Danish National Research Foundation

CENTRE FOR ICE AND CLIMATE

Mechanical Energy Constraints for Climate

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with Alford, Eden, Large, Lindsay, Potemra, Small

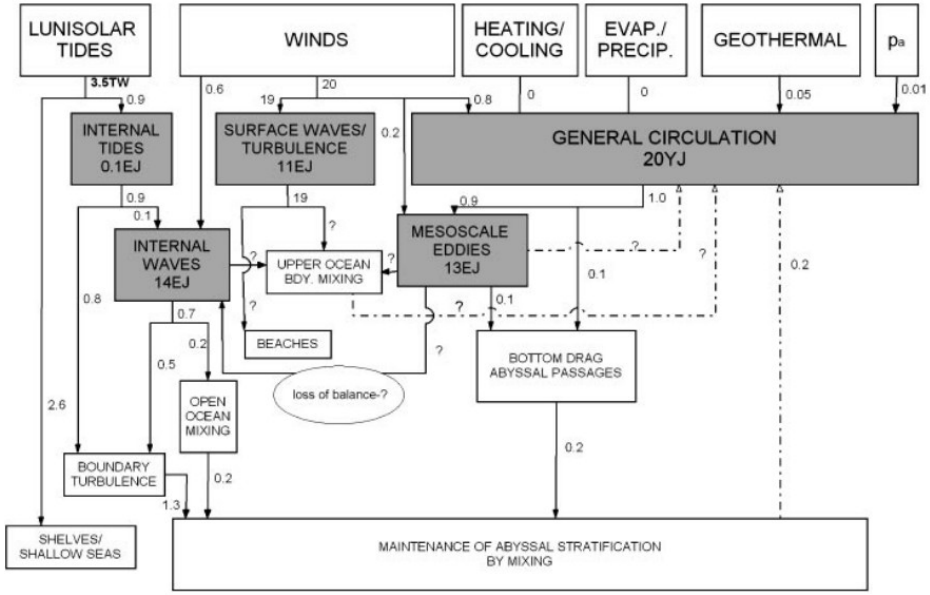
- using GCMs to connect theory & observations of diapycnal mixing with climate

- relevant magnitudes

- what does it NOT matter for?
  (AMOC)

- where does it matter?
  (tropical upper ocean)

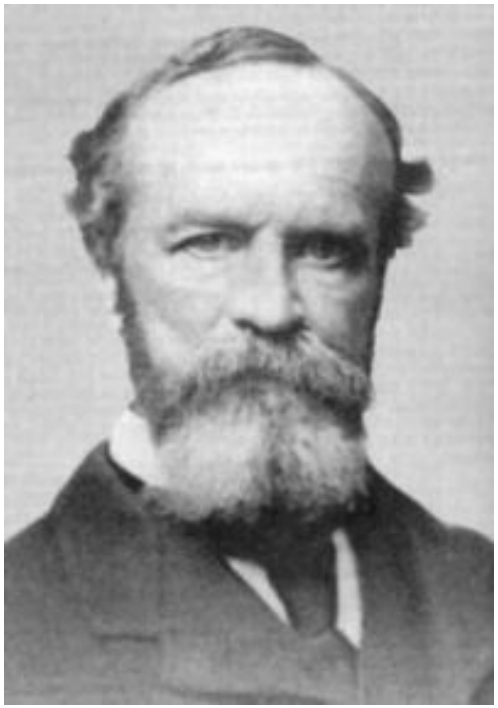
All shown model results are multidecadal averages based on fully coupled CCSM integrations



