Geophysical Research Abstracts
Vol. 13, EGU2011-513, 2011
EGU General Assembly 2011

How oceanic anticyclones are favoured through large-scale and cyclogeostrophic barotropic instabilites

Gaele Perret (1), Thomas Dubos (2), and Alexandre Stegner (3)

(1) LOMC, CNRS, Université du Havre, Le Havre, France (perretg@univ-lehavre.fr), (2) LMD, CNRS, Ecole Polytechnique, Palaiseau, France , (3) LMD, CNRS, Ecole Normale Supérieure, Paris, France

Large-scale vortices, i.e. eddies whose characteristic length scale is larger than the local Rossby radius of deformation Rd, are ubiquitous in the oceans, with anticyclonic vortices more prevalent than cyclonic ones. In particular, large-scale anticyclones are frequently observed in the lee of oceanic archipelago. To explain the predominance of anticyclones among large-scale eddies, the specific stability or robustness properties of already formed shallow-water vortices has been investigated. In this study we focus on possible asymmetries occuring during the generation process itself of vortices through barotropic instabilty of parallel flows. The initial stage and the nonlinear stage of the instability are studied by means of linear stability analysis and direct numerical simulations of the one-layer rotating shallow water equations, respectively. A wide variety of parallel flows are studied : isolated shears, the Bickley jet and a family of wakes obtained by combining two shears of opposite signs.

Our results show that when the flow is characterised by finite relative isopycnal deviation the barotropic instability favors the formation of large-scale anticyclonic eddies. We emphasize here that the cyclone-anticyclone asymmetry of parallel flows may appear at the linear stage of the instability. This asymmetry finds its origin in the linear stability property of localized shear flows. Indeed, for both the cyclogeostrophic regime (finite Rossby number) or the frontal geostrophic regime (small Burger number) an anticyclonic shear flow has higher linear growth rates than an equivalent cyclonic shear flow. The nonlinear saturation then leads to the formation of almost axisymmetric anticyclones, while the cyclones tend to be more elongated in the shear direction.

However, while some unstable parallel flows exhibit the asymmetry at the linear stage, others exhibit such asymmetry at the nonlinear stage only. If the distance separating two shear regions is large enough, the barotropic instability develops independently in each shear, leading in the frontal and the cyclogeostrophic regime to a significant cyclone-anticyclone asymmetry at the linear stage. Conversely, if the two shear regions are close to each other, the shears tend to be coupled at the linear stage. The most unstable pertubation then resembles the sinuous mode of the Bickley jet, making no distinction between regions of cyclonic or anticyclonic vorticity. Nevertheless, when the nonlinear saturation occurs, large-scale anticyclones tend to be axisymmetric while the cyclonic structures are highly distorted and elongated along the jet meander.

For realistic large-scale wakes, such as Hawaiian or the Canaria archipelago wakes, both anticyclonic and cyclonic shears with different intensity and width coexist. Large-scale shears will be in FG regime whereas smaller shears will obey QG or cyclogeostrophic regime. Therefore, quantitative predictions on typical vortex shedding frequencies could be provided by taking into account the interactions and the relative stability between shears.