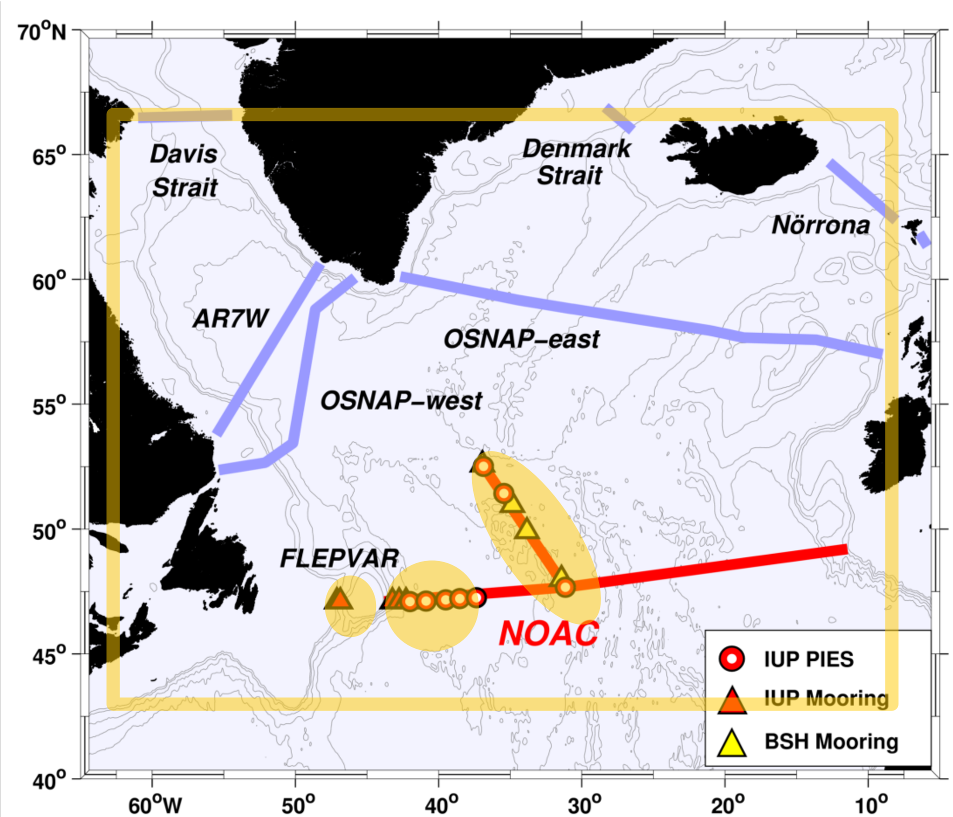
The Bremen NOAC observing system in the subpolar North Atlantic

Dagmar Kieke, Monika Rhein, Achim Roessler, Christian Mertens, Reiner Steinfeldt, and Linn Schneider

Universität Bremen*

NOAC – North Atlantic Changes …



NOAC objectives:

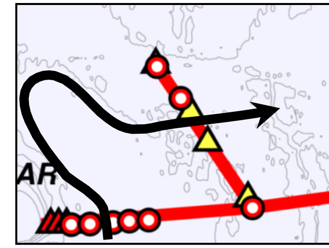
- strength of the subpolar gyre
- strength of the deep water export in the DWBC and across the MAR
- relation between NAC variations and DWBC variability
- formation and property changes of LSW

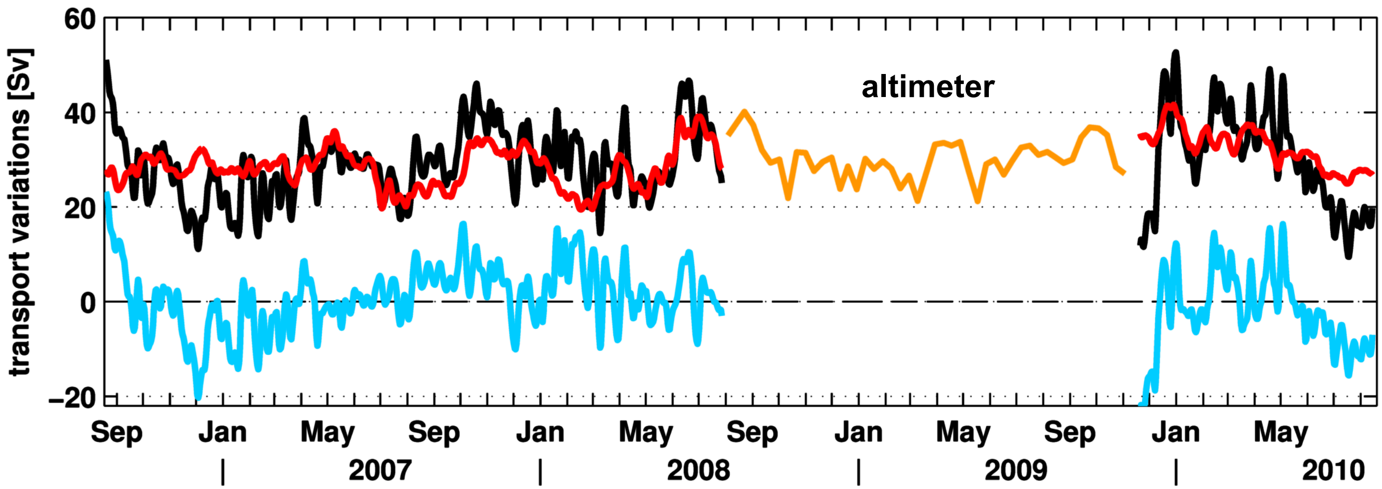
Long-term NOAC observatories:

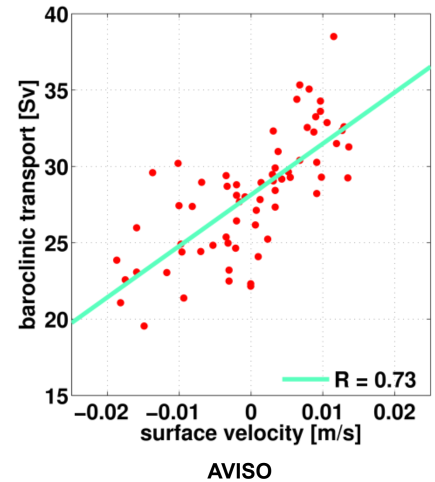
•large-scale hydrography/tracer surveys every 2nd year
•PIES along MAR and 47°N (presently 8)
•deep-sea moorings in the DWBC (presently 1; 3 between 2009-2011)

