Large-scale implications of small-scale bottom-intensified mixing

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in collaboration with

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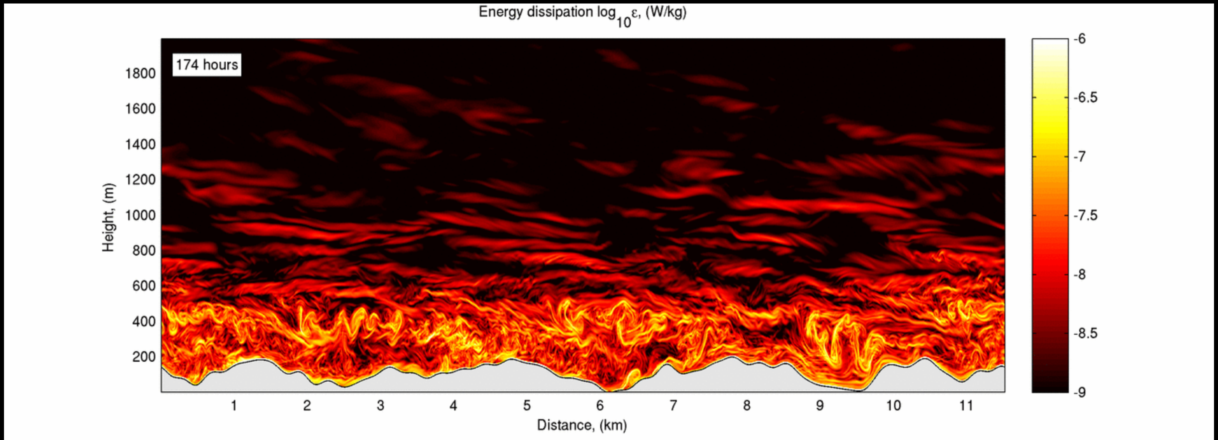
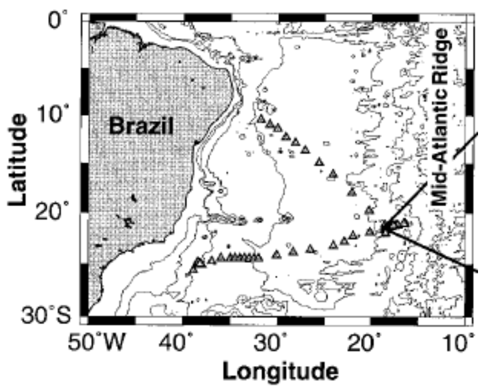


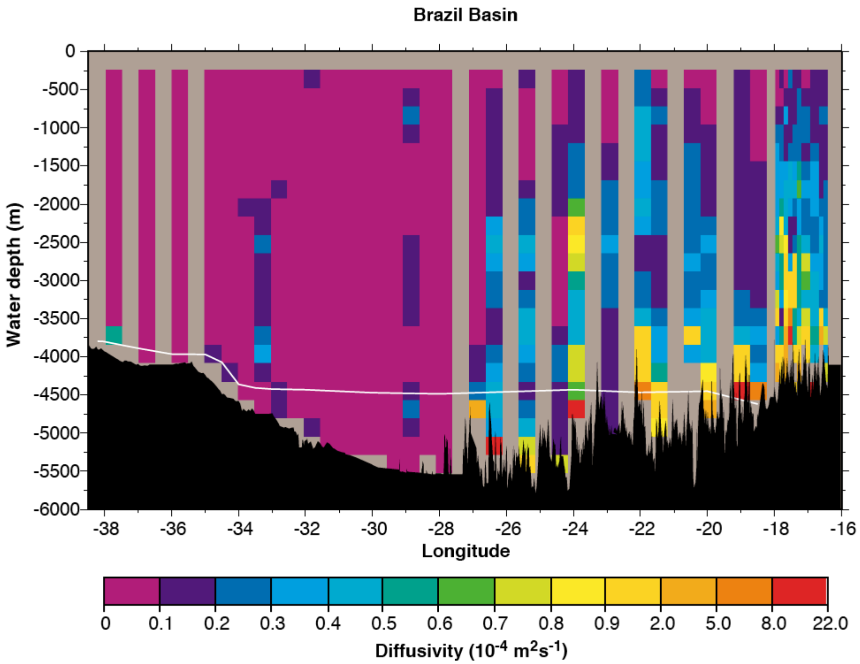
Contents

Charles Saxon, The New Yorker Collection

Brazil Basin observations of mixing

– Diapycnal mixing is enhanced in the *abyssal ocean* above *rough topography*





observed!

