Boulder Fluid Dynamics Seminar Series

Tuesday, January 27, 2015
3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center (DLC)
University of Colorado at Boulder

Two-way Interactions in Particle-Laden Turbulent Channel Flow: Results from Particle-Resolved Simulations

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Modulation of the carrier phase turbulence by finite-size inertial particles is relevant to many industrial (e.g., particle transport in pipeline and drag reduction) and environmental applications (e.g., effect of sea-spray droplets on hurricane development). The nature and level of modulation depend on many factors including scales and geometric configurations of the carrier phase flow and particle characteristics such as size, density, mass loading. Finite-size particles may introduce both local viscous dissipation and kinetic energy production.

In this talk, I will discuss our on-going work to develop a particle-resolved simulation of wall-bounded, turbulent particle-laden flow using the mesoscopic lattice Boltzmann (LB) approach. The talk consists of two parts. The first part concerns implementation details, specifically, the treatments at the fluid-moving particle interfaces within the LB approach and careful validation of the approach. In the second part, we study flow modulation by finite-size particles in a particle-laden turbulent channel flow. Results of single-phase turbulent channel flows are first compared to published benchmark DNS results to validate the lattice Boltzmann approach. In this talk, particles are assumed to have a same density as the fluid, and two different particle sizes of the order 10 to 20 wall units are considered. The relative changes due to the presence of solid particles, of the mean flow velocity and rms velocity fluctuations are compared to results from a finite-difference direct forcing (i.e., macroscopic) approach. Phase-partitioned statistics are compared to reveal some local dynamics within each phase. The particle concentration distribution across the channel shows that there is a dynamic equilibrium location resembling the Segre-Silberberg effect known for a laminar wall-bounded flow.

Tracer Evolution in the Oceanic Mixed Layer

Katherine Smith, *University of Colorado, Boulder*

Ocean tracers such as carbon dioxide, nutrients, and plankton evolve primarily in the oceanic mixed layer where air-sea gas exchange occurs and light is plentiful for photosynthesis. It is well known from prior observational and computational studies that there can be substantial heterogeneity, or patchiness, in the spatial distribution of ocean tracers due to both vertical and horizontal turbulent mixing across a wide range of scales. The contribution of submesoscale turbulent processes to these distributions is not completely understood, however, particularly in the sub-kilometer range. Within this range, both large-scale, quasi-geostrophic eddies and small-scale, three-dimensional turbulence are active, resulting in substantial dynamical complexity from which tracer heterogeneity can arise. In this talk, results from large eddy simulations of the evolution of a large scale temperature front are used to examine the role of multi-scale turbulent mixing on distributions of idealized ocean tracers from scales of 20km down to 5m. The simulations include the effects of wave-driven Langmuir turbulence by solving the wave-averaged Boussinesq equations with an imposed Stokes drift velocity. Tracers with different source, initial, and boundary conditions are examined in order to understand the respective roles of both small-scale, near-surface vertical mixing and larger-scale upwelling motions typically associated with submesoscale eddies. Tracer evolution is characterized using spatial concentration distributions, multi-scale fluxes, and spectra, and the implications of the results for computational modeling of air-sea gas exchange and upper-ocean tracer transport are outlined.