AMOC Variability and Its Impact on Atlantic Heat Transport in ECCO V4r5

Clark Zimmerman [1] Yifei Fan [2] Tanvir Shahriar [3]

[1]UW–Madison [2]Penn State [3]UT Austin

Overview

Objective

Understanding AMOC variability in the Past 3 decades and its impact on Atlantic heat transport in ECCO V4r5.

Highlights

- A Python routine to compute the density-space AMOC.
- Comparison of depth-space and density-space AMOC mean state and variability.
  - Subpolar AMOC signal is only captured in density space.
  - Both frameworks show meridional incoherence in interannual AMOC variability.
- Diagnosis of the sharp 2010 drop in MHT at 30°N using EMU Attribution and Adjoint tools.
  - Anomalous weak subtropical easterlies are responsible! Likely linked with negative NAO phase.

Resources Used

- **ECCO V4r5:** temperature, density, volume flux, velocity, and grid products.
- **Tools:** `ecco_v4_py`, `ecco_access`, OSS, P-Cluster, EMU Tools.
- ESS25 Tutorials, `ecco_v4_py` Tutorials.

Math Background

Streamfunction Representations

$$\psi(y,z) = \int_z^0 \int_{x_w}^{x_e} v(x,y,z')\,dx\,dz'$$

Streamfunction in Depth Space

$$\psi(y,\sigma) = \int_\sigma^\infty \int_{x_w}^{x_e} v(x,y,\sigma')\,dx\,d\sigma'$$

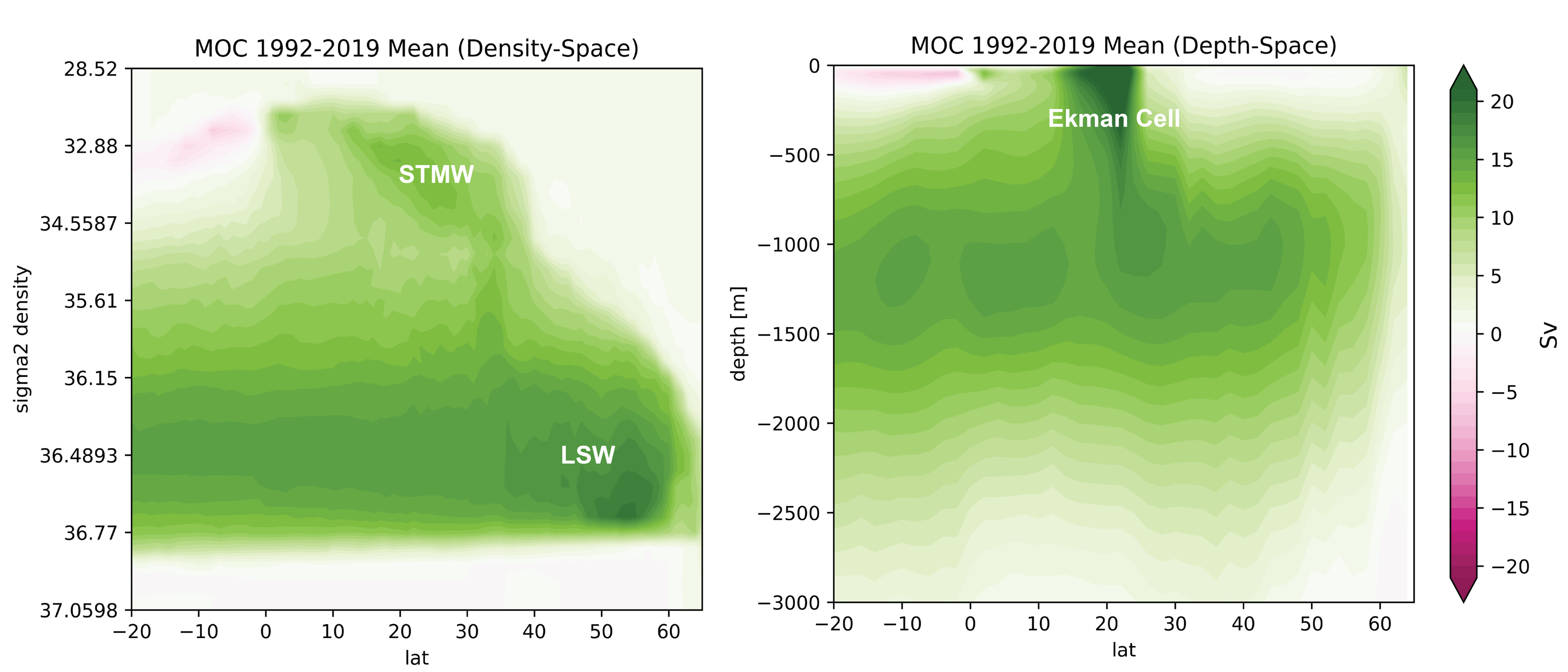
Streamfunction in Density Space

Ocean Heat Transport (OHT)

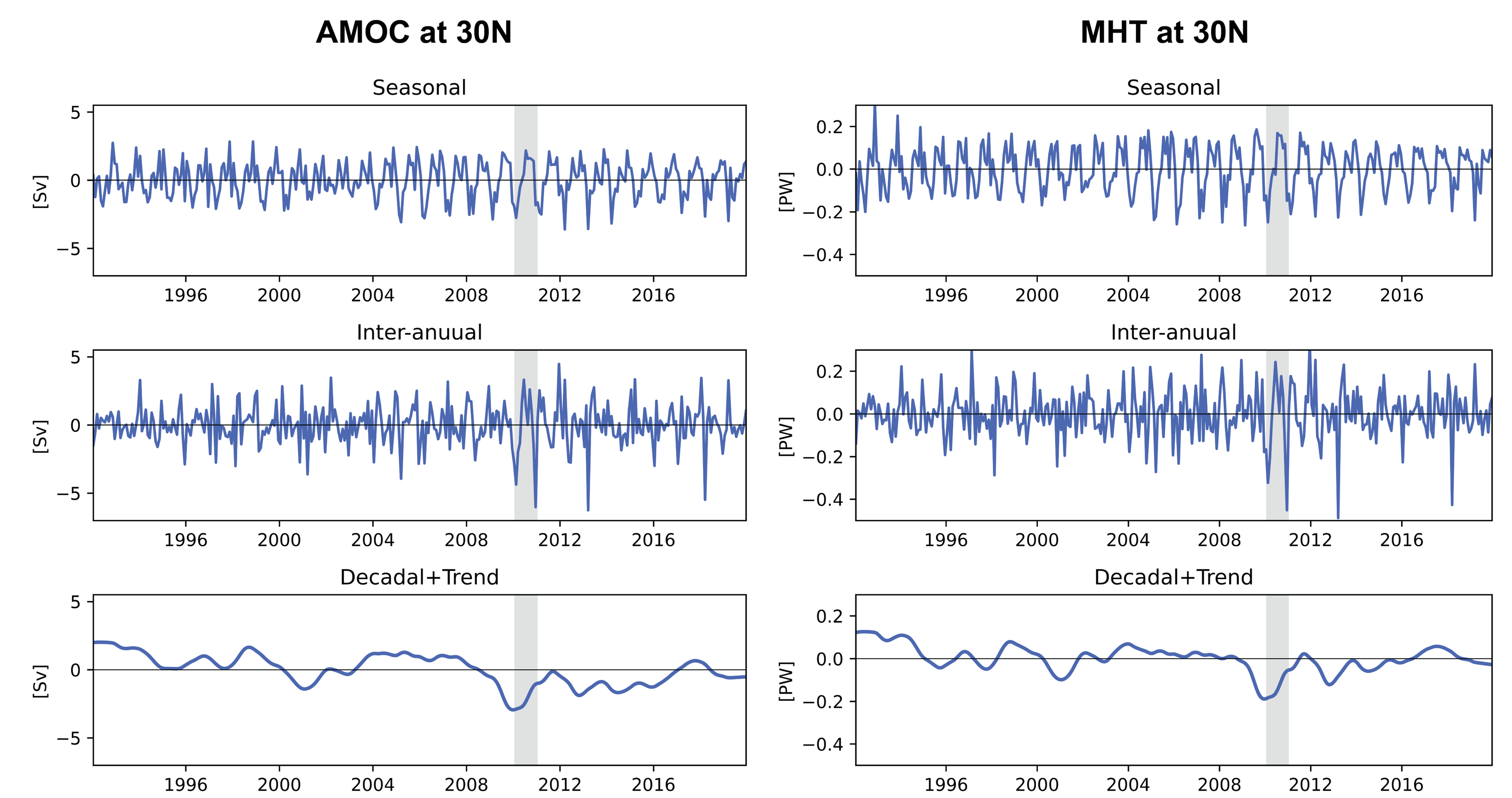
$$\mathrm{OHT}(y) = \rho_0 c_p \int_{x_w}^{x_e} \int_{-H}^{0} v(x,y,z)\,T(x,y,z)\,dz\,dx$$