1. Strength of the subpolar gyre at the Mid-Atlantic Ridge derived from PIES

- geostrophic transport variation relative to 3400 dbar
- Argo-/CTD for transfering travel times into geostrophic transports (GEM technique)



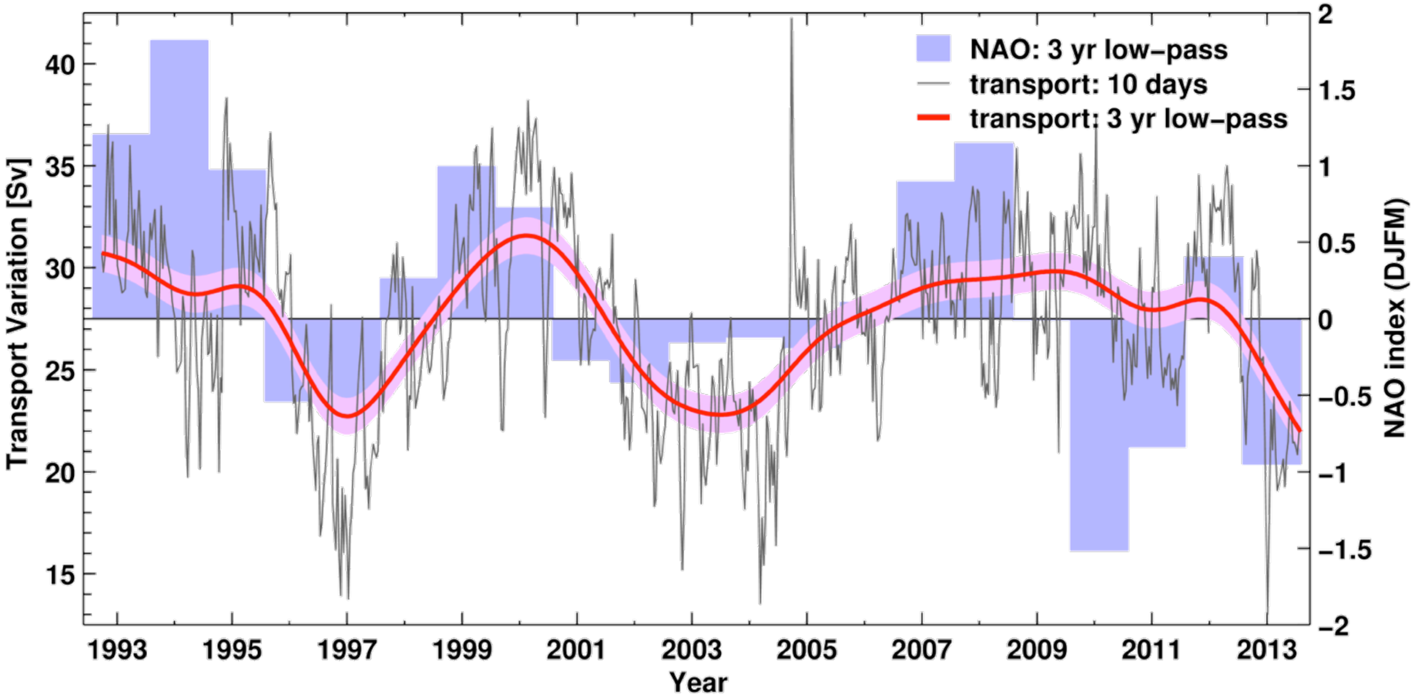


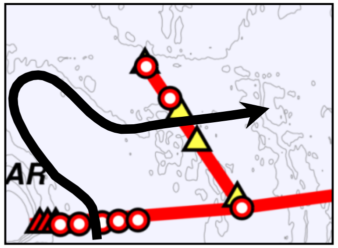


baroclinic (travel time)	29±5 Sv
barotropic (bottom pressure)	0±7 Sv
sum (baroclinic+barotropic)	29±9 Sv

Roessler et al. (2014, in prep.)

1. Strength of the subpolar gyre at the Mid-Atlantic Ridge derived from altimeter



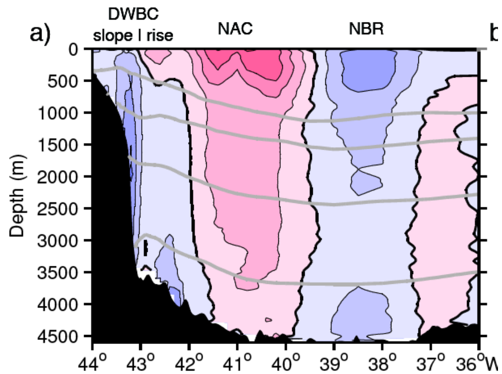


→ altimeter transports show high short-term but also interannual variability

→ correlation to one particular NAO index
(„Hurrell"-index based on SLP difference between Azores and Iceland),
but not to other indices („Hurrell"-Lisbon-Iceland, „Jones et al.")

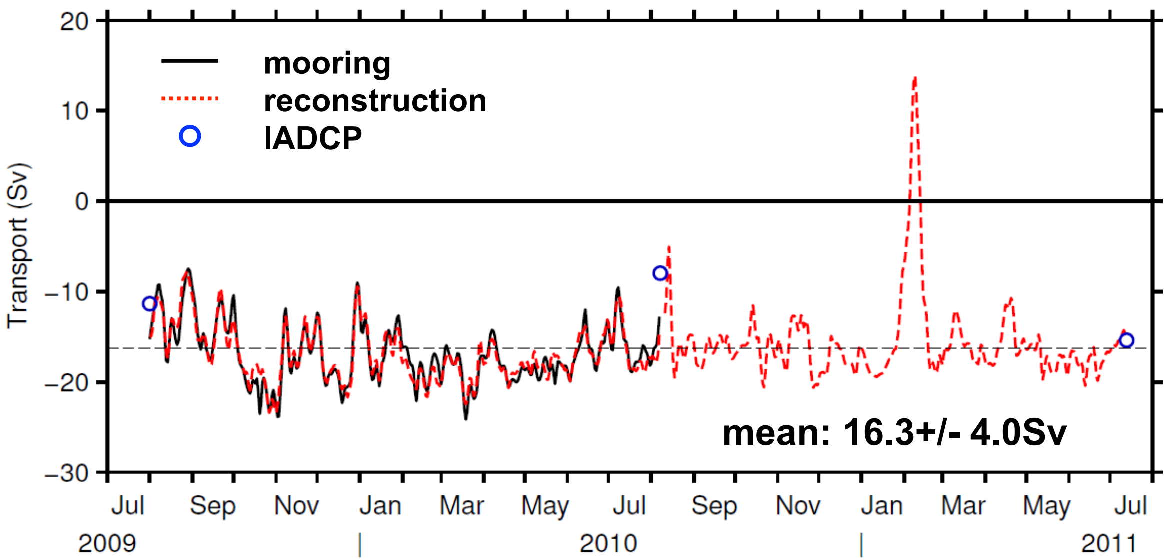
Roessler et al. (2014, in prep.)

