Near-Inertial waves extract energy from barotropic quasi-geostrophic flow

Cesar B. Rocha[1], Gregory L. Wagner[2], and William R. Young[1]

1: Scripps Institution of Oceanography; 2: Massachusetts Institution of Technology

Recent studies suggest that stimulated imbalance—the transfer of energy from geostrophic flows to *existing* internal waves—serves as a major sink of ocean mesoscale energy en route to viscous dissipation. We use simplified solutions of the Xie & Vanneste (2015) model, which couples near-inertial waves with quasi-geostrophic flow, to study stimulated imbalance associated with vertical vorticity and lateral strain. The simplified solutions assume barotropic quasi-geostrophic flow, constant stratification, and single-plane wave near-inertial vertical structure on the f-plane. The wave-potential energy equation clarifies the physics of wave-energy generation, which occurs at the expenses of geostrophic kinetic energy. There are two sources of wave potential energy: (1) the convergence of the wave flux of near-inertial kinetic energy into anticyclones; and (2) the enhancement of lateral gradients of the wave field.

We quantify the energy conversion using numerical solutions of quasi-inviscid initial-value problems with oceanographic parameters. The wave initial condition is a uniform (laterally coherent) inertial oscillation. And the quasi-geostrophic initial condition is a steady dipole or a turbulent field emergent from random initial conditions. Geostrophic straining accounts for the bulk generation of wave potential energy, which represents a sink of 10-50% of the initial geostrophic kinetic energy. But refraction is fundamental to this problem because it creates the eddy-scale lateral gradients of near-inertial velocity that are enhanced by advection. In these quasi-inviscid solutions, wave dispersion is the only mechanism that stops the energy conversion by moving the waves out of the straining regions.