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Adjustment of the buoyant lens in the equatorial ocean

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Recent in-situ observations suggest that a significant part of the energy in the upper equatorial ocean is associated with mesoscale frontal structures and motions with period smaller than 10 days which do not fit the free equatorial wave theory. Taking a step toward a description of essentially nonlinear frontal regimes in the equatorial ocean, we consider the adjustment of a buoyant lens with outcropping boundary in the vicinity of the equator within the 1-1/2 layer reduced gravity model.

The problem is addresed with high resolution finite volume numerical techniques which were specially designed to handle outcropping isopycnals. The governing parameters are the meridional to zonal scale aspect ratio δ and the ratio γ of Coriolis to pressure force on the meridional boundary.

For typical parameters $\delta \sim$ 1-10 and $\gamma \sim 1$, the lens, initially at rest, spreads eastward according to classical gravity current theories. Due to barotropic instability, its westward extrusion is arrested. Two anticyclonic vortices emerge on the western edge of the lens and reach latitudes controlled by angular momentum conservation. Meanwhile rapid finite amplitude westward wave motions develop on the spreading current. Wave structure is predicted by linear analysis of small amplitude motions on a zonally symetric outcropping current which are found to be linearly stable.

Since dimensional length and time scales are found to depend only on the initial buoyancy anomaly, this overall scenario is valid for any buoyant lens whatever its horizontal scale.