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STUDY OF IMPACT ON HALO CORONAL MASS EJECTIONS ON GEOMAGNETIC ACTIVITY

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ABSTRACT:- In this study, we investigate the solar origins and interplanetary properties of geomagnetic activity halo coronal mass ejections (CMEs) that produced intense geomagnetic storms. Observations indicate that full-halo CMEs are potential contributors to intense geomagnetic activity on Earth. However, it is worth noting that not all full-halo CMEs lead to significant geomagnetic storms, which adds complexity to the task of space weather forecasting. Our investigation delves into the solar origins and flare connections of these geoeffective CMEs and their interplanetary effects, specifically, solar wind speed, and the southward component of the interplanetary magnetic field Bz. The objective is to elucidate the relationship between solar and interplanetary parameters. Specifically, this study aims to identify solar parameters that govern key interplanetary parameters responsible for generating significant geomagnetic storms. Our findings indicate that fast full-halo CMEs, associated with powerful flares and originating from favourable locations (i.e., near the central meridian and at low to mid-latitudes), are the most likely candidates for producing intense geomagnetic storms. Additionally, our results demonstrate that the intensity of geomagnetic storms is most strongly influenced by the southward component of the interplanetary magnetic field, but is less dependent on the initial speed of the CME.

KEYWORDS:- Cosmic ray intensity, Impact Halo CME and Geomagnetic activity.

INTRODUCTION:-

Coronal Mass Ejections have a much wider mass energy and in comparisons to another known solar outputs and interplanetary features. They can influence within heliospheric and magnetosphere of earth causing major geomagnetic activity. Recent space craft and ground based observations of CME events improved our knowledge of the development of CMEs and their impact on space weather. Gosling in 1991 proposed that contrary to the previous wisdom solar flares had nothing whatever to do with geomagnetic disturbances. Results obtained from solar minimum mission (SMM) reported that flares are not related with occurrence of CME events.

Recent CME observations provide CME rates to the solar scientist to draw the primary relationship of CME events with geomagnetic activity particularly on long-term basis. Occurrence rate of CMEs are adopted in solar terrestrial relationship studies. Combining skylab, SMM, Helios (Photometer) and solar wind observations, Webb and Howard (1994) found a rate of 0.31 to 0.77 CME/day for the solar minimum years and 1.77 to 3.11 CMEs/day for the solar maximum years. Observations also indicate CME occurrence rate more than 6 during solar maximum.

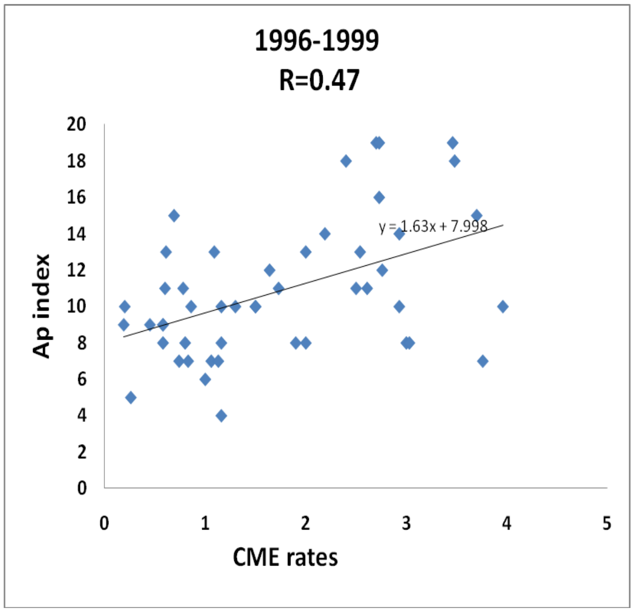
In the present work, we have calculated the CME rates for the period of 1996 to 2008. We find out that in sunspot minimum phase the occurrence rate is minimum of 23 solar cycle, that is 0.56 CMEs per day where as in sunspot maximum phase 2002, the occurrence rate is maximum for 23 cycle that is 4.63 CMEs per day, The average CME occurrence rate for solar cycle 23 is 2.9 CMEs per day. To show the relationship between CME rates and geomagnetic disturbed index Ap. we have done the year wise correlative analysis and derived the coefficients of correlations from 1996 to 2008. Twelve monthly mean values of CME rates are correlated against the twelve months mean values of Ap index for each year and derived the correlation coefficients. These correlation coefficients are shown in Figure 4.18 in previous section 4.7.2. To study the relationship between Ap index and CME rates we have again correlated the monthly mean values of these two indices for the year 1996 to 1999, which represents the ascending phase of solar cycle 23. This period also show A > 0 epoch of solar magnetic cycle. Figure 4.27 shows the cross plot between monthly mean values of CME rates and Ap-index. Distribution of points and correlation of coefficient value (R = 0.47) indicate normal and positive correlation. We have again done similar correlative analysis for the period of 2006 to 2008, as shown in figure 4.28. Distribution of points and correlation value indicate poor correlation. This is expected due abnormal long minima of solar cycle 23. Correlative analysis which are varies period of period indicate that only CME rates are not a adequate parameter to study the solar terrestrial relationship.

