# A parameterization of local and remote tidal mixing

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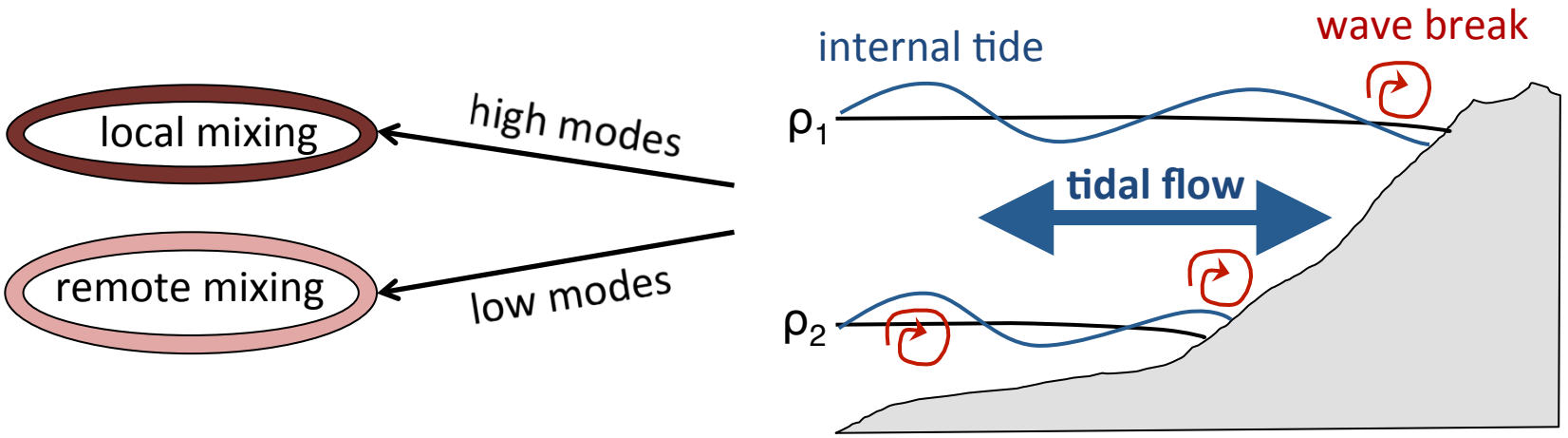
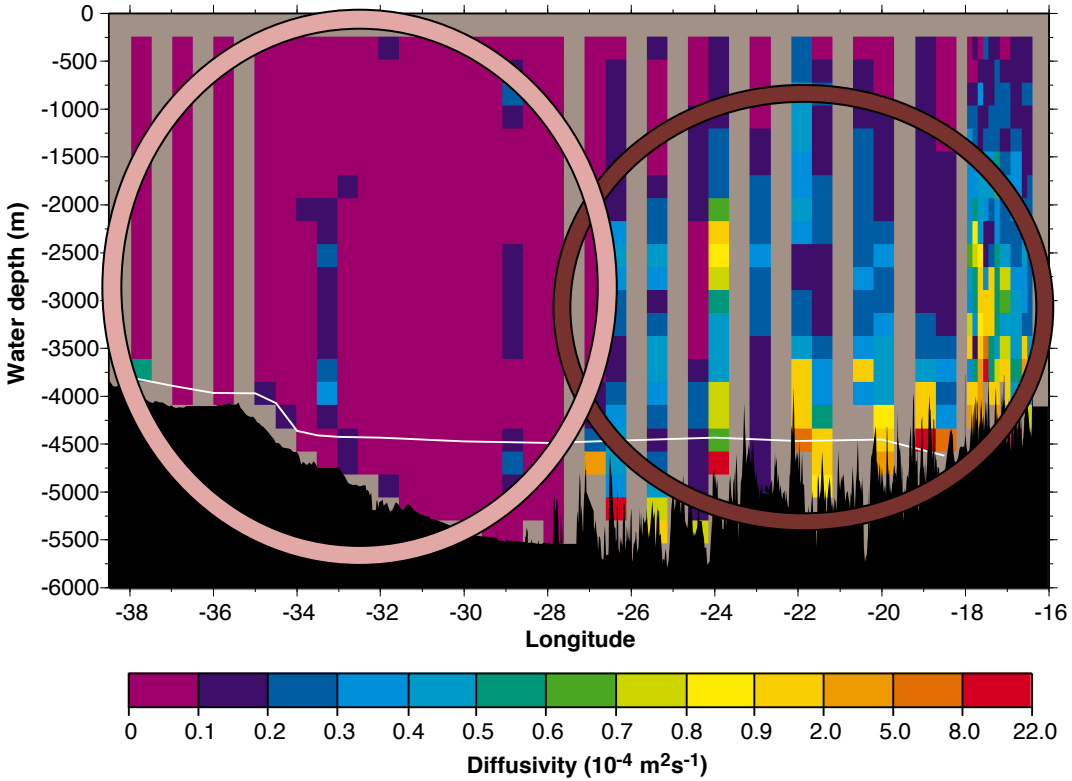
EGU 2020 – Sharing Geoscience Online

# 1. Introduction

# What is tidal mixing?




Depth-longitude transect of turbulent diffusivity across the Brazil Basin.

From Polzin et al. (1997).

# Typical practice in OGCMs

- Remote: tuneable background $K_z$ ($\approx 10^{-5}$ $m^2 s^{-1}$).
  - Independent of ocean state.
  - No control on (evolving) energy required to maintain such background mixing.

- Local: bottom-intensified mixing energy.
  - 2D map of locally-dissipating internal tide energy (qE).
  - Fixed (exponential) vertical energy structure (F).

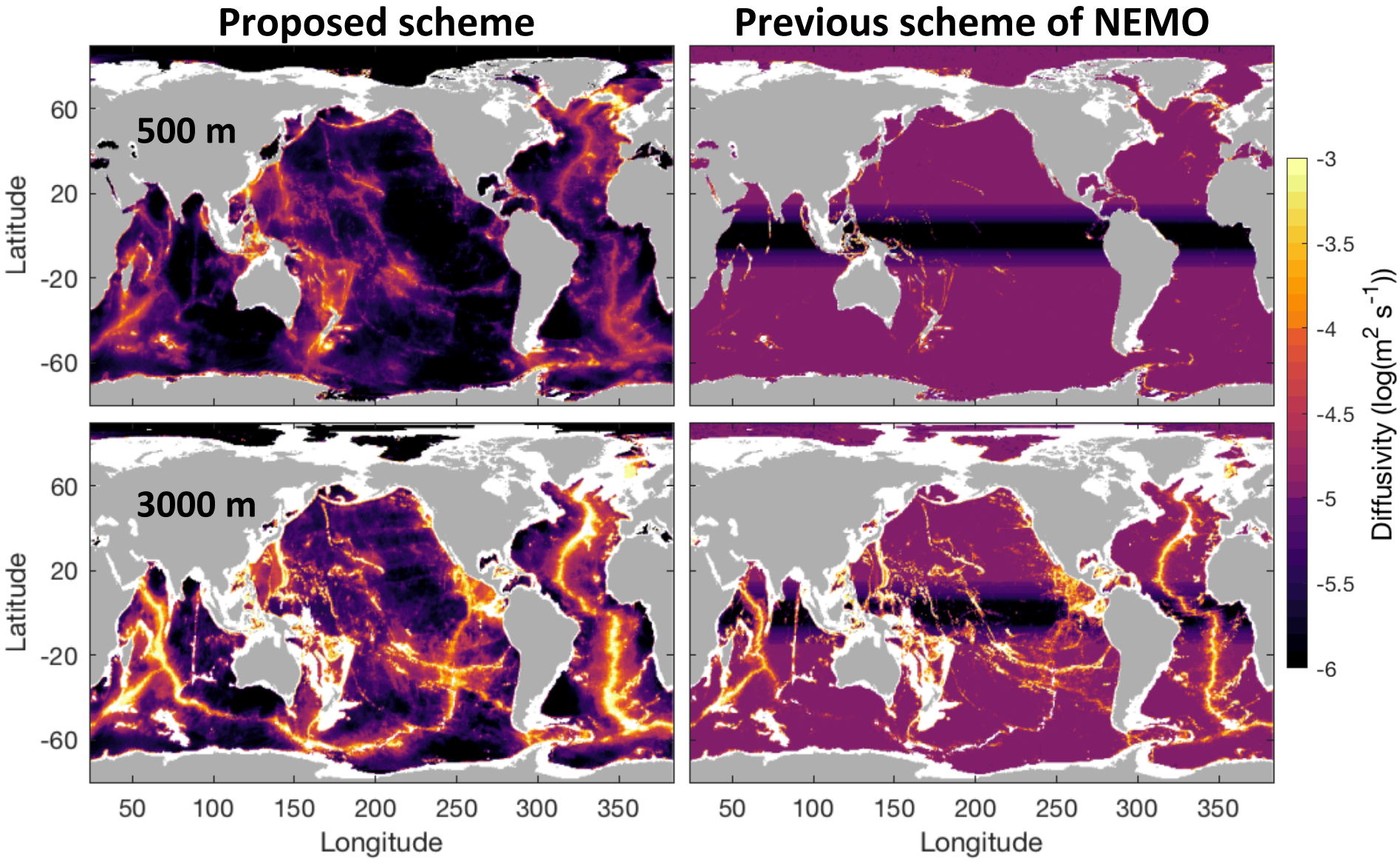
$$K_z = 0.2\, qE\, F / \rho N^2$$

# Proposed mixing scheme

- No background diffusivity.

