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RESEARCH ARTICLE

STUDY OF GEOMAGNETIC STORM OBSERVED DURING MARCH 1989

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ABSTRACT

In this paper we have studied the cause of geomagnetic storm on 13-March, 1989 of solar cycle-22. We conjectured that the solar variability is basic cause of geomagnetic storm. For our study we have utilized daily value of solar parameter (sunspot number, solar proton flux, solar flare class, frequency occurrence of solar flare) as well as geomagnetic disturbance indices (Ap, Kp, Dst) and cosmic ray intensity data from ground based neutron monitor of Moscow having magnetic cut-off rigidity 2.42 GV, latitude 55.47N and longitude 37.32E. We observed that a severe geomagnetic storm struck earth on March 13, 1989 (Lermer, 1995; CBC. News, 2005). It occurred during active phase of solar cycle-22 and gave a result that it disrupts human atmosphere and their communication system.

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INTRODUCTION

A solar flare was first observed by Richard Christopher Carrington and Richard Hodgson in 1859. (Discription of singular appearance seen in the sun on sept 1, 1859) A solar flare is sudden flash of brightness observed near the sun surface. It involves a very broad spectrum of emission requiring an energy 6×1025 joules. X-ray and UV-radiation emitted by solar flare affect earth ionosphere and disrupt long radio emission at decimetre wavelength. The frequency of occurrence of solar flares varies, from several per day when the sun is particularly "active'' to less than one every week the sun is "quiet'', following 11-year cycle (solar cycle).they produce radiation across electromagnetic spectrum at all wavelength. On July 23, 2012 a massive and potentially damaging solar super storm (solar flare, coronal mass ejection and solar EMP) barely missed earth, according to NASA. (Philips, Dr. Tony 2014; Staff, 2014). A coronal mass ejection (CME) is the massive bursts of gas (plasma) and magnetic field arising from solar corona and being released into solar wind. CME typically reach earth one to five days after leaving the sun. During their propagation CMEs and solar flare interact with the solar wind and interplanetary magnetic field (IMF).

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As a consequence slow CMEs are accelerated toward the speed of the solar wind and fast CMEs are decelerated toward the speed of solar wind. A solar flare interacts the solar wind resulting in a cause of solar proton event (SPE). When the halo CMEs and solar flare interacting with continuously coming cosmic ray toward the earth the result is decreased cosmic ray reach on to the surface of earth. Halo CMEs and solar flare are fundamental cause of the geomagnetic storm and aurora oval near to the earth. When the magnetospheric currents connect with aurora, result is increased geomagnetic storm (GMS). It means the auroras are also the cause of GMS. Additionally, massive solar flare are sometimes accompanied by CMEs which can trigger geomagnetic storm that have been known to disable satellite and knock out terrestrial electric power grid for extended period of times. The radiation risks posed by solar flares are major concern in discussion of a manned mission to Mars, the Moon or other planets. Energetic protons can pass through the human body, causing biochemical damage (New study questions the effect of cosmic proton radiation on human cells, 2008), presenting a hazard to astronauts during interplanetary travel.

Data Analysis

For this study we have taken daily average value data of solar parameter (sunspot no. And solar proton flux) and geomagnetic disturbance indices (Ap, Kp and Dst) from website (www.omniweb.gsfc.nasa.gov) as well as daily average value data of solar parameter (solar flare class and frequency occurrence of solar flare) taken from website (www.hesperia.gsfc.nasa.gov) and cosmic ray intensity from ground based neutron monitor of Moscow having magnetic cut-off rigidity (Rc~2.42 GV) and coordinate on earth is latitude 55.47N as well as longitude 37.32E. For analysing our results we have taken Loowe and Pollse Dst index and five-level geomagnetic storm scale (G-scale) and solar storm scale (S-scale) from NOAA. The table given below will help with that.

RESULT AND DISCUSSION

Fig. (1) Shown the X-class solar flare associated with no. of X-class solar flare. The flare ejects the clouds of electrons, ions and atoms through the corona of the sun into space. These clouds typically reach the earth one or two days. On 6-March (65th days) of year 1989, huge solar flare event (X15 class) occurred on the surface of the sun consequently, this flare built a background path between sun and earth via interplanetary medium for the other solar flare, SPE and CMEs. (www.nascom.nasa.gov/hotspot/x17/) After the 6-March 1989, large no. of solar flare event occurred up to 13-March 1989 i.e. shown in Fig. (1), (2) and (3). Fig. (4) Shown the sunspot no. associated with the flare class.

