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The Association of large Geomagnetic Storms with different Solar Transients and Long-Term Semi-Annual Variations of SSCs

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ABSTRACT:-
Many types of solar transient's coronal mass ejections (CMEs), coronal holes (CHs), solar flares (SF); solar proton events (SPE) are responsible for large geomagnetic disturbances. Basic differences between these solar transients are that the some solar activities arises through corotating flows and some of them with transients disturbances in solar wind streams different Transients.Two types of interplanetary disturbances (i.e. IP shocks and Magnetic clouds) are also responsible for large geomagnetic disturbances. The semi-annual variation has been attributed to an interplanetary magnetic field effect as the Earth orbits around the Sun; southward component of interplanetary magnetic field is statistically more likely twice a year, increasing the coupling between the solar wind and magnetosphere. As a result, more storms occur during equinoctial months than during the solstitial months.

I. INTRODUCTION:-

The solar and interplanetary causes of large geomagnetic storms have been discussed so for by many researchers. The associations among large solar flares, interplanetary shocks and sporadic geomagnetic storms have long been recognized. A solar proton event occurs when high-energy protons, ejected from the Sun's surface during a solar flare, get caught by the earth's magnetic field and cause ionization in the ionosphere. The effect is similar to auroral events, the difference being that electrons and not protons are involved. The events typically occur where the earth's magnetic field is lowest, at the north pole, south pole, and South Atlantic magnetic anomaly. **(Gosling J. T. 1973)[1].** Coronal holes are the region of the open field lines and responsible for recurrent geomagnetic storms. Skylab observations show that the coronal holes (CHs), coronal mass ejections (CMEs) and eruptive prominences have causal link with solar activity and energy emitting regions, and they produced large geomagnetic storms. Recently, **(Kahler, 1992)[2]** a new concept has been developed that coronal mass ejections are the agent driving interplanetary shocks and large geomagnetic storms.

Long-Term Variability:-

The coronal mass ejections related shocks accelerate solar energetic particle (SEP) events associated with major interplanetary disturbances. The coronal mass ejections (CMEs) arises due to high solar activity and associated with transient disturbances arising from solar activity in magnetically closed regions, and mainly produces interplanetary disturbances that causes large non-recurrent geomagnetic storms at the Earth, **(Gosling,1993)[3]** whereas, coronal holes are associated with corotating flows in solar wind streams, arising from magnetically open regions and could produce interplanetary disturbances that causes recurrent geomagnetic disturbances. Both solar activities (CMEs and Chs) can produce interplanetary shocks that are responsible for geomagnetic disturbances, but there appear regions lying on lower (less than 30°) and high (more than 30°) latitudes. An important paradigm shift such that the coronal mass ejections and not solar flares are considered the key causal link with solar activity and to be drived all large geomagnetic storms and their associated effects**. (Webb, 1992;)[4]**. Some time it is seen that a large geomagnetic storm may be caused by more than one solar activity. So it is a difficult job to assess real causes of geomagnetic disturbances. Therefore, we have shown the semi-annual variations of selected large geomagnetic storm events occurring during interval (1986-2002), which are plotted in **Figure 1.** This plot indicates that in the first half annual part (January-July),

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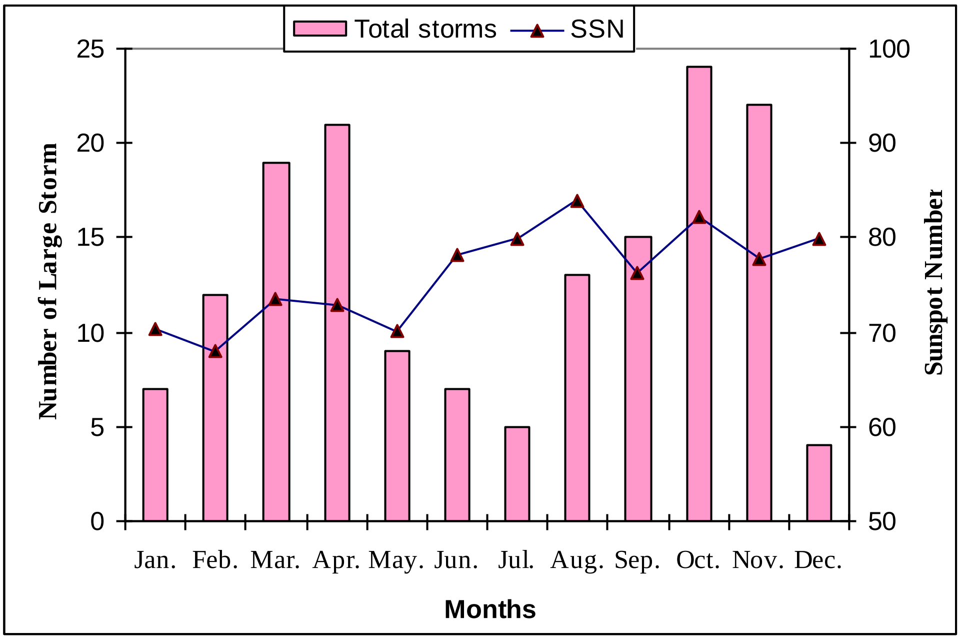

Figure 1 Depicts monthly variations of large geomagnetic storms and their association with sunspot number that is observed during 1986-2002.

In the present work, we have investigated solar causes, type of solar wind streams and interplanetary shocks of selected 158 large geomagnetic storms,The maximum value of solar wind speed (SWV), interplanetary magnetic field (IMF B) and southward component (IMF B_z)

Semi-annual Variability:-

The semi-annual variation has been attributed to an interplanetary magnetic field effect as the Earth orbits around the Sun; southward component of interplanetary magnetic field is statistically more likely twice a year, increasing the coupling between the solar wind and magnetosphere **(Russell-McPherron, 1973)**[5]. As a result, more storms occur during equinoctial months than during the solstitial months. The occurrence rate of large geomagnetic storms displays a pronounced semi-annual variation.

occurrence rate for large geomagnetic storms is maximum during March and April months. Similarly, in next half (July-December), occurrence rate is higher during October and November months. These results shows that the March, April, October and November months were more disturbed months and maximum solar activities occur during these months. It is also found that the 47% large storm events occurring during these months**. (Akasofu, S.-I.1980)**[6], The semi-annual variation of large storm events shows a cyclic variation peaking around the April and October months. The semi-annual variations of geomagnetic activity have been analyzed by a number of methods. It is usually treated as a statistical effect and attributed to a mechanism that gives stronger solar wind-magnetosphere coupling, on the average, in spring and fall seasons. We have also shown the semi-annual variation of large storms and their associations with SSCs that are shown in **Figure 2**. This figure does not show any clear association between semi-annual variation of large storms and SSCs.

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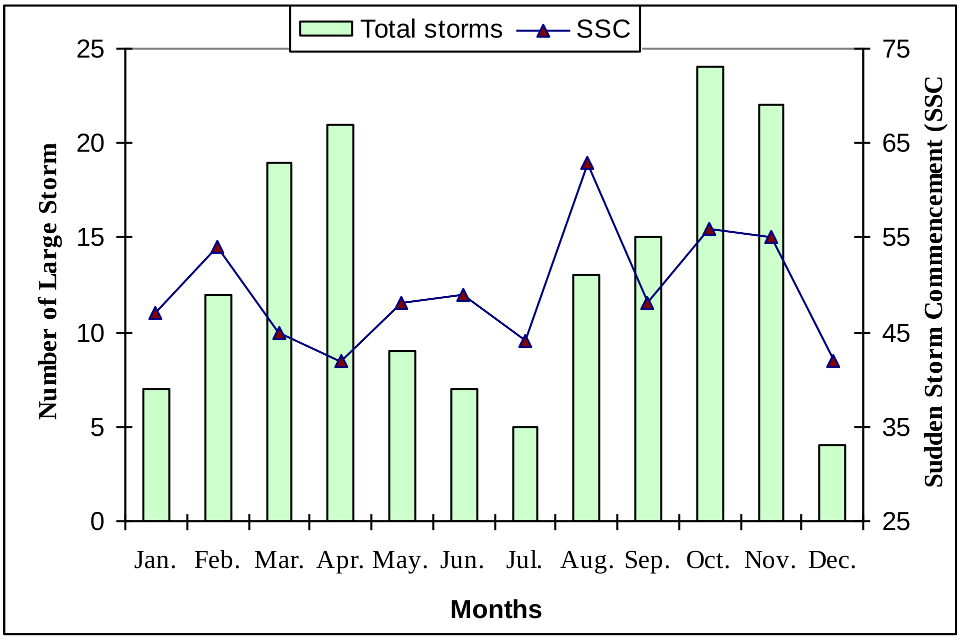

Figure 2. Depicts monthly variations of large geomagnetic storms and their association with SSC that is observed during 1986-2002.

