Fingerprints of Subpolar AMOC Variability on Decadal Time Scales

R. Kopte, J. Fischer, J. Karstensen, M. Visbeck, R. Zantopp

2014 US AMOC Science Team Meeting
Seattle, WA
September 9-11, 2014

RACE!

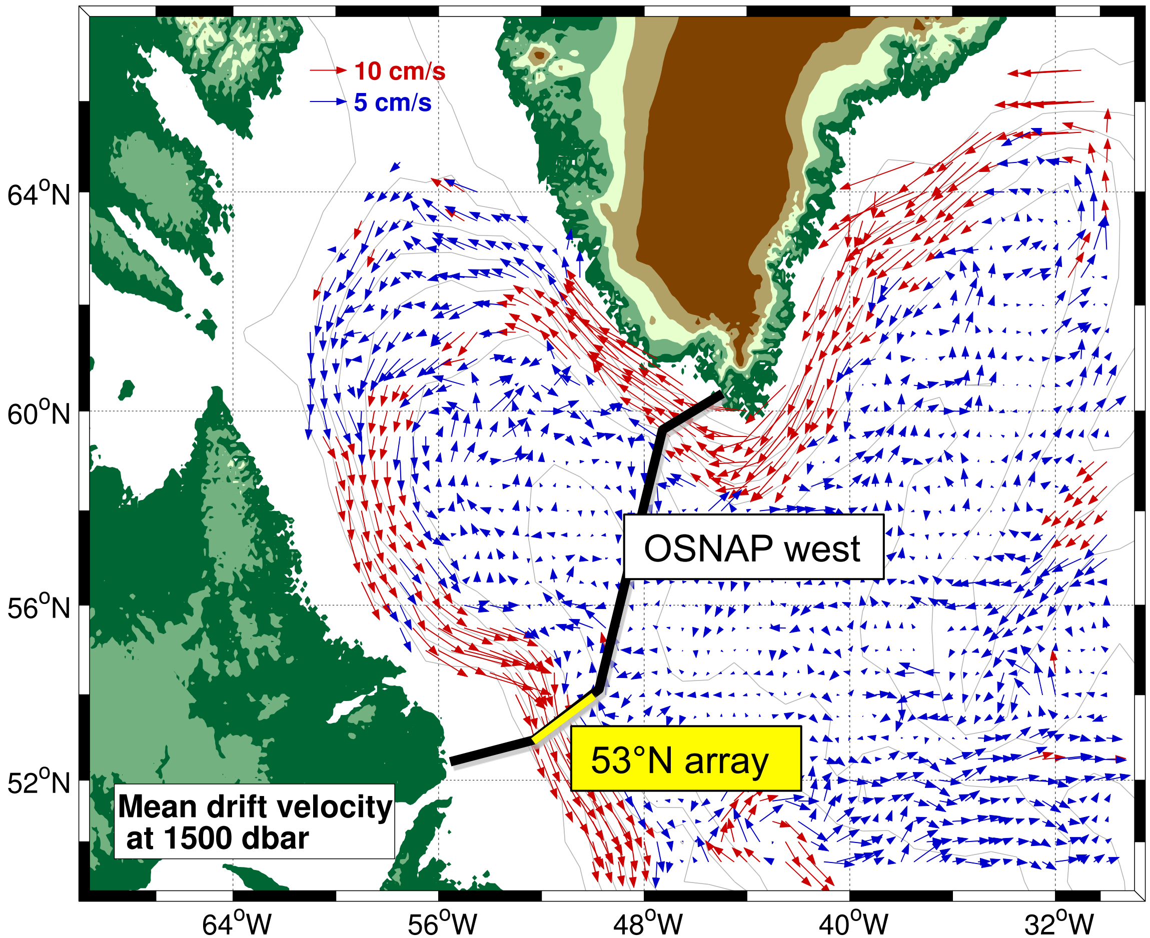
REGIONAL ATLANTIC CIRCULATION AND GLOBAL CHANGE

NACLIM

GEOMAR

Mid-depth circulation in the SPNA

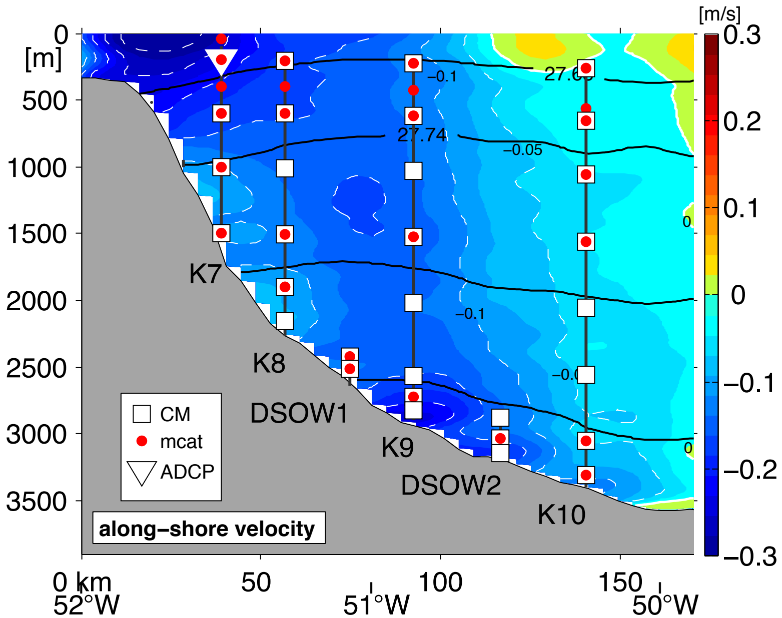
GEOMAR

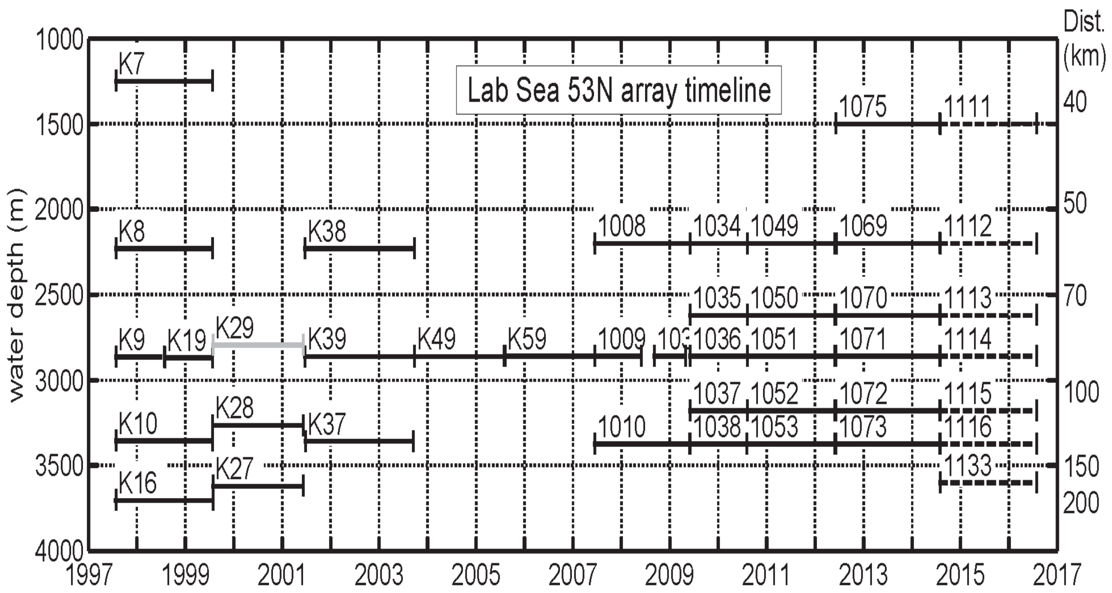


Mean circulation at 1500 m depth derived from Argo deep displacements (ANDRO atlas, *Ollitrault and Rannou., 2013*)

HELMHOLTZ ASSOCIATION

Configuration of the 53°N array





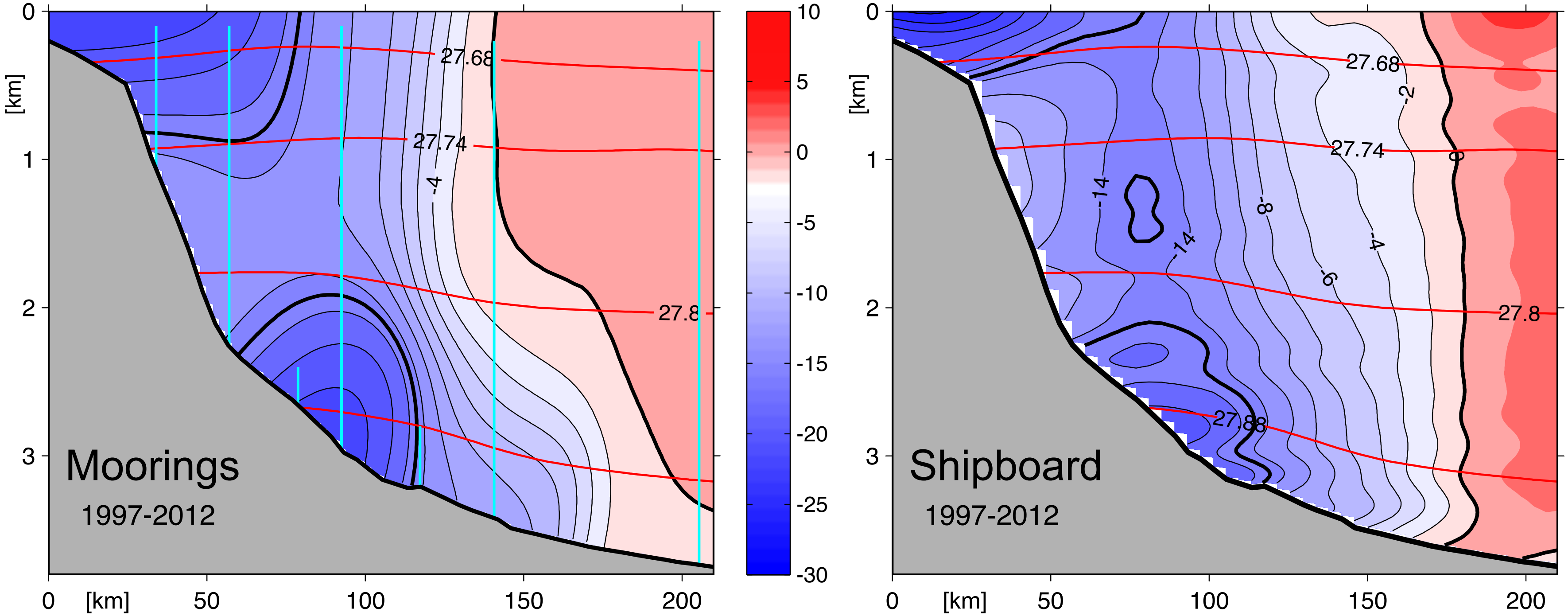
- After last month recovery:
  17 years of ocean top-to-bottom observations are available

- All 3 branches of NADW (LSW, NEADW, DSOW) pass the array on their way south

- Length of the time series allows analysis on a number of time scales
  - **Intra-seasonal**
  - **Seasonal**
  - **Interannual**
  - **(More and more) multi-year**

