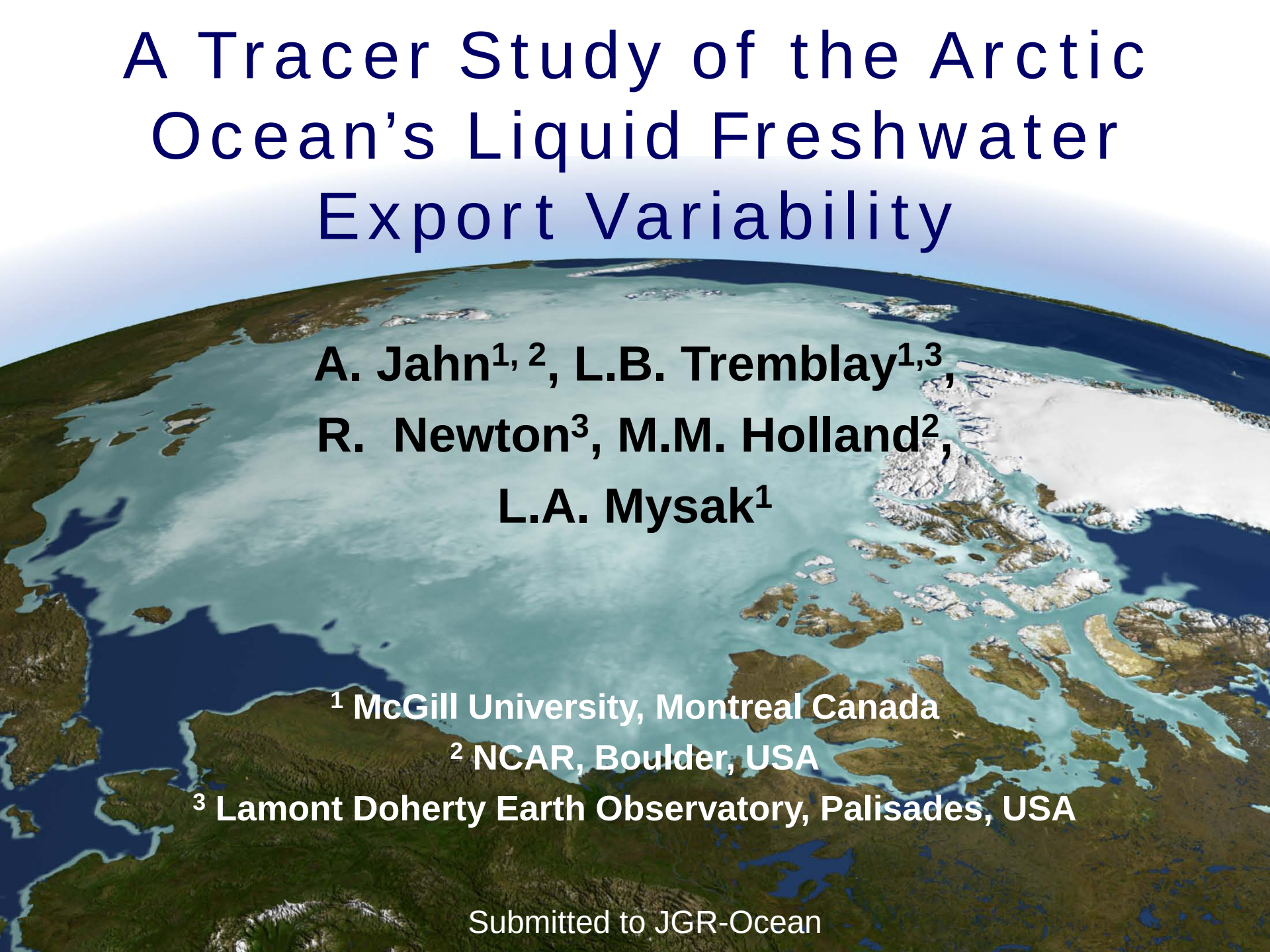
A Tracer Study of the Arctic Ocean's Liquid Freshwater Export Variability



A. Jahn[1, 2], L.B. Tremblay[1,3], R. Newton[3], M.M. Holland[2], L.A. Mysak[1]

[1] McGill University, Montreal Canada

[2] NCAR, Boulder, USA

[3] Lamont Doherty Earth Observatory, Palisades, USA

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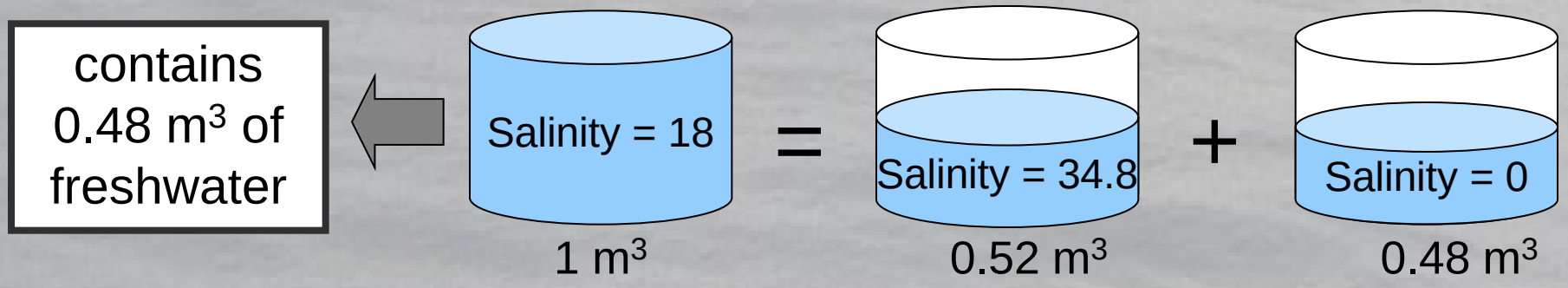
Definition of freshwater

- Freshwater (FW) in the Arctic is defined relative to S_{ref}=34.8 (Aagaard and Carmack, 1989)

- Amount of FW in a volume of salt water:



