Vary-Chap specification of the topside ionosphere and extension to plasmasphere

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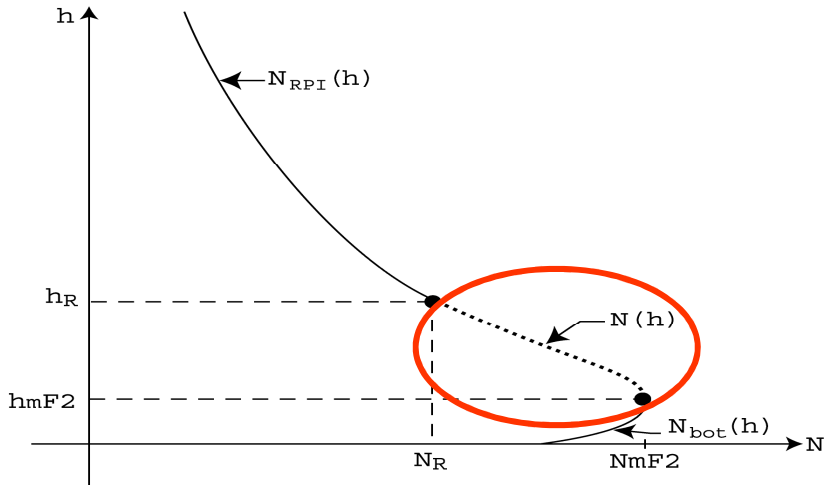
The Vary-Chap Model

- **Represent** measured ISIS topside profiles as **Vary-Chap functions**
- **Parameterize the shape function S(h)** in the Vary-Chap function
- **Model S(h)** as function of local time, latitude, and season



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Represent every measured ISIS-2 Profile as a Vary-Chap Function

$$\frac{N(h)}{N_m} = \frac{1}{\sqrt{S(h)}} \exp\left[\frac{1}{2}(1 - y - \exp(-y))\right] \qquad y(h) = \frac{1}{h_m}\int_{h_m}^{h} \frac{dh}{S(h)}$$

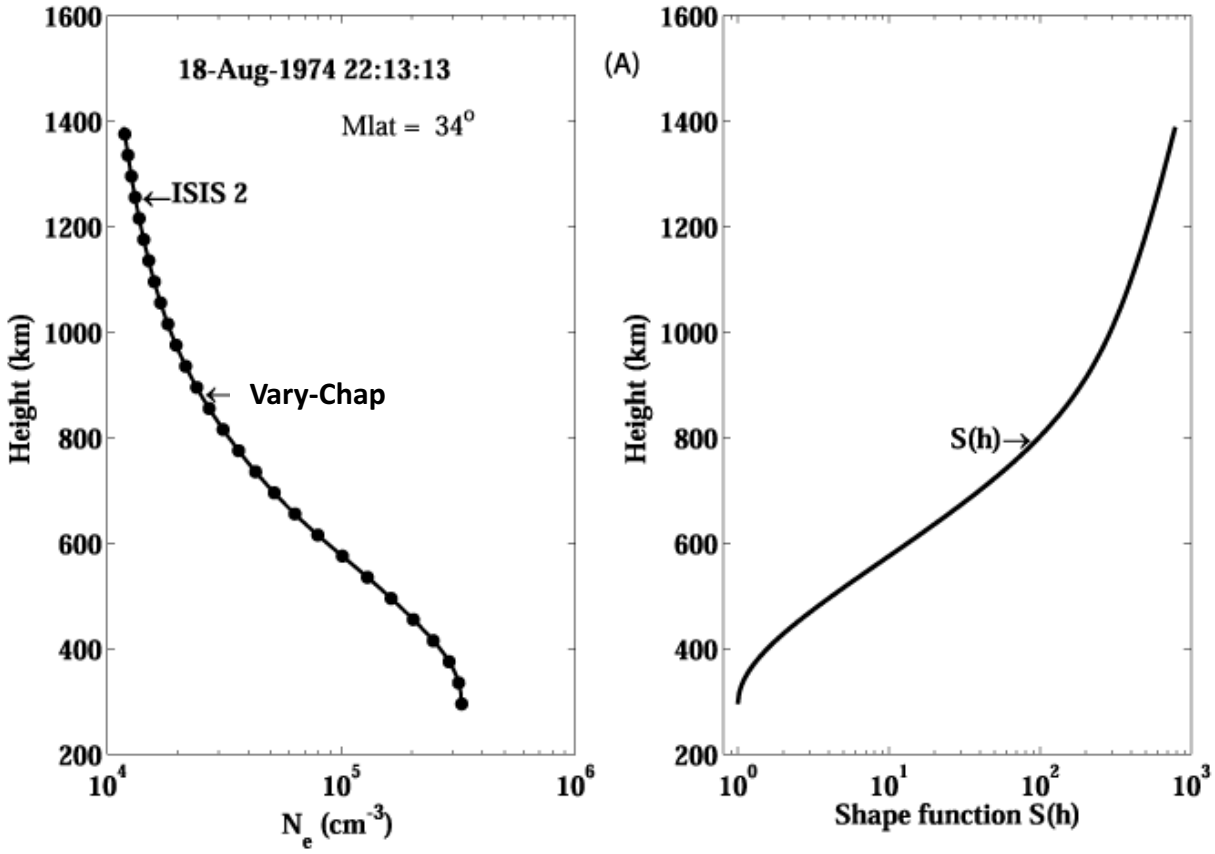
[see Nsumei et al., RS 2012]