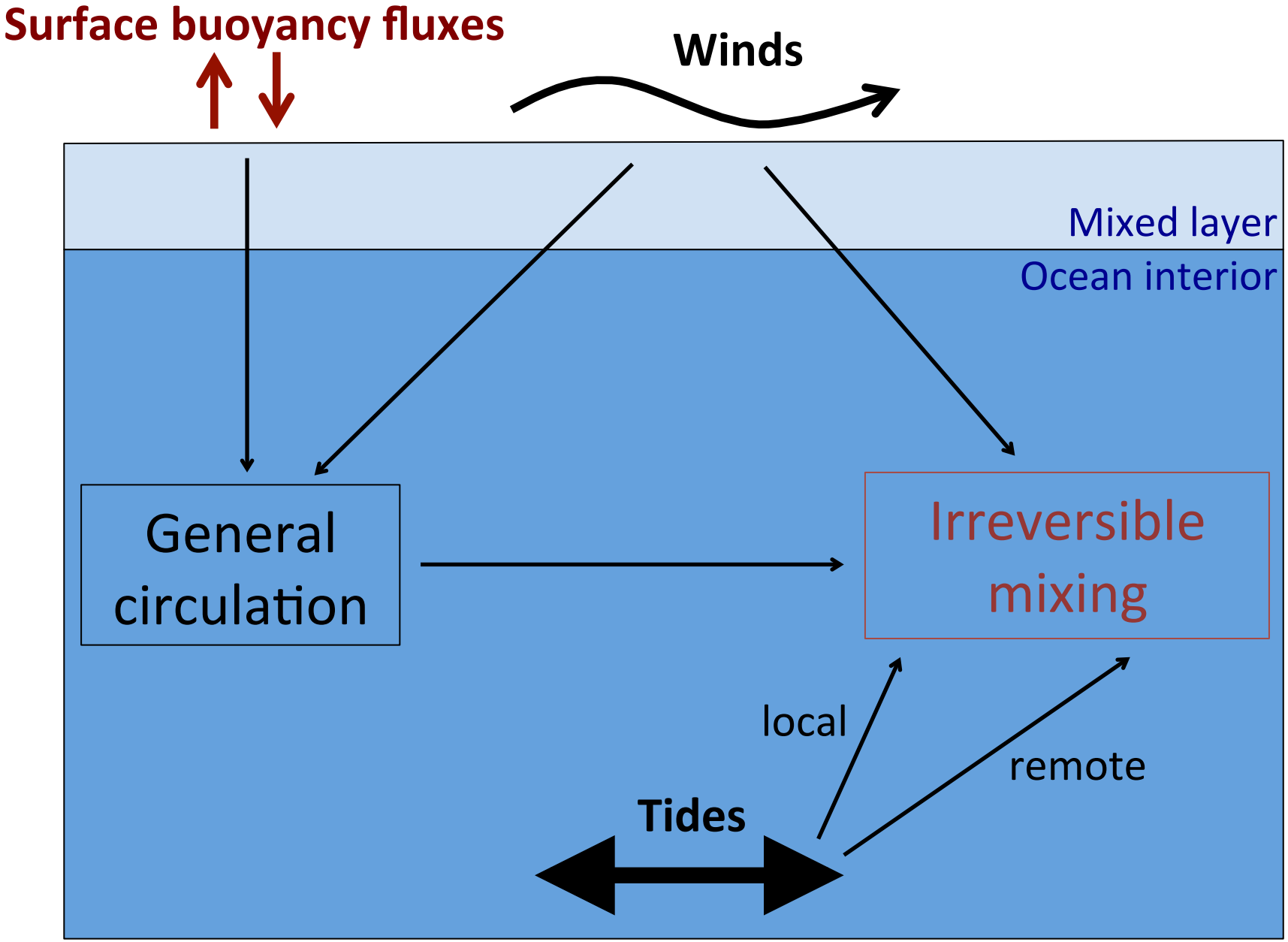
- All mixing comes from known energy sources.
  - 4 static 2D maps of internal tide energy dissipation (for 4 dissipative processes).
  - Stratification-dependent vertical structures (each map goes with a specific vertical structure).

