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スーパー地球のマントル対流の数値シミュレーション
Numerical models of thermal convection in the mantle of super-Earths

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Numerical models are developed for thermal convection of compressible fluid in a deep mantle with the ratio of its depth to the thermal scale height D much larger than 1 to understand the nature of mantle convection in super-Earths. The viscosity is constant and the Prandtl number is infinite. A linear stability analysis shows that thermal convection is possible in super-Earths only when the thermal expansivity significantly decreases with increasing pressure, as is the case for the real mantle materials; thermal convection is totally inhibited when the thermal expansivity is constant. A systematic numerical simulation carried out to clarify the Nusselt number-Rayleigh number relationship shows that the efficiency of convective heat transport decreases by a factor of up to 2 as D increases. The Nusselt number may not be high enough to extract all the heat generated in the mantle by heat producing elements, and it may be difficult to sustain core-dynamo in super-Earths. Our numerical experiments also show that the Nusselt number significantly depends on the surface temperature. The mantle evolution may depend more strongly on the surface environment in super-Earths than it does in the terrestrial planets of our solar system.

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