Experimental and numerical study of a rapidly rotating spherical convection.

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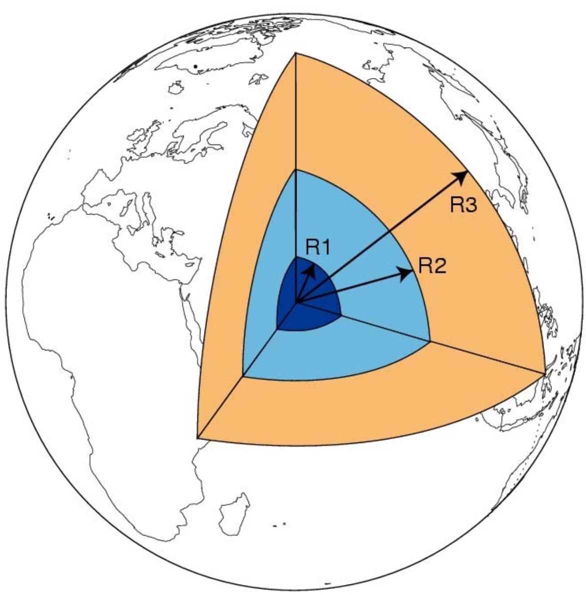


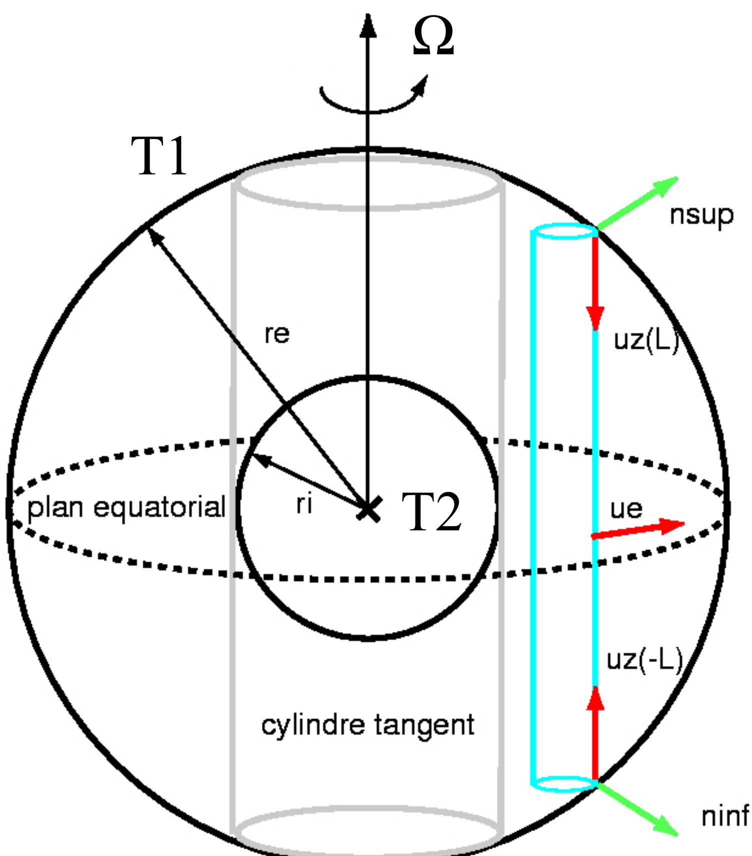
EGS - 04/2002

2D quasi-geostrophic numerical model

rapid rotation ⇒ the **Coriolis force** is dominant

… **Proudman Taylor** condition.

⇒ **z-invariance**: the vorticity ω and the temperature $\langle T \rangle_z$ are described in the **equatorial plane**.
(*Busse 70*, *Cardin & Olson 94*)



Dimensionless numbers:

Navier-Stokes equations:

•Rayleigh number **Ra**

Buoyancy vs ***thermal diffusivity & viscosity***

•Ekman number **E** ($\sim 10^{-6}$)

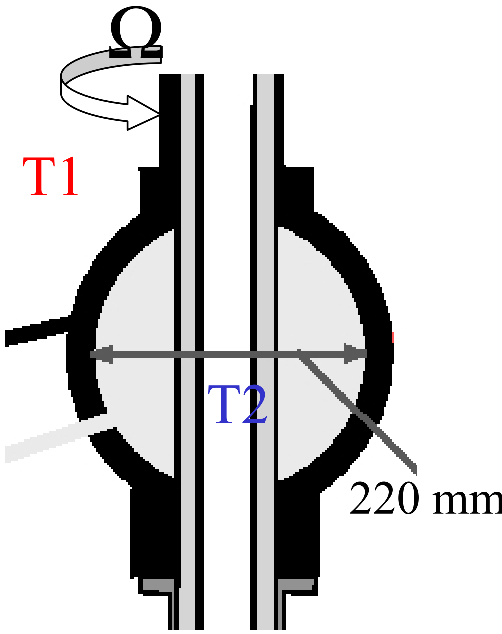
Viscosity vs ***Coriolis force***

Temperature equation:

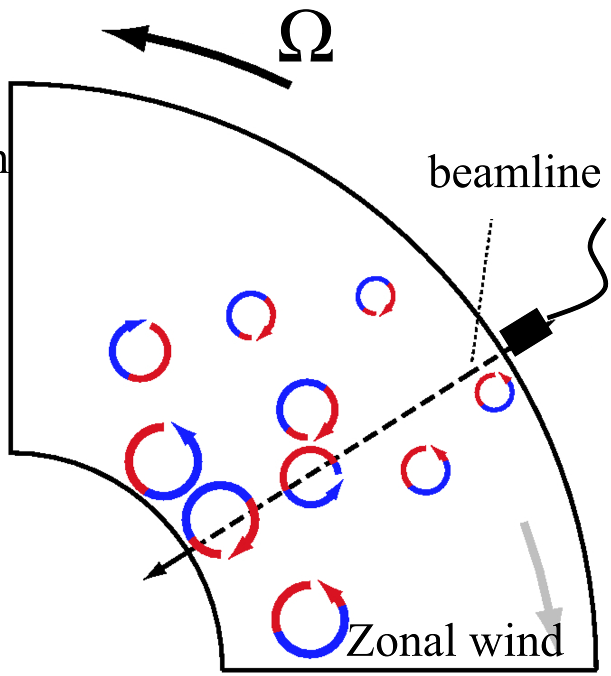
•Prandtl number **P**

Viscosity vs ***thermal diffusivity***

Experimental set-up



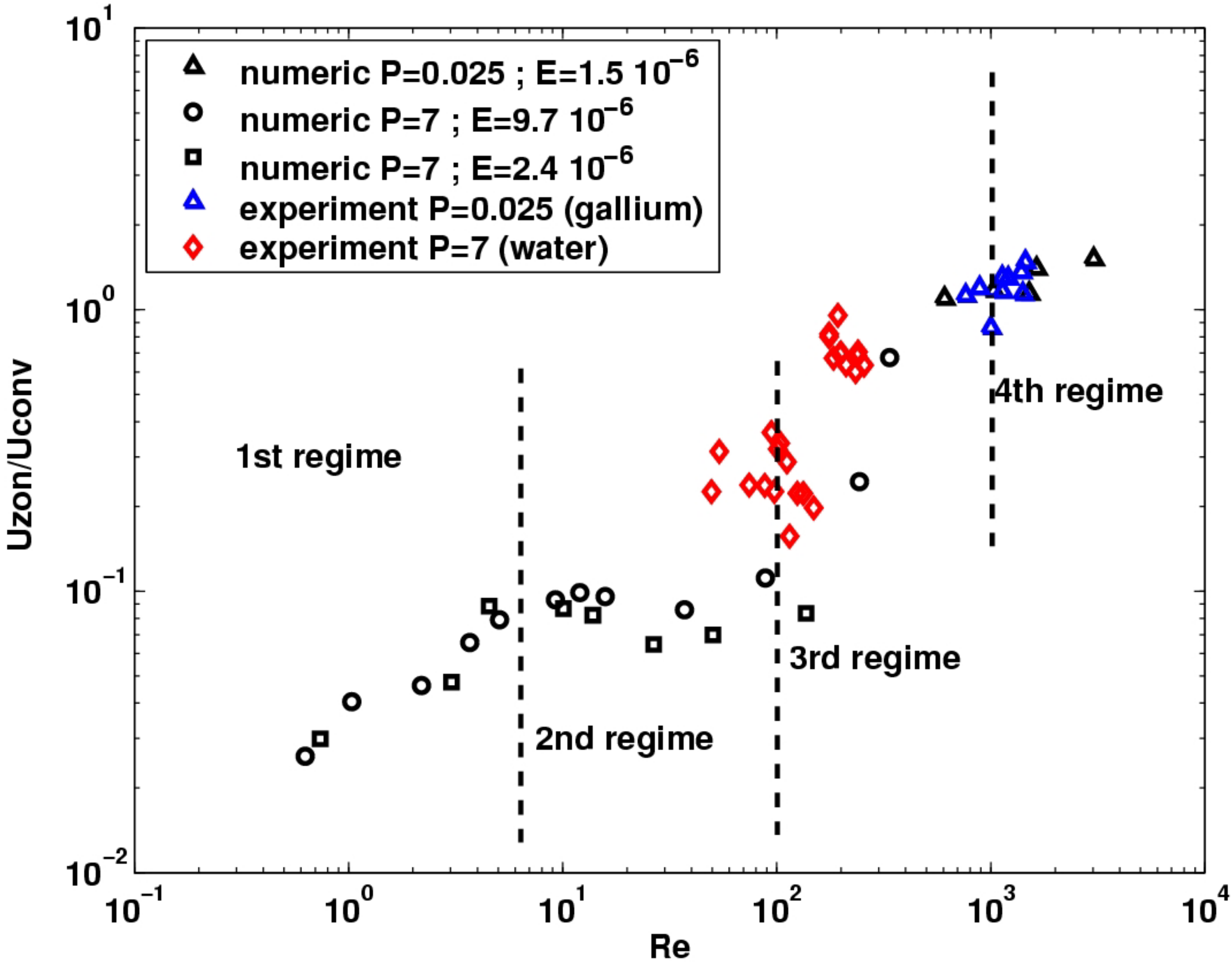
HF Doppler velocimetry: measurement of the convective and mean azimutal velocities.