$$\kappa_v = \Gamma \frac{\varepsilon}{N^2}$$

(Osborn, 1980)

implemented

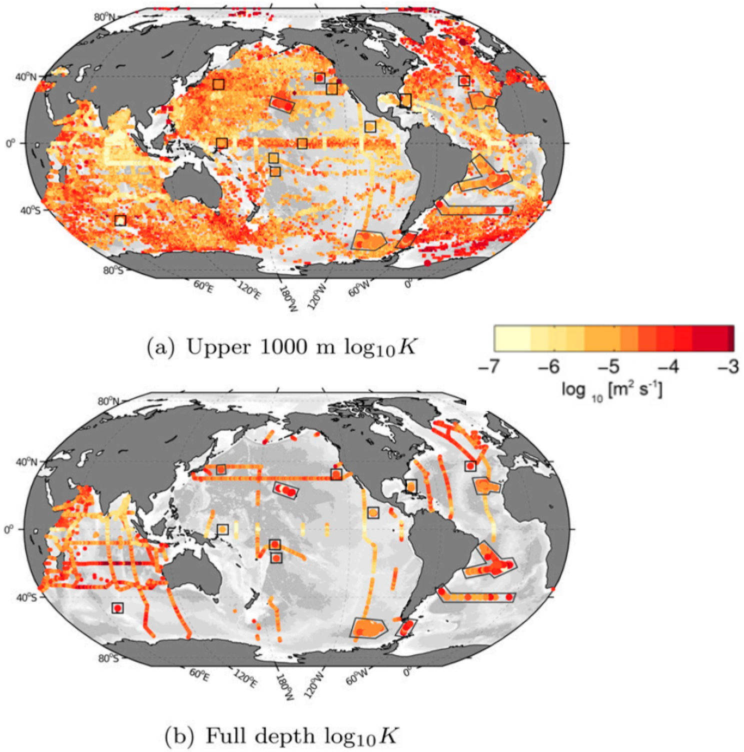
Observations provide measurements of turbulent (i.e. sub-grid scale) buoyancy flux:

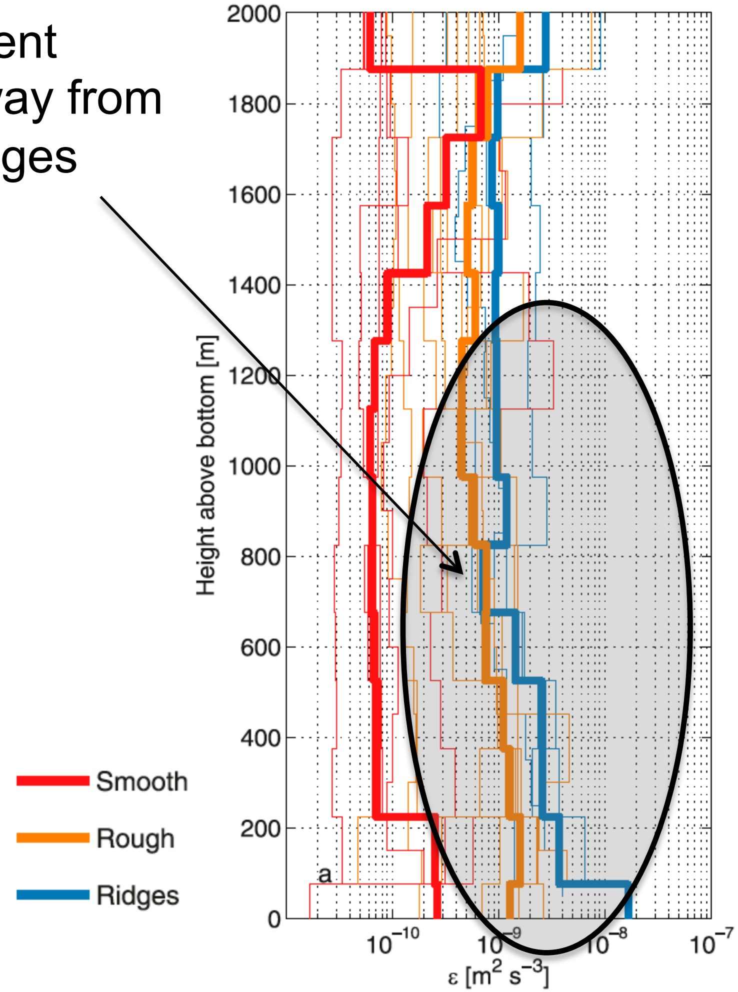
$$\overline{w'b'} = \kappa_v N^2 = \Gamma \varepsilon$$

Polzin et al. (1997), *Science*

Global patterns of mixing from observations

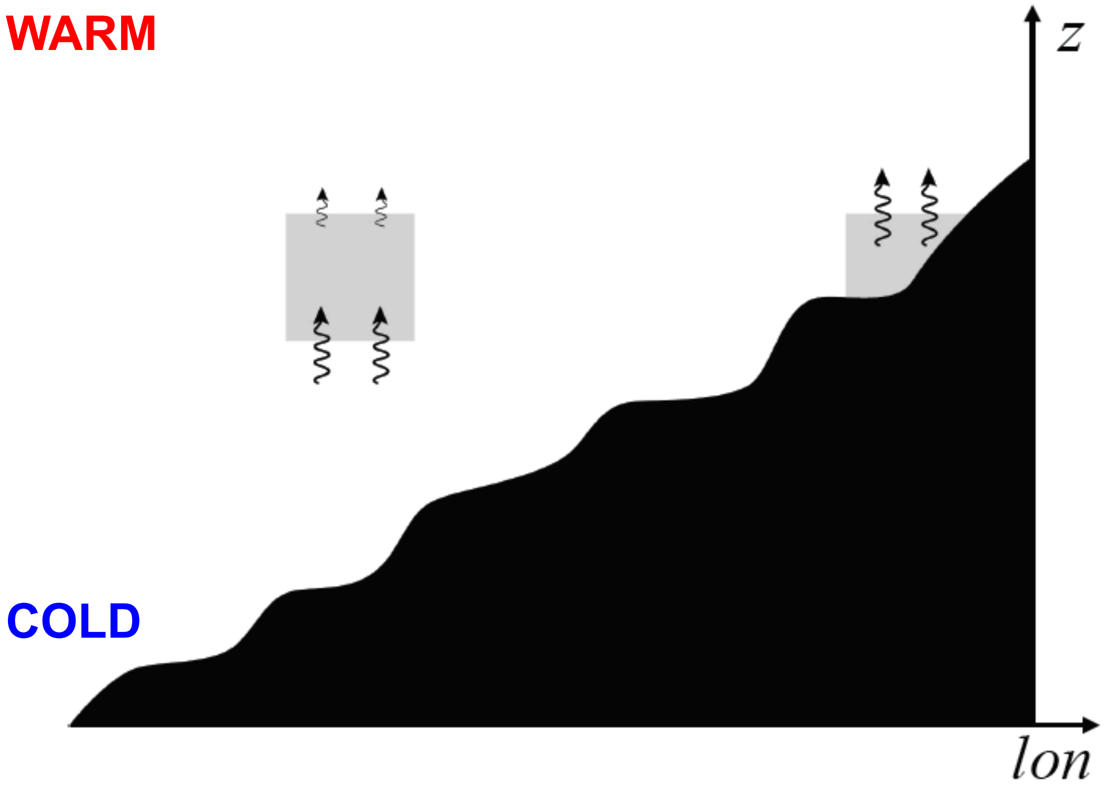
– Turbulent energy dissipation (i.e. turbulent buoyancy flux) decays exponentially away from rough bottom topography and ocean ridges





