Abstract View

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The Free Kelvin Wave in Finite-Difference Numerical Models

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ABSTRACT

The effects of viscosity and finite- differencing on free Kelvin waves in numerical models (which employ the Arakawa *B*- or *C*-grid difference schemes) are investigated using the *f*-plane shallow-water equations with offshore finite-difference grids, (assuming alongshore geostrophy). Three nondimensional parameters arise: Δ [=(offshore grid spacing)/(Rossby radius)], ϵ characterizes the offshore lateral viscous effect and α the combined vertical and alongshore viscous effect. This study is more relevant to *baroclinic* Kelvin waves which tend to suffer poor offshore resolution because of their small Rossby radii.

For inviscid models ($\epsilon = \alpha = 0$), as Δ increases (resolution worsens), the alongshore speed increases dramatically in the *B*-grid, but stays constant at the gravity wave speed in the *C*-grid. Models with damping only ($\alpha > 0$, $\epsilon = 0$) behave similarly. With lateral viscosity ($\epsilon > 0$, $\alpha > 0$), increasing ϵ decreases the speed in both the *B*- and *C*-grids—the drop in speed being less severe when the free-slip boundary condition is imposed instead of the no-slip one. As Δ increases, the speed declines in the *B*-grid, but in the *C*-grid, worsening resolution cancels the viscous slow-down, with speed rising to that when $\epsilon = 0$.

Our theory predicts the alongshore phase speed, the temporal decay rate and the offshore structure for *B*- and *C*-grid models of given viscosity and grid-spacing and of given boundary conditions (e.g., no-slip or free-slip). The predictions are checked against observations from two- and three-dimensional model—including the Bryan-Cox model—with good agreement.

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