PEAK CHARACTERISTICS OF THE F2 REGION OVER BUENOS AIRES: OBSERVATIONS AND PREDICTIONS

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ABSTRACT

The objective of this paper is to check the validity of International Reference Ionosphere (IRI) model topredict the maximum critical frequency of the F2-region of the ionosphere (*foF2*) and its height (*hmF2*) using ionosonde observations recorded at Buenos Aires , Argentina (34.6° S, 301.7° E; modip: 32.2° S).
Data corresponding to different seasonal and solar activity conditions have been used. CCIR and URSI options have been used to model calculations. The results show that, generally, the CCIR *foF2* predictions are slightly better than URSI *foF2* ones. Disagreements between observed and predicted foF2 values have been found, but in most of cases the deviations are not higher than 20%. The differences between observed and modelled values of *hmF2* are attributed to the propagation factor M(3000)F2.

Keywords: Ionosphere; F2-region; IRI model

RESUMEN

El objetivo del presente trabajo es chequear la validez del modelo de la Ionosfera Internacional de Referencia (IRI) para predecir la frecuencia crítica de la región F2 (*foF2*) y su altura (*hmF2*) haciendo uso de mediciones llevadas a cabo en Buenos Aires , Argentina (34.6° S, 301.7° E; modip: 32.2° S). La base de datos incluye ionogramas obtenidos bajo diferentes condiciones estacionales y de actividad solar. La opciones URSI and CCIR del modelo IRI han sido usadas para calcular las predicciones del modelo. Los resultados muestran que, en general, las predicciones de *foF2* calculadas con CCIR son ligeramente mejores que las de URSI. Discrepancias entre los valores experimentales y predichos de *foF2* han sido observadas pero en la mayoría de los casos las diferencias no superan el 20%. Las diferencias entre los valores experimentales y modelados de *hmF2* son atribuidas al factor de propagación adoptado por el IRI para sus predicciones.

Palabras claves: Ionosfera; foF2; hmF2; IRI model

INTRODUCTION

Information about the parameters of peak of the F2-layer: the critical frequency (*foF2*) and its height *(hmF2)* are of great importance for ionospheric radio-wave propagation studies, as well as for understanding the physics of the F2-region. While foF2 values can be obtained directly from the ionograms, the real heights are difficult to obtain from them. To solve this, a propagation factor M(3000)F2 (defined as MUF/foF2, where MUF is the maximum usable frequency refracted from the F2-layer of the ionosphere, could be received at a distance of 3000 km and foF2 is the critical frequency of the F2 –layer), was therefore devised that could derived graphically, directly from ionograms.
One of the most widely used empirical models is the International Reference Ionosphere (IRI) model

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(Bilitza and Reinisch, 2008). It is an empirical standard model of the ionosphere updated periodically. Over the years it has led improvements through several versions that has been tested and modified with extensive participation by the International research community and it has led to improvements through several versions (Bilitza, 1990; Bilitza and Reinisch, 2008, among others). For the worldwide description of the peak in the F2- region (*foF2*), the International Radio Consultative Committee (CCIR) coefficients maps (1967 a, 1967 b) and the International Union of Radio Science (URSI) coefficients map (Rush et al., 1989) are used as choices in the IRI model.
The description of *hmF2* has been reported earlier by Shimazaki (1955), who was first to describe the strong anti-correlation between *hmF2* and M (3000) F2 and his empirical formula of *hmF2*, modified later by Bradley and Dudeney (1973), Bilitza et al. (1979) and Bilitza (1990), who added the correction for retardation suffered by radio waves going through the underlying ionospheric regions.
In a previous work, Ezquer et al. (2008a) used measurements of the peak characteristics of F2-region (*foF2* and *hmF2*) over Tucumán (26.9 °S, 294.6° E) station placed near the southern peak of the equatorial anomaly, to check the validity of the IRI model. They found for foF2 deviations as high as 50%.
The objective of the present paper is to check the validity of the IRI model (Bilitza and Reinisch, 2008) to predict the parameters of the peak in the F2-region: the critical frequency of the F2-region (*foF2*) and its height (*hmF2*), using ionograms recorded at Buenos Aires during different seasonal and solar activity conditions.

