Geofísica Internacional (1991) Vol. 30, Num. 4, pp. 249-252

Comparative study of ionogram F2 peak height from different techniques

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RESUMEN

Hicimos una intercomparación entre los parámetros de altura hmF2, hpF2 y hmF2(M(3000)) deducidos de la curva h'(f) para identificar las condiciones y tendencias, si existiesen, bajo las cuales el hmF2, de acuerdo con el análisis de la altura verdadera de POLAN, podría ser mejor representado por cualquiera de los otros dos parámetros que son obtenidos por consideraciones simples. El análisis es efectuado para una estación de latitud baja y otra ecuatorial, y para dos meses diferentes, representativos del verano y equinoccio locales. El análisis muestra que ambos, el hpF2 y el hmF2(M(3000)), son casi coincidentes durante la noche y dan una muy buena estimación del hmF2 (de acuerdo con el código POLAN), implicando que cualquiera de ellos puede ser usado para representar la altura del pico de la capa F2, dentro de la misma precisión. Sin embargo, durante el día el hpF2 da valores generalmente más altos que el hmF2(M(3000)), siendo la diferencia más pronunciada durante los meses de diciembre (verano local). Durante el día se observa también que el valor estimado de hmF2(M(3000)) supera el de hmF2 (obtenido de POLAN) en la estación ecuatorial, y es inferior al mismo en la estación de latitud baja, mientras que el valor de hpF2 es, en general, superior en ambas localidades.

PALABRAS CLAVE: altura pico de la capa F, altura real.

ABSTRACT

We have carried out an intercomparison of the layer height parameters hmF2, hpF2 and hpF2[M(3000)] all deduced from h'(f) curve, in order to identify the conditions and trends, if any, under which the hmF2, according to the POLAN true height analysis, could be best represented by either of the other two parameters that are obtained empirically from simple considerations. The analysis is carried out for a low-latitude and an equatorial station, for two different months, representative of local summer and equinox. The analysis shows that during nighttime hpF2 and hmF2[M(3000)] are almost coincident and both of them give a very good estimation of hmF2 (according to the POLAN code), implying that either of them could be used to represent the F2 layer peak height within the same precision. During daytime, however, hpF2 is generally higher than hmF2[M(3000)], the difference being more pronounced during December (local summer) months. It is observed that during daytime hmF2[M(3000)] overestimates hmF2 (derived using POLAN) over the equatorial station and underestimates it over the low-latitude station, while hpF2 generally overestimates it at both locations.

KEY WORDS: F layer peak height, true height.

INTRODUCTION

The F2 layer peak height, hmF2, is widely used in different research and practical applications and the ionogram from bottomside sounders is the most abundant source of this parameters. Also, there exist analysis techniques, such as POLAN code (Titheridge, 1985), that provide reliable determination (within ±5 km) of this parameter from ionograms (see also Paul, 1967). However, the processing of data in applications requiring large geographical and local time coverage is rather time consuming. In such cases the parameters hpF2 and hmF2[M(3000)], that can be obtained from routinely scaled ionograms, have been used extensively in ionospheric work, to represent the real F2 peak (de Paula *et al.*, 1981; Miller *et al.*, 1987; Forbes *et al.*, 1988; Abdu *et al.*, 1990). Recently, Berkey and Stonehocker (1989) made a comparison of hmF2 deduced from POLAN and the hmF2[M(3000)] for a 28 hours interval in a midlatitude station and they have found a good correlation between the two parameters.

The parameter hpF2 is the height of the maximum electron density for a parabolic profile, and is obtained directly from h'(f) profiles as the virtual height read at $0.834 f_o F2$ (Piggott and Rawer, 1978). The hmF2 [M(3000)] was first introduced by Shimazaki (1955) as hmF2 = 1490/M(3000)F2-176, where ionospheric transmission factor, M(3000)F2, is the maximum usable frequency for a path of 3000 km for F2-layer reflection. In this work we have carried out an intercomparison of the F layer height parameters hmF2, hpF2, and hmF2[M(3000)] over Fortaleza (4°S, 38°W) and over Cachoeira Paulista (23°S, 45°W) for March and December 1988.

