Acta Astronautica 121 (2016) 179–199

Contents lists available at ScienceDirect

Acta Astronautica

journal homepage: www.elsevier.com/locate/actaastro

On geomagnetic storms and associated solar activity phenomena observed during 1996–2009

Nishant Mittal [a,*], V.K. Verma [b]

[a] Dept. of Physics, H. R. Institute of Technology, Ghaziabad 201003, India
[b] Uttrakhand Space Application Centre, Dehradun 248006, India

ARTICLE INFO

Article history:
Received 12 August 2015
Received in revised form
19 December 2015
Accepted 25 December 2015
Available online 11 January 2016

Keywords:
Sun
Solar flares
Coronal mass ejections
ICMEs
Arrival time
GMS

ABSTRACT

Here we present study of Geomagnetic storms (GMS) and its relation with solar flares, coronal mass ejections (CMEs) and coronal holes (CHs). The arrival of CMEs in the vicinity of the Earth plays an important role and affects solar terrestrial environment. The space weather prediction about GMS can be only possible if we know the CMEs arrival time at 1 AU. In the present study we have investigated 153 CMEs observed during the time period of 1996–2009 to know the arrival times of CMEs associated with the GMS. In study we found that the strength of GMS didn't depend on the speed and accelerations of CMEs but strength of GMS depend on the importance of solar flares. We also found that the strength of GMS are excellently correlated with southward magnetic field near Earth at 1 AU and support earlier result of investigators. The arrival time of CMEs near Earth at 1 AU, can be calculated using equations for linear and initial speed of CMEs with error ± 5 h. We have also discussed the various results obtained in present investigation in view recent scenario of solar helio-physics.

1. Introduction

It is now well-known that space weather is significantly controlled by coronal mass ejections (CMEs) which can affect our Earth environment in many ways [1–4]. There are several important studies illustrating the importance of CMEs/ICMEs in controlling space weather, in particular geomagnetic storms [5–11]. With the biasing of source region to the western hemisphere, CMEs originating close to the central meridian of the Sun directed towards the earth are the most geoeffective. It is very important to know when a solar disturbance would reach the Earth [12–14] because the space weather is affected by geomagnetic storm (GMS) and precautions can be taken for prevent of hazards to humans in space, effects on satellites, radio communication, GPS satellite errors, geomagnetic induced current, aurora. CMEs are dynamically expelled and driven by the coronal magnetic fields which decrease during their passage through the interplanetary space where some other processes (like magnetic flux; current sheath, shocks etc) may accelerate them. These CMEs interaction with the ambient solar wind may provide the necessary drag for acceleration or de-acceleration of CMEs depending on their speeds [15,16]. Earlier, Verma and Pande [17] and Verma [18–20] suggested that the CME events are perhaps have been produced by some mechanism, in which the mass ejected by some solar flares, gets connected with the open magnetic lines of CHs (coronal holes: source of high speed solar winds) and moves along them to appear as CMEs. The papers of Liu et al. [21a], Liu [21b], Jiang et al. [22] and Asai et al. [23,24] carried out studied about CMEs and found that CHs close to the active region involved in the coronal mass ejections.

The arrival times of CMEs at 1 AU is studied by Gopalswamy et al. [25,26] within error of 10.7 h. Michalek et al. [16] used the space speed (the speed with which the

* Corresponding author. Mobile: +91 9456662599.
E-mail address: nishantphysics@gmail.com (N. Mittal).

http://dx.doi.org/10.1016/j.actaastro.2015.12.038
0094-5765/

Table 1
Table 1 show various parameter of Geomagnetic Storms associated CMEs, solar flares and CHs data set used in this study.

CME onset	ICME	D_{ST}	ICME speed (km/s)	CMEs linear speed (km/s)	CMEs initial speed (km/s)	Obs. TT (hrs)	Calculated travel time (hrs) for CMEs speeds		Acc.	Location	CH distance	Flare class	Total mag. field (B)	Southward magnetic field (B_Z)
							Linear	Initial						
12/19/96 16:30	12/23/96 17:00	−18	360	469	xxxx	96.500	100.25			S14W09	10	C	10	−4.1
1/6/97 15:11	1/10/97 4:00	−78	450	136	51	84.817	141.83	165.89	4.1	S18E06	90	A1.1	14	−15.3
2/7/97 0:30	2/10/97 2:00	−68	450	490	270	73.500	88.41	115.43	14.3	S38W31	20	—	8	−7.7
4/7/97 14:28	4/11/97 6:00	−82	460	878	850	87.533	62.12	63.44	3.3	S28E19	10	C6.8	20	−7.6
5/12/97 5:30	5/15/97 9:00	−115	450	464	580	75.500	90.93	80.69	−15	N21W08	60	C1.3	21	−24.6
5/21/97 21:00	5/26/97 16:00	−74	340	296	271	115.000	130.68	136.02	1.4	N05W12	60	M1.3	10	−7.5
7/30/97 4:46	8/3/97 13:00	−49	400	104	90	104.233	164.90	169.61	0.8	N42W10	10	—	16	−10.9
8/30/97 1:30	9/3/97 13:00	−98	410	371	291	107.500	106.41	118.56	9.3	N30E17	10	M1.4	14	−14
9/17/97 20:29	9/21/97 21:00	−38	440	377	377	96.517	101.73	101.73	0	N45W16	20	—	16	−3.35
9/28/97 1:08	10/1/97 16:00	−98	450	359	317	86.867	102.73	108.36	2.8	N35E10	10	—	10	−6.98
10/6/97 15:28	10/10/97 22:00	−130	400	293	74	102.533	119.93	175.34	15.9	N25E12	10		12	−10.3
10/21/97 18:04	10/25/97 2:00	−64		523	552	79.933			−2.9	N16E07	50	C3.3		−9.4
10/23/97 11:26	10/27/97 0:00	−60	500	503	443	84.567	82.86	88.13	3.7				7	−6.35
11/4/97 6:10	11/7/97 4:00	−110	400	785	1009	69.833	70.13	58.99	−22.1	S14W33	10	X2.1	11	−12.5
11/19/97 17:00	11/22/97 19:00	−108	510	150	166	74.000	125.92	122.94	−5.1	N24E05	50	C1.6	17	−13.3
12/6/97 10:27	12/10/97 18:00	−60	350	397	243	103.550	111.26	140.15	9	N18W44	10	C1.2	12	−10.3
12/26/97 2:31	12/30/97 10:00	−77	370	197	124	103.483	146.58	168.24	5.5	S24E14	10		12	−10.55
1/2/98 23:28	1/7/98 1:00	−77	400	438	337	97.533	99.18	112.77	6.5	N24W42	40	B6.4	16	−12.3
1/17/98 4:09	1/21/98 6:00	−11	380	350	242	97.850	113.85	133.62	5.6	S41E17	30	–	13	−4.2
1/25/98 15:27	1/29/98 20:00	−55	380	693	773	100.550	77.46	72.08	−7.4	N21E25	10	C1.1	7	−7.3
2/14/98 6:55	2/17/98 10:00	−100	400	123	111	75.083	158.91	162.64	0.7				12	−8.6
2/28/98 12:48	3/4/98 13:00	−36	350	176	127	96.200	158.00	174.23	2.9	S24W01	40		12	−7.25
4/29/98 16:59	5/2/98 5:00	−85	520	1374	1602	60.017	43.88	39.17	−44.8	S18E20	10	M6.8	11	−8.3