Making AABW Salty with Buoyancy Feedbacks from the North

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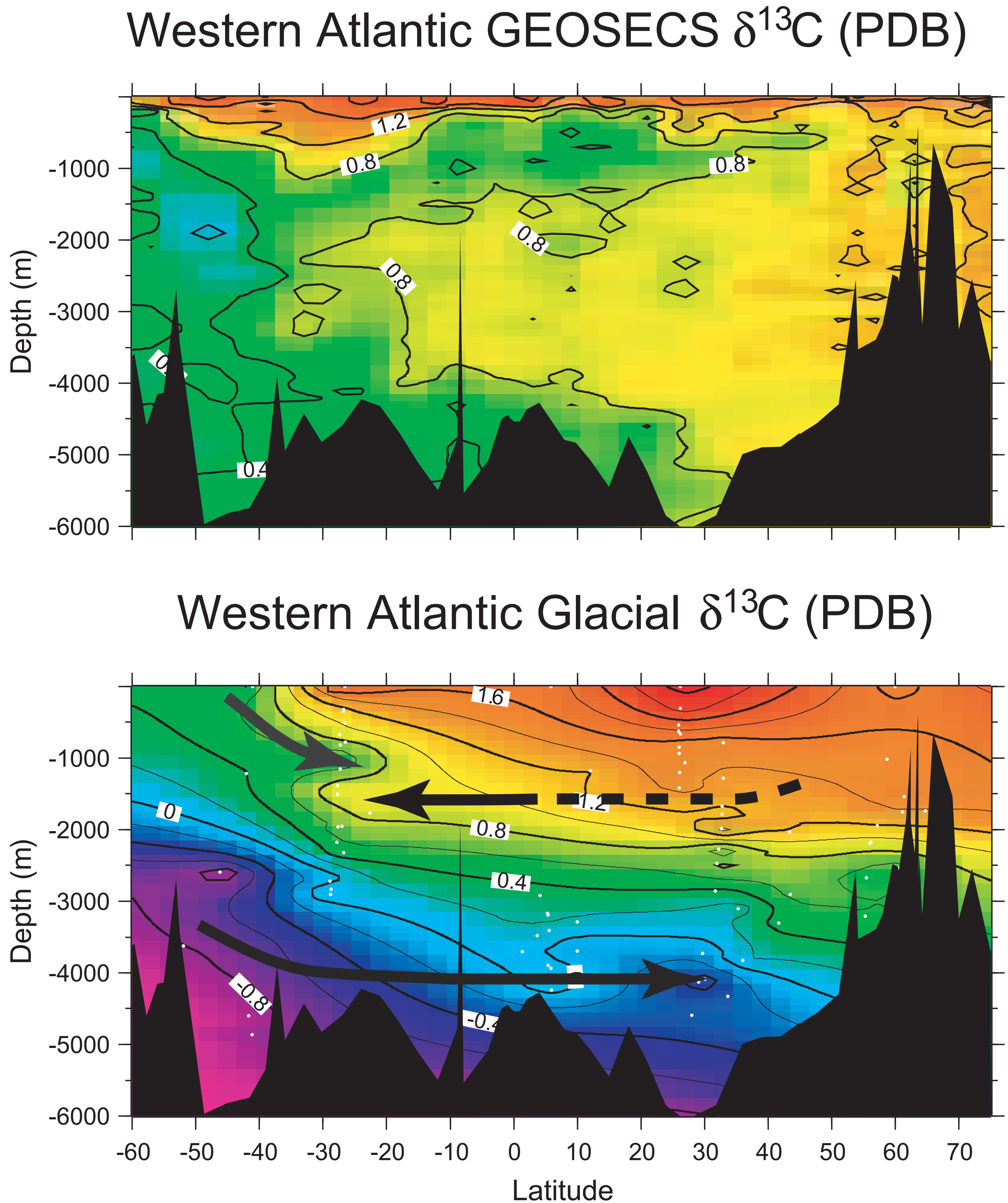
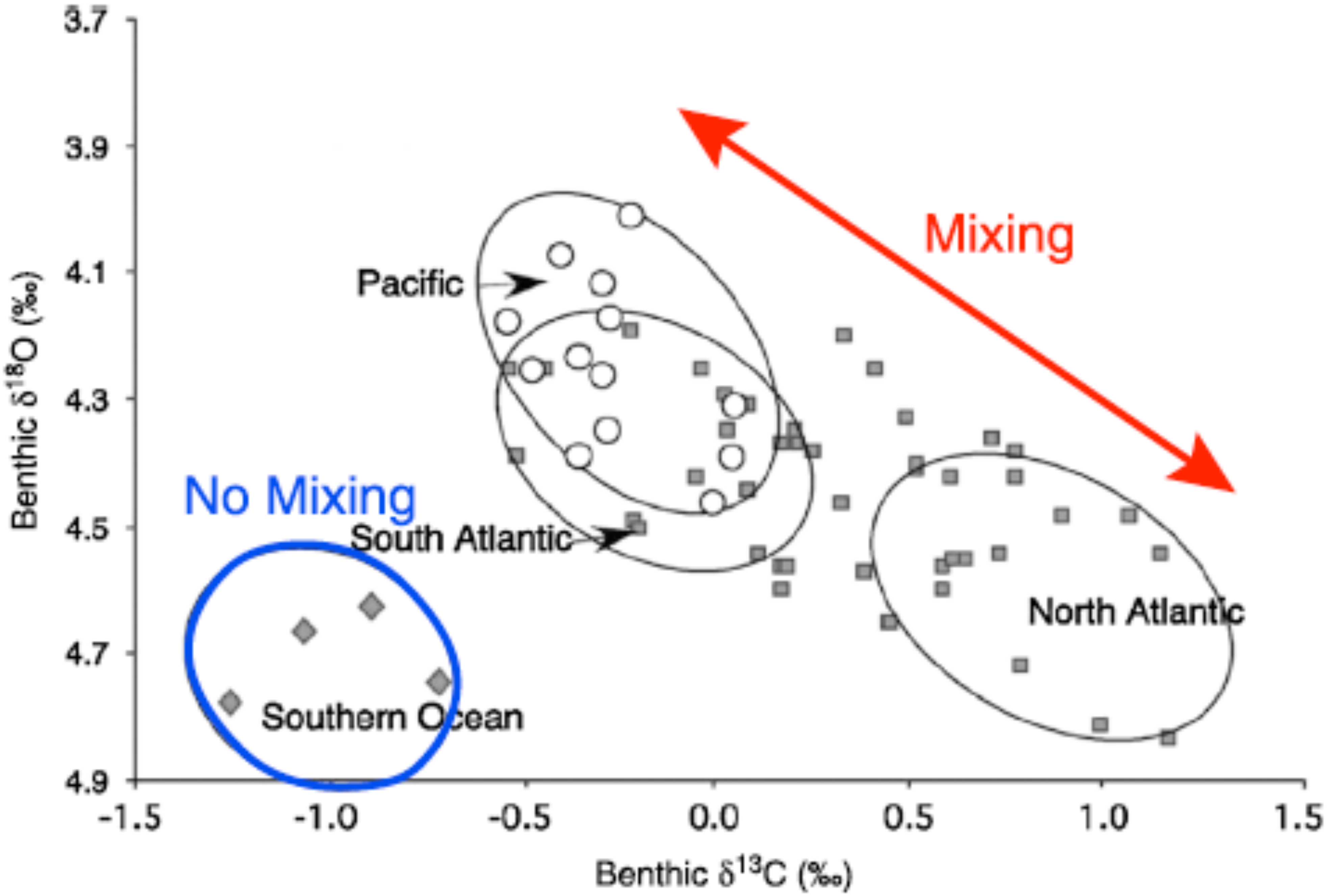


How can we extract the information content from the LGM tracer distribution without over interpreting it?

Curry and Oppo, 2005

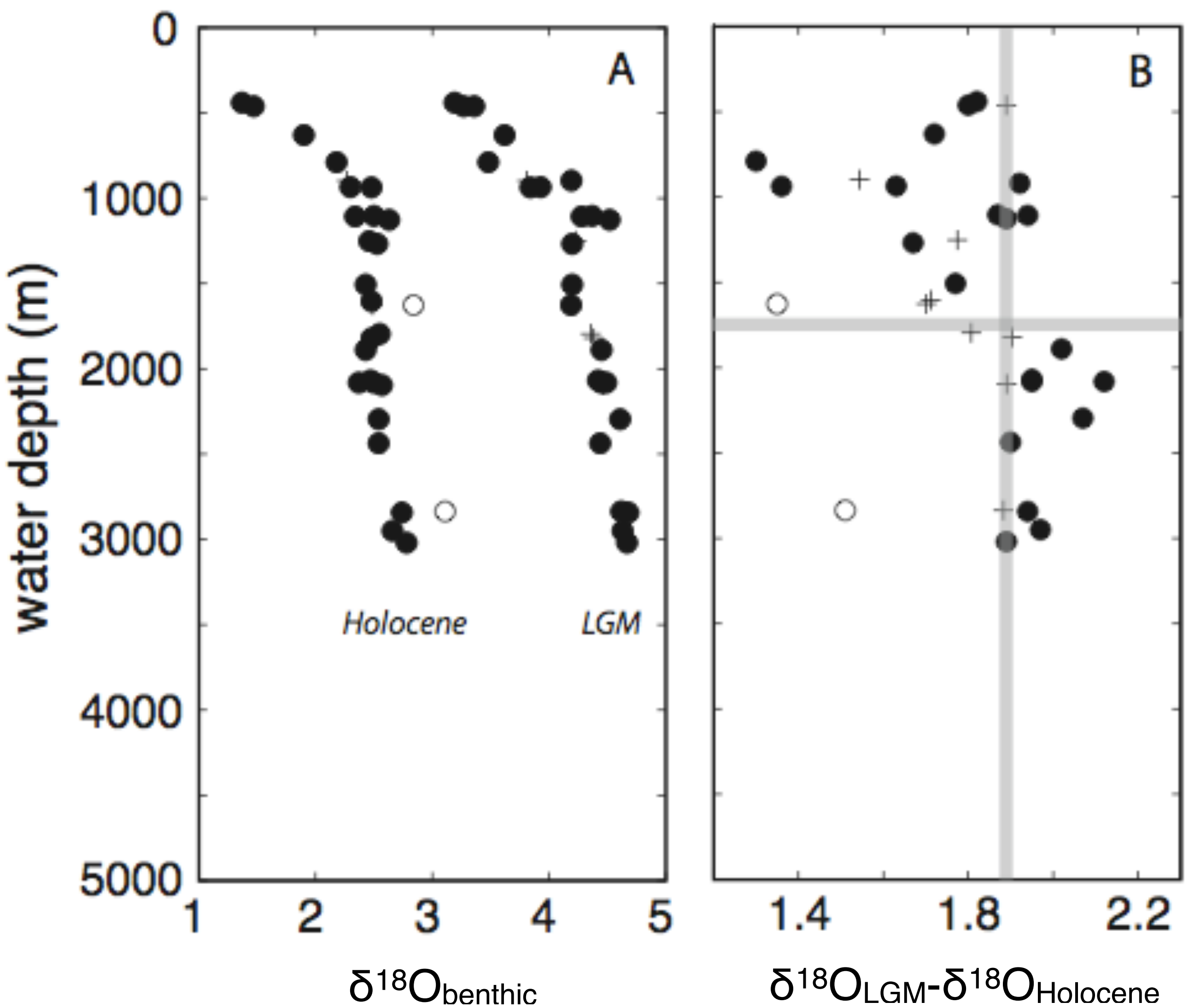
LGM Benthic $\delta^{18}O$ and $\delta^{13}C$ Show 2-Cell Separation



Adkins, 2013, but after:
Duplessey et al., 2002

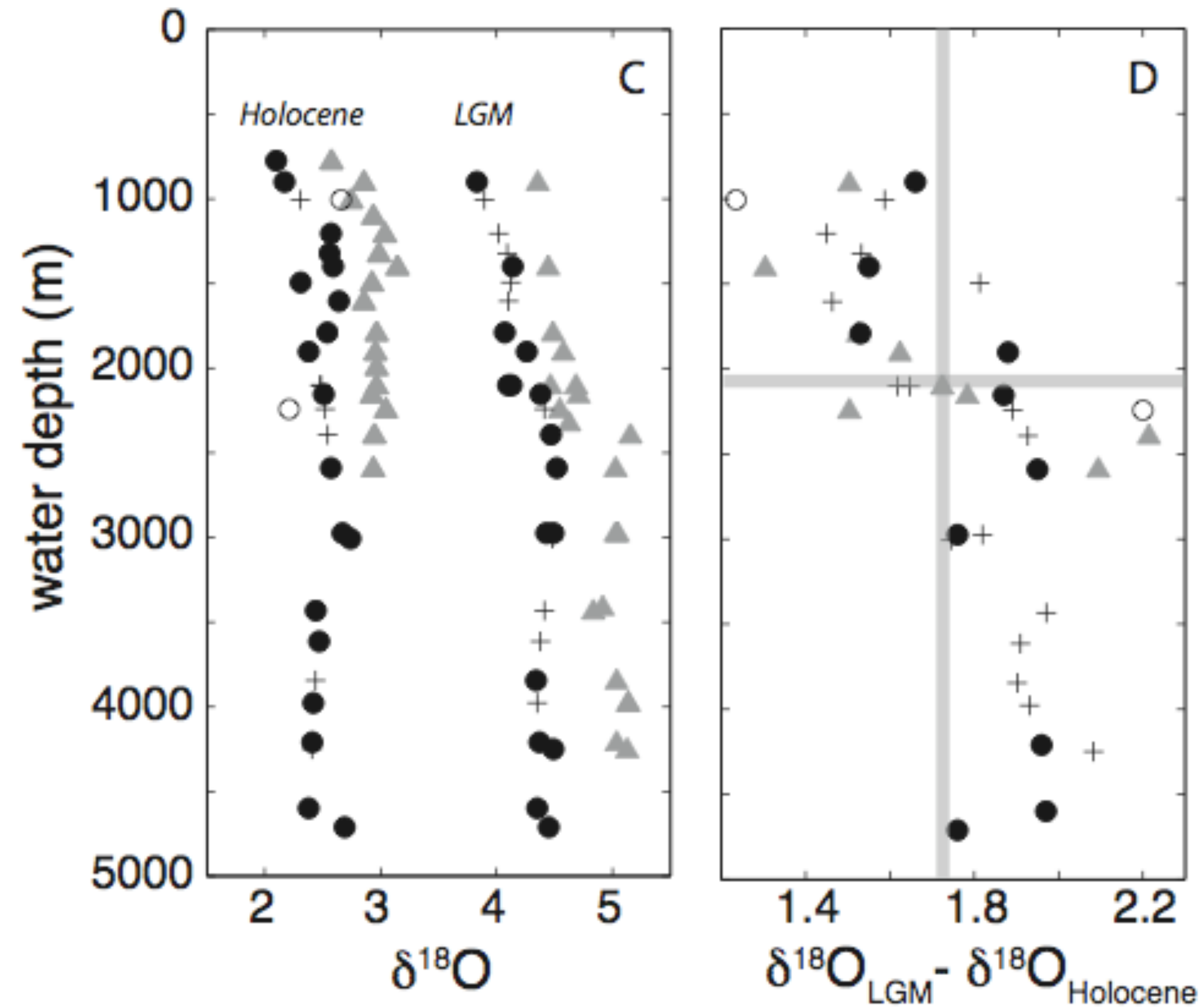
Profiles of $\delta^{18}O_{foram}$ in the N and S Atlantic

Brazil Margin (30°S)



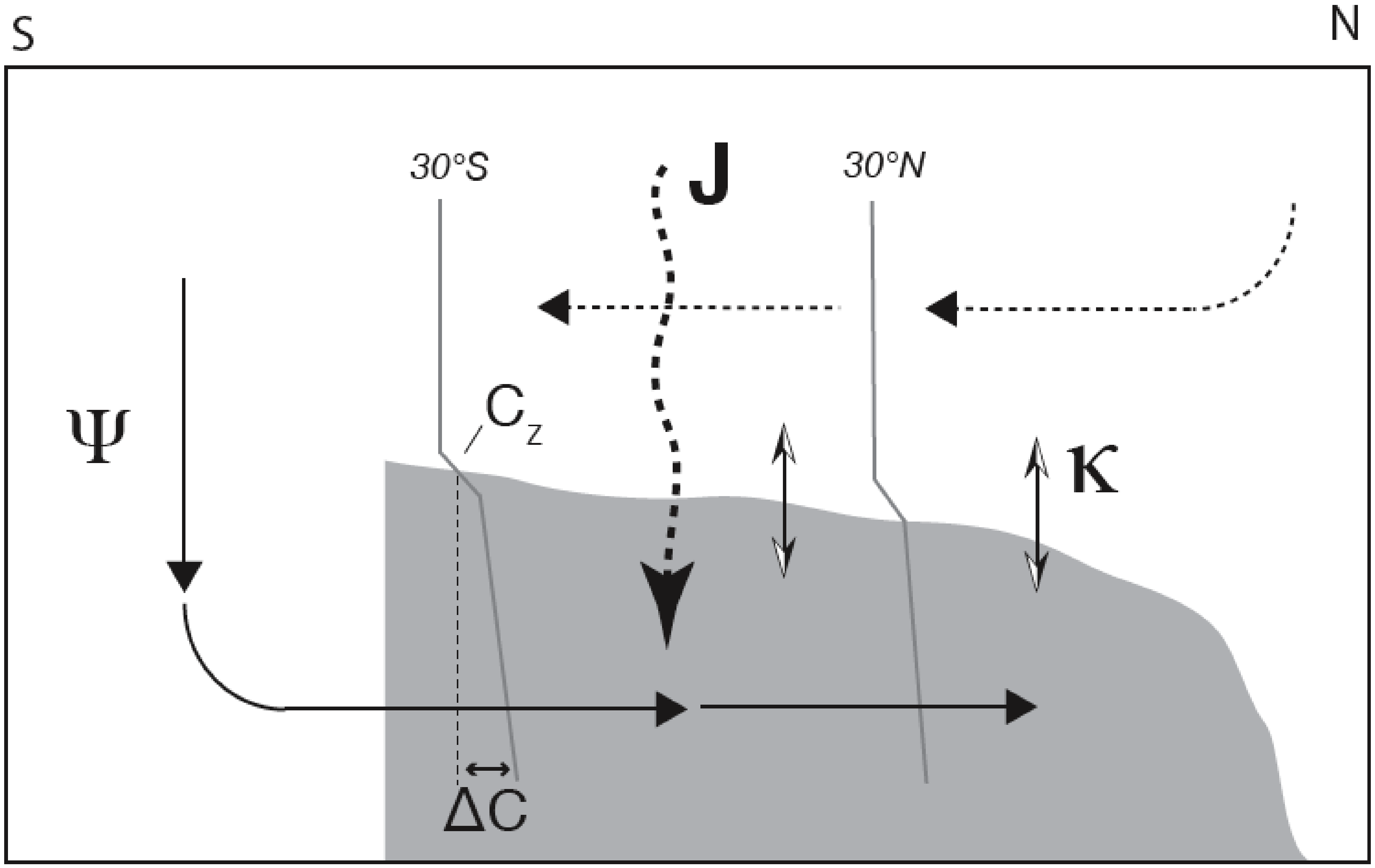
Curry and Oppo, 2005

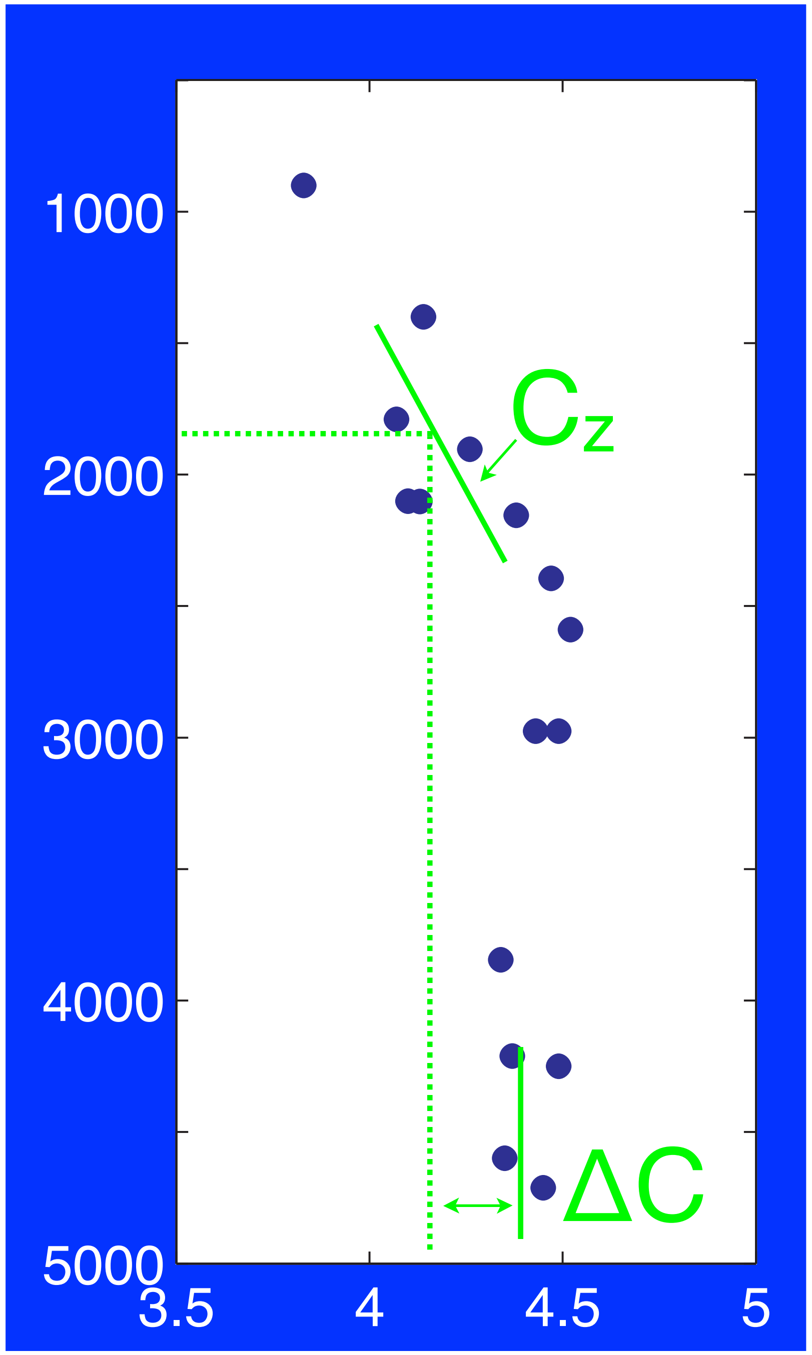
Blake Ridge (30°N)



