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How Rossby waves break: Preliminary results from POLYMODE

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How do Rossby waves break in the ocean? In the atmosphere one has weather in the troposphere, and the stratosphere is sufficiently near radiative equilibrium that one might invoke radiative damping as an important diabatic process. Neither of these processes is relevant to the ocean. In the ocean, the standard concept is to consider the stratified interior as an ideal fluid and place all dissipative processes in either the bottom boundary layer or associate them with eddy/mixed layer interactions. This conceptual framework is typically abetted by a lack of sufficient observations to construct energy, momentum and vorticity budgets that might point to "missing forces".

Sufficient observations to construct such budgets were obtained as part of the POLYMODE Local Dynamcs Experiment (LDE). The LDE was a 15 month (May 1978 - July 1979) study of mesoscale ocean variability. It featured arrays of moored current meters, neutrally buoyant floats, standard hydrographic station techniques and the use of vertically profiling instrumentation.

Brown, Owens and Bryden [1986: Eddy-potential vorticity fluxes in the Gulf Stream Recirculation. *J. Phys. Oceanogr.*, **16**, 523–1531] used the LDE current meter array data to estimate a potential vorticity flux of $\overline{u'q'} = 1.6 \times 10^{-7} ms^{-2}$. One way of interpreting this flux is to construct an enstrophy (potential vorticity squared) budget. Neglecting time dependence, horizontal inhomogeneity and boundary dissipation, the product of the potential vorticity flux and the mean potential vorticity gradient is balanced by the 2-D curl of the internal wave momentum flux divergence. This later term represents an eddy-internal wave interaction mechanism. *If* one were willing to cast that mechanism as a effective viscosity, and since the mesoscale velocity gradients are resolved in the LDE, one can obtain an order of magnitude estimate for the viscosity coefficients assuming a balance between the potential vorticity fluxes and interior

horizontal friction ($\nu_h \cong 1000$ m^{2}s^{-1}) or interior vertical friction ($\nu_v \cong 0.01$ m^2 s^{-1}). Brown and Owens [1981: Observations of the horizontal interactions between the internal wave field and the mesoscale flow. *J. Phys. Oceanogr.*, **11**, 1474–1480] directly estimate a coupling coefficient of ($\nu_h \cong 100$ m^2 s^{-1}) from the LDE current meter data in the southern recirculation gyre. Ruddick and Joyce [1979: Observations of interaction between the internal wavefield and low-frequency flows in the North Atlantic, *J. Phys. Oceanogr.*, **9**, 498–517] directly estimate ($\nu_v \cong$ 0.01 m^2 s^{-1}) from POLYMODE-2 current meter data from the northern recirculation gyre. If applicable to the southern recirculation gyre, the later estimate is sufficient to **locally** close the enstrophy budget. Thus Rossby waves break through an adiabatic coupling to the internal wavefield.

How is this coupling to be interpreted? Ruddick and Joyce argue that it constitutes a critical layer process. The internal wave - eddy coupling examined in [Müller, P., 1976. On the diffusion of momentum and mass by internal gravity waves. *J. Fluid Mech.*, **77**, 789–823.] and more lately in [Bühler and McIntyre, 2004. Wave capture and wave-vortex duality. *submitted to J. Fluid Mech.*] is based upon an assumption of action conservation, which eliminates the possibility of a critical layer interaction. An example of such an internal wave critical layer process obtained from the more recent TWIST (Turbulence and Waves above Irregularly Sloping Topography) observational program will be presented.