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Testing the limits of quasi-geostrophic theory

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 compared to the laboratory, in terms of the wavenumber regime diagram, the wave amplitudes, and the wave speeds. The biases are shown to be consequences of the model's treatment of Ekman and Stewartson boundary layers and its neglect of interfacial surface tension. Consequently, the biases 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.

Reference

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