Mean alongshore flow at 53°N

GEOMAR

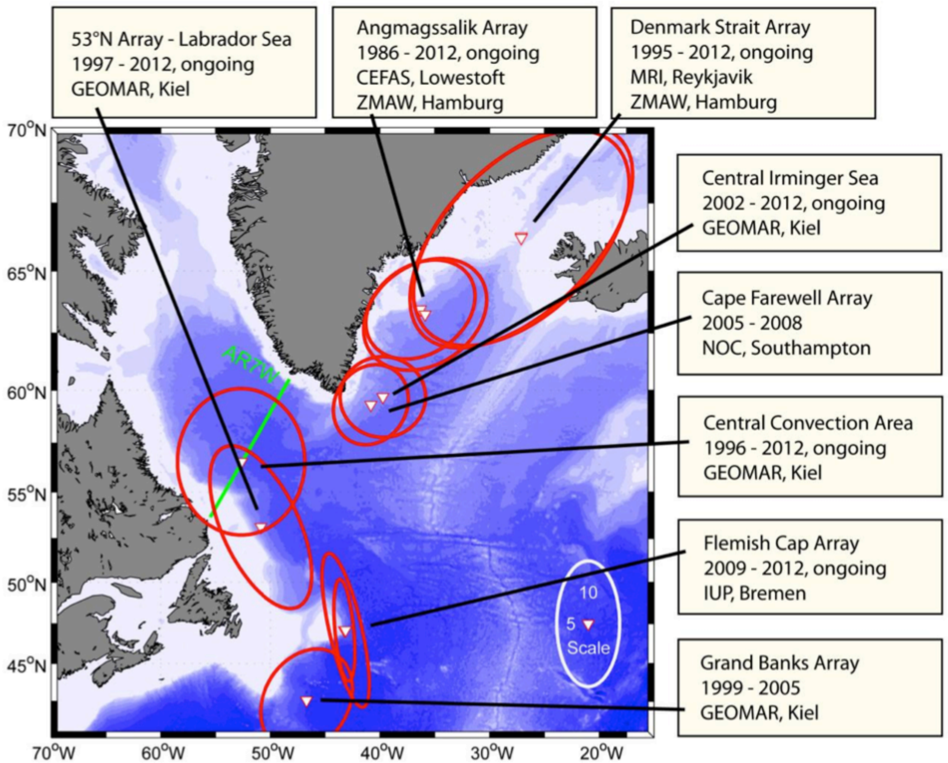


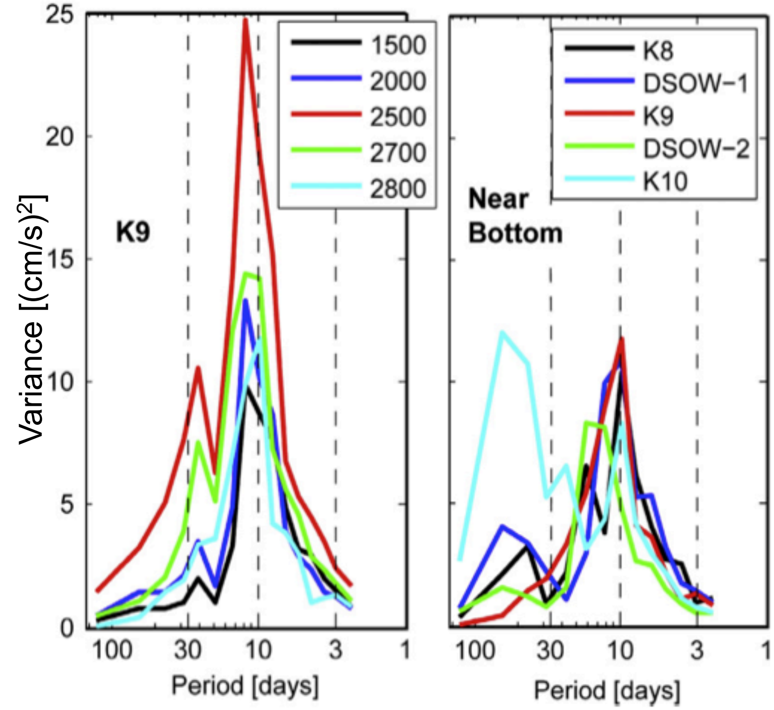
Three flow regimes

- Shallow Labrador Current
- Deep Western Boundary Current with deep velocity core
- Offshore recirculation

Intra-seasonal variability

GEOMAR

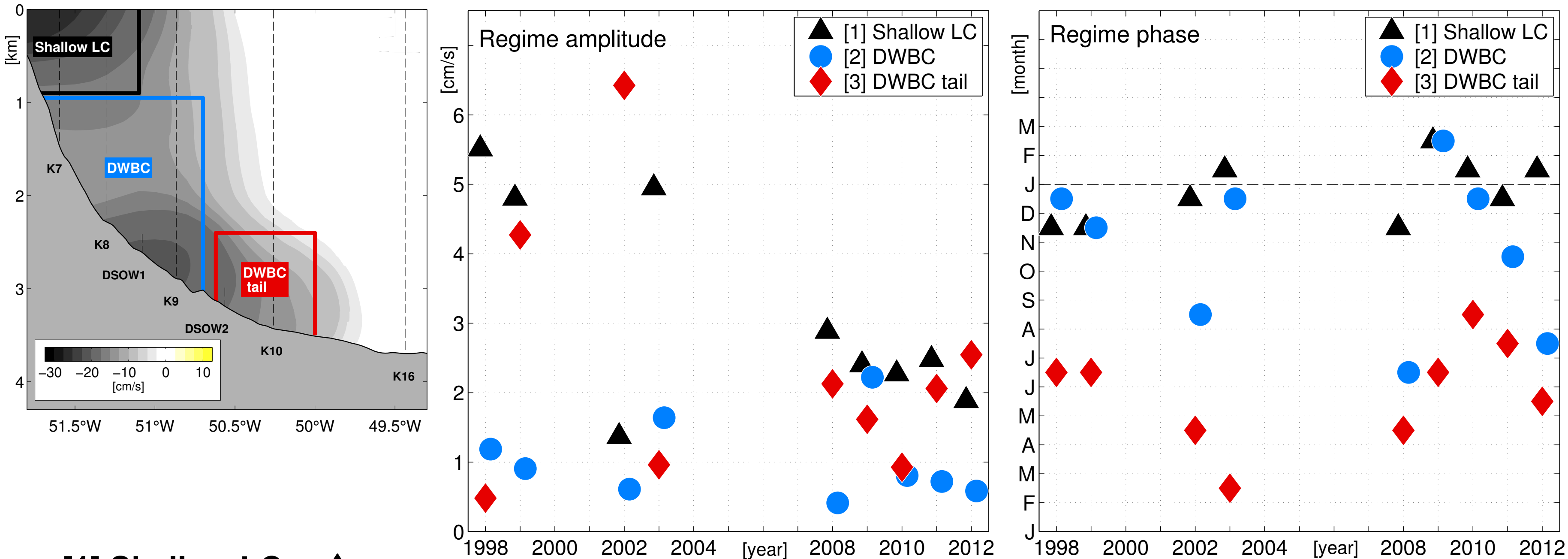




- **Study using 6 DWBC arrays (+ interior moorings)**
- **Dominant variability** is in the **week-to-month period range**
- **Topographic waves** trapped by steep topography all around the western margin

Fischer et al., 2014, PiO in press

Seasonal variability



[1] Shallow LC: ▲
- Varying seasonal amplitudes up to 6 cm/s
- Phase lock to winter months

[2] DWBC: ●
- Seasonal amplitudes below 2 cm/s
- No phase lock

[3] DWBC tail: ♦
- Single years of enhanced seasonal amplitudes
- Phase in May/June

Indicating:

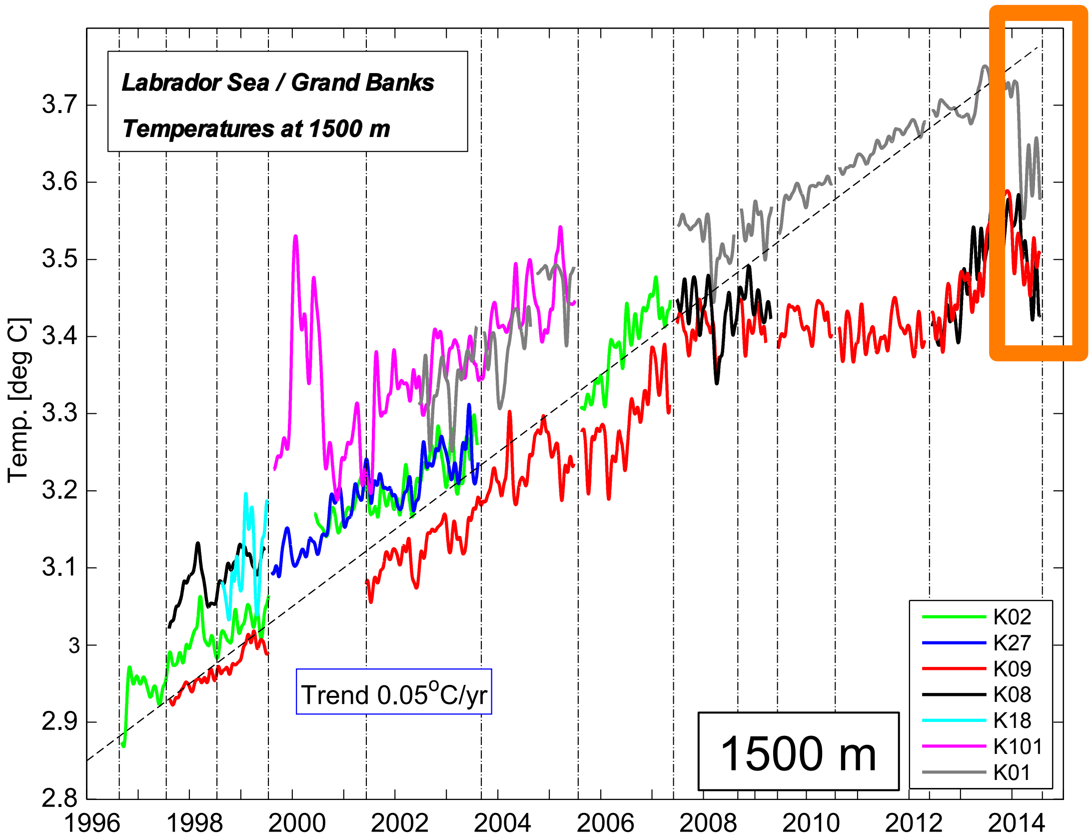
▶ **No 'intervening' frequency** between intra-seasonal variability and possible long-term fluctuations/trends

Kopte, 2013 (MSc. Thesis)

GEOMAR
HELMHOLTZ ASSOCIATION

Long-term temperature changes: Boundary current versus central LabSea

GEOMAR



Potential temperature evolution at LSW level

K9/K8 – in boundary current

K1/K101 – in the central LabSea

- Uniform warming in entire Labrador Sea (<2000m) due to weak convection until 2008
- Since 2008: warming confined to central Labrador Sea
- Last month recovery: 2013/2014 had deep (>1500m) convection – warming in central Labrador Sea stopped!?

