Extending Measured Bottomside EDPs to the Topside Ionosphere and Plasmasphere

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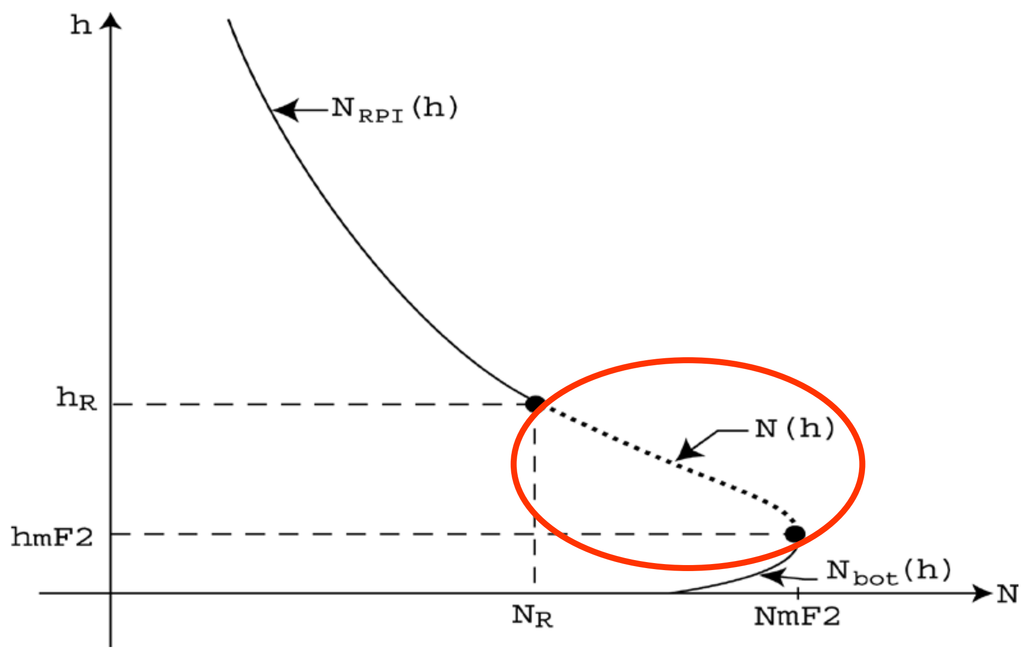
Objective

- Develop an empirical model of the topside profile from hmF2 through the plasmasphere using sounding data from ISIS and IMAGE satellites
- This talk will focus on the construction of the Vary-Chap model of the topside profile for use in IRI



ISIS mission

- ISIS mission has provided a global coverage of the topside ionosphere over more than an entire solar cycle.

- These data extend from the launch of Alouette 1 in September, 1962 to March, 1983 .

- Not all of the data during this time period were processed into electron density profiles.

ISIS mission

- In addition, most of the data extending from March, 1983 up to the turn-off of ISIS 1& 2 in January, 1990 exist only in the original analog telemetry tapes stored in Canada.

- Most of these tapes have now been destroyed due to problems with media deterioration and the cost of tape storage.

- NASA has rated the rescue and transformation of these data as one of its highest priority projects.

Profile Database

1. Topside
   - ~85,000 automatic-scaled ISIS-2 profiles.
   - ~250,000 manually-scaled Alouette1,2 and ISIS1,2 profiles.

α β h_t

2. Bottomside
   - Large database of ground-based ionogram profiles (IRI model)
   - NmF2 and hmF2 from bottomside profile are used to construct the topside profile.

3. IMAGE/RPI plasmasphere profiles

Modeling ISIS data

The Vary-Chap with shape function S(h) is represented by the following equation

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

- **The parameterized Shape function is represented by three parameters: Alpha, Beta, and HT. Parameter HT (transition Height) determines the transition point between regions dominated by H+ ions and regions dominated by O+ ions. Parameter Alpha determines the steepness of S*(h) for h>HT, and parameter Beta determines the topside thickness of the F2 layer.**

$$\frac{1}{S^*(h)} = \frac{1}{c_1}\left[\operatorname{sech}^2\left(\frac{z-1}{\beta/h_m}\right)\right] + \frac{1}{c_2}\frac{z}{(1+z^2)^\alpha} \qquad (2)$$

$$1 = \frac{1}{c_1} + \frac{1}{c_2\,(2)^\alpha} \qquad (3)$$

$$\frac{1}{c_1}\left[\operatorname{sech}^2\left(\frac{z_T-1}{\beta/h_m}\right)\right] = \frac{1}{c_2}\frac{z_T}{(1+z_T^2)^\alpha}; \quad z_T = \frac{h_T}{h_m}. \qquad (4)$$

Modeling ISIS data Cont.

