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Diurnal variation of *B* parameters over Havana at low solar activity

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RESUMEN

Se presenta una tabla preliminar de los valores medios horarios de los parámetros de la región F2 del perfil de densidad electrónica de base: *B0* (parámetro de espesor) y *B1* (parámetro de forma) en el intervalo 00:00-23:00 LT. Se utilizaron en este estudio datos de sondeo vertical observados en La Habana (23°N; 278°E; Dip 54.6°N; Modip: 44.8°N) durante un periodo de invierno y baja actividad solar (R_{12}≈15). La variación diurna de *B0* exhibe valores mayores durante la noche que durante el día. El parámetro *B1* presenta en general valores superiores por el día.

PALABRAS CLAVE: Ionosfera, parámetros *B*, IRI, perfil N(h).

ABSTRACT

We present a preliminary table of mean values of the F2 region bottomside parameters *B0* (thickness parameter) and *B1* (shape parameter) for the time interval 00.00 LT-23.00 LT. Data from vertical ionospheric soundings at Havana (23°N; 278°E; Dip 54.6°N; Modip 44.8°N) during wintertime and low solar activity (R_{12}≈15) were used in the study. The diurnal variation of *B0* shows higher values during nighttime than during daytime. The *B1* parameter tends to be lower during nighttime than during daytime.

KEY WORDS: Bottomside ionosphere, *B* parameters, IRI, N(h) Profile.

INTRODUCTION

A comparison of experimental concentration profiles below the hmF2 with those generated by the International Reference Ionosphere (IRI) Model has shown some remarkable differences with low latitudes (Reinisch and Huang, 1996). Similar results were obtained by Adeniyi and Radicella over an equatorial region in the cases of high solar activity (Adeniyi and Radicella, 1998a), and low solar activity (Adeniyi and Radicella, 1998b). All these authors found that the IRI'95 model in general underestimates *B0* values. Recently Bilitza *et al*. (2000) carried out a study using data from several stations that had not yet been used in the IRI development, and deduced a new table of *B0* values that was included in the new version of IRI (Bilitza *et al*., 2001).

The region right below the F2 peak (bottomside F region), is represented in IRI by the following mathematical expression:

$$N(h) = N_m F2 \frac{\exp(-X^{B1})}{\cosh(X)} ,$$

where:

$$X = \frac{h_m F2 - h}{B0} .$$

It can easily be shown that *B0* is the height difference between hmF2 and the height $h_{0.24}$ where the electron density profile has dropped down to 0.24**NmF2*. *B0* therefore provides a measure of the thickness of the bottomside profile. *B1* parameter determines the shape of the profile between *hmF2* and $h_{0.24}$ and was set to 3 up to the IRI'2000 version. Bilitza *et al*. (2000) also defined new values for *B1*.

The IRI model provides two options for the calculation of *B0*, one of them based on a table of values deduced from ionosonde measurements (Bilitza *et al*., 2000; Bilitza, 2001). The other option is based on Gulyaeva's (1987) model for the half density height, which is defined as the height where the bottomside density has dropped down to half the F2 peak density.

The aim of the present paper is to analyze the diurnal variation of the B bottomside parameters *B0* and *B1* using data from vertical ionospheric soundings recorded at Havana and to compare with the corresponding IRI'2000

(UMLCAR Edition, 1999) table values. Besides, we check the general behaviour of the obtained *B* parameters at local noon and midnight with the new table values proposed in Bilitza *et al*., 2000, and Bilitza, 2001, using data from a station not included in the last formulation of the model.

MATERIALS AND METHODS

In this study, we used 320 hourly ionogram recorded at Havana (lat 23°N, long 278°E, dip 54.6°N, modip 44.8°N) corresponding to the wintertime of a low solar activity period (January 1976, R_{12}=15 and January 1977, R_{12}=17).The period analysed covers the 24 hours of the day. The electron density profiles were calculated using the POLAN ionogram inversion program (Titheridge, 1985, 1995). IRI'2000 prediction was obtained using CCIR and tabulated values option.

RESULTS AND DISCUSSION

Table 1 shows the hourly averages of the *B0* and *B1* parameters observed at Havana for the period analysed with the corresponding table values and IRI'2000 (UMLCAR Edition) prediction. The standard deviations are also indicated for each case.

The diurnal variation of the parameter *B0* (Figure 1) shows greater values during the night, reaching an absolute maximum at 20:00 LT, similar to the diurnal variation observed over Jicamarca (Reinisch and Huang, 1996) and in Pruhonice (Mosert *et al*., 1999a). This behaviour is contrary to the observed in Ouagadougou (Adeniyi and Radicella, 1997) and San Juan; (Mosert *et al.,* 1999b) where higher values of *B0* during daytime than during nighttime were reported.

Table 1

Hourly averages and standard deviations of the *B0* and *B1* values for Havana with the corresponding IRI'2000 *B0* predictions. The quantity (n) of ionograms used in the study is also indicated. Winter (January), $R_{12} \approx 15$.

