Abstract Submitted
for the DFD13 Meeting of
The American Physical Society

Statistical classification of flow morphology in rapidly rotating Rayleigh-Bénard convection: A numerical and experimental synthesis[1]

DAVID NIEVES, ANTONIO RUBIO, KEITH JULIEN, University of Colorado at Boulder — We use experimentally accessible statistical measures to distinguish between flow morphologies in rapidly rotating Rayleigh-Bénard convection (RRBC). Transitions between different flow regimes are identified for the fixed non-dimensional Prandtl number $\sigma = 7$ in terms of the reduced Rayleigh number $\widetilde{Ra} = RaE^{4/3}$, where E is the non-dimensional Ekman number. Using cross-correlations of synthetic thermistor time signals we find that the flow transitions from the cellular regime to the convective Taylor column (CTC) regime at $\widetilde{Ra} \approx 20$, and from the CTC regime to the plume regime at $\widetilde{Ra} \approx 57$. Additionally, the horizontal flow structure is elucidated via spatial cross-correlations of vertically separated thermal fluctuations. Length, time, and velocity scales are produced for coherent columnar structures via spatial and temporal cross-correlations. Length, time and velocity scale data is seen to fit power-laws of the form $\alpha(\widetilde{Ra} - \widetilde{Ra}_c)^\beta$, where $\widetilde{Ra}_c$ is the critical Rayleigh number for the onset of stationary convection. Through direct numerical simulation of non-hydrostatic quasi-geostrophic equations, a detailed examination of the flow morphology in RRBC is carried out.

[1]NSF FRG No. DMS-0855010

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Date submitted: 02 Aug 2013 Electronic form version 1.4