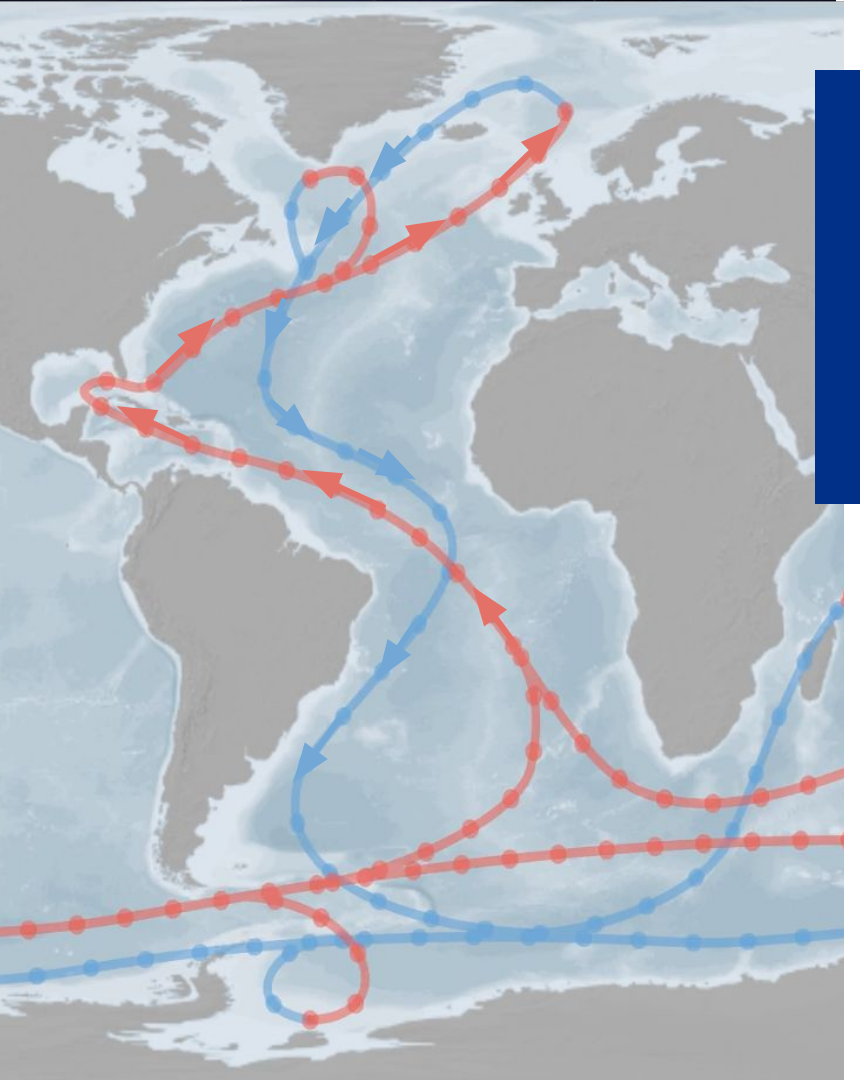


Attributing the historical AMOC changes

Presenter: Sang-Ki Lee

Atlantic Oceanographic & Meteorological Laboratory
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Our Goal

Utilizing historical hydrographic observations to reconstruct the AMOC pathways and to attribute their changes during the recent and the entire instrumental periods.

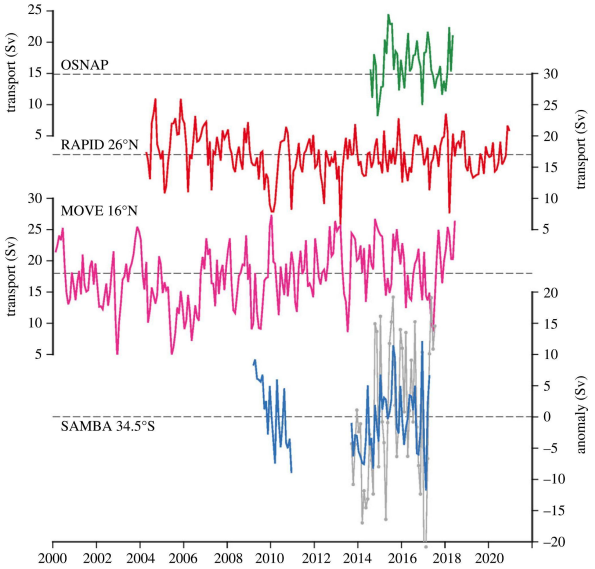
Attributing the historical AMOC changes

2019
Validated a method to construct the mean AMOC pathways utilizing hydrographic data

2023
Estimated interdecadal changes in the historical AMOC using hydrographic data

2024
Addressed why climate models display a stronger-than-observed weakening of the AMOC

Volkov et al. (2020)

