Stockholm University

OBSERVED MECHANISMS TRIGGERING THE RECENT WARMING IN THE EASTERN SUBPOLAR NORTH ATLANTIC SINCE 2016

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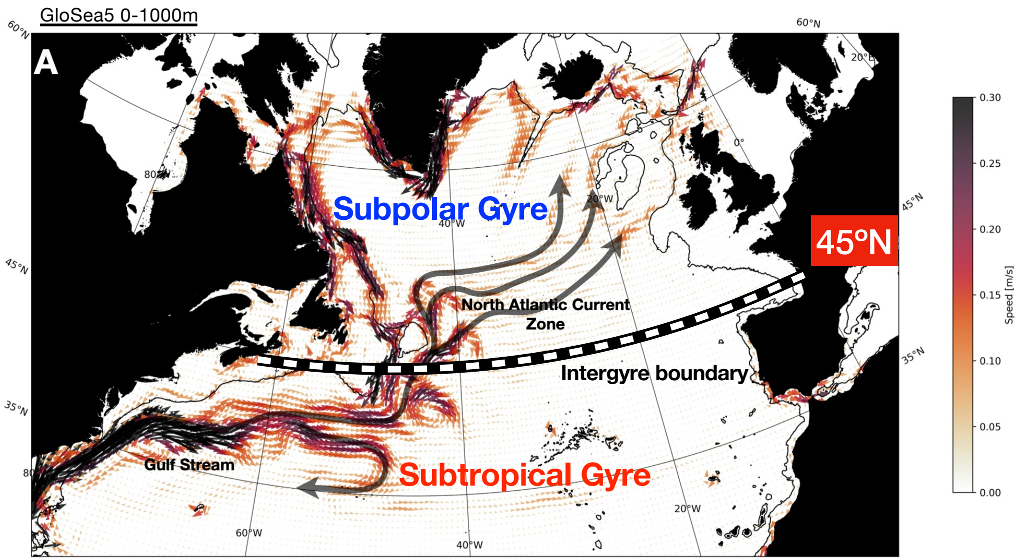
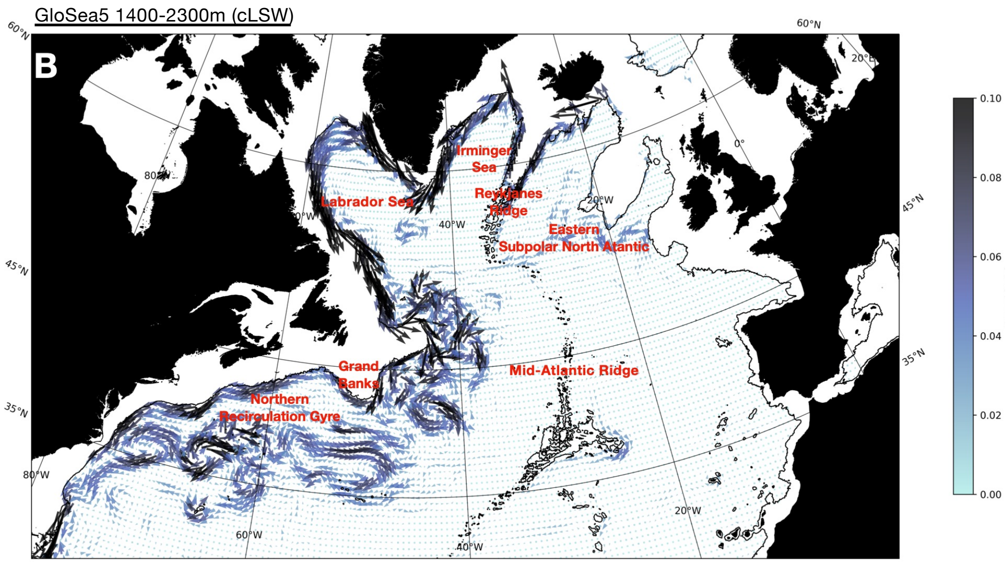
North Atlantic Ocean circulation

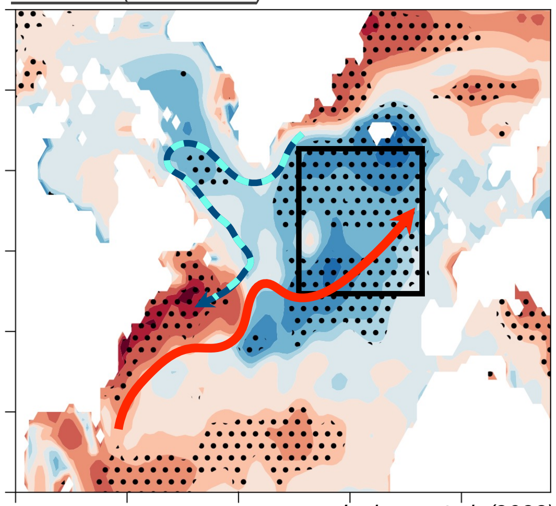




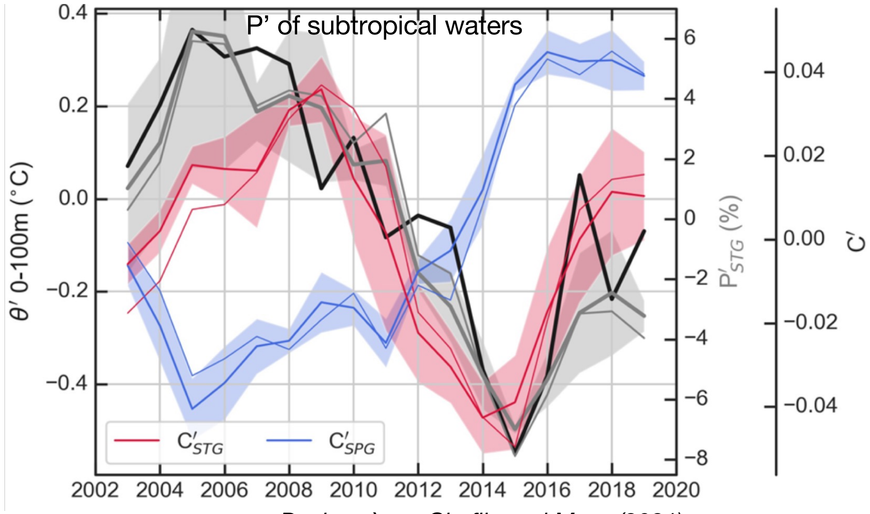
Introduction and key question

- The subpolar North Atlantic (SPNA) is characterized by pronounced decadal thermal reversals.
- Modeling work have generally connected these reversals to AMOC states.
- