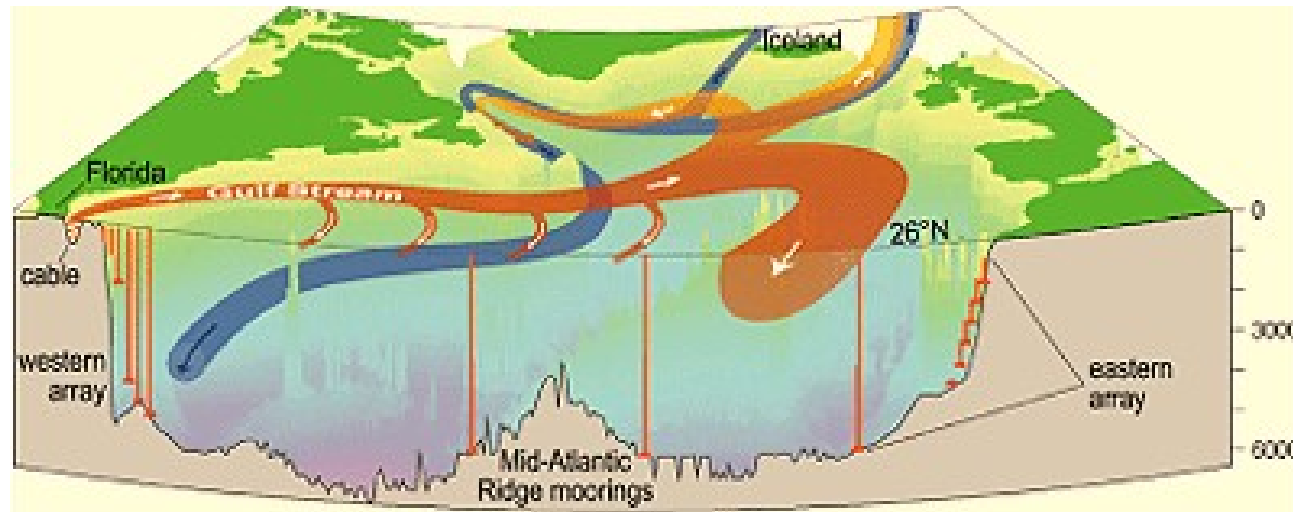


# Southern Ocean Winds, Diapycnal Diffusion and the Atlantic Meridional Overturning

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# Overview

- diapycnal diffusivity
- Southern Ocean winds & eddies
- a theory for everything
- ... and GCM against all
- Conclusions



Tropen Sonne, Nolde

# Some Background

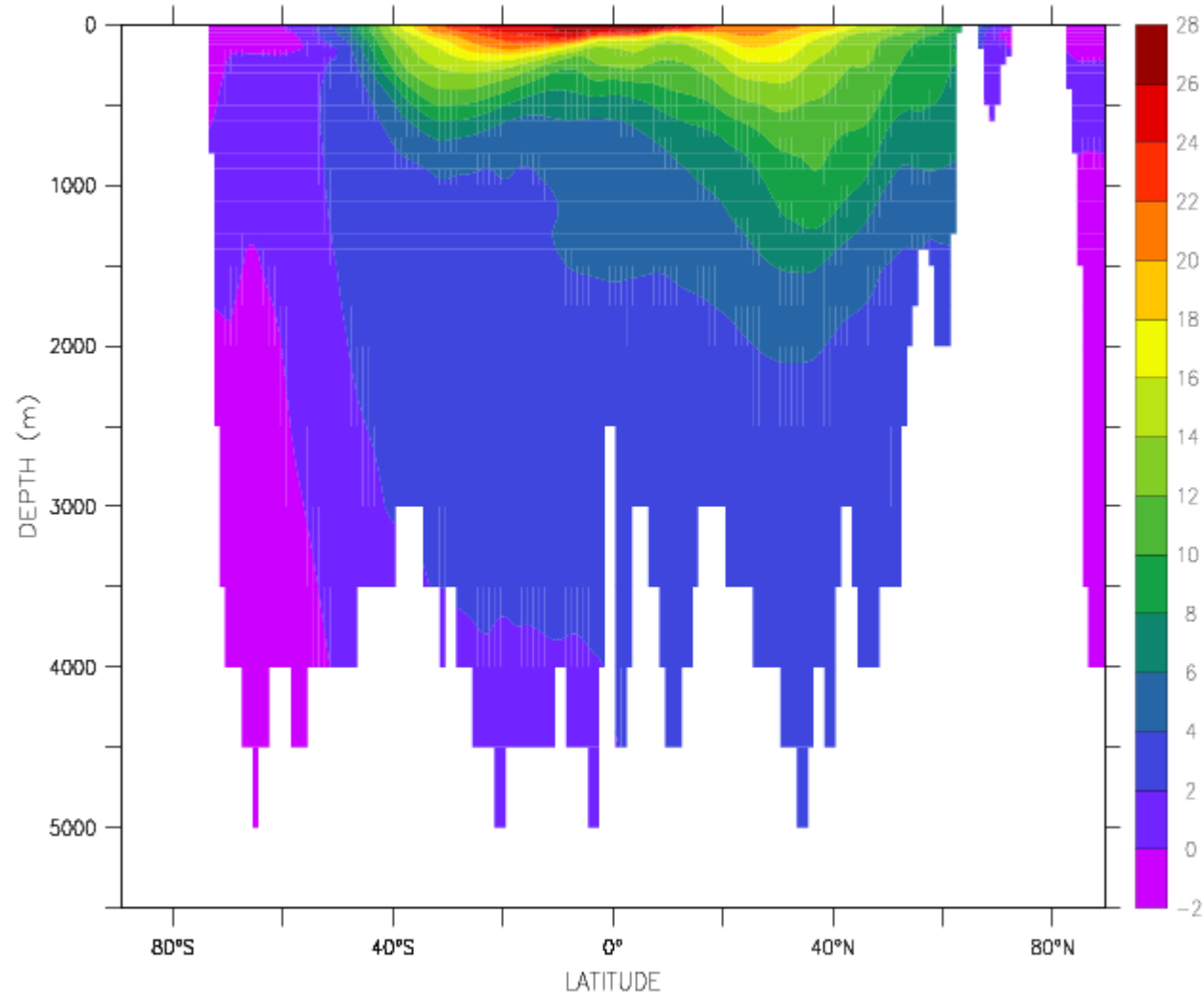
Sandstroem (1908): heating and cooling on same geopotential

