

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

$$\text{RPE} = g \int_{\Omega} z \rho^*(z) dV$$

- ▶ *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
 - ▶ $\Delta RPE_{adv} = RPE_{post\ adv} - RPE_{pre\ adv}$
 - ▶ $\Delta RPE_{ale} = RPE_{post\ ale} - RPE_{pre\ ale}$

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:

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

Overflow

Low viscosity

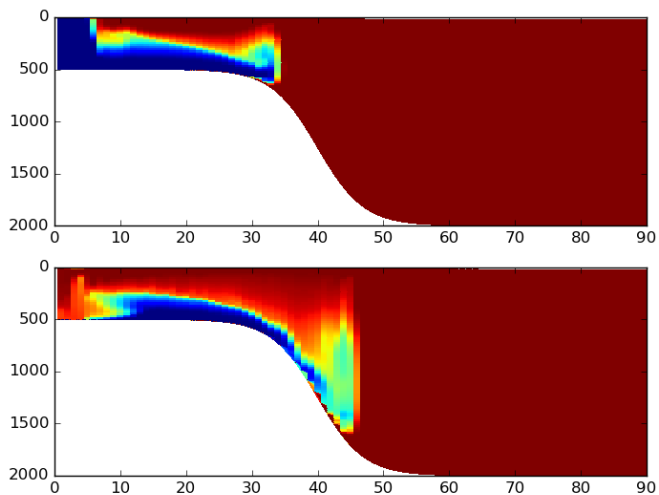


Figure 1: z^* coordinate at $Re_{\Delta} = 1.5 \times 10^5$

High viscosity

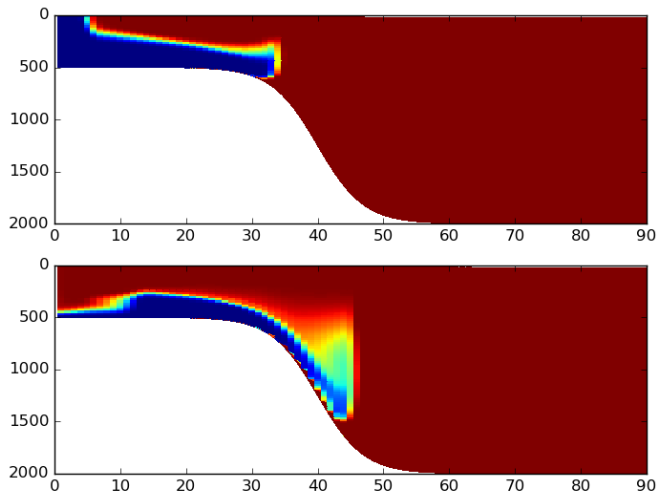


Figure 2: z^* coordinate at $Re_\Delta = 1.5$

Low viscosity (σ)

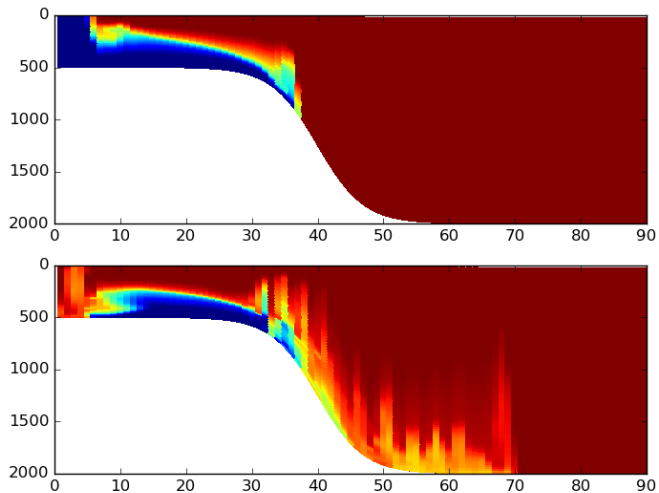


Figure 3: Sigma coordinate at $Re_{\Delta} = 1.5 \times 10^5$

High viscosity (σ)

