Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Boussinesq approximation in rapidly rotating flows[1] JAGMOHAN SINGH, H. M. BLACKBURN, Monash University, Australia, J. M. LOPEZ, Arizona State University, USA, A. J. SMITS, Princeton University, USA — Rotating thermal convection (RTC) comprises of a thermal buoyant plume surrounded by a swirling flow. RTC is fundamental to many geophysical and engineering flows including tornados, firewhirls, dust devils and gas turbine combustors. Over the decades, RTC has been studied experimentally and numerically and it is shown that the axial buoyancy due to gravity in the presence of swirling creates a large updraft and aids to the formation of these columnar flows. In numerical simulations, the gravitational buoyancy is commonly modelled via the Boussinesq approximation which ignores the density variations in the momentum equation except in the terms multiplied by the gravity. However, a similar approach leads to additional buoyancy terms due to centrifugal forces, Coriolis forces and the inertia. The buoyancy due to centrifugal forces has recently started gaining attention but the other buoyancy terms are still overlooked and ignored. In this study, we systematically investigate the effect of different buoyancy terms in the Navier–Stokes equations via direct numerical simulations for flow inside the rotating container with an axial temperature gradient. Our results demonstrate that the buoyancy due to Coriolis forces and the inertia can change the flow behaviour significantly.

[1]The current study was supported by the ARC grant DP160103961. The computational resources provided by Pawsey under the grant D77 are greatly acknowledged.

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Date submitted: 15 Aug 2019 Electronic form version 1.4