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

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POLAR 2018

Wind stress forcing in the Arctic and North Atlantic oceans

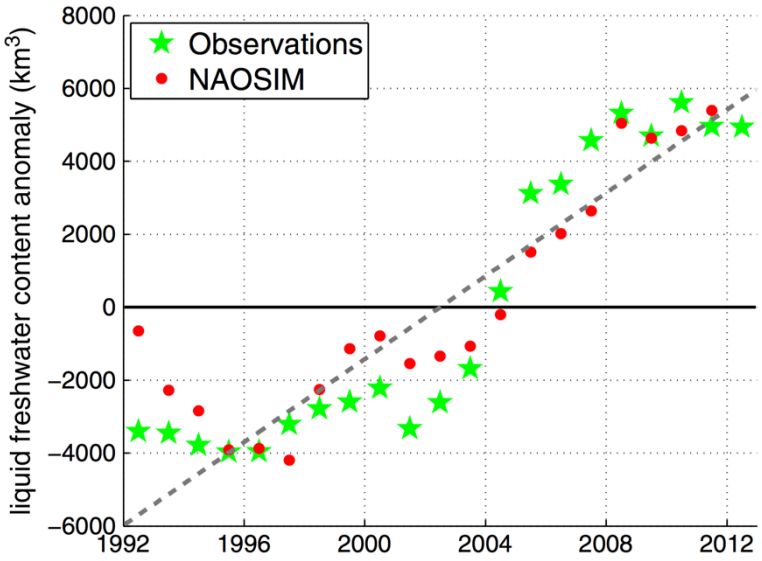
JACOBS UNIVERSITY

RACE! REGIONAL ATLANTIC CIRCULATION AND GLOBAL CHANGE

POLMAR

HELMHOLTZ ASSOCIATION

Motivation



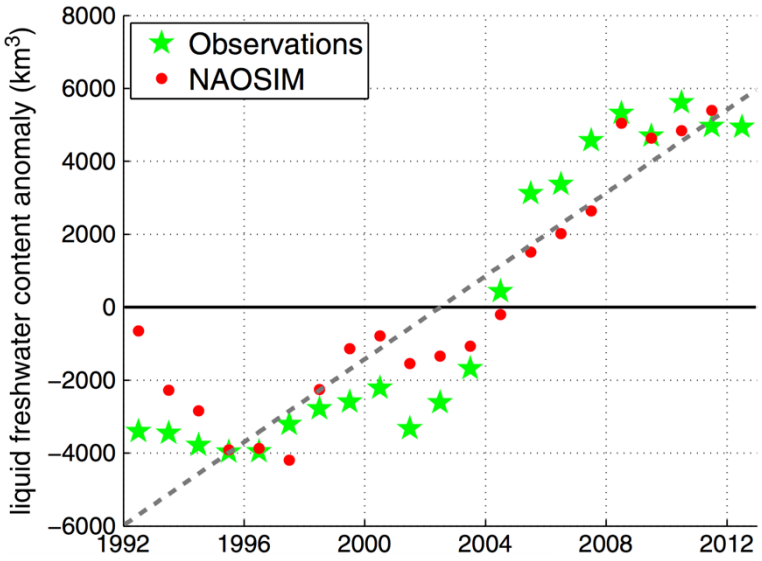
Arctic Ocean liquid freshwater content increase
observed around 10,000 km^3 between 1992-2012 (Rabe et al. 2014)

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

$S_{ref} = 35$

h = depth of 34 isohaline

Motivation



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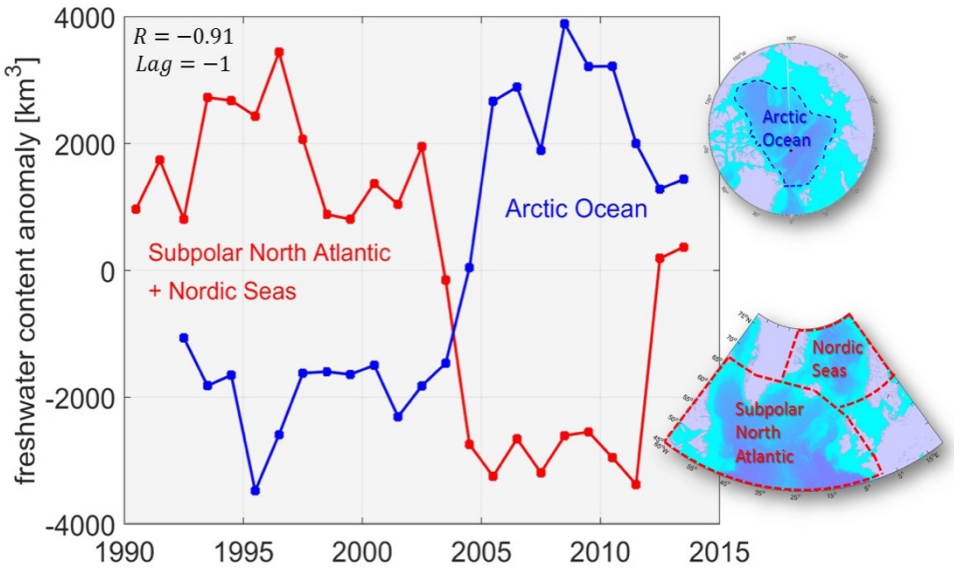
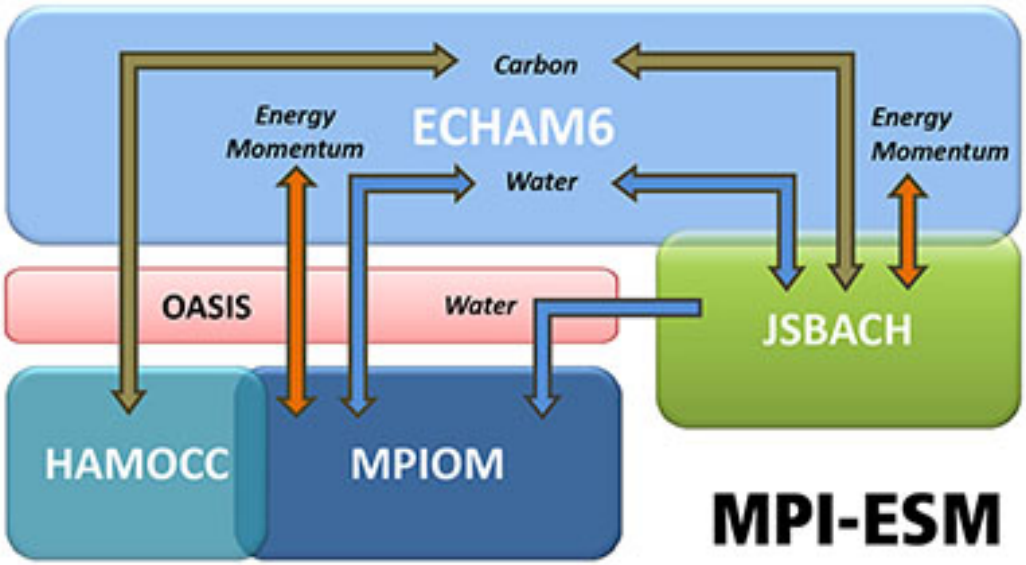


Anomalies in the Arctic Ocean, and the **Subpolar North Atlantic and the Nordic Seas** are significantly anti-correlated (95 % confidence). The similar size and the timing of anomalies **suggest an oscillation** (Horn et al. in review)

Methods

- Max Planck Institute Earth System Model



MPI-ESM structure of model components (*Giorgetta et al., 2013*)

