Study of Wall Modes in Rapidly Rotating Convection

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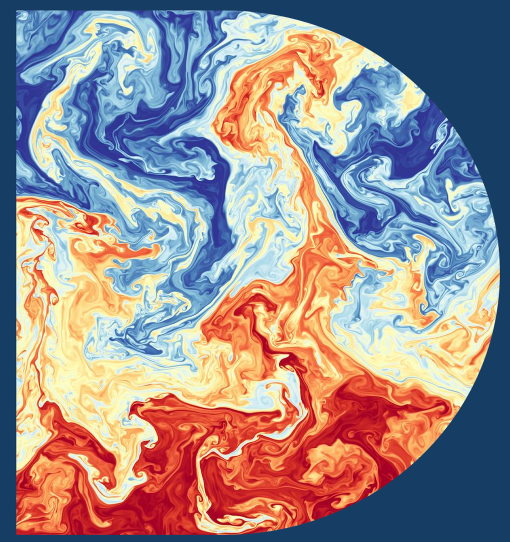

Background

- Dedalus is an open framework for solving partial differential equations. Using this framework, based in Python, we were interested in utilizing this tool to simulate convection currents under certain conditions. By generating a mesh of a cylinder, assuming it was heated from the bottom, and giving it varying parameters the framework was validated against already existing simulations and trials. The larger goal with these simulations is to be able to add parameters that allow the observed fluid to have magnetic properties and observe magnetic field amplification during as the liquid is rotating rapidly.

Simulation Parameters

R/Rc	R	Gamma	Ekman	Prandtl	Slices	Timeseires
4	112.9514	4/5	1.00E-06	1	0.01	0.05
5	141.1893	4/5	1.00E-06	1	0.01	0.05
6	169.4271	4/5	1.00E-06	1	0.01	0.05
4	112.9514	4/5	1.00E-06	1	0.002	0.01
5	141.1893	4/5	1.00E-06	1	0.002	0.01
6	169.4271	4/5	1.00E-06	1	0.002	0.01
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6	169.4271	4/5	1.00E-06	1	0.002	0.002

Conclusions

•Over the course of this project, benchmarks were reached in validation. The creation of movies to show timestep progression of the fluid was fine tuned to display the nonlinear and linearized states of the system.

•The direction of rotation of the fluid in the chamber was confirmed by observation as well as taking a Fourier transform of the system's equations to further validate the rotation and progression of the rotation period.

•A good basis was reached for further expansion in this research in coming years. The goal will be to expand into magnetohydrodynamics, by adding additional parameters to the rotating convection and observing not only wall modes, but also magnetic field amplification/development through rotation and convection in the fluid.

