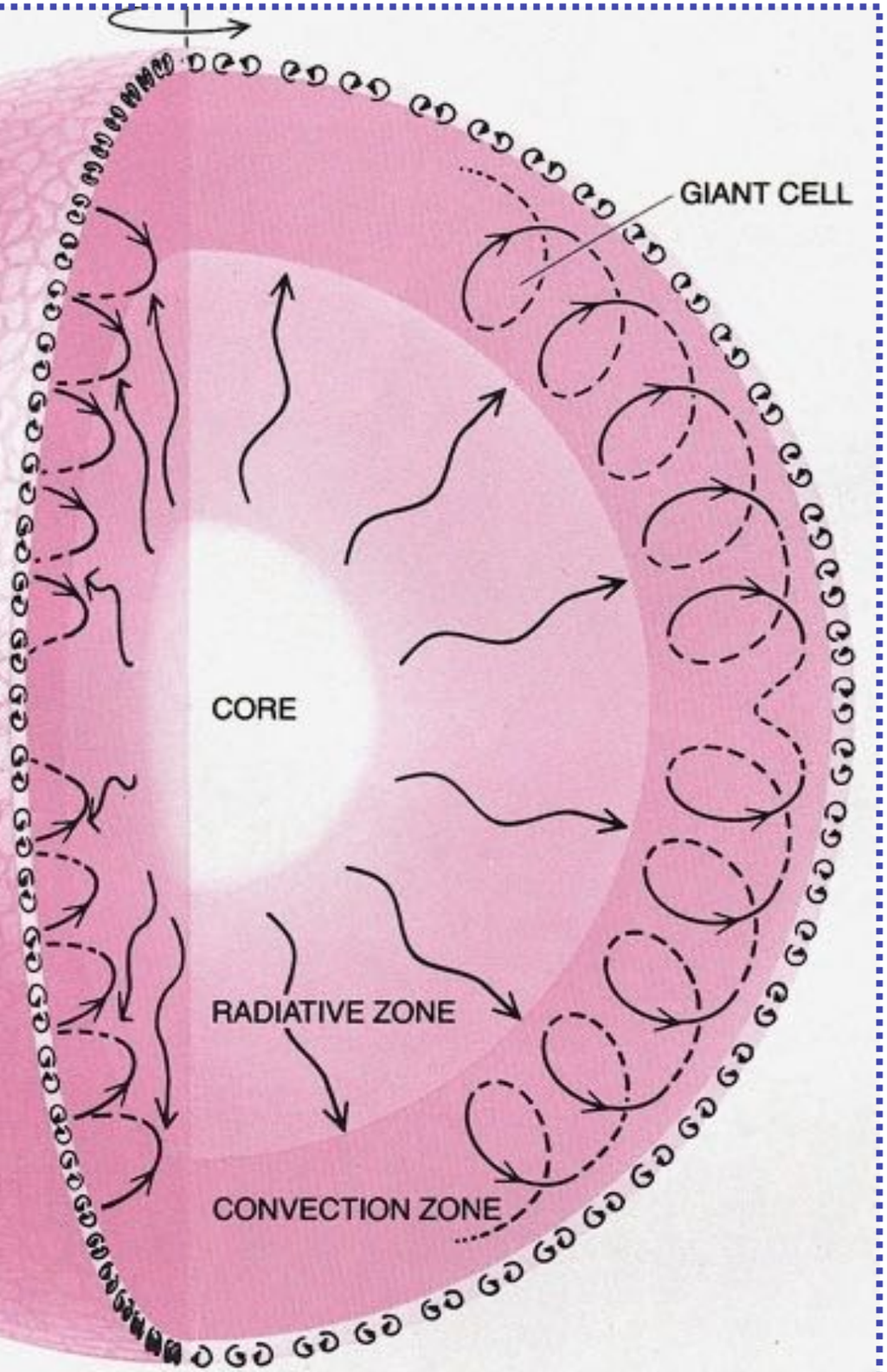
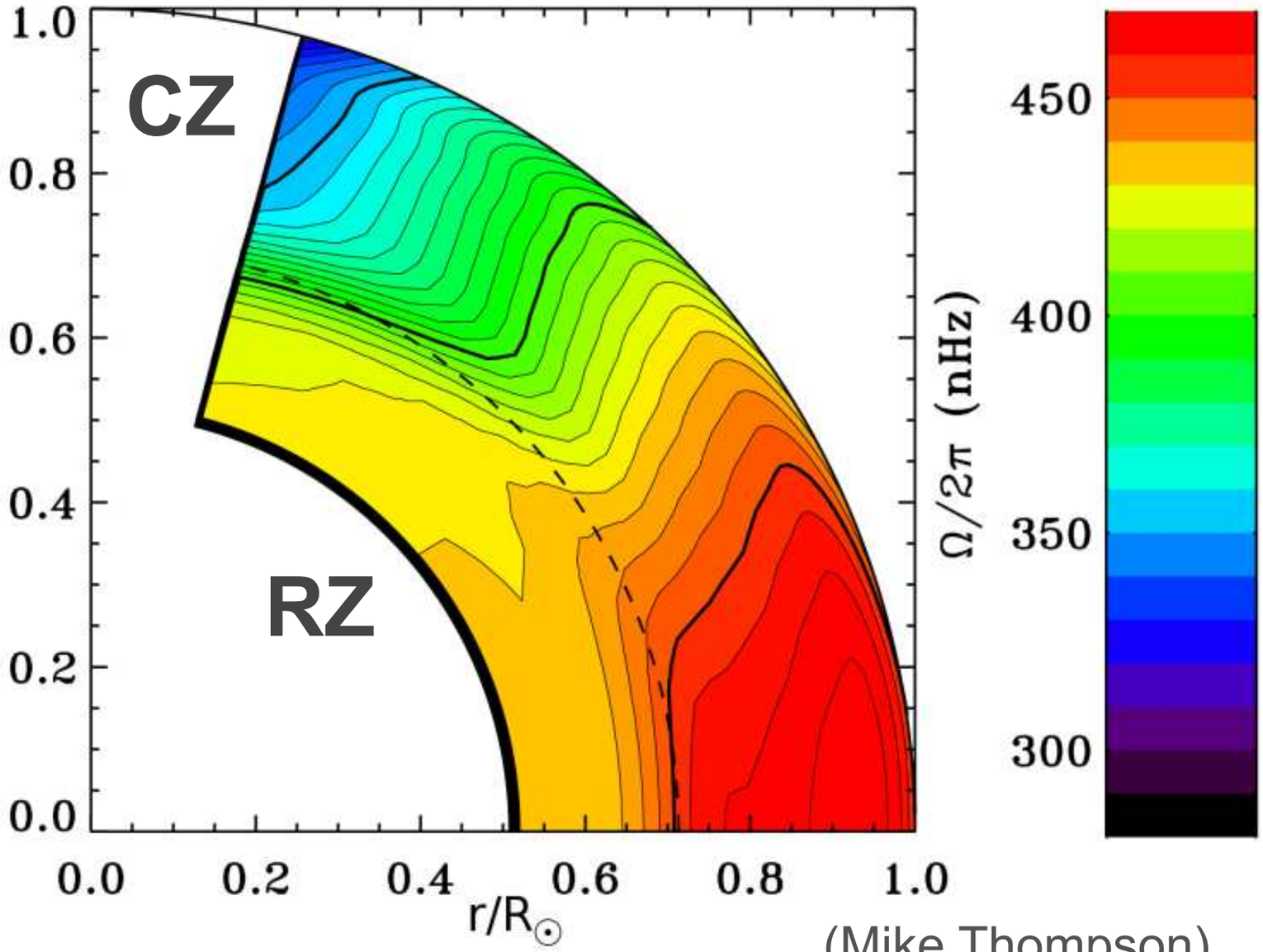
Flows in the hearts of stars

Ben Brown
University of Colorado
LASP and Dept Astrophysical and Planetary Sciences

Inside the Sun

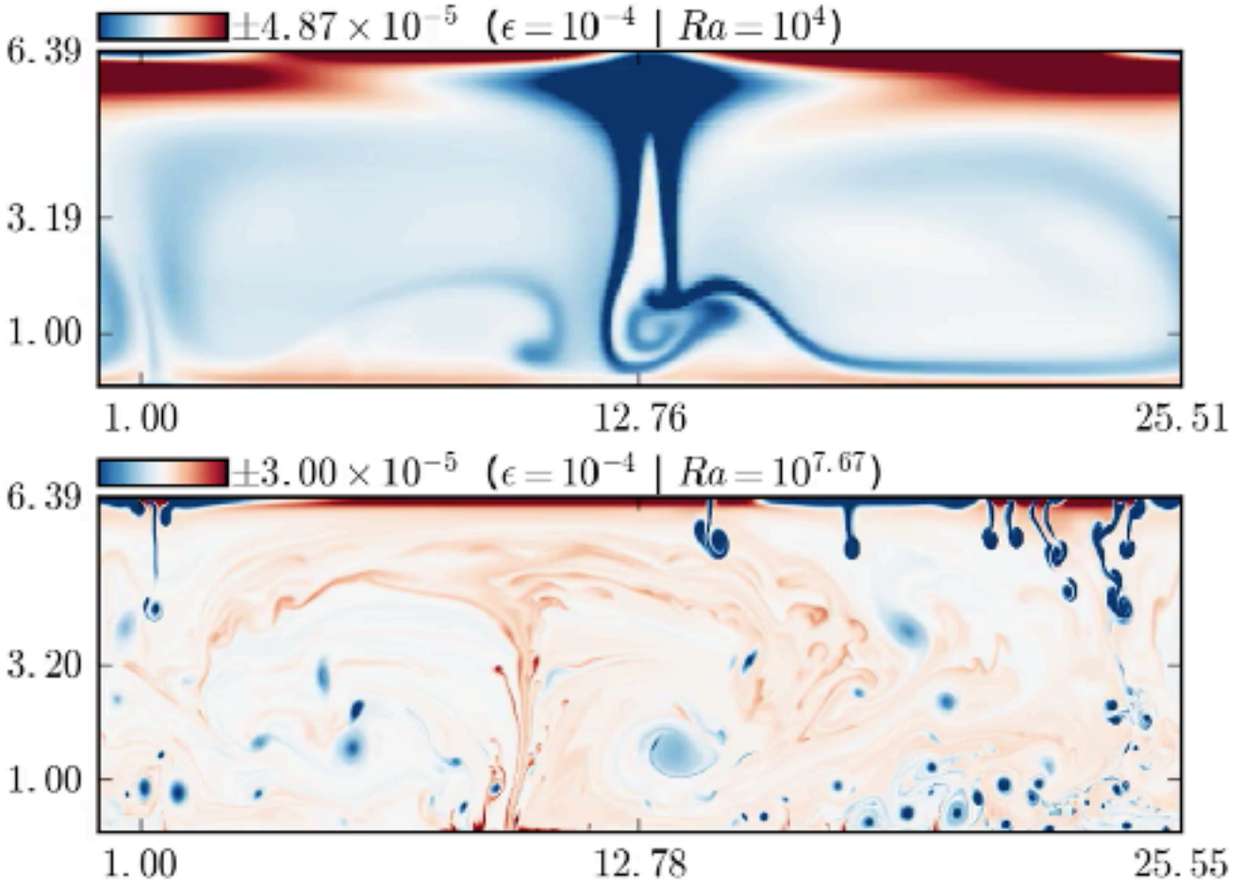


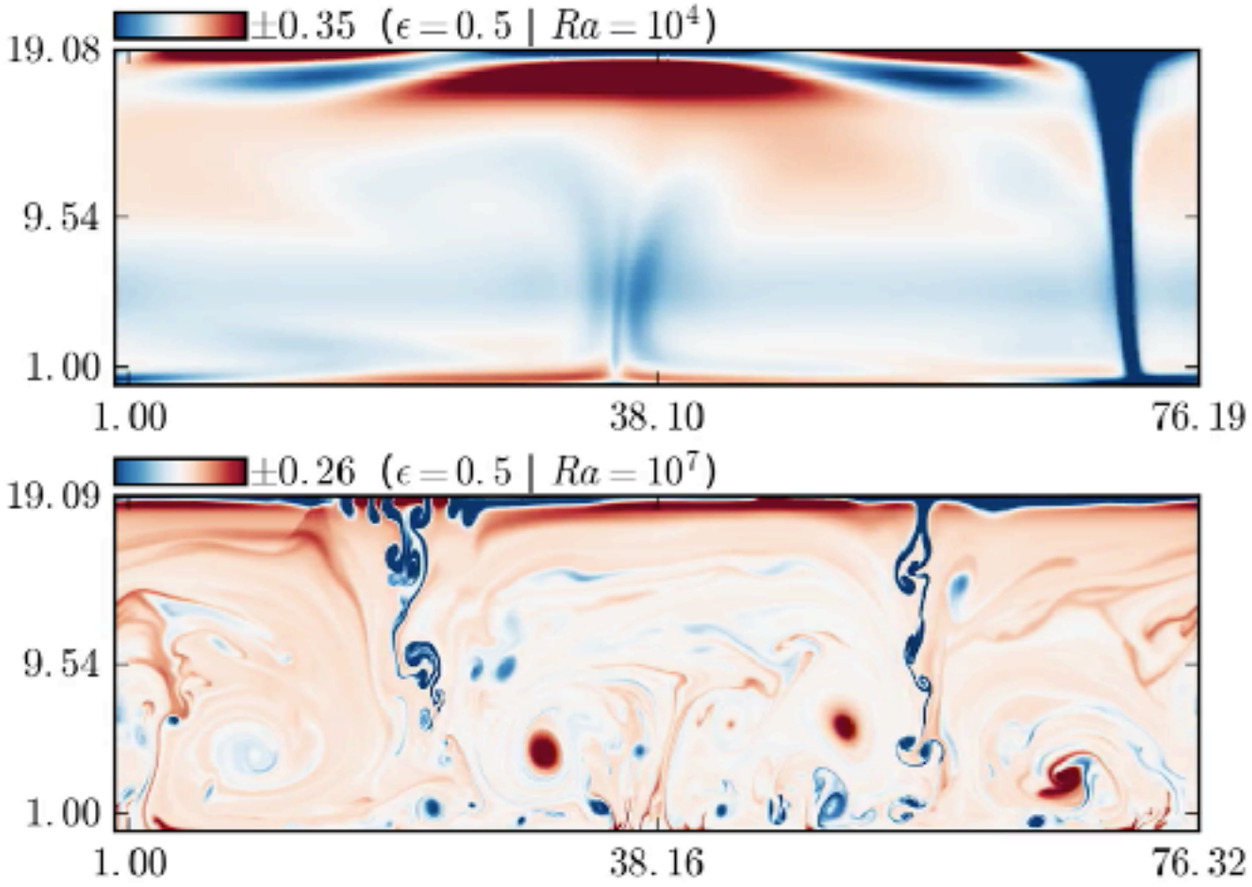


(Mike Thompson)

Properties of deep solar convection
(CZ depth of 200 Mm or $0.3R_{sol}$)
$Re \sim 10^{15}$ $E \sim 10^{-15}$ $Pr \sim 10^{-5}$ $Pm \sim 10^{-2}$
Ro ~ 1 (or maybe small!)

Stratified convection: flows





Low Mach number

$$\mathrm{Ma} \sim 10^{-4}$$

High Mach number

$$\mathrm{Ma} \sim 1$$

2-D simulations with 3 density scale heights of stratification. Fully compressible equations. Top plots are comparable to typical Rayleigh numbers in global scale simulations, while bottom plots are 1-2 orders of magnitude past state of the art. Flows behave very similarly at high and low Mach.

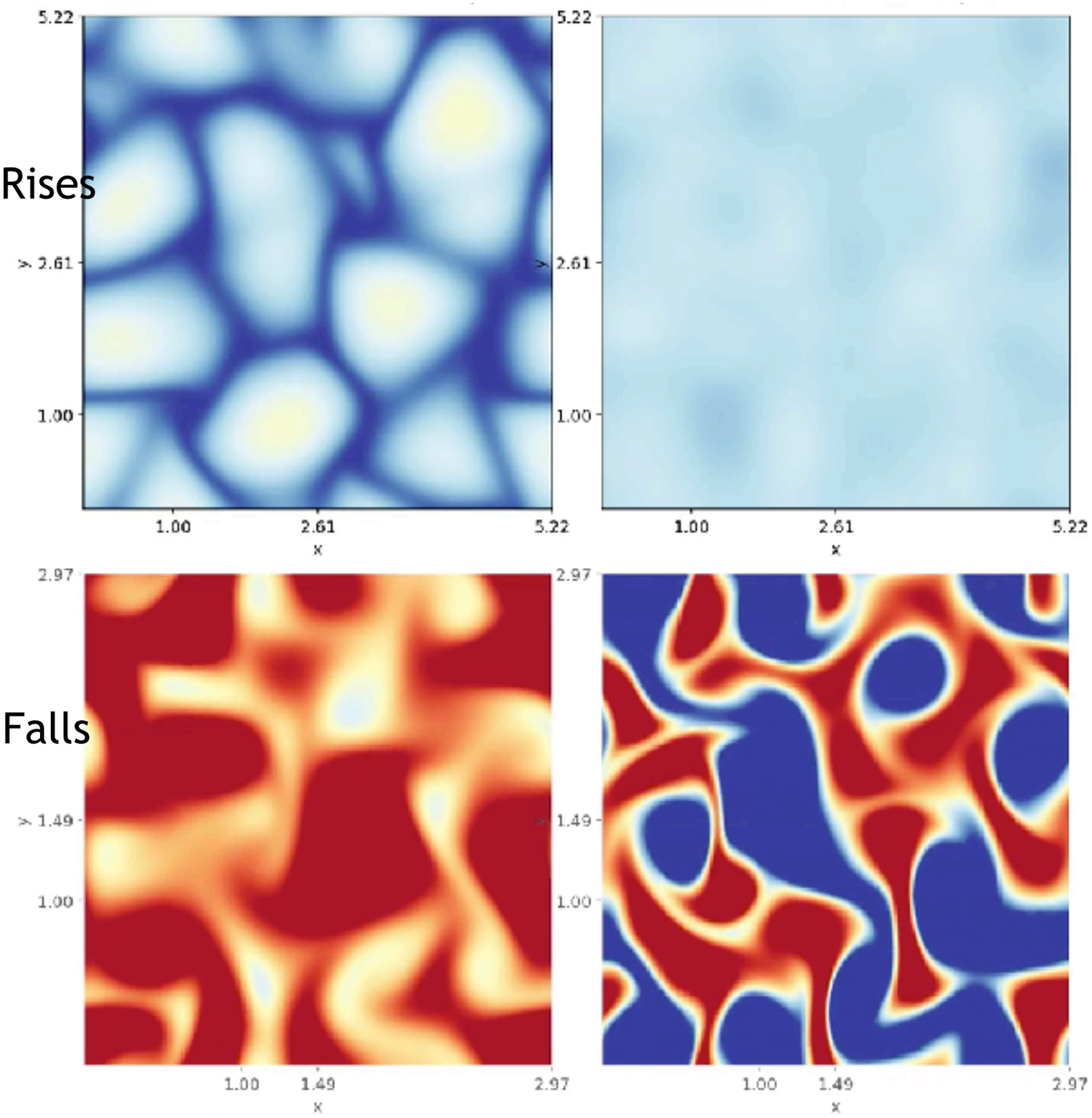
(Anders & Brown 2017 PRF & Arxiv)

Stratified convection: flows and rotation

Buoyantly Rises

Entropy

Buoyantly Falls



Top of layer

Middle of layer

Slowly rotating
Ro ~ 3

Same low Mach number, same strong stratification

Rapidly rotating
Ro ~0.1

(Thanks Katie Manduca! Manduca et al in prep)

How do flows change with rotation?

In non rotating flows, high and low Mach flows behave similarly.
What about when rotation is added?

To answer:

- 3-D visualization of flow fields, visual characterization of flow structures.

- compare measured heat transport in rotating flows to measured heat transport in non-rotating flows. Determine: are scalings the same?

Scope: semester long project. Data analysis and 3-d visualization can be conducted on a laptop, simulations run on supercomputer.

Need some familiarity with python, Mac or Linux, comfort learning and manipulating mathematical equations with vector calculus (fluid equations)

Team: Evan Anders, Baylee Bordwell, Ryan Diaz-Perez, Alicia Aarnio,
Katie Manduca, Tayler Quist

contact: bpbrown@colorado.edu

suggested reading: Anders & Brown 2017 PRF; on Arxiv