Ann. Geophys., t 34, fasc. 1, 1978, p. 47-49

On the onset of equatorial spread-F

by

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ABSTRACT – *Using quarter-hourly ionogram data at Kodaikanal (Geo Mag Lat 0 6°N, Dip 3.5°N) for a one year period of high solar activity, a study is made of the behaviour of F-region around the time of the post sunset appearance of spread-F The results indicate the absence of any particular threshold height for the bottom of the F-region for the onset of spread-F. Flucuating east-west electric field does not appear to be a prerequisite for the onset of equatorial spread-F.*

RESUME. – *On a fait une étude du comportement de la région F aux alentours du temps de l'apparition de spread-F après le coucher du soleil, en utilisant des ionogrammes enregistrés tous les quarts d'heure à KODAIKANAL (Latitude géomagnétique 0,6°N, Dip 3,5°N) pendant une période d'un an de forte activité solaire Les résultats indiquent l'absence d'une hauteur seuil particulière pour la limite inférieure de la région F pour le déclenchement du spread-F Il paraît que le champ électrique fluctuant est-ouest n'est pas nécessaire au déclenchement du spread-F Il paraît que le champ électrique fluctuant est-ouest n'est pas nécessaire au déclenchement du spread-F équatorial.*

Introduction

The phenomenon of equatorial spread-F as observed on bottomside ionograms has been extensively studied over the past two and half decades using published ionospheric data (refer to Clemesha and Wright, 1966 and to references in Skinner and Kelleher, 1971 for earlier work) and in recent times using original ionogram data (Chandra and Rastogi, 1972 ; Sastri and Murthy 1975a ; Sastri et al., 1975). Although partial reflection from small field aligned irregularities in F-region ionization is widely considered to be responsible for equatorial spread-F, the mechanisms responsible for the production and sustenance of the irregularities are not yet clear (refer to Farley et al., 1970).

One of the well established features of equatorial spread-F is the close association of its onset with the post sunset rise of the F-region. From a comparative study of the average nocturnal variation of $h'F$ on nights with and without spread-F at two equatorial stations . Kodaikanal and Huancayo around a period of high solar activity, Rao (1966) inferred the presence of a threshold height of about 400 Km. for the occurrence of spread-F in the post sunset period. The VHF scatter observations of Farely et al., (1970) also indicate that the bottom of the F-region is to be above some threshold altitude for the irregularities and hence spread-F to manifest.

McClure and Woodman (1972) noticed similarities in the statistical patterns of equatorial spread-F and electrostatic turbulence. Hanson et al., (1973) suggested that turbulent electric fields in the F-region could be a necessary condition for equatorial spread-F. Recently Somayajulu et al., (1975) observed significant fluctuations in $h'F$ at Trivandrum (Dip 0.6°S) on night with long enduring spread-F. In contrast they noticed that nights with short duration spread-F exhibit only a single maximum in $h'F$ and devoid of any significant fluctuations in $h'F$. Since fluctuations in $h'F$ correspond to vertical motion of the F-region which at the equator is attributed mainly to electrodynamic drift caused by east-west electric field, they suggested that fluctuating east-west electric field forms one of the prerequisites of spread-F generating and sustaining mechanisms.

In this brief communication, we present the results of a study of the behaviour of F-region at the time of the onset of equatorial spread-F. The study is based on the quater-hourly ionogram data at Kodaikanal (Geo. Mag. Lat: 0.6°N, Dip 3.5°N) for a one year period

(January-December 1958) of high solar activity (Mean sunspot number R_z = 185). The analysis essentially consisted of a careful examination of the quarter-hourly ionograms in the post sunset period and the values of $h'F$ at the first post sunset appearance of spread-F on individual nights are noted down. Following accepted practicle, the value of $h'F$ is taken to represent the true hight of the bottom of the F-region.

