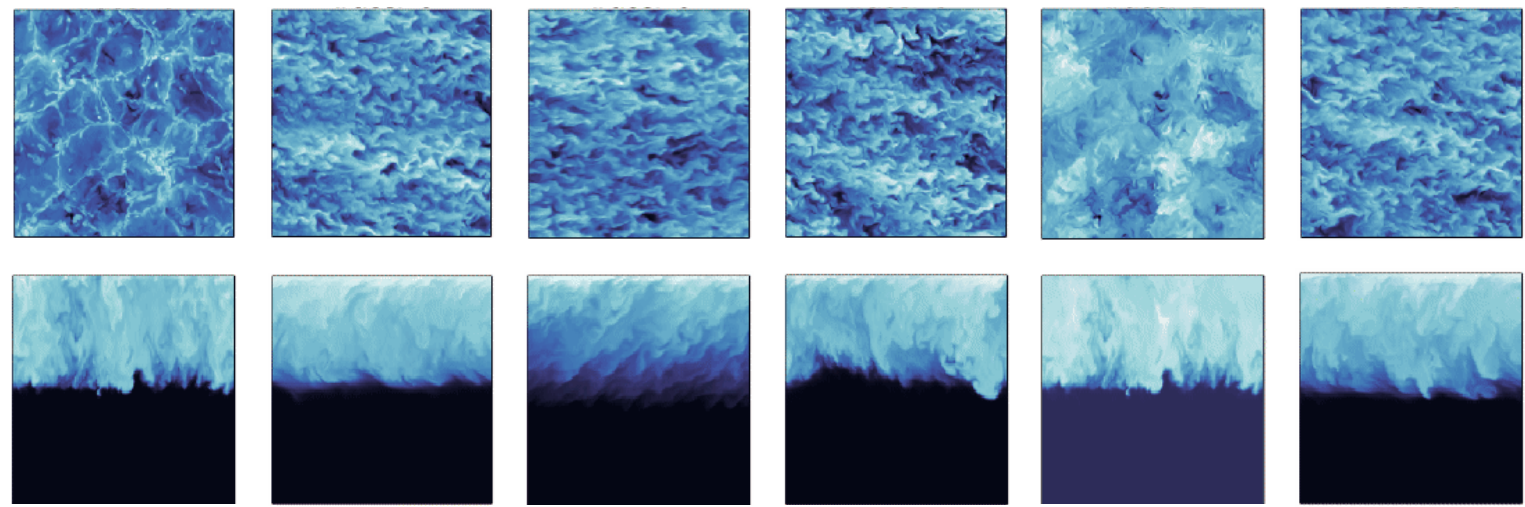


LESbrary: A library of Large Eddy Simulation data for training ocean mixing parameterizations



Gregory L Wagner, Ali Ramadhan, Adeline Hillier, Andre Souza, Raffaele Ferrari, and the Climate Modeling Alliance



Problem formulation



- I. Large eddy simulations in horizontally-periodic domains provide “synthetic data”.

$$\partial_t T_{\text{LES}} + \mathbf{u} \cdot \nabla T_{\text{LES}} = \nabla \cdot \kappa_{\text{LES}} \nabla T_{\text{LES}}$$

github.com/climate-machine/Oceananigans.jl

- II. We quantify the discrepancy (error) between horizontally-averaged LES data and parameterized 1D solutions.

$$\mathcal{L} \stackrel{\text{def}}{=} \left\| T_{\text{model}} - \frac{1}{A} \int T_{\text{LES}} dA \right\|^2$$

- III. Error minimization optimizes free parameters or trains neural networks embedded in 1D models.

$$\partial_t T_{\text{model}} = \partial_z (\mathbb{C}_K \ell \sqrt{e} \partial_z T_{\text{model}})$$



