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# Numerical modelling of subducting slabs by three-dimensional mantle convection with trench migration

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We are developing numerical models of three-dimensional mantle convection in order to study the formation and the dynamic behaviors of stagnant slabs. A time-dependent thermal convection of Boussinesq fluid in a rectangular box of 1320 km height and 7920 km width is considered. We have included both the exothermic olivine to spinel and the endothermic post-spinel phase transitions at around 410 and 660 km depths from the top surface, respectively. The viscosity of mantle material is assumed to be exponentially dependent on temperature and pressure (or depth). We also take into account the effects of the sudden increase in viscosity at the 660km depth. The computational domain is divided into the 'oceanic' and 'continental' regions on the left-hand and right-hand sides, respectively. The initial distribution of temperature in the 'oceanic' region is set by a half-space cooling model moving at a uniform velocity. The plate subduction is imposed by applying different kinematic boundary conditions to the top surface of the 'oceanic' and 'continental' sides. In addition, we take into account the effect of trench migration, by extending the two-dimensional approach by van Hunen et al. (2000) to a three-dimensional one. Here we assume the subduction below an actively overriding continent which moves oceanward at a given rate with respect to the deep mantle. We also included a thin layer of weak 'lubricating' material along the top surface of the 'oceanic plate' in order to accommodate a strong shear deformation along the 'plate boundary'. The lubrication at the plate boundary is modeled by applying maximum yield strength in the regions with the weak materials which are advected along with the subduction of 'oceanic plate'. The numerical calculations are performed by using our multigrid-based code designed for large-scale three-dimensional experiments. In this code, the motion of highly viscous and incompressible fluid is iteratively solved for the primitive variables (velocity and pressure). The advection of 'lubricating' material is calculated by the semi-Lagrangian conservative scheme developed by Furuichi et al. (2008).

We have conducted preliminary two-dimensional calculations by ignoring the variations of subducting behavior in the direction of trench axis. In these calculations we have studied the influences on the slab dynamics of (a) the trench retreat, and the discontinuous changes in (b) viscosity and (c) density associated with the phase transition at the 660km depth. Our calculations show that the motion of overriding plate is of the primary importance on the formation of stagnant slabs: For a sufficiently fast trench retreat, the subducting slab tends to stagnate near the 660km depth. We also found that the stagnant slabs are hardly formed solely by the Earth-like values of viscosity or density jumps at the 660km depth. This indicates that the slab stagnation of the Earth comes from a delicate interplay between the nature of 660km discontinuity and surface motions. We will further explore the truly three-dimensional dynamics of stagnant slabs, by expanding our models in the along-axis direction.