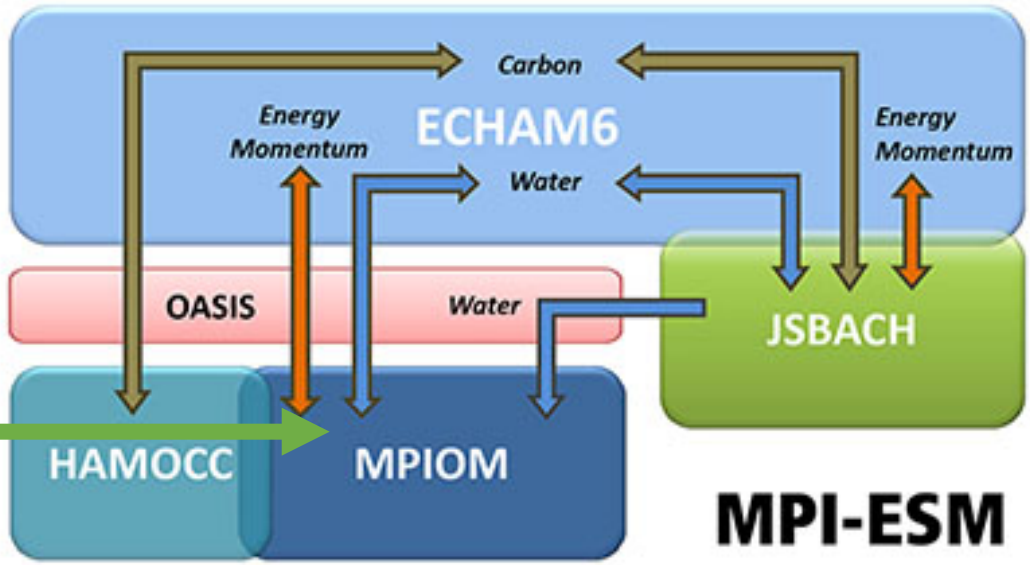
- Fully coupled
- Low resolution version – MPIOM ocean component:
  - 1.5° horizontal resolution (15 - 185 km)
  - poles over Antarctica and Greenland
  - non eddy-resolving (*Jungclaus et al. 2013*)

Methods

Modini

Thoma et al. 2015

Observations
Energy/Momentum



MPI-ESM structure of model components (*Giorgetta et al., 2013*)

- Partial coupling technique (*Thoma et al. 2015*)
- MPIOM driven by prescribed wind stress anomalies
- Wind stress forcing from NCEPcfsr (*Saha et al. 2010*)

Experiment Design

Fully coupled control runs with wind speed from coupling
(with historical CMIP5 scenario + RCP4.5 from 2006)

1850 → 2016

Experiment Design

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CTRL x 10

Ensemble generation with lagged initialization

Experiment Design

Fully coupled control runs with wind speed from coupling
(with historical CMIP5 scenario + RCP4.5 from 2006)

CTRL x 10

Ensemble generation with lagged initialization

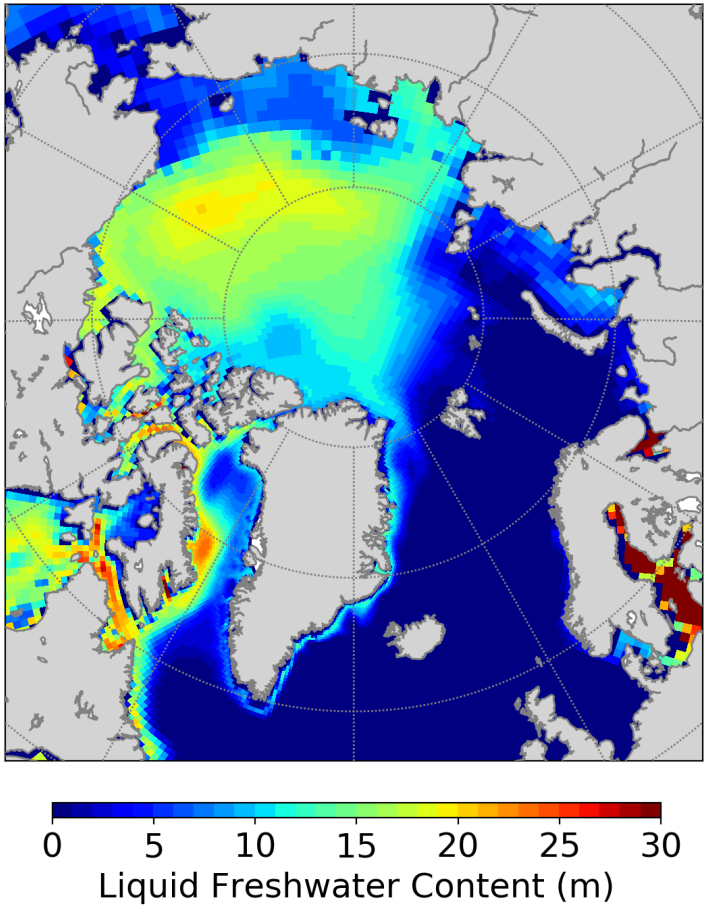
Modini runs with external forcing from **NCEPcfsr**

