Using the yin-yang grid to model thermo-chemical mantle convection with large viscosity contrasts in a 3-D spherical shell

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Here I report a new version of the old 3-D finite volume multigrid code Stag3D [1], recently adapted to spherical geometry using the "yin-yang" grid introduced by [2]. This grid allows the orthogonal staggered-grid primitive-variable discretization of the original code to be maintained, together with fast solution of the velocity-pressure system using a multigrid solver. Compared to the first implementation of this grid for the mantle problem [3], Stag3D-yy uses the minimum overlap yin-yang grid in order to avoid the possibility of differing solutions in the overlapping areas. Additionally, most features of the original code, implemented over many years, are retained, including: the compressible anelastic approximation, tracking of major- and trace-element variations using a tracers (marker-in-cell technique), multiple phase changes including both olivine and pyroxene-garnet systems, and a nonlinear visco-plastic rheology. The code can switch between spherical-shell, Cartesian, a single spherical patch or various 2D geometries by changing only one input switch. A multigrid solver allows efficient solution of large problems (e.g., > 1 billion degrees of freedom) on only modest-sized beowulf clusters (e.g., 64 CPUs). Recent improvements to the multigrid scheme allow large viscosity variations to be modelled, e.g., 13 orders of magnitude globally with 8 orders of magnitude between adjacent points, with only a moderate performance penalty. Performance, scaling, and scientific results will be presented.

References

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