Analysis of Evaporative Duct Variability from Large Eddy Simulations

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This study utilizes Large Eddy Simulation (LES) modeling of the marine atmospheric surface layer (MASL) to examine variations of evaporative duct (ED) properties that occur at scales of turbulent energy containing eddies (ECE) resolved by LES. Current operational methods for characterizing the evaporative duct rely solely on surface layer models, which are based on Monin Obukhov Similarity Theory (MOST), to create vertical mean state variable profiles which determine ED properties. This approach outputs spatially/temporally averaged MASL and ducting conditions, and does not capture the variations to ducting properties that exist over small length and time scales.

This study first examines the spatially averaged profiles/ducting conditions from LES for comparison and evaluation against MOST-based evaporation duct models such as the Naval Atmospheric Vertical Surface Layer Model (NAVSLaM). Turbulent properties are then examined via statistical and spectral methods to quantify the spatial scales and magnitudes of refractivity variations. Our analysis then utilizes conditional sampling and compositing techniques to characterize the dynamic and thermodynamic properties of convective updrafts and downdrafts under both stable and unstable conditions, and the resulting effects of these features on ED characteristics, such as duct strength and height. Lastly, the net/range integrated effects of these ECE scale variations is assessed by utilizing the VTRPE EM propagation model to illustrate the impact of small-scale variability on electromagnetic wave propagation in the evaporation duct. Such impact will be examined for different mean ED conditions and under a variety of different modeled frequency and sensor geometries.