On the Geometric Dependence of Scintillation and Stochastic Structure Models

by

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Stochastic Structure Models

- Parameterized structure models provide the interface between propagation theory and real-world observations.

  Caveats:

  – Highly field-aligned structures do not support definitive statistical variations along the field lines.

  – Structure realizations derived by imposing an amplitude variation on uncorrelated Fourier modes are non-physical.

- This talk with introduce a configuration-space model that preserves known structure characteristics with realizable *striations.*

Two Structure Realization Approaches

Summation of Fourier components

$$\delta N(\mathbf{r})/N_0 = \iiint \sqrt{\Phi_{\delta N/N_0}(\mathbf{K})}\,\eta(\mathbf{K})\exp\{i\mathbf{K}\cdot\mathbf{r}\}\frac{d\mathbf{K}}{(2\pi)^3}$$

Summation of Striations

$$\delta N(\zeta_s,\boldsymbol{\zeta}_\tau)/N_0 = \frac{1}{N_s}\sum_k F_k p_s(|\zeta_s-\zeta_s^k|)p_\perp(|\boldsymbol{\zeta}_\tau-\boldsymbol{\zeta}_\tau^k|/\sigma_k)$$

$$\delta N(\boldsymbol{\kappa}_s)/N_0 = \frac{1}{N_s}\sum_k F_k\sigma_k^2\hat{p}_\perp^{(2)}(\kappa_s\sigma_k)\exp\{-i\boldsymbol{\kappa}_s\cdot\boldsymbol{\rho}_s^k\}$$

$$\langle|\Delta N(\boldsymbol{\kappa}_s)|^2\rangle/N_0^2 = \frac{1}{N_s}\sum_k F_k^2\sigma_k\left|\hat{p}_\perp^{(n_d)}(\kappa_s\sigma_k)\right|^2 \qquad n_d = \begin{cases}1\\2\end{cases}$$

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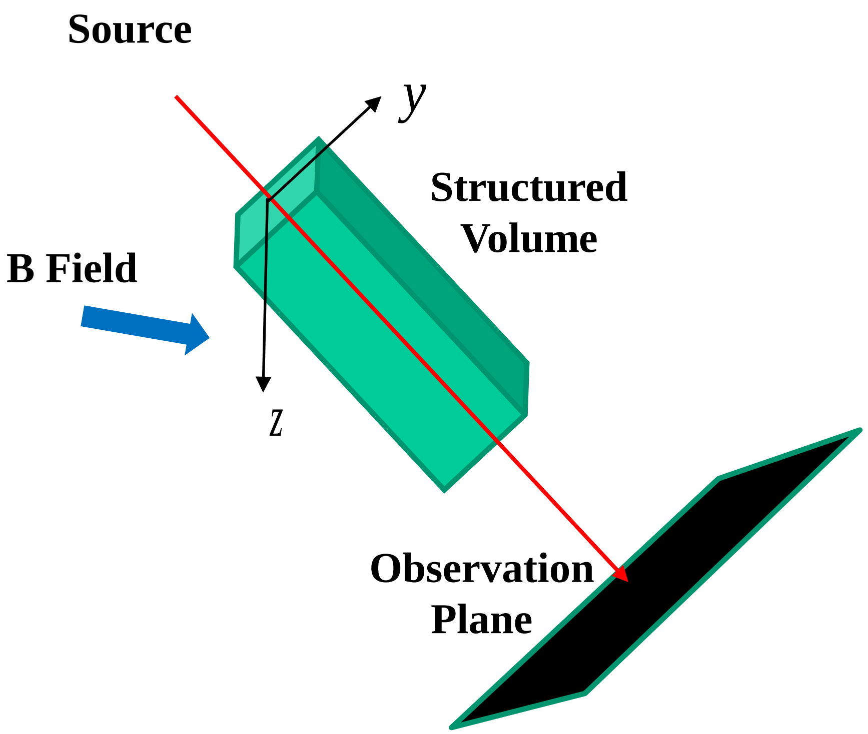
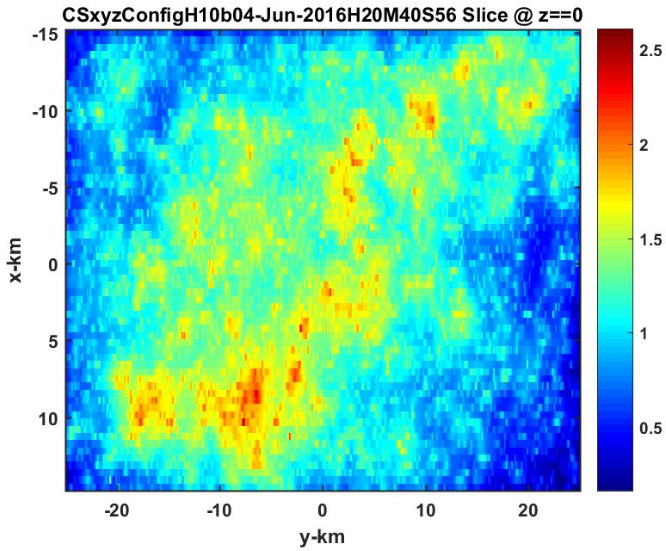
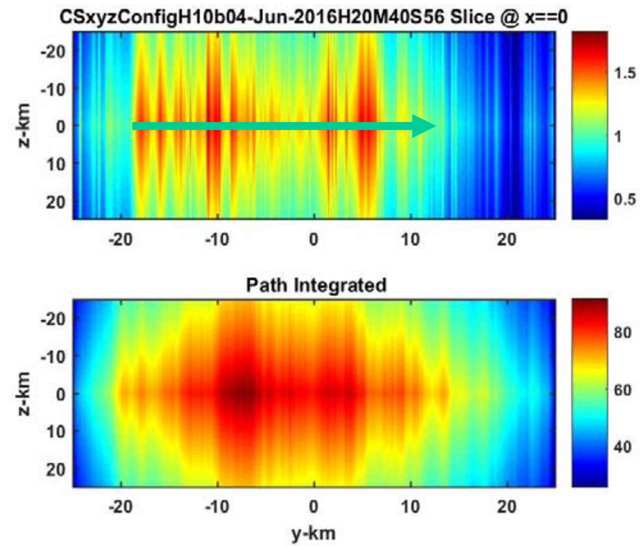
Propagation Geometry



