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Stabilization, Preconditioner and Solver for Modeling Variable Viscosity Mantle Convection

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We present significant improvements to the spherical finite-element discretization and to the iterative solver of the mantle convection code Terra. The stabilization of a Q_1-Q_1 finite-element discretization of the Stokes equations has been studied in a two-dimensional square domain in terms of evaluating its spectral properties depending on grid spacing, viscosity model and viscosity contrast. It could be shown that the spectrum of the Schur complement becomes independent of the grid spacing when the stabilization proposed in [1] is applied. It is also independent of the viscosity contrast when S is scaled by the diagonal of the viscosity-weighted pressure mass matrix M_μ [2]. Furthermore, different Krylov methods have been studied in terms of their preconditioners and iteration parameters. Based on the results of the two-dimensional study, the equal-order discretization of Terra was stabilized, the viscosity-weighted pressure mass matrix M_μ was used as a Schur-complement preconditioner and the existing pressure correction algorithm was refined. Therewith a significant drop in iteration numbers was achieved for a model with large radial and lateral viscosity variations.

References

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