Two-dimensional numerical experiments on highly compressible thermal convection in the mantle of super-Earths

*Masanori Kameyama[1,2]

1. Geodynamics Research Center, Ehime University, 2. Japan Agency for Marine-Earth Science and Technology

We conduct a series of numerical experiments of thermal convection of highly compressible fluids in two-dimensional rectangular box or spherical annulus, in order to study the mantle convection on super-Earths. The thermal conductivity and viscosity are assumed to exponentially depend on depth and temperature, respectively, while the variations in thermodynamic properties (thermal expansivity and reference density) with depth are taken to be relevant for the super-Earths with 10 times the Earth's. From our experiments we identified a distinct regime of convecting flow patterns induced by the interplay between the adiabatic temperature change and the spatial variations in viscosity and thermal conductivity. That is, for the cases with strong temperature-dependent viscosity and depth-dependent thermal conductivity, a "deep stratosphere" of stable thermal stratification is formed at the base of the mantle, in addition to thick stagnant lids at their top surfaces. In the "deep stratosphere", the fluid motion is insignificant particularly in the vertical direction in spite of smallest viscosity owing to its strong dependence on temperature. We also found that the occurrence of "deep stratosphere" tends to be suppressed for the cases with spherical geometry, owing the reduction of the surface area with depth which helps increase the temperature gradient in the lowermost mantle. Our finding may further imply that both the effects of adiabatic compression and those of spherical geometry of mantle are of crucial importance in understanding the mantle dynamics of massive super-Earths in the presence ofspatial variations in physical properties.

Keywords: super-Earths, mantle convection, adiabatic compression, viscosity, thermal conductivity

