Abstract View

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Upwelling and Coastal Jets in a Continuously Stratified Ocean

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ABSTRACT

A simple, linear, two-dimensional, f-plane model of coastal upwelling in a continuously stratified ocean is investigated. The transient response of the fluid to an impulsively applied alongshore wind stress, the nature of the approach to a steady state, and the final steady state flow are studied. Particular attention is given here to an examination, in the continuously stratified case, of the interrelation of upwelling and the phenomenon of a baroclinic coastal jet. The coastal jet is a feature which has appeared in studies of the transient response of two-layer fluid models near a coast. The stratification parameter $S = (\delta N/f)^2$, where $\delta = H/L$ is the aspect ratio, H the depth, L a characteristic horizontal scale, N the Brunt-Väisälä frequency, and f the Coriolis parameter, is assumed to lie in the range $O(Ev^{1/2}) < S \leq O(1)$, where $\lambda = E_v/E_H$ and where E_H and E_v are respectively the horizontal and vertical Ekman numbers. It is also assumed that L is large enough that $S \ll 1$ and $\lambda \gg 1$. These are the conditions for which, during the transient flow, a baroclinc coastal jet is present in an inviscid upwelling layer of width $O(S^{1/2})$. It also appears that these conditions are reasonable for oceanic upwelling regions. The jet development is initiated on a time scale of $O(E_v^{-1/2})$. A steady state is reached in the $O(S^{1/2})$ upwelling layer on a longer diffusive time scale of $O(SE_H^{-1})$. For $S\lambda < O(1)$, the alongshore current outside the $O(S^{1/2})$ layer increases in magnitude with time, by diffusive spreading of the boundary effects, in an additional boundary layer of width $O(\lambda^{-1/2})$. It reaches a steady state on a yet longer time scale of $O(E_v^{-1})$. For $S\lambda = O(1)$, the two boundary layers merge and adjust on the same time scale. The final steady state is characterized by a coastal current which is confined to the $O(S^{1/2})$ and $O(\lambda^{-1/2})$ boundary layers.

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