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Dependence of GMS with Ap $\geq$ 50 on solar feature's locations

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Abstract. An attempt has been made to locate the solar features and their effective locations on the solar disk causing the geomagnetic storms (GMSs) with $A_p \geq 50$ on Earth. Eighty four GMSs have been investigated using solar geophysical data (SGD) and interplanetary data during the period 1978-93. It is observed statistically that H_α, X-ray solar flares and active prominences and disappearing filaments (APDFs) which have occurred within lower heliographic latitudinal/longitudinal zones are associated with larger number of GMSs at Earth.

1 Introduction

Geomagnetic storms (GMSs) are generally caused by magnetically open, long lived, high speed solar wind streams (HSSWS) produced from solar coronal holes (Sheeley Jr and Harvey, 1981; Feynman and Gu, 1986); H_α, X-ray solar flares (Garcia and Dryer, 1987); isolated disappearing filaments (Cane et al, 1986). Geomagnetic disturbances are also related to high values of the product of solar wind velocity (V) and interplanetary magnetic field (IMF) strength, B i.e., VB leading to cause GMS (Sabbah, 2000). Although, there has been a substantial growth in our knowledge of solar causes of GMSs, there are still unanswered questions, need to be solved to predict the occurrence of GMS.

2 Analysis of Data

Association of eighty four GMSs having $A_p \geq 50$ with solar features have been investigated during the period Jan 1978 - Dec 1993. The position of H_α and X-ray solar flares and APDFs (Solar Geophys. Data Reps. 1978-93) have been noted 49 to 127 Hours prior the occurrence of GMSs at Earth depending upon the solar wind velocity, V (Couzens and King, 1986, 1989, 1994).

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3 Results and Discussion

The association of GMSs with importance of H_α, X-ray solar flares is shown in Fig. 1 (a,b). During 1978-93, it is observed that 42.8%, 31.4% and 8.6% GMSs are associated with H_α solar flares of importance SF, SN and 1N respectively; whereas, 56.5%, 21.7% and 13.0% GMSs are associated with X-ray solar flares of importance SF, 1N and 2B respectively. Actually, solar flares of higher importance are able to produce fast IP shocks in interplanetary medium which causes large GMSs (Akasofu and Yoshida, 1967; Lockwood, 1971 and Pudovkin and Chertkov, 1976). Fast and slow interplanetary shocks are not only associated with higher importance of solar flares but they are also associated with different properties of solar flares eg., NOAA region, location (in helio-latitude/longitude) shape and size and duration of occurring (Klassen et al, 1999). In that case, solar flares of lower importance which are associated with fast shocks may produce more intense GMSs. Thus, no significant correlation between magnitude (intensity) of GMS and importance of H_α and X-ray solar flares have been observed. Further, frequency histogram of GMSs with different heliographic latitude (North-South) and heliographic longitude (East-West) of H_α, X-ray solar flares and APDFs have been plotted for the period 1978-93 in Figs.2(a,b), 3(a,b) and 4(a,b) respectively. It is apparent from Fig.2(a) that 61.1% of GMSs are produced by northern H_α solar flares and mostly effective latitudinal zone for producing GMSs is lying between $(0\text{-}30)^0$N; whereas, 38.9% of GMSs are produced by southern H_α solar flares and mostly effective latitudinal zones for producing GMSs lie between $(0\text{-}30)^0$S. At the heliolatitude in the range $(0\text{-}30)^0$N to $(0\text{-}30)^0$S, there is concentration of 94.5% of H_α solar flares associated with GMSs and no storm is produced by H_α