Wunsch & Ferrari 2004

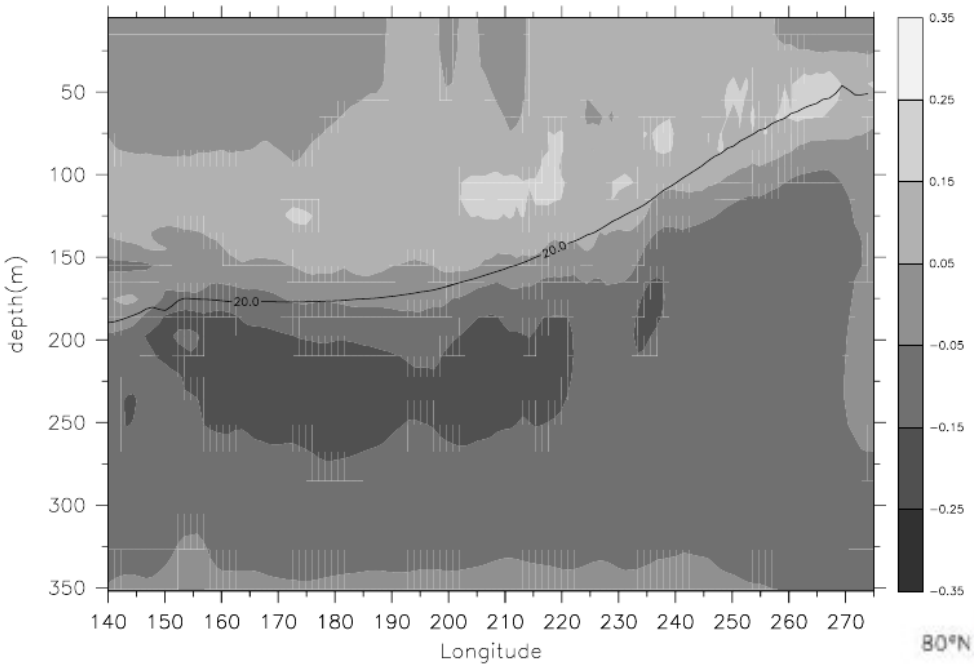
A Pragmatic Approach

A belief is true, if in the long run it works for all of us, and guides us expeditiously through our semihospitable world.



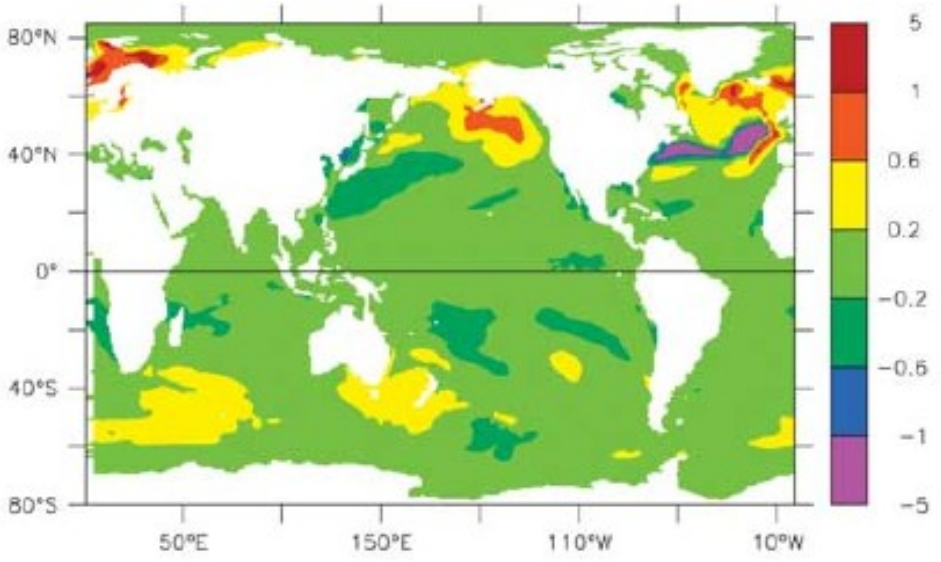
William James

Relevant Magnitudes



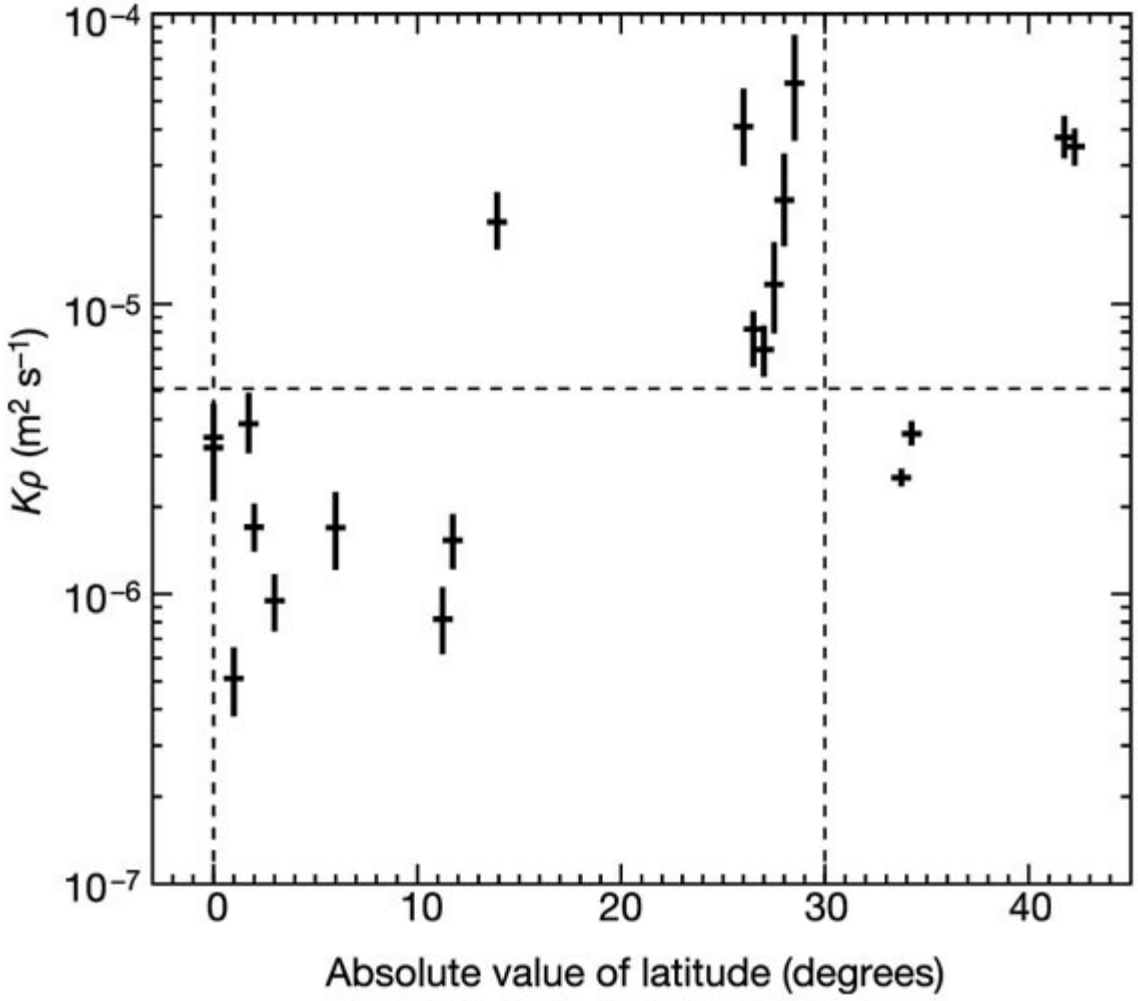
Difference in equatorial temperature after reducing diffusivity from 0.03 to 0.01 cm2/s