# Consequent change in vertical diffusivity in NEMO

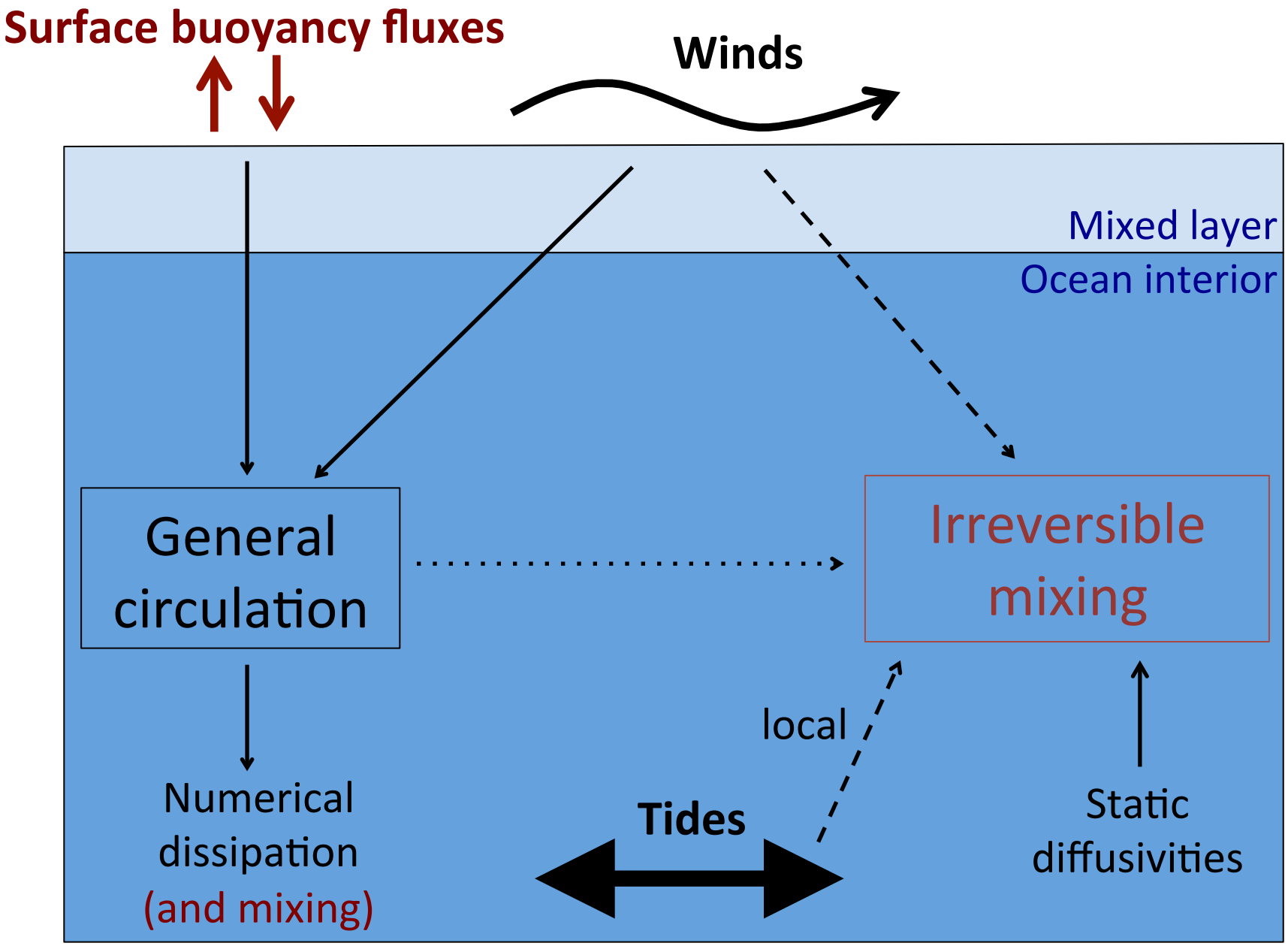


# 2. Implications for energetic consistency of ocean models

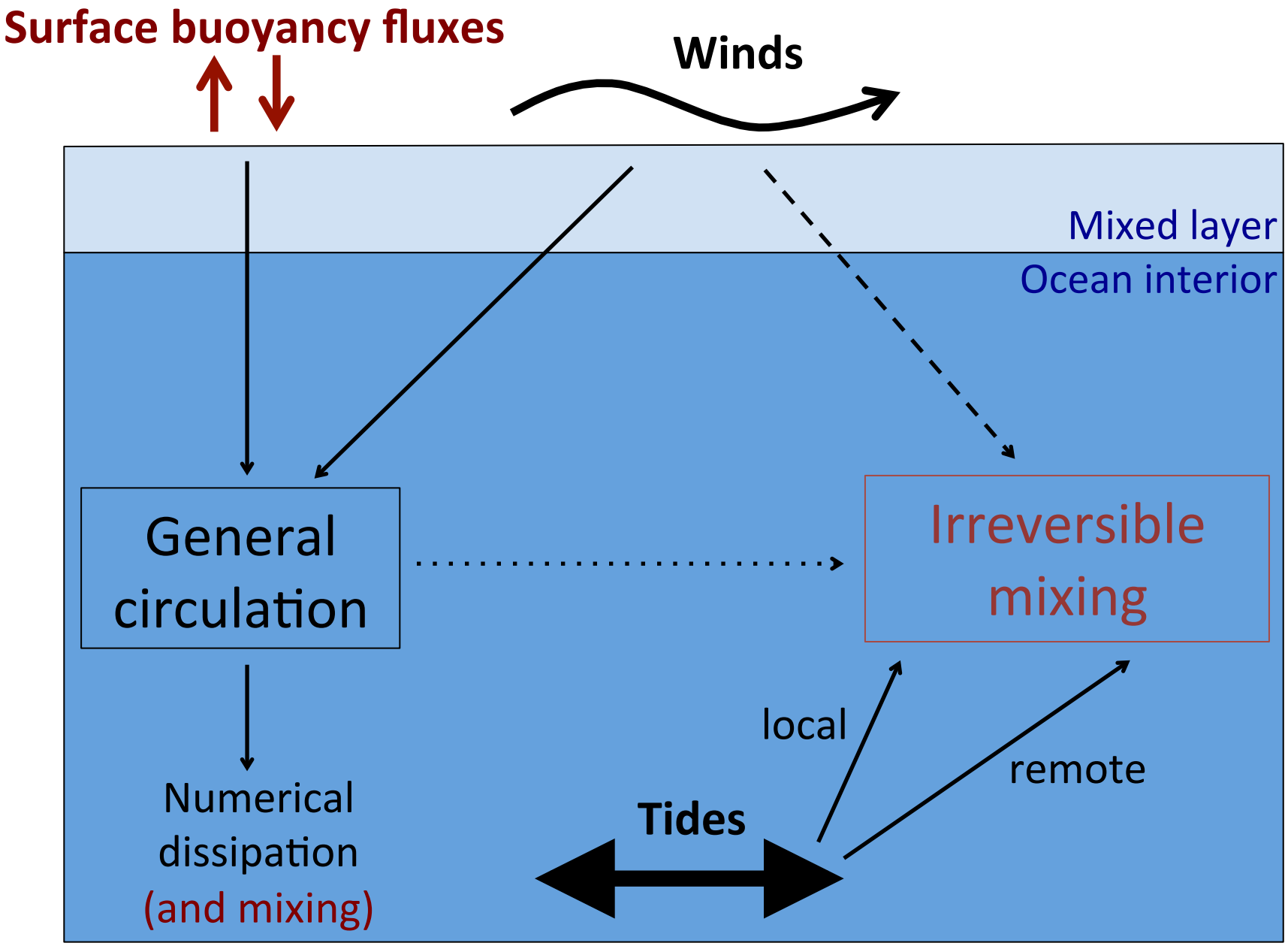
# Energy flows in real ocean



# Energy flows in typical ocean models

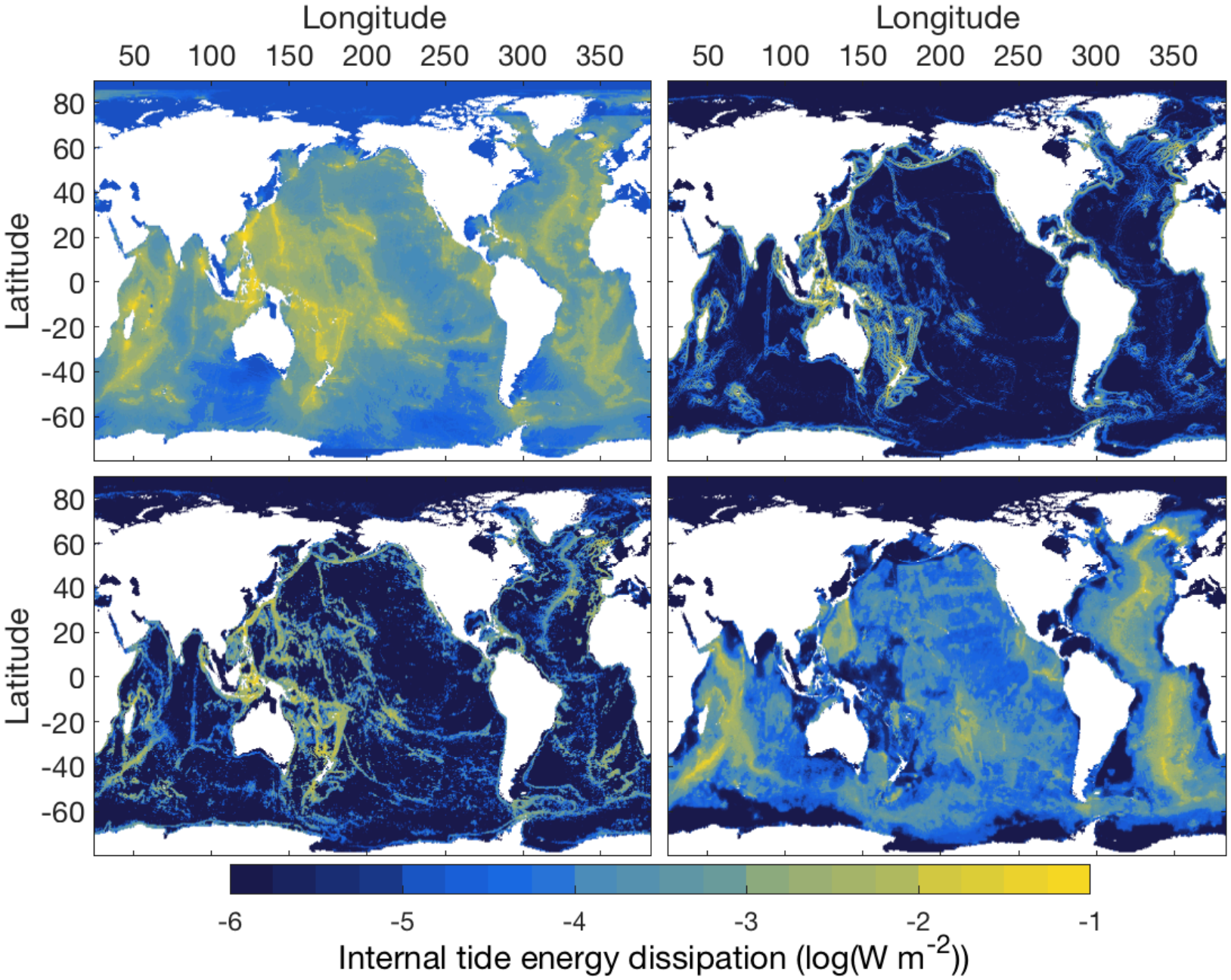


# Energy flows in models with proposed scheme

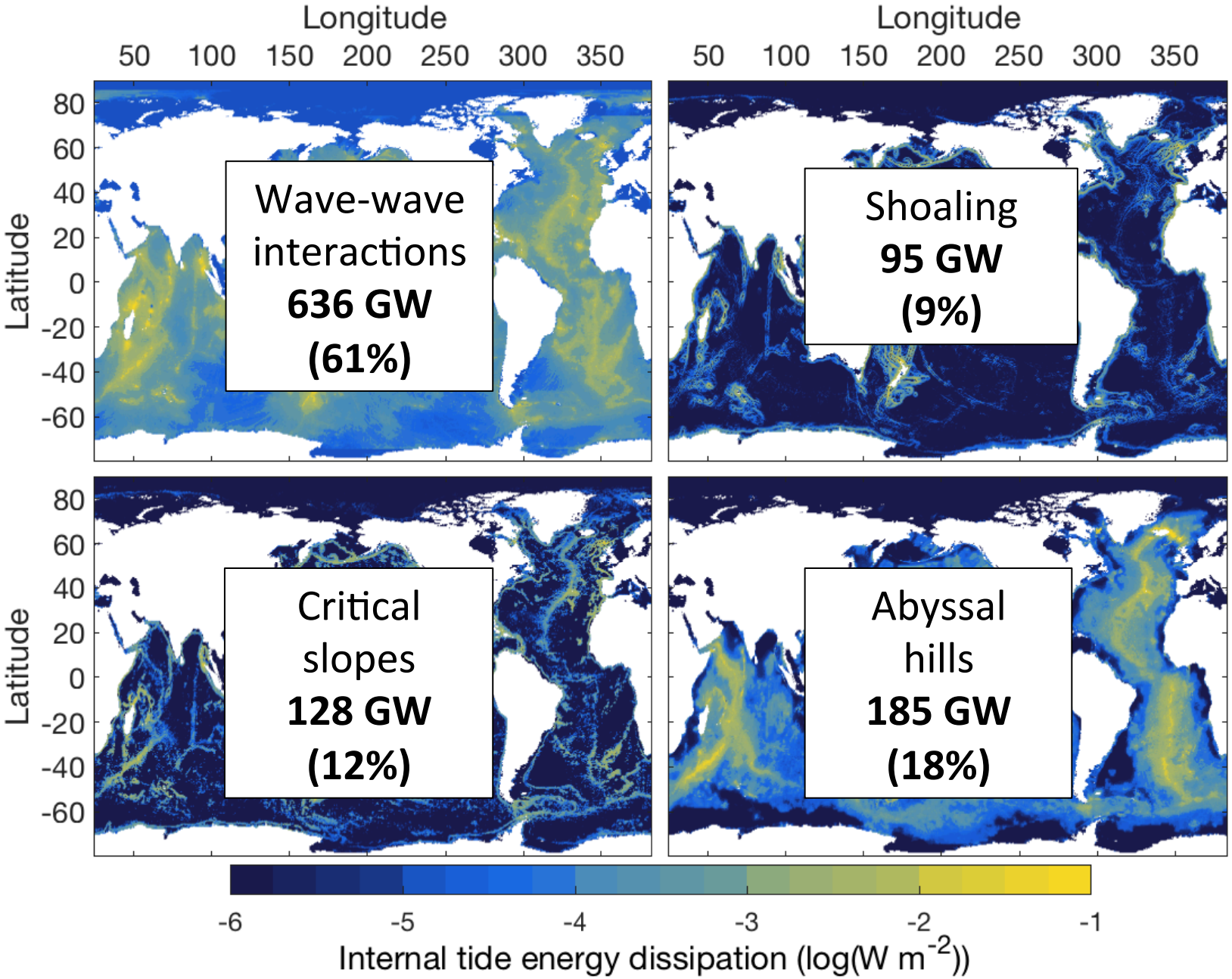


