The role of wind stress in the Arctic and North Atlantic freshwater covariability

T. Kovacs[1,2], R. Gerdes[1,2]

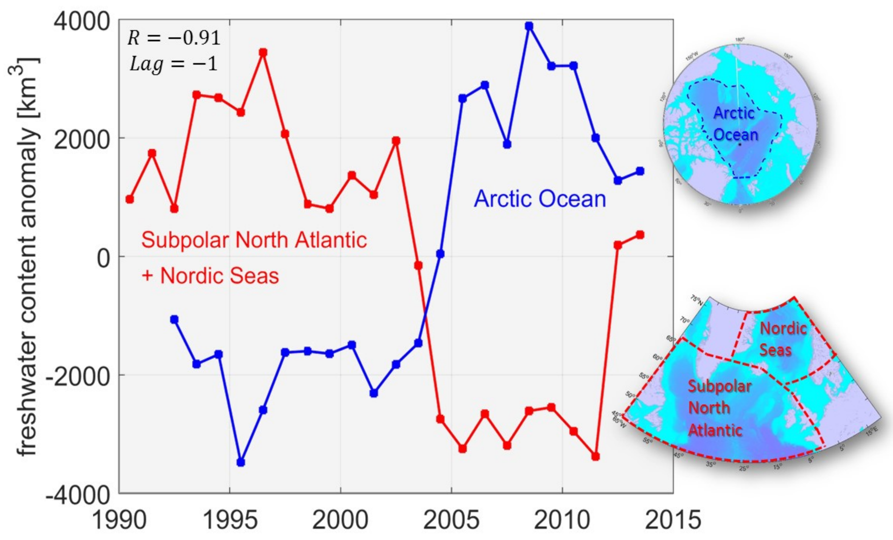
1. Alfred Wegener Institute, Bremerhaven, Germany 2. Jacobs University, Bremen, Germany

ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

JACOBS UNIVERSITY

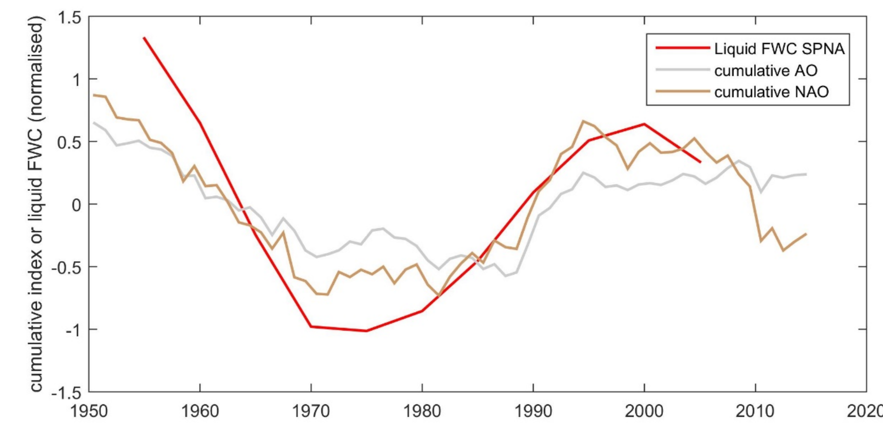
C14

Motivation



The **freshwater content anomalies of the Arctic Ocean**, and the **Subpolar North Atlantic and the Nordic Seas** show a significant anti-correlation. Their size and timing **suggest an oscillation** (Horn et al. in review).

The evolution of liquid **freshwater content** in the Subpolar North Atlantic **correlates** with time series of cumulative **AO and NAO indices** (Horn et al. in review).



Observed freshwater content anomalies in the Arctic and North Atlantic oceans:

RACE!

This work is supported by the cooperative project 03F0729E (RACE II, Regional Atlantic Circulation and Global Climate), funded by the German Federal Ministry for Education and Research (BMBF)

Bundesministerium für Bildung und Forschung

How robust is the link on a longer time scale?

Is there really a link between them?

What is the role of atmospheric forcing?

Methods

Fully coupled historical control runs of the Max Planck Institute Earth System Model (MPI-ESM)

1850 — 2016

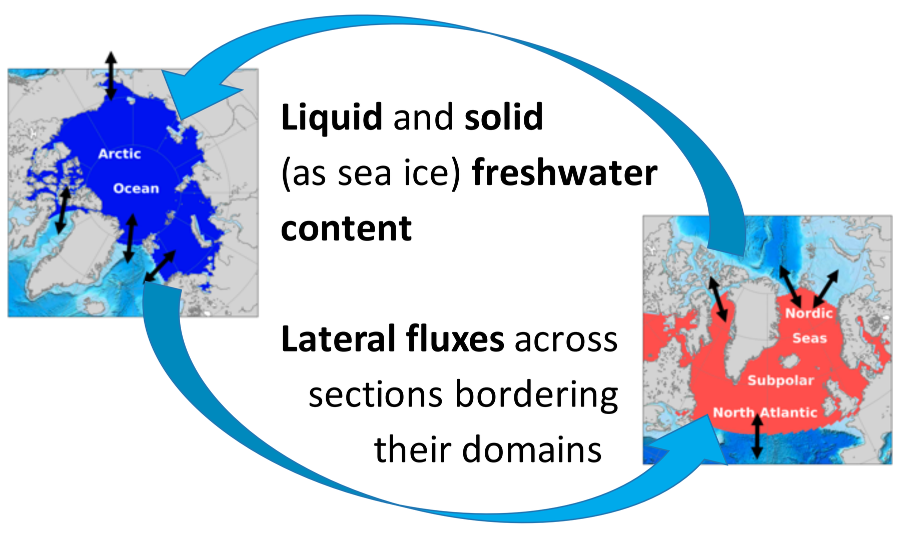
2 ensemble members showed below

$$LFWC = \oint \int_{z=0m}^{h} \frac{S_{ref} - S}{S_{ref}} dz\, dA$$

$S_{ref} = 34.8$

h = full depth of water column

Freshwater in the **Arctic Ocean** and the **Subpolar North Atlantic Ocean and the Nordic Seas**



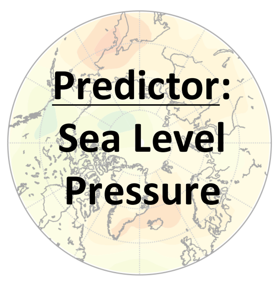
Redundancy Analysis (RDA)

A technique for identifying pairs of patterns through a regression model.

The method is similar to Singular Value Decomposition (SVD) that maximizes the cross-covariance, but in RDA the linked patterns are selected by maximizing the predictand variance, as properties of the predictors (i.e. the variance they represent) are irrelevant to the problem.

Tyler (1982), von Storch and Zwiers (1998)

