Pergamon

Adv. Space Res. Vol. 16, No. 1, pp. (1)121–(1)124, 1995

0273–1177/95 $9.50 + 0.00

0273–1177(95)00109–3

ON INFORMATIONS OBTAINABLE FROM DIGITAL IONOGRAMS AND THEIR CORRESPONDING REAL-HEIGHT PROFILES

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ABSTRACT

A set of more than 800 hourly ionograms recorded at Millstone Hill during July 89 and November 90 and inverted at the University of Massachusetts Lowell is the source of this study. This set contains the virtual and real-height profiles and the main classical ionospheric parameters. It is used in order to test the precision of different procedures leading to hmF2 the height of the maximum concentration in the F2 region, and also to establish the possibility of representing the real-height profile of the F2 region by a suitable generalized Chapman function.

DETERMINATION OF hm FROM THE IONOGRAMS

It is well know that a very good correlation exists between the M(3000)F2 factor obtained from the ionogram virtual heights and the value of hmF2 the height of the maximum of ionization of the F2 region /1-3/. A reasonable correlation exists also between hm and the virtual heights scaled at frequencies such as .834 foF2 or .7071 foF2 /4/. The parameter hpF2 = h`(.834 foF2) has been scaled during a long period of time and abandonned because of the influence of the underlying ionization.

Four ways of evaluating hm will be tested and then improved. Finally, the relevant accuracy will be evaluated.

In the first step, we will consider the four methods of evaluation of hm

$$hm = h`(.7071\ foF2) \qquad (1)\ /4/$$

$$hm = h`(.834\ fof2) = hpF2 \qquad (2)$$

$$hm = 1490 / [M(3000)F2 + dM] - 176$$

with $dM = 0.18 / (X - 1.4) + 0.096\ (R12 - 25) / 150$ (3) /5/

where $X = foF2 / foE$ or 1.7

R12 12-month smoothed sunspot number

or $dM = f1\ f2 / (X - f3) + f4$ (4) /2/

with f1, f2, f3, f4 as defined in the IRI 1990

The accuracy of hm determined by each of the four methods can be seen in histograms of $R = (hm_{LOW} - hm) / hm$ where hm_{LOW} is the value of hm computed with the ARTIST method (Table 1).

One sees that:
a) the distributions obtained by methods (1) and (2) are very assymmetric about $R = 0$ obviously by the influence of the underlying ionization. On the contrary, as is well known, methods (3) and (4) are mainly free from this effect,
b) some distributions are not very well centered around zero.

In the second step, the introduction of a multiplying factor k, such that the final value of hm is equal to k multiplied by the hm determined in the first step, able to eliminate the effects a) and b) is tempted.

The factor k is defined according to

$$ki = \begin{cases} ai + bi\, foF2 + ci\, \Delta & \text{when } f_l = foE \\ & \qquad i = 1, 2, 3, 4 \\ di + ei\, foF2 + fi / \Delta & \text{when } f_l = foF1 \end{cases}$$

where f_l is the minimum plasma frequency of the F2 region, $\Delta = foF2 - f_l$ and the coefficients ai, . . . , fi are determined by least squares fits.

Using those coefficients k one obtains new histograms (Table 2). In all the methods, the distributions are now symmetrical around zero, the effect of the underlying ionization is removed or at least reduced and the width of the distributions is smaller. After these operations, one has

Errors limits in %	-22/-14	-14/-10	-10/-6	-6/-2	-2/2	2/6	6/10	10/14	14/26	26/34
Case 1	3	6	36	185	259	174	33	5	3	2
Case 2	2	8	32	207	332	194	39	4	2	
Case 3		2	41	235	365	162	10	2		
Case 4			12	176	459	147	22	1		

So with method 4, all the errors are located between -10 and +10 %, 56 % of them lie between -2 and +2 %, and 95 % between -6 and +6 % (1 % corresponds to nearly 3 km). The distribution of method 3 is very similar. Methods 1 and 2 show a broader dispersion, but 98 % of the results of method 2 are in the -10 to +10 % range. The main weakness of method 1 comes from the fact that often $f_l > .7071$ foF2.

So, in more than half the cases, the IRI method with a suitable coefficient k allows to determine hm with an error of less than 6 km. This shows the accuracy of the IRI method when it is applied to hourly values of M. It may be noted that part of the errors may be due to the procedure used for computing the real-height profiles /6/.