Table 1. has shown the Loowe Pollse Dst Index for size of geomagnetic storm

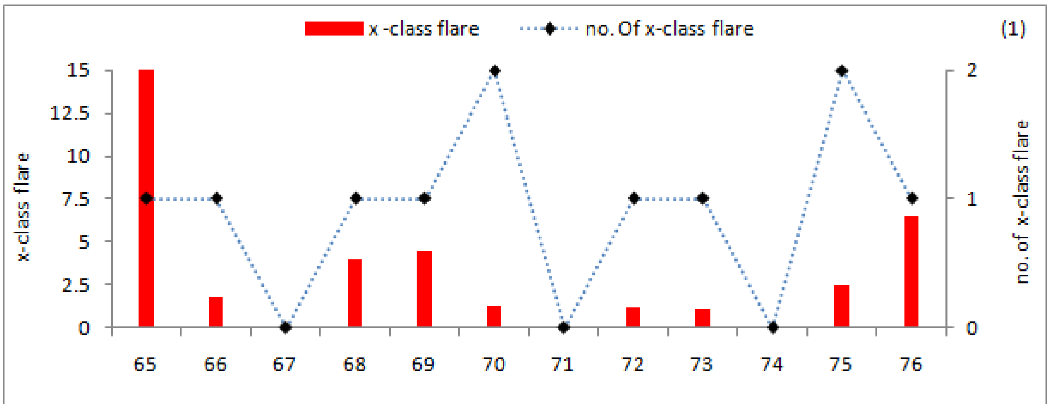
Geomagnetic storm	Dst index
Weak storm	Dst > -50nT
Moderate storm	100Nt < Dst ≤ -50nT
Intense storm	-250 < Dst ≤ -100nT
Super storm	Dst ≤ -250nT

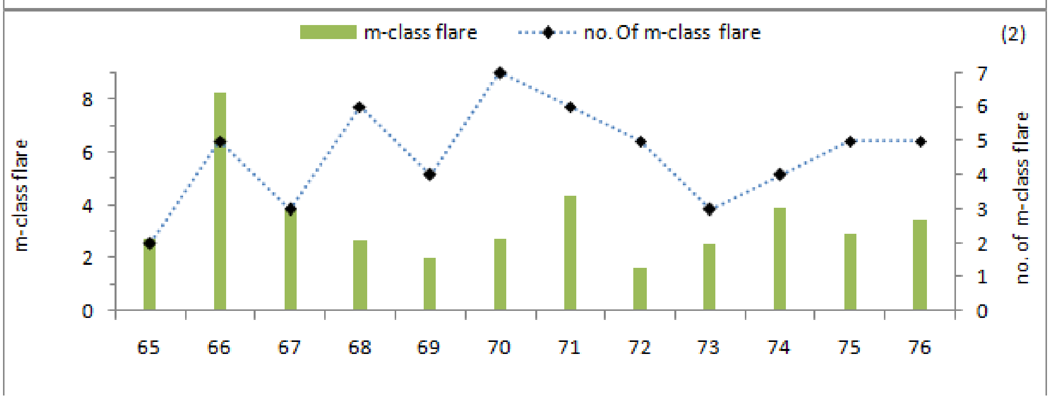
Table 2. has shown the five level Geomagnetic storm from (NOAA G-Scale)

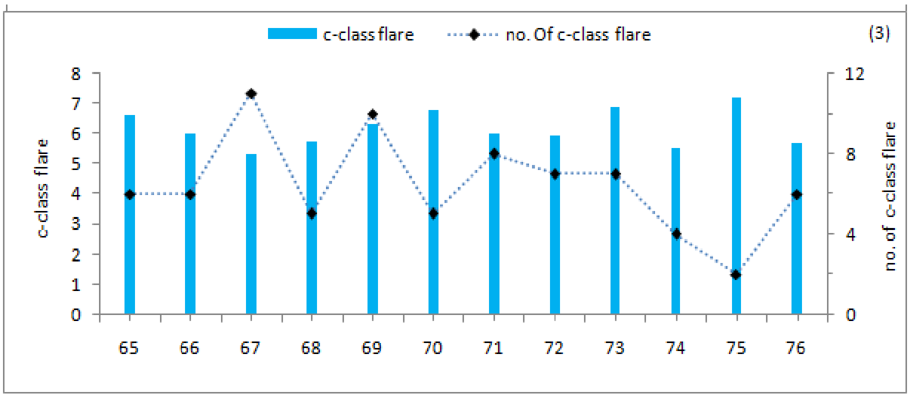
G-scale	Kp*10	Ap	Magnetic latitude	Auroral activity
G0	40 or lower	27 or lower	58^o or above	Below storm
G1	50	48	56^o	Minor storm
G2	60	80	54^o	Moderate storm
G3	70	132	52^o	Strong storm
G4	80	207	50^o	Severe storm
G5	90	400	48^0 or below	Extreme storm

