Study of the Equatorial and Low latitude Spread-F Occurrence Characteristics and their Possible Predictions in the Indian zone

<u>R. S. Dabas¹</u>, Rupesh M. Das¹, V. K. Vohra¹, S. C. Garg¹, C. V. <u>Devasia²</u>, K. S. V. Subbarao², K. Niranjan³ and P. V. S. Rama Rao³

Radio and Atmospheric Sciences Division, National Physical Laboratory, New Delhi – 110012, India Space Physics Laboratory, Vikram Sarabhai Space Centre, Trivandrum-695022, India Department of Physics, Andhra University, Visakhapatnam-530003, India rajdabas@nplindia.ernet.in

For the prediction of equatorial spread-F irregularities, simultaneous ionosonde and scintillation data from Trivandrum (8.2N, 76.9E), Waltair (17.7N, 83.3E) and Delhi (28.6N, 77.2E) is examined in relation to daily h'F and ExB drift velocity determined from the rise of h'F between 1800 and 1900 LT over the magnetic equator. It is noted that except summer, spread-F at Trivandrum, Waltair and Delhi are observed only when ExB (h'F) is more than about 15m/s (325km), 20m/s (350km) and 25m/s (375km) respectively. Night-to-night occurrences of spread-F can be predicted using threshold values of h'F or ExB with a success rate of more than 90 %, 50% and 15 % respectively at Trivandrum, Waltair and Delhi.

Introduction:

The equatorial and low latitude ionosphere is highly dynamic, unpredictable and is characterised by the existence of daytime equatorial ionisation anomaly (EIA) and night time intense equatorial plasma bubble associated irregularities caused by the E and F region dynamo processes generating eastward electric fields. These irregularities, also known as equatorial spread F (ESF), affect almost all radio communication and navigational systems utilising the earth-space propagation path. Current attention is directed toward understanding the cause and effect relationships of ESF irregularities in order to gain prediction capability in the equatorial and low latitude region where the effect is most severe. Significant progress has been made during the past two or three decades in understanding the basic plasma processes governing the generation and growth of the equatorial plasma bubble and associated ionospheric irregularities. In the present study, multi-station digital ionosonde and scintillation data from the Indian zone (see figure 1) is utilise to study the night-to-night occurrence characteristics of equatorial spread-F irregularities and their latitudinal growth in relation to the pre-reversal enhancement in equatorial h'F and its rate of rise (vertical ExB drift) and the ratio of low latitude and equatorial foF2 as indicator of anomaly strength. Main objective of the study is to find out whether there exist is any threshold values of the above controlling parameters conducive for the onset and growth of spread-F/scintillation activity in Indian zone for their possible forecasting on night-to-night basis.

Results and Discussion

To study the night-to-night occurrence, altitudinal/latitudinal growth of equatorial spread-F irregularities, and their relationship with controlling parameters, daily digital ionosonde data from Trivandrum (8.2 N, 76.9 E), Waltair (17.7 N, 83.3E) and Delhi (28.6 N, 77.2 E) for the high solar activity period January to December 2001 is analysed. 250 MHz scintillation data from Bhopal (23.2 N, 77.6 E) for the equinoxes (March-April, September-October 2001), and 4 GHz scintillation data from INSAT-1B (74 ° E) satellite at Chenglepet (10.4 ° N, 79.5°E) and Sikandarabad (26.8° N; 77.8° E) for September-October, 1989 periods has also been utilized. The results of analysis shows that during winter and equinoxial months spread F/scintillation occurrences at these locations are associated with the generation of equatorial plasma bubble and associated irregularities whereas in summer they are caused by irregularities generated locally.

To gain forecasting capability of spread-F irregularities, their night-to-night occurrences at these locations are examined in relation to evening hours variations of h'F and dh'F/dt (ExB drift velocity) determined from the rise of F-region Ionograms Trace altitude at 4 MHz between 1800 LT to 1900 LT over the magnetic equator using Trivandrum daily ionosonde data. The maximum h'F and ExB drift are observed during the equinoxial period and minimum during summer. It is noted that except summer, spread-F at Trivandrum, Waltair and Delhi are observed only when ExB (h'F) is more than about 15 m/s (325km), 20 m/s (350km) and 25 m/s (375km) respectively (see figure 2). In addition, similar study, using equatorial h'F and ExB values obtained from Trivandrum ionograms, is carried out with simultaneous 4 GHz scintillation observations at two locations (one near magnetic equator and other near Delhi) during September-October 1989. Results of the study (see figure 3) again shows that spread-F

and scintillations near equator are observed when ExB (h'F) is more than 15 m/s (325 km) whereas 4GHz scintillations, near Delhi, are observed only when ExB (h'F) is more than 30 m/s (400 km). Also, intensity of 4GHz scintillation at low latitude is found to be positively correlated with both ExB and h'F values whereas no such correlation is found with that of equatorial scintillations. The results of the study indicates that, for the satellite communication and navigation applications, night-to-night occurrences of spread F, in the Indian zone, can be predicted using the evening hours threshold h'F or ExB drift velocity values (obtained from equatorial ionosonde observations) with success rate of about more than 90 %, 50% and 15 % respectively in the case of Trivandrum, Waltair and Delhi. In the case of 4 GHz scintillations, the success rate is about 30 % to observe scintillation over low latitude. The above results show that at or near magnetic equator threshold values of ExB or h'F can be successfully used for the prediction of spread-F/scintillations but prediction of their latitudinal extent depends upon some other parameters as well e.g. background ionisation etc.



Figure 1. Locations of Ionosonde and Scintillation observing stations



Figure 2. Evening hours ExB & h'F values over the magnetic equator when Spread-F is observed at Trivandrum, Waltair and Delhi during -2001



TRV. SPREAD-F AND SKD.(1989),CHPT.(1989),BHOPAL(2001) VHF SCINT. (MARCH,APRIL,OCTOBER and NOVEMBER)

Figure 3. Evening hours ExB & h'F values over the magnetic equator when 4 GHz scintillations are observed at Chenglepet and Sikandarabad during Sept.-Oct. 1989 and VHF scintillations are observed at Bhopal during March-April & Sept.-Oct. 2001