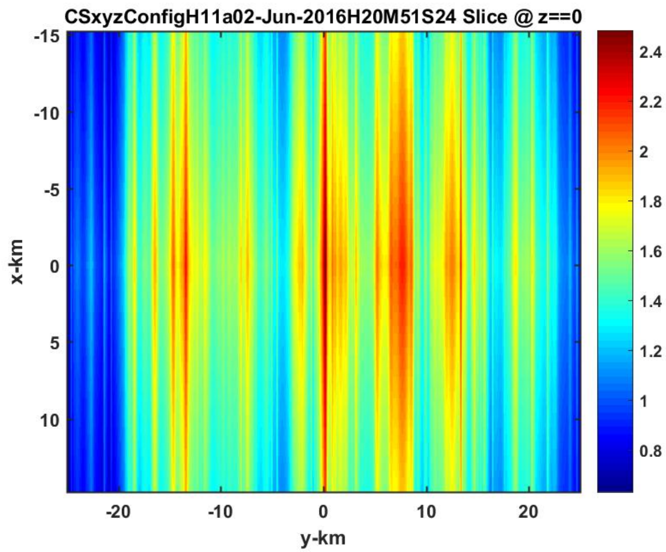
Cardinal Orientations

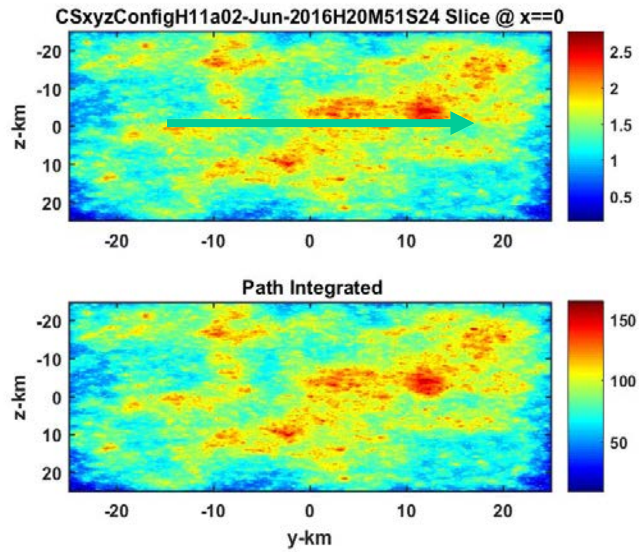
Cross Field





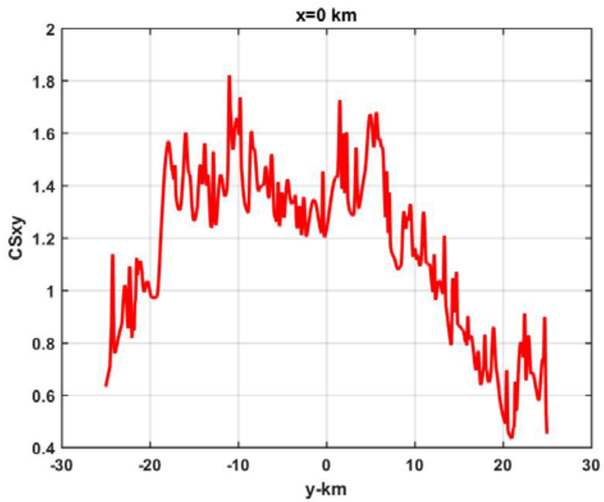
Along Field