Example of application followed here: *Kauker and Meier (JGR, 2003)*

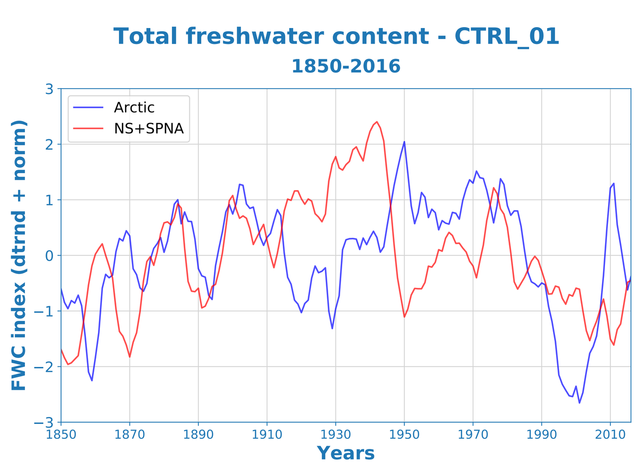


Results

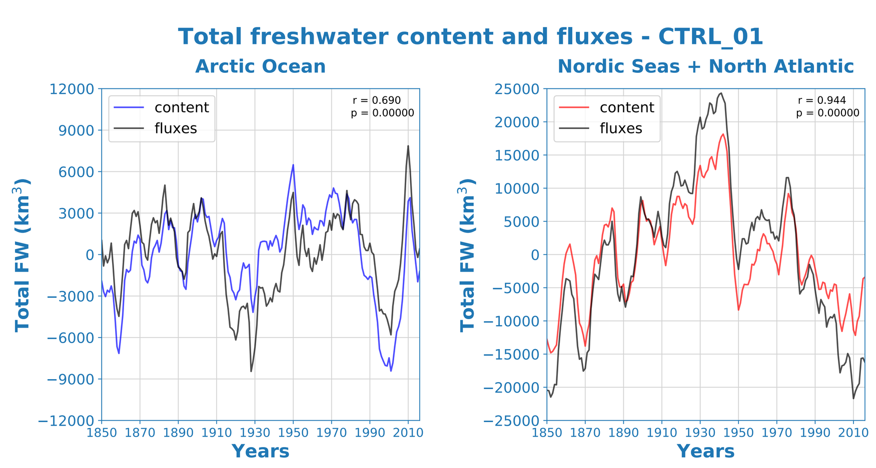
Freshwater covariability

Realization CTRL_01

Ensemble member 01 shows two 20-30 years long periods with anti-correlation, but there are multidecadal periods with no link, and with positive correlation too.

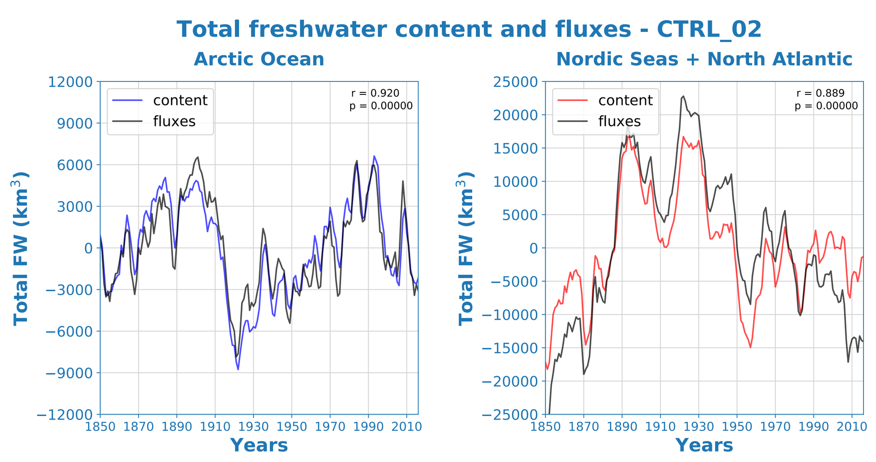


Comparing the content and the cumulative lateral fluxes across sections bordering their domains, there is a significant correlation for both basins.



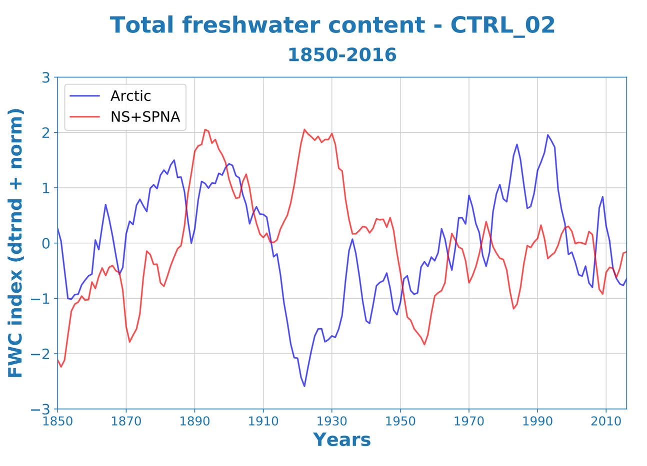
There is potential for an anticorrelation, but it is not persistent. Lateral fluxes explain most of the variability in the content. The two basins share most of their borders, thus it is reasonable to assume a connection.

