Spurious Mixing in MOM6

An energetic approach

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Overview

Motivation

- Understand the numerical accuracy of different:
  - remapping schemes
  - advection schemes
  - vertical coordinates
- Evaluate MOM6?

Reference (background) potential energy

- The lowest potential energy state of a fluid
  - Adiabatically resort to a stratified state
- Should be constant in an unforced model with closed boundaries
  - Increased by mixing; centre of mass is raised

$$\mathrm{RPE} = g \int_\Omega z \rho^*(z) \, \mathrm{d}V$$

- *Gives no localised information*

Looking at a timestep

- MOM6 is a generalised vertical coordinate model (ALE)
  - Clear distinction between along- and across-coordinate dynamics
- Take differences in RPE from different parts of a timestep to determine their contribution
  - $\Delta\mathrm{RPE}_{\text{adv}} = \mathrm{RPE}_{\text{post adv}} - \mathrm{RPE}_{\text{pre adv}}$
  - $\Delta\mathrm{RPE}_{\text{ale}} = \mathrm{RPE}_{\text{post ale}} - \mathrm{RPE}_{\text{pre ale}}$

Experiments

Overview

- We follow experiments from Ilicak et al. (2012) and Petersen et al. (2015):
  - Lock exchange (dam break)
  - Overflow (downslope flow)
  - Internal gravity waves
  - Baroclinic eddies
- Spurious mixing is investigated as a function of the grid Reynolds number:

$$\mathrm{Re}_\Delta = \frac{U \Delta x}{\nu_h}$$

Overflow

Low viscosity

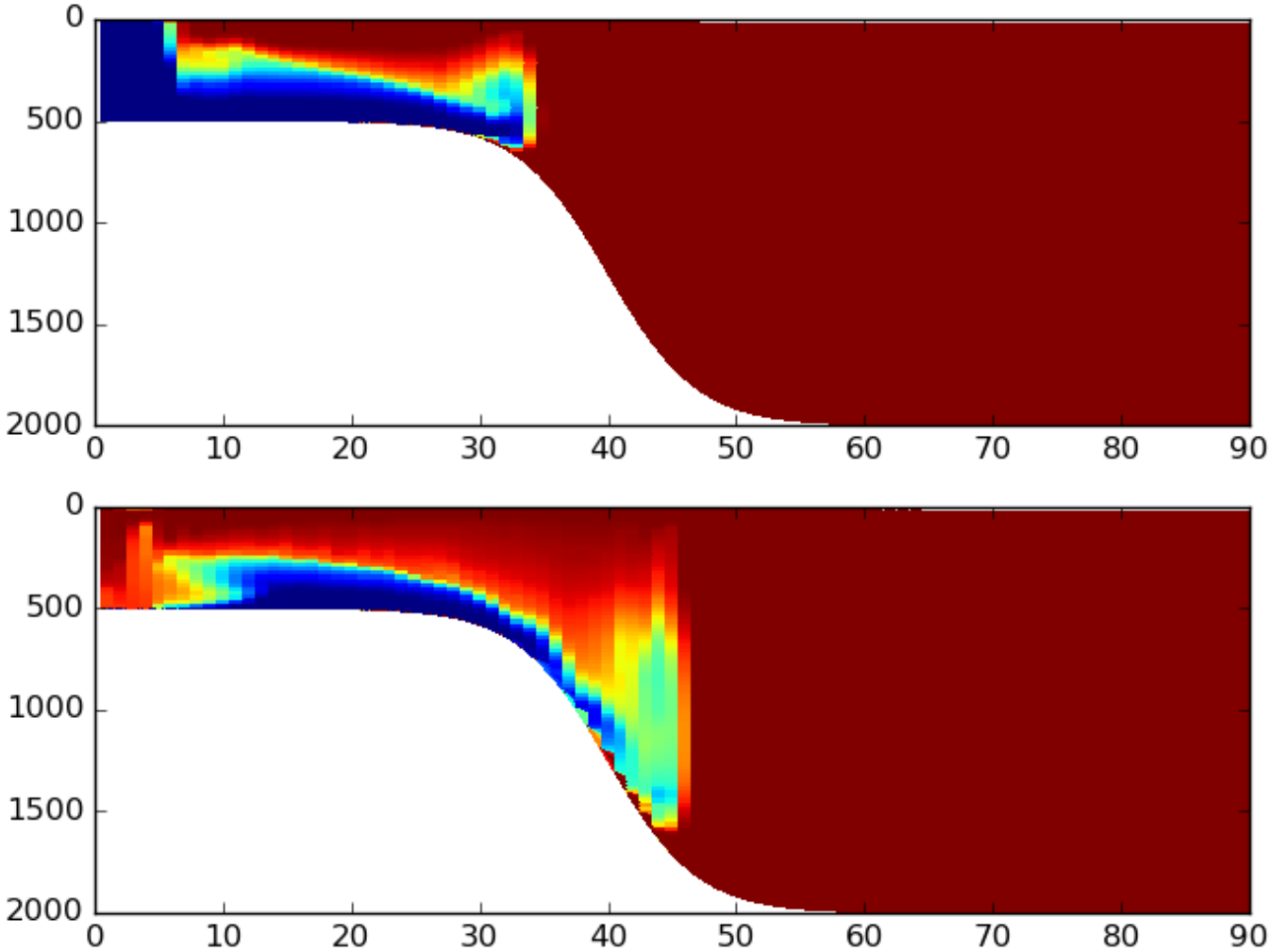

Figure 1: z^* coordinate at $Re_\Delta = 1.5 \times 10^5$

High viscosity

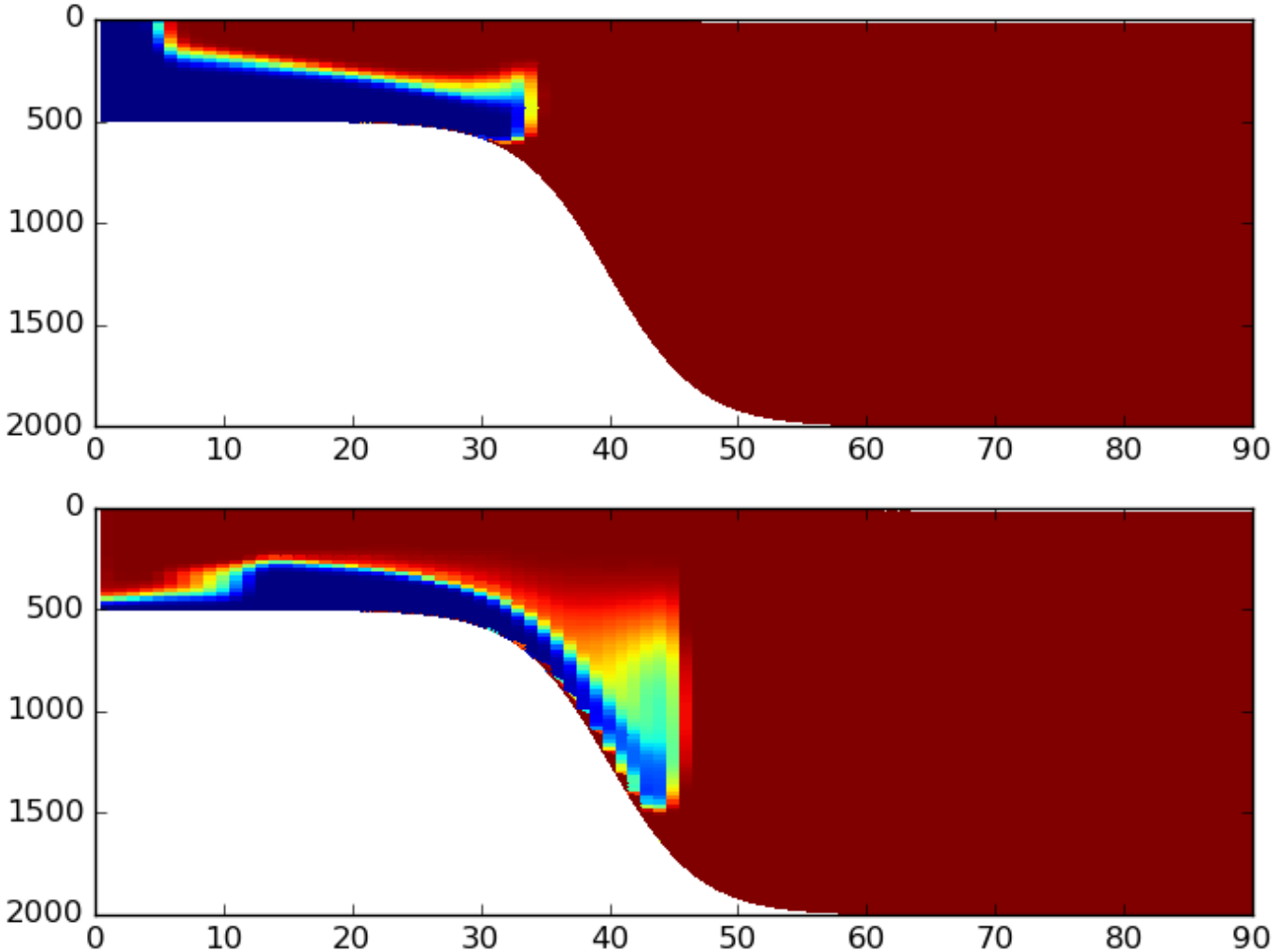

Figure 2: z^* coordinate at $Re_\Delta = 1.5$

Low viscosity (sigma)

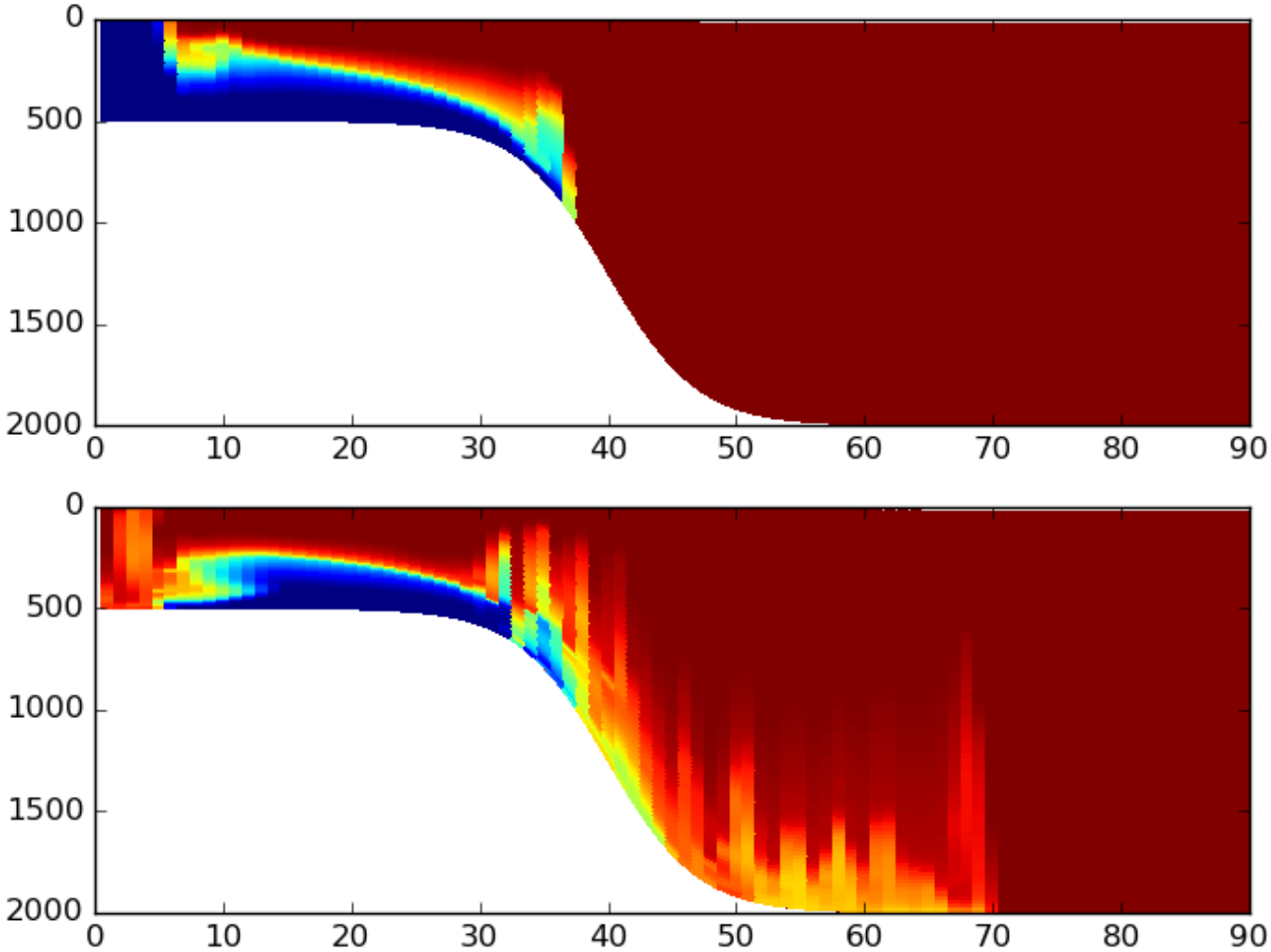

Figure 3: Sigma coordinate at $Re_\Delta = 1.5 \times 10^5$

High viscosity (sigma)