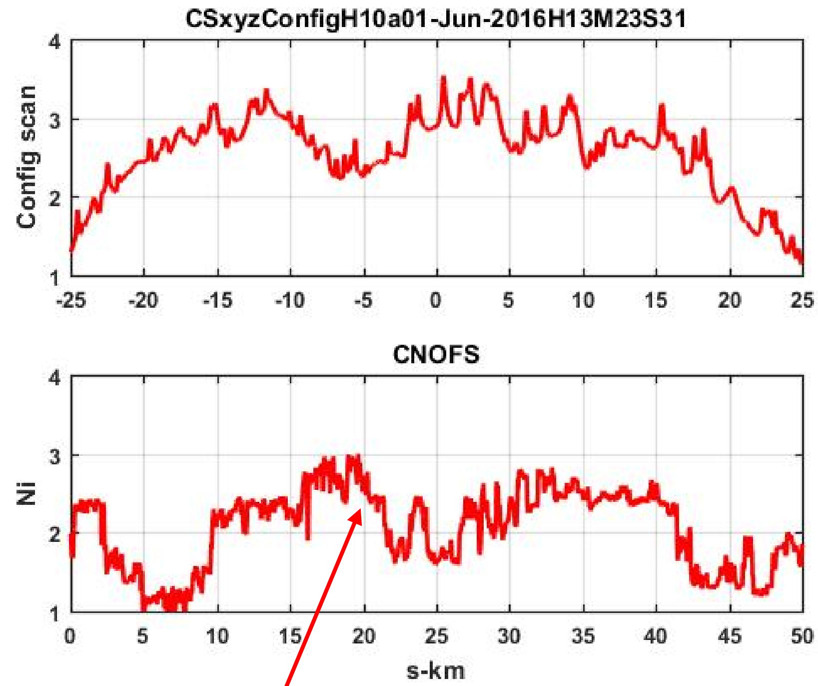




1D Cross-Field Scans

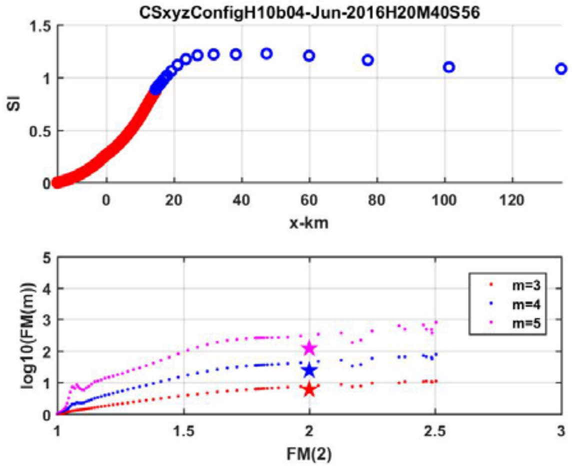
Cross Field

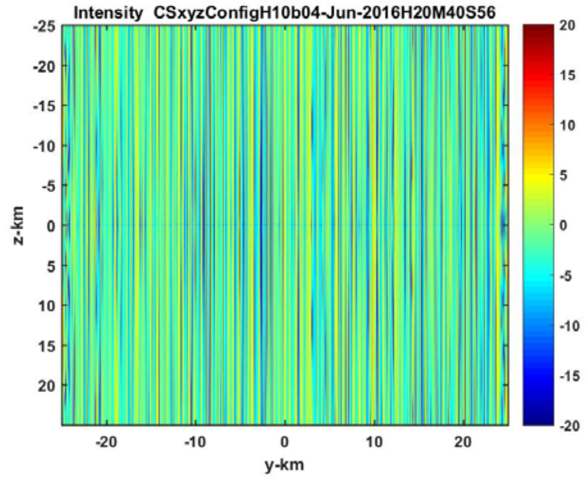