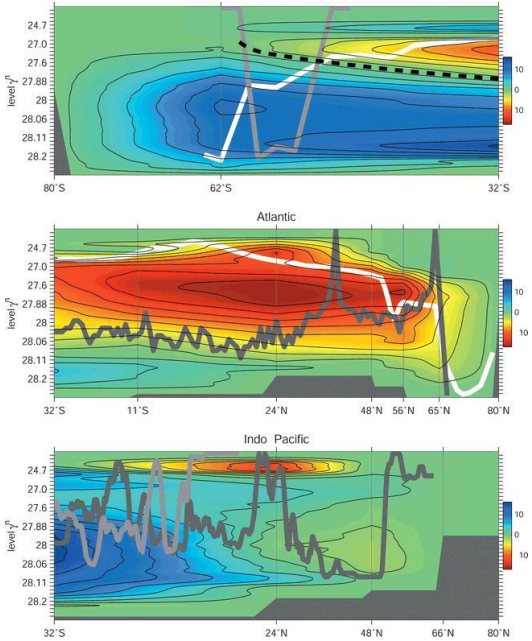


Frajka-Williams et al. (2023)

Utilizing hydrographic data to construct the mean AMOC pathways

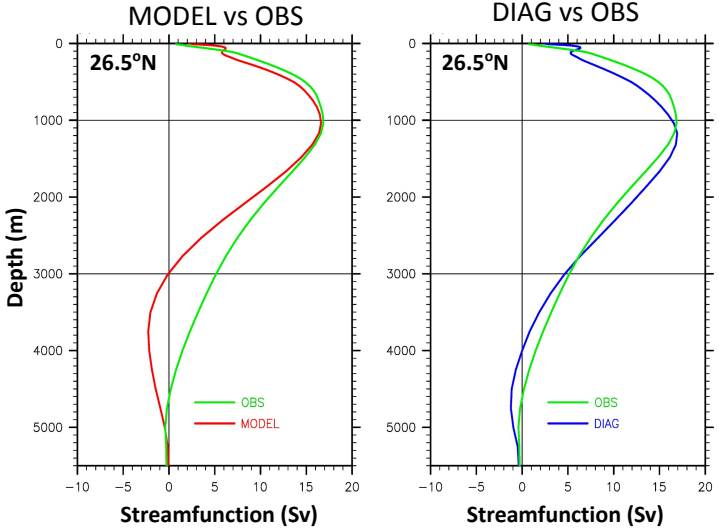
Inverse-model estimate of the AMOC

Lumpkin & Speer (2007)



- Inverse models have several critical limitations
- Constrained an ocean model using hydrographic T/S data
- Reconstructed AMOC profile matches well with the observation

Hydrography-based estimate of the AMOC



Lee et al. (2019)