DATA USED

Ionosonde measurements obtained at Buenos Aires (34.6° S, 301.7° E; modip: 32.2° S) have been used to calculate the monthly median values of the critical frequency of the F2 region (*foF2exp*) and of the experimental real height corresponding to the peak in the F2-Region (*hmF2exp*) . The data base includes ionograms obtained during different seasons of a year of low solar activity (LSA): 1996 (Rz12= 9.1) and a year of high solar activity (HSA): 1982 (Rz12= 114).
The monthly median values of *foF2exp* and *hmF2exp* have calculated for each hour during the representative months of the four seasons: January (summer), July (winter), April (fall) and October (spring).In this work, median values are used as monthly value because they have the advantage of being less affected by large deviations in the value of foF2 that can occur during magnetic storms. The *hmF2exp* values have been derived from the experimental M(3000)F2 factor scaled from the ionograms and using the very known empirical formula (Bilitza et al., 1979; Bilitza,1990):
hmF2exp.=1490/[M(3000)F2exp.+DM]–176 (1)
where DM is a correction factor that depends on the critical frequencies de the E and F2 regions, the solar activity and magnetic dip angle.
The predicted values of *foF2* have been obtained using the two IRI options (CCIR and URSI), from now *foF2 IRI CCIR* and *foF2 IRI URSI*. The predicted values of hmF2 have been obtained by the CCIR option provided by the model for hmF2, from now *hmF2 IRI CCIR* (Bilitza et al., 1979: Bilitza, 1990).
The deviations between the modeled and experimental values have been calculated for the two parameters as follows:
D %= [(modeled value – experimental value) / experimental value] x100 (2)

RESULTS

Figure 1 illustrates the comparisons between the experimental monthly median values of foF2 (*foF2exp*) and the two corresponding IRI predicted values (*foF2 IRI CCIR and foF2 IRI URSI*) for the months of January and July, representing summer and winter months respectively, for the years 1996 and 1982. Figure 2 depicts the same comparisons for the equinoctial months: April and October, representing fall and spring respectively. The analysis of the figures shows that, in general, the shape of the 3 curves (*foF2 exp, foF2 IRI CCIR and foF2 IRI URSI*) are similar: the minimum values are observed around sunrise (0400-0600 LT) and the maximum ones are present at midday or post midday hours. Although some exceptions have been found (October 1996), the model predicts the minimum *foF2* value at earlier times than those observed in the measurements. This behavior has been also found by Ezquer et al. (2008b) using stations of other latitudes.

They showed that the sunrise minimum in *foF2* is often shifted by 1 or even 2 h compared to the CCIR and URSI *foF2* model. The *foF2* values are lower in winter than in summer with equinoctial maximum during daytime. The solar activity effect on foF2 is also observed: higher values are observed in HSA than in LSA. This behavior is also observed in the IRI predictions.

For space constraints, the comparison between the *hmF2exp* values and the *hmF2IRI CCIR* predictions are not shown. However, Table 1 summarizes the results for *foF2 IRI CCIR, foF2 IRI URSI* and *hmF2 IRI CCIR* predictions. It shows, for the representative months of the four seasons: January, April, July and October and the two years, the percentage of cases with values of |D%| less than 10%, between 10 and 20 %, between 20 and 30 % and greater than 30% .It can be seen that *foF2 IRI CCIR* predictions are in general slightly better than the corresponding *foF2 IRI URSI* ones. In general the *foF2 IRI* predictions are better than those corresponding to *hmF2 IRI* ones. These results suggest that the IRI performance in predicting M (3000) F2 is worst than in predicting the parameter *foF2*.

It is important to take into account that the IRI model have been formulated using mainly data from the Northern hemisphere. The disagreements between observations and IRI predictions suggest that it is necessary to improve the peak parameters models in the IRI model formulation. The models need to include a greater data base, particularly from the Southern hemisphere.

CONCLUSIONS

The validity of the International Reference ionosphere (IRI) model to predict the electron density of the F2 region (*foF2*) and its height *(hmF2*) over Buenos Aires has been checked. In general, the predictions of foF2 are slightly better using the CCIR IRI option that the URSI one. In most of cases the deviations are less than 20%. For *hmF2*, greater disagreements have been observed, indicating that the IRI performance in predicting foF2 is better than in predicting the propagation factor M(3000)F2.

In order to improve the performance of the IRI model, additional mapping efforts will be done considering a greater data base mainly from the Southern hemisphere.

