J. Geomag. Geoelectr., **29**, 497-502, 1977

Small Scale Fluctuations in the *F*-Region Critical Frequency at Kodaikanal

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(Received December 5, 1976; Revised March 12, 1977)

Some preliminary results obtained on the small scale fluctuations in the *F*-region critical frequency at Kodaikanal (Dip 3.5°) using 1-min interval ionograms, are presented. Spectral analysis showed the fluctuations to contain dominant periods in the range 5-60 min.

1. Introduction

The characteristics of Travelling Ionospheric Disturbances (TID's) have been studied by several investigators using the various available radio techniques (MUNRO, 1950, 1958; VALVERDE, 1958; CHAN and VILLARD, 1962; TITHERIDGE, 1963, 1968a, b; GEORGES, 1968; DAVIS and DA ROSA, 1969; KENT and GUPTA, 1971; REDDY and RAO, 1971; SASTRI and SUBRAHMANYAM, 1973; MURTHY and RAO, 1974). It is now widely considered that TID's correspond to disturbances of neutral gas associated with the passage of atmospheric gravity waves in the ionosphere (HINES, 1960; PITTEWAY and HINES, 1965; HINES and REDDY, 1967; HOOKE, 1968; TESTUD and FRANCOIS, 1971). Theoretical investigations of the propagation characteristics of atmospheric gravity waves assuming a model atmosphere and ionosphere and also the ionospheric response to the same, have been carried out by several workers (MIDGLEY and LIEMOHN, 1966; HINES, 1968; KLOSTERMEYER, 1969a, b; HOOKE, 1968, 1970; NELSON, 1968; THOME, 1968). HOOKE (1968) studied in detail the ionospheric response to individual gravity waves as a function of azimuth of propagation and found the response to be highly anisotropic, the anisotropy being dependent on the wave parameters, the geomagnetic dip and the prevailing ionization density gradients. He showed that the probability for causing perturbation in the electron density is more for gravity waves travelling in meridional direction than in zonal direction. A continuous spectrum of grvity waves travelling meridionally over the globe produces different effects at different latitudes, i.e., the preferred periods in the electron density perturbations will be different latitudes. NAGPAL and GUPTA (1973) reported some evidence in support of this feature from a study of fluctuations in f_0F_2 at Delhi, Ahmedabad and Huancayo.

In view of the paucity of observations on the characteristics of TID's at low dip latitudes and the importance ot the same, a systematic study of TID's has been started at Kodaikanal (Geograph. Lat. 10°14′N, Geomag. Lat. 0.6°N, Dip 3.5°) and this brief communication is devoted to a presentation of some of the preliminary results. The experimental technique adopted by us is similar in principle to that of KENT and GUPTA (1971), i.e., continuous monitoring of f_oF_2 at 1 min-intervals, but differs in detail in that the fluctuations in f_oF_2 are monitored automatically with a C-3 ionosonde rather than manually as was done by Kent and Gupta. Observations are usually made during the period 0900–1600 hr LT to avoid large fluctuations in f_oF_2 due to production and loss of ionisation around sunrise and sunset times respectively. The accuracy of scaling f_oF_2 from our ionograms is ± 50 kHz. Observations made during the 4-month period from October 1974 through January 1975 are presented and discussed in this short paper. The period of observation on individual occasions ranged from 4 to 6 hr. Examination of the f_oF_2 data thus gathered showed small scale fluctuations superimposed on the diuranal trend in f_oF_2. The diurnal variation of f_oF_2 at Kodaikanal generally (on magnetically quite days) shows a pre-noon maximum at around 0900 hr and a post-noon maximum around 1700 hr with a minimum (noon bite-out) around 1100 hr. Since the main aim of the present study is to infor the dominant periods of small-scale fluctuations in f_oF_2, the diurnal trend has to be first removed from the observed data of f_oF_2. For this, using a standard procedure, a straight line is fitted for most of the records which are taken between 1100–1630 hr, during which period it is always observed a linear increase in f_oF_2. For records taken between 0900–1500 hr, two straight lines are fitted, one between the pre-noon maximum to the minimum, during which period the variation of f_oF_2 is almost a linear decrease, and another between the minimum to the post-noon maximum, during which period f_oF_2 increases almost linearly. After fitting the straight lines, the trend is removed from the observed data of f_oF_2. The detrended fluctuations are then subjected to a spectral analysis which consists in evaluating the auto correlation function which is Fourier transformed to give the raw power spectrum. The raw power spectrum is then smoothed using the Hamming weight (BLACKMAN and TUKEY, 1959).

