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Simple Models of Oceanic Fronts

There are many physical processes that transfer energy between different length scales in the oceans. In this talk, we investigate mechanisms through which energy cascades from the mesoscale $O(100\,km)$ to the submesoscale $O(10\,km)$ for oceanic fronts in a reduced gravity shallow water model. One possibility is that linear instabilities can produce energy directly at the small scales. A second is that the direct energy transfer occurs in the nonlinear regime after the perturbations become mature.

This investigation is done using two distinct idealized profiles for an oceanic front. The first profile has a interfacial depth that is a smooth hyperbolic tangent profile and is an extension of the piecewise constant Potential Vorticity profile studied in Boss, Paldor and Thompson (1996). By considering a range of minimum depths, we find that the most unstable mode exists in a one-model and does not need two layers, as previously speculated. Also,we cannot confirm the existence of a secondary instability at smaller length scales due to a gravity-vortical wave instability. The second is the parabolic double front from Scherer and Zeitlin (2008). We find more unstable modes than previously presented and also categorize them based on the mode number. We also study the nonlinear evolution of these oceanic fronts and determine that vanishing layer depths have significant effects on the unstable dynamics that arise. Our results suggest that the nonlinear dynamics of a front can be very efficient at generating submesoscale motions.