Results

Figure 1 shows mass plots of $h'F$ at the time of the first post sunset appearance of spread-F corresponding to individual nights as a function of planetary magnetic index Ap. As the post sunset behaviour of $h'F$ in the

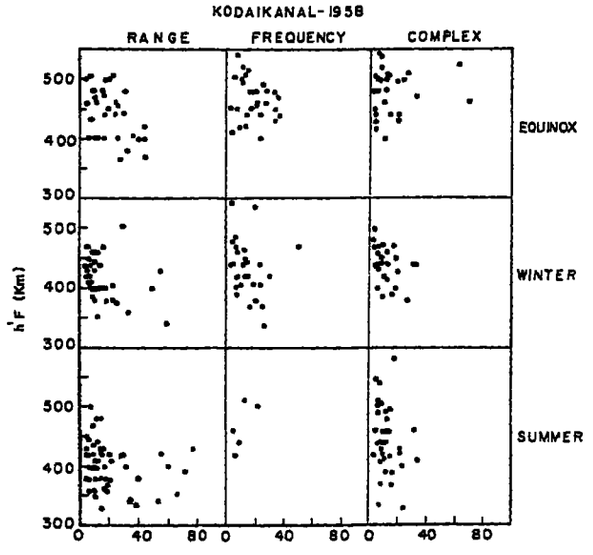

Fig. 1

Mass Plots of $h'F$ at the time of first post sunset appearance of spread-F at Kodaikanal during 1958.

electrojet region is known to be influenced by geomagnetic activity and hence could contribute to variability in the values of $h'F$ on individual nights, the mass plots are drawn as a function of Ap The season wise breakup is felt necessary inview of the earlier work of Rao (1966) which indicates the percentage occurrence of spread-F associated with different hights of the F-region to be dependent on season. Besides, it has been noticed that the spread-F configuration is not the same on individual nights at the time of the onset in the post sunset period. It is therefore felt desirable to study mass plots of $h'F$ separately for different types of configurations, which is all the more appropriate as the observations of Farley et al (1970) refer to a particular class of spread-F wherein irregularities are noticed only at the bottomside of the F-region. In the present study, spread-F configurations at the time of onset are divided into three groups; range, frequency and complex. The range group consists of two types of configurations: one where in spreading is present only at the low frequency end of the F-layer trace with clear cut $FoF2$ cusps and the other wherein spreading extends over the entire frequency range of the F-layer trace. The frequency group is characterised by configuration wherein spread exists only at and around the criticial frequency. Configurations which do not fall either into range or frequency group are termed complex. It can be seen from Fig. 1 that there is considerable scatter (by about 250 Km,) in the values of $h'F$ at the time of onset of spread-F irrespective of the type of configuration and season. This behaviour indicates the absence of any particular threshold height for the onset of equatorial spread-F. In a recent study, we have noticed that there is no particular threshold height for the bottom of the F-region for the sustenance of equatorial spread-F (Sastri and Murthy, 1975b). It is therefore apparent that the onset and sustenance of equatorial spread-F does not depend only on the height of the F-region.

It is extensively reported in literature that enchanced geomagnetic activity leads to an inhibition of the occurrence of equatorial spread-F. However, not much is known about the effect of geomagnetic activity on the onset of equatorial spread-F. In Fig. 2 we show the distributions of Kp for nights with and without the onset of spread-F in the post sunset period at Kodaikanal. Since the onset of spread-F is noticed to occur mostly between 1800-2100 I.S.T., the Kp value corresponding to the 3 hour interval 12-15 U.T. (1730-2030 I.S.T.) is taken into consideration. It can be seen from Fig. 2 that nights with onset of spread-F are usually associated with low values of Kp ($Kp \leqslant 3$) and nights without onset with high values of Kp ($Kp > 3$) indicating that ingeneral, enhanced geomagnetic activity leads to an inhibition of the onset of equatorial spread-F in the post sunset period.

