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Inertial instability in the 2 layer rotating shallow water model

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We undertake an exhaustive study of inertial instability and its nonlinear saturation in the 2 layer rotating shallow water (RSW) model. A barotropic balanced jet on the f-plane is taken as a background flow. First, thorough analytical and numerical investigation of the linear stability problem is provided under hypothesis of strict homogeneity in the along-flow direction (one-dimensional "symmetric instability"), and the unstable modes are identified. The dependence of the instability on Rossby and Burger numbers of the jet is investigated. The nonlinear development of the instability is studied in this context with the help of high-resolution well-balanced finite-volume numerical code recently developed for multi-layer RSW, which is initialized with the most unstable mode found by the linear stability analysis. It is shown that inertial instability is saturated by reorganization of the mean flow, without homogenization of the anticyclonic region, where unstable modes reside.

These results are then compared with fully two-dimensional problem, which is studied along the same lines. The barotropic instability competes with inertial instability in this case. We show that for sufficiently strong anticyclonic shears the inertial instability still has the dominant growth rate. We study, again, the nonlinear development of the most instable inertial mode, and show that homogenization of the region of strong anticyclonic shear of the flow does take place.