Seasonally Variable Controls of Freshwater Export through Denmark Strait

Emma Boland[1], Yavor Kostov[1], Dani Jones[2]

1. British Antarctic Survey, 2. Cooperative Institute for Great Lakes Research (CIGLR), University of Michigan

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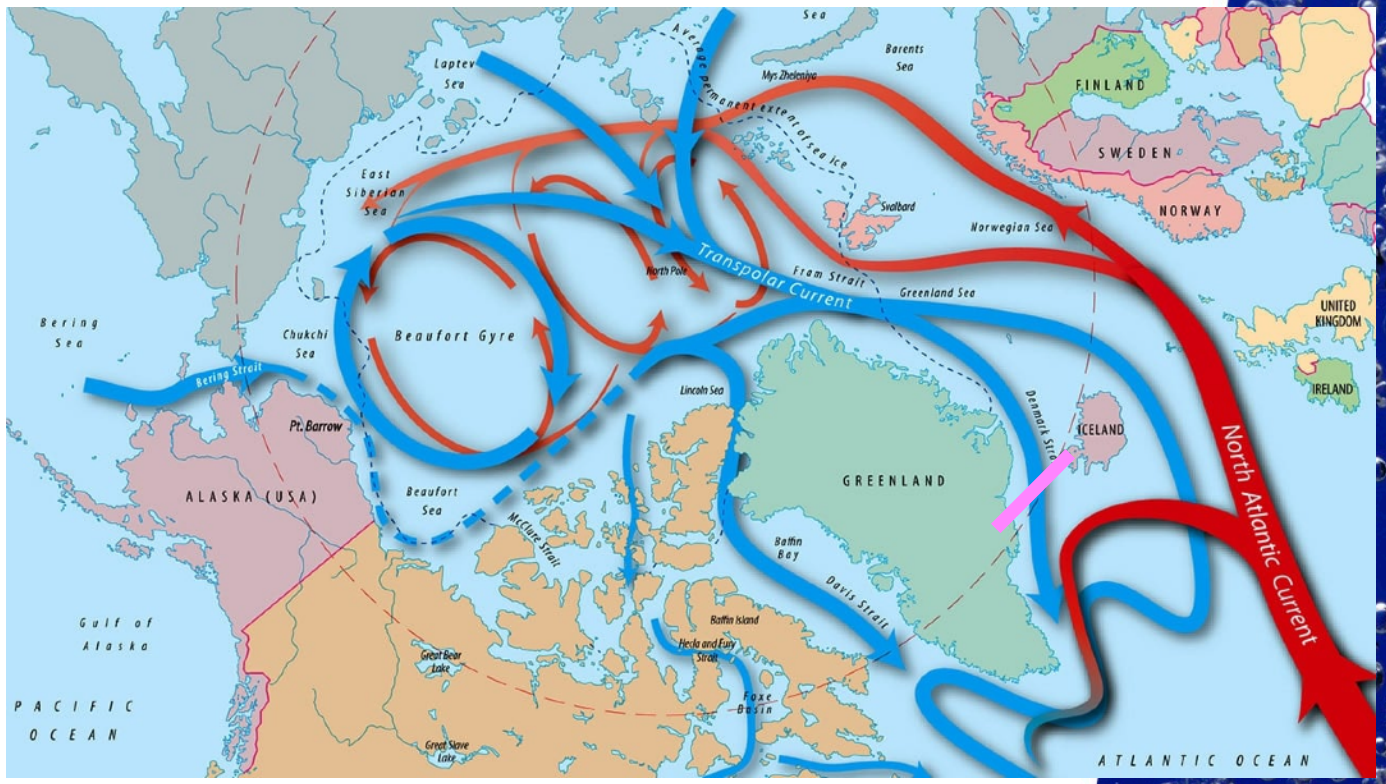
Background

The Arctic is a region of large **freshwater** inputs and outputs:

