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Scattering, trapping and breaking of waves interacting with a baroclinic vortex

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Vortices are redundantly present in large-scale geophysical flows. They are surrounded by inertia-gravity waves that may affect their dynamics. Here, we investigate the interaction of inertia-gravity waves with a baroclinic vortex in a rotating stratified fluid using WKB theory adapted to cylindrical coordinates. The trapping of wave energy along critical layers is characterized as a function of the vortex aspect-ratio, H/R, and the wave-Froude-number, Fr_w, based on the wavelength and the maximum azimuthal velocity of the vortex and wave frequency. With increasing Fr_w the trapping-region focuses, implying larger amplifications of the energy for the trapped waves. The aspect-ratio H/R controls the polarization of the trapped waves and the location of the trapping region in the field of the vortex. When viscous effects are included, the maximal amplification of wave energy becomes a function of Fr_w and a Reynolds number based on the vortex shear. The validity of the WKB approximation will be estimated by a comparison with a pseudo-spectral numerical simulation. In experiments with elongated vortices, wave-breaking occurs when the amplified waves become locally unstable. The relevance of the WKB theory as a predictive tool for wave-breaking will be discussed through a comparison with experimental observations.