Keigwin, 2004

A Schematic of the Tracer Balance



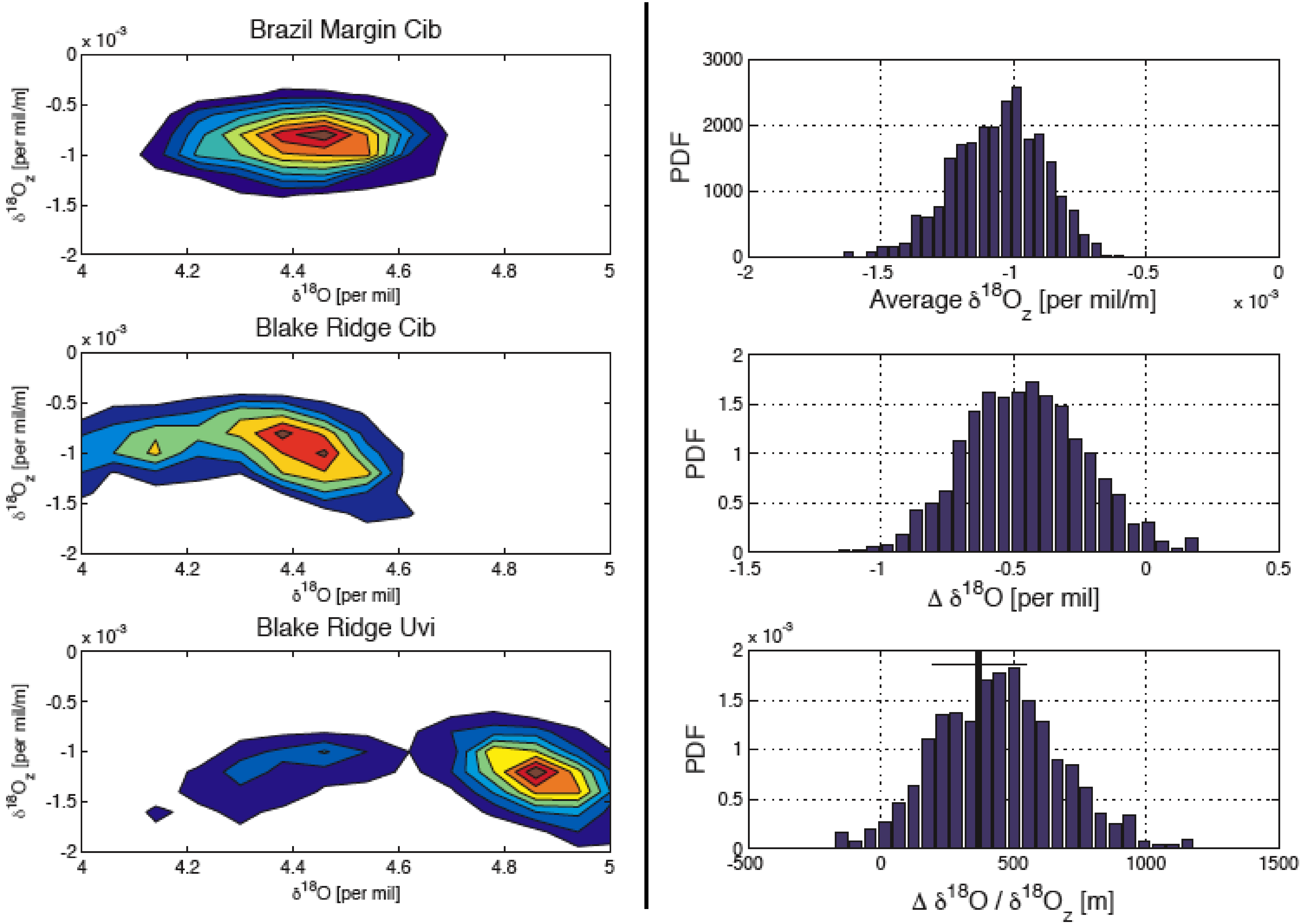


$$\Psi\,\Delta C \sim K\,C_z\,\text{Area}$$

$$w\,\Delta C \sim K\,C_z$$ (Munk's "Abyssal Recipies")

LAF, 2013

Monte Carlo results for the LGM $\delta^{18}O$ profiles



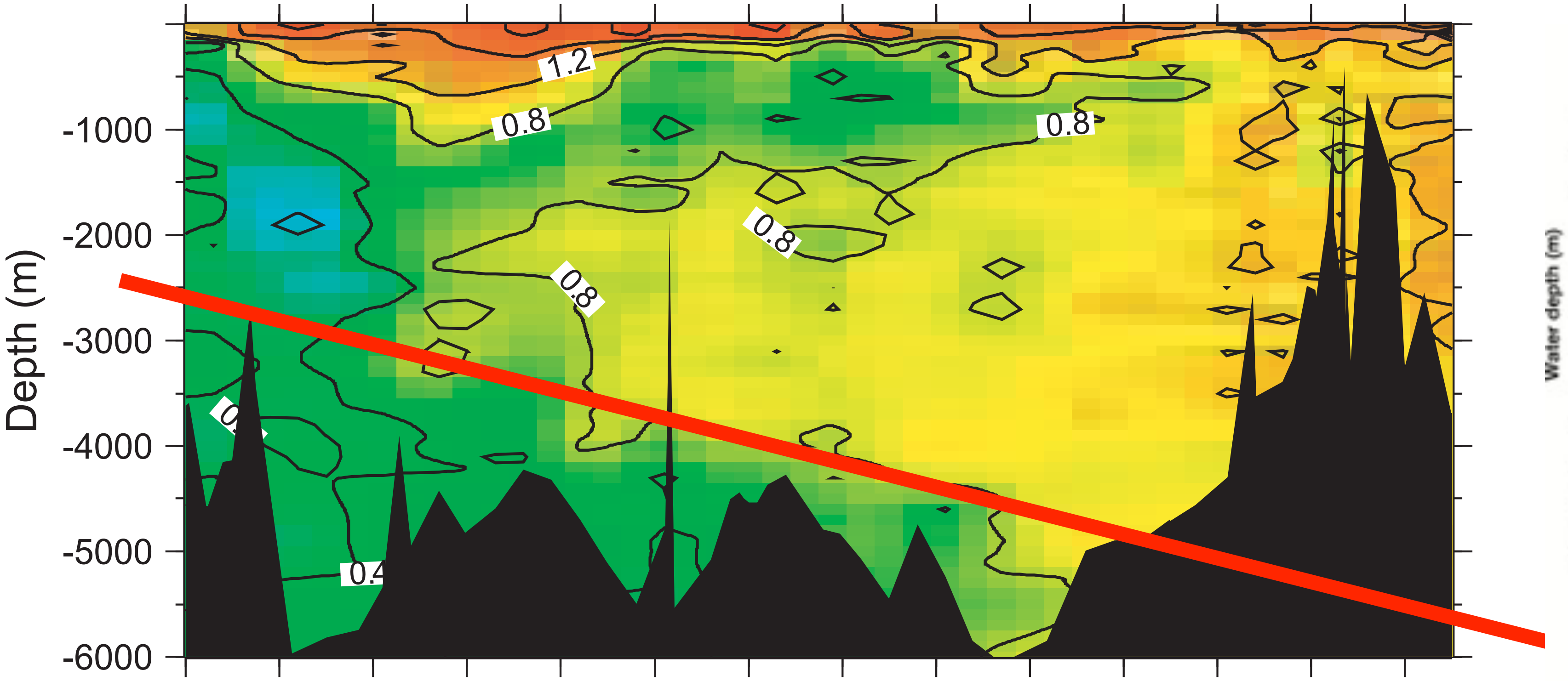
Results for the tracer mass balance

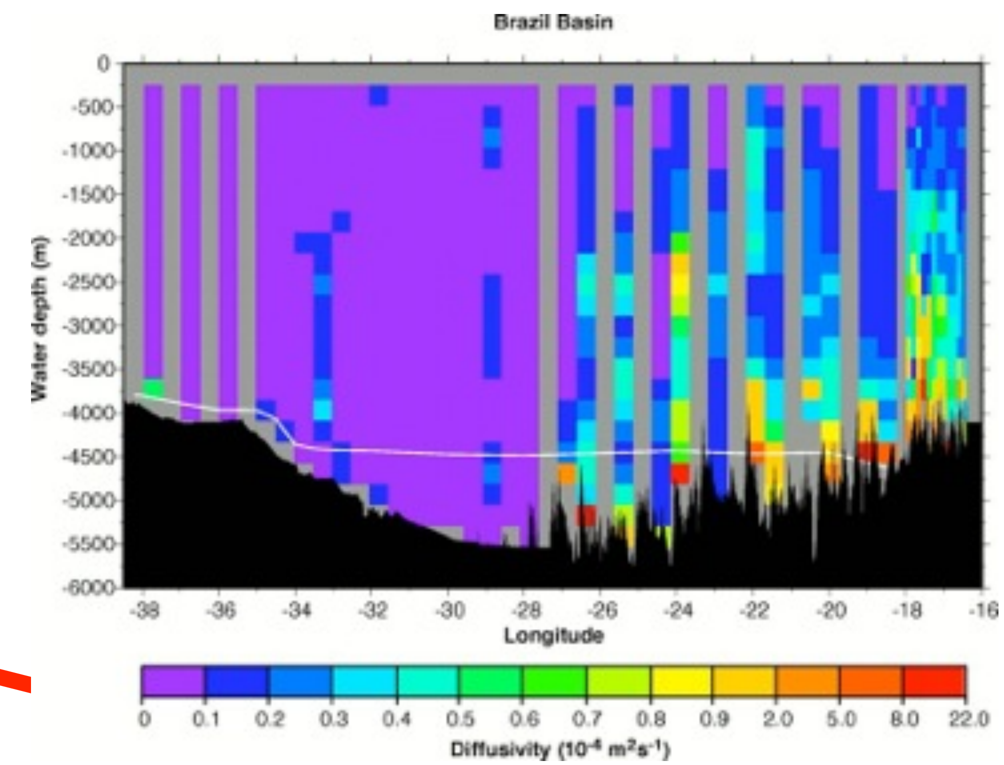
	$\delta^{18}O_z$ (‰/m)	$\Delta\delta^{18}O$ (‰)	$\delta^{13}C_z$ (‰/m)	$\Delta\delta^{13}C$ (‰)	**Area (m^2)**	**Ψ/K (m)**	*Pe*
Modern	-3.1±0.8e-4	-0.12±0.04	4.8±1.0e-4	0.24±0.05	**4.7±0.5e12**	**1.8±0.8e10**	1.3±0.7
LGM	-1.0±0.2e-3	-0.46±0.23	1.2±0.2e-3	1.14±0.25	**4.5±0.9e13**	**1.6±0.9e11**	2.1±1.3

The ratio of transport to diffusion is **8x** larger at the LGM due largely to an increase in the area (volume) of the southern source water mass, and the similar ratio of $\delta^{18}O$ gradients between the two times

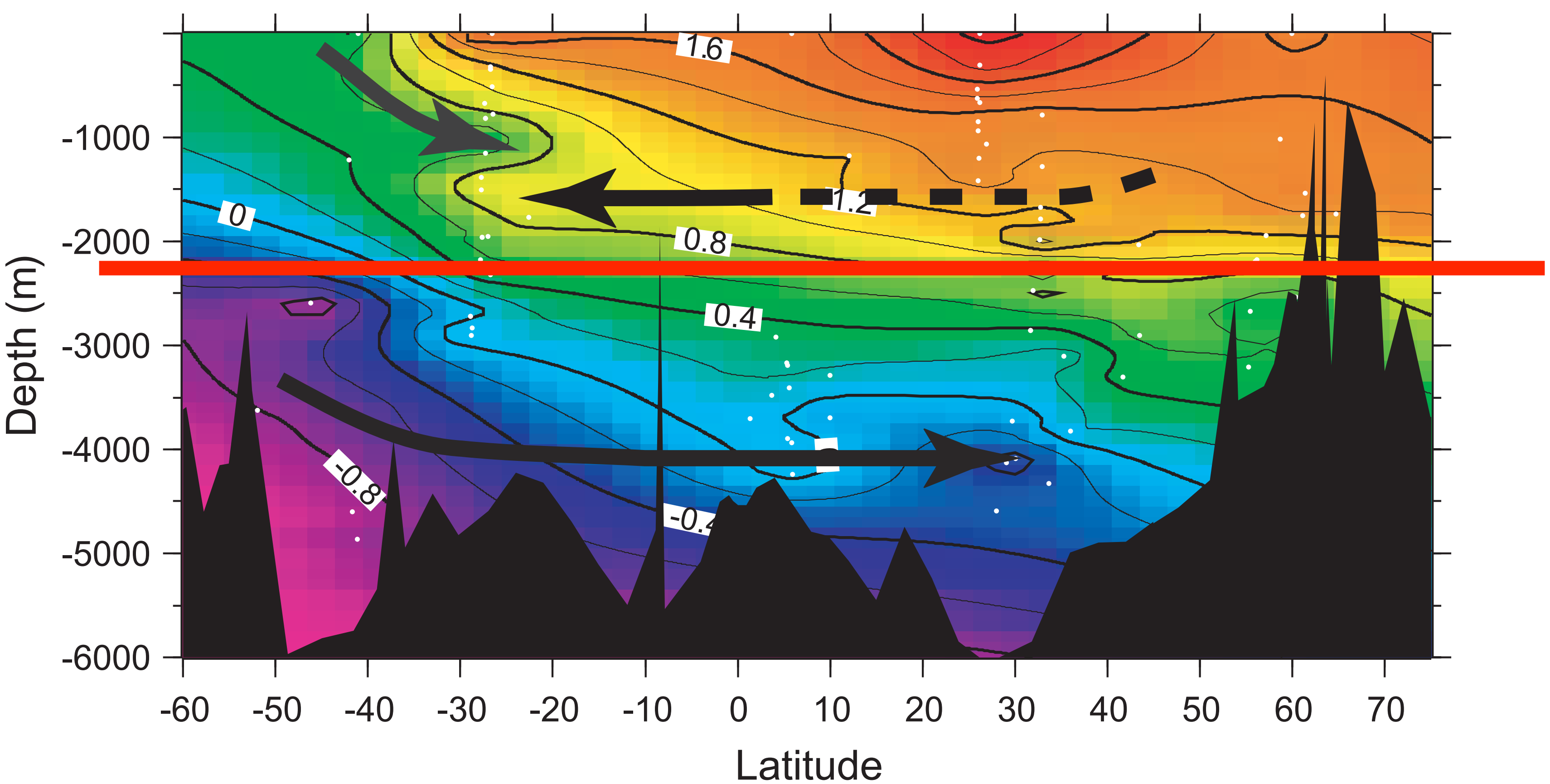
LAF, 2013

Western Atlantic GEOSECS $\delta^{13}C$ (PDB)