2. DWBC variability at 47°N derived from mooring array, 2009-2011



→ two DWBC cores:
slope – max velocity at mid-depth
rise – bottom-intensified

→ top-to-bottom NAC and
considerable recirculation

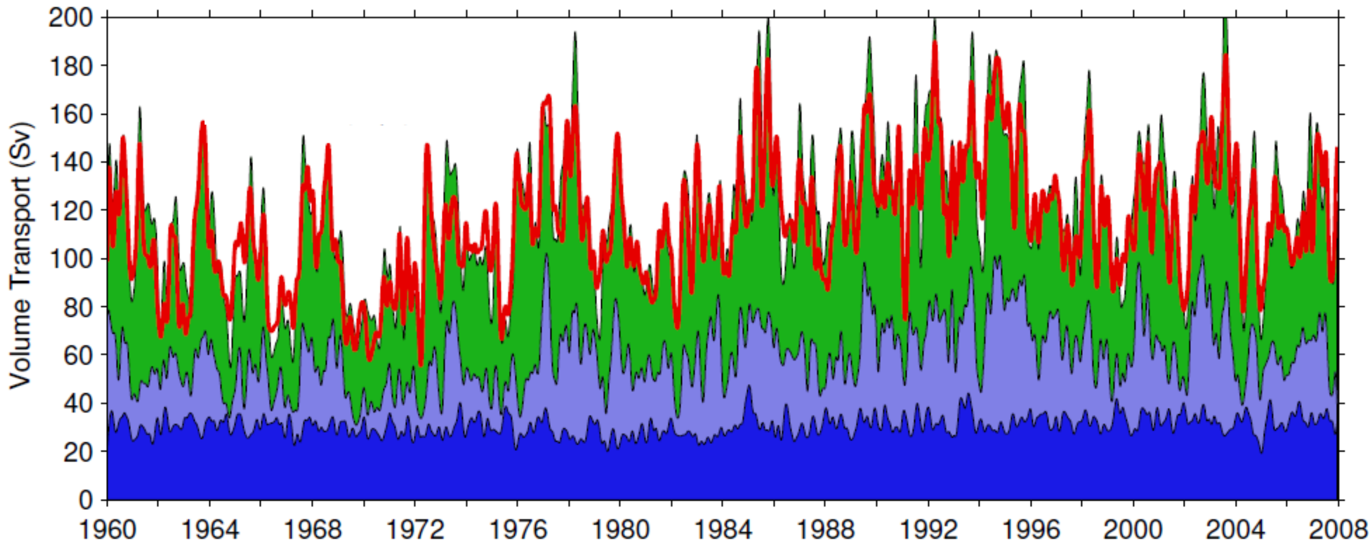


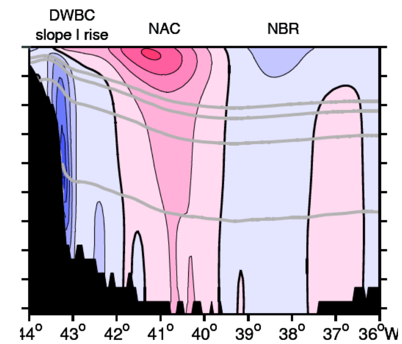
net deep water transport of the DWBC above continental slope below σ_θ = 27.68 kg/m^3

→ no apparent seasonal cycle
→ large transport variability on short time scales
→ maximum variability of meridional velocity at time scales between 20-50 days

Mertens et al. (2014, JGR, in revision)

2. DWBC variability at 47°N derived from VIKING20 model (1/20°), 1960-2008





accumulated top-to-bottom southward volume transport across 47°N partitioned into contributing components (low-pass filter: 100 days)

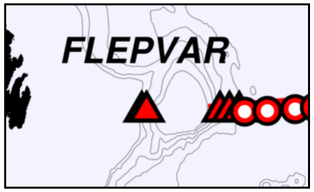
→ energetic short-term fluctuations and considerable intraseasonal to interannual variability

→ DWBC-slope is decoupled from NAC

→ transports in the DWBC-rise and NB recirculation co-vary with NAC

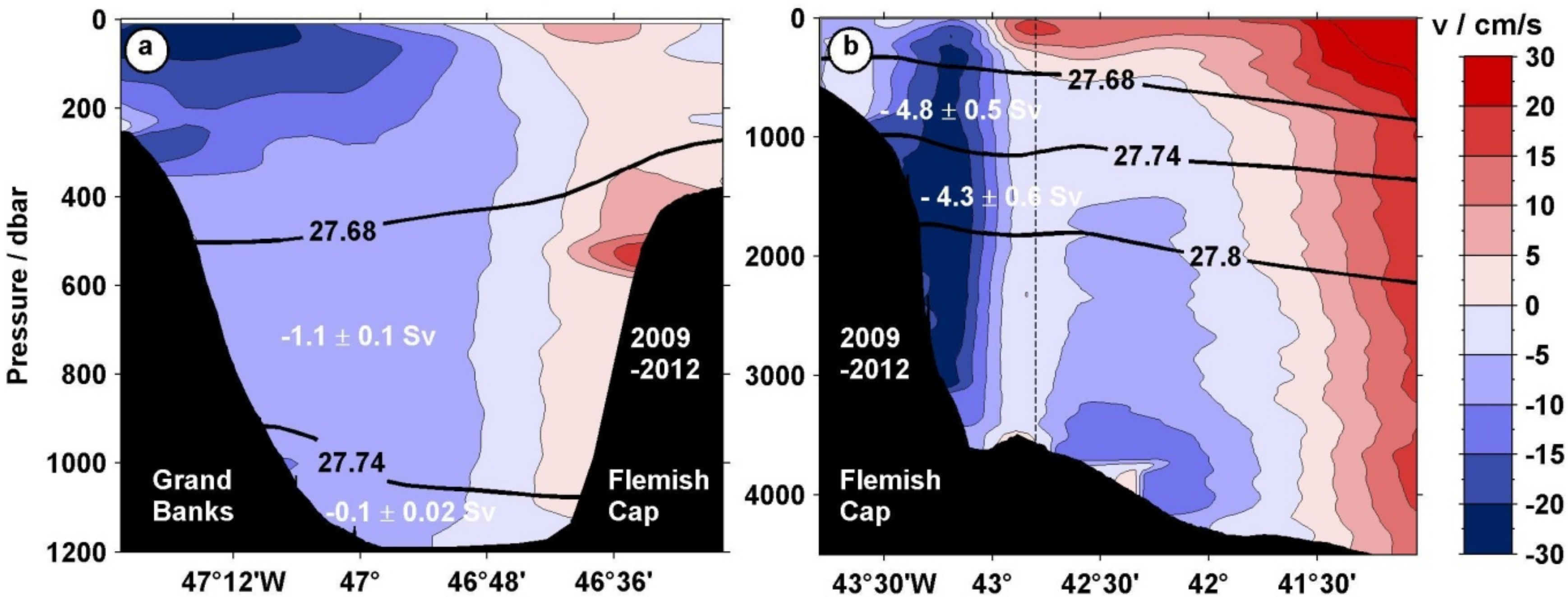
Mertens et al. (2014, JGR, in revision)

