



CME Association of geomagnetic storms occurred in January- December 2011

Ruchi Nigam¹ and R.K.Tiwari²

¹Jabalpur Engineering College, Jabalpur, India, 482011

²Govt.New Science College, Rewa, India, 486001

Abstract: The period of January- December 2011 was the active part of 24th solar cycle, close to solar cycle maximum, a significant number of powerful X-ray flares were recorded. In this solar cycle, maximum sunspot number at 1 hour resolution is 136 (OMNI DATA). During that period the Sun became very active. The plural numbers of active region appeared on the solar surface. The identification of solar sources for selected 11 geomagnetic storms (disturbance storm index $Dst < -50$ nT) that occurred in January- December 2011 has been done. It is found that 73% geomagnetic storms are identified with CMEs. Solar flare associated with CME is major cause of 64% geomagnetic storms. The results are in satisfactory agreement with previous investigations. But in this study although the value of minimum interplanetary magnetic field Bz for 7 out of 11 geomagnetic storms ($Dst < -50$ nT) is less than -10 nT but none in the case it is continue for long duration (> 3 hours).

Keywords: Solar Wind; Coronal Mass Ejection (CME); Solar Flare; Geomagnetic storm; Interplanetary Magnetic Field (IMF)

I. Introduction

The study of geomagnetic storms is a particular concern for mankind [1]. With the onset of geomagnetic storms substantial southward distortions of the interplanetary magnetic field and impulsive increase in the solar wind are well associated [2]. Coronal mass ejections (CMEs) have been identified as a prime causal link between solar activity and large geomagnetic storms [3]. Ejected solar material is propelled outward into interplanetary space, where it interacts with the background solar wind and distorts the IMF. This distortion together with the internal magnetic structure of CME itself can produce large Bz deflections of Earth, with the amplitudes depending on CME physical configuration, CME launch position background solar wind structure and the position of Earth. Bothmer and Schewenn [4] investigated the solar wind input conditions for major geomagnetic storms during 1966-1990. They found 41 of 43 storms caused by transient shock – associated CMEs, caused by transient region (CIR), and 1 caused by a CIR. Intense geomagnetic storms caused by fast CMEs were found to be independent of the phase of solar cycle. Certain manifestation of solar activity can generate large scale disturbances that propagate through the interplanetary medium. These interplanetary disturbances (IPD), often preceded by shocks, modify both solar wind (SW) and interplanetary magnetic field parameters. The situations with southward changes of IMF and impulsive increase of solar wind dynamic pressure are “geo-effective” and well associated with onset of geomagnetic storms [5].

II. Data and Method

An overview of 11 geomagnetic storm events with $Dst < -50$ nT, that occurred in the interval January 2011 to December 2011 is given in Table 1. In table 1 corresponding to storm date, there is an attempt to find the solar and interplanetary sources of geomagnetic storms. The CME data were taken from the LASCO CME Catalog (http://cdaw.gsfc.nasa.gov/CME_list/). The geoeffectiveness is determined by the magnetic disturbance produced in the Earth, which is measured by the Disturbance Storm Time (Dst) index. Here a geomagnetic storm means that, at peak time, the Dst index is ≤ -50 nT. The Dst index was obtained from site <http://omniweb.gsfc.nasa.gov>. The interplanetary shock (IP Shock) data are taken from SOHO/CELIAS/MTOF (www.umd.edu).

III. Observational Results

January 2011 to December 2011 period was characterized by several large active regions in the solar disk some of them are AR 1289, 1302, 1164, 1226, 1261, complex structure of 1280 to 1286. These regions produced nearby all major solar flares and CME events during their across the solar disk. Coronal mass ejections (CMEs), as a product and manifestation of solar activity, significantly influence process in the interplanetary medium during their outward propagation; they also affect planetary bodies (Magnetosphere) in the heliosphere [6]. According to Gosling [7] a CME in the solar wind generally a large, three –dimensional structure, usually driving a shock

wave in the solar wind when it propagates faster than the ambient plasma. From table 1, total numbers of geomagnetic storms are 11, out of which 7 storms were associated with fast CME, only 1 associated with slow moving CME. Solar flares are prime cause for 8 geomagnetic storms. Solar flare associated with CME is major cause of 7/11 (64%) geomagnetic storms. In this period 7 out of 11 were linked with coronal holes and high speed solar wind stream. The value of interplanetary magnetic field for all geomagnetic storms is found to be >10 nT and IMF Bz is < -6 nT. In terms of planetary index K $\ast 10$, it is > 43 and solar wind velocity > 411 km/sec for all geomagnetic storms.

