The Day Before Tomorrow

Understanding AMOC Variability in the Past Three Decades and Its Impact on Atlantic Heat Transport in ECCO V4r5 & V4r4

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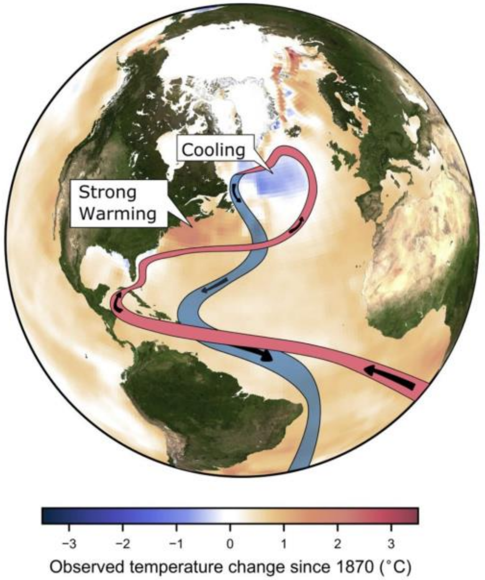
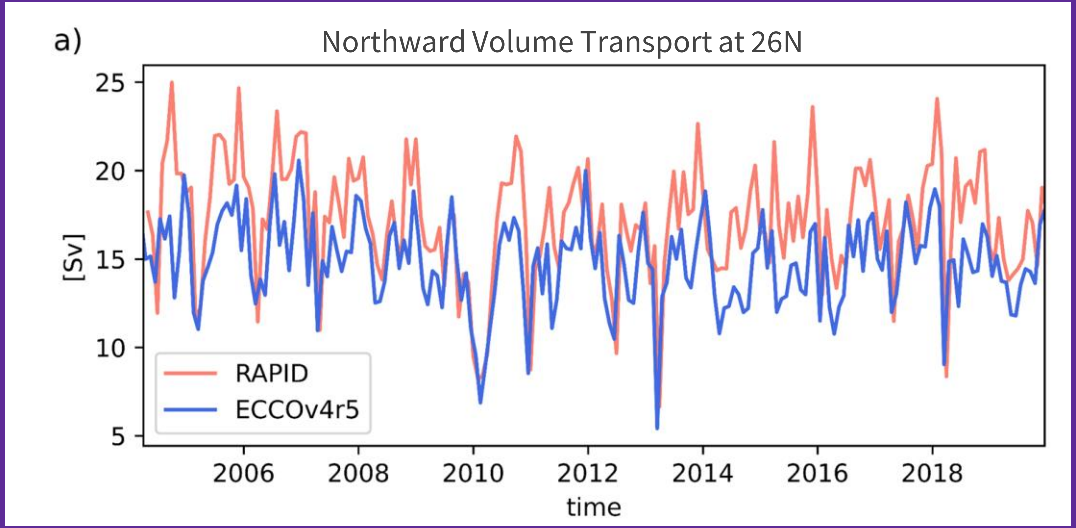
Motivation

Ongoing debates on AMOC trends due to a shortage of observation. “North Atlantic warming hole” is suggested as an indicator of weakening AMOC (Caesar et al. 2018).

Choice of vertical AMOC coordinate leads to divergent results. Density coordinate is suggested to be more informative of the large-scale, three-dimensional AMOC structure than depth coordinate (Foukal & Chafik 2024).

AMOC in ECCO V4r5 agrees well with RAPID observation at 26N, better than the previous version as documented in Wunsch & Heimbach (2013).