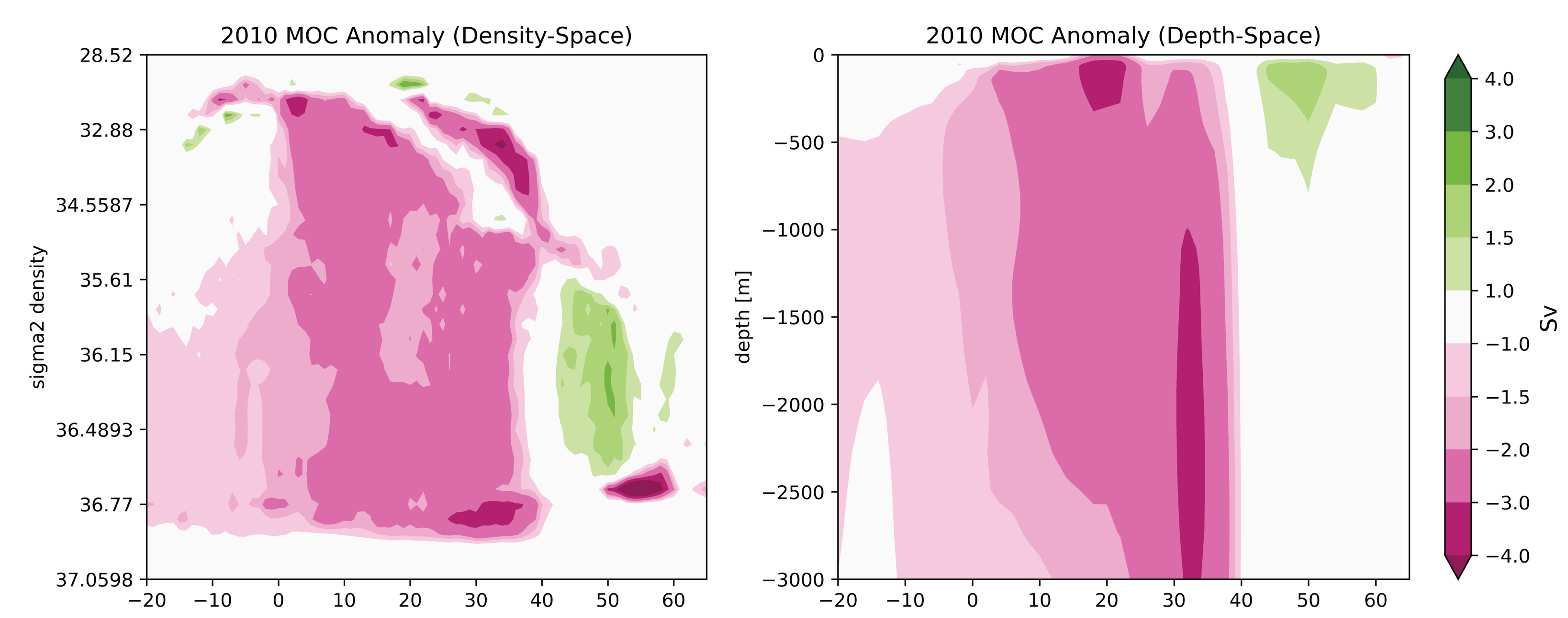
Where ρ_0 is the reference density, c_p is the specific heat capacity, v is meridional velocity, T is temperature, and σ is the potential density (e.g., σ_2 referenced to 2000 dbar).