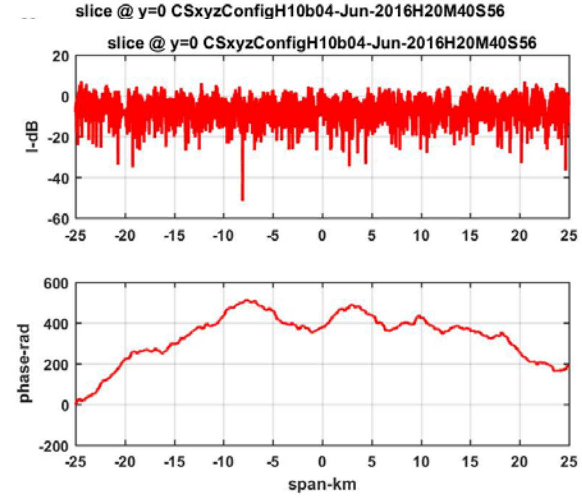


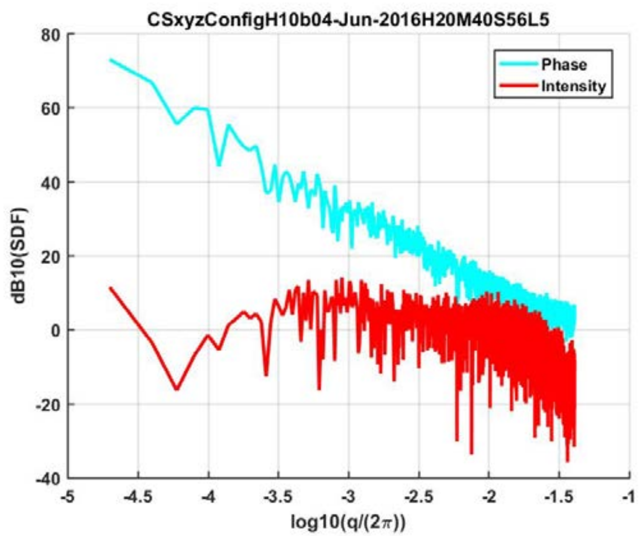
C/NOFS Data

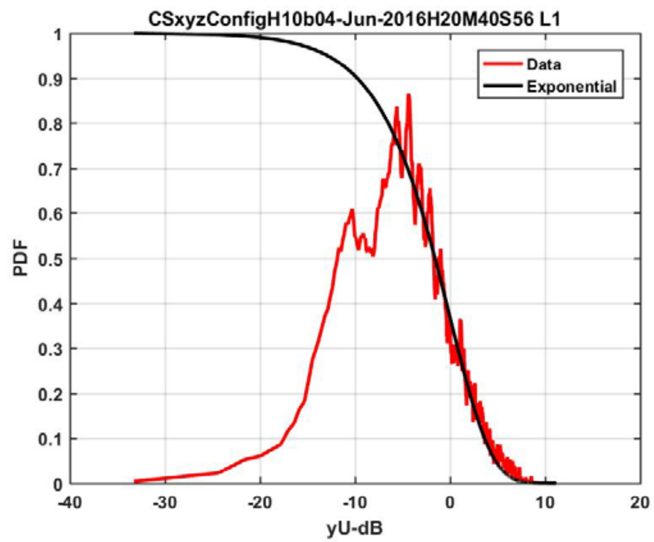
Propagation Cross Field











