Amplitude morphology of GPS radio occultation data for sporadic-E layers

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Outline

• Relation between electron density and amplitude profiles by simulations
• Analysis method of irregular degree (ID) index
• Analysis results and comparisons
• Conclusions
Horizontal distribution of added $Es$ layer

Altitude: 100 km  
Max thickness: 4 km  
Horizontal extension: 500 km

\[ N_e(x, y) = N_b + N_{Es}(x, y) \]

\[ N_{Es}(x, y) = C \cdot N_{\text{max}} \cos\left(\frac{(x-x_0)\pi}{500}\right) \cos\left(\frac{(y-y_0)\pi}{4\cos\left(\frac{(x-x_0)\pi}{500}\right)}\right), \]

if \[ -\frac{\pi}{2} < \frac{(x-x_0)\pi}{500} < \frac{\pi}{2} \quad \text{and} \quad -\frac{\pi}{2} < \frac{(y-y_0)\pi}{4\cos\left(\frac{(x-x_0)\pi}{500}\right)} < \frac{\pi}{2} \]

\[ N_{Es}(x, y) = 0, \text{else} \]

\(N_b\): background electron density  
\(N_{Es}\): electron density of $Es$ layer  
\(N_{\text{max}}\): max electron density of $Es$ layer  
\(C\): used for consider the curvature  
\((x_0, y_0)\): the coordinate of the max electron density of $Es$ layer
Electron density profiles for simulations

\[ N_{\text{max}} : 0, 0.5 \times 10^5, 1 \times 10^5, 3 \times 10^5, 6 \times 10^5 \text{ cm}^{-3} \]
Simulated amplitude profiles

\[ N_{\text{max}} : 0 cm^{-3} \]
\[ N_{\text{max}} : 0.5 \times 10^5 cm^{-3} \]
\[ N_{\text{max}} : 1 \times 10^5 cm^{-3} \]
\[ N_{\text{max}} : 3 \times 10^5 cm^{-3} \]
\[ N_{\text{max}} : 6 \times 10^5 cm^{-3} \]
Horizontal distribution of added $Es$ layers with irregularities

$N_{\text{max}} : 1 \times 10^5 \text{ cm}^{-3}$
Simulated amplitude profiles

(a) Simulated amplitude profile 1

(b) Simulated amplitude profile 2
Profiles of observational SNR and analysis process
LT-Lat-Alt analysis of the ID index of the MLT Es layer
Distribution of the MLT ID index and horizontal wind shear from HWM07

- Winter
- Spring
- Summer
- Autumn

Lat = -40 deg.
Lat = 20 deg.
Lat = 40 deg.
Lat = 20 deg.
Distributions of altitude of the SLT (left) and MLT (right) Es layers

Winter

Spring

Summer

Autumn

Local Time
Distributions of maximum ID of the SLT (left) and MLT (middle) Es layers.
Conclusions (1)

- Based on the similar altitude distributions of the SLT and MLT Es layers, the SLT Es layer is almost coexist with the MLT Es layer.
- The different maximum ID distributions between SLT and MLT Es layers indicate their formation mechanisms are different.
- The MLT Es layer is probably formed by wind shear, and the SLT Es layer, whose maxID distributions in the four seasons are like the distribution of $N_m E$, is associated with the solar zenith angle.
Conclusions (2)

- The Es layer is formed in the region where the vertical electron velocity is zero and the gradient of vertical velocity is large [Whitehead, 1961].
- During and after the formation of the Es layer, some irregular structures are caused by the effect of certain external forces, such as the wind shear and gravity waves.
- In contrast to the simulations in this study and the above description, the MLT Es layer is caused by irregular structures.
Conclusions (3)

- The SLT Es layer can be regarded as an Es layer which has not been influenced by external forces.
- With the smaller solar zenith angle, the ionization rate becomes larger in the $E$ region. With a larger electron density in $E$ region, a higher electron density is formed in the Es layer. Therefore it is reasonable that the maxID distributions of the SLT Es layer are similar to the $N_mE$ distribution.
Thank You for Your Attention!!