# 3. Ingredients of the mixing parameterization

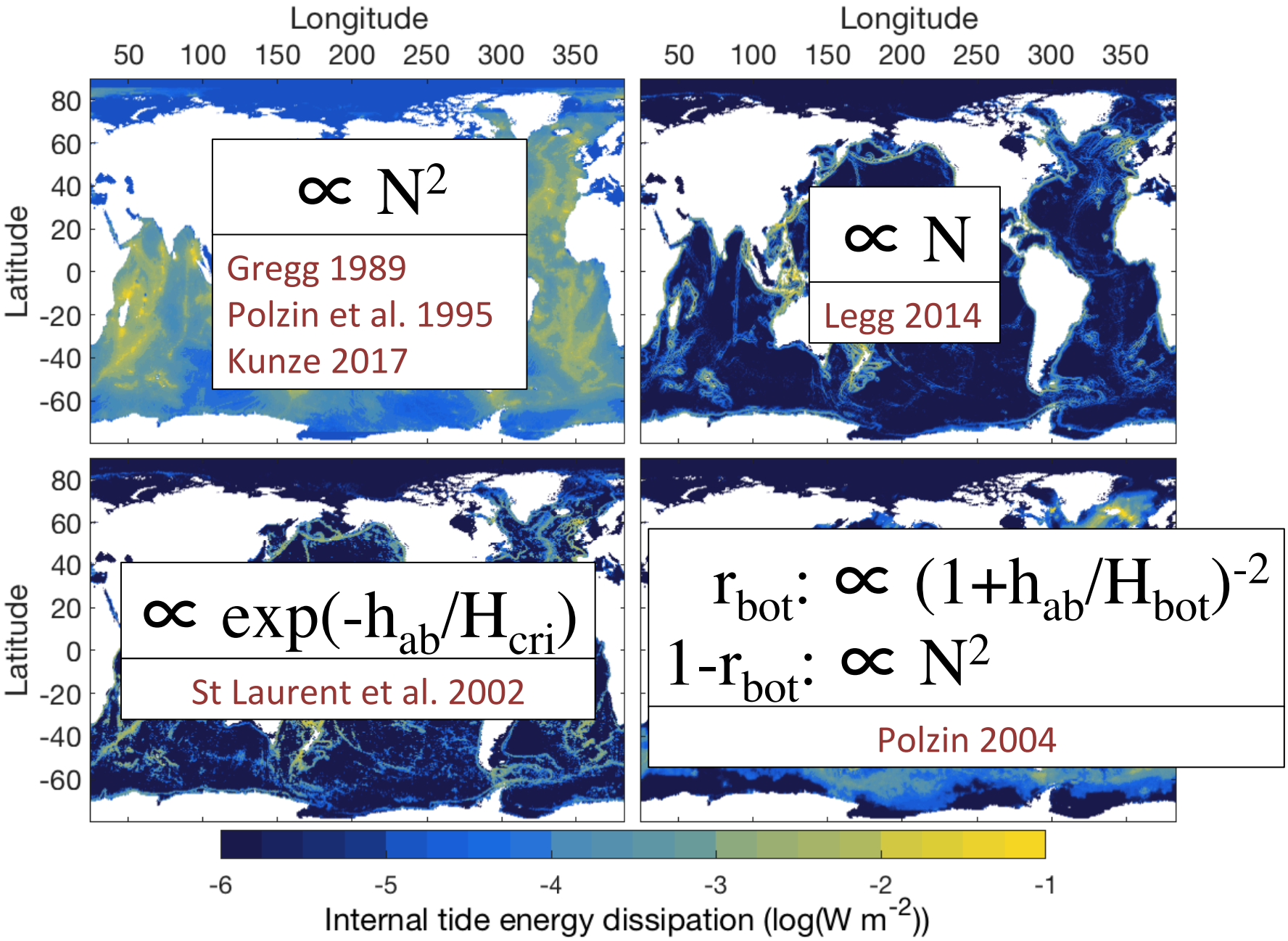
# 4 static maps of power input to turbulence…



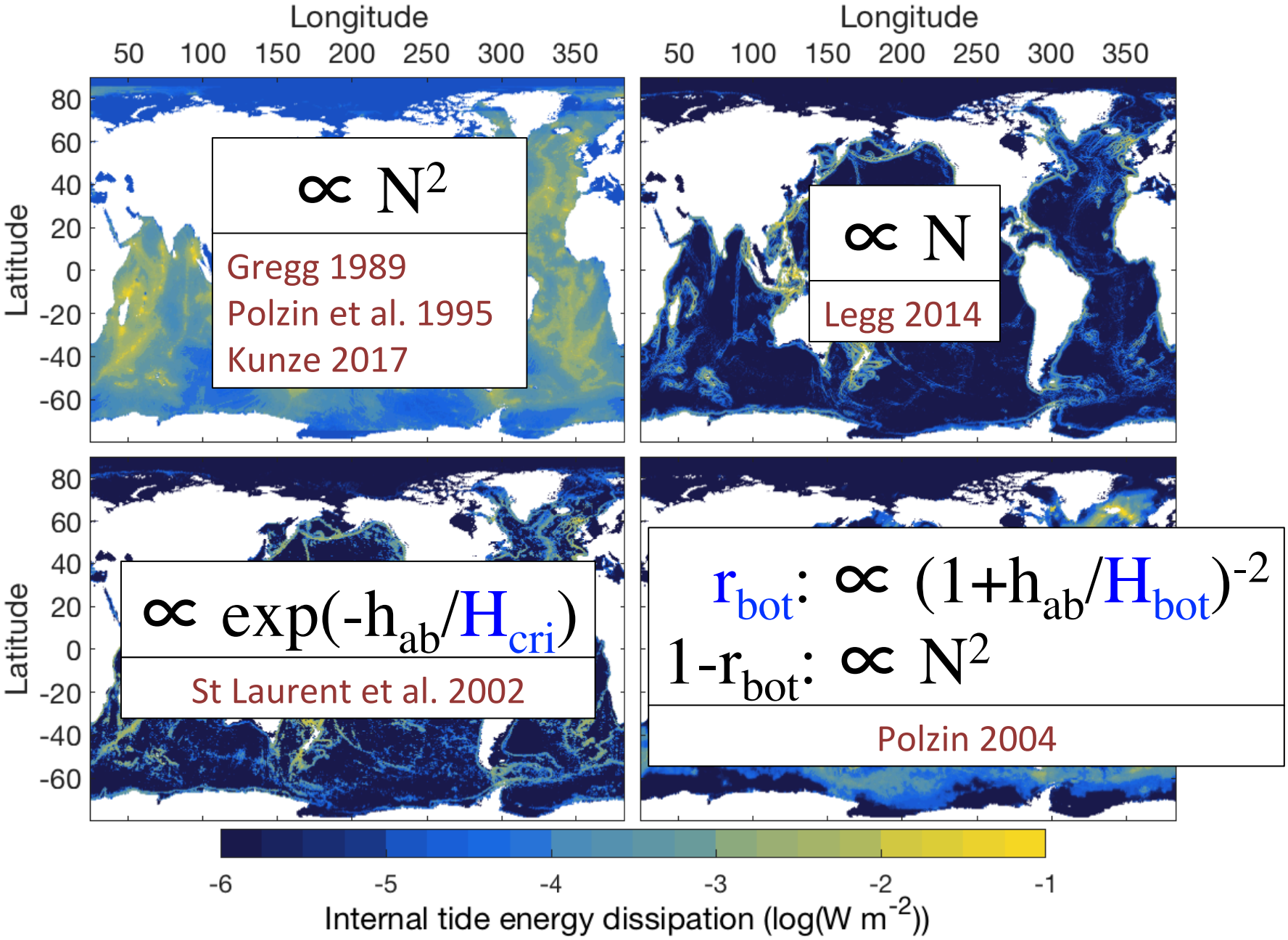
# …corresponding to 4 processes…



# …and 4 vertical structures…



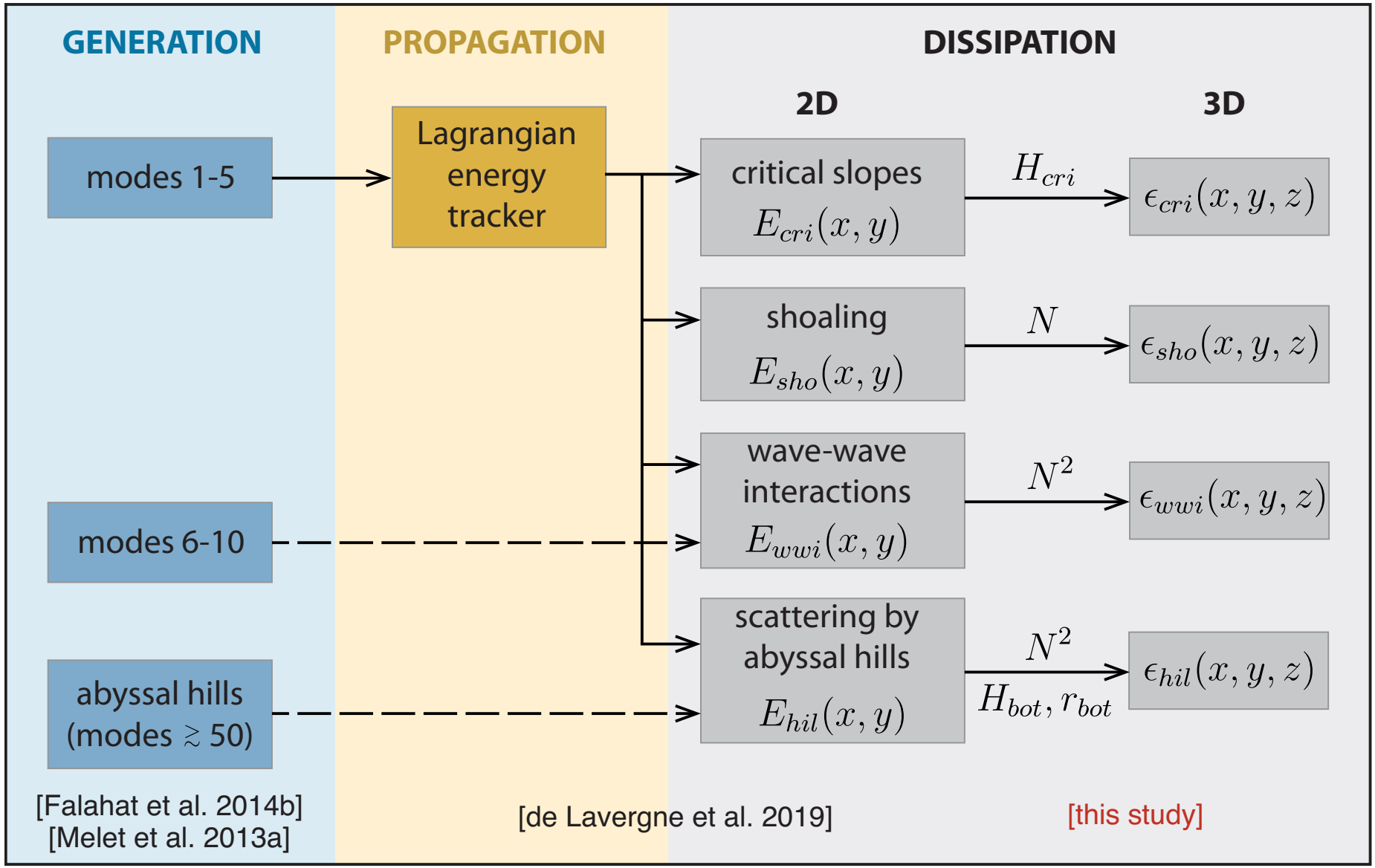
# …including 3 parameters mapped using obs.



