The 475th Geodynamics Seminar

Numerical experiments on thermal convection of highly compressible fluids with variable physical properties

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Abstract

We carried out numerical experiments of thermal convection of highly compressible fluids in a two-dimensional axisymmetric geometry, in order to study the influences of adiabatic compression and depth-dependent thermodynamic properties on the up-welling plumes in the mantles of massive super-Earths. We employed an increase in thermal expansivity and a decrease in the (reference) density with depth, both of which are taken to be relevant to Super-Earths with up to 10 times the mass of the Earth's. We found that, in the presence of strong adiabatic compression, thermal convection becomes weaker and, in order words, the values of thermal expansivity is larger at depth. The reason of such counter-intuitive effects can be understood from the stronger effect of adiabatic temperature change during the vertical motion of convecting fluids for larger thermal expansion: The temperature in the upwelling plumes decreases during their ascent, which tends to suppress their ascent by reducing thermal buoyancy. We also found that the thermal state in the convecting mantle is almost unchanged by the changes in the depth-dependence in the reference density. Our findings therefore suggest that the effects of strong compression on convecting flows are not due to the increase in density with pressure but due to the change in temperature due to adiabatic (de)compression.

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