Difference in SST after increasing diffusivity from 0.1 to 0.17 cm2/s



In today's OGCMs, spurious diapycnal mixing is much smaller than observational uncertainty!

Relevant Magnitudes



Gregg et al. 2003

Relevant Magnitudes

How do we constrain the diffusivity (κ)?

- inverse modelling or water mass budget (Munk, Walin, Gordon)

- microstructure measurements (Alford, Dengler, Gregg, Polzin, Rhein)

- tracer release (Ledwell, Watson & Law)

- adjoint techniques (Wunsch, Stammer)

- energy sources/sinks (Munk, Wunsch)

Davies (1994ab): You will never figure it out!

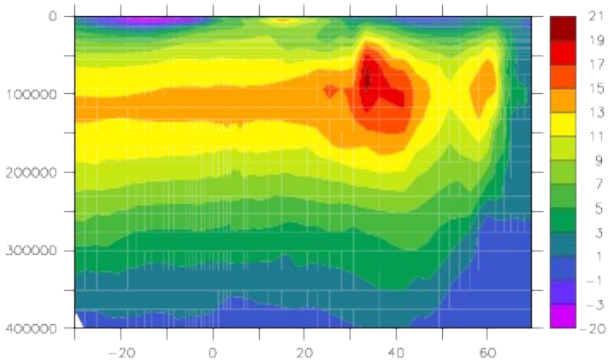
Large scatter, but it appears that for the MOC the details don't seem to matter.

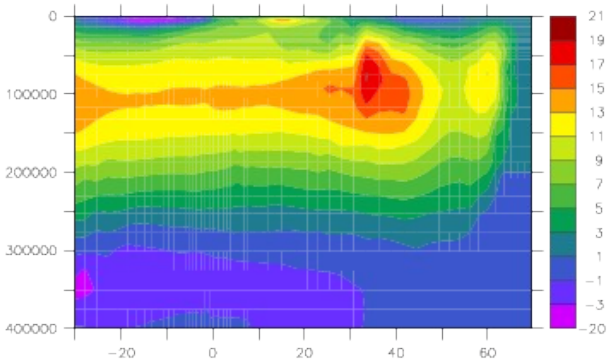
Where does it NOT matter?