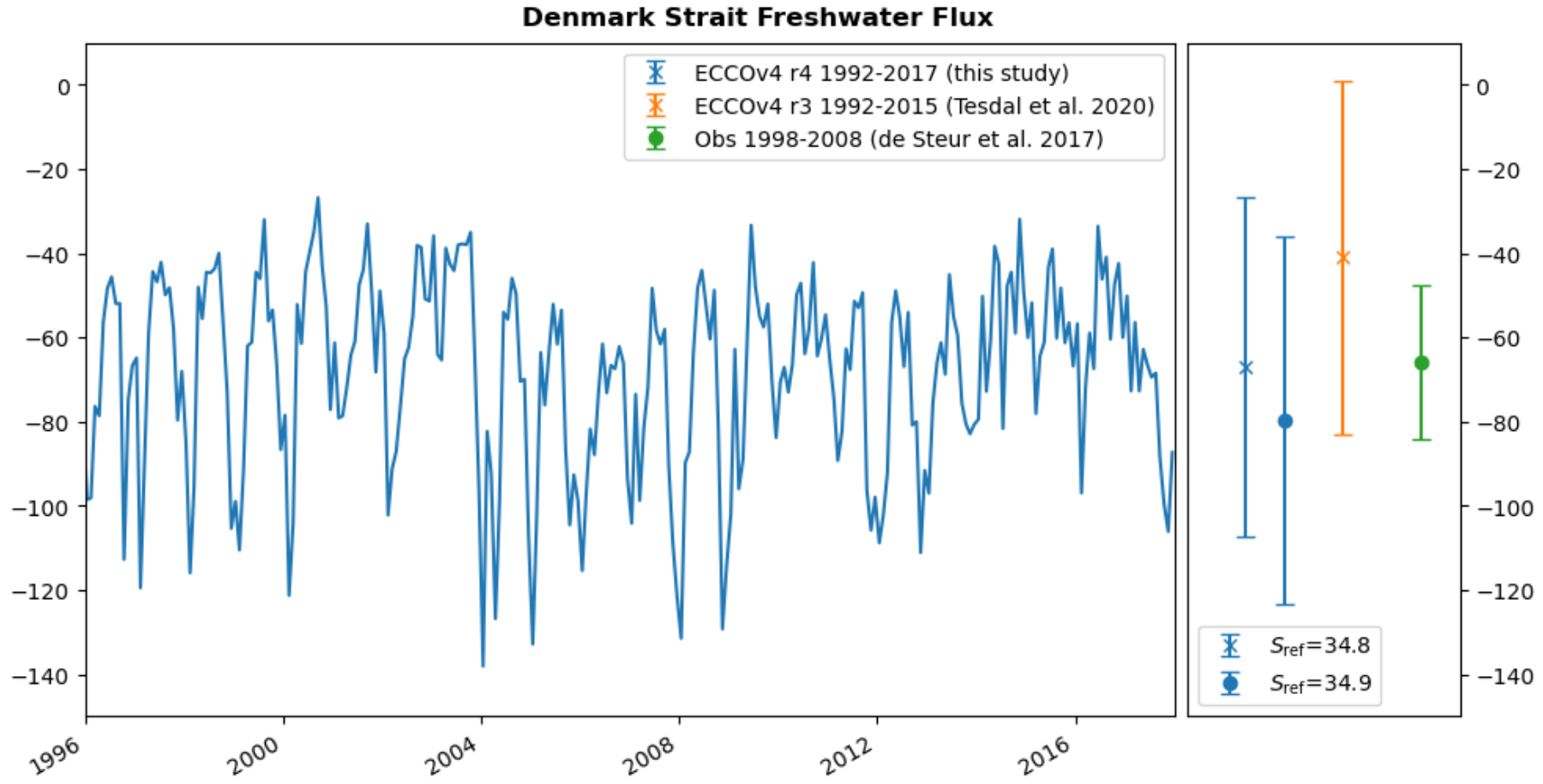
- **11%** of global rivers discharge into the Arctic Ocean
- **Net precipitation** and **inflow** from the Pacific bring more freshwater
- Freshwater is **exported** as sea-ice flows and via ocean pathways through the Canadian Archipelago and through Fram Strait into the **Sub-Polar North Atlantic**
- The Denmark Strait is one of the main export routes into the SPNA

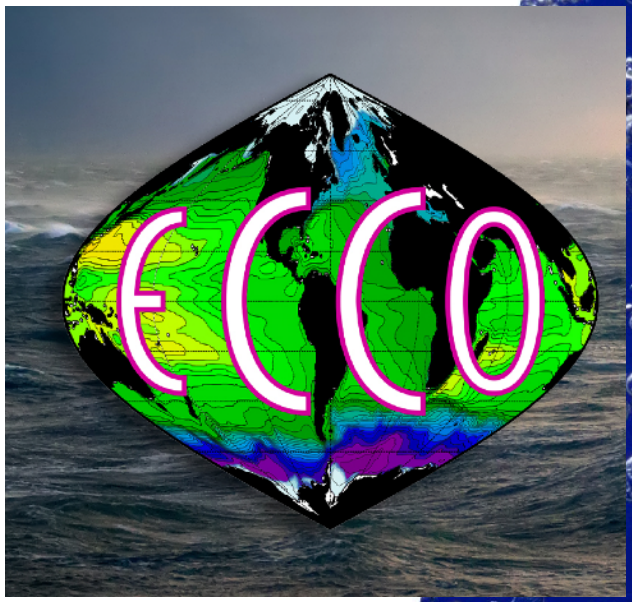
Image: WHOI



Background

Tool: ECCOv4 r4 state estimate (1992-2017), adjoint sensitivity experiments.





