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Current progresses on numerical simulations of global-scale geodynamics: Methods and applications

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SUMMARY

Here we introduce the state-of-the-art of numerical schemes to simulate the global-scale of dynamics in Earth's interior and their applications to reproduce the realistic dynamics and evolution regarding with numerical simulations of mantle dynamics with developed numerical schemes and state-of-the-art software for global-scale dynamics in Earth's interior.

The dynamics of Earth's interior (especially in the silicate mantle) can be described as the Stokes flow because Earth's mantle can be assumed highly viscous fluid with the long time-scale such as the age of the Earth (4.5 Gyrs). Toward simulating the realistic Stokes flow for Earth's interior, multigrid-based numerical schemes have been developed to solve the Stokes flow under the tough condition such as spherical geometry, free surface, large viscosity variations, complicated rheological models and material differentiation. These elements required from real Earth's situations are very important for simulating the global-scale of dynamics from the plate to the core. These schemes are the state-of-the art of numerical schemes for geodynamics modeling and have been already adopted for the vector-parallel architecture such as the Earth Simulator 2. With the applications for these schemes to the global-scale of geodynamics, we can simulate the mantle convection including the plate-like behavior and material differentiation induced by partial melting. The numerical simulation of core formation in the 3-D spherical geometry is also possible.

Here, we will show our simulation result of thermo-chemical evolution of Earth's mantle and core over 4.5 Gyrs to understand present structure of the core and mantle constrained by seismological and geological analyses. In addition, we will present the preliminary result on the early Earth event, i.e. core formation, which focuses on duration time- and horizontal length-scale of sinking metal rich layer into the center of the Earth under a self gravitating field. Finally, we will introduce an abstract of our new modeling packages called as "Numerical Earth Model Suite (NEMS)", which can simulate entire thermal history of Earth's core and mantle, in terms, from the early Earth to the present Earth as a coupled system.