Abstract View

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On Ocean Spindown I: A Linear Experiment

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ABSTRACT

The spindown of an ocean is investigated, using a two-layer numerical model. At the initial instant, a pool of warm water the size of the Coral Sea occupies the subtropical portion of the top layer; the pool is initially in geostrophic balance, with depth-averaged flow equal to zero. The ocean is allowed to develop freely in the absence of wind and heating. Horizontal temperature contrasts are very weak, so the flow is accurately linear.

The warm pool first moves to the western boundary, via internal Rossby waves. A progressive wave of downwelling then develops, which transports heat up to the equator, along the equator, and around the eastern and poleward boundaries; the region of warm water generated as a result near the eastern boundary is separated from the colder ocean interior by a “front,” which spreads inward via internal Rossby waves.

The net effect of all these motions is to spread the pool of warm water, which was initially concentrated in a small area, out over the rest of the ocean; the potential energy released in this process is dissipated by friction, mainly against the western boundary.

An analytic theory of this spindown process shows that the downwelling waves around the boundaries are similar to Kelvin waves, though there are important differences due to friction and the β effect.

For linear, first internal mode disturbances of the kind considered here, the pressure and the heat content are proportional to one another; it is shown that this allows a simple physical interpretation of many of the phenomena in the model, which may also be useful in the real ocean.

Application is made to the El Niñe, and the associated global fluctuations in the atmosphere and ocean. Bjerknes hypothesized that these fluctuations are generated spontaneously by interaction between the ocean Ekman layer and the atmosphere near the equator; it is suggested here that Bierknes'instability mechanism may be strengthened if deeper oceanic effects are also included.

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