# Planetary-scale perturbations on ionosphere F-region at equatorial and tropical latitude

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## Abstract

Spectral analysis technique has been used to investigate planetary wave (PWs) perturbation on equatorial ionospheric F-region. We use ground-based critical frequency of the F2-region ($f_oF_2$) and peak height ($h_mF_2$) data, obtained from Ibadan, from January to December 1958 (IGY-period), a year of solar maximum, with $R_z$=185. Wave amplitude variation is estimated between ~ 2.86-6.70 MHz and ~23-30 km in $f_oF_2$ and $h_mF_2$ data respectively. Approximately 2-day and 10-day periodicities are found in $h_mF_2$ and $f_oF_2$ spectra respectively. Our results are valuable for applications in radio propagation and telecommunications, as they are responsible for part of the radiowave propagation condition predictions.

## 1 Introduction

Equatorial atmosphere-ionosphere system has been the subject of extensive theoretical, modeling and experimental investigations these days. These studies have determined the nature, generation, propagation, and dissipation mechanisms of planetary waves, tidal waves, gravity waves as well as infrasonic waves from lower-lying regions. However, there is still considerable difficulty in the understanding of the equational dynamical and electrodynamical coupling processes responsible for large variability in the equatorial ionospheric phenomena; particularly at the equatorial and tropical latitude. The critical frequency of $F_2$ region and the peak height, $hmF_2$ are fundamental parameters that are used in the specification and predication of the structure of the $F_2$ region. Waves can propagate vertically upward from the lower into the upper layers of the middle atmosphere, observational data manifest these waves. The thermospheric winds are highly variable as a result of changes in the global tidal forcing and effects of irregular winds, planetary, and gravity waves [1]-[2]. Several recent studies suggest that planetary waves play an important role in the electrodynamics of the lower thermosphere [3-5]. These planetary waves in turn may modify the oscillation of the ionospheric parameters. In this study, we use ground-based observational data from Ibadan to study the spectral structures of $F_2$ region parameters.

## 2 Data

We use the hourly-recorded ionospheric sounding data of critical frequency, $f_oF_2$ and Peak height, $h_mF_2$ at Ibadan (7.4$^0$N, 3.9$^0$E; 6$^0$S dip), a tropical latitude station in Nigeria. The data cover the period of International Geophysical Year (IGY: 1957/58); a year of high sunspot number, with $R_z$ = 185. Our database is grouped as follows: geomagnetically quiet-day time and quiet-nighttime, geomagnetically disturbed-daytime and disturbed nighttime conditions. Fourier transforms are subsequently used on the data sets to produce spectral structures of $f_0F_2$ and $h_mF_2$.

## 3 Results

The top panels in Fig 1 give the spectral structures of $f_0F_2$ during the quiet daytime and nighttime conditions. The bottom panels show the disturbed daytime and nighttime conditions. Geomagnetic quiet period here is defined as Kp indices smaller or equal to 3, while geomagnetic disturbed period is defined as Kp indices greater than 3. As can be seen, Fig 1 several periodicities in the $f_0F_2$ spectra. Also, the amplitudes of the strongest peak during the daytime quiet and disturbed periods are comparable, and the quiet and disturbed nighttime conditions are comparable as well. Double-peak structures can be seen in Fig 1 (a), (b) and (d) in the strongest peak in each case. The spectral pattern are very similar in plots (a) and (b). a weaker terdiurnal (8-hour) oscillations are found in these plots as well. The periodicities observed during disturbed nighttime are quite different. These features are in agreement with the work of [6].

Figure 2 (panels a to d) shows $h_mF_2$ spectra. Relatively fewer peaks are observed in Fig 2. Also, Fig 2(a) shows three well-defined peaks. Two visible peaks can be seen in Fig 2(c). The variations are smooth during nighttime conditions (plots b and d).

