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物性の空間変化がマントル対流パターンに与える影響の数値解析
Numerical investigations of the effects of spatial variations in physical properties on the mantle convective patterns

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We performed a linear stability analysis on the onset of thermal convection of fluid in the presence of spatial variation of physical properties such as viscosity, thermal expansivity and conductivity. The viscosity of the fluid is exponentially dependent on temperature, while thermal expansivity and conductivity are linearly dependent on pressure (or depth). The planar layer model geometry is employed. The top and bottom boundary conditions for velocity are taken to be either free-slip or rigid surface while the temperature are fixed on the boundaries. Velocity and temperature distributions are solved for infinitesimal perturbations for given horizontal wave number. We seek for the condition for the onset of convection by changing the values of Rayleigh number and wave number. Then, we examine the influence on incipient convection patterns of the magnitude in spatial variation in physical properties.

Our analysis successfully reproduced the transition in flow patterns into the 'stagnant lid' regime where a thick and stagnant lid of cold fluid develops at the top surface because of the very strong temperature dependence of viscosity. These flow patterns are quite similar to those obtained in finite-amplitude convection. Moreover, we found that the presence of spatial variation in thermal expansivity and conductivity, together with the strong temperature dependency in viscosities, changes the convective planform and moderately affects the onset of stagnant lid regime. In the presentation, the details of numerical results would be shown and discussed for describing the nature of the stagnant lid convection.

キーワード: マントル対流, 線形安定性解析, 温度依存粘性率, 圧力依存熱膨張率, 圧力依存熱伝導率, スタグナントリッド型対流
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