Modeling refractivity fluctuations with random functions

Ted Rogers[1], Qing Wang[2], and Shouping Wang[3]

[1] SPAWAR Systems Center, San Diego, 92152-5000
[2] Naval Postgraduate School, Monterey
[3] Naval Research Laboratory, Monterey

Fluctuations in the refractive index n can be characterized with the refractive structure function index C_n^2. C_n^2 is often modeled as decreasing exponentially with height and having a dependence on latitude and season. A subset of the components of C_n^2 are at scales below that which can be resolved with the grid spacing of large eddy simulation (LES). The output of mesoscale numerical weather prediction (NWP) models can be wholly outside those scale lengths. When electromagnetic (EM) parabolic equation (PE) models are run using refractivity from a mesoscale NWP model, a troposcatter model is often run within the PE model to add what amounts to sub-grid fluctuation $n'(r, z)$ to the NWP output $n(r, z)$ where r is range and z is height.

As seen in Gilbert, et al., *Radio Science,* 34(6), 1999, a large jump in C_n^2 can occur at the top of the boundary layer (z_i). In that region, C_n^2 can jump by two or more orders of magnitude from values in the mixed layer. The jump is (at least) partially driven by local variations in z_i.

In this talk we explore the use of random functions as a means to add the effects of sub-grid turbulence. The rationale for using random functions is that C_n^2 is a measurement of what amounts to displacement with respect to a horizontally- or time-averaged vertical profile; i.e., a parcel at $r, z + \delta z$ as a parcel at z in the mean profile. Thus we replace the model:

$$n(r, z) \;=\; n^{NWP}(r, z) + n'(r, z)$$

(where the matrix of n' values exhibit Kolmogorov's wave-number dependence) with

$$n(r, z) \;=\; n^{NWP}(r, z + z'(r, z)) + n'(r, z)$$

where $z'(r, z)$ is a set of height perturbations. The presentation will show the random function model can replicates the behavior of C_n^2 seen in LES output without using LES. We will describe progress in relating the probability densities for $z'(r, z)$ and $n'(r, z)$ to quantities that can be diagnosed from mesoscale NWP output.