Geophysical Research Letters

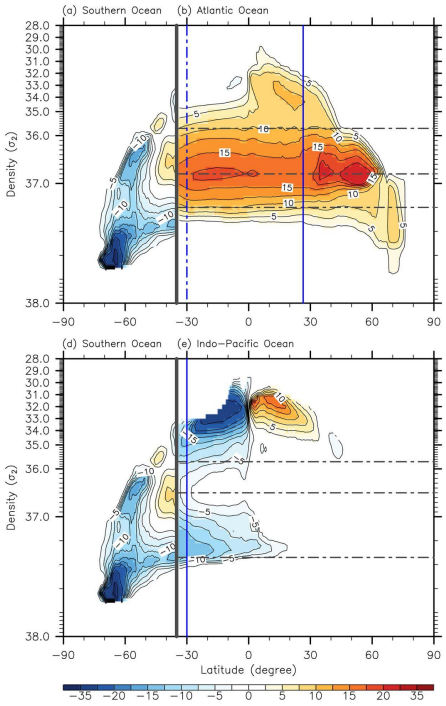
RESEARCH LETTER
10.1029/2018GL080940

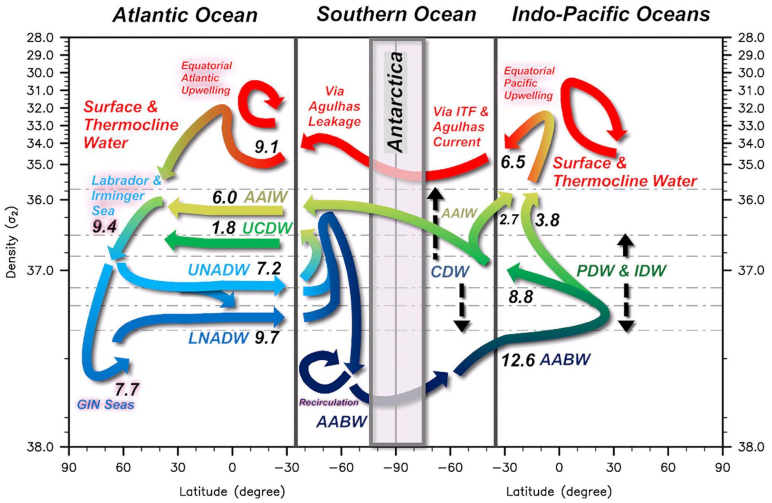
Global Meridional Overturning Circulation Inferred From a Data-Constrained Ocean & Sea-Ice Model

Sang-Ki Lee[1], Rick Lumpkin[1], Molly O. Baringer[1], Christopher S. Meinen[1], Marlos Goes[1,2], Shenfu Dong[1], Hosmay Lopez[1,2], and Stephen G. Yeager[3]

- The pathways of global MOC revisited & validated against observations
- Highlighted several underexplored & poorly captured features in models

Hydrography-based AMOC

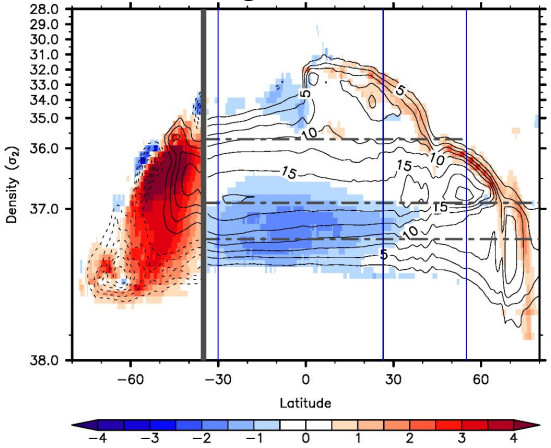




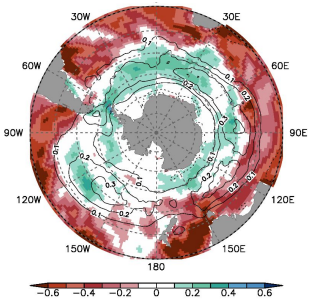
Estimating interdecadal changes in the historical AMOC

- Constrained an ocean using hydrographic T/S data for each decade
- Global changes in the MOC emerging from the Southern Ocean
- The upper cell expanded & strengthened, and the lower cell contracted & weakened

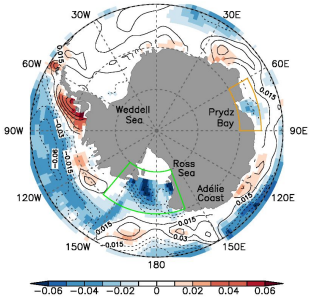
Hydrography-based AMOC & its changes in 2005-17