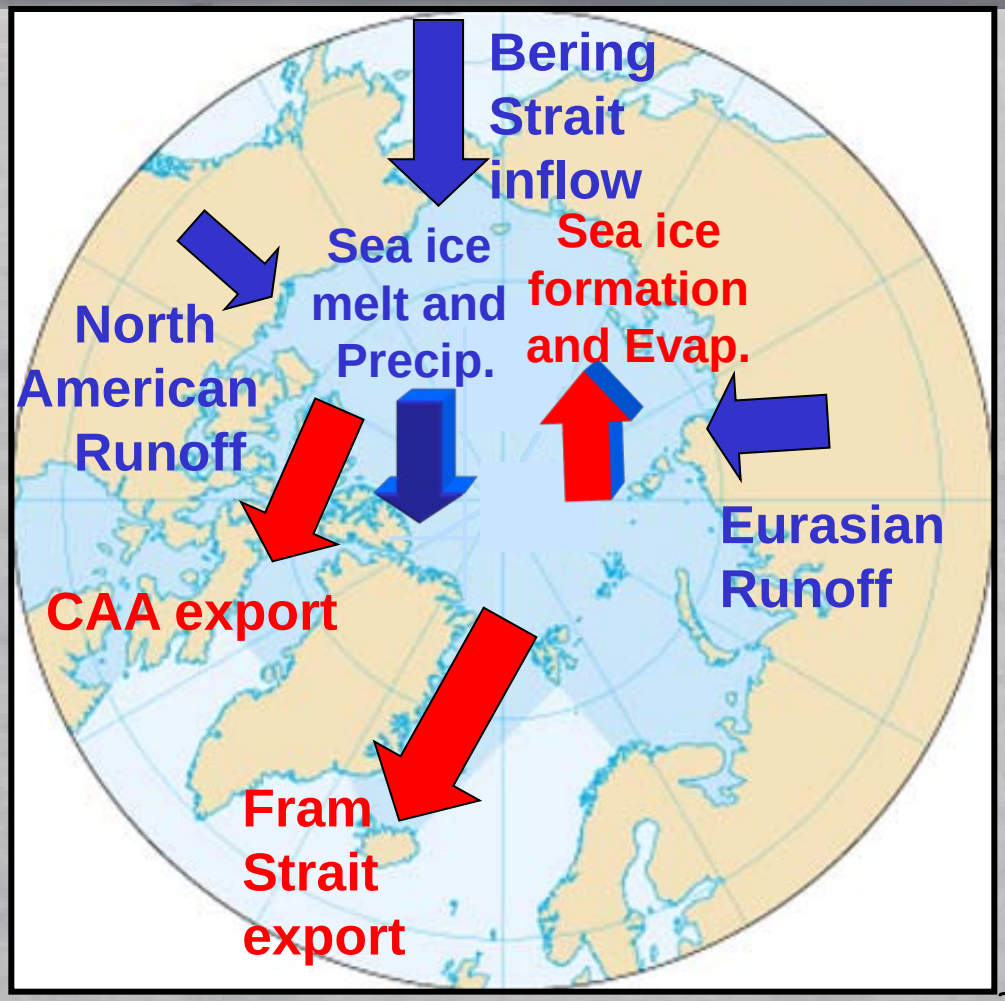
Liquid freshwater in the Arctic Ocean

FW sources:

- Sea-ice melt
- River runoff
- Bering Strait inflow
- Precipitation

FW sinks:

- Sea-ice formation
- Fram Strait export
- CAA export
- Evaporation

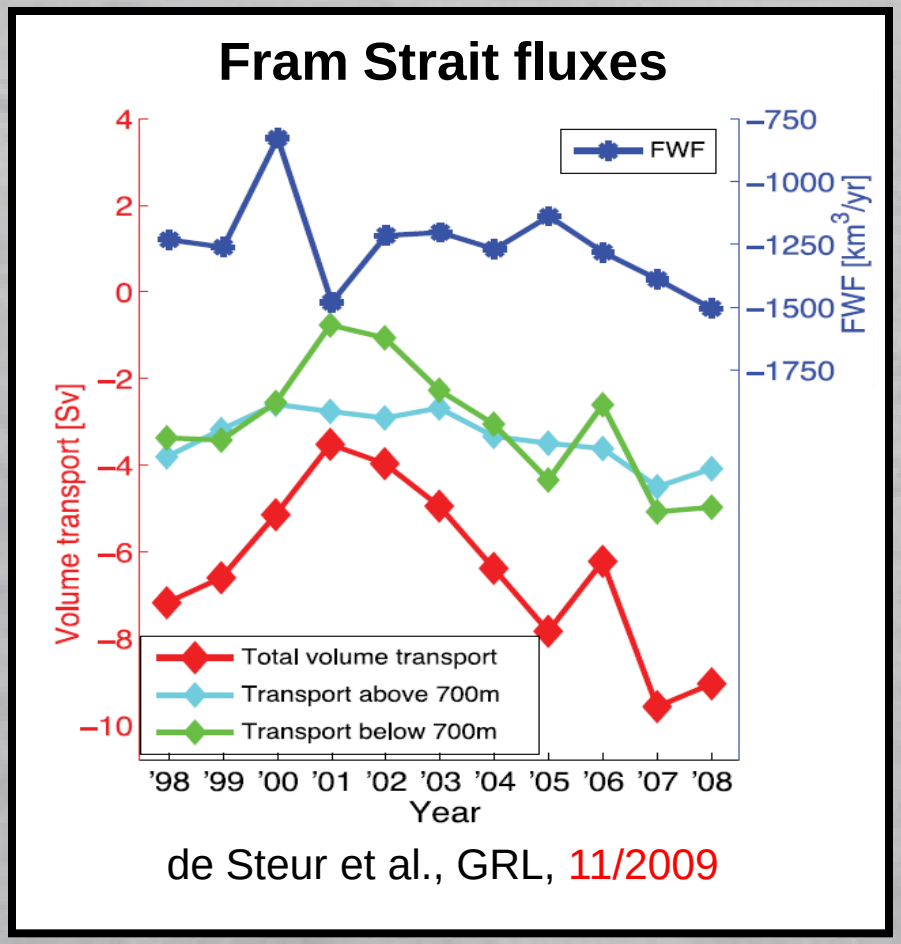


Objective: What is driving the variability of the liquid FW export from the Arctic?

Method

Approach:

- Use model simulations, due to lack of long-term observations of the liquid FW export from the Arctic
- Salinity alone is not enough to understand variability, due to many different FW sources



de Steur et al., GRL, 11/2009

Experiment with the CCSM3

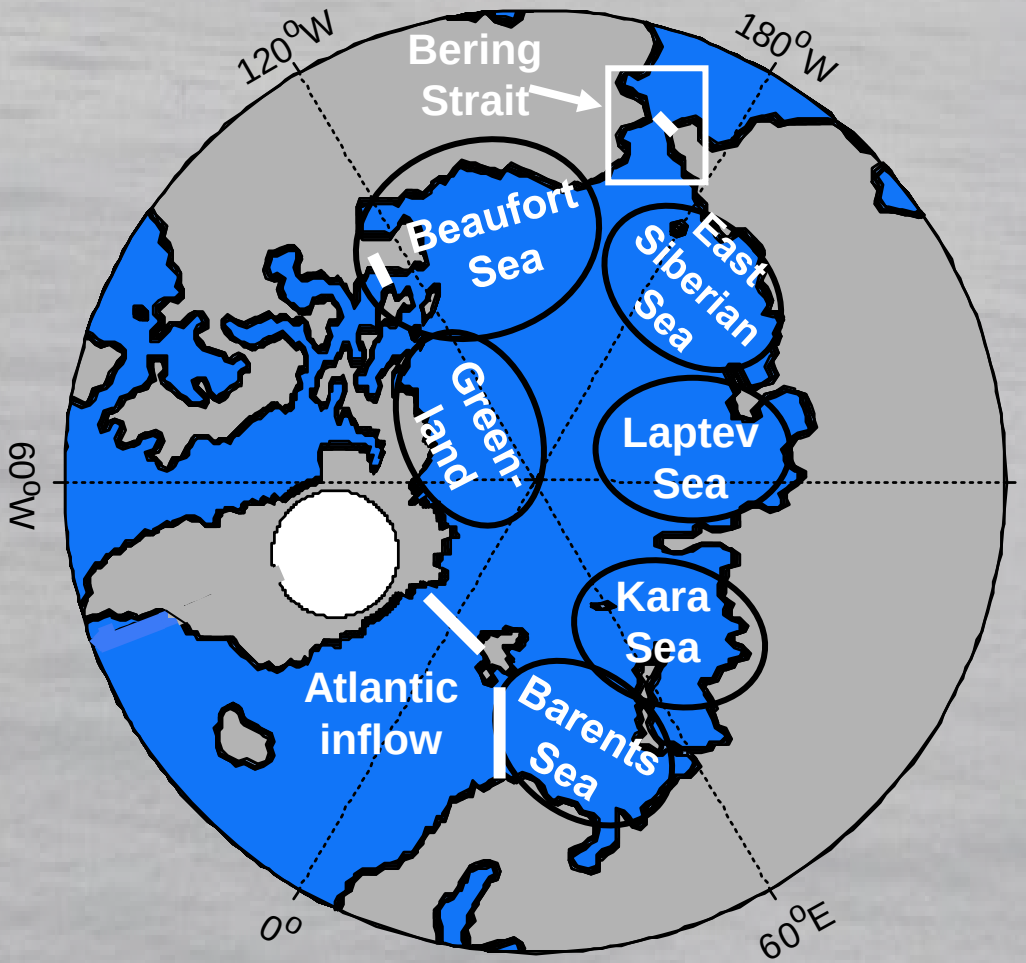
FW Tracers:

