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Equatorial Spread-F Configurations & Geomagnetic Activity

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Using quarter-hourly ionogram data at Kodaikanal (geomag. lat : 0.6°N; dip : 3·5°N) for the period 1957-63 a study is made of the effect of geomagnetic activity on the occurrence of range and frequency types of spread-F. It is found that the occurrence of both range and frequency types of spread-F shows a significant negative correlation with geomagnetic activity but only during years of high sunspot activity

One well documented feature of the phenomenon of equatorial spread-F is the inhibiting effect of geomagnetic activity on its occurrence, which influence is noticed to be most apparent during the premidnight period of high sunspot activity conditions.[1-7] Most of these earlier studies were, however, based on published ionospheric data bulletins. A more gainful approach that is now being adopted for morphological studies of equatorial spread-F is to make use of ionogram data to provide information on the type of spread-F and hence a better insight into the phenomenon.[6,8-10] It is known that spread-F manifests usually in two basic forms referred to as range and frequency types on equatorial ionograms.[8,9,11] The range type of spread-F is characterized by the presence of spread either only at the low frequency end of the F-layer trace with clear cut f_0F2 cusps or over the entire frequency range of the F-layer trace. The frequency type of spread-F, on the otherhand, is characterized by the presence of spread only at and around the critical frequency (f_0F2). The mechanisms responsible for these two basic types of spread-F on equatorial ionograms are considered to be different. The range type of spread-F has been explained as due to scattering from thin field-aligned irregularities in F-region ionization, and the frequency type of spread-F as due to ducting or waveguide propagation of radio waves by thick field-aligned irregularities.[12,13] The physical processes involved in the production and maintenance of these field-aligned irregularities are yet to be established,[14] although some progress has been made in the very recent times.[15,16]

In this communication, we present the results of a study of the effect of geomagnetic activity on the occurrence of range and frequency types of spread-F at Kodaikanal (geomag. lat: 0·6°N; dip: 3·5°N), an electrojet station in the Indian equatorial region. The study is felt worthwhile in view of the paucity of information in literature on the effect of geomagnetic activity on individual types of spread-F at electrojet stations. The study is based on the original quarter-hourly ionogram data at Kodaikanal covering the period 1957-1963, encompassing conditions of high, moderate and low sunspot activities. The analysis consisted of a careful visual examination of the ionograms to note down the presence and if so the type of spread-F at 15-min intervals for each night. From these data, the percentage occurrence (defined as the ratio of the number of ionogram frames exhibiting spread-F to the total number of ionogram frames examined, multiplied by 100) of either type of spread-F (range or frequency) is calculated for each night for the entire 7-yr period considered. It is to be emphasized here that rather unusual forms of spread-F are known to exist on equatorial ionograms,[8,9] and these have not been taken into consideration in the analysis. The effect of geomagnetic activity is studied by evaluating the cross-correlation for each year between the daily values of the planetary geomagnetic index (A_p) and the occurrence of range and frequency types of spread-F with time shifts from −4 to +4 days.

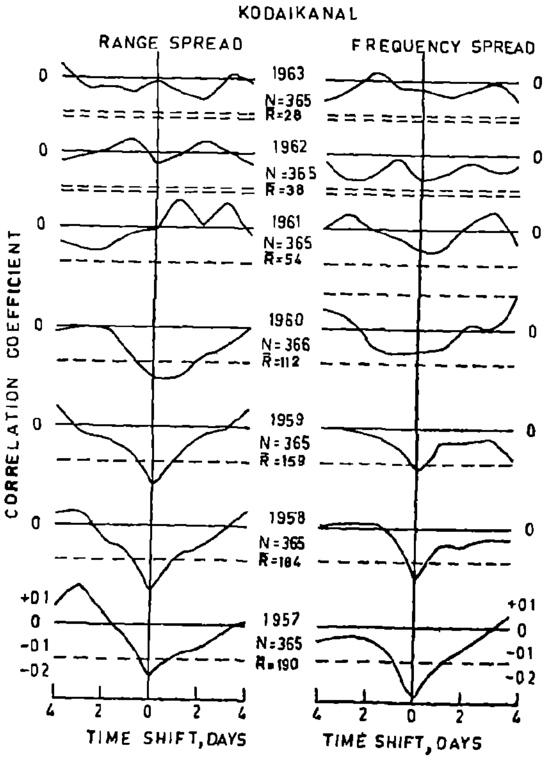

Fig. 1 — Cross-correlograms between A_p and the occurrence of range and frequency types of spread-F for each year from 1957 to 1963 (The horizontal dotted lines on the plots indicate the correlation coefficient corresponding to a significance level of 99% for the data sample (N=No. of data points) used. $\bar{R}$ represents the annual mean of the sunspot number.)

In Fig 1 are shown the cross-correlograms between A_p and the occurrence of range and frequency types of spread-F for each year from 1957 to 1963. It can be clearly seen from Fig. 1 that there is a significant negative correlation (level of significance > 99%) at zero time lag between A_p and the occurrence of both range and frequency types of spread-F during years of high sunspot activity. No such trend is, however, apparent during periods of low sunspot activity. These findings thus indicate that the marked inhibiting influence of geomagnetic activity on the occurrence of spread-F at Kodaikanal during high sunspot activity conditions noticed in earlier studies[1,4,9] represents the behaviour of both range and frequency types of spread-F. This behaviour of spread-F configurations at Kodaikanal in relation to geomagnetic activity is different from that at Chungli (24·95°N; 121·-°E dip; 19°N), near Taipei, where only the range type of spread-F is reported to exhibit a significant negative correlation with geomagnetic activity.[17] Further studies are therefore needed to assess whether the difference in behaviour at Kodaikanal and Chungli represents a longitudinal or latitudinal effect.