3. ULSW export through Flemish Pass at 47°N



Flemish Pass

DWBC



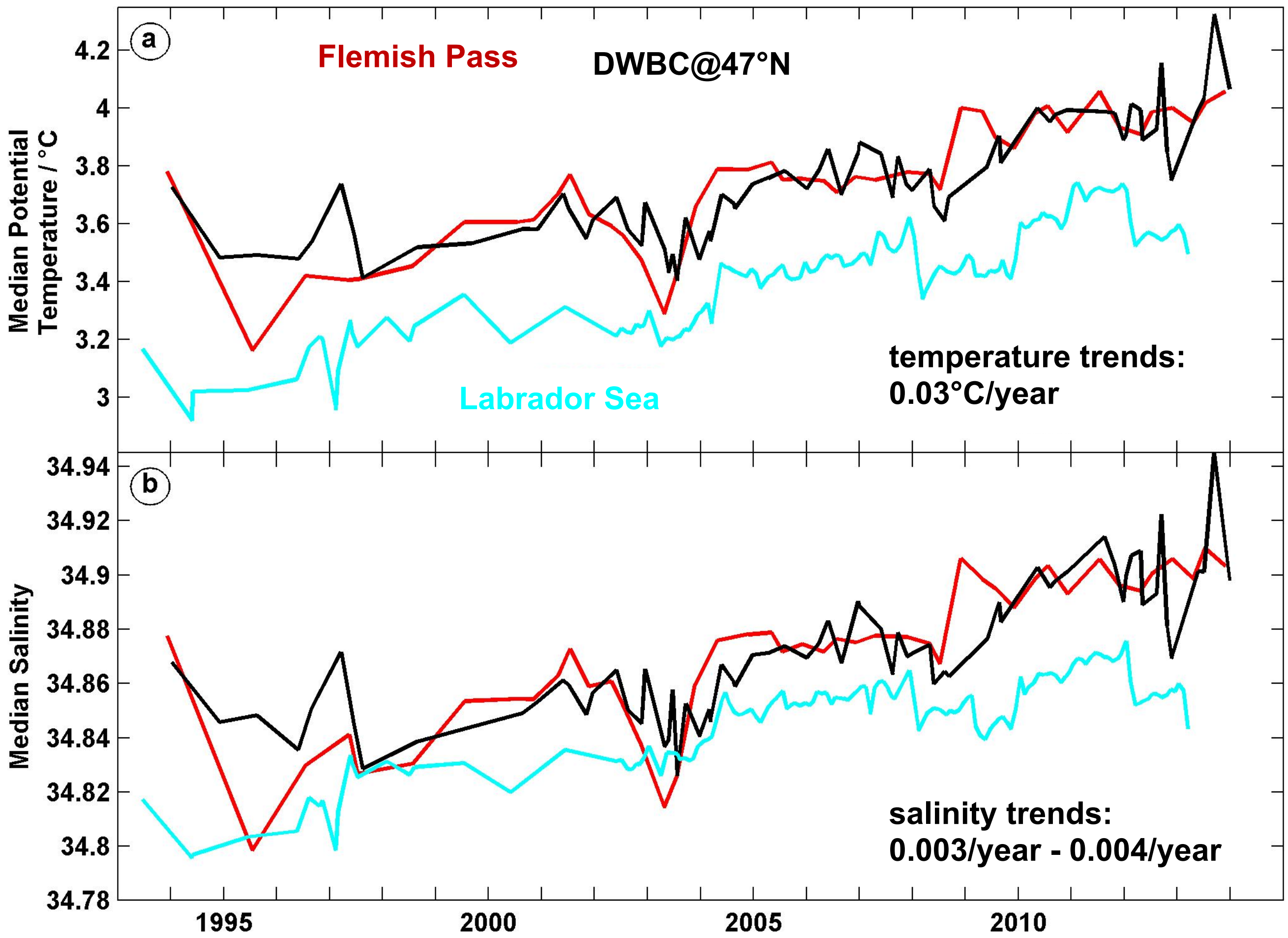
uLSW mean 2009-2014:
1.18 +/- 0.06 Sv

uLSW mean 2009-2014:
4.7+/- 0.2 Sv (slope core)

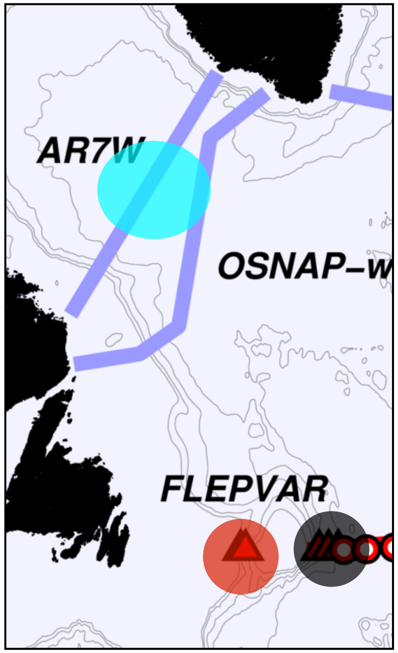
→ ULSW in FP export is about 22-25% of ULSW transport in DWBC (slope core)

Schneider et al. (2014, in prep.)

