Effect of PPV Phase Transition on Mantle Convection in Three-Dimensional Spherical Shell

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Since the finding post-perovskite (PPV) phase under high pressure such as near core mantle boundary by experimental researches, some numerical models of mantle convection including the PPV phase transition have been presented as to whether this phase transition can affect on mantle dynamics. They simulated thermal convection with the PPV phase transition in two-dimensional cylindrical geometry or three-dimensional Cartesian geometry. Here, we present numerical model of thermal convection in three dimensional spherical shell geometry with post-perovskite (PPV) phase transition and clarify the effect of the phase transition on thermal structure in the mantle.

We calculate time-dependent thermal convection of incompressible and infinite Prandtl number fluid in a spherical shell. Both internal and basal heating are considered. Other two phase changes, which are exothermic one at 410 km depth and endothermic one at 660 km depth, are also included. Clapeyron-slope of them is assumed to be 4MPa/K for the exothermic one and to be -4MPa/K for the endothermic one. Boussinesq approximation is employed, and the temperature- and pressure- dependencies of viscosity and other physical properties are ignored. We use TERRA code for thermal convection simulation, which employs a finite element method. In this study, the mantle is divided into 128 spherical shells and the surface is discretized so that the resolution is about 30 km. We use Earth Simulator to achieve the computational mesh with such high resolution. We assume the negative or positive Clapeyron-slope of the PPV phase transition, though the experimental and theoretical studies indicated that this transition is exothermic one. In addition, we change the depth of the phase change, so we calculate two cases as furrows; the PPV phase transition exists in thermal boundary layer on the bottom of the mantle or above that layer. We have found that this phase transition hardly affect on the thermal convection and modify little thermal structure in the mantle.

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