Solve for S(h) :

$$S(h) = \left(\frac{N(h)}{N_m}\right)^{-2} X \cdot (1 - \ln X) \qquad \text{Note that} \quad S(h_m) = 1$$

where $$X(h) = 1 + \frac{1}{h_m}\int_{h_m}^{h} \left(\frac{N(h)}{N_m}\right)^{2} dh$$

Starting with the measured ISIS-2 Ne profile



Profile Modeling

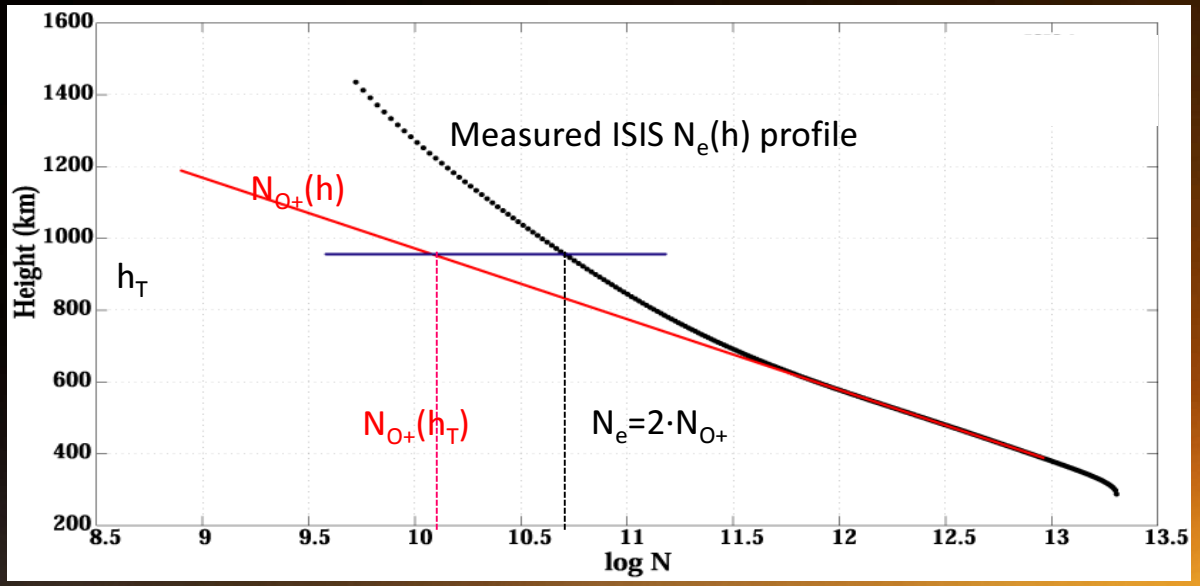
- S(H) is modeled as function of local time, latitude, and season.
- A parametric presentation of S(h) is selected:

  $S^*(h; \alpha, \beta, h_T)$

  h_T is determined for each N(h) profile as the height where $N_e = 2\ N(O^+)$ [Marinov and Kutiev, 2004]

  α and β are determined by least squares fitting $S^*(h)$ to S(h)