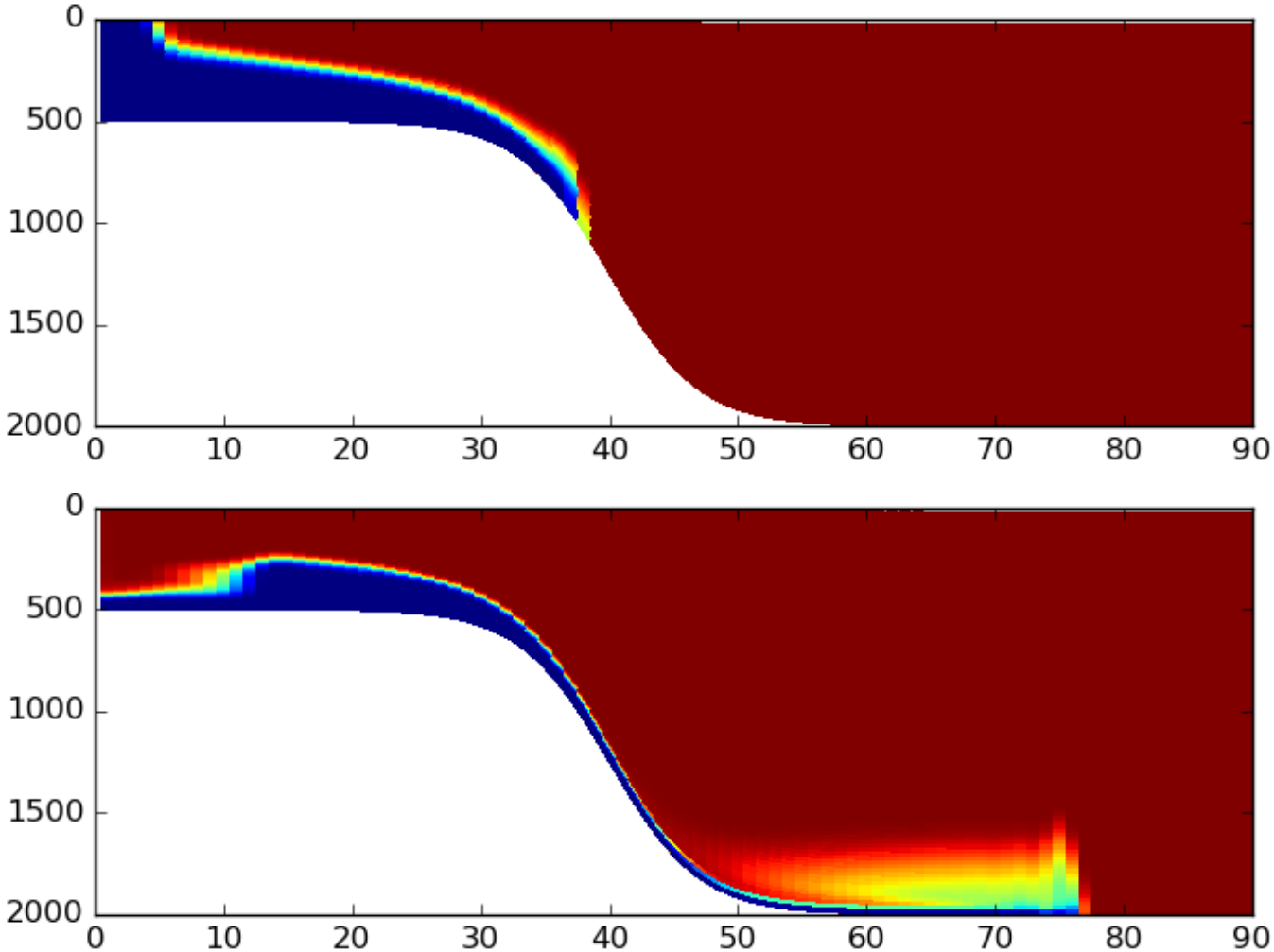

Figure 4: Sigma coordinate at $Re_\Delta = 1.5$

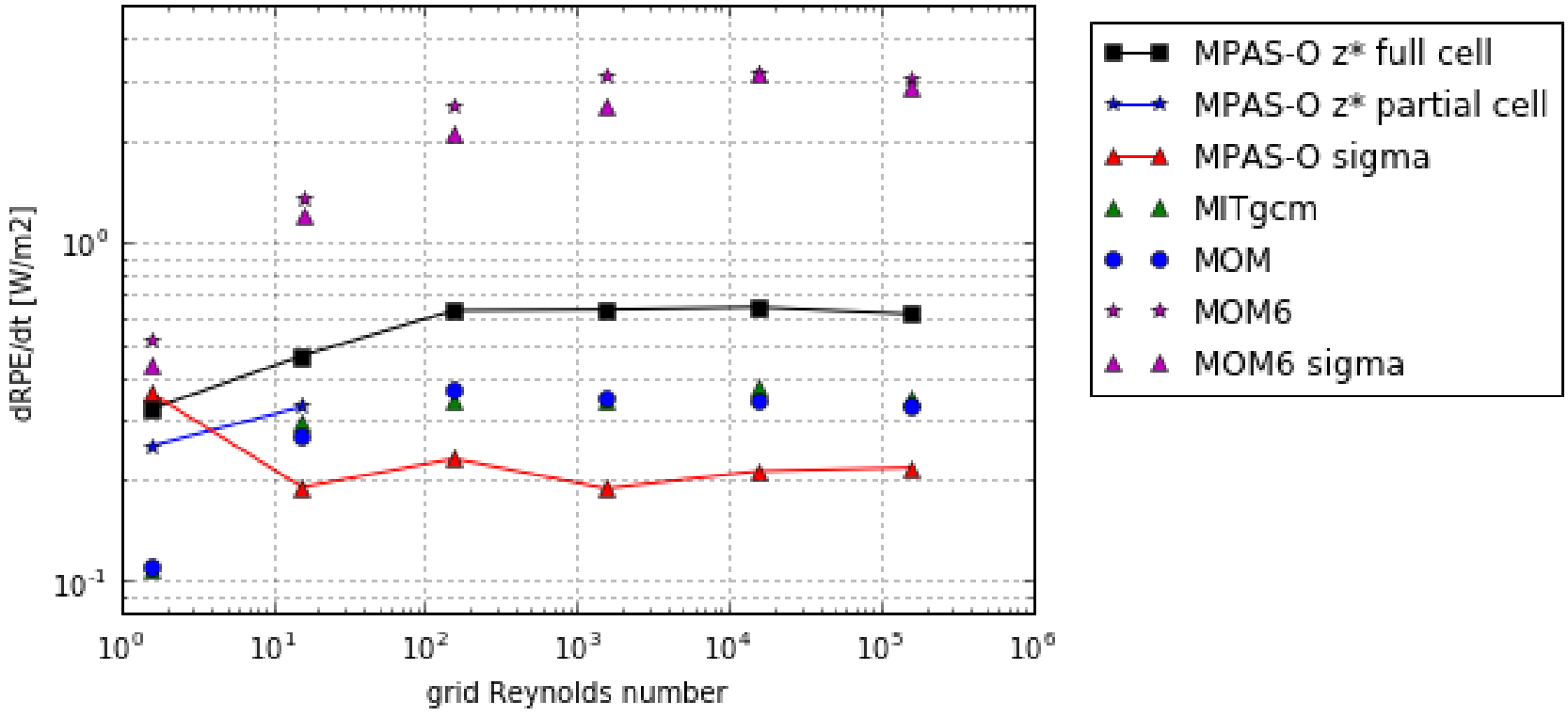

Figure 5: Model comparison (mean dRPE/dt over entire run)