Jeffrey (1925): turbulence mixes heat downward

Munk (1966): downward diffusion is balanced by abyssal upwelling

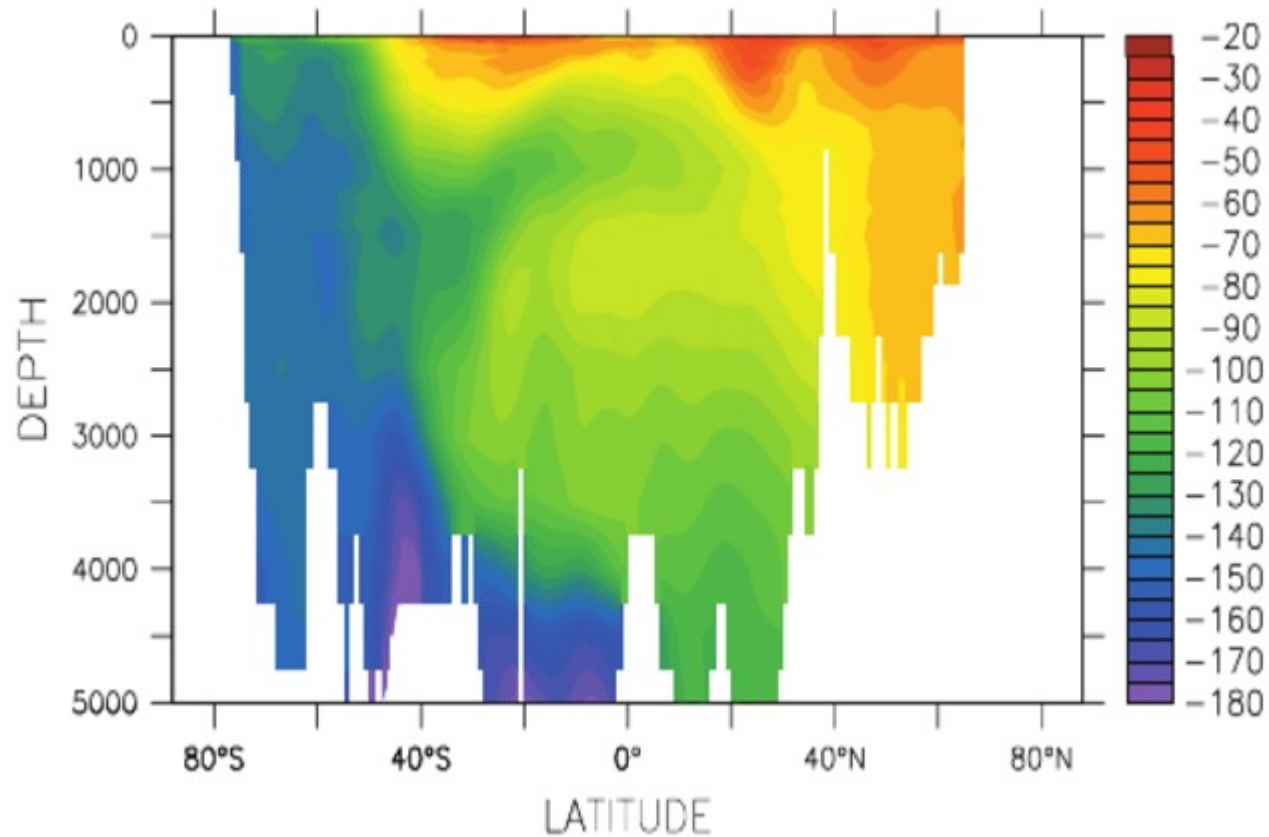
Munk and Wunsch (1998): Where does all the energy come from?