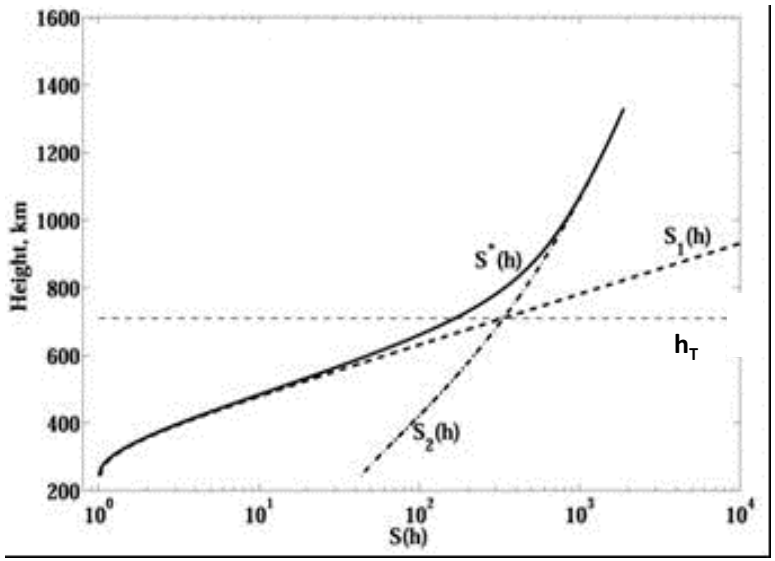
Find h_T for each Ne profile



[Marinov, Kutiev, et al., 2004]

Parameterizing the S(h) function

Each S(h) profile is represented by an analytical function $S^*(h)$ which depends on parameters α, β, and h_T :



$$S_2(h) = c_2 \frac{\left[1+z^2\right]^{\alpha}}{z} \qquad \text{high altitudes}$$

$$S_1(h) = c_1 \left[\cosh^2\left(\frac{z-1}{\beta / h_m}\right)\right] \qquad \text{near peak}$$