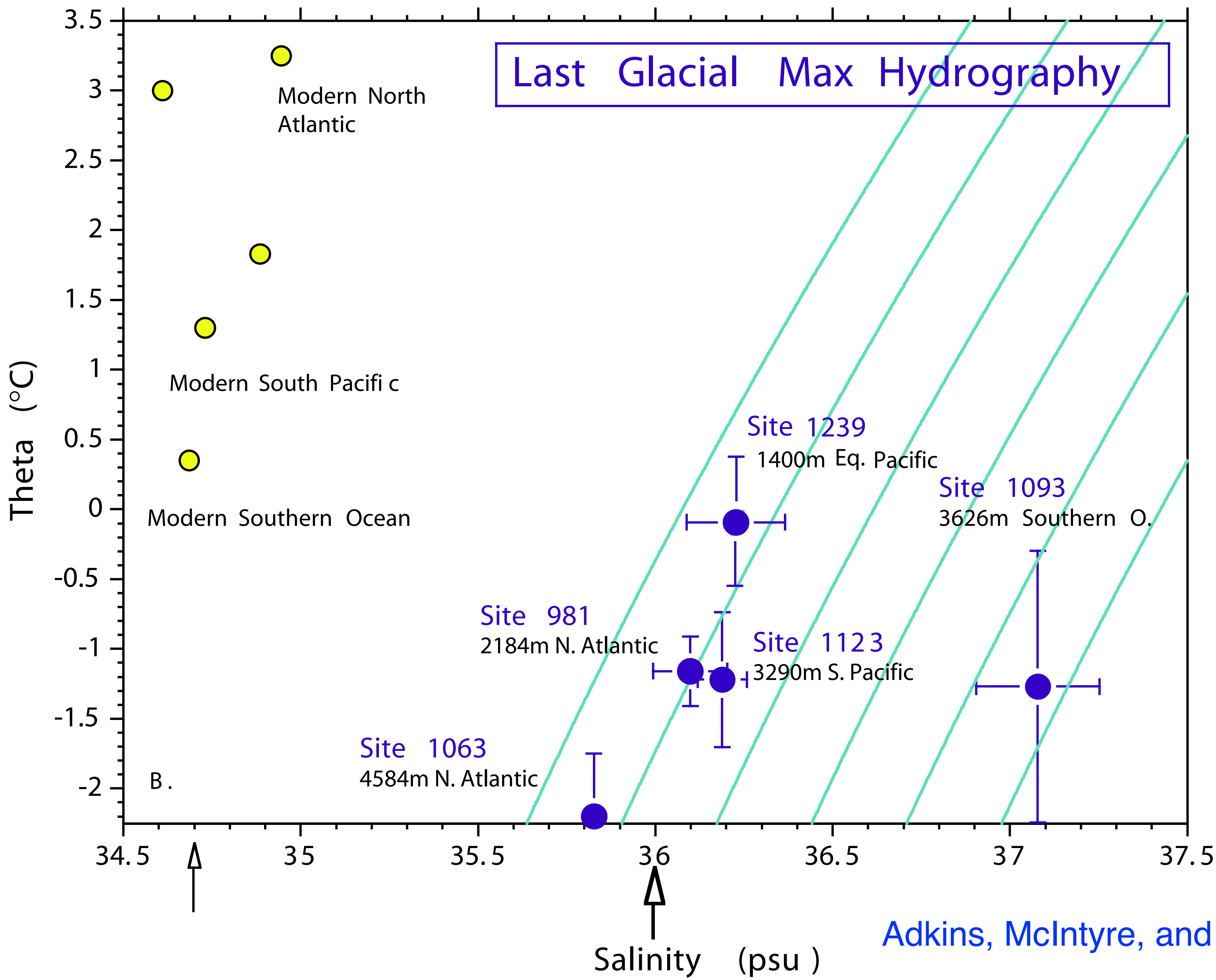
Western Atlantic Glacial $\delta^{13}C$ (PDB)



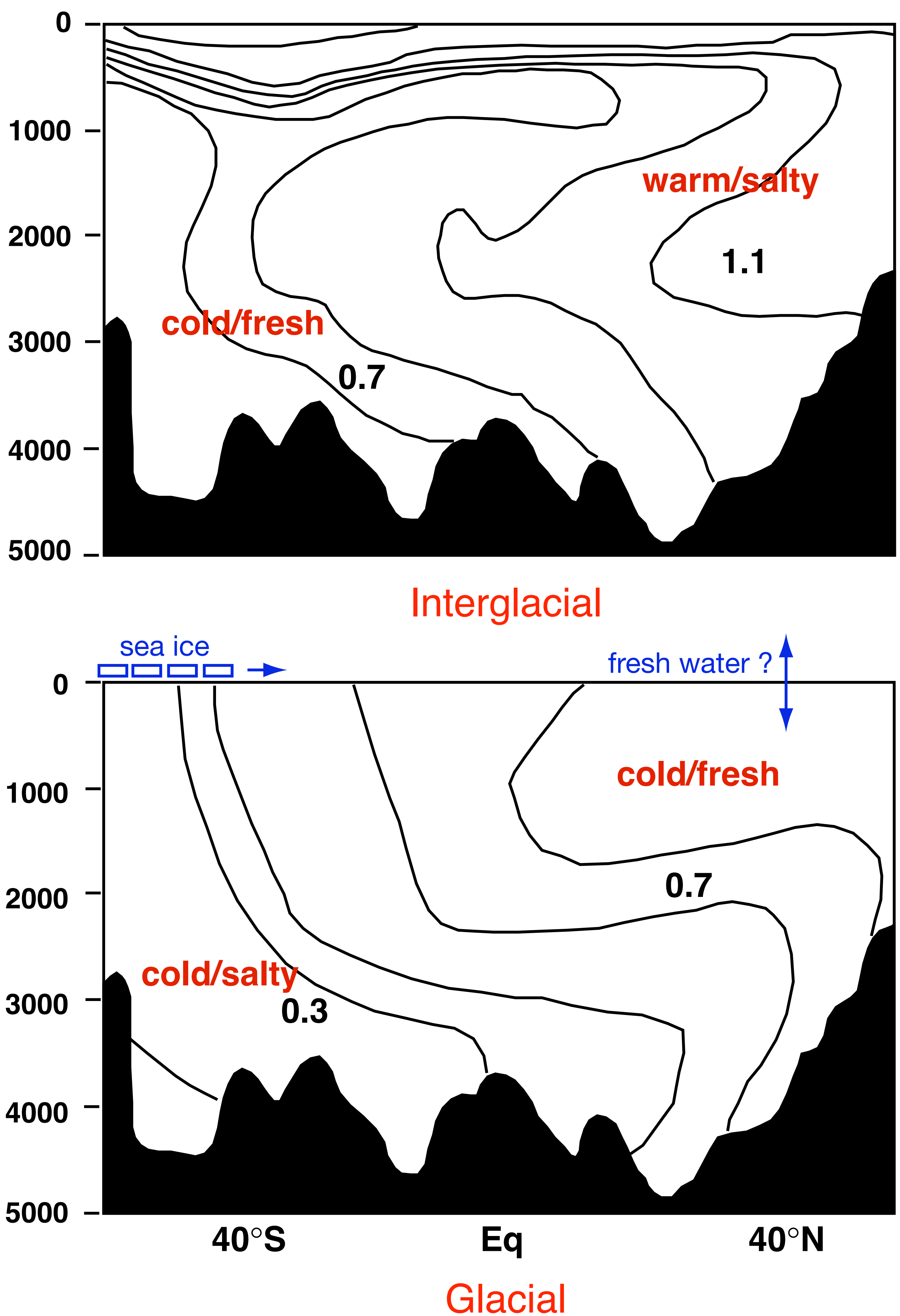
Curry and Oppo, 2005

Glacial Maximum T and S for the Deep Ocean

(Based on pore fluid measurements of [Cl] and $\delta^{18}O$)



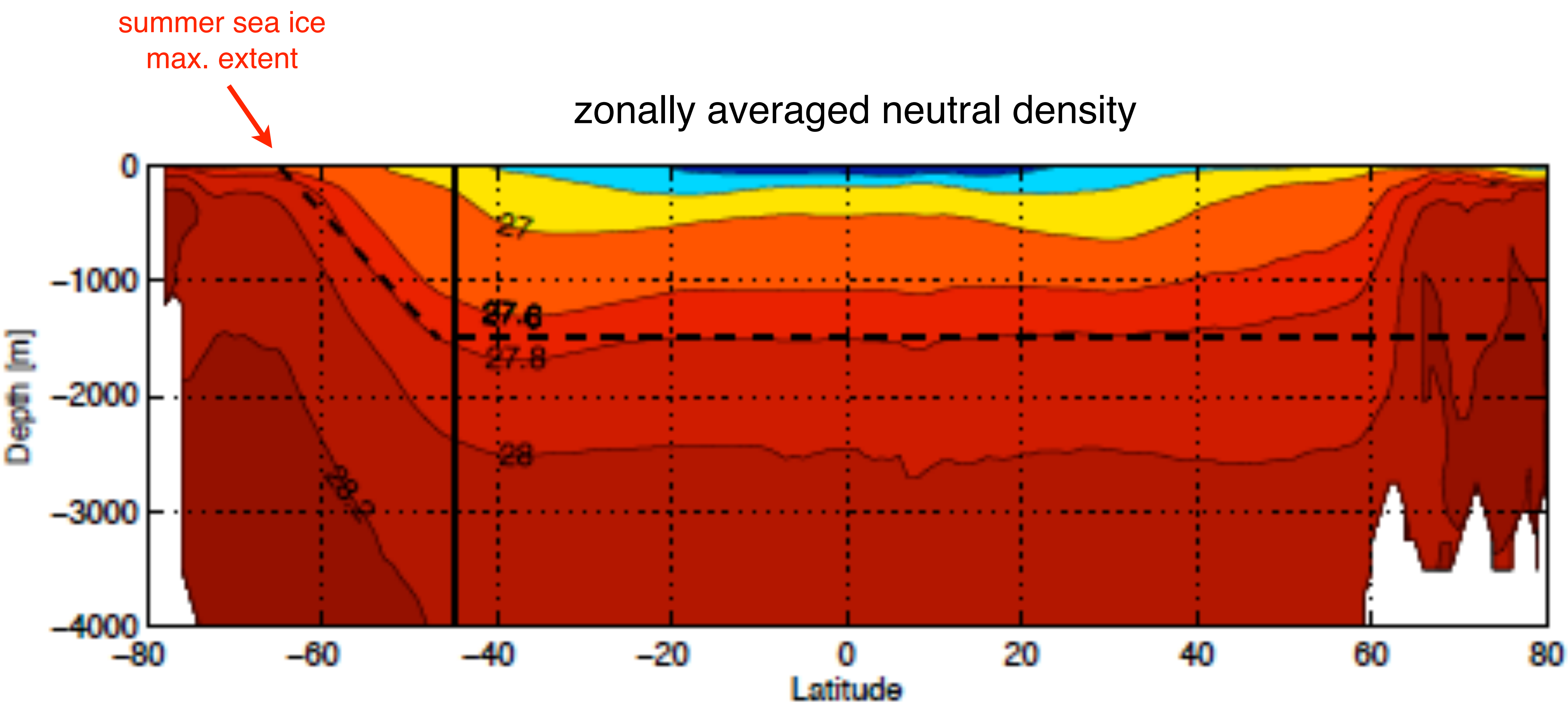
Adkins, McIntyre, and Schrag, 2002



Oddly, the LGM really does seem to be a 2-cell structure (at least in the Atlantic)

How did this come about?

