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Coupled versus decoupled multigrid solvers for variable viscosity Stokes problems using a staggered finite difference scheme.

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In order to solve high-resolution 3D problems in computational geodynamics it is crucial to use multigrid solvers in combination with parallel computers. A number of approaches are currently in use in the community, which can broadly be divided into coupled and decoupled approaches. In the decoupled approach, an algebraic or geometric multigrid method is used as a preconditioner for the velocity equations only while an iterative approach such as Schur complement reduction used to solve the outer velocity-pressure equations. In the coupled approach, on the other hand, a multigrid approach is applied to both the velocity and pressure equations.
The coupled multigrid approaches are typically employed in combination with staggered finite difference discretizations, whereas the decoupled approach is the method of choice in many of the existing finite element codes. Yet, it is unclear whether there are differences in speed between the two approaches, and if so, how this depends on the initial guess.
Here, we implemented both approaches in combination with a staggered finite difference discretization and test the robustness of the two approaches with respect to large jumps in viscosity contrast, as well as their computational efficiency as a function of the initial guess.

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