2. Results

Table 1 gives the statistics of the records used for the present study. In all 10 records are analysed and the results are presented below.

Figure 1 shows a typical example of the fluctuation in f_oF_2 observed at Kodaikanal on 10 January 1975, together with the corresponding frequency

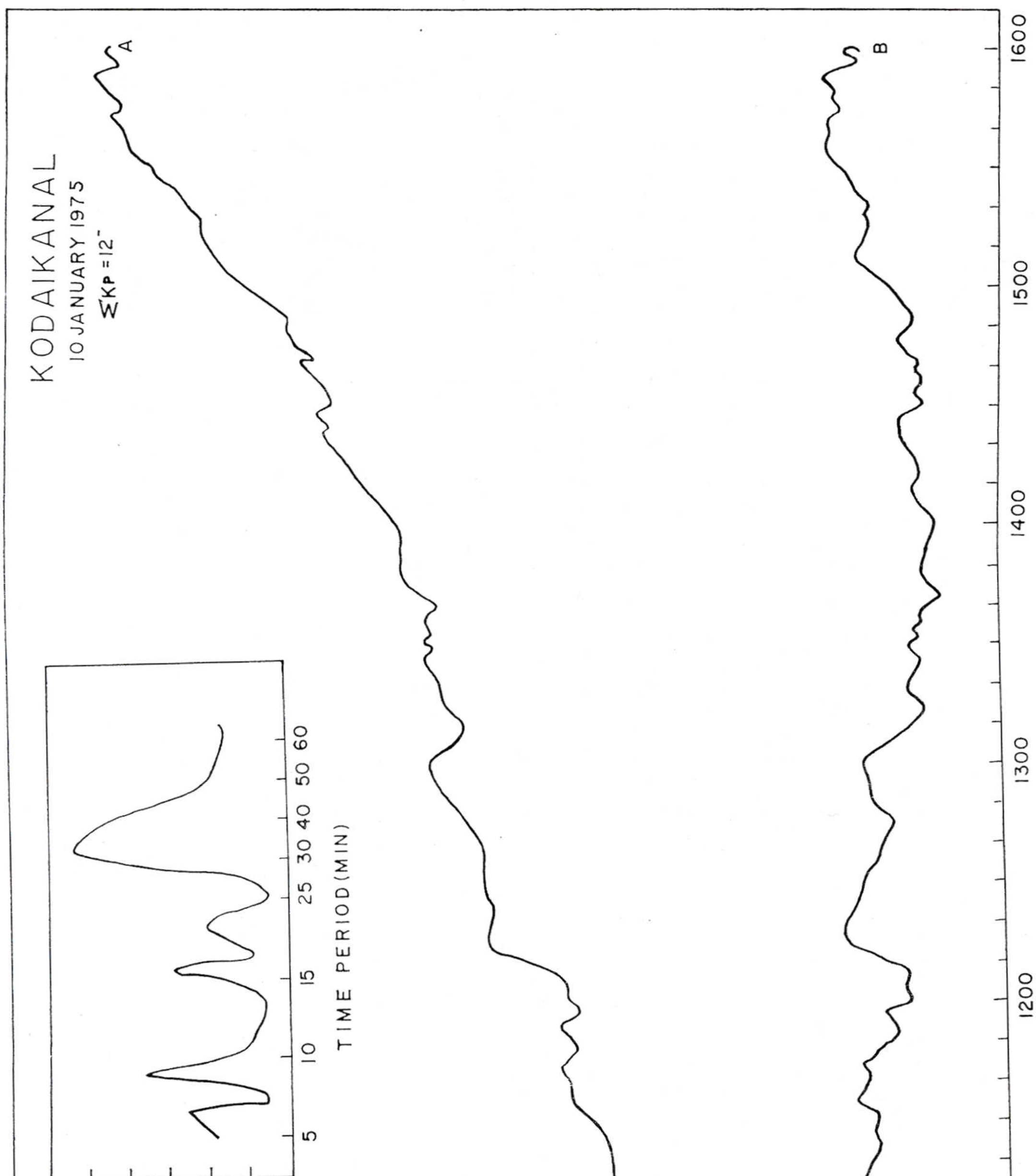

Fig. 1. A typical example of fluctuations in f_oF_2 during day time observed at Kodaikanal on 10 January 1975. Curve A shows the actual time variation of f_oF_2 and Curve B is the detrended version of the same. Also shown in the inset is the corresponding frequency spectrum.