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Table 1.Percentage of cases in which the |D % | are less than 10%, between 10-20%, between 20-30% and greater than 30% for Buenos Aires, for the representative months on summer (January), fall (April), winter (July) and Spring (October), years 1996 (low solar activity) and 1982 (high solar activity)

		D% foF2 IRI – CCIR				D% foF2 IRI - URSI				D% hmF2 IRI - CCIR			
		<10	10-20	20-30	>30	<10	10-20	20-30	>30	<10	10-20	20-30	>30
1996	***Jan***	62	38	0	0	75	17	8	0	29	8	17	45
	Ap	26	58	16	0	37	38	21	4	12	21	25	41
	Jul	65	23	0	12	24	41	29	6	6	35	23	35
	Oct	50	38	8	4	13	42	37	8		33	21	45
1982	***Jan***	50	34	16		70	30	0	0	46	33	17	4
	Ap	46	25	21	8	50	17	25	8	33	17	12	38
	Jul	33	38	21	8	5	16	25	54	46	42	12	0
	Oct	87	13	0	0	75	25	0	0	79	21	0	0

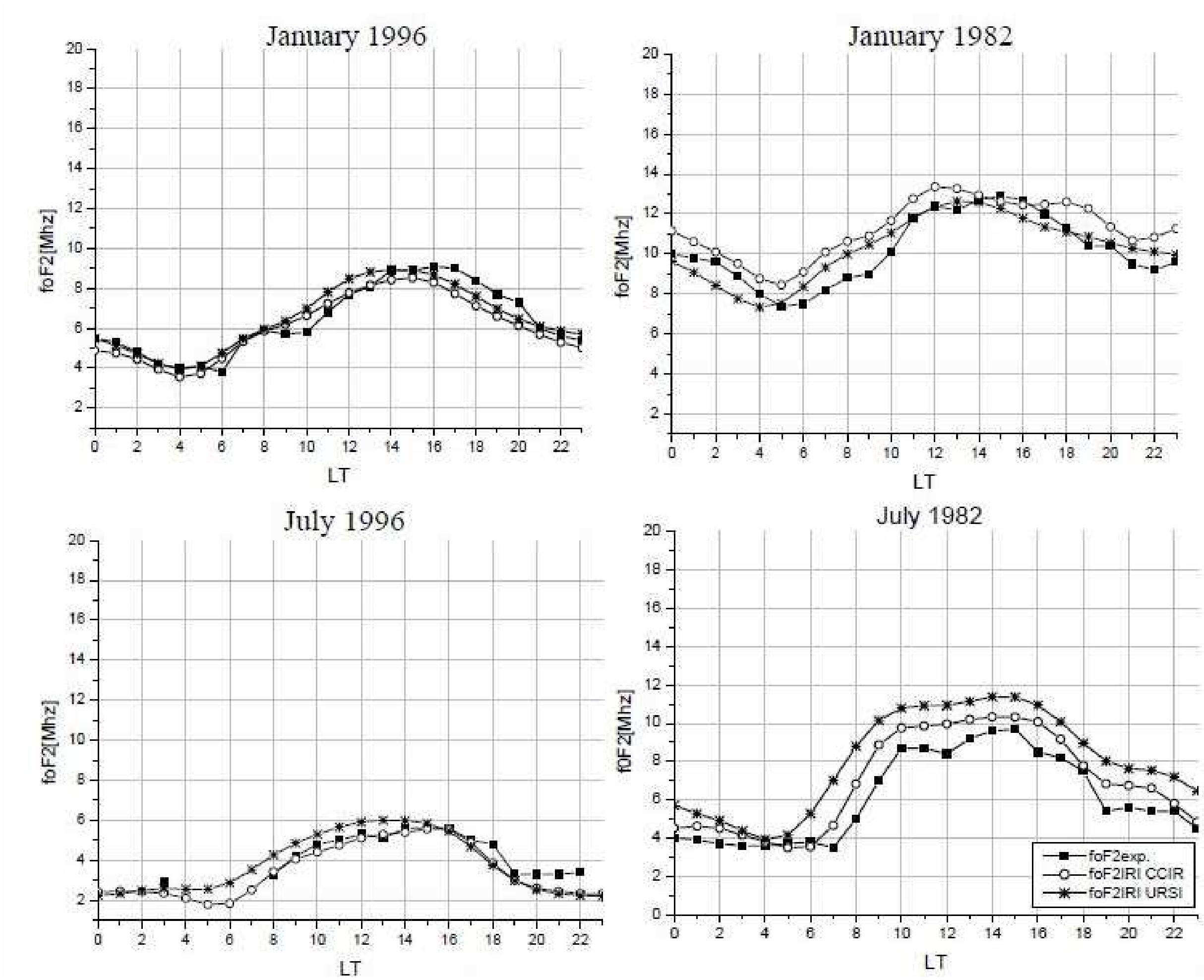

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Figure 1. Comparison between experimental monthly median values of *foF2*, in Mhz and the corresponding IRI predictions (CCIR and URSI) for Summer: January 1996 (Rz12=10) and 1982 (RZ12=137) and for Winter: July 1996 (Rz12=8) and 1982 (Rz12= 115)

