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"The Solar Flares in Association of Large Geomagnetic Storms with Solar Proton, Coronal Holes, And Coronal Mass Ejections, Events"

Dr.Brijesh Singh Chauhan[1] and Dr. A.K.Tripathi[2]

1. Department of Physics, Govt. Arts and Commerce College Majhauli Sidhi(M.P.)

2. Department of Physics, S.G.S. Govt. P.G. College, Sidhi (M.P.)

Abstract:-

The solar flare occurs when magnetic energy that has built up in the solar atmosphere is suddenly released.Transient, radiative and corpuscular emission from Sun associated with solar flare produces outstanding disturbances in the environment of the Earth, which cause geomagnetic disturbances at the various locations on the earth's surface.A Solar Proton Event (SEP) occurs when high-energy protons are ejected from the Sun's surface during fast solar eruptions and causes geomagnetic and ionospheric disturbances on large scale.These effects are similar to auroral events;Coronal holes are sources of high-speed solar wind streams and are the longest-lived signature of solar features. The dynamic behaviour of soft X-ray coronal holes can be observed;

Introduction:-

The solar flare is a most spectacular short-lived phenomenon that occurs on the. A Solar Proton Event (SEP) occurs when high-energy protons are ejected from the Sun's surface during fast solar eruptions and causes geomagnetic and ionospheric disturbances on large scale.These effects are similar to auroral events, the difference being that electrons and not protons are involved. (Akasofu, and Yoshida,S.-I.1967)[1] These events typically occur the mechanism of release of energy is associated with magnetic reconnection.There are two basic phenomena that occur during magnetic reconnection in the flare site. One of them is rapid heating of coronal and chromospheric material, (Akasofu S.-I.1972)[2]. This expands outward into interplanetary medium and produces interplanetary shocks that cause geomagnetic field disturbances and auroras. Coronal holes are sources of high-

speed solar wind streams and are the longest-lived signature of solar features.The dynamic behaviour of soft X-ray coronal holes. (Agrawal,S.P.1976)[3].The Yokhoh observations showed that production of coronal holes and their changes can be associated with restructuring of large-scale coronal disturbances including filament eruption and flares.

Large Geomagnetic Storms with Solar Flares:-

Transient radiative and corpuscular emission from Sun associated with solar flare produces outstanding disturbances in the environment of the Earth, which cause geomagnetic disturbances at the various locations on the earth's surface. The solar flare is a most spectacular short-lived phenomenon that occurs on the surface of the Sun and is responsible for solar energetic particles (SEPs) events and geomagnetic storms. Large solar flares occur in magnetically complex regions where the field is often strong sheared.The mechanism of release of energy is associated with magnetic reconnection.There are two basic phenomena that occur during magnetic reconnection in the flare site.(Alan,H.1994)[4].One of them is rapid heating of coronal and chromospheric material, which expands outward into interplanetary medium and produces interplanetary shocks that cause geomagnetic field disturbances and auroras. The other phenomenon is associated with particle acceleration, which represents the energy aspect of the solar flare. Number of researchers.Have shown the association of different types of geomagnetic storms with solar flares and suggested that solar flare of higher importance can produce large geomagnetic storms. (Axford,W.I.1962)[5].The transit time of solar plasma from the Sun to Earth is nearly 3-4 days. The association of a geomagnetic storm with a solar flare has been made by considering the velocity of solar wind on the day of storm. In this work, an attempt has been made to examine the association of selected 158 large geomagnetic storms with large solar flares (Imp ≥ 1B). This association is shown in Figure1.

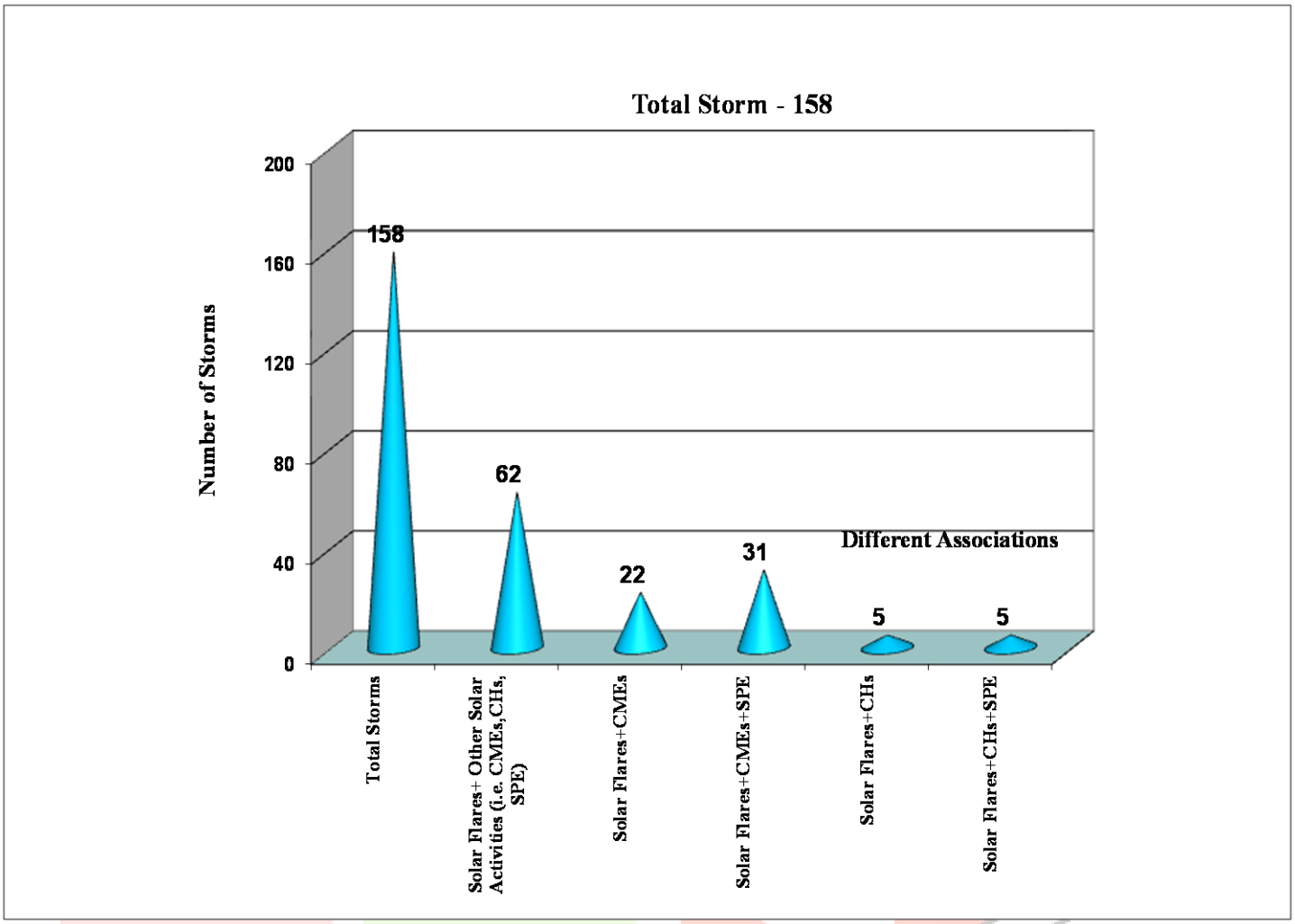


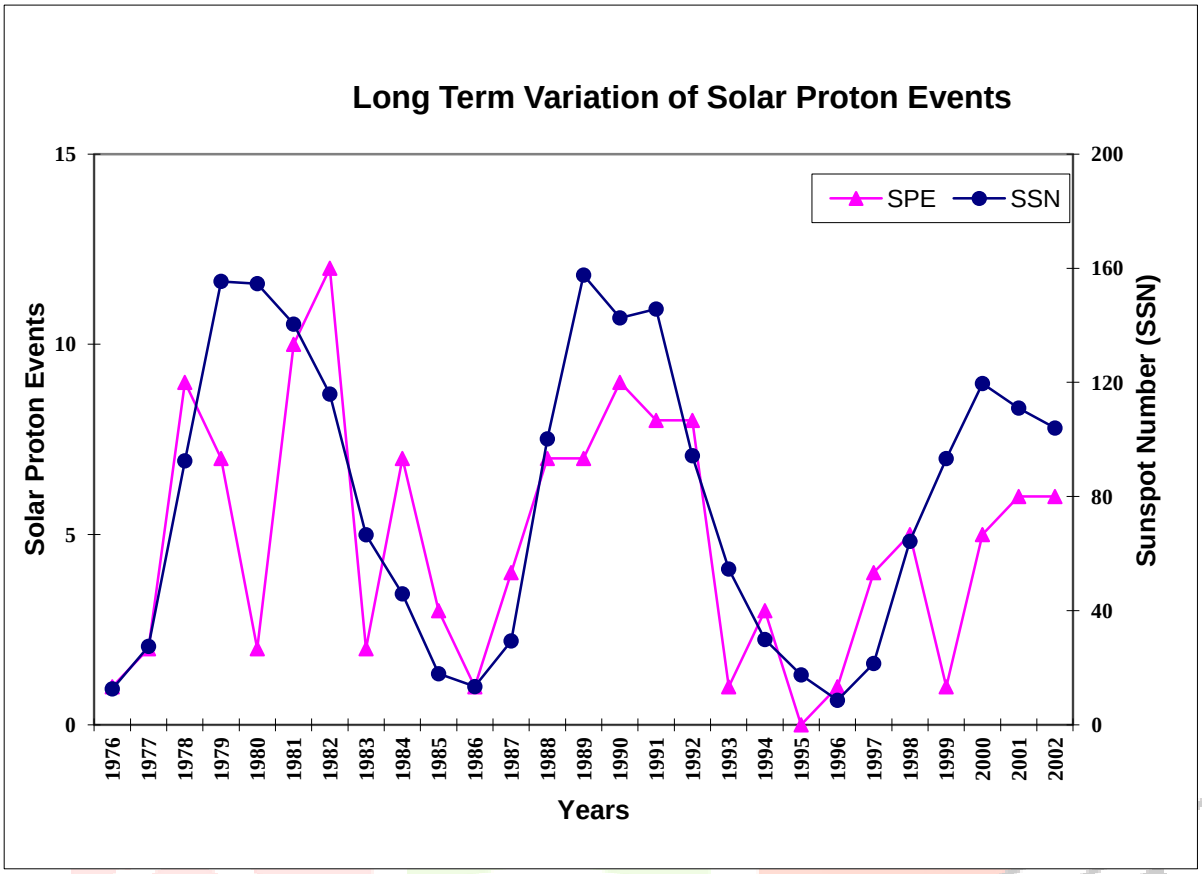
Figure1. Shows the association of 158 large geomagnetic storms with solar flares and other solar activities.

This association shows that the approximately 39% large geomagnetic storms were associated with large solar flares + other solar activities (i.e. CMEs, CHs, SPE). This result indicates that the solar flares are also a major cause which affected the geomagnetic activities on major scale. Actually, (Bame, S. J.,1967)[6] solar flares of higher importance are able to produce IP shocks that are able to produce large geomagnetic disturbances.The magnitude of geomagnetic storms are related with fast and slow shocks, which are associated with different properties (i.e. time duration, X-ray burst, area, NOAA region, location and the shape) of the solar flares.

Geomagnetic Storms with Solar Proton Events:-

These effects are similar to auroral events, the difference being that electrons and not protons are involved. These events typically occur at the north pole, south pole, and South Atlantic magnetic anomaly, where the earth's magnetic field is lowest. The more severe proton events can cause widespread disruption to electrical grids and the propagation of electromagnetic signals. (Barlow, W.H. 1848)[7] Occurrence of solar proton events are directly associated with fast solar eruptions. Occurrence of fast solar eruptions varies with 11-year sunspot cycle. So, it is important to

investigate the association of solar proton events with sunspot cycle on long-term basis. In this communication, we find an association of occurrence of solar proton events (energy ≥10 MeV) with 11-year sunspot cycle, during the period 1976-2002 that are plotted in Figure2.



This association shows that the occurrence of solar proton events vary with 11-year sunspot cycle. Studies of solar proton events are widely useful in the field of geophysics. Solar proton events of energy (≥30 MeV) are most harmful to us and they produce major geomagnetic disturbances.(Berchem, J.,1982)[8] Many recent studies have shown that the solar proton events are an important cause to produce large geomagnetic disturbance.In this work, we have shown an association of selected 158 large geomagnetic storms with solar proton events, during the period 1986-2002.This association is depicted in Figure3.Shows the association of 158 large geomagnetic storms with solar proton events (energy ≥10 MeV) and other solar activities, observed during 1986-2002.We find that, out of selected large geomagnetic storms 37% were associated with solar proton events and other solar activities. (Cane, H. V.1985)[9] .The different combination associations of solar proton events and other solar activities are also analysed in the Out of 59 solar proton events associated large geomagnetic storm events, 21 are associated with coronal mass ejections and 31 are associated with coronal mass ejections and solar flares both. These results indicate that maximum number of solar proton events is released from Sun during ejection of coronal mass ejections or solar flares. (Chen, J.,1998)[10] .It is also found that a geomagnetic storm is associated with coronal mass

ejections and solar proton events having large magnitude and affects our communication or power system on large scale.