During the period January-December 1958, we have 20 nights on which ionograms are available at 5 minute intervals. These 20 nights are noticed to be scattered over the year and correspond to different levels of geomagnetic activity, thus providing a suitable sample to examine whether fluctuating east-west electric field is a prerequisite for the onset of spread-F. $h'F$ values at 5 minute intervals have been scaled for these 20 nights during the time interval 1800-2100 I.S.T. It is found that there are no significant short period fluctuations in $h'F$ around the time of onset of spread-F on any of these nights. This can be seen from Figure 3 wherein the post sunset behaviour of $h'F$ is presented for some of these nights. It is apparent therefore that fluctuating

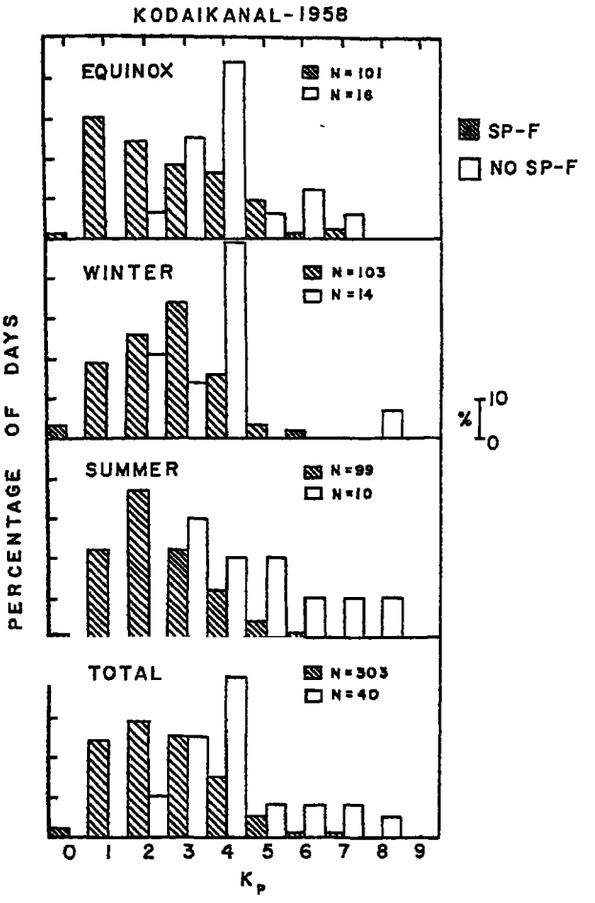

Fig. 2

Distribution of *Kp* (1730-2030 IST) for nights with and without onset of spread-*F* in the post sunset period.

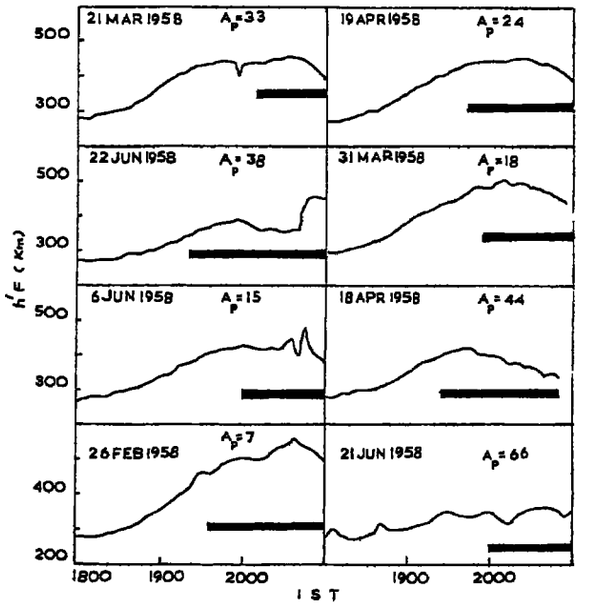

Fig. 3

Typical examples of the post sunset variation of *h'F* (from 5 min. interval ionograms) at Kodaikanal. The dark areas on the plots indicate the presence of spread-*F*.

east-west electric field is not necessarily a prerequisite for the onset of equatorial spread-*F*.

manuscrit reçu le 03.06.1977

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