- River runoff into different shelf seas
- Bering Strait FW import
- Atlantic FW import
- Evaporation and precipitation
- sea-ice formation and melt

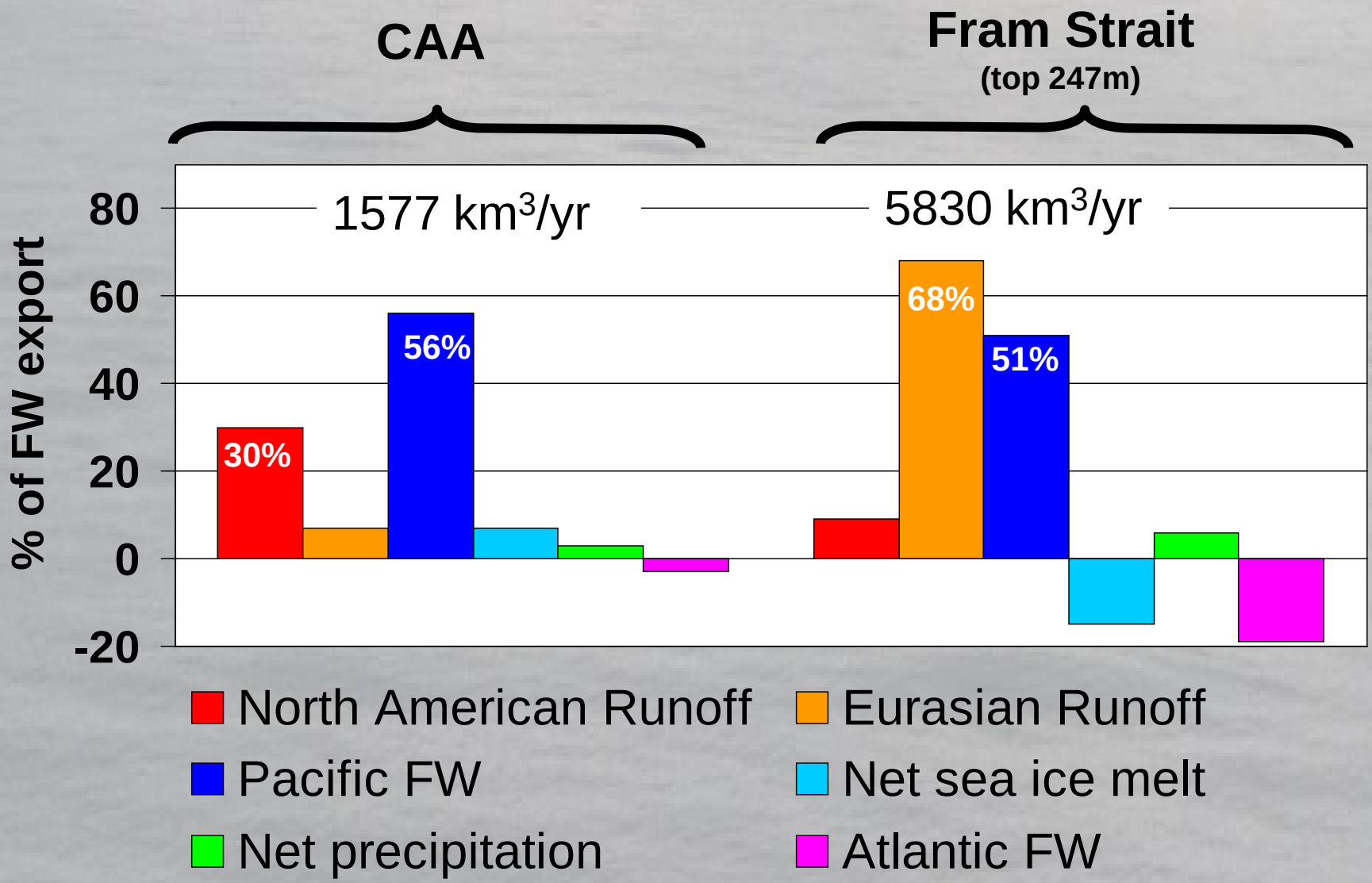
CCSM3 simulation:

- Equilibrium simulation with constant 1990 CO_2 and orbital forcing (b30.009)
- Resolution: 1°

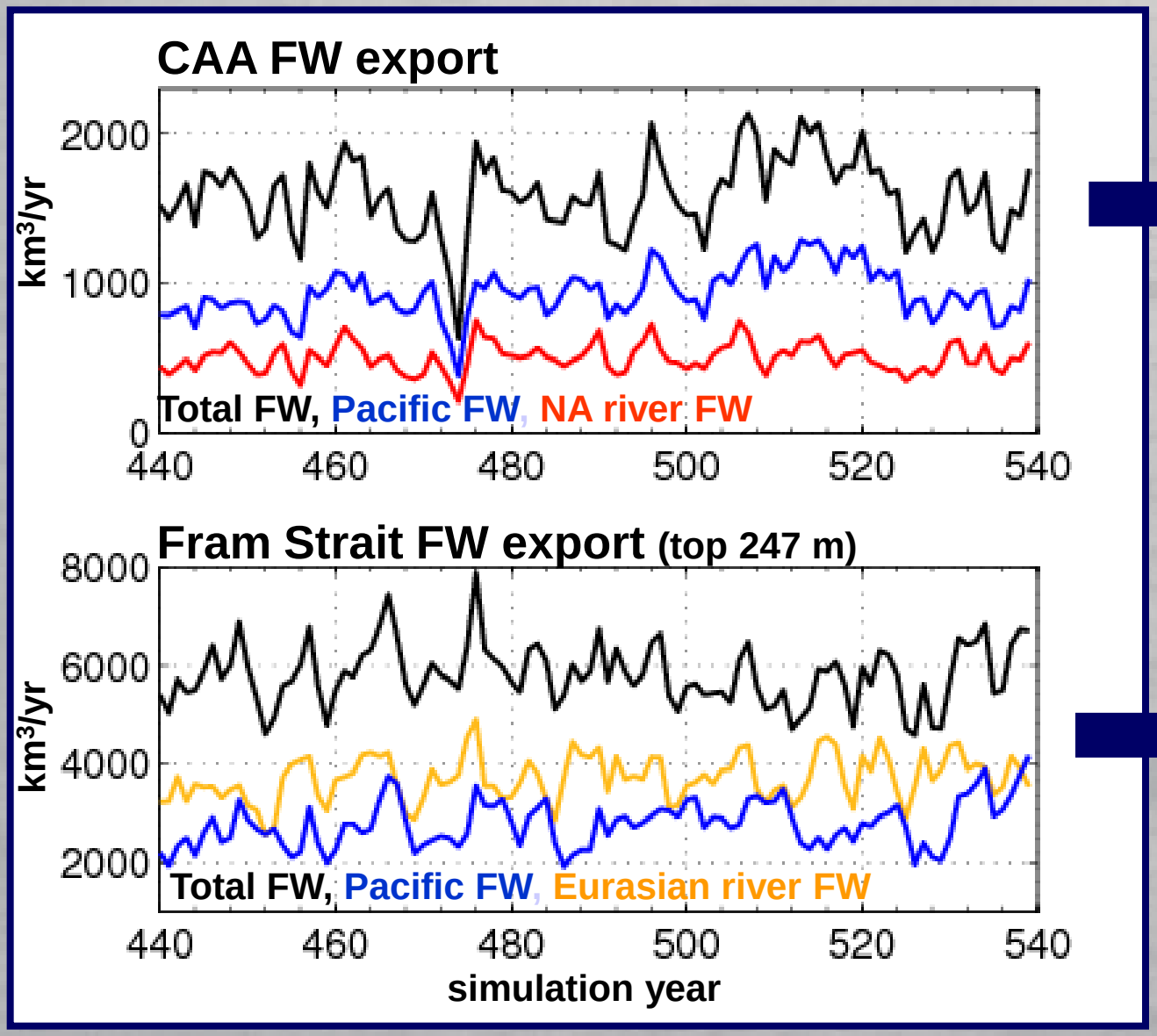
  →CAA: Barrow Strait open, Nares Strait closed



