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Quasi-geostrophic (QG) and non-QG equilibration of fully developed baroclinic instability

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Fully developed, strongly nonlinear baroclinic instabilities and the resulting equilibrated wave patterns are modelled using QUAGMIRE 1.4, a quasi-geostrophic numerical model of rotating, stratified flow in a rotating, cylindrical annulus. The simulated flow may be continuously stratified over multi levels with forcing of the perturbation potential vorticity via a relaxation to a specified potential vorticity field. The latter may be obtained from simulations using a fully time-dependent, 3D Boussinesq Navier-Stokes model at the same point in parameter space. Numerical runs using both QUAGMIRE and the N-S models have been carried out over a range of different temperature contrasts from 2 to 16 degrees Celsius and rotation rates from 0.3 to 1.6 radians per second in a domain equivalent to a real laboratory experiment, with the objective of comparing modes of equilibration between systems obeying both QG and full N-S equations.

Steady state, periodic and mixed wave behaviour have been observed with some interesting patterns and trends emerging. Results using the QG approach show either less stable and coherent flows or much longer time scales needed to reach a steady state compared with both N-S simulations and corresponding laboratory experiments. In addition, a higher proportion of the energy of the system seems to be retained in higher wave modes in QG simulations than observed in laboratory experiments or N-S models. These results will be presented and discussed in terms of QG and more general mechanisms for the equilibration of baroclinic instability.