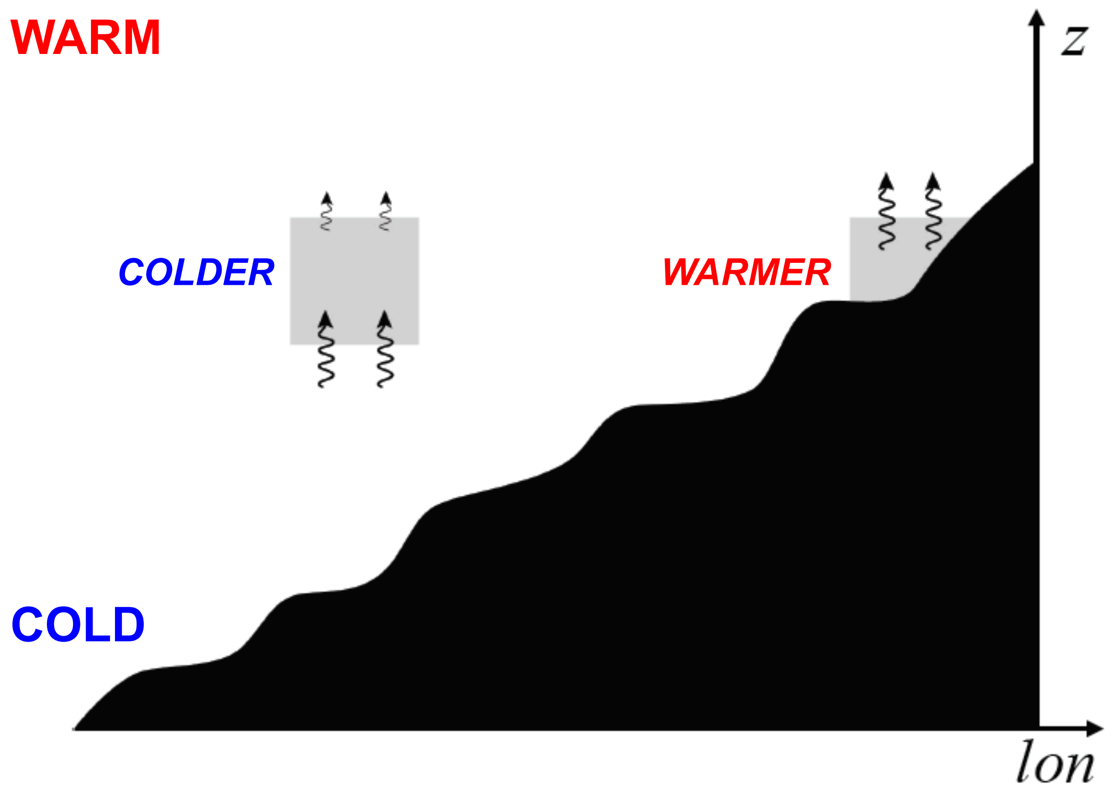
Waterhouse et al. (2014), *JPO*

Diapycnal upwelling and downwelling



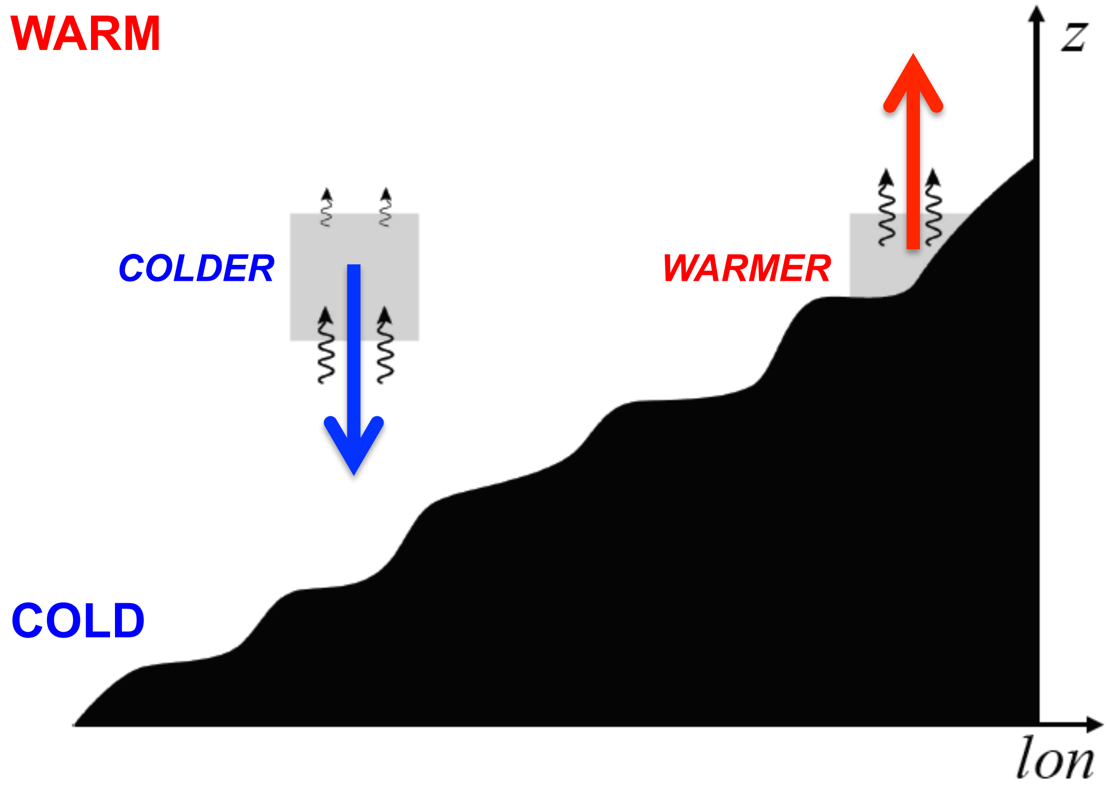
Ferrari et al. (2016), *JPO*

Diapycnal upwelling and downwelling



Ferrari et al. (2016), *JPO*

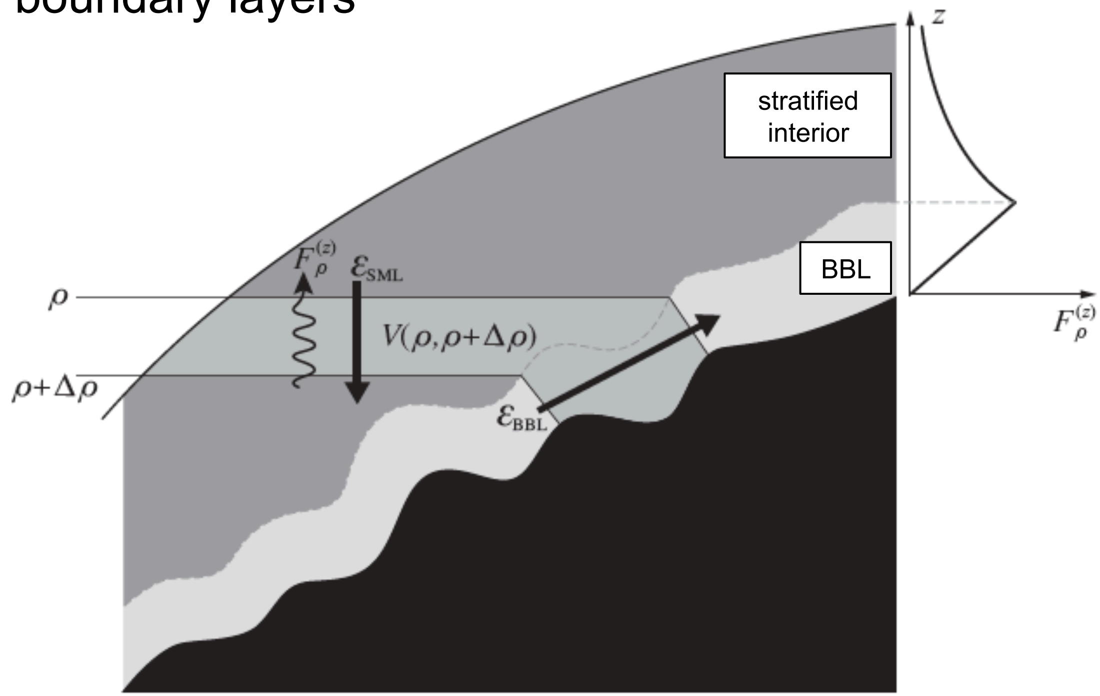
Diapycnal upwelling and downwelling



Ferrari et al. (2016), *JPO*

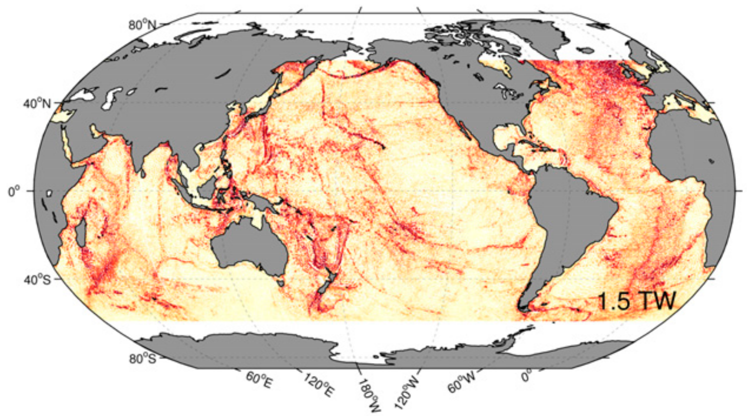
Diapycnal upwelling and downwelling

– Bottom-intensified mixing drives *downwelling* in the stratified ocean interior and *upwelling* in bottom boundary layers