Sources of liquid FW export



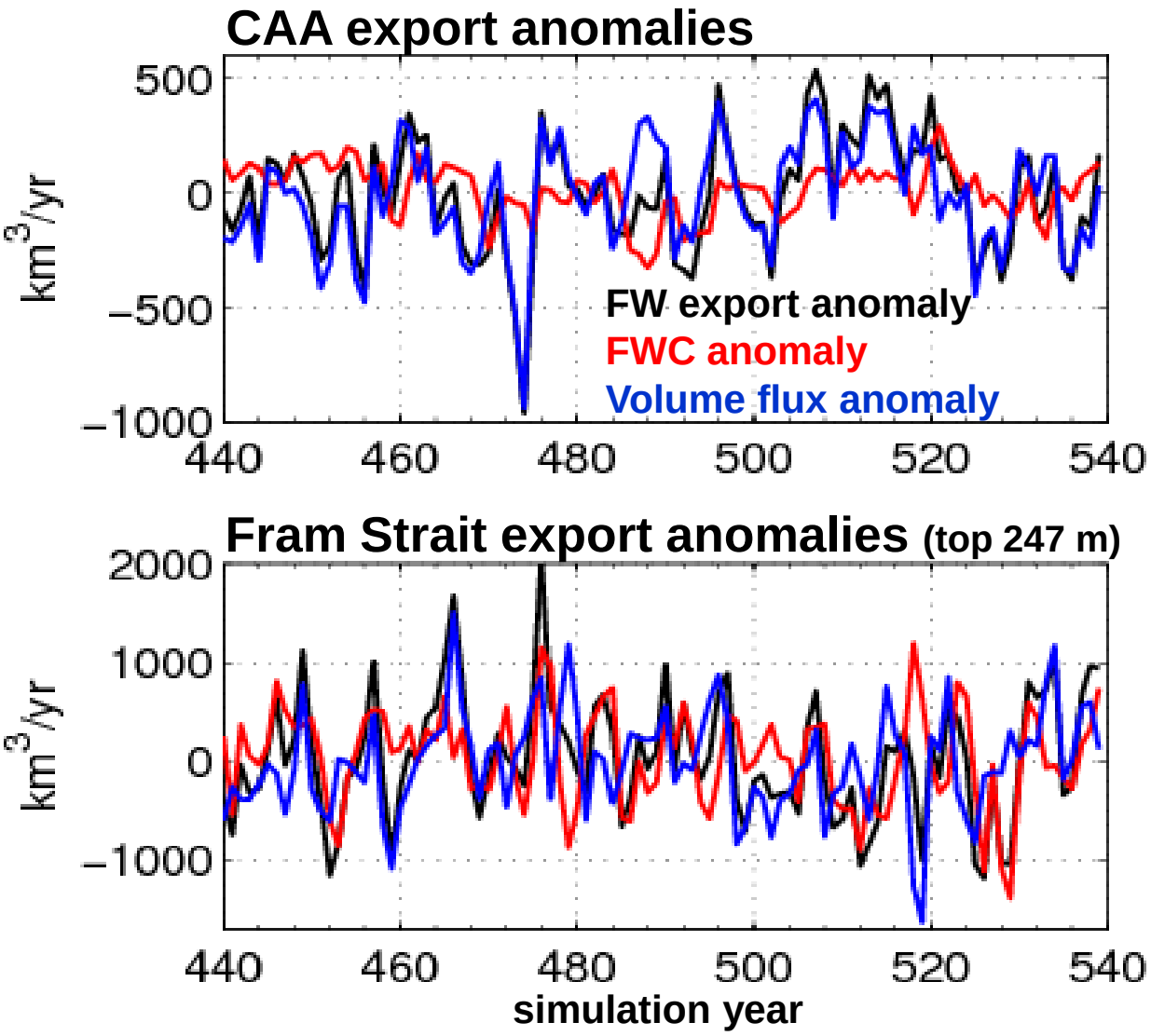
FW export variability from different sources



In phase

Not in phase

Reasons for FW export variability



Variability dominated by volume flux anomalies

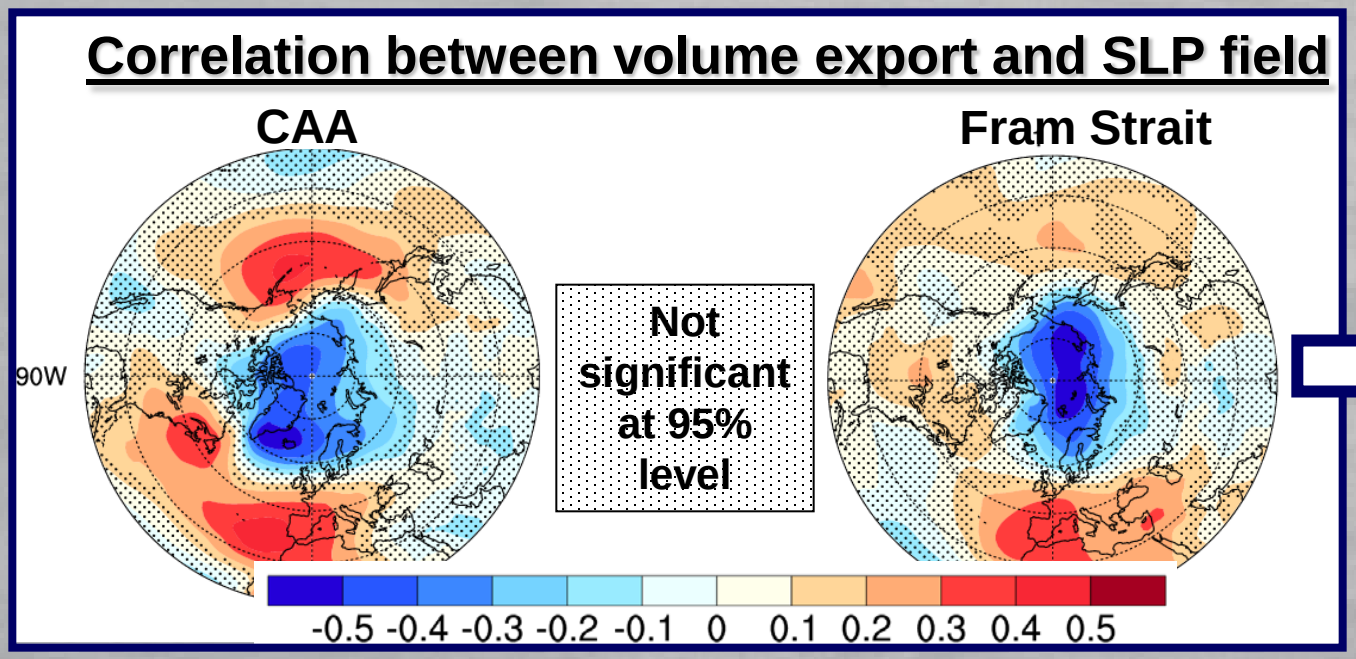
(r^2=78% and 10%)

Strong influence of FWC and volume flux anomalies

(r^2=36% and 43%)

