Finite Prandtl Convection

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Convection in fluids with Prandtl numbers of order 10^4 is important in a wide variety of planetary situations such as the partially molten ice plumes of Europa or the magma oceans of early planetary interiors. Convection in fluids with Prandtl numbers above 10^3, have previously been modeled numerically using the infinite Prandtl approximation. This is the same approximation used for the Earths mantle, which has a Prandtl number of 10^5. It was assumed that by Prandtl numbers of order 10^3, the inertial terms no longer contributed significantly towards the convection behavior. This assumption, however, had not been previously tested numerically due to the fact that the inertial terms in the finite Prandtl equations become very stiff as Prandtl number increases requiring increasing grid sizes. We conducted studies of 2-D plumes with Prandtl numbers up 2×10^4. We found that these plumes tend to be hotter and to grow much faster than those modeled using the infinite Prandtl approximation.