Geomagnetic Storms with Coronal Holes:-

Coronal holes are sources of high-speed solar wind streams and are the longest-lived signature of solar features. The dynamic behaviour of soft X-ray coronal holes can be observed with the Yokhoh SXT. The Yokhoh observations showed that production of coronal holes and their changes can be associated with restructuring of large-scale coronal disturbances including filament eruption and flares have shown that the solar source regions were always accompanied by coronal holes and suggested the transient activity at hole boundaries that can produce interplanetary shocks.(Crooker,N.U.1994)[11].A class of geomagnetic disturbances with the mean solar rotation period (27 days) recurs over several solar rotations.Postulated the so-called solar M-region as the source of these recurrent disturbances. According to many new concepts, it is believed that coronal holes may produce large geomagnetic disturbances.It is also observed that, during solar maximum phase maximum number of geomagnetic storms is non-recurrent type and predominantly associated with CMEs. During solar minimum, maximum geomagnetic storms are recurrent type and caused by coronal holes.(Dubey,S.C.&Mishra A. P.1997)[12] The geomagnetic storms may be classified into two main categories on the basis of main phase onset known as sudden commencement and gradual commencement storms. We have shown an association of sudden commencement and gradual commencement geomagnetic storms among selected 158 large geomagnetic storms with 11-year sunspot cycle during the period 1986-2002.These associations are plotted in Figure4.

