Observational perspective on decadal variability in the NAS

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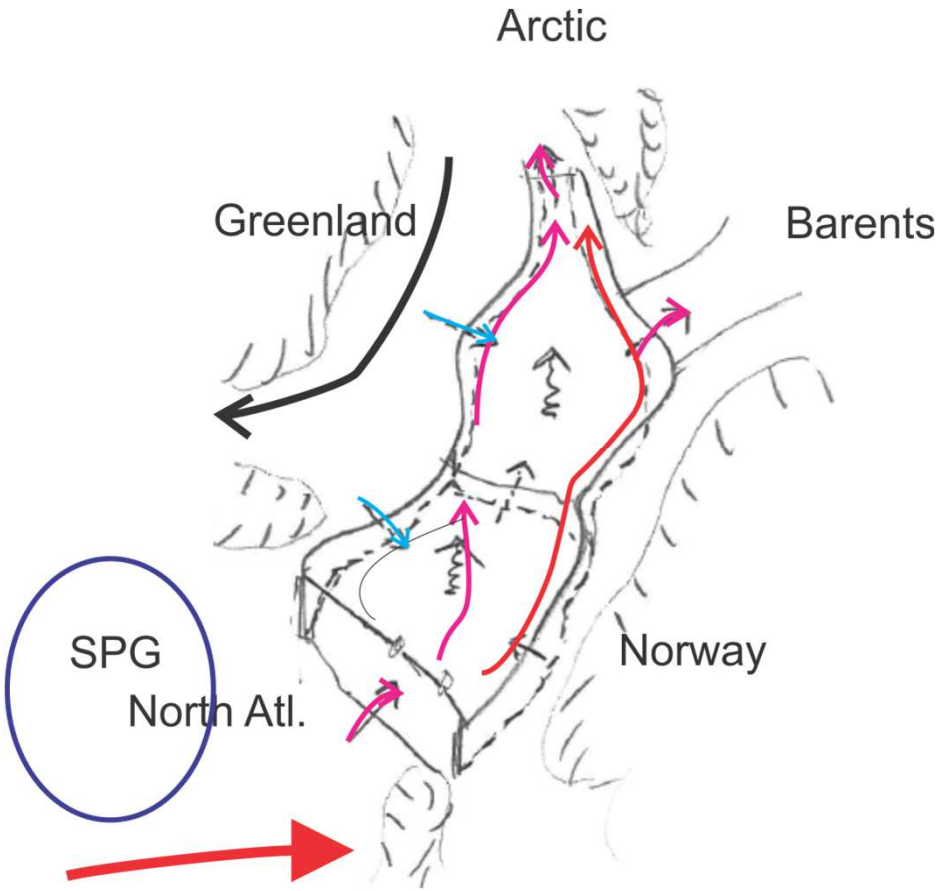
IMR/Bjerknes

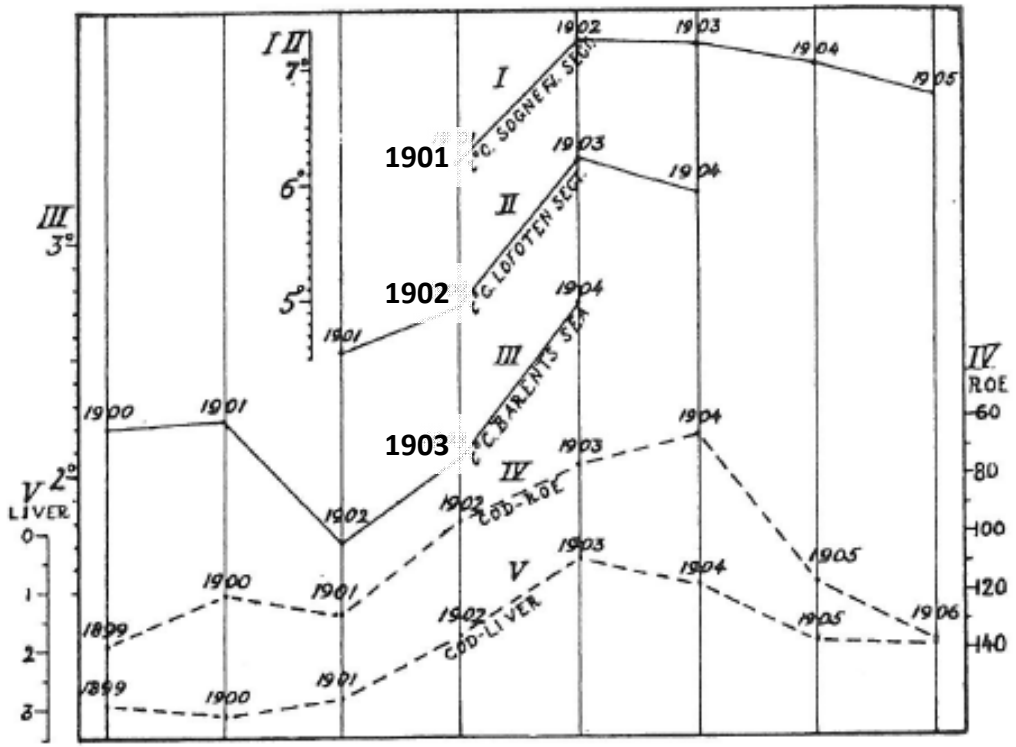
NorthAtlantic<-> **Nordic Seas** <-> Arctic



Predictability due to:
- Circulation changes, V’
- Propagting anomalies, T’, S’

- Some qualitative examples
- Budgets; Heat, Freshwater

Anomalies due to change in properties (T’, S’)

