Transports of freshwater and heat in the subtropical North Atlantic

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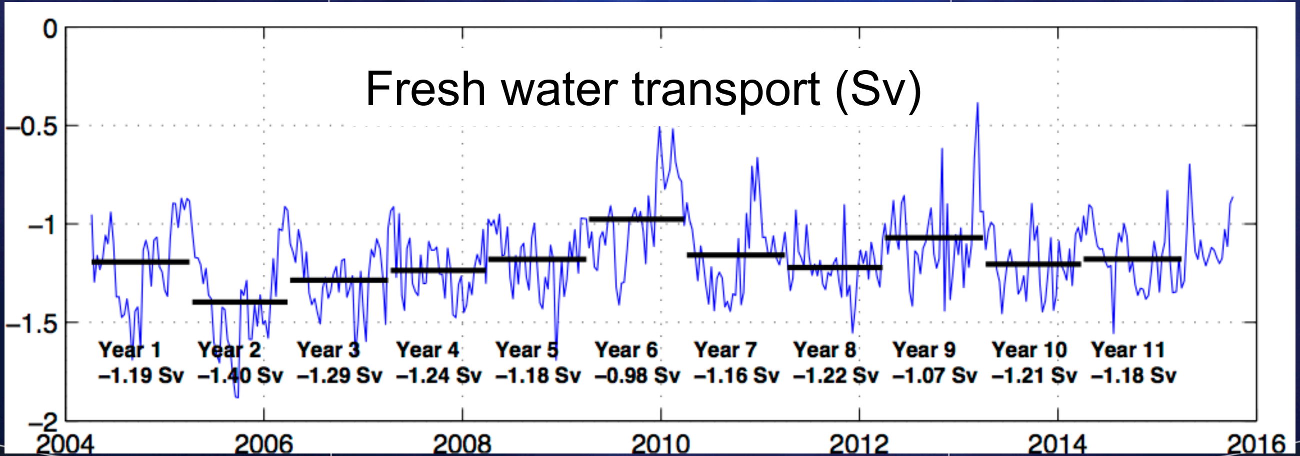
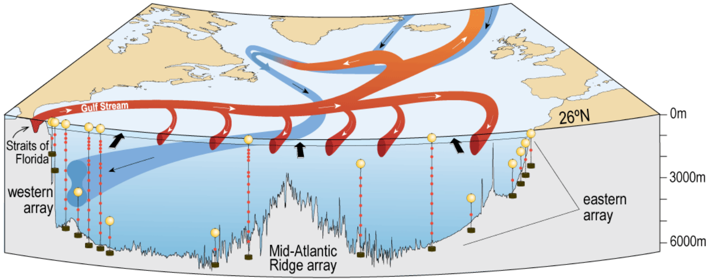


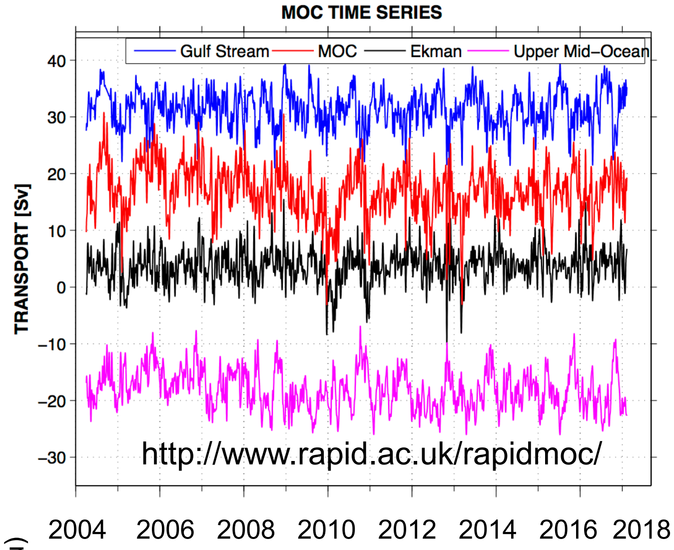
noc.ac.uk

Oxford, 21st September 2017

Observations

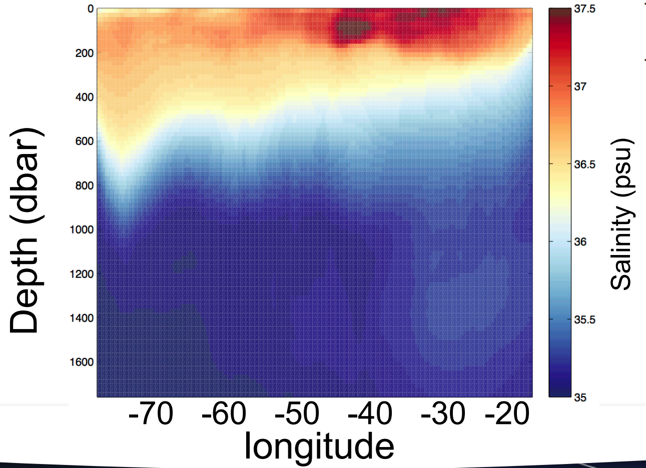


Temperature and salinity data from the RAPID-AMOC array



Transport time series from the RAPID-AMOC array

Optimally interpolated Argo data (top 1800db)

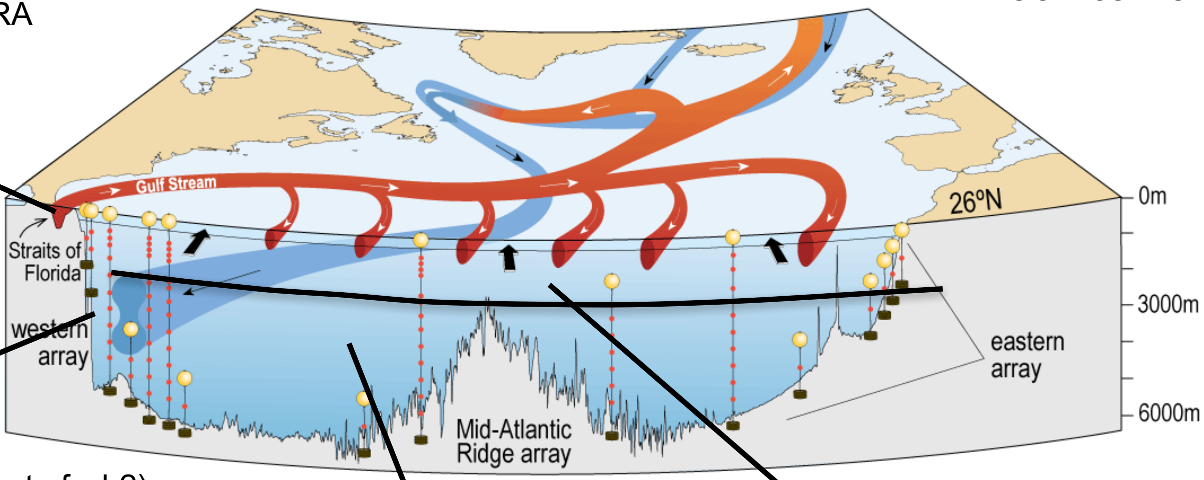


Method

Estimates of temperature, salinity And velocity fields every 10 days 2004 to 2015

Ekman (uppermost layer)
Salinity from Argo OI
Transport from ERA

Florida Straits
Cable transport +
Transport weighted salinity
(Szuts and Meinen, 2012)



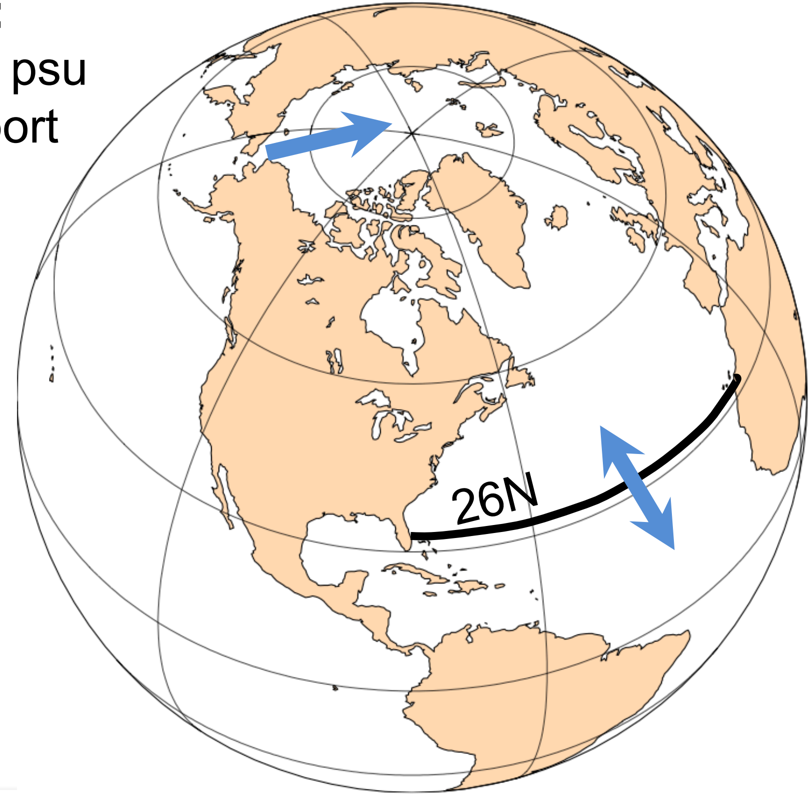
Western Boundary Wedge (west of wb2)
Transport and salinity from
RAPID-AMOC moorings

Interior > 1800db (east of wb2)
Transport and salinity from
RAPID-AMOC moorings

Interior < 1800db (east of wb2)
Salinity from Argo OI
Transport from Argo density field
referenced to RAPID-AMOC
transports

Method

Bering Strait:
0.8 Sv at 32.5 psu
Salinity transport of 26 Sv psu
(Woodgate et al., 2005)



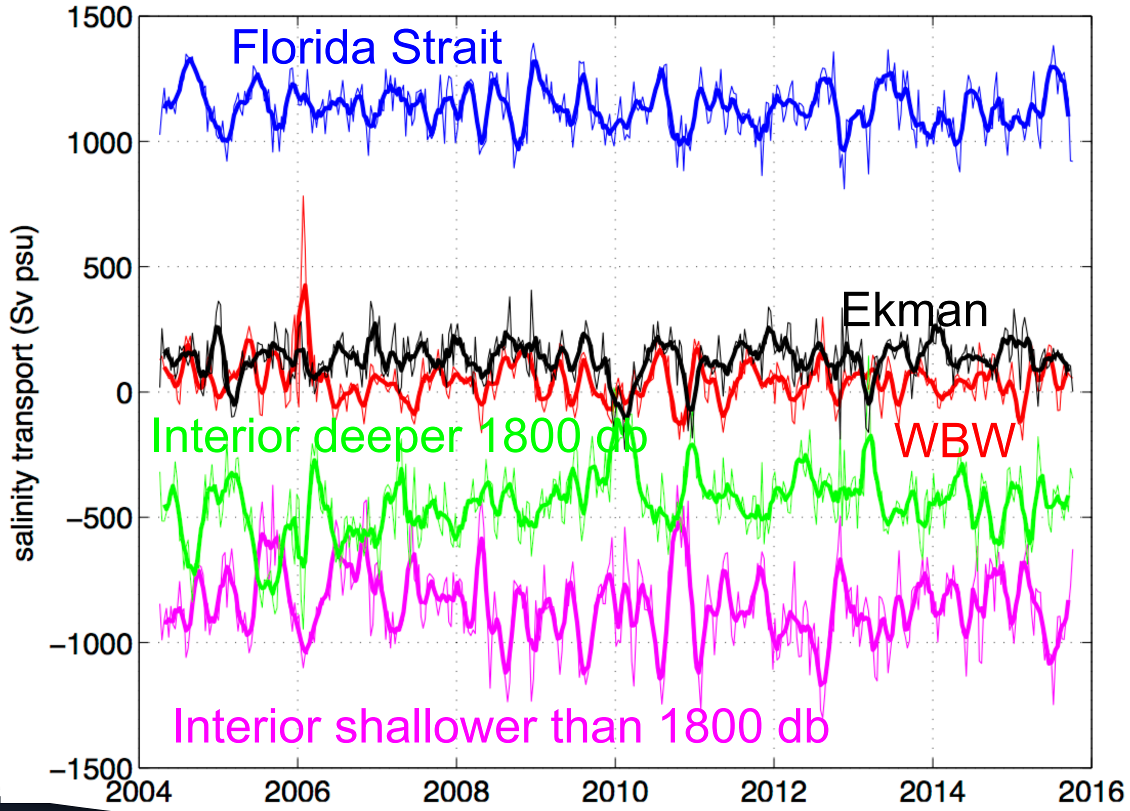
Set the section salinity transport equal to the Baring Strait salinity transport.

Salt is conserved between BS and 26N

The net volume flux across the Section is the freshwater flux.

$$FW = -1x(\ 26.0 - ST_{26N}) / \overline{Sal_{26N}}$$

Salinity Transports 26N



FS: 1135 ± 102 Sv psu

Ekman: 133.2 ± 94.2 Sv psu

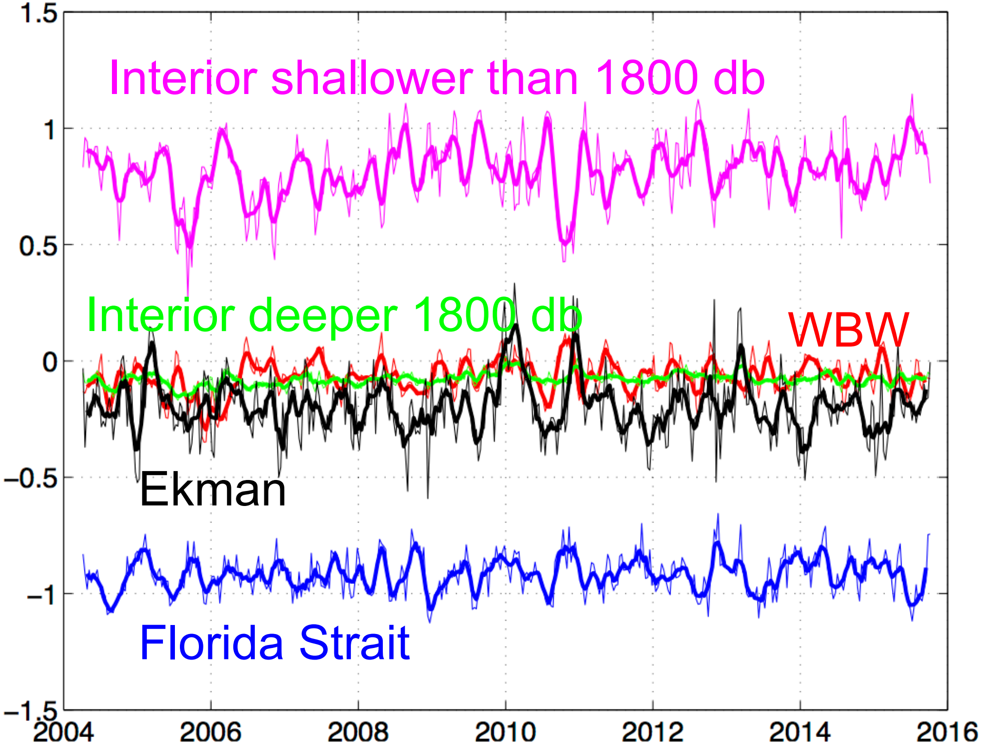
WBW: 45.8 ± 98.5 Sv psu

Int deep: -447.6 ±147.7 Sv psu

Int shallow: -851.2 ± 165.5 Sv psu

+ve Northwards

Equivalent Fresh water transports

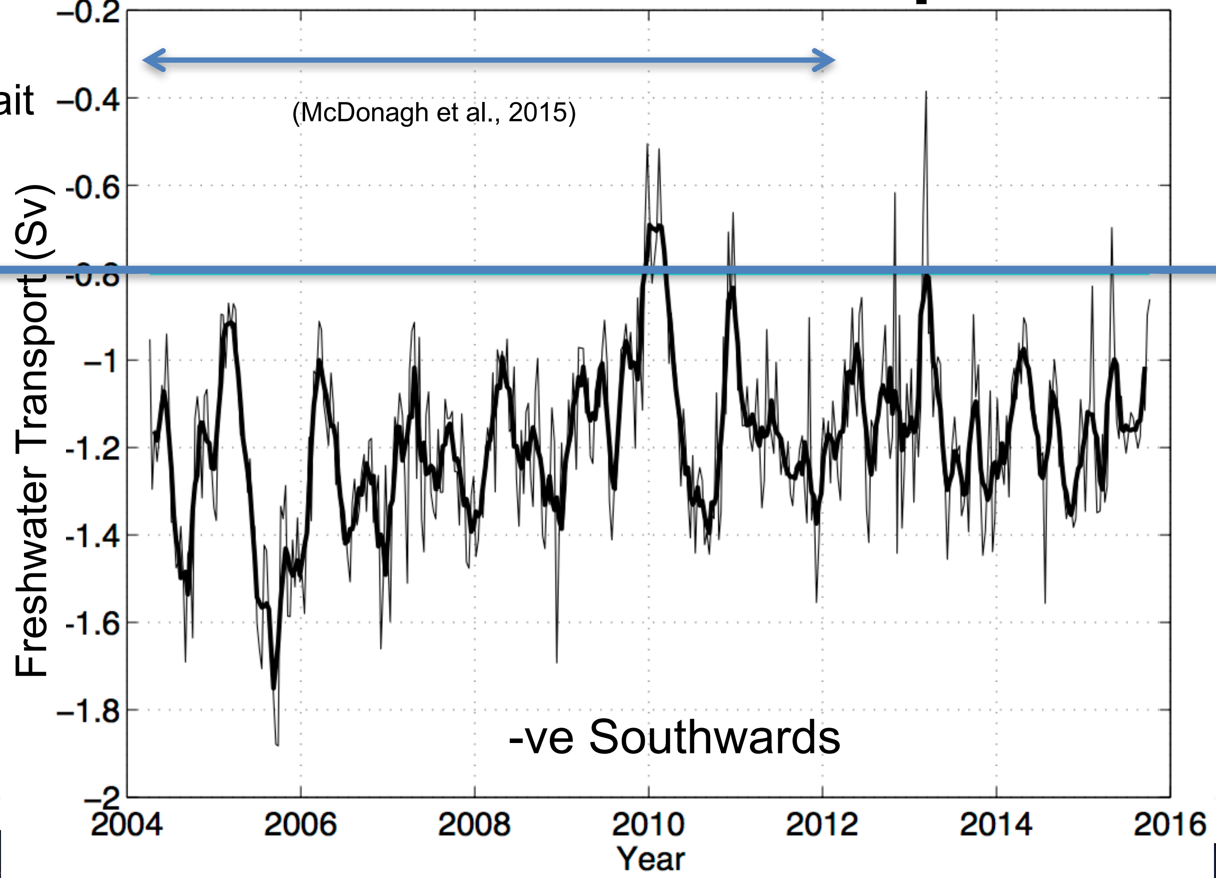


+ve Northwards

Dominant balance between the Florida Straits (-0.91 Sv) and the upper interior (0.81 Sv)

Freshwater Transport at 26N

Bering Strait
-0.8 Sv

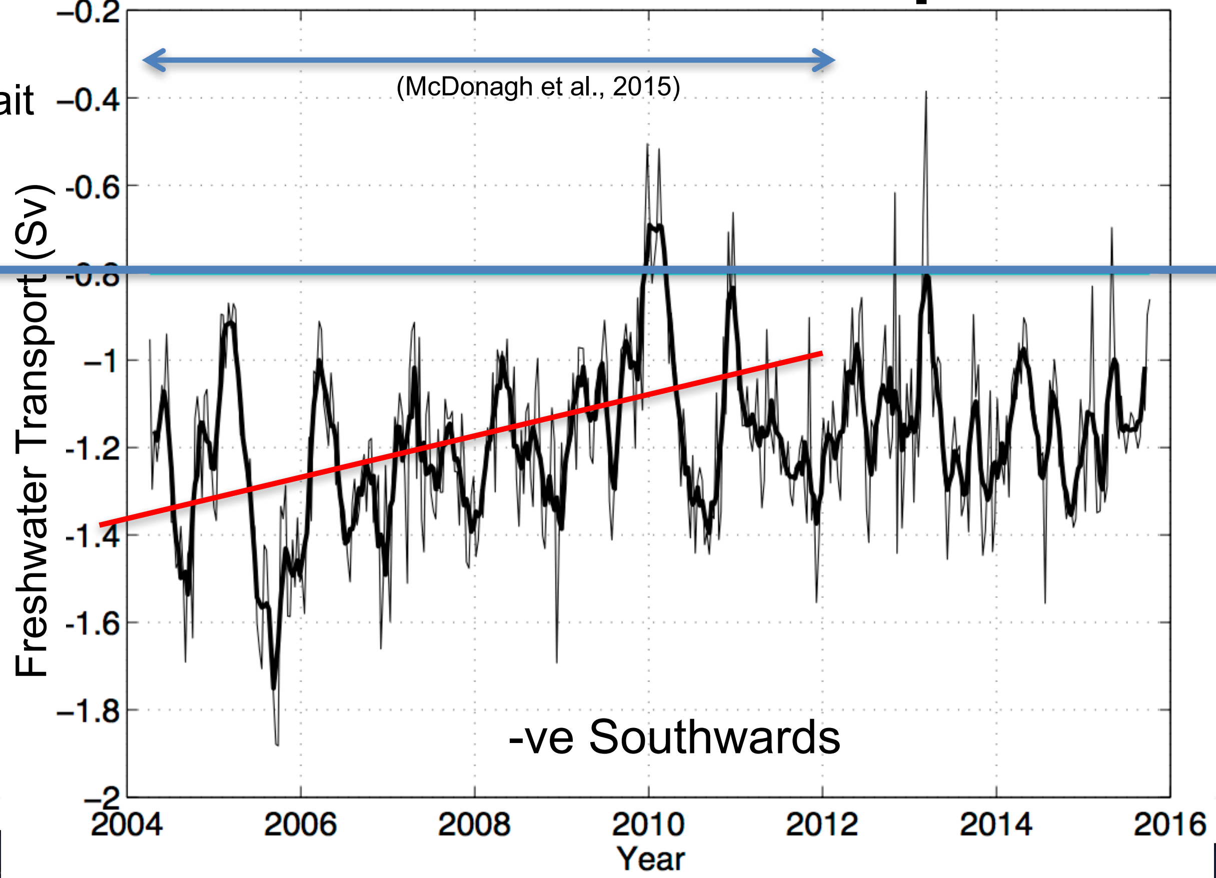


E>P
Net freshwater loss

E<P
Input of freshwater
Into the ocean

Freshwater Transport at 26N

Bering Strait
-0.8 Sv



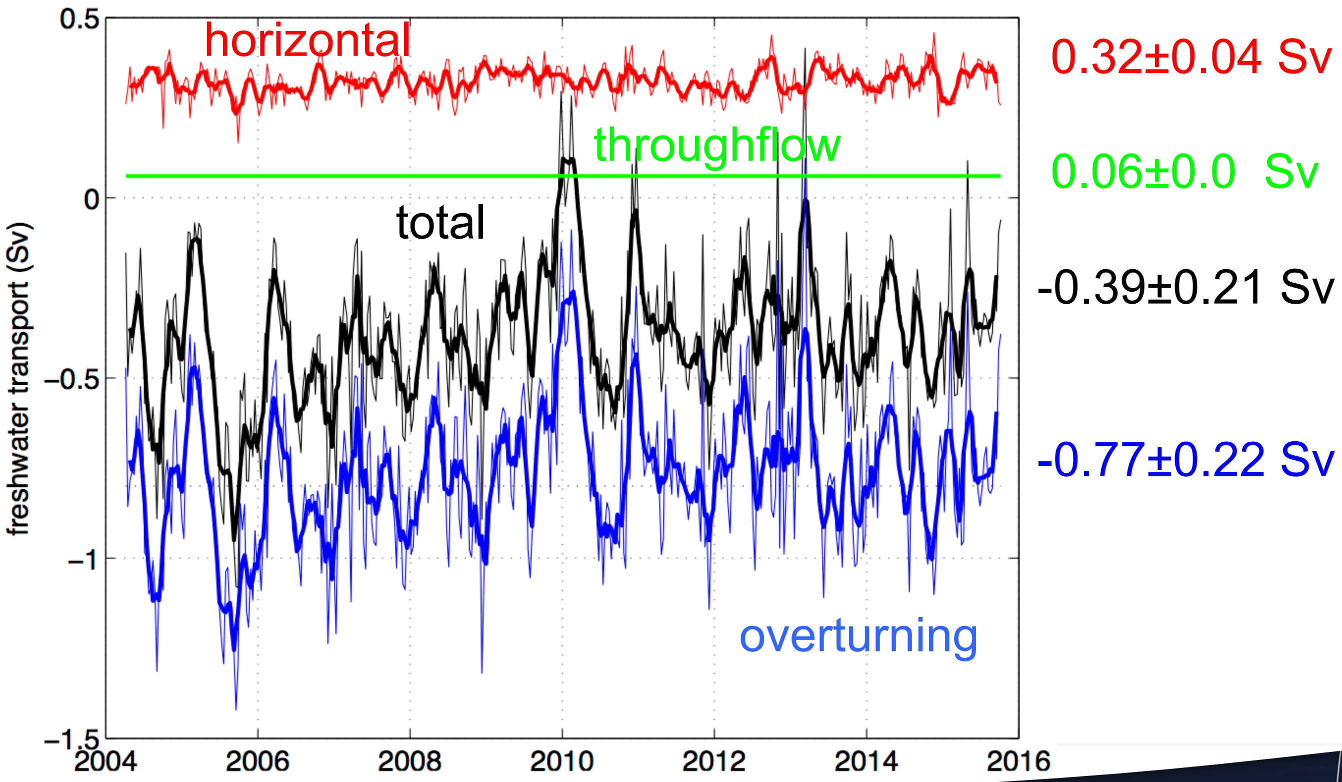
E>P
Net freshwater loss

E<P
Input of freshwater
Into the ocean

Components freshwater DIVERGENCE

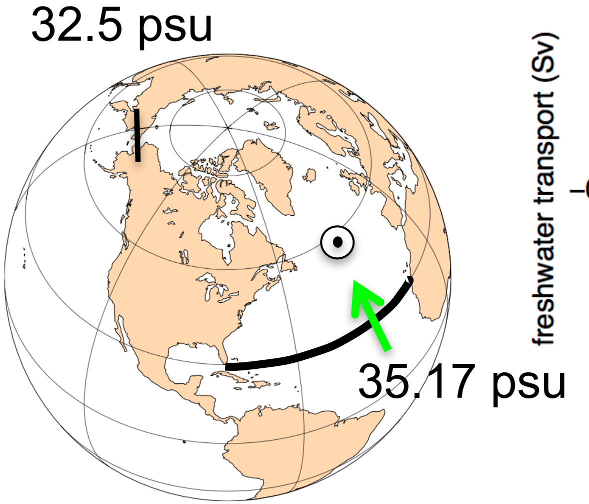
Fresh Water
Divergence Includes:

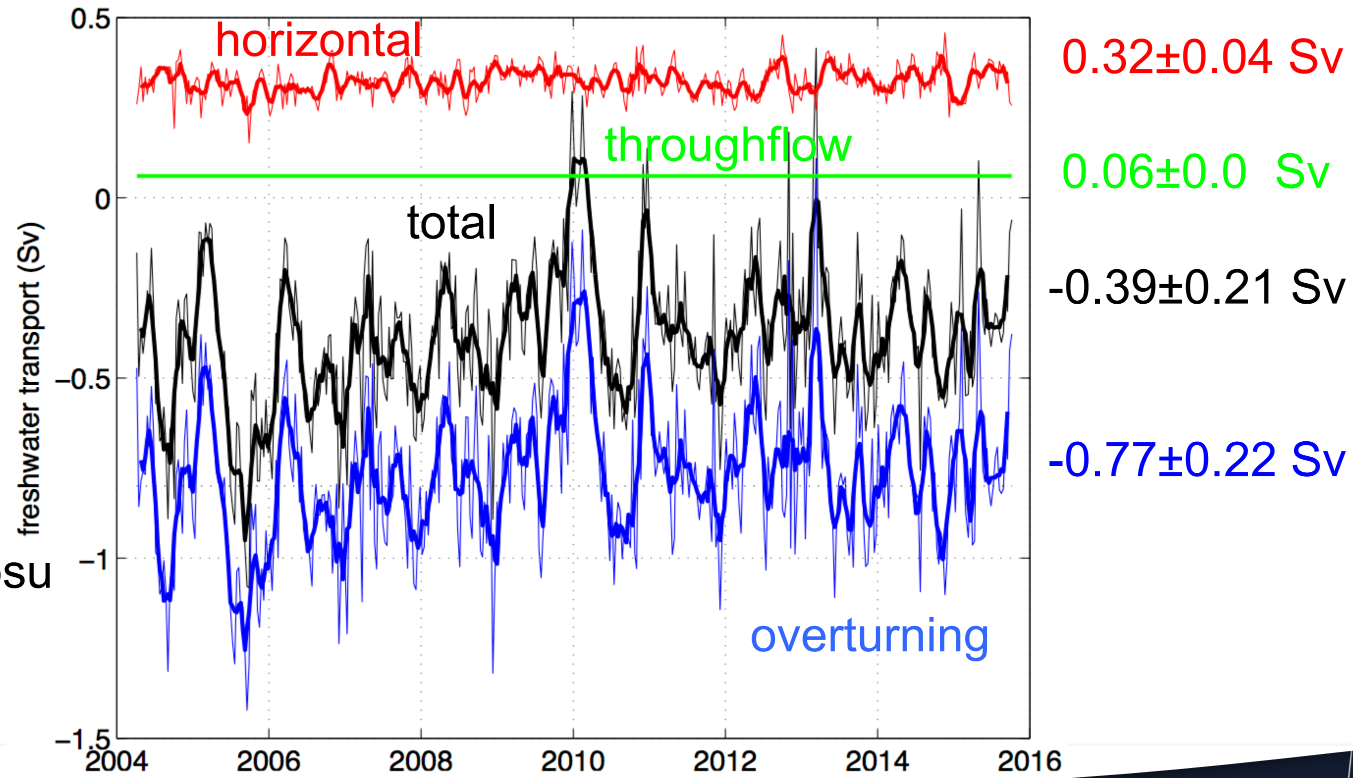
air-sea fluxes (E-P),
runoff,
ice/melt formation,
oceanic storage of
Fresh water



Components freshwater DIVERGENCE

Throughflow
Loss of freshwater
Between BS and 26N.

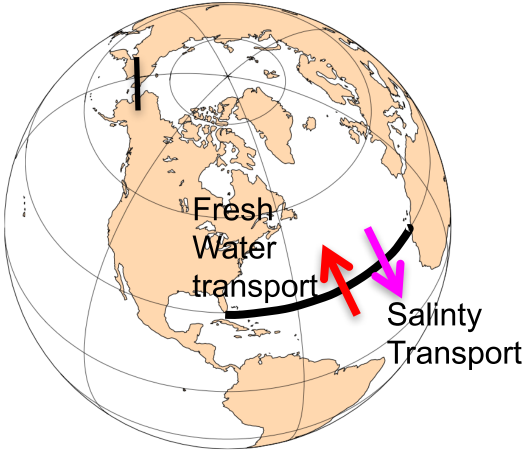


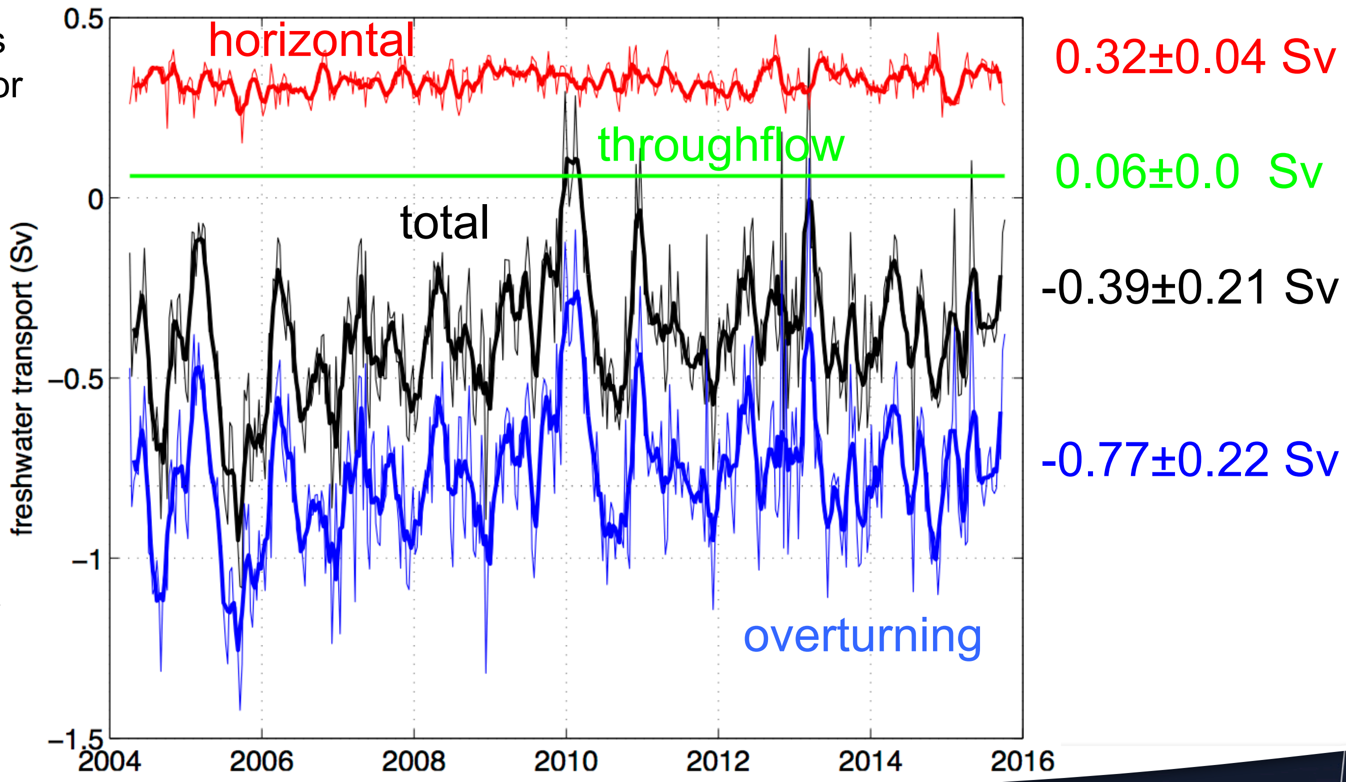


Components freshwater DIVERGENCE

Horizontal

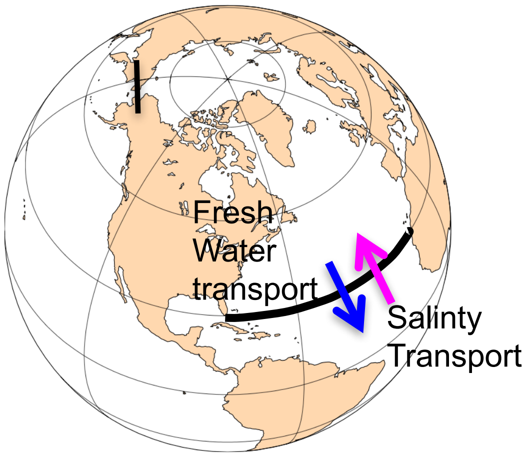
Balance between the northwards flowing FS current and the interior upper ocean return flow

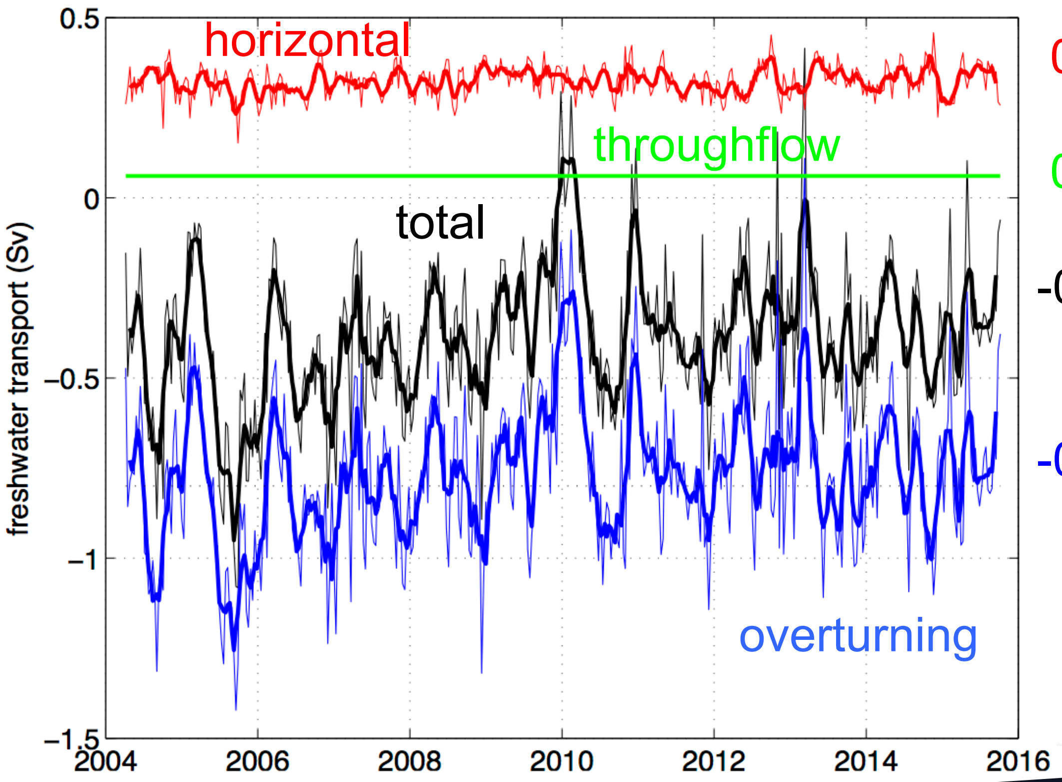




Components freshwater DIVERGENCE

Overturning
Largest and most variable component.

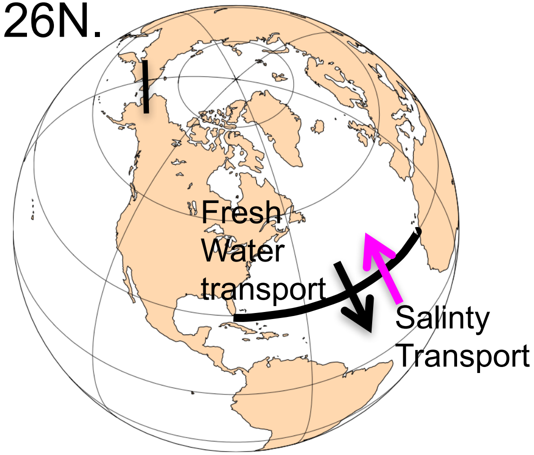


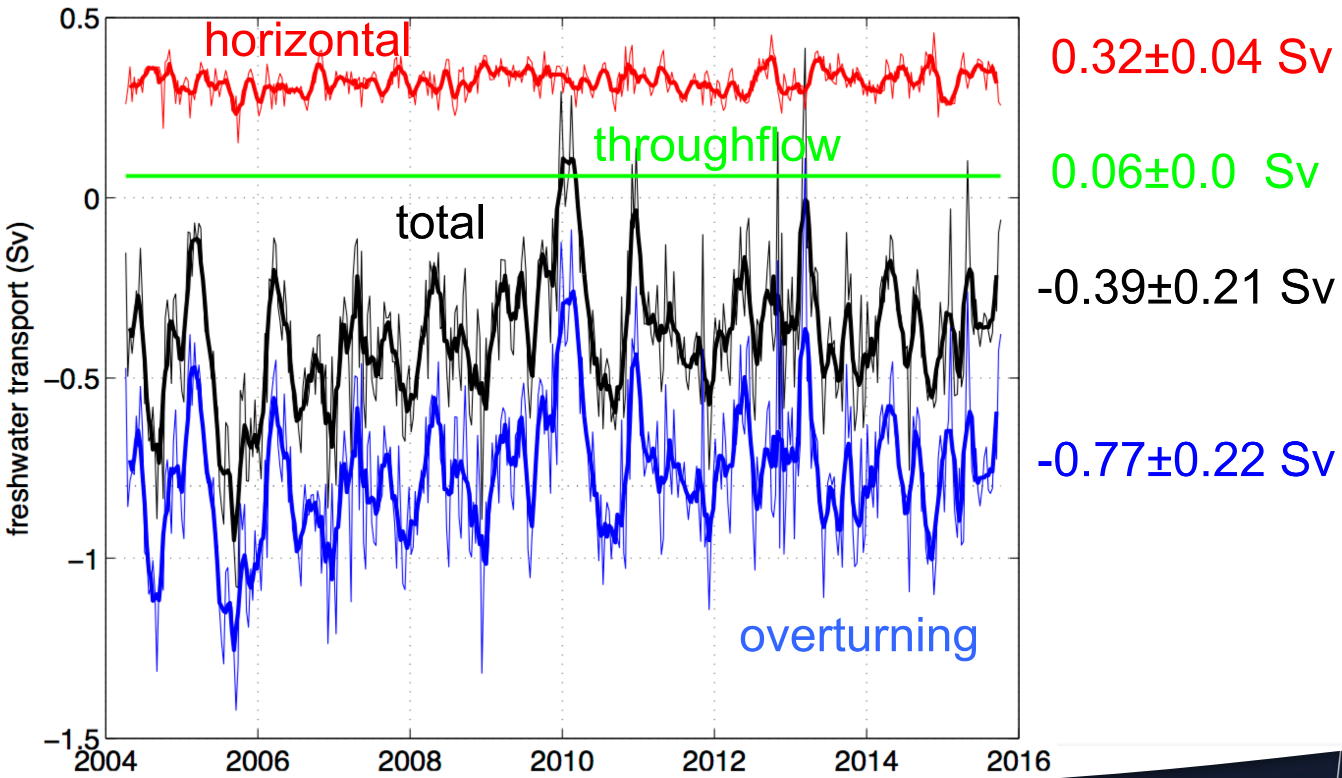


0.32±0.04 Sv
0.06±0.0 Sv
-0.39±0.21 Sv
-0.77±0.22 Sv

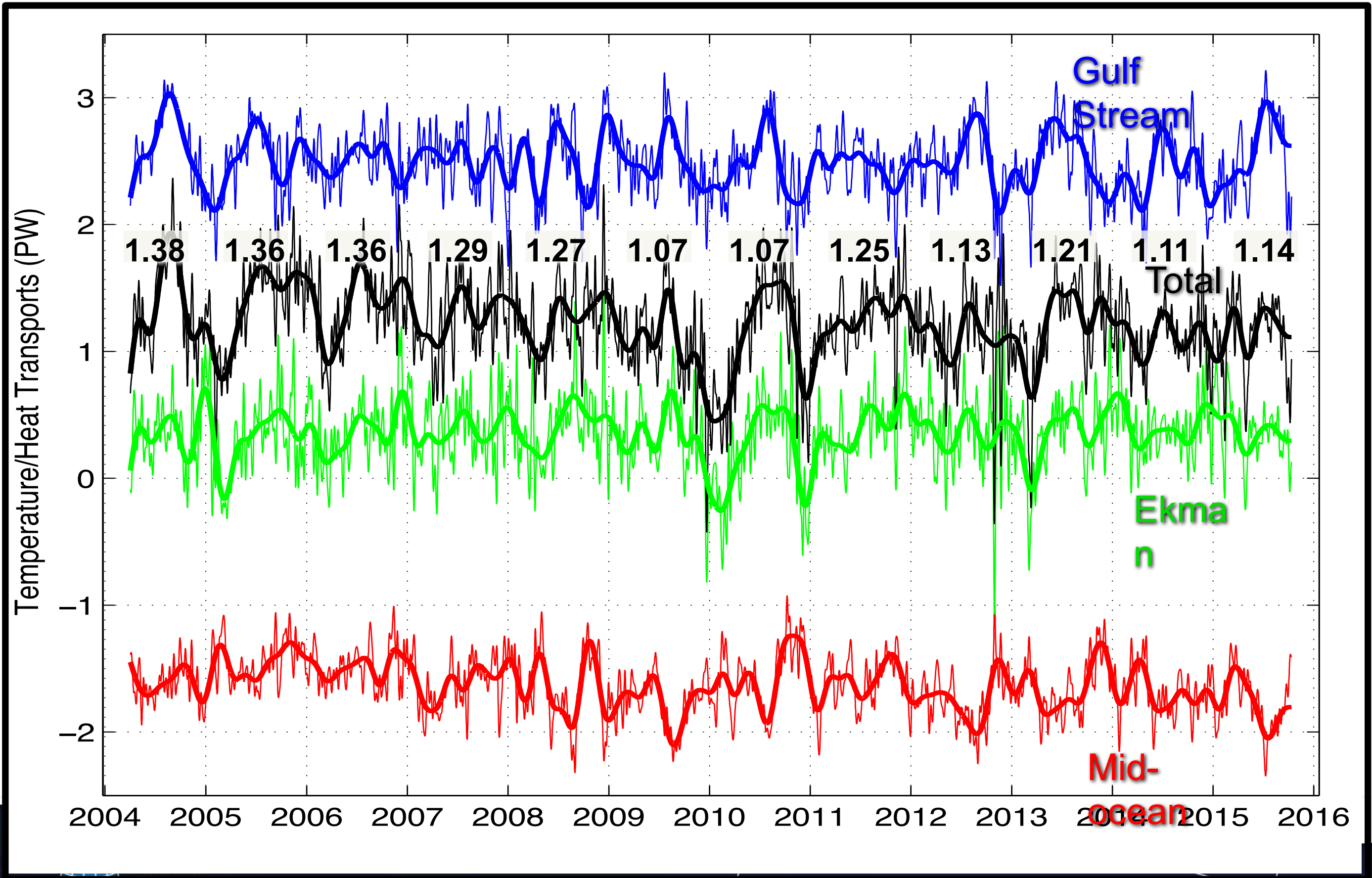
Components freshwater DIVERGENCE

Total:
Freshwater INPUT
Into the North Atlantic
ocean between BS and
26N.





Heat Transport at 26N (time series updated to 2015)



2004-2015
mean heat transport:
1.22±0.11 PW

Multi-year averages:

2004-2008
1.33±0.05 PW

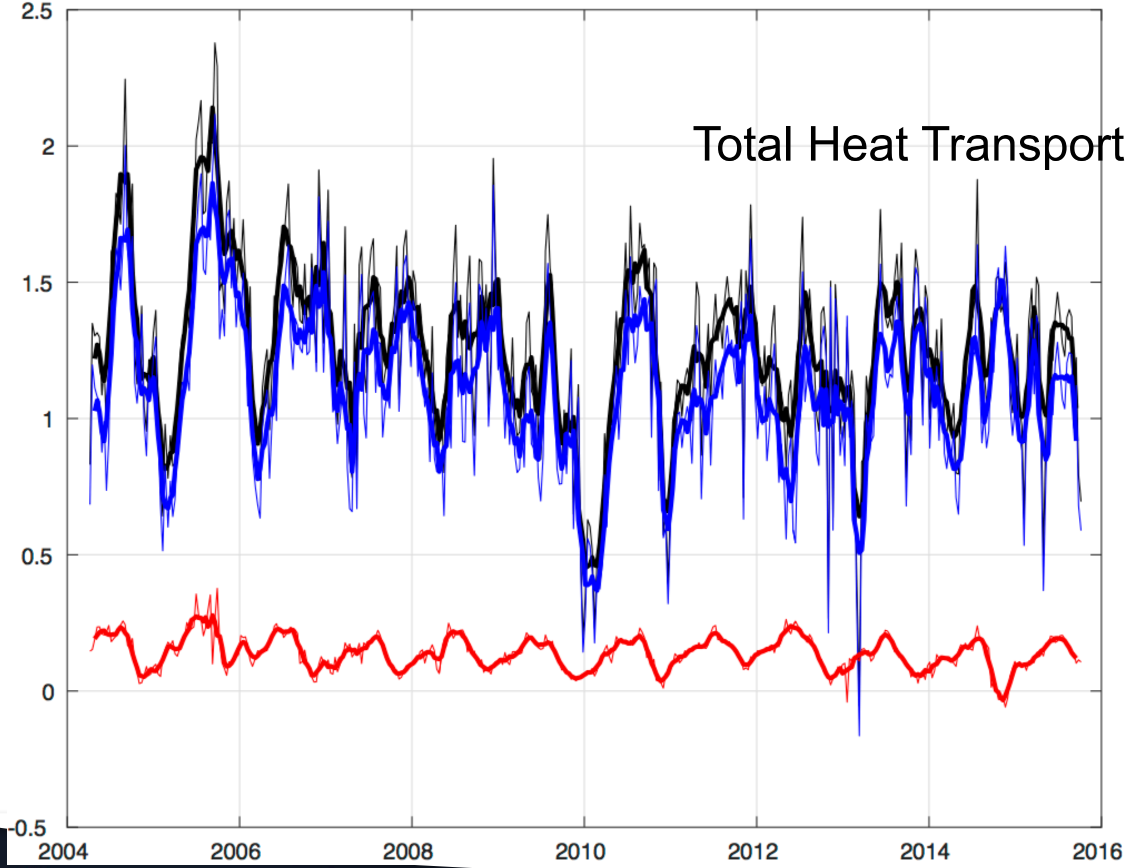
2009-2015
1.14±0.07 PW

2011-2015
1.17±0.06 PW

+ve Northwards

http://www.rsmas.miami.edu/users/mocha/mocha_results.htm

Heat Transport at 26N

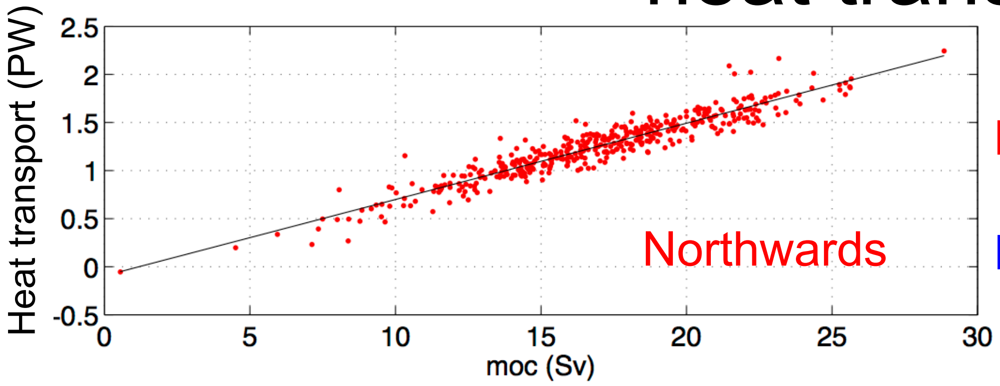


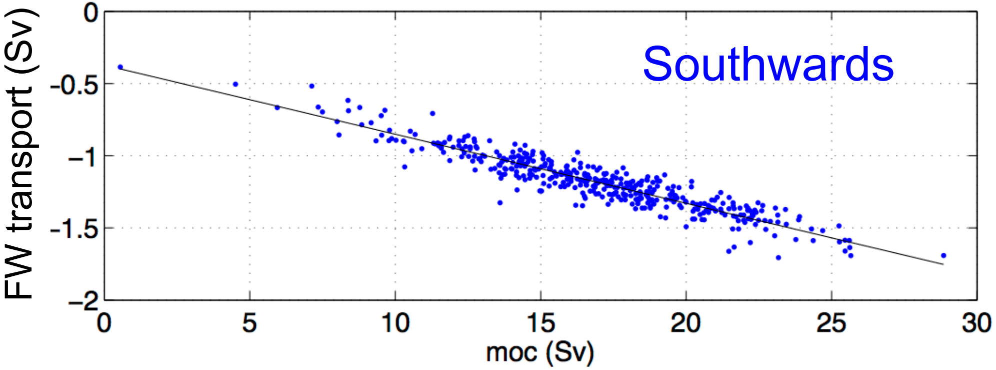
Total Heat Transport = 1.25 ± 0.34 PW

Overturning : 1.11 ± 0.33 PW

Horizontal = 0.14 ± 0.06 PW

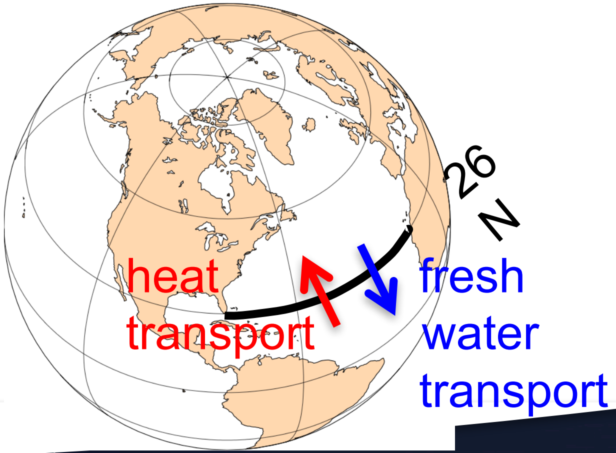
Relationship between AMOC, freshwater and heat transports



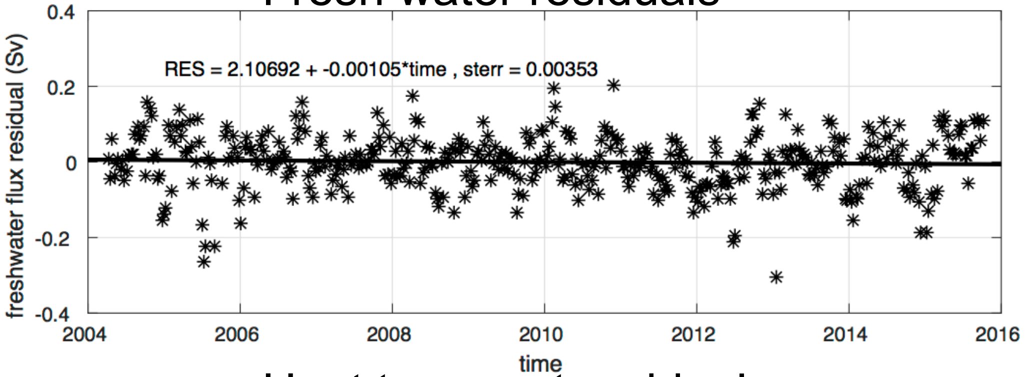


Heat transport=-0.10 + 0.79MOC, R^2=**0.89**

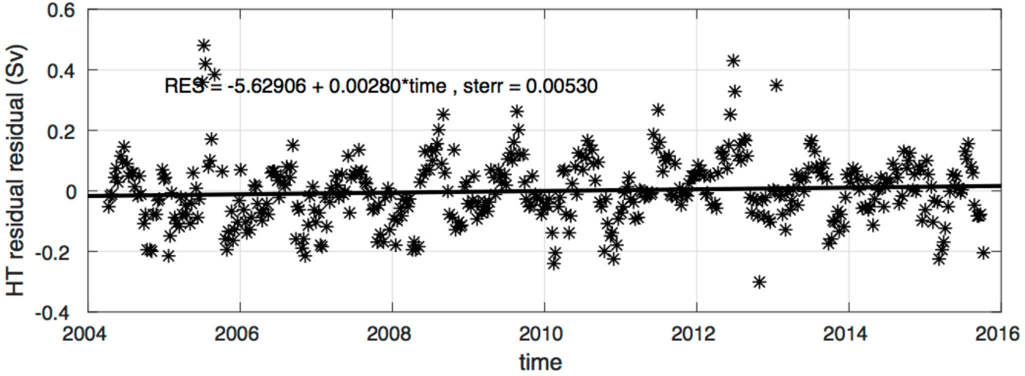
FW transport = -0.37 - 0.048MOC,R^2=**0.87**



Fresh water residuals



Heat transport residuals



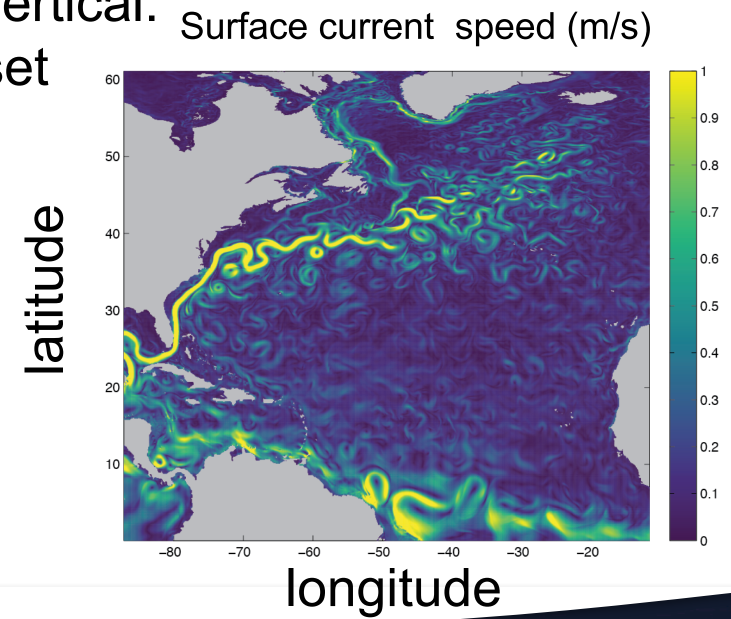
2004 to 2012 **(McDonagh et al., 2015)**
Increasing –ve residuals over time.

Consistent with an increase in upper ocean salinity **at 26N**.

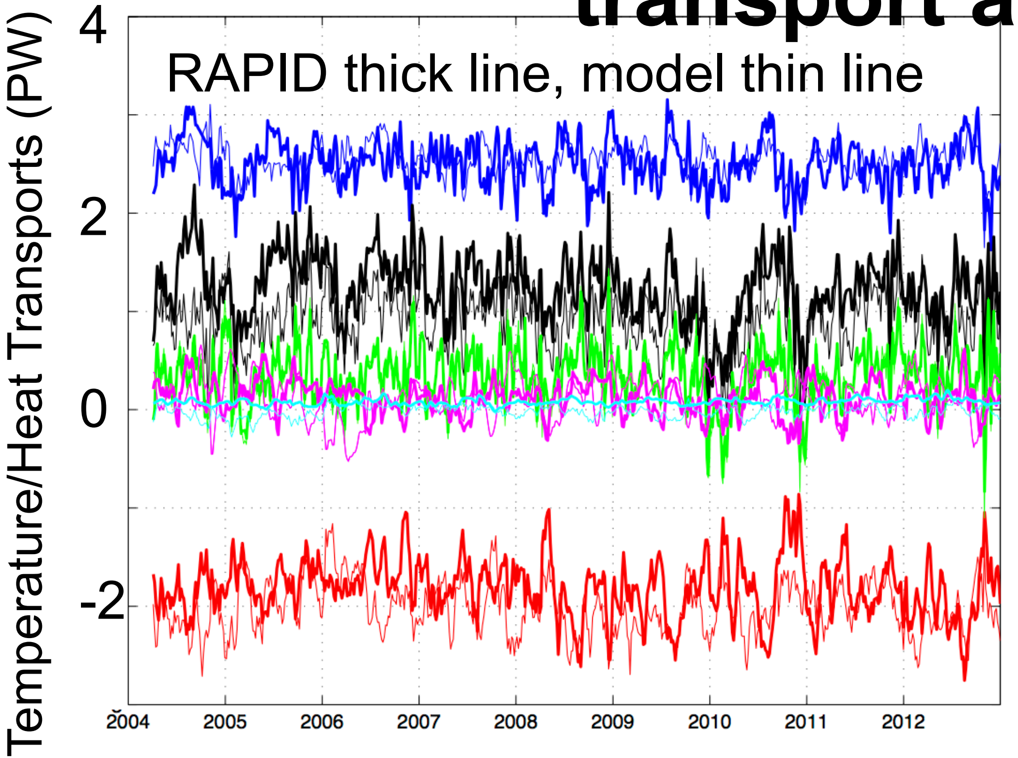
Consistent with an increase in upper ocean temperature **at 26N**.

Can an ocean only model reproduce the Heat transport at 26N?

- NEMO-LIM2 ocean circulation/sea ice model (Marzocchi, 2015; Moat, 2016)
- 1/12 degree Horizontal with 75 levels in the vertical.
- Forced by the Drakkar Surface Forcing dataset
  (air temperature, winds, humidity,
  surface radiative heat fluxes
  and precipitation)
- Eddy resolving (in Mid latitudes)
- Run from 1958 to 2015



Can an ocean only model reproduce the Heat transport at 26N?

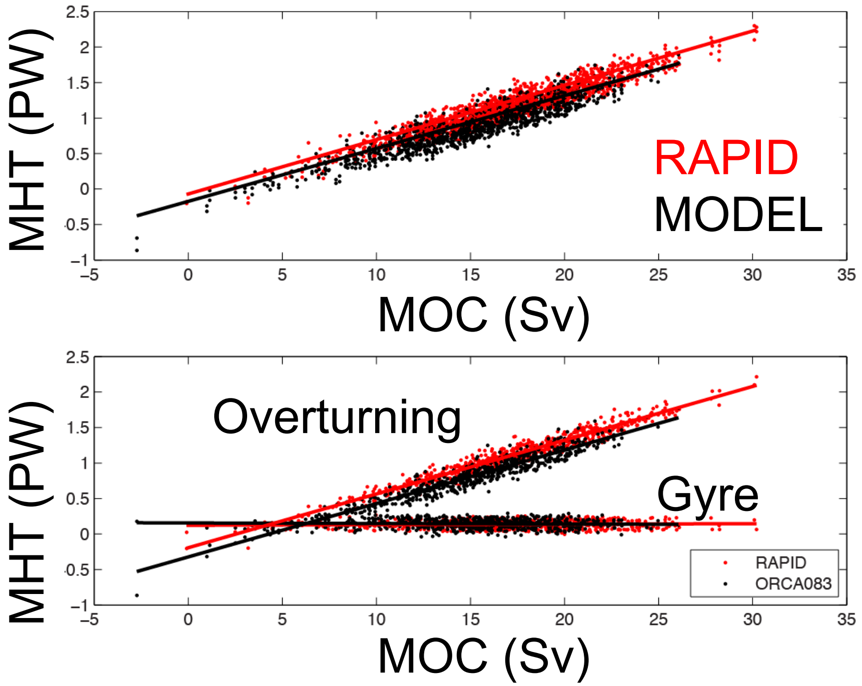


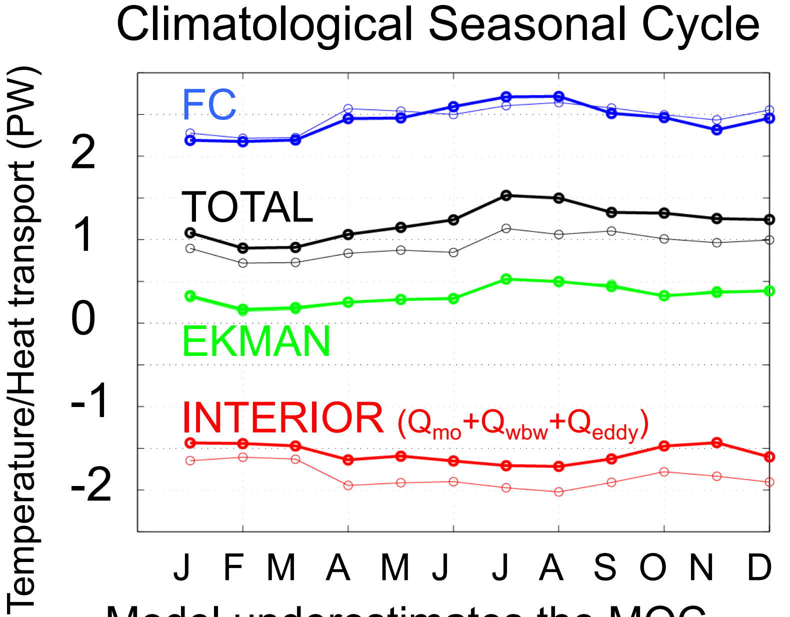
	ORCA083 (PW)	RAPID (PW)
FC	2.54 ± 0.16	2.50 ± 0.25
EKMAN	0.34 ± 0.31	0.35 ± 0.30
Mid- Ocean	-2.02 ± 0.27	-1.81 ± 0.31
WBW	0.12 ± 0.21	0.12 ± 0.18
EDDY	-0.02 ± 0.06	0.08 ± 0.03
Total heat transport	**0.93 ± 0.32**	**1.24 ± 0.36**

ORCA12 HT 0.3 PW lower than RAPID, but good agreement in the variability.

(Moat et al., JGR-Oceans, 2016)

RAPID MODEL comparison at 26.5°N





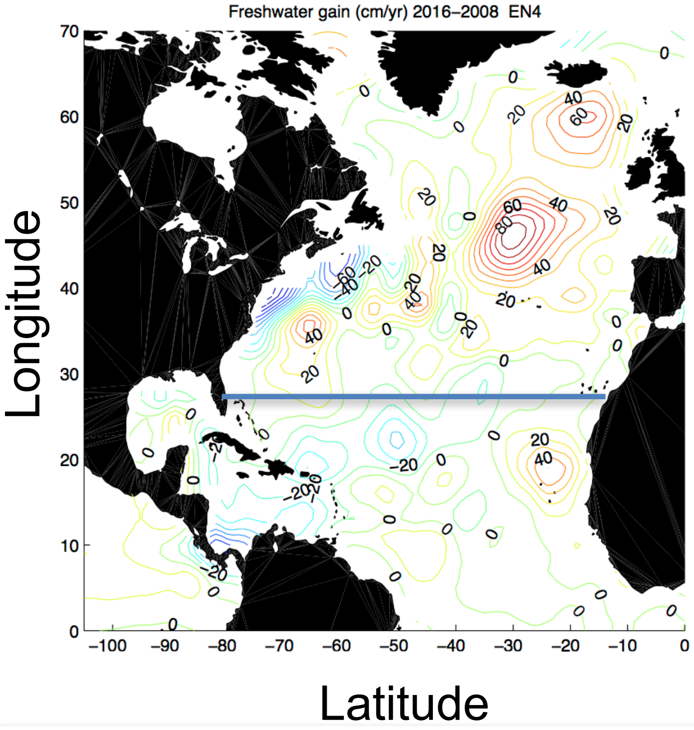
Model underestimates the MOC (2004 to 2012)

RAPID: 17.20±4.60 Sv

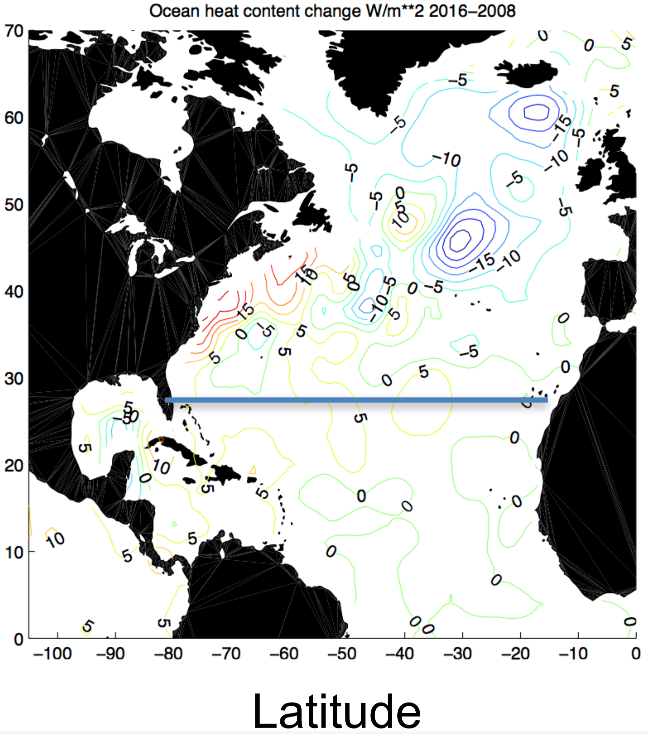
ORCA083: 15.18±4.03 Sv

Freshwater and heat storage (upper 1000 m)

Freshwater Gain



Ocean heat content change



2008 to 2016

AMOC 26N lower by 2.5 Sv

Freshening and cooling In the region of the North Atlantic current

Why?

Slow down of the MOC.

Ocean current position changing.

Surface fluxes.

Summary

Extended the fresh water time series at 26N to October 2015.

data will be made available soon.

Heat transport time series at 26N April 2004 to October 2015

available: https://www.rsmas.miami.edu/users/mocha/mocha_results.htm

Variability in the heat and freshwater transports is dominated by variability in the MOC

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