# 4. Methodology to construct the parameterization

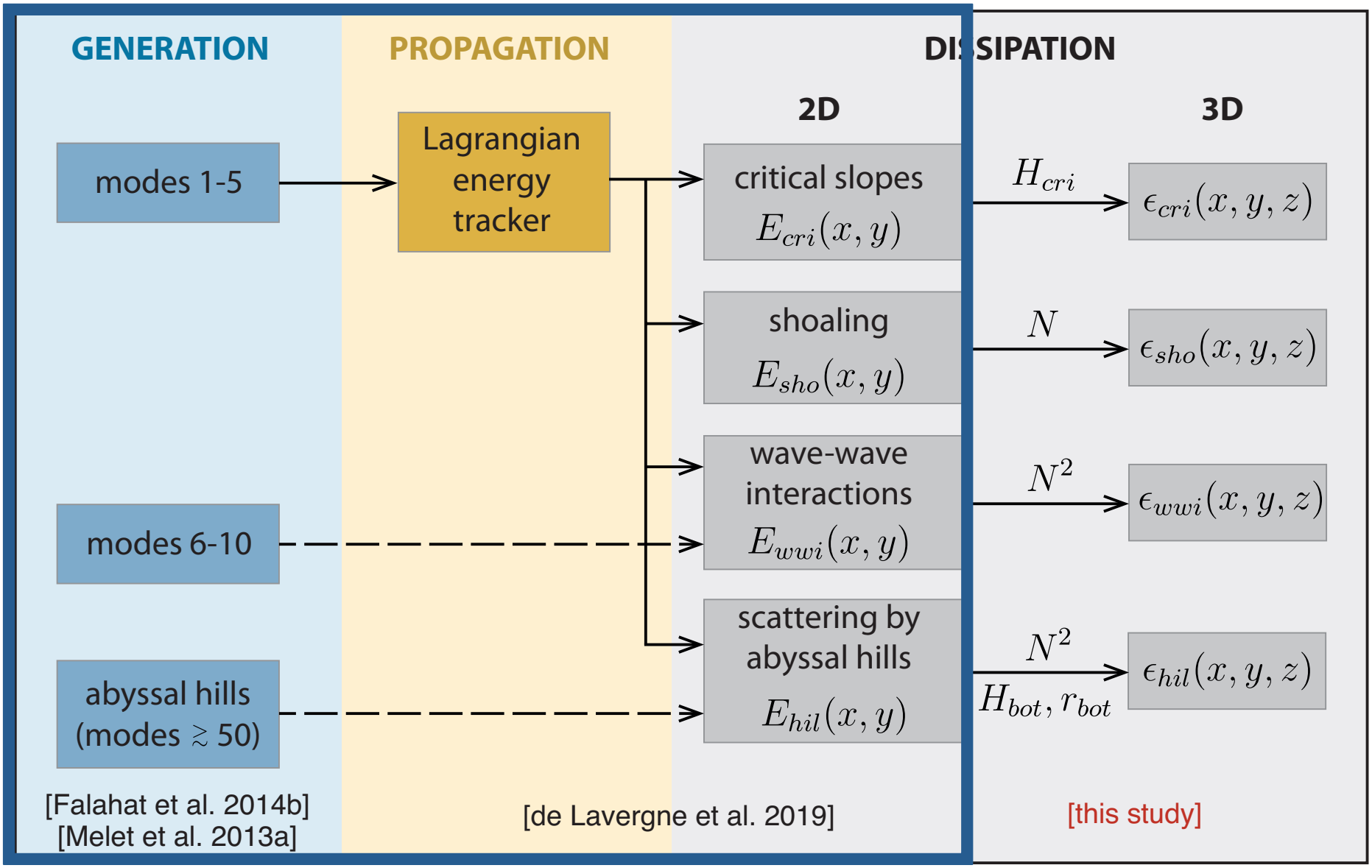
# Methodology

## Tracking the energy of internal tides from sources to sinks



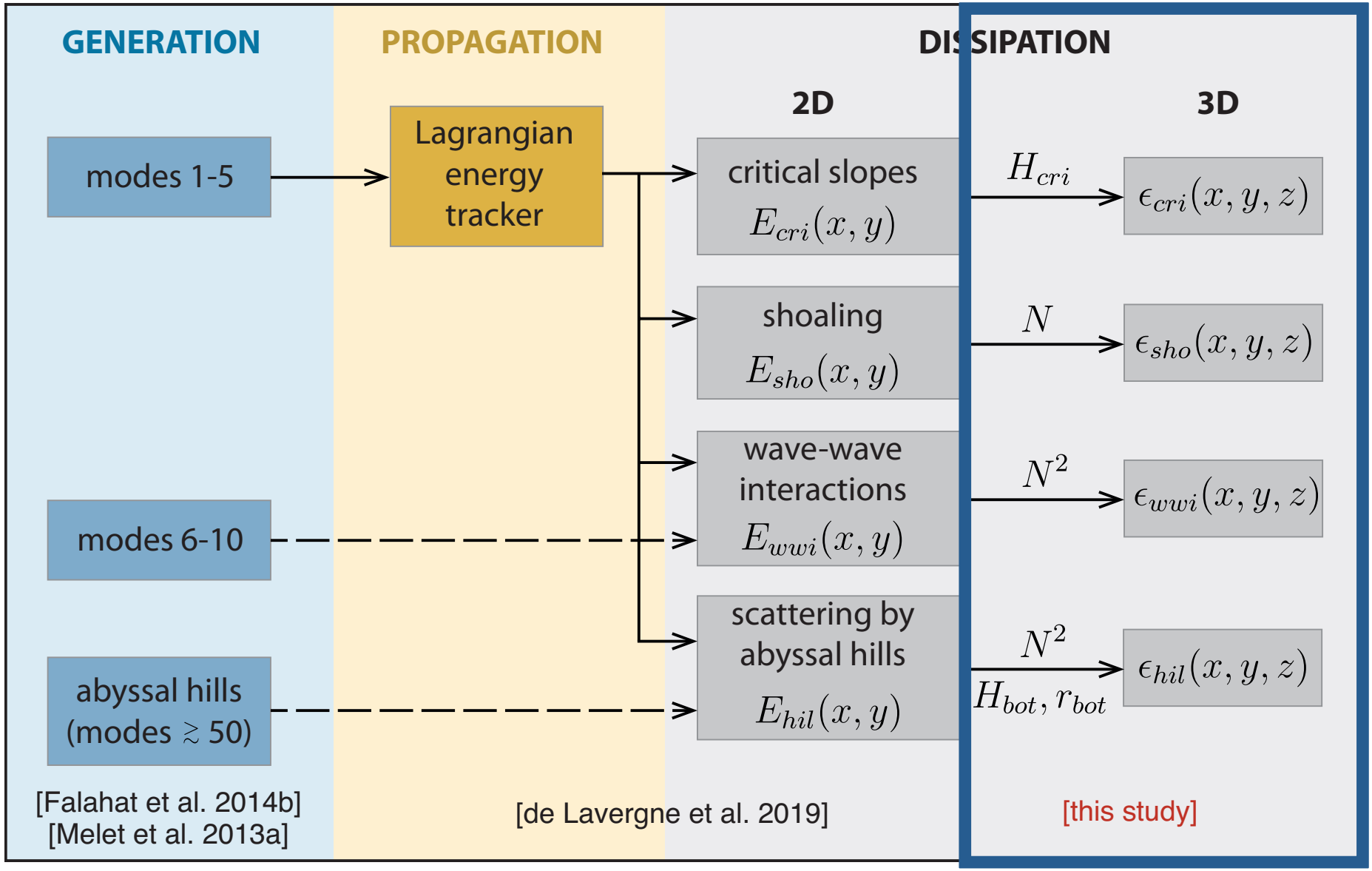
# Methodology

## 2D mapping using the WOCE climatology of stratification



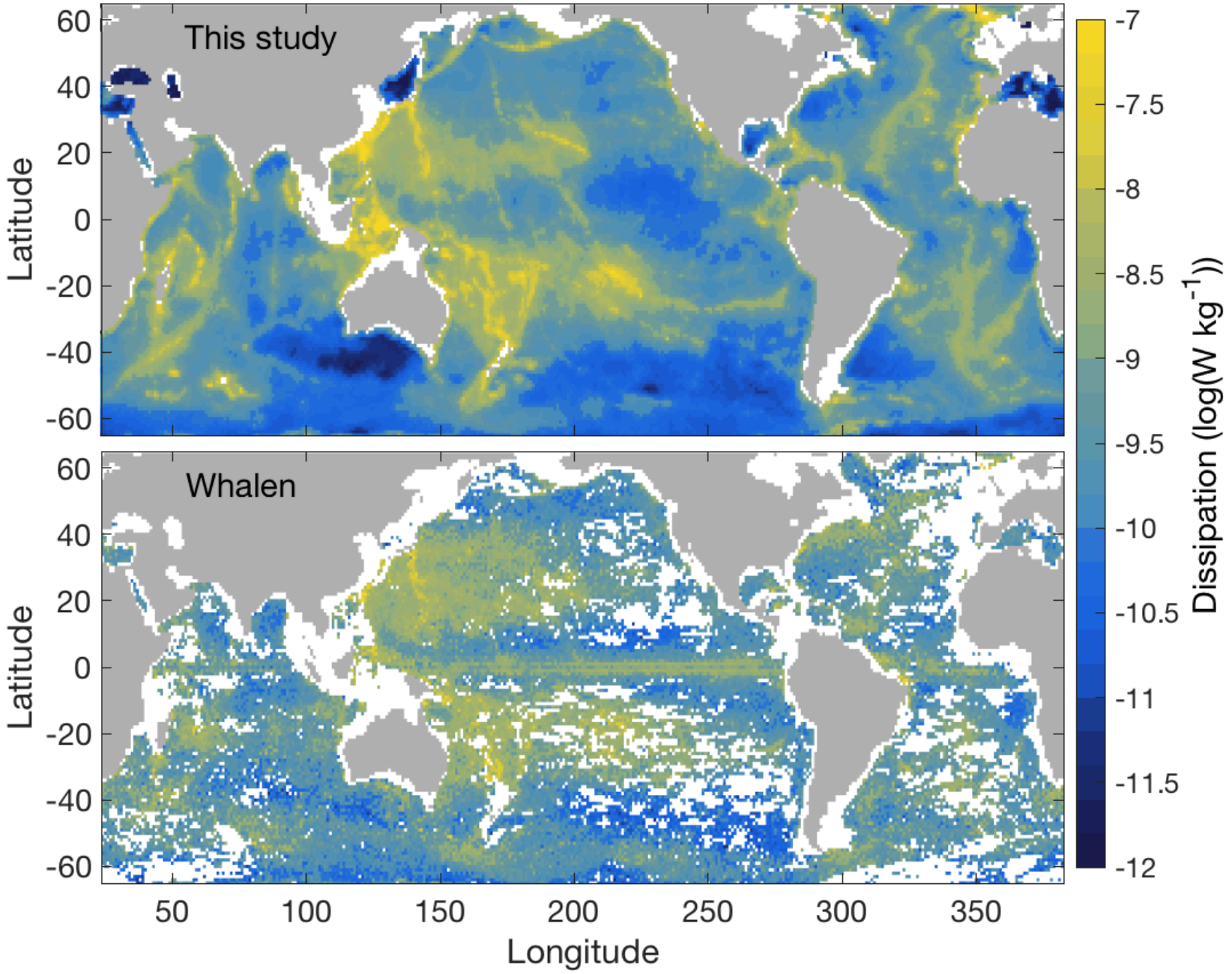