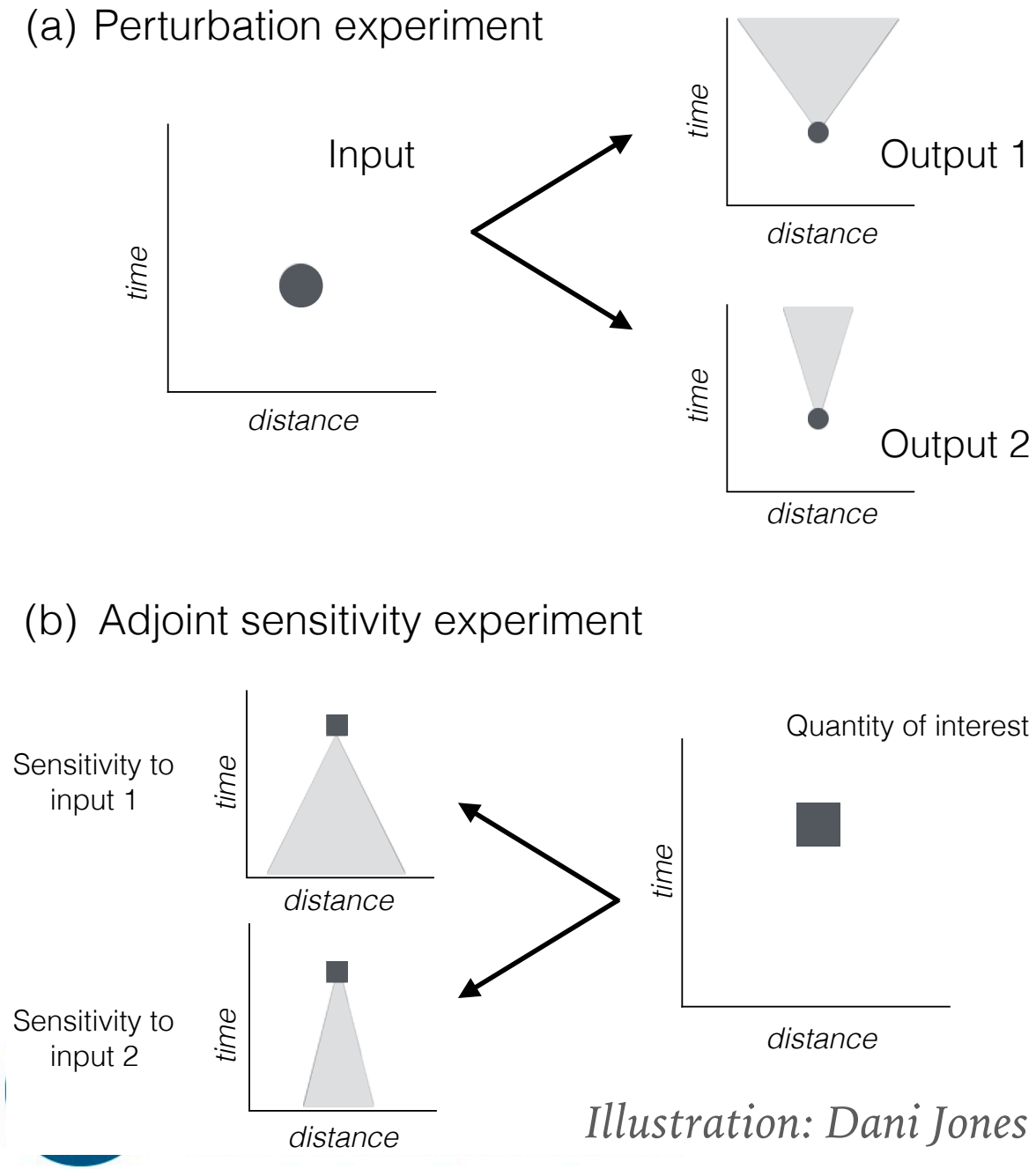


Illustration: Dani Jones

Adjoint modelling

- **Traditional** approach: **perturb** surface forcings (heat flux, wind stress etc) and see how these impact **quantity of interest** (mode water properties).
- **Adjoint** approach: Run a (linear) model **backwards** to directly calculate **tendencies.**
- Produces **maps of sensitivity** at multiple lags for any state **variable of interest**.

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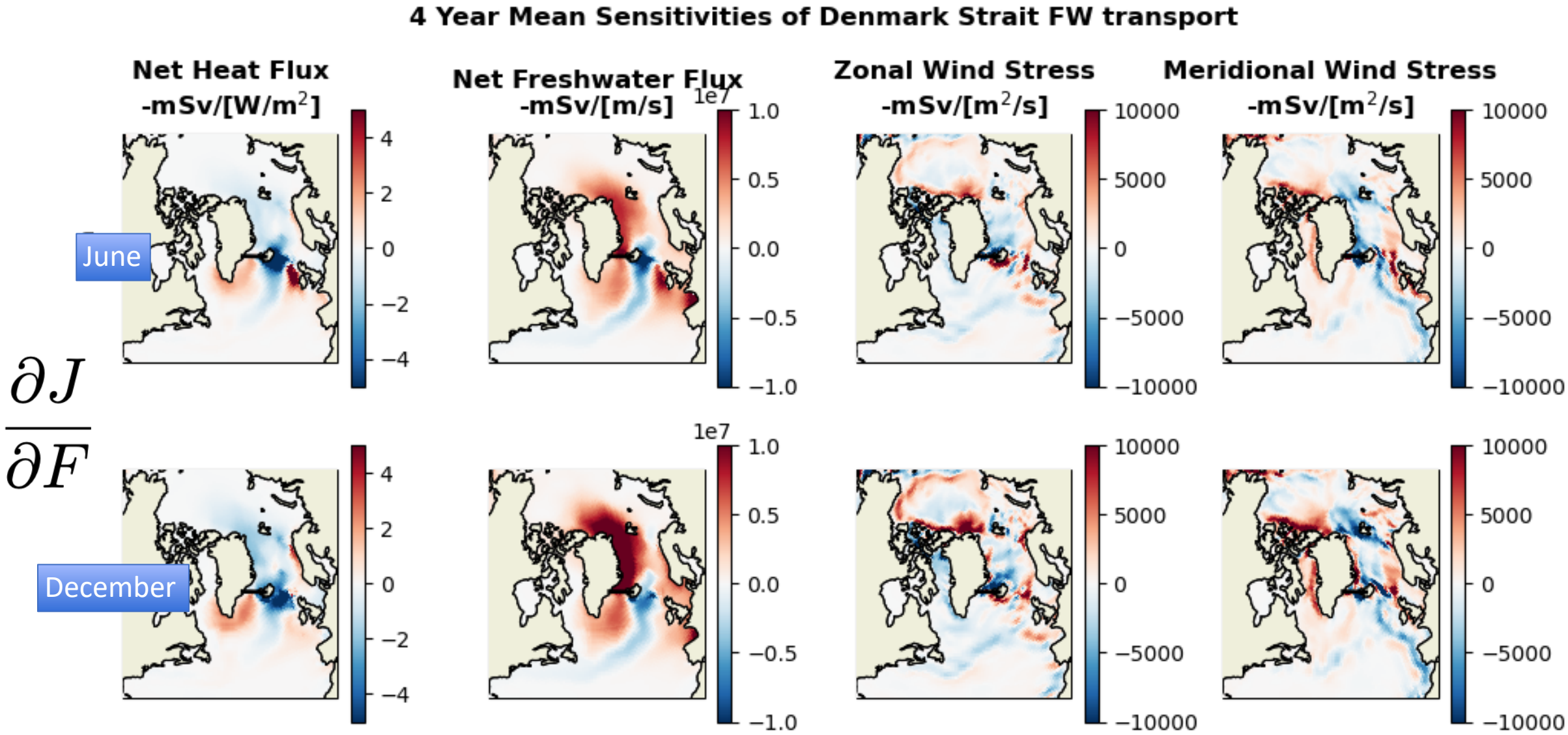
Adjoint sensitivities

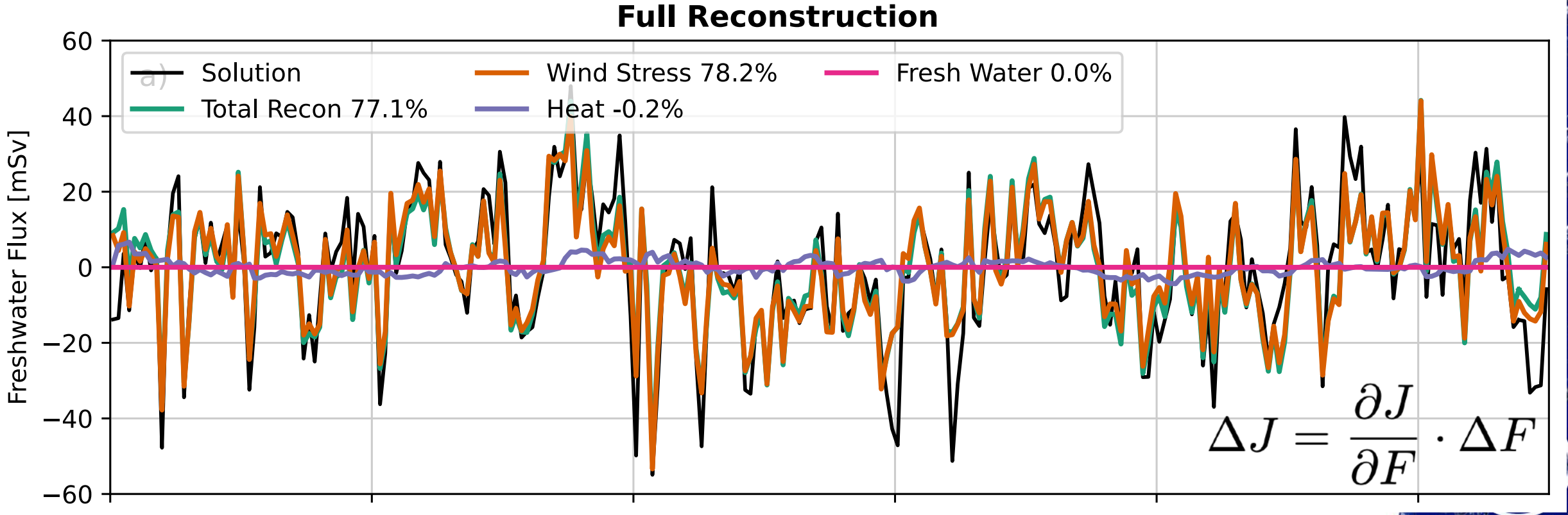
$$J = \int_z \int_m \mathrm{FWflux}$$



4 year Memory Reconstruction

Create reconstructions based on ensemble of 3 target years, using **4 years of memory**.

78% of variance in FW transport anomaly explained by reconstruction - almost entirely due to **wind stress**.