- Sequences of convection in boundary current/ central Labrador Sea?
- Unknown: Impact of warming on circulation in Labrador Sea

Update from *Fischer et al., 2010*

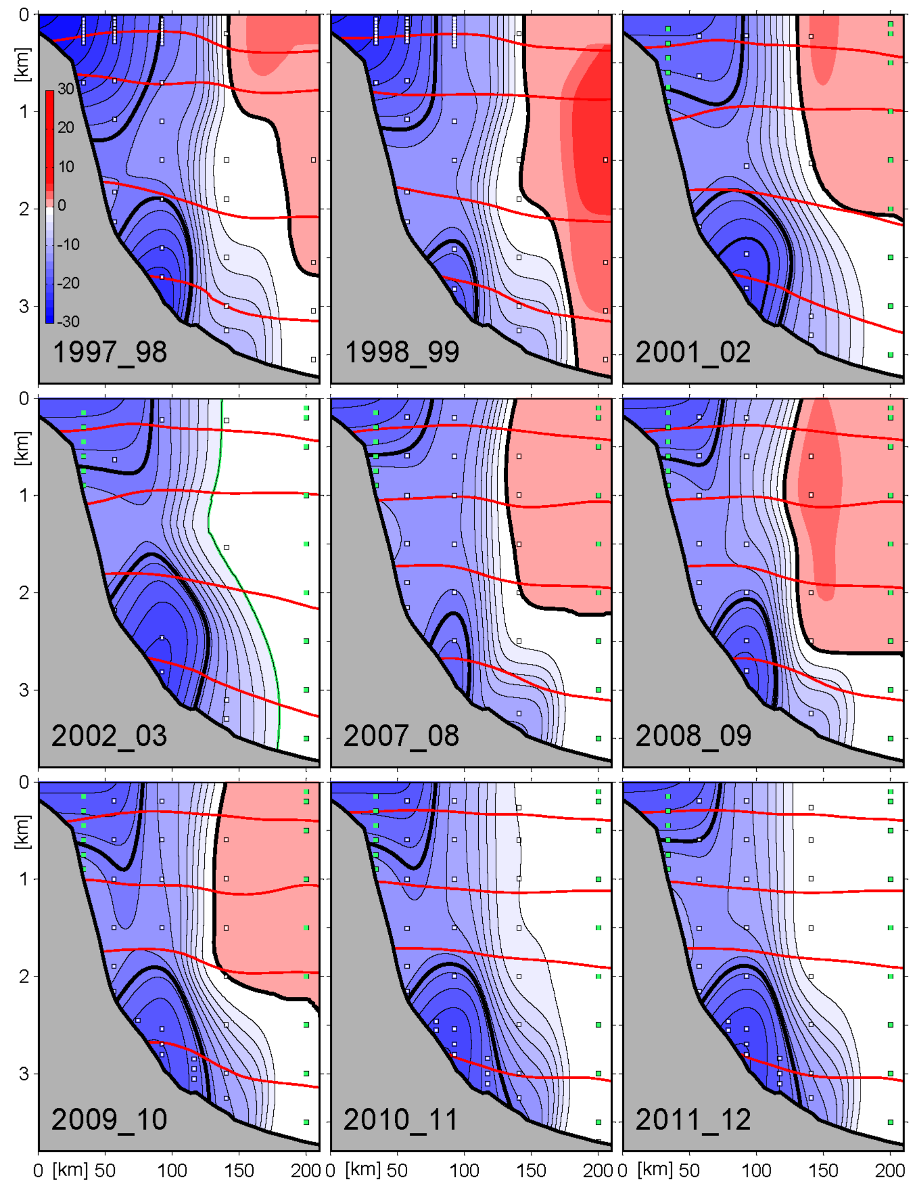
HELMHOLTZ ASSOCIATION

Structure of the flow field

- Summer-to-summer averages of the flow field
  - White dots: Moored records
  - Green dots: Best estimate data to terminate Deep Labrador Current properly
  - Red: Mean position of isopycnals representing water mass boundaries

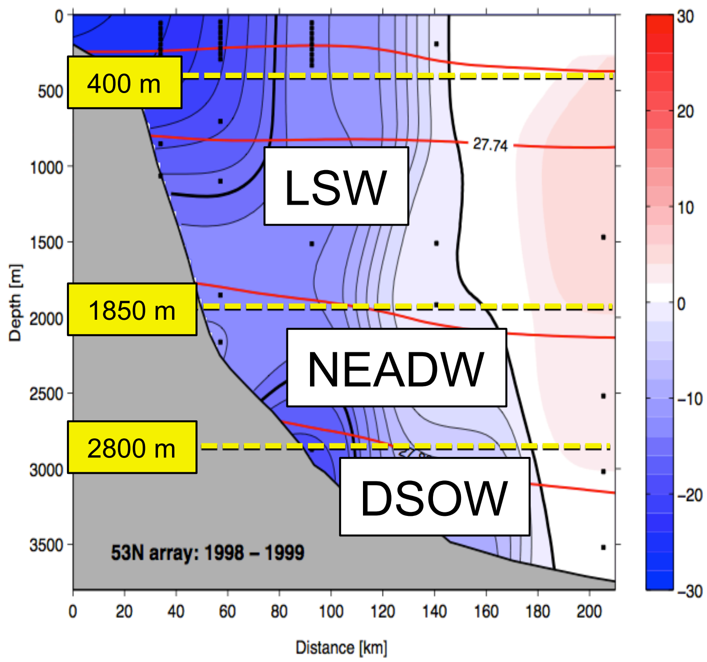
Indicating:

- General structure of the flow field is persistent throughout the observational period
- Strength of deep core appears to vary interannually