ALTERNATIVE ANALYTICAL REPRESENTATION OF F2 PROFILES

Yonezawa /7/ has shown that the profile of the F2-region looks like an α - Chapman distribution. More flexible analytical representations of Chapman distributions have been proposed by Nicolet & Bossy /8/ and Argence & al. /9/. One among them has the expression

$$f_N = f_c \exp\{(1 + \beta)(1 - \zeta - e^{-\zeta}) / k\}$$

where f_c is the critical frequency at hm, f_N the plasma frequency at h
$\zeta = \ln(H / Hm) / \beta$ with $H = Hm + \beta\,(h - hm)$ and $k = 2$ or 4
H is a linearly variable scale height with the slope β.

The ARTIST profiles have been approximated by this analytical expression for $k = 2$. The errors of the representation are normally less than 10 km apart from the neighborhood of f_l the

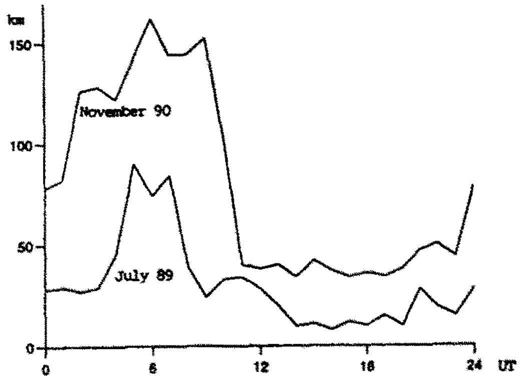

Figure 1a: Variation of Hm with time.

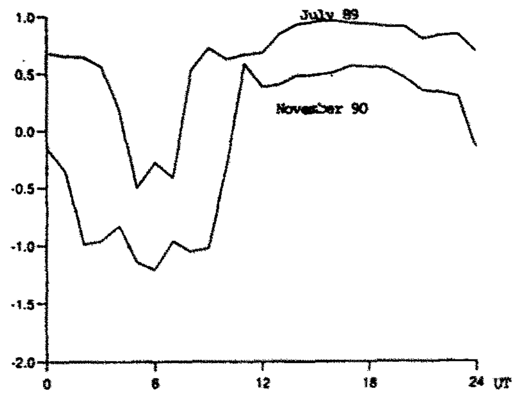

Figure 1b: Variation of β with time.

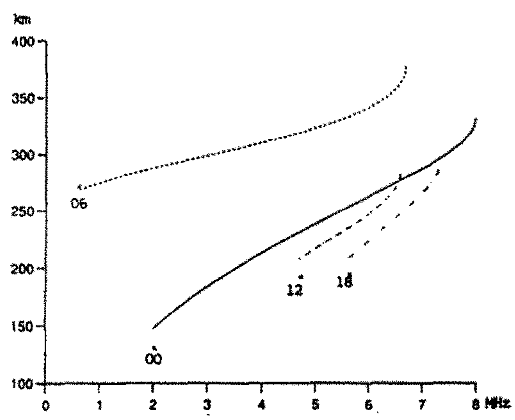

Figure 2a: Median profiles of the F2 region for July '89.

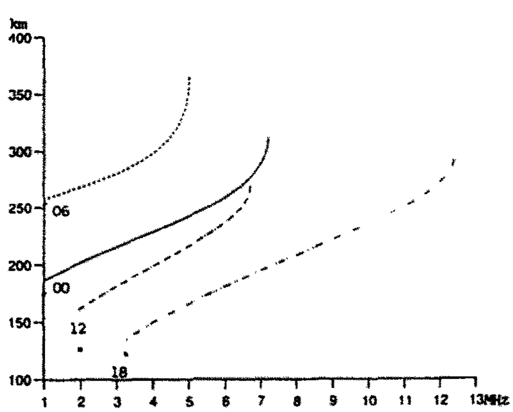

Figure 2b: Median profiles of the F2 region for November '90.

minimum plasma frequency of F2. Therefore the profiles can be expressed depending on the physical parameters: foF2, f_l, hm, Hm, β and eventually on k. The variation with time of the parameters Hm and β shows systematic features : Hm is greatest during the night and the minimum of β (negative) appears also during the night (in the present study around 06 UT). (Figures 1 a & b).

Figures 2 a & b show the median profiles of region F2 for the hours 00, 06, 12 and 18, together with as crosses the corresponding median height h_l at the minimum frequency. The accuracy of this indirect determination of h_l is reasonnable. (Tables in Appendix F)

ACKNOWLEDGMENTS

The data used have been provided by the University of Massachussets Lowell where I had also the possibility to discuss the results with B. Reinisch, X. Huang and R. Gamache. This study has also been sponsored in part by a grant "Crédit aux Chercheurs" of the Fonds de la Recherche Scientifique.

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(Tables in Appendix F)