# Methodology

## Vertical structure applied to model-simulated $N^2(z)$

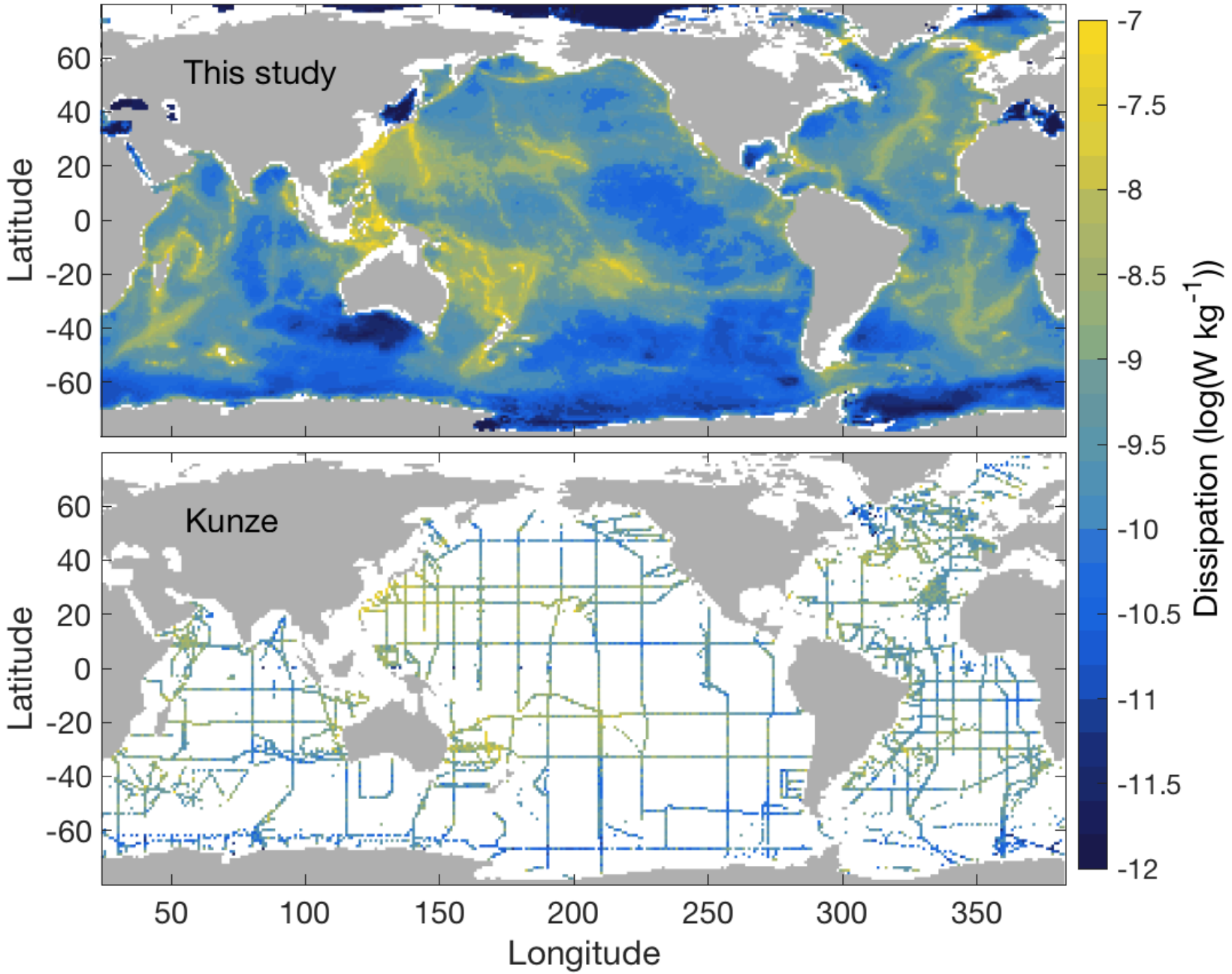


# 5. Comparison with finestructure observations

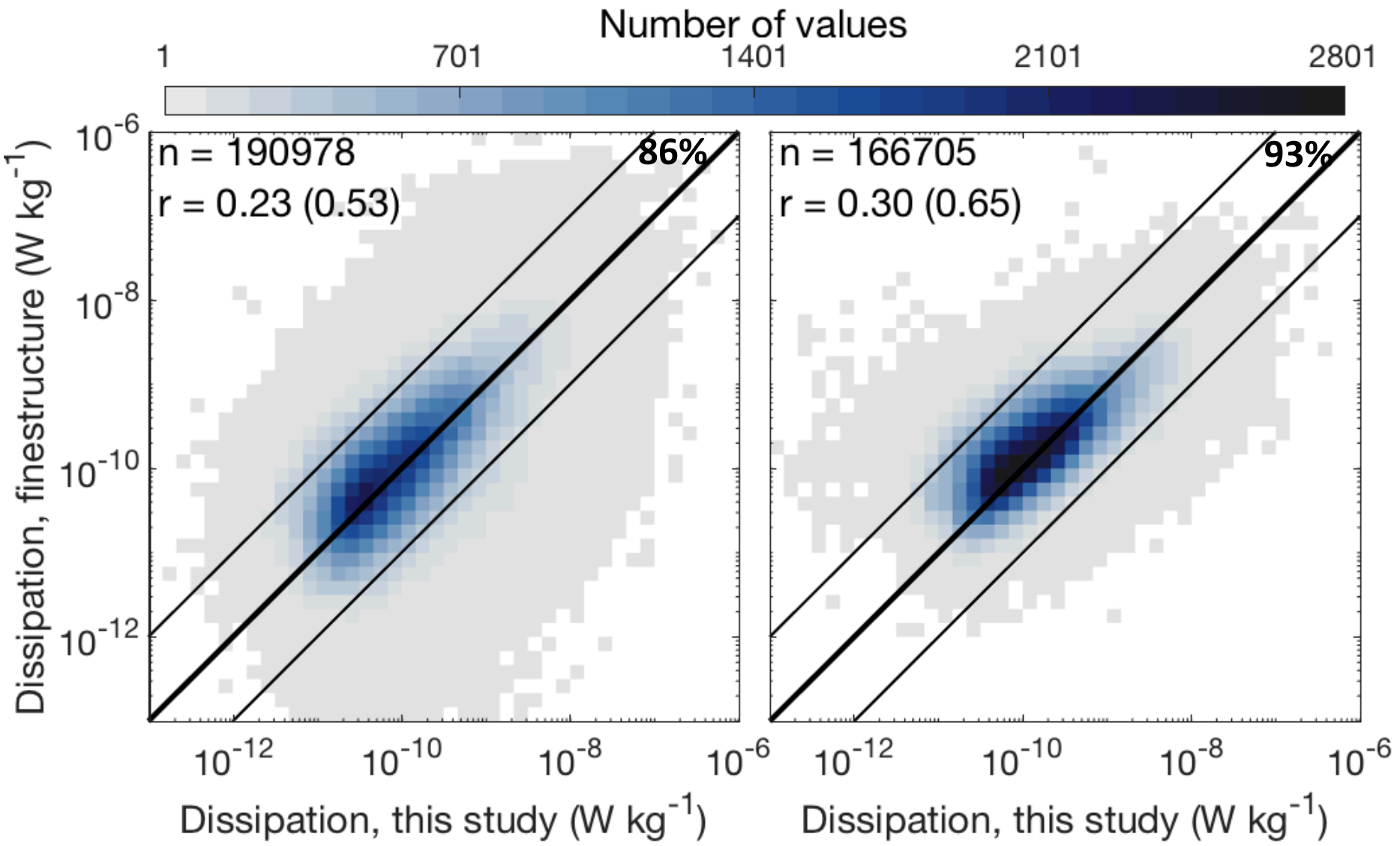
# Param (top) vs Argo-finestructure (bottom) at 400m



