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Investigating Marine Boundary Layer Parameterizations for Improved Off-Shore Wind Predictions by Combining Observations with Models via State Estimation

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Despite advances in model representation of the spatial and temporal evolution of the atmospheric boundary layer (ABL) a fundamental understanding of the processes shaping the Marine Boundary Layer (MBL) is still lacking. As part of a project funded by the U.S. Department of Energy, we are tackling this problem by combining available atmosphere and ocean observations with advanced coupled atmosphere-wave models, and via state estimation (SE) methodologies. The over-arching goal is to achieve significant advances in the scientific understanding and prediction of the underlying physical processes of the MBL, with an emphasis on the coupling between the atmosphere and the ocean via momentum and heat fluxes. We are using the single-column model (SCM) and three-dimensional (3D) versions of the Weather Research and Forecasting (WRF) model, observations of MBL structure as provided by coastal and offshore remote sensing platforms and meteorological towers, and probabilistic SE. We are systematically investigating the errors in the treatment of the surface layer of the MBL, identifying structural model inadequacies associated with its representation. We expect one key deficiency of current model representations of the surface layer of the MBL that can have a profound effect on fluxes estimates: the use of Monin-Obukhov similarity theory (MOST). This theory was developed for continental ABLs using land-based measurements, which accounts for mechanical and thermal forcing on turbulence but neglects the influence of ocean waves. We have developed an atmosphere-wave coupled modeling system by interfacing WRF with a wave model (Wavewatch III – WWIII), which is used for evaluating errors in the representation of wave-induced forcing on the energy balance at the interface between atmosphere and ocean. The Data Assimilation Research Testbed (DART) includes the SE algorithms that provide the framework for obtaining spatial and temporal statistics of wind-error evolution (and hence the surface-layer fluxes), along with objective tuning of model parameters. Budgets for the first and second moments of residual error reveal primary error sources, which via SE are be corrected allowing to greatly improve offshore wind forecasts. Results over a domain center at the FINO 1 covering northern Europe for the month of July, and from October to November of 2006 will be presented.