Geophysical Research Abstracts
Vol. 16, EGU2014-7324, 2014
EGU General Assembly 2014

Centrifugal, barotropic and baroclinic instabilities of isolated ageostrophic anticyclones in the two-layer rotating shallow-water model and their nonlinear saturation

Noé Lahaye (1) and Vladimir Zeitlin (2)

(1) Laboratoire de Météorologie Dynamique (LMD), Paris, France, (2) Laboratoire de Météorologie Dynamique (LMD), Paris, France and Institut Universitaire de France

Mesoscale and submesoscales eddies are ubiquitous in the ocean, and much effort is dedicated to the analysis of such structures, especially in what concerns their stability. While quasi-geostrophic (barotropic and baroclinic) instabilities have been well documented for the last decades, we have fully realized relatively recently that other ageostrophic instabilities – in particular the centrifugal instability – play a role in the submesoscale dynamics. The importance of such a mechanism, besides being responsible for coherent vortex structure breakdown, resides in the fact that it produces overturning vertical motions that enhance strong mixing and energy dissipation. The impact of the vertical structure of the flow (vertical shear and stratification) upon the centrifugal instablity is still an issue to be clarified.

In this paper, we study the instabilities of the isolated anticyclonic vortices in the 2-layer rotating shallow water model at Rossby numbers up to 2, with the main goal to understand the interplay between the classical centrifugal instability and other possible ageostrophic instabilities.

We find that different types of instabilities with low azimuthal wavenumbers exist, and may compete. In a wide range of parameters an asymmetric version of the standard centrifugal instability has larger growth rate than this latter. The dependence of the instabilities on the parameters of the flow: Rossby and Burger numbers, vertical shear, and the ratios of the layers' thicknesses and densities is investigated. The zones of dominance of each instability are determined in the parameter space. It is shown that density step tends to inhibit the centrifugal instabilities and may thus play a key role on the issue of the destabilization process in parameters regimes where they compete with the barotropic instability.

Nonlinear saturation of these instabilities is then studied with the help of a high-resolution finite-volume numerical scheme, by using the unstable modes identified from the linear stability analysis as initial conditions. Differences in nonlinear development of the competing centrifugal and ageostrophic barotropic instabilities are evidenced.