Potential Student Research Projects

We will explore one of two research projects this summer. The choice of projects will depend on the interests and background of the students.

1. Coriolis discretization and vorticity errors in numerical models

Obtaining accurate simulations of the coastal ocean flow is important for understanding the dynamics and ecology of the ocean. However, performing these simulations in regions with a steep slope in the ocean bottom (e.g., just offshore of the continental shelf break) is known to be particularly challenging. One standard discretization of the equations of motion, while accurately conserving energy, can produce significant errors in a related quantity called vorticity (related to the curl of the velocity), particularly over a steep slope. This research project is to explore this error, both through analytical and numerical exploration, explain why it's present, and look for ways to minimize the error.

Prerequisites: Multivariable calculus (especially curl and divergence), familiarity with partial differential equations a bonus. Numerical analysis (finite difference approximations) would be very helpful. Computer experience, including familiarity with software such as ssh, fortran, and matlab very helpful.

2. Exact solutions of upwelling and downwelling over sloping topography

Typical summertime wind patterns off the California coast push the near-surface ocean water offshore, which in turn causes deep water to be drawn up to the surface near the coast. This drawing up of deep water ("upwelling") is an important process because the deep water is laden with nutrients that feed the base of the food chain in the coastal ocean. Under some assumptions, the upwelling process can be modeled with a set of coupled partial differential equations. An exact solution of these partial differential equations, assuming a constant-depth ocean, has been used to study upwelling dynamics. However, with a (rather clever!) change of variables, the exact solution over constant-depth ocean can be transformed into a new solution over variable-depth ocean, and also transformed into a solution that describes the "downwelling" process (where the winds and fluid paths reverse direction). Preliminary exploration of this new solution shows that the downwelling solution captures surprising aspects of downwelling seen in more realistic numerical simulations. This research project involves exploring these new upwelling and downwelling solutions, documenting how they depend on the slope of the ocean bottom, and carefully comparing them to numerical simulations that include more complete dynamics.

Prerequisites: Multivariable calculus. Familiarity with partial differential equations very helpful. Computer experience, including familiarity with software such as maple, matlab, ssh and fortran would be beneficial.