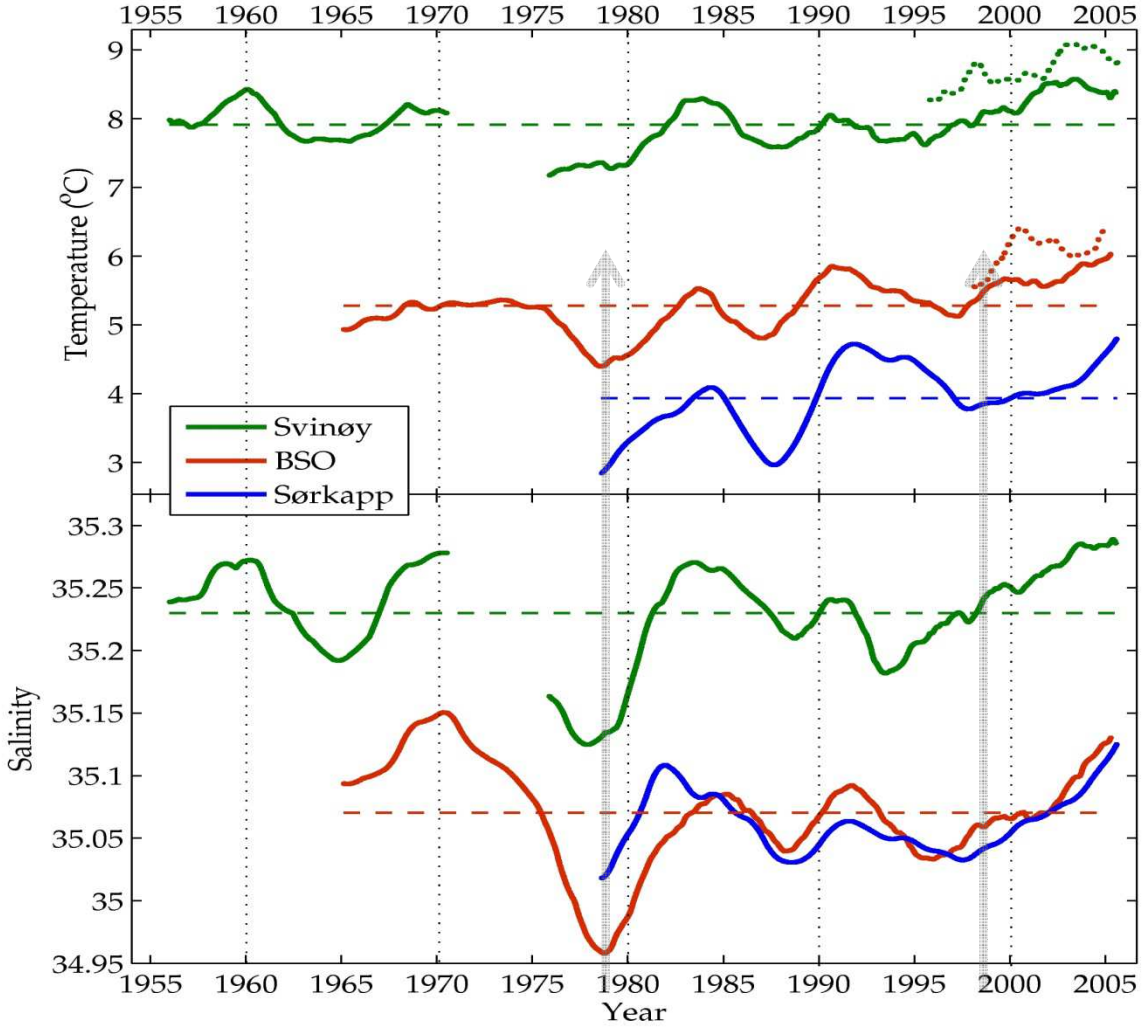


I & II Mean Temperature of intermediate Atlantic Water in Sognefjord and Lofoten Section.
III Mean Temp. of Barents Sea Stations (cf. Fig. 59).
IV Quantity at Cod-Roe obtained during the Lofoten Fisheries (in Litres per 1000 Fish; scale to the right).
V Quantity of Cod-Liver obtained during the Lofoten Fisheries (in Hectolitres per 1000 Fish; scale to the left).

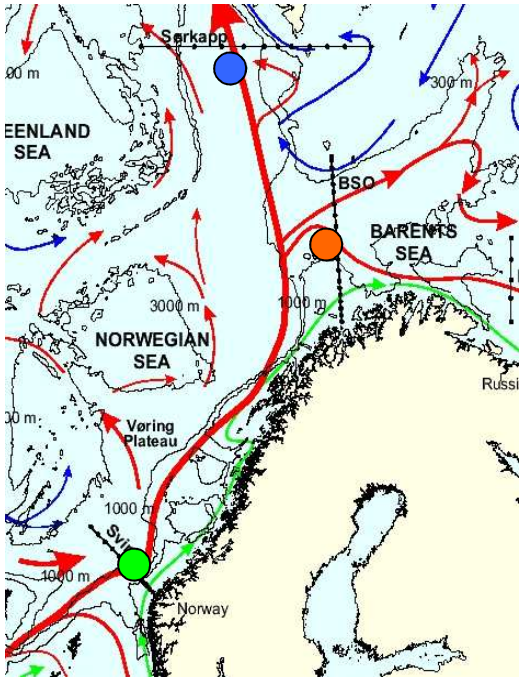
Old history;
Both lagged signals,
and effects on biology (cod)

Helland-Hansen & Nansen (1909)