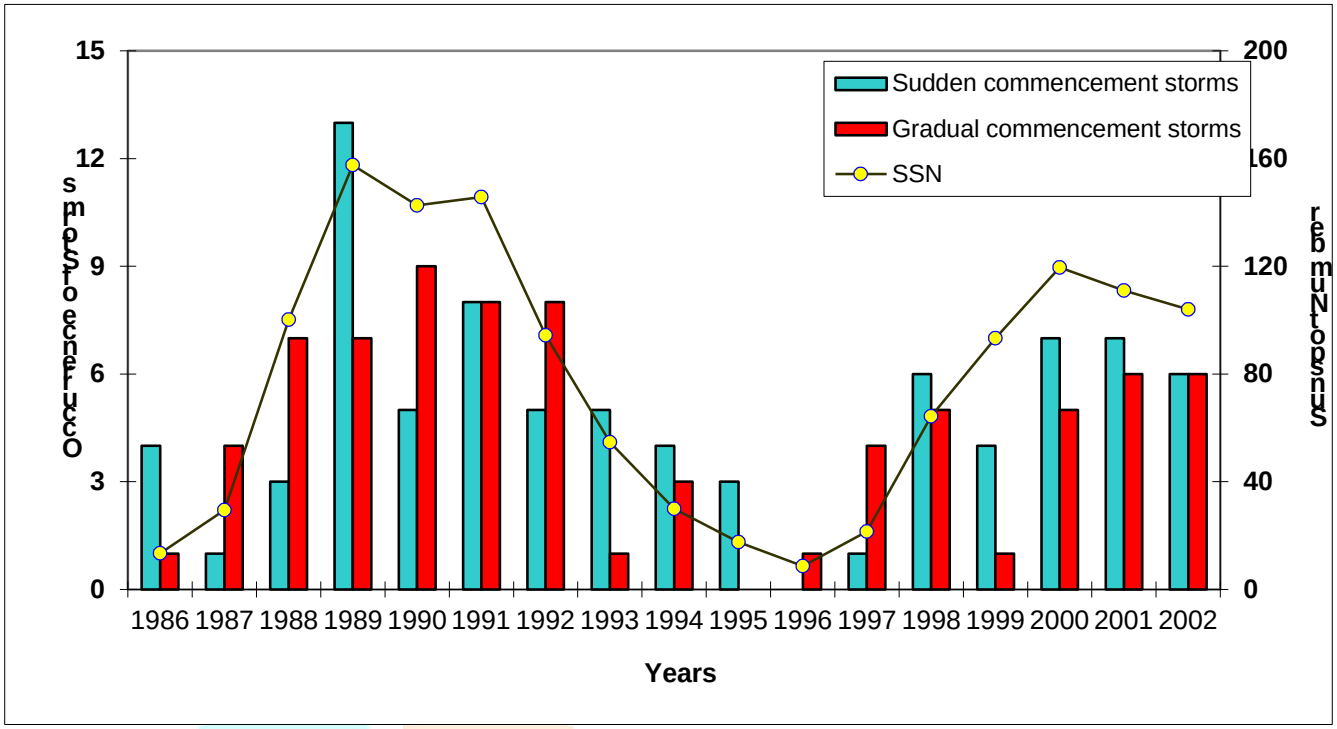


Figure4.Shows the association of sudden commencement and gradual commencement large geomagnetic storms with 11-year sunspot cycle, observed during 1986-2002.

From this plot, we have analysed that the maximum number of sudden commencement geomagnetic storms occurred during solar maximum, while maximum number of gradual commencement geomagnetic storms are observed during solar maximum phase except some peculiarities. Association of selected 158 large geomagnetic storms with coronal holes is shown in Figure5.

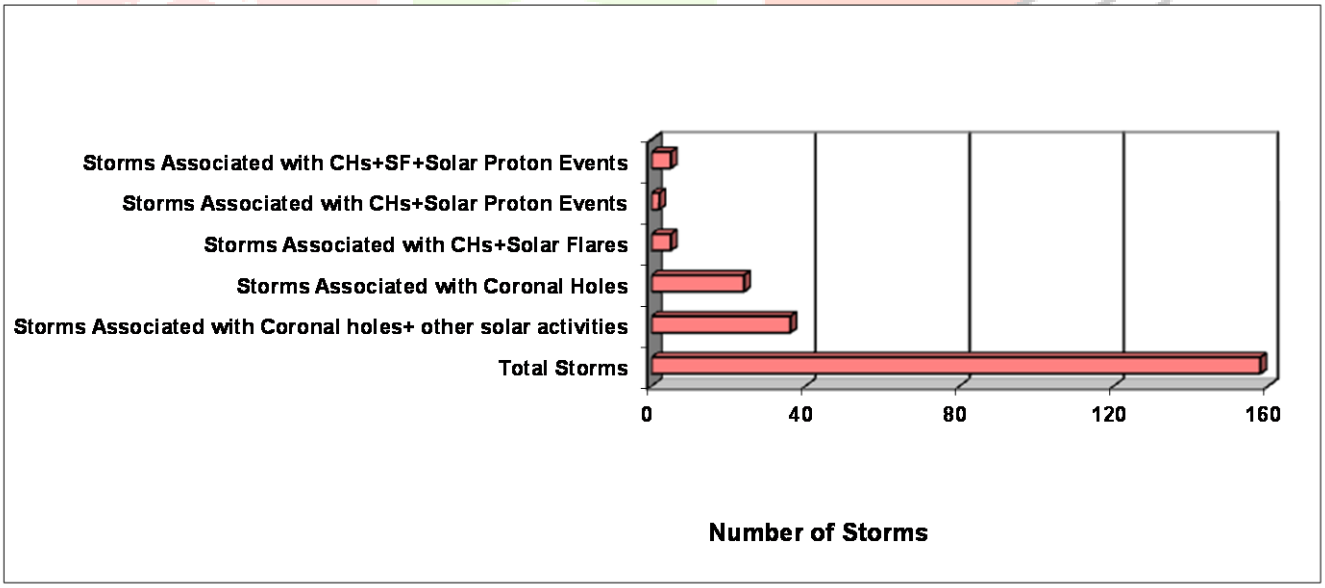


Figure5.Shows the association of 158 large geomagnetic storms with coronal holes and other solar activities, observed during 1986-2002.

We find that, out of selected large geomagnetic storms 23% were associated with coronal holes. (Farrugia,C.J.1996)[13] The different combination associations of coronal holes and other solar activities are also shown in the figure. Out of 36 coronal holes associated large geomagnetic storm

events, 12 are associated with coronal holes and other solar activities. It is also found that during solar minimum, maximum numbers of large storm events are caused by coronal holes.

