ISSN: 2455-1848
International Journal of Innovative Research & Growth
A Peer Reviewed & Referred International Journal
Volume-8 Issue-1 November-2018
Impact Factor-3.0
www.ijirg.com, editor@ijirg.com

Theoretical Study Of Geomagnetic Storms With CMEs And Solar Flares

[1]Preetam Singh Gour, [2]Shiva Soni
[1,2]Jaipur National University, Jaipur, Rajasthan, India
Email: - singhpreetamsingh@gmail.com, shivasoni21@gmail.com

Abstract
In this article we have taken the data of coronal mass ejections (CMEs), solar flares and geomagnetic storms (GMS) for the period 2000-2010. For this time duration we have found 31 geomagnetic storms events, out of which 29 (93.54%) geomagnetic storms are associated with CMEs. Out of 29 geomagnetic storms 20 (68.96%) are associated with halo CMES and 9 (31.03%) are associated with partial halo CMEs. Again we observe that all the geomagnetic storms are associated with solar flares of different categories but most of the geomagnetic storms (64.51%) are related to M class X-ray solar flares. We have found the positive weak correlation between magnitude of geomagnetic storms and coronal mass ejections with correlation coefficient 0.13 between these two events.
Keywords: - *Coronal mass ejections, Geomagnetic storms, Solar flares.*

1- INTRODUCTION

Solar energetic particle (SEP) events are observed by spacecraft in the heliosphere in association with solar transient eruptive events, such as flares and coronal mass ejections (CMEs) (Agueda et al., 2014). The magnetic field of the sun is the main driver of its flaring activity. Solar flares are the manifestation of an energy release process. During solar flares, magnetic energy of 10^{28}–10^{34} ergs is released in the solar chromosphere and corona over a few minutes, by means of magnetic reconnection processes. It is clear that an understanding of the role of the magnetic reconnection process in solar flares is crucial, but also complex and difficult to understand mainly due to the complex magnetic environment associated with this process (Aanstasiadis, 2002).

From the occurrence of a coronal mass ejection (CME) on the Sun until even after its passage over a spacecraft, energetic particle observations in the interplanetary medium help us to discern the development and structure of CMEs both close to the Sun and in the interplanetary (IP) medium. Solar energetic particles (SEPs) originate in at least two different ways both of which are likely related to CMEs (Cane et al., 2010). CME ejected from the sun is one of the main solar phenomena. The Earth-directed CMEs are very important, since they can produce geomagnetic storms. Usually these CMEs are seen as Halo CMEs (Howard et al., 1982). The relation between CMEs and the other phenomena has been examined by many researches (e.g., Munro et al., 1979 and Kahler, 1992).

2- SOURCES OF DATA

Data has been taken from the NSSDC omni web data system which has been created in late 1994 for enhanced access to the near earth solar wind, magnetic field and plasma data of omni data set. 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 are taken from STP solar data (http://www.ngdc.noaa.gov/stp/solar/solardataservices.html). Data has given in table-1