Inter-annual variations in Atlantic water



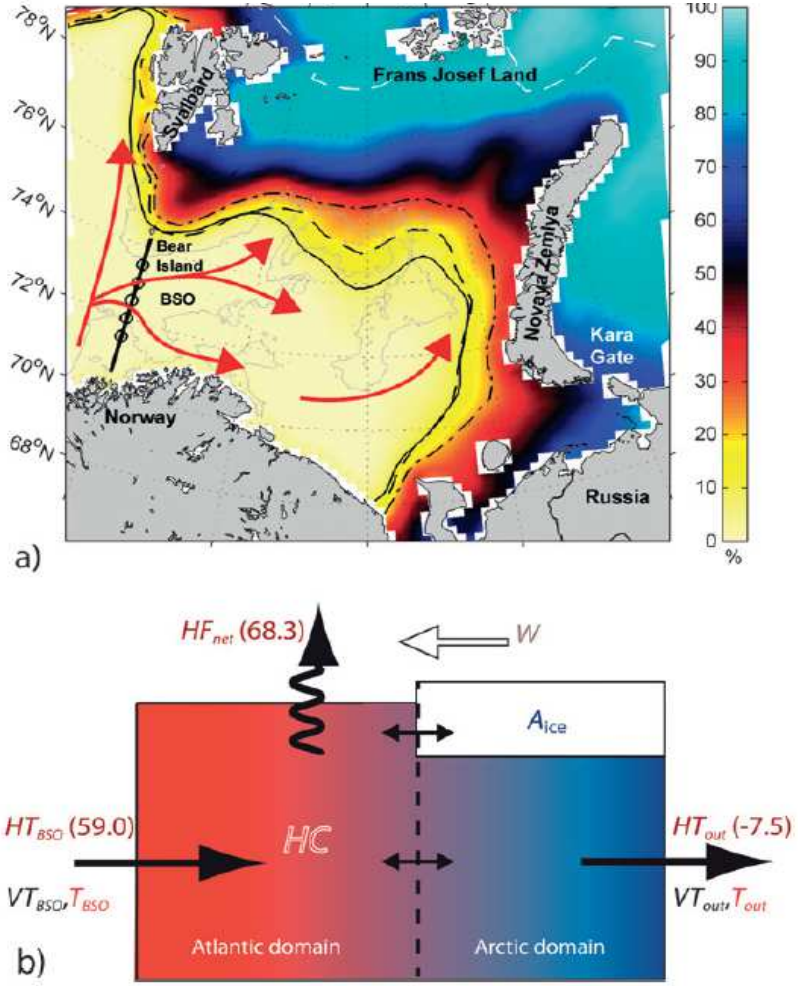
GSA SPG

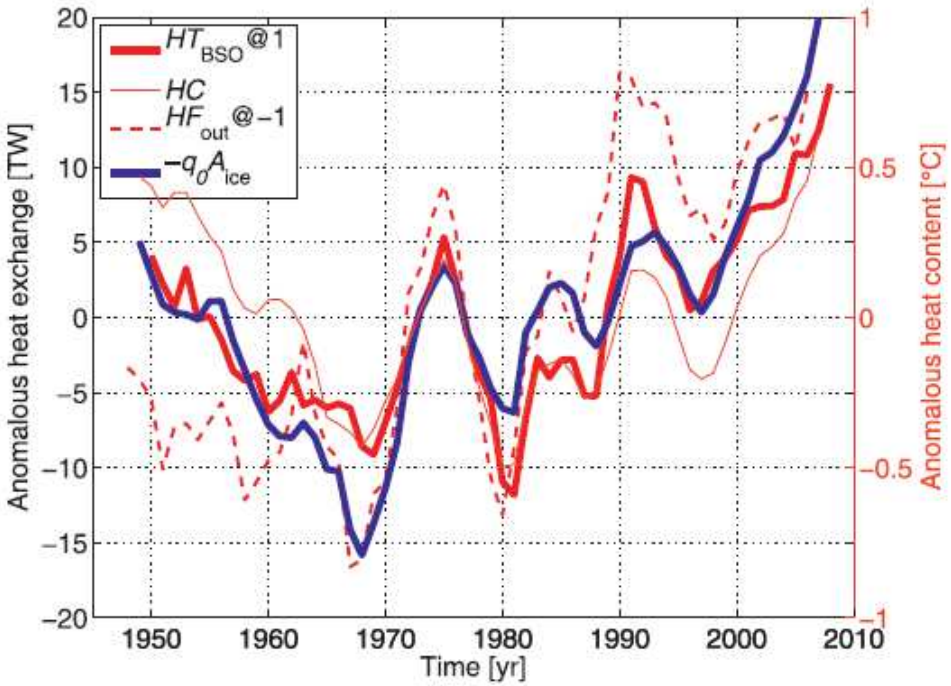


-trend since 1970'ies
-inter-annual variations
-anomalies trough the system, in general **not** dampened.

e.g.;Furevik, 2001;Skagseth et al. 2008

Helland-Hansen & Nansen, 1909: suggested relation between AW and sea ice. Quantitative based on observations -model



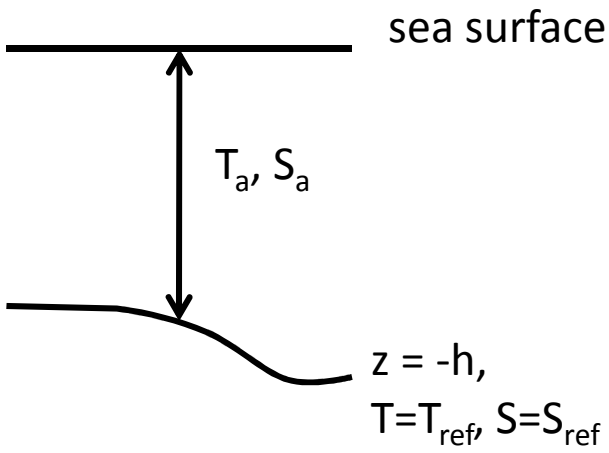


Sea ice lag heat transport in BSO with 1 year

Årthun et al, J. Clim. 2012

Heat/freshwater content

Integrate temperature/salinity, relative to a reference temperature/salinity (T_{ref}/S_{ref}), from the sea surface to a reference surface (z=-h),



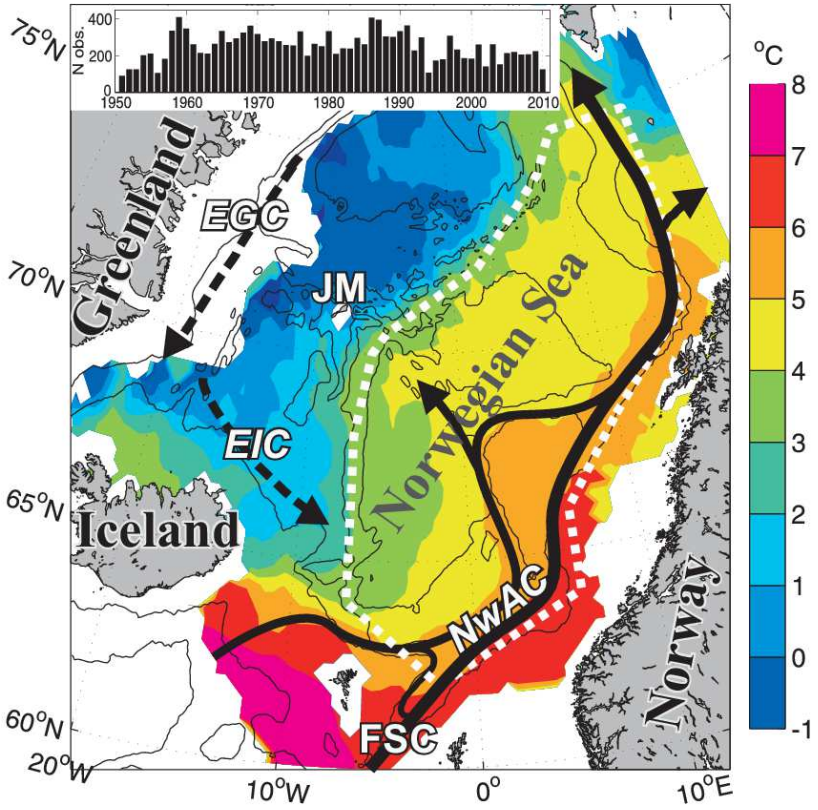
Data: ICES, PINRO, ARGO
Period: 15 Apr – 15 Jun

h = the depth of the **specific density anomaly surface** δ=2.1 m^3kg^{-1} (corresponds to ~σ_t=27.9 kgm^{-3}, Rossby et al., 2009)

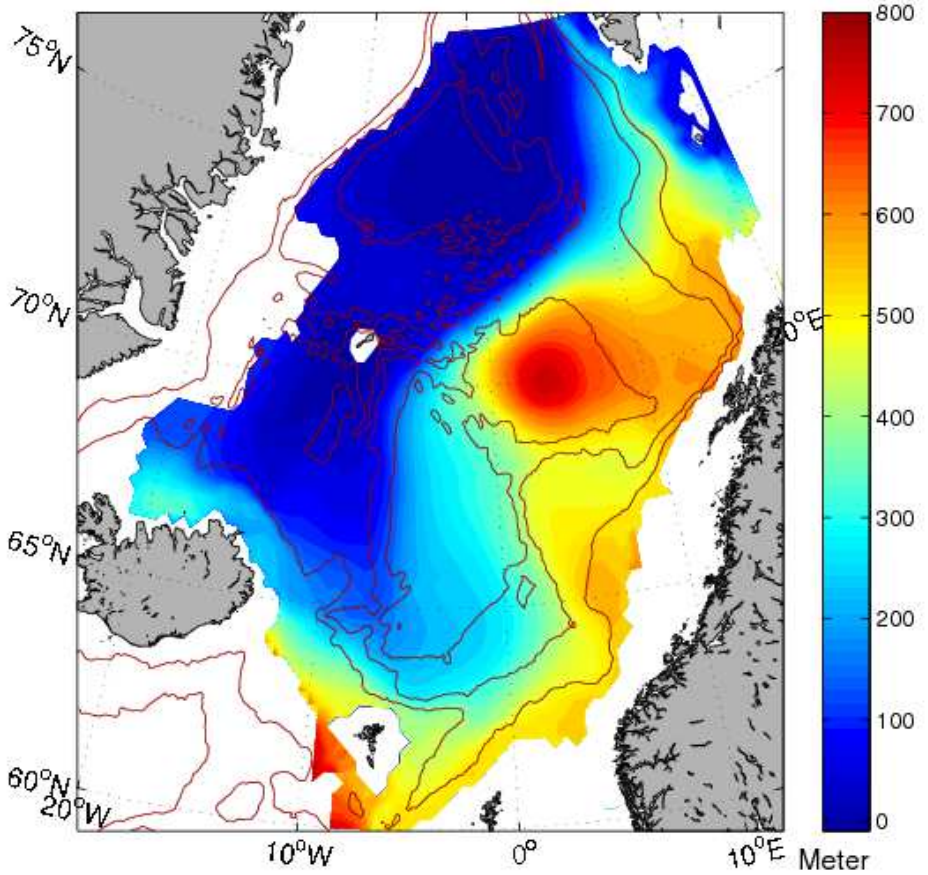
***R**elative* **H**eat/**F**reshwater **C**ontent ~= $f(h') + g(T_a'/S_a')$