NCEP x 10

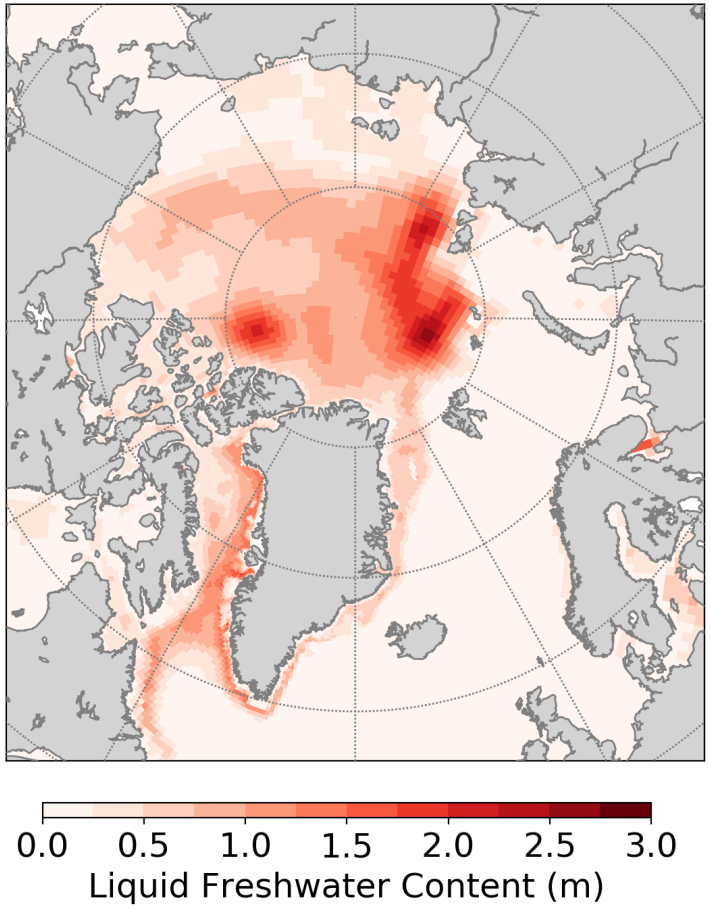
Liquid Freshwater Content

CTRL ENS Climatology 1980-2000

Ensemble Mean



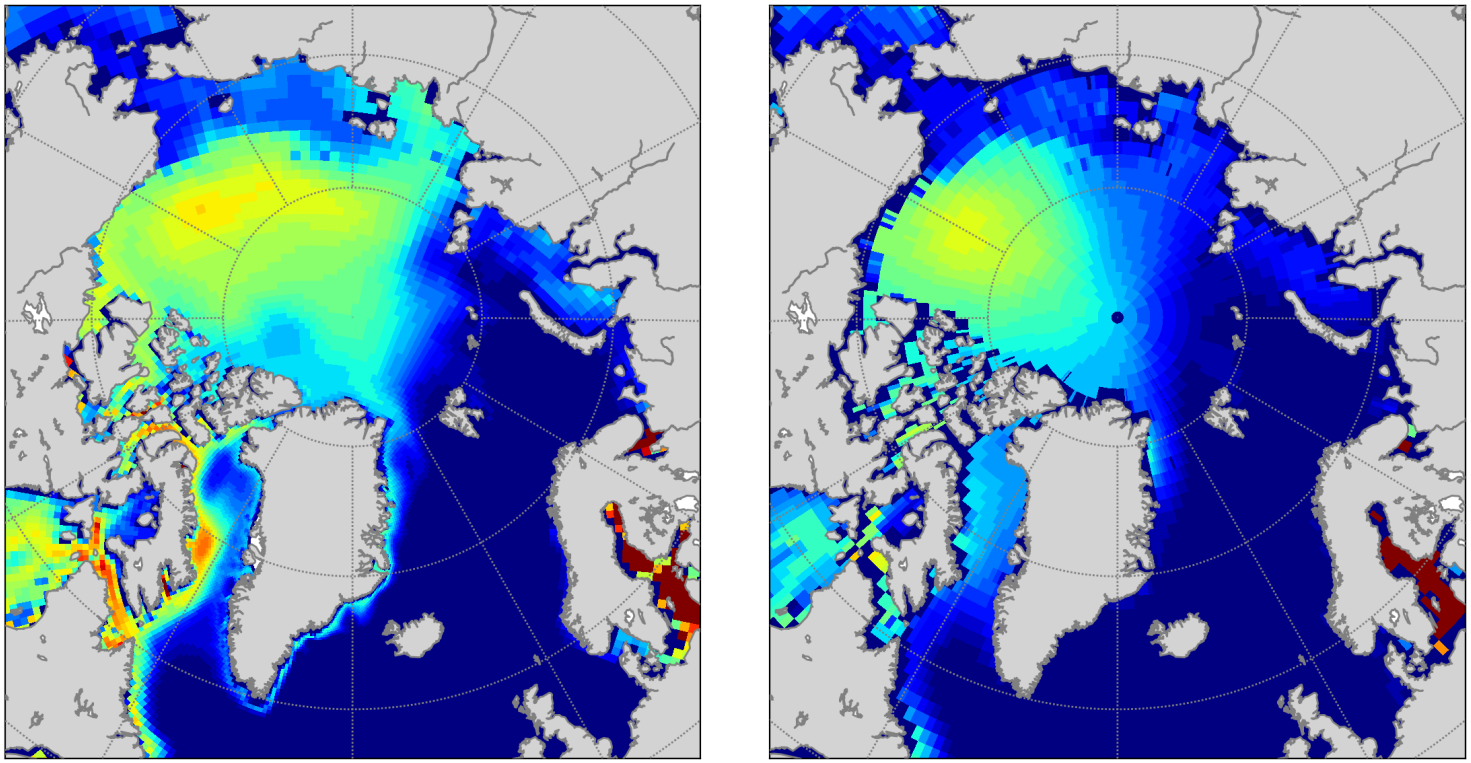
Ensemble Std

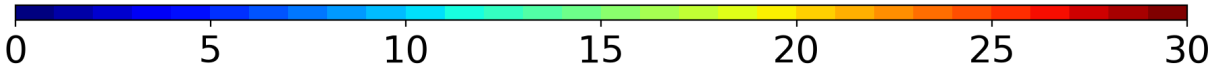


Liquid Freshwater Content

1980-2000 Climatology

Model CTRL ENS | **Observations**

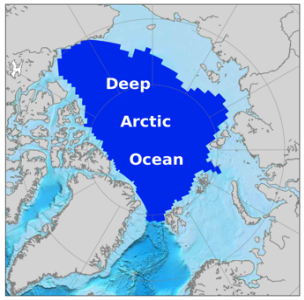




Liquid Freshwater Content (m)

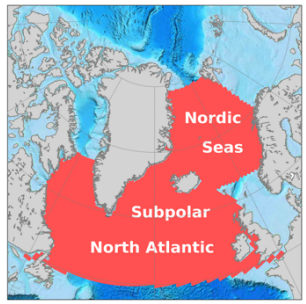
Observational data: from PHC3.0 (*Steele et al. 2001*)

Liquid Freshwater Content



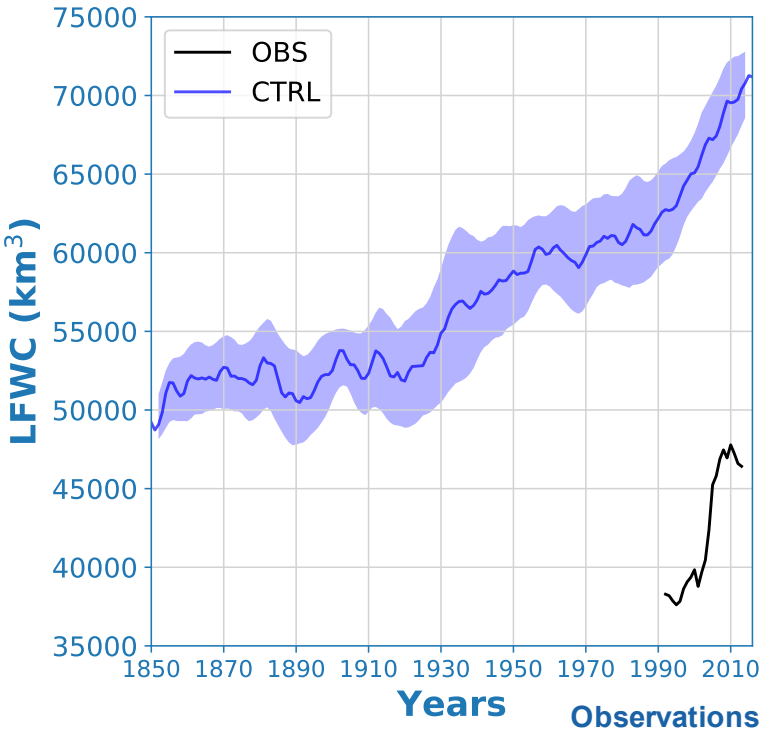
$$LFWC = \oint \int_{z=0m}^{h} \frac{S_{ref} - S}{S_{ref}} dz \; dA$$

h = depth of 34 isohaline $S_{ref} = 35$ h = 2000 m

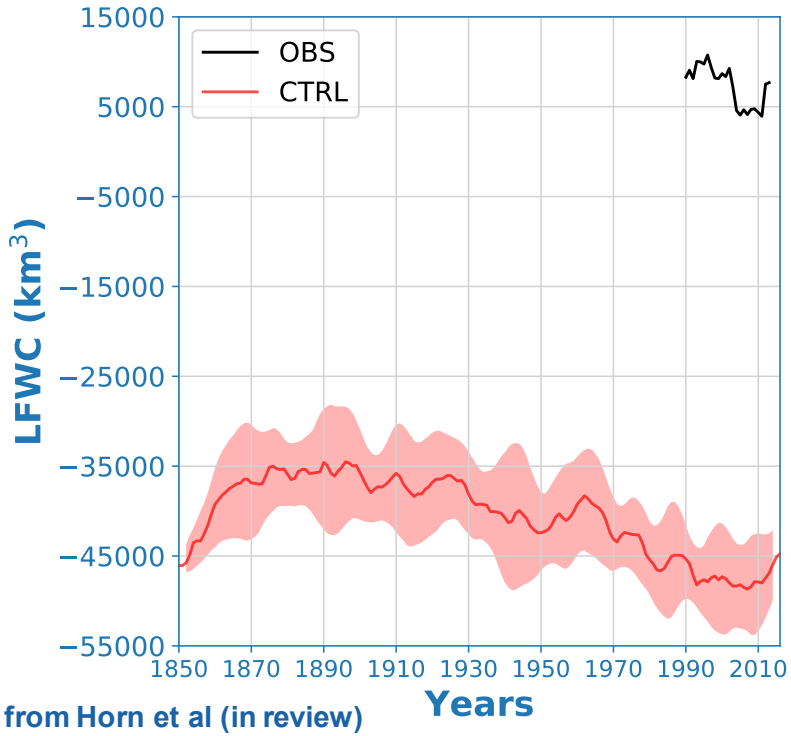


Liquid Freshwater Content

Arctic deep regions

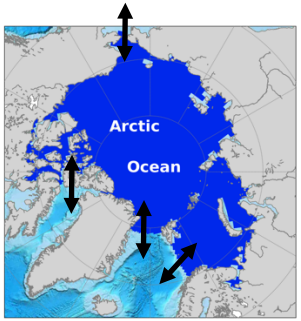


Nordic Seas + North Atlantic

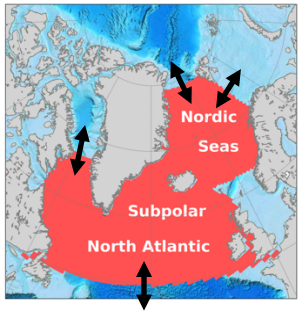


Observations are from Horn et al (in review)

Freshwater Content

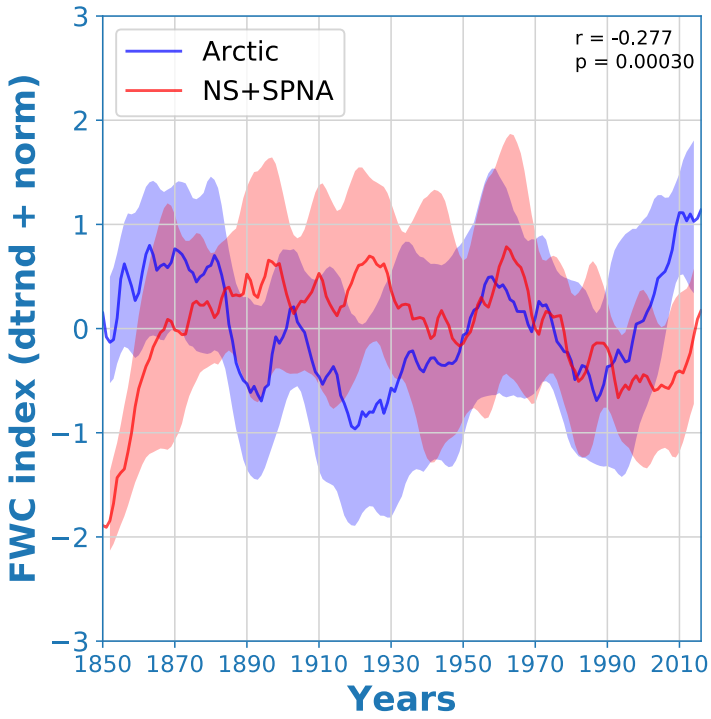


Signs of anti-correlation in fully coupled control runs.
Large ensemble spread, no sign in recent decades.

