Adaptation of the lower ionosphere IRI model to vertical sounding data

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It is proposed the method using adaption of the altitude dependence of the electron plasma frequency, the $f_N(h)$-profile, of the lower ionosphere to vertical sounding data. For this, the $f_N(h)$-profile of the IRI model in the range of heights $h_0 \le h \le h_m$ and plasma frequencies $f_{N0} \le f_N \le f_c$ is approximated by the expression

$$f_N(h) = f_c exp\{-[(h_m - h)/H(h)]^3\}$$

where h_0= 65 km, h_m – the maximum height, f_c - critical frequency of the E-layer; $H(h)$ - the height scale, depending on the altitude. The problem is solved in dimensionless form using the conversion:

$$\frac{h_m - h}{H(h)} = \frac{h_m - h_0}{H(h)}\frac{h_m - h}{h_m - h_0} = \frac{h_m - h_0}{H_0(1 + bx^2)}x = \frac{a}{1 + bx^2}x, \qquad x = \frac{h_m - h}{h_m - h_0}, \qquad a = \frac{h_m - h_0}{H_0}.$$

The parameters a and h_m must be defined, the parameter b is obtained from the condition $f_N(h_0) = f_{N0}$, which gives $b = a/\left(log(f_c/f_{N0})\right)^{1/3} - 1$. Adaptation of approximating expression for the absorption measurements of radio waves L and effective altitudes h' is carried out by minimizing the functional

$$S(a, h_m) = \sum_{i=1}^{n}\left[\left(h'_{exp,i} - h'_{calc,i}\right)/h'_{exp,i}\right]^2 + \sum_{j=1}^{r}\left[\left(L_{exp,j} - L_{calc,j}\right)/L_{exp,j}\right]^2.$$

Here the indices «*exp*» and «*calc*» refer to the experimental and calculated values of absorption and effective height. Absorption is calculated according to the formulas of the generalized magneto-ionic theory [1].
Example of the IRI model adaptation is shown in Figure 1 for one of the rocket and ground-based experiments in the mid-latitudes of the European part of Russia. Measurements of n = 5 effective heights and r = 2 absorption at frequencies of 2.00 and 2.25 MHz were used.

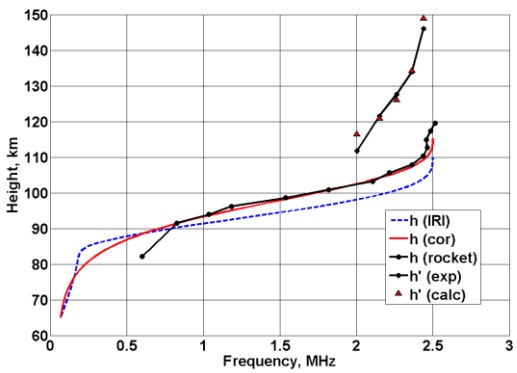

Figure 1. Adaptation of the IRI model to the data of the vertical sounding for event 1976.10.14, LT = 11.3 h

Thus, the proposed method can provide a good agreement between the model and experimental $f_N(h)$-profiles.

Reference

1. K. G. Budden, "Effect of Electron Collisions on the Formulas of Magneto-Ionic Theory," *Radio Science*, **69D**, 2, February 1965, pp. 191-211.