Table 3. has shown the five level Solar storm from (NOAA G-Scale)

S-scale	Description	Flux threshold (particle cm^{-2} s^{-1} sr^{-1}) E=10 MeV
S1	Minor storm	10^1
S2	Moderate storm	10^2
S3	Strong storm	10^3
S4	Severe storm	10^4
S5	Extreme storm	10^5

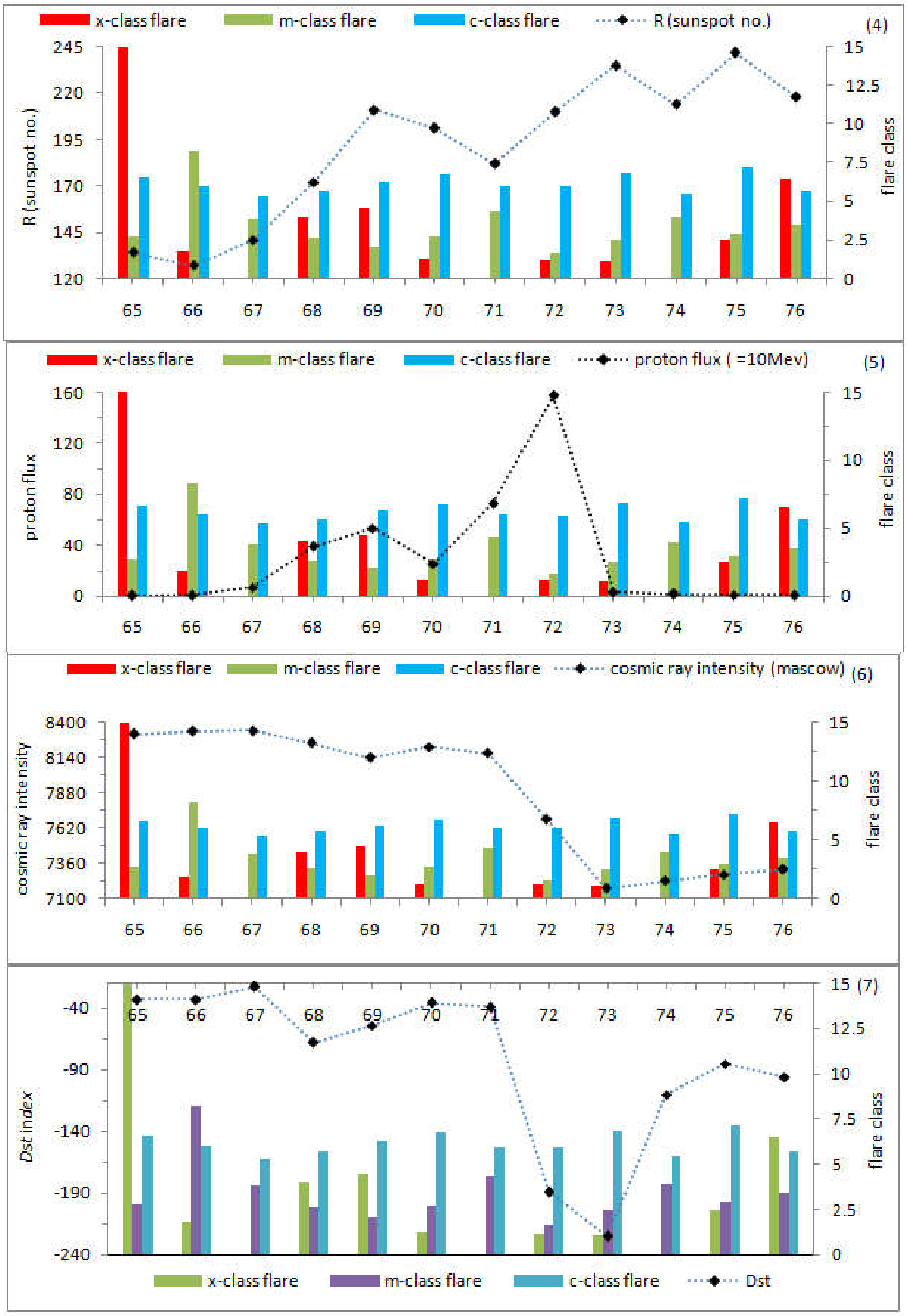






Day of year →

Figure (1), (2) & (3) has shown the relationship between flare class and corresponding no. of flares during March-1989 (for 12 days)