P - E & wind changes in 2005-17



Upper ocean density & salinity changes in 2005-17



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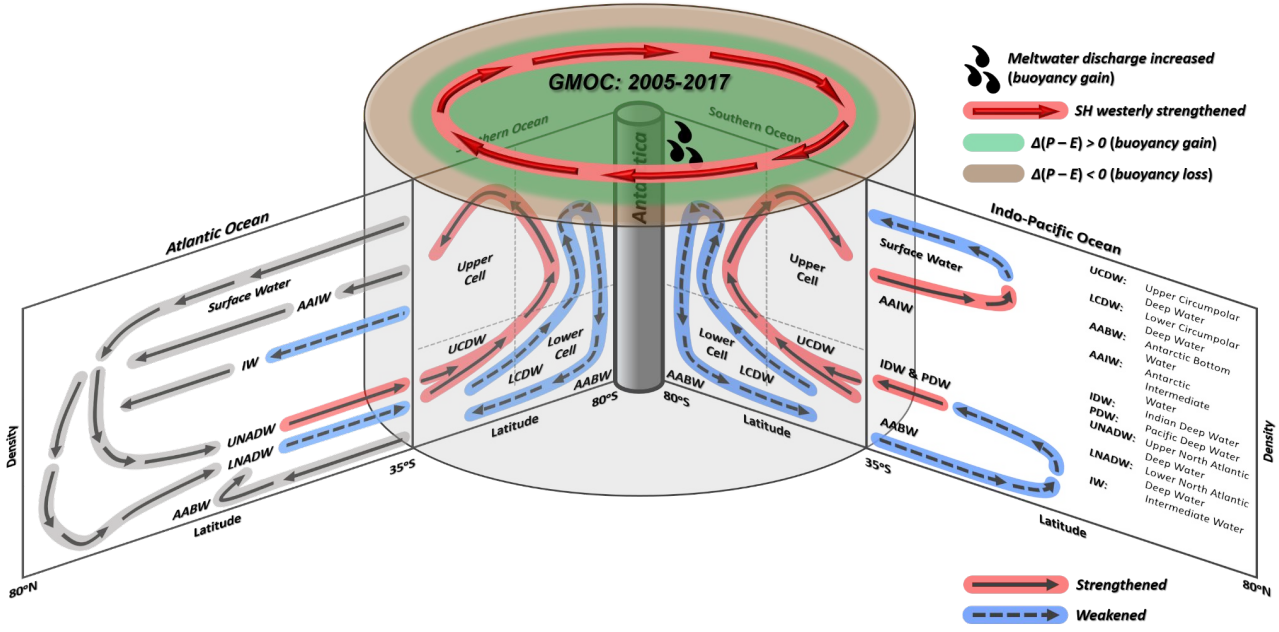
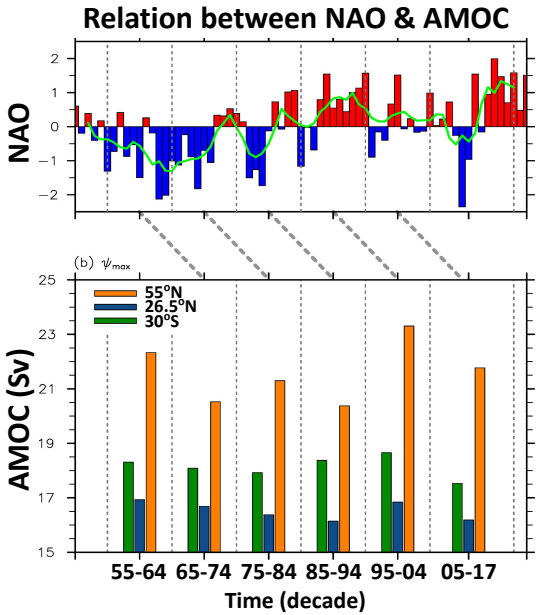
earth & environment

ARTICLE

https://doi.org/10.1038/s43247-023-00727-3 OPEN

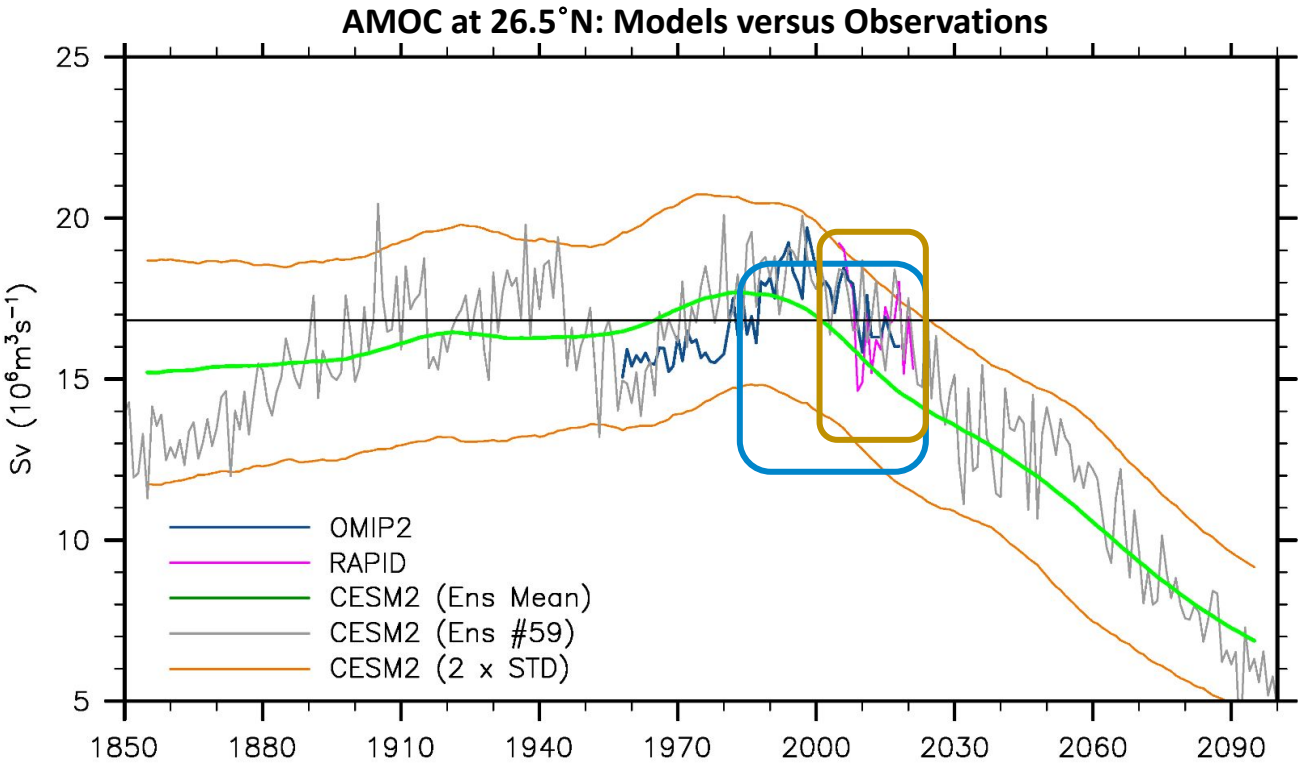
Human-induced changes in the global meridional overturning circulation are emerging from the Southern Ocean