Forcing of velocity anomalies

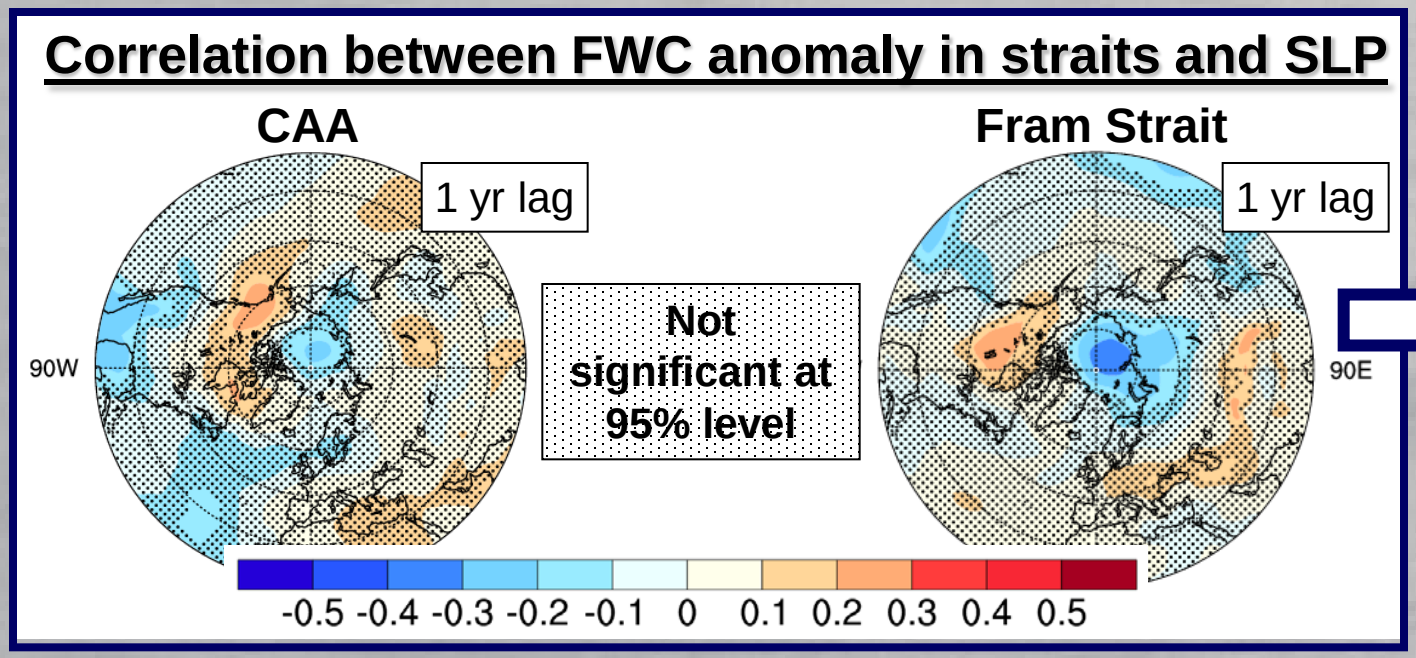
- **Velocity anomalies:**
  - **CAA:** velocity changes are driven by SSH changes between the Beaufort Sea and Baffin Bay
  - **Fram Strait:** velocity changes are due to:
    - changes in the geostrophic flow due to salinity changes in the inflow (Atlantic water)
    - local surface wind



Forcing of FWC anomalies

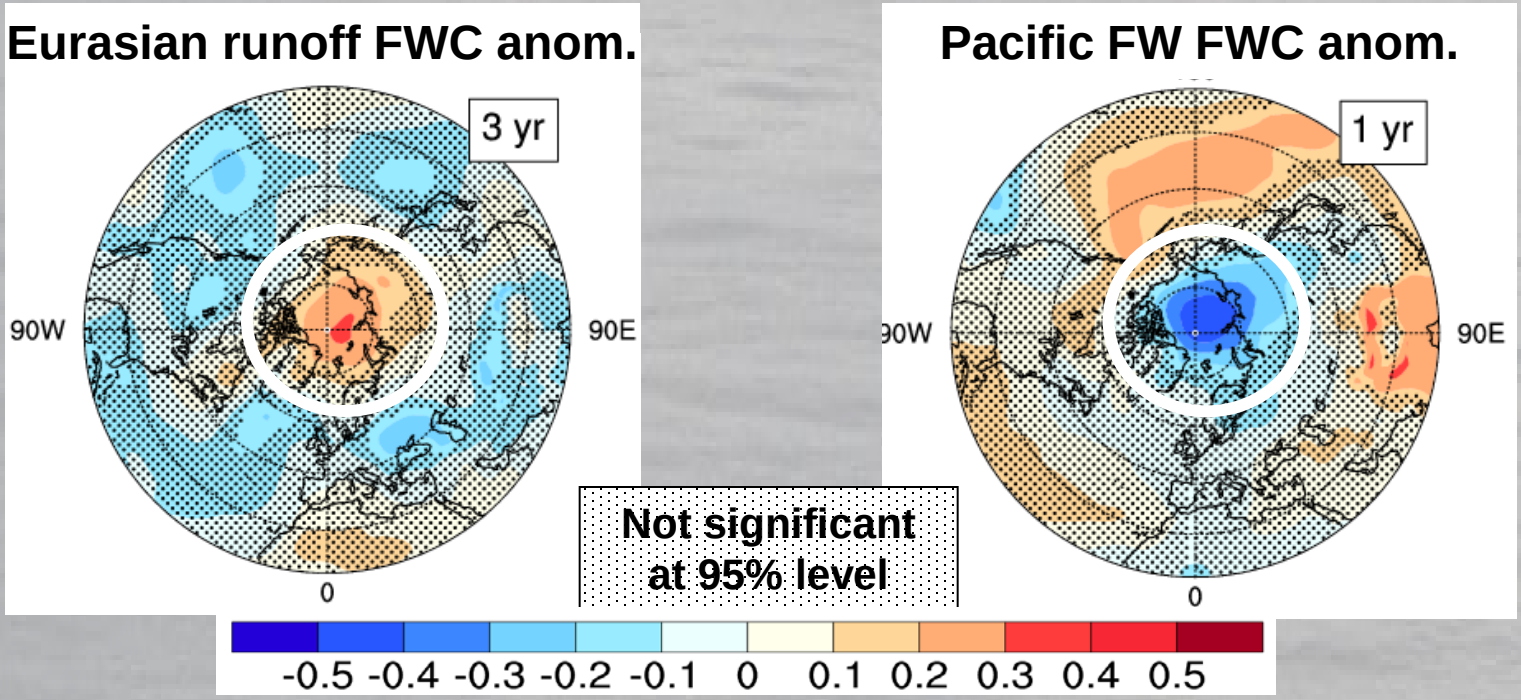
- **FWC anomalies:**
  - Changes in supply of FW → changes in FW distribution in the Arctic Ocean

