Abstract View

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Finite Amplitude Effects on Deep Planetary Circulation over Topography

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ABSTRACT

Steady flow over large-scale bathymetric changes of a uniform zonal current in a two-layer fluid is studied under the assumptions that it is geostrophic, that relative vorticity can be ignored, that variations in the planetary vorticity are important and that the upper layer is infinitely thick. This is an extension of the analytic work by Rhines to situations in which the interface can have finite deformations. As concluded by Rhines, both from a small amplitude theory and from numerical integration of the time-dependent initial value problem, there are several features of the resulting solutions that bear close resemblance to the classical channel hydraulics phenomenon. These include the downward (upward) dip of the interface when the flow is subcritical (supercritical) with respect to the long Rossby wave phase speed and the formation of sharp frontal regions downstream of the topography. With respect to the latter it is shown in this steady state analysis that the front arises, not from a hydraulic effect in the conventional sense, but from the intersection of characteristics carrying conflicting information from different parts of the boundary. Concomitant with caustic formation is an induced change in upstream conditions. The Froude number dependence is determined. For the small Froude numbers expected of the midocean deep circulation only very large topographic features such as the mid-Atlantic Ridge can be expected to induce a caustic.