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“Study of Different Type Intense Geomagnetic Storms”

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ABSTRACT

The solar wind originating from the Sun hit the Earth by hot magnetized supersonic collisionless plasma carrying a large amount of kinetic and electrical energy. Some of this energy finds its way into our magnetosphere creating geomagnetic storms, substorms and aurora.The storms are most directly related to specific solar wind events, while the substorm activity is more complicated because of the temporal storing of energy in the magnetotail and the auroral oval. Various types of geomagnetic disturbances and their possible solar and interplanetary causes are explained in this work that provides a better aspect to understand the solar-terrestrial relationship.

I. INTRODUCTION

Geomagnetic storms are large disturbances in the earth’s magnetosphere, often persisting for several days are more.During geomagnetic storms strong electric currents flowing within the geomagnetosphere and ionosphere.These currents perturb the magnetic field measured at the earth’s surface, the aurora brightens and extended to low magnetic latitudes, and intense fluxes of energetic charge particles are generated within the magnetosphere. Solar output in term of solar plasma and magnetic field ejected out into interplanetary medium consequently create the perturbation in the geomagnetic field. The another geomagnetic index, auroral electrojet magnetic intensity index A_E which has been introduced by (Bargatze, L. F., Baker, D. N.1985)[1].Is measured auroral electrojet intensity of the energy dissipated in the ionosphere and energy of precipitating electrons on the auroral and polar regions.

Intense Geomagnetic Storms

Some of this energy finds its way into our magnetosphere creating geomagnetic storms, substorms and aurora. The storms are most directly related to specific solar wind events, while the substorm activity is more complicated because of the temporal storing of energy in the magnetotail and the auroral oval. The major geomagnetic storms are very harmful to us and affect space weather on large scale. Many scientific systems are affected during geomagnetic disturbances. (Gosling,J.T.Bame,S.J.1993)[2].Was the first person to make systematic observations of the "Spontaneous electrical currents observed in the wires of the electric telegraph".After that various researchers measure many large geomagnetic storms and their adverse effects. On the evening of the 19th March 1847, a brilliant aurora was seen, and during the whole time it remained visible. During 27th October 1848 a heavy disturbances was measured on the telegraph. On 19th February 1852 a brilliant auroral display was observed. A magnetic storm from 28th August to 2nd September 1858 produced widespread effects on the telegraph system in Europe and North America. During 30th May 1869 the aurora borealis, which was visible in Switzerland from 7 to 9 p.m., of the sixteen lines terminated in the telegraphic office. The telluric currents attained an extraordinary development during the aurora of 4th February 1872, which we have mentioned as one of the most extensive known; it was seen in the whole of the West of Asia, in the North of Africa, throughout Europe, and on the Atlantic as far as Florida and Greenland; at the same time an aurora was observed in part of the southern hemisphere. The disturbances in telegraphic communication were not less extensive, and were observed with great care, in great part of Europe. Telluric currents observed in England on 17th November 1882 and communication was interrupted as long as the disturbance lasted.During 31st October 1903 practically the world's whole telegraph system was upset. On 25th September 1909, telegraph disturbances occurred in many parts of the world and were accompanied by auroral displays down to magnetic latitudes of 30º. (Berchem.J.1982)[3]. Show that a great magnetic storm occurred on 13-15th May 1921. On 22nd September 1946 a maximum current of 93 amps was measured in a transformer neutral at Port Arthur. On 22nd September 1968 a power system 230kV tripped due to saturation of transformer cores and excessive 3rd harmonic currents in ground relays. On 10th February 1958 a magnetic storm caused disruption of service on the TAT-1 transatlantic cable. Abnormal power flows occurred in the power system in Minnesota. On 13th November 1960 disturbances occurred on power feeding circuits on transatlantic cables. The power system in Sweden experienced tripping of 30 line circuit breakers. A major magnetic storm occurred on 4th August 1972 and caused an outage of the L4 cable system in the continental US and problems on power systems. During 13th July 1982, four transformers and 15 lines tripped in Sweden. A great magnetic storm occurred on 13th March 1989, that caused a nine-hour blackout of the 21,000 MV Hydro Québec, electric power system. Telluric currents induced by the storm created harmonic voltages and currents of considerable intensity on the La Grande network.Protective relay operations occurred on power systems in North America during geomagnetic disturbances on 22-24th March, 28th April, 16th May, 4-5th June, 10th June and 28-29th October 1991.