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

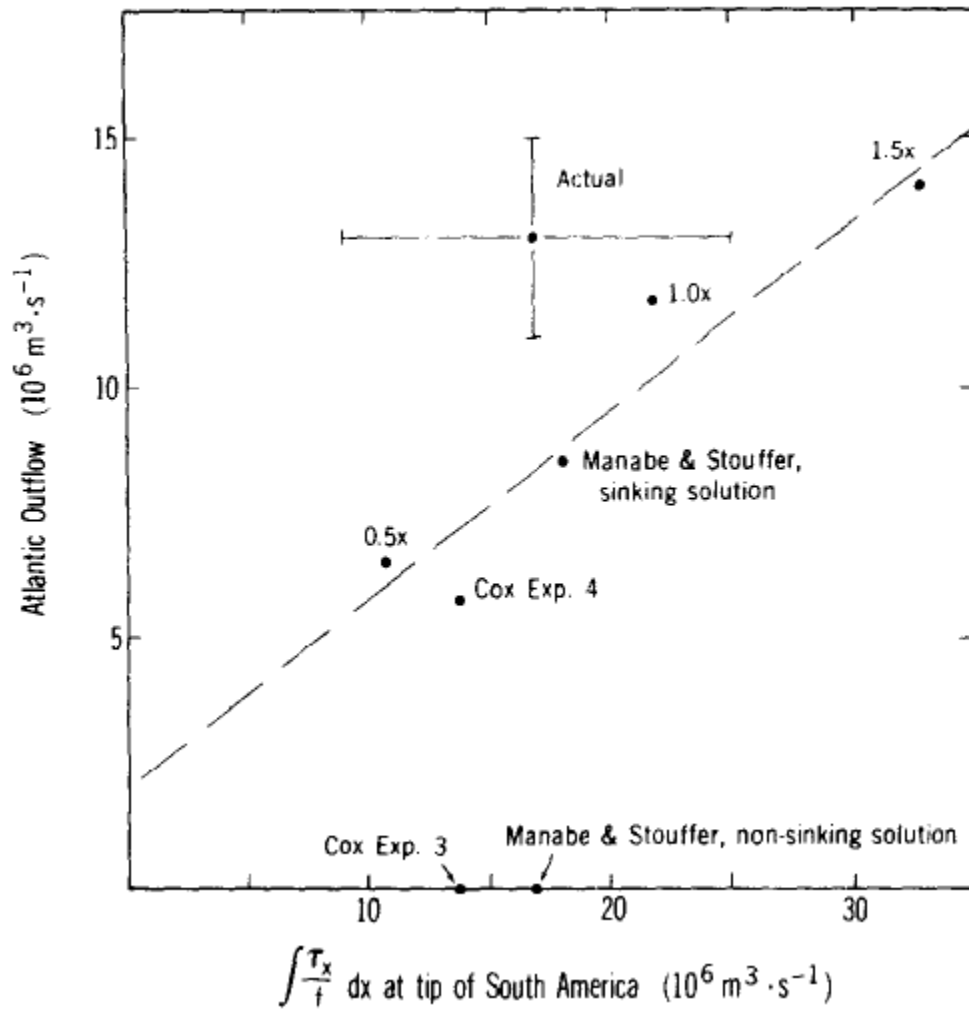
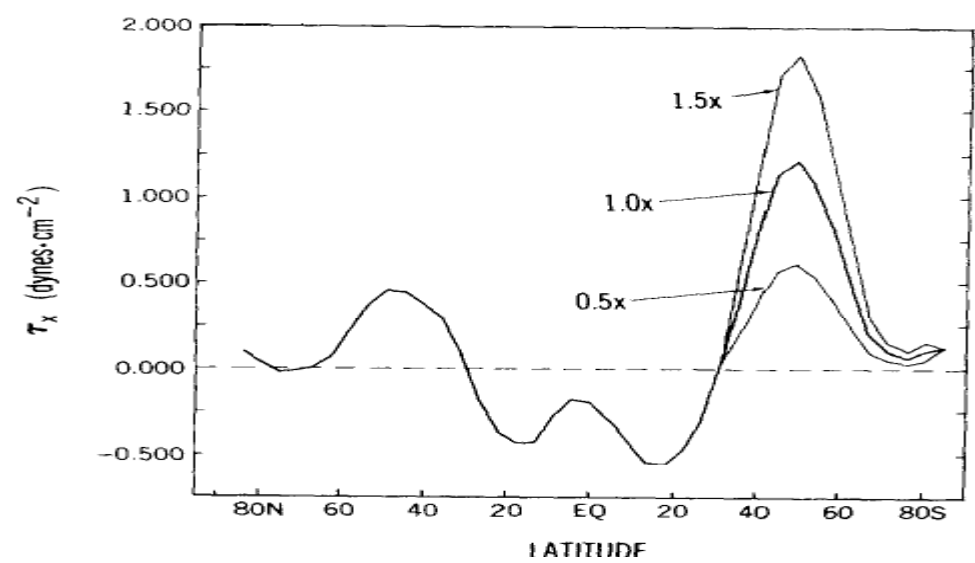


