Direct Resolution of Low-Level RF Refractivity using NWP

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As computing capabilities continue to increase exponentially, numerical weather prediction (NWP) codes such as the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) and the Weather Research and Forecast model (WRF) are increasingly being run at very high horizontal and vertical resolution. For example, on a standard Dell server with 100+ GB RAM and 12 processors, regional simulations with 1-m vertical resolution in the lower part of the boundary layer are nearly operational. Therefore, in theory, given accurate representation of water-vapor exchange processes via surface layer and planetary boundary layer (PBL) parameterizations, low-level atmospheric features like evaporative ducts, near-surface temperature inversions and moist, marine layers can be explicitly resolved. This could eliminate the need for blending of refractivity profiles using a surface layer scheme and the upper air column and avoids any discrepancies that may be introduced when using a different surface layer scheme from that in the underlying NWP model.

Given these advances, it is reasonable to consider what role high-resolution NWP can play in directly characterizing anomalous propagation features in the lower PBL. There are advantages and disadvantages to this approach. On one hand, NWP models can capture more physical processes than traditional bulk flux approaches (e.g. TOGA-COARE and NAVSLaM). For example, shallow marine layers and near-surface frontal temperature inversions are resolvable with high-resolution NWP. On the other hand, high resolution does not ensure high accuracy. NWP model solutions are only as good as their underlying physical parameterizations, their degree of air-sea boundary coupling, and their initialization techniques. Data assimilation techniques can mitigate these issues somewhat if *in situ* data are present, but data assimilation is no silver bullet; without proper parameterizations and spatial resolution, the resulting solution will remain highly inaccurate. Furthermore, as the horizontal resolution of models exceed ~1-2 km, the “mesoscale no-man’s land” becomes relevant. This is where PBL parameterizations become questionable in terms of how they handle turbulent exchange processes. Lastly, vertical gradients of water vapor drive phenomena of interest to radio frequency (RF) propagation forecasts. Water vapor gradient is not a standard skill metric, and it is risky to assume that “higher fidelity” NWP configurations automatically produce better forecasts for RF-propagation applications.

In order to explore some of these issues, a series of WRF simulations with varying vertical resolution were performed along the east coast of the United States in March, 2015. The purpose of these simulations was to: a) capture both stable and unstable atmospheric conditions in order to compare bulk model approaches (NAVSLaM) with direct resolution of atmospheric features; and b) to determine how much variability in the solution is introduced by different combinations of PBL and surface layer parameterizations. Here we present the results of comparisons between NAVSLaM and WRF.