This result indicates that during most disturbed months, various types of solar activities are taking place, but maximum solar activities are not creating sudden storm commencement. The study of semi-annual variation of geomagnetic storms have important role in space weather predication.

Long-term and Semi-annual Variations of SSCs :-

Sudden storm commencements followed by a geomagnetic storm or by an increase in activity lasting at least one hour. When a shock wave is generated in the solar wind hits the earth's magnetosphere and produces a large magnetic impulse. This impulse is called a sudden storm commencement (SSC) and it causes an instantaneous compression and distortion of the geomagnetosphere. Once the initial shock wave has passed the solar wind returns to normal pressure and the magnetosphere recovers. Over the next several hours, the magnetic field remains fairly stable with only minor fluctuations. All geomagnetic storms are not beginning with a SSC. SSC impulses are caused by fast solar eruptions (i.e. coronal mass ejections, solar flares etc.), which have huge solar explosions. The solar activities vary with 11-year sunspot cycle, so here a question arises that how does SSCs vary with sunspot cycle. For solution of this question, we have shown an association of occurrence of SSCs with 11-year sunspot cycle, **(Kivelson,M.G.1995)**[7] during the period 1986-2002, which is shown in **Figure 3.** This analysis shows that the annually occurred value of SSC follows with SSN except some peculiarities.

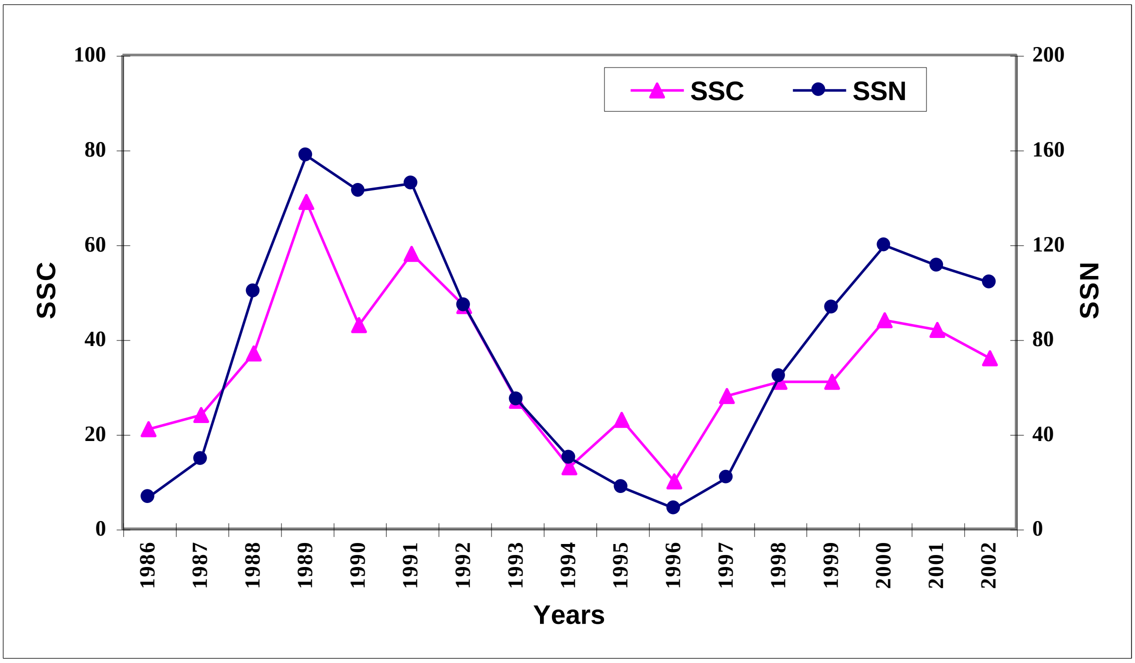

Figure3. Depicts annual variation of sudden storm commencement (SSC) with annual sunspot number (SSN) observed during 1986-2002.

