Reconciling Two-Component Power Law Spectra

By

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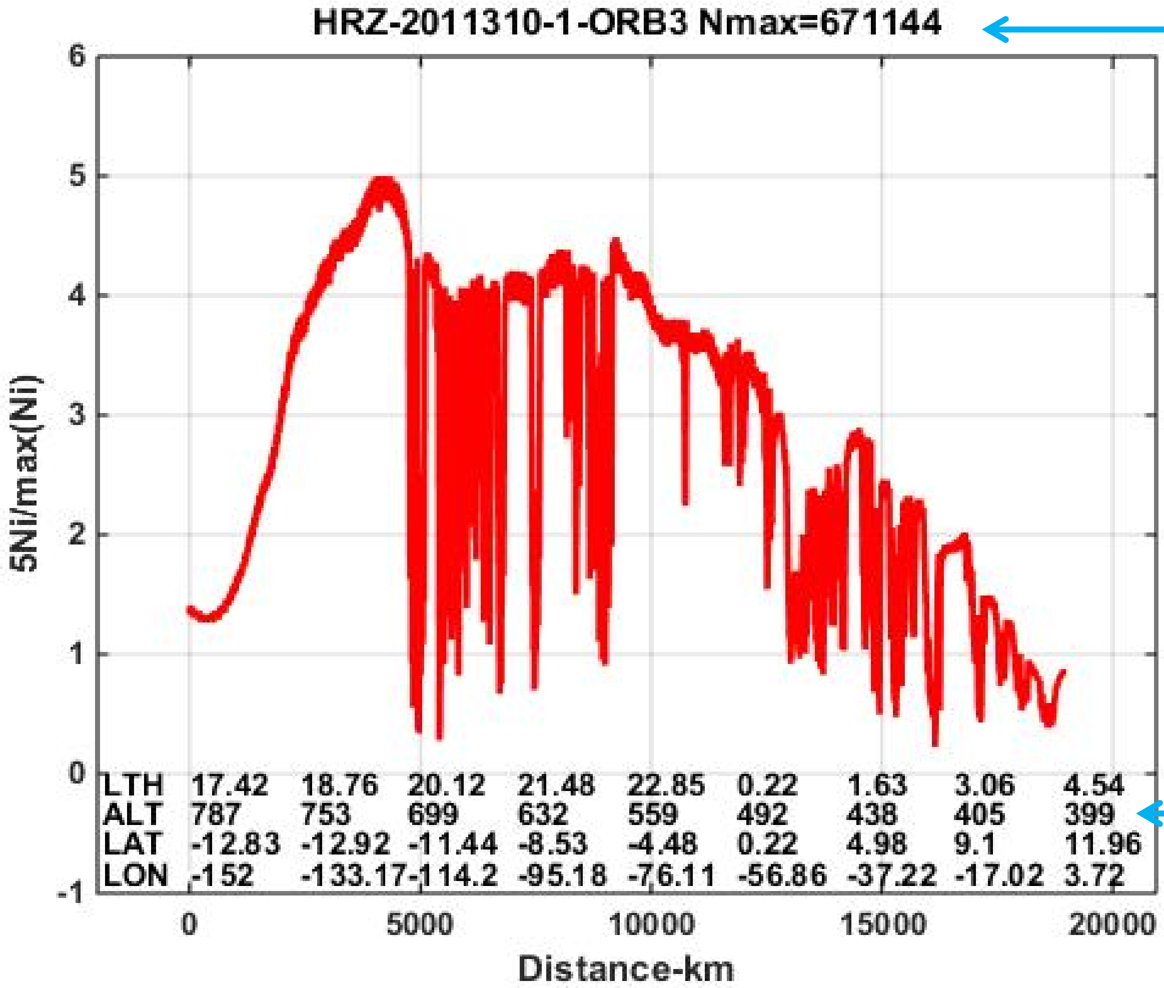
Introduction

- The dynamic evolution of ESF involves structure scales from thousands of kilometers to meters
- **Intermediate-scale** structure from hundreds of kilometers to hundreds of meters comprises both quasi-deterministic and stochastic components
  - Intermediate-scale structure is highly anisotropic with a slowly varying (*frozen*) spatial distribution of structure scales
  - Only well-developed sub-regions are amenable to definitive statistical characterization
- A wavelet-based analysis procedure has been developed to generate a segmentation and classify each segment using a two-component inverse-power-law hypothesis doi:10.1002/2013RS005272
  - The initial analysis did not provide a definitive identification of the two-component power-law structure know to be associated with ESF from both earlier rocket, satellite, and scintillation diagnostics
  - This paper describes the analysis of additional data covering operations during the four-year period 2011, 2012, 2013 and 2014

