

Freshwater covariability in the Arctic and North Atlantic

Horn, M., Schauer, U., and Rabe, B. (in prep.)

Why do we care about freshwater?

Ocean's salinity changes only due to the addition or removal of freshwater by

- Precipitation/evaporation
- Continental run-off
- Sea ice melting/formation

Arctic Ocean

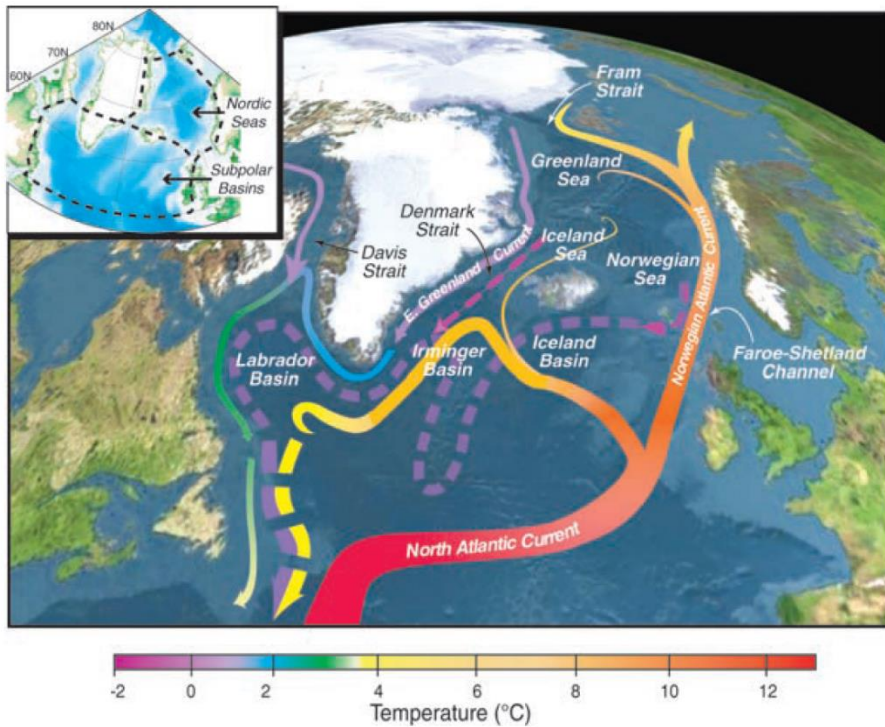
- Insulation effect of the fresh surface layer

Subpolar North Atlantic and Nordic Seas

- Deep water formation (Meridional Overturning Circulation)

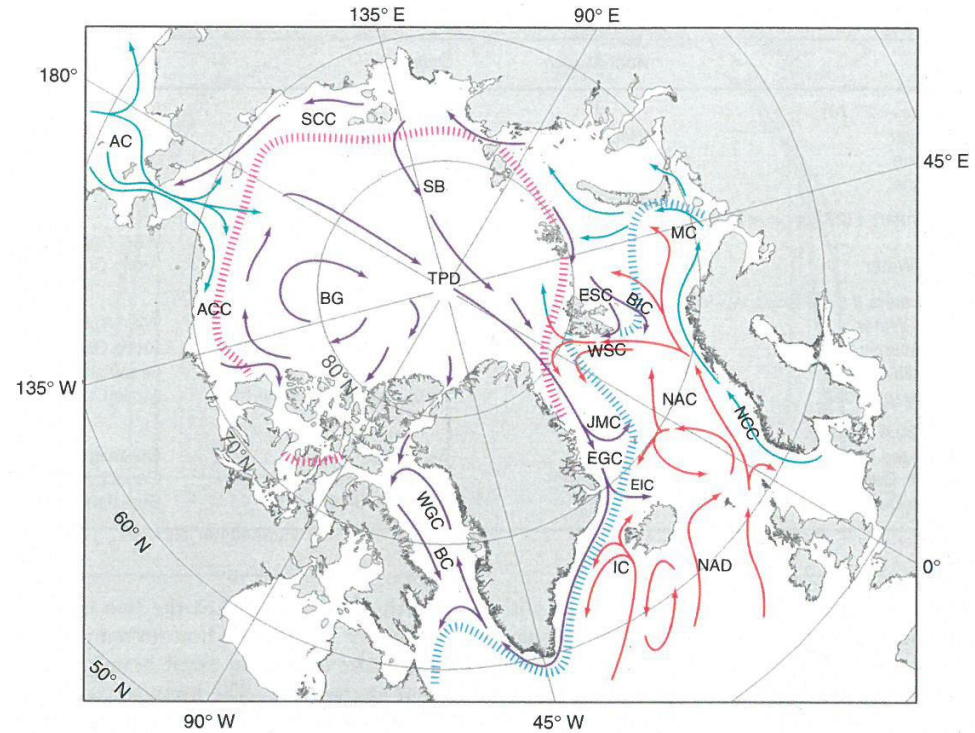
Circulation

Subpolar North Atlantic and Nordic Seas



Curry and Mauritzen (2005)

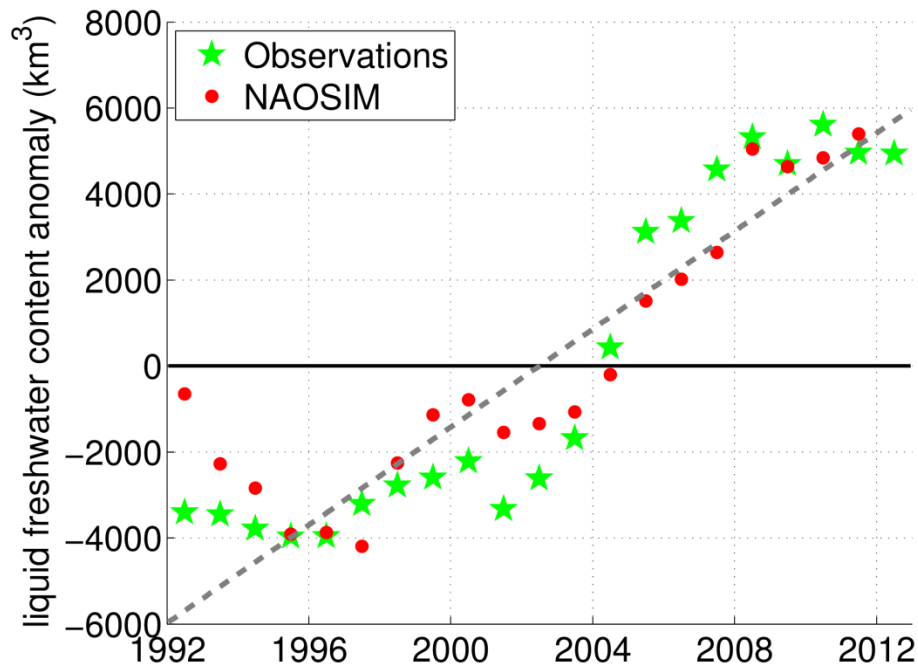
Arctic Ocean



Rudels (2009)

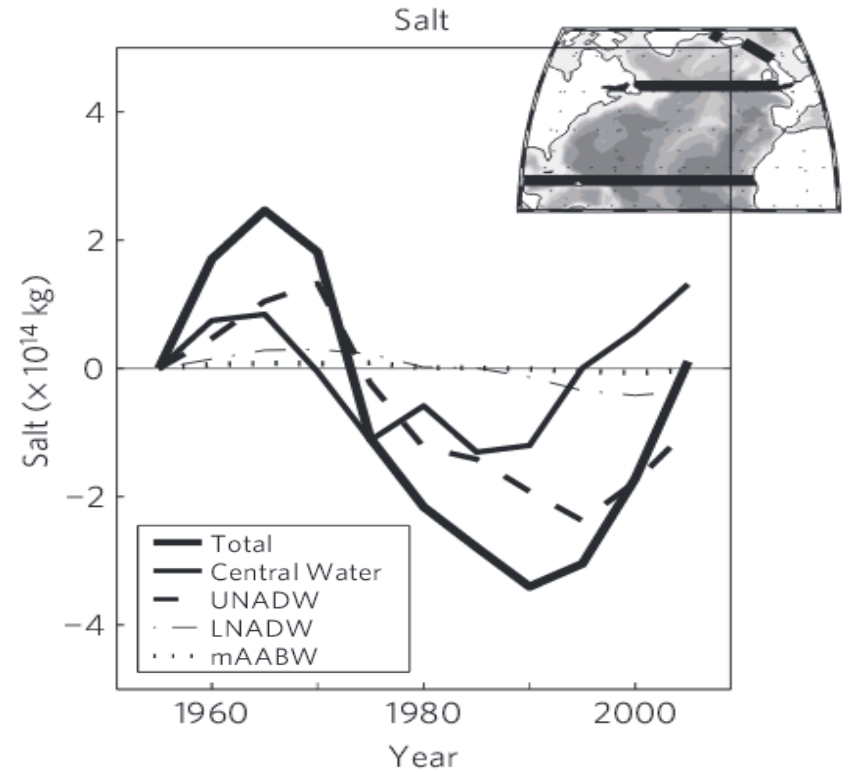
Recent freshwater changes

Arctic Ocean



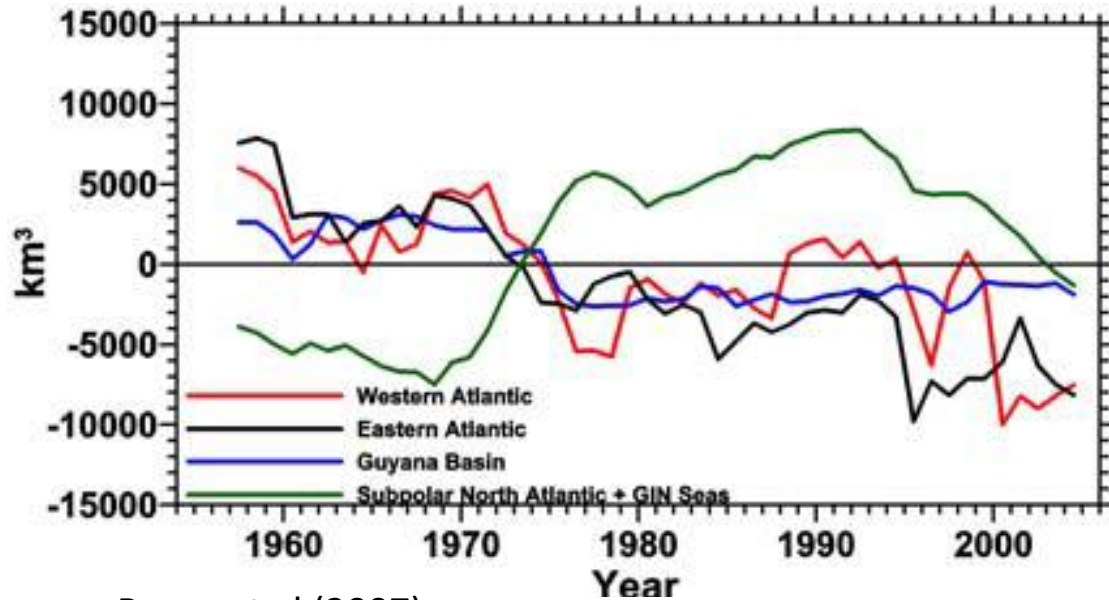
Rabe et al. (2014)

Subpolar North Atlantic

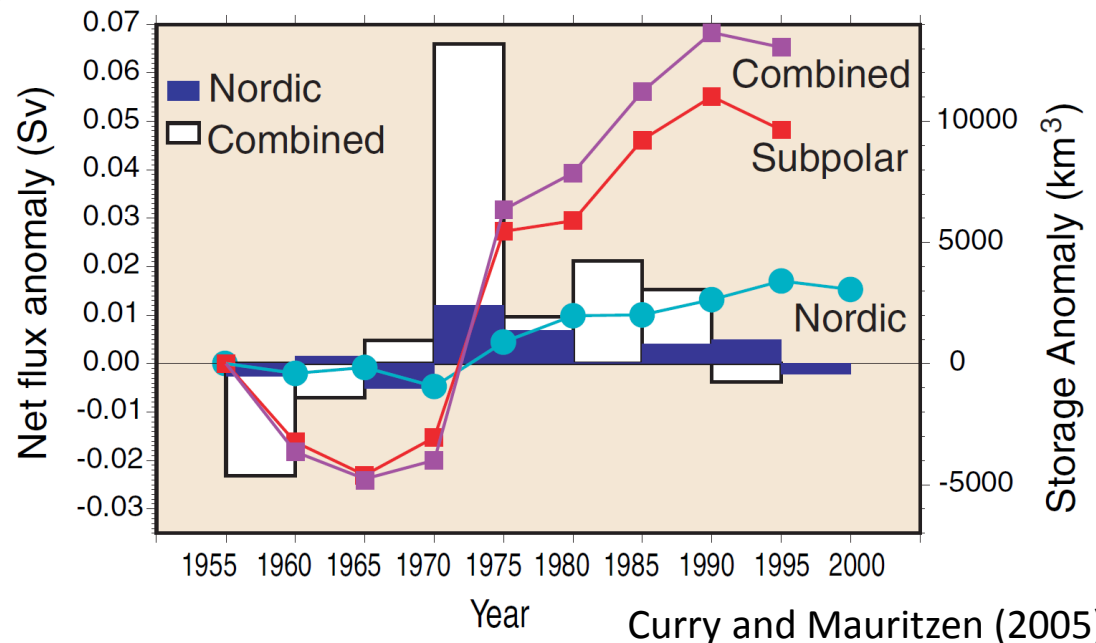
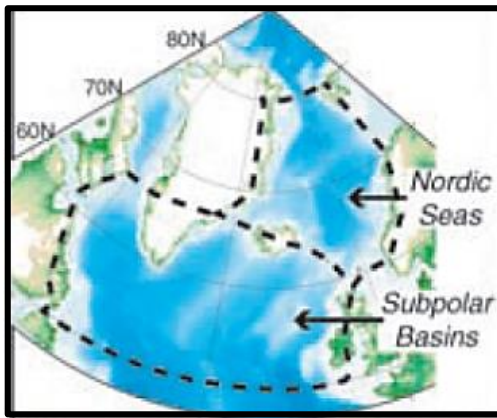


Mauritzen et al. (2012)

Freshwater variability in the North Atlantic



Boyer et al (2007)



Curry and Mauritzen (2005)