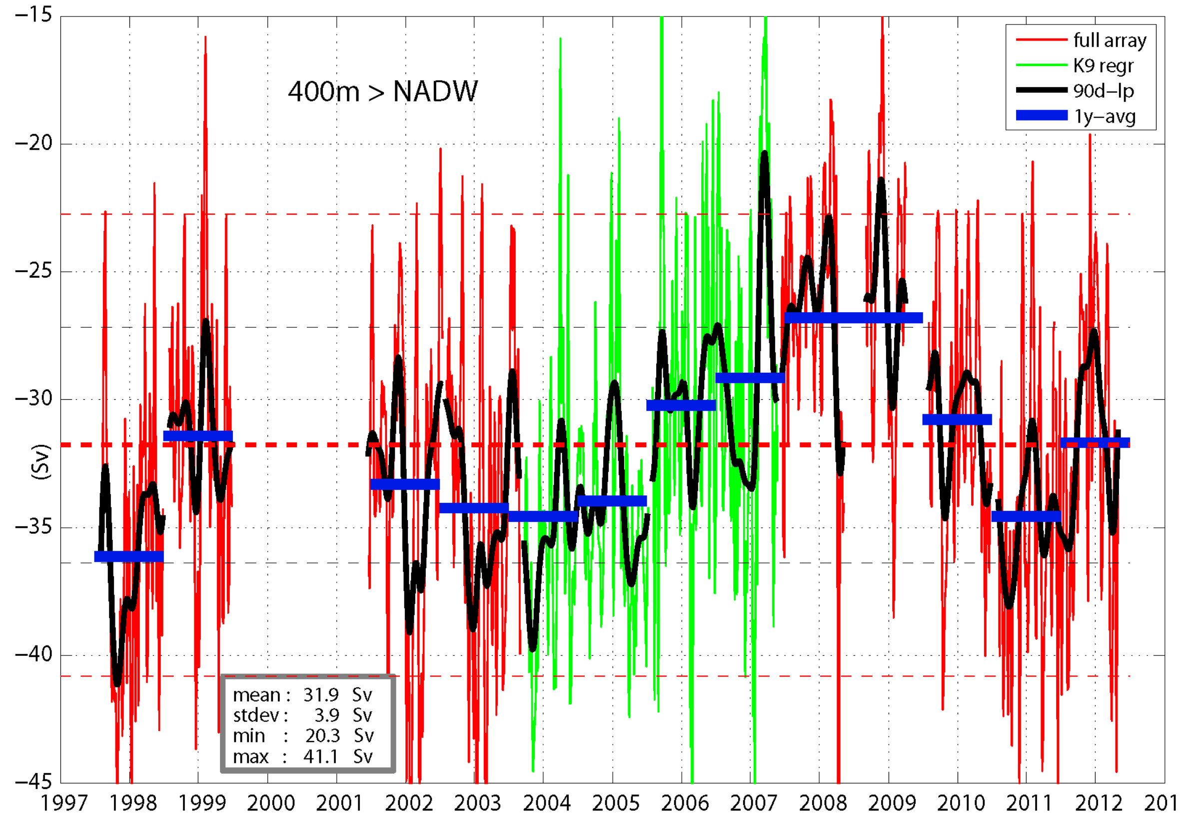


HELMHOLTZ ASSOCIATION

NADW transport time series

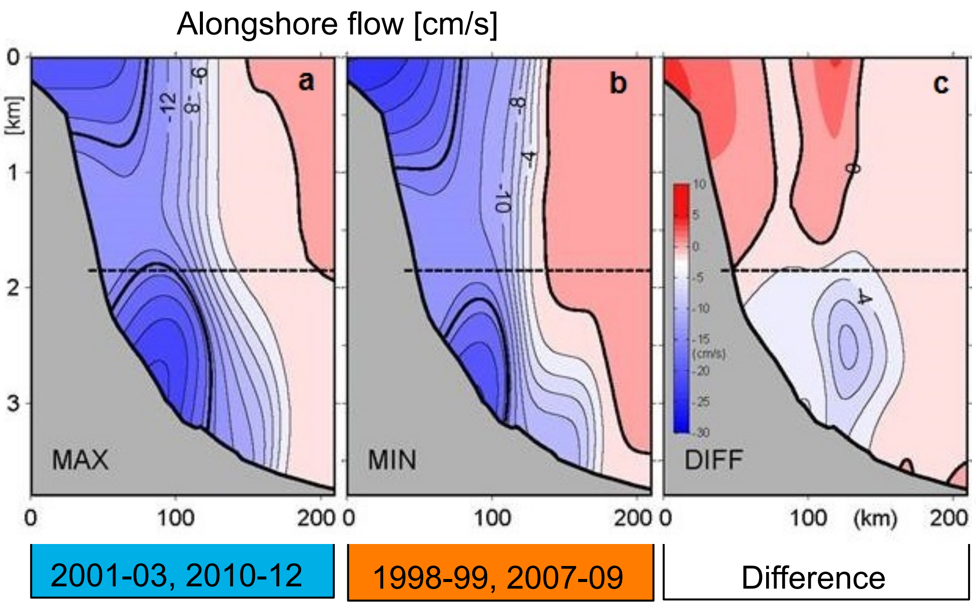


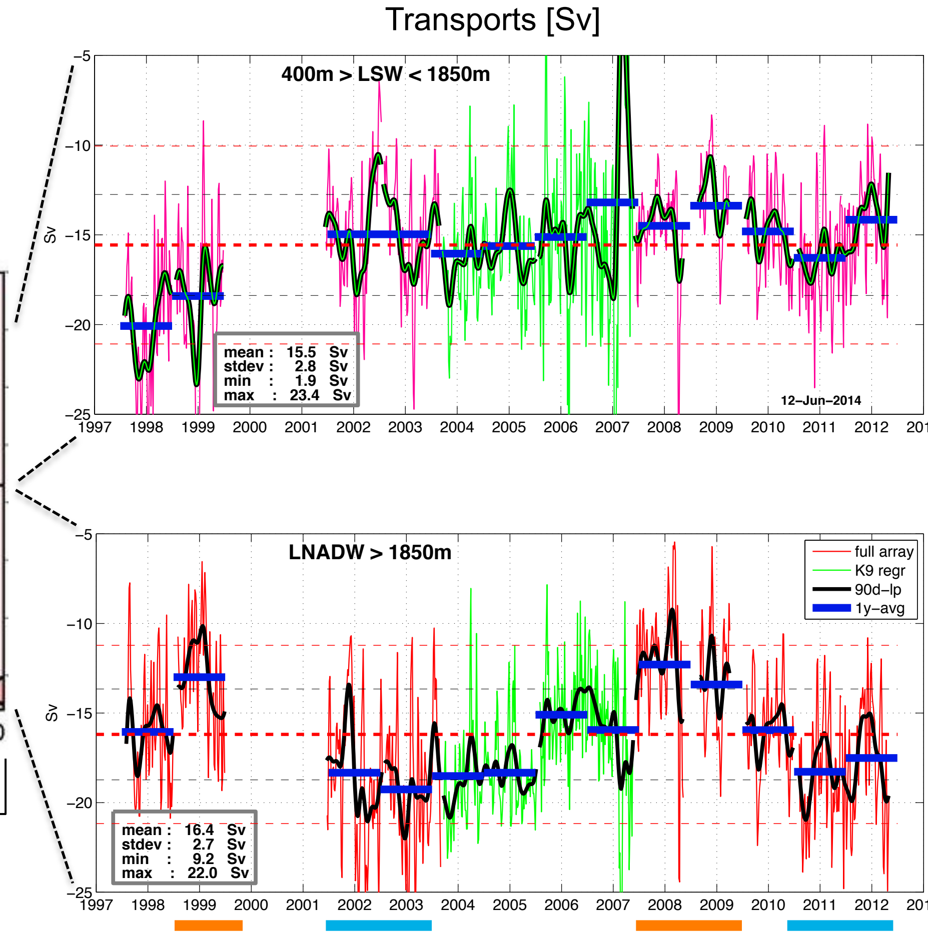
- Use isodepths as proxy for isopycnals for transport calculations
- During 2003-2007 only central mooring K9 in place: Transport estimate by multiparameter regression



- **Long-term fluctuations evident in NADW transport**

Which layers cause fluctuations?