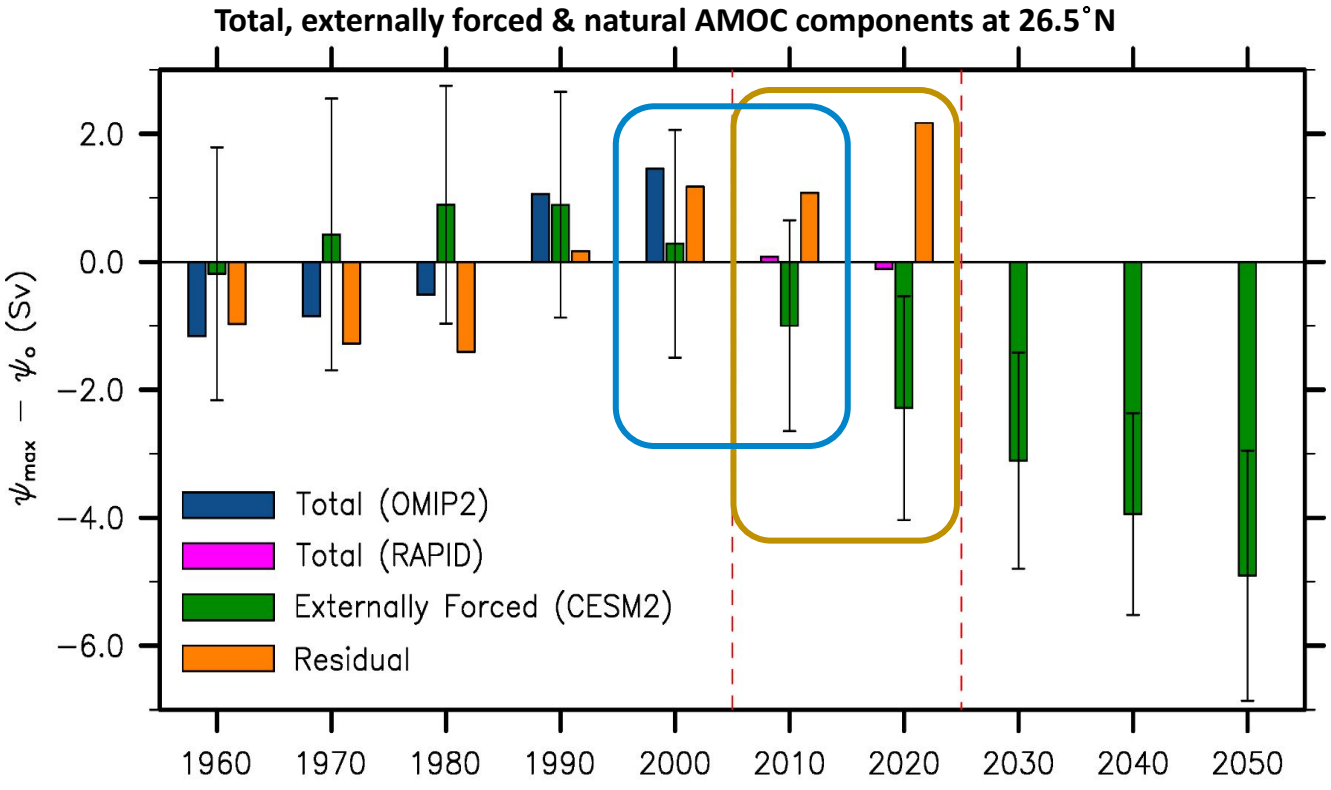
- No robust trend in the historical AMOC
- Interdecadal changes driven by the North Atlantic Oscillation (NAO)