60,000 Automatic scaled profiles

250,000 Manually scaled profiles

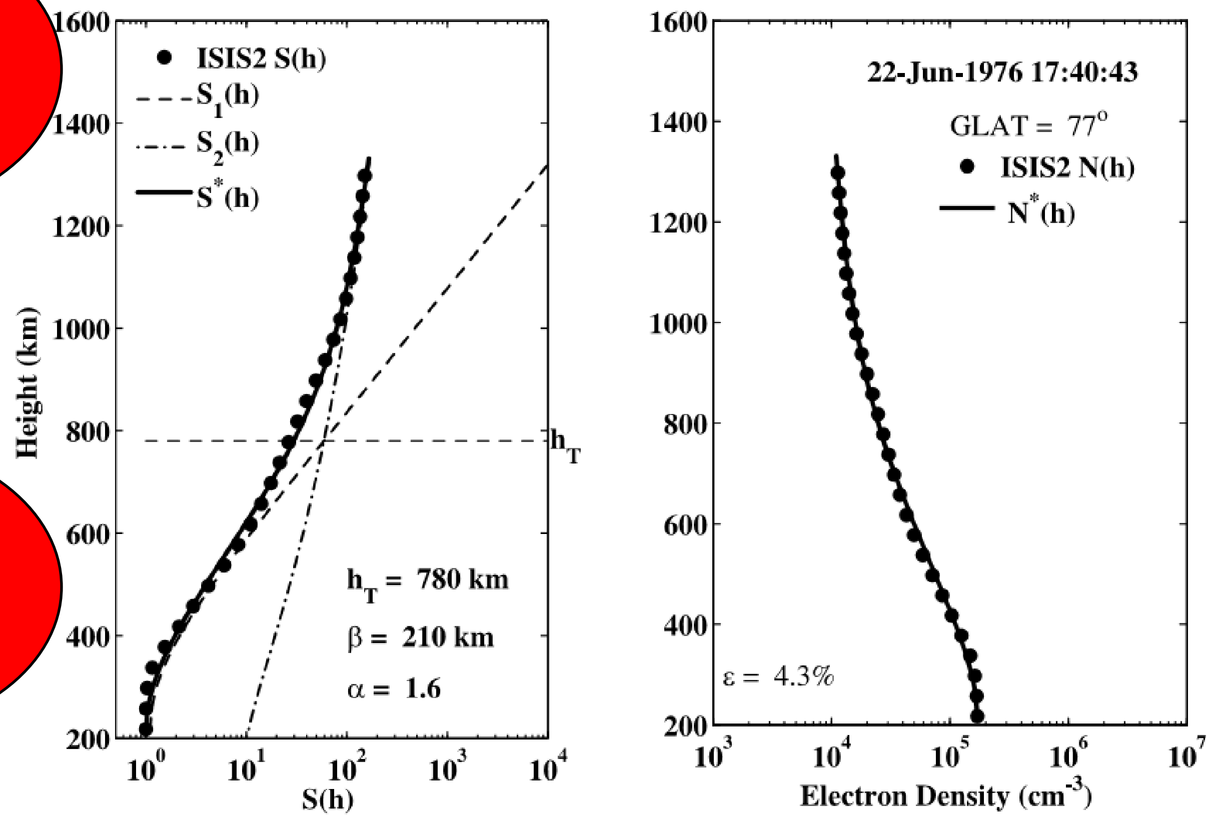
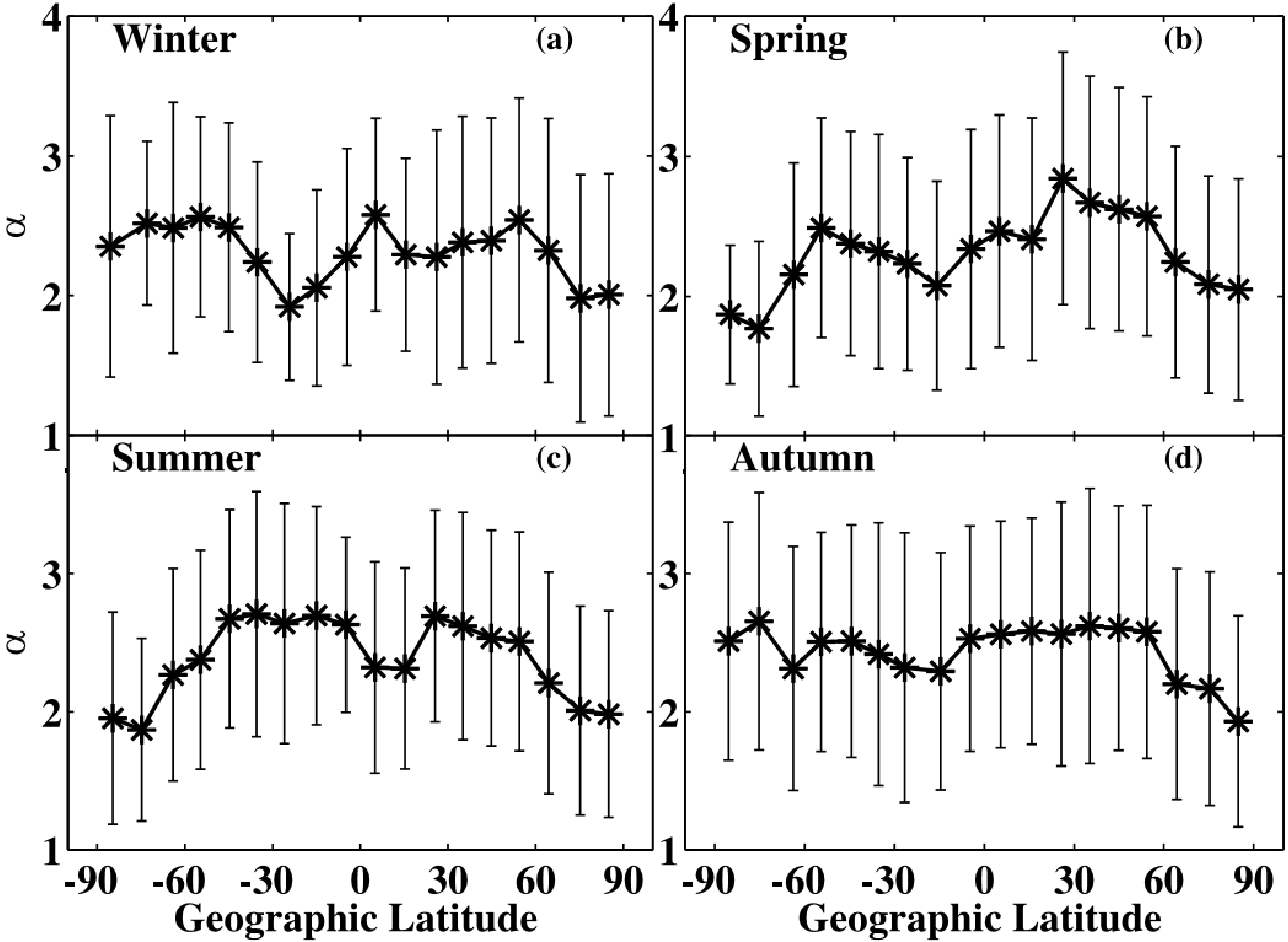


