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Instabilities of two-layer shallow-water flows with vertical shear in the rotating annulus

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Being motivated by the recent experiments on instabilities of the two-layer flows in the rotating annulus with superrotating top, we perform a full stability analysis for such system in the shallow-water approximation. We use the collocation method which is benchmarked by comparison with analytically solvable one-layer shallow-water equations linearised about a state of cyclogeostrophic equilibrium. We describe different kinds of instabilities of the cyclogeostrophically balanced state of solid-body rotation of each layer (baroclinic, Rossby-Kelvin, and Kelvin-Helmholtz instabilities), and give the corresponding growth rates and the structure of the unstable modes. We obtain the full stability diagram in the space of parameters of the problem and demonstrate the existence of crossover regions where baroclinic and Rossby-Kelvin, and Rossby-Kelvin and Kelvin-Helmholtz instabilities, respectively, compete having similar growth rates.