Geomagnetic Storms with Coronal Mass Ejections:-

Many researchers embrace a new paradigm that the coronal mass ejections (CMEs), a subset of which are associated with both flares and filament eruptions, is the crucial link between solar activity and transient disturbances at Earth. CMEs are vast structures of plasma and magnetic fields that are expelled from the Sun into the heliosphere. CMEs drive maximum number of large geomagnetic storms and their attendant effects, such as auroral displays. (Farrugia,C.J.1997)[14] Remote sensing and in-situ spacecraft observations detect the expelled material. Fast CMEs produce transient IP shocks, which cause sudden commencements at Earth. The CME-related shocks also accelerate the solar energetic particle (SEP) events associated with major interplanetary disturbances and with radiation hazards at Earth. This new paradigm has important implications for the development of instruments and techniques to predict IP disturbances and geomagnetic activity. The magnitude of geomagnetic storms is highly correlated with solar wind speed and the strength of the southward component (IMF B_s) of the interplanetary magnetic field. Geomagnetic storms are often preceded by abrupt increases in the northward component of the earth's magnetic field, called sudden commencements, which are well correlated with IP shocks. Strong correlations were found between geomagnetic disturbances and large, sustained values of IMF B_s in magnetic clouds at 1 AU. Compound streams, which are formed by faster streams overtaking slower ones, often involve magnetic clouds and can be associated with geomagnetic storms. . (Feynman, J. and 1994)[15].In this communication,we have investigated an association of selected 158 large geomagnetic storms with CMEs, which are shown inFigure6.

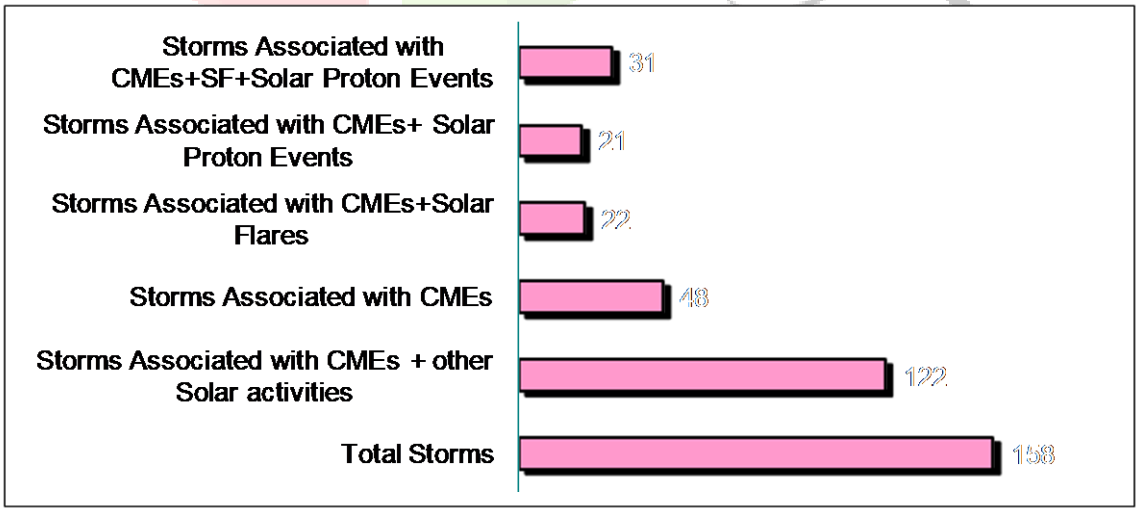


Figure6.Shows the association of 158 large geomagnetic storms with coronal mass ejections and other solar activities, observed during 1986-2002.

We find that, out of selected large geomagnetic storms, 77% were associated with CMEs. The different combination associations of CMEs and other solar activities are also shown in the figure. It is also found that during solar maximum, maximum numbers of large storm events are caused by coronal mass ejections.

Conclusion:-

The observations showed that production of coronal holes and their changes can be associated with restructuring of large-scale coronal disturbances including filament eruption and flares. magnitude of geomagnetic storms are related with fast and slow shocks, which are associated with different properties (i.e. time duration, X-ray burst, area, NOAA region, location and the shape) of the solar flares.These results indicate that maximum number of solar proton events is released from Sun during ejection of coronal mass ejections or solar flares. (Kahler, S. W.1992)[16]. It is also found that a geomagnetic storm is associated with coronal mass ejections and solar proton events having large magnitude and affects our communication or power system on large scale. Out of 36 coronal holes associated large geomagnetic storm events, 12 are associated with coronal holes and other solar activities. It is also found that during solar minimum, maximum numbers of large storm events are caused by coronal holes.The different combination associations of CMEs and other solar activities are also shown in the figure. It is also found that during solar maximum, maximum numbers of large storm events are caused by coronal mass ejections;

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