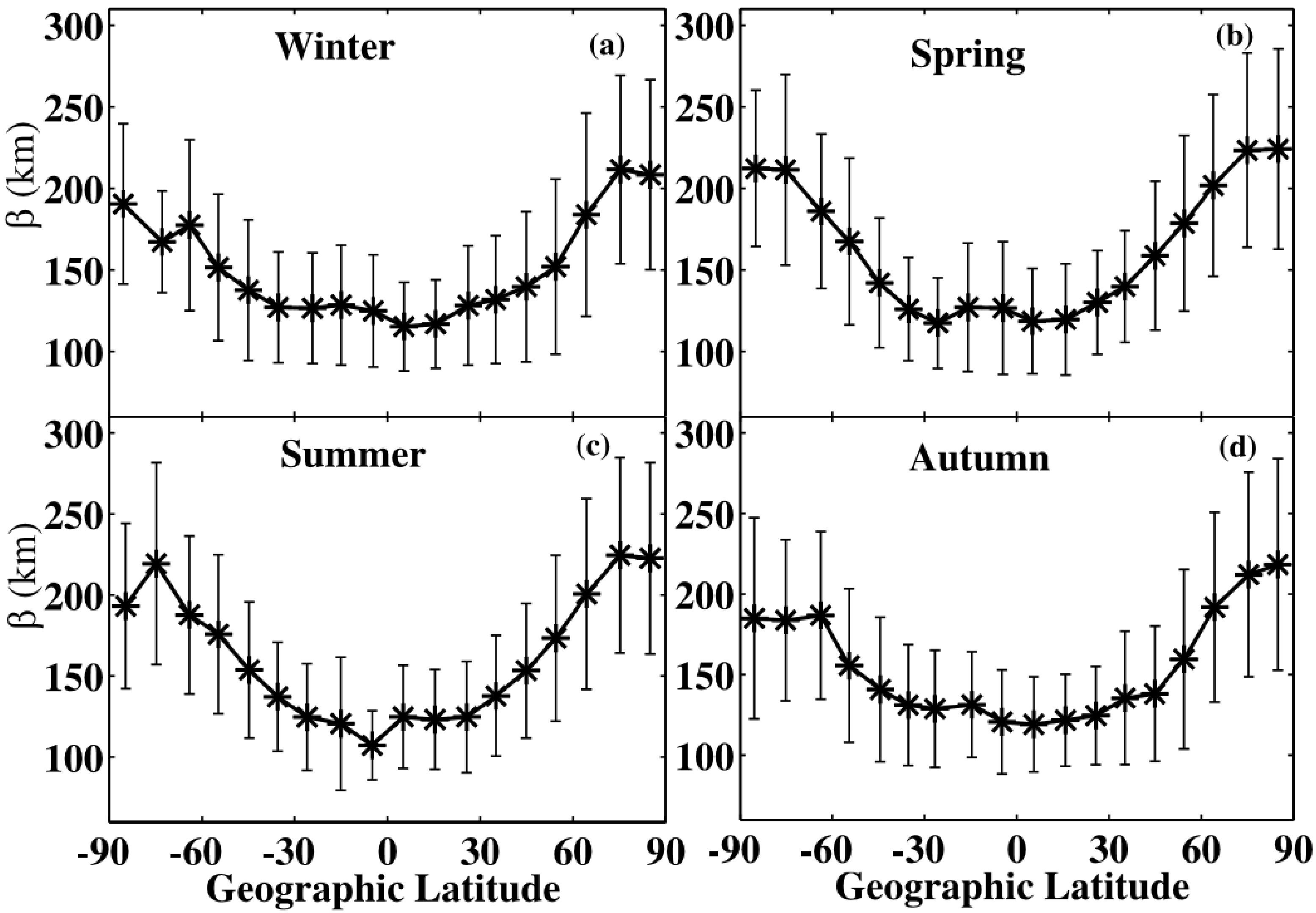
Figure 1. Vary-Chap construction for a high latitude profile (GLAT = 77°), 22 June 1976. (left) Parameterized shape function S_j*(h) (solid line) and its component functions S_{j1} and S_{j2} derived by fitting to S_j(h) (dots). (right) Parameterized Vary-Chap profile N_j*(h) (solid line) superposed on the measured profile N_j(h) (dots).

α parameter seasonal variations



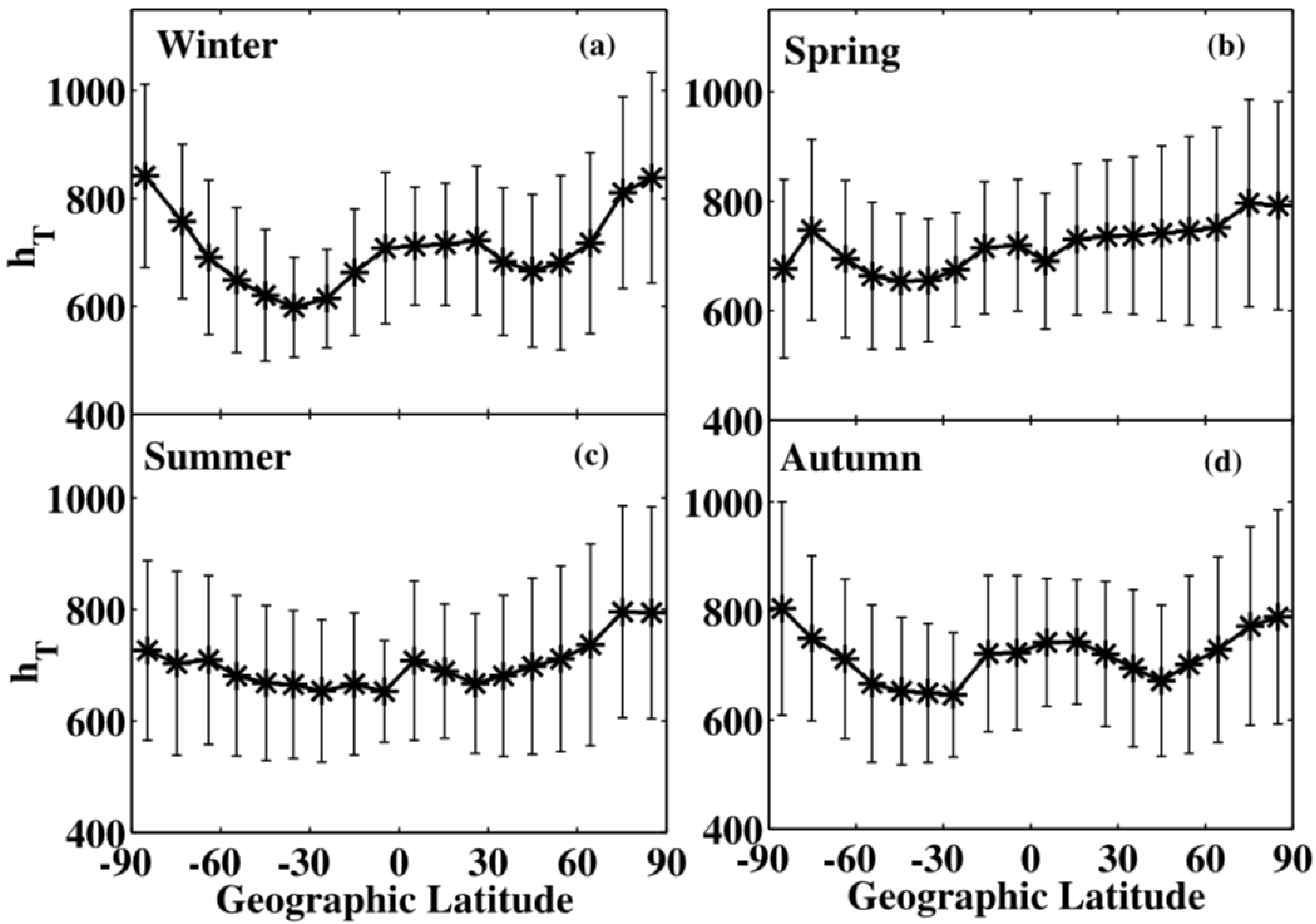
Steepness parameter α versus geographic latitude for (a) winter, (b) spring, (c) summer, and (d) autumn.