solar flares beyond 40^0N and 40^0S. It is observable from Fig. 2(b) that 61.1% GMSs are produced by eastern H_α solar flares; whereas, 38.9% GMSs are produced by western H_α solar flares. Further, 80.6% H_α solar flares at the heliolongitude in the range $(0\text{-}50)^0$E to $(0\text{-}50)^0$W are associated with GMSs. Remaining 19.4% GMSs are associated with H_α solar flares distributed beyond 50^0 E and 50^0 W or over the range $(50\text{-}90)^0$E and $(50\text{-}90)^0$W. Thus, it may be derived from here that H_α solar flares occurred within lower heliographic latitude and longitude produce maximum number of GMSs. Further, it is observed from Fig. 3(a) that 66.7% and 33.3% GMSs are produced by northern and southern X-ray solar flares and mostly effective latitudinal zone for producing GMSs is lying between $(0\text{-}40)^0$N to $(0\text{-}30)^0$S respectively. At the heliolatitude in the range $(0\text{-}40)^0$N to $(0\text{-}40)^0$S, there is a concentration of 100% of X-ray solar flares associated with GMSs and no storm is produced by X-ray solar flares beyond 40^0N and 40^0S. It is apparent from Fig. 3(b) that 45.9% and 54.1% GMSs are produced by eastern X-ray solar flares and western X-ray solar flares and mostly effective longitudinal zone for producing GMS is lying between $(0\text{-}50)^0$E and $(0\text{-}50)^0$W respectively (Bavassano et al, 1994). At the heliolongitude in the range $(0\text{-}50)^0$E to $(0\text{-}50)^0$W, there is concentration of 91.7% of X-ray solar flares associated with GMSs and no storm is produced by X-ray solar flares beyond 70^0E and 60^0W.

It is observed from Fig. 4(a) that 69.3% and 30.7% GMSs are produced by northern and southern APDFs and mostly effective latitudinal zone for producing GMSs is lying between $(0\text{-}30)^0$N and $(0\text{-}30)^0$S respectively. At the heliolatitude in the range $(0\text{-}30)^0$N to $(0\text{-}30)^0$S, there is concentration of 88.5% of APDFs associated with GMSs and no storm is produced by APDFs beyond 40^0N and 40^0S. Remaining 11.5% of APDFs, distributed over the range $(30\text{-}50)^0$N and $(30\text{-}50)^0$S are associated with GMSs. Again Fig. 4(b) shows that 53.9% GMSs and 46% GMSs are produced by eastern and western APDFs respectively and mostly effective longitudinal zone for producing GMSs is lying between $(0\text{-}40)^0$E and $(0\text{-}50)^0$W respectively. At the heliolongitude in the range $(0\text{-}40)^0$E to $(0\text{-}50)^0$W, there is concentration of 69.3% of APDFs associated with GMSs. Remaining 31.7% of APDFs, associated with GMSs are distributed over the range $(40\text{-}90)^0$E and $(50\text{-}90)^0$W. Thus, it may be inferred that APDFs, occurred within lower heliographical latitude/longitude are able to produce a strong configuration of closed magnetic region which causes fast/slow I.P. shock in interplanetary medium leading to the occurrence of GMSs on the Earth.

4 Conclusions

From the rigorous analysis of data, the following conclusions are drawn :

(i) H_α, X-ray solar flares and APDFs in lower heliolatitude and longitude produce larger number of GMSs. No GMS is produced by H_α, X-ray solar flares beyond 40^0N and 40^0S.

(ii) No significant correlation between magnitude (intensity) of GMSs and Importance of H_α, X-ray solar flares and APDFs have been observed.

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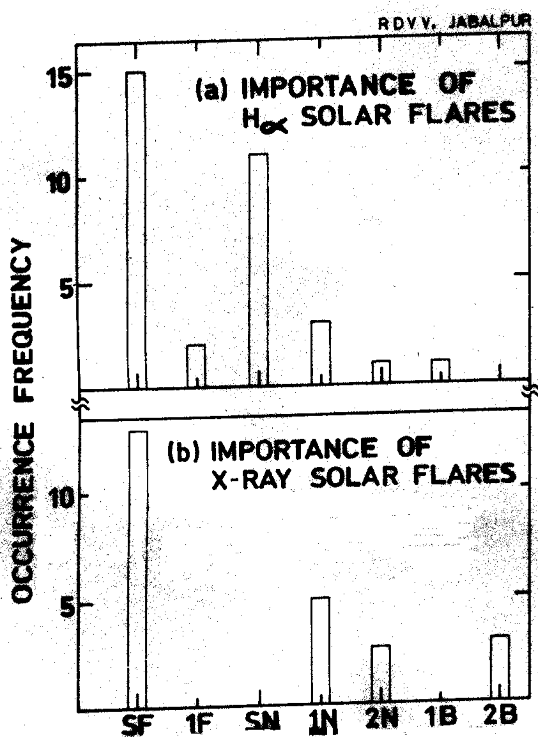

Fig 1. The occurrence frequency of (a) Hα and (b) X-ray solar flares' importance plotted histographically during 1978-93.