Attributing the historical AMOC changes



- Models: A robust slowdown since the mid-1980s
- OBS: A stable AMOC in the past 20 years

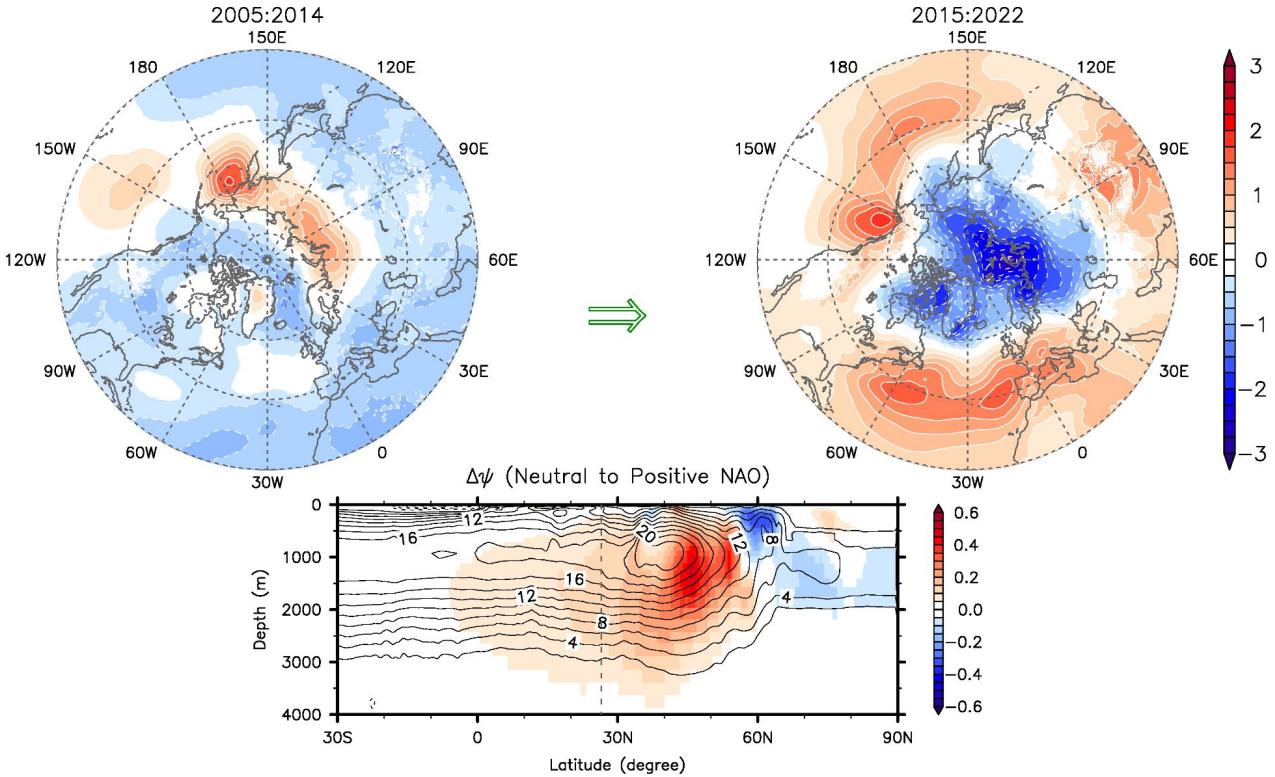
Attributing the historical AMOC changes



- An extensive weakening in the 2000s (blue box) due to anthropogenic forcing
- The natural component has strengthened since the early 2010s (brown box)
- Resulted in a pause in the AMOC weakening

