A new Vary-Chap model of topside electron density profiles based on ISIS-2 sounding data

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Using ISIS-2 topside sounding data, a new representative model of the topside electron density distribution is being developed for use in IRI. A major challenge for topside *N(h)* modeling is finding a suitable mathematical representation of the topside vertical profiles. Many representations have been proposed including exponential functions, Epstein functions, sech-squared functions, and Chapman functions with one or two fixed scale heights. The Vary-Chap function is a generalized α-Chapman profile, based on the work by Rishbeth and Garriott [1969], that uses a continuously varying shape function S(h):

$$\frac{N(h)}{N_m} = [S(h)]^{1/2} \exp\left[\frac{1}{2}(1 - Y - \exp(-Y))\right], \qquad Y(h) = \frac{1}{h_m}\int_{h_m}^{h} \frac{dx}{S(x)} \tag{1}$$

Here N_m and h_m are the density and height of the F2 peak. According to Huang and Reinisch [2001], Equation (1) can be solved for S(h) as function of N(h):

$$S(h) = \left(\frac{N(h)}{N_m}\right)^{-2} \left\{1 + \int_1^z \left(\frac{N(z)}{N_m}\right)^2 dz\right\} \left[1 - \ln\left\{1 + \int_1^z \left(\frac{N(z)}{N_m}\right)^2 dz\right\}\right], \qquad z = \frac{h}{h_m} \tag{2}$$

The shape functions S(h) were derived for ~ 80,000 ISIS-2 topside profiles. Each shape function is expressed as a parameterized function S*(h)

$$S^*(h) = \frac{1}{S_1^{-1}(h) + S_2^{-1}(h)} \tag{3}$$

with

$$S_1(h) = c_1(B, h_T, \alpha)\left[sech^2\left(\frac{h - h_m}{B}\right)\right]^{-1}$$

$$S_2(h) = c_2(B, h_T, \alpha)\frac{(1 + z^2)^{\alpha}}{z}, \qquad z = \frac{h}{h_m}$$

The coefficients c_1 and c_2 are functions of the parameters B, h_T, and α where B defines the topside layer thickness, h_T is defined as the transition height where $S_1 = c_1 S_2$, and α defines the steepness of S*(h) for heights above h_T.

This functional representation characterizes the shape of the topside profile without directly depending on the F2 peak height and density. The selected function S*(h) allows to solve the integral in (1) analytically assuring time-efficient processing of the profile data. The three parameters in S* are binned according to season, latitude,

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local time, and solar activity. The example in Figure 1 illustrates the Vary-Chap process for a mid latitude topside profile.

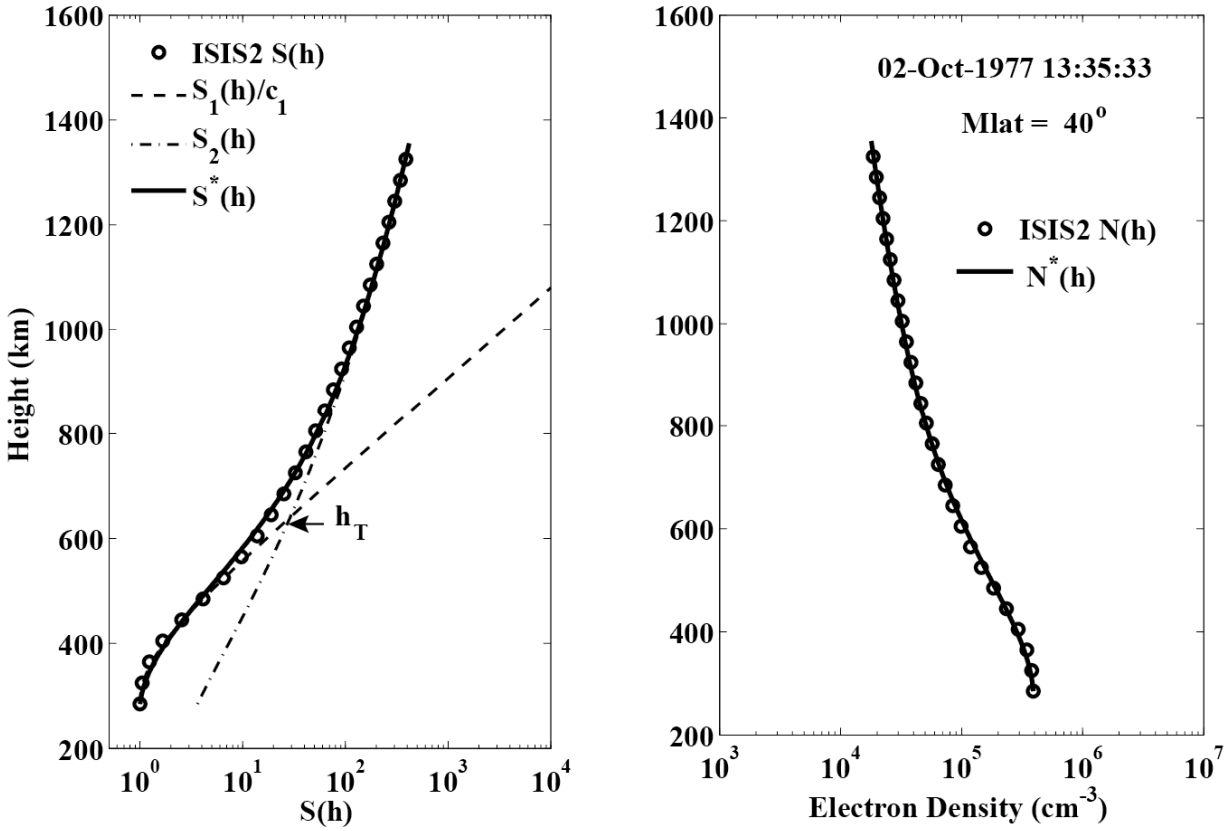

Figure 1. The left panel shows functions S_1/c_1 and S_2, and the composite function S*; the circles show the shape function S(h) derived from the ISIS profile. The right panel show the measured ISIS profile N(h) (circles) and the reconstructed profile N*(h) calculated with the shape function S*.

References

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