<u>Experimental (black) and numerical (red) parameters :</u>

P	E	Ra/Rac
0.025 (gallium)	$7\text{-}15.10^{-7}$	1-4
	15.10^{-7}	up to 5
7 (water)	$2\text{-}10.10^{-6}$	5-100
	$2\text{-}10.10^{-6}$	up to 100

Experimental-Numerical comparison



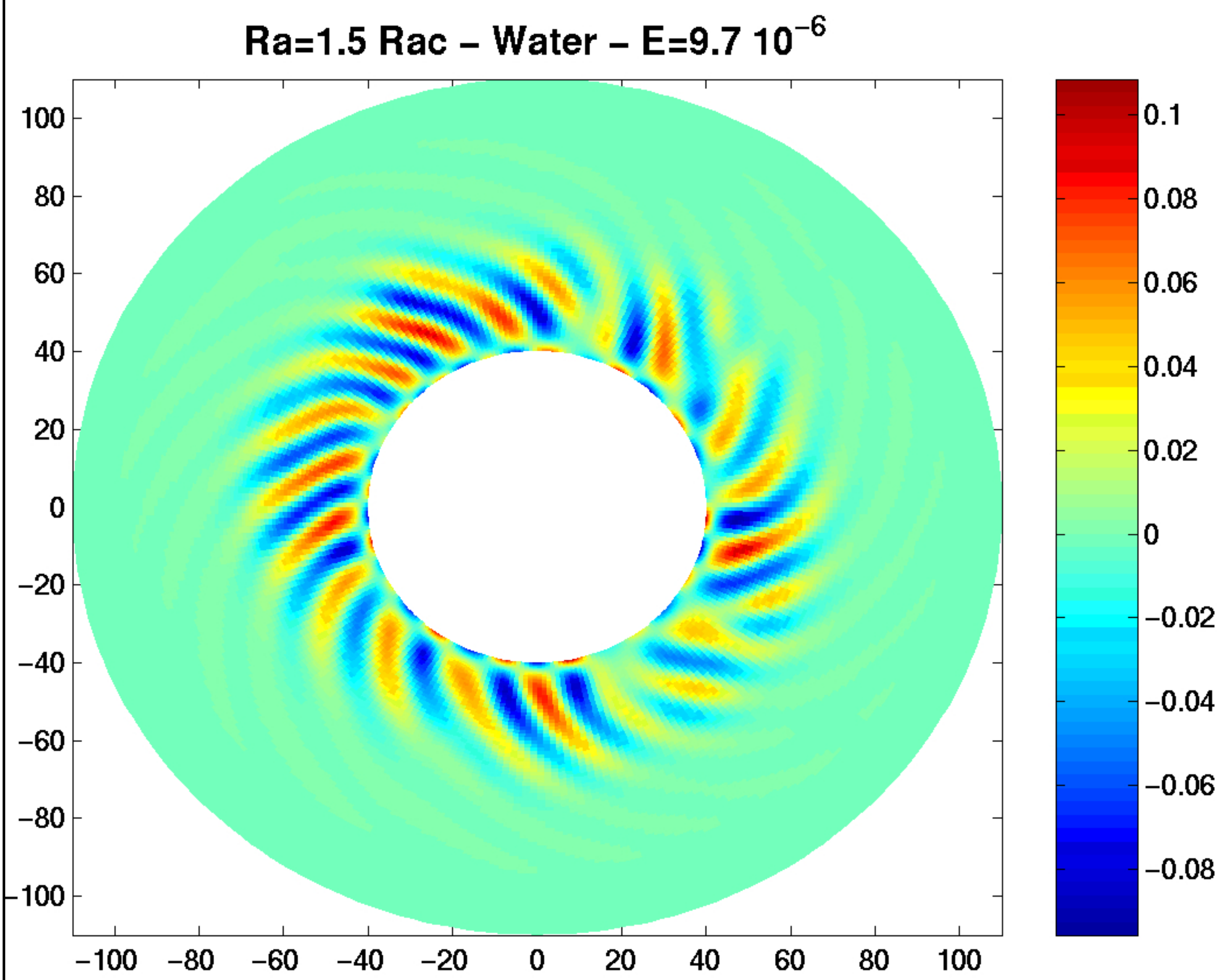
the Reynolds number **Re** (~ vigor of movement)… a way for comparing the energies of convective and mean zonal velocities.