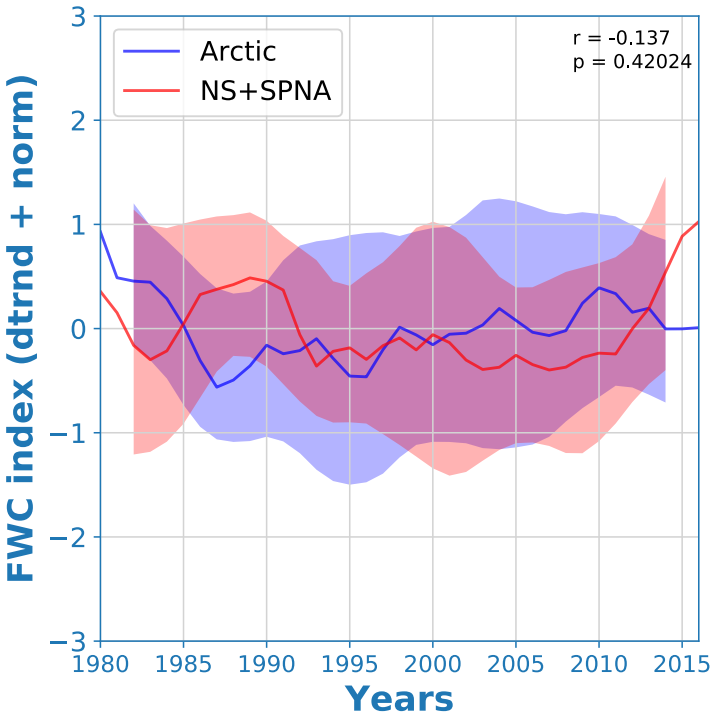


Total freshwater content - CTRL

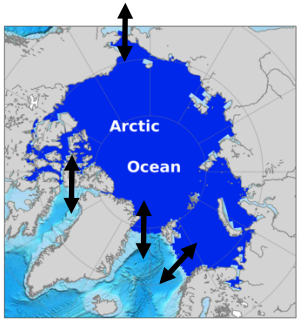
1850-2016



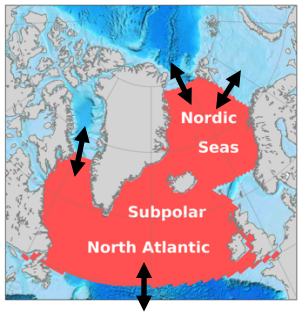
1980-2016



Freshwater Content - Fluxes

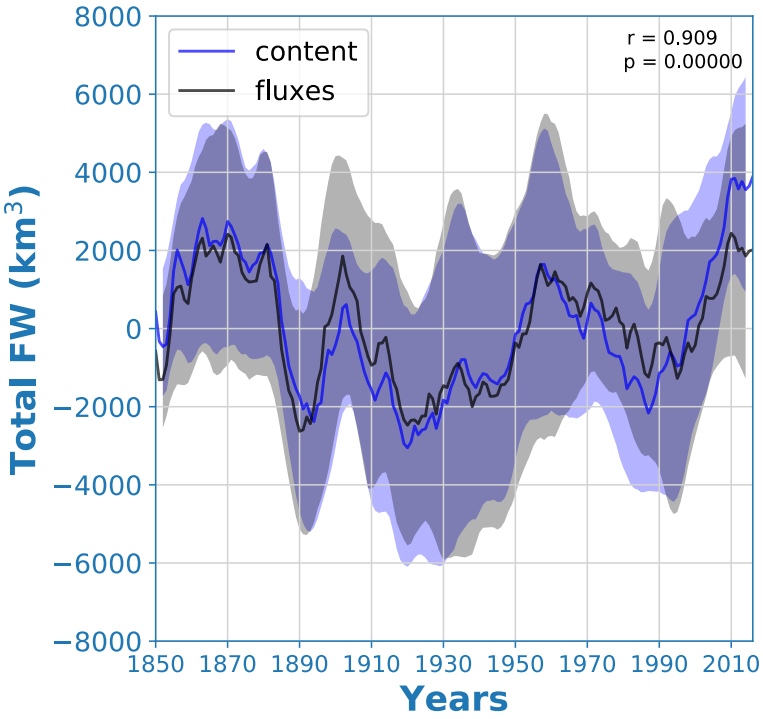


Most of the variability in the contents can be explained by lateral fluxes

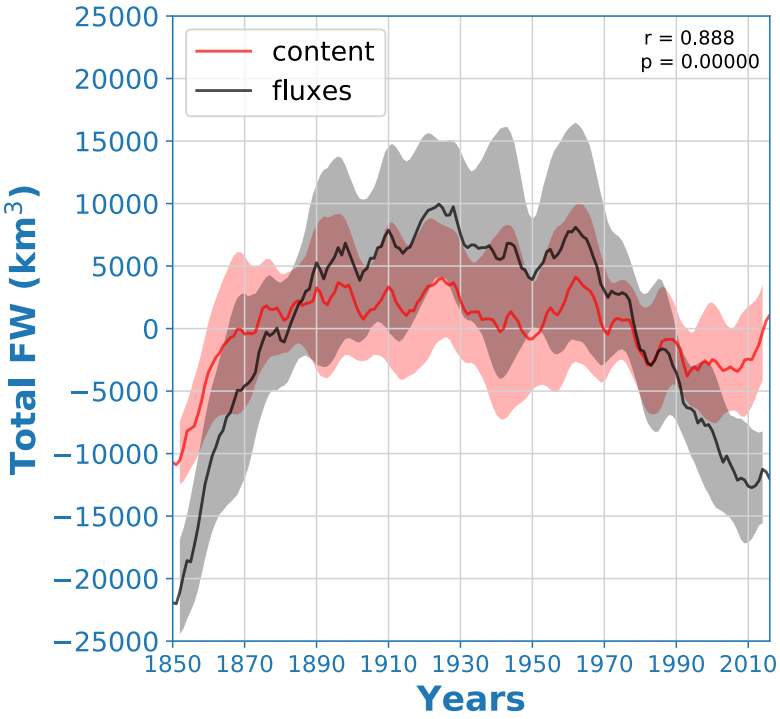


Total freshwater content and fluxes

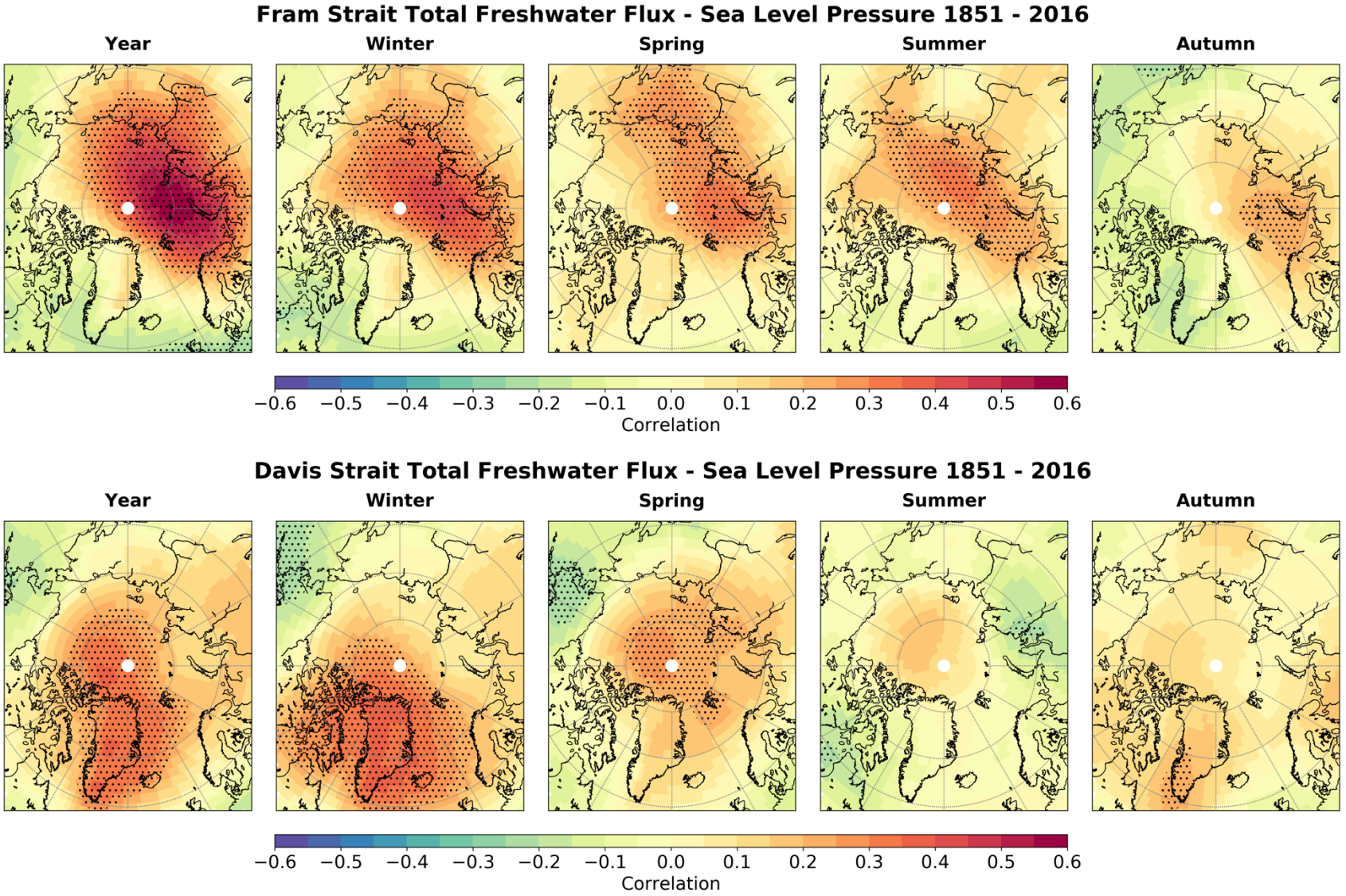
Arctic Ocean



Nordic Seas + North Atlantic



Drivers of freshwater fluxes



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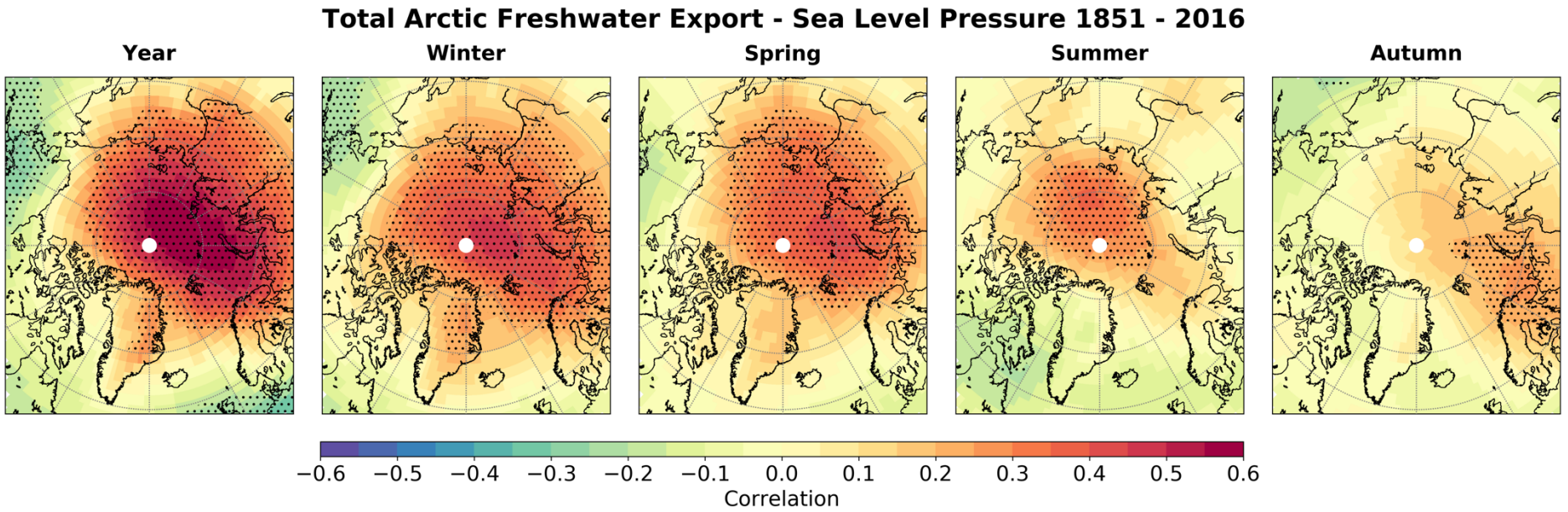
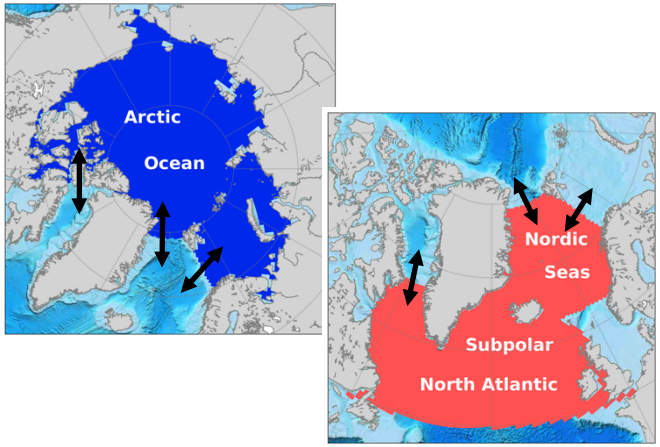
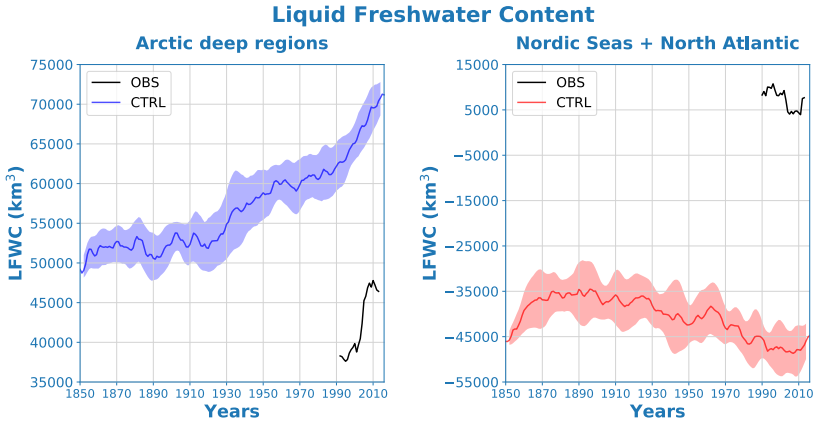
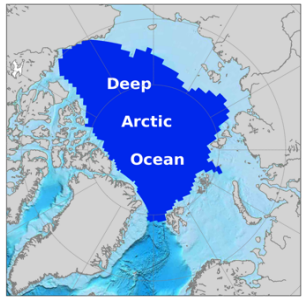


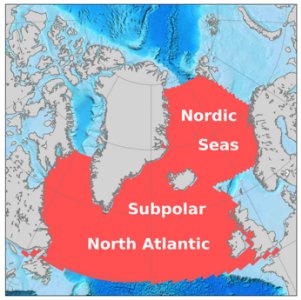


Atmospheric forcing plays a role in the variability of freshwater fluxes between the Arctic and the Nordic Seas and the North Atlantic

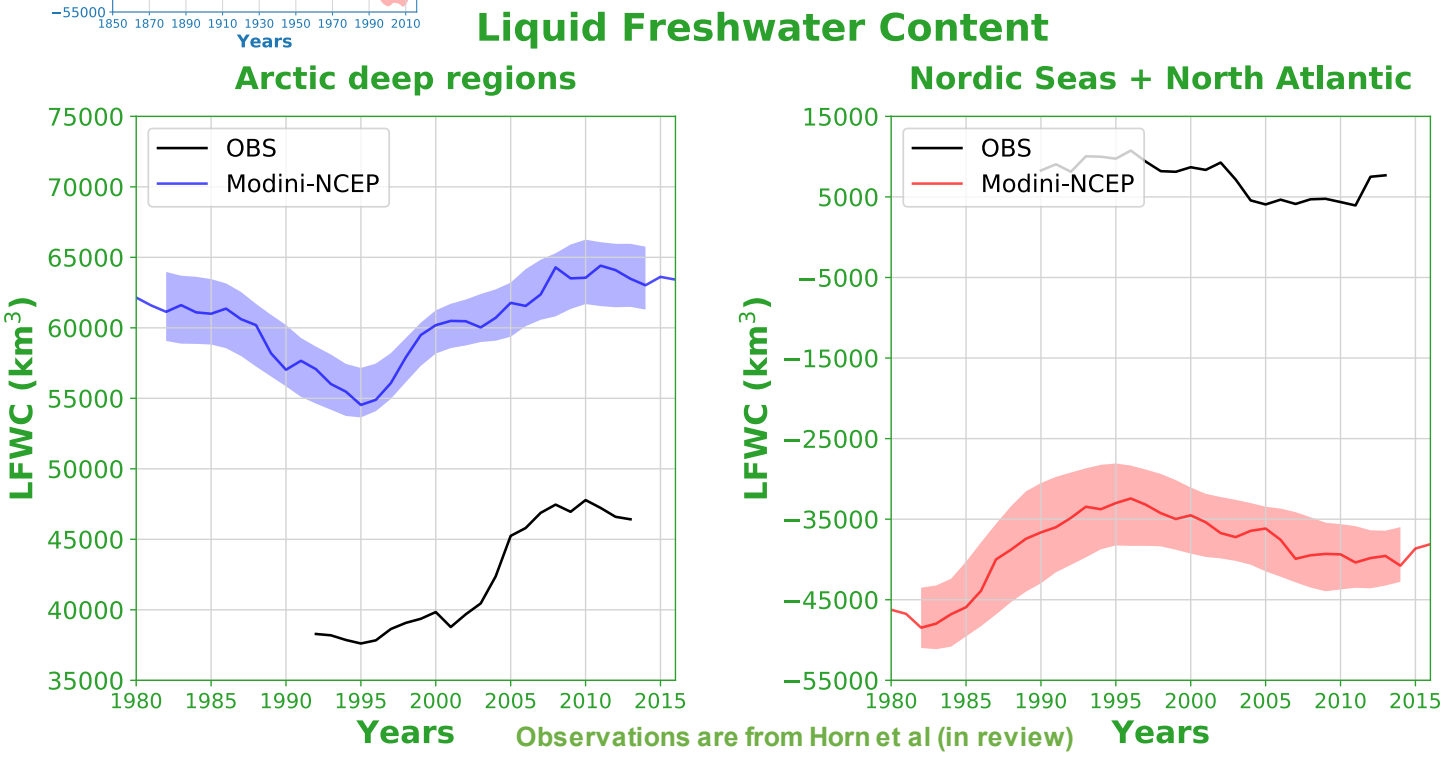
Runs with external wind forcing







Somewhat reduced bias in **Modini runs with NCEP** wind forcing



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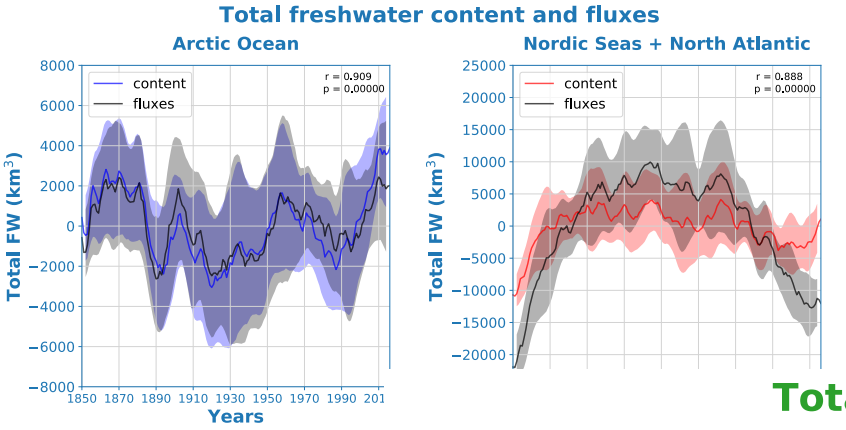
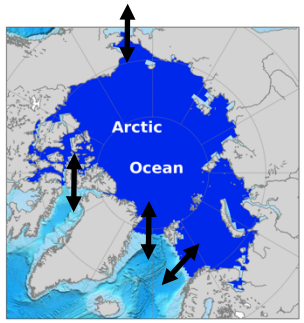
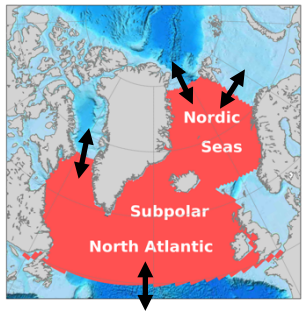
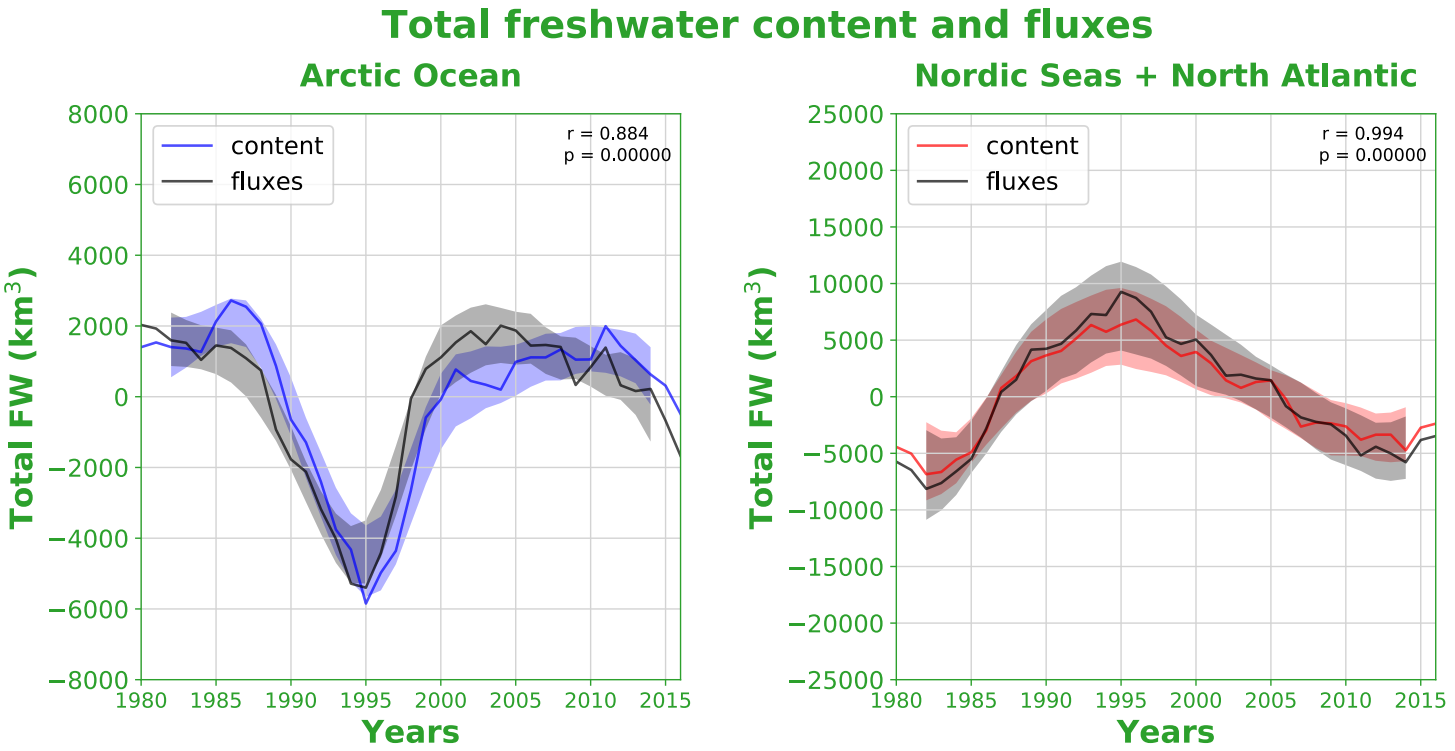