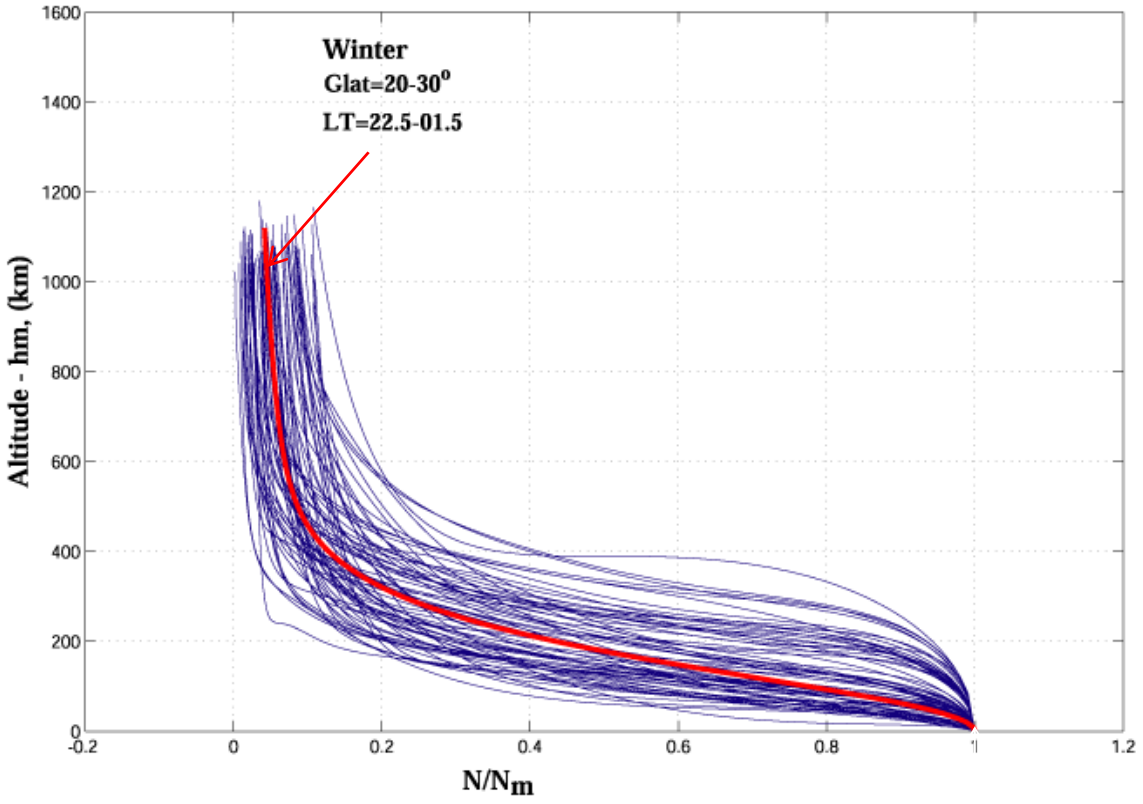
$$\text{At } h_T: \quad S_1 = S_2$$

$$z = \frac{h}{h_m}; \quad c_i = c_i(\alpha, \beta, h_T)$$

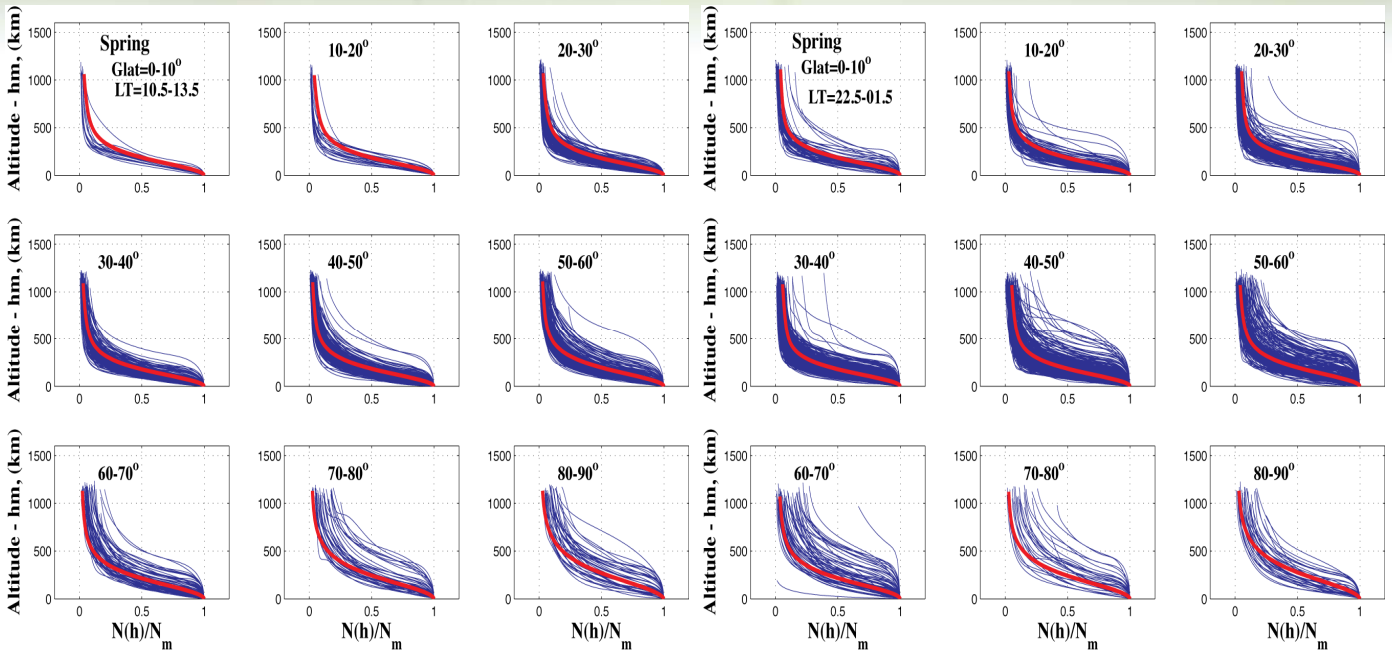
$$\frac{1}{S^*(h)} = \frac{1}{S_1(h)} + \frac{1}{S_2(h)}$$