# Param (top) vs ship-finestructure (bottom) at 400m



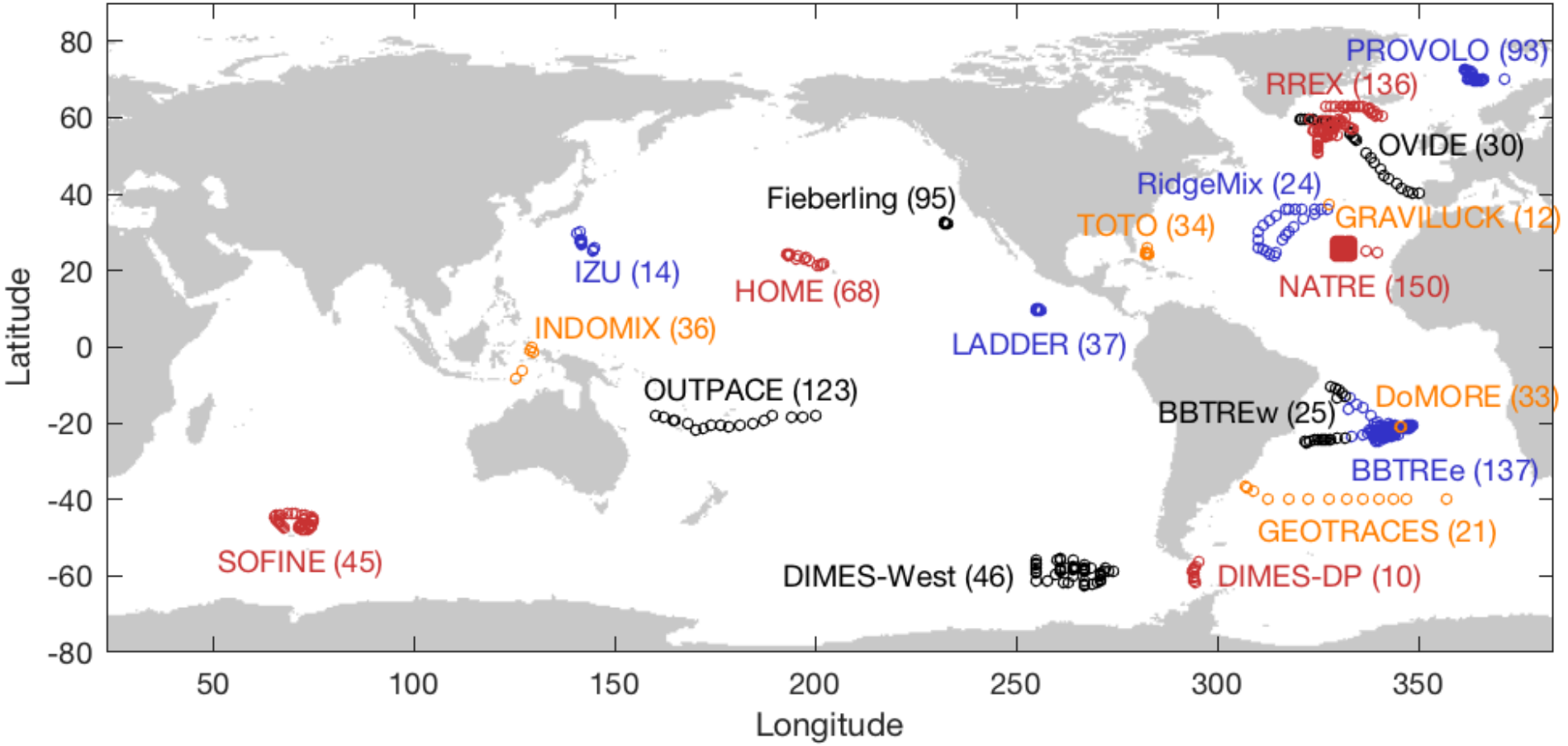
# Two-dimensional histograms, param vs obs



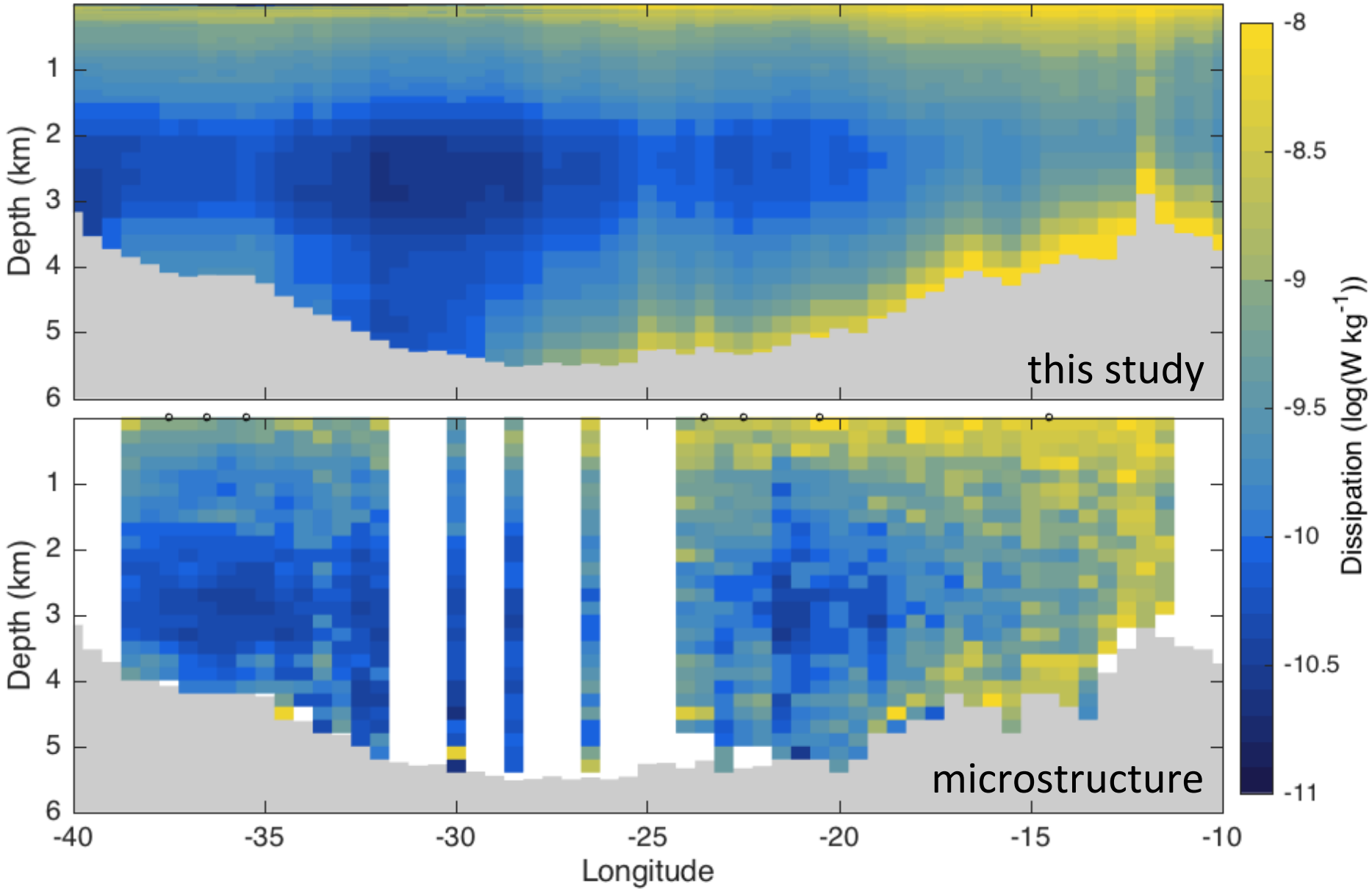
# 6. Comparison with microstructure observations

