximum negative value of Dst with respect to IMF B z(southward),Solar wind velocity V, geomagnetic indices kp, ap separately. In

this figure, a significant correlation (r=0.65) can be seen between Dst & IMF Bz, that is, according to this studied the strength of the geomagnetic storm is strongly dependent on the southward component Bz, whereas the correlation coefficient between Dst and Solar wind velocity V is (-0.325) . Therefore the greater GMS are not necessarily associated with greater values of solar wind velocity, have been observed. Similarly no definite relationship(r= -0.32) between GMSs intensity and Proton density parameters is found. It has been verified that geomagnetic storm intensity is correlated well with the total magnetic indices Kp (r= -0.653) and ap (r= -o.658).

TABLE I. SHOWS THE OCCURRENCE OF THE GEOMAGNETIC STORMS WITH THEIR CLASSIFICATION OF INTENSITY.

Geomagnetic storms	Dst magnitude	No.of events
Total GMSs		59
Moderate storms	(-60 nTto <-100 nT)	42
Intense storms	(-100 nT to< -200 nT)	15
Severe storms	(-200 nT to< -300 nT)	2
Super storms	more than ,-300 nT	0

TABLE 2:SHOW THE DETAIL OF INTENSE GEOMAGNETIC STORMS OF SOLAR CYCLE 24 WITH ASSOCIATED CME AND SOLAR FLARE.

Dete of storms	Onset time of storms	Magnitude of storm	Class of CME	
dd/mm/yy	dd/mm/ yy(hrs,UT)	(nt)		Flares
1	2	3	4	5
6 Aug.2011	5/8/11(13)	-115	halo	M6.0,
26Sep.2011	26/9/11(11)	-118	halo	X1.9,
9mar.2012	9/3/12(00)	-131	halo	X5.4,X1.3
24Apr.2012	23/4/12(18)	-108	Halo	*
15Jul.2012	15/7/12(02)	-127	partial halo	X1.4
1oct.2012	30/9/12(14)	-119	halo	C3.7
17mar.2013	17/3/13(7)	-132	Halo	M1.2
1jun.2013	1/6/13(01)	-119	partial halo	*
19Feb.2014	18/2/14(16)	-116	partial halo	*
7Jan.2015	7/1/15(00)	-100	other	C
17mar.2015	16/3/15(07)	-223	Halo	C9
23June.2015	22/6/15(22)	-204	other	M1.0
9Sep.2015	8/7/15(20)	-100	partial halo	M1.7,C-CLASS
7oct.2015	7/10/15(00)	-124	partial halo	C
20Dec.2015	20/12/15(01)	-170	Halo	*
1Jan.2016	31/12/15(09)	-110	partial halo	M1.8
6mar.2016	6/3/2016	-100		*

Note: sign * indicates no data available

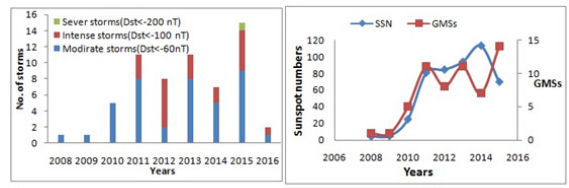

Fig 1:[A] Shows the histogram of Yearly magnitude distribution oF GMSs,for the time period 2008- May2016. and [B] show yearly total number of Geomagnetic storms (Dst<-60 NT) distribution with average yearly sunspot number

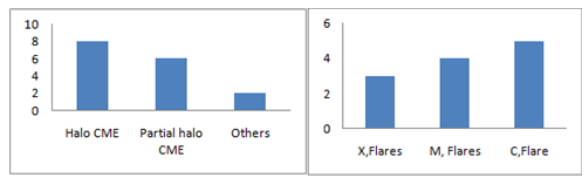

Fig.2: shows the association of CMEs and Solar flare with intense GMSs of solar cycle 24

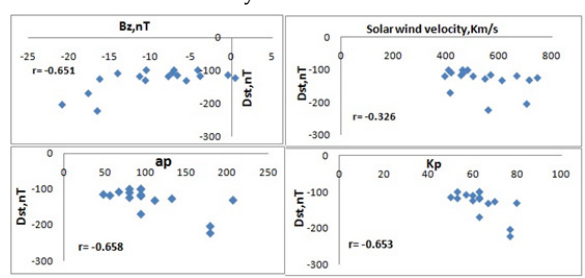

Fig.3: Shows the correlation of intense geomagnetic storms with respect to IMF Bz, solar wind velocity, geomagnetic indices Kp, and ap, separately for the period 2008 to May 2016.

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