Validation

Compare N/N_m model with measured ISIS-2 profiles



Spring



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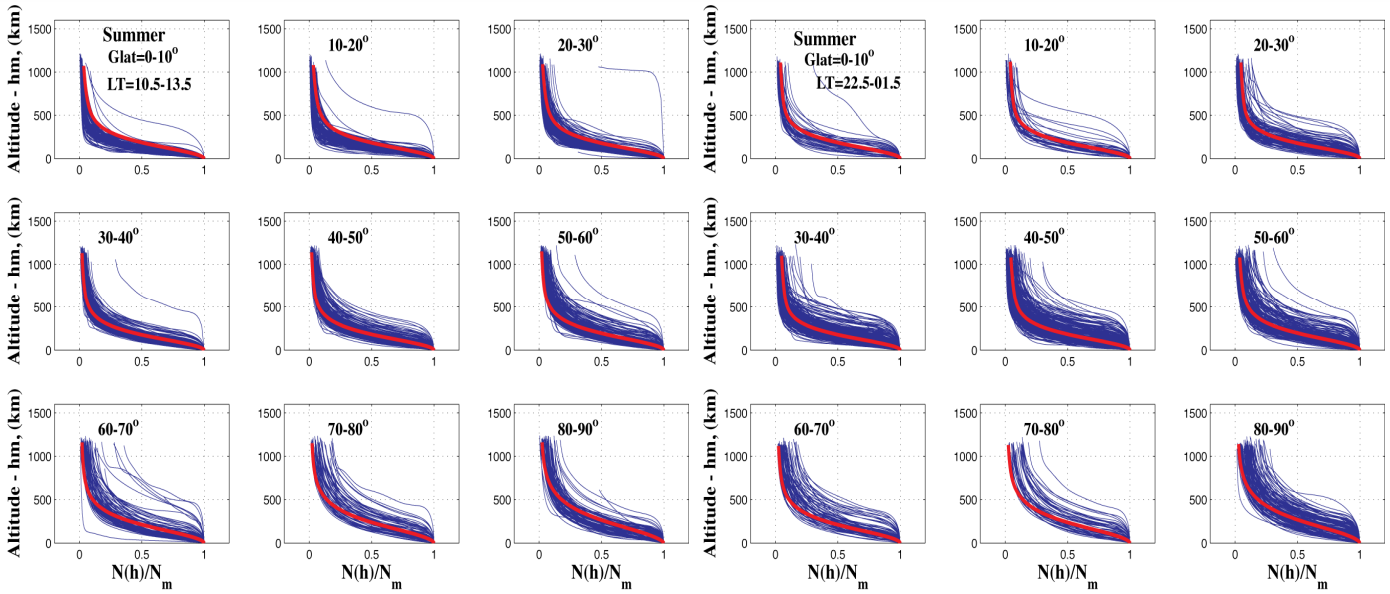
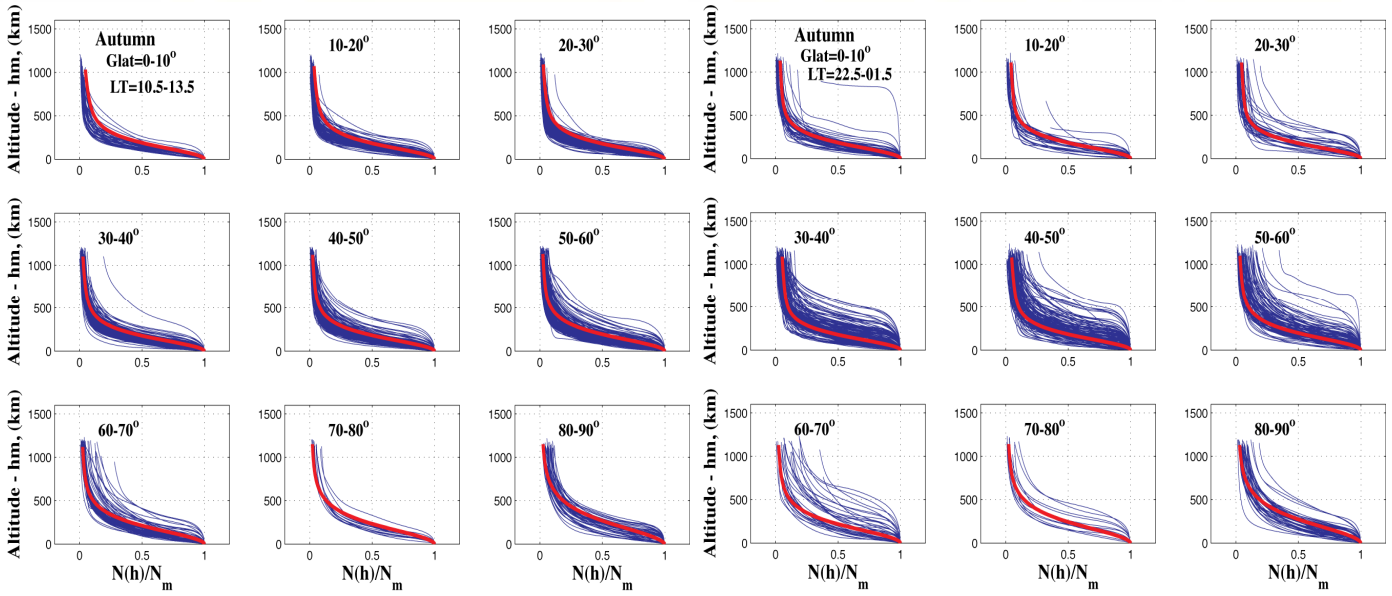
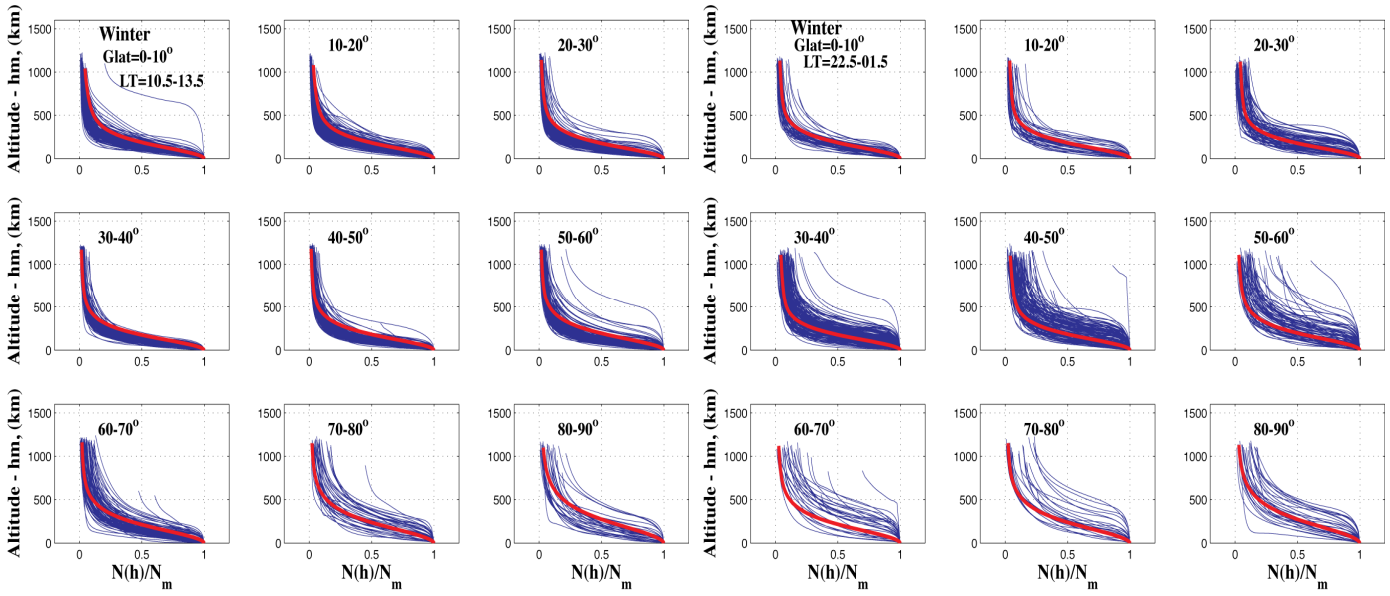