3. ULSW export through Flemish Pass at 47°N



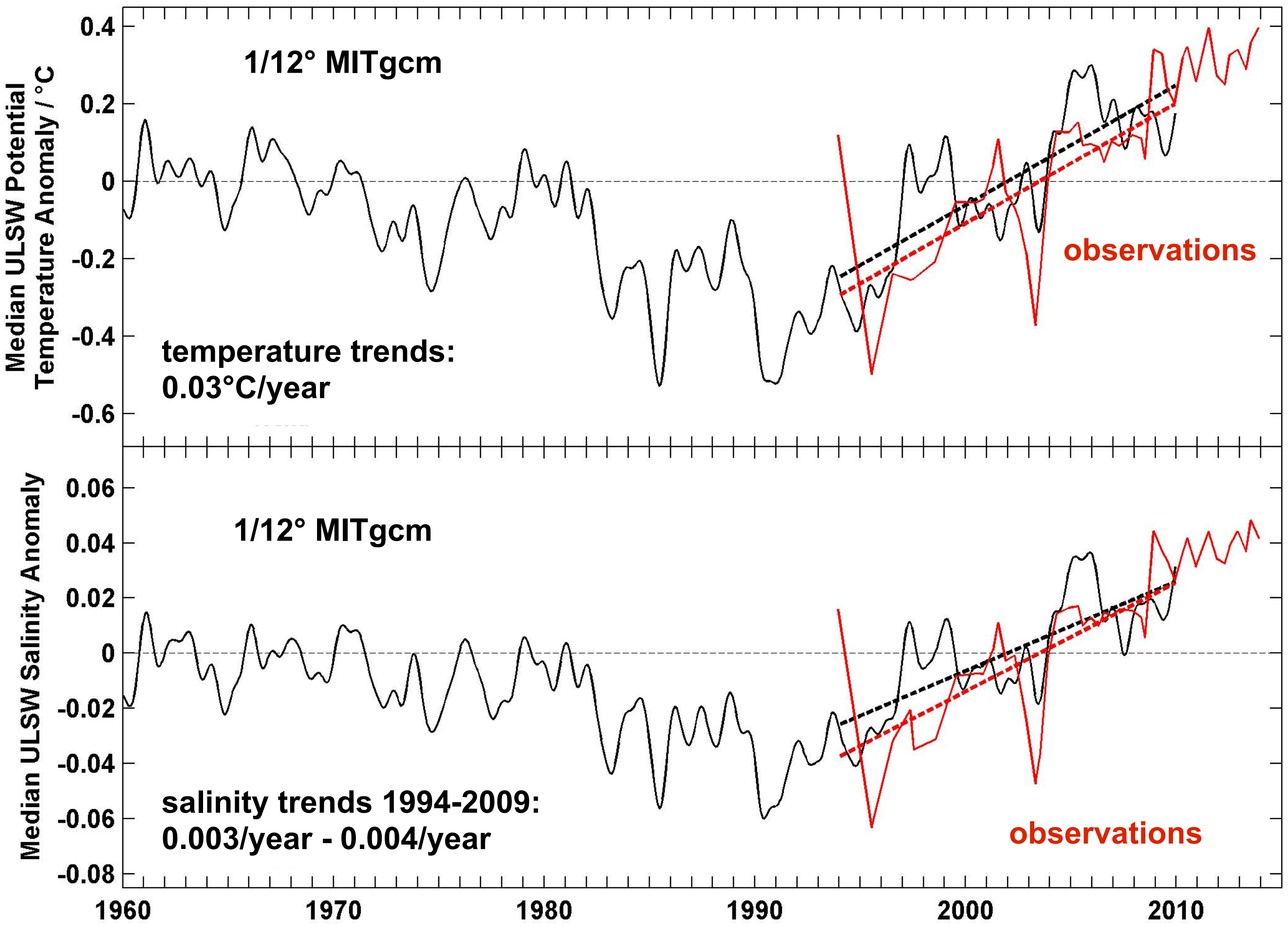
hydrographic variability of ULSW



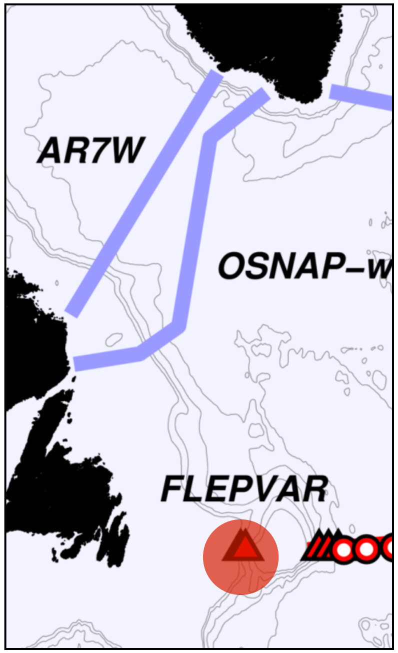
→ long-term trend indicating comparable rates of warming and increasing salinity
(Fischer et al., 2010: 0.05°C/year seen in moorings)

Schneider et al. (2014, in prep.)

3. ULSW export through Flemish Pass at 47°N



observed hydrographic ULSW anomalies in Flemish Pass compared to 1/12° MITgcm (ZMAW, Hamburg), 1960-2013



→ similar trends in observations and model
→ observed trend is part of multi-decadal oscillation