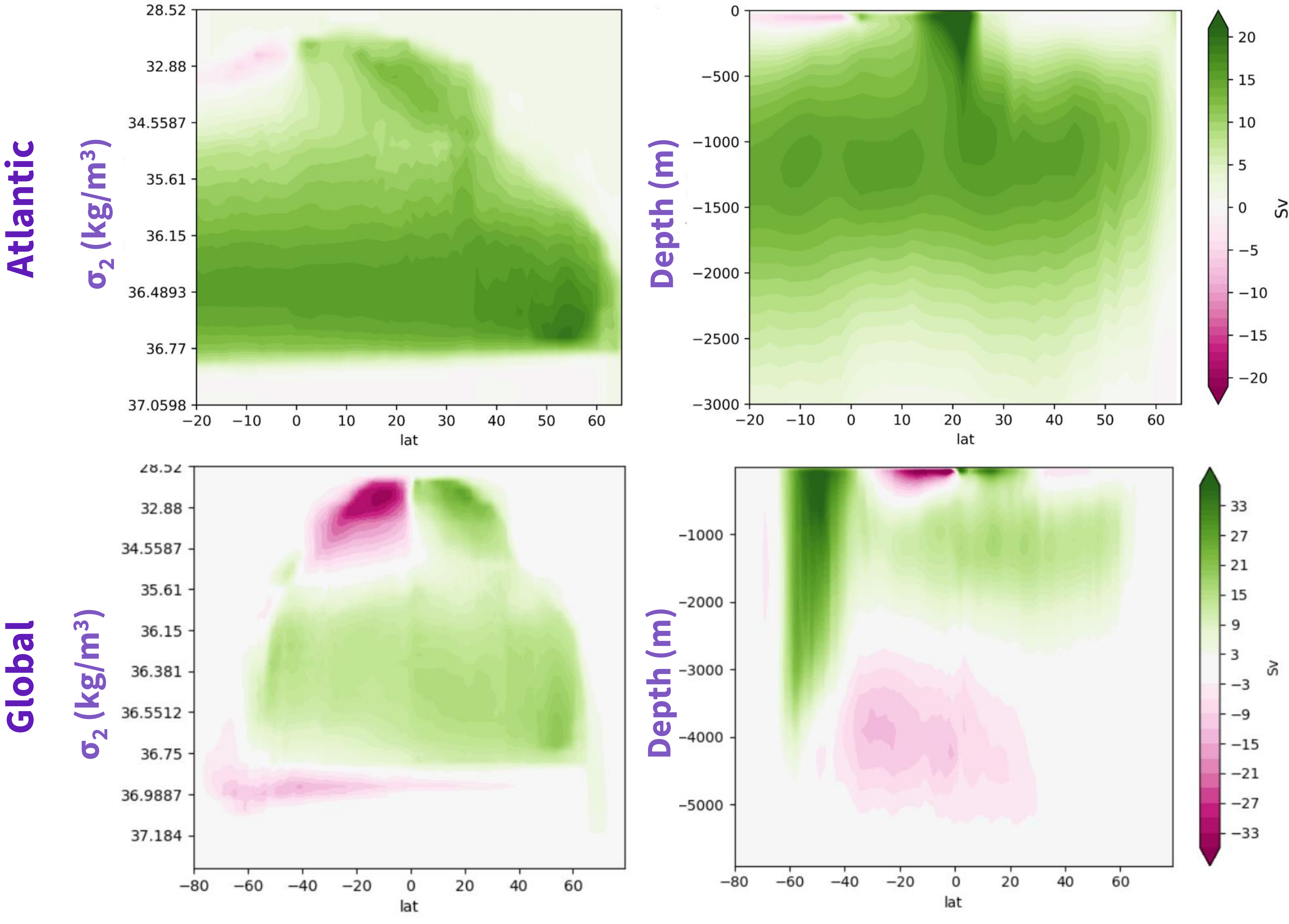




Research Questions:

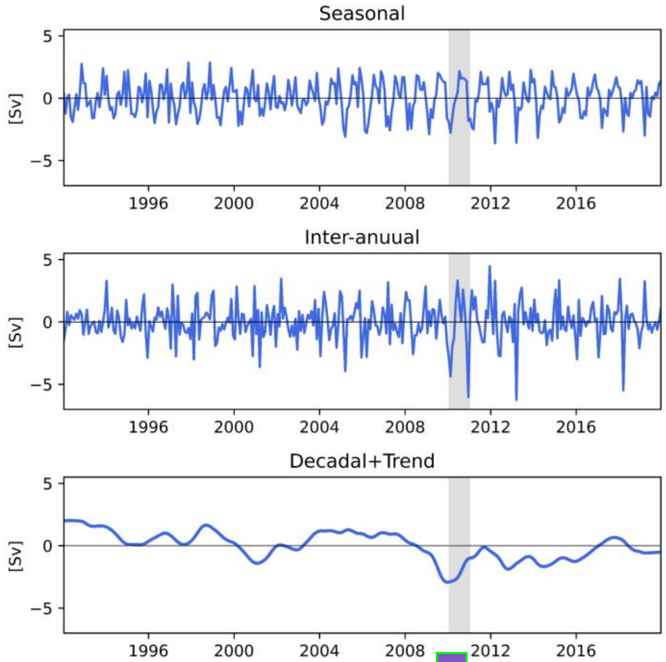
(1) Are AMOC mean state and variability consistent in depth- and density-space?
(2) How does it influence MHT?
(3) Physical forcings responsible for the variability?
(4) Is AMOC variability coherent across latitudes?

