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Transient growth on horizontal shear with vertical stratification
CRISTOBAL ARRATIA, JEAN-MARC CHOMAZ, LadHyX, Ecole Polytechnique-CNRS, SABINE ORTIZ, LadHyX - ENSTA — We report an investigation of the three-dimensional stability of an horizontal shear flow, the hyperbolic tangent velocity profile, in an inviscid, stably stratified fluid. A previous work by Deloncle et al.(2007) shows that the most unstable mode for this flow is two-dimensional. However, for strong stratification, the range of unstable vertical wavenumbers widens proportionally to the inverse of the Froude number. This means that the stronger the stratification, the smaller the vertical scales that can be destabilized. This is consistent with the self-similarity found by Billant and Chomaz (2001). Here we extend that previous result by computing the optimal perturbations that maximize the energy growth up to a time horizon T as a function of the streamwise and spanwise wavenumbers. We concentrate on short optimization times in the strong stratification limit, where the Billant and Chomaz self-similarity is verified to hold. The gravity wave components of the perturbations are obtained by means of a Craya-Herring decomposition which, in the absence of shear, corresponds to an exact separation between gravity waves and vortical modes for the linear dynamics. Intense excitation of gravity waves due to transient growth of perturbations is found in a broad region of the wavevector plane, gravity waves being eventually emitted away from the shear layer.

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