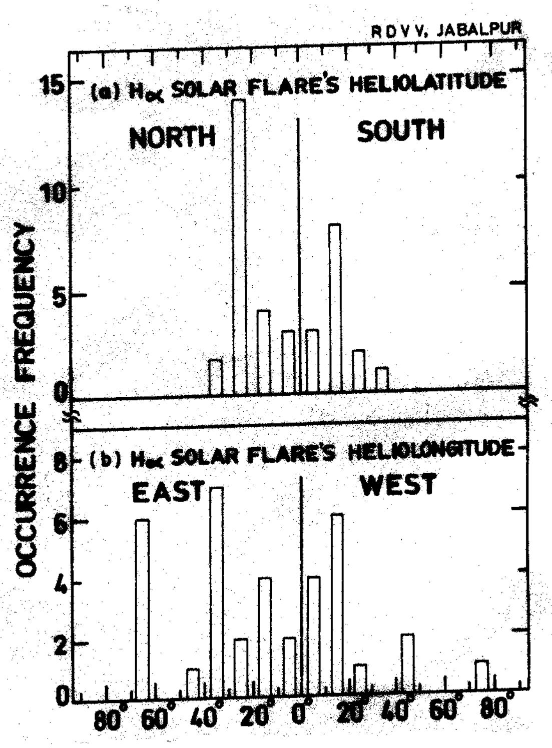

Fig 2. The occurrence frequency of Hα solar flares' helio- (a) latitude and (b) longitude plotted histographically during 1978-93.

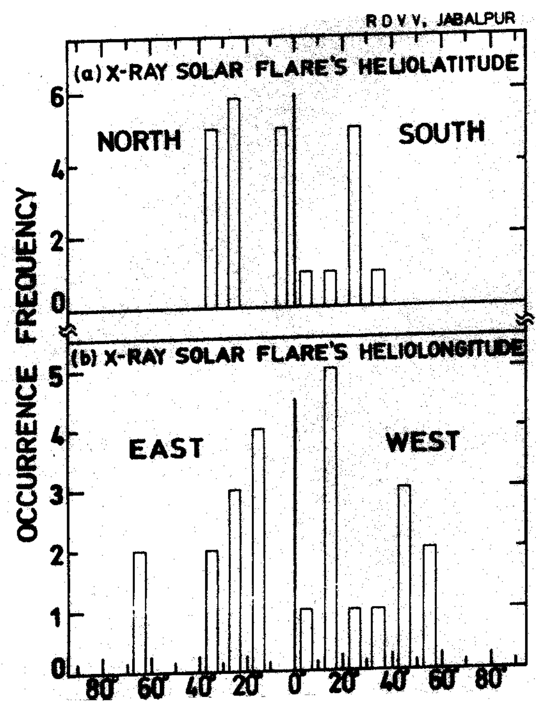

Fig 3. The occurrence frequency of X-ray solar flares' helio- (a) latitude and (b) longitude plotted histographically during 1978-93.

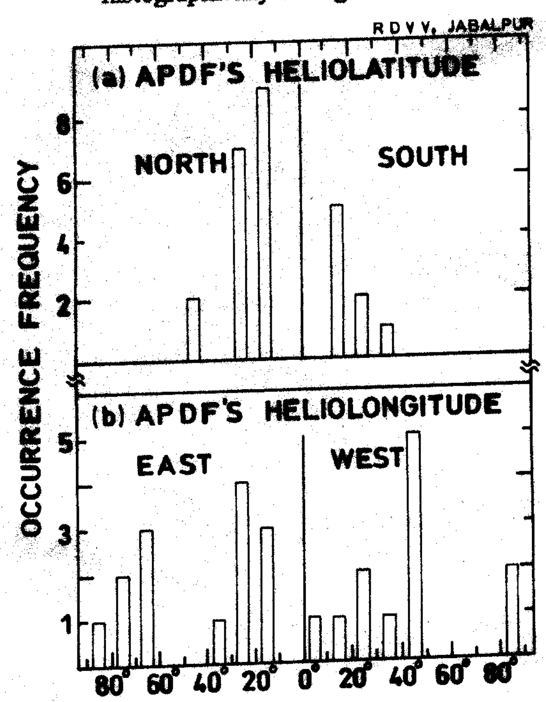

Fig 4. The occurrence frequency of APDFs' helio- (a) latitude and (b) longitude plotted histographically during 1978-93.