Baroclinic eddies

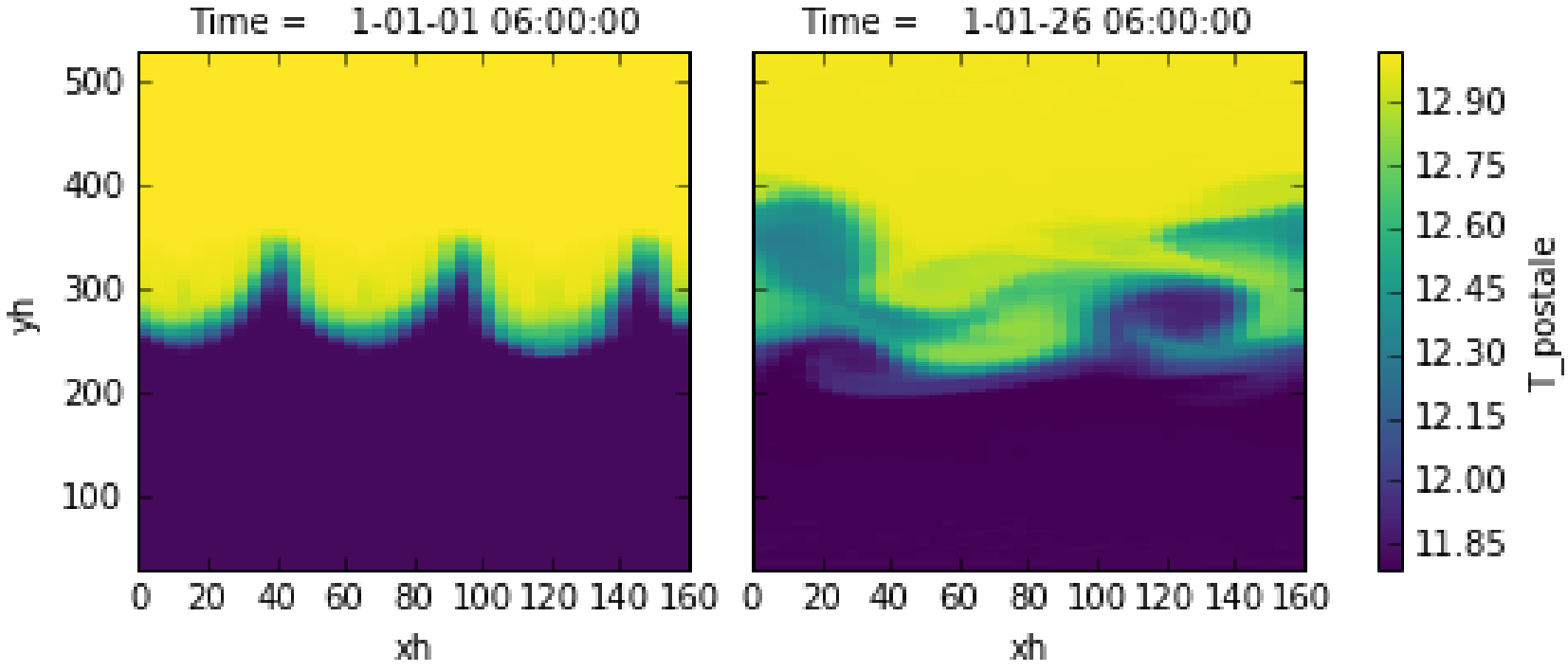

Figure 6: Surface snapshot

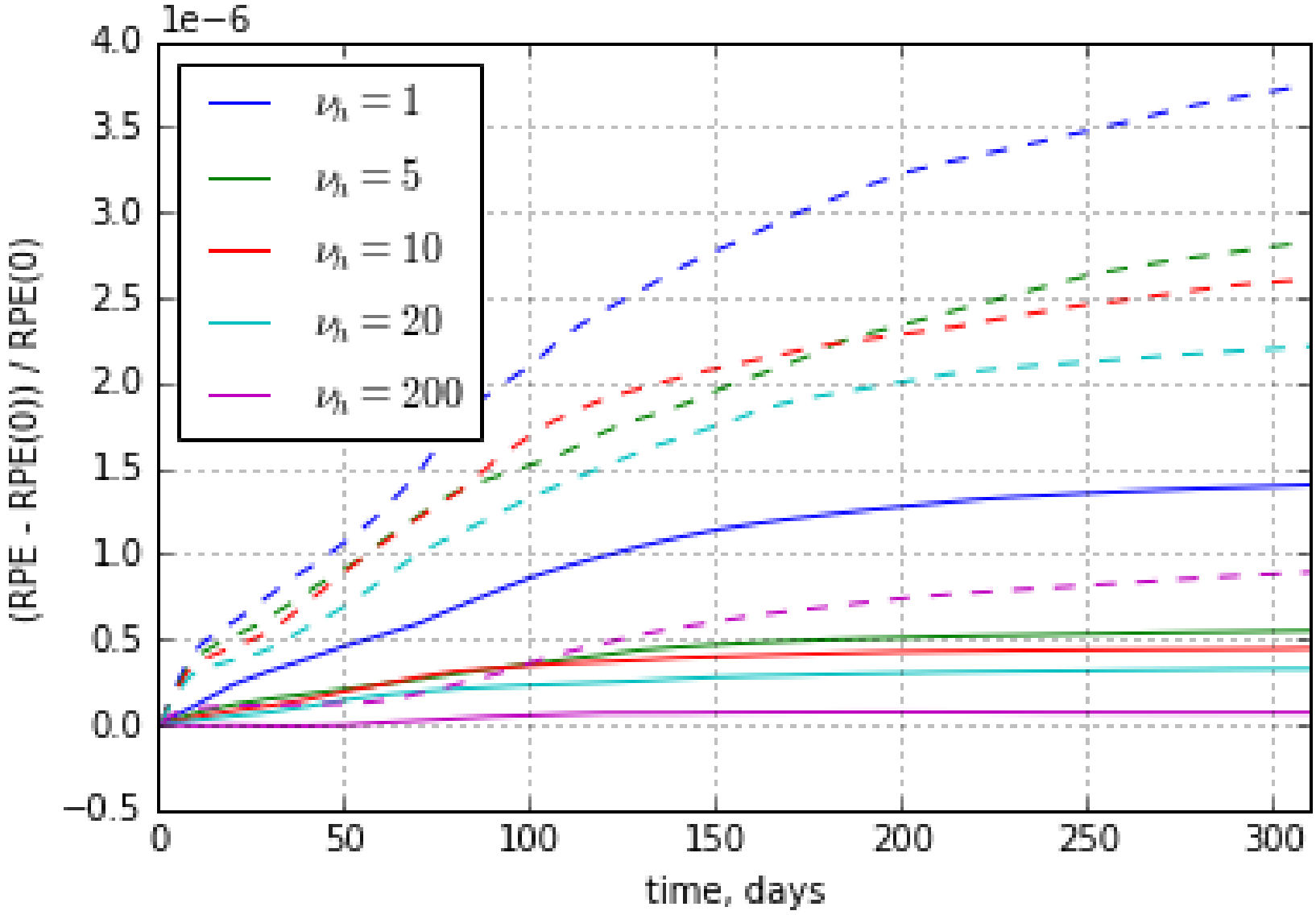

Figure 7: Solid: MPAS-O, dashed: MOM6

