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Numerical simulations of planetary convection onset at various Prandtl numbers

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An almost adiabatic model of linear thermal convection in planetary cores is investigated. The onset of convection in this model is mainly driven by superadiabatic heat and/or compositional buoyancy sources at the inner and outer boundaries of the spherical shell. The mathematical problem is defined by a spherical shell filled with viscous fluid with fixed fluxes of heat (positive or negative) emerging from inner and outer spheres. Time-dependent instabilities are studied for a range of the Rayleigh-type number, for values of the Ekman number down to 10^{-5}. Small values of the Prandtl number (down to 0.001) are used to model thermal planetary convection onset. It is found that critical parameters of convection (critical Rayleigh number, frequency and azimuthal wavenumber) considerably vary with the change of the inner core radius. The onset of combined compositional-thermal turbulent planetary convection is simulated with the Prandtl number set to the unity. It is shown that the critical Rayleigh number greatly increases as we decrease superadiabatic value of the outer heat flux. Finally, the onset of compositional convection is investigated in the large compositional Prandtl number limit. In this case our attention is confined to the Prandtl number range $10 \leq \mathrm{Pr} \leq 1000$.