Studies of major storms

Due to these effects, studies of major storms are widely applicable for space weather and various power/communication utilities. According to many recent concepts two types of coronal transients termed as coronal mass ejections and coronal holes are mostly responsible for large geomagnetic storms. CMEs can be associated with three types of solar activities (i.e. solar flares, eruptive prominences and X-ray bursts). Several studies.(Cane, H. V.1985)[4].Show that the 60-80 % type-2 radio-bursts are associated with CMEs.Found that nearly half of all CMEs with V>400 km/sec were associated with type-4 radio-burst. These types of radio-bursts produce strong IP shocks that cause large geomagnetic storm.(Chen,J.1998)[5].Two types of solar wind streams (corotating flows and transient disturbances) and two types of interplanetary shocks (IP shocks and magnetic clouds) are also responsible for major ionospheric and geomagnetic disturbances.The various interplanetary parameters are also affecting the magnitude of large geomagnetic storms.The north-south component of interplanetary magnetic fields provides an opportunity to enter solar plasma and field within geomagnetospher.(Cane,H.V.Von Rosenvinge.T.T.1986)[6].So these solar and interplanetary transients have which types of role during a geomagnetic storm is the area of great interest. According to many recent studies intense geomagnetic storms can be classified on the basis of their magnitude, into three kinds termed as: large, major and severe geomagnetic storms. All these geomagnetic storms are harmful to us and affect on large scale, but severe geomagnetic storms are most dangerous. We have classified the selected 158 large geomagnetic storms on the intensity scale, which are noted in Table 1.

Types of storms	**D_{st} range (nT)**	**Number of observed geomagnetic Storms**
Large storms	**-150 to -100**	**103**
Major storms	**-250 to -151**	**40**
Severe storms	**< -250**	**15**

Table 1.: Classification of large geomagnetic storms

Many recent studies have shown that fast solar eruptions are mainly responsible for great geomagnetic storms. For better understanding of association of intense geomagnetic storms with different solar transients, we have discussed some of the intense geomagnetic storms and their associative solar causes that are occurred during our study period (1986-2002).

Severe geomagnetic storm

A severe geomagnetic storm was observed during 28th October 1991 having peak magnitude of –251 nT. This severe geomagnetic storm is a unique storm event which is associated with many solar activities.(Hewish,A.1988)[7].A list of occurring solar events 04 days before occurring of this events are summarised in Table 2.

S. No.	Dates	Time (UT)	Duration	Associated solar events
01	24/10/91	16:54	20 min.	Solar flare (Importance - 1B)
02	25/10/91	10:48	08 min.	Solar flare (Importance - 1B)
03	26/10/91	00:21	193 min.	CME (Type - 4 radio-burst)
04	27/10/91	05:39	237 min.	CME (Type - 4 radio-burst)
05	28/10/91	12:27	09 min.	Solar flare (Importance - 1B)
06	28/10/91	13:00	60 min.	Solar Proton Event (40 MeV)

Table 2.:List of various solar events observed during 24-28th October 1991.

The solar origin of this storm event is coronal holes. Equatorial and polar coronal holes are present in coordinates (32º, 20º, I) and (45º, 90º, I) respectively. Solar flare of importance 1B has been measured at 24th, 25th and 28th October 1991. CMEs associated this chapter radio-bursts are also observed during 26th and 27th October 1991. Solar proton events of energy 40 MeV was also observed during 28th October 1991. Thus overall cause of this geomagnetic storm can be taken as coronal mass ejection and coronal holes. (Berchem,J.and Russell,C. T.1982)[8].A large solar flare and solar proton event are also caused this storm.Due to these effects this storm having large magnitude –251 nT with many peaks.We have also observed a peculiar geomagnetic storm containing its magnitude -599 nT, and the largest storm event of the solar cycle 22. This storm is occurred on 14th March 1989. The total energy dissipated in the magnetosphere during the storm is 1.97×10^{25} ergs. Many solar activities will process before 3-4 days before to onset date of this storm. We have compiled a list of important CMEs events in Table3.Which are mostly responsible for this biggest geomagnetic storm event.

S.No.	Dates	Time (UT)	Duration	Associated solar events
01	10/03/89	19:18	121 min.	CME (Type - 4 radio-burst)
02	10/03/89	19:20	119 min.	CME (Type - 2 radio-burst)
03	12/03/89	07:27	268 min.	CMEs (Flare-spray)
04	13/03/89	08:28	57 min.	CMEs (Flare-spray)

Table 3. List of important CMEs events observed during 10-13th March 1989.