However, it is important to note that, $f_0F_2$ spectra exhibit peaks whose periods are integral fraction of solar day, by contrast, these features are not found in $h_mF_2$ spectra. In addition, a clear long period oscillation is obvious in $f_0F_2$ data with almost 11-13-day periodicity. This result is consistent with 10-day tropospherically forced planetary ware reported by [7], on the other hand, about less than 2-day oscillation is a persistent feature of $h_mF_2$ spectra. There is strong wave amplitudes variability in $f_0F_2$ and $h_mF_2$ spectral. $f_0F_2$ wave amplitude varies between ~ 2.86 to 6.70 MHZ whereas an $h_mF_2$ wave amplitude change is between 23-30 km. Thus, the perturbations induced by the planetary waves from below may contribute to the observed daily variability in the peak height of electron density and critical frequency of $F_2$ layer. This result is close agreement with conclusion of [8]. [9] pointed out that recent results from airglow, radar and ionospheric sounding observations demonstrate the existence of significant planetary wave influence on plasma parameters at E and F region heights over equatorial latitudes. Upward transport of wave energy and momentum due to gravity-, tidal- and planetary waves from below and extra-tropics control the phenomenology of the equational atmosphere-ionosphere system [9]. Tides generated in the troposphere and stratosphere propagate into the lower thermosphere, dissipating their energy at 100-150 km altitude, thus releasing considerable amounts of momentum and energy into the region [10].

Nonetheless, the results of the present study clearly indicate the forcing effects on the upper ionosphere. Our results are valuable for applications in radio propagation and telecommunications, as they are responsible for part of uncertainty of the radio wave propagation condition predictions.

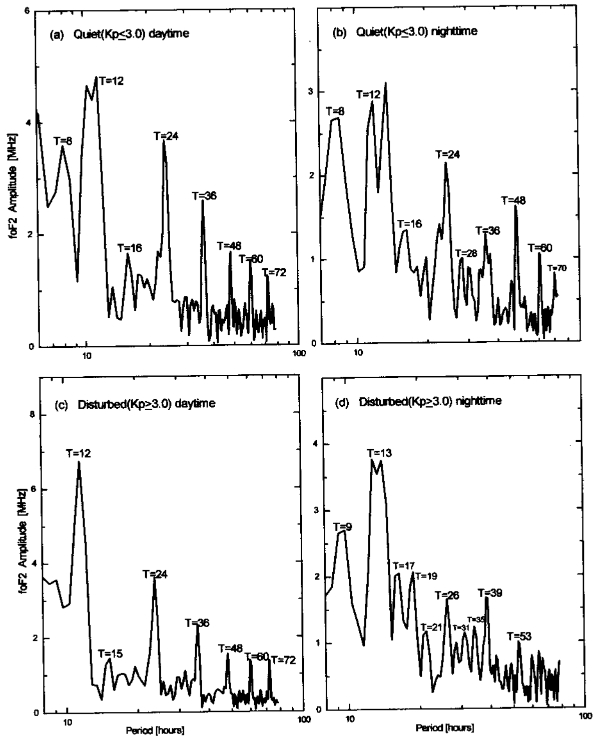


Fig. 1. Spectra structures of F2 region critical frequency(foF2) for low and high geomagnetic activity conditions and for daytime and nighttime sectors during solar maximum.

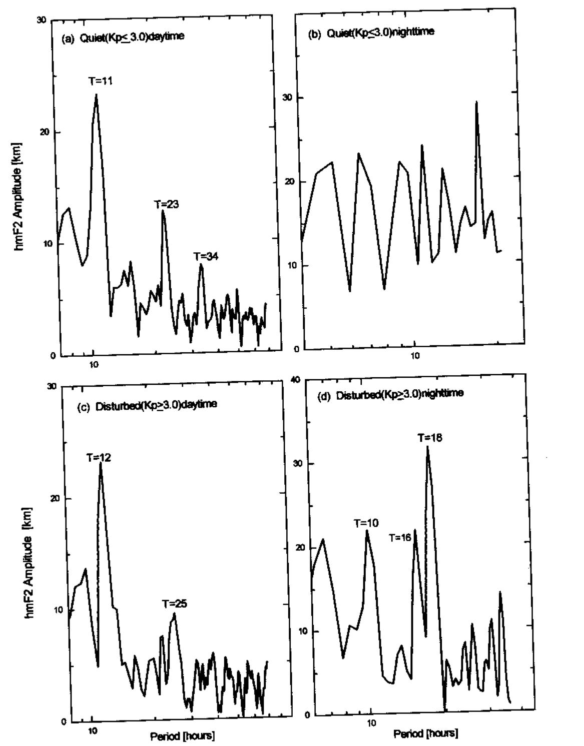


Fig. 2. Spectra structures of peak height of F2 layer for:quiet-daytime, quiet-nighttime, disturbed-daytime and disturbed nighttime conditions under high solar flux.

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