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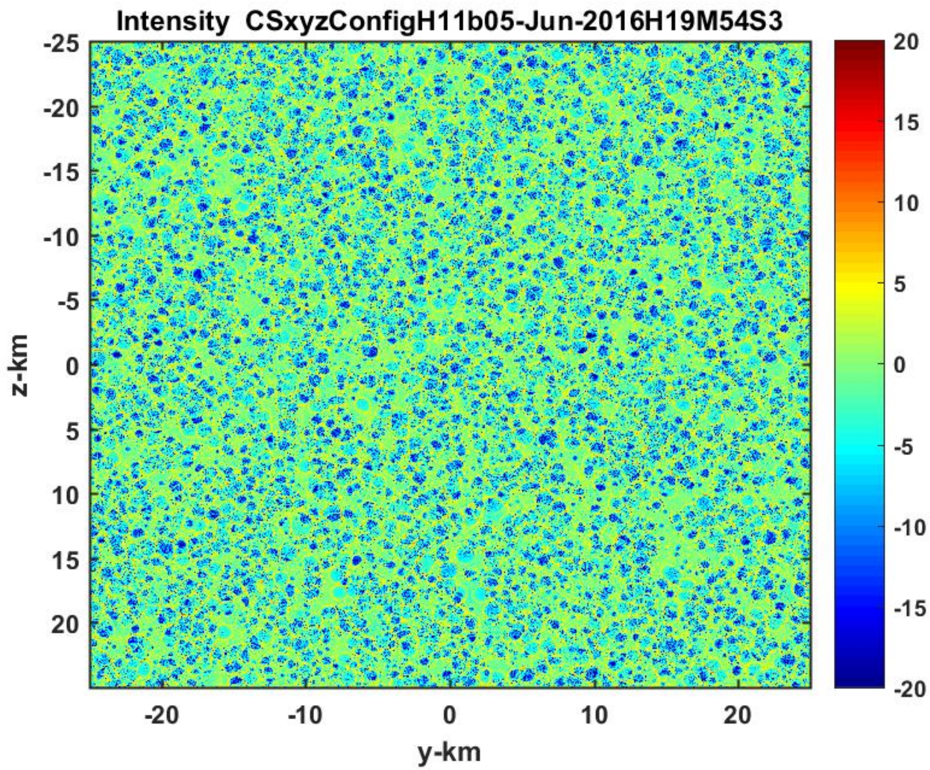
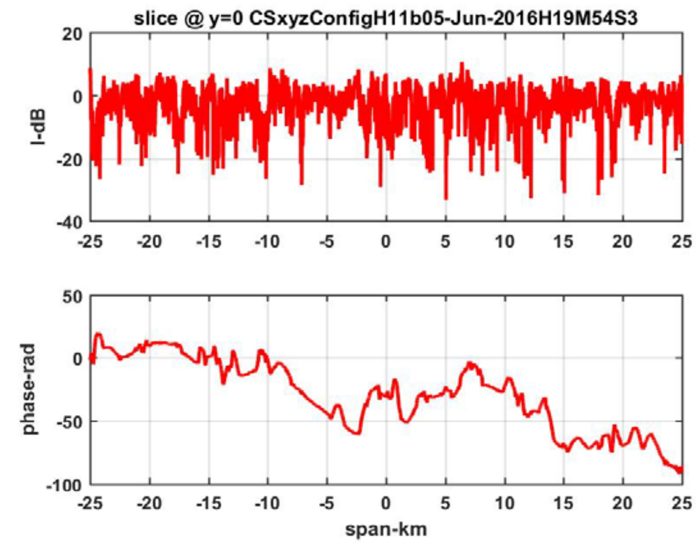
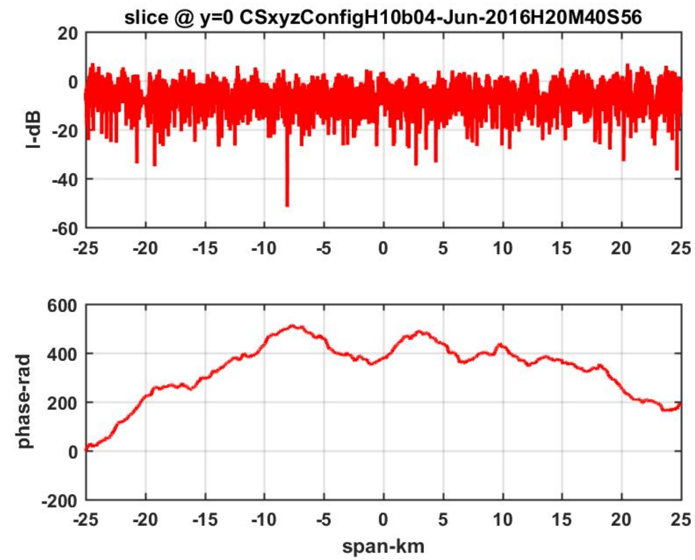
Propagation Along Field