Mainly important for Fram Strait



Some influence of SLP in the central Arctic, but not of AO

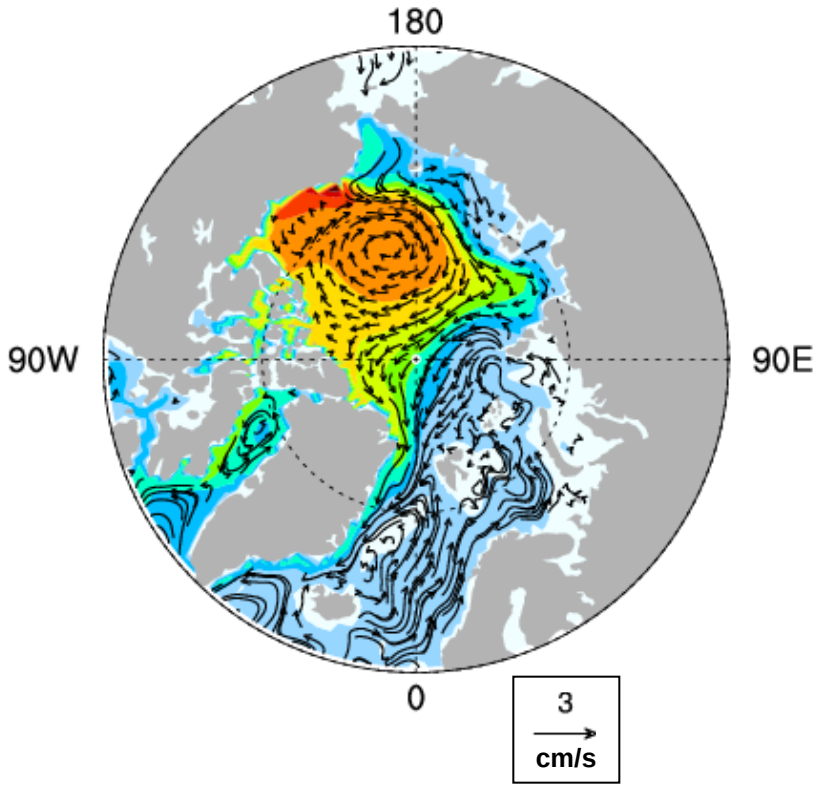
Correlation of Fram Strait FWC anomaly and SLP



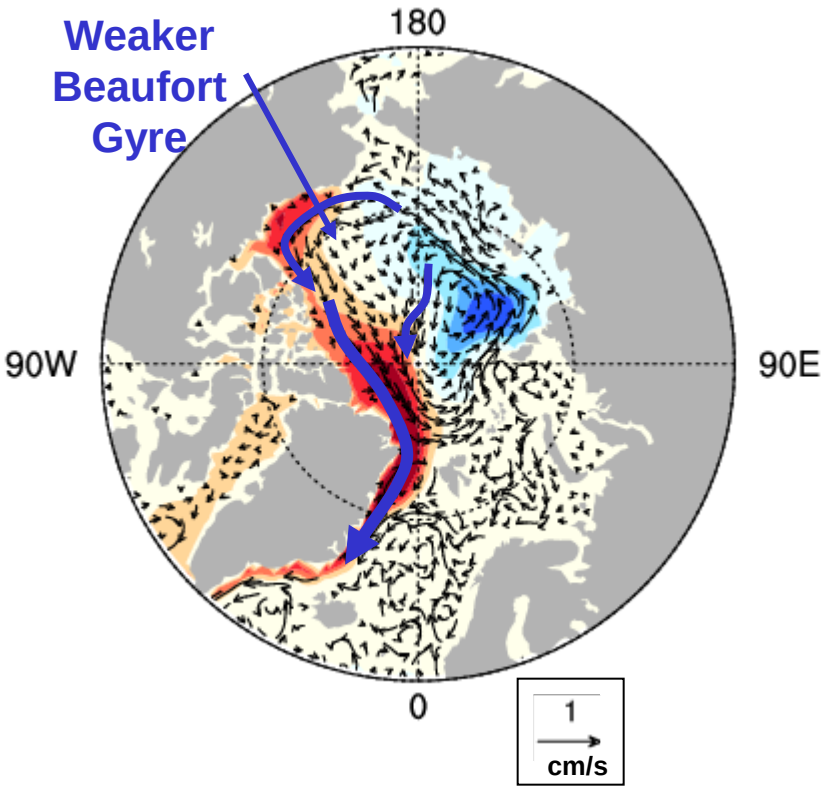
The correlation of Eurasian runoff and Pacific FWC in Fram Strait with the SLP has opposite signs and occurs at different lags

Pathway of Pacific FW to Fram Strait

Mean Pacific FW column



Pacific FW column change between high – low Pacific FWC in Fram Strait



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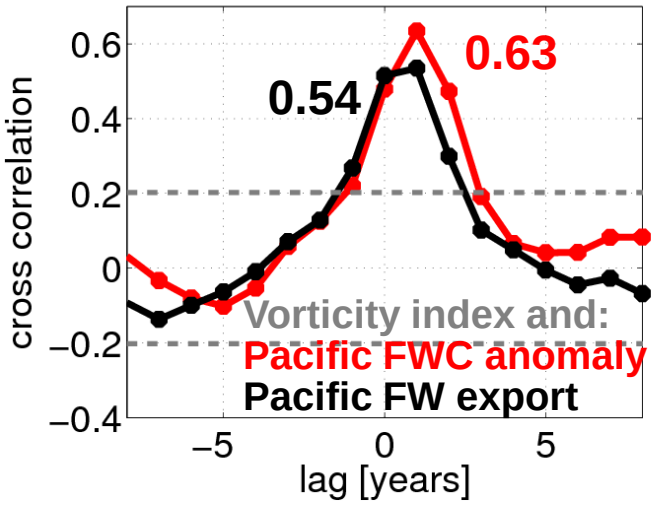
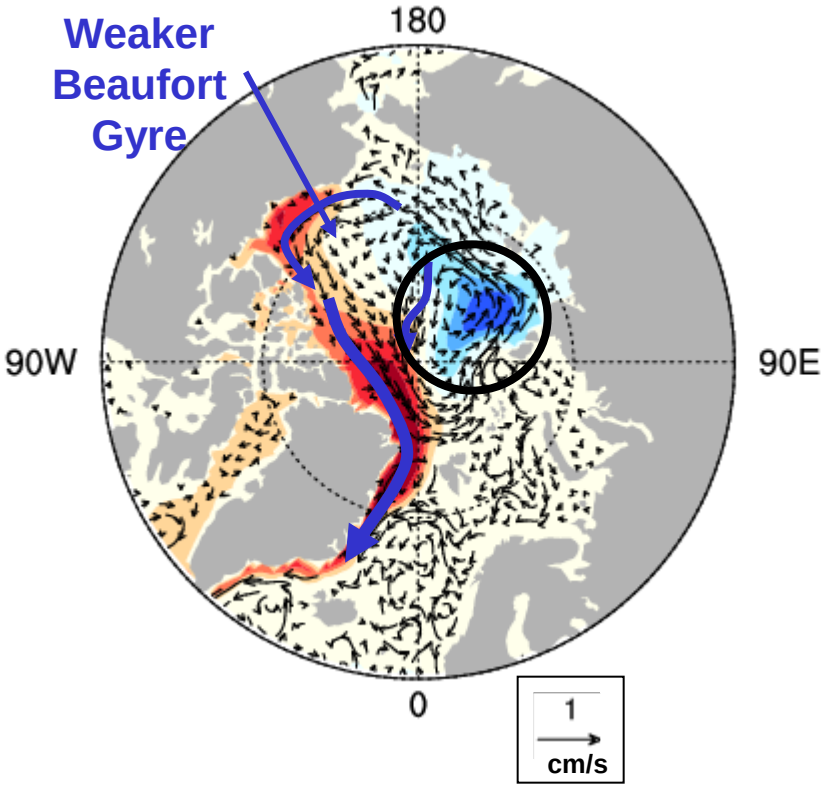