Uncertainties in IPCC climate-models

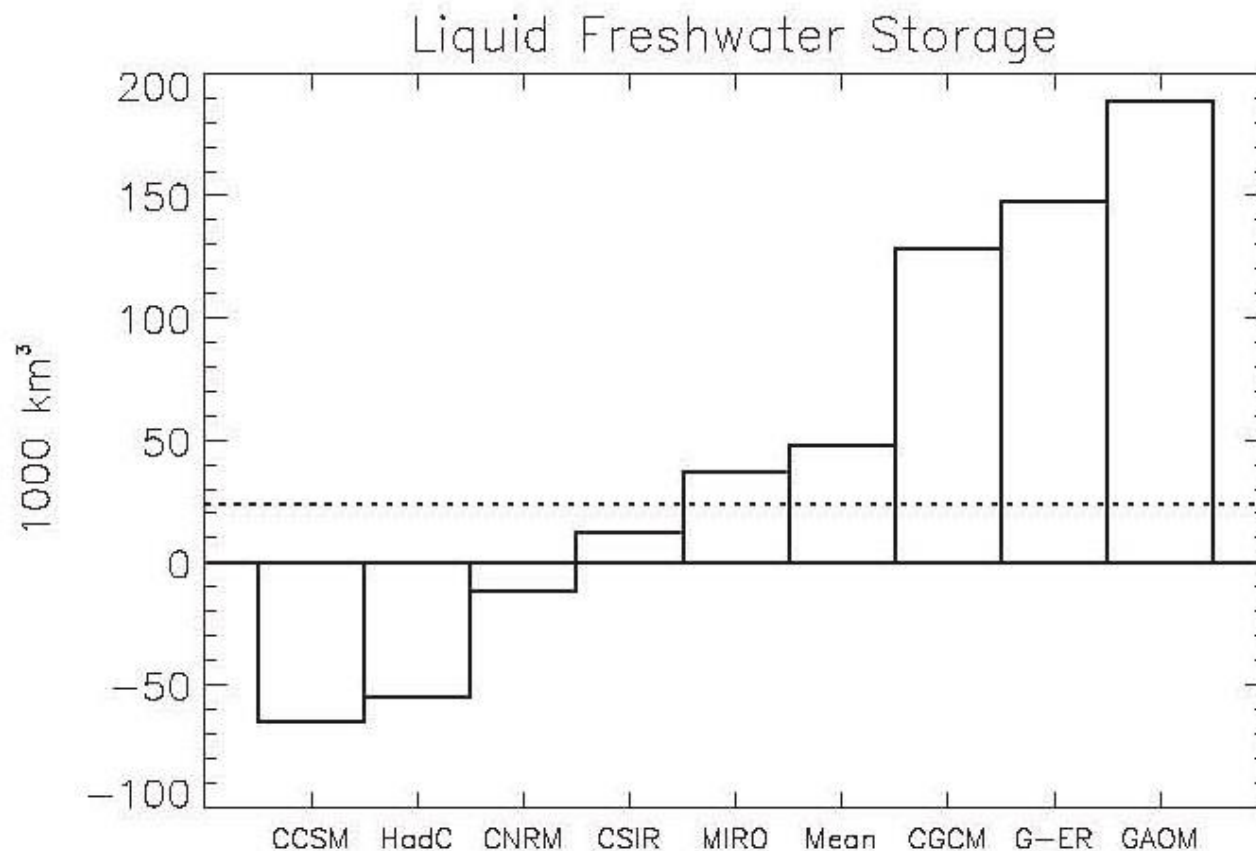
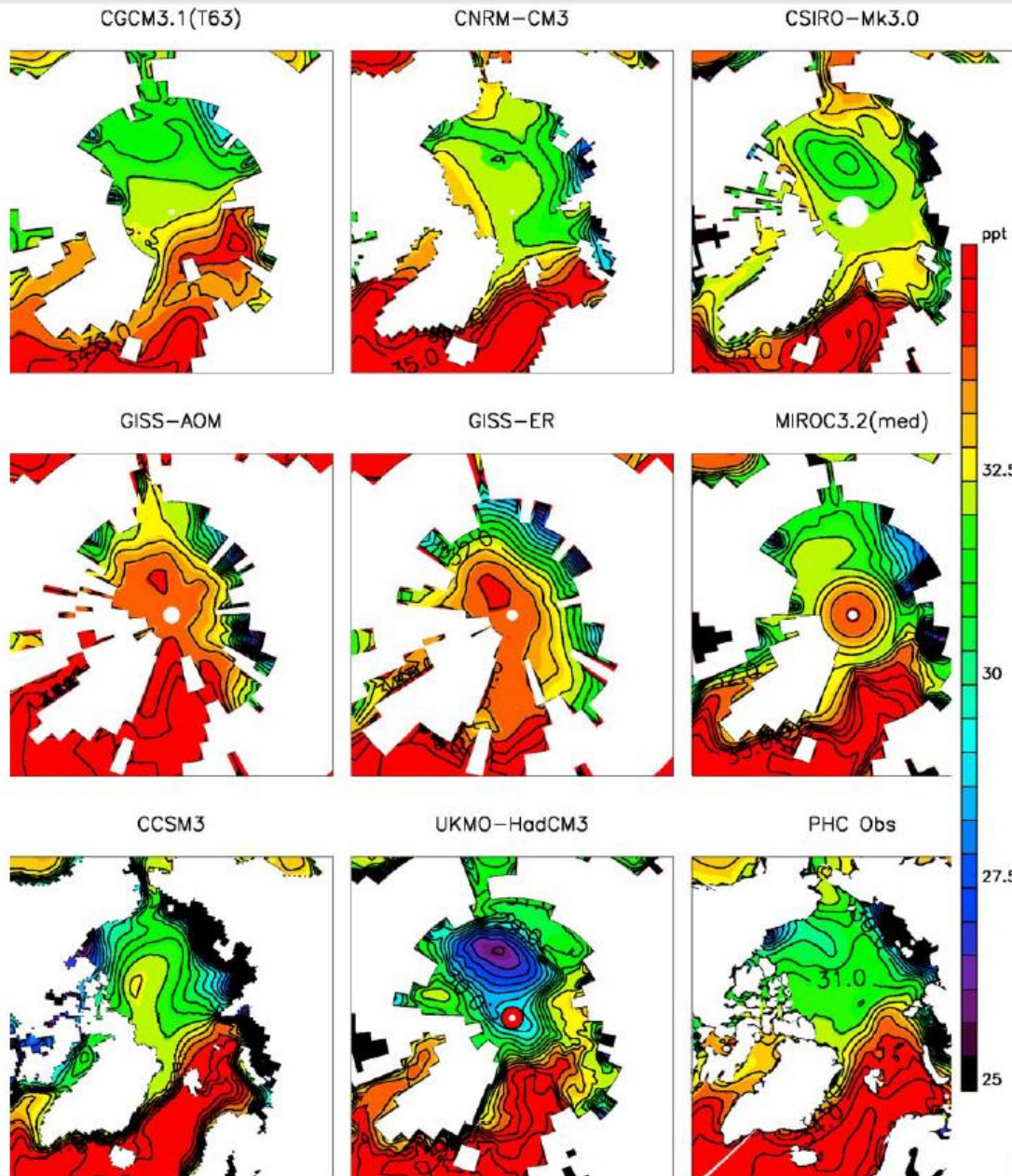


Figure 4. Ocean freshwater storage from the models and for the multimodel ensemble mean averaged for the period 1990–1999. The dotted line shows the observed value.

