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Stability of Oceanic Vortices: a Solution to the Problem

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It is well-known that oceanic vortices exist for years, whereas almost all theoretical studies indicate that they must be unstable. A rare exception is the work by Dewar & Killworth (1995), who demonstrated that a Gaussian vortex in the upper layer of a two-layer ocean becomes stable if accompanied by a weak co-rotating circulation in the lower layer. Note that this paper assumed the lower-layer circulation to have the same profile as the main (upper-layer) vortex. The present paper considers the case, where the profile of the circulation in the lower layer is determined by the condition that potential vorticity (PV) there is constant – which models a vortex surrounded by water of a different origin. Given that most oceanic vortices are shed by frontal currents, such model appears to be more realistic than any ad hoc choice. The stability of vortices with uniform lower-layer PV is examined for both quasigeostrophic and ageostrophic cases, numerically and asymptotically, assuming that the upper layer of the ocean is thin. It is shown that such vortices are stable in a wide range of parameters. The effect of vortex stabilization is interpreted through representation of the unstable disturbance by two phase-locked Rossby waves, rotating around the vortex in the upper and lower layers. Then, if the lower-layer PV gradient is zero, it cannot support the corresponding wave, which inhibits the instability.

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