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A communication-avoiding implicit-explicit method for a free-surface ocean model. (English)

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Summary: We examine a nonlinear elimination method for the free-surface ocean equations based on barotropic-baroclinic decomposition. The two dimensional scalar continuity equation is treated implicitly with a preconditioned Jacobian-free Newton-Krylov method (JFNK). The remaining three dimensional equations are subcycled explicitly within the JFNK residual evaluation with a method known as nonlinear elimination. In this approach, the memory footprint of the underlying Krylov vector is greatly reduced over that required by fully coupled implicit methods. The method is second-order accurate and scales algorithmically, with allowed timesteps much larger than fully explicit methods. Moreover, the hierarchical nature of the algorithm lends itself readily to emerging architectures. In particular, we introduce a communication staging strategy for the three dimensional explicit system that greatly reduces the communication costs of the algorithm and provides a key advantage as communication costs continue to dominate relative to floating point costs in emerging architectures.

MSC:

86-08	Computational methods for problems pertaining to geophysics
65M06	Finite difference methods for initial value and initial-boundary value problems involving PDEs
65M22	Numerical solution of discretized equations for initial value and initial-boundary value problems involving PDEs
86A05	Hydrology, hydrography, oceanography

Keywords:

ocean modeling; IMEX method; Jacobian-free Newton-Krylov methods; nonlinear elimination; communication-avoiding algorithm

Software:

GFDL; HYCOM; ML; MPAS-Ocean; NITSOL; OpenMPI; Parallel netCDF; POP; Trilinos

Full Text: DOI

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