Table- 1 Data of Geomagnetic Storms, Solar Flares and Coronal Mass Ejections

Geomagnetic Storms Dst≤-90Nt						Solar flare			Coronal Mass Ejections			
S.No.	Date	Year	Day	Hour	Magnitude of GMS	Date	Time	Type	Date	Time	Type	Speed of CMEs in Km/S
1	22.01.2000	2000	22	14	-98	18.01.2000	1707	M	18.01.2000	17:54:05	Halo	739
2	24.05.2000	2000	145	1	-164	21.05.2000	1019	C	22.05.2000	1:50:05	Halo	649
3	15.07.2000	2000	197	15	-308	14.07.2000	1003	X	14.07.2000	10:54:07	Halo	1674
4	15.09.2000	2000	259	19	-221	12.09.2000	1131	M	12.09.2000	17:30:05	Halo	1053
5	24.09.2000	2000	268	17	-191	21.09.2000	908	C	22.09.2000	10:50:05	Partial	378
6	13.10.2000	2000	287	14	-100	12.10.2000	2026	M	11.10.2000	6:50:05	Partial	799
7	10.11.2000	2000	315	7	-102	08.11.2000	2242	M	08.11.2000	4:50:23	Halo	474
8	23.03.2002	2002	82	14	-107	22.03.2002	1012	M	22.03.2002	11:06:05	Halo	1750
9	17.04.2002	2002	107	11	-149	14.04.2002	2334	M	15.04.2002	3:50:05	Halo	720
10	11.05.2002	2002	131	13	-103	09.05.2002	647	B	08.05.2002	13:50:05	Halo	614
11	23.05.2002	2002	143	11	-172	20.05.2002	1521	X	21.05.2002	21:50:05	Partial	853
12	01.08.2002	2002	213	10	-98	29.07.2002	229	M	29.07.2002	23:30:05	Partial	360
13	04.09.2002	2002	247	1	-179	01.09.2002	930	C	Na	na	Na	na
14	30.09.2002	2002	273	1	-179	27.09.2002	1259	M	26.09.2002	1:31:44	Partial	178
15	16.06.2003	2003	167	5	-152	15.06.2003	2325	X	14.06.2003	1:54:05	Partial	875
16	10.07.2003	2003	191	17	-128	09.07.2003	2159	M	Na	na	Na	Na
17	28.10.2003	2003	301	5	-382	26.10.2003	557	X	27.10.2003	8:30:05	Partial	1322
18	20.11.2003	2003	324	2	-417	17.11.2003	855	M	18.11.2003	8:50:05	Halo	1660
19	22.07.2004	2004	204	18	-115	20.07.2004	1222	M	20.07.2004	13:31:52	Halo	710
20	24.07.2004	2004	206	10	-201	22.07.2004	14	M	22.07.2004	8:30:05	Partial	899
21	07.11.2004	2004	312	19	-415	04.11.2004	2253	M	04.11.2004	9:54:05	Halo	653
22	07.01.2005	2005	7	12	-94	04.01.2005	38	B	05.01.2005	15:30:06	Halo	735
23	16.01.2005	2005	16	20	-117	14.01.2005	1353	M	15.01.2005	6:30:05	Halo	2049
24	07.05.2005	2005	127	19	-275	06.05.2005	1111	M	05.05.2005	20:30:05	Halo	1180
25	28.05.2005	2005	148	11	-155	27.05.2005	1153	M	26.05.2005	15:06:05	Halo	586
26	10.07.2005	2005	191	11	-100	07.07.2005	1607	M	09.07.2005	22:30:05	Halo	1540
27	24.08.2005	2005	236	6	-248	22.08.2005	1646	M	22.08.2005	17:30:05	Halo	2378
28	14.12.2006	2006	348	14	-155	13.12.2006	214	X	13.12.2006	2:54:04	Halo	1774
29	07.03.2010	2010	67	0	-140	04.03.2010	1029	M	05.03.2010	4:00:05	Halo	1531
30	4/23/2010	2010	114	15	-119	20.04.2010	1646	C	19.04.2010	15:12:09	Partial	540
31	17.06.2010	2010	169	0	-151	14.06.2010	1252	M	14.06.2010	14:12:07	Halo	987

3- RESULT AND DISCUSSION

In this article we have taken the average value of magnitude of geomagnetic storms and respective coronal mass ejections for the period 2000-2010. We observe that the total geomagnetic storms are 31 for this period, out of these 29 are related to coronal mass ejections. Further we observe that out of 29, 20 are related to halo coronal mass ejection and 9 related to partial halo coronal mass ejection. The association rates are 68.96% and 31.03% respectively. We have found the positive weak correlation between magnitude of geomagnetic storms and coronal mass ejections. Positive correlation with correlation coefficient 0.13 has been found between these two events.