The Southern Ocean is one key to setting stratification of the ocean interior

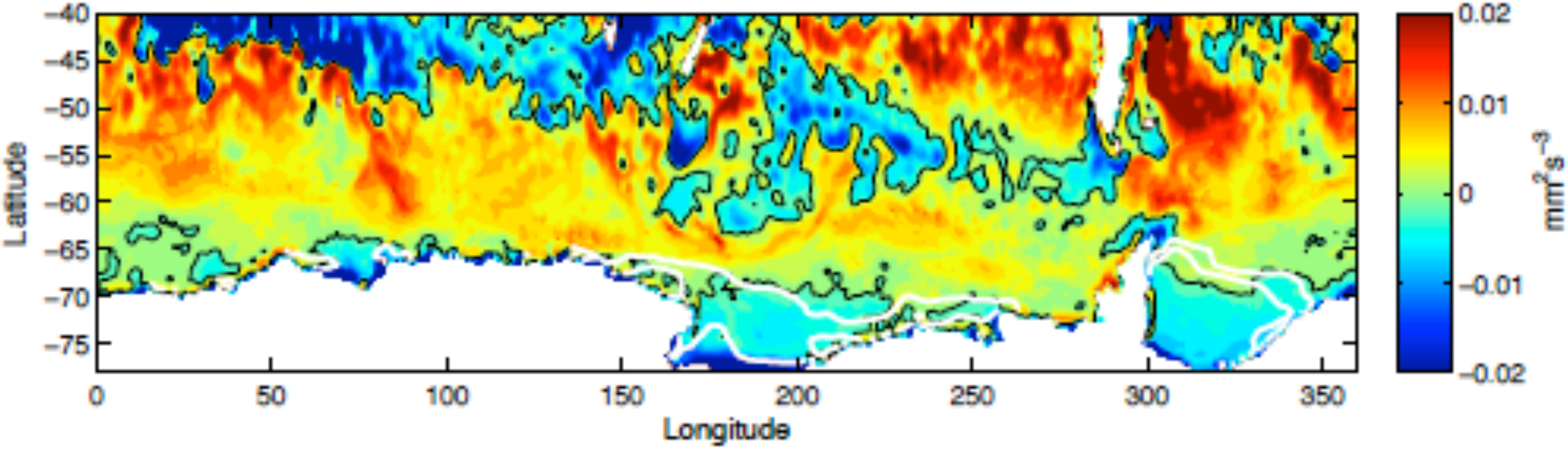


dashed line slope = $\frac{\tau_0}{f\rho K}$

Ferarri et al., 2014

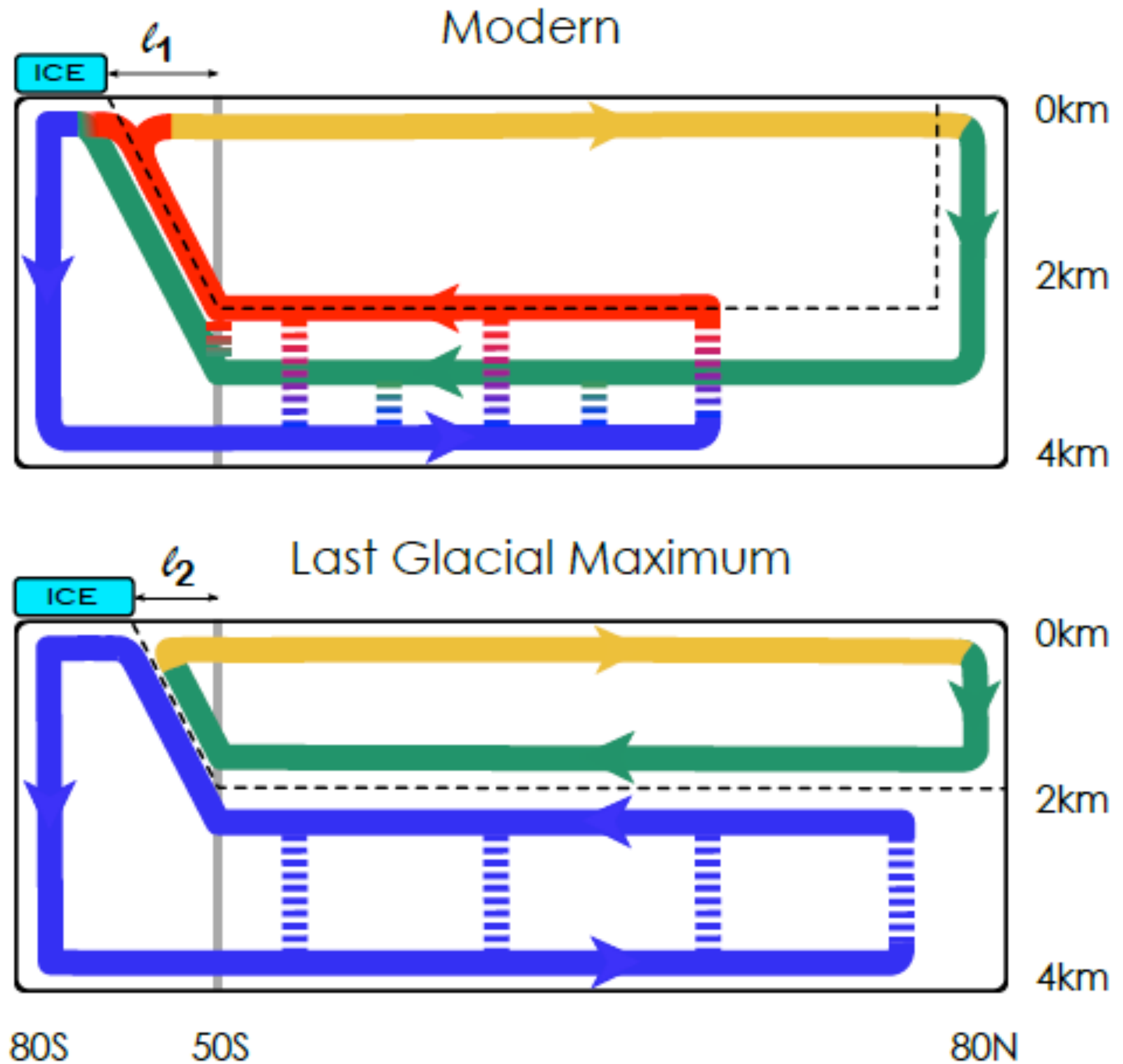
Annual Mean Buoyancy Flux from SO State Estimate

(Negative is out of the ocean)



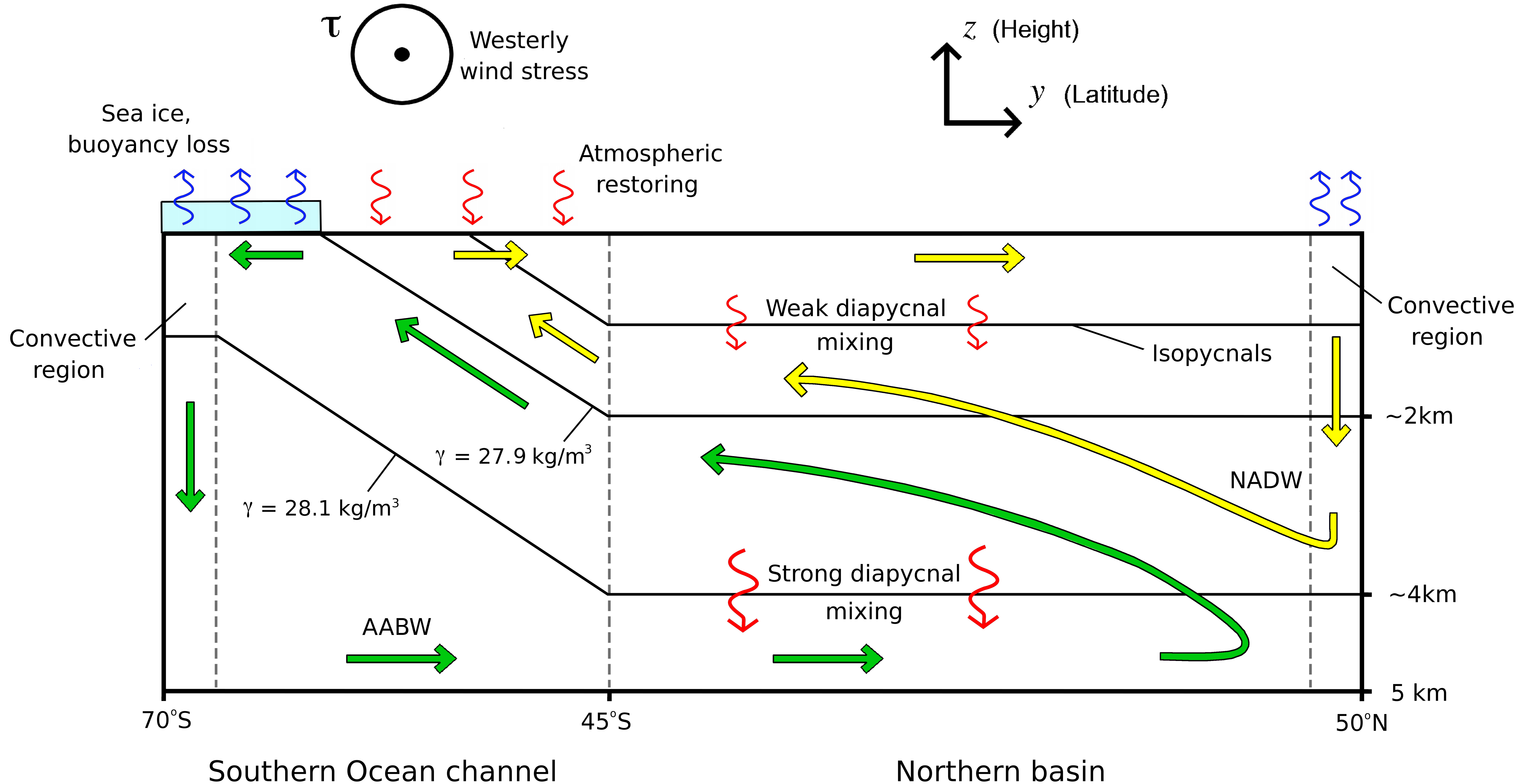
Ferarri et al., 2014

2 Stable Steady-States from the interaction of vertical mixing and sea ice extent.



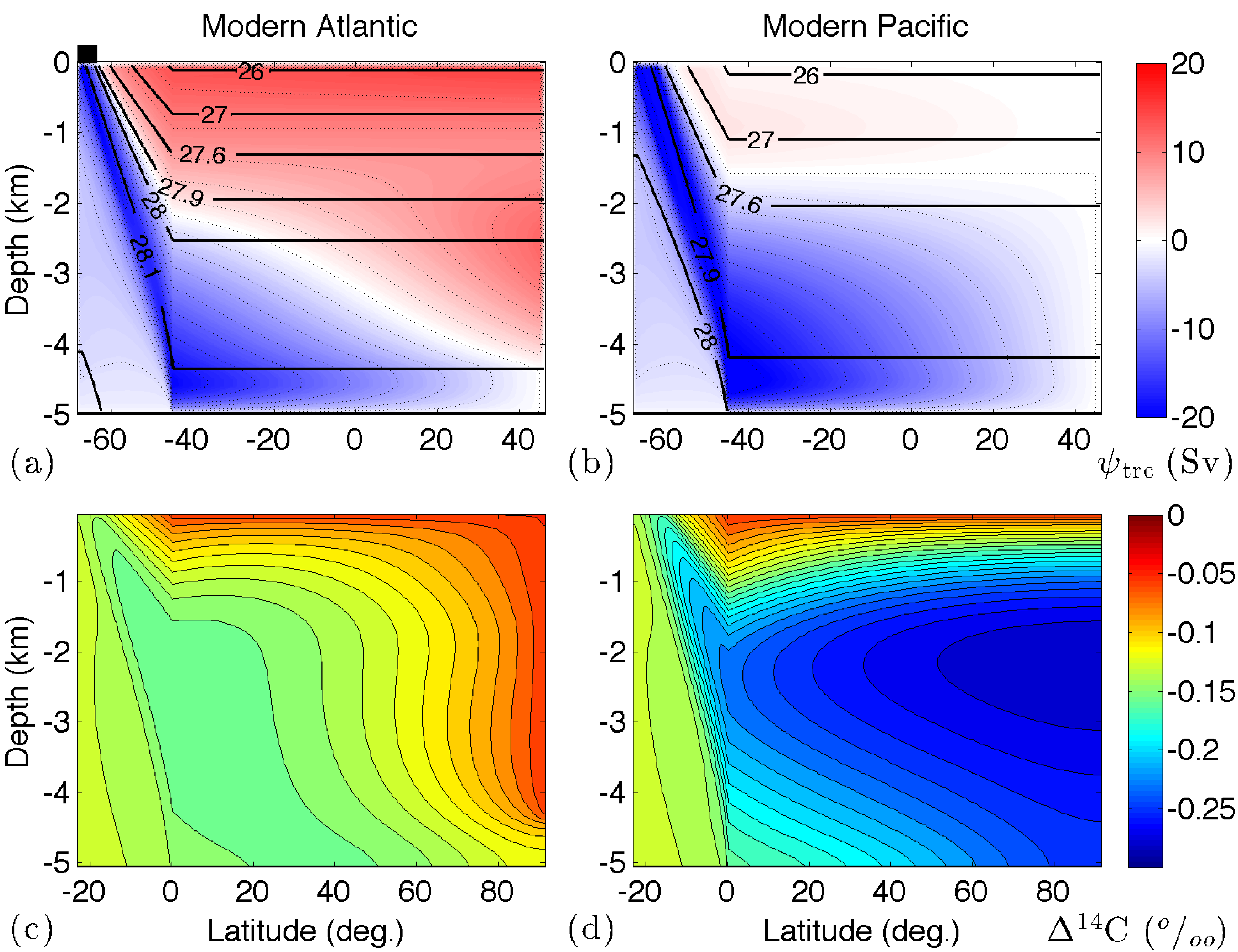
Ferarri et al., 2014

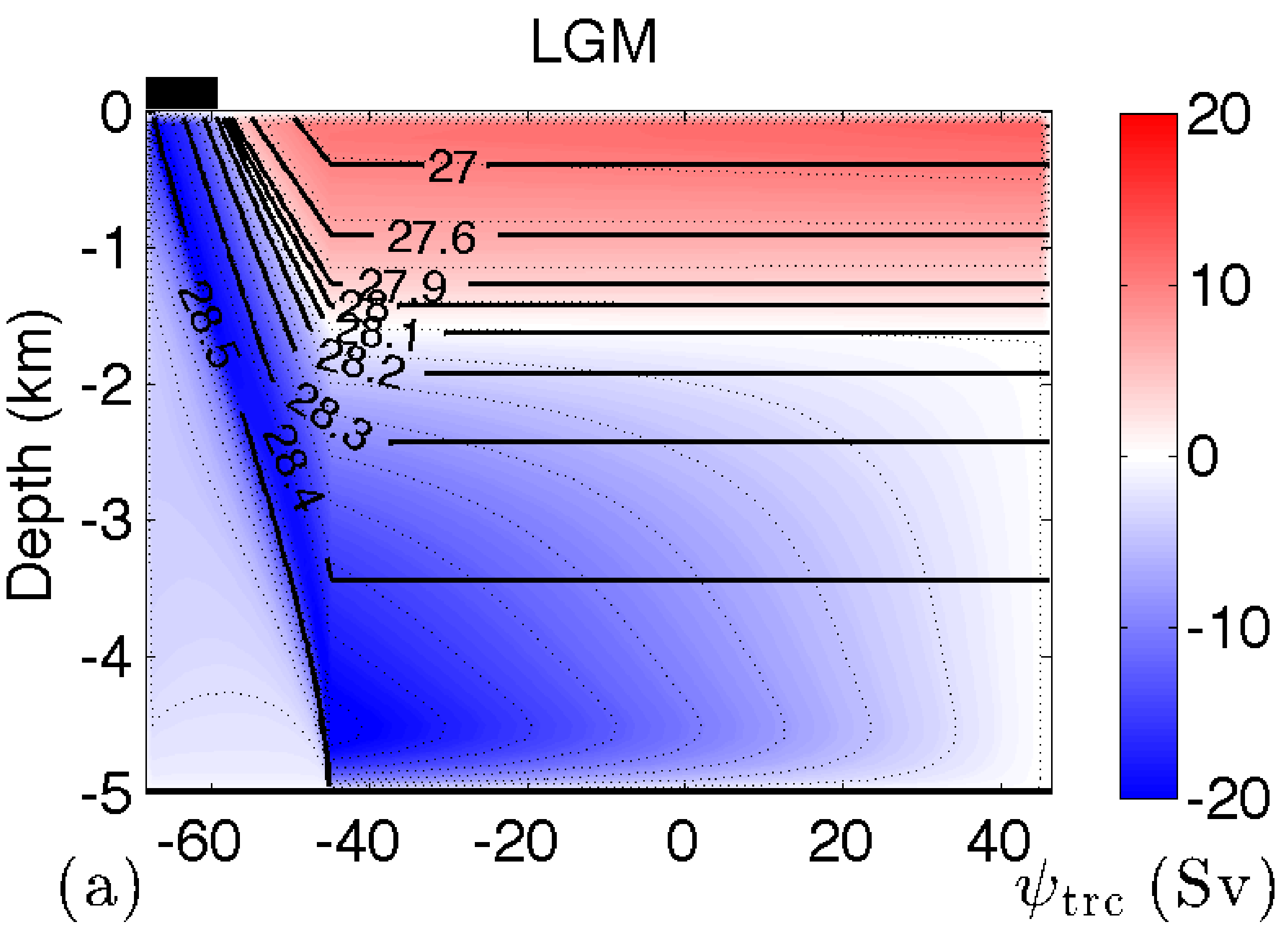
A 2-D residual circulation model to look at these issues



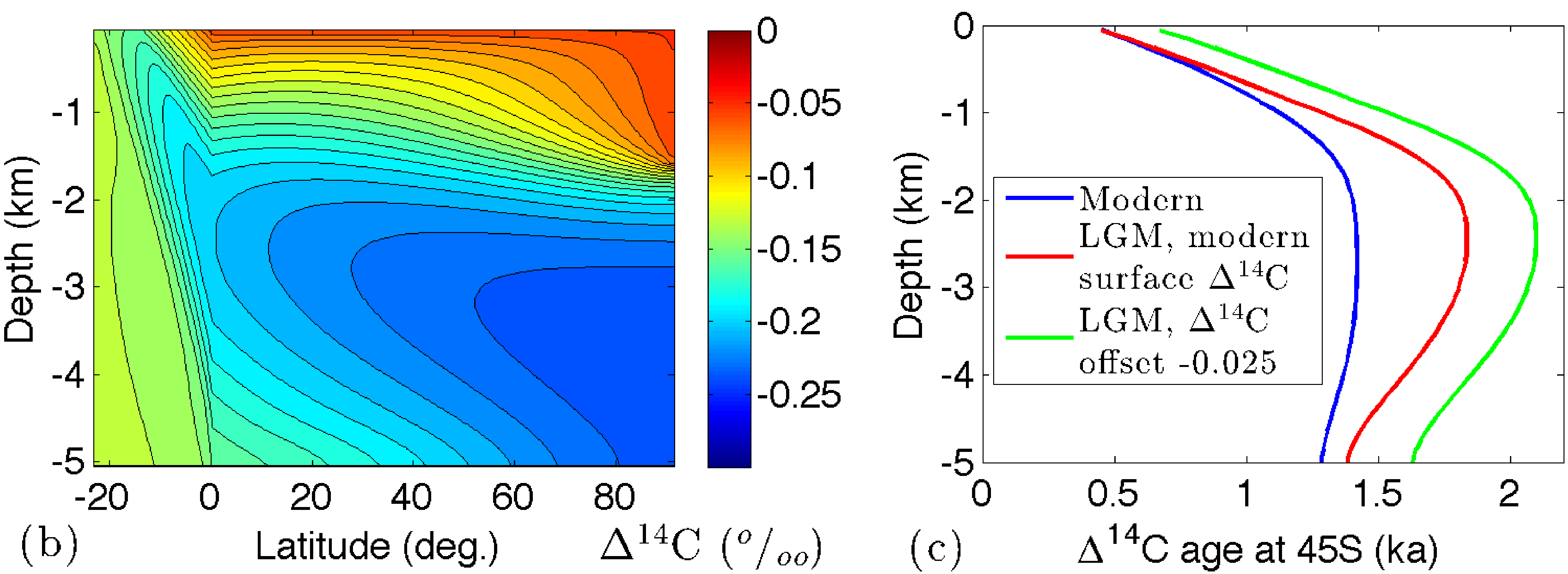
Burke et al., submitted

Model Results for the Atlantic and Pacific

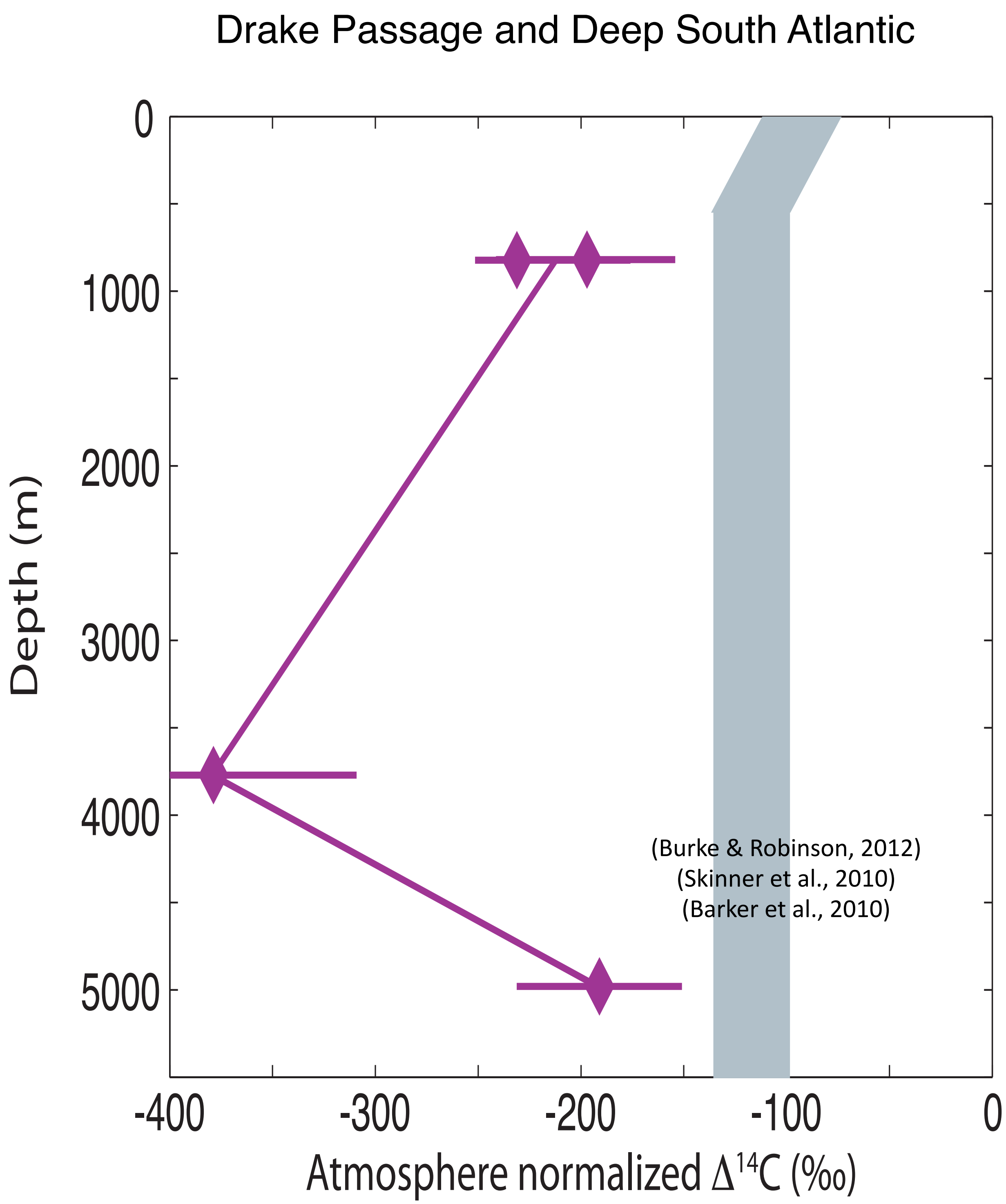


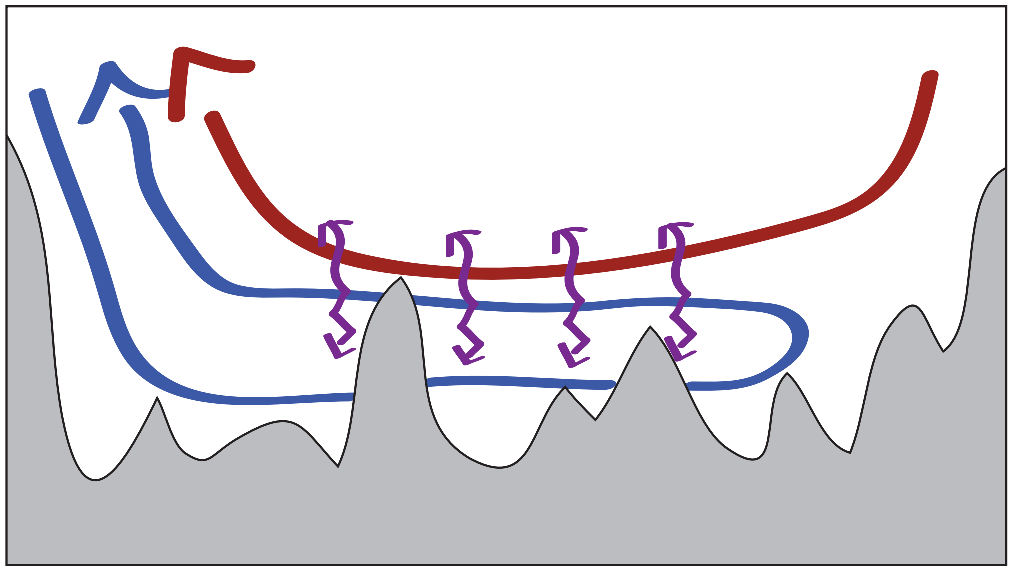


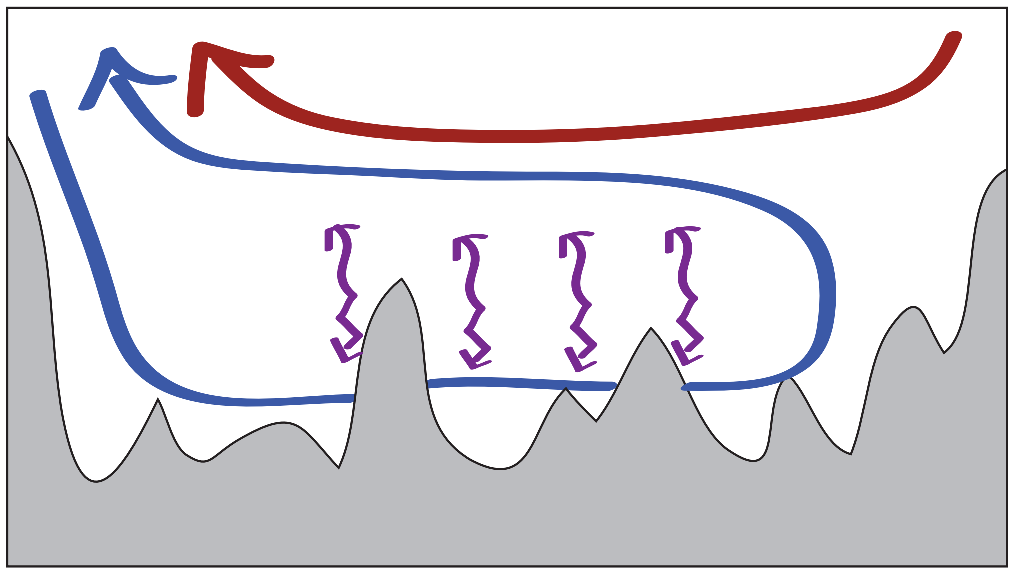
In the LGM Atlantic there is a shoaling of the deep water boundary, and a ^{14}C bulge.



Radiocarbon has a 'mid-depth bulge' at LGM

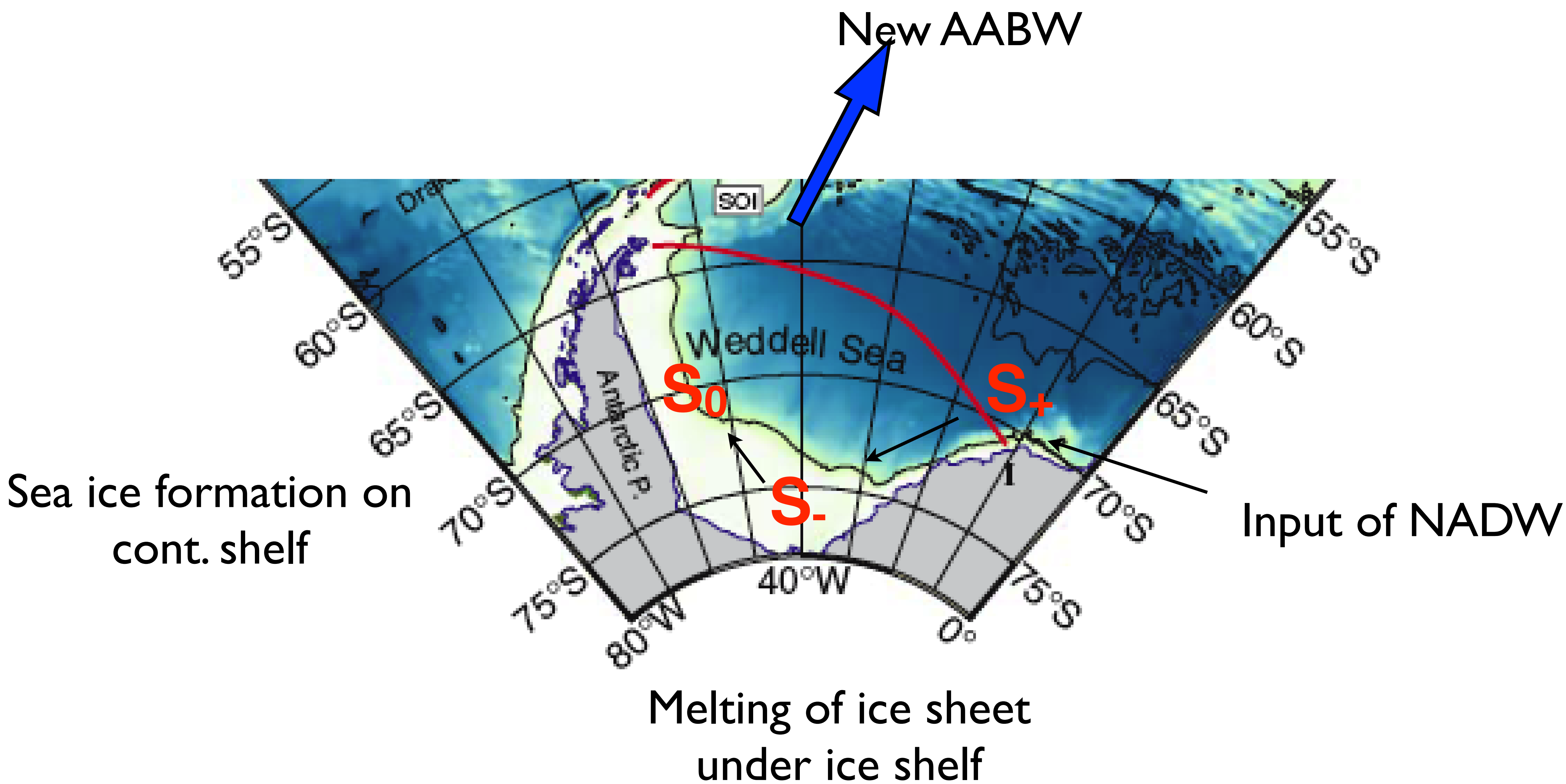






How did this southern cell get so salty without the modern salt contribution of NADW?

(and is there a feedback that causes the Southern Cell to be denser than the Northern Cell?)



-30 mSv of fresh water melts around the whole of Antarctica

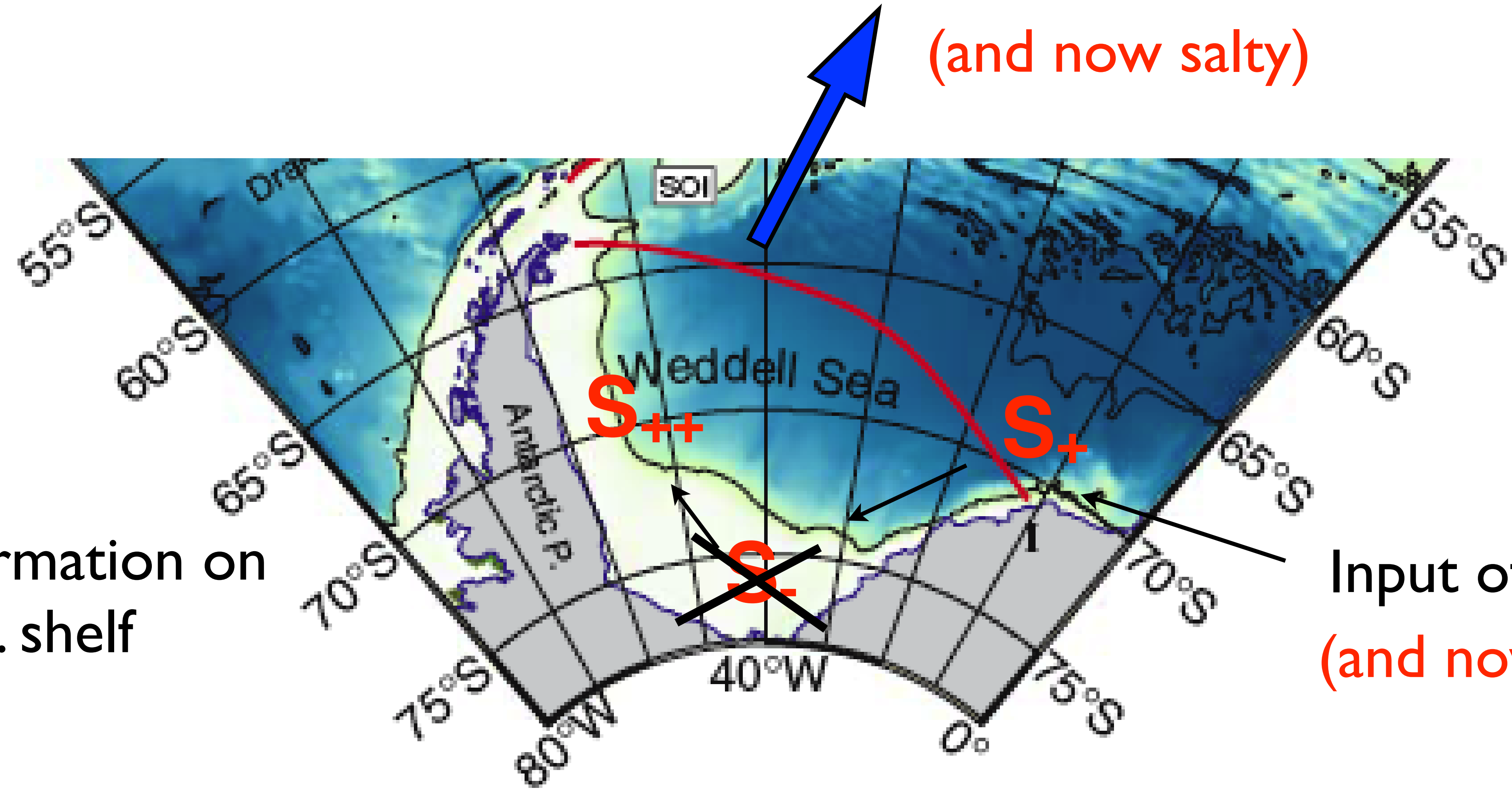
(over half of which is in the Weddell domain)

after Hellmer, 2004

A Glacial version of AABW in the Weddell Sea

New AABW

(and now salty)