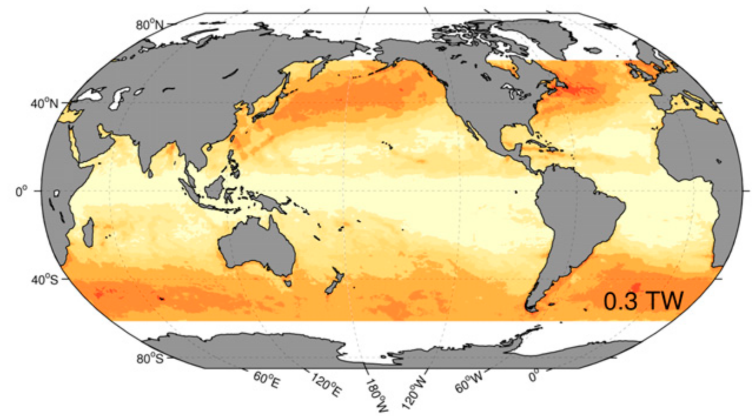


Ferrari et al. (2016), *JPO*

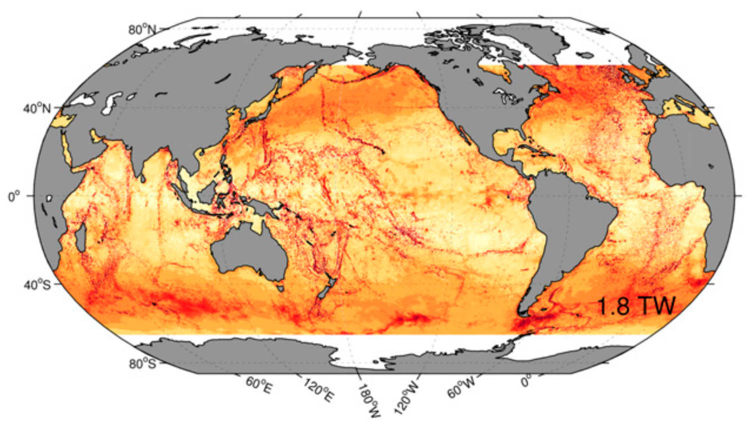
Energy sources for mixing



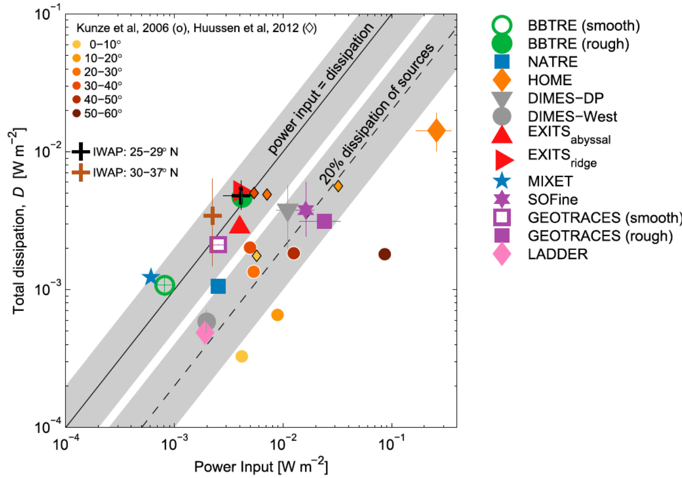
(a) Internal tides



(b) Near-inertial waves



(c) Total source terms



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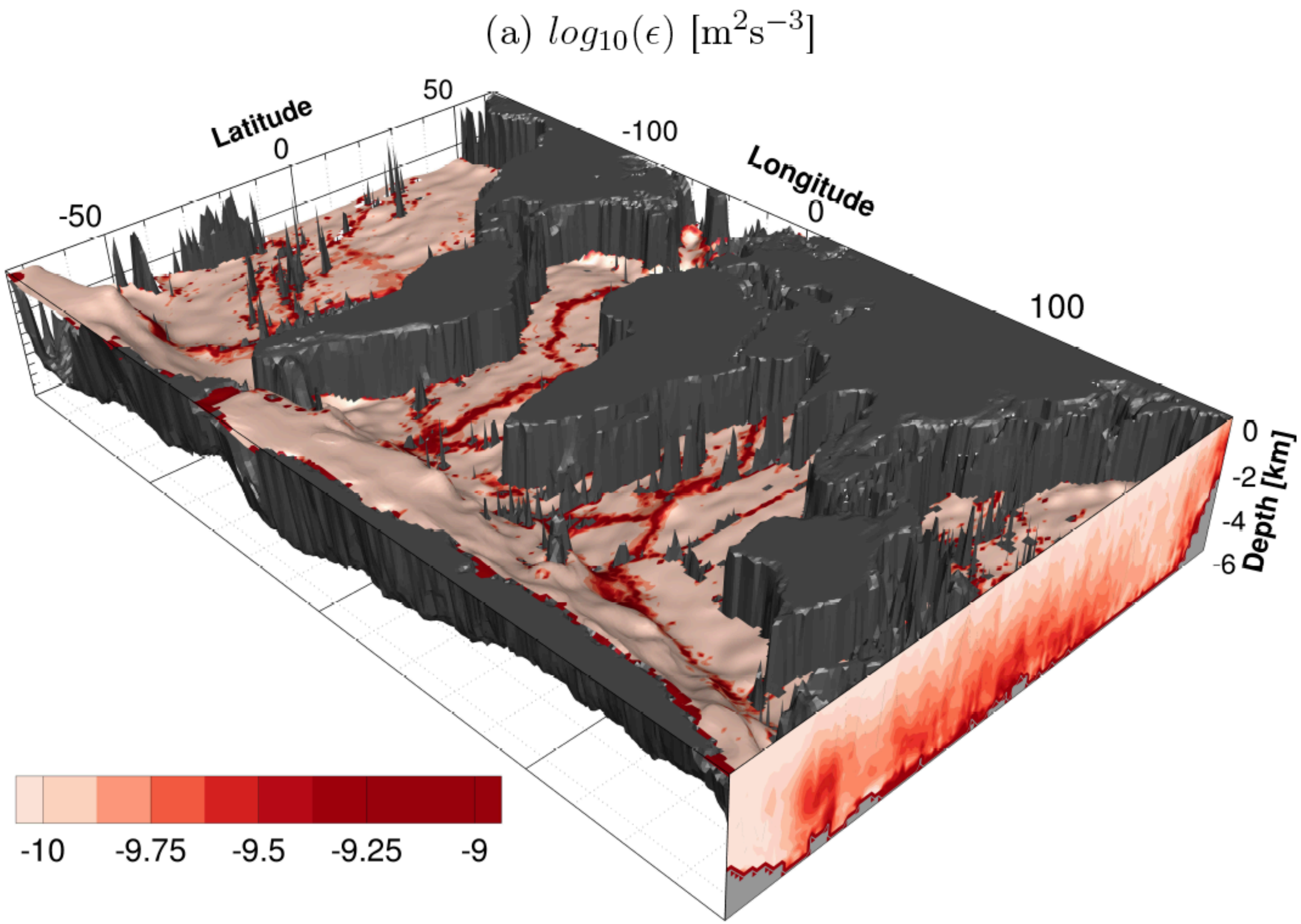
Waterhouse et al. (2014), *JPO*

