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Barotropic, baroclinic, and inertial instabilities of the Gaussian jet on the equatorial β-plane in rotating shallow water model

Bruno Ribstein (1), Ann-Sophie Tissier (2), Vladimir Zeitlin (2,3)

(1) Institut für Atmosphäre und Umwelt, Goethe-Universität, Frankfurt am Main, Germany (ribstein@iau.uni-frankfurt.de), (2) LMD, Univ. P. et M. Curie, and ENS, Paris, France, (3) Institut Universitaire de France

abstract

A detailed linear stability analysis of an easterly barotropic Gaussian jet centered at the equator is performed in the long-wave sector in the framework of one- and two-layer shallow-water models on the equatorial β-plane. It is shown that the dominant instability of the jet is due to phase-locking and resonance between Yanai waves, although the standard barotropic and baroclinic instabilities due to the resonance between Rossby waves are also present.

In the one-layer case this dominant instability has non-zero growth rate at zero wavenumber for high enough Rossby and low enough Burger numbers, thus reproducing the classical symmetric inertial instability. Yet its asymmetric counterpart has the highest growth rate [1, 2].

In the two-layer case the dominant instability may be barotropic or baroclinic, the latter being stronger, with the maximum of the growth rate shifting towards smaller downstream wavenumbers as Rossby number increases at fixed Burger number and given thickness and density ratios [1, 2]. At large enough Rossby numbers this instability has a non-zero growth rate limit at zero wavenumber, giving the baroclinic symmetric inertial instability. Again, the maximal growth rate is achieved at small but non-zero wavenumbers, corresponding to the asymmetric inertial instability. At high enough Rossby number and low enough Burger number not only the baroclinic, but also the barotropic symmetric instability appears, as well as higher meridional modes of the baroclinic symmetric instability. Still, all of them are dominated by their asymmetric counterparts.

Direct numerical simulations of the saturation of the leading instabilities are performed, showing that the barotropic species of the instability saturates by forming a double vortex street subject to nonlinear oscillations, while the baroclinic, the most vigorous one, saturates by producing strong vertical shears and related dissipation and mixing.

Key words: Rotating equatorial β-plane flows, Baroclinic instability, Barotropic instability, Inertial instability

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References :

[1] F. Bouchut, B. Ribstein, and V. Zeitlin. Inertial, barotropic, and baroclinic instabilities of the Bickley jet in two-layer rotating shallow water model. *Phys. Fluids.*, 23:126601, 2011.

[2] B. Ribstein, R. Plougonven, and V. Zeitlin. Inertial vs baroclinic instability of the bickley jet in continuously stratified rotating fluid. *J. Fluid Mech.*, accepted, 2014.