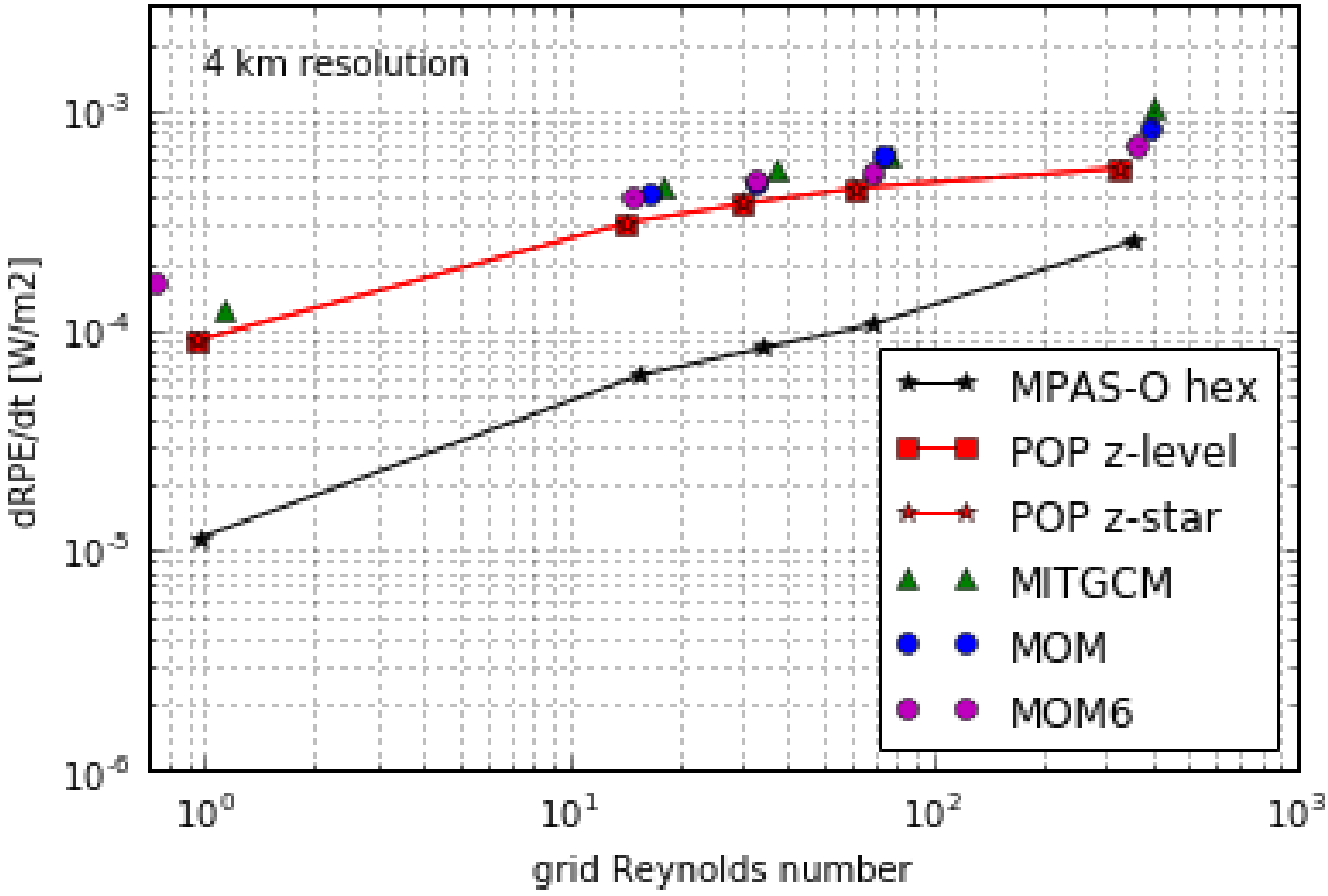

Figure 8: Model comparison

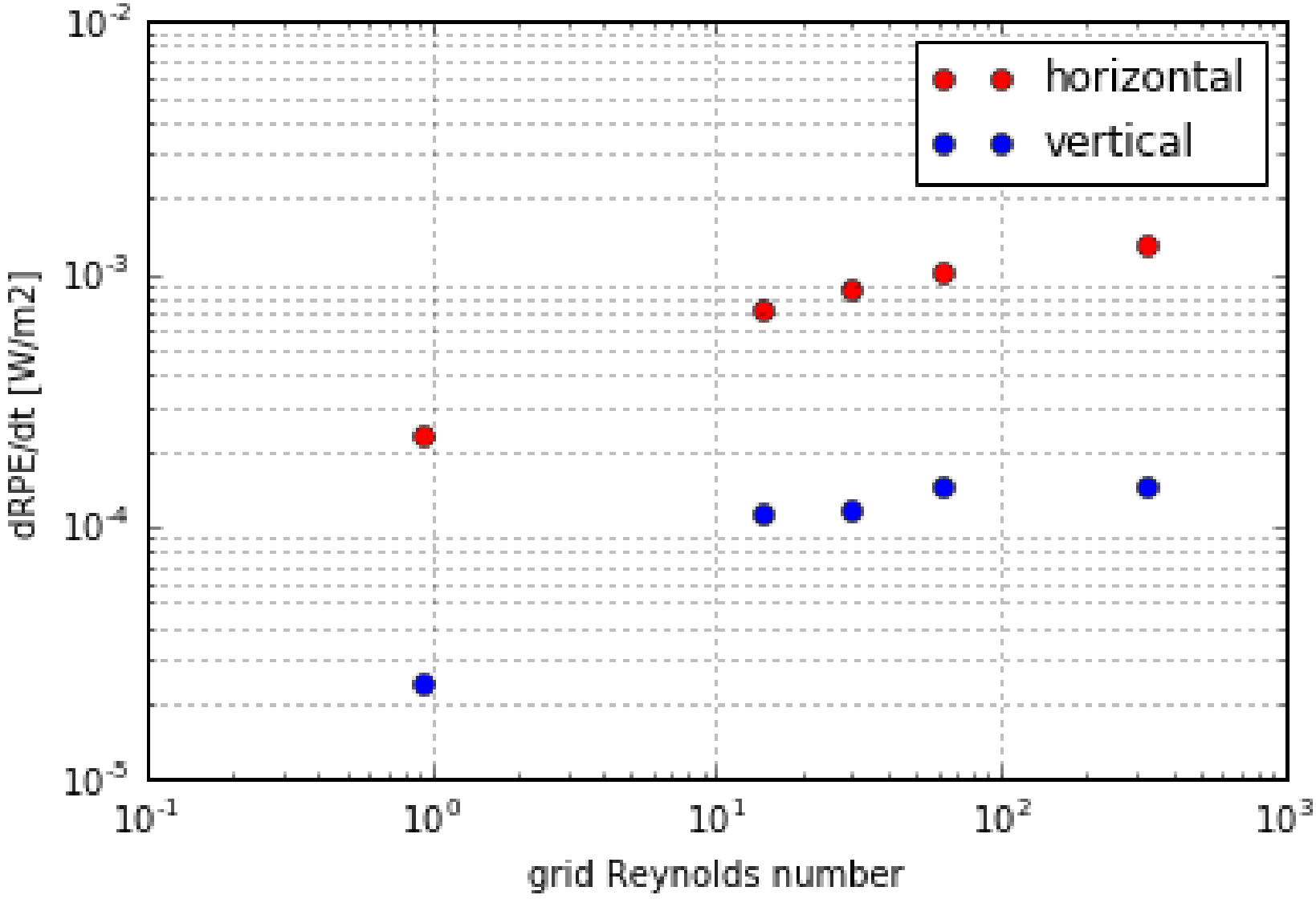

Figure 9: Direction split

Internal waves

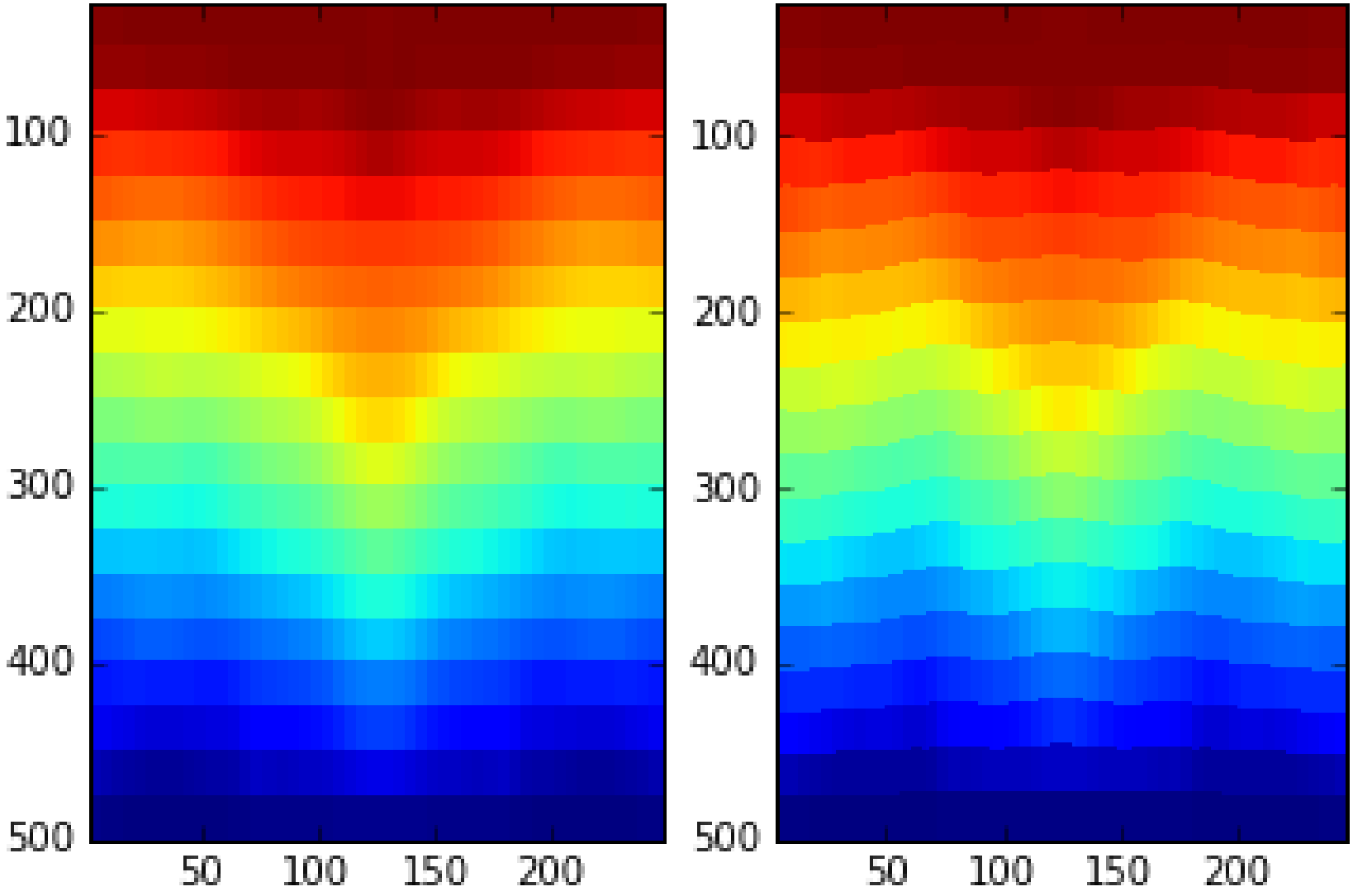