LT	n	B0 (Km)			B1	
		Avr.	StDev.	IRI'2000	Avr.	StDev.
0	10	64	13	77	2.4	0.2
1	10	53	10	76	2.9	0.4
2	10	44	9	76	3.0	0.4
3	7	48	8	76	3.2	0.5
4	8	46	12	75	2.8	0.5
5	7	58	10	74	2.8	0.5
6	9	52	7	71	3.0	0.6
7	8	52	4	67	3.2	0.4
8	11	51	15	63	2.6	0.5
9	10	47	13	61	2.6	0.5
10	10	44	5	60	3.1	0.5
11	9	50	14	60	3.0	0.5
12	9	57	12	60	2.9	0.5
13	10	59	7	60	2.8	0.5
14	10	58	11	60	2.6	0.7
15	10	61	14	61	2.6	0.5
16	8	57	15	62	2.6	0.5
17	9	54	11	65	2.4	0.6
18	9	71	15	70	2.0	0.5
19	9	89	7	73	1.7	0.2
20	10	98	16	75	1.7	0.1
21	10	93	15	76	1.7	0.4
22	9	83	10	76	1.7	0.2
23	9	82	11	76	2.0	0.4

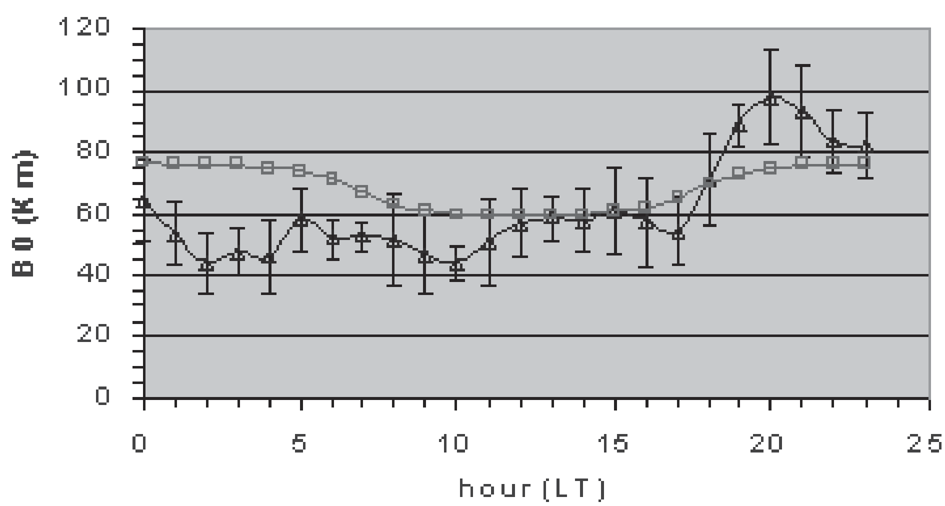

Fig. 1. Hourly average *B0* values for Havana (triangles) and IRI'2000 UMLCAR Edition tabulated values (squares). Winter (January), $R_{12} \approx 15$.

The *B0* values ranges between 98 and 44 while the corresponding IRI'2000 UMLCAR Edition, 1999 predictions varies between 77 and 60. The highest discrepancies are observed during nighttime. The IRI'2000 underestimates the *B0* values between 19:00-23:00 LT period. The rest of the day the *B0* values are overestimated by the model.

We calculated the *B0* averages of five hours centred around 00:00 (22:00-02:00), 06:00 (04:00-08:00), 12:00 (10:00-14:00) and 18:00 (16:00-21:00) LT (Figure 2), for both the experimental and modelled (UMLCAR Edition) values. It can be seen once more that *B0* presents higher values during nighttime than daytime.

We compare our *B0* values at 00:00 and 12:00 with those reported in Bilitza (2001). In the Figure 3, taken from the aforementioned paper, we pointed out our experimental values at noon (***n***) and at midnight (***m***). Non remarkable differences were found, $\Delta B0_n$ = 8 km and $\Delta B0_m$= 6 km.

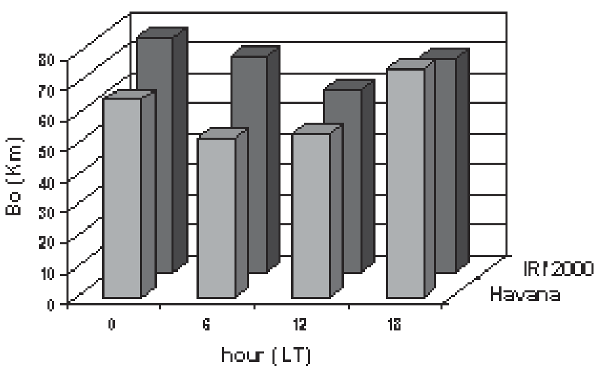

Fig. 2. Average *B0* five hours centred values for Havana and IRI'2000 UMLCAR Edition tabulated values. Winter (January), $R_{12} \approx 15$.