Sea ice formation on cont. shelf

Input of NADW

(and now colder)

Melting of ice sheet under ice shelf

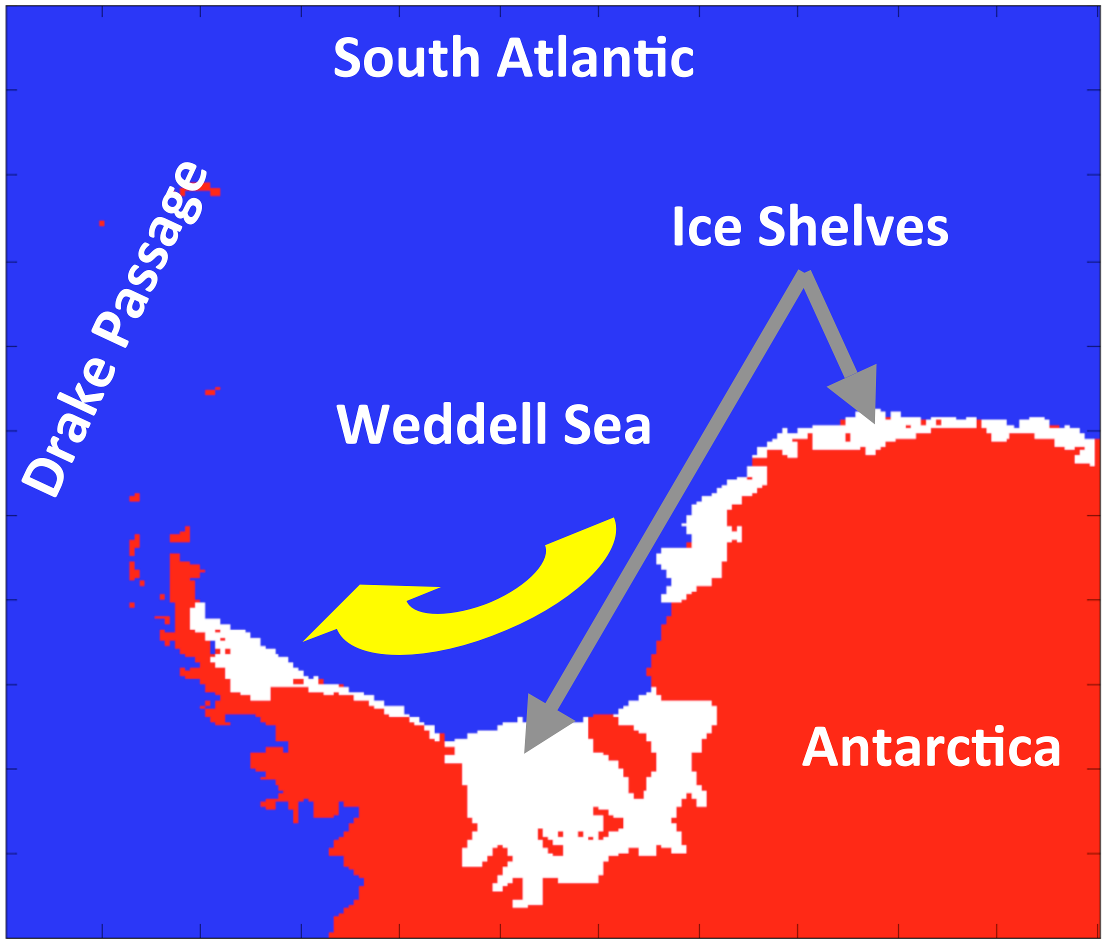
-30 mSv of fresh water melts around the whole of Antarctica

(over half of which is in the Weddell domain)

after Hellmer, 2004

experiment setup (control)

domain (top down view):



horizontal resolution: ≈ 18 km

vertical resolution: 50 layers, 10 to 450 m

surface boundary: blended reanalysis from NCEP and ECMWF

ocean (H_2O) boundaries: U,V, S,θ at every grid point, interpolated from monthly diagnostics of global solution

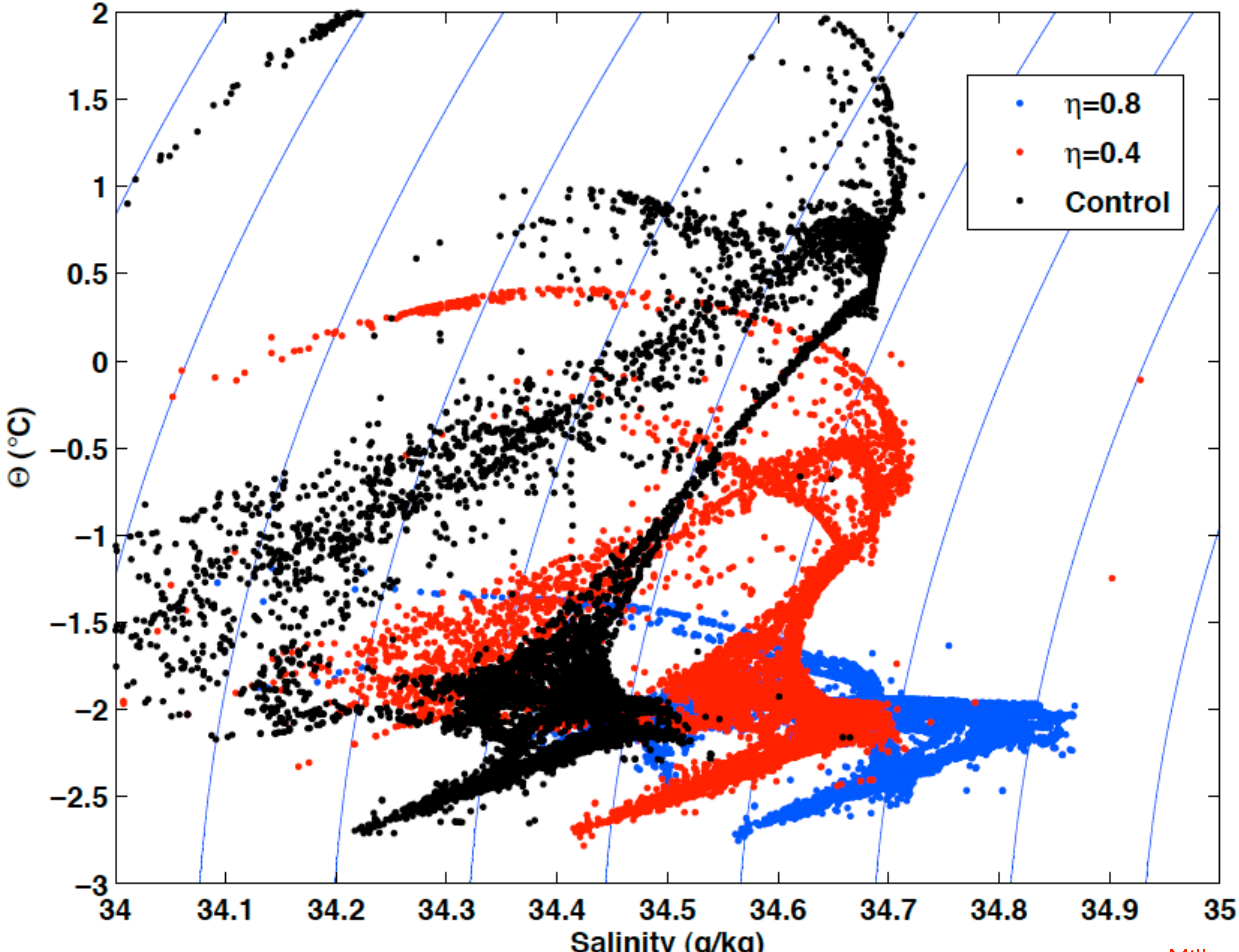
ocean (sea ice) boundaries: U,V, A, H, at each point interpolated from daily diagnostics of global solution

equation of state: fully non-linear (50+ terms)

bathymetry: modern, including ice shelf cavities, represented using partial cells

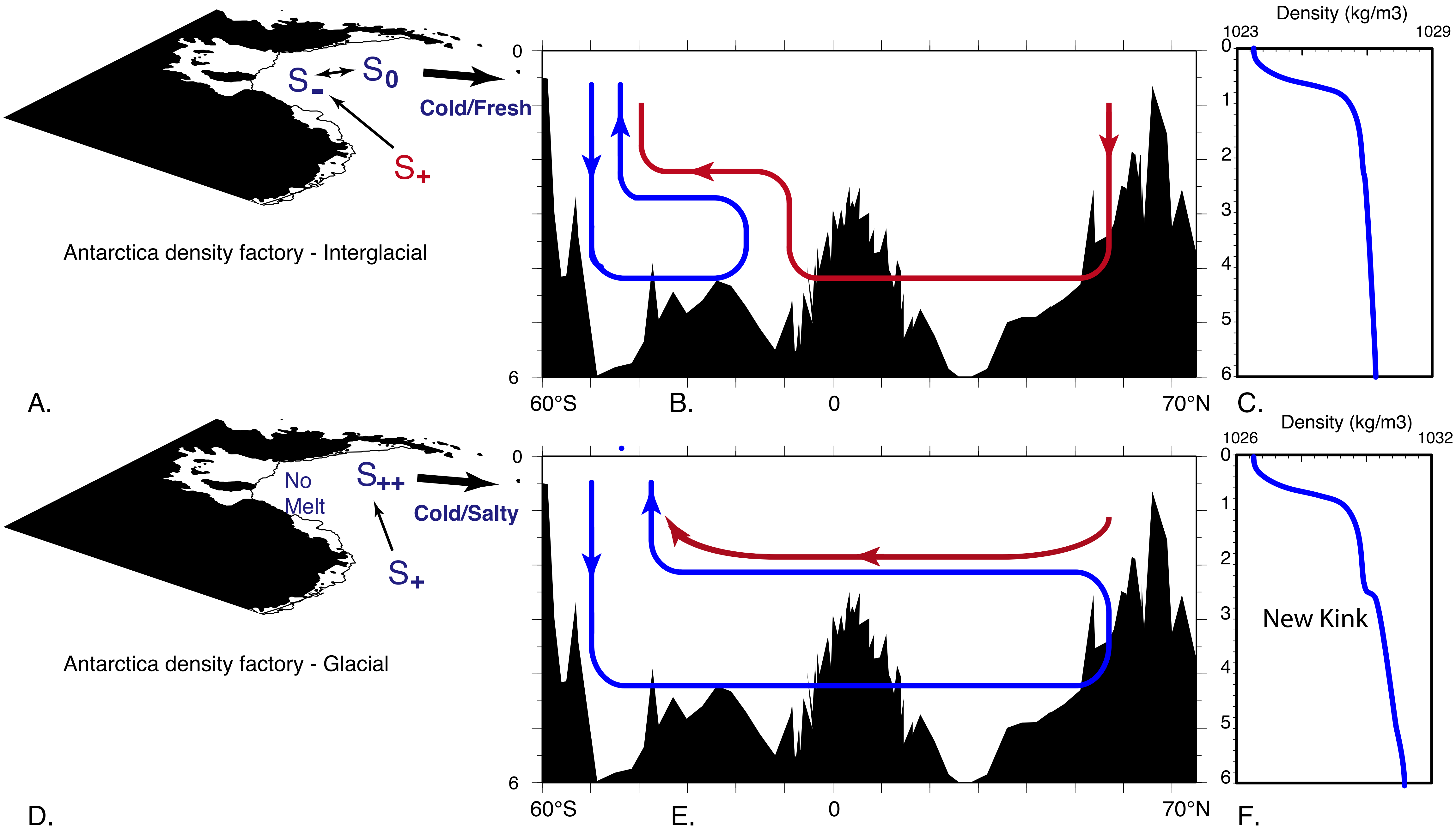
Miller et al., 2012

Cooling Increases the Salinity of Deep Water Precursors



Miller et al., 2012

A cartoon of how the 2 stable steady-states might work



Adkins, 2013