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Instability of surface lenticular vortices: results from laboratory experiments and numerical simulations

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We examine the instability of lenticular vortices – or lenses – in a stratified rotating fluid. The simplest configuration is one in which the lenses overlay a deep layer and have a free surface, and this can be studied using a two-layer rotating shallow water model.
We report results from laboratory experiments and high-resolution direct numerical simulations of the destabilization of vortices with constant potential vorticity, and compare these to a linear stability analysis. The stability properties of the system are governed by two parameters: the typical upper-layer potential vorticity and the size (depth) of the vortex. Good agreement is found between analytical, numerical and experimental results for the growth rate and wavenumber of the instability. The nonlinear saturation of the instability is associated with conversion from potential to kinetic energy and weak emission of gravity waves, giving rise to the formation of coherent vortex multipoles with trapped waves. The impact of flow in the lower layer is examined. In particular, it is shown that the growth rate can be strongly affected and the instability can be suppressed for certain types of weak co-rotating flow.