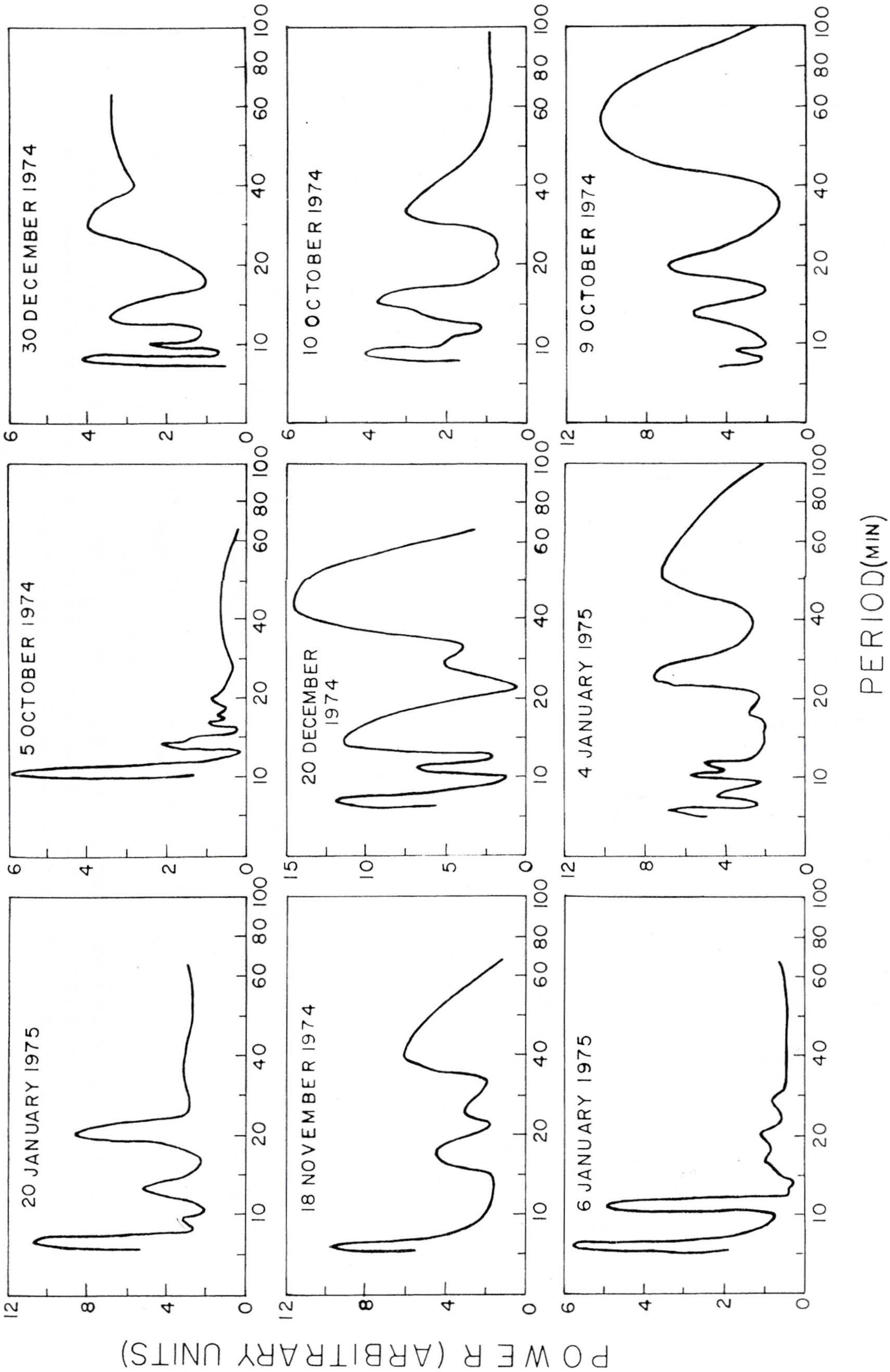

Fig. 2. Frequency spectra of fluctuations in f_oF_2 during day time observed at Kodaikanal during the period October 1974–January 1975.

Table 1. Statistics of the records used for the study of small scale fluctuations in f_0F_2 at Kodaikanal.

Date	Duration of the record hours (I.S.T.)	Number of datapoints	Standard error (±MHz)	Dominant periods (min)	No. of degrees of freedom at longer periods (*K*)
5-10-74	1200–1600	241	0.05	10	—
9-10-74	0900–1250	231	0.02	13, 20, 50–70	5
10-10-74	0918–1502	345	0.048	8, 15, 28	3
18-11-74	0900–1500	361	0.054	6, 40	4
20-12-74	1111–1555	285	0.050	7, 14, 45	5
30-12-74	1100–1508	309	0.040	8, 14, 28	4
4-1-75	1100–1600	301	0.050	6, 10, 27, 52	4
6-1-75	1100–1600	301	0.031	6, 11	—
10-1-75	1100–1600	301	0.046	9, 33	4
20-1-75	1130–1630	301	0.010	6, 20	2

spectrum. Curve A represents the time variation of f_oF_2 and curve B is the detrended version showing the fluctuations in f_oF_2. It can be seen from Fig. 1 that there are two dominant periods around 9 min and 33 min in the fluctuations of f_oF_2 on this day. The power spectra for the remaining 9 occasions are presented in Fig. 2. One striking feature of all the 10 spectra investigated, as can be seen from Figs. 1 and 2 is the presence of several maxima and minima, although these do not occur at the same period on individual occasions. The dominant periods are found to be in the range 5–60 min. From Table 1 it can be seen that the number of degrees of freedom (K) at longer periods is found to be between 2 and 5. The spectrum is said to be moderatly smooth, if $K>3$ (BLACKMAN and TUKEY, 1959). Hence the observed spectra at longer periods can be taken to be fairly accurate.

The spectral features of the fluctuations in f_oF_2 observed by us bear close resemblance to the medium scale TID's studied by several workers using various sensitive radio techniques (GEORGES, 1968; KENT and GUPTA, 1971; TITHERIDGE, 1968a, b; REDDY and RAO, 1971; SASTRI and SUBRAHMANYAM, 1973: MURTHY and RAO, 1974). We attribute the observed fluctuations in f_oF_2 to be due to atmospheric gravity waves as the dominant periods of the fluctuations fall within the known frequency spectrum of gravity waves.

The authors are grateful to Dr. M.K.V. Bappu, Director, Indian Institute of Astrophysics, for his encouragement and interest in this work. The assistance of Shri K. Sasidharan in some of the computational work is thankfully acknowledged.

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