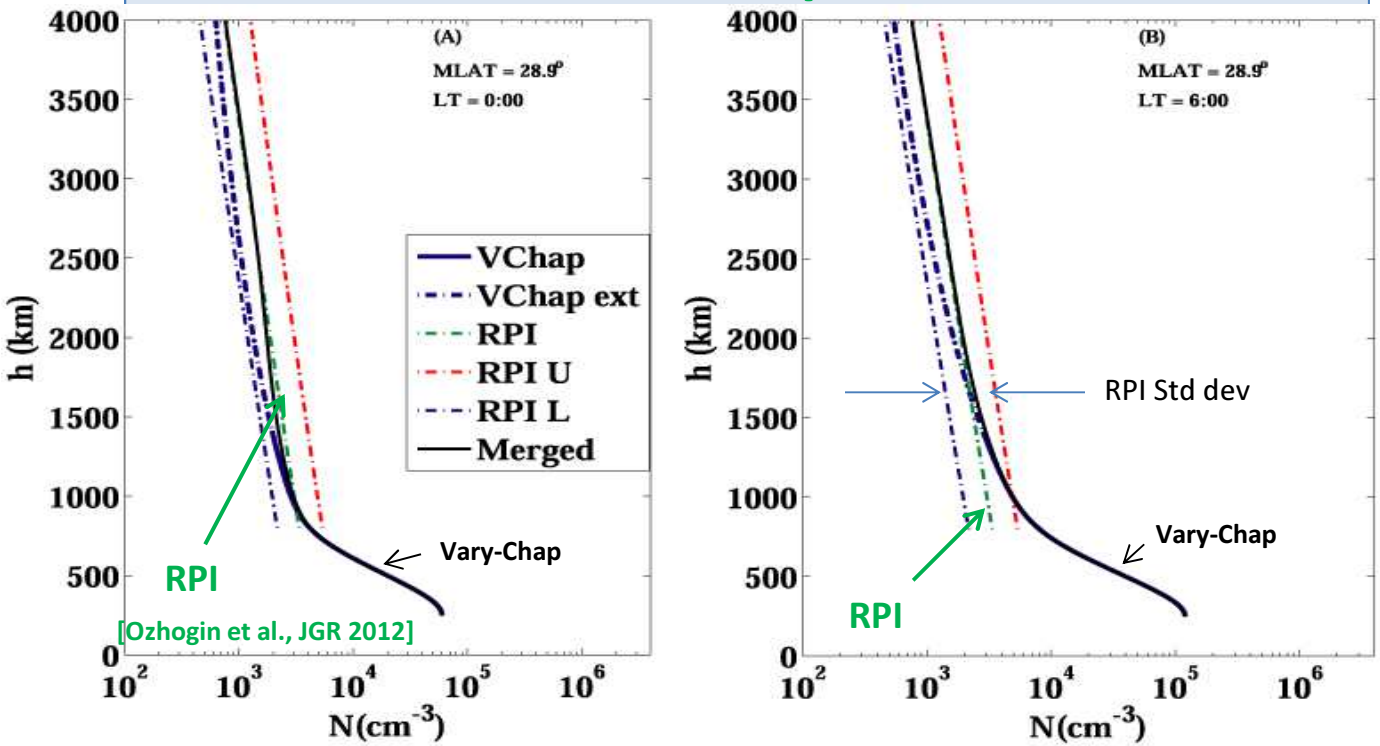

Autumn


Autumn
Glat=0-10°
LT=10.5-13.5
10-20°
20-30°
Autumn
Glat=0-10°
LT=22.5-01.5
10-20°
20-30°
30-40°
40-50°
50-60°
30-40°
40-50°
50-60°
60-70°
70-80°
80-90°
60-70°
70-80°
80-90°
Altitude - hm, (km)
N(h)/N_m


Winter


Winter
Glat=0-10°
LT=10.5-13.5
10-20°
20-30°
Winter
Glat=0-10°
LT=22.5-01.5
10-20°
20-30°
30-40°
40-50°
50-60°
30-40°
40-50°
50-60°
60-70°
70-80°
80-90°
60-70°
70-80°
80-90°
Altitude - hm, (km)
N(h)/N_m

Merging Vary-Chap Topside Profile
with RPI Plasmasphere Profile



Reinisch et al., Modeling the F2 topside and plasmasphere for IRI using IMAGE/RPI and ISIS data, Adv. Space Res., 39, 731-738, 2007

Nsumei et al., New Vary-Chap profile of the topside ionosphere electron density distribution for use with the IRI Model and the GIRO real time data, *Radio Sci.*, 2012

SUMMARY

- Measured topside profiles are expressed as Chapman functions with continuously varying plasma scale height using shape function S(h)
- The shape function S(h) is represented by a parameterized function S*(h) which allows analytical integration for the calculation of $N(h)/N_m$
- Model parameters (α, β, h_T) are determined as means of (α_i, β_i, h_{Ti}) for each lat/LT/season bin
- S* does not depend on foF2 and hmF2, therefore
  - The topside profile can be constructed for any measured bottomside profile


Dalu
감사합니다
Gracias
Danke
Ευχαριστίες
THANK YOU
Obrigado
Köszönöm
Grazie
Спасибо
Dank
Tack
谢谢
Merci
ありがとう
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