Figure 10: Snapshot

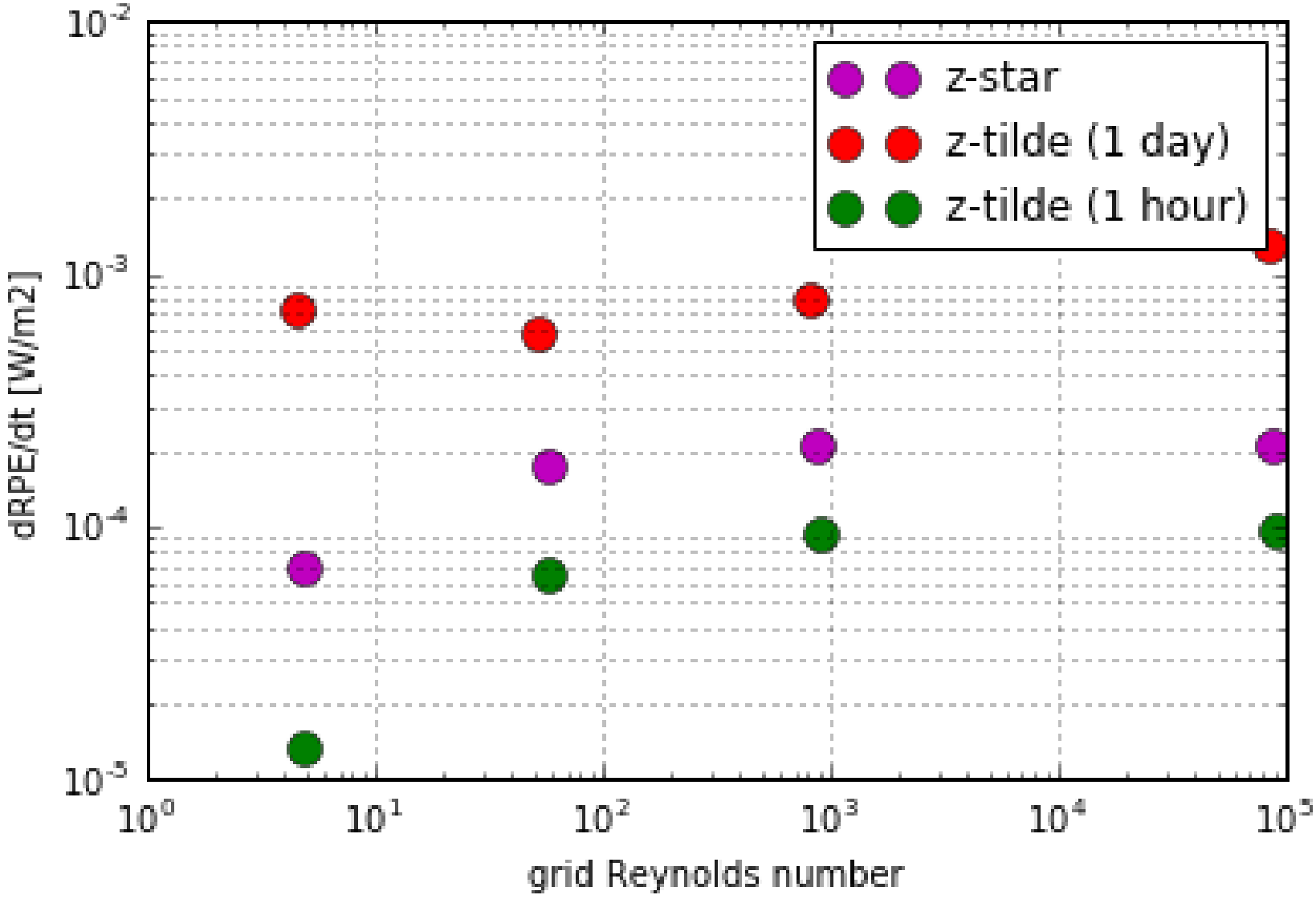

Figure 11: Effect of coordinates

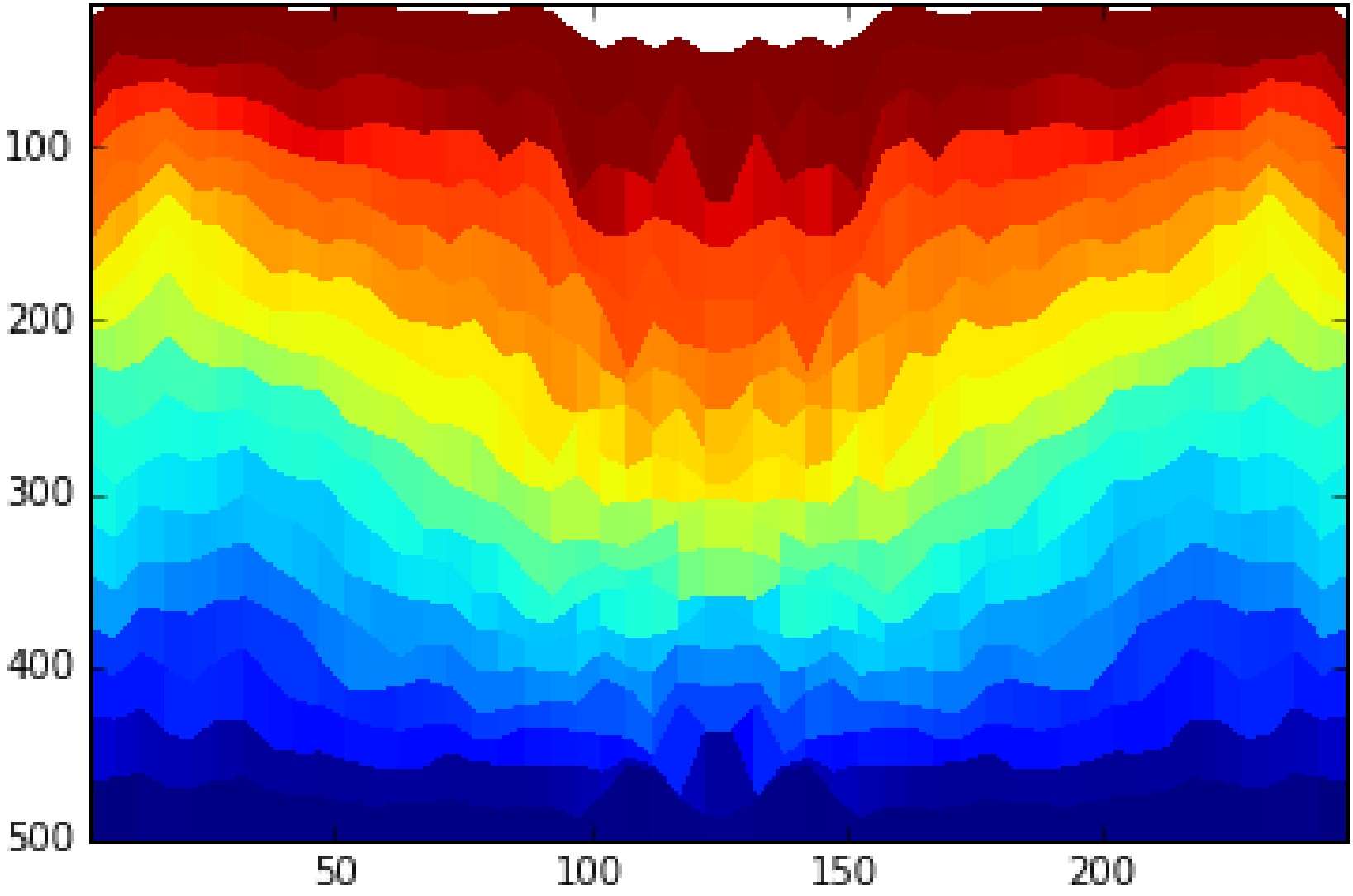

Figure 12: An explanation