1992 - 2019 Mean Meridional Streamfunction

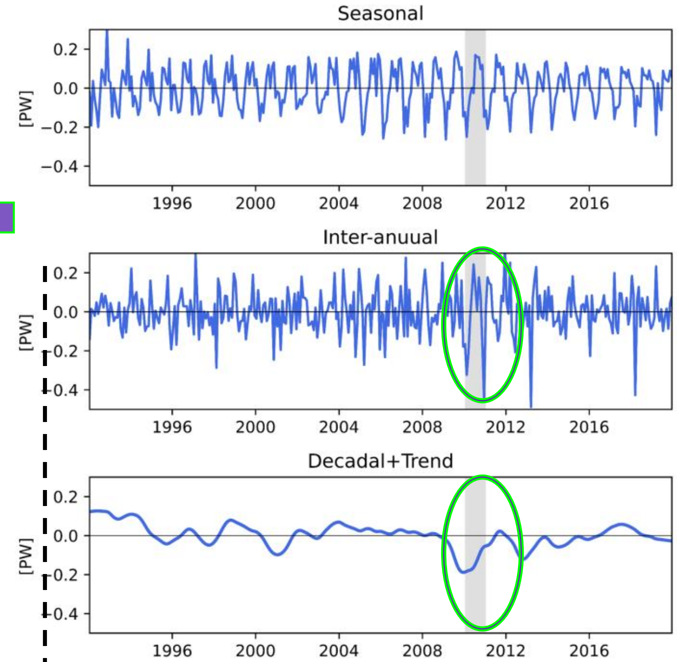


AMOC and MHT variability

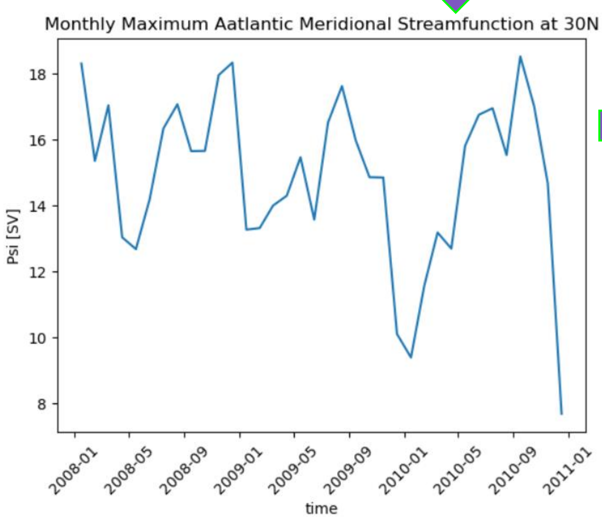
AMOC Variability at 30N

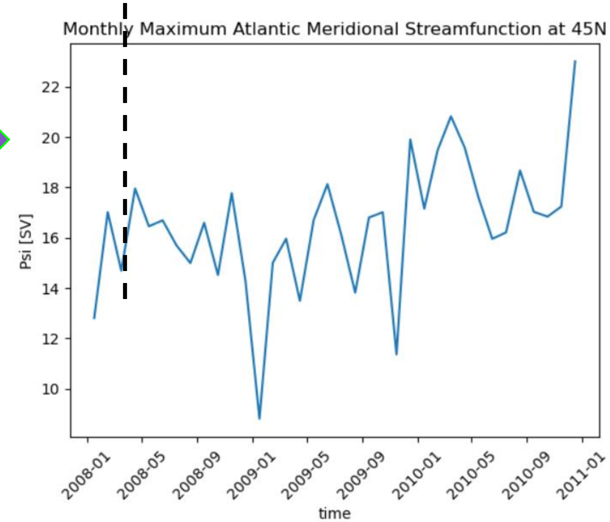


MHT Variability at 30N



2010 drop associated with inter-annual & decadal variability

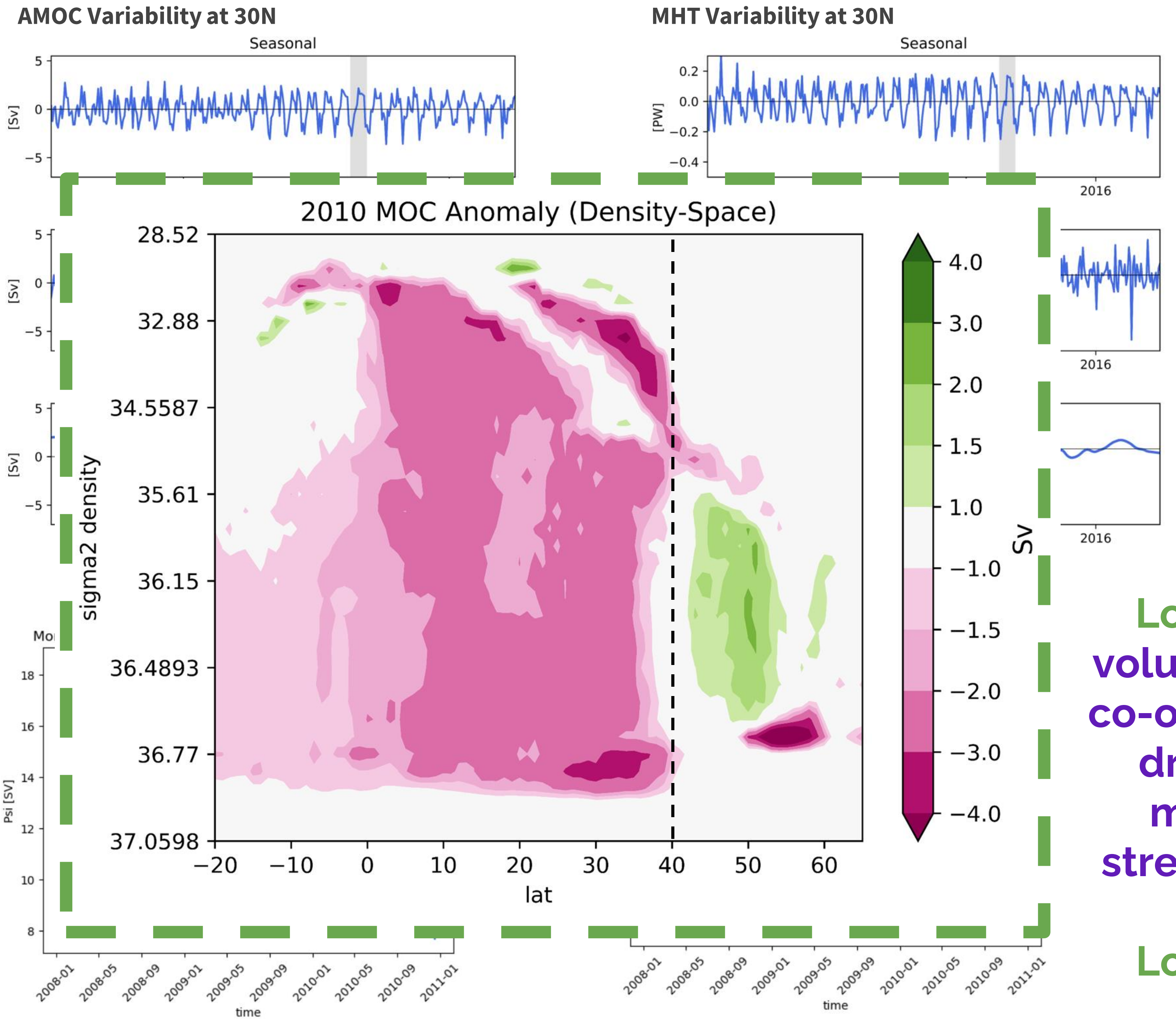




Local drop in volume transport co-occurring with drop in MHT; meanwhile, strengthening in SPNA

Local cause?

AMOC and MHT variability



2010 drop associated with inter-annual & decadal variability

Local drop in volume transport co-occurring with drop in MHT; meanwhile, strengthening in SPNA

Local cause?

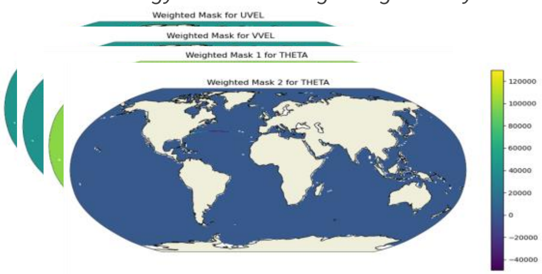
What caused the 2010 decrease in MHT at 30N?

