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# Statistical Relation Of Coronal Mass Ejections And Solar Wind Disturbances With Radio Bursts Related Geomagnetic Storms

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***Abstract***
*We have studied radio bursts (RB) related geomagnetic storm of magnitude ≤-90 nT, during the period of 1997- 2008 with coronal mass ejections and solar wind disturbances. We have found that most of the RB related geomagnetic storms are found to be associated with coronal mass ejections (CMEs). Out of 42 geomagnetic storms 37 (88.09%) geomagnetic storms are found to be associated with coronal mass ejections (CMEs). Most of the CMEs are associated with halo and partial halo CMEs the association rates are 67.57% and 32.43% respectively. It was concluded that there is a positive correlation between magnitude of radio bursts related geomagnetic storms and speed of associated CMEs.Further we have concluded that geomagnetic storms are closely related to solar wind disturbances (density and pressure). Positive co-relation with correlation coefficient 0.26 has been found between magnitude of geomagnetic storms and magnitude of change in solar wind plasma density and 0.41 between magnitudes of geomagnetic storms and magnitude of change in solar wind plasma pressure.*
***Keywords:*** *Geomagnetic storms, coronal mass ejections, solar wind disturbances, Radio bursts*.

## 1- INTRODUCTION

Geomagnetic storms are generally defined by periods of intense solar wind–magnetosphere (SW-M) coupling usually associated with extreme conditions in the solar wind (SW), such as coronal mass ejections (CMEs) or co-rotating interaction regions (CIRs). Coronal mass ejections (CMEs) are the energetic solar events in which huge amount of solar plasma materials are ejected into the heliosphere from the sun and generate large disturbances in solar wind plasma parameters and geomagnetic storms in geomagnetic field [Correiaa, 2005: Cane, 2000: Michalek, 2006: St. Cyr, 2000: Webb, 2000: Gopalswamy, 2006: Manoharan, 2006: Verma et al, 2009: Verma, 2012]. It is believed that the main cause of intense geomagnetic storms is the large IMF structure which has an intense and long duration southward magnetic field component, Bz [Tsurutani,et al, 1988 : Echer,et al, 2004]. They interact with the earth's magnetic field and facilitate the transport of energy into the earth's atmosphere through the reconnection process. .Correiaa and De Souza [2005] have presented the identification of solar coronal mass ejection (CME) sources for selected major geomagnetic storms in the geomagnetic field of geomagnetosphere. They have inferred that full halo CMEs originating from active regions associated with X-ray solar flares and propagating in the western hemisphere, cause strong geomagnetic storms. Michalek, G. 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. Gopalswamy [2009] have studied geoeffectiviness of halo and partial halo coronal mass ejections and concluded that the geoeffectiveness of partial halo CMEs is lower because they are of low speed and likely to make a glancing impact on earth rather than halo coronal mass ejections. Gonzalez, et al [2011] have presented a review on the interplanetary causes of intense geomagnetic storms ( Dst≤-100 nT), that occurred during solar cycle 23 (1997-2005). They have reported that the most common interplanetary structures leading to the development of intense storm were magnetic clouds, sheath fields, sheath fields followed by a magnetic cloud and corotating interaction regions at the leading fronts of high speed streams. However, the relative importance of each of those driving structures has been shown to vary with the solar cycle phase. They have also studied super intense geomagnetic storm (Dst≤-250 nT) in more detail for solar cycle 23, and found that these storms are associated with magnetic clouds and sheath fields following interplanetary shocks. Eun-Young et al [2010] have investigated the interplanetary conditions of 82 intense geomagnetic storms from 1998 to 2006, and compared many different criteria of interplanetary conditions for the occurrence of the intense geomagnetic storms (Dst ≤ −100 nT). 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) pointed 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, CMEs and II type radio bursts related intense Geomagnetic storms observed during the period of 1997 to 2008 have been studied with solar wind disturbances to know the physical process responsible for geomagnetic storms.

**2- EXPERIMENTAL DATA**

In this investigation hourly Dst indices of geomagnetic field have been used over the period 1997 to 2008 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. 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 solar STP data (http://www.ngdc.noaa.gov/stp/solar/solardataser vices.html.) have been used. Data is shown below table no.1.

**Table-1 Association of radio bursts Associated Geomagnetic Storms≤-90 nT with Solar Wind Disturbances for the period of 1997-2008.**

| Geomagnetic Storms Dst≤-90nT | | | | | | Radio Bursts | | Solar wind Pressure | | | Solar wind Density | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S. No. | Date | Year | Day | Hour | Magnitude of GMS | Date | Type | Day | Hour | Magnitude of jump | Day | Hour | Magnitude of jump |
| 1 | 10.04.1997 | 1997 | 100 | 19 | -102 | 07.04.97 | II, IV | 99 | 19 | 8.47 | 101 | 11 | 15.3 |
| 2 | 15.05.1997 | 1997 | 135 | 5 | -115 | 12.05.97 | II,IV | 134 | 7 | 8.85 | 134 | 12 | 8.6 |
| 3 | 02.05.1998 | 1998 | 122 | 9 | -203 | 29.04.98 | II,IV | 122 | 11 | 18.5 | 122 | 11 | 33.6 |
| 4 | 25.06.1998 | 1998 | 176 | 22 | -111 | 22.06.98 | II,IV | 176 | 2 | 7.71 | 176 | 2 | 17.6 |
| 5 | 19.10.1998 | 1998 | 292 | 2 | -111 | 18.10.98 | II | 291 | 18 | 19.53 | 292 | 5 | 20.4 |
| 6 | 07.11.1998 | 1998 | 311 | 11 | -139 | 05.11.98 | II,IV | 312 | 2 | 5.28 | 311 | 5 | 8.8 |
| 7 | 13.11.1998 | 1998 | 317 | 0 | -132 | 09.11.98 | II | 316 | 0 | 9.07 | 316 | 0 | 30.1 |
| 8 | 17.02.1999 | 1999 | 48 | 7 | -128 | 14.02.99 | II,IV | 47 | 12 | 4.55 | 47 | 10 | 8 |
| 9 | 28.02.1999 | 1999 | 59 | 17 | -94 | 24.02.99 | II | 59 | 2 | 14.33 | 58 | 22 | 51.4 |
| 10 | 12.09.1999 | 1999 | 255 | 7 | -103 | 08.09.99 | II,IV | 254 | 19 | 13.49 | 254 | 17 | 32.5 |
| 11 | 21.10.1999 | 1999 | 294 | 23 | -257 | 17.10.99 | II | 294 | 10 | 25.69 | 294 | 15 | 12 |
| 12 | 22.01.2000 | 2000 | 22 | 14 | -98 | 18.01.2000 | II,IV | 21 | 22 | 2.07 | 21 | 21 | 8.2 |
| 13 | 24.05.2000 | 2000 | 145 | 1 | -164 | 22.05.00 | IV | 144 | 9 | 26.61 | 144 | 16 | 13.3 |
| 14 | 15.07.2000 | 2000 | 197 | 15 | -308 | 12.07.00 | II,IV | 196 | 15 | 28.13 | 196 | 15 | 21.7 |
| 15 | 15.09.2000 | 2000 | 259 | 19 | -221 | 12.09.00 | II | 259 | 0 | 4.54 | 258 | 20 | 17.7 |
| 16 | 24.09.2000 | 2000 | 268 | 17 | -191 | 22.09.00 | IV | 269 | 3 | 2.72 | 269 | 3 | 7 |
| 17 | 13.10.2000 | 2000 | 287 | 14 | -100 | 09.10.00 | II,IV | 286 | 16 | 10.27 | 288 | 0 | 6.5 |
| 18 | 10.11.2000 | 2000 | 315 | 7 | -102 | 08.11.00 | IV | 314 | 9 | 5.48 | 314 | 9 | 11.6 |