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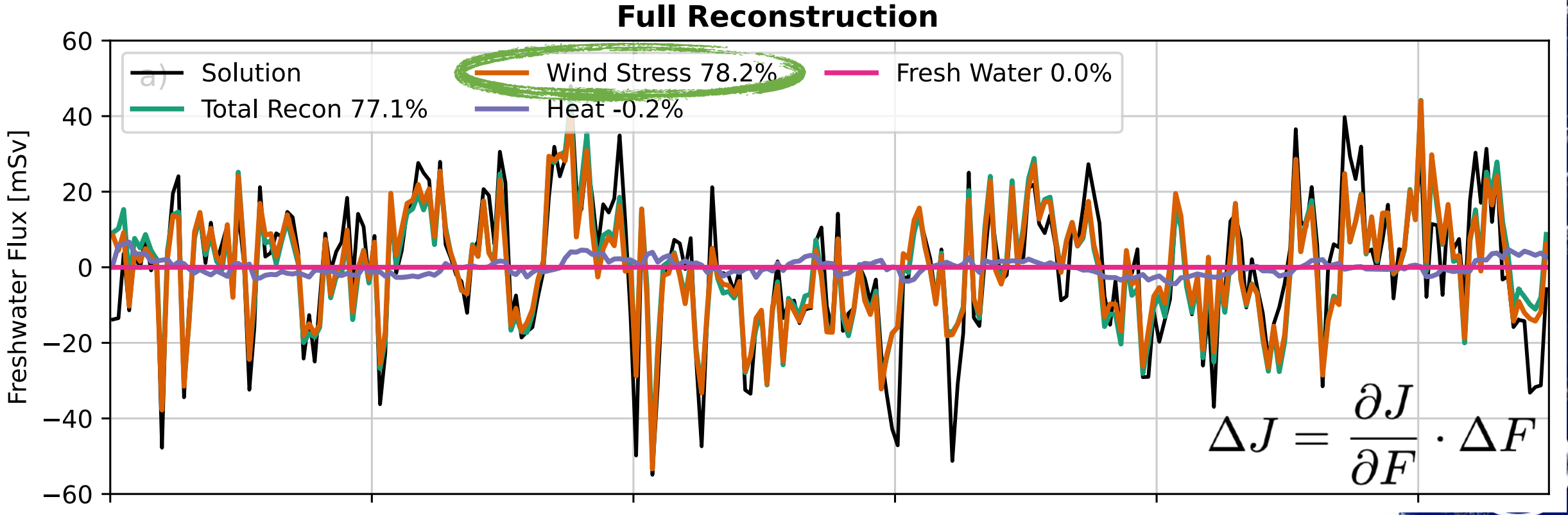
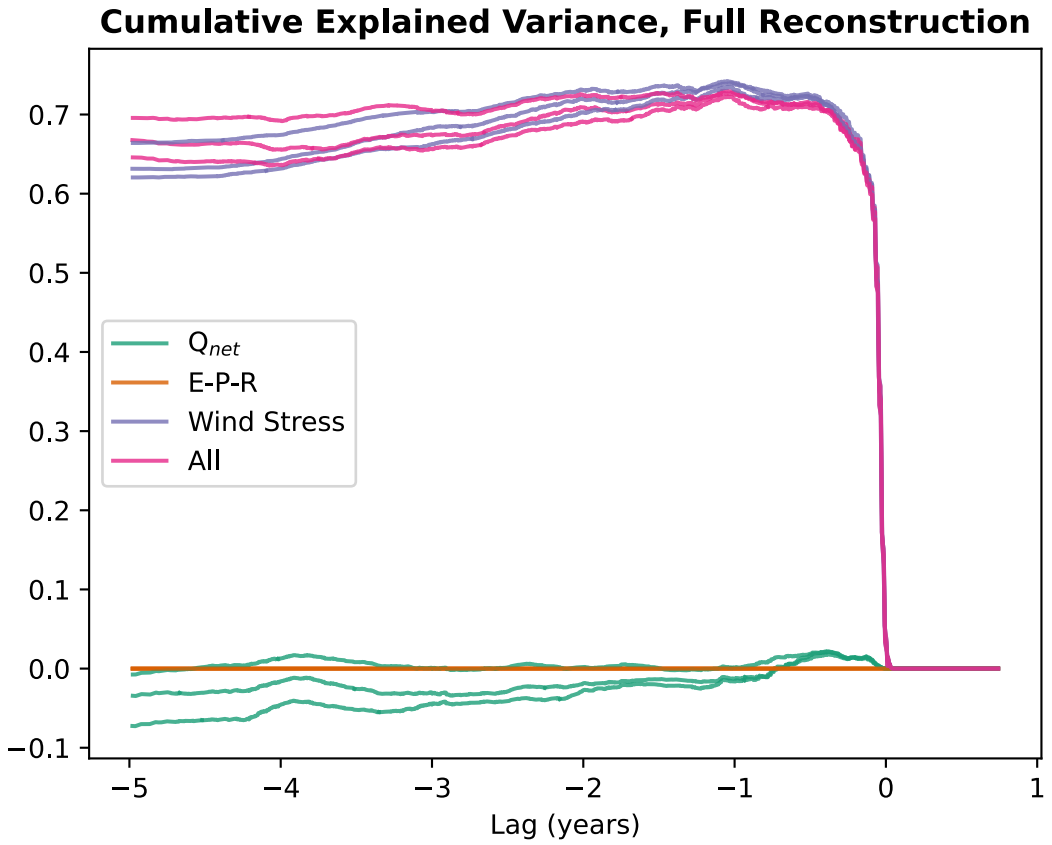