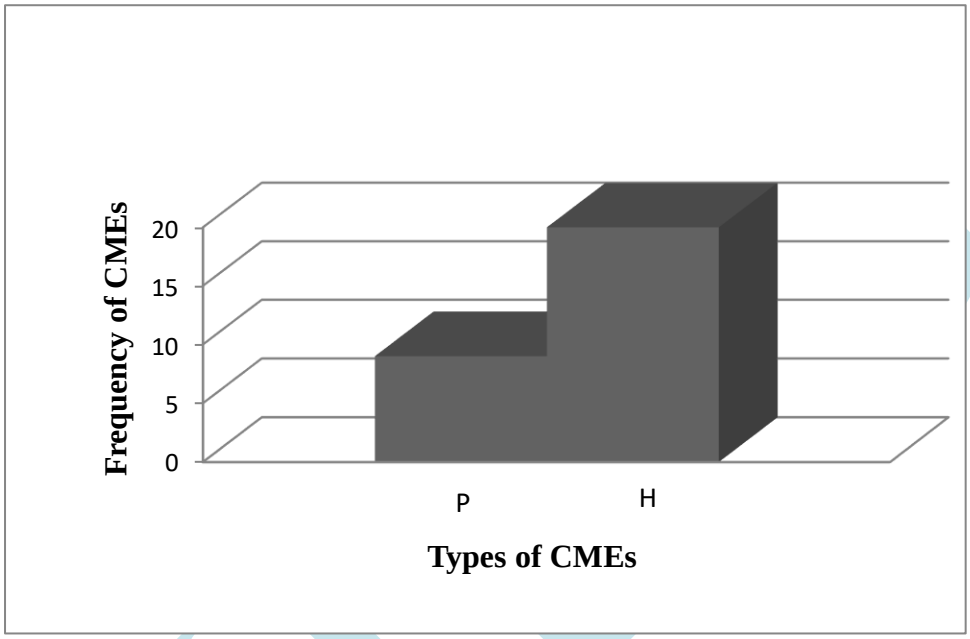

Figure-1: Types of associated CMEs.

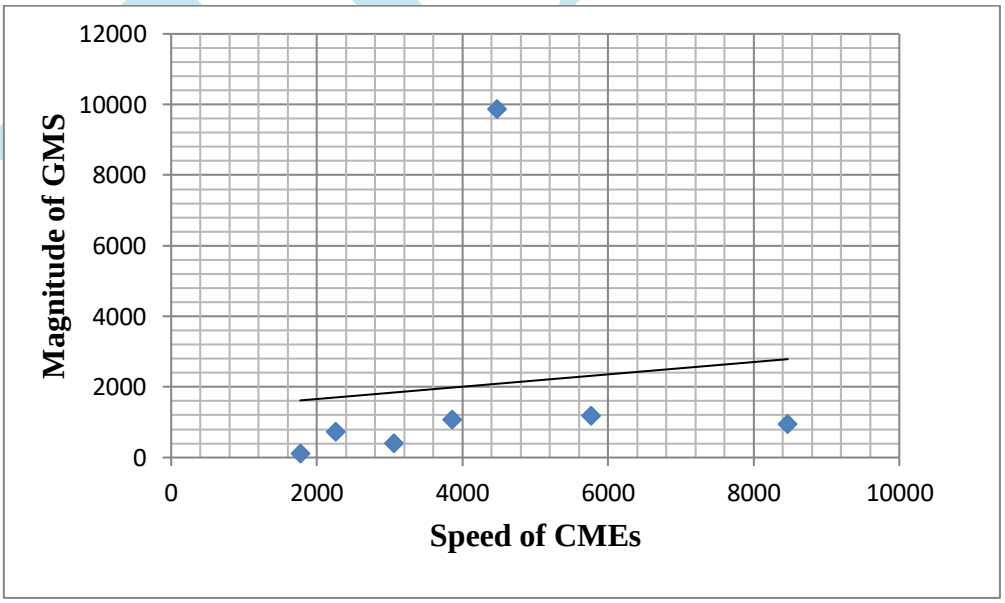

Figure-2: Scatter plot between magnitude of GMS and Associated CMEs.

Furthermore we have found that all of the geomagnetic storms related to solar flares of different categories, we have observed that 20 geomagnetic storms related to M class solar flares, 5 geomagnetic storms related to X class solar flares, 4 are related to C class solar flares and 2 are related to B class solar flares. The association rates of M-class, C-class, X-class and B-class solar flares are 64.51%, 16.12%, 12.90% and 6.45% respectively. We observed that most of the geomagnetic storms are related to M class X-ray solar flares.