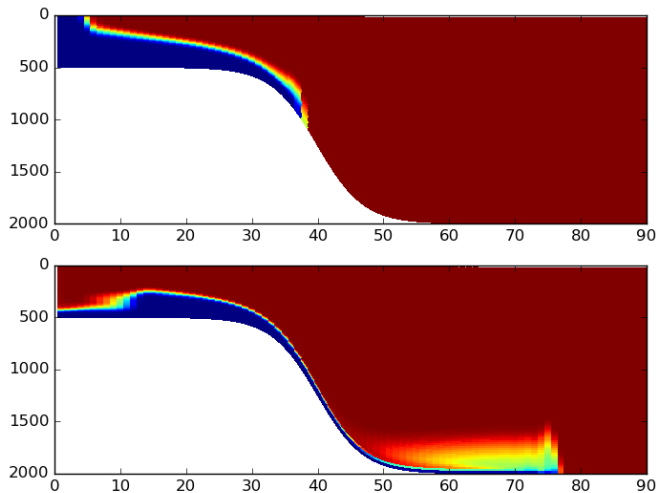


Figure 4: Sigma coordinate at $Re_{\Delta} = 1.5$

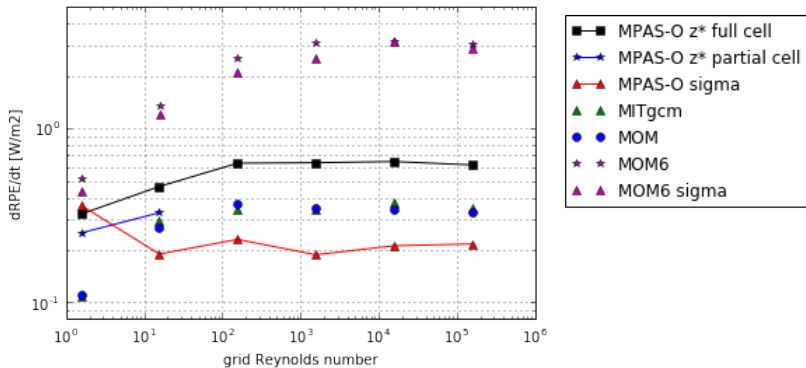


Figure 5: Model comparison (mean dRPE/dt over entire run)

