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Inertial-Symmetric Instability Energetics.

Submesoscale oceanic density fronts are structures in which stratification and rotation play an important role, while being only typically 10 km wide and evolve over the course of a few days. They are prone to ageostrophic instabilities called inertial-symmetric instabilities. We argue in this article that drainage of potential, rather than kinetic, energy from the front is a leading-order source of their growth. We illustrate our point with two-dimensional Boussinesq numerical simulations of oceanic density fronts on the f-plane. A set of two-dimensional initial conditions covers the submesoscale portion of a three-dimensional parameter space consisting of the Richardson and Rossby numbers, and a measure of stratification or latitude. Because we let the lateral density gradient decay with depth, the parameter space map is non-trivial, excluding low-Rossby, low-Richardson combinations. Dissipation effectively selects the largest growing mode, and inertial-symmetric instability in a confined unstable region creates flow cells that recirculate outside the unstable region, disturbing isopycnal locations. As the ageostrophic flow grows in amplitude, isopycnals eventually get significantly displaced. Systematically, such isopycnal displacements correspond to a drainage of available potential energy from the geostrophic fronts to the ageostrophic perturbations. In the majority of our experiments, this energy drainage is at least as important as the drainage of kinetic energy from the front. Various constraints, some physical, some numerical, result in our experiments to behave like inertial rather than symmetric instabilities. Our results depend very weakly on the Richardson number and more on the Rossby number and relative stratification.