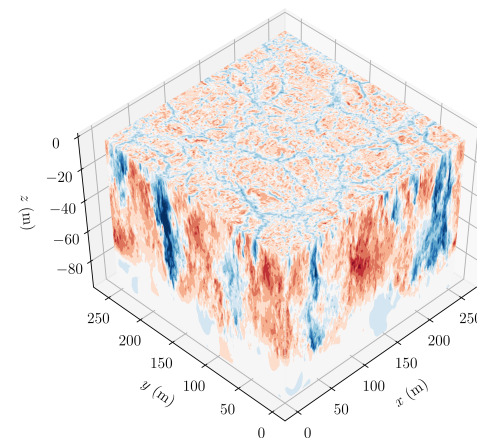
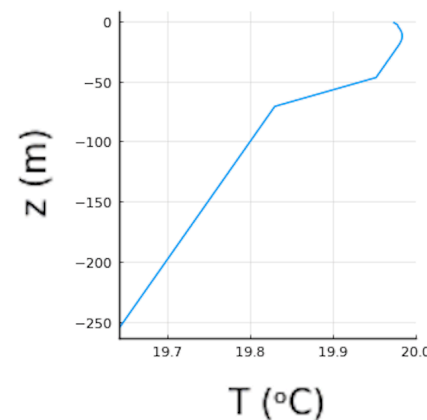
uncertain free parameter



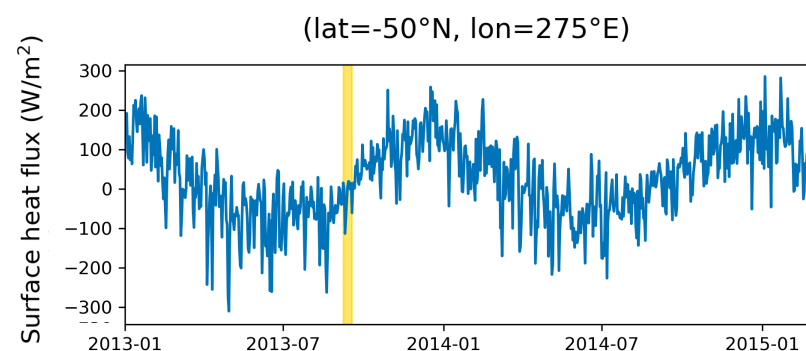
Data generation



- I. We define “**idealized**” and “**realistic**” numerical experiments.
- II. **Idealized** experiments impose constant surface fluxes over uniform or non-uniform initial density stratification.



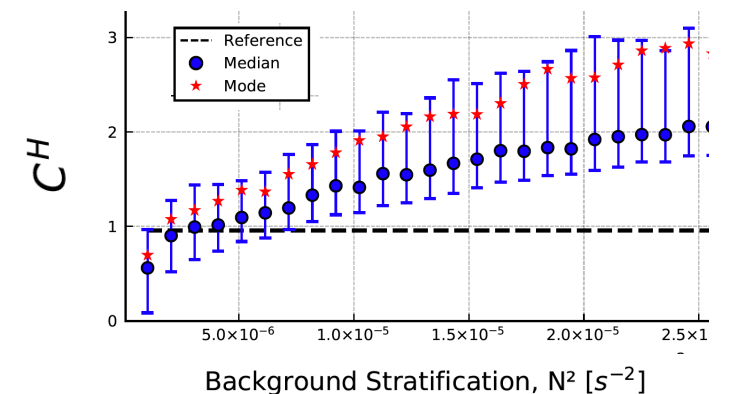
- III. **Realistic** cases are boundary-forced by reanalysis and gently relaxed to the ECCO ocean state estimate.



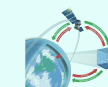
Applications



- I. Calibration and uncertainty quantification of free parameters ([Souza et al, JAMES, 2020](#)).



- II. Training neural networks embedded in 1D PDEs ([Ramadhan et al, in prep](#)).



ClimateMachine



- I. The ClimateMachine is an Earth system model that synthesizes diverse data:

1. Constrain free parameters to physics
Match parameterizations to high-res simulations
2. Constrain to global observations in present climate
Refine parameterizations in global context