β parameter seasonal variations



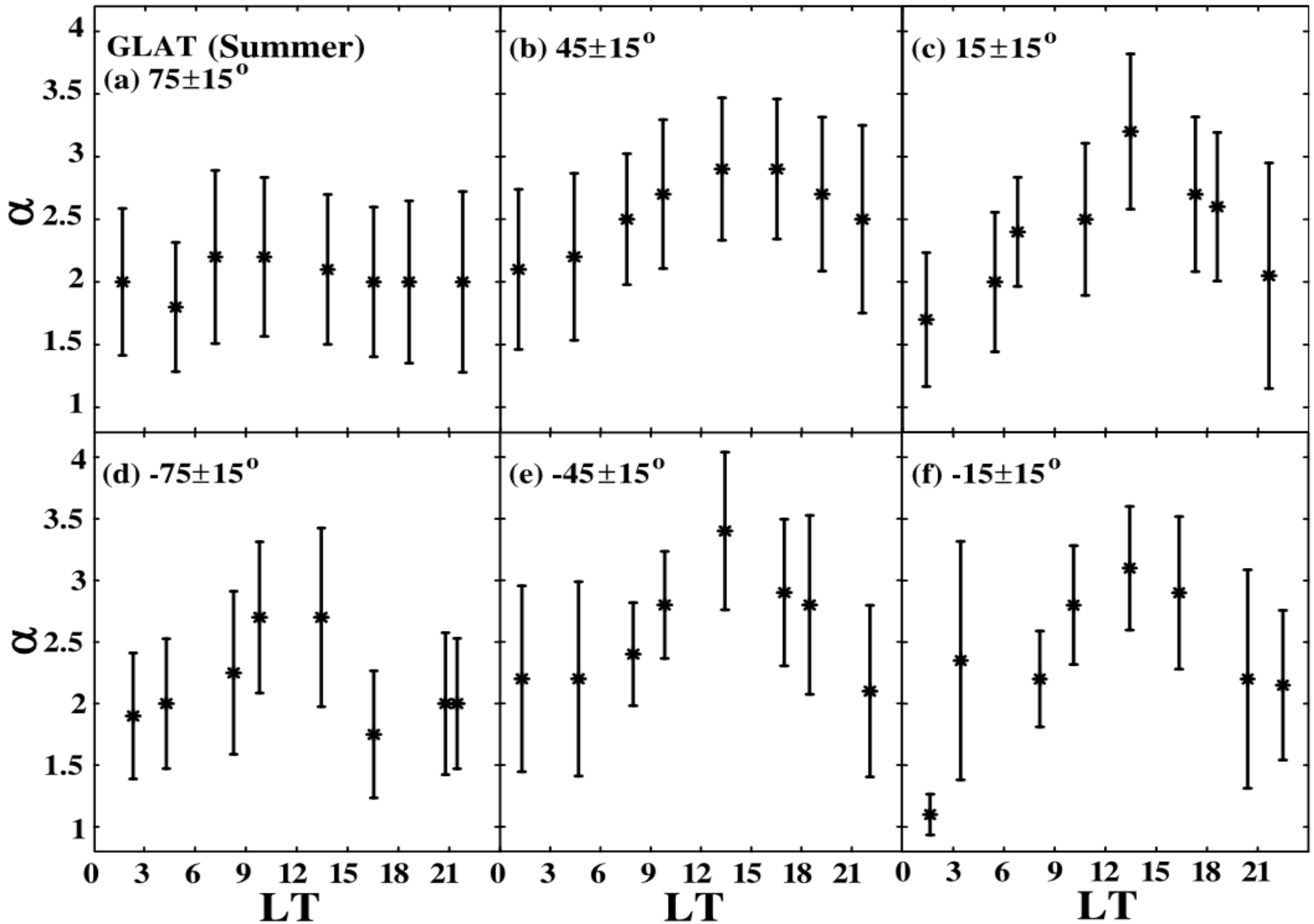
Thickness parameter β versus geographic latitude for (a) winter, (b) spring, (c) summer, and (d) autumn.

h_t parameter seasonal variations



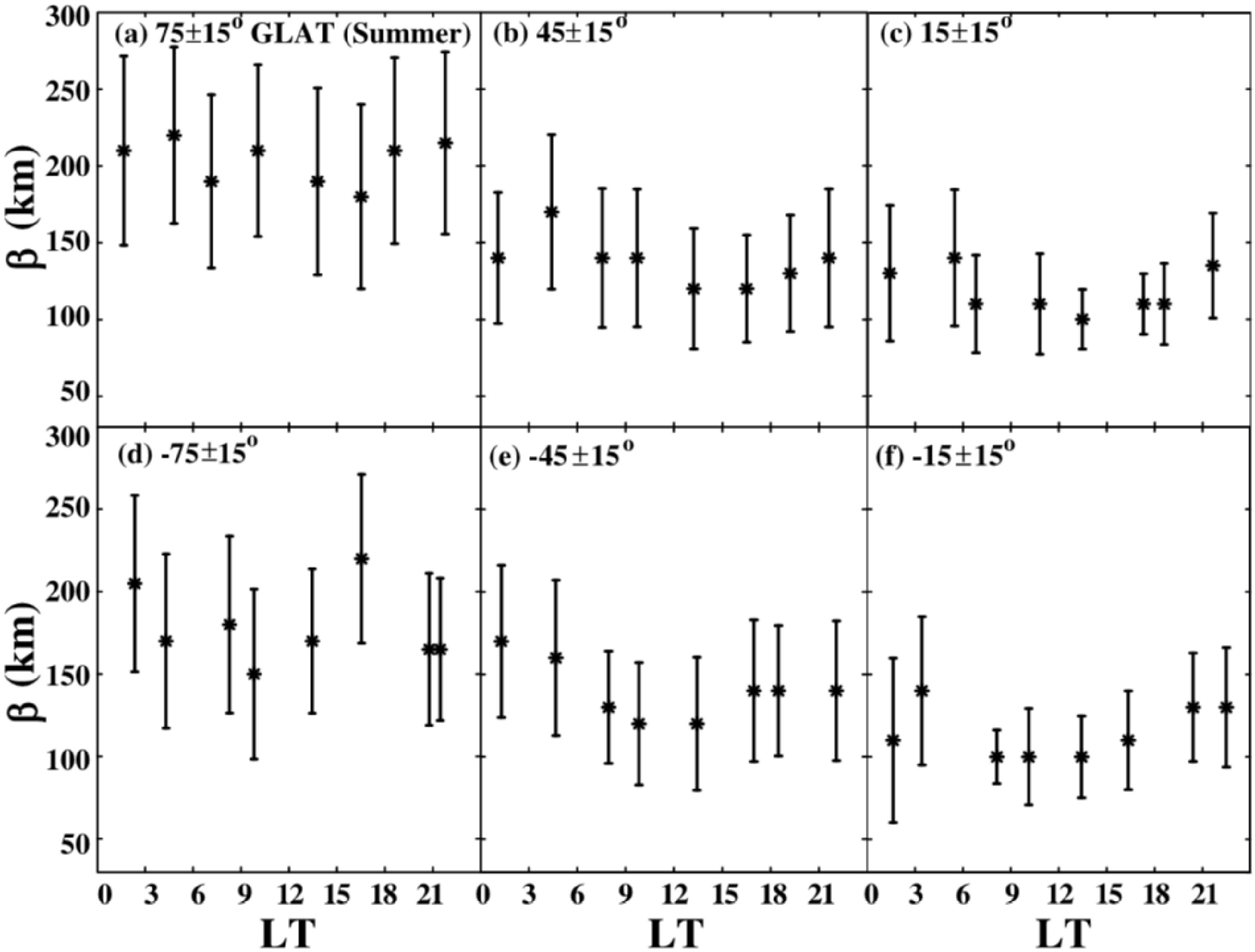
Transition height parameter h_T versus geographic latitude plots for (a) winter, (b) spring, (c) summer, and (d) autumn, averaged over all local times.