A quantitative approach based on hydrography: 1950-2010

Depth-mean T above (σ_t=27.9)



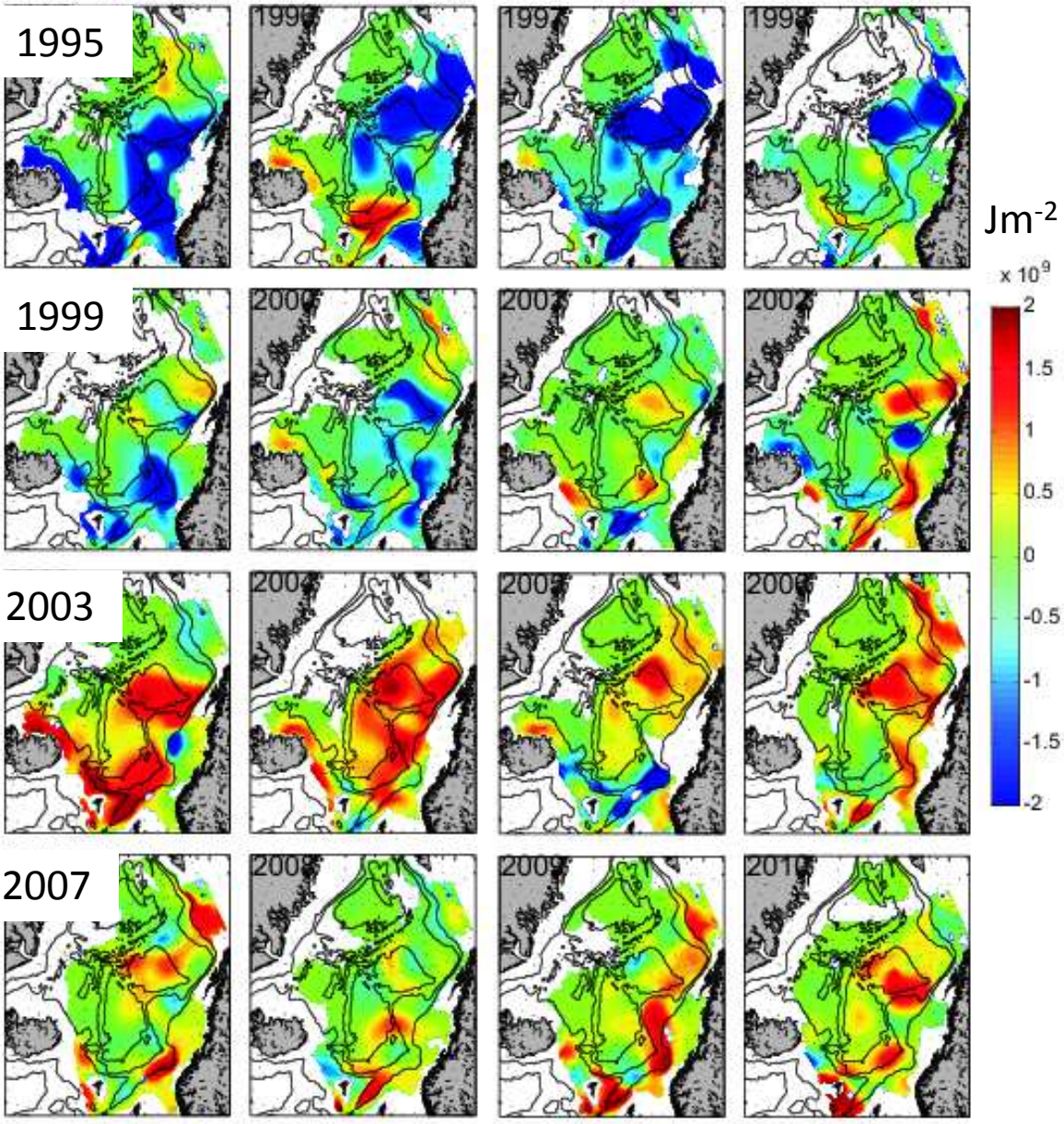
Time-averaged **depth** of the density surface (σ_t=27.9)



Grid: 0.25º * .5º (mer, zon)

Skagseth and Mork (2012); Mork et al (2014)