Realization CTRL_02



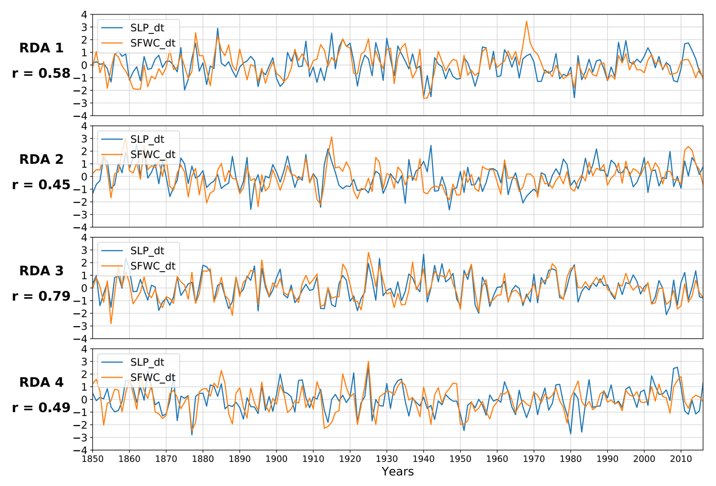
Ensemble member 02 shows similarly high correlations for freshwater content and fluxes for both the Arctic Ocean, and for the Subpolar North Atlantic and the Nordic Seas.

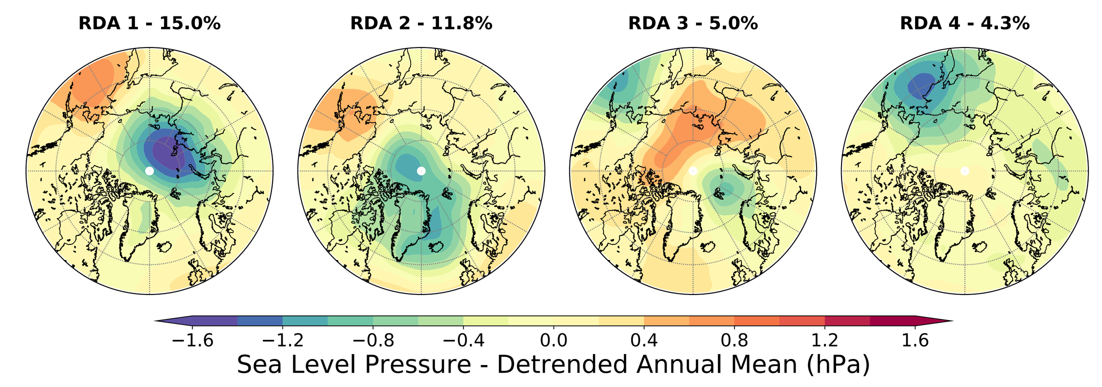
Periods with anticorrelation also present, and they are longer and stronger for this realization. About one third of the total 167 years show an oscillating behaviour similar to that seen in observations from recent decades.

