# H-Cmes and Ii-Type Radio Bursts Related Intense Geomagnetic Storms in Relation With Interplanetary Magnetic Field and Solar Wind Disturbances

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| **Praveen Kumar Gupta** | Department of physics, govt. P. G. College Panna (M. P.) |
| **Puspraj Singh** | Department of physics, govt. P. G. College Panna (M. P.) |
| **Devendra Sharma** | Department of physics, govt. P. G. College Panna (M. P.) |
| **P. K. Chamadia** | Department of physics,Govt. P. G. College Satna (M. P.) |

**ABSTRACT**    We have studied H-CMEs and II-type radio bursts related intense geomagnetic storm (Dst≤-100 nT) associated with X-ray solar flare, Interplanetary Magnetic Fields and solar wind disturbances, during the period of 2001-2012. We have found that all the II-type related intense geomagnetic storms are associated with X-ray solar flares of different categories. The association rates of class X, class M, class C and class B, X-ray solar flares have been found 18.18%, 54.55%, 18.18% and 9.09% respectively. Further we have concluded that intense geomagnetic storms are closely related to interplanetary magnetic fields and change in solar wind disturbances (temperature and pressure). Positive co-relation with correlation coefficient 0.63 has been found between magnitude of intense geomagnetic storms and magnitude of change in southward components of interplanetary magnetic field. Further positive co-relation with correlation coefficient 0.63 has been found between magnitude of intense geomagnetic storms and magnitude of change in solar wind plasma temperature and 0.82 between magnitudes of intense geomagnetic storms and magnitude of change in solar wind plasma pressure.

## I-Introduction

The solar activity, solar flares and coronal mass ejections are most energetic solar events in the heliosphere and are widely recognized as being responsible for production of geomagnetic disturbances in geomagnetic field. It is generally believed that long intervals of enhanced southward interplanetary magnetic field (IMF) and the high solar wind speed are the primary causes of intense geomagnetic disturbances and that the solar sources of such geoeffective solar wind structures are usually CMEs (Gopalswamy et.al., 2005; Srivastava and Venkatakrishnan,2004; Zhang et.al.,2003; Webb et.al.,2000). Evidence has been presented that the properties of the earth-directed CMEs, such as the internal structure of the magnetic field may determine whether or not a geomagnetic storm subsequently occurs (Can et.al., 2000).This suggests that the magnetic field serves as a link between flares, CMEs and geomagnetic storms.

Several scientists have studied interrelationship between solar flares coronal mass ejections and geomagnetic storms, (Webb et. al., 2000; Zhao & Webb, 2003) and have concluded that flares, CMEs and geomagnetic storms are closely related magnetically. Michalek et. al. (2006) have concluded that halo coronal mass ejections (HCMEs) originating from regions close to the center of the sun are likely to be geoeffective. They have showed that only fast halo CMEs (with space velocities higher than ~1000 km/s) and originating from the western hemisphere close to the solar center could cause intense geomagnetic storms. The main cause of geomagnetic storms is believed to be the large IMF structure which has an intense and long duration southward magnetic fields component, Bz (Tsur utaniandGonzalez,1995;Tsurutani,1988). Verma et. al. (2009) have studied geomagnetic storms Dst < - 50nT observed during the period of 1997-2006, with halo and partial halo coronal mass ejections associated with X-ray solar flares of different categories and concluded that they have concluded that majority of the observed geomagnetic storms are found that halo and partial halo CMEs associated with X ray solar flares are most potential candidates for production of geomagnetic storms.

Yurchyshyn (2004) have analyzed data for major geomagnetic storms and found a relationship between hourly averaged magnitude of the Bz component of IMF and projected speed of CMEs launched from the central part of the solar disk. They have concluded that CMEs with V> 1000 Km/s are capable of furnishing. Gonzalez and Tsurutani (1987) point-ed out a relation between the Dst index and the strength of the IMF, which produced the geomagnetic disturbance: intense storms (Dst [23]± 100 nT) were caused by large southwardly directed magnetic fields, where Bz ° ± 10 nT.  Later Cane et al. (2000) studied 83 events from 1996 to 1999 and found a high correlation (0.74) between the intensity of the southwardly directed IMF, Bz, and the Dst index. Recently, Wu and Lepping (2002) used hourly averaged OMNI data for 135 events from 1965 to 1998 and they found the correlation to be 0.86. In this investigation, Halo CMEs and II type radio bursts related intense Geomagnetic storms observed during the period of 2001 to 2012 have been studied with X-ray solar flares, solar wind disturbances and interplanetary magnetic field to know the physical process responsible for geomagnetic storms.

## II-Experimental Data

In this investigation hourly Dst indices of geomagnetic field have been used over the period 2001 to 2012 to determine onset time, maximum depression time, magnitude of geomagnetic storms. This data has been taken from the NSSDC Omni web data system which been created in late 1994 for enhanced access to the near earth solar wind, magnetic field and plasma data of Omni data set, which consists of one hour resolution near earth, solar wind magnetic field and plasma data, energetic proton fluxes and  geomagnetic and solar activity indices. The data of coronal mass ejections (CMEs) have been taken from SOHO large angle spectrometric, coronagraph (SOHO / LASCO) and extreme ultraviolet imaging telescope (SOHO/EIT) data. To determine disturbances in solar wind parameters and interplanetary magnetic, hourly data have been used, these data has also been taken from Omni web data  (http://omniweb.gsfc.nasa.gov/form/dxi.html)). The data of X-ray solar flares, radio bursts, and other solar data, solar geophysical data report U.S. Department of commerce, NOAA monthly issue and solarSTPdata(http://www.ngdc.noaa.gov/stp/solar/solardataservices.html.) have been used.

**Table-1 Association of Halo Coronal Mass Ejection and II Type radio bursts Associated Geomagnetic Storms≤-100nT with X-Ray Solar Flares, Solar Wind Disturbances and Interplanetary Magnetic Field (Bz) for the period of 2001-2012.**

| S.N. | Date | Geomagnetic Storms≤-100nT Start time in dd(hh) | Magnitude in nT | CMEs Start time in dd(hh) | Type | Radio Bursts Start time in dd(hh) | Type | Solar Flares Start time in dd(hh) | Class | IMFBz Start time in dd(hh) | Magnitude in nT | Temperature Start time in dd(hh) | Magnitude in Kelvin | Pressure Start time in dd(hh) | Magnitude in npa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 19.03.01 | 19(11) | -150 | 18(02) | H | 18(11) | II | 18(04) | B-58 | 19(23) | -13.3 | na | na | na | na |
| 2 | 17.08.01 | 17(17) | -102 | 15(23) | H | 15(23) | II | 16(02) | B-76 | 17(14) | -16.6 | 17(08) | 299070 | 17(10) | 20.76 |
| 3 | 21.10.01 | 21(16) | -178 | 19(01) | H | 19(01) | II | 19(01) | X-16 | 21(16) | -11.6 | 21(15) | 422395 | 21(13) | 25.54 |
| 4 | 24.11.01 | 24(06) | -223 | 22(20) | H | 22(20) | II | 22(20) | M-38 | 24(10) | -55.4 | 24(03) | 1659599 | 24(02) | 77.46 |
| 5 | 18.08.02 | 18(22) | -110 | 16(12) | H | 16(12) | II | 16(12) | M-52 | 18(21) | -3.01 | 18(11) | 484987 | 18(15) | 8.07 |
| 6 | 22.01.04 | 22(05) | -144 | 20(00) | H | 20(07) | II | 20(07) | M-61 | 22(10) | -10.2 | 22(00) | 501487 | 22(00) | 13.5 |
| 7 | 07.05.05 | 07(20) | -126 | 05(20) | H | 05(20) | II | 05(20) | C-78 | 07(18) | -10.1 | 07(18) | 866682 | 07(16) | 10.12 |
| 8 | 05.08.11 | 05(20) | -111 | 04(04) | H | 03(08) | II | 04(04) | M-93 | 05(16) | -19.3 | 05(17) | 470261 | 05(16) | 21.84 |
| 9 | 26.09.11 | 26(15) | -111 | 24(12) | H | 24(08) | II | 24(13) | M-71 | 26(17) | -26.5 | 26(10) | 945715 | 26(11) | 13.24 |
| 10 | 24.10.11 | 24(21) | -147 | 22(10) | H | 21(08) | II | 22(10) | M-13 | 24(21) | -18.2 | 24(14) | 440239 | 24(14) | 14.68 |
| 11 | 15.07.12 | 15(02) | -130 | 12(17) | H | 12(08) | II | 12(15) | X-14 | 15(05) | -19.3 | 14(08) | 456825 | 14(16) | 17.26 |
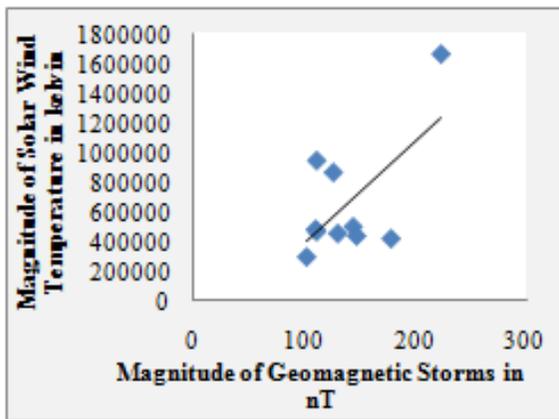