Relative Heat Content (RHC) anomaly

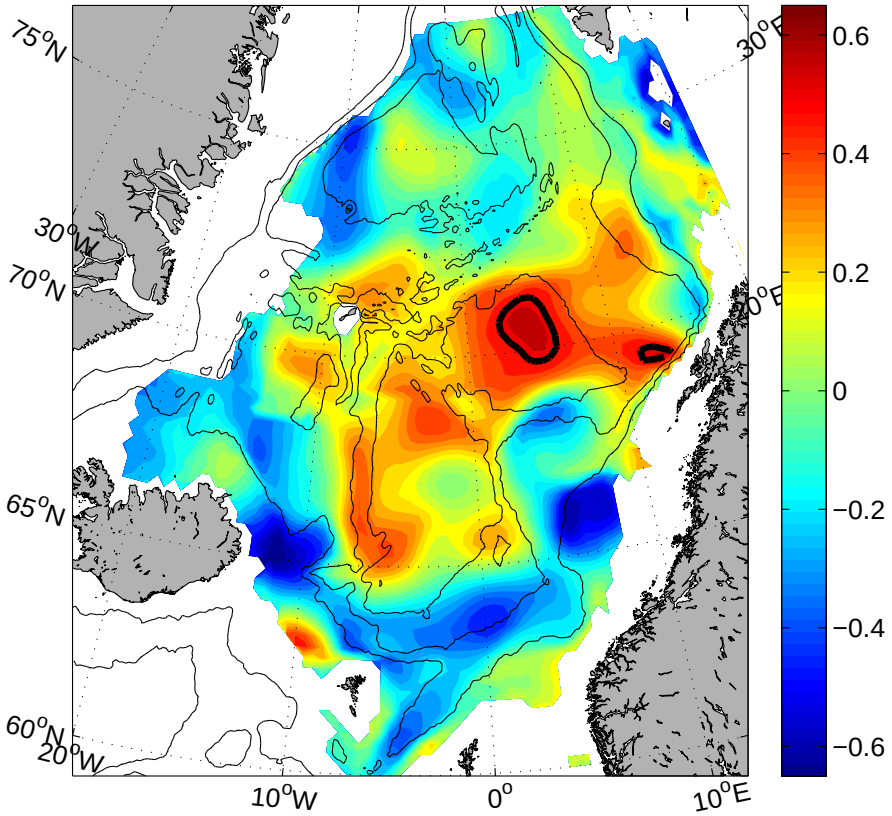


1995-2002

- RHC increase
- propagation

2003-2010

Memory of the ocean: autocorrelation

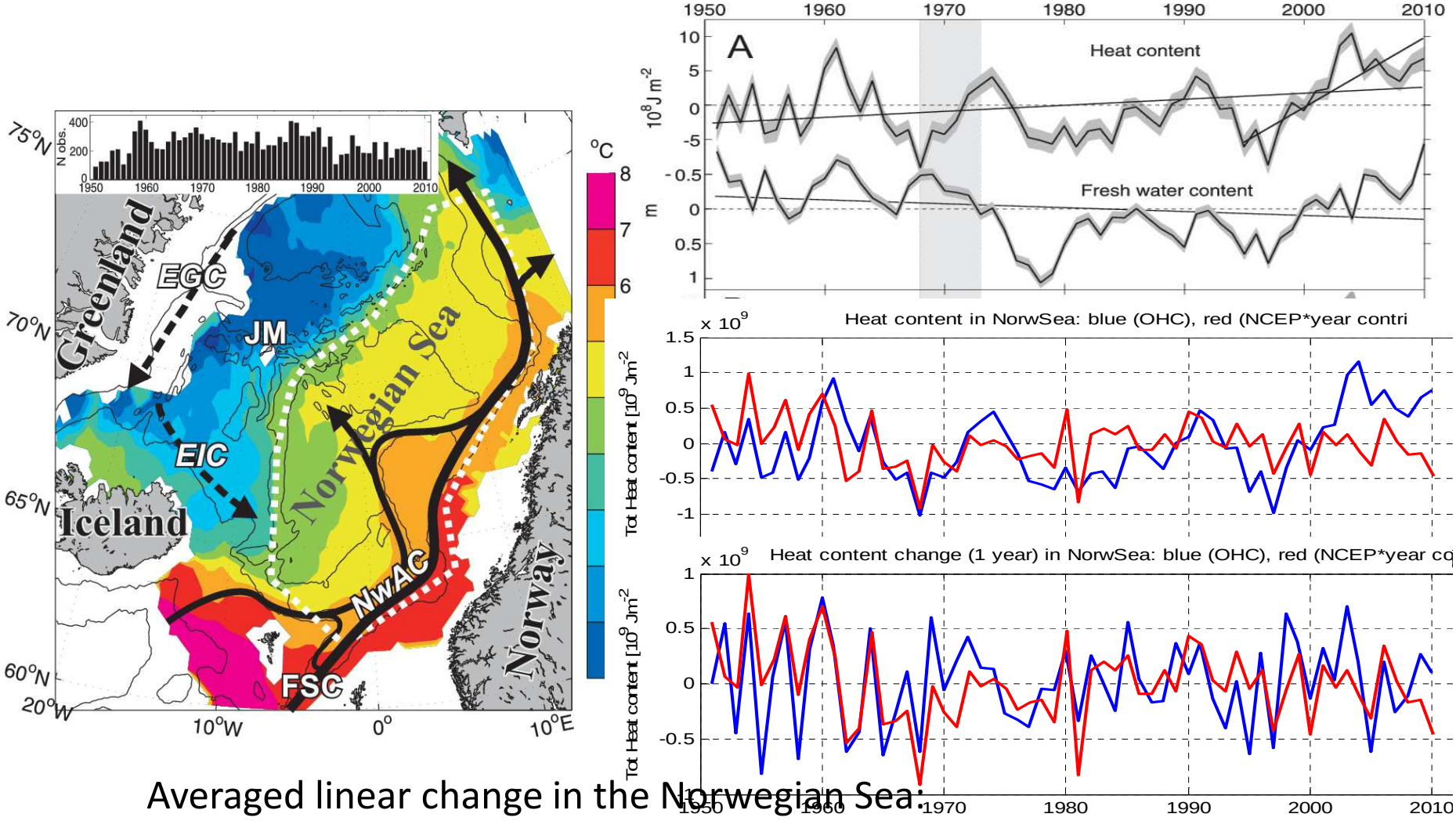


Autocorrelation (one year lag) in heat content from **detrended** data.

Data 1995-2010

Skagseth and Mork (2012)

RHC/ RFC 1951-2010 from hydrography



Averaged linear change in the Norwegian Sea:

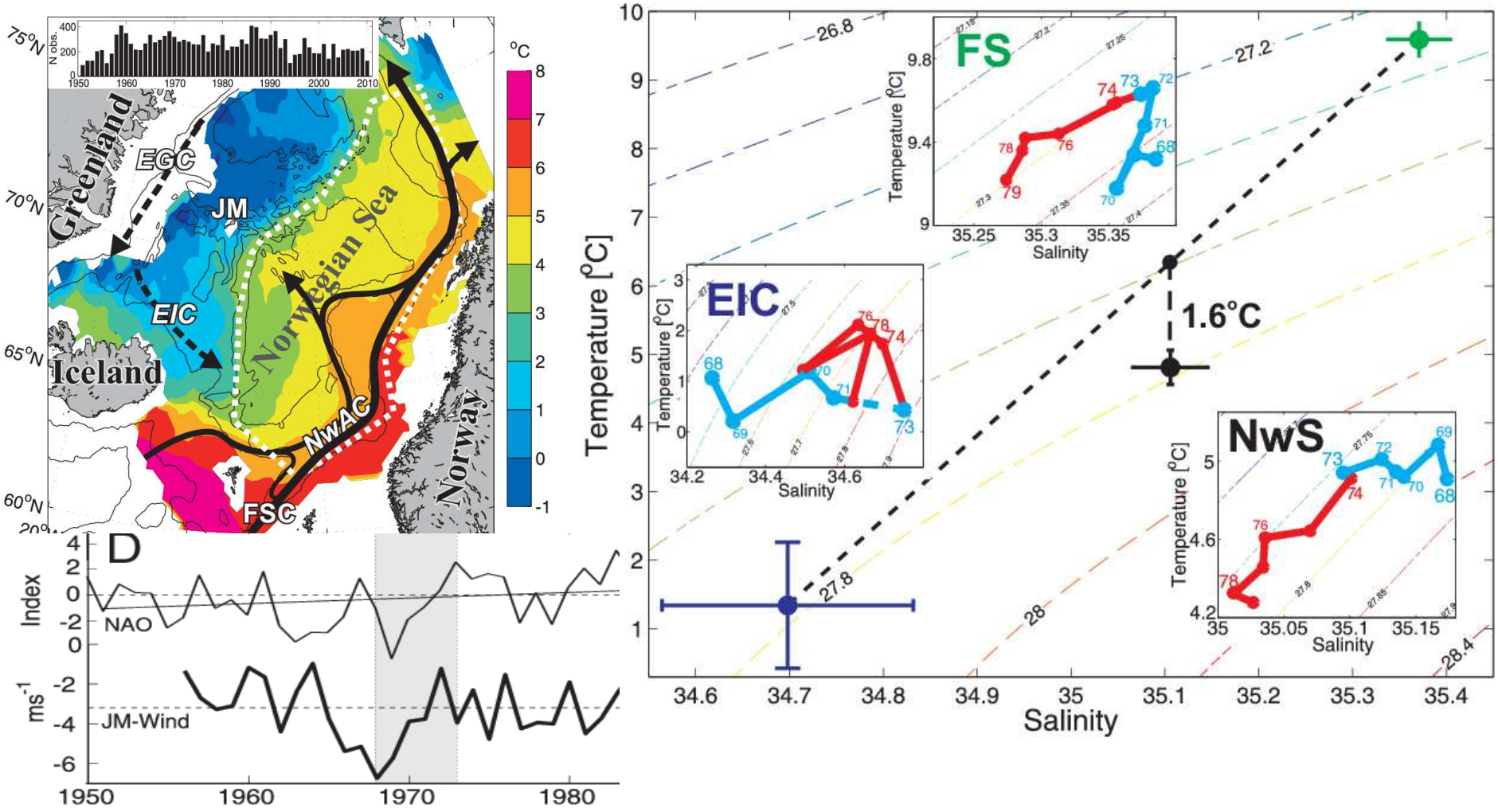
Total: **0.3 Wm^{-2}**; from T_a:-0.1 Wm^{-2}, from h: 0.4 Wm^{-2}

N.Atl: 0.7 Wm^{-2} (1970-2000), Palmer and Haines (2009)

Norw.S.: 3.2 Wm^{-2} (1995-2010), Skagseth and Mork (2012)

Mork et al. (2014)

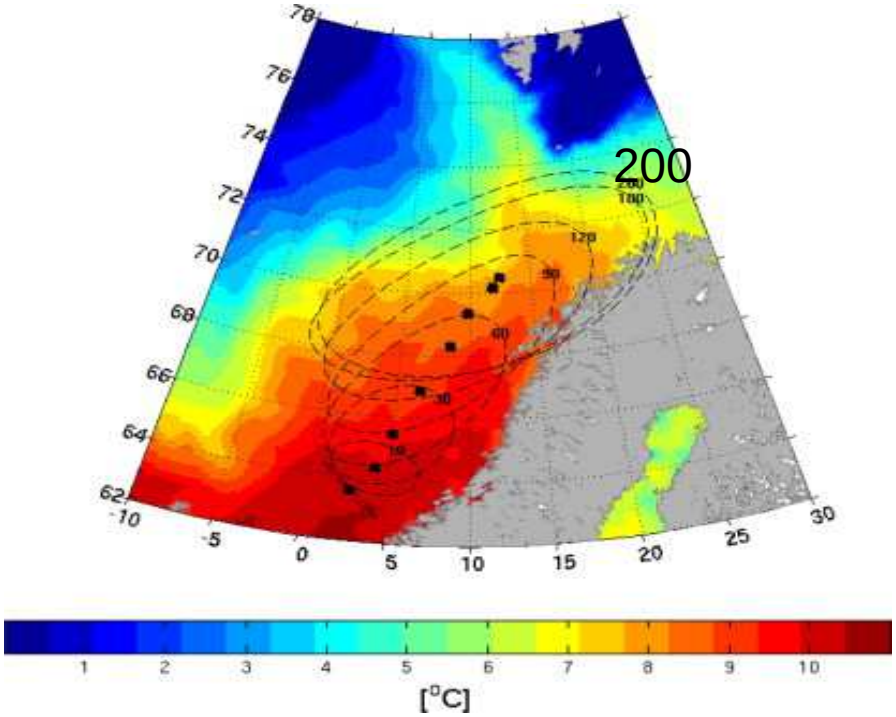
Challenge: Influence from Arctic Water



Freshwater stored in Iceland Sea due to anomalous winds about 1968, then released via EIC leading to a delayed freshening of the NorwS 1970' →

Mork et al (2014)

Poleward transport of atlantic water with surface drifters

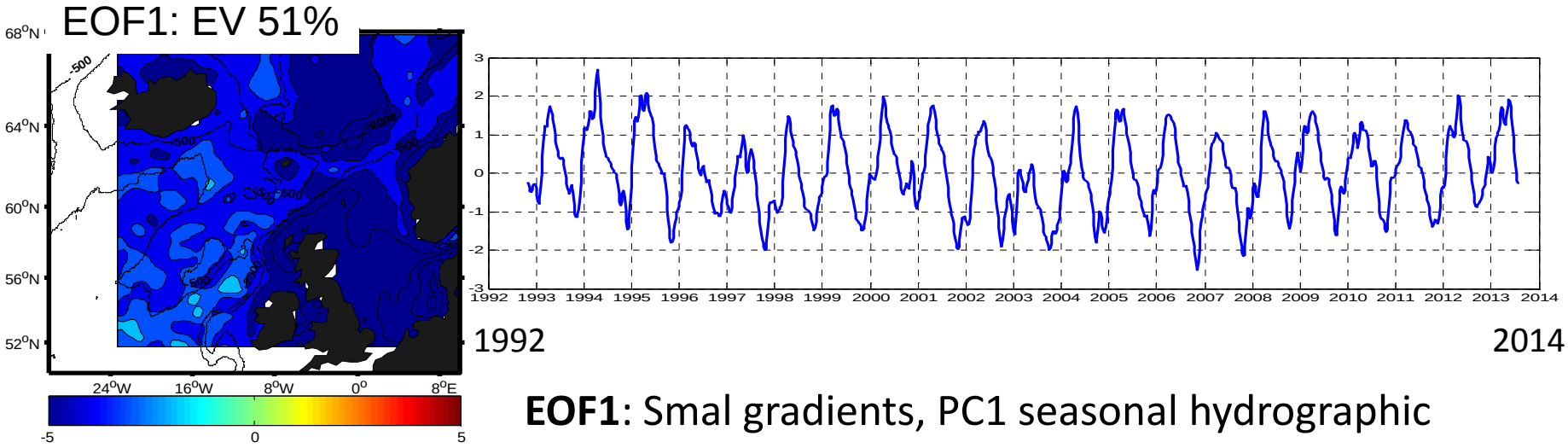


Synthetic driters
Release from Svinøy
- Advection and ”realistic diffusion”

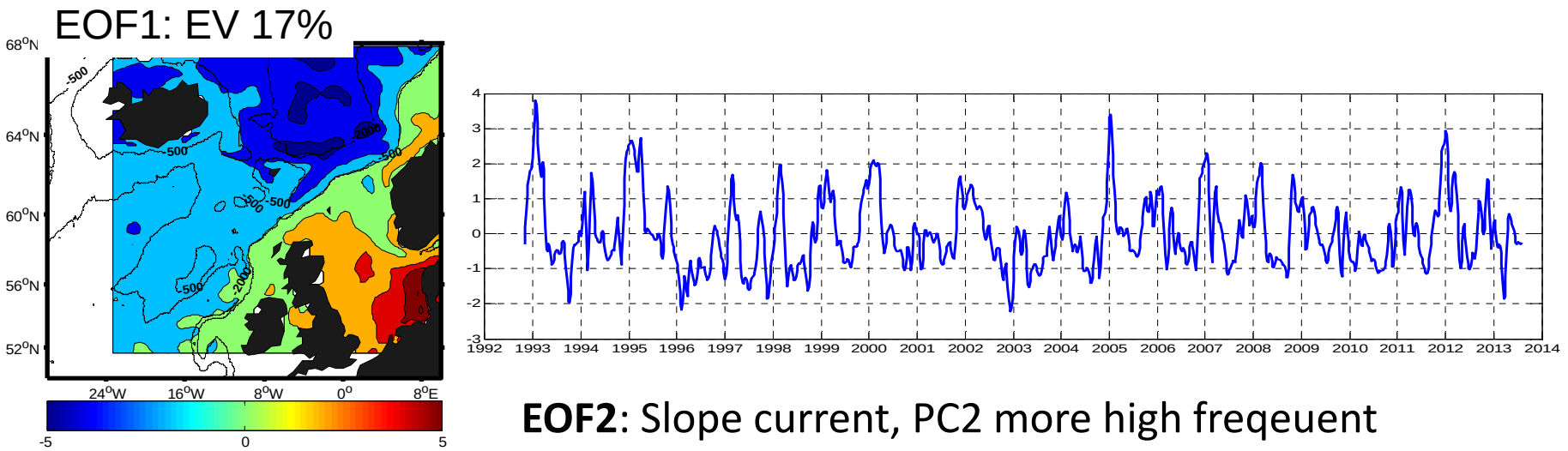
The variance ellipses for a cluster of drifters originating at Svin?y (crosses) at 10, 30, 60, 90, 120, 180 and 200 days superimposed on the mean surface temperature field from the TOPAZ Reanalysis for 2003 - the year of passage of a warm...

Koszalka et al., 2012

Circulation from SSH-altimeter



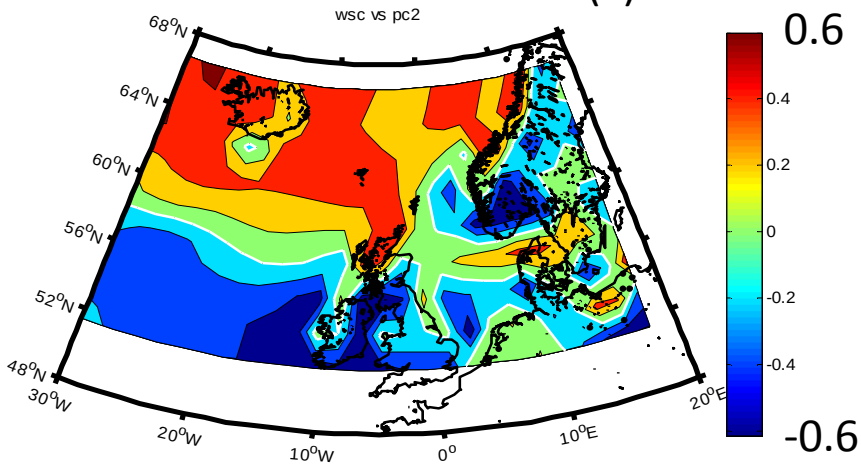
EOF1: Smal gradients, PC1 seasonal hydrographic changes, in phase thus little dynamic effect



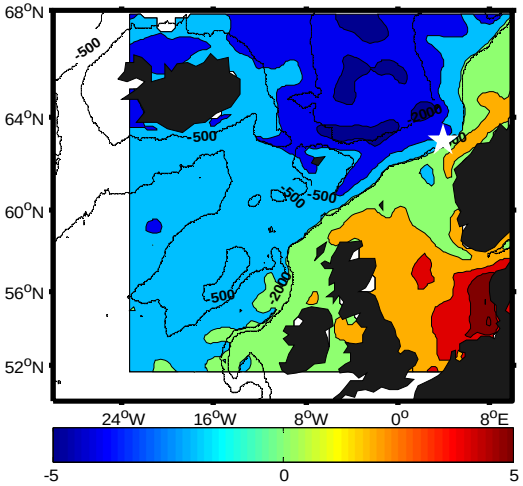
EOF2: Slope current, PC2 more high freqeuent variability, dynamic effect

Circulation from SSH-altimeter (cont)

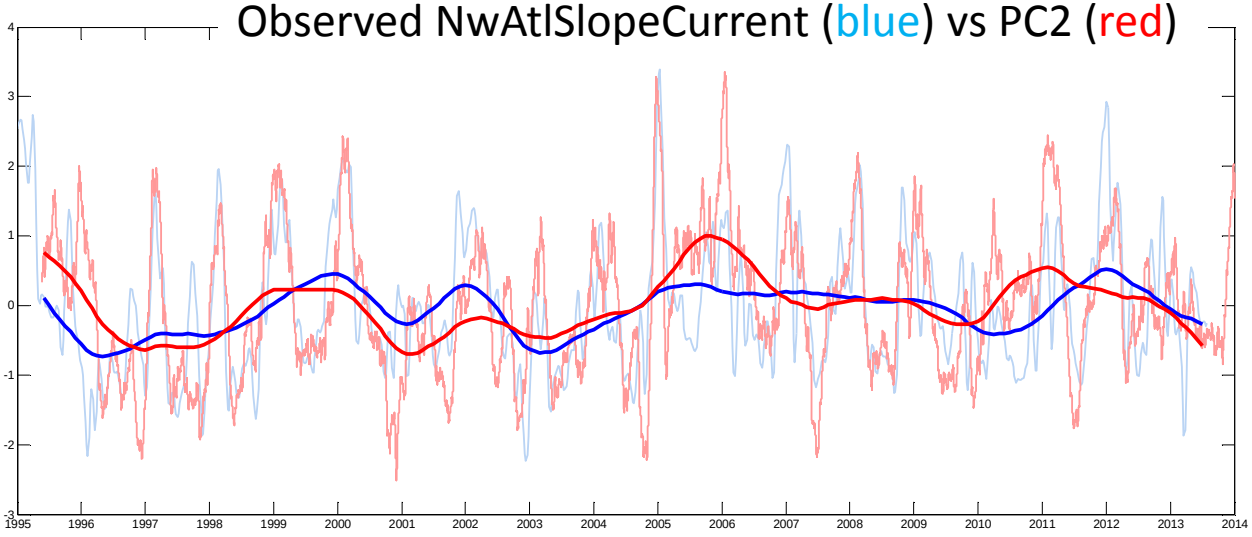
Correlation: PC2 vs curl(τ)