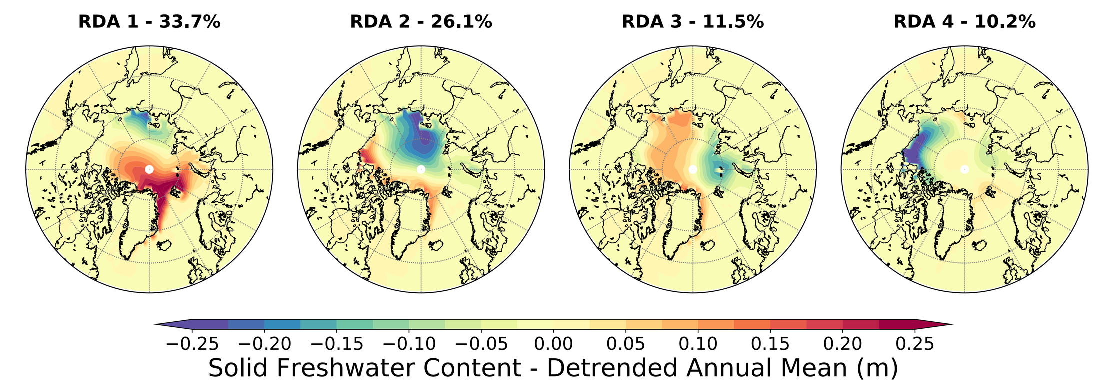


Atmospheric drivers of Solid FWC

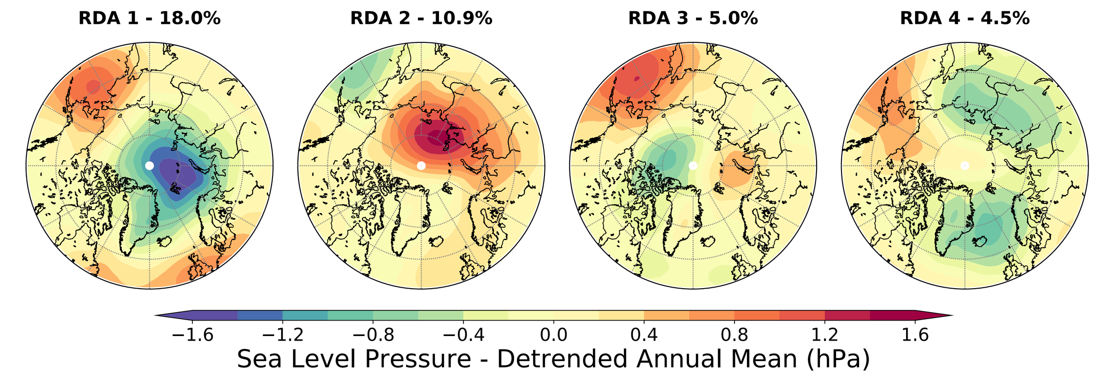
Main features of solid FWC (e.g. sea ice) are driven by atmospheric pressure patterns that only partly resemble the AO. Anomalous ice export and thickness redistribution are the main prominent features of the variability.

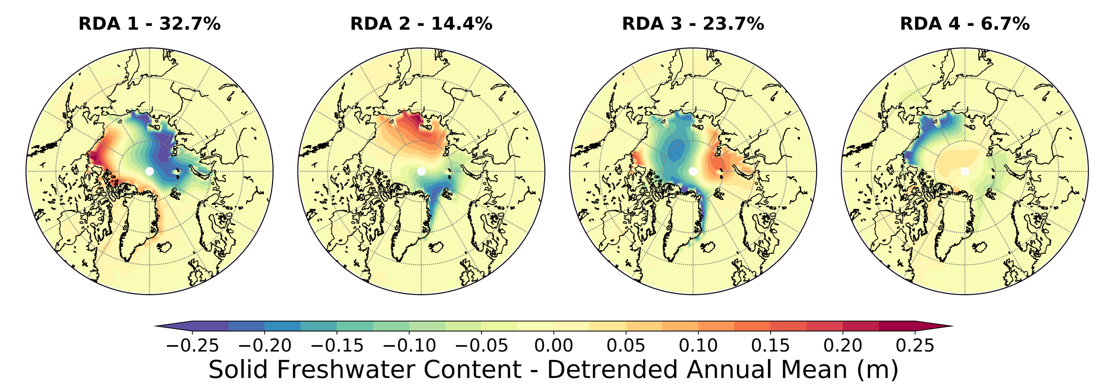




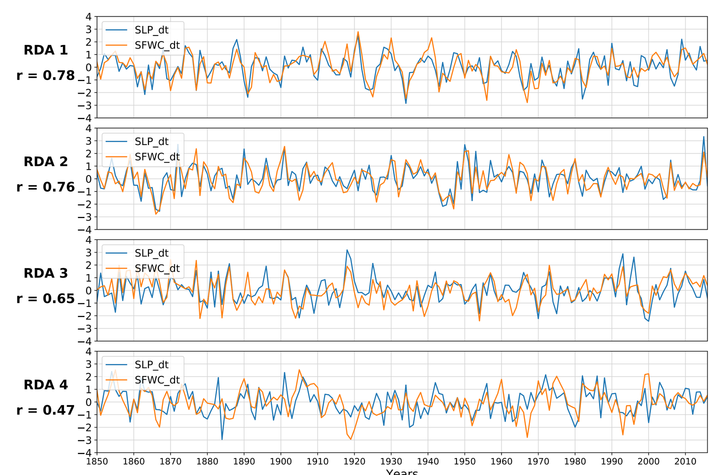


Leading RDA modes of Solid FWC variability show a dipole within the Arctic basin for both members. Corresponding SLP patterns can be explained by the effect of wind stress.





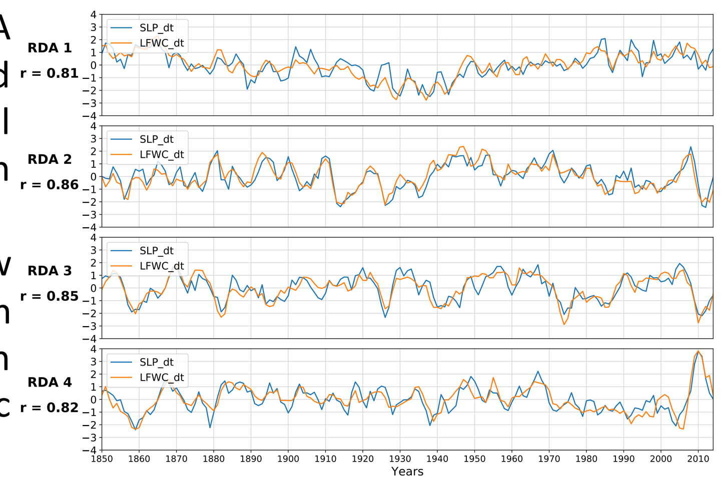
For member 02 the leading RDA mode of SLP is very similar to member 01 but the corresponding pattern in solid FWC is different, suggesting the importance of the location of the pressure anomaly.

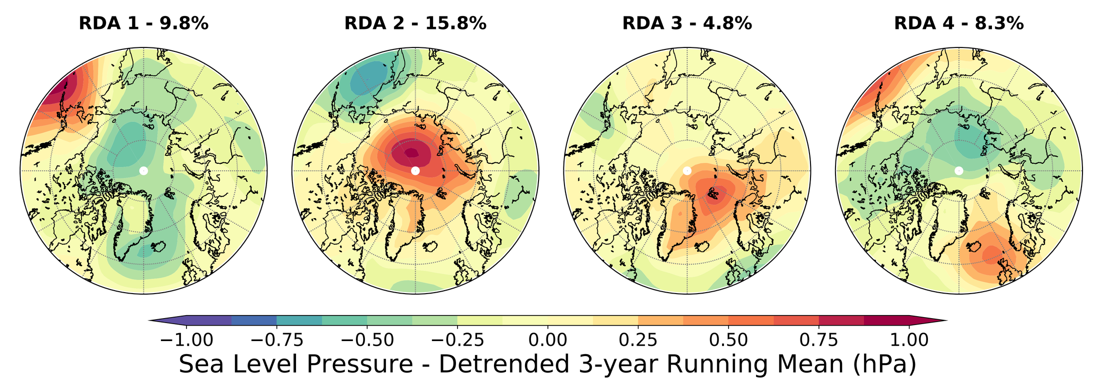


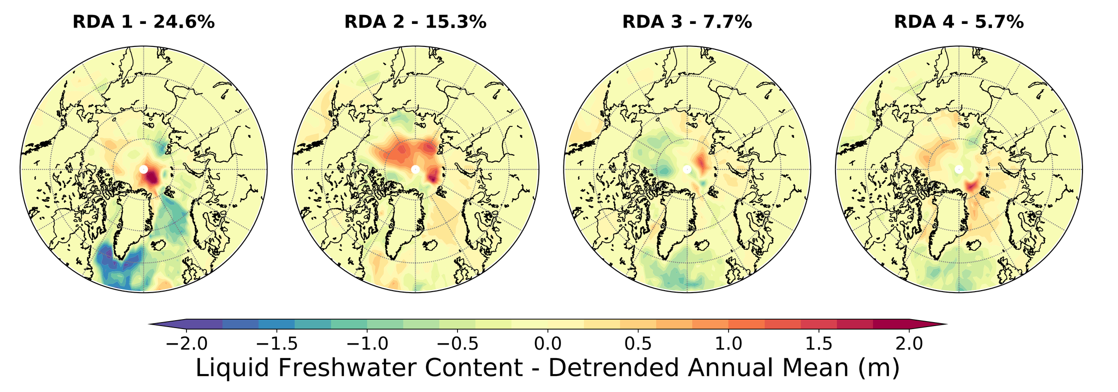
Atmospheric drivers of Liquid FWC

Times series of leading RDA modes of liquid FWC and corresponding sea level pressure show high correlation.

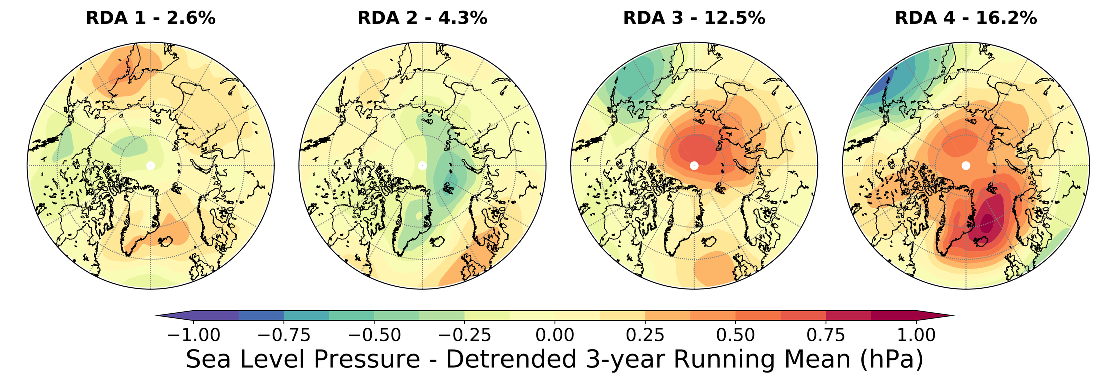
Pairs of patterns show distinct features such as an AO-like pressure pattern and a response in Arctic FWC content (RDA 2)

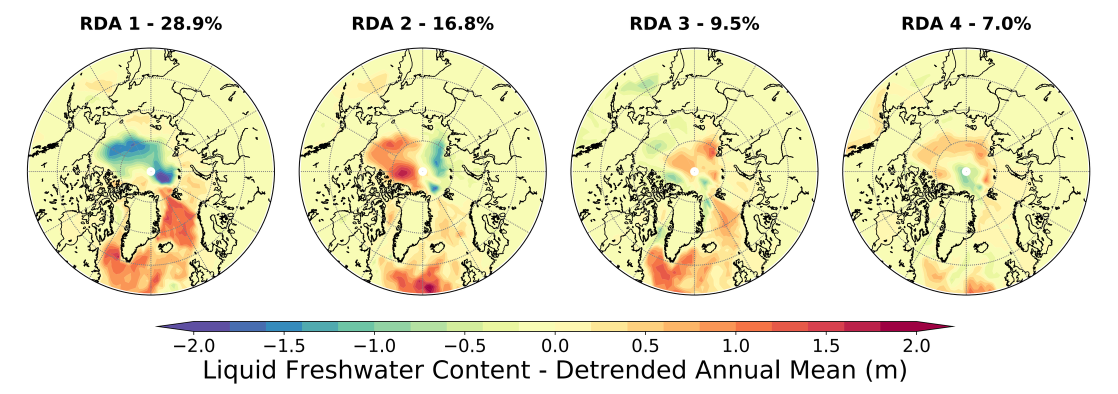






RDA modes of Liquid FWC are less robust across ensemble members. A pressure dipole over the Beaufort and Greenland seas could be responsible for the oscillating pattern?





The leading RDA mode of FWC is a distinct pattern with opposite signs in the Arctic and the North Atlantic. The corresponding SLP pattern shows a pressure dipole that explains only 2.6% of the SLP variance, but is likely to play an important role in the FWC covariability.