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A SYNTHESIS OF IONOSPHERIC VALLEY IN THE COMPUTATION OF N(h)-PROFILES

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The ionospheric valley situated above the peak of E region casts a rather difficult problem in the computation of N(h) profiles. Few papers on this appeared in the literatures. The methods reported by Howe and McKinnis[1], and by Becker[2] give only the informations about the width of the valley but not about the depth. In this paper, a synthesis of the shape of ionospheric valley is described.

The ionospheric valley is assumed to be composed of 4 segments, AB, BC, CD, and DE, forming a continuous curve, as shown in the figure. First the lower side of the E layer is determined, say by Titheridge's polynomial method[3]. Its symmetrical upper half multiplied by a constant α_1 and then added to ax is used to represent the true height h for the segment AB. The segment CD is represented by $h = b(x - \alpha_2)^{2/3}$ apart from a constant term, and BC is its symmetrical lower half. A quadratic function in $x-x_0$, which has 2 parameters α_3 and α_4, is fitted to the segment DE. Under the restrictions (i) the slopes at points B and D are continuous, (ii) x_c-x_0 and $x_0-\alpha_2$ are equal, and (iii) the absolute value of the slopes at B and D are equal, the number of parameters of the ionospheric valley can be reduced to four, that is, α_1, α_2, α_3, and α_4.

The virtual height h' and true height are related by the well-known formula $h' = \int_0^{h_r} \mu' dh$. By transforming the integral to that which is integrated with respect to x, we may express a virtual height by linear equation in 3 unknowns, α_1, α_3 and α_4, with coefficients in integral forms. The remaining parameter α_2 is involved in the integrand and lower limit of an integral, and therefore has to be determined by the trial-and-error method. With n(>4) observed virtual heights, half of them from the ordinary F trace and the others from the extraordinary one, we may obtain a system of n linear equations. For several assigned values of α_2, the other three parameters can be determined by the method of least squares, and then the value of α_2 is so chosen that the minimum mean square error is minimum.

The result of computation for a simple deep valley[4] shows that the errors in the depth and width of the valley are 0.05 MHz and 1.4 km respectively. The computed shape of the valley is in good agreement with the model profile. The parameter α_2 decides the depth of valley, and α_3 together with α_2 the approximate width of valley. The α_4 is important in fitting the portion of DE where the value of x is larger than x_0. With limited informations available from a h'-f trace, the number of parameters should be as small as possible. However, with only 3 parameters, the results of computation are not only inaccurate, but also inadequate in deciding the value of α_2, because the minimum mean square error as a function of α_2 is not well-behaved. That is, it shows a broad minimum and sometimes double minima. The inclusion of parameter α_1 is necessary probably because it affects the shape of valley near foE which in turn gives rise to important contribution to the virtual heights at the frequencies employed.

The applicability of this method to the other types of valley and the effect of changing the function which represents the bottom of the valley will also be studied.

References

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