Highly Disturbed C/NOSF Example



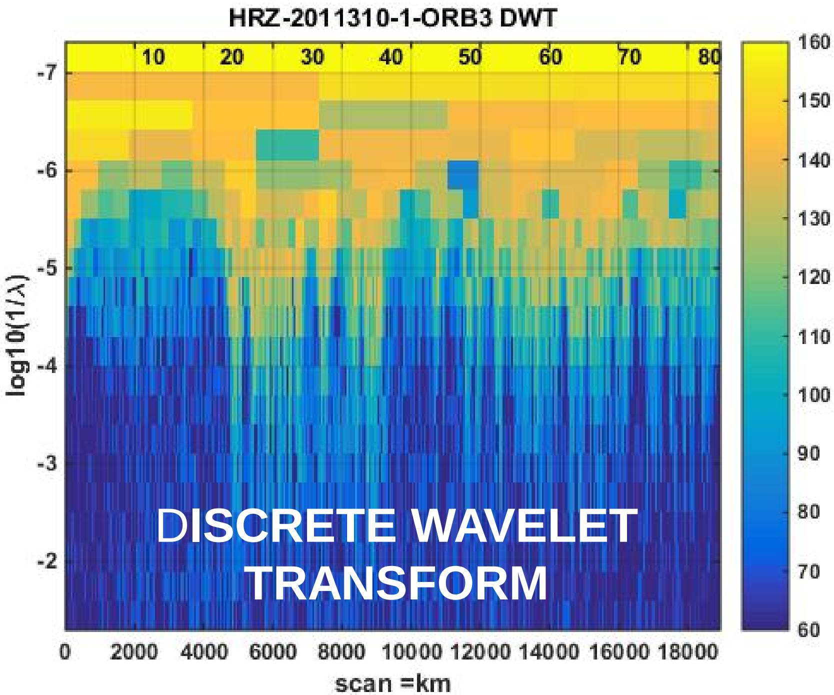
$6.7 \times 10^{13}\ \text{m}^{-3}$

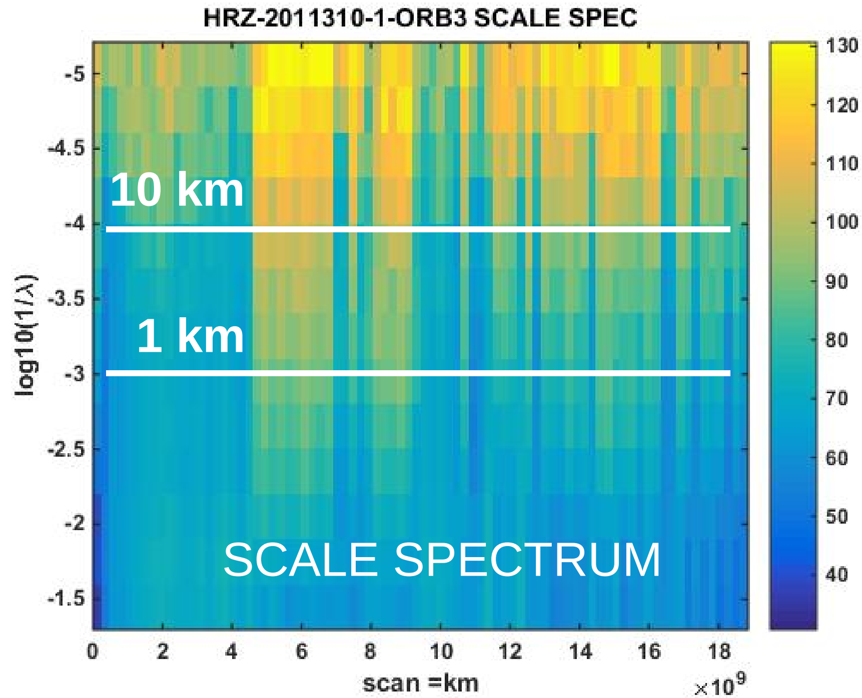
1,349,950 samples at 14.03 m

400 km altitude variation

Uniform spatial scale derived by interpolation of uniform time sampling

Wavelet Based Analysis