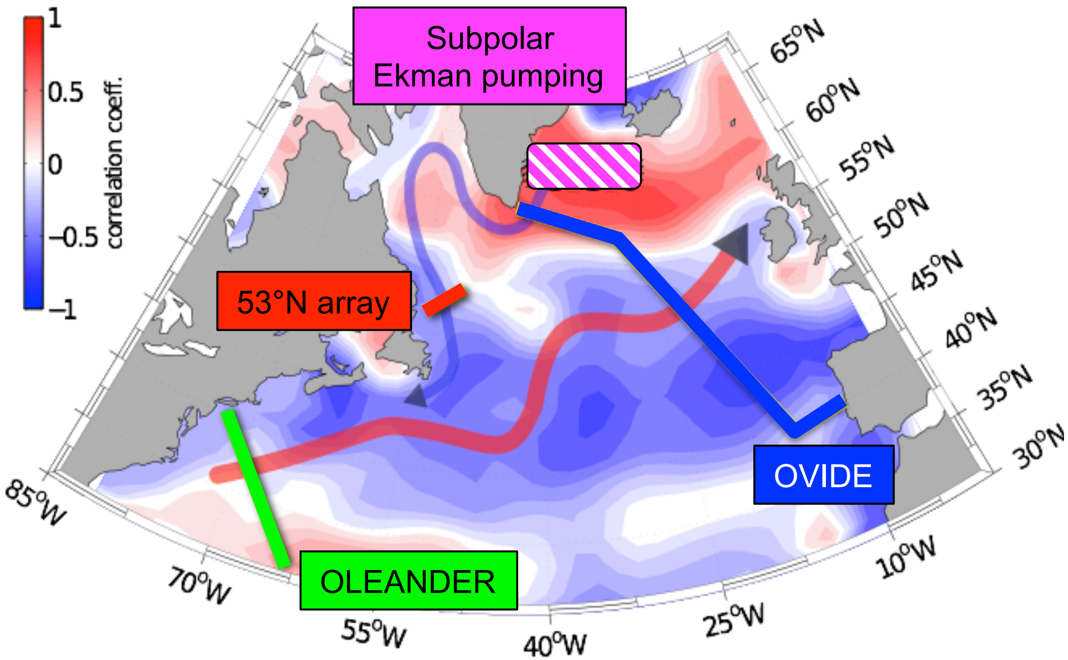


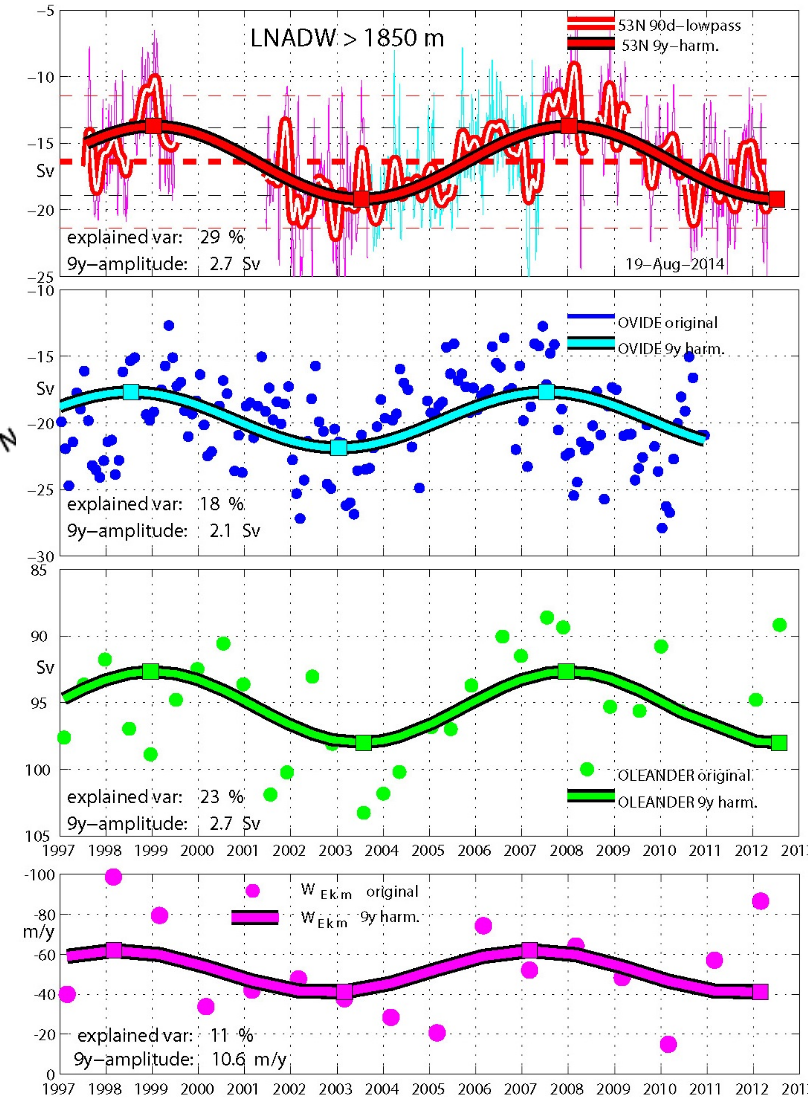


- **The LSW layer (upper) does not participate in the decadal variability (lower)**

AMOC fluctuations in the North Atlantic

GEOMAR





- Coherent 9-year variability in **lower** (53°N array) and **upper** (OVIDE, OLEANDER) **AMOC limb** time series
- Phase of **upper** and **lower AMOC limb** correspond within uncertainty (<1 year)
- Winter-time **wind stress curl** in northern subpolar gyre is in phase with the AMOC fluctuations

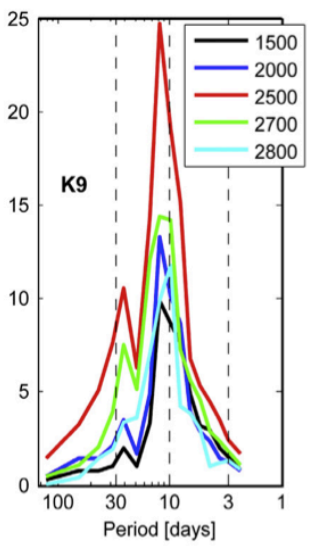
HELMHOLTZ ASSOCIATION

Summary

GEOMAR

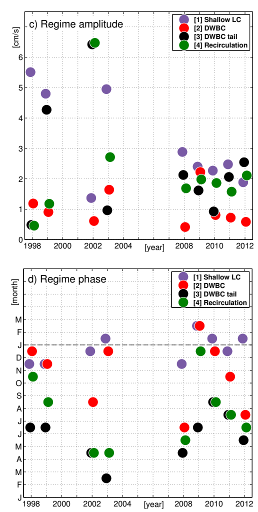
- **15 years (1997-2012)** of **ocean top-to-bottom observations** of the boundary current system at 53°N are investigated with regard to the **variability of the alongshore flow and transports** on various time scales:

Intra-seasonal



- High-energetic