Mean State Comparison

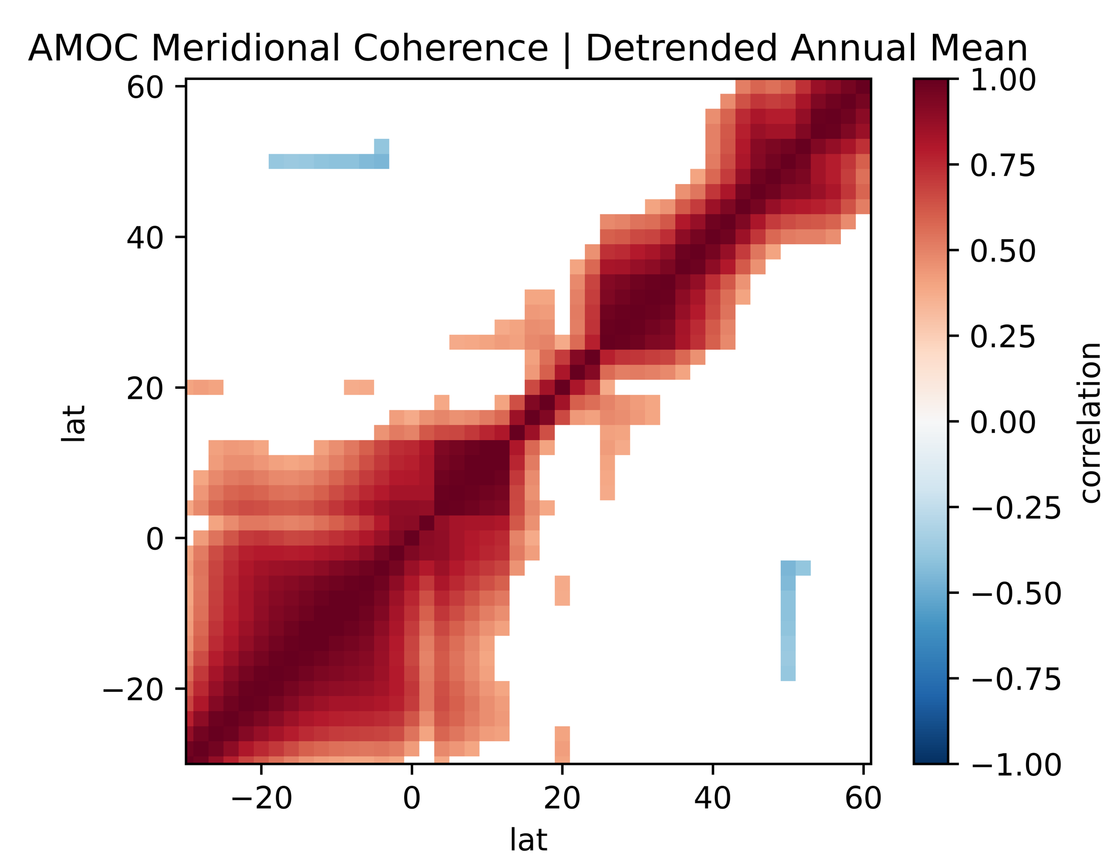


Sharp Decrease in 2010

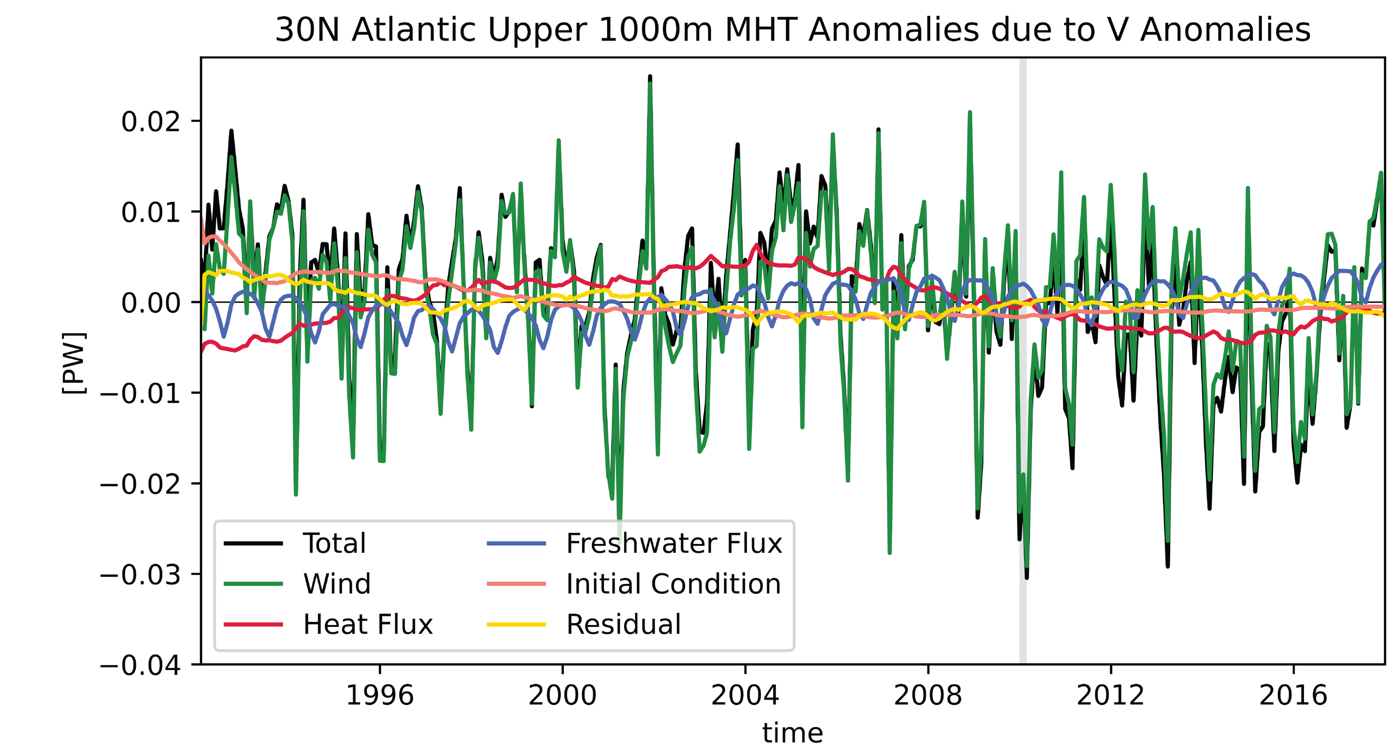


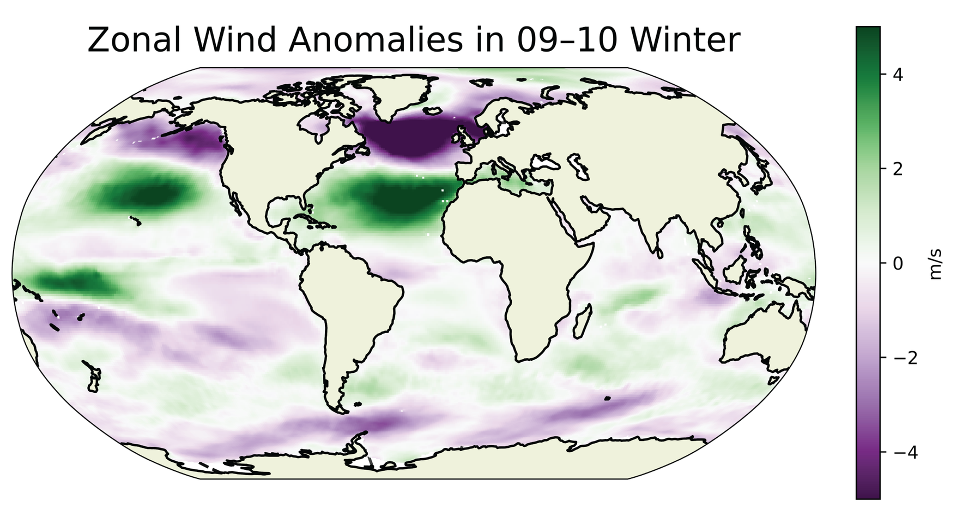


Meridional Coherence



Attribution of the Decrease

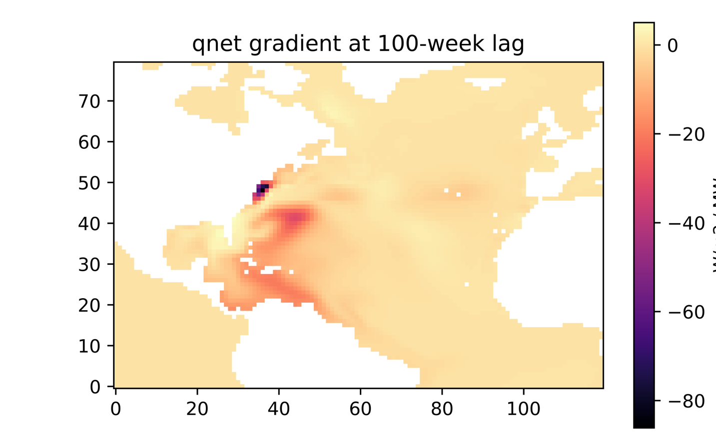




Conclusion

Challenges

- Inconsistent adjoint run behavior — one worked while another failed, possibly due to conflicts with the P-cluster or other system issues.
- Job queue delays and limited runtime — the convolution run had not started by the time this poster was completed.



Future Work

- Complete all adjoint runs to identify controls on the 2010 velocity anomalies at 30°N.
- Run convolution simulations to further investigate causality.
- Investigate strong seasonality in AMOC at 10°N and its negative correlation with subpolar North Atlantic and South Atlantic MOC.

References

[1] Carl Wunsch and Patrick Heimbach.
Two decades of the amoc: Anatomy, variations, extremes, prediction, and overcoming its limitations.
Journal of Climate, 26(18):7167–7186, 2013.