

3-D Mantle Convection Simulation Program on Earth Simulator

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I developed the computation program of mantle convection in three-dimensional rectangular box based on the finite difference method, as a part of the activities of the Solid Earth Simulation Consortium. The fundamental equations are discretized by the finite volume method. The momentum and continuity equations are solved simultaneously by the SIMPLER algorithm (Patankar, 1980). The energy equation is solved by the power-law method (Patankar, 1980) for the advection and diffusion terms, and by either explicit or fully implicit scheme for the time integration. The spatial variations in material properties, such as viscosity and thermal conductivity, can be incorporated. The discretized equations are solved by the conjugate gradient (CG) or bi-conjugate gradient (BiCG) method, depending on the nature of simultaneous linear equation. Both the localized ILU(0) factorization or the red-black symmetric SOR methods are employed as a parallelized preconditioner for CG or BiCG solvers. The calculations are parallelized by the domain decomposition method; the computed domain is divided into small rectangular subdomains, and each computation node is devoted to the solution within a subdomain. The node-to-node communication is performed by the MPI utilities. As a further optimizations for the Earth Simulator, several modifications are carried out to enhance the vectorization and SMP parallelization. The calculation using a coarse mesh system (512x128x128 meshes) shows a moderate performance, up to 30% calculation speed relative to the ideal speed of the Earth Simulator. A better performance of the calculations is expected by further optimizations and refinement of computation mesh system.