Center for Environmental & Applied Fluid Mechanics

“Multi-Scale Modeling of Real-World Atmospheric Boundary Layers: Coupling Weather and GPU-Accelerated Large-Eddy Simulation Models for Actionable Science”

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Abstract: The atmospheric boundary layer (ABL) is characterized by a broad range of scales strongly interacting across the entire energy spectrum. However, historical limitations on computational capabilities have precluded the simulation of both the turbulence field and associated time-varying mesoscale forcing. Consequently, most microscale turbulence-resolving large-eddy simulations (LES) of flows in the ABL focus on idealized, canonical boundary layers, for which simplified large-scale forcing was applicable. One way to accomplish the goals of obtaining higher-fidelity turbulence information, while incorporating variability arising from the largescale forcing, is through mesoscale/microscale coupling (MMC). In this talk, we will present an overview of the challenges and progress made on MMC over the last decade utilizing mesoscale numerical weather prediction and LES models, particularly regarding turbulence initiation in techniques. The benefits of this approach will be demonstrated using the nesting capabilities of the Weather Research and Forecasting (WRF) model through validation with data from field experiments. In this context, the Research Applications Laboratory of NSF NCAR has pursued development of computationally efficient LES modeling capabilities for real-world micrometeorology using the GPU-accelerated FastEddy® model. The computationally efficiency of FastEddy® together with an optimized coupling strategy is enabling multi-scale exploration of the complex and heterogeneous urban environment beyond the ability of CPU-based models. Examples of building-resolving ABL modeling with the WRF-to-FastEddy® coupling framework will be presented, showcasing the added value of the multi-scale modeling approach. At the end of the talk, our latest efforts in LES-to-LES nesting to reach sub-meter grid spacings will be discussed. These include a variety of real-world opportunities to exploit high-fidelity realizations of near-surface ABL processes for applications from machine learning model development to tactical microscale weather forecasting for decision-support purposes.

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