**Figure-1 Shows scatter plot between magnitude of intense geomagnetic storms and magnitude of change in solar wind temperature showing positive correlation with correlation coefficient 0.63.**
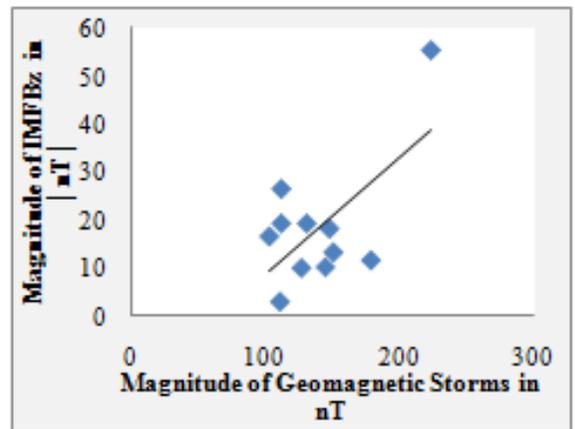


**Figure-3 Shows scatter plot between magnitude of intense geomagnetic storms and magnitude of IMFBz showing positive correlation with correlation coefficient 0.63.**

### III-Data Analysis and Results

In this study we have observed 11 intense geomagnetic storms (Dst≤-100nT) associated with halo coronal mass ejections (CMEs), solar radio bursts, solar flare and interplanetary parameters occurred during the period 2001 to 2012 (see Table No.1). We have found that all the intense geomagnetic storms are associated with X-ray solar flares of different categories. The association rates of class X, class M, class C and class B, X-ray solar flares have been found 18.18%, 54.55%, 18.18% and 9.09% respectively. From the data analysis of halo CMEs and II type radio bursts related intense geomagnetic and interplanetary parameters, we have found that halo CMEs and II type radio bursts related intense geomagnetic storms are closely related to disturbances in solar wind plasma parameters and southward component of interplanetary magnetic field (Bz). Further to see how the magnitudes of intense geomagnetic storms are correlated with the magnitude of change in solar wind plasma temperature and pressure, we have plotted scatter plot between magnitude of intense geomagnetic storms and magnitude of change in solar wind plasma parameters (temperature and pressure). The resulting scatter plots are shown in figure 1 and 2. From the fig it is clear that maximum intense geomagnetic storms which have large magnitude are associated with such change in solar wind plasma temperature and pressure which have relatively large magnitudes values. We have also calculated correlation coefficient statistically and found positive correlation between magnitude of intense geomagnetic storms and magnitude of change in solar wind plasma parameters (temperature and pressure) with correlation coefficient 0.63 between magnitude of geomagnetic storms and magnitude of change in
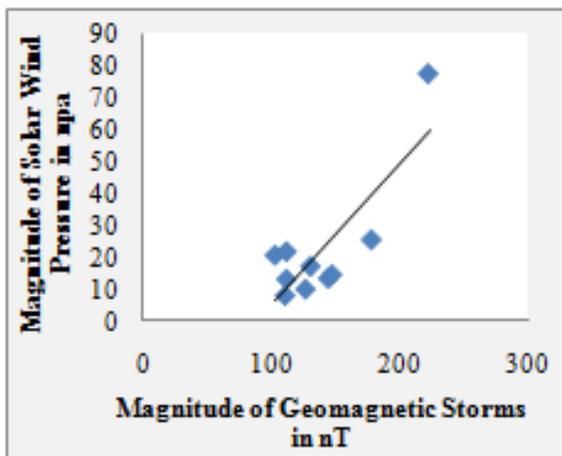


**Figure-2 Shows scatter plot between magnitude of intense geomagnetic storms and magnitude of change in solar wind pressure showing positive correlation with correlation coefficient 0.82.**

solar wind plasma temperature and 0.82 between magnitude of intense geomagnetic storms and magnitude of change in solar wind plasma pressure. Further to see how the magnitude of intense geomagnetic storms are correlated with the magnitude of change in southward components of interplanetary magnetic fields (Bz), a scatter diagram have been plotted between the magnitude of intense geomagnetic storms and magnitude of value of change in southward components of interplanetary magnetic fields (Bz) in fig.3. From the fig it is clear that maximum intense geomagnetic storms which have large magnitude are associated with such change in southward components of interplanetary magnetic fields (Bz) which have relatively large magnitudes values. Positive correlations with correlation coefficient 0.63 have also been found between magnitude of intense geomagnetic and magnitude of southward component (Bz).

## IV. Conclusion

From our study, all the halo CMEs and II type radio bursts related intense geomagnetic storms have been identified as intense geomagnetic storms and associated with different types of X-ray solar flares. The positive correlation between magnitude of intense geomagnetic storms and magnitude of change in solar wind plasma temperature, pressure and southward components of interplanetary magnetic fields (Bz) suggest that disturbances in solar and interplanetary parameters play crucial role in producing intense geomagnetic storms. These results shows that halo coronal mass ejections and II type radio bursts associated with X-ray solar flares, solar wind plasma temperature, pressure and southward components of IMF(Bz) are very much effective in producing intense geomagnetic storms.

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