Thermal core-mantle interaction and stable stratification effects on supercritical convection

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The motion of the fluid in the Earth core is turbulent in nature which is the origin of the Earth’s magnetic field. Convective flows occur in the outer core due to the super-adiabatic temperature gradients. Due to the slow secular cooling of the core, the temperature gradient can fall below the adiabatic temperature gradient near the core-mantle transition zone and a stratified layer which is stable to convection can occur as believed to exist based on various geomagnetic studies. In the present work, thermal convection in the outer core is modeled using a simplified plane layer geometry to study the effects of core-mantle interaction and stably stratified layers on core convection. Various levels of buoyancy forcing from subcritical to supercritical regimes for non-rotating to rapidly rotating fluid is investigated at different diffusivity ratios. The spatio-temporal pattern of convective flows is determined with various combinations of thermal boundary conditions and stable stratifications. Apart from the observation that convective flows penetrate into the stably stratified region to a greater extent for higher rotation rates, their temporal characteristics show modified time scales compared to homogeneous and unstably stratified convection. Although the heterogeneous thermal boundary condition constrains the convection to regions of higher temperature gradients, enhanced thermal diffusion is observed to break these constraints. Finally the combined effect of heterogeneity and stable stratification produce complex flow patterns in supercritical regimes with completely different spectral characteristics.

Keywords: Stable stratification, Core-mantle interaction, Core convection