DATA ANALYSIS AND RESULTS

The ionograms used in this analysis were registered in films on a C4 ionosonde (Fortaleza) and on a Magnetic AB ionosonde (Cachoeira Paulista). The ionograms were manually scaled (using a digitizing table and a micro-computer) for each hour during the periods March 14-22, 1988, and December 3-12, 1988, for both stations. The POLAN code was run for each hour to yield the hmF2 values. The three parameters were then intercompared on a day to day basis as well as their average for each month and each station.

Figures 1 to 4 show the average F2 peak height as a function of local time deduced by the three different techniques. It can be noted that the best correlation among the three parameters is obtained during nighttime when very

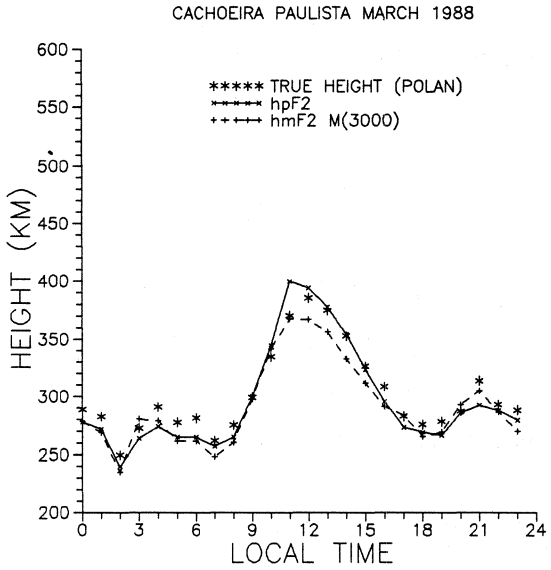

Fig. 1. Comparison between the F2 layer parameters hpF2, hmF2[M(3000)] and hmF2(POLAN) over Cachoeira Paulista for March 1988.

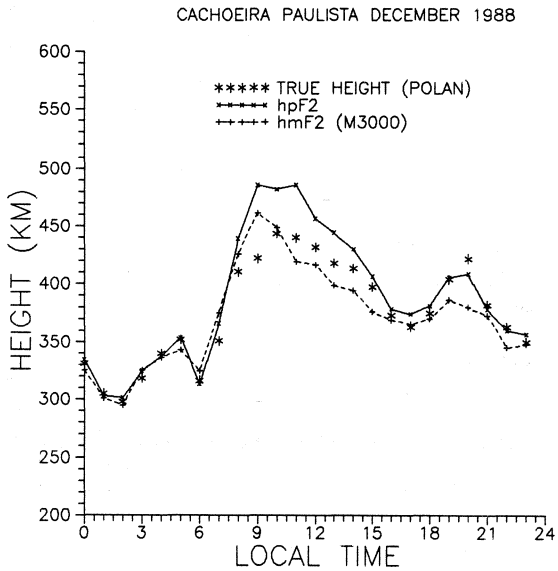

Fig. 2. Same as Figure 1 but for December 1988.

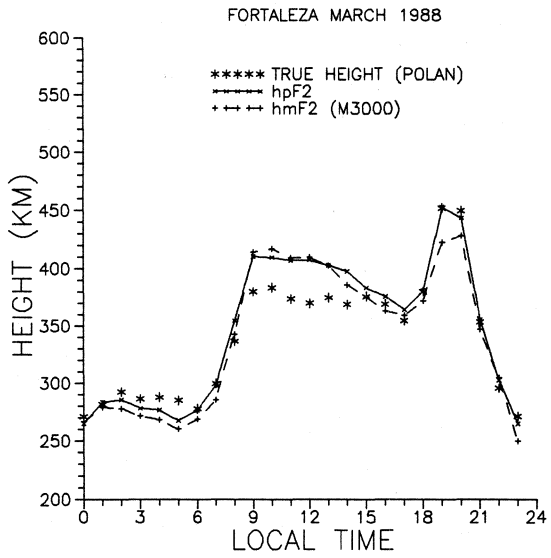

Fig. 3. Same as Figure 1 but over Fortaleza.

