Validating NEMO

Comparing Model Configurations and Observations

Thomas GANTZ

Supervised by Sébastien Masson

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Goals

Personal Goals

- **MSc HPC:** Parallel PDEs
- **Climate modelling?**
- **Learning:**
  - Variables: `SST`, `SSS`, `MLD`, ...
  - Python: `xarray`, `matplotlib`, ...
  - Dynamics: GFD, El Niño, ...

NEMO Goals

- **Upgrade:** New NEMO version
- **Accuracy:** Error with respect to observations
- **Sensitivity:** Highest-impact parameters:
  - Numerical schemes
  - Coefficient calculation
  - Features

Methods

1 Introduction

Simulations

- **ORCA05:** 0.5° resolution
- **2010-2022 (13 years):** monthly means
- **Forcing:** observed atmosphere
- **15 configurations:**
  - 00: benchmark
  - 01, 02, 05: advection schemes
  - 14: surface current feedback
  - 04, 06, 07: diffusion coefficient
  - 08, 09, 10, 12: lateral diffusion

Equations

$$\frac{\partial U_h}{\partial t} = \underbrace{-\left[(\nabla \times U) \times U + \tfrac{1}{2}\nabla(U^2)\right]_h}_{\text{advection}} \underbrace{-f\,\mathbf{k} \times U_h}_{\text{Coriolis}} \underbrace{-\frac{1}{\rho_0}\nabla_h p}_{\text{pressure}} \underbrace{+D^U}_{\text{diffusion}} \underbrace{+F^U}_{\text{forcing}}$$

$$\frac{\partial T}{\partial t} = \underbrace{-\nabla \cdot (TU)}_{\text{advection}} \underbrace{+D^T}_{\text{diffusion}} \underbrace{+F^T}_{\text{forcing}}$$

advection | Coriolis | pressure | diffusion | forcing

- **Momentum**
- **Tracers:** T, S are *active*
- **Formulation:** vector-invariant or flux form

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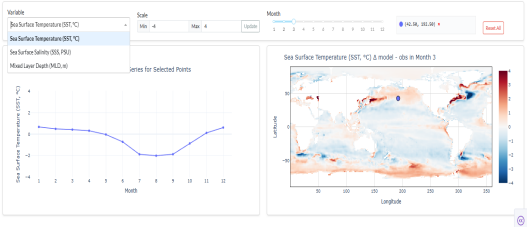
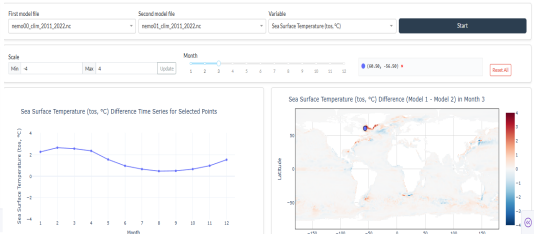
Interactive Plotting

2 Tools

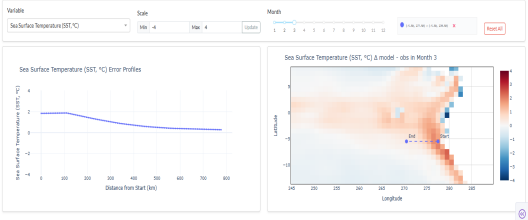
Model-Observation Error Explorer



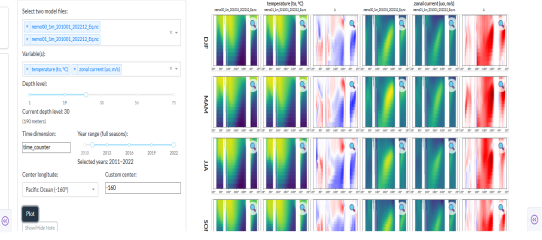
Model-Model Difference Viewer (Horizontal)