1st Regime

convection treshold continuation

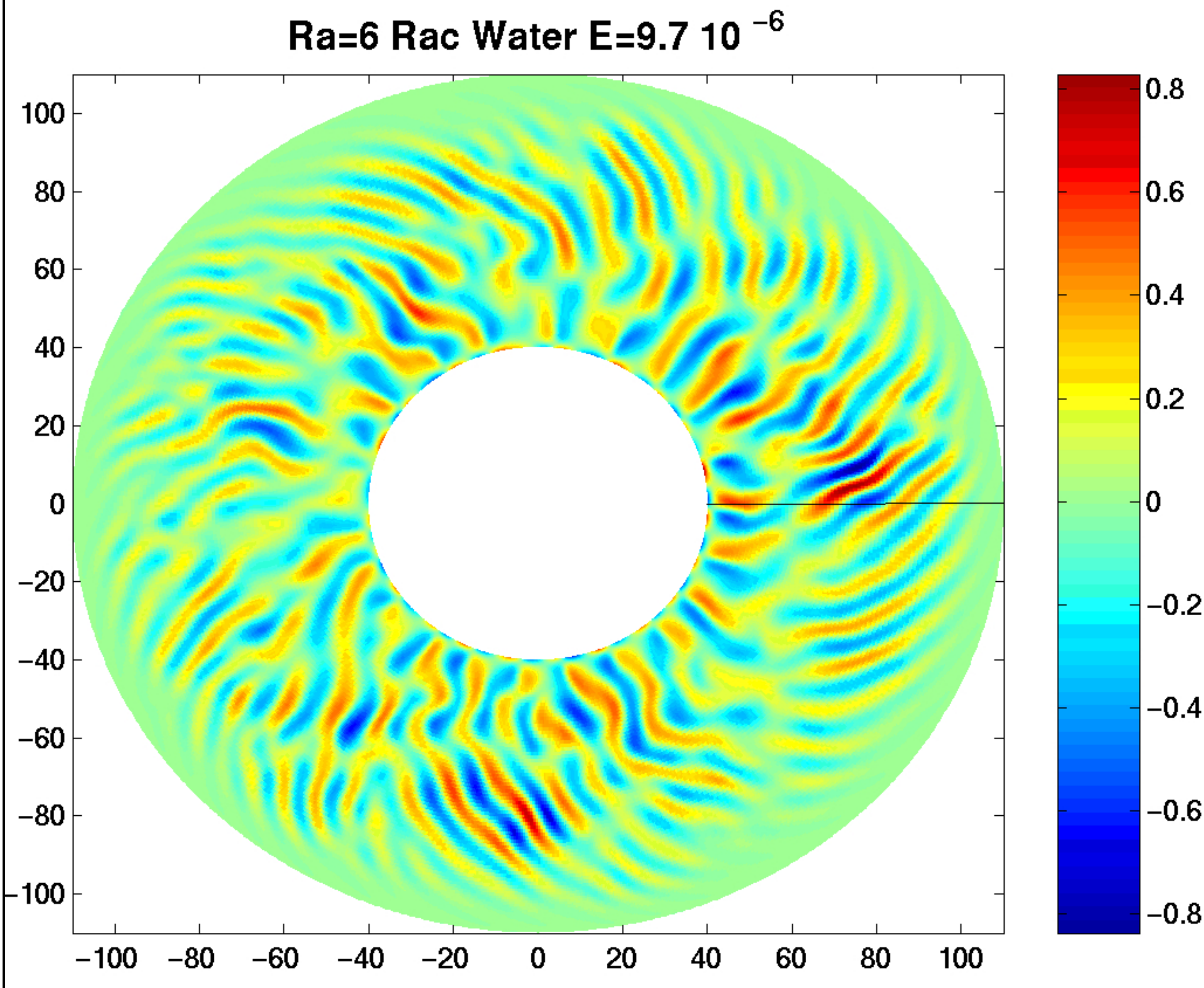
with thermal Rossby wave

« necklace of columns » (*Busse, 70*)



2nd regime

saturation of the viscous balance
spiralisation of the columns
… destabilisation of the waves.