In a very recent study (communicated) of spread-F configurations at Kodaikanal for the period 1957-63, we have noticed that during periods of high sunspot activity, range type of spread-F occurs predominantly during the pre-midnight hours with a peak around 20-21 hrs LT and frequency type of spread-F during the post-midnight period with a broad maximum around 00-02 hrs LT. It is well known that the equatorial F-region exhibits a marked increase in height in the post-sunset period especially during high sunspot activity conditions.[1,2,6,8] At Kodaikanal in particular, the variation of h'F (widely taken to represent the height of the bottom of the nocturnal F-region) in the post-sunset period exhibits a peak around 20-21 hrs LT.[7] The above observations suggest that the occurrence of range spread-F is closely connected with the post-sunset height rise of the F-region. The negative correlation of range spread with geomagnetic activity noticed in the present study can be explained, at least in a qualitative way, in terms of the above understanding as the post-sunset height rise at Kodaikanal is known to be reduced during geomagnetically disturbed days compared to quiet days, during high sunspot activity conditions.[18] Further studies nevertheless are very much required to throw light on the way the influence of geomagnetic activity is brought about for the following reasons. The post-sunset height rise of F-region is partly apparent due to loss of ionization by recombination and diffusion at that time. The direct measurements of F-region vertical drift at Jicamarca, however, indicate the involvement of a true vertical drift in the post-sunset height rise as they clearly show the presence of a peak in the upward vertical drift just prior to the reversal around the sunset time.[19,20] There is no agreed opinion at the moment as to the importance of the factors associated with the post-sunset height rise (i.e. pre-reversal peak in F-region vertical drift and the altitude attained, the latter depending on vertical drift recombination and perhaps diffusion). To elaborate, the vhf scatter observations at Jicamarca indicate that the bottom of the F-region is to be above some threshold altitude for the irregularities and hence spread-F to occur in the post-sunset period.[14] Our recent detailed studies at Kodaikanal, both for high and low sunspot activity conditions, did not show the presence of any particular threshold height for the occurrence of spread-F in the post-sunset period, suggesting that the post-sunset occurrence of spread-F is not uniquely dependent on the height attained.[21,22] The inhibiting influence of geomagnetic activity on the occurrence of frequency type of spread-F during high sunspot activity years evident in the present study is a new and interesting feature of equatorial spread-F. As already mentioned, the frequency type of spread-F is considered to be due to ducting by thick field-aligned irregularities. There is not much information in literature, however, as to the parameters or processes involved in the generation and maintenance of such irregularities. Further work on this aspect is necessary to help in an understanding of the behaviour of frequency type of spread F.

References

1. Bhargava B N, *Indian J. Met Geophys.*, **9** (1958), 35.
2. Lyon A J, Skinner, N J & Wright R W H, *J. atmos. terr. Phys.*, **21** (1961), 100.
3. Rao C V S & Mitra S N, *J. geophys Res.*, **67** (1962), 127.
4. Rangaswamy S & Kapasi K B, *J. atmos. terr. Phys*, **25** (1963), 721.
5. Marasigan V, *J. atmos. terr. Phys.*, **18** (1960), 43.
6. Skinner N J & Keller R F, *Annls Géophys.*, **27** (1971), 181.
7. Chandra H & Rastogi R G, *Annls. Géophys*, **28** (1972), 709.
8. Chandra H & Rastogi R G, *Annls Géophys.*, **28** (1972), 37.
9. Sastri J H & Murthy B S, *Annls Géophys.*, **31** (1975), 285.
10. Sastri J H, Murthy B S & Sasidharan K, *Annls Géophys.*, **31** (1975), 409.
11. Clemesha B R & Wright R W H, *Spread-F and its effect on radio wave propagation and communication*, edited by P Newman, Technivision, Maidenhead, England, 1966, 3.
12. Calvert W & Cohen R, *J. geophys. Res.*, **66** (1961), 3125.
13. Pitteway M L V & Cohen R, *J. geophys Res.*, **66** (1961), 3141.
14. Farley D T, Balsley B B, Woodman R F & McClure J P, *J. geophys. Res.*, **75** (1970), 7199.
15. Woodman R F & La Hozic, *J. geophys. Res.*, **81** (1976), 5447.
16. Morse F A, Edgar B C, Koons H C, Rice C J, Heikkila W J, Haffman J H, Tinsley B A, Winnigham J D, Cristensen A B, Woodman R F, Pomalaza J & Teixeira N R, *J. geophys Res*, **82** (1977), 578.
17. Huang C M, *J. geophys. Res.*, **75** (1970), 4833.
18. Rangaswamy S & Kapasi K B, *J atmos. terr. Phys.*, **26** (1964), 871.
19. Balsley B B & Woodman R F, *J. atmos. terr. Phys.*, **31** (1969), 865.
20. Woodman R F, *J. geophys. Res*, **75** (1970), 6249.
21. Sastri J H & Murthy B S, *Annls Géophys*, **34** (1978), 47.
22. Sastri J H, Subrahmanyam V, Sasidharan K & Srirama Rao M, *Curr. Sci.*, **47** (1978), 451.