Abstract View

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The Internal Barotropic Instability of Surface-Intensified Eddies. Part I: Generalized Theory of Isolated Eddies

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ABSTRACT

Gent and McWilliams have identified the mechanism of internal barotropic instability for axisymmetric vortices which are purely barotropic, but are immersed in a stratified environment. The energy source is the kinetic energy of the barotropic vortex, which can be converted into baroclinic energy by growing oscillations of finite vertical scale. This occurs when the eddy is too tall and thin. The present paper deals with the generalized instability problem of surface-intensified eddies, presenting a complex vertical structure. We first consider the class of eddies whose horizontal size is either close to (or smaller than) the first radius of deformation. On an *f*-plane, such eddies are more stable than their purely barotropic counterpart to internal barotropic instability, all the more so that they are fat. This result, which is fond through the identification of the linearly unstable normal modes, is also confirmed through direct numerical simulations. The β-effect acts asymmetrically with regard to internal barotropic instability between purely barotropic and surface-intensified eddies: it stabilizes purely barotropic vortices, wile it enhances the instability of surface-intensified ones. Nonlinear destabilization of vortices can also occur when they undergo finite-amplitude perturbations, for instance, through their interaction with other structures. The Tourbillon eddy is shown to be weakly unstable to linear barotropic instability, but can be destabilized nonlinearly by finite-amplitude perturbations. Finally, eddies whose horizontal size is at least twice as large as the radius of deformation are shown to be primarily unstable to baroclinic instability.

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