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Modern solvers for global mantle convection: StagYY with StagBL

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We present the first integration of the StagBL library with the advanced mantle convection code StagYY.

StagBL is an open-source parallel solver and discretization library for geodynamic simulation, encapsulating and optimizing operations essential to staggered-grid finite volume Stokes flow solvers. These form the basis for highly-efficient application codes for long-term mantle convection and lithospheric dynamics. StagBL prevents common bottlenecks to improving scalability, swapping solvers, adapting to new architectures, and optimizing performance. The StagBL project addresses these issues by providing a streamlined library to provide a path to performance from toy codes to quality, scalable implementations. It provides a parallel staggered-grid abstraction in C and Fortran, and an interface (DMStag) for PETSc. Planned features allow applications to define boundary conditions, interact with particle systems, and efficiently solve Stokes systems in small (direct solver), medium (simple preconditioners), and large (block factorization and multigrid) model regimes. By implementing common kernels beneath a uniform abstraction layer, StagBL enables optimization for modern hardware, thus reducing community barriers to large-scale parallel simulation on modern architectures, and a platform to develop innovative new tools. By working directly with leading application codes and providing an API and examples for others, StagBL aims to become a community tool supplying scalable, portable, reproducible performance to novel science in regional- and planet-scale geodynamics.

By introducing a uniform grid abstraction, StagBL enables experimentation with several distributed coarse grid solvers for multigrid solution of the Stokes equations within a difficult 3D simulation, thus bringing the flexibility of modern solvers to a mature application. We report on parameter spaces opened for exploration with these new capabilities. We also discuss recent developments in porting performance-critical operator kernels to GPUs, and experiments running these on the Piz Daint hybrid supercomputer. Software engineering strategies associated with incremental integration of a library into a mature research code are discussed.