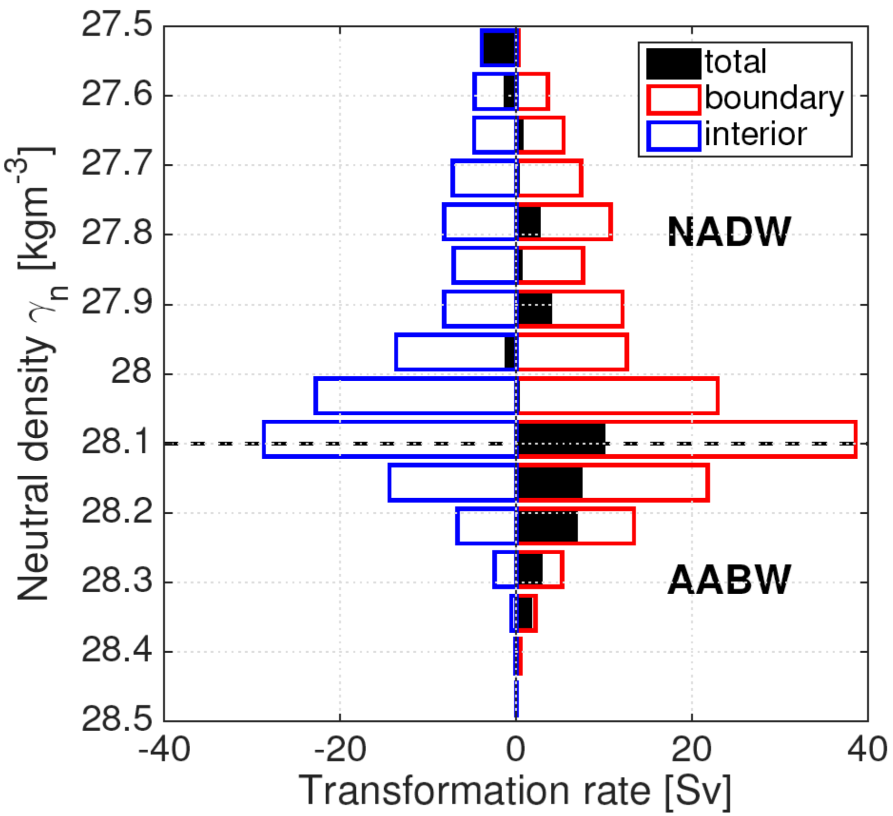
Global estimate of turbulent energy dissipation



Mashayek et al, *in prep*

Global water-mass transformation rates

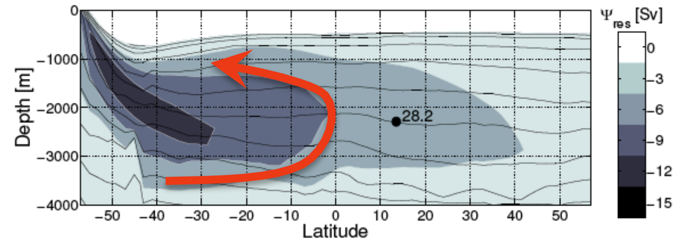
- Total mixing-driven upwelling (balancing the formation of AABW) is a residual between *downwelling* in the stratified ocean interior and stronger *upwelling* in bottom boundary layers

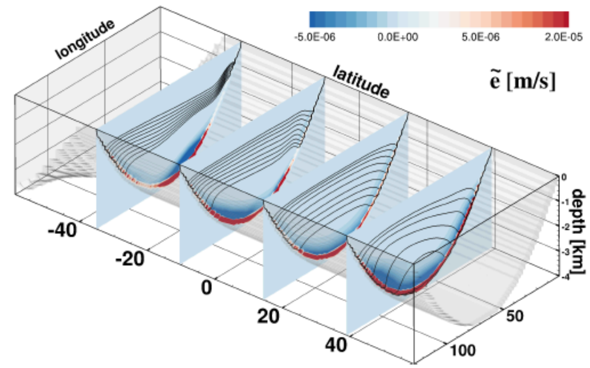


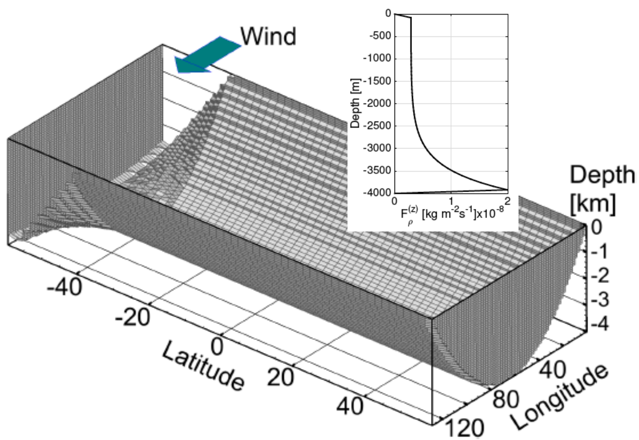
Ferrari et al. (2016), *JPO*

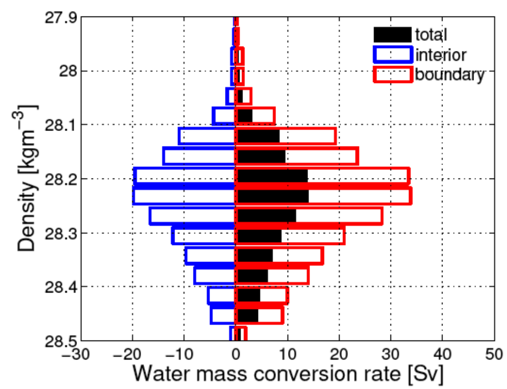
Idealised model results

- Coarse-resolution ocean MITgcm with a prescribed turbulent buoyancy flux, $\overline{w'b'}(z)$, instead of diapycnal diffusivity, $\kappa_v(z)$
- Produces usual overturning circulation, but with downwelling in the interior and upwelling along boundaries