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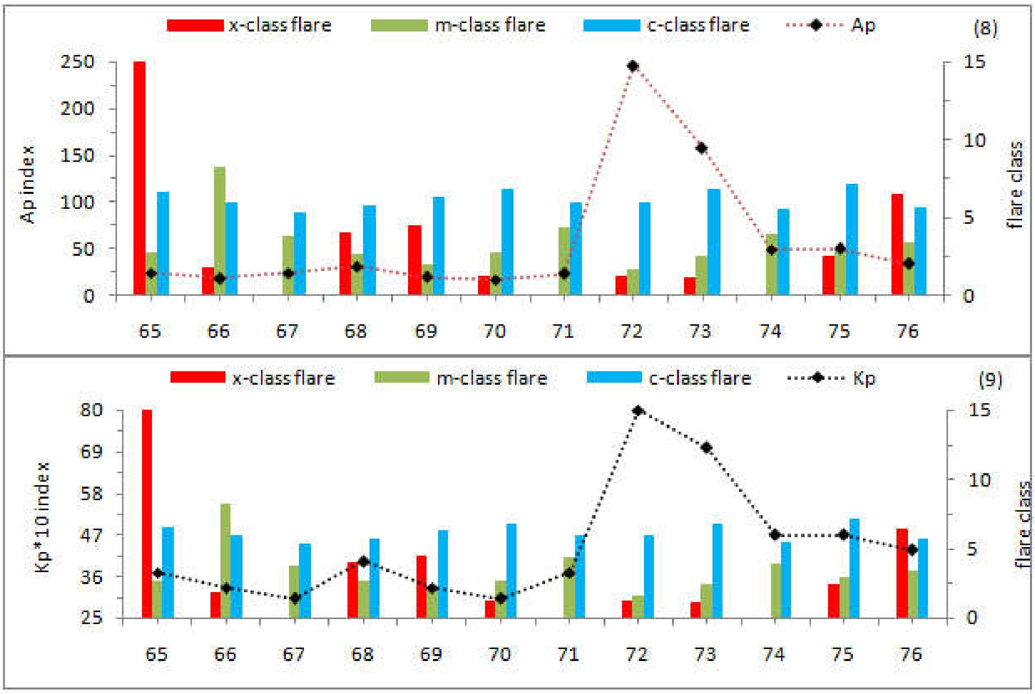

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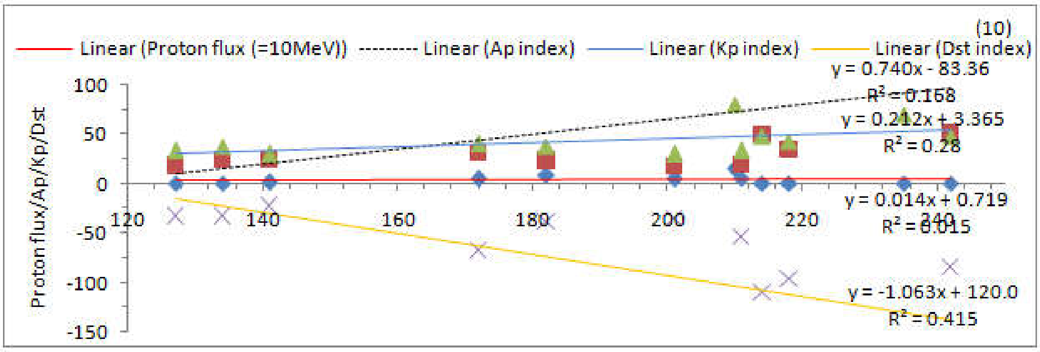
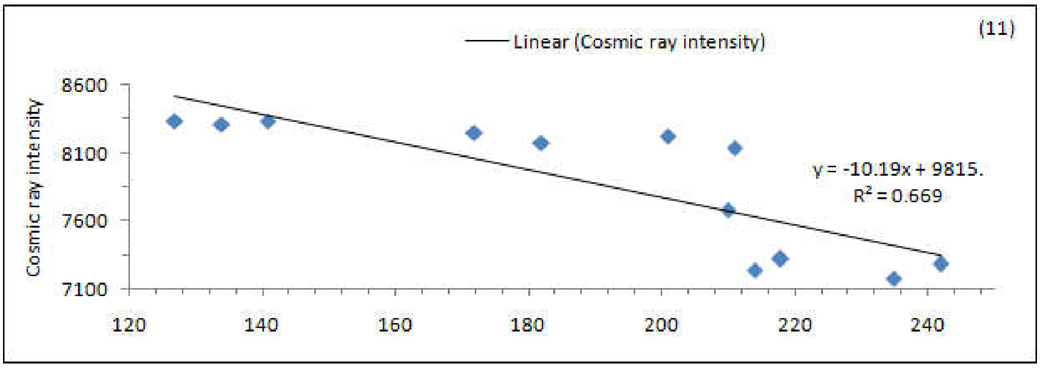
Figure (4) to (9) has shown the relationship of flare class between solar parameter (sunspot no. and proton flux), cosmic ray intensity and geomagnetic disturbance indices (Ap, Kp, Dst) during March-1989 (for 12 days)