α parameter diurnal variations



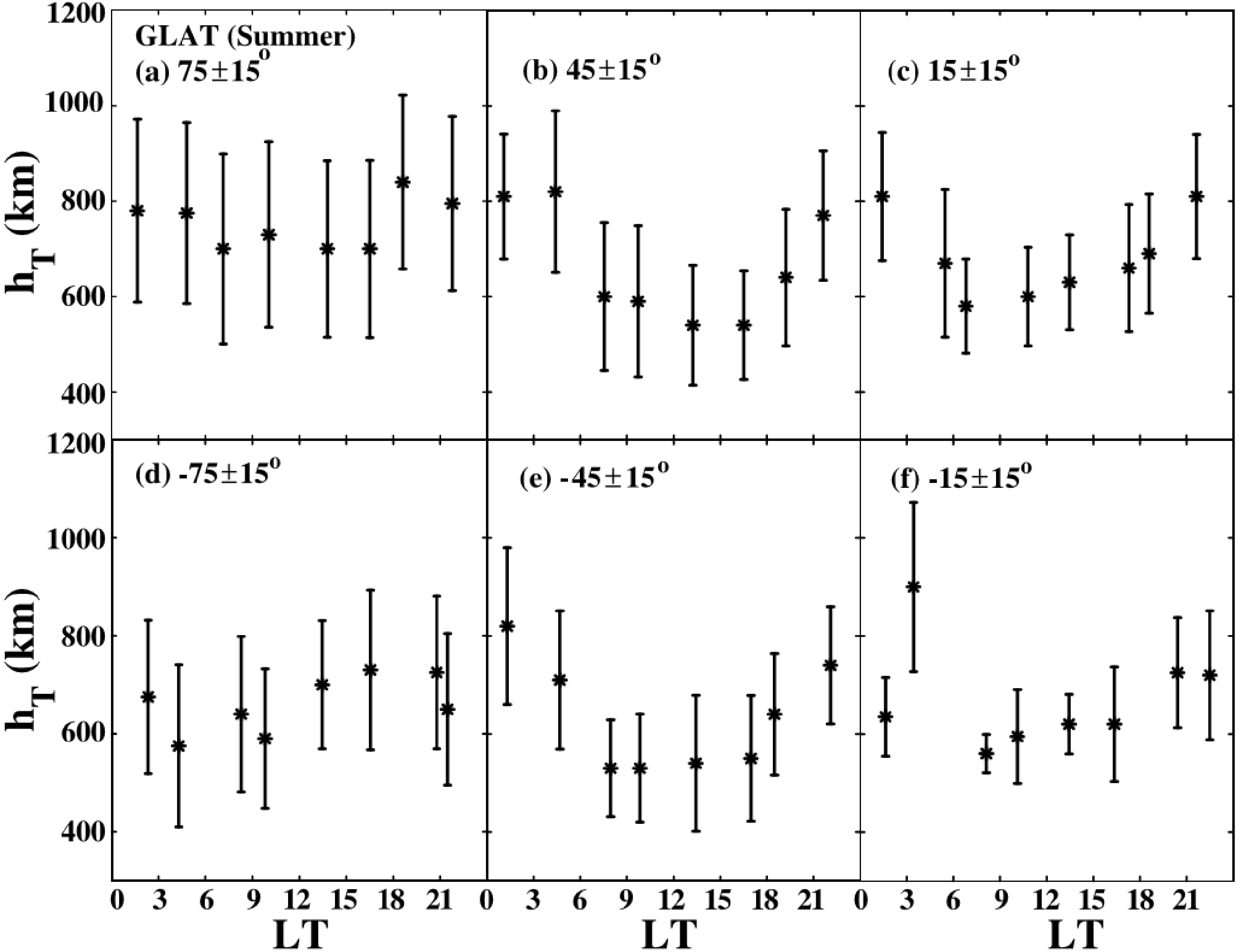
Diurnal variations for summer of the mean values and standard deviations of α.

β parameter diurnal variations

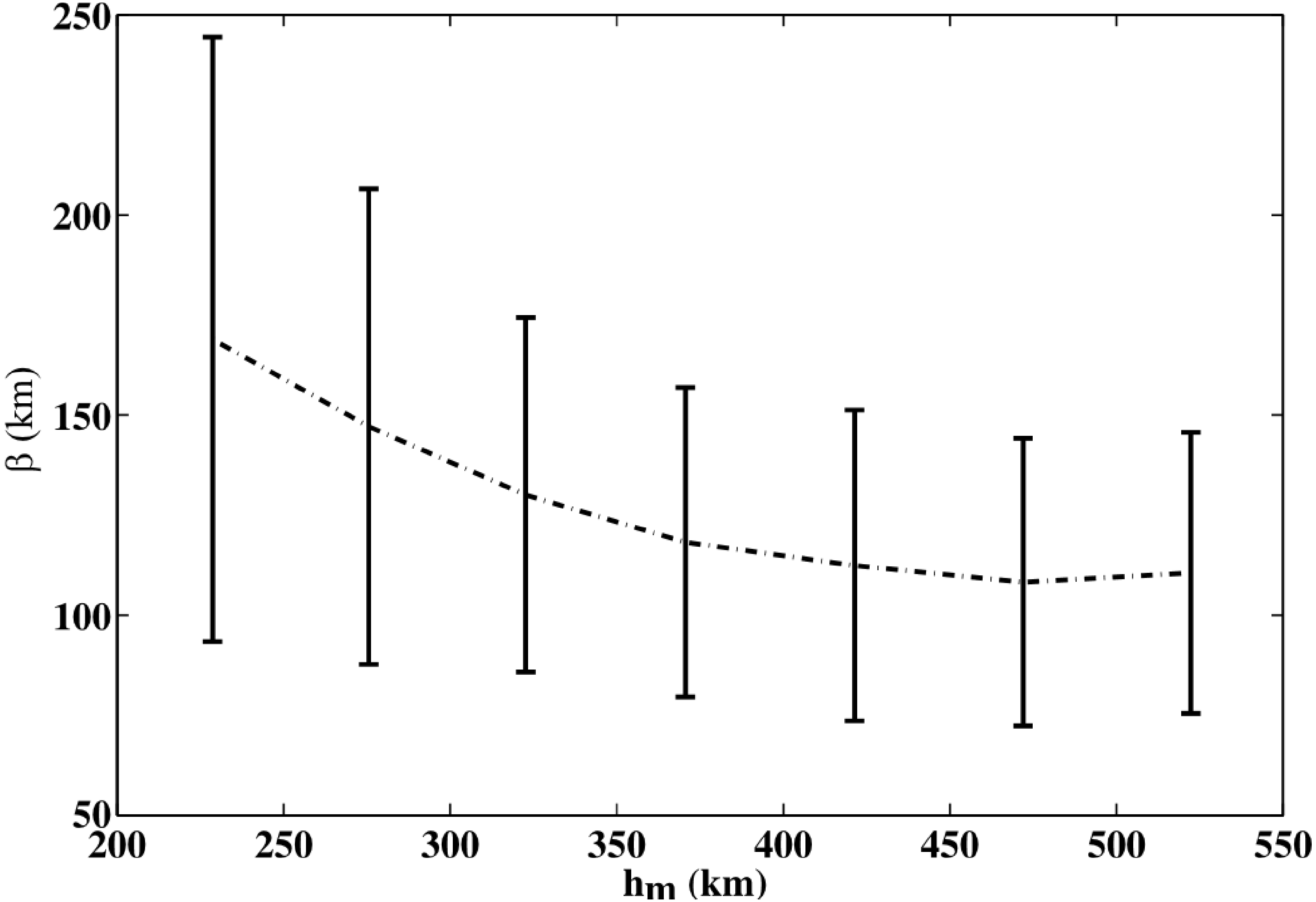


Diurnal variations for summer of the mean values and standard deviations of β.