MATERIAL & METHODS:-

The data for the halo coronal mass ejections were obtained from a catalogue that includes all manually identified CMEs from 1996 onwards. This catalogue is based on observations obtained from the Large Angle and Spectrometric Coronagraph (LASCO) instrument aboard the Solar and Heliospheric Observatory (SOHO) mission (Anonymous 2005; Gopalswamy et al., 2010). This catalogue provides comprehensive information on various characteristics of each CME, including the date and time of its occurrence within Lassos field of view, CME linear speed (LS), acceleration, location, associated solar flare class, and other pertinent information. In our study, we utilized data from both LASCO and the Extreme Ultraviolet Imaging Telescope (EIT) (Artzner et al. 1995) to examine the solar origins of the CMEs. The Extreme Ultraviolet Imaging Telescope (EIT) captures images of the Sun in four different wavelength bands, including one specific band that measures at 195 Angstroms. We used images from the LASCO coronagraphs C2 and C3, which provide a combined field of view ranging from 2 to 30 solar radii, for tracking the CMEs in the outer corona. The time at which the initial brightening was observed in the EIT images was deemed to be the initiation point of the flare or CME activity. We follow a criterion similar to that of (Y. M. Wang et al., 2002; Srivastava and Venkatakrishnan 2004) to determine the solar source of a geomagnetic storm. For the purpose of this study, we have selected a temporal the storm.