Classification

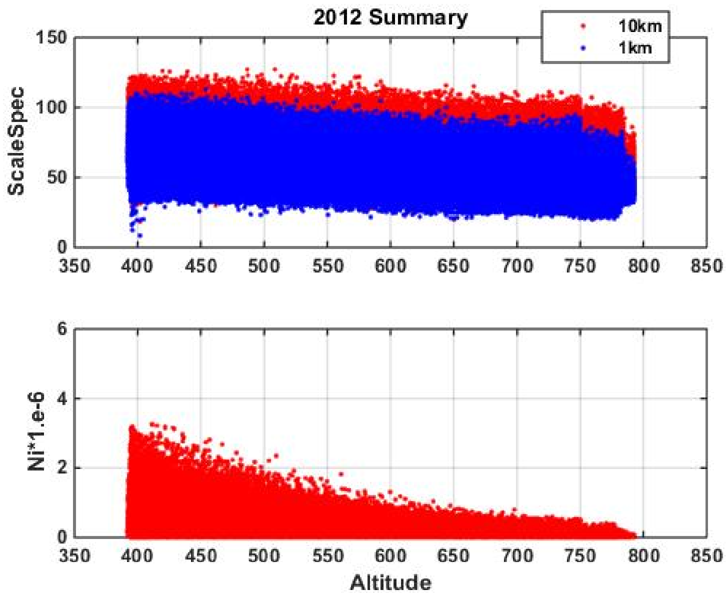
Original data => 80 segments spanning 229 km (16,384 samples)
20 logarithmically resolved scales

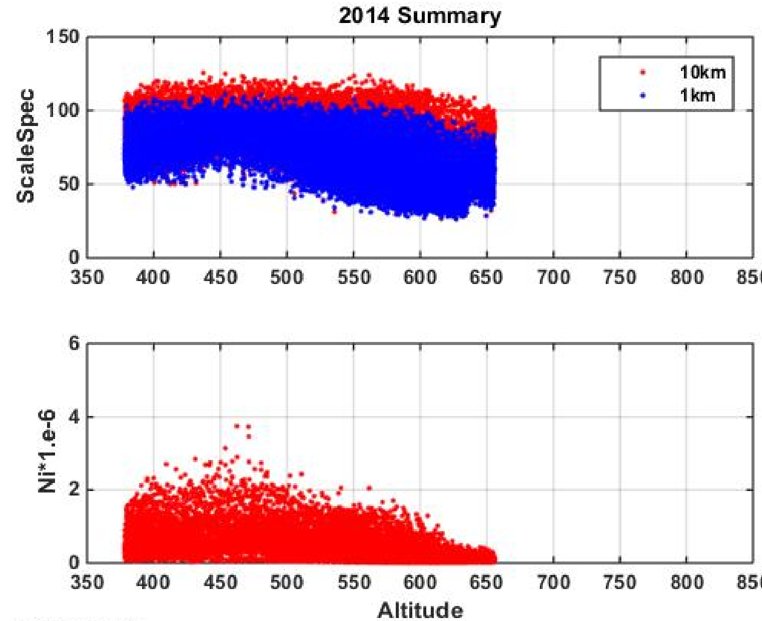
$$\varphi(q) = \begin{cases} C_1 q^{-p_1} & q < q_0 \\ C_2 q^{-p_2} & q > q_0 \end{cases}$$