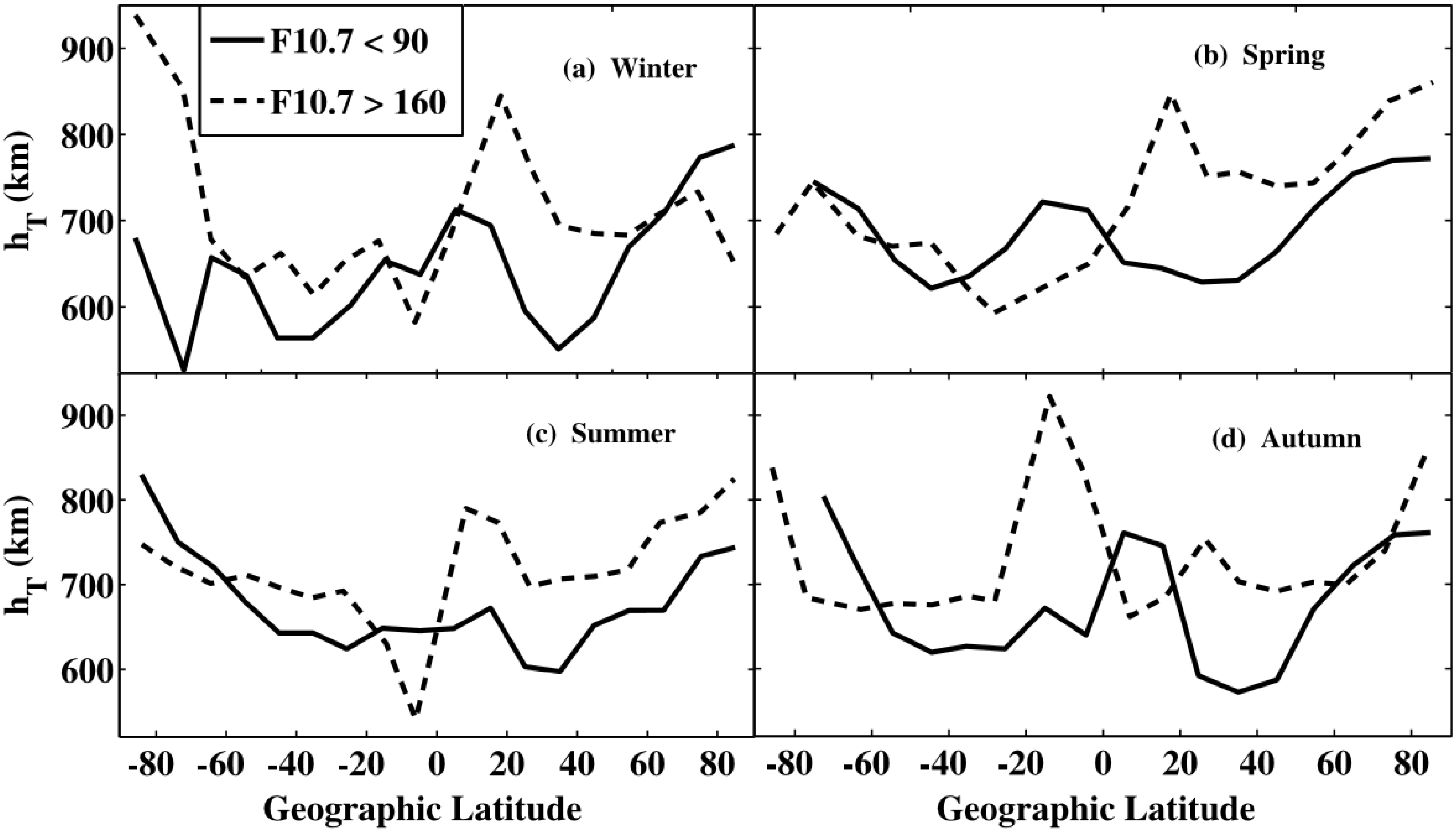
ht parameter diurnal variations



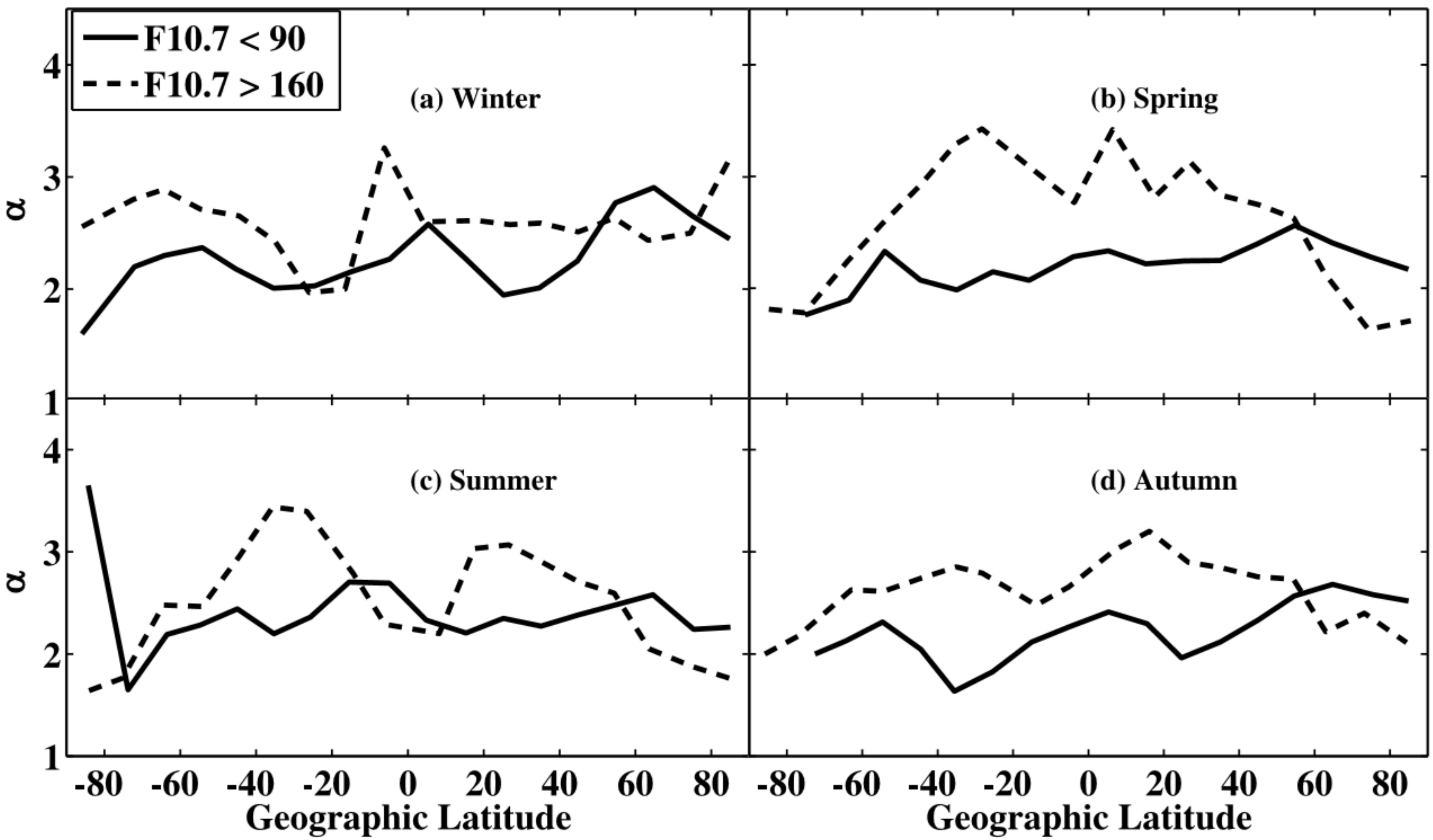
Diurnal variations for summer of the mean values and standard deviations of h_T.



