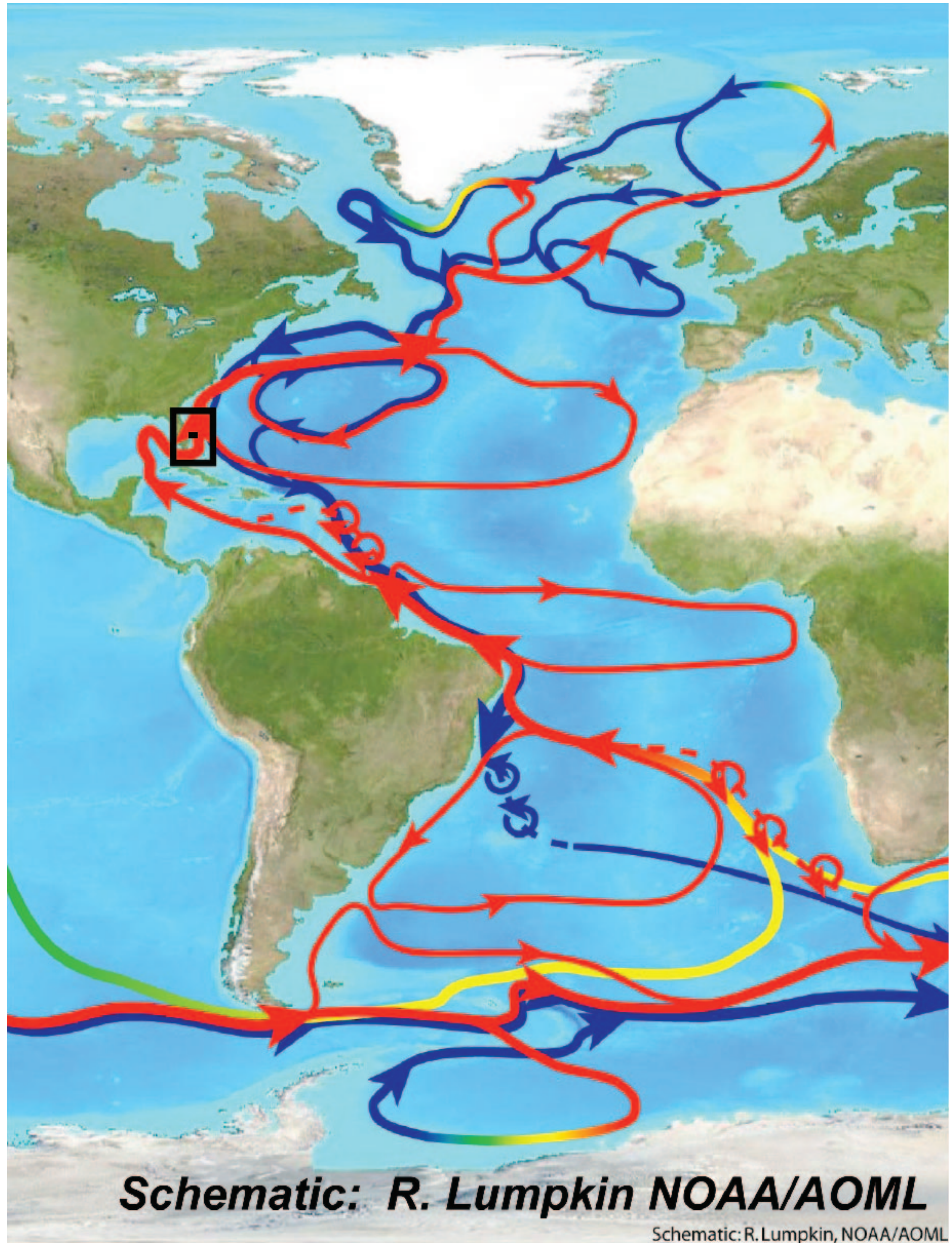
Observations of salt transport and salinity changes in the Florida Current, and Implications for oceanic advection

Zoltan Szuts (APL UW)
Chris Meinen (AOML NOAA)



Recent insight from AMOC observation

AMOC considered large-scale coherent flow, but (Lozier, 2016):

- DWBC not continuous (Bower et al., 2009)
- Surface Gulf Stream doesn't extend to subpolar gyre (Brambilla and Talley, 2006; Foukal and Lozier, 2016)
- Limited meridional coherence of AMOC (in subpolar gyre, lower branch, upper branch,)

The Florida Current connects N and S hemispheres (Schmitz and Richardson, 1991) – how continuous is its advective signal?

AMOC Stability: large-scale and modeling

AMOC stability: what is ocean feedback?

Advection and **diffusion** carry anomalies imposed by ***air-sea fluxes***

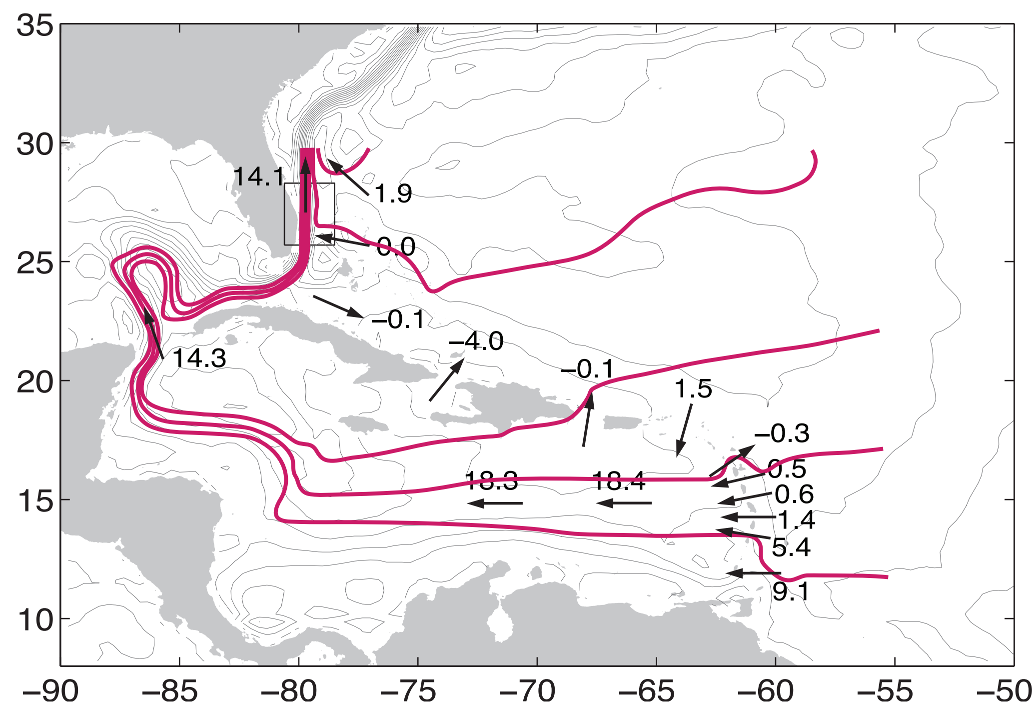
Advection: salt advection feedback, M_{ov} (TT3 webinars; Dijkstra, 2007; others)

Advection-diffusion: depends on balance (Wolfe & Cessi, 2014)

Air-sea forcing imposes its own structure – how?

Johns et al. (2002):
AMOC flows into E Caribbean

What is AMOC salt signal?
From where does it come?
Is WBC a pipe, a leaky pipe, or something else entirely?