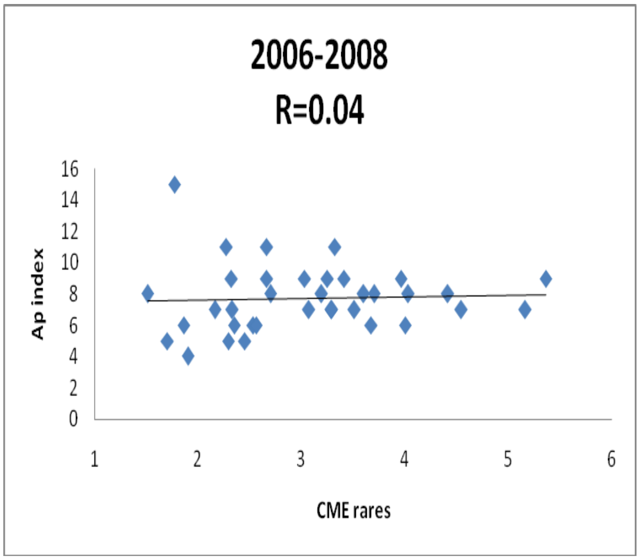
RESULTS AND DISCUSSION:-

Recent observation of CMEs and their impact on interplanetary space, old concept about solar flare influence is almost changed such that CMEs not flares are the real culprit in geomagnetic disturbances. Several research work done after the identification of CMEs, halo CMEs are investigated as more effective in geomagnetic disturbances (Tiwari and Shrivastava 2005; Gopalswamy et al 2007). Halo CMEs expand rapidly and appear to surround the occulting disk of the observing coronagraph. The SOHO and LASCO mission routinely observes halo CMEs. Requirements of geo-effectiveness of CMEs are (i) the CMEs most arrive at Earth (ii) have a southward component of their magnetic field. CMEs originating from close to the disk centre (within 45 degree from the disk centre) propagate roughly along the sun-earth line, so the front side halos are highly Likely to arrive earth. In this analysis, we have taken halo CMEs events from SOHO LASCO catalogue to derive their influence on geomagnetic activity. In this analysis Ap-index daily values are taken as geomagnetic parameter. For this purpose Chree method of super epoch has been adopted for the intervals at 1998-1999, 2000-2001 and 2006-2007, covering the ascending, high and low solar activity periods respectively.

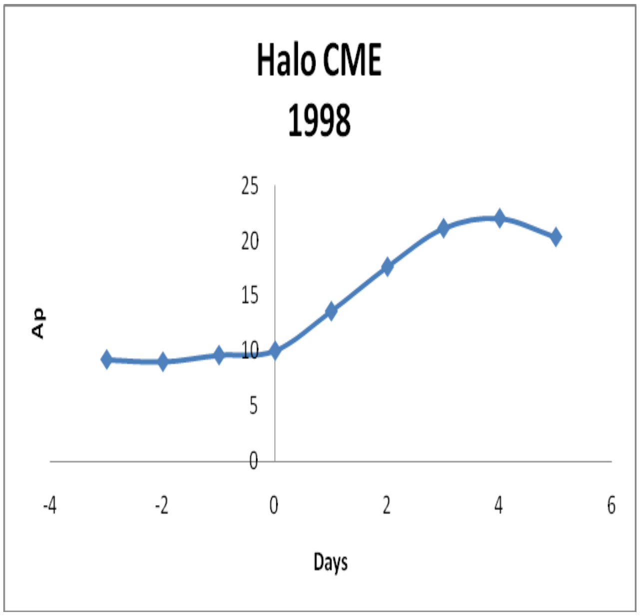


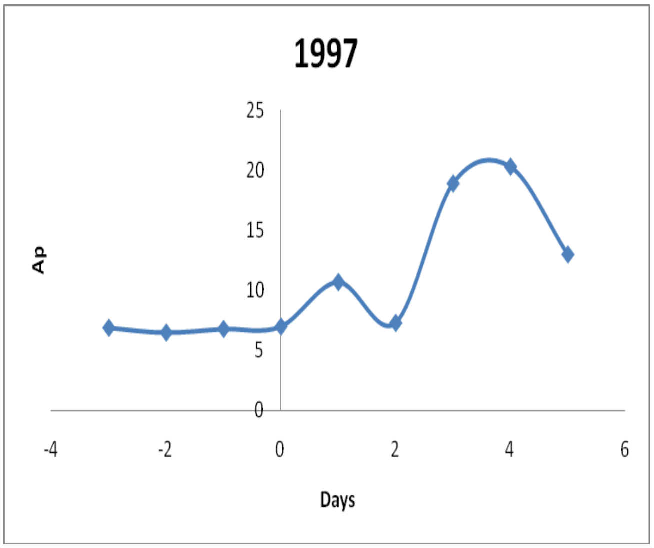
1. Shows the cross plot between monthly mean values of CME rates and Ap index for the Period of 1996 to 1999

Figure 1. shows the results of Chree analysis, in which the daily values of Ap-index for -3 to +5 days have been plotted corresponding to occurrence to halo CMEs. Zero day is correspond to occurrence date of halo CMEs. Upper panel of Figure 1. shows the result of 1996 and lower panel shows the results



2..Shows the cross plot between monthly mean values of CME rates and Ap index for the Period of 2006TO 2008.





3. Shows the results of chree analysis for geomagnetic activity using Ap index from -3 to +5 days for the period of 1996 to 1997.