The solar origin of this geomagnetic storm event is CMEs (type-4) radio-burst swhich occurs during (19:18-21:19 UT) at 10th March 1989. After two minutes another CMEs (type-2) radio-burst takes place. (Burlaga,L.F.1995)[9]. The time durations for these radio-bursts are 121 and 119 minutes respectively. Many solar events occur during 10-13th March 1989. Equatorial and polar coronal holes are also present in coordinates (21°, 17°,E) and (36°, 81°, E). A large solar flare of importance 4B and Sudden disappearing filaments are also seen on solar disk at position (N30°, E18°) and (S01°, W12°) respectively. During this period, solar disk is more active for producing various solar activities.The time evolution of different solar activities of distinguished active NOAA/USAF region 5395, which appeared on solar disk through 6-19th March 1989 are remarkable. The region 5395 first appeared on solar disk on 6th March 1989 at the location 29° N, 85° E. This region stayed on the northern hemisphere,(Kahler,S.W.1992)[10].As a single biggest active region, during its passage from the east to the west limb of the Sun.At the latter stage of the appearance, the region 5395 extended in the east-west direction by about 30° in solar longitude. Moreover, it manifested the highest solar activity in the series of recurring regions and produced the largest number of flares among the entire active region visible on the solar disk.The total number of Hα flares, including sub-flares, produced by the region 5395 is 765. Solar proton events of energy 3500 MeV are also emitted during 8-13th March 1989. Due to these large scale coronal disturbances a huge amount of solar plasma and fields reaches on the earth's magnetosphere that causes this peculiar storm.

Large geomagnetic storm

A large geomagnetic storm observed during 25th April 1989. This storm is sudden commencement type having peak magnitude -132 nT. During the main phase of this storm solar wind speed and IMF magnitude peaking around 661 km/s and 22.5 nT respectively.(Crooker,N.U.1994)[11].The solar origin of this storm is CMEs type-2 radio-burst that occurred during (03:47-03:51 and 06:00-06:05 UT) at 22nd April 1989. A solar flare of importance 1B was also observed during 22nd April 1989. Many solar events occurring one after the other during 22-23rd April 1989, are listed in Table 4. So, this storm having long longevity and many small peaks. This storm is mainly caused by CMEs type-2 radio-bursts.

S. No.	Dates	Time (UT)	Duration	Associated solar events
01	22/4/89	03:47	04 min.	CME (Type-2 radio-burst)
02	22/4/89	06:00	05 min.	CME (Type-2 radio-burst)
03	22/4/89	06:55	18 min.	CME (Flare surge)
04	22/4/89	08:23	05 min.	Solar flare (Importance - 1B)
05	23/4/89	07:20	40 min.	CME (Flare surge)
06	23/4/89	08:35	105 min.	CME (Flare surge)
07	23/4/89	23:55	49 min.	Solar flare (Importance - 1B)
08	23/4/89	08:48	47 min.	CME (Flare surge)
09	23/4/89	07:18	17 min.	CME (Flare surge)

Table 4.:List of various solar events observed during 22-23rd April 1989.

At last we have described a major geomagnetic storm event observed during 8th July 1991, having peak magnitude -198 nT. During the main phase of this storm, solar wind velocity and IMF magnitude peaking around 747 km/s and 32.5 nT respectively. The solar origin of this storm is CMEs type-4 radio-bursts that occurred during (10:02-10:12 UT) at 5th July 1991 (Dubey,S.C.and Mishra A. P.1997)[12].Solar flares of importance 1B and 2B are also observed during this time. Solar proton events of energy 2300 MeV are also observed at 7th July 1991. The different solar activities that take place on solar surface during 5-6th July.1991,(Farrugia,C. J.1996)[13].Are listed in Table 5.This major geomagnetic storm event is mainly caused by CMEs associated with large solar flare and solar proton events.

S. No.	Dates	Time (UT)	Duration	Associated solar events
01	5/7/91	05:00	38 min.	Solar flare (Importance - 1B)
02	5/7/91	08:35	108 min.	Solar flare (Importance - 2B)
03	5/7/91	10:02	10 min.	CME (Type- 4 radio-burst)
04	6/7/91	08:36	204 min.	Solar flare (Importance - 1B)
05	6/7/91	17:37	37 min.	Solar flare (Importance - 2B)

Table 5. List of various solar events observed during 5-6th July 1991.

II. CONCLUSION

The major geomagnetic storms are very harmful to us and affect space weather on large scale.Many scientific systems are affected during geomagnetic disturbances(Farrugia,C.J.1997)[14].The seven La Grande network static var compensators on line tripped one after the other.Many other power utilities in North America experienced problems ranging from minor voltage fluctuations to tripping out of lines and capacitors.Thus overall cause of this geomagnetic storm can be taken as coronal mass ejection and coronal holes (Feynman.J.1994)[15].A large solar flare and solar proton event are also caused this storm. Due to these effects this storm having large magnitude –251 nT with many peaks,

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