Use EMU Adjoints, Attribution, and Convolution to identify the causes

(Overcome) Challenge: How to define a linear objective function for our quality of interest?

$$\mathrm{OHT}(y) = \rho_0 c_p \int_{x_w}^{x_e} \int_{-H}^{0} v(x,y,z)\, T(x,y,z)\, dz\, dx \longrightarrow V'\bar{T} + \bar{V}T'$$

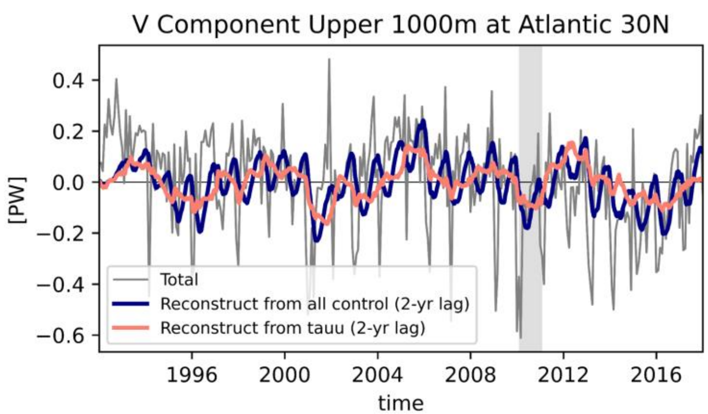
Four climatology- and area-weighted geometry masks



☐ "**T as objf**" run worked!

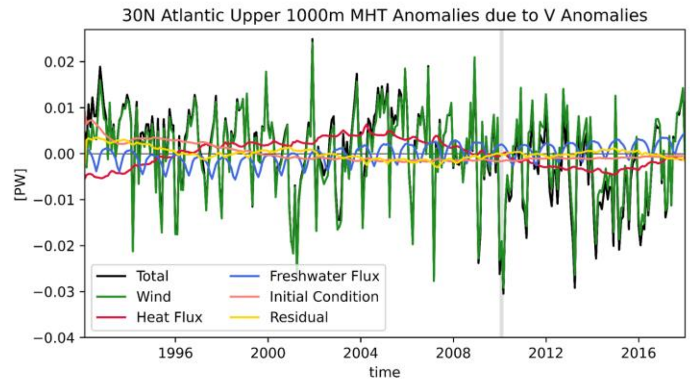
☐ "**V as objf**" run didn't?!

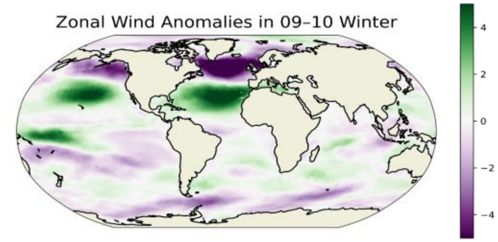
Fixed!



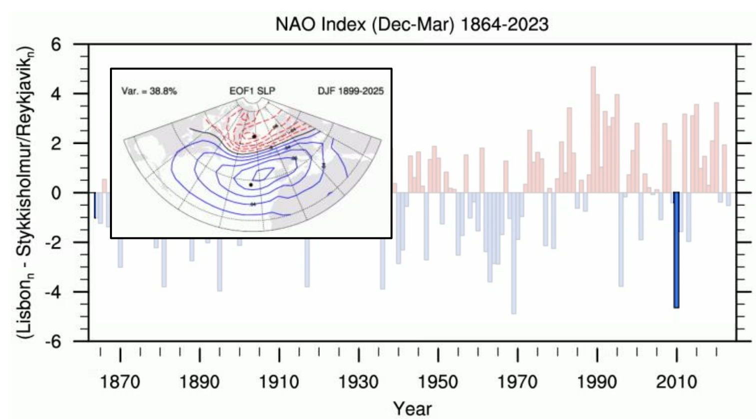
Local zonal wind forcings account for a large portion of interannual & decadal variability. Total–reconstruction difference due to forcings > 2 year lags? Non-representation of wind-forcing on intra-annual time scales?

Wind forcing causes velocity anomaly at Atlantic 30N in 2010





Weak subtropical easterlies are likely linked with the **–NAO** event.



Reflection

CHALLENGES

- P cluster glitches that failed our adjoints? And Job queues
- ECCO grids (sometimes, U is V)
- Information overload…
- Interpreting EMU outputs (would appreciate a more detailed documentation of output variables' meanings)

NEW SKILLS ACQUIRED

- `ecco_v4_py`, EMU tools.
- Adaptability
- Communication & Responsibility
- Conflict Resolution (LOL)
- Learned how to use GitHub effectively

THINGS LEARNED

- Compute AMOC in density space.
- Diagnosing abrupt changes in Atlantic MHT using EMU Attribution and Adjoint tools.

WHAT IF THERE WERE ANOTHER WEEK…

- Further analyze convolution simulations and adjust experiment set-ups.
- Examine strong seasonality in 10°N AMOC and the negative correlation with subpolar North Atlantic and South Atlantic MOC.