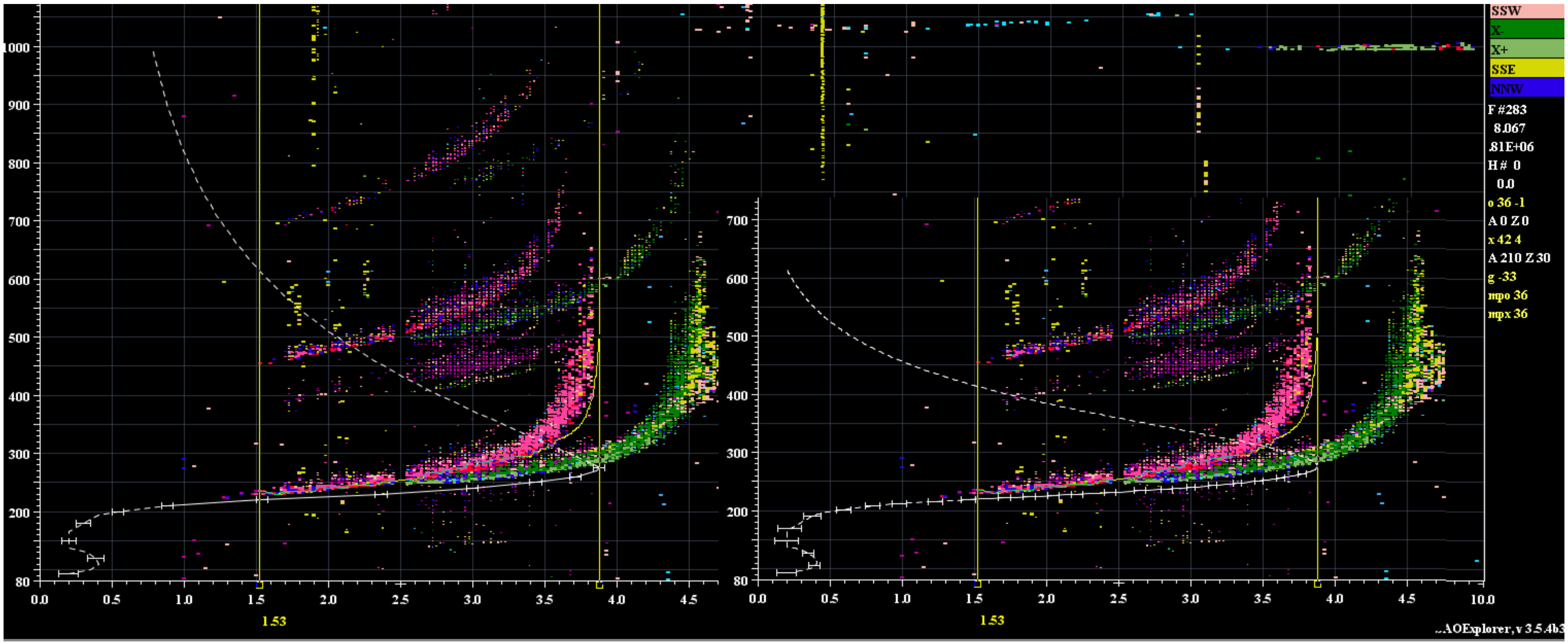
Thickness parameter β versus F2-layer peak height hm. The mean value of β and its standard deviation decrease with increasing hmF2.



