Boulder Fluid and Thermal Sciences Seminar Series

Tuesday, February 28, 2017
3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center (DLC)
University of Colorado, Boulder

Development of a Wind Plant Large-Eddy Simulation with Measurement-Driven Atmospheric Inflow

Eliot Quon, *National Renewable Energy Laboratory*

This presentation details the development of an aeroelastic wind plant model with large-eddy simulation (LES) aerodynamics. The chosen LES solver is the Simulator for Wind Farm Applications (SOWFA) based on the OpenFOAM framework, coupled to NREL's comprehensive aeroelastic analysis tool, FAST. An atmospheric boundary layer (ABL) precursor simulation was constructed based on assessments of available meteorological tower and radar data—sourced from an operational wind plant—over a 3-hour window occurring 2 hours after sunrise. The precursor was tuned to the specific atmospheric conditions that occurred both prior to and during the measurement campaign, enabling capture of a night-to-day transition in the turbulent ABL. Challenges encountered during development of the precursor highlight more general difficulties in synthesizing weather-scale and wind plant-scale data. In the absence of height-varying temperature measurements, spatially averaged radar data were sufficient in this case to characterize the atmospheric stability of the wind plant in terms of the shear profile, and near-ground temperature sensors provided a reasonable estimate of the ground heating rate describing the morning transition. A full aeroelastic simulation was then performed for a subset of turbines within the wind plant, driven by the precursor. Analysis of two turbines within the array, one directly waked by the other, demonstrated good agreement with measured time-averaged loads.

The Sensitivity of Rotating Rayleigh-Bénard Convection to Ekman Pumping

Meredith Plumley, *University of Colorado, Boulder*

Rapidly rotating convection is relevant in many geophysical and astrophysical settings, including planetary interiors, oceans and atmospheres. To study these systems, the canonical paradigm of rotating Rayleigh-Bénard convection, or the flow between two rotating parallel plates heated from below, is investigated using three methods: asymptotic methods, DNS and laboratory experiments. While simulations have seen good agreement in results for stress free boundary conditions, the case of no-slip boundaries presents an interesting difference. Along these boundaries, Ekman layers form and Ekman pumping occurs. Recent results have shown that Ekman pumping has a nontrivial effect on the flow even at low Ekman number. However, at present, DNS and laboratory experiments cannot probe the regime of asymptotically small Ekman numbers. Using a combination of results from DNS and the asymptotic model, we form the 2D surface of the heat transfer as a function of the Rayleigh number and the Ekman number for no-slip boundaries. This surface covers a range of data only accessible through the use of the asymptotically reduced model. These results provide insight into the sensitivity of the flow to Ekman pumping and allow for an empirical determination of the heat transfer enhancement due to no-slip boundaries at low Ekman, a regime of interest for modeling planetary interiors. The results also serve as a foundation for the next generation of laboratory experiments.