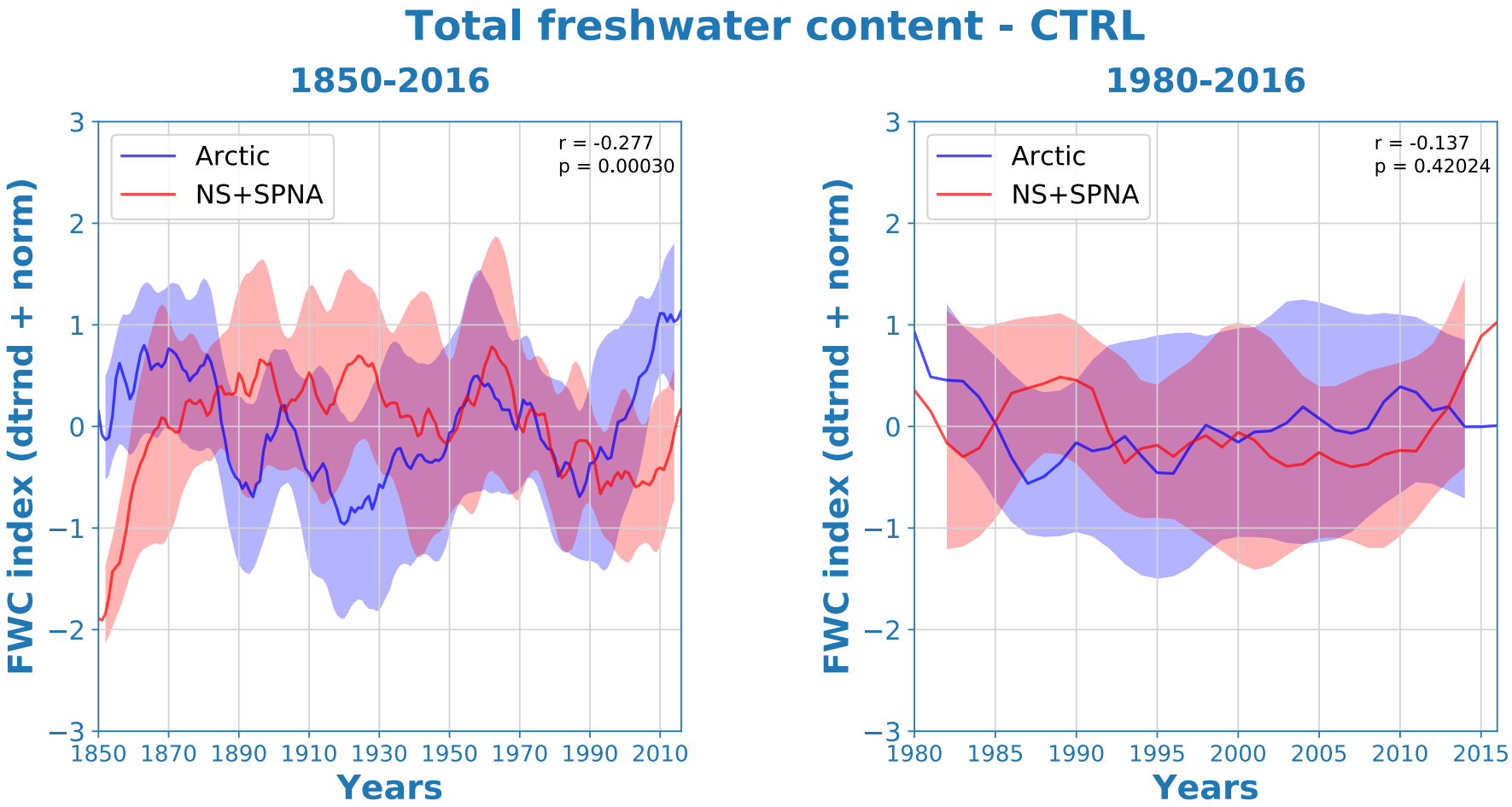




Dominance of the lateral fluxes, smaller ensemble spread

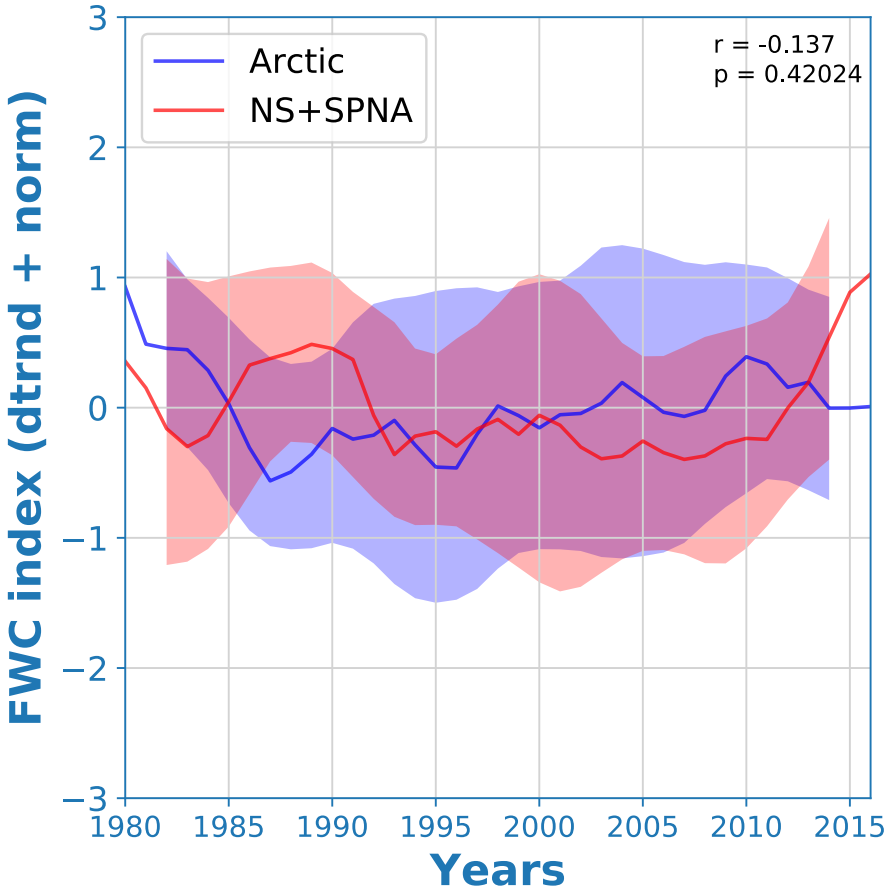


Runs with external wind forcing



Runs with external wind forcing

Total freshwater content - CTRL
1980-2016



Runs with external wind forcing

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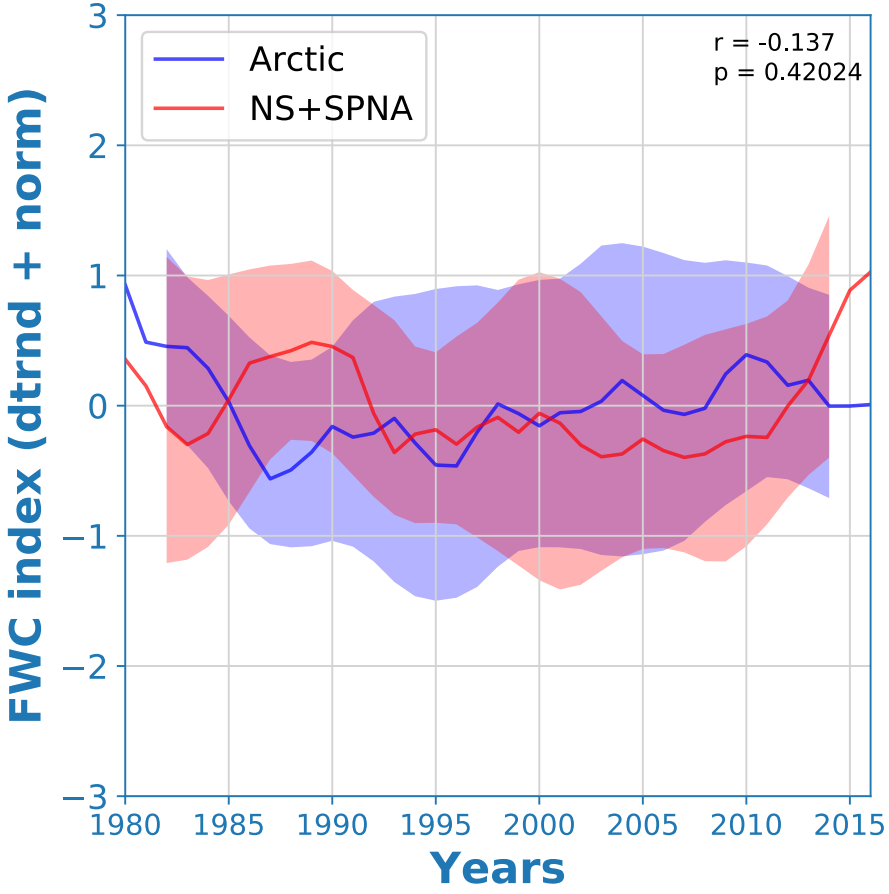
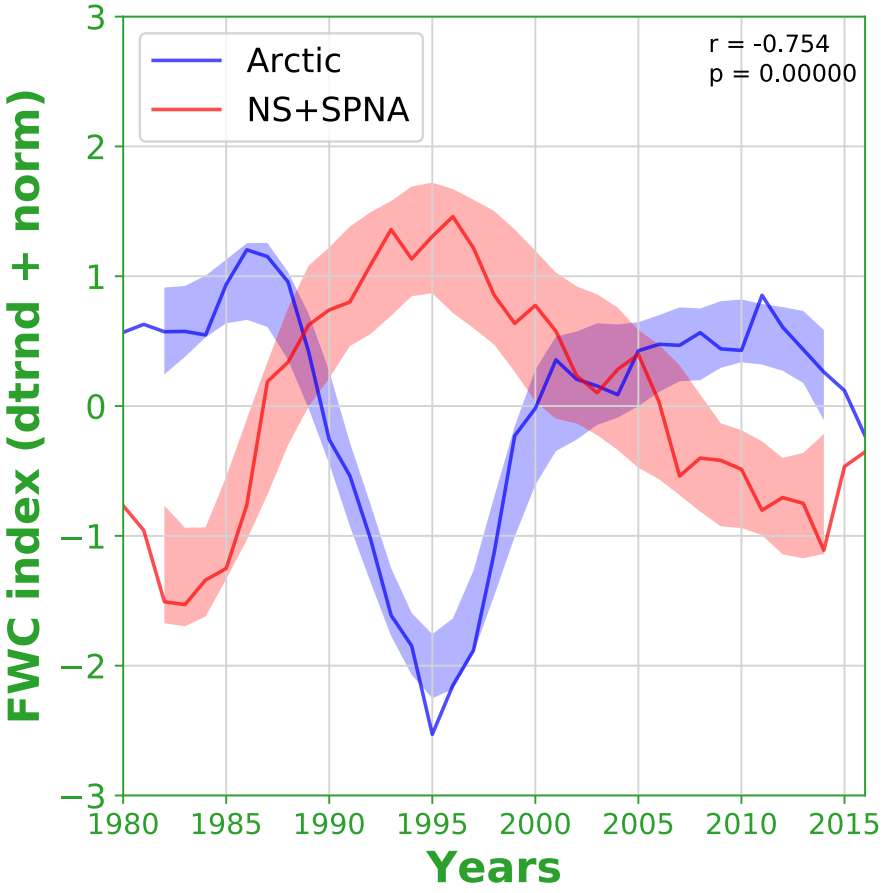


Modini-NCEP
1980-2016



Summary

Model experiments with the MPI-ESM: **fully coupled control runs** and **partially coupled Modini-MPI-ESM runs** with prescribed wind forcing

- Model results are closer to observations in Modini runs.
- Most of the variability can be explained by the lateral fluxes. Smaller ensemble spread for Modini runs.
- Limited anti-correlation in fully coupled runs with large ensemble spread. No clear connection in recent decades. Modini runs with prescribed wind forcing show significant anti-correlation for recent decades.