Baroclinic eddies

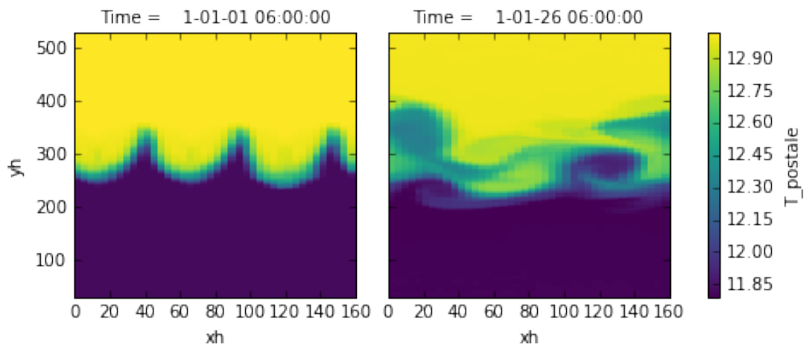


Figure 6: Surface snapshot

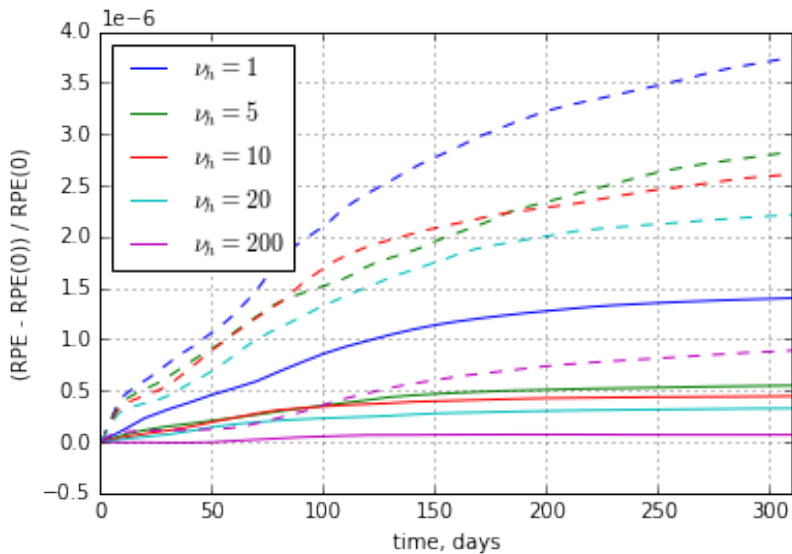


Figure 7: Solid: MPAS-O, dashed: MOM6

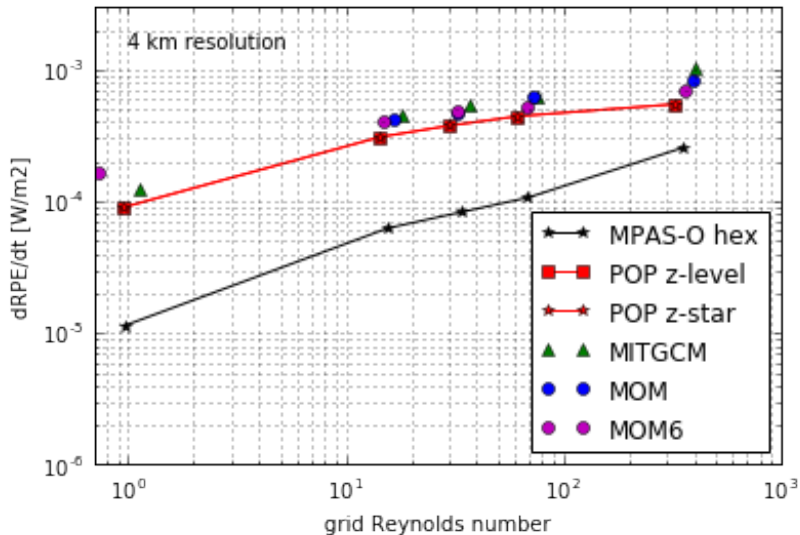


Figure 8: Model comparison

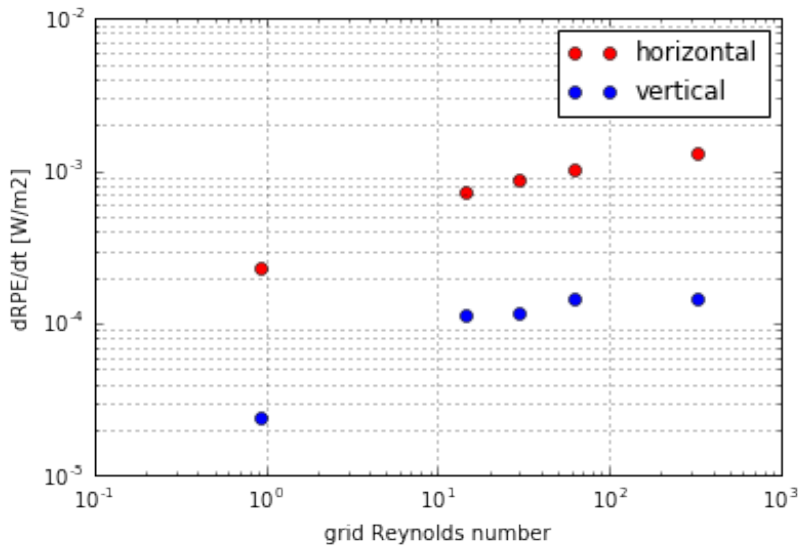


Figure 9: Direction split

Internal waves