Attributing the historical AMOC changes

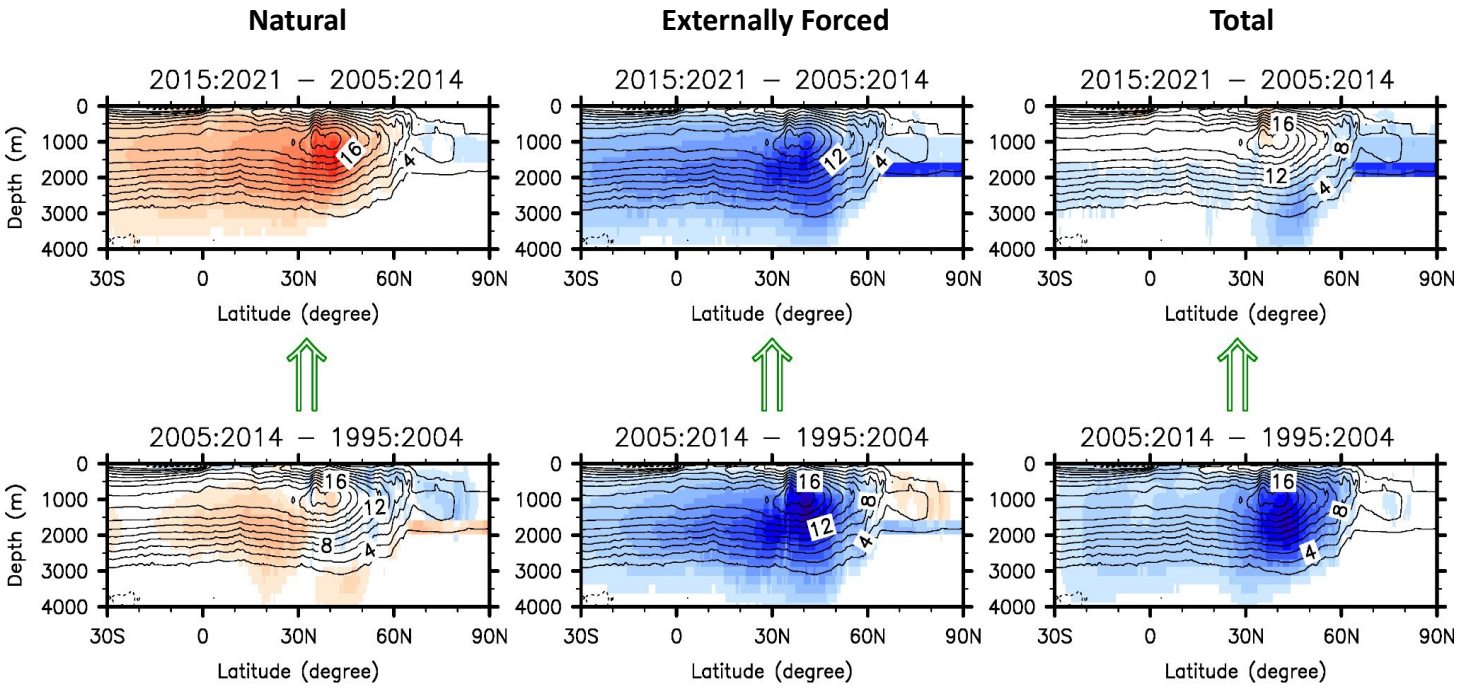
An increase in the natural AMOC component due to (+) NAO



- The natural AMOC strengthened due to a strong positive NAO since the early 2010s

Attributing the historical AMOC changes

Changes in natural, externally forced and total AMOC components



nature communications

Article

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A pause in the weakening of the Atlantic meridional overturning circulation since the early 2010s

