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A parallel Jacobian-free Newton-Krylov solver for a coupled sea ice-ocean model. (English)

Zbl 1349.86008
J. Comput. Phys. 257, Part A, 901-911 (2014).

Summary: The most common representation of sea ice dynamics in climate models assumes that sea ice is a quasi-continuous non-normal fluid with a viscous-plastic rheology. This rheology leads to non-linear sea ice momentum equations that are notoriously difficult to solve. Recently a Jacobian-free Newton-Krylov (JFNK) solver was shown to solve the equations accurately at moderate costs. This solver is extended for massive parallel architectures and vector computers and implemented in a coupled sea ice-ocean general circulation model for climate studies. Numerical performance is discussed along with numerical difficulties in realistic applications with up to 1920 CPUs. The parallel JFNK-solver's scalability competes with traditional solvers although the collective communication overhead starts to show a little earlier. When accuracy of the solution is required (i. e. reduction of the residual norm of the momentum equations of more that one or two orders of magnitude) the JFNK-solver is unrivalled in efficiency. The new implementation opens up the opportunity to explore physical mechanisms in the context of large scale sea ice models and climate models and to clearly differentiate these physical effects from numerical artifacts.

MSC:

86-08	Computational methods for problems pertaining to geophysics
76M20	Finite difference methods applied to problems in fluid mechanics
65M06	Finite difference methods for initial value and initial-boundary value problems involving PDEs
76T99	Multiphase and multicomponent flows
86A05	Hydrology, hydrography, oceanography
86A60	Geological problems

Keywords:

sea ice dynamics; numerical sea ice modeling; Jacobian-free Newton-Krylov solver; preconditioning; parallel implementation; vector implementation

Software:

MITgcm; PETSc; TAF

Full Text: DOI

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