observed temperature at 20W (Levitus)

# Toggweiler and Samuels, 1995: a fresh start

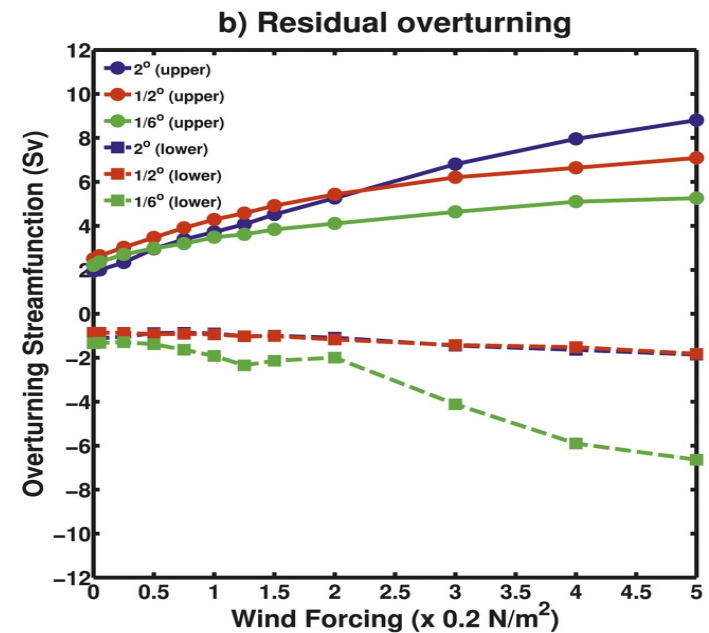
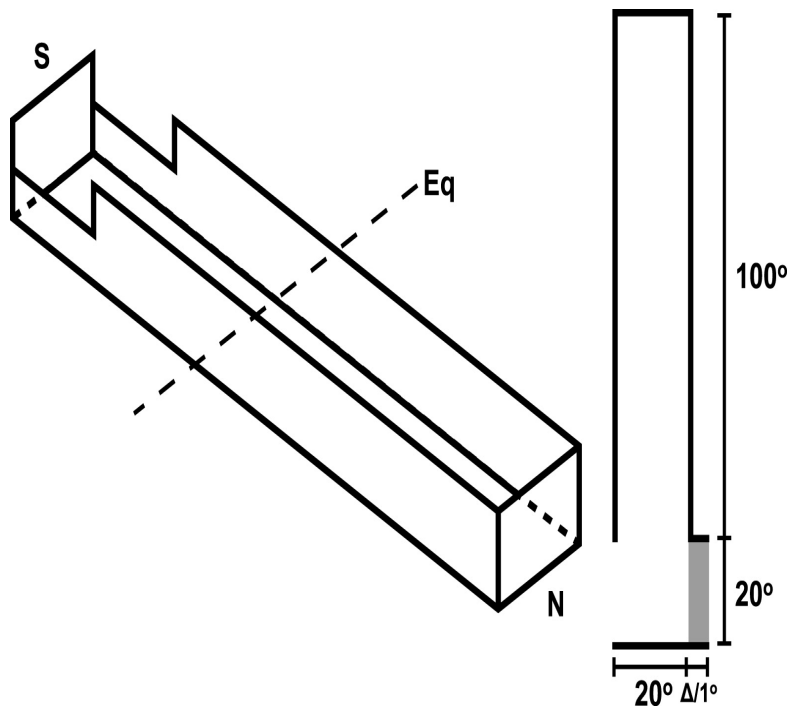