Florida Current at 27°N: Data and Structure

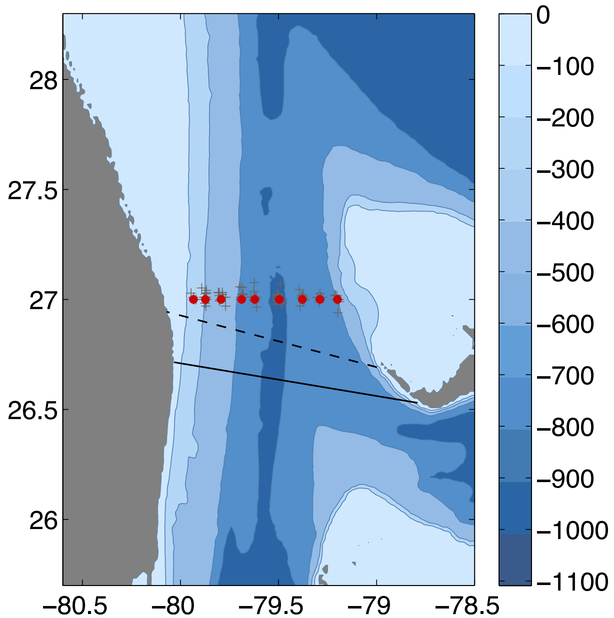
Data at 9 common stations

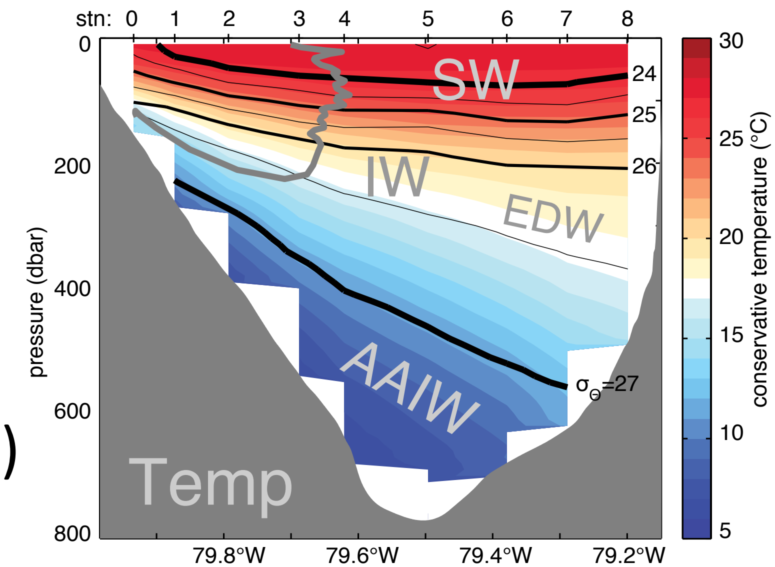
NOAA AOML, CTD/LADCP

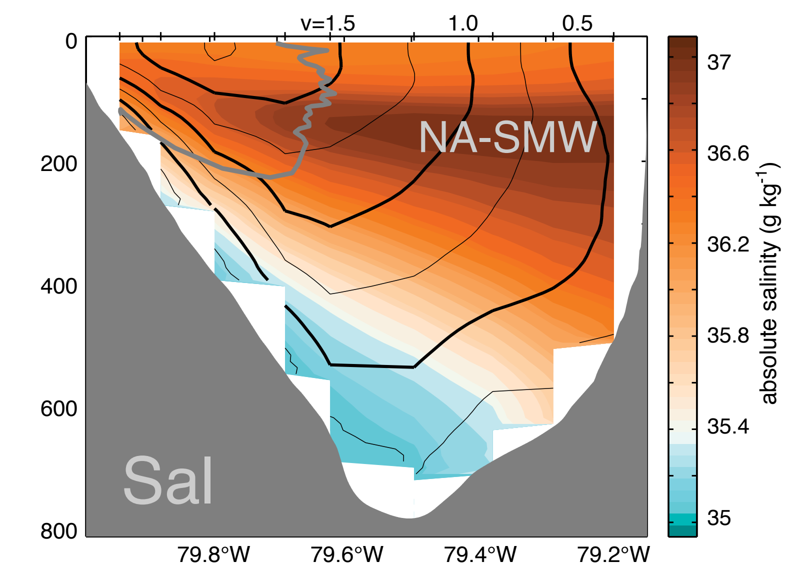
(2000-2014, 51 transects)

STACS, CTD and Velocity

(1982-1985, ~11 transects)







Water Masses

Surface Water

(<24 kg/m^3)

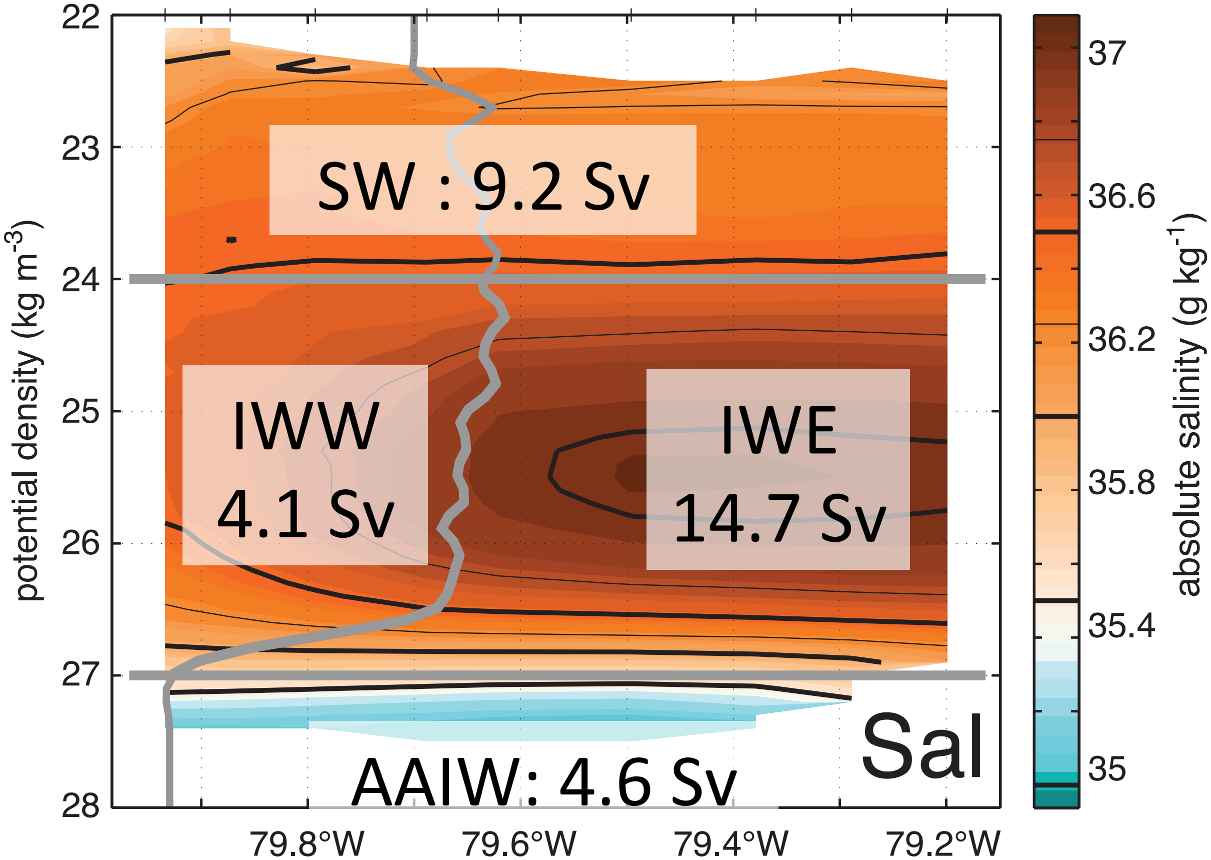
Intermediate Water

W/E divided by EPV barrier (gray line)

Antarctic Intermediate Water

(>27 kg/m^3)

Mean Transport: Which regions supply AMOC?



AMOC needs 17 Sv, which water masses contribute?

IWW certain

SW unlikely, <2.5 Sv

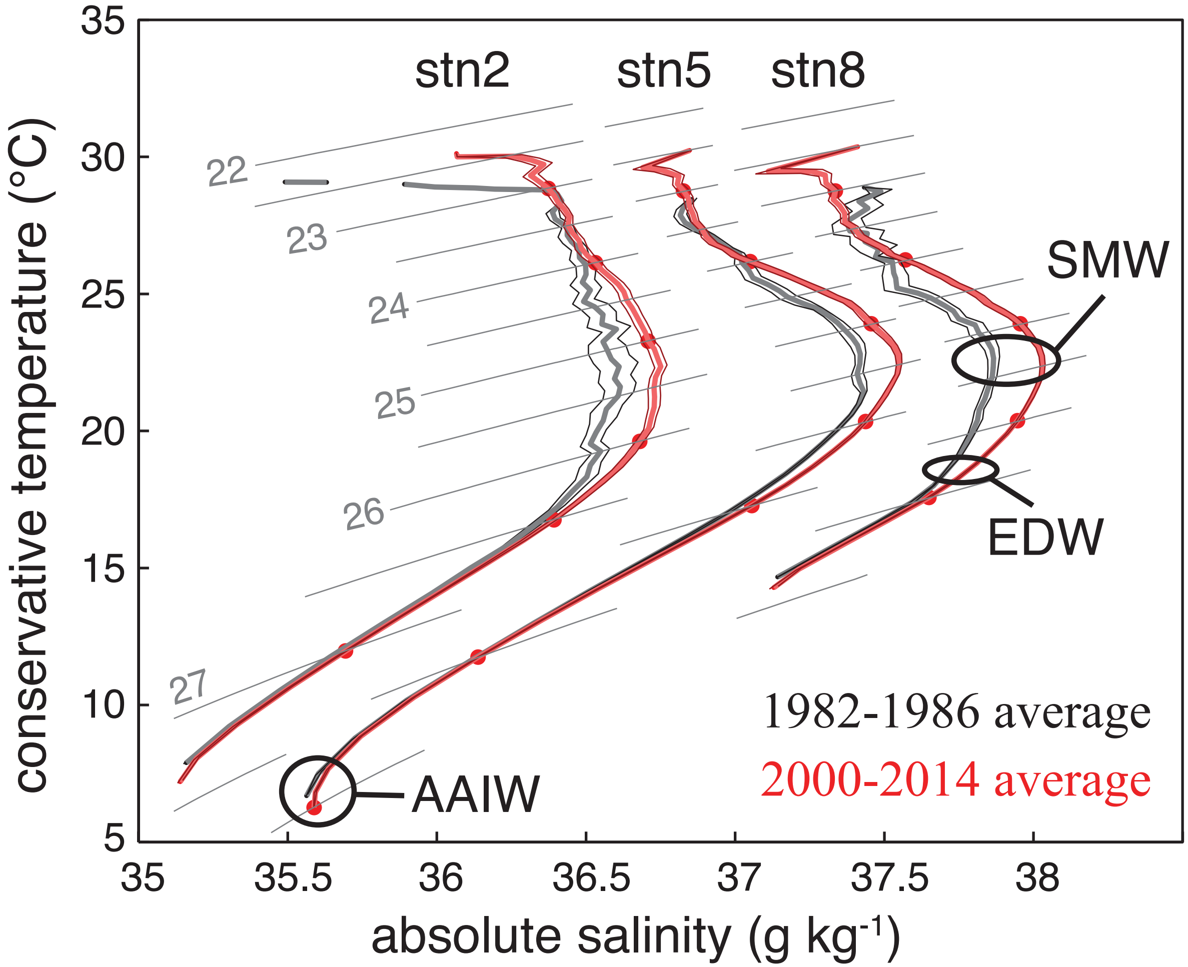
AAIW likely

IWE necessary, >6 Sv

Clear contributions by water mass origin:

North Atl Subtropics (IWE) >35%
South Atl (AAIW) 27%
mixed (IWW, SW) ~38%

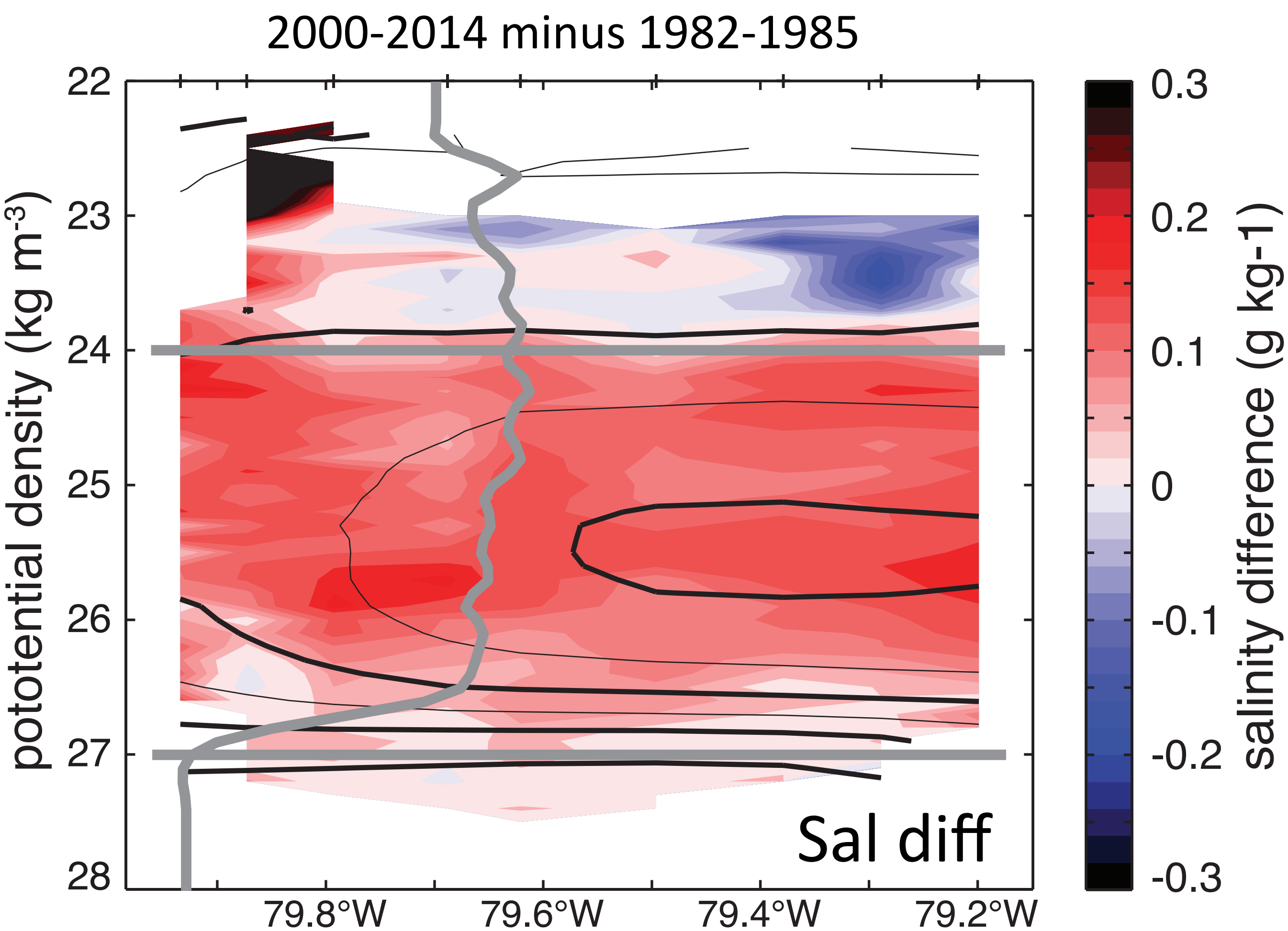
Water Properties: decadal changes



Distinct water masses have become saltier.

(Salinity Max Water, Eighteen Degree Water, AAIW)

Decadal salinification across entire Strait



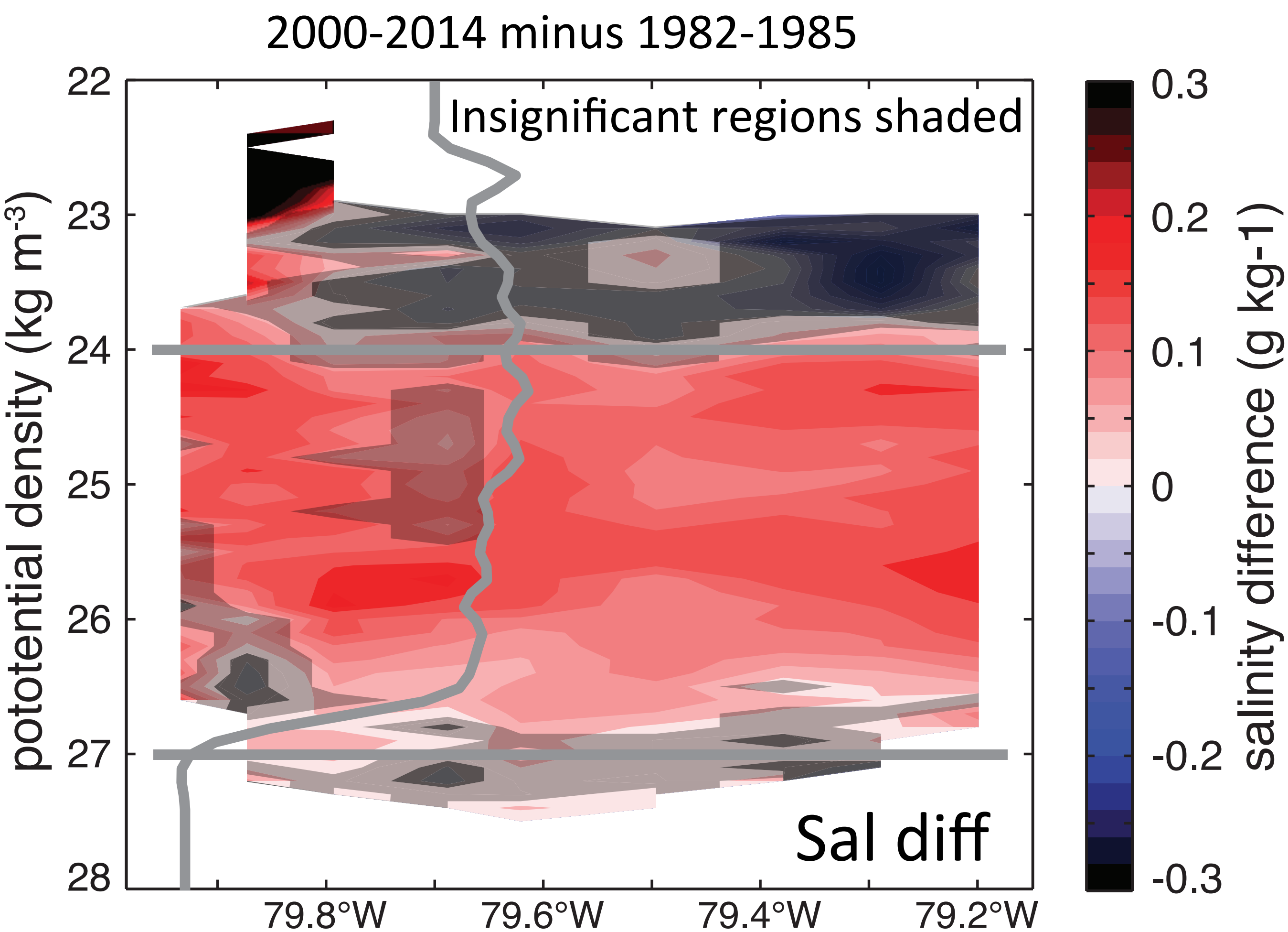
Entire subsurface became saltier.

Durack and Wijfels (2010): Saltier subtropics from more evaporation, but Southern Ocean (AAIW) fresher from more precip.

Below 24 kg/m^3, no freshening present, all salinification.

(Surface layer requires seasonal analysis)

Decadal salinification across entire Strait



AAIW salinification is not significant (nor is SW).

(Stratification and origin production rates are details inessential here.)

Salinification of almost all IW layer is robust, strongest in IWE.

Meaningful Salt Transport without Mass Conservation

$$T_{\mathrm{sal}} = \iint (S - S_{\mathrm{ref}}) v \, \mathrm{d}x \, \mathrm{d}z$$

Decompose a zonal transect into:

$$S(x,z) = S_0 + S_p(z) + S'(x,z)$$

$$S_0 = \iint S \, dx \, dz$$

$$S_p(z) = \int (S - S_0) \, dx, \qquad \int S_p \, dz = 0$$

$$S'(x,z) = S(x,z) - S_0 - S_p(z), \qquad \iint S' dx \, dz = 0$$

(decomposition from Bryden et al., 2009; McDonagh et al., 2015)

For an incomplete section, e.g. Florida Straits:

Throughflow = S_0*v, Overturning = (S-S_0)*v, Gyre = (S-S_0-S_p)*v

Decadal salt transport changes

Salt Transport ($Sv\ g\ kg^{-1}$)	**Gyre** ($S_{ref}=S_p$)			**Overturning** ($S_{ref}=S_0$)		
	1980s	2000s	diff	1980s	2000s	diff
SW	-0.38	-0.30±0.11	0.09	9.0	9.7±0.4	**0.7**
IW-W	-1.68	-0.85±0.07	**0.83**	6.3	4.8±0.2	**-1.5**
IW-E	-1.74	-0.91±0.14	**0.83**	16.3	18.0±0.3	**1.7**
AAIW	-1.45	-1.36±0.09	0.09	-0.08	0.07±0.03	**0.15**
total	-5.25	-3.42±0.29	**1.83**	31.5	32.5±0.4	**1.0**

Gyre carries much more salt: more evaporation, non-dynamical

Overturning carries a little more salt: AAIW now carries salt N
IW exchange reflects volume transport change -> large impact.

Subtropical evaporation (salinification) and water masses dominate.

Conclusions

In the Florida Current, the subtropical North Atlantic
has a large impact on:

- Average northward volume transport
- Decadal increases of salinity
- Decadal increases of northward salt transport

Mixing of nearby air-sea forcing is essential for WBC salt advection.

Our findings

- Agree with recent observations
- Provide a reason why coarse-resolution and eddy-resolving simulations have different advective-diffusive balances.