Ionospheric Structure, Stochastic TEC, and Scintillation Diagnostics

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Outline

• New/Revised Ionospheric structure model
  • New EPB simulations

• Configuration-space simulations (Review)

• New Diagnostic Measurements
  • Stochastic TEC (Review)
Stochastic variation is two-dimensional in cross-field slice planes, one-dimensional in meridional slice-planes.
An Ionospheric Structure Model


<table>
<thead>
<tr>
<th>Configuration Space Model</th>
<th>Path Integration Diagnostics</th>
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<tbody>
<tr>
<td>$\Phi_{\Delta N_x}(\kappa_s) = C_s \left{ \begin{array}{ll} \kappa_s^{p_1} &amp; \text{for } \kappa_s \leq q_0 \ q_0^{-p_1} \kappa_s^{-p_2} &amp; \text{for } \kappa_s \leq q_0 \end{array} \right.$</td>
<td>$\Phi_{\Delta \phi}(\kappa_y) = L \int \frac{\sin^2(\kappa_y L/2)}{(\kappa_y L/2)^2} \Phi_{\Delta N_x}(\kappa_x, \kappa_y, \kappa_z) \frac{dk_x}{2\pi} \frac{dk_z}{2\pi}$</td>
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<tr>
<td>$\kappa_s^2 = \begin{pmatrix} C &amp; \kappa_x \ \kappa &amp; C \end{pmatrix} \begin{pmatrix} C &amp; \kappa_x \ \kappa &amp; C \end{pmatrix}^T$</td>
<td>$\simeq L \int \Phi_{\Delta N_x}(\kappa_x, \kappa_y) \frac{dk_x}{2\pi}$</td>
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<tr>
<td>$\Phi_{\Delta N_y}(q_s) = C_s^{-1} \left{ \begin{array}{ll} q_s^{-\eta_1} &amp; \text{for } q_s \leq q_0 \ q_0^{\eta_1} q_s^{-\eta_2} &amp; \text{for } q_s \leq q_0 \end{array} \right.$</td>
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$$\Delta N(x, \rho) = \frac{1}{N_s} \sum_{k=1}^{N_s} F(k)p_{||}(\zeta/\sigma_s)p_{\perp} \left( \frac{(s + \eta S_x)^2 + (t + \eta T_x)^2}{\sigma_k} \right)$$

$$\Phi_{N_x}(\kappa_x, \kappa) = \frac{1}{N_s^2} \sum_{j=1}^{N_s} C_j^2 \sigma_j^{2\gamma_j + (3 - \epsilon(3))}$$

$$\times \iint p_{\perp} \left( \frac{s^2 + t^2}{\sigma_x} \right) \exp \{ -i(\kappa_z s + \kappa_x t) \} \, ds \, dt \, 2\pi \delta(\kappa_x)$$
EPB Simulations

4:37
DOI 10.1186/s40645-017-0153-6

5:83
https://doi.org/10.1186/s40645-018-0243-0
EPB
Structure Progression & Onset
Configuration Space Simulations
Phase-Screen Equivalence

Three Paths to Diagnostic Analysis

1. Complex field => Back Propagation => PSD => IPE
2. Intensity => PSD => 2D Theory => IPE (S4)
3. TEC => PSD => IPE (ROTI)

Stochastic TEC → Phase → 3D Prop → 1D Scan

2D Projection → 2D Prop
Summary & Future Effort

• Summary
  • A compact ionospheric structure model defined by 4 parameters and the magnetic field direction was introduced
  • New EPB simulations provide evidence of systematic structure parameter variation
  • For all but moderate to strong GNSS scintillation, structure diagnostics can be applied directly to TEC with ROTI <= S4
• Future effort
  • Reconcile IPE results from the diagnostic measures with the 3D model, in situ measurements, and EPB simulations
  • New EPB simulations will be presented at AGU 2019 San Francisco

THANK YOU
• A Tribute to Andrzej Wernik

Wernik, A. W., L. Alfonsi, and M. Materassi (2007),
Scintillation modeling using in situ data, Radio Sci., 42,
RS1002, doi:10.1029/2006RS003512