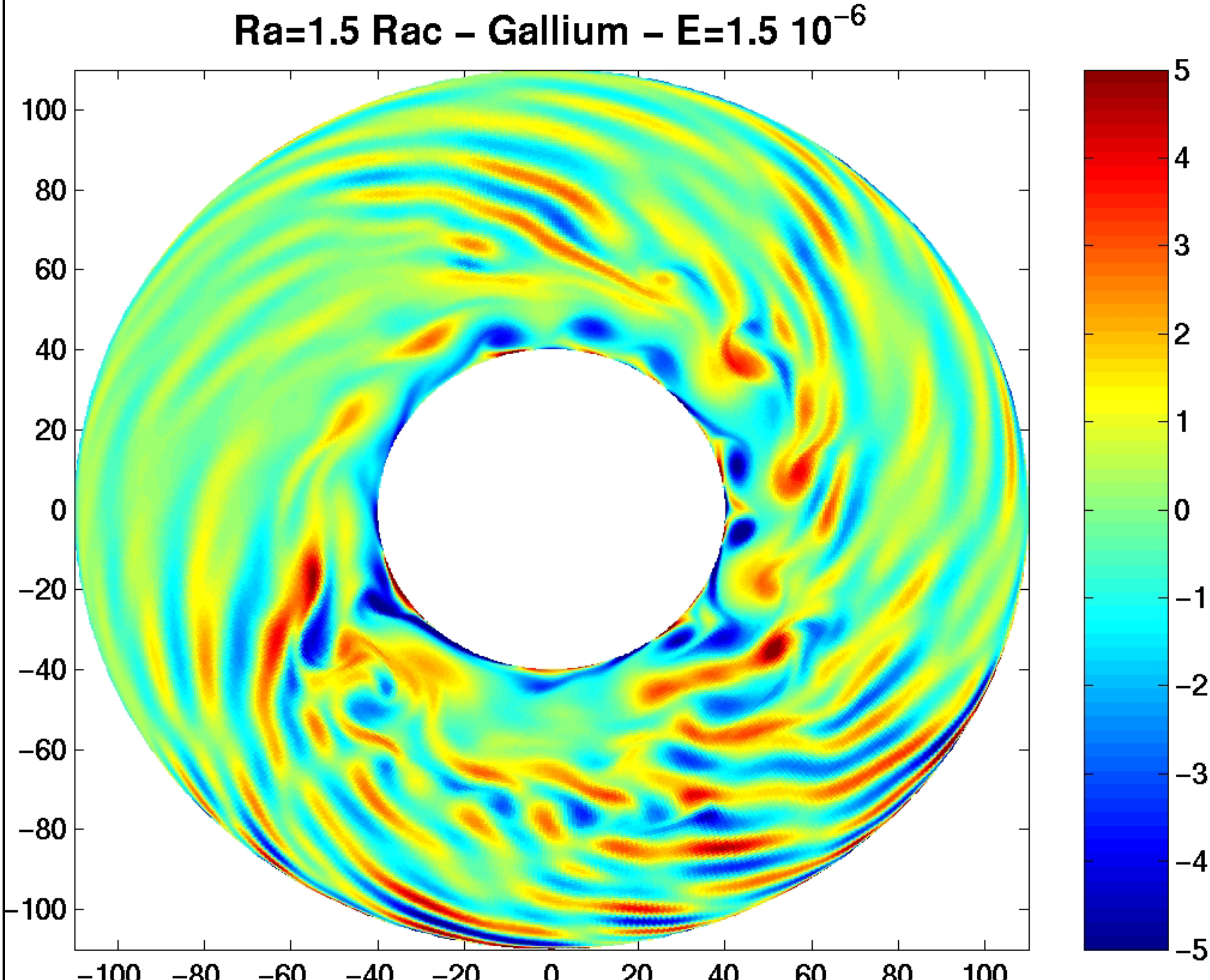


3^{rd} regime

inertial balance

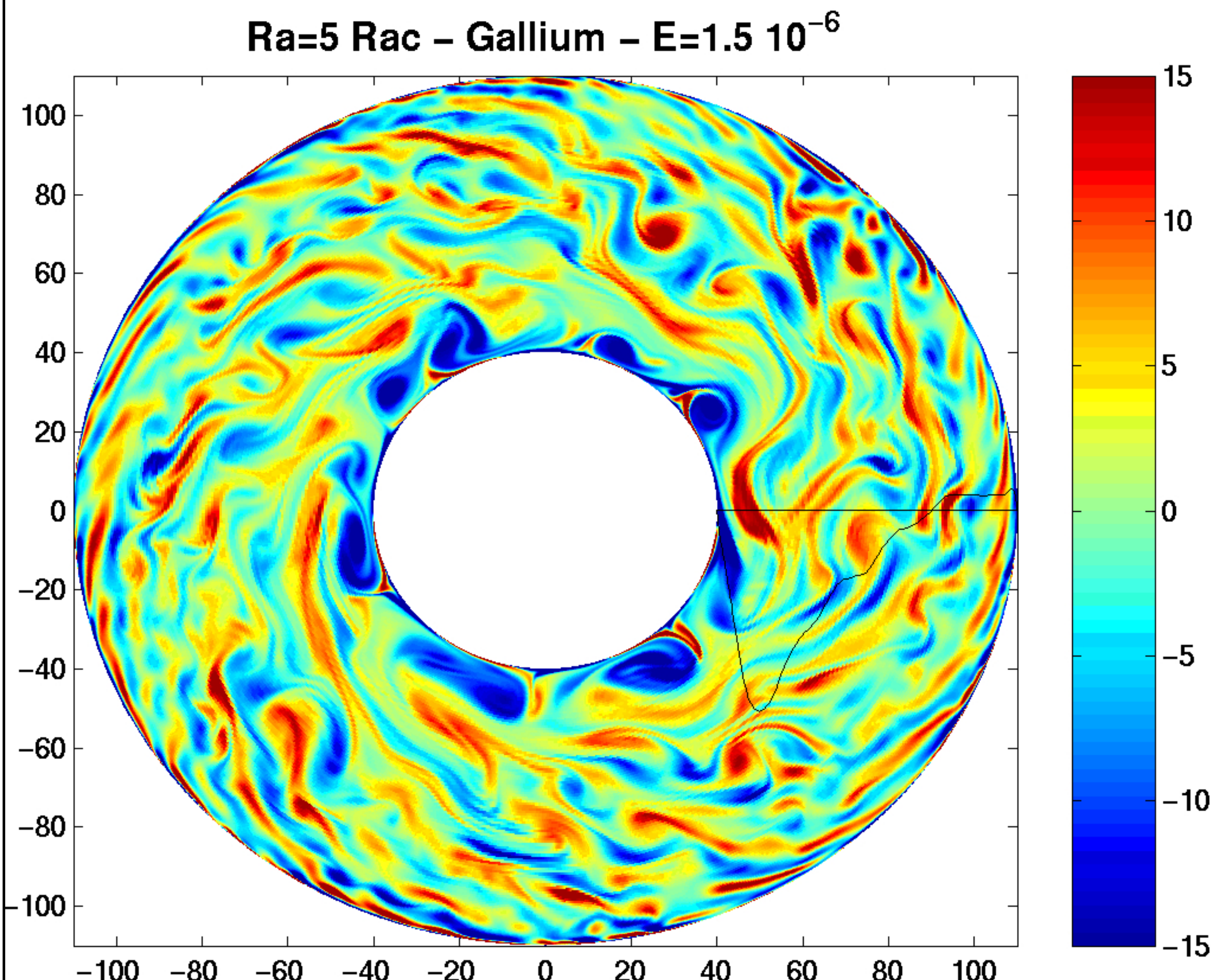
thermal instability ~ vorticity variations

convective flow creates strong zonal flow.

