Effects of upper ocean turbulence on biogeochemical tracers

Katherine Smith
Department of Applied Mathematics and Theoretical Physics
University of Cambridge

May 2nd, 2019

The Earth's ocean is the largest reservoir of carbon in the climate system and the dynamics of the upper ocean boundary layer - the interface between atmosphere and ocean - and the effect of dynamics on upper ocean carbon cycling and export into the ocean interior is a crucial process in the evolution of Earth's climate. Carbon cycling and export in and out of the upper ocean is controlled primarily by biogeochemical tracers such as carbon dioxide, nutrients, plankton, and particulate organic matter (POM). Thus the concentration, vertical distribution, growth rate, and residence time of these tracers within the upper ocean are key parameters that determine carbon transfer rates between the atmosphere and ocean interior. However, these climate-crucial biogeochemical tracers reside within multi-scale, turbulent boundary layer flows —from centimeter scale isotropic turbulence to kilometer-size submesoscale eddies, fronts, and filaments — which often evolve on similar time scales as important biological and chemical processes and are characterized by vertical velocities that rival the sinking rates of carbon containing POM. This time-scale and velocity-scale matching means that the evolution of upper ocean biogeochemical traces depend strongly on the details of the multi-scale turbulent dynamics present.

Multi-scale turbulence and its effects on important biogeochemical tracers will not be fully resolved by Earth system models for the foreseeable future. Thus, accurate prediction of carbon transfer from the atmosphere through the ocean surface boundary layer and into the interior of the ocean requires a parameterization framework that faithfully captures multi-scale turbulent dynamics, biogeochemical dynamics, and their interaction. In this talk, I present an overview of the work I have done thus far using computational methods to better understand these biogeochemical tracer - turbulence interactions, from the development of reduced-order biogeochemical models to performing high-fidelity large eddy- and direct numerical- simulations of tracer-turbulence interactions. Additionally, I discuss the impacts of these results on parameterization development and potential future work to extend these efforts.