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Preconditioners for Ocean Simulation

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We examine preconditioners for free-surface, fully implicit, fully coupled time integration of the momentum and continuity equations of ocean dynamics; thus reducing errors and increasing stability due to traditional operator splitting. We consider two solution strategies to the problem.

In the first approach, the full nonlinear system is solved via Jacobian-free Newton-Krylov (JFNK), where we reformulate semi-implicit barotropic-baroclinic splitting as a preconditioner. This preconditioner has the property that it can be reduced to a lower dimensional, horizontal problem of a scalar variable that can be made amenable to multigrid methods.

In the second approach, JFNK is applied to the lower dimensional, barotropic problem and the remaining three dimensional problem is treated via nonlinear elimination within the function evaluation of JFNK. This method is appealing because the Krylov vector and JFNK machinery reside in the lower dimensional problem. In addition, the preconditioner is formulated in a similar way to the first approach.

In each approach, the key to effective preconditioning is the ability to transform a hyperbolic system to a single parabolic problem of a scalar variable which can be treated effectively by multigrid methods. We provide numerical examples and comparisons among the approaches.