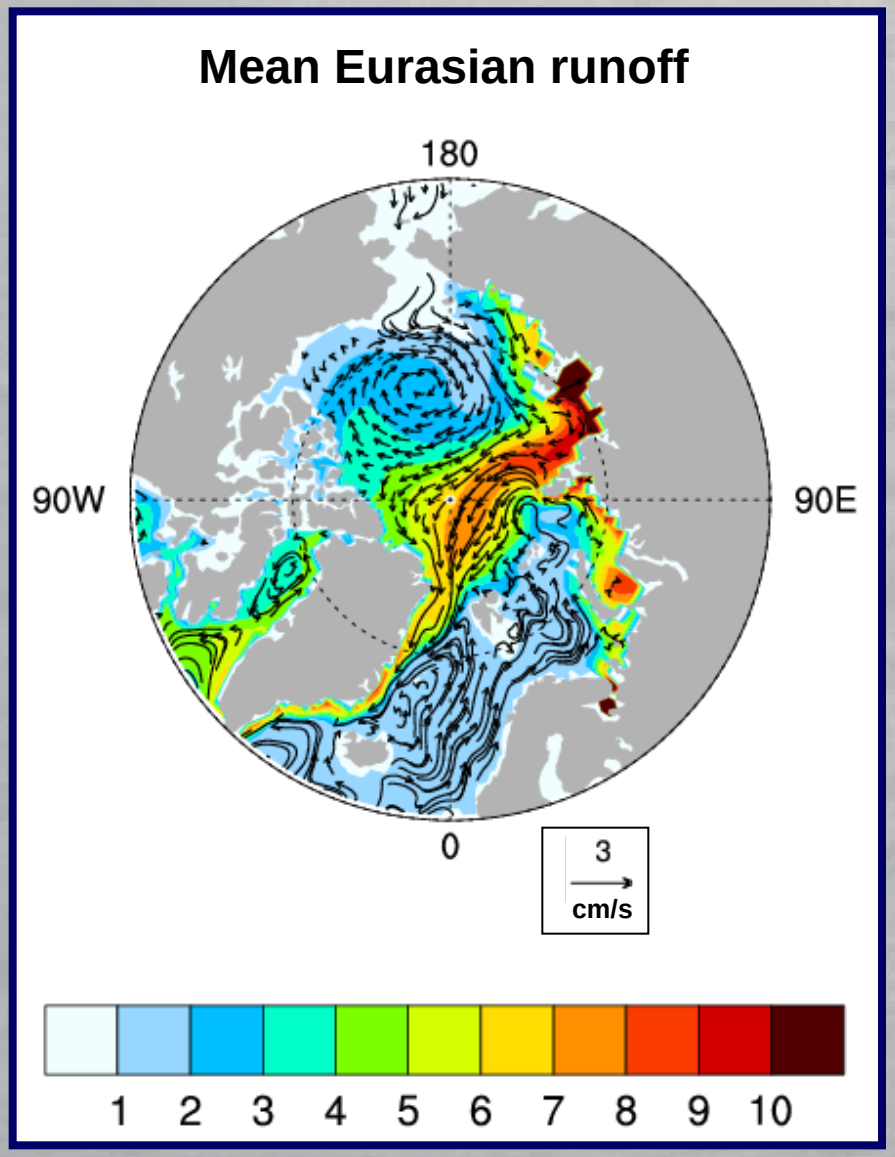
High Pacific FWC in Fram Strait during a positive Vorticity index

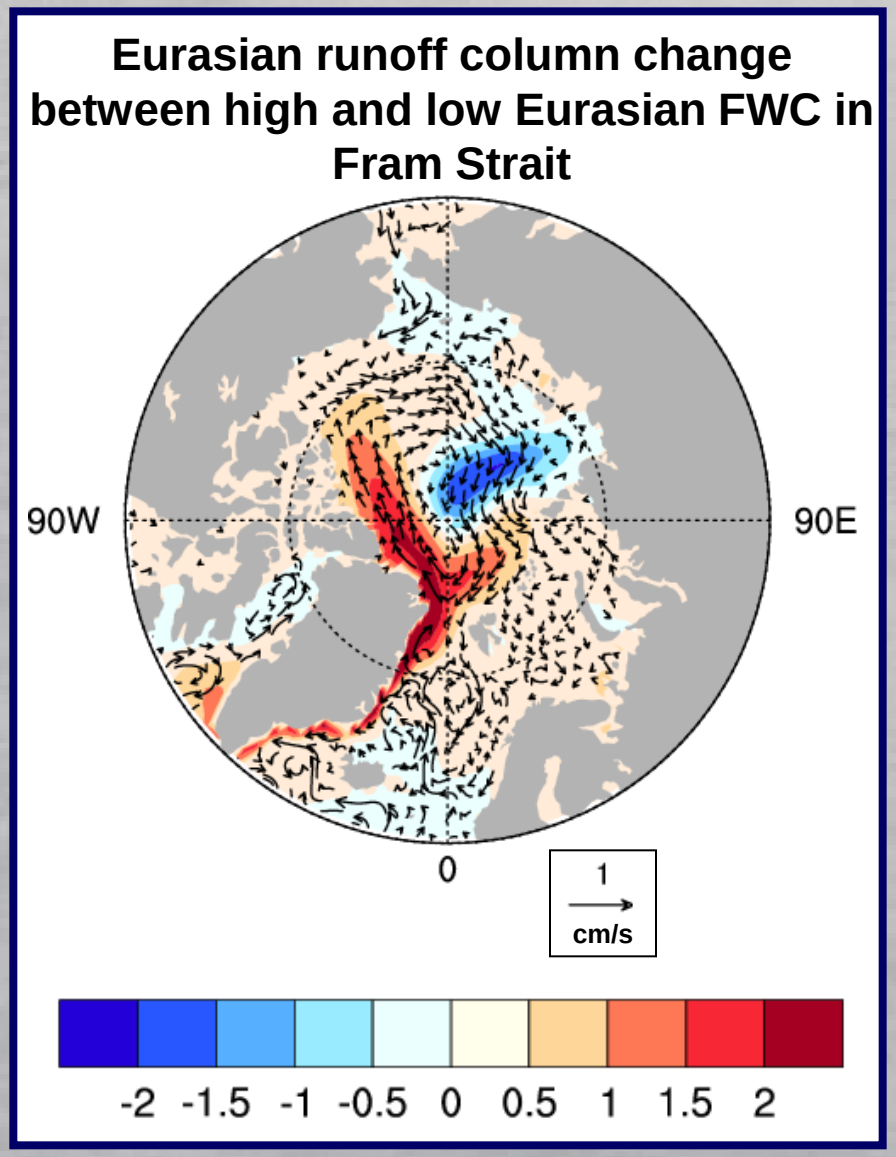
→ due to release of Pacific FW from a weaker Beaufort