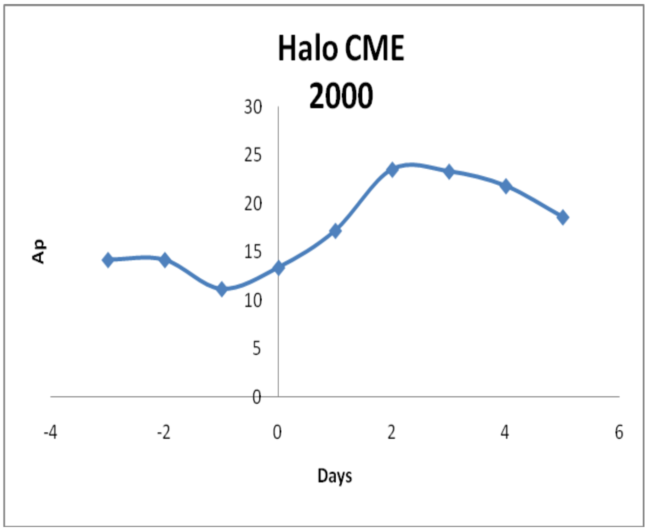
Zero days are the onset day of halo CME. of 1997. Both of the year's show a slight increases in geomagnetic values after the onset day of halo CMEs. Maximum peaks are observed 2 to 3 days after the onset (zero) days. We have again done similar analysis for the years of 2000 and 2001. These two years represents the maximum solar activities. The results of Chree analysis for the years 2000 and 2001 are shown in Figure 4.30. Significant increases after the onset day of halo CMEs are seen, which support the findings of the year 1996 to 1997. Slight different results are found from the similar analysis for the years 2006 and 2007 as shown in Figure 4.31. Year 2006 shows peak increase value on onset day of halo CMEs on the other hand two peaks are seen for the year 2007. Such type of results are expected due to abnormal behaviour of solar activity during solar cycle minima of solar cycle 23.

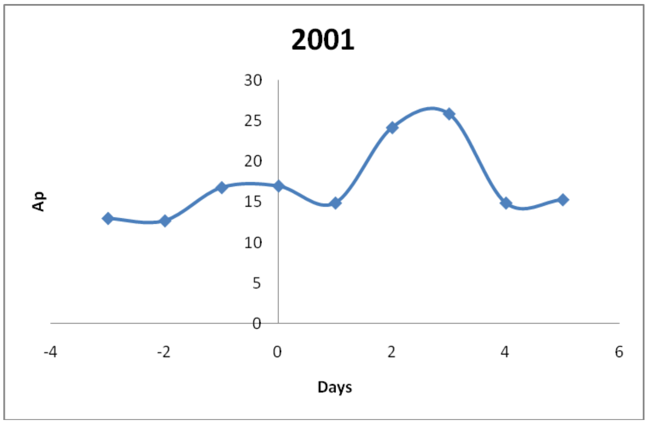
Theoretically, we can explain these results that compression and raping of magnetic field line leading edge of the halo CME and IP field are prime cause of strong southward field which lead to provide large geomagnetic disturbance. .

4.10 Association of Forbush decreases with Coronal Mass Ejections:

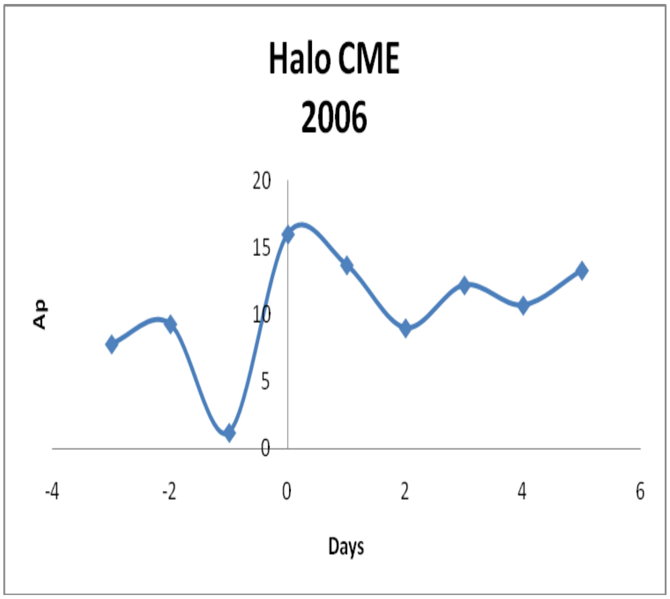
Forbush decrease event is a transit decrease in the cosmic ray intensity which is characterized by a sudden onset of decrease and reaching a minimum within 24 hours, followed by a gradual recovery. Morrison 1956 reported that such a decrees is developed in cosmic ray intensity due to perturbations in interplanetary magnetic field. Several theoretical model are reported in literature time to time about occurrence of Forbush decrease (Fds).