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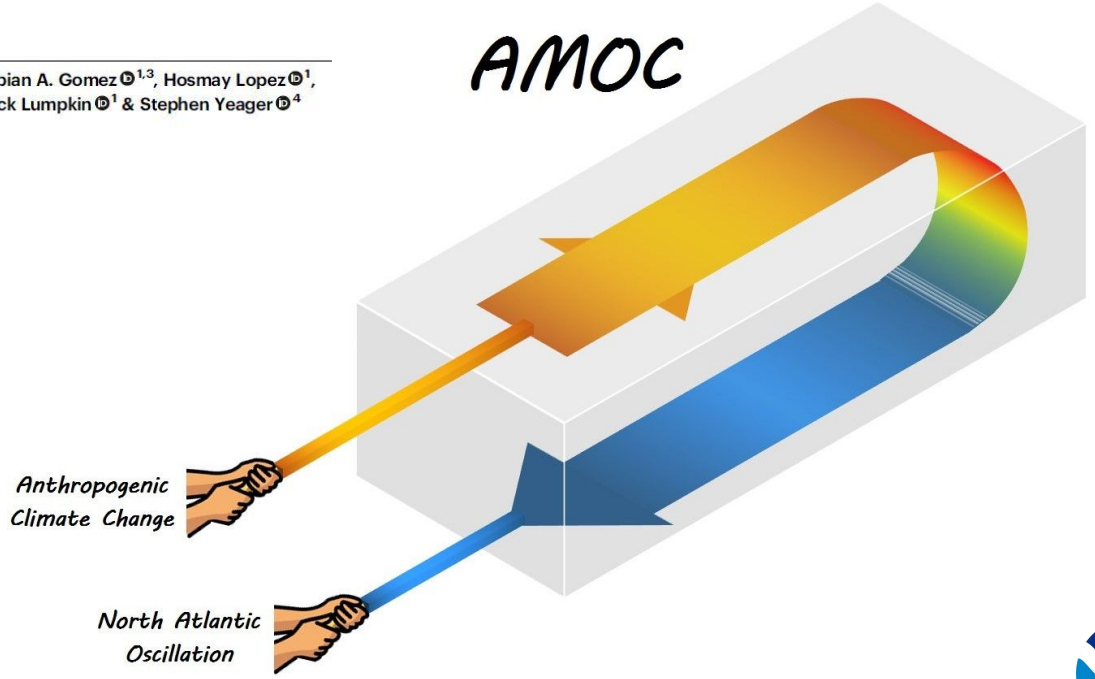
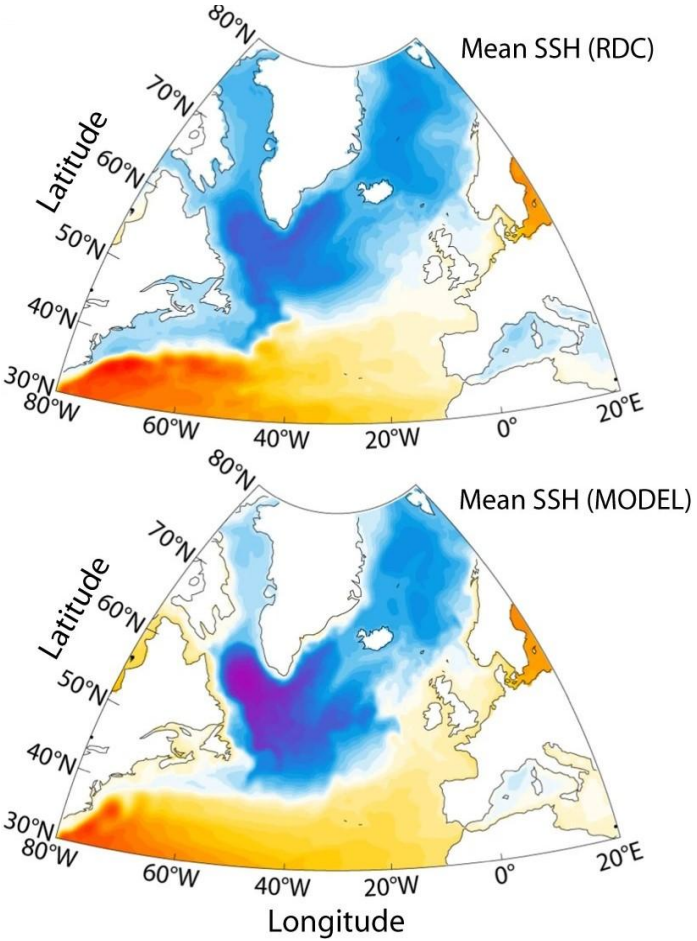
Sang-Ki Lee[1] ✉, Dongmin Kim[1,2], Fabian A. Gomez[1,3], Hosmay Lopez[1], Denis L. Volkov[1,2], Shenfu Dong[1], Rick Lumpkin[1] & Stephen Yeager[4]



What's Next?

- A high-resolution (1/4°) reconstruction of the historial AMOC
- Update the AMOC reconstruction every five years
- Interactions between natural & anthropogenic forcing



Zhang and Thomas (2021)

Collaborators

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Lee, S.-K., R. Lumpkin, M.O. Baringer, C.S. Meinen, M. Goes, S. Dong, H. Lopez, and S.G. Yeager. 2019: Global meridional overturning circulation inferred from a data-constrained ocean and sea-ice model. *Geophysical Research Letters*, **46**(3):1521-1530, https://doi.org/10.1029/2018GL080940

Lee, S.-K., R. Lumpkin, F. Gomez, S. Yeager, H. Lopez, F. Tagklis, S. Dong, W. Aguiar, D. Kim, and M. Baringer. 2023: Human-induced changes in the global meridional overturning circulation are emerging from the Southern Ocean. *Communications Earth & Environment*, **4**:69, https://doi.org/10.1038/s43247-023-00727-3

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