Pacific FW column change between high – low Pacific FWC in Fram Strait



Pathway of Eurasian runoff to Fram Strait





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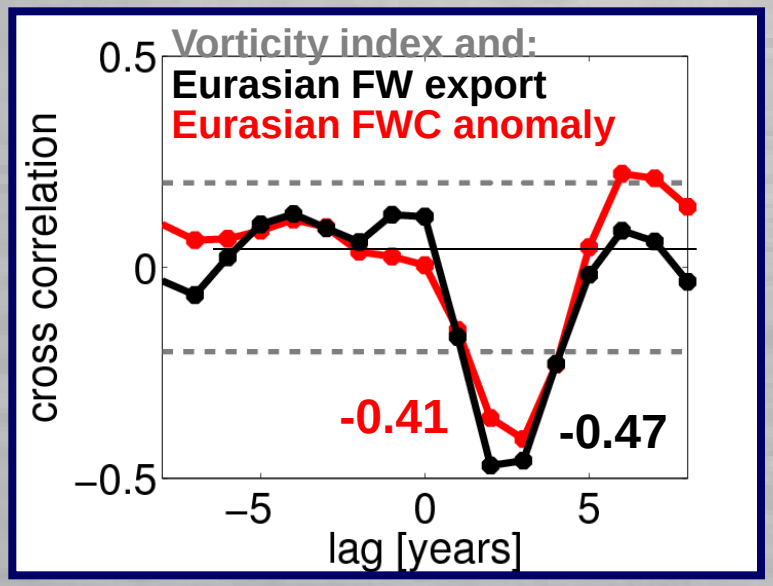
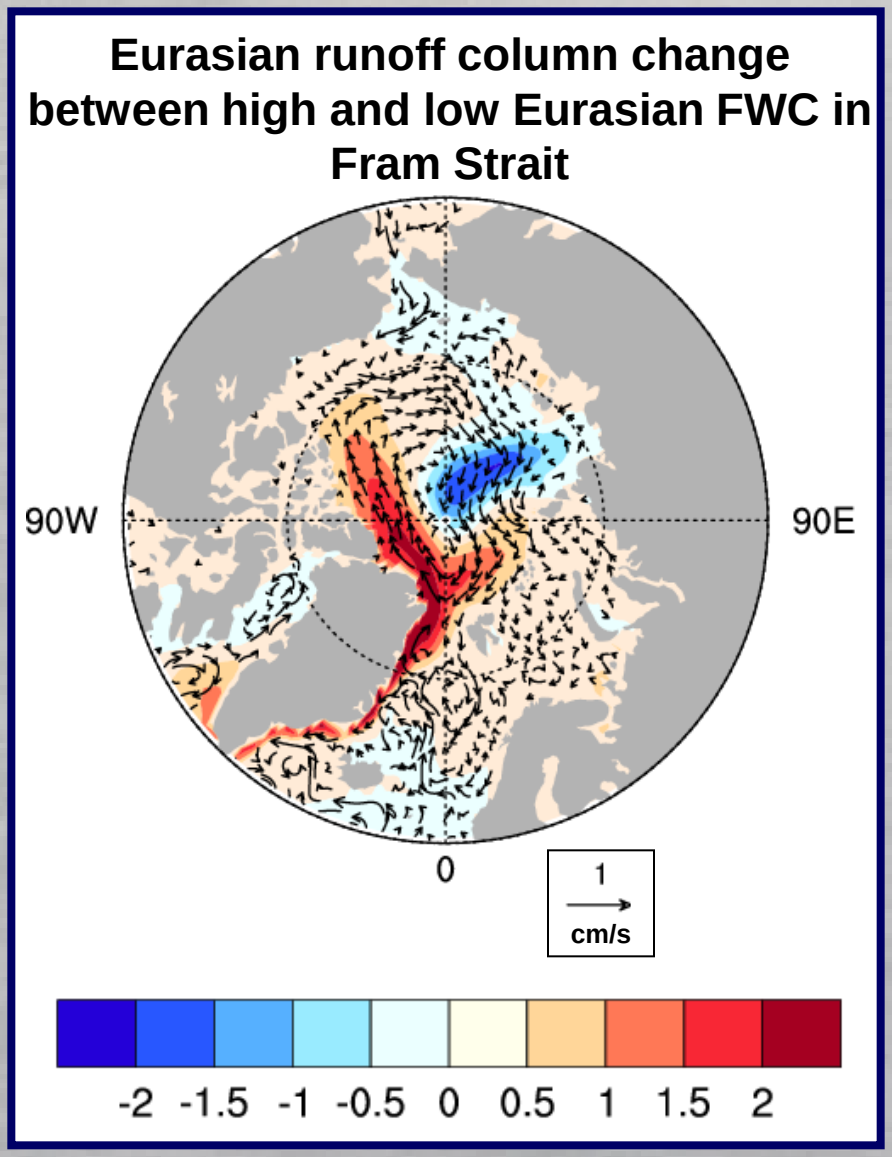
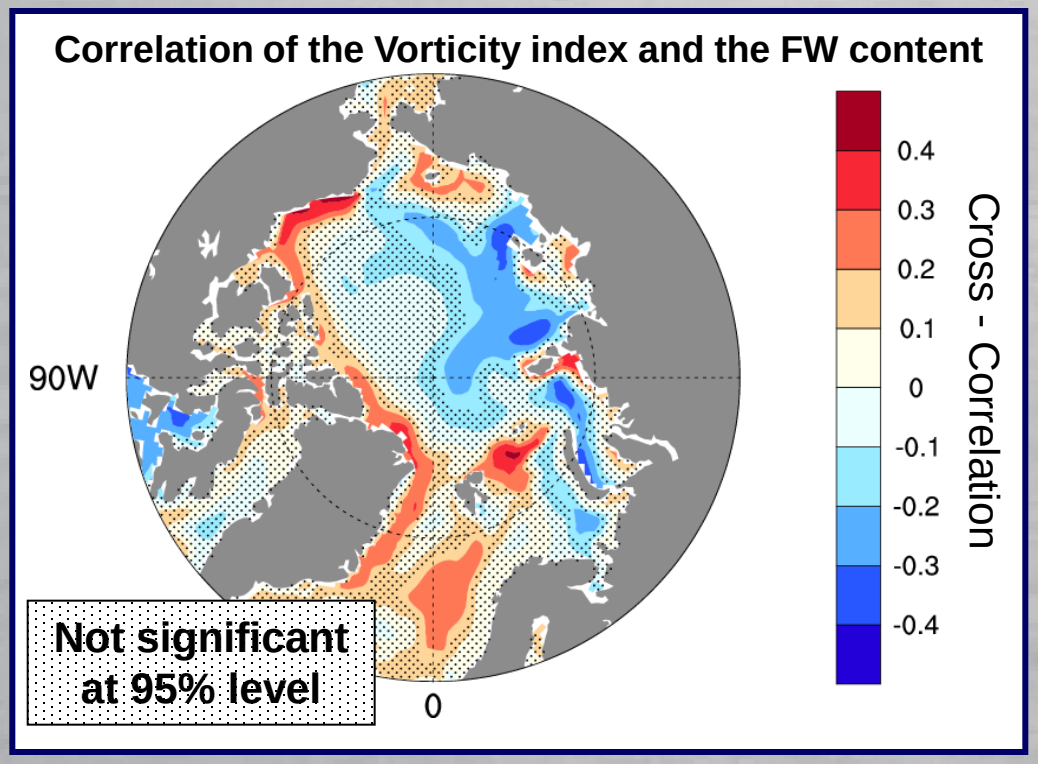


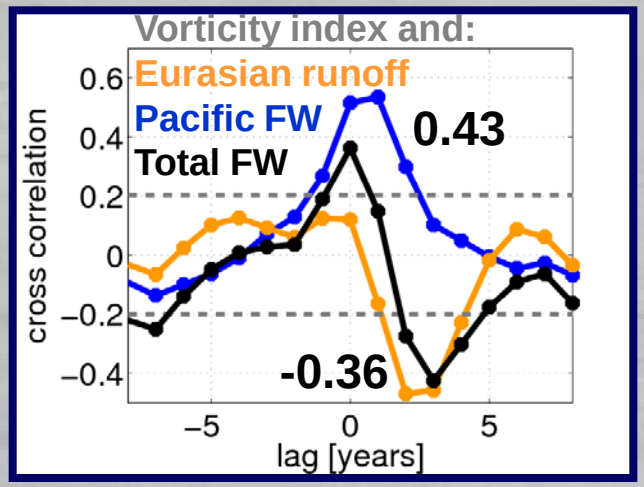
Increased Eurasian runoff content in Fram Strait three years after Vorticity index is negative

→due to release of runoff from shelf during negative Vorticity index phase



Summary: Pathway of FW to Fram Strait





FWC anomalies in Fram Strait are due to release of FW from storage

→ the release is driven by the Vorticity index, which has different effects in the Beaufort Gyre and on the Eurasian shelf

Summary:

- Velocity changes dominate the CAA FW export variability, but velocity and FW concentration anomalies explain equal parts of the FW export variability in Fram Strait

- The variability of the liquid FW export is caused by changes in the cyclonicity of the atmospheric forcing.
  - →Arctic-centered atmospheric forcing (Vorticity index) affects the FWC of the export
  - →Large-scale atmospheric forcing (Arctic Oscillation) affects the volume flux export

- The FW concentration anomalies in Fram Strait are due to the release of FW from the Beaufort Gyre (Pacific FW) and from the Eurasian shelf (Eurasian runoff), and are driven by the Vorticity index

Contact: ajahn@ucar.edu