Discussion

- High-order advection schemes?
- The effect of CFL number (edge differencing)
- Coordinate choices

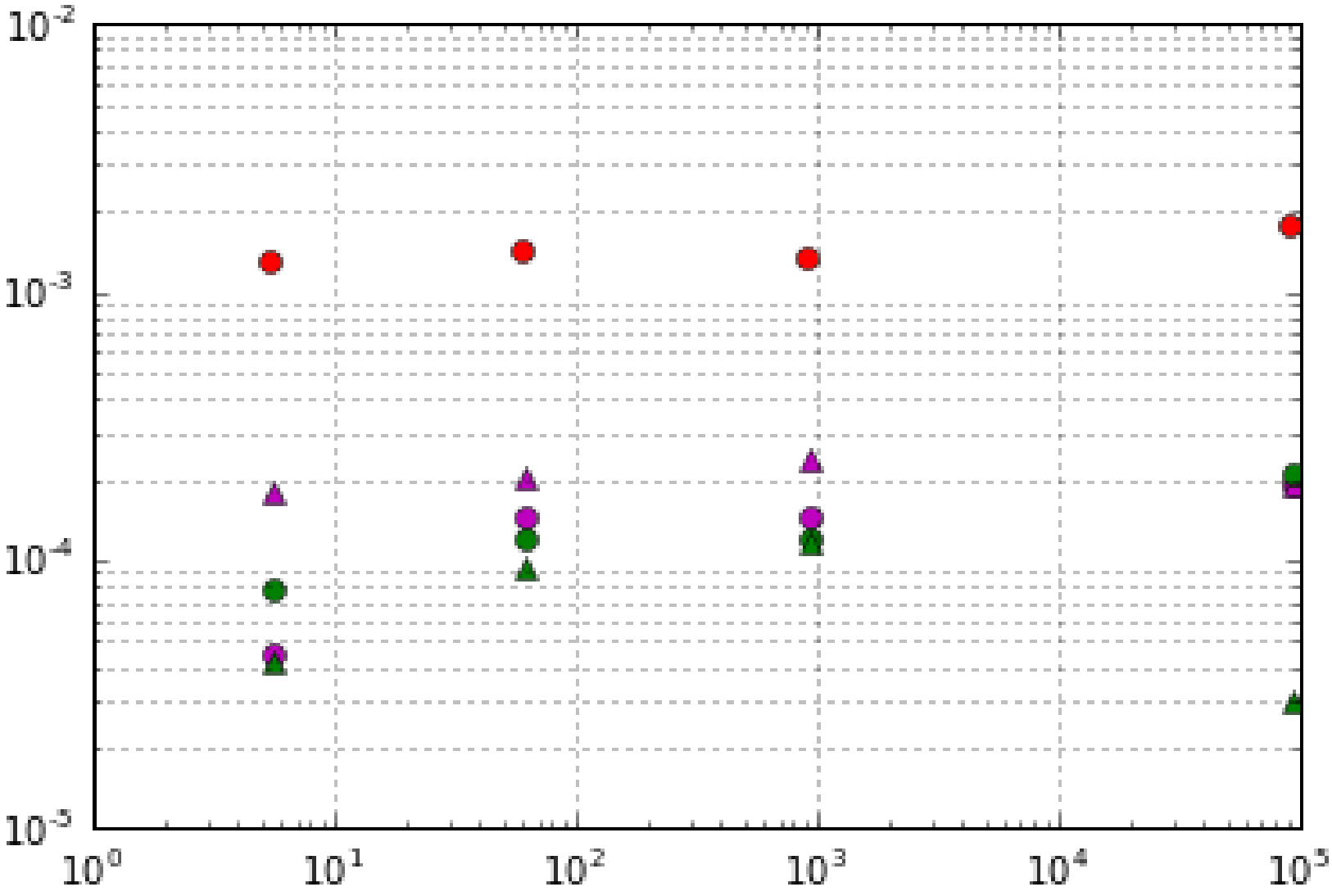

Figure 13: