巨大スーパーアースのマントル対流シミュレーション
Thermal convection in the mantle of massive super-Earths

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Understanding thermal convection in the mantle of super-Earths is one of the most important key to clarifying their thermal history, surface environment, and habitability. The reason is that the plate motion, material circulation, the vigor of core convection and planetary dynamos are controlled by the thermal convection.
In contrast to the Earth’s interior, the strong adiabatic compression effect is important in massive super-Earths. We have studied the thermal convection in massive super-Earths (about ten times the Earth’s mass) with this effect by the ACuTEMAN method [Kameyama M., 2005]. We also take account for high Rayleigh number which is relevant for super-Earths, and temperature-dependent viscosity contrast and depth-dependent thermal expansion coefficient.
The summary of results is as follows. (a) The activity of ascending hot plumes is considerably lowered compared with that of descending cold plumes. (b) The efficiency of heat transport by thermal convection is lowered compared with the results of Boussinesq (no adiabatic compression) models. The thickness of plate at the surface is considerably thicker than that of the Earth. (c) From the convective regime diagram, the threshold value of viscosity contrast for transition to the stagnant-lid regime convection increases as Rayleigh number increases in contrast to the result of Boussinesq models (in which the threshold value is constant). The details of a-c are given in Miyagoshi et al. [2014, 2015].
We also found that the convection remains in the initial transient stage for a substantial portion of the thermal history of massive super-Earths. In the transient stage, the convection is layered. Cold plumes descend from the surface very slowly, and the convection remains inactive in the upper layer, until the cold plume heads descend to the layering boundary. The layering boundary is located at the depth where the actual temperature gradient coincide with the adiabatic temperature gradient. After the initial transient stage, cold plumes penetrate through the boundary, and the convective structure changes to the whole layer one.

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