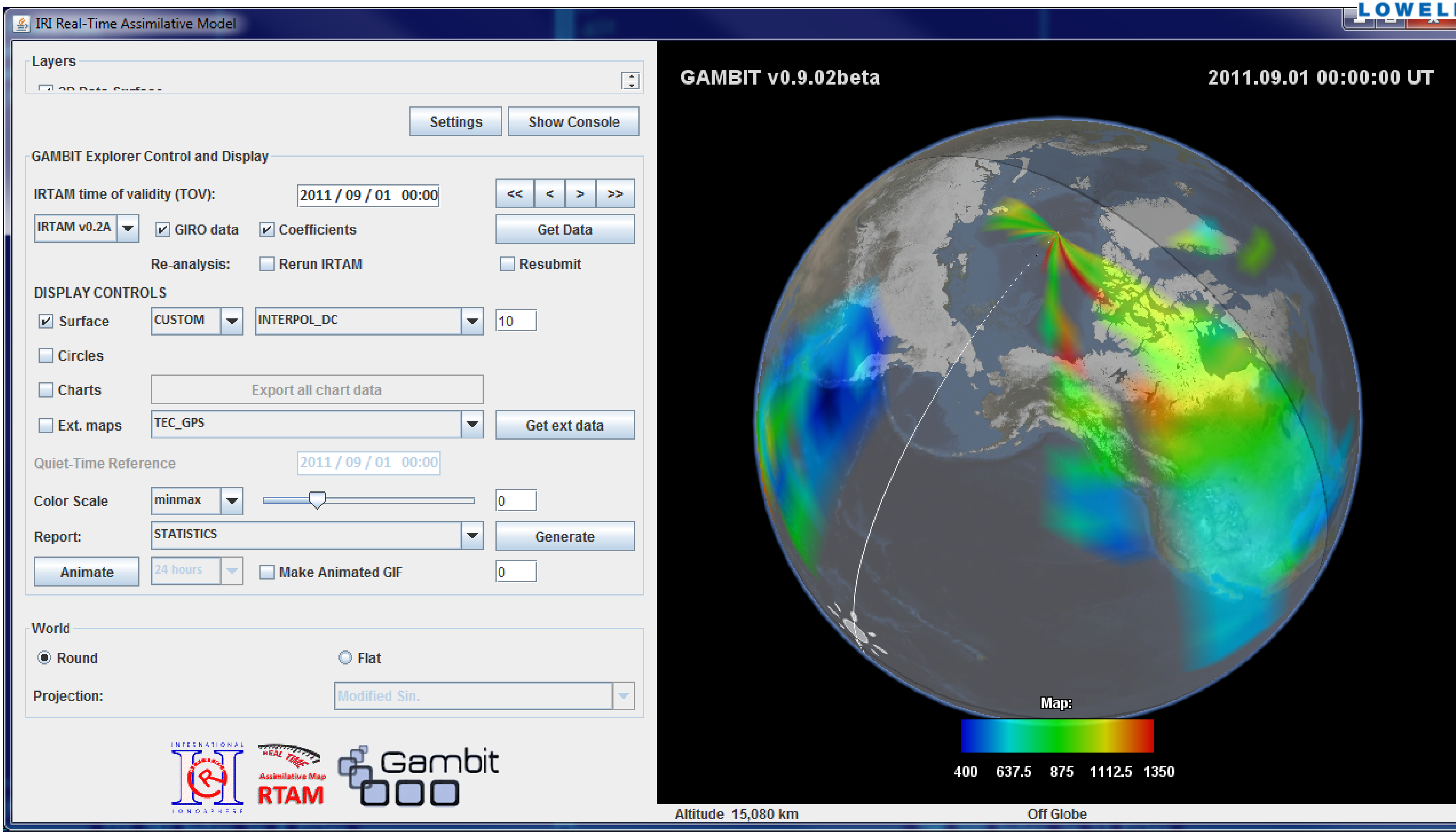
The h_T values for PF10.7 < 90 and PF10.7 > 160, averaged over all local times.



The α values for PF10.7 < 90 and PF10.7 > 160, averaged over all local times.



Vary-Chap profile representation for the topside profile (left) compared to Modeled IRI topside profile (right). The Vary-Chap representation shows significant increase in TEC comparing to IRI model. Millstone Hill on 10 February 2017


IRI Real-Time Assimilative Model
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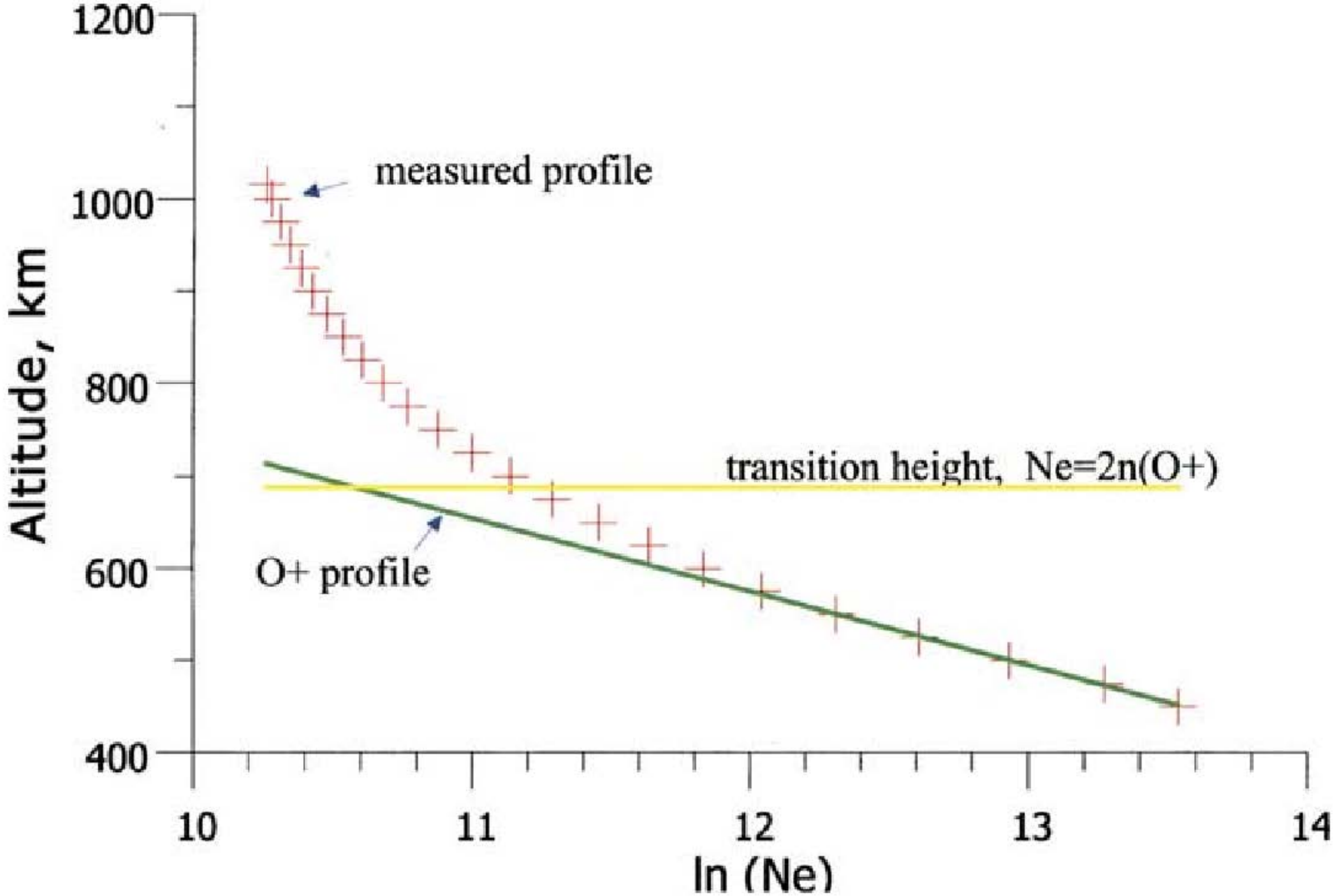
Altitude 15,080 km
Off Globe

Conclusion

- The new Vary-Chap profile model for the topside ionosphere describes the profile from hmF2 to 1400 km as function of local time, month and location.

- The IRI model provides monthly median maps of foF2 and hmF2 that are based on CCIR or URSI coefficients, as well as the bottomside and topside N(h) profiles.

- The Vary-Chap topside profile can be implemented as an option into the IRI electron density model.Also,theVary-Chap profile can replace the Chapman topside profile with constant scale height currently produced by the GIRO Digisondes.


measured profile
transition height, Ne=2n(O+)
O+ profile
Altitude, km
1200
1000
800
600
400
10
11
12
13
14
ln (Ne)