| 19 | 23.03.2002 | 2002 | 82 | 14 | -107 | 20.03.02 | II | 82 | 4 | 4.58 | 82 | 4 | 12.9 |
| 20 | 17.04.2002 | 2002 | 107 | 11 | -149 | 15.04.02 | II,IV | 107 | 1 | 1.23 | 107 | 1 | 3.8 |
| 21 | 11.05.2002 | 2002 | 131 | 13 | -103 | 07.05.02 | IV | 131 | 18 | 2.85 | 131 | 7 | 48.2 |
| 22 | 23.05.2002 | 2002 | 143 | 11 | -172 | 21.05.02 | II | 142 | 15 | 1.97 | 143 | 22 | 0 |
| 23 | 01.08.2002 | 2002 | 213 | 10 | -98 | 29.07.02 | II,IV | 212 | 23 | 7.05 | 213 | 2 | 12.4 |
| 24 | 04.09.2002 | 2002 | 247 | 1 | -179 | 02.09.02 | II | 246 | 1 | 2.5 | 246 | 3 | 6.6 |
| 25 | 30.09.2002 | 2002 | 273 | 1 | -179 | 27.09.02 | II | 272 | 11 | 1.91 | 272 | 10 | 18.3 |
| 26 | 16.06.2003 | 2003 | 167 | 5 | -152 | 15.06.03 | II,IV | 167 | 19 | 3.35 | 167 | 19 | 5.9 |
| 27 | 10.07.2003 | 2003 | 191 | 17 | -128 | 09.07.03 | II | 190 | 18 | 6.06 | 190 | 17 | 20.1 |
| 28 | 28.10.2003 | 2003 | 301 | 5 | -382 | 26.10.03 | II,IV | 300 | 21 | 6 | 300 | 21 | 6.7 |
| 29 | 20.11.2003 | 2003 | 324 | 2 | -417 | 18.11.03 | II,IV | 323 | 20 | 15.68 | 323 | 2 | 19.3 |
| 30 | 22.07.2004 | 2004 | 204 | 18 | -115 | 20.07.04 | II,IV | 204 | 7 | 5.56 | 204 | 5 | 11.9 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 24.07.2004 | 2004 | 206 | 10 | -201 | 21.07.04 | IV | 205 | 14 | 12.69 | 205 | 14 | 16.9 |
| 32 | 07.11.2004 | 2004 | 312 | 19 | -415 | 04.11.04 | II,IV | 312 | 1 | 33.19 | 313 | 11 | 0.8 |
| 33 | 07.01.2005 | 2005 | 7 | 12 | -94 | 04.01.05 | II,IV | 7 | 3 | 24.57 | 7 | 6 | 28.4 |
| 34 | 16.01.2005 | 2005 | 16 | 20 | -117 | 15.01.05 | II,IV | 15 | 20 | 51.9 | 15 | 20 | 52.5 |
| 35 | 07.05.2005 | 2005 | 127 | 19 | -275 | 05.05.05 | II | 128 | 5 | 13.21 | 127 | 16 | 34.6 |
| 36 | 28.05.2005 | 2005 | 148 | 11 | -155 | 26.05.05 | IV | 147 | 11 | 10.28 | 147 | 11 | 3.7 |
| 37 | 10.07.2005 | 2005 | 191 | 11 | -100 | 07.07.05 | IV | 192 | 6 | 5.95 | 192 | 6 | 12.3 |
| 38 | 24.08.2005 | 2005 | 236 | 6 | -248 | 22.08.05 | II,IV | 235 | 15 | 30.14 | 235 | 22 | 23.5 |
| 39 | 14.12.2006 | 2006 | 348 | 14 | -155 | 13.12.06 | IV | 347 | 16 | 12.81 | 348 | 10 | 7.3 |