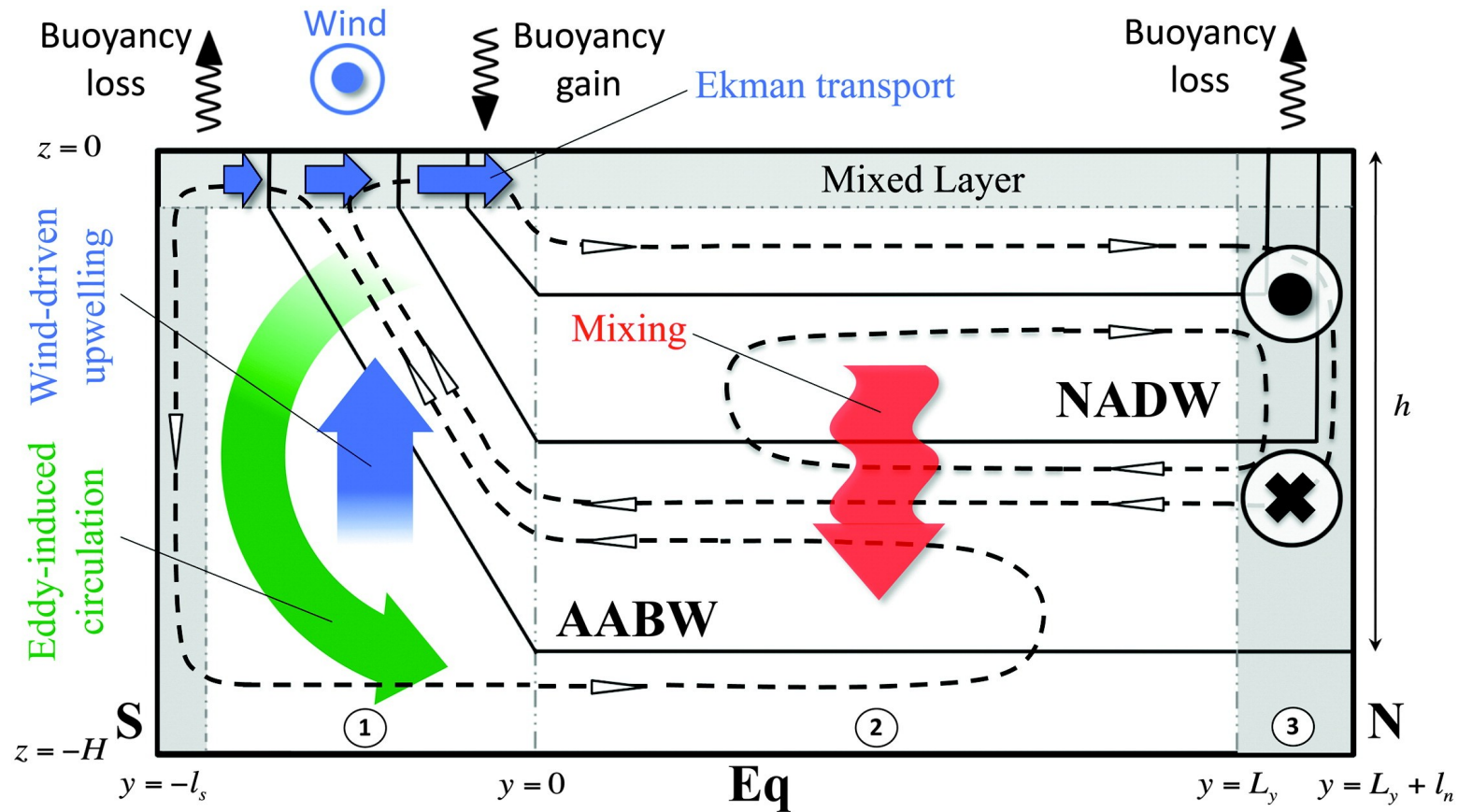
Radiocarbon along 28W (Key et al. 2004, based on WOCE)



AMOC  $\sim$  SO winds

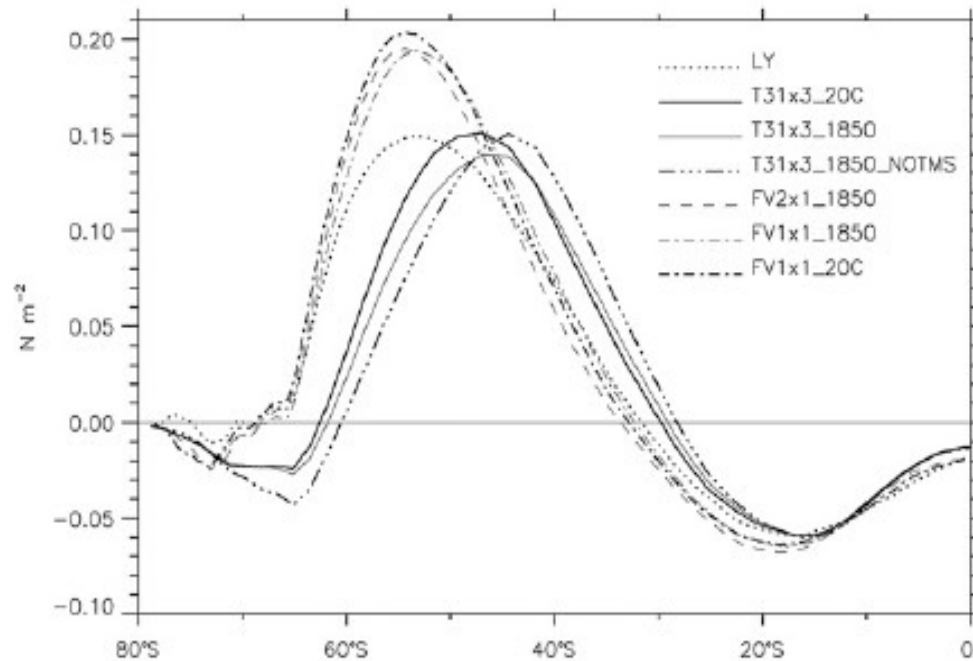
# Real Oceanographers, Real Eddies: Munday, Johnson and Marshall, 2013