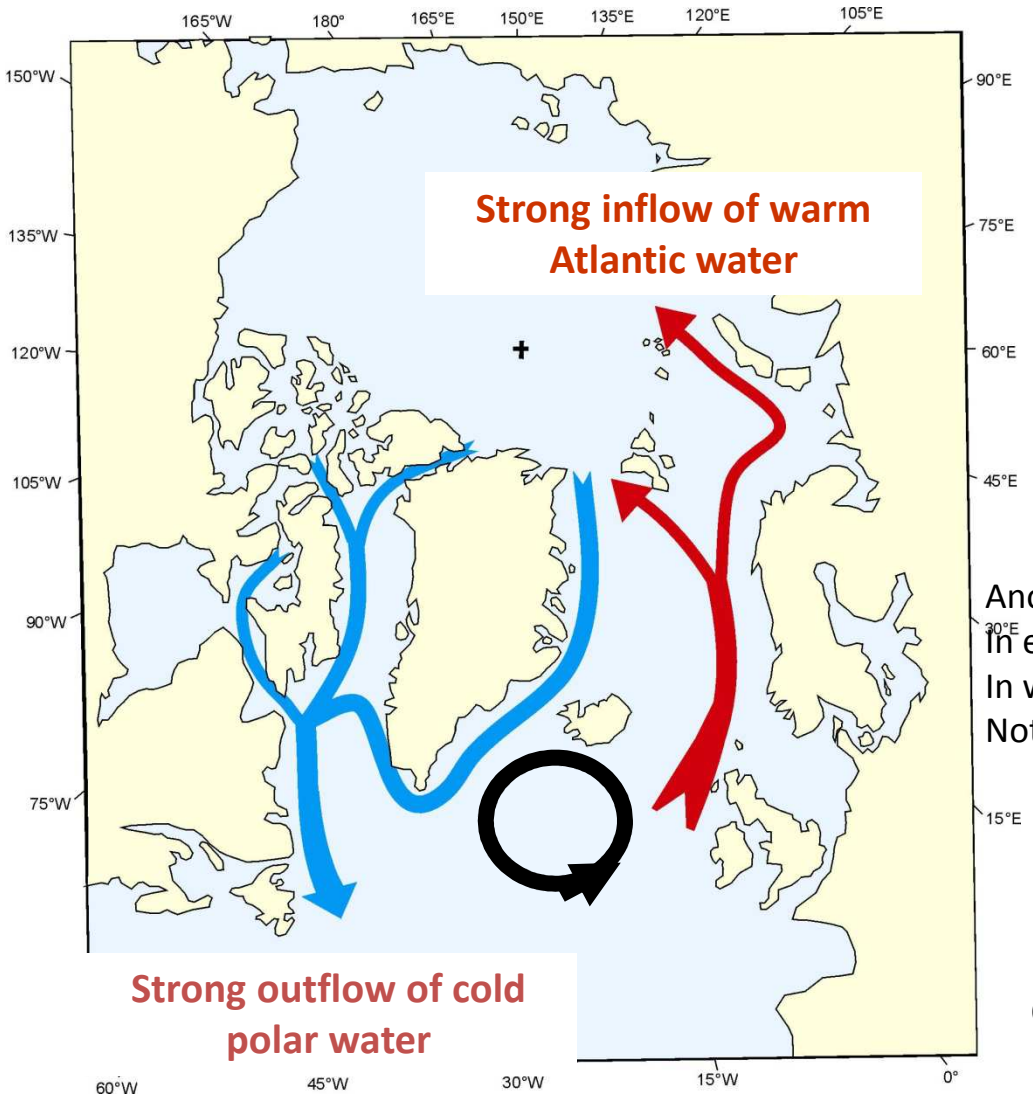
EOF#2



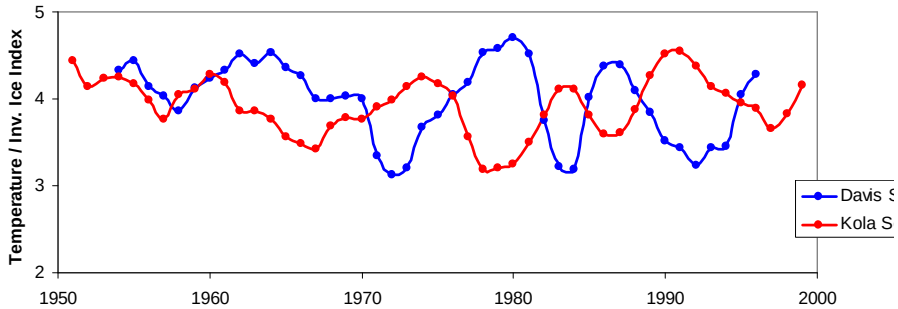
Observed NwAtlSlopeCurrent (blue) vs PC2 (red)



Anomalies due to: V’



Opposite phase of decadal climate variations in the Barents and the Labrador Sea



Anomalous strong wind; spin up the circulation
In east: decreasing gradient (T and S) → positive anomaly
In west: increasing gradient (T and S) → negative anomaly.
Note: Coherent changes **not** advective

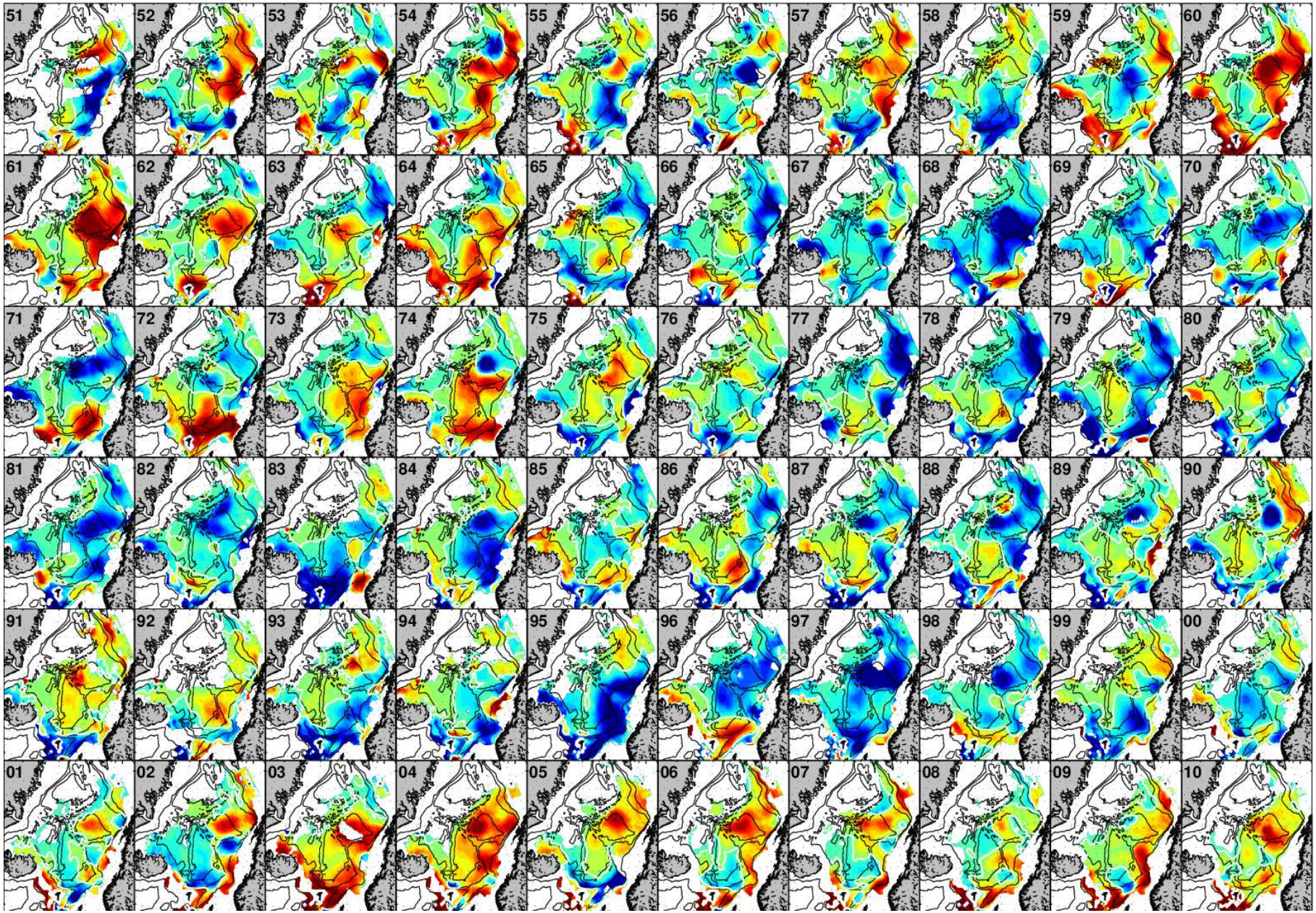
Sundby and Drinkwater (2007)

But also NAO driven change in heat flux contrubute to the same!

Conclusion

- Year to year changes in hydrography – T, S exist in terms of RHC, RFC. 1950 ->, A good testcase for modellers; variability.
- Observational evidence of T’, S’ through the NAS is numerours (maybe not well understood)
- Obsservational evidence demonstrating the effect of V’ are less clear (*except of some events GSA, SPG*)

Heat content anomaly 1951-2010



Mork et al, in prep

NAO and SubPolarGyre