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A JOINT EXPERIMENTAL/NUMERICAL STUDY OF THE BAROCLINIC/INERTIA-GRAVITY WAVE INTERACTION

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We compare the results of a laboratory fluid dynamics experiment exhibiting two distinct classes of instability, with a filtered numerical model exhibiting only one class. The laboratory apparatus is an isothermal, rotating, two-layer annulus system, forced by a differentially-rotating lid which imposes a velocity shear across the fluid interface. The numerical model (QUAGMIRE - QUAsi-Geostrophic annulus Model for Investigating Rotating fluids Experiments) is a new hybrid finite-difference/spectral model which efficiently integrates the N-layer QG equations in cylindrical geometry with annular boundary conditions.

For super-critical Froude number, the flow is unstable to travelling baroclinic waves in both the laboratory and numerical experiments. In addition, low-amplitude high-wavenumber inertia-gravity waves are ubiquitously generated in the laboratory experiments only. By construction, QUAGMIRE does not exhibit these unbalanced modes. We use the model velocity field and Richardson number to estimate the spontaneous emission of the unbalanced waves. Regions in which the model local Richardson number falls below unity coincide with the generation region of the laboratory inertia-gravity waves. We infer that the unbalanced modes are generated via a shear instability mechanism at the fluid interface.

We compare model and laboratory baroclinic wave transition curves in [Froude number, dissipation parameter] space, as well as equilibrated baroclinic wave amplitudes, phase speeds and wavelengths. The quantitative agreement is good, except that the model overestimates the transition curve dissipation parameters by a factor of about 5. The close agreement suggests that the baroclinic/gravity wave interaction is too weak to fundamentally alter the character of the baroclinic modes.