Sunspot number→

Figure (10) has shown the multiple correlative scattered curve between sunspot no. and (proton flux, Ap, Kp, Dst) during March- 1989 (for 12 days)

Figure (11) has shown the correlative scattered curve between sunspot no. and cosmic ray intensity during March-1989 (for 12 days)

Table 4. has shown the magnitude of Solar storm and Geomagnetic storm during 13-March 1989

Solar Storm	Solar Proton Flux (E=10Mev)	Geomagnetic Storm	Dst Index	Kp Index	Auroral Activity	
					Latitude	Storm
Moderate	157.05	Intense	-250 < Dst ≤ -100nT	8	50^0	Severe

The sunspot activity increases from the 6-March up to 9-march consequently, a big halo CME event occurred 9-March. (Geomagnetic storm can threaten electric power grid. Earth in space, 1997) We have study that the CMEs reach to the earth one or five days. After three days (12-March) this CMEs event arrived onto the surface of earth. We have studied that CMEs have a large no. of solar plasma and magnetic field. This plasma consists of mostly electrons, protons and alpha particles with energy usually between 1.5 to 10 KeV. The solar plasma has typically velocity of 750 km/second a temperature of 8×105 K. Near earth surface the CMEs firstly interact to the cosmic rays which coming continuously from the interstellar space give result cosmic ray intensity decreases which are shown in Fig. (6). After few minutes interacting with cosmic rays this halo CMEs event arrived same days (12-March) onto the magnetosphere give a result of geomagnetic storm. For monitoring geomagnetic storm we have used three geomagnetic indices i.e. Dst, Ap and Kp.

The disturbance storm time (Dst) index is measure in the context of space weather. It give introduction about the strength of the ring current around the earth caused by solar protons and electrons. (Masters, Jeff 2012) The ring current around earth produces a magnetic field that is directly opposite earth magnetic field. If the difference between solar electrons and protons gets higher, then earth magnetic field becomes weaker. A negative Dst value means the earth magnetic field is weakened which is shown in Fig. (7), this is particularly the case during solar storm. The Ap index provides a daily average level for geomagnetic activity shown in Fig. (8) Associated with solar flare class. The Ap values is obtained by averaging the eight, 3-hour value of ap for each day. To get these ap values you first need to convert the 3-hour Kp values to ap values. The Ap value is thus a geomagnetic activity where days high levels of geomagnetic activity have a higher daily Ap values. It means 13-March have a higher geomagnetic activity.

The Kp index is global geomagnetic storm index shown in fig. (9) Associated with solar flare class. The Kp index ranges 0 to 9, where a value 0 means that is very little geomagnetic activity and a value of 9 means extreme geomagnetic storming. The aurora could have be seen as far south as Texas. (A configuration of storm, 2009) In addition to their currents produced in the magnetosphere that follow the magnetic, called Field aligned currents and these connect to intense current in the auroral ionosphere. These auroras auroral currents is called the auroral eletrojets, also produced large magnetic disturbances. Together, all of these currents add the magnetic deviations they produce on the ground, are used to generate a planetary geomagnetic disturbance index called Kp.

The correlative study of this article is shown in Fig. (10) and (11). We have compared our results by the Table (1), (2) and (3) we gets, results i.e. shown in Table (4). If we saw the positive peak of Fig. (4), (5), (8) and (9) having a same polarity during March 1989, resulting gave the sign of geomagnetic disturbance storm during this period. Similarly, the negative peak of Fig. (6) and (7) gave same result during March 1989.

Conclusion

The statistical results obtained here over a short period of time signify that the 13-march geomagnetic storm of solar cycle 22 is biggest event after Carrington event 1859. (Lerner, 1995) As like Carrington event this was disrupted major of human atmosphere and communication system. A river of charged particles and electrons in the ionosphere flowed from west to east, including powerful electrical currents in the ground that surged into many natural nooks and crannies (A configuration of storm, 2009).

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