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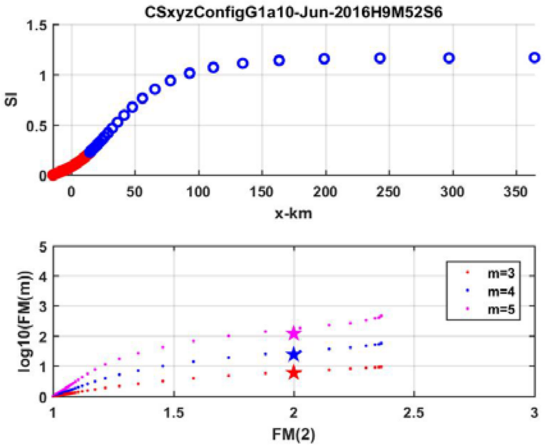
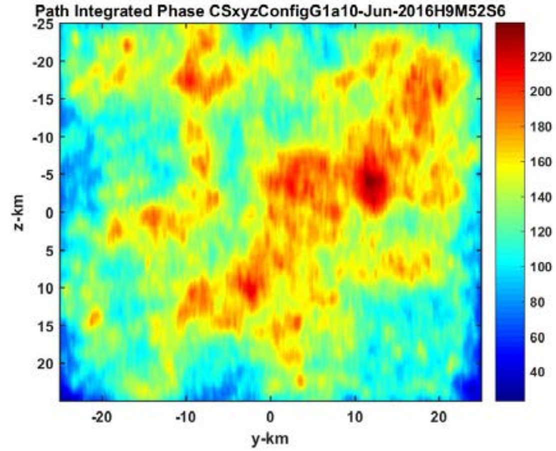
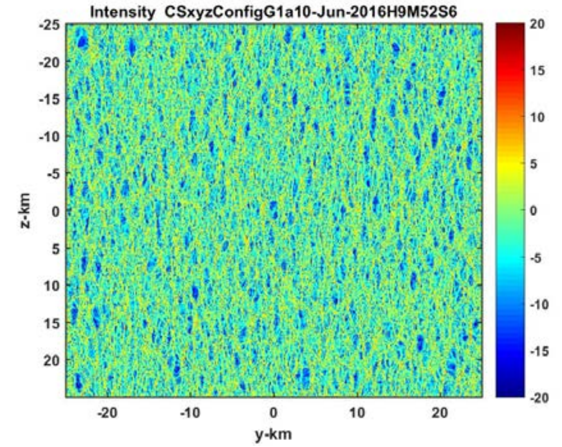
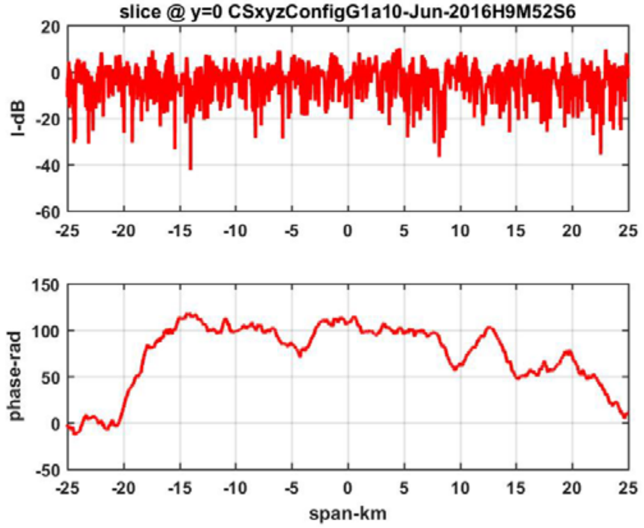
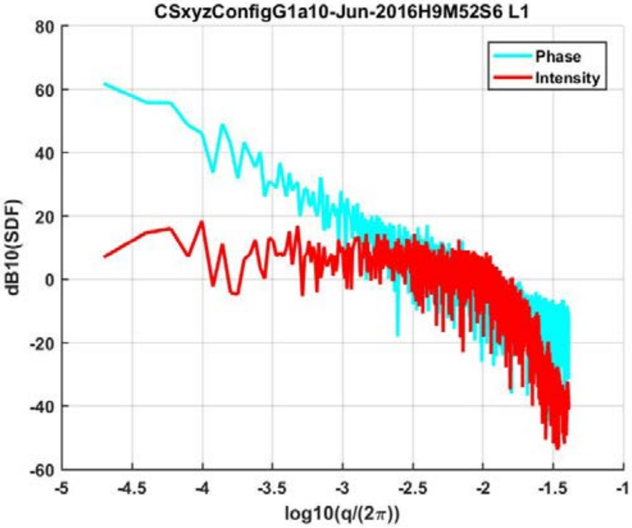
A Directed Example











