Multidisciplinary Simulation, Estimation, and Assimilation Systems

Seminar Series

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Large-eddy simulations and mean and turbulence dynamics in unsteady Ekman flows

Abstract: Unsteady geostrophic forcing in the atmosphere or ocean not only influences the mean wind, but also affects the turbulent statistics. In these geophysical wall-bounded flows, it is important to understand when and if turbulence is in quasi-equilibrium with the mean flow. To that end, one needs to understand how the turbulence decays or develops, and how do the turbulent production, transport and dissipation respond to changes in the imposed forcing. The knowledge obtained from studying these questions help us understand the underlying physical dynamics of the unsteady boundary layers and develop better turbulence closures for weather/climate models and engineering applications. The present study focuses on the unsteady Ekman boundary layer where pressure gradient forces, Coriolis forces, and turbulent friction forces interact but are not in equilibrium. We perform a suite of large-eddy simulations with variable forcing and acquire the corresponding resolved turbulent kinetic energy budget terms for each simulation. Many cases with unsteady geostrophic forcing are simulated to examine how the turbulence is modulated by the variability of mean pressure gradient. We also examined the influence of the forcing variability time scale on the turbulence equilibrium and TKE budget, and assessed the implications for mean-turbulence nonlinear interactions and turbulence modeling in such flows.

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