The *B1* hourly averages show some irregularity in their variation (Figure 4), although they present a light tendency to be greater during the daytime hours than during nighttime. This behaviour is more clearly exposed for the *B1* averages of five hours centred around 00, 06, 12 and 18 LT (Figure 5) This behaviour is not in agreement with the diurnal variation reported by Bilitza with *B1* varying from 1.8 for daytime and 2.6 for night time (Bilitza *et al.*, 2000; Bilitza, 2001) .

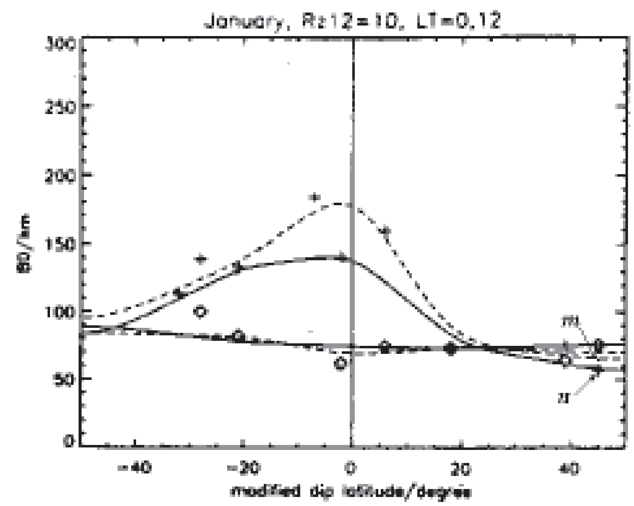

Fig. 3. Average *B0* values versus modified dip latitude for local noon (plus signs) and midnight (diamonds) for January, (R_{12} = 10), LT= 00, 12. Also included are the current *B0* model (solid curves) and the new *B0* model (dashed curves) The lower curves are for midnight, and the upper curves are for noon. Besides, the experimental *B0* values from Havana (Modip 44.8°N) have been pointed out at noon (***n***) and midnight (***m***) for Winter (January), $R_{12} \approx 15$. The figure was taken from Bilitza (2001).

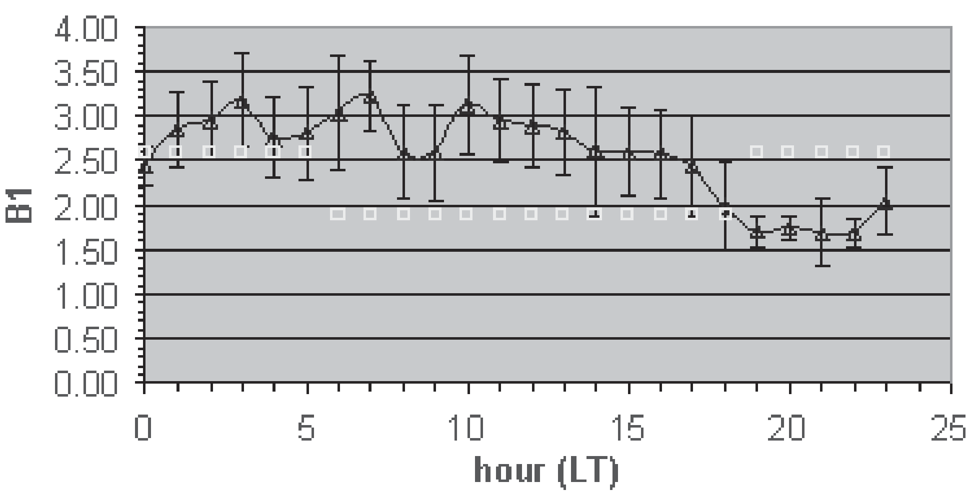

Fig. 4. Hourly averages of *B1* (triangles) and IRI'2001 *B1* values (squares). Winter (January), $R_{12} \approx 15$.

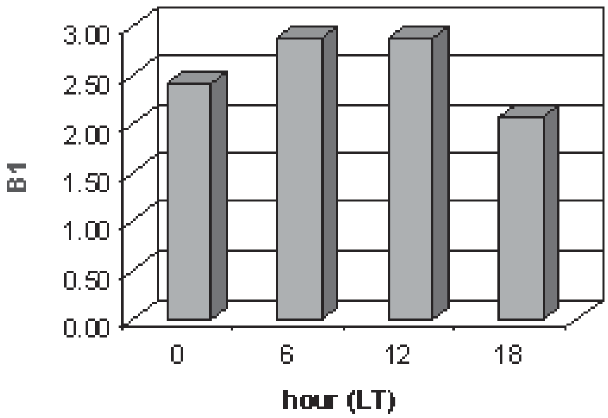

Fig. 5. Average *B1* five hours centred values for Havana and IRI'2001 B1 values (squares). Winter (January), $R_{12} \approx 15$.

CONCLUSIONS

A preliminary report on the diurnal variation of the bottomside parameters *B0* and *B1* over Havana has been presented using data recorded during wintertime and a low solar activity period. The comparisons with the Bilitza results (Bilitza *et al.*, 2000) show non remarkable differences at noon and midnight for *B0* parameter. The behaviour of *B1* is not in agreement with the diurnal variation of the aforementioned reported values. An extension of this study must be done for other seasonal and solar activity conditions.

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