IV. Discussion

The study of the origin of the major geomagnetic storms associated with a solar active period of January 2011 to December 2011 gives the opportunity to have some new information about the origin of geomagnetic storms. The CMEs that produced the major geomagnetic storms were associated with X-ray flare. From Table 1, it is seen that magnetic storms (8/11) was caused by a CME propagating in a solar wind disturbed by previous CMEs that preceded it. Out of 8, 7 associated with fast full halo or partial halo CMEs. Only one is associated with slow moving CME. In the intensification of geomagnetic storms, show that the acceleration of the energetic protons can be produced by interacting CMEs [8&9] or by CMEs propagating in a disturbed solar wind [10]. The present results are consistent with Cane and Richardson [11] work that showed the fastest CMEs and the strongest magnetic storms tend to occur after the maximum of the solar cycle. Coronal holes are regions of abnormally low density and temperature in the solar corona [12]. Neupert and Pizzo [13] showed that some coronal holes are associated with high speed wind streams and that the series of coronal holes observed from 1972 through 1973 from OSO 7 strongly correlated with current geomagnetic variations. In this study high speed stream (HSS) from coronal hole on earth side is responsible for geomagnetic storms (7/11). Interplanetary events with the southward IMF component Bz < -10 and with a duration larger than 3 hours have one to one causal relationship with intense (Dst < -100 nT) geomagnetic storms [14]. Geomagnetic storms are caused by a combination of Bz from injected magnetic cloud structures with Bz generated by interplanetary dynamic interaction [15]. Tang *et al* [16] deal with interplanetary and solar causes of 10 geomagnetic storms (Dst < -100 nT) that occurred in the interval August 16, 1978 to December 28, 1979. These events were documented and discussed by Gonzalez and Tsurutani [14] with the use of Dst data together with interplanetary magnetic field and plasma data collected by ISEE 3 satellite, while it was in of the Earth in its halo orbit about L₁ libration point. Gonzalez and Tsurutani [14] have claimed that a common interplanetary feature for these storm events were long duration (> 3 hours), large and negative (-10 nT) interplanetary magnetic field (IMF) Bz events. But in this study although the value of minimum interplanetary magnetic field Bz for 7 out of 11 geomagnetic storms (Dst < -50 nT) is less than -10 nT but none in the case it is continue for long duration (> 3 hours).

V. References

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Table 1: Shows the major geomagnetic storms and associated parameters occurred in January-December 2011

S.No.	Date/Month	Dst_{min}- 50nT minimum (nT)	B _{max} Maximum (nT)	B _z Minimum (nT)	V(Km/sec) Maximum	Kp* 10 maximum	Ap maximum	CME	Interplanetary Shock	Solar Flare	Coronal hole
1	04- 02- 2011	-56	21.2	-15.6	647 (5 Feb.)	57	67	No	No shock	No	High speed stream from coronal hole
2	1-03- 2011	-61	14.1	-11.1	687 (2 Mar.)	53	56	No	No shock	No	Coronal hole
3	11-03- 2011	-80	14.1	-8.9	561 (12 Mar.)	57 (12 Mar.)	67 (12 Mar.)	Halo CME	IP shock	X 1.5 class solar flare	Coronal hole
4	28-05- 2011	-80	13	-10.7	752 (29 May)	63	94	No	No shock	M 1 class solar flare	Coronal hole
5	5-07- 2011	-57	10.1 (4 July)	-8.7 (4 July)	411 (4 July)	43	32	CME	No shock	C class solar flare	Coronal hole
6	6-08- 2011	- 113	29.4 (5 August)	-18.7 (5 August)	611 (5 August)	77	179 (5 August)	Halo CME	IP shock	M 1 class solar flare	Coronal hole
7	10-09- 2011	-64	19.3 (9-Sept.)	-14.2 (9-Sept.)	560 (9-Sept.)	57	67 (9-Sept.)	Partial Halo CME	IP shock	X 1.8 solar flare	Coronal hole
8	17-09- 2011	-63	13.6	-9	549	53	56	Partial Halo CME	IP shock	No	No
9	26-09- 2011	- 103	34.2	-16.4	704	80	94	Halo CME	IP shock	X 1.9 class solar flare	No
10	25-10- 2011	- 137	24	-11.6 (24-Oct.)	534 (24-Oct.)	73	154	CME	IP shock	M 1.3 class solar flare	No
11	1-11- 2011	-61	13	-6.2 (31-Oct.)	436	47	39	Slow moving CME	IP shock	M 1 class solar flare	No