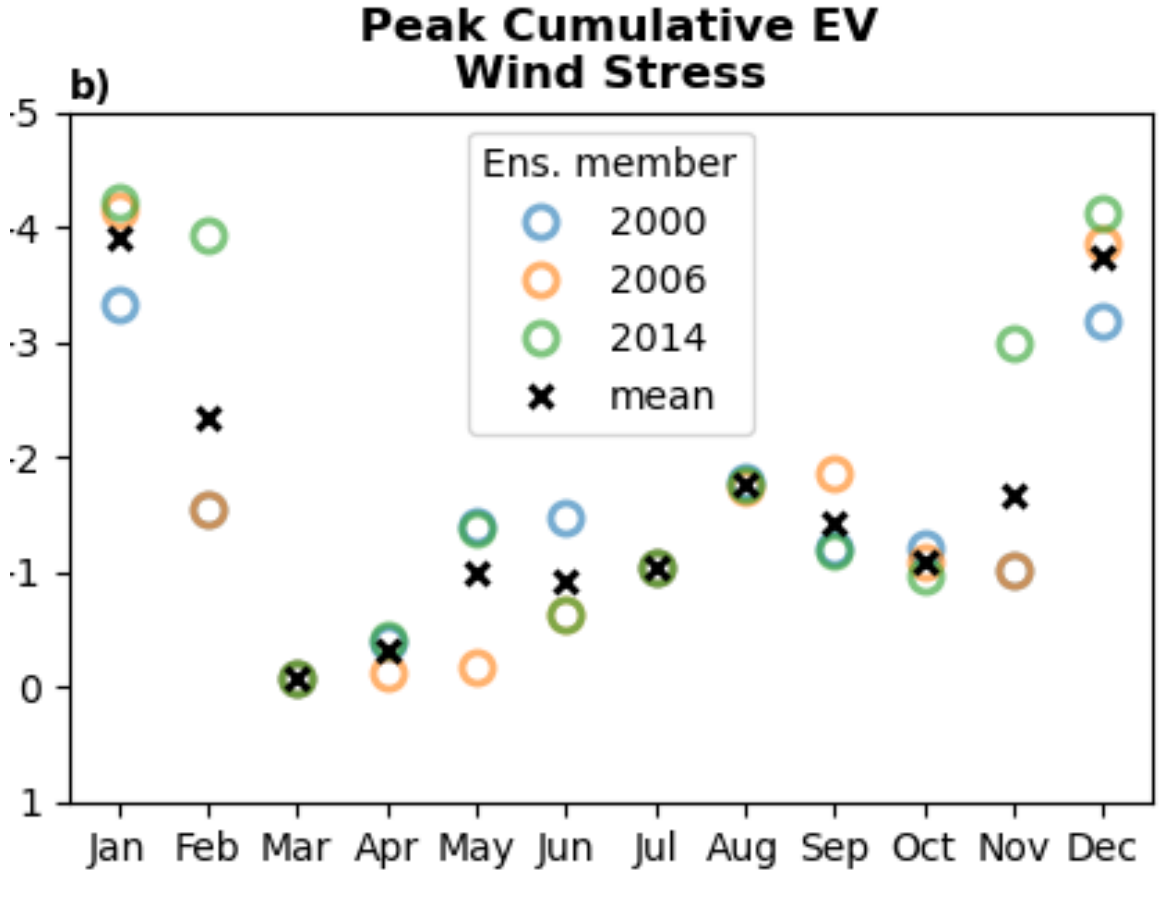
Peak Explained Variance

$$EV = 1 - \frac{var[\text{Sol} - \text{Rec}]}{var[\text{Sol}]}$$

We **don't** have to use full four years of sensitivities.

For each month, find the **optimal** '**memory**' by finding the peak **explained variance**:

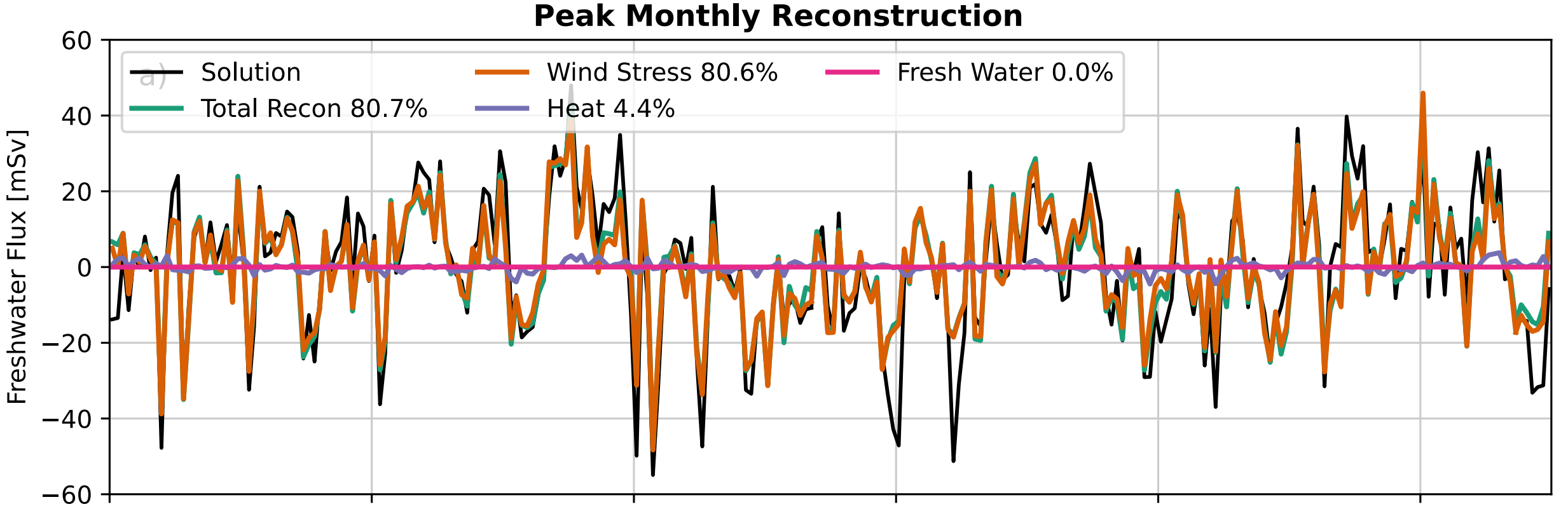




Optimal Memory Reconstruction

Using **optimal memory** (a few months — 4 years):

80% of the variance in FW flux anomalies can be reconstructed using **wind stress alone**



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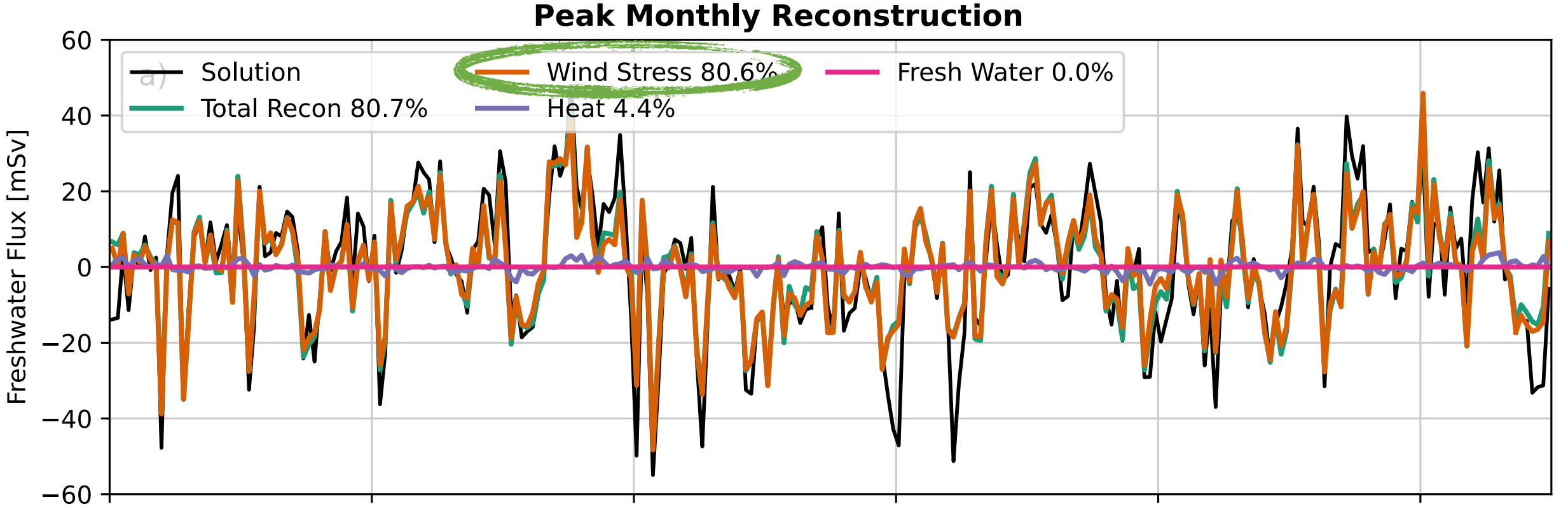
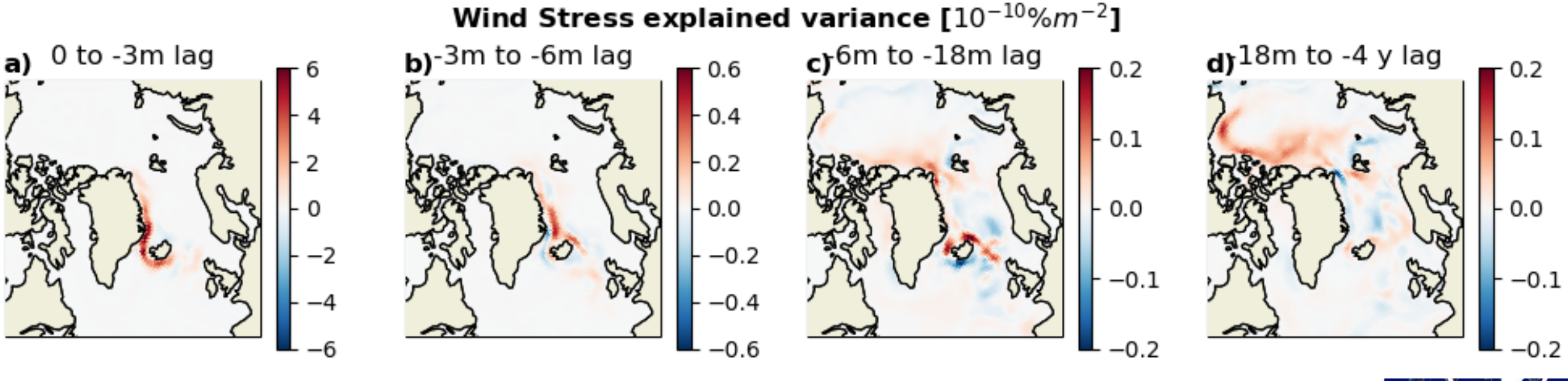


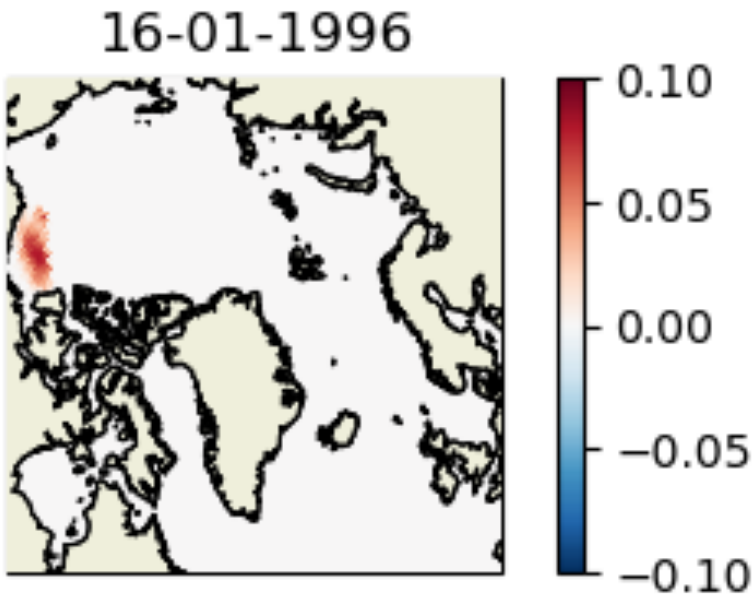
Location of explained variance

- **First 3 months: Local wind** variability explains most variance in Denmark Strait FW flux
- **18m - 4 years: Arctic wind** variability explains most variance (NB an order of magnitude less)



Perturbation experiment: Beaufort Gyre

Zonal wind stress perturbation



- One month wind stress perturbation in Jan 1996
- Peak in southward volume and fw transports in February
- Decay marked by winter increases in fw transport?

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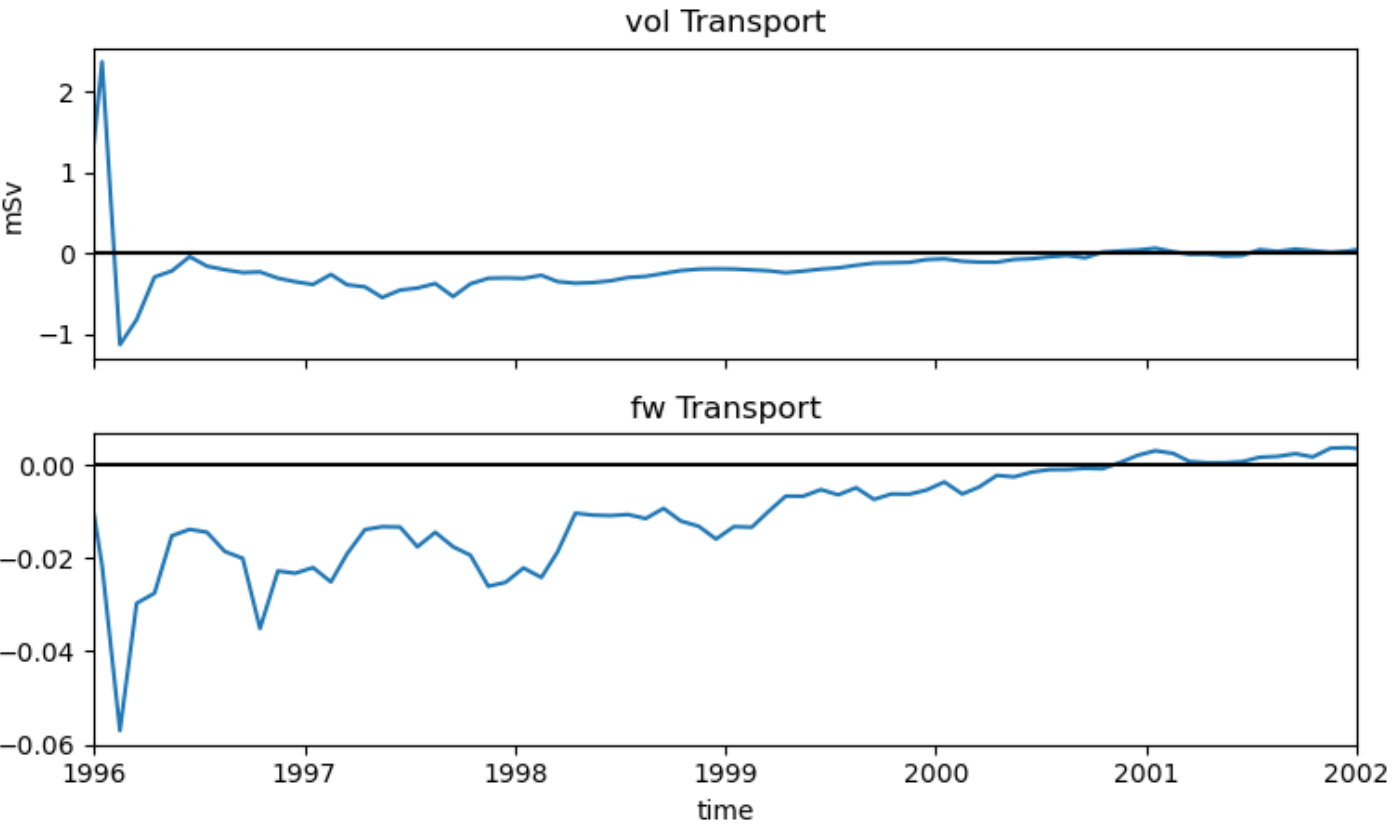
Perturbation experiment: Beaufort Gyre

Linear Transport response at Denmark Strait



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Conclusions

- **Successful reconstruction** of Denmark Strait Freshwater transport anomaly time series is possible (using only experiments from year 2000)
- Dominated by **wind stress** - explaining up to **80% variability**
- **Seasonal** variability in optimal '**memory**': winter months have a longer memory, linking them with Arctic wind variance
- **In progress**: verifying results with
  - Direct perturbation experiments

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