Vortices in a cylindrical annulus

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Thermal convection has been shown to be determinant in the formation and intensity of some meteorological events such as dust devils and cyclones: dust devils are likely to form in the presence of large horizontal temperature gradients [1], and the evolution of hurricane intensity depends, among other factors, on the heat exchange with the upper layer of the ocean under the core of the hurricane [2, 3].

We consider a fluid in a cylindrical annulus heated from below with a Gaussian profile, the governing equations are the incompressible Boussinesq Navier-Stokes equations. For the numerical implementation, non-linearities are treated with Newtons method. For the discretization (for basic state and linear stability analysis) we use a spectral method by expanding the fields in Chebyshev polynomials and evaluating at the Gauss-Lobatto points [4, 5]. Convergence properties of the numerical method depend on the parameters present in the problem.

Under certain thermal and geometrical conditions, a stable vortex, very similar to a dust devil, can be generated from a convective instability. The horizontal temperature gradient at the bottom of the annulus and the vertical temperature gradient, determine the intensity of the vortex formed and its behavior can be controlled thermally by cooling or heating adequately the bottom boundary [6]. These results connect with that observed for the evolution of the intensity of cyclones and dust devils.

References

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