Subgrid-scale Variability of the Index of Refraction in Different Types of Atmospheric Boundary Layers from Large Eddy Simulations

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Predictions of radar signal propagation often rely on forecasts of atmospheric refraction from mesoscale models with a nominal horizontal grid resolution of a few to tens of kilometers. While the model forecast fields generate mean profiles of temperature and humidity for each horizontal grid, and hence the vertical variation of the index of refraction, there is significant subgrid-scale variability that is not represented by these model-derived profiles. However, electromagnetic (EM) waves propagate in the instantaneous refraction field of the real atmosphere and not in the volume-averaged mean refractive index field produced by the mesoscale models. This study will investigate the magnitude of the subgrid-scale variability and demonstrate the uncertainty such variability may produce in signal propagation forecasts using simulated fields from large eddy simulations (LES) models and the Advanced Refractivity Effects Prediction System (AREPS).

We will use statistical analyses of the LES fields in different types of atmospheric boundary layers, both over the ocean and over land, with different cloud conditions to explore the following issues: 1) the horizontal variability in the vertical profile of the index of refraction on length scales smaller than the mesoscale grids; 2) the subgrid-scale variability in different types of boundary layers; 3) the uncertainty associated with radar propagation resulting from subgrid-scale variability in profiles of the index of refraction; and 4) a probabilistic approach to representing subgrid-scale variability in the index of refraction that will augment mesoscale forecast input in propagation models. The LES analyses should result in a family of probability distribution functions. We will present propagation loss results from AREPS using multiple profiles sampled from these probability functions to obtain an ensemble of EM propagation forecasts quantifying the expected influence of subgrid-scale variability on radar signal propagation.