Residual AMOC in CCSM

NULL

0.30 TW



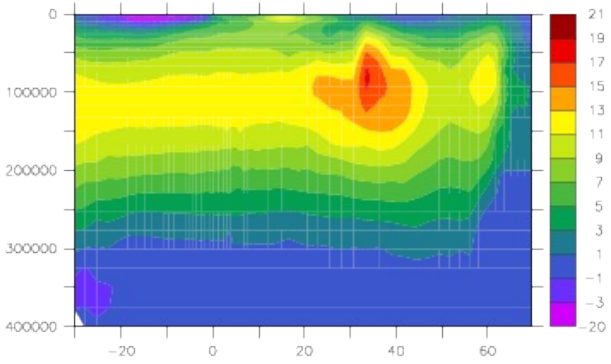


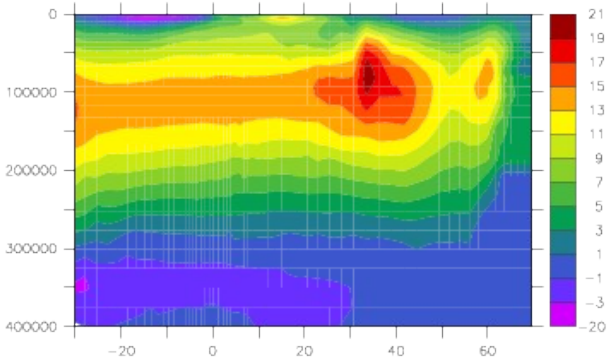
DIFF

0.16 TW

CONT

0.26 TW





TWO

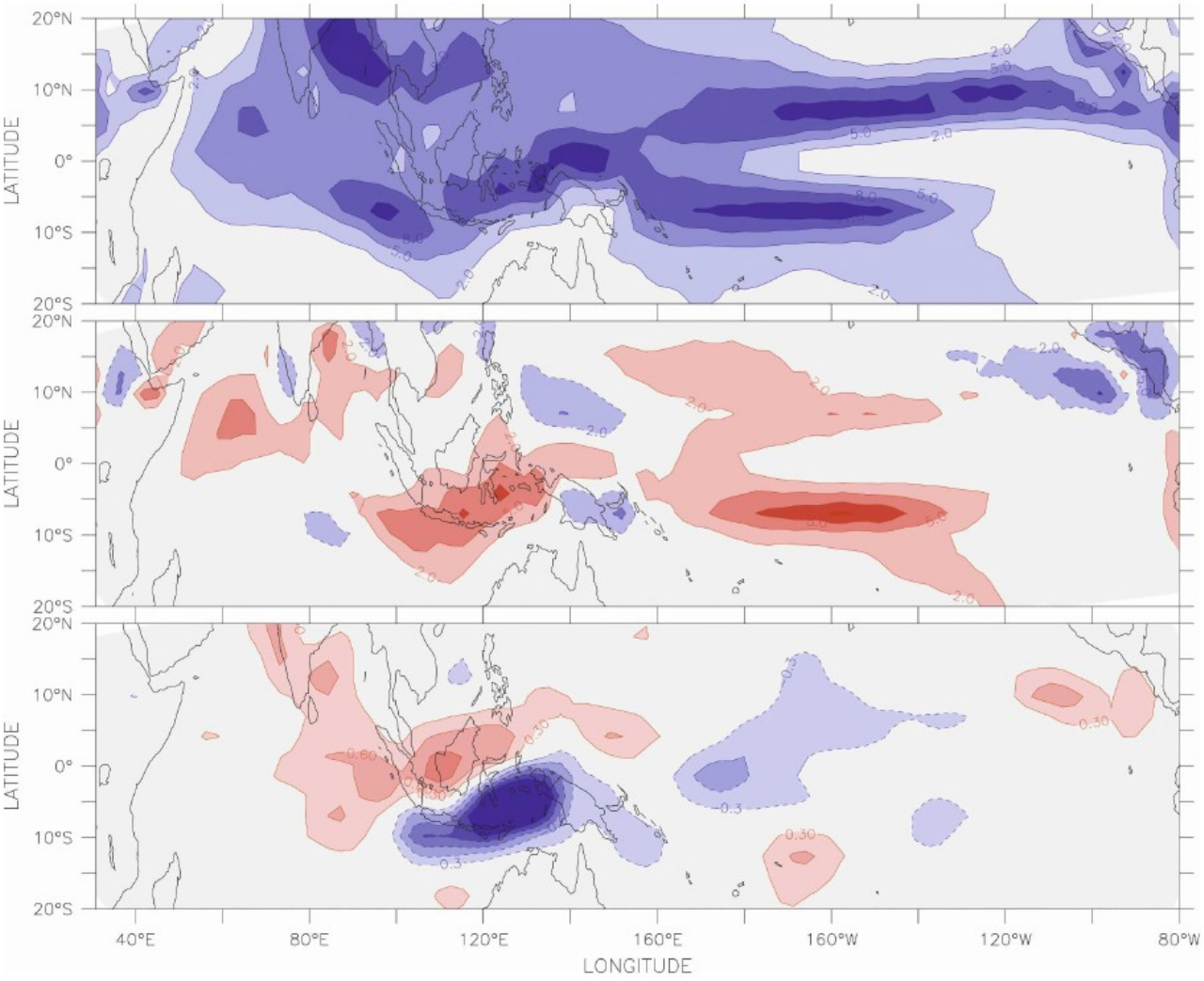
0.29 TW

Where does it matter?

precip in CCSM

bias

change with observed diff. in Banda Sea

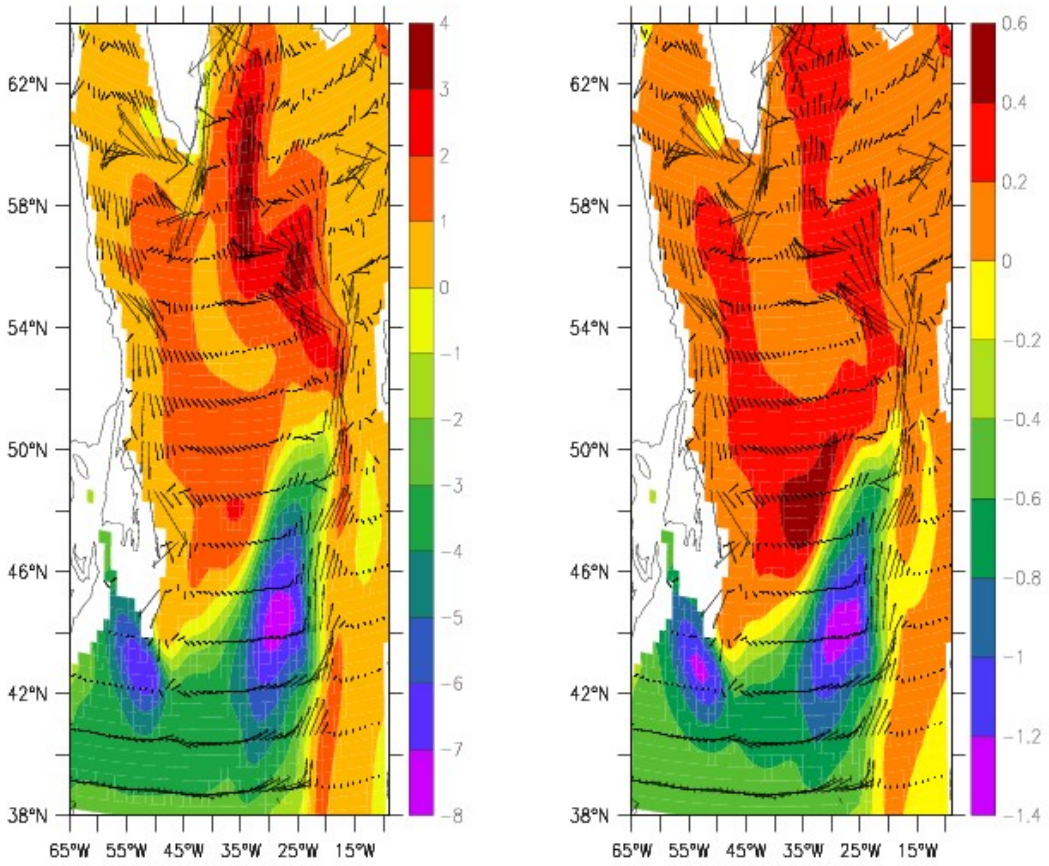


Where does it matter?

The North Atlantic Response

difference in temperature on the 1.028 isopycnal

vectors: velocity in control on the same surface

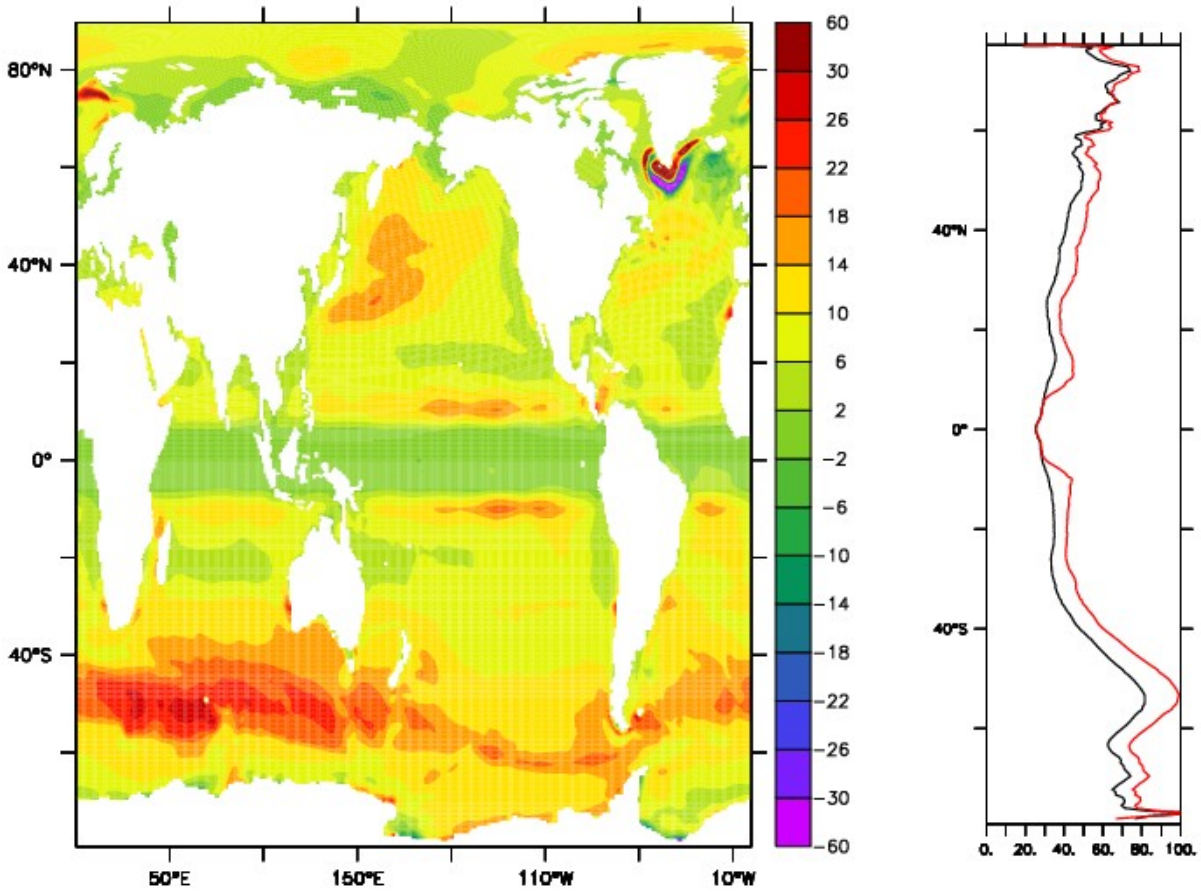


difference in salinity on the 1.028 isopycnal

PSI - control

Where does it matter?

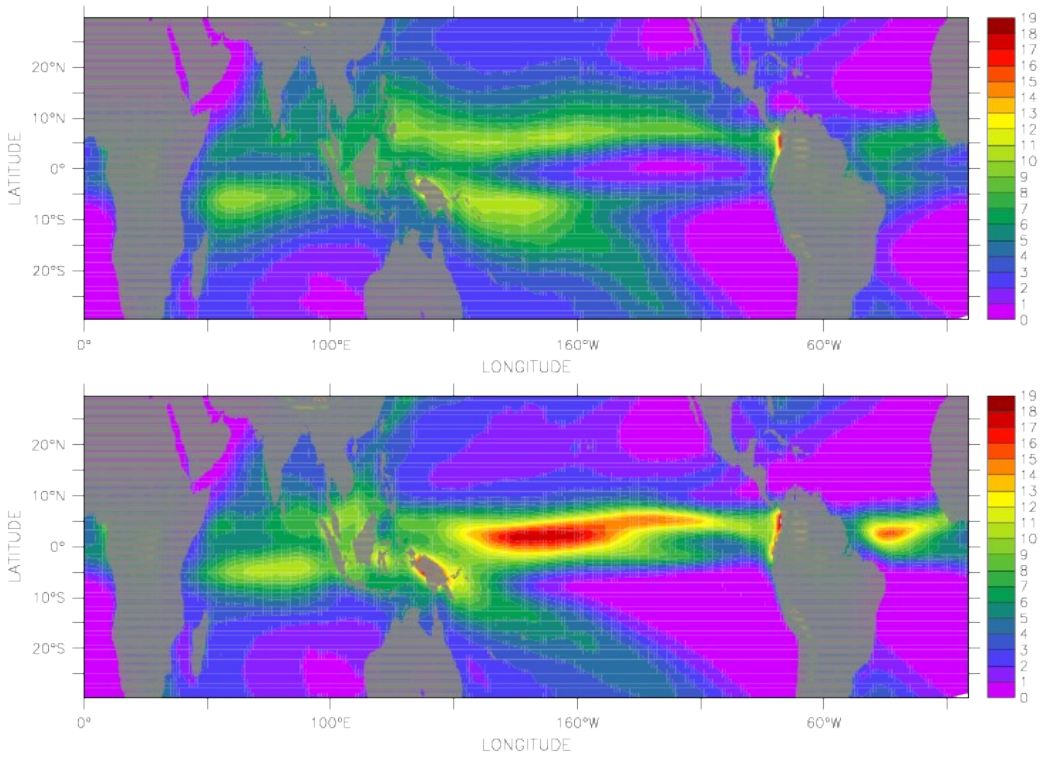
Global impact of Near-Inertial Waves



change in boundary layer depth

Where does it matter?

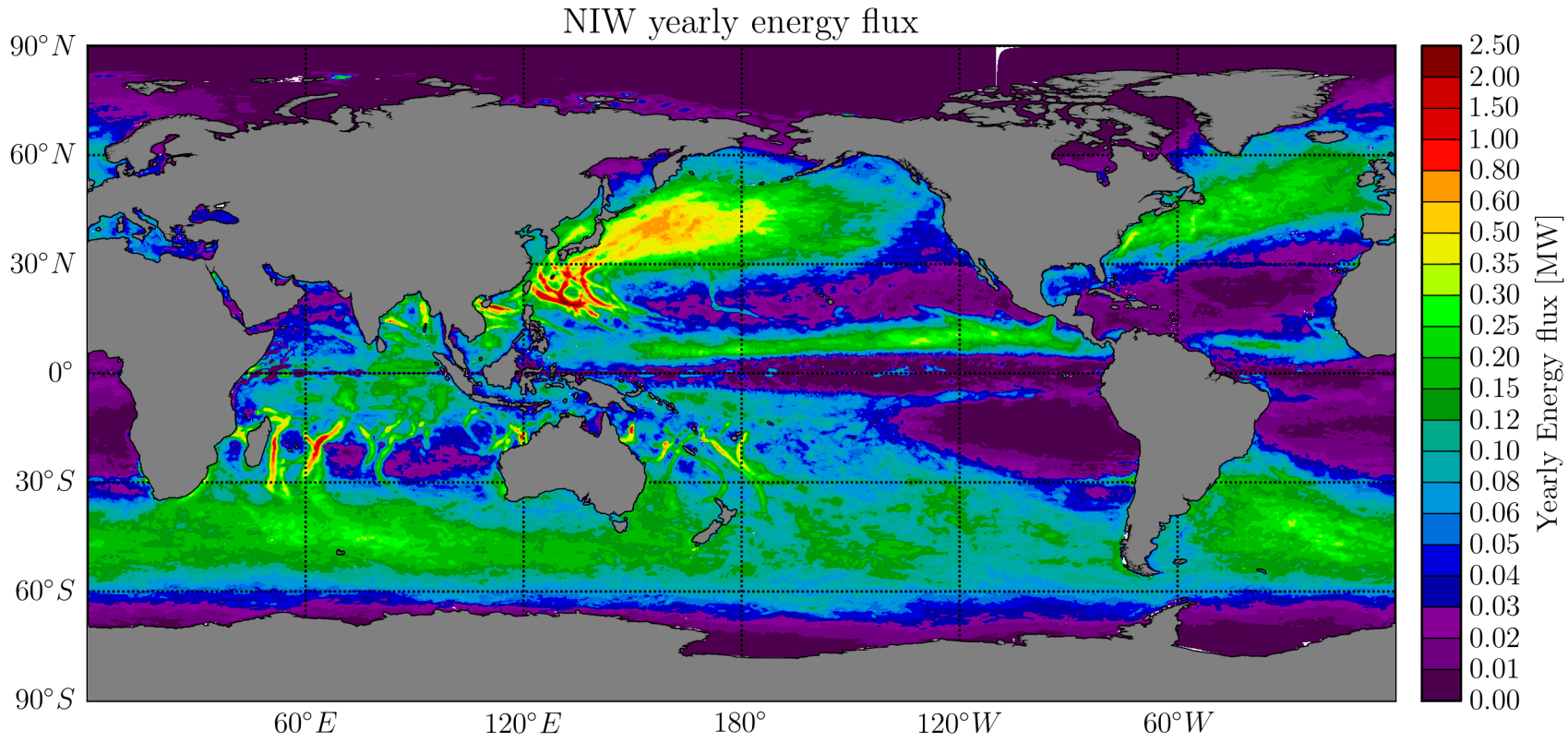
Precipitation in CCSM with NIWs



0.34 TW

0.68 TW

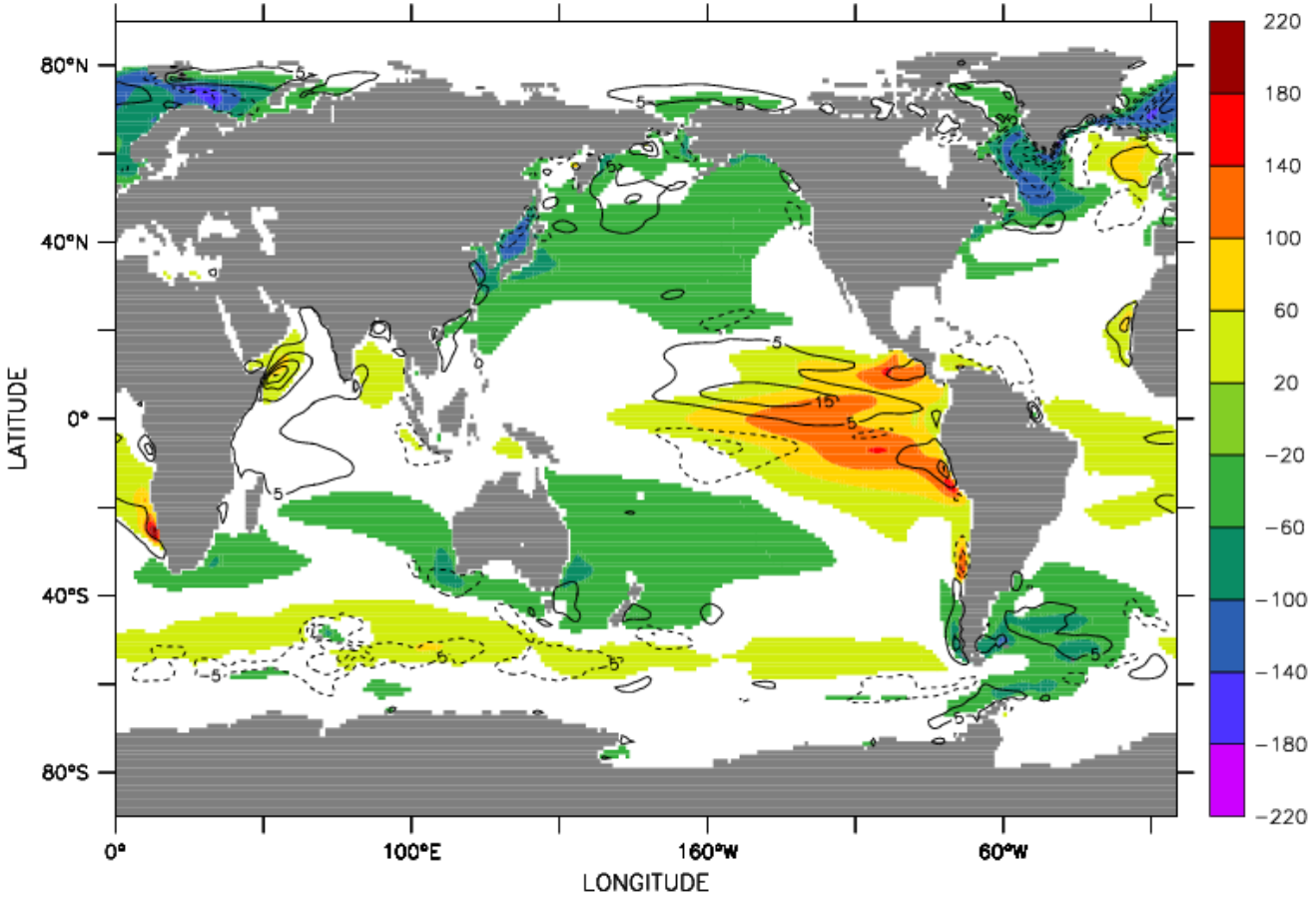
Where does it matter?



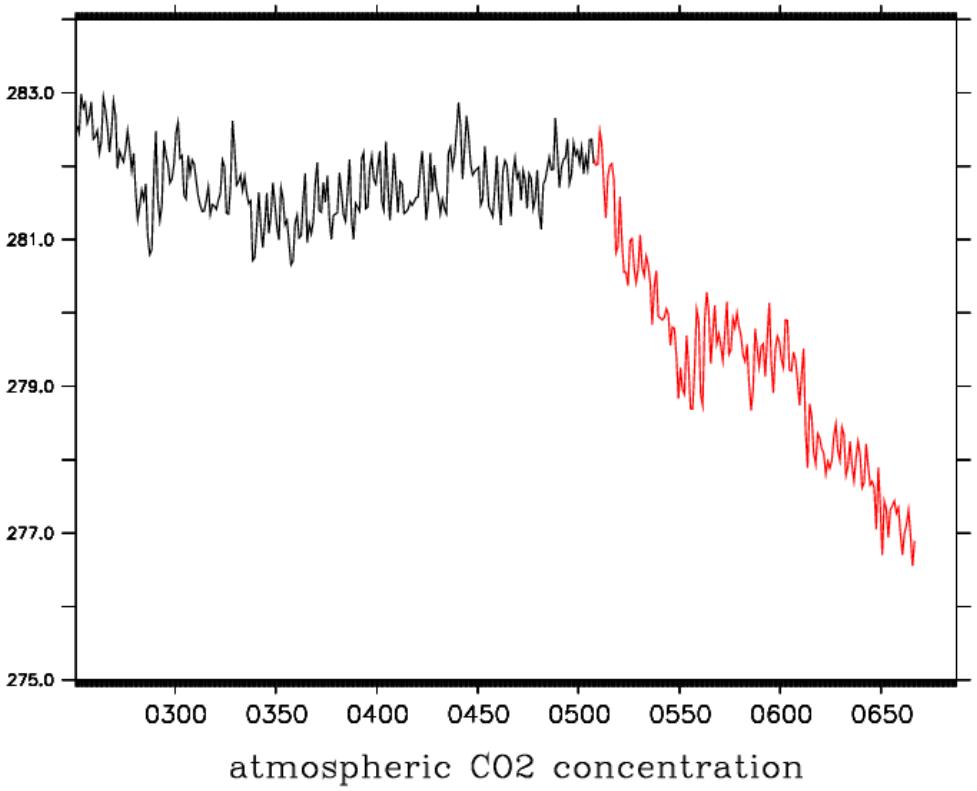
CESM, 0.25 degree AGCM, 0.1 degree OGCM: 0.43 TW

Where does it matter?

color: mean ocean to atmosphere carbon fluxes in control
contour lines: OP115-CONT; solid lines indicate
atmospheric gain of CO_2 in OP115.



Where does it matter?



Black: inception scenario with standard diffusivity
Red: inception scenario with 20% reduced diffusivity

Conclusions

- observational uncertainties in diffusivity are much larger than the ones resulting from spurious diapycnal mixing

- we cannot constrain the AMOC through mechanical energy considerations

- in the thermocline diapycnal mixing matters enormously, but cannot be constrained sufficiently by observations

- for the mixed layer we need better information about winds on small spatial and temporal scales

- the way forward seems to be better parameterizations of diffusivities informed by process studies in the tropical thermocline