Model-Observation Error Profile Explorer



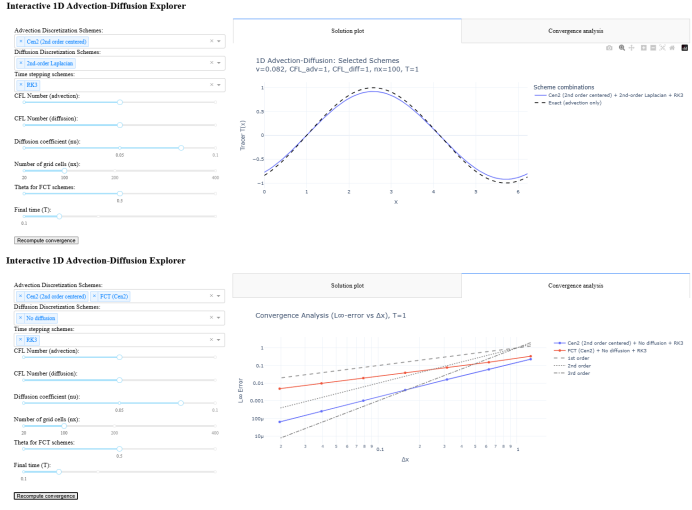
Model-Model Difference Viewer (Vertical)



Scheme Explorer

2 Tools

$$\frac{\partial c}{\partial t} = \underbrace{-\nabla \cdot (\mathbf{v}c)}_{\text{advection}} + \underbrace{\nabla \cdot (D \nabla c)}_{\text{diffusion}}$$



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3 Quantitative Results

Zonal SST

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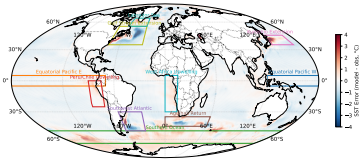
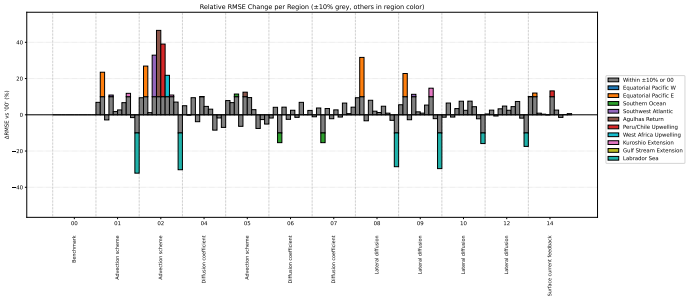
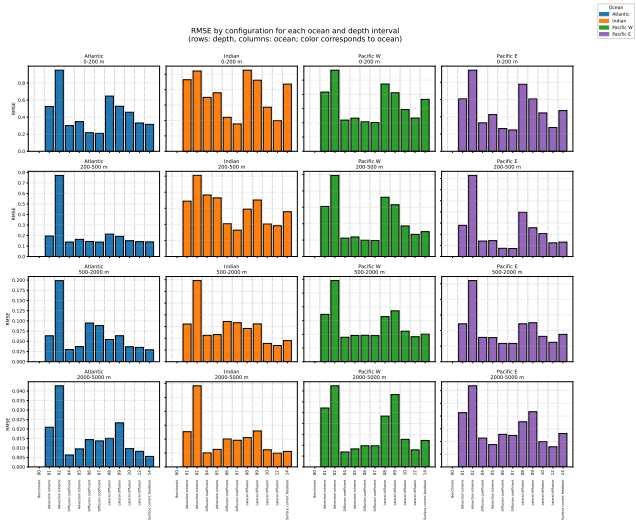




- Benchmark is the best configuration (no clearly superior alternative)
- Zones of interest: Equatorial Eastern Pacific, Labrador Sea, and Southern Ocean
- Highlights the importance of a physically coherent tracer advection scheme

Equatorial Vertical Slice of Temperature

3 Quantitative Results



- Zones of interest: Upper ocean
- Advection schemes and lateral diffusion are key contributors
- Lateral diffusion induces significant errors in the Equatorial Eastern Pacific

Thank you for listening!

Questions?

 github.com/gantz-thomas-gantz