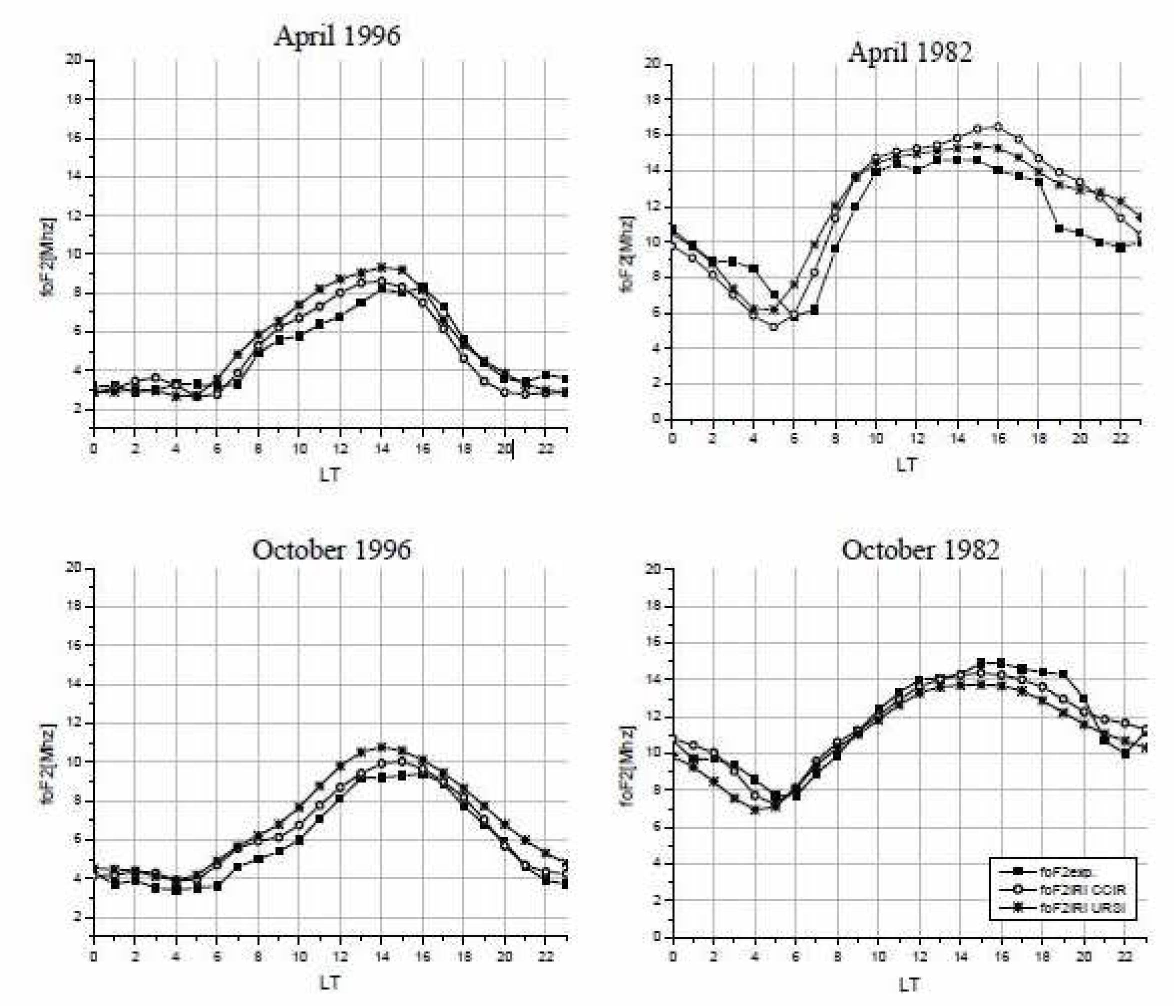

Figure 2. Comparison between experimental monthly median values of *foF2,* in Mhz and the corresponding IRI predictions (CCIR and URSI) for Fall: April 1996 (Rz12=8) and 1982 (RZ12=124) and for Spring: October 1996 (Rz12=9) and 1982 (Rz12= 96)

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