# Microstructure data

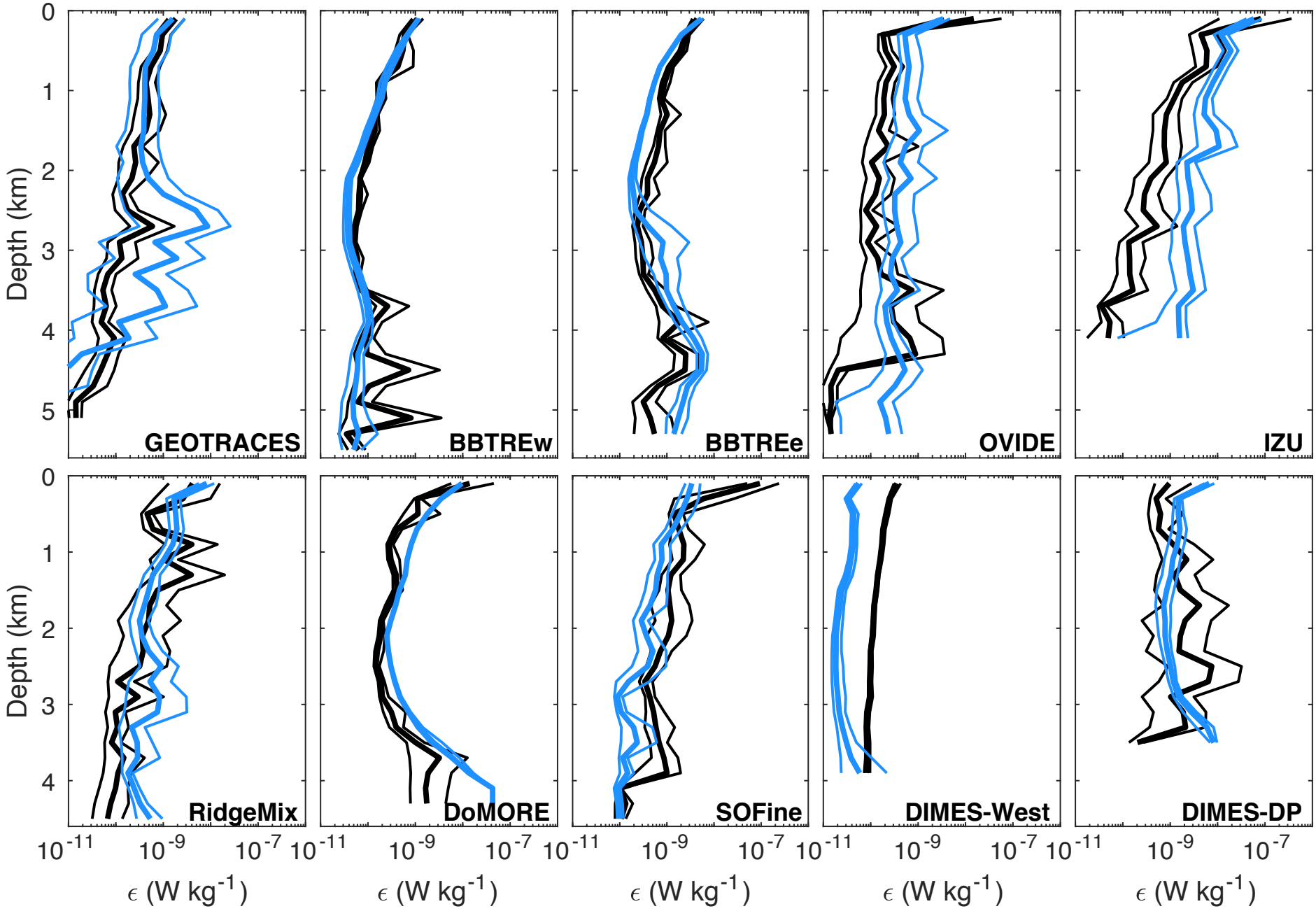
19 projects, 1169 profiles



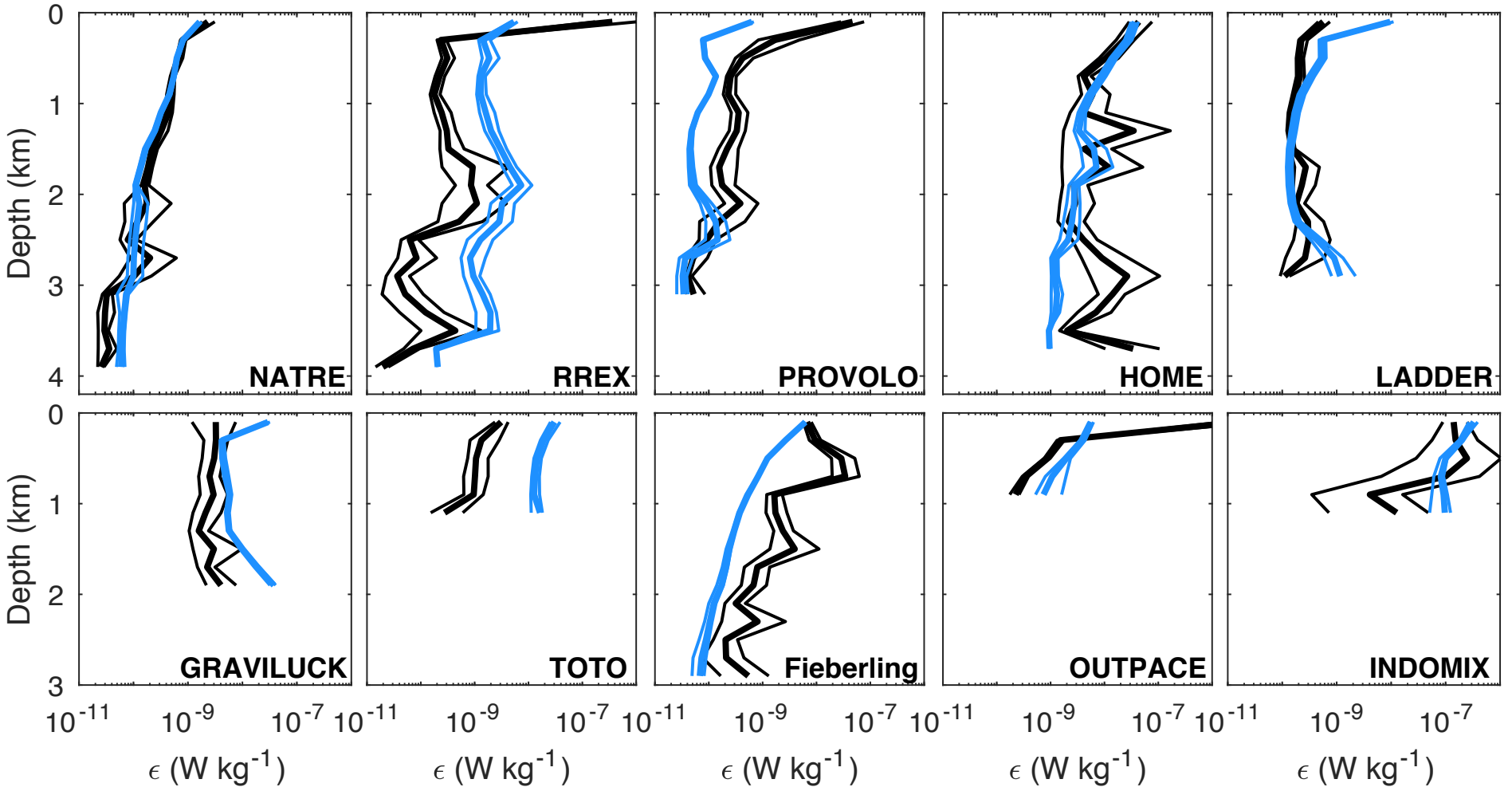
# Brazil Basin transect, param (top) vs obs (bottom)



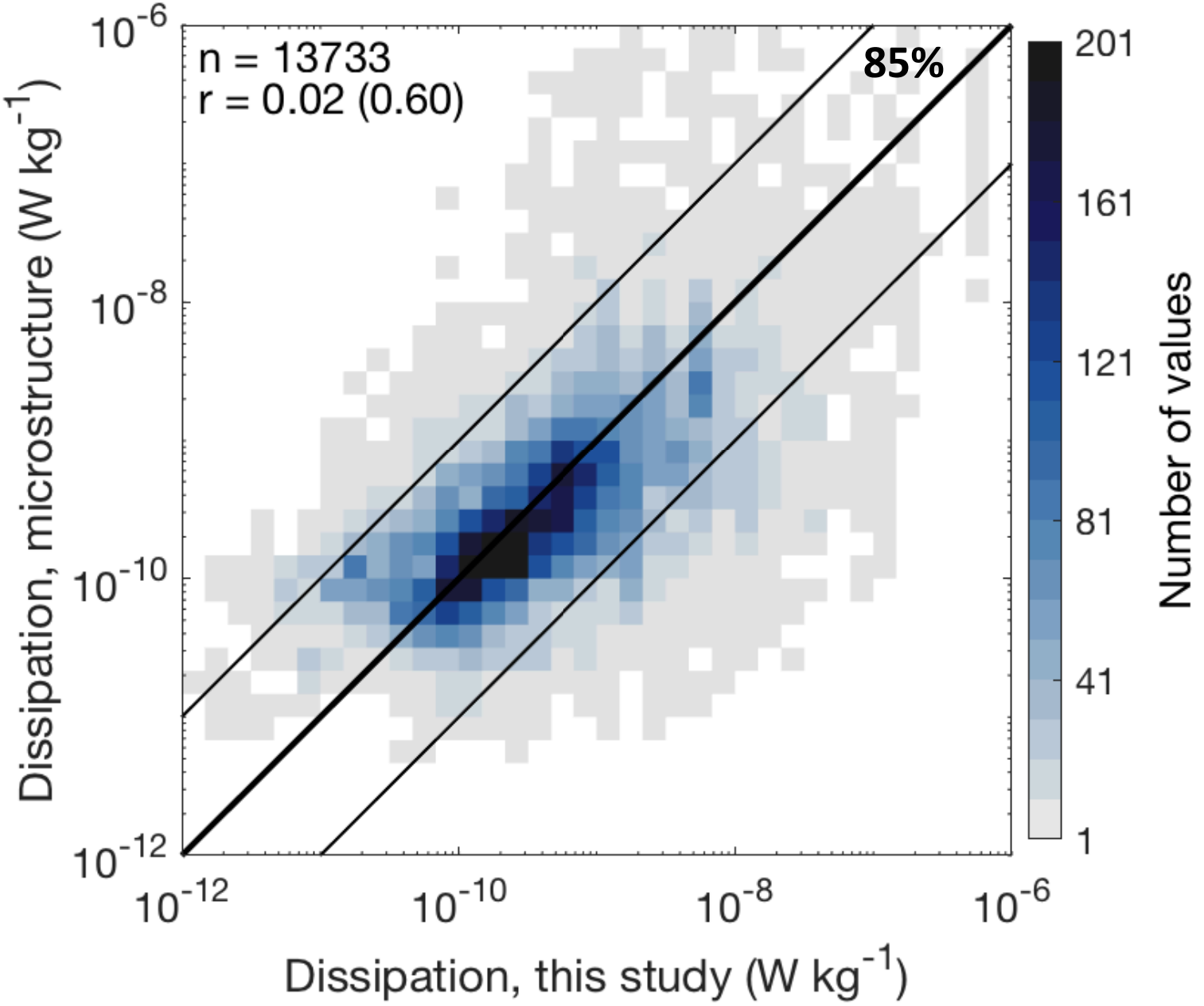
# Project-mean profiles, param (blue) vs obs (black)



# Project-mean profiles, param (blue) vs obs(black)



# Two-dimensional histogram, param vs obs



# 7. Conclusions

# Conclusions (1/2)

- Global 3D map of internal tide-driven mixing.
  - Numerous simplifications and substantial uncertainties.
  - Encouraging comparison with microstructure and with upper-ocean finestructure observations.
  - Range of applications: mixing climatology, forward models, inverse models, budgets, etc.

- Successful implementation in NEMO.
  - A step toward energetic consistency.
  - Static 2D maps (much) better than static diffusivities!
  - Low computational cost.
  - Used in several models participating to CMIP6.

# Conclusions (2/2)

- Maps publicly available on SEANOE:
https://doi.org/10.17882/73082

- Documentation in two open-access publications:

de Lavergne, Vic, Madec, Roquet, Waterhouse, Whalen, Cuypers, Bouruet-Aubertot, Ferron, Hibiya. A parameterization of local and remote tidal mixing. *JAMES*, in press.
https://doi.org/10.1029/2020MS002065

de Lavergne, Falahat, Madec, Roquet, Nycander, Vic. Toward global maps of internal tide energy sinks. *Ocean Modelling*, 137, 52-75 (2019).
https://doi.org/10.1016/j.ocemod.2019.03.010