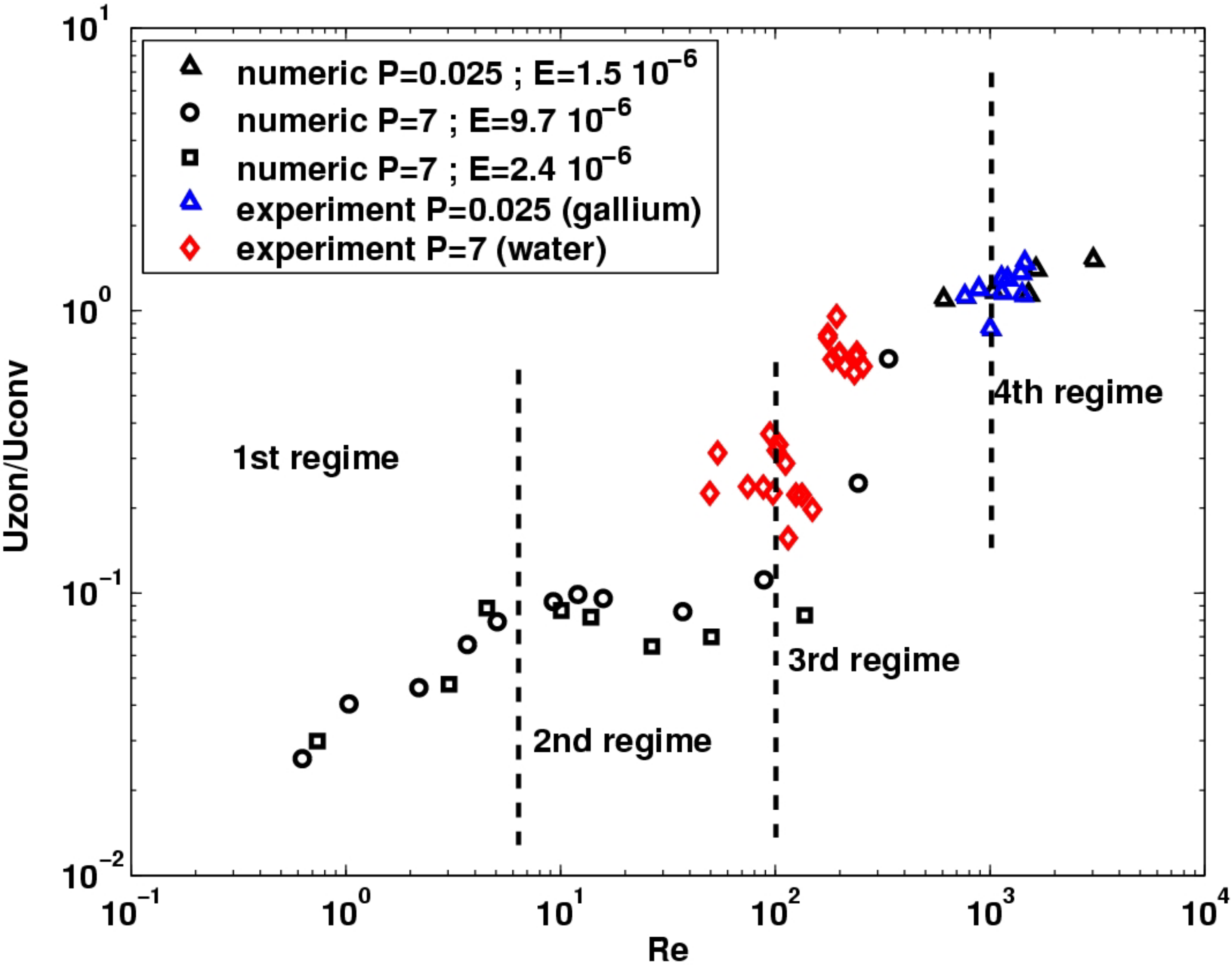


4^{th} regime

inertial scaling saturation by Ekman friction
(top and bottom columns boundary)