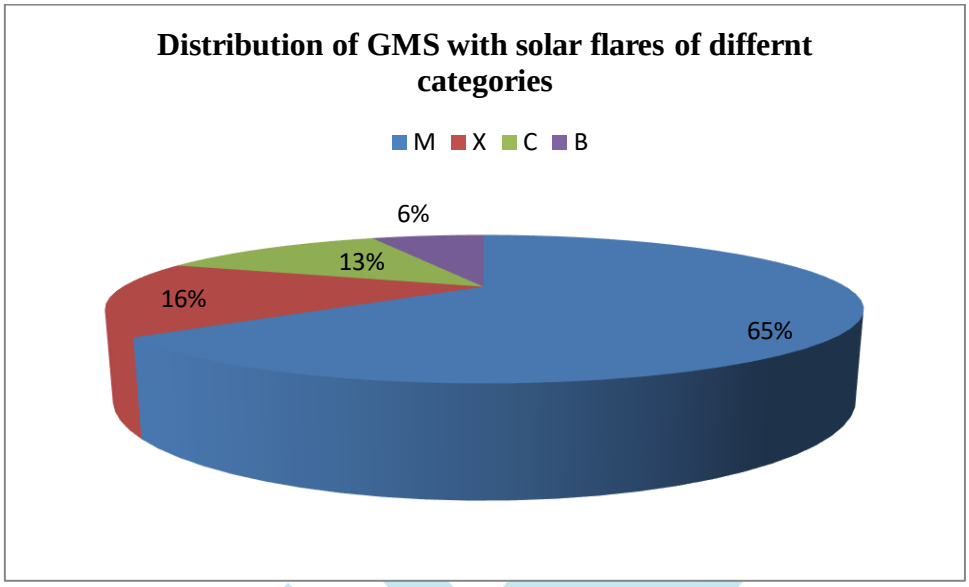

Figure-3: Distribution of GMS with different categories of X-ray solar flares.

4- CONCLUSION

In this study we have studied geomagnetic storms (GMS) with coronal mass ejections (CMEs) and solar flares during 2000 to 2010. For this duration we observe 31 geomagnetic storms and most of them are associated with CMEs that is every CMEs event will occur geomagnetic storms. Further we observe that all the GMS are associated with solar flares of different categories with association rates 64.51%, 16.12%, 12.90% and 6.45% for M class, X class, C class and B class respectively. We conclude that most of the GMS are related to CMEs as well as solar flares.

5- ACKNOWLEDGEMENT

Authors are very thankful to all database providers and also thanks to Dr. P. L. Verma to provide guidance for this study.

6- REFERENCES

i. Agueda, N., K.-L. Klein, N. Vilmer, R. Rodríguez-Gasén, O. Malandraki, et al. (2014), Release timescales of solar energetic particles in the low corona. A&A, 570, A5.

ii. Aanstasiadis, A. (2002), Acceleration of solar energetic particles: the case of solar flares. J. Atmos. Sol. Terr. Phys., 64(5), 481–488.

iii. Aschwanden, M.J. (2002), Particle acceleration and kinematics in solar flares – a synthesis of recent observations and theoretical concepts (Invited Review). Space Sci. Rev., 101(1–2), 1–227.

iv. Balach C.C. (1999), SEC proton prediction model: verification and analysis. Radiat. Meas., 30(3), 231–250.

v. Balch, C.C. (2008), Updated verification of the Space Weather Prediction Center's solar energetic particle prediction model. Space Weather, 6, S01001, 1–13.

vi. Belov, A., H. Garcia, V. Kurt, H. Mavromichalaki, and M. Gerontidou (2005), Proton enhancements and their relation to the X-ray flares during the three last solar cycles. Sol. Phys., 229 (1), 135–159.