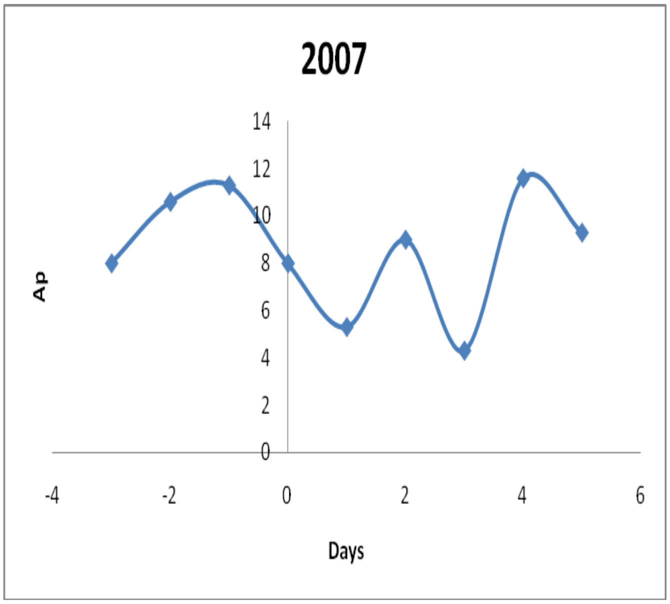
Enhanced drift model was reported by Cheng, et al 1990. Other hand several researchers concentrated on effusive or scattering models (Webbercnz and Cane 2000; Badruddin, 2002).





2 Same as figure 1 but for the year 2000 to 2001





4. Same as figure 1 but for the year 2006 to 2007

Both of these two models are agree on the irregularities in associated interplanetary disturbances. Cane et al 1996 and Cane 2000 have approved the association of Fds with Coronal Mass Ejections. They also found that the depth of a Fd event is dependent on the heliolongitude of the active region which ejected the associated CME. The easily availability of CME events data from SOHO, LASCO mission, provide us a great opportunity to study and investigate the association of CMEs with Fd events.

In this work we compile a list of Fd events. Earlier we have also obtained the CME rates. In figure 5 we compare the occurrence rate of CMEs and number of events of Fds per year starting from 1996 to 2008. We observe almost similar variational pattern on long-term basis in both CME rates and Fd events. However trend is broken during 2006 to 2008, which the minimum phase of solar cycle 23. Further we have correlated the CME rates with number of Fd events. Figure 6 shows the cross plot between annual mean values of CME rates and No. of Fd events. Distribution of points show positive and high correlation between Fds and CME rates coefficient of correlation value (0.58) is also given in Figure, which support our result.

CONCLUSION -:

In the present work we have taken Cosmic ray count rates from two different stations show strong positive correlations. Occurrence of CME rates positively correlated with geomagnetic indices. Large number of CMEs are found during the period of high geomagnetic disturbances. CME rates show negative and high correlation with Cosmic ray intensity variations. Transient decrease in Cosmic ray intensity are found in influence of halo CMEs, decrease are started after 2-3, days from the onset day of halo CME. CME rates do not show any significant relation with geomagnetic activity. A normal and positive correlation is observed for A > 0 epoch (1996 to 1999). Halo CMEs produce enhancements increases in geomagnetic field on short-term basis.

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