

Thermal Image Velocimetry for rapidly rotating fluid dynamics applications

¹Rémy Monville, ²Céline Guervilly, ¹Hao Cao, ¹Jonathan Aurnou

¹University of California Los Angeles US, ²University of Newcastle, UK

UCLA College | Physical Sciences
Earth, Planetary & Space Sciences

spinlabucla
SIMULATED PLANETARY INTERIORS LAB

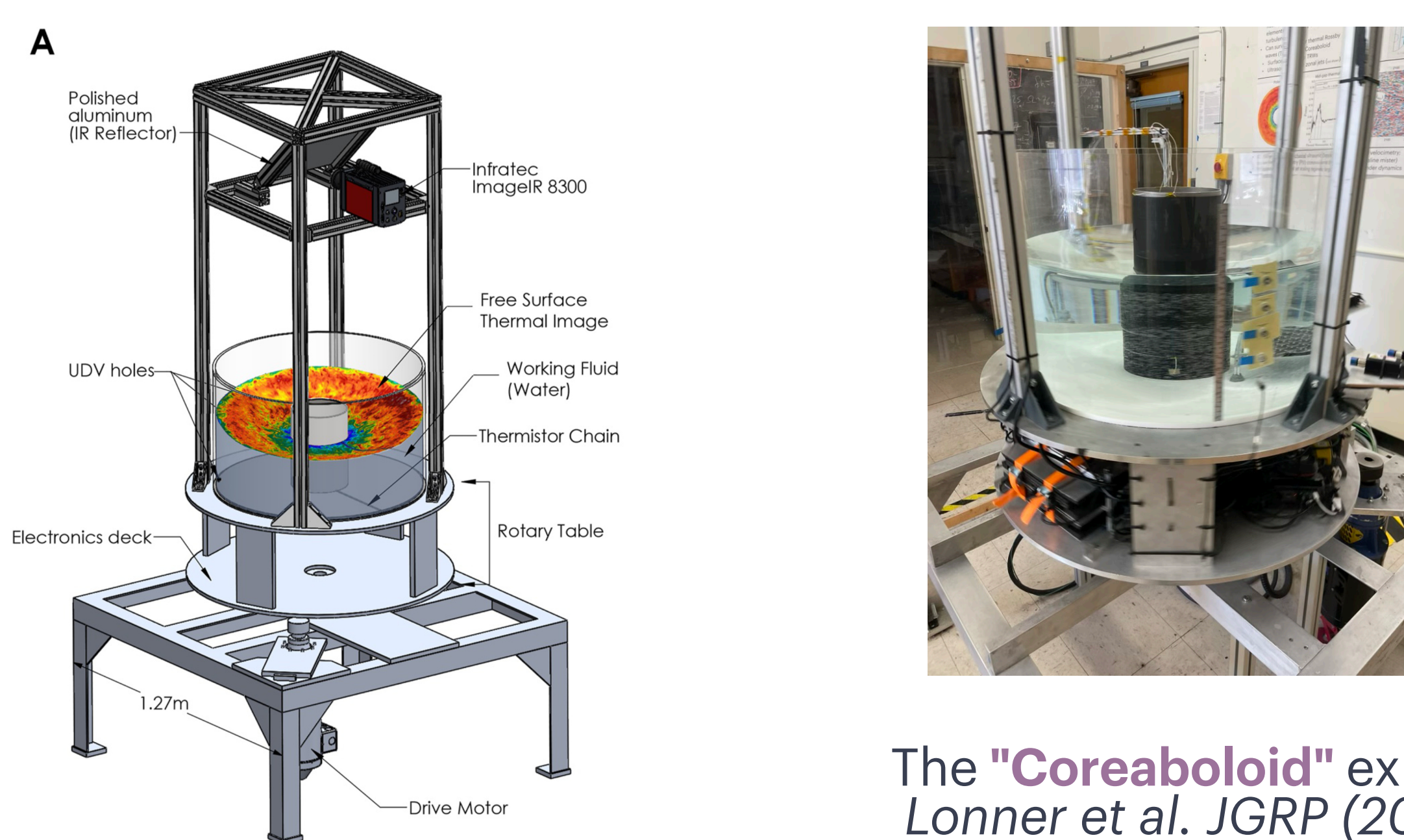
Newcastle University

Keypoints

- Velocimetry using free-surface **Infra-red measurement** and **tracking of the temperature structures**
- Alternative to Particle image velocimetry (PIV), which is difficult to implement in some **geometries**, e.g. in **paraboloids**
- Present a benchmark study using **Quasi-Geostrophic simulations** reproducing the **"Coreaboloid"** experimental setup
- Results: **high accuracy** of the inversion, allowing a detailed recovery of the **flow**

Motivations

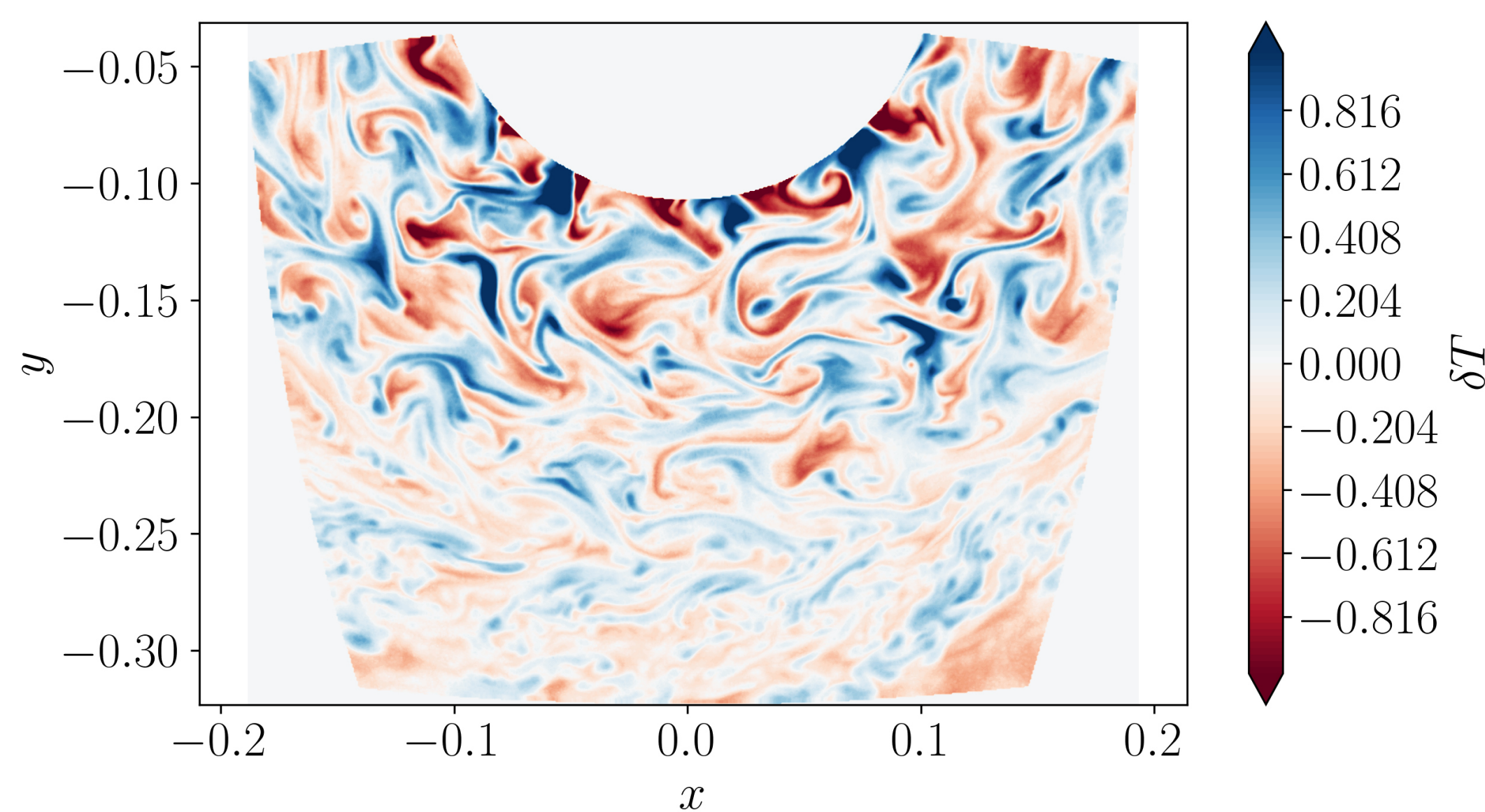
Paraboloid fluid surface experiments



The **"Coreaboloid"** experiment, Lonner et al. JGRP (2022)

Thermal forcing + β effects + rapid rotation :
Convective instability, generation of **zonal jets**

Infra-red measurement of the **free surface temperature field**

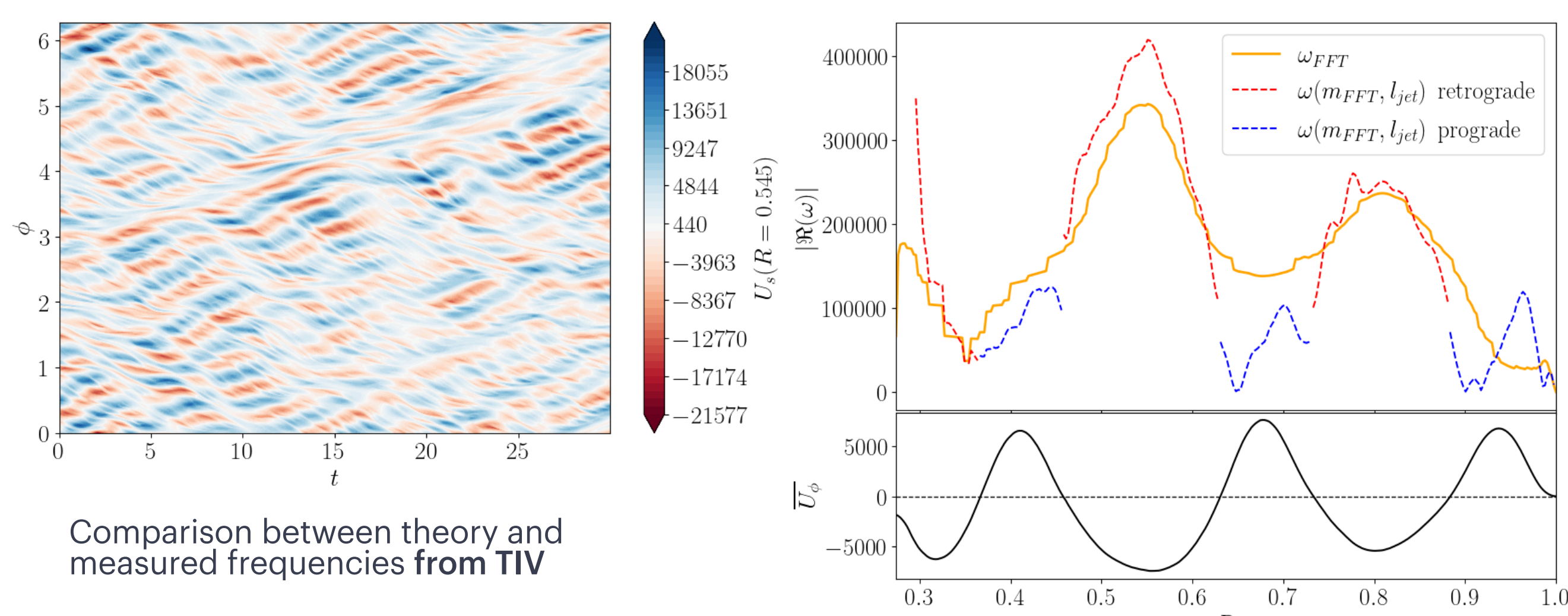


Detection of Rossby Waves

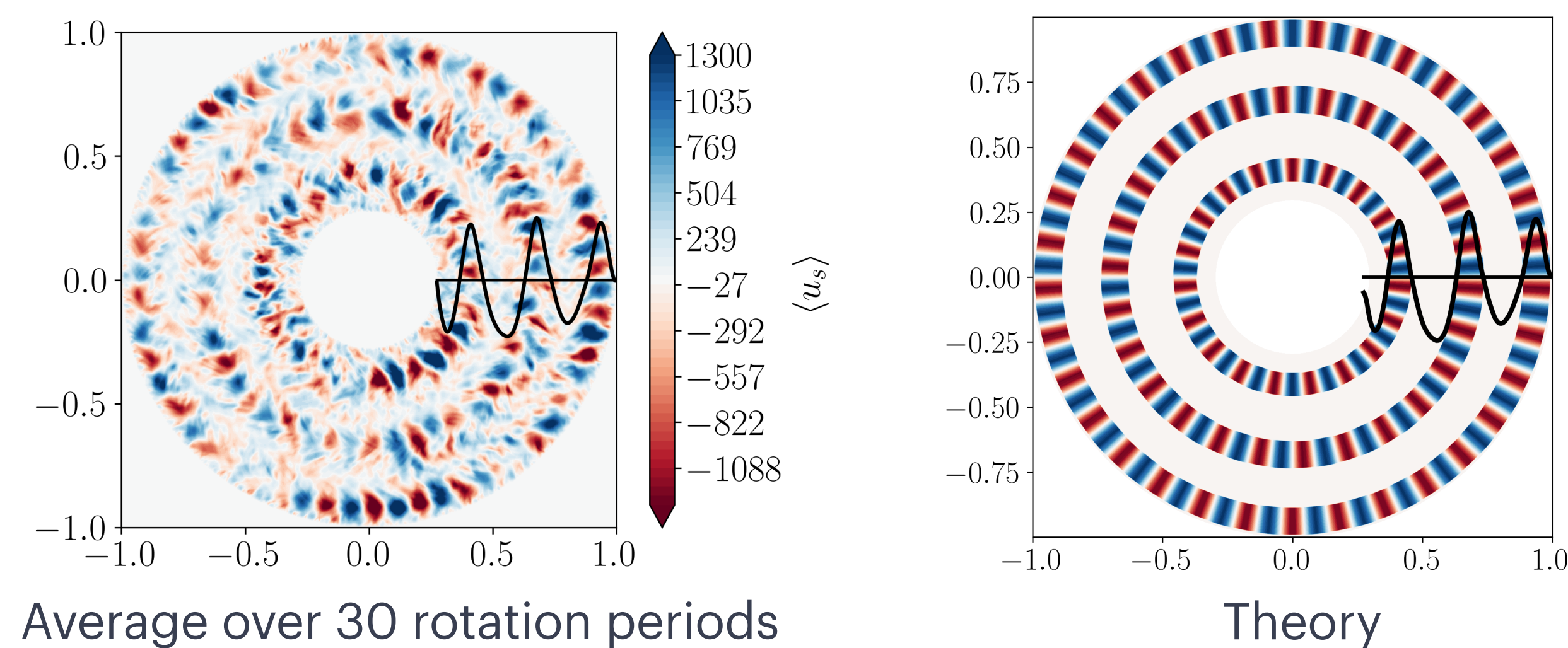
Can we do physics using TIV method ?

Local **Rossby waves** dispersion relation

$$\omega = -\frac{mU_0}{s} + \frac{ms(\tilde{\beta} - \partial_s \zeta_0)}{m^2 + (ls - i)^2}$$



Stationary Rossby Waves

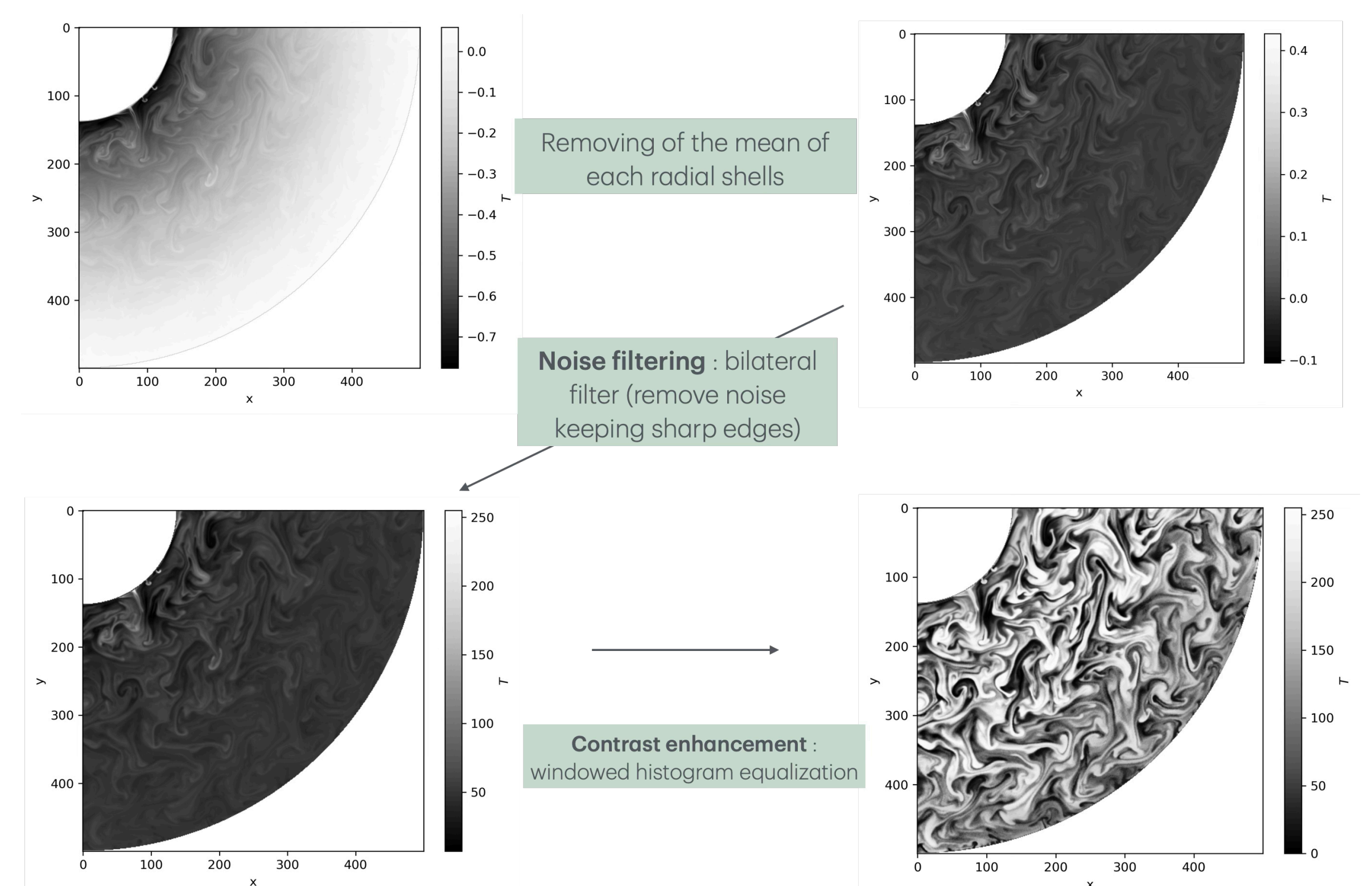


Thermal Image Velocimetry (TIV)

Objective: recover low Ro ($u \approx u(x,y)$) velocity field using surface temperature as a **passive tracer**

This study : Test the reliability of TIV on synthetic data from **Quasi-geostrophic simulations**

Filtering of the QG thermal fields:

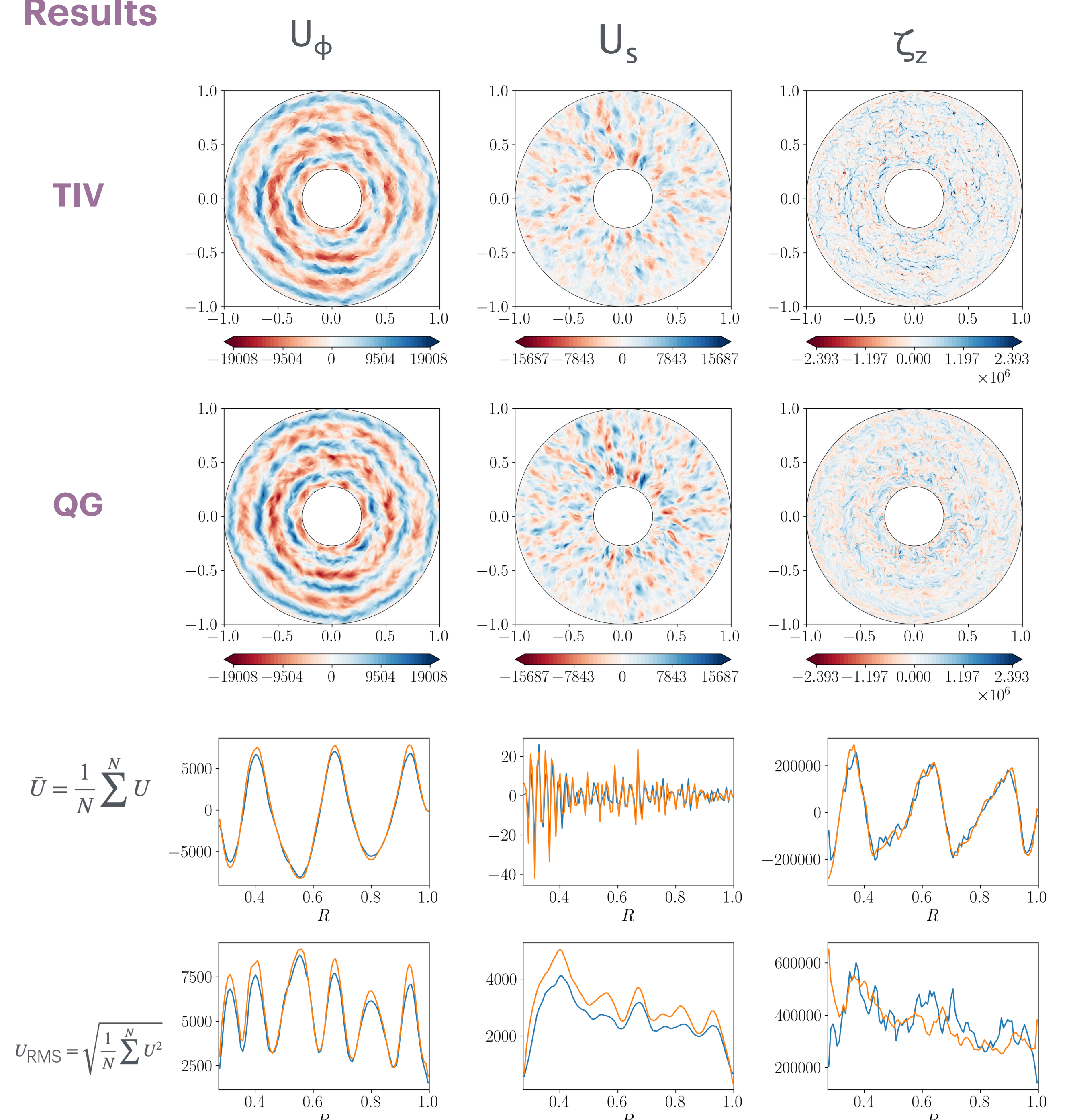


Optical flow (OF) method:

- **Farneback algorithm** : dense OF method based on the approximation of pixels neighborhood by a quadratic **polynomial** and the **illumination continuity** between 2 frames

- Correction of the **incompressibility** of the flow (Helmholtz decomposition), assuming the flow is z-invariant

Results



@monville remy.monville@epss.ucla.edu