Multiannual to decadal circulation variability in the subpolar North Atlantic – A modal decomposition
Deep-Water export from the Labrador Sea, sea level pressure and atmospheric forcing fields.
By: J. Fischer, J. Karstensen, M. Visbeck, R. Zantopp, and R. Kopte

The traditional assignment of gyre circulation to wind-forcing and overturning to buoyancy forcing has ignored the impact of winds on overturning pathways and mechanics. Lozier’s review, Science 2012

Here, we will show evidence of such a wind induced overturning mode on quasi decadal time scales in the subpolar North Atlantic.
Large scale forcing represented by NAO reveals strong decadal (magenta) and multidecadal (green) variability: Note the transition from negative to positive NAO in 1975. Modal decomposition by SSA (Ghil et al., 2002).

J. Hurrell’s winter (December through March) index of the NAO based on the difference of normalized sea level pressure (SLP) between Lisbon, Portugal and Stykkisholmur/Reykjavik, Iceland since 1864. “ICY” for severe winters in e.g. Northern Germany and weak convection in Labrador sea.
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Branches of NADW pass the array on their way south (LSW, NEADW, DSOW)
- Currently 17 years of top-to-bottom ocean current observations
- New array (2014-2016) was supplemented with additional instrumentation due to its role in the international OSNAP program

- Length of the time series allows analysis on time scales:
  - Intra-seasonal
  - Seasonal
  - Interannual
  - Multiannual / Decadal
averaged over approximately 360 year-long current meter records (left), and averaged over approximately 140 profiles obtained by LADCP during the array service cruises (right). Blue color for flow toward the exit of the Labrador Sea – red for recirculation into the Labrador Sea. Isopycnals for components of North Atlantic Deep Water.
Summer-to-summer averages of the flow field

- White dots: Moored records
- Green dots: Best estimate data to terminate Deep Labrador Current properly
- Red: Location of isopycnals representing water mass boundaries during the respective mooring period.

Definition of water mass layers in the DWBC:

- LSW between 400m depth and 1850m / 27.68 – 27.80
- NEADW between 1850m and 2800m / 27.80 – 27.88
- DSOW from 2800m to the bottom / 27.88 – bottom
Mean NADW transport is \(~32\) Sv
Standard deviation is \(~4\) Sv
Layer Transports behave differently

Multiyear oscillations in the Lower NADW range; LSW is more stable after year 2000

What are the causes and consequences of this behaviour?
Fill gaps in transport time series by iterative SSA technique as a basis for further modal decomposition and time series analysis:

This transport-record contains gaps of different length: from almost two years to just a few days during Array service. The gaps are replaced iteratively by many temporal EOF-modes including most of the variability.

Red curve is the 9y-harmonic fitted to the 5d transport time series still including the gaps; Annual mean tranports as blue bars, and black line is reconstruction of the time series by modes 1 to 6. See spectrum to the right ---- No Trend after removing the oscillations!!!
Wavelet Spectrum of SLP data in the eastern part of the North Atlantic shows 6-12 year oscillations beginning in the 1970ies and increasing in amplitude and periodicity -- this is the multiannual / decadal variability that is evident in the NAO time series.

Very clearly seen in individual (St. John’s) SLP records.

S. Jevrejeva et al., 2006 Analysis of SLP data by SSA Decomposition for the Region North East Atlantic
Sarafanov et al. (2009)

Mercier et al. (2013)

Trend?
Oscillation?
Very preliminary:

- Deep (LNADW) transport appears correlated with Windstress-Curl over the Irminger Sea (Region I, Milliff & Morzel, 2001)
- LSW transports at 53°N behave differently – more related to curl over Labsea (Region II)
- What happened to other multiannual variability visible in NAO? – why is there a spectral gap at 53°N at interannual time scales?
- How large is the impact of this quasi-decadal mode on heat transport?
- Will this signal be exported to the subtropics? May be to 26°N?
Summary

• We find coherent quasi decadal variability in upper layer northward transport (OVIDE – Mercier et al., 2013) and deep (LNADW levels) southward transport with large (30% transport range)

• Imprinted on the DWBC in Irminger Sea through NAO driven wind stress curl variability

• Signal is communicated long the western boundary to the Labrador Sea (and beyond?) -- this already is an export of the signal -- thus part of the overturning.

• Communication via waves or advection??

• LSW transport variability has shorter time scales (5y) and is controlled by wind (heatflux?) over the Labrador Sea

• This is part of the overturning in the SPNA – has impact on ocean heat transport

• Determination of eventual “Trends” in the presence of decadal oscillations requires much longer time series

Thank You for Your Attention!