vii. Benz, A.O. (2008), Flare observations,

Living Rev. Sol. Phys., 5 (1), 1–64.
viii. Bougeret, J.-L., M. Kaiser, P. Kellogg, R. Manning, K. Goetz, et al. (1995), Waves: The radio and plasma wave investigation on the Wind spacecraft. Space Sci. Rev., 71 (1–4), 231–263.
ix. Bougeret, J.-L., K. Goetz, M. Kaiser, S. Bale, P. Kellogg, et al. (2008), S/ WAVES: The radio and plasma wave investigation on the STEREO mission. Space Sci. Rev., 136 (1–4), 487–528.
x. Brueckner, G., R. Howard, M. Koomen, C. Korendyke, D. Michels, et al. (1995), The large angle spectroscopic coronagraph (LASCO). Sol. Phys., 162 (1–2), 357–402.
xi. Cane, H., and D. Lario (2006), An introduction to CMEs and energetic particles. Space Sci. Rev., 123 (1–3), 45–56.
xii. Cane, H.V., W. Erickson, and N. Prestage (2002), Solar flares, type III radio bursts, coronal mass ejections, and energetic particles. J. Geophys. Res. [Space Phys.], 107 (A10), SSH–14.
Xiii. Cane, H. V., I. G. Richardson, and T. T. von Rosenvinge (2010), A study of solar energetic particle events of 1997–2006: Their composition and associations, J. Geophys. Res.,115, A08101, 1–18.
xiv. Cliver, E. (1996), Solar flare gamma-ray emission and energetic particles in space. In: High energy solar physics, AIP Publishing, Melville, New York, vol. 374, pp. 45–60.
xv. Colaninno, R.C., and A. Vourlidas (2009), First determination of the true mass of coronal mass ejections: a novel approach to using the two STEREO viewpoints. Astrophys. J., 698 (1), 852.
xvi. Crosby, N., D. Heynderickx, P. Jiggens, A. Aran, and B. Sanahuja (2015), SEPEM: a tool for statistical modelling the solar energetic particle environment. Space Weather, 13, 406–426.
xvii. Dennis, B.R., and D.M. Zarro (1993), The Neupert effect: what can it tell us about the impulsive and gradual phases of solar flares? Sol. Phys., 146 (1), 177–190.
xviii. Dierckxsens, M., K. Tziotziou, S. Dalla, I. Patsou, M. Marsh, N. Crosby, O. Malandraki, and G. Tsiropoula (2015), Relationship between solar energetic particles and properties of flares and CMEs: statistical analysis of solar cycle 23 events. Sol. Phys., 290 (3), 841–874.
xix. Dougherty, B.L., H. Zirin, and K. Hsu (2002), Statistical correlations between solar microwave bursts and coronal mass ejections. Astrophys. J., 577 (1), 457.
xx. Dresing, N., R. Gómez-Herrero, A. Klassen, B. Heber, Y. Kartavykh, and W. Dröge (2012), the large longitudinal spread of solar energetic particles during the 17 January 2010 solar event. Sol. Phys., 281 (1), 281–300.
xxi. Dröge, W., Y. Kartavykh, N. Dresing, B. Heber, and A. Klassen (2014), Wide longitudinal distribution of interplanetary electrons following the 7 Februay 2010 solar events: observations and transport modeling. J. Geophys. Res. [Space Phys.], 119 (8), 6074–6094.
xxii. Cane H.V.I.G. Richardson, and G.wibberenze (1997), J. Geophys.Res. 102(A4) 7086.
xxiii. Cane, H. V. (2000), Space Sci. Rev., Vol. 93, pp. 55-77.
xxiv. Cliver, E. W., Ling, A. G., & Richardson, I. G. (2003), ApJ, 592, 574.
xxv. Chuchkov E. A. Tulupov V. I. . Okhlopkovand V. P Lyubimov G. P. (2009), Moscow University Physics Bulletin Volume 64, Number 3 / June, 2009.
xxvi. Howard, R.A., Michels, D.J., Sheeley Jr., N.R., Koomen, M.J., (1982), The Astrophysical Journal 263, L101.
xxvii. Munro, R.H., Gosling, J.T., Hildner, E., MacQueen, R.M., Poland, A.I., Ross, C.L., (1979), the association of coronal mass ejection transients with other forms of solar activity. Solar Physics 61, 201.