The occurrence of geomagnetic disturbances having a semi-annual variability that are also associated with solar activity. In this communication, we have analysed the association of monthly occurrence of SSC with monthly mean SSN, during the period 1986-2002.These associations are depicted in **Figure 4**.

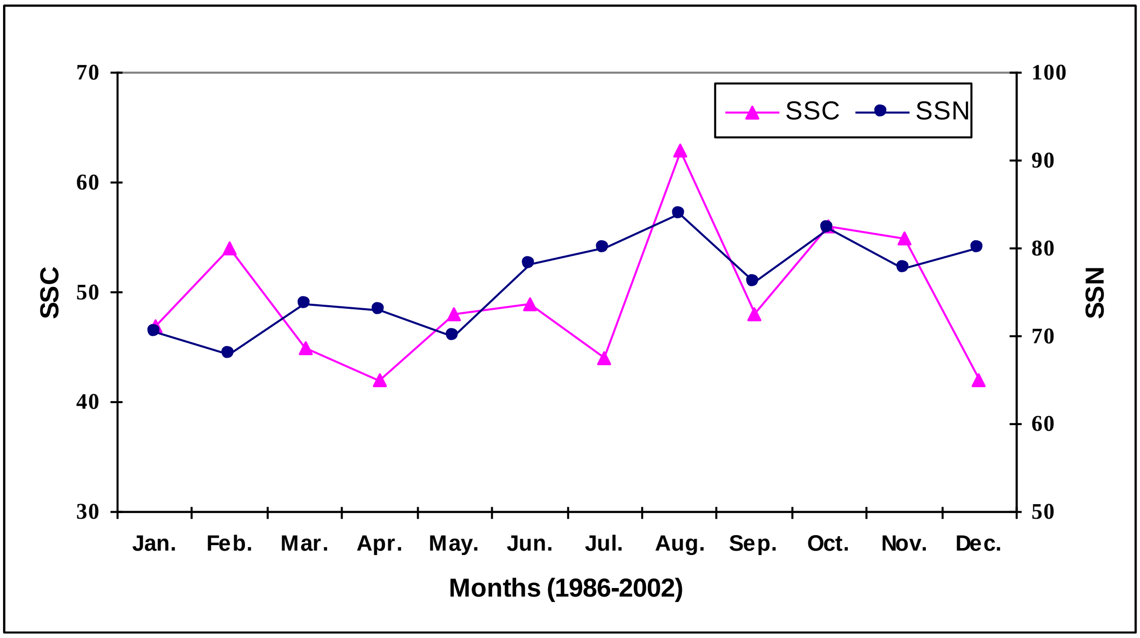

Figure 4. Depicts monthly variation of sudden storm commencement (SSC) with monthly mean sunspot number (SSN) observed during 1986-2002.

This analysis have not shown any clear association between them and deals that the occurrence of SSCs have not semi-annual variability as like as occurrence of geomagnetic disturbances. **(Agrawal, S. P. 1976)**[8]. In this communication, It is found that out of 15 severe

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geomagnetic storm events,14 were associated with coronal mass ejections (CMEs) and only 01 storm was associated with coronal holes (CHs). It is also found that out of CMEs associated severe storm events 09 were associated with large solar flares and solar proton events with higher energy. These storm events have large magnitude comparatively other storm events. Out of selected severe storm events all storm events were associated with transient disturbances in solar wind streams.

II. CONCLUSION:-

We have also found that 14 severe storm events are caused by fast interplanetary shocks and only one severe storm event was caused by magnetic clouds. From these observations, **(Allan,D.W.1962)[9].** We find that severe geomagnetic storms are mostly caused by coronal mass ejections, transient disturbances in solar wind streams and fast interplanetary shocks and verified the latest paradigm of CMEs, solar wind streams and interplanetary shocks as discussed by scientific community. Studies of severe geomagnetic storms are widely applicable in the field of space weather phenomena, satellite communications,Nvigation and power systems. We cannot stop these harmful geomagnetic storm events any way but protect to our scientific systems or us by forecasting of them.

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