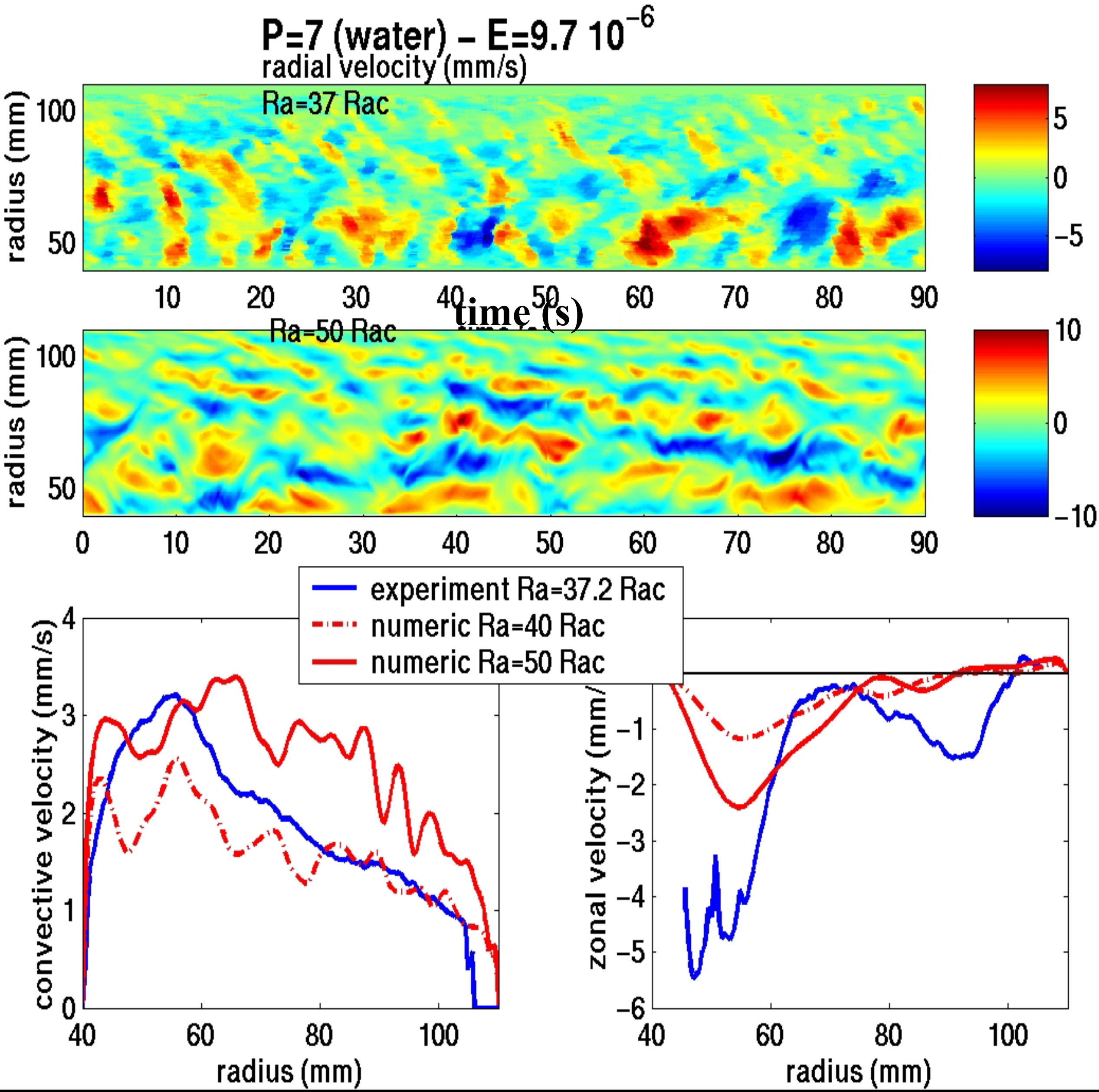


Experimental-Numerical comparison

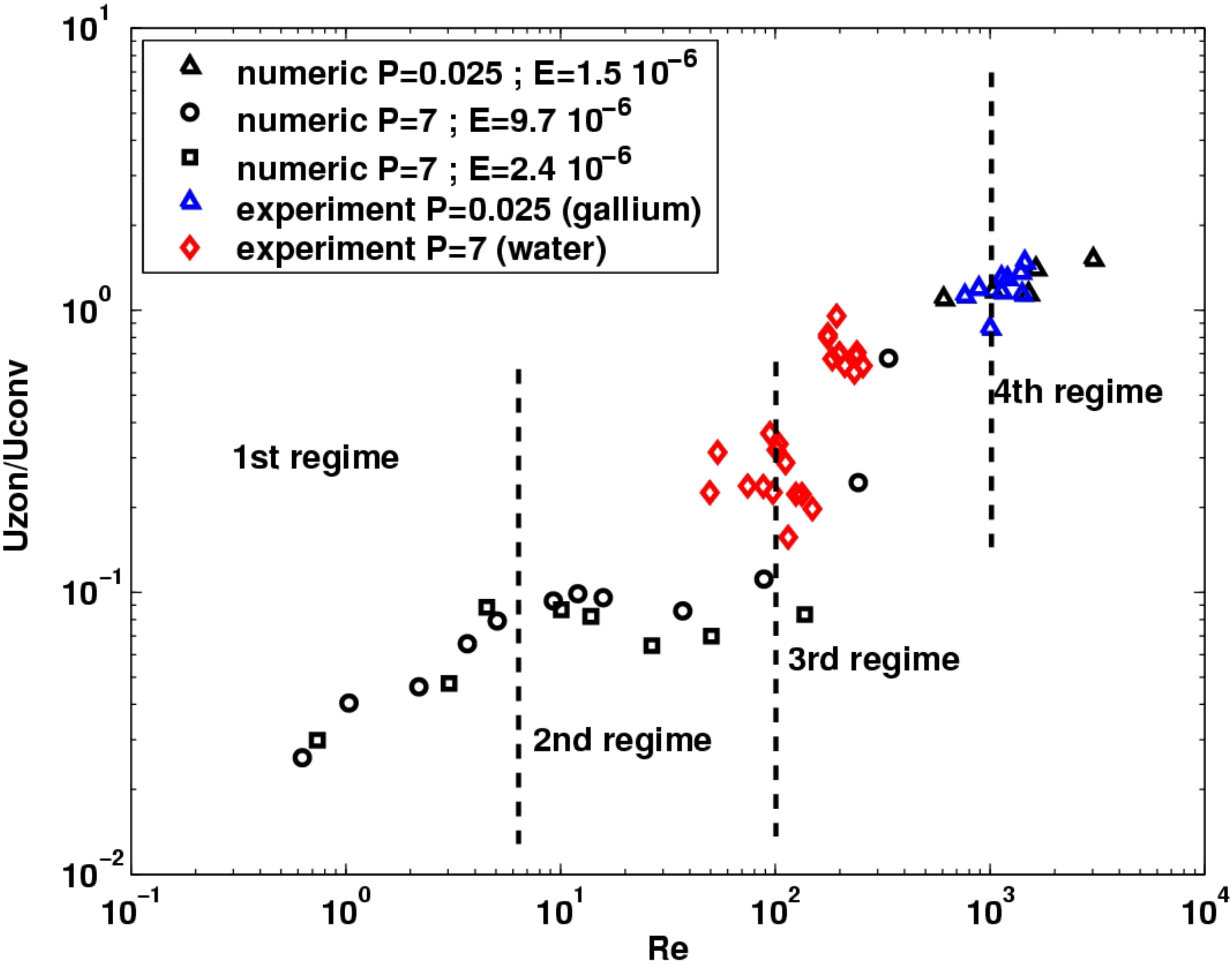


the Reynolds number **Re** (~ vigor of movement)… a way for comparing the energies of convective and mean zonal velocities.