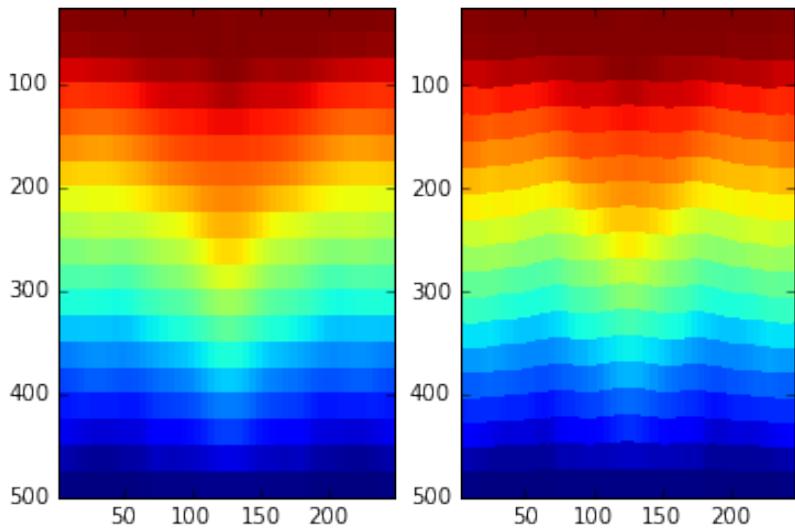


Figure 10: Snapshot

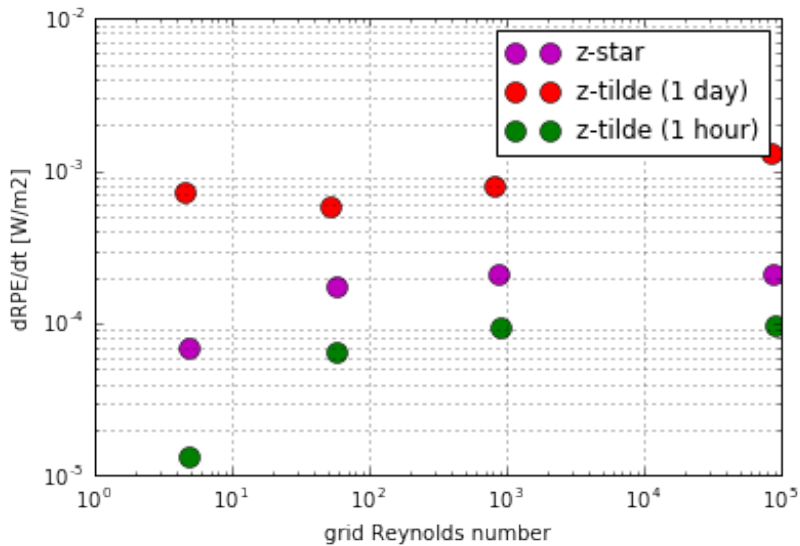


Figure 11: Effect of coordinates

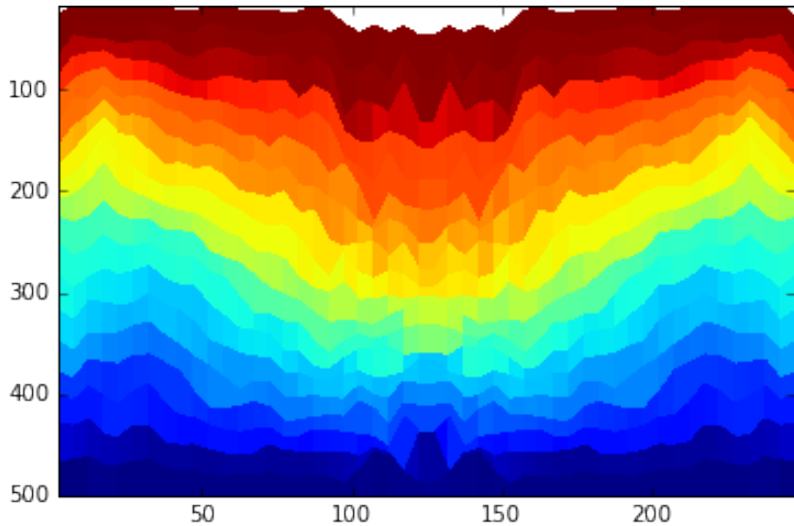


Figure 12: An explanation

Discussion

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

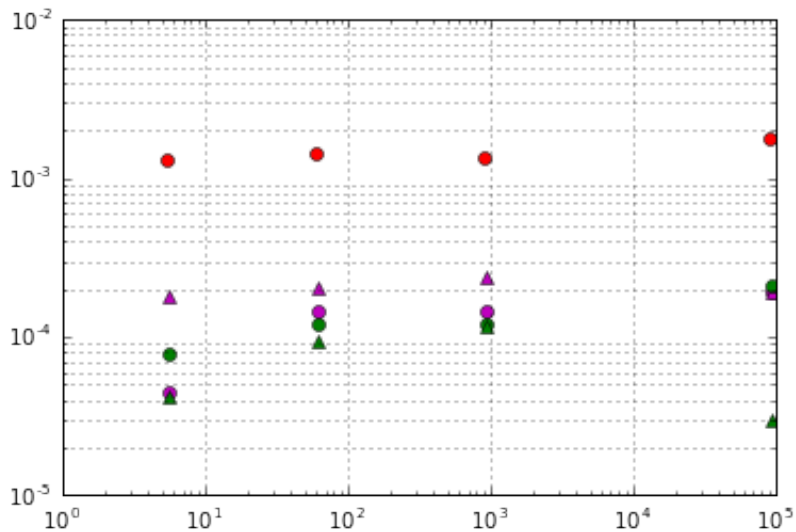


Figure 13: