Abstract View

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Quasi-Geostrophic Topographically Generated Mean Flow over the Continental Margin

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ABSTRACT

Observations of oppositely directed, monthly mean alongshore currents and wind stress over the continental margin off the Pacific coast of North America motivate the theoretical examination of mean flow generation by topographic lee-wave drag. We formulate a barotropic model for wind-forced shelf-slope flow over variable topography. Our central objective is an analytical expression for mean flow generation in a simple case. We specify a linear cross-shelf slope with sinusoidal alongshore variations and use the approximation of Hart, which yields a system with only parametric cross-shelf dependence when the alongshore scales are short compared to the cross-shelf scales. The inviscid unforced equations have two constants of the motion and reduce to a quartic Hamiltonian system similar to that of Duffing's equation. For weak new-resonant time-periodic forcing, we use the method of averaging to obtain evolution equations for the amplitudes of small oscillations. All steady solutions of the averaged equations, which correspond to steadily oscillating small amplitude currents in the model, have mean current in the direction of the observed currents (poleward on an eastern boundary). Multiple equilibria occur. Mean current generation is most efficient for low frequencies, short wavelength topographic variations, and comparable alongshore and cross-shelf topographic slopes. The mean Lagrangian flow is along isobaths. Numerical solutions of the model equations compare well with the averaging analysis predictions. For certain parameter ranges, all steady solutions of the averaged equations are linearly unstable. In these ranges, numerical solutions of the averaged equations yield limit cycles, period doubling sequences, and chaotic behavior, suggesting that the response of slope flow to atmospheric forcing may be irregular.

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