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Ferrari et al. (2016), *JPO*

Summary

– Total upwelling of abyssal dense waters is a residual between *downwelling* in the ocean interior and stronger *upwelling* along boundary layers, unlike "Abyssal Recipes" by Munk (1966)

– This mixing-driven overturning circulation has implications for the *horizontal* abyssal circulation (e.g. Stommel, 1958) as well as for *distribution* and *ventilation* of tracers in the deep ocean

– While global models are invaluable for our understanding of oceans and climate, some aspects of the model solution can be *built-in* by our parameterizations and might be *unphysical* until proper parameterizations are developed and implemented (e.g. Deacon cell in the 90s!)

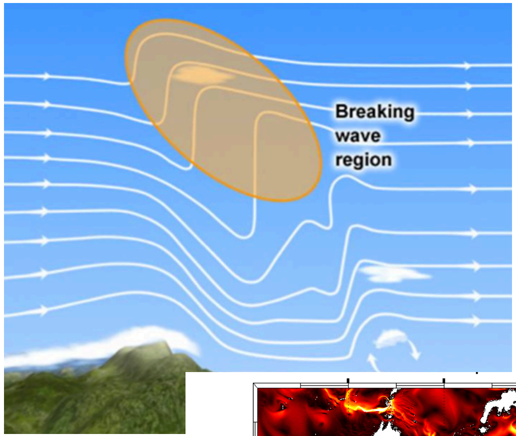
References:
Ferrari, R., A. Mashayek, T. McDougall, M. Nikurashin, and J. M. Campin: Turning ocean mixing upside down, Journal of Physical Oceanography, published online 27 April, 2016
de Lavergne, C., G. Madec, J. Le Sommer, G. A. J. Nurser, and A. C. Naveira Garabato, 2016: On the consumption of Antarctic Bottom Water in the abyssal ocean. Journal of Physical Oceanography, 46, 635–661.

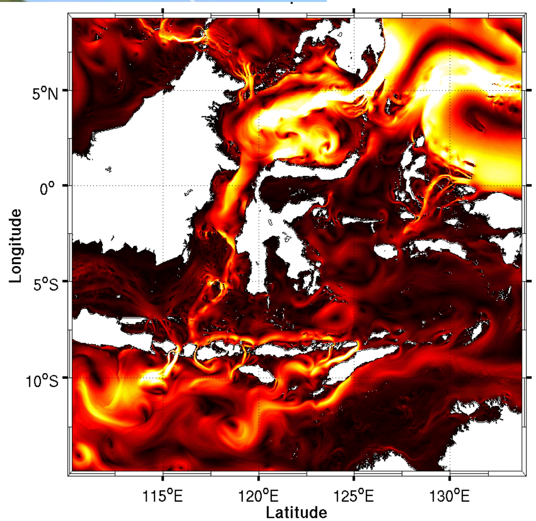
Ongoing PhD projects

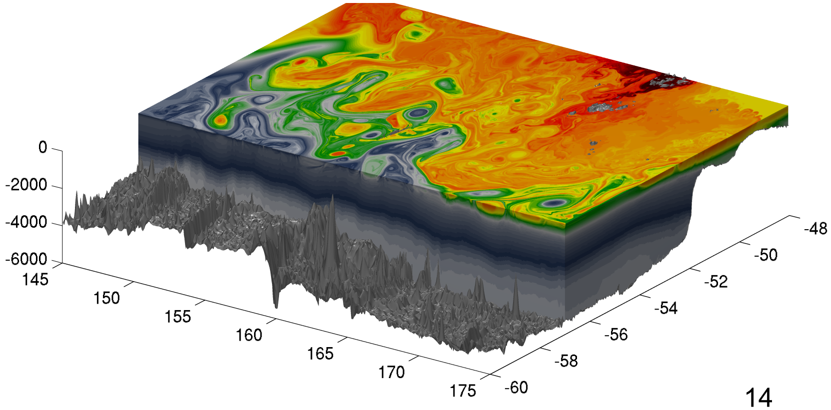
– **PhD Luwei Yang**, The role of *wave momentum stresses* for the equilibration of the ACC fronts and eddies and for the ACC/MOC sensitivity to winds.

– **PhD Ana Berger**, Volume and heat transports of the Indonesian Throughflow and their partitioning across main outflows into the Indian Ocean; Possible implications for the western Australia boundary current system.

– **PhD Andrea Cranenburgh**, ARC DP "How does topography break the ACC?" The role of standing meander in Macquarie Ridge region for the ACC sensitivity to winds.







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