Geophysical Research Abstracts
Vol. 12, EGU2010-427, 2010
EGU General Assembly 2010

Testing the limits of quasi-geostrophic theory: application to observed laboratory flows outside the quasi-geostrophic regime

Paul Williams (1), Peter Read (2), and Thomas Haine (3)

(1) Department of Meteorology, University of Reading, Reading, United Kingdom (p.d.williams@reading.ac.uk), (2) Department of Physics, University of Oxford, Oxford, United Kingdom, (3) Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, USA

We compare laboratory observations of equilibrated baroclinic waves in the rotating two-layer annulus, with numerical simulations from a quasi-geostrophic model. The laboratory experiments lie well outside the quasi-geostrophic regime: the Rossby number reaches unity; the depth-to-width aspect ratio is large; and the fluid contains ageostrophic inertia-gravity waves.

Despite being formally inapplicable, the quasi-geostrophic model captures the laboratory flows reasonably well. The model displays several systematic biases, which are consequences of its treatment of boundary layers and neglect of interfacial surface tension, and which may be explained without invoking the dynamical effects of the moderate Rossby number, large aspect ratio or inertia-gravity waves. We conclude that quasi-geostrophic theory appears to continue to apply well outside its formal bounds.

This is an unexpected and intriguing result that could not have been predicted from the existing literature. It is also potentially useful, for example by permitting the use of a low-order quasi-geostrophic model to easily map out the bifurcation structure — which would be very difficult with a primitive equations model — followed by the use of a primitive equations model for more quantitative agreement in specific cases.

Reference

Williams, PD, PL Read and TWN Haine (2010) Testing the limits of quasi-geostrophic theory: application to observed laboratory flows outside the quasi-geostrophic regime. *Journal of Fluid Mechanics*, in press.