Uncertainties in IPCC climate-models



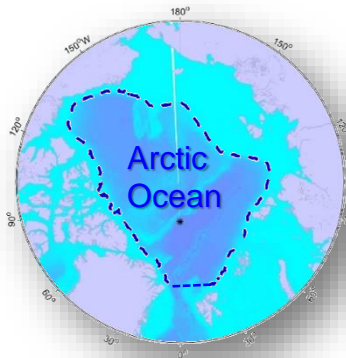
Sea Surface Salinity
Average from 1990-1999

Holland et al. (2007)

Data and calculations

Inventory of liquid freshwater

$$LFWI = \int_{z=0m}^h \frac{S_{ref}-S}{S_{ref}} dz \quad [m]$$



Liquid freshwater content:

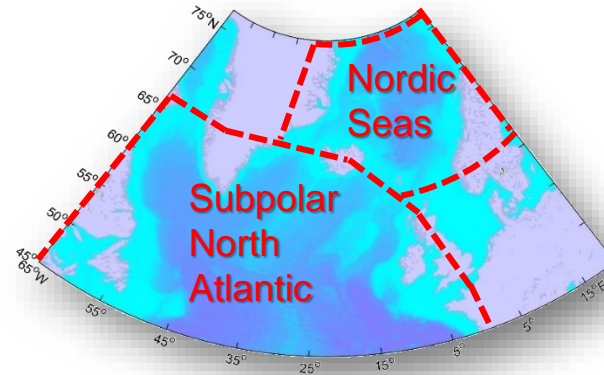
- Rabe et al. (2014)
- 1992 – 2013
- $S_{ref} = 35$
- h = depth of 34 isohaline

Solid freshwater content:

- Haine et al. (2015)
- PIOMAS assimilation product

Liquid freshwater content

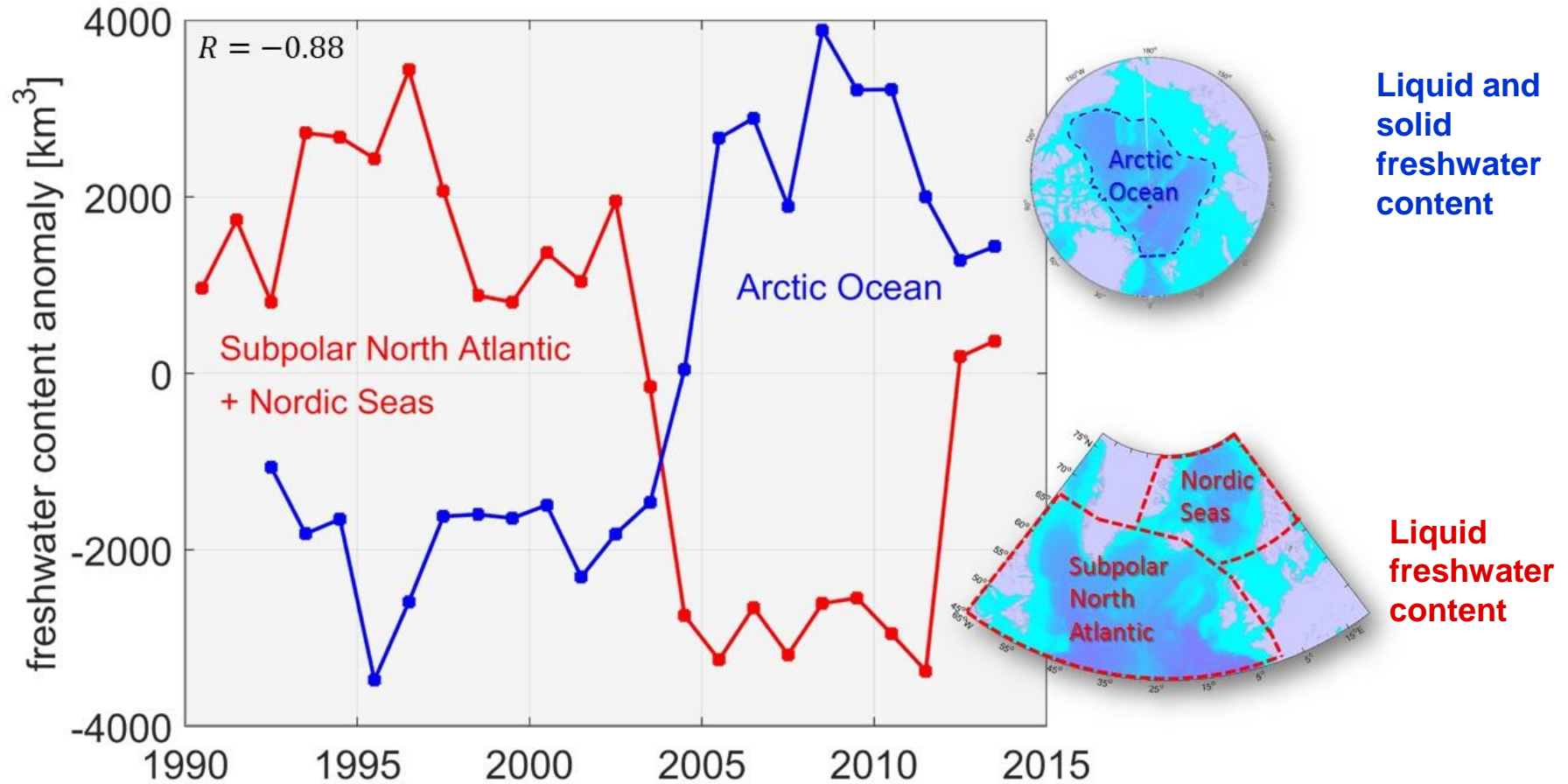
$$LFWC = \oint LFWI dA \quad [km^3]$$



Liquid freshwater content:

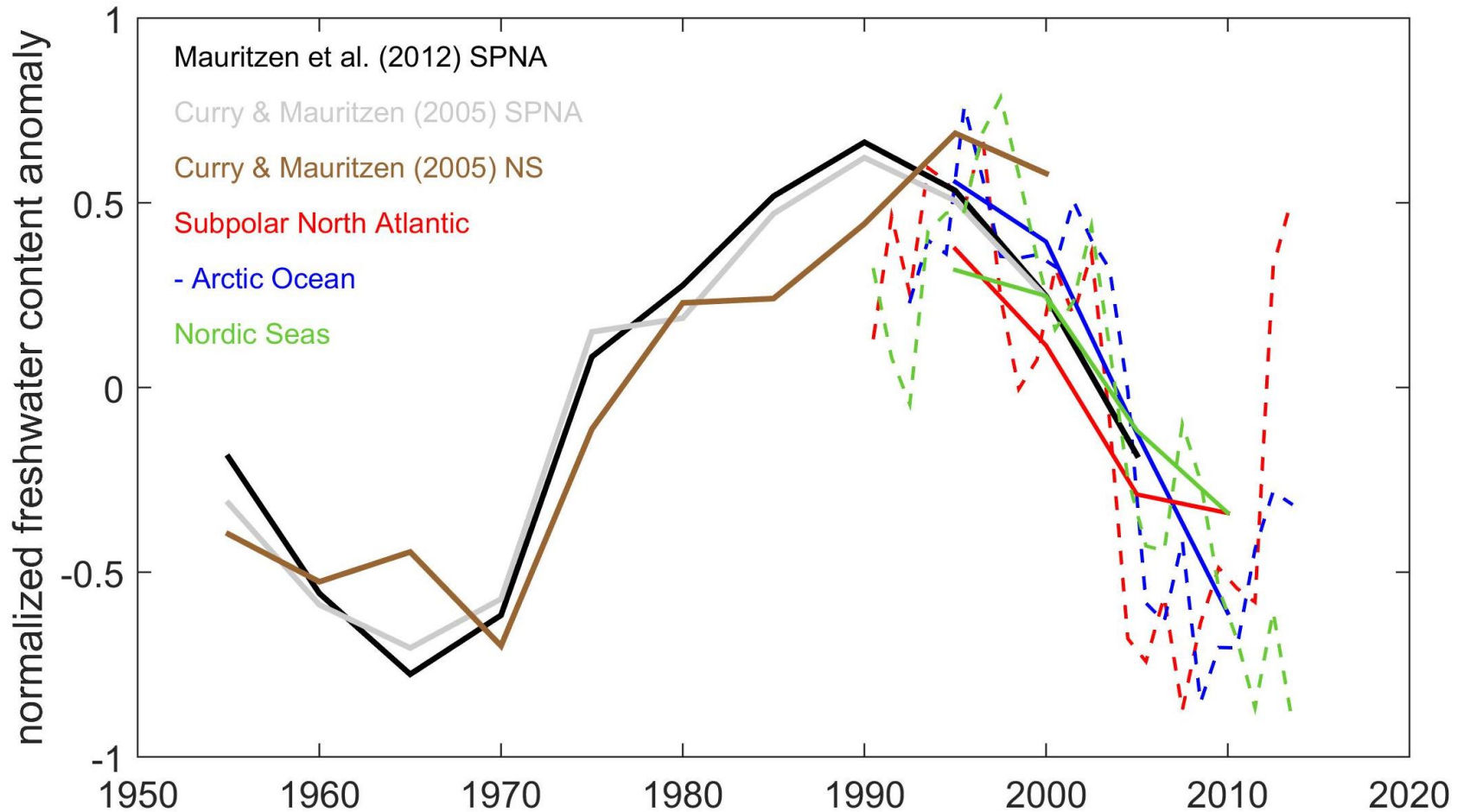
- CORA salinity fields (Cabanes et al., 2013)
- 1990 – 2013
- $S_{ref} = 35$
- $h = 2000$ m

Freshwater variability



- The freshwater contents are **significantly anti-correlated** (95 % Confidence).
- The amount of the **anomalies** are of the **same size**.
- Freshwater anomalies suggest an **oscillation**.

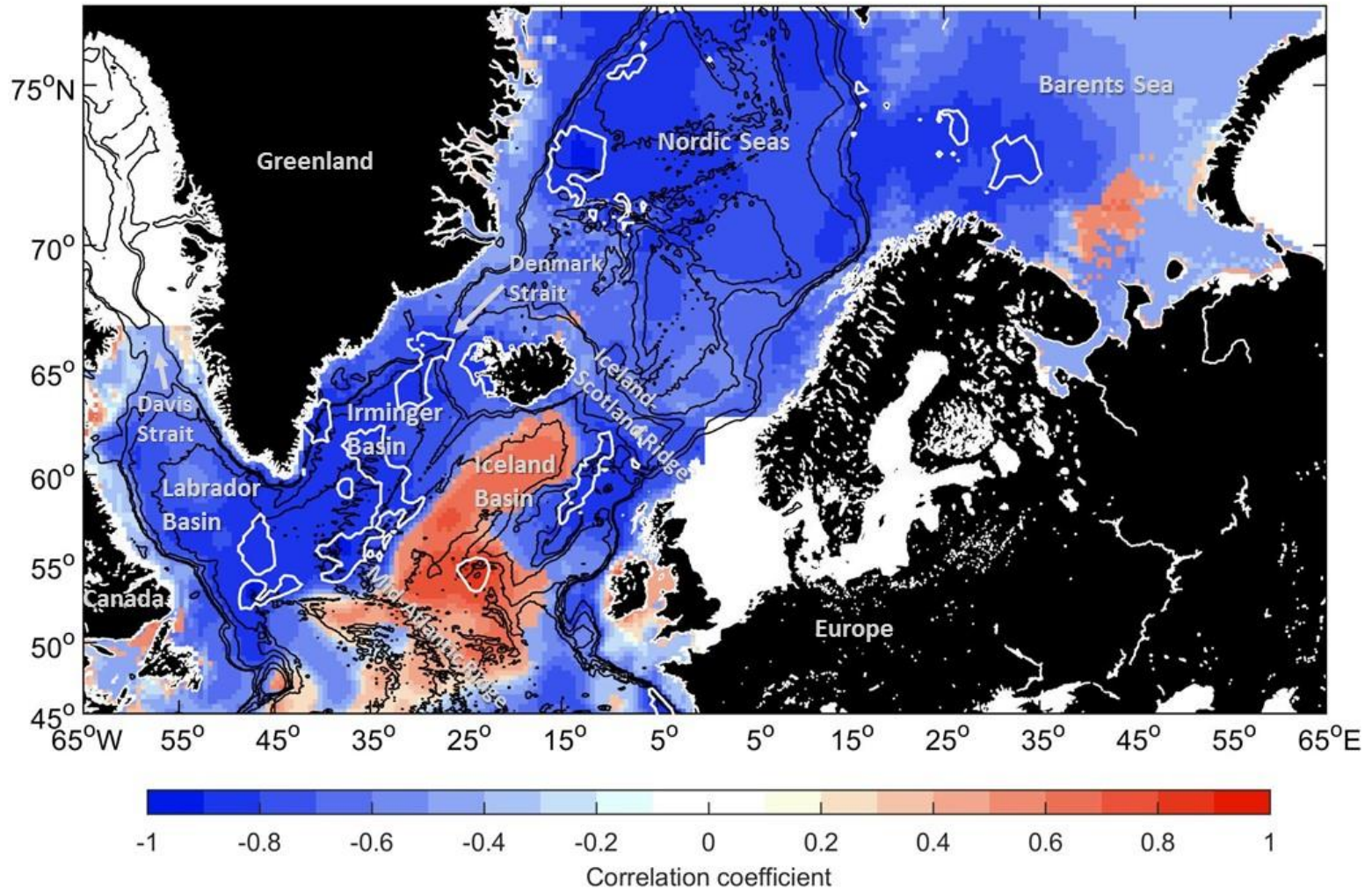
Freshwater variability



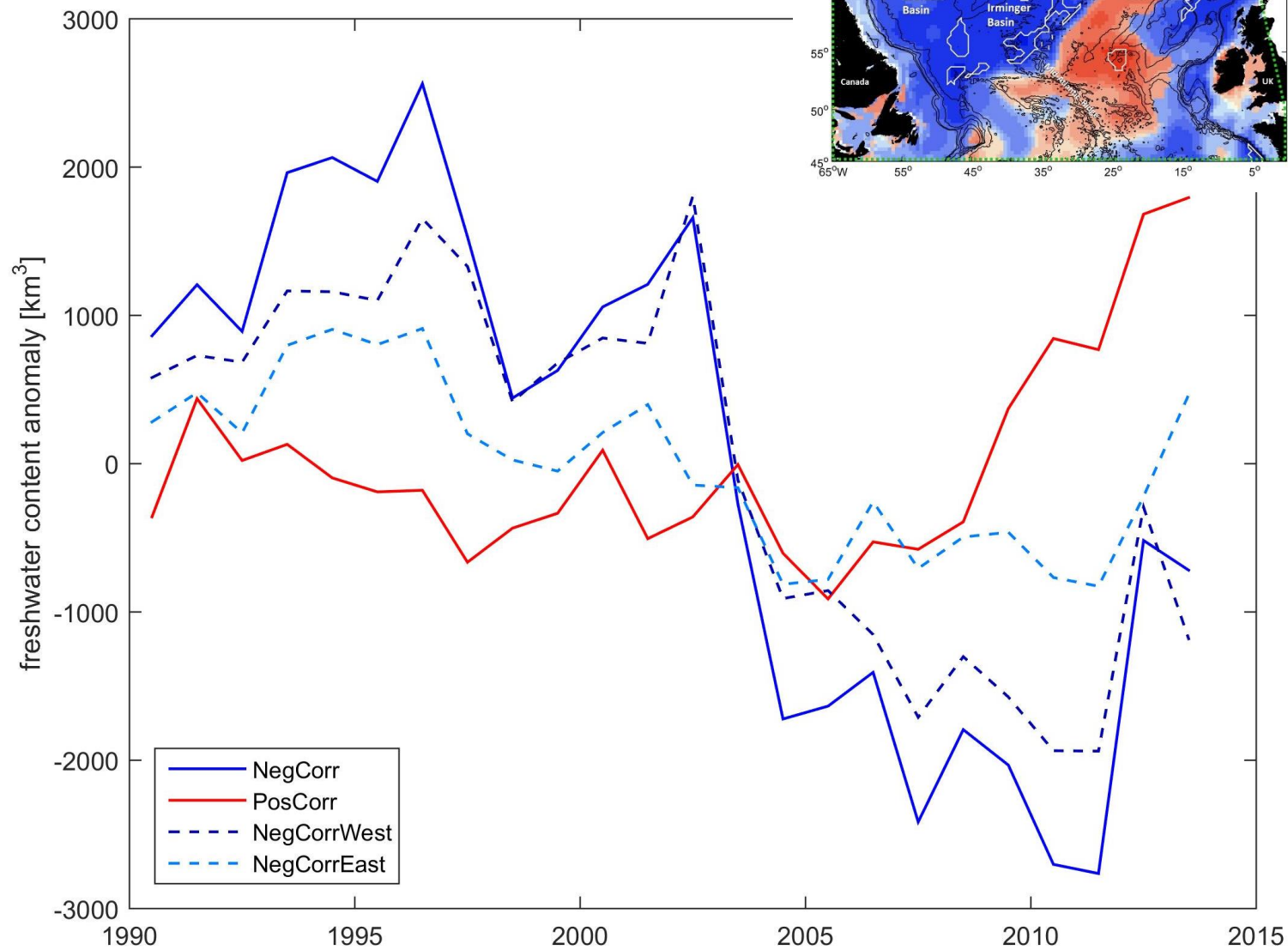
The anomalies have been normalised by twice their standard deviation

➤ Time series hint at **multidecadal oscillations**.

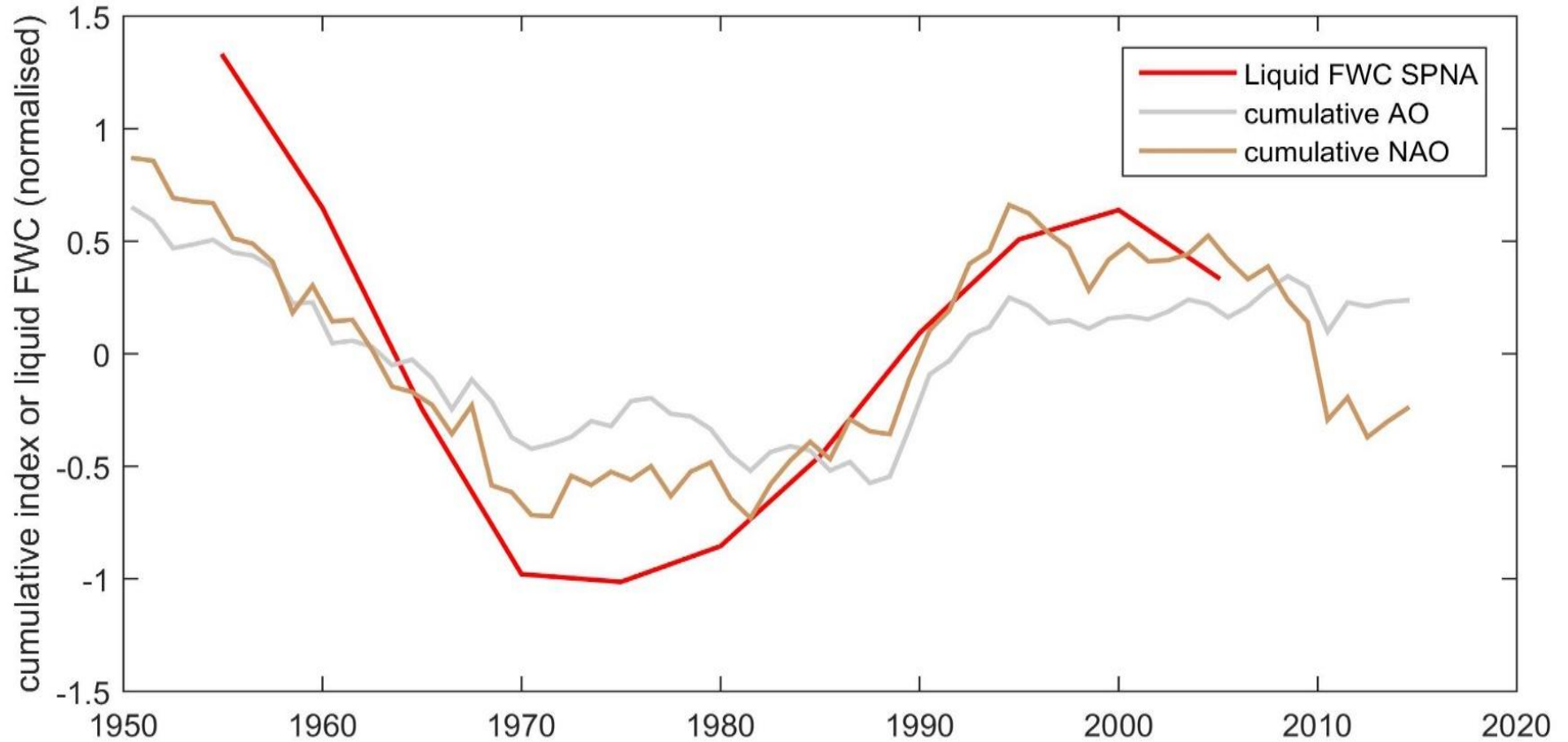
Correlation with the freshwater content of the Arctic Ocean



Positive vs negative Correlation



North Atlantic and Arctic Oscillation Index



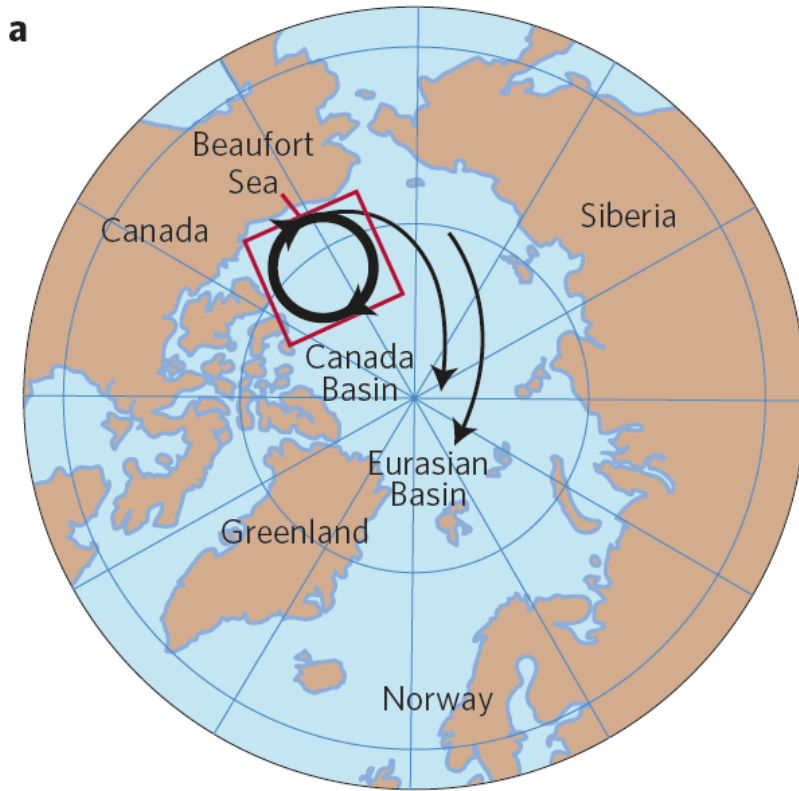
The time series have been normalised by twice their standard deviation, detrended and demeaned.

- The cumulative oscillation indices and the liquid freshwater content of the subpolar North Atlantic are **significantly correlated**.

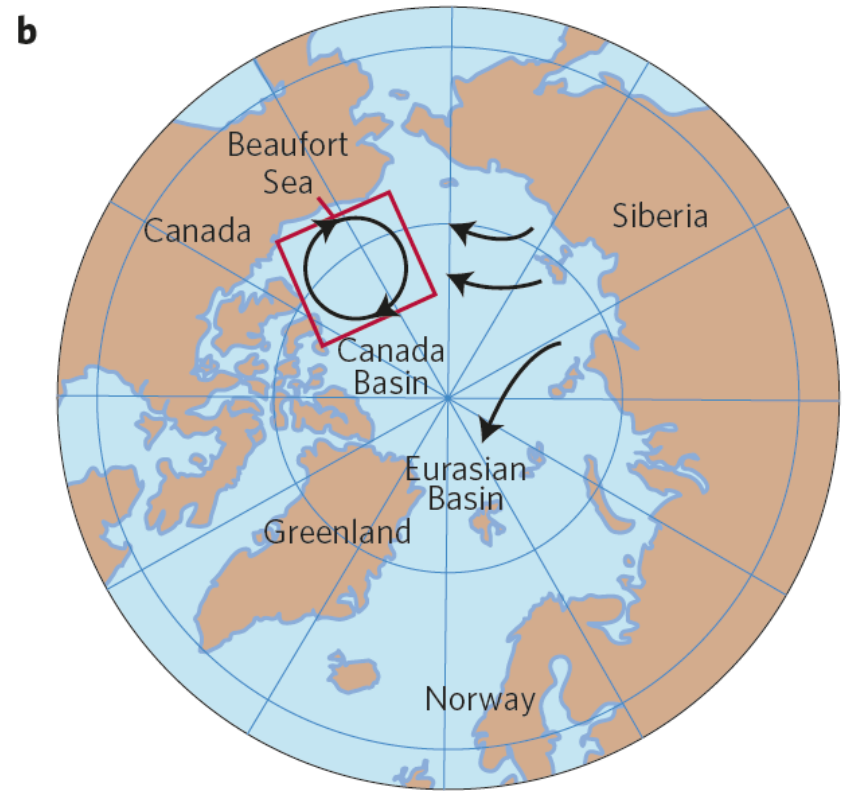
Arctic circulation modes

Arctic Oscillation Index

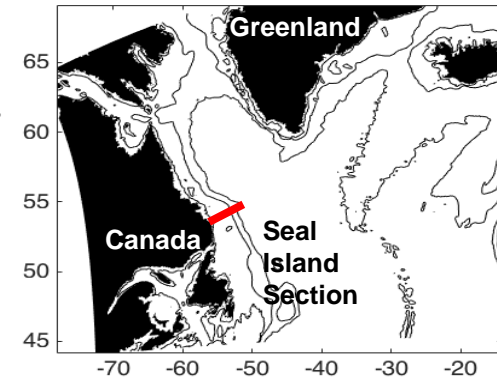
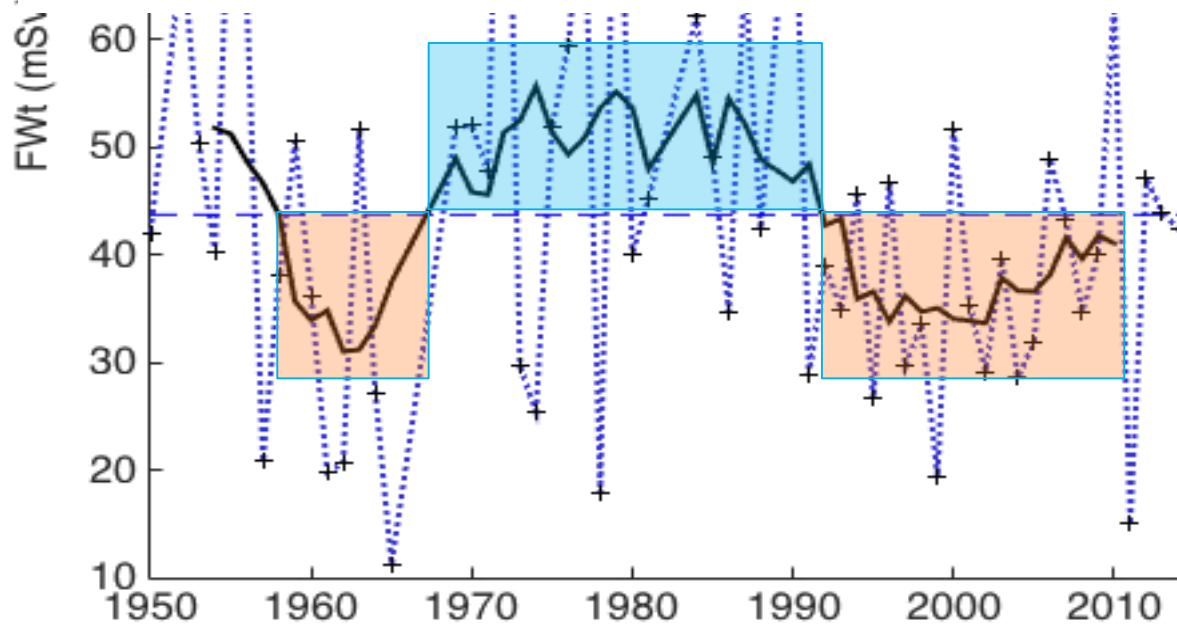
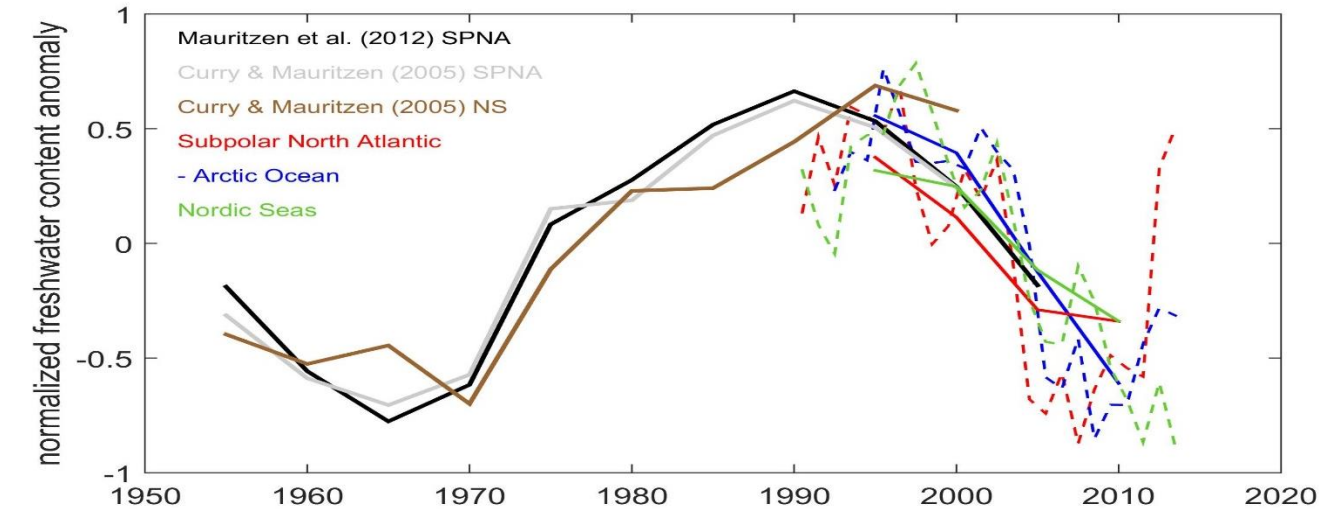
low



high



Arctic freshwater transport in the Labrador Current



Florindo-López et al. (2015)

Conclusions

Freshwater changes of the Arctic Ocean and of the subpolar North Atlantic

+ Nordic Seas has been **anti-correlated** during the last 20 years.

The **Arctic Ocean is the dominating source** for freshwater changes in

the sub-Arctic North Atlantic on multidecadal time scales

The changes are likely to **result from changing exports** into the subpolar North Atlantic driven by or even interacting with **changes in the atmospheric oscillation.**

Outlook

Observations:

- Comparison with freshwater changes in the subtropical North Atlantic
 - Check the influence from the south

Model:

- Investigation of circulation changes related to different atmospheric conditions
 - Check if scales are matching
- Comparison of export rates in Fram Strait and through the Canadian-Arctic-Archipelago
 - Which export path is more important

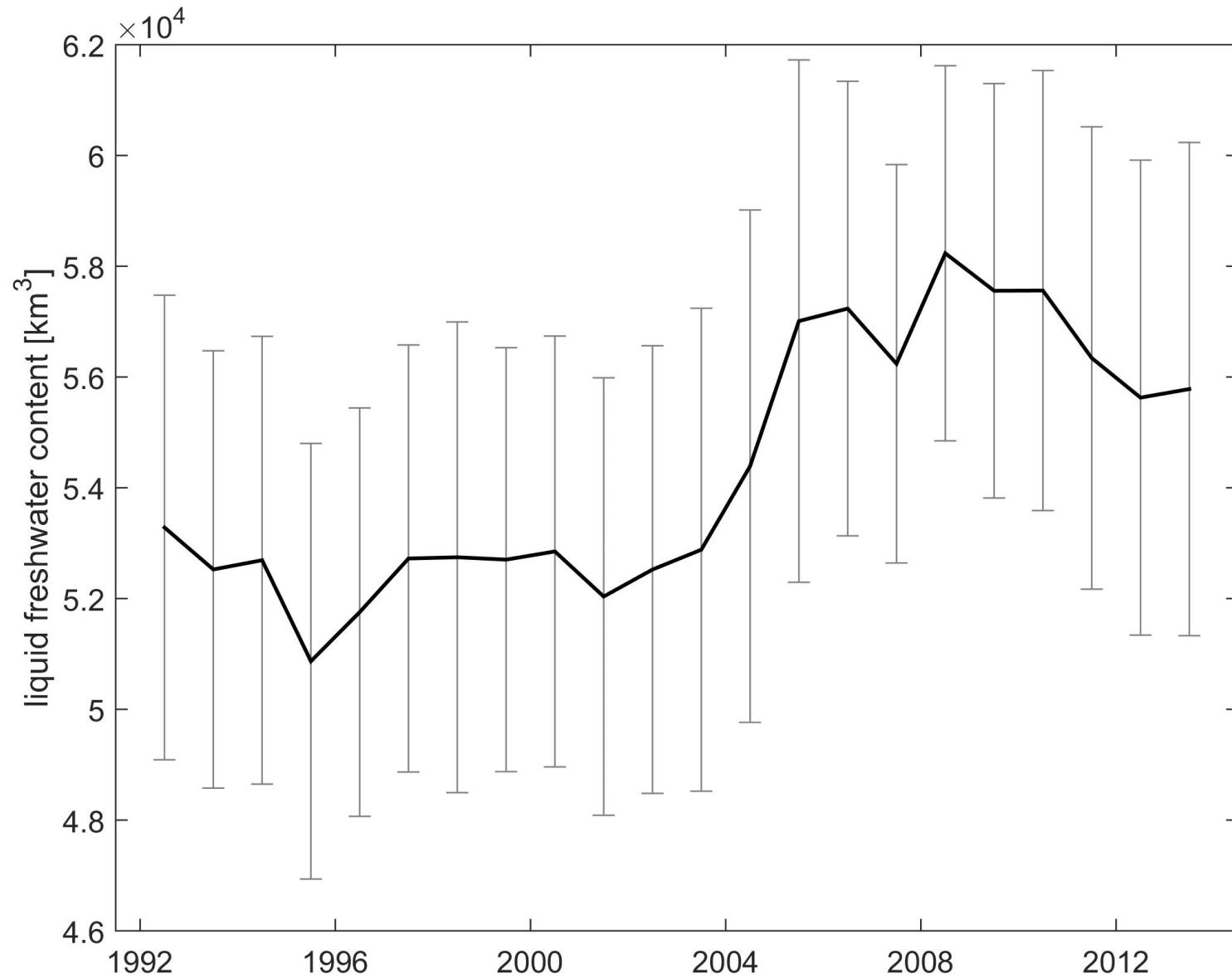


**Thank you for your
attention**

References

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Error of Arctic liquid freshwater content



Error of North Atlantic liquid freshwater content