Results

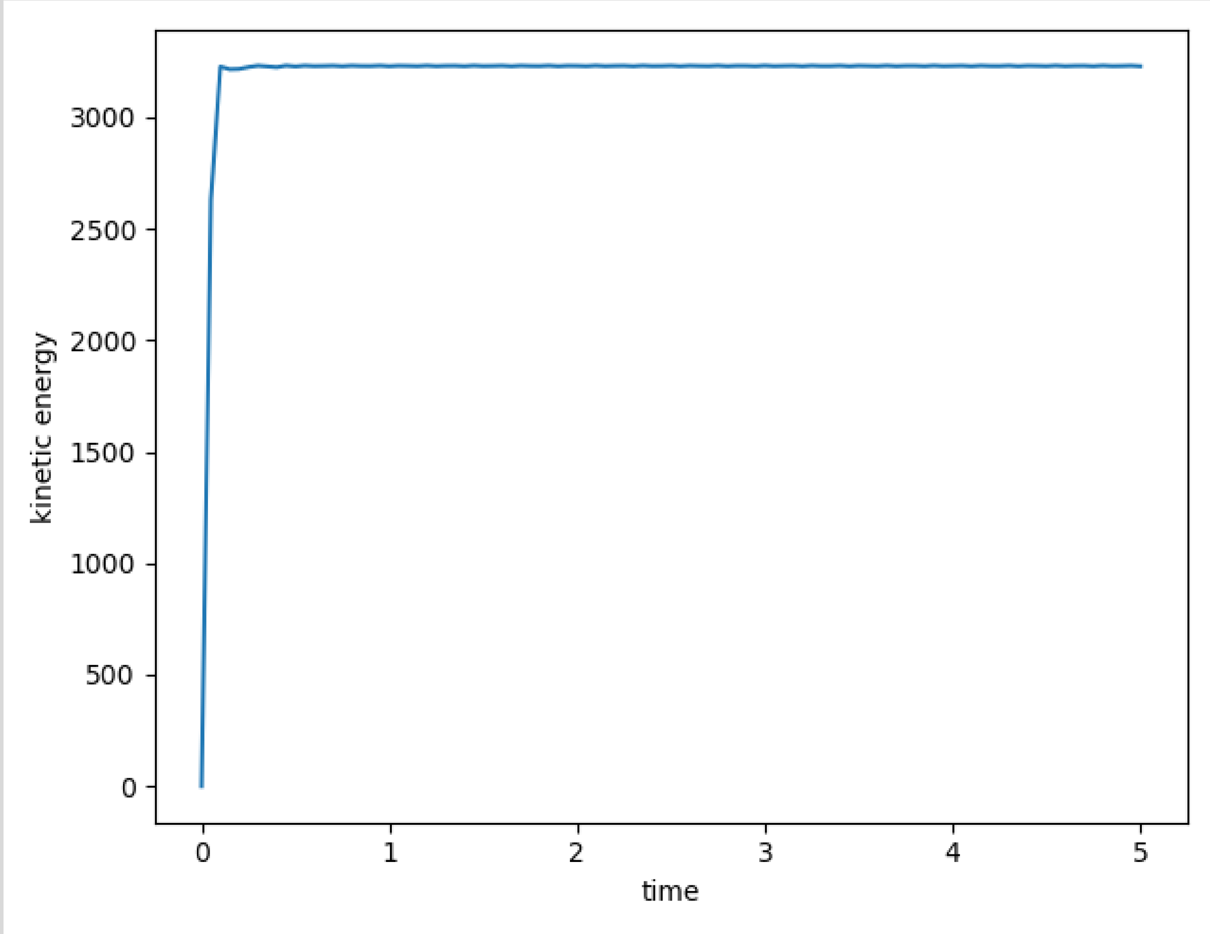
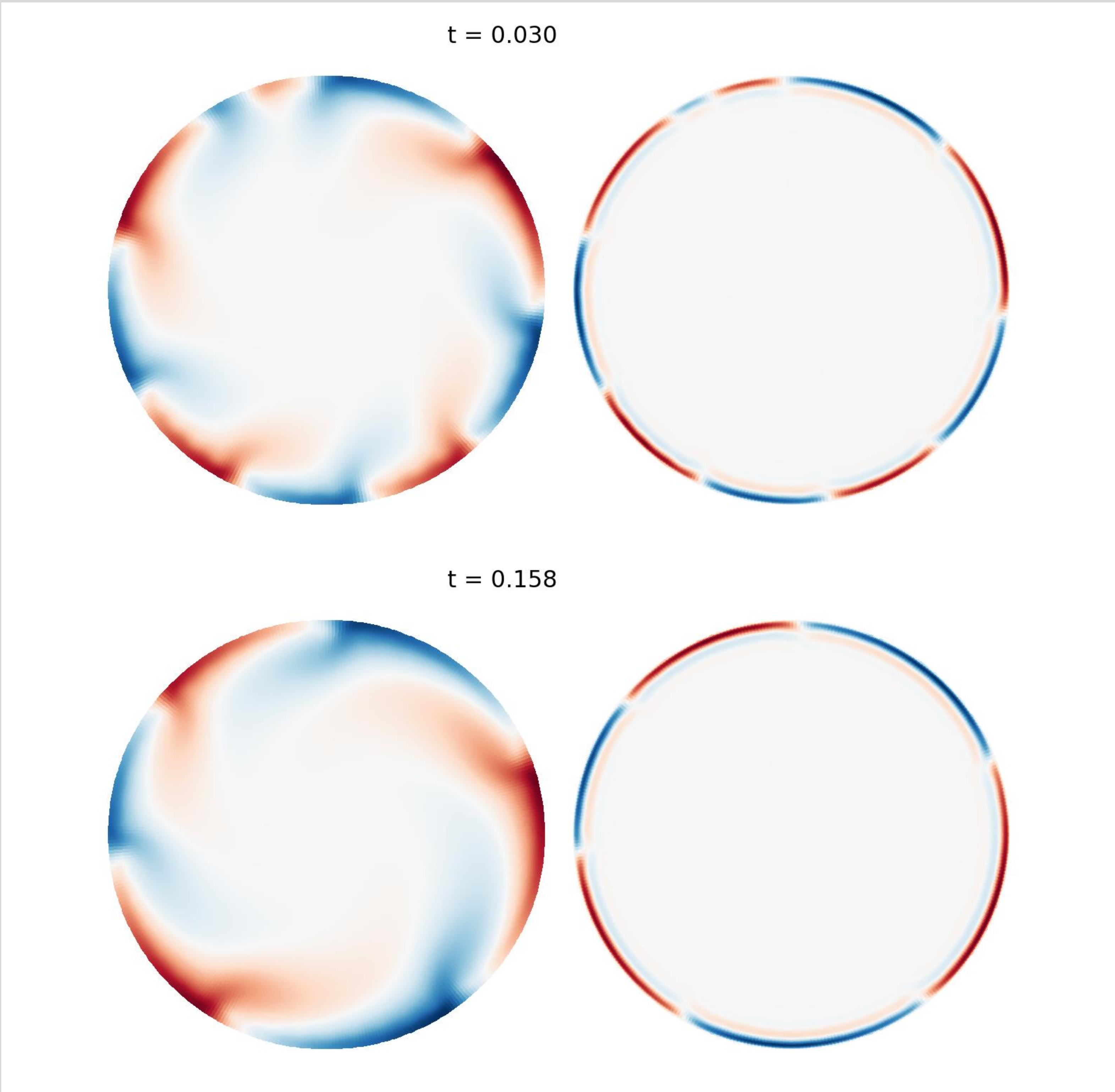