1-3: Circulation and transports in the western subpolar gyre

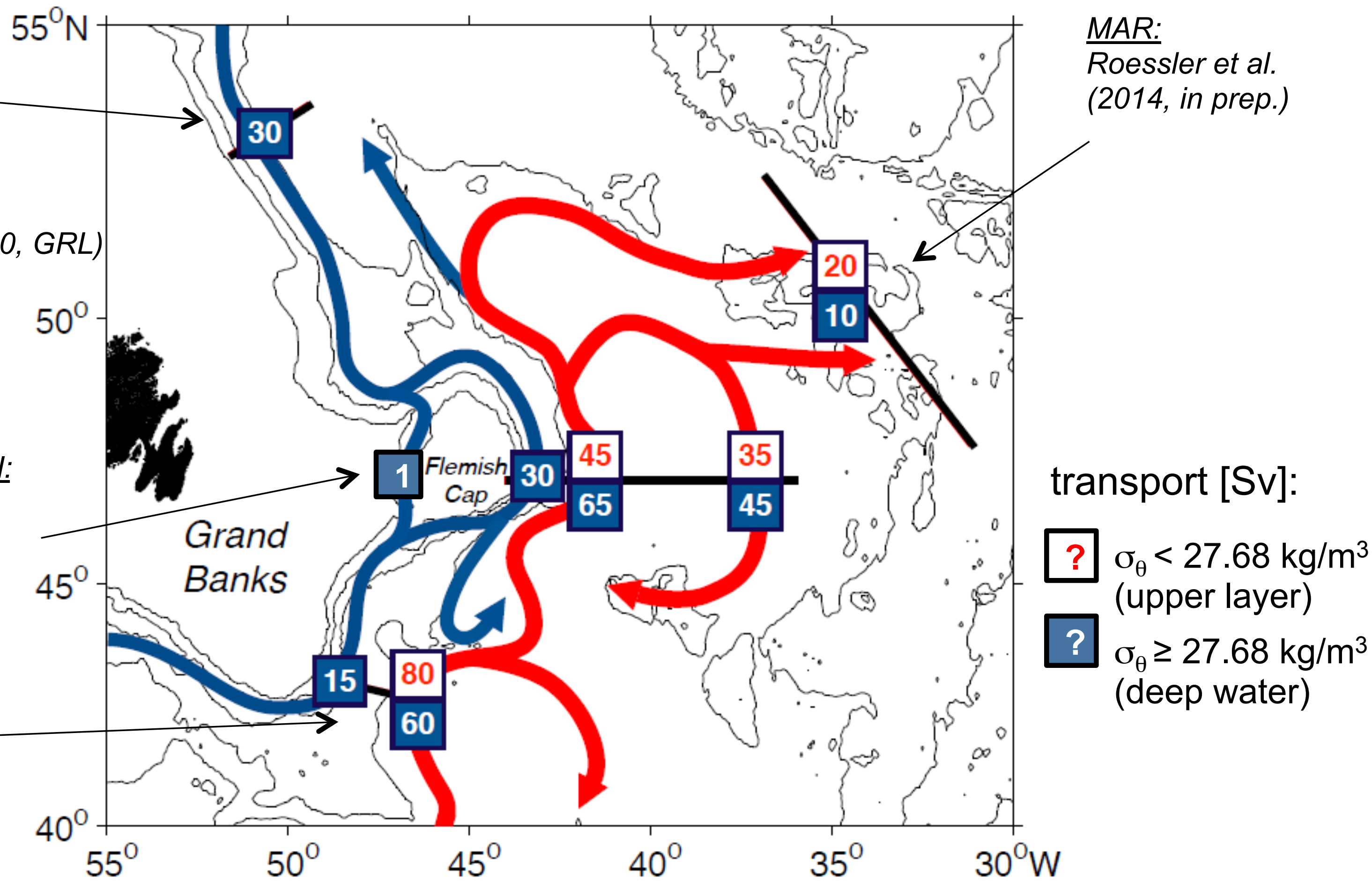
53°N:
Dengler et al.
(2006, GRL),

Fischer et al.
(2004, JPO) & (2010, GRL)

Flemish Pass, 47°N:
Schneider et al.
(2014, in prep.)
only LSW !

42°N:
Schott et al.
(2004, JPO) &
(2006, GRL)

MAR:
Roessler et al.
(2014, in prep.)



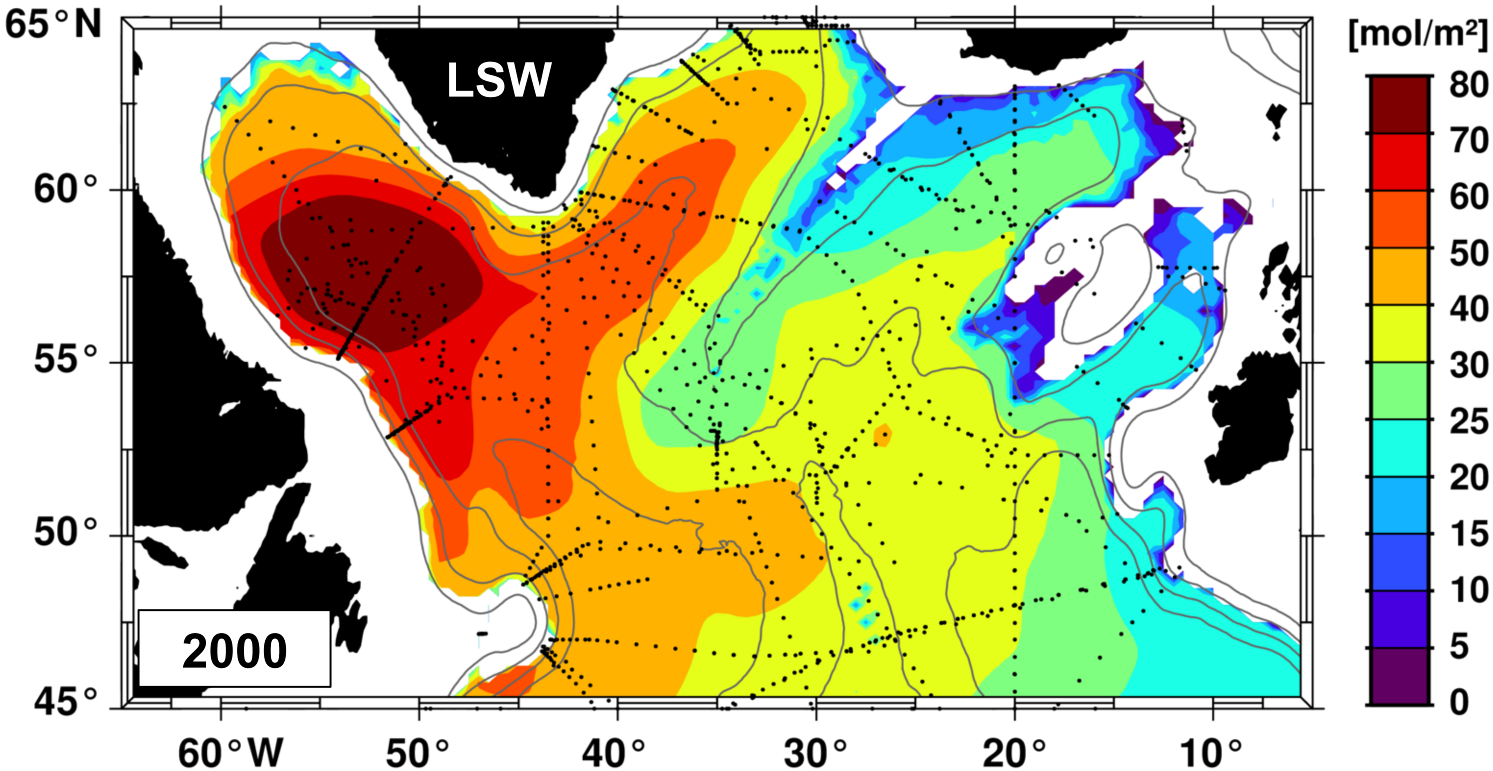
→ 110 Sv northward NAC transport, 80 Sv local recirculation, only 30 Sv cross MAR
→ 30 Sv of DWBC transport, 15 Sv recirculating into NAC

Mertens et al. (2014, JGR, in revision)

4. Anthropogenic carbon (C_{ant}) in the LSW layers: Σ(uLSW+dLSW)

application of *Tracer Time Distributions* (TTDs) to infer C_{ant} inventory from CFC observations

CFC data from 1995-2005 referenced to year 2000

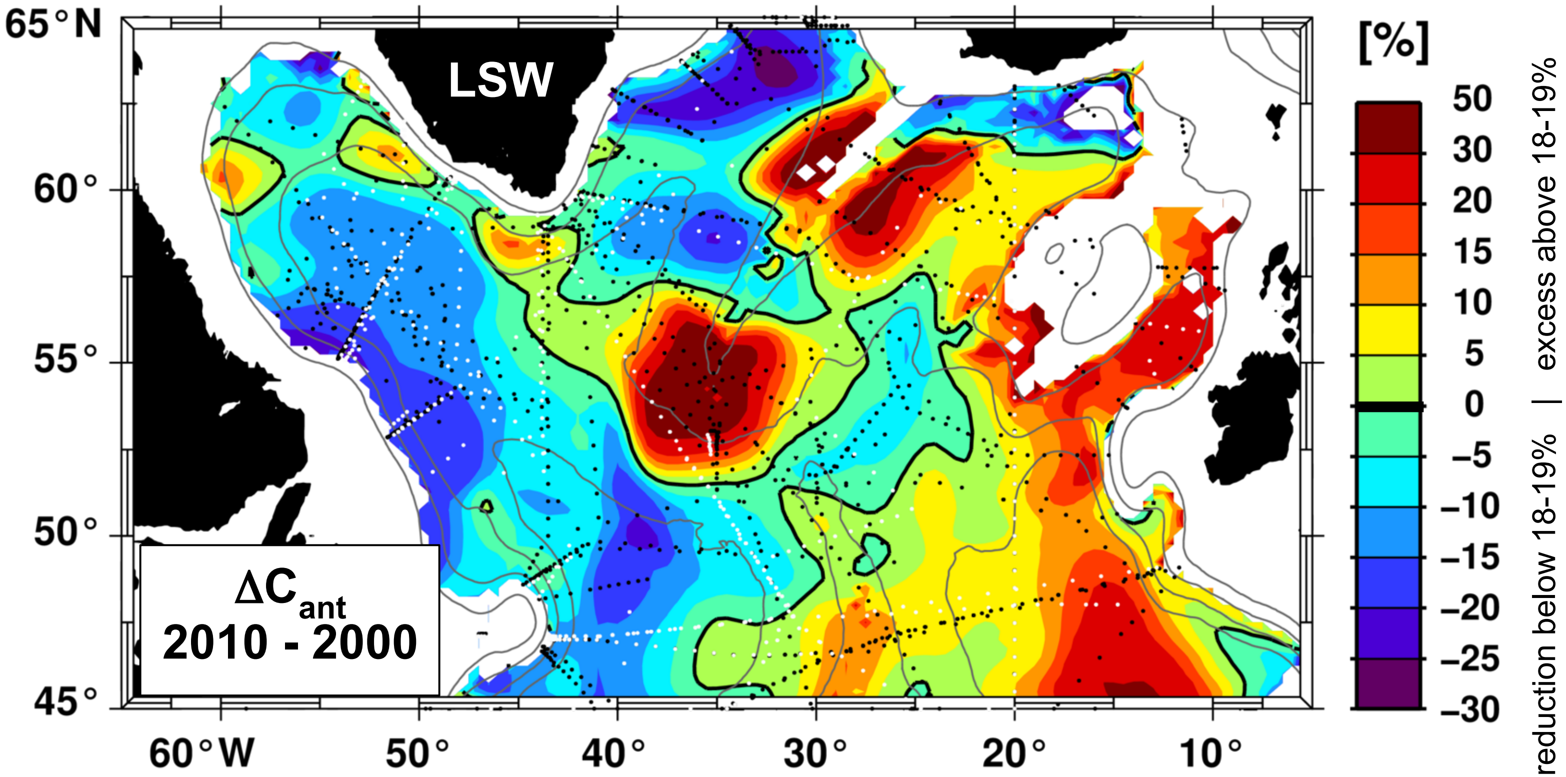


→ bulk of C_{ant} load stored in Labrador Sea, export along LSW pathways ...

Steinfeldt et al. (2014, in prep.)

4. C_{ant} inventory change between 2000 and 2010

C_{ant} inventory difference between year 2010 and 2000
relative to an expected increase of 18-19 % due to rise atmospheric CO_2 levels