$$\frac{\Delta b h^2}{f_3} - \left( \frac{\tau_0}{\rho_0 f_1} - K_e \frac{h}{l_s} \right) L_x = \frac{\kappa_v}{h} L_x L_y. \quad (4.4)$$

NADW production – SO upwelling = mixing driven upwelling



Shields et al. 2012

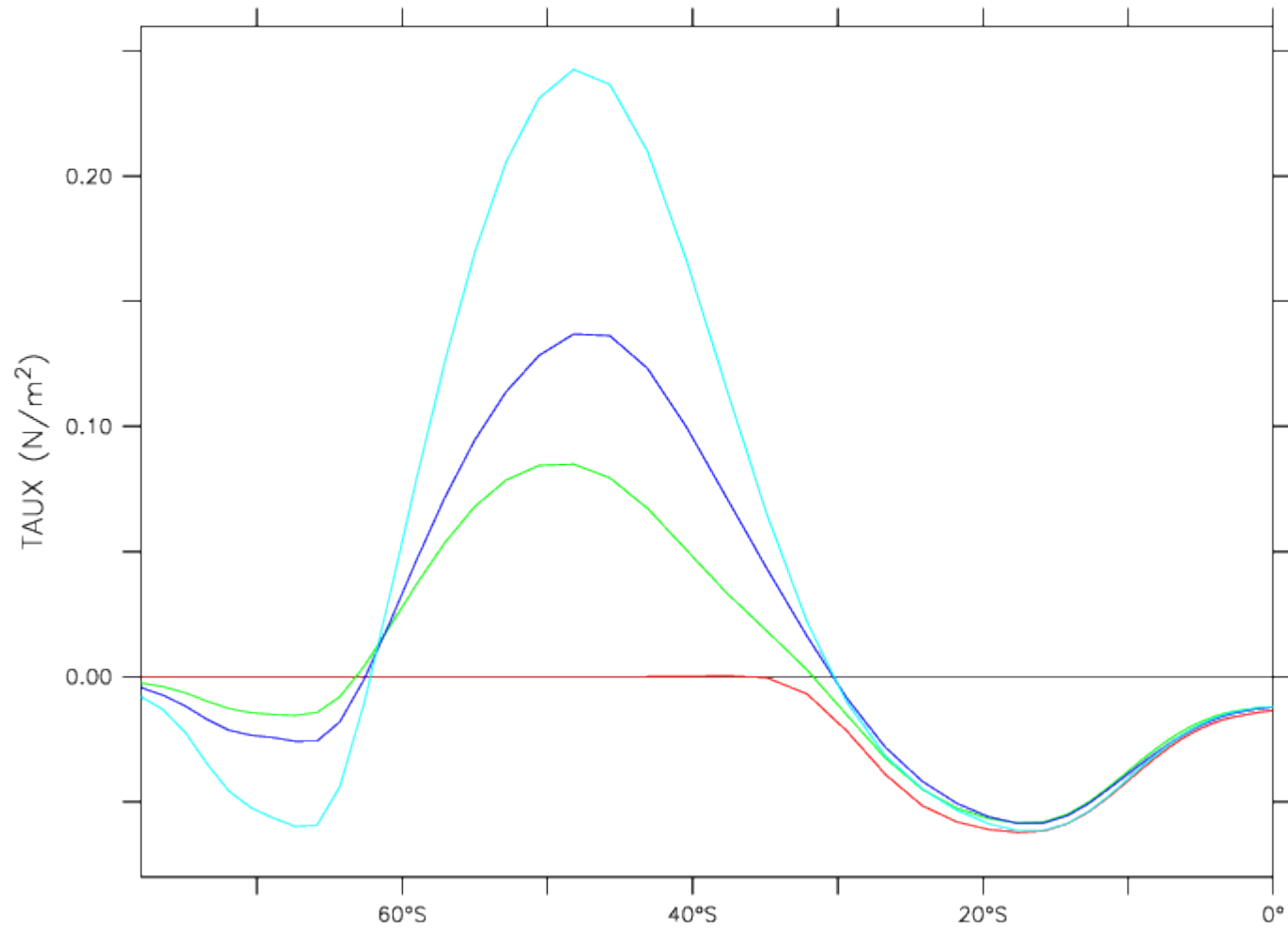
The GCM: CCSM4 in its T31x3 configuration:

3.75 x 3.75 degree, 26 levels in the atmosphere  
 0.6 - 3 degree, 60 levels in the ocean

Danabasoglu & Marshall the Elder (2007) version  
 of stratification dependent isopycnal and thickness  
 diffusion



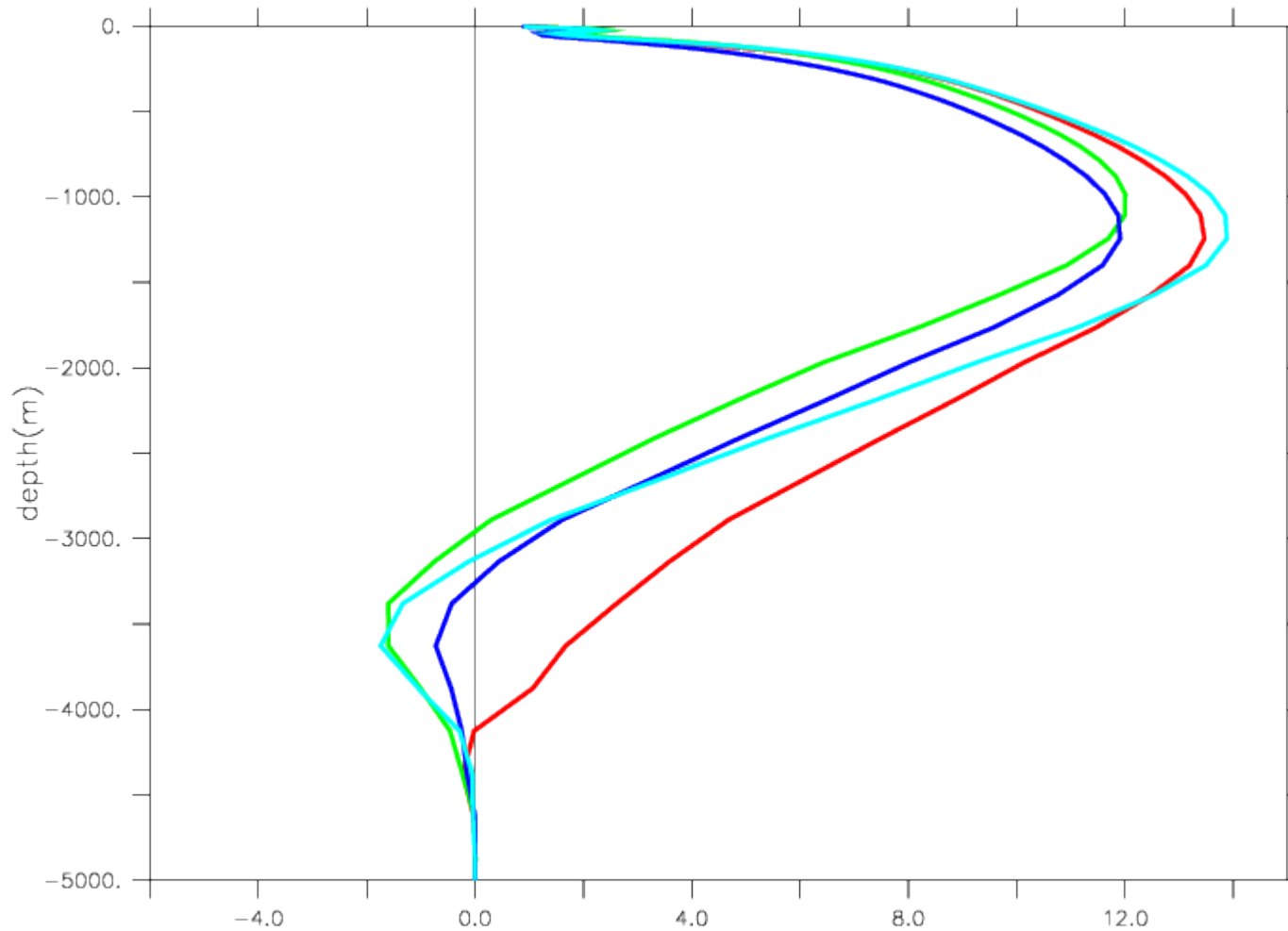
# zonally averaged wind stress



NULL, HALF, CONT, TWO

# AMOC at equator

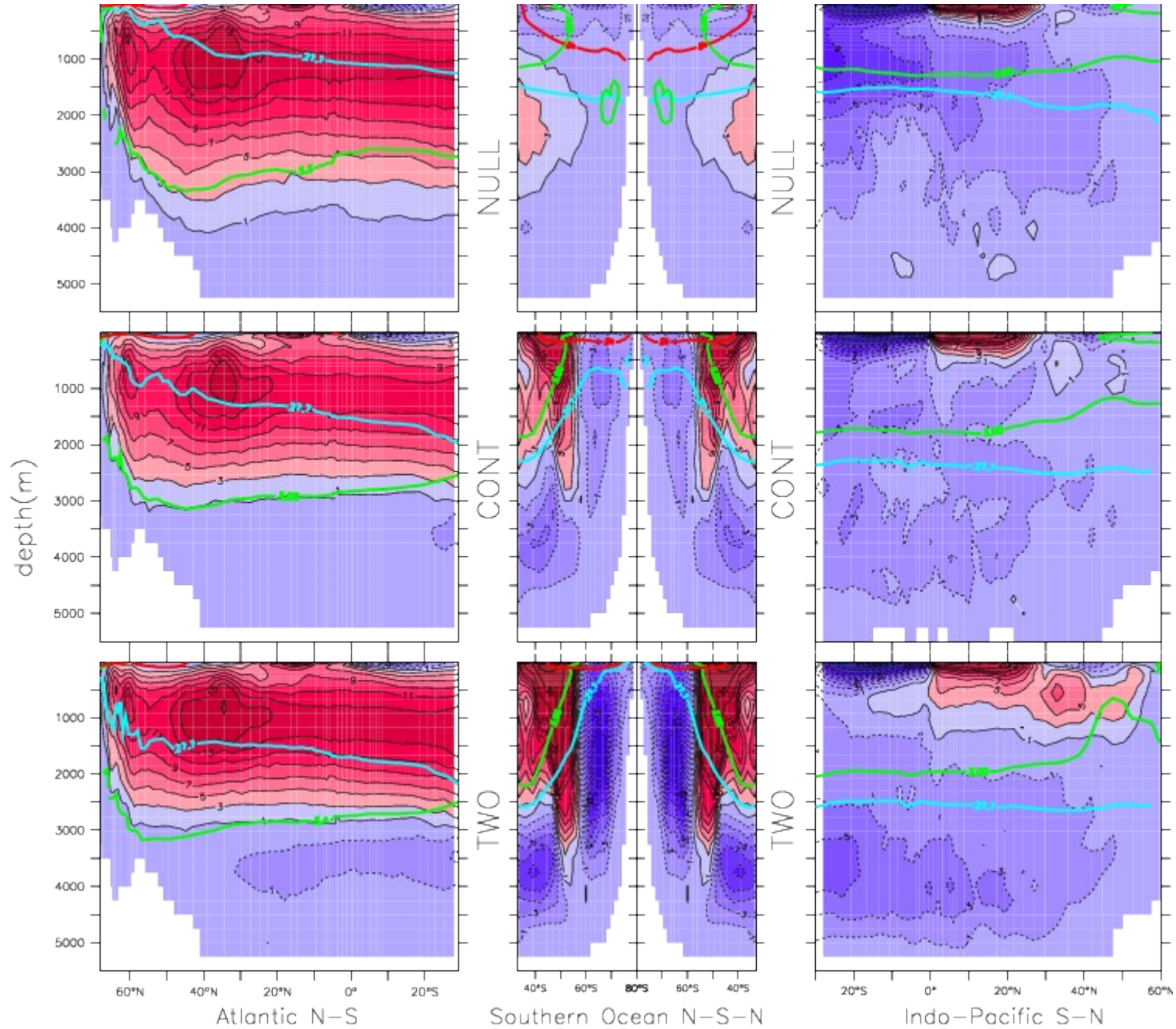
NULL, HALF, CONT, TWO



Exp.	$\tau_{max}$	$AMOC_{eq}$	$Up_{Pacific}$	$SO_{Euler}$	$SO_{eddy}$	$SO_{resid.}$	$\kappa_{GM}$
NULL	0.00	13	9	5	-7	4	500
HALF	0.09	12	7	20	-11	15	570
CONT	0.14	12	3	35	-15	26	610
TWO	0.25	14	1	60	-22	42	700

# Residual Overturning in the various basins

NULL



CONT

TWO

Blue: sigma27; Red: 34.3 psu; Green: 3 C

# Conclusions

- Within realistic parameter ranges the AMOC is mostly independent from ocean turbulence or Southern Ocean winds
- This result has to be corroborated with an eddy resolving GCM, and with a more physical parameterization of diapycnal mixing, or maybe just repeating Munday et al. with a Pacific basin
- ... and, of course, we still have to figure out what the AMOC depends on