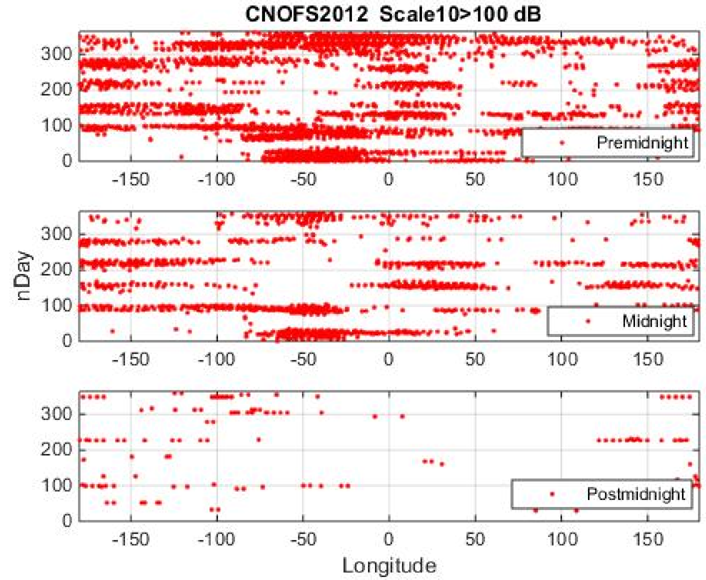
$$C_2 = C_1 q_0^{p_2 - p_1}$$

$$q_0 = \exp(\ln(C_2) - \ln(C_1))/(p_2 - p_1)$$

Morphology





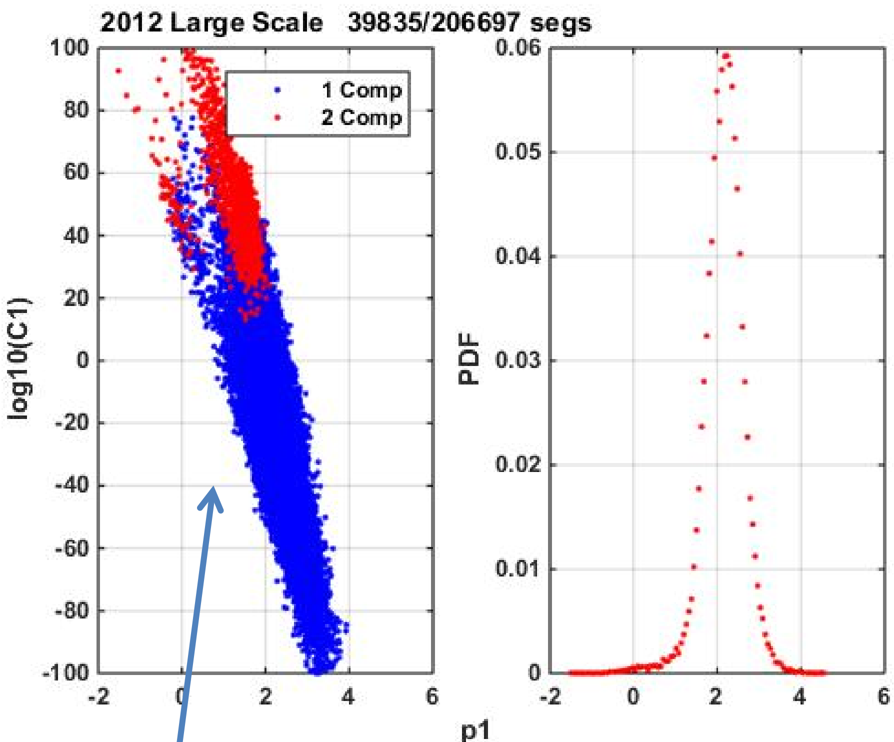


Evening

Midnight

Morning

Intermediate Scale Structure



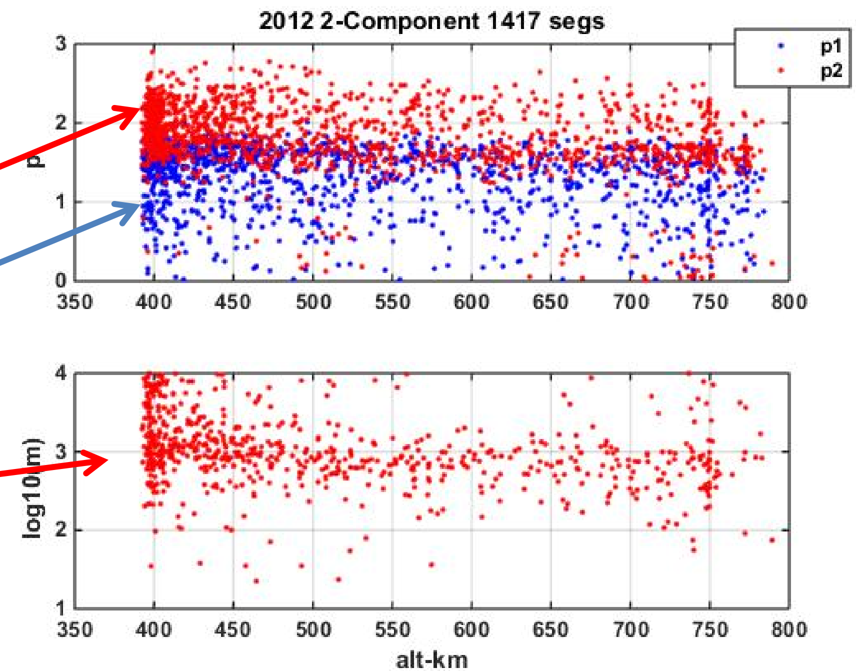
Year 2012

206,697 segments classified

39,835 support power-law

1,417 two-component

Identical patterns observed for 2011, 2013 and 2014



LARGE SCALE

SMALL SCALE

BREAK SCALE

Systematic p1 decrease with increasing C1

Conclusions

- The most highly disturbed passes as identified by the large-scale turbulence parameter C1 are characterized by two-component power-laws with p1 approaching 1 and p2 exceeding 2
- The p1 index varies inversely with increasing C1, possibly a characteristic of structure development
- Two-component spectra are generally associated with the largest mean segment density levels, but they are observed over the full altitude range

Scintillation Forecast
Strong-scatter theory
U>1 => severe