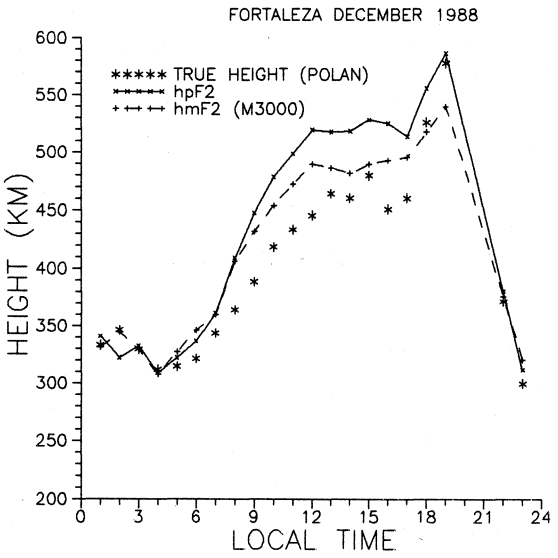

Fig. 4. Same as Figure 1 but over Fortaleza for December 1988.

few underlying ionization is present. During such periods hpF2 and hmF2[M(3000)] are almost coincident over both stations for the two periods included in this study. During daytime, on the other hand, the correlations are not as good as during nighttime periods. One common feature that can be observed during daytime is that hpF2 is always higher than hmF2[M(3000)] and almost always higher than hmF2 as deduced from POLAN code. The behavior of hmF2 [M(3000)] in relation to hmF2 (POLAN) shows some variability from one station to the other. Over Fortaleza hmF2[M(3000)] is almost always higher than hmF2. In such cases the modifications introduced in Shimazaki's formula to take into account a correction for the retardation by underlying ionization, as the one proposed by Bradley and Dudeney (1973), should give better results for the hmF2[M(3000)] values because the effects of that correction is to lower the deduced hmF2[M(3000)] during daytime and let them unchanged during nighttime, when no E-layer is present (see also Berkey and Stonehocker, 1989). Over Cachoeira Paulista, however, hmF2[M(3000)] underestimates the F layer peak height between ~1100 LT and 1500 LT during both periods analyzed in this work. In

Table 1

Mean deviation of the hpF2(Δ_1) and hmF2[M(3000)](Δ_2) in relation to hmF2 (POLAN)

	FZ 03/88		FZ 12/88		CP 03/88		CP 12/88	
Local Time	Δ_1	Δ_2	Δ_1	Δ_2	Δ_1	Δ_2	Δ_1	Δ_2
0000 to 2400	17	20	43	28	11	13	21	18
0600 to 1800	23	23	55	32	11	13	29	19
2400 to 0600	8	17	12	17	11	13	5	15

such cases the use of Bradley and Dudeney's (1973) formula would make the correlation between the hmF2[M(3000)] and the hmF2 (POLAN) even worse. So the statement of Berkey and Stonehocker (1989) that the formulation of Bradley and Dudeney (1973) gives the best correlation between hmF2[M(3000)] and hmF2 (POLAN) is not valid in our low latitude station Cachoeira Paulista, at least during the two periods analyzed in this work.

Table 1 shows the mean deviations from the true height values calculated as

$$\Delta_j = \sqrt{\sum_i x_i^2 / n} \ ,$$

where

$$x_i = \text{hmF2(POLAN)}_i - (h_j)_i \ ,$$

$$h_j = \text{hpF2} \quad \text{for } j = 1 \ ,$$

$$h_j = \text{hmF2[M(3000)]} \quad \text{for } j = 2 \ ,$$

and n is the number of data points. We can observe that the mean nighttime deviations are of the order of 12 km while the daytime deviations can be as large as 55 km. The higher daytime deviation is observed in hpF2, over Fortaleza during December 1988, and the lowest is observed also in hpF2 but over Cachoeira Paulista during March 1988. The daytime deviations are always greater than the nighttime deviations, except over Cachoeira Paulista on March 1988, when they are coincident. Although during daytime the deviations in hpF2 in relation to hmF2 are generally higher than the corresponding deviations in hmF2[M(3000)], they are always positive. This is an important point if empirical corrections will be applied to the data for ionospheric studies and predictions.

CONCLUSIONS

The comparison between the F layer peak height derived from three different methods showed good agreement during nighttime. During daytime hpF2 and hmF2[M(3000)] deviates from hmF2 by as much as 55 km and 32 km, respectively. hpF2 is always higher than the real F2 peak height during daytime over both Cachoeira Paulista and Fortaleza. This consistent behavior facilitates the use of empirical corrections to the data. On the other hand, hmF2[M(3000)]is sometimes above and sometimes below the hmF2. The usual corrections that take into account the underlying ionization have the effect to lower the hmF2[M(3000)] values, so they cannot be used indistinctly in our data.

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