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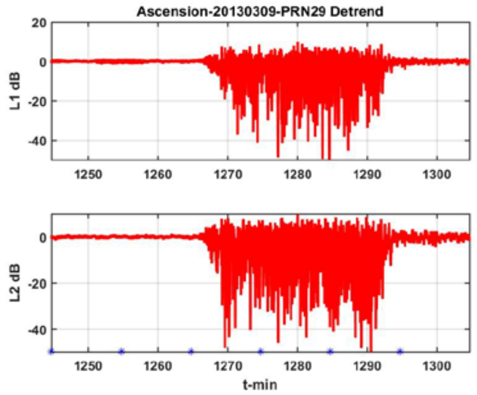
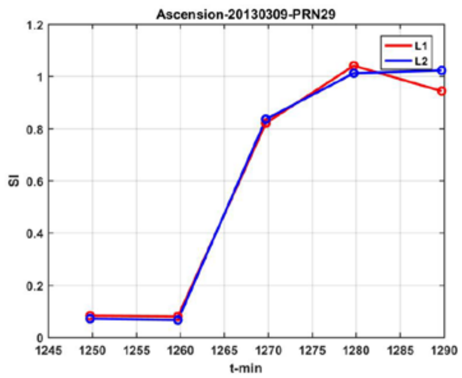
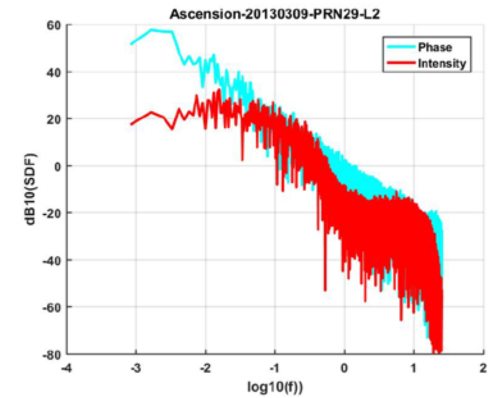
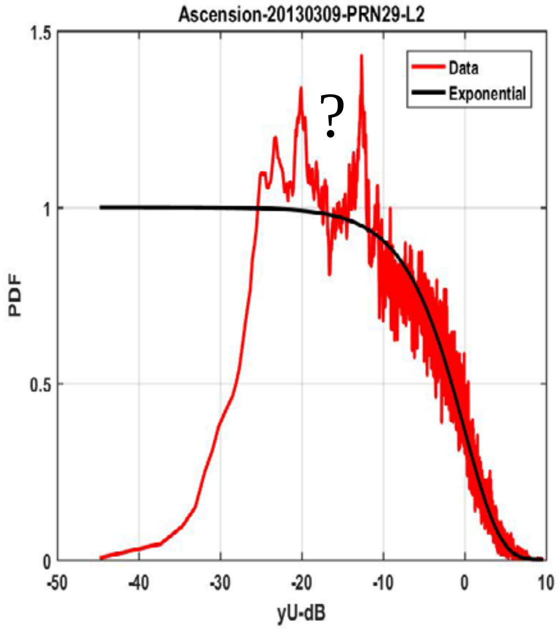
Ascension Island Data