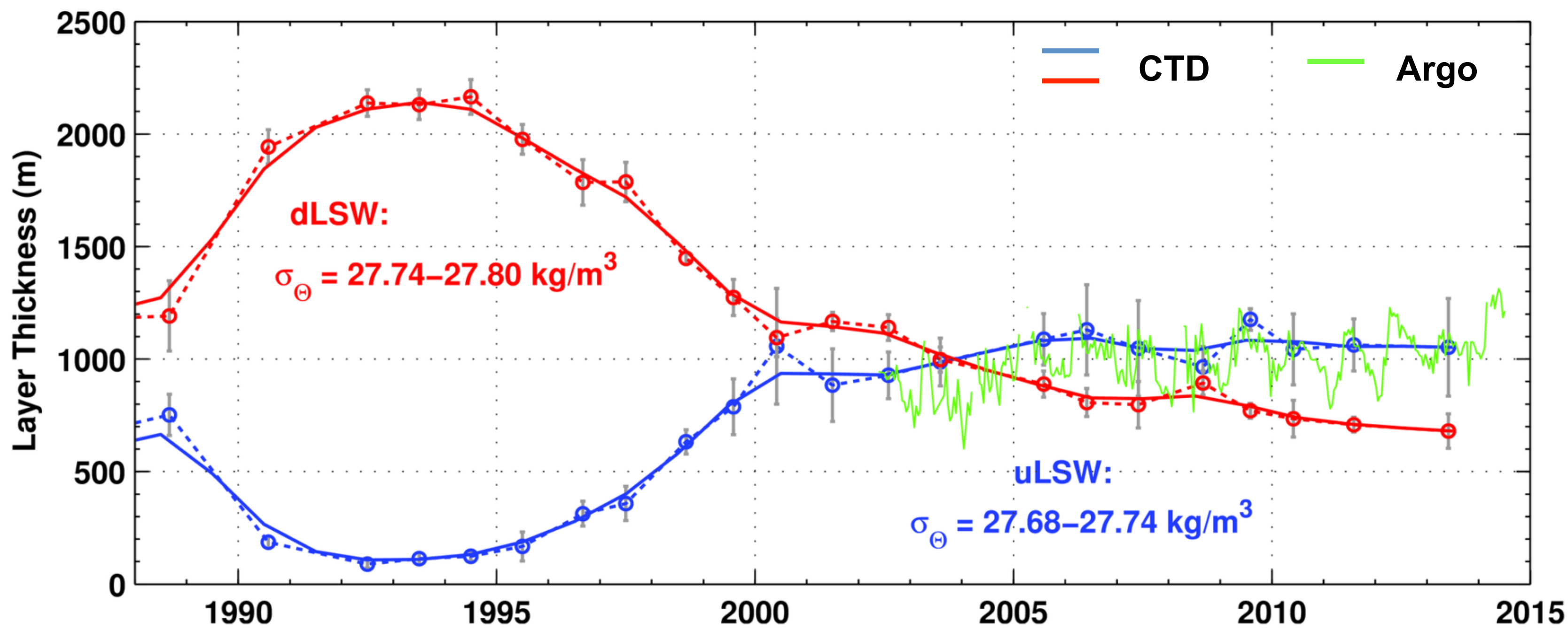


CFC data from 2006-2013 referenced to year 2010

→ greatest reduction along DWBC and major LSW spreading pathways
→ increase in eastern basin
→ more export of C_{ant} than input through LSW formation

Steinfeldt et al. (2014, in prep.)

4. Change of LSW formation

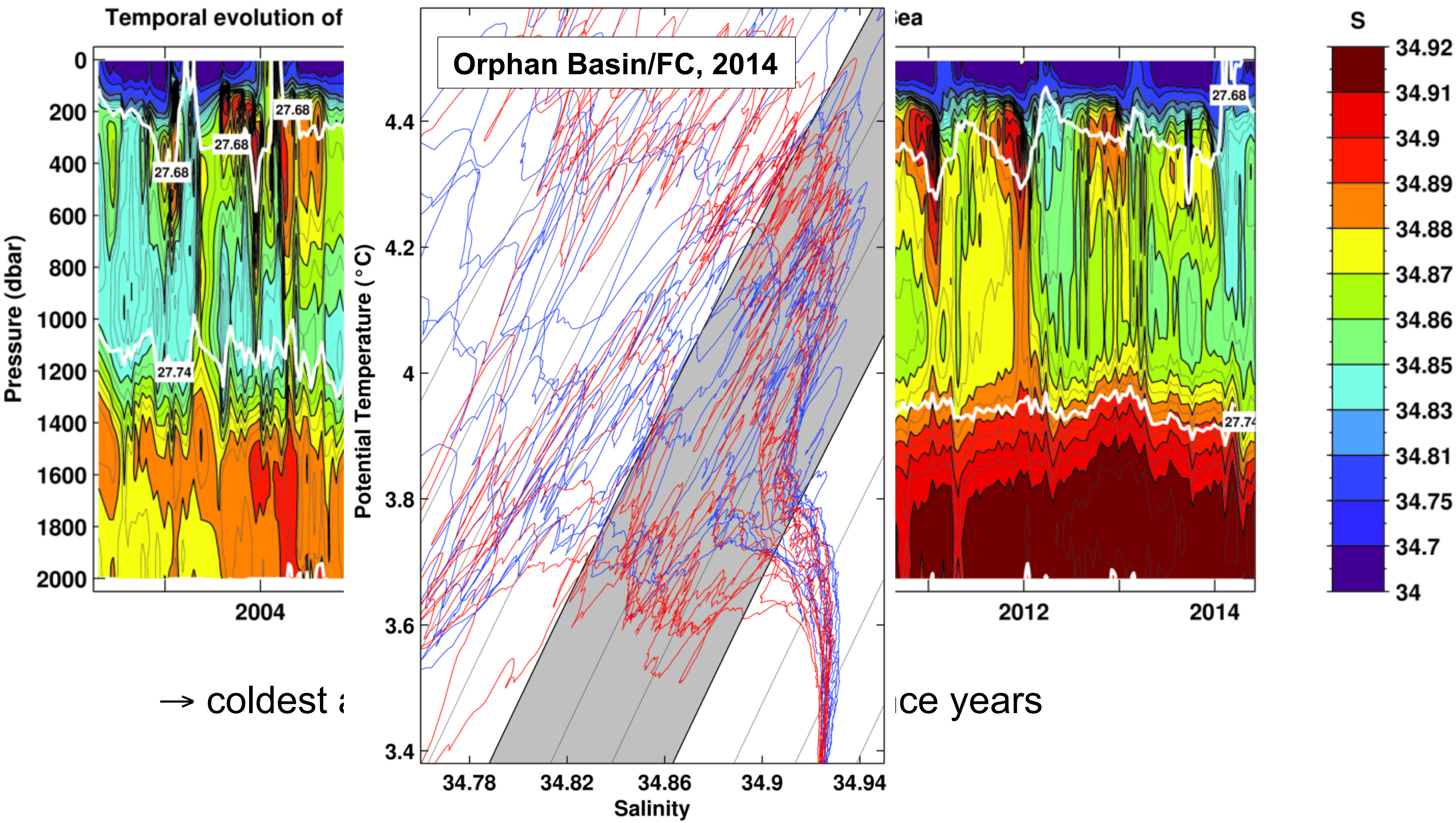


layer thickness evolution in the central Labradror Sea

→ CTD and Argo match well, but Argo does reveal seasonal cycle, while CTD shows a flattening

→ winter forcing 2013/2014 resulted in largest uLSW thicknesses

4. Change of LSW formation



→ coldest … ce years

Kieke et al. (2014, in prep.)

RACE!

Summary

- NOAC delivers important insights into the variability at the southern boundary of the subpolar North Atlantic
- estimates for the strength and the variability of the deep water export and properties and import and recirculation of NAC