Boulder Fluid and Thermal Sciences Seminar Series

Tuesday, May 31, 2016
3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center (DLC)
University of Colorado, Boulder

Shedding LIGHT on eddy-induced mixing in an idealized circumpolar current via online particle tracking

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Many common offline diagnostics, such as Lagrangian particle tracking, will have to be computed online as computing architectures approach Exascale. In this talk I describe development of the online Lagrangian In-situ Global High-performance particle Tracking (LIGHT) diagnostic within the Model for Prediction Across Scales Ocean (MPAS-O) component of the Department of Energy's Accelerated Climate model for Energy (ACME). LIGHT is fully parallel and capable of advecting the same number of Lagrangian particles as Eulerian grid cells. Lagrangian trajectories can be used to quantify mixing due to mesoscale eddies using two approaches: dispersion- and transport-based mixing metrics. In this talk, I highlight dispersion-based metrics and use filtering to quantify mixing occurring due to eddies, the mean flow, and nonlinear interactions in an idealized circumpolar current. Meridional diffusivity depth-variability is assessed via space-time dispersion of particle clusters over ten years' worth of a million online particle trajectories. Diffusivity in the jet is largest near the critical layer supporting mixing suppression and critical layer theory. However, it attenuates less rapidly with depth in the jet than both eddy velocity and kinetic energy scalings suggest. A mean-eddy scale separation hypothesis is suspect because both nonlinear upper bound and lower bound diffusivity estimates are large and mixing arises from nonlinearity, i.e., eddy-produced initial filamentation that background mean shear further strains to produce enhanced mixing. Nonlinearity accounts for the majority of the total diffusivity. Eddy and mean flow interactions appear to reduce nonlinear upper bound mixing, but for the lower bound enhance diffusivity near the critical layer. Broadly, this work suggests that diffusivity parameterizations accounting for both diffusivity nonlinearity and depth variability are needed.

Biography: Dr. Phillip J. Wolfram is a computational fluid dynamist in the Theoretical division Fluid Dynamics and Solid Mechanics group at Los Alamos National Laboratory with expertise in numerical methods and modeling of small- and large-scale environmental flows. His work has centered on understanding mixing processes within complex flows, most recently for secondary flows in channel networks in the Sacramento San Joaquin Delta and geostrophic turbulence in idealized Northern Atlantic and Southern Ocean flows. He uses fluid mechanics, algorithms, high-performance computing, software engineering, and advanced visualization techniques to increase knowledge of computation, analysis, and the physics of complex, eddy-driven mixing processes, with emphasis on coastal and climate applications. He is an expert in development and application of unstructured computational fluid dynamics, especially nonhydrostatic processes and in-situ Lagrangian particle tracking techniques.