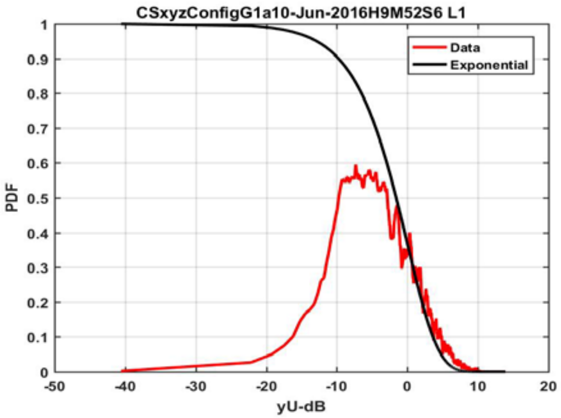








Simulation PDF



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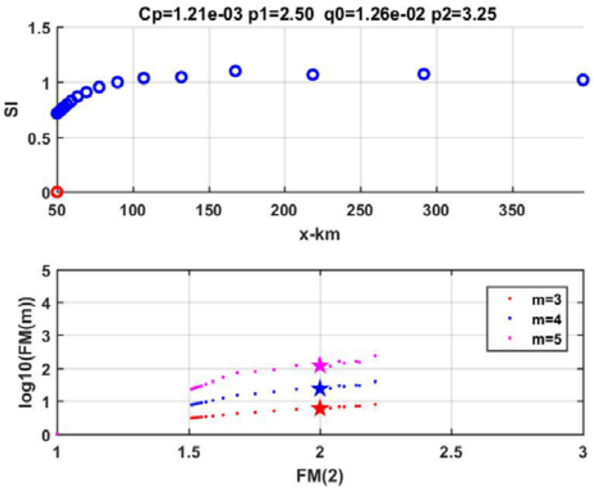
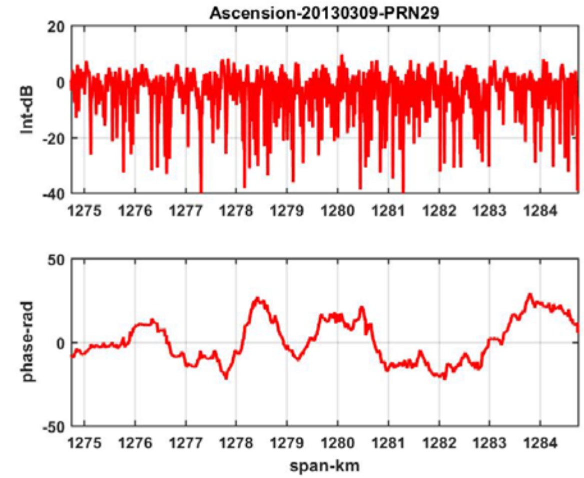
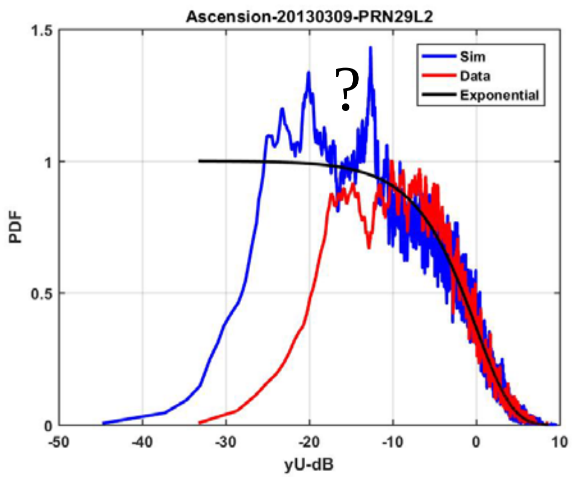
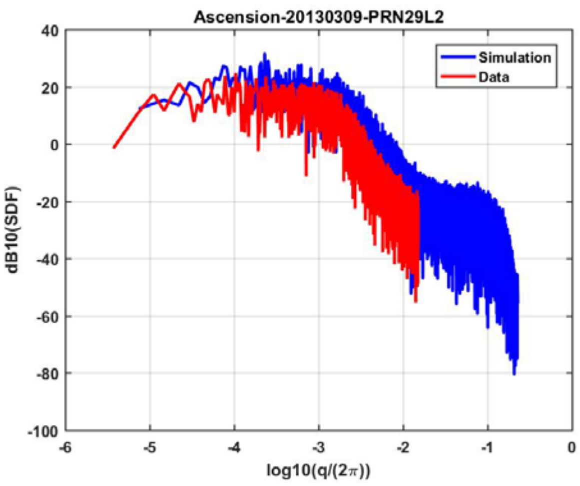
One-Dimensional Phase Screen









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Conclusions

- Cross-field and field-aligned propagation geometries generate measurement-plane structure that preserve striation size-distributions.
- Textural differences depend on field-aligned structure, which is currently being investigated.
- Fully two-dimensional or equivalent phase screens capture the stochastic structure.
- Conventional structure realizations also capture the stochastic structure.
- Structure defined by striation distributions has ramifications for data interpretation. PDFs are more sensitive to structural differences than PSDs.
- The ramification of field curvature remains to be investigated.

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Successive Bifurcation Rule

$\sigma_j = \sigma_{\max} 2^{-j}$ Striation scale

$N_j = 2^{d-j}$ Number of striations at scale *j*

$F_j = \sigma_j^{-\eta}$ Strength of striation at scale *j*