Figure 1: Kinetic energy versus time plot for configuration 7 highlighting excessive computation time window



Figures 2: Frames of convection at different timesteps. (Top) The nonlinear convection phase. (Bottom) The linear phase.

Methodology

- All simulations were run using the Dedalus framework developed to solve partial differential equations.
- Using the Premise server on UNH's campus along with Python scripts we were able to complete large computation volume to solve the equations describing the wall mode propagation in varying timesteps.
- To get an overview of wall mode behavior during rapidly rotating convection various parameters were used to allow for cross reference with an already existing data pool. The crucial factor determining the number of modes created and their propagation is dependent on the 'R' value or Rayleigh number that characterizes the flow regime.
- The use of a known dataset was done to validate the accuracy of the simulation outputs as the Dedalus scripts for wall mode convection are still in development. This also meant that there were roadblocks and debugging that had to occur during the study.

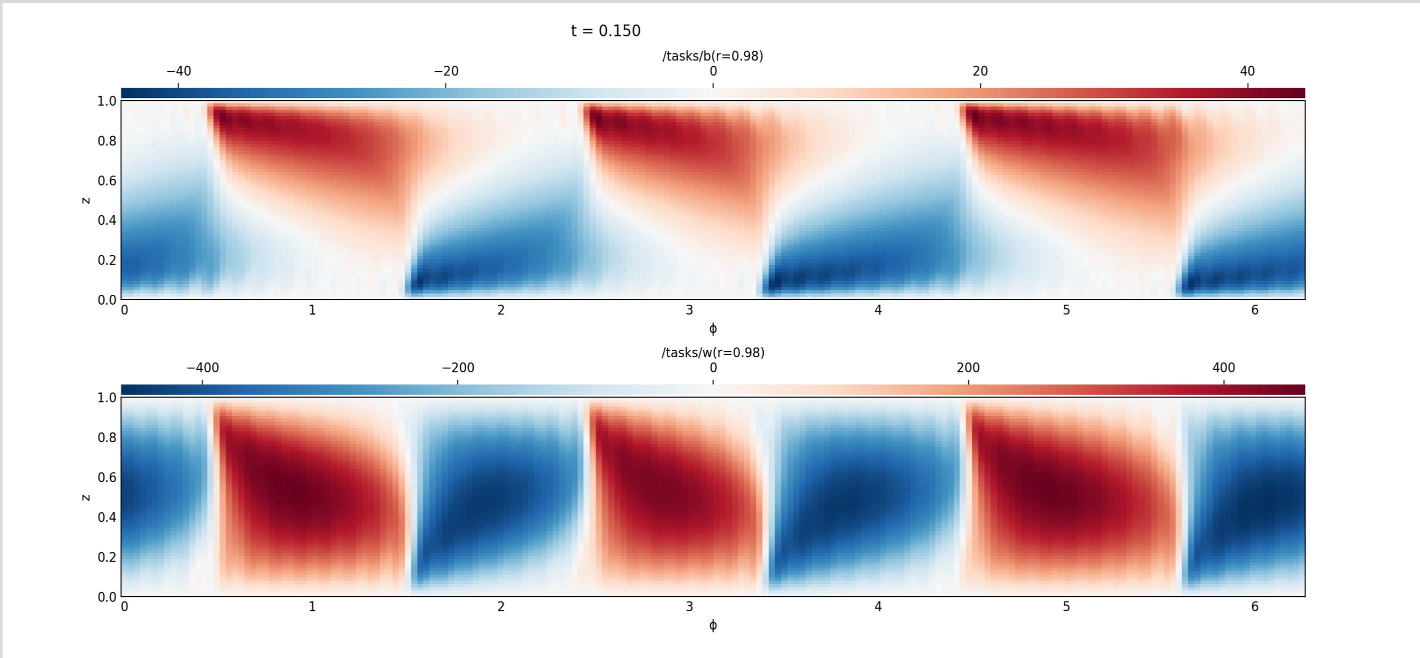


Figure 4: View along the height of the convection cylinder showing temperature variation with height.

References

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