Experiment Ra=37 Rac versus Numeric Ra=50 Rac (inertial regime)

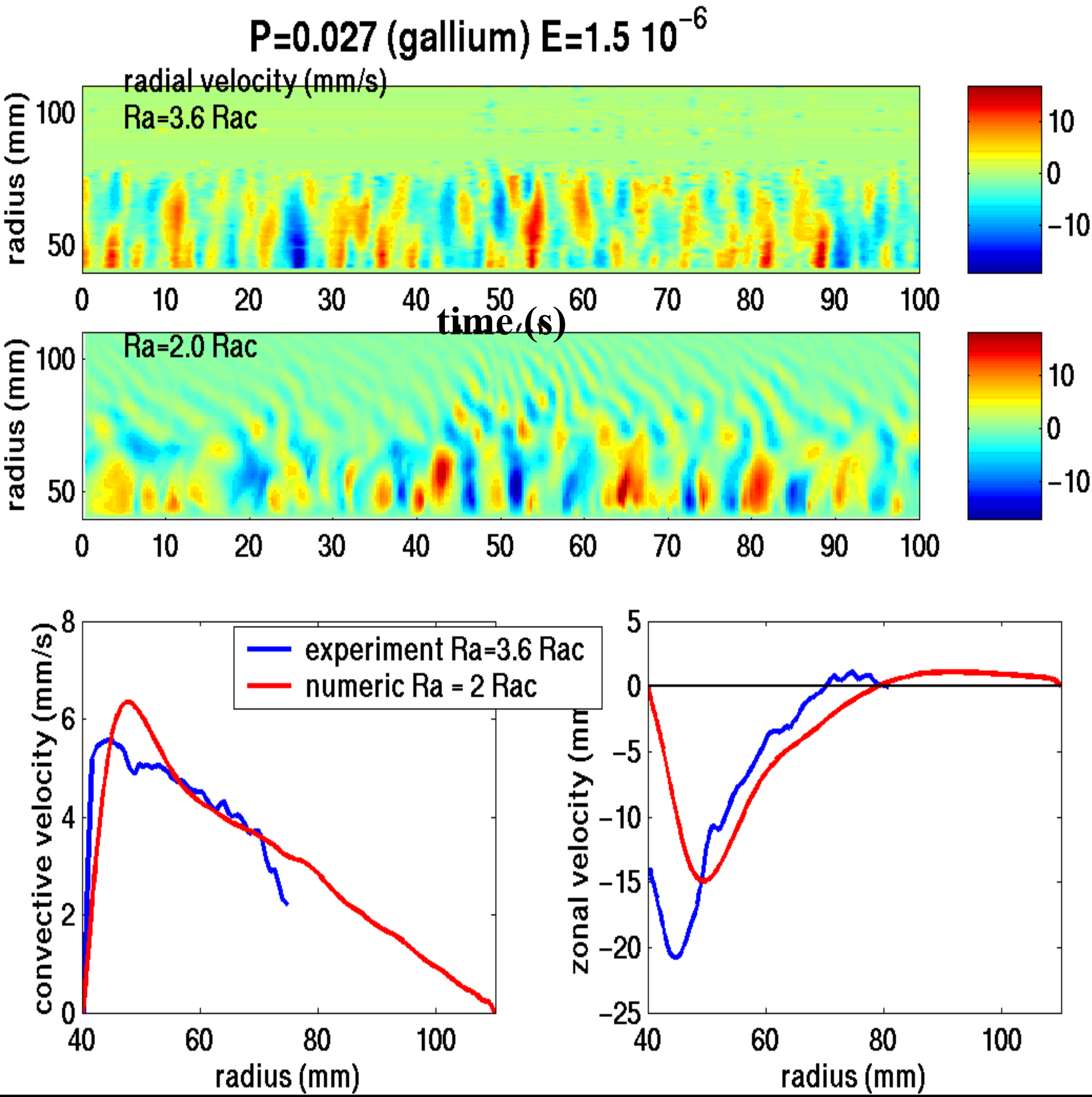


Experimental-Numerical comparison



the Reynolds number **Re** (~ vigor of movement)… a way for comparing the energies of convective and mean zonal velocities.

Experiment Ra=3.6 Rac
versus
Numeric Ra=2.0 Rac
(inertial regime)



Implications for the Earth's outer core

With:
• the estimation of 10 TW for the global heat flux at the CMB (*Labrosse & al 97*);
• the inertial scaling verified in experiments and numerical simulations (*Aubert & al 2000*),

we obtain:

$$u_{conv} \approx 10^{-3} m/s$$

$$u_{zon} \approx 10^{-2} m/s$$

$$\delta \approx 10 km$$

$$Re \approx 10^{8}$$

… surprising **small structures** (*Hulot & al 90)*
and **strong zonal wind** (*Jault & al 8*8).

aim of further experiments: influence of a magnetic field on the zonal wind, the radial size...