- Topographic waves

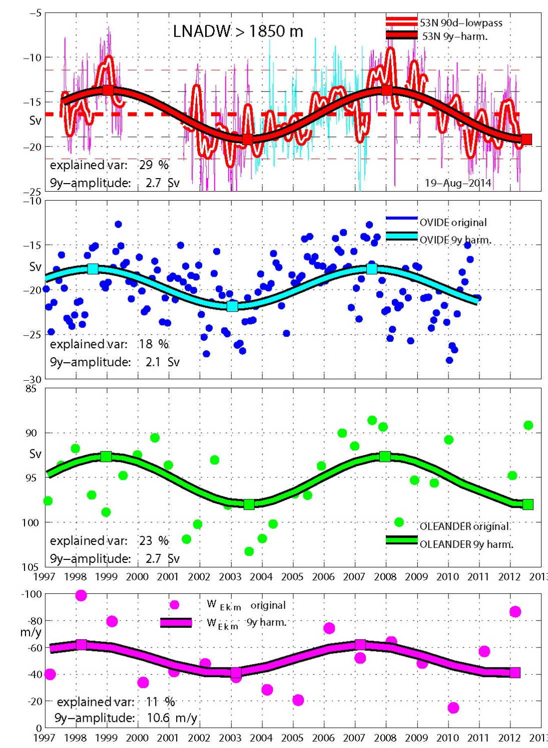
Seasonal



- No significant seasonal cycle in DWBC

Interannual - Decadal

- 9y-fluctuations in Deep Labrador Current
- Coherent with decadal fluctuations across Gulf Stream and shallow AMOC, and atmospheric forcing
- Decadal fluctuations of same magnitude as proposed centennial AMOC decline



Outlook

- 17 years of full ocean depth observations make the “53°N array” DWBC-records increasingly attractive for joint observation/model studies (envisioned)
- Within OSNAP, the “53°N array” is an important component of the trans-basin observational efforts
  - Provides continuous current and hydrographic observations of the boundary current system
  - Serves as southern constraint for estimating interior geostrophic velocities

- **New array (2014-2016) was installed last month**
- **Next turnaround in summer 2016 – Shiptime is funded**