Numerical simulations on the upwelling plumes in the mantle of super-Earths in 2-D axisymmetric geometry

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We carried out numerical simulations on the upwelling plumes in the mantle of the Earth and that of super-Earths. The objects of our study are (1) to confirm the validity of our program which is newly developed for this study by comparing our numerical results with those of earlier studies on the upwelling plumes in the Earth's mantle and (2) to examine the effects of temperature-dependent viscosity and internal heating rate on upwelling plumes in the mantle of super-Earths. In this study, we consider a major upwelling plume at the center of 2-D axisymmetric model. We have carried out two series of numerical simulations. In a first series, we calculated thermal convection in an incompressible Boussinesq fluid under the conditions identical to those in earlier studies. In a second series, we performed simulations under the conditions for the mantle of super-Earths using the truncated anelastic liquid approximation (TALA).
In the first series of our simulations, we obtained the results similar to earlier ones, such as the increase in the heat flow at the top and bottom boundaries in proportion to Ra^{13}, demonstrating the validity of the numerical simulation in this study. Furthermore, the second series of our study of the mantle of super-Earths showed that (1) temperature-dependence of viscosity tends to reduce plume heat transport, and (2) the variation of compressibility does not affect the detail of the loss of plume heat flux during their ascent. We also found that heat can flow downward into the core when the chondritic rate of internal heating is present in the mantle of super-Earths, demonstrating significant effects of the internal heating rate on the convection and thermal state in the mantle of super-Earths.

Keywords: super-Earths, mantle convection, internal heating