## 3- DATA ANALYSIS AND RESULTS

In this study we have observed 42geomagnetic storms (Dst≤-90nT) associated with halo coronal mass ejections (CMEs), solar radio bursts, occurred during the period 1997 to 2008. From the data analysis of CMEs and radio bursts related geomagnetic and interplanetary parameters, we have found that CMEs and radio bursts related geomagnetic storms are closely related to disturbances in solar wind plasma parameters. Further to see how the magnitudes of geomagnetic storms are correlated with the magnitude of change in solar wind plasma density and pressure, we have plotted scatter plot between magnitude of geomagnetic storms and magnitude of change in solar wind plasma parameters (density and pressure). The resulting scatter plots are shown in figure 1 and 2. From the fig it is clear that maximum geomagnetic storms which have large magnitude are associated with such change in solar wind plasma density and pressure which have relatively large magnitudes values. We have also calculated correlation coefficient statistically and found positive correlation between magnitude of geomagnetic storms and magnitude of change in solar wind plasma parameters (density and pressure) with correlation coefficient 0.26 between magnitude of geomagnetic storms and magnitude of change in solar wind plasma density and 0.41 between magnitude of geomagnetic storms and magnitude of change in solar wind plasma pressure.

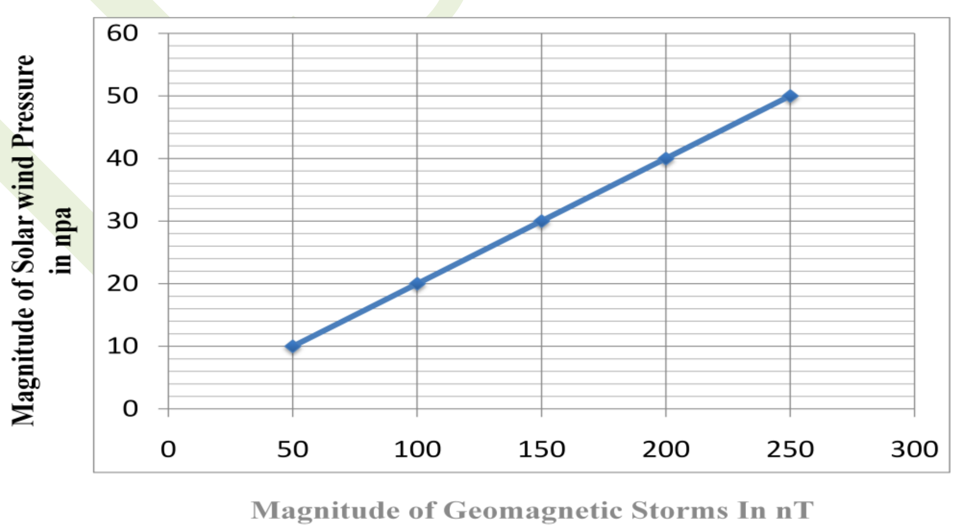


**Figure-1 Shows scatter plot between magnitude of geomagnetic storms and magnitude of change in solar wind plasma pressure showing positive correlation with correlation coefficient 0.41.**

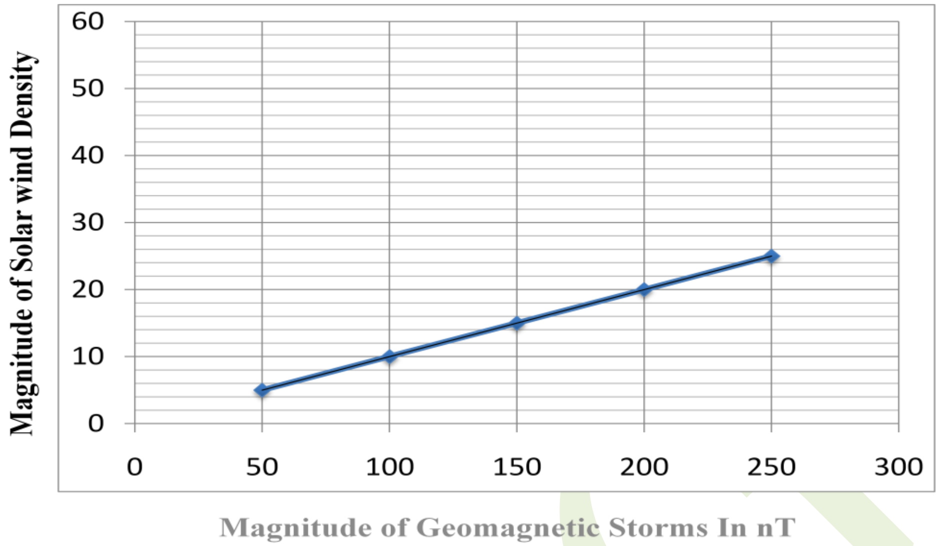


**Figure-2 Shows scatter plot between magnitude of geomagnetic storms and magnitude of change in solar wind plasma density showing positive correlation with correlation coefficient 0.26.**

## 4- CONCLUSION

From our study, all the CMEs and radio bursts related 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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