The effect of compressibility on thermal convection

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Abstract

The properties of fully developed compressible convection substantially differ from the Boussinesq case the main two reasons for it being that the thermal and kinetic energies in compressible systems are comparable thus the work of the buoyancy force and the viscous heating significantly contribute to the total heat flux in the system. Moreover, convection tends to be most vigorous in the region where the density is smallest, i.e. near the top. We study here the influence of stratification on the Rayleigh (and Prandtl) number dependence of the Nusselt number in anelastic convection (that is with significant density stratification). It is reported, that the dynamics of the top and bottom boundary layers differs significantly. The top boundary layer is typically thicker and the entropy jump across it is larger than in case of the bottom boundary layer and thus, in connection with the fact that the convective velocities are largest near the top, the viscous heating at the top layer is much stronger and it is much more likely to become compressible as the stratification is increased. The top boundary layer is also more prone to instability than the bottom one, since the local Reynolds number based on the boundary layer thickness and the convective velocity is significantly larger in the former case.