Abstract View

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Mean Flow Generation on a Continental Margin by Periodic Wind Forcing

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ABSTRACT

The generation of an alongshore mean flow by the nonlinear interaction of forced barotropic shelf waves over a continental margin is studied using a wind-forced, f-plane model with bottom friction in an attempt to develop a model for poleward eastern boundary undercurrents. It is assumed that the Rossby number is small and that the flow obeys a long-wave approximations. A periodic alongshore wind stress traveling along the coast forces the fluid by a nonzero wind stress at the coast (coastal forcing) or by a wind-stress-curl-driven oceanic flow that images on the slope (interior forcing). Expressions are derived for the alongshore (v) and cross-shelf (u) mean velocities in terms of the lowest order periodic velocities. An expression for the correlation coefficients of vu_x, where x is the cross-shelf coordinate, is derived that depends only on the sign of the bottom slope, the magnitude of friction, the local water depth and the forcing frequency. The momentum flux and Reynolds stress in the surface and bottom Ekman layers make a significant contribution to the mean flow. The Eulerian and Lagrangian mean flows have similar qualitative characteristics. The flow pattern is dependent on the type of forcing, coastal or interior, but in both cases the response is greatest at the free wave resonant frequencies. Along eastern boundaries, the mass transport for coastal forcing is equatorward, i.e., opposite to the direction of propagation of long, free shelf waves, at the mode 1 resonant frequency and poleward at the mode 2 resonant frequency, with magnitudes, for a wind stress of 1 dyn cm^{-2}, of -0.17×10^{12} and 10.11×10^{12} cm^3 s^{-1}, respectively. The mean alongshore velocities associated with these resonances are typically of order 1 cm s^{-1}. For interior forcing, the flow is poleward everywhere with a maximum near the shelf break. For a periodic oceanic velocity at the slope-interior junction with an amplitude of 1 cm s^{-1} the maximum alongshore mean flow and mass transport, at the first mode resonant frequency, are about 1 cm s^{-1} and 0.1×10^{12} cm^3 s^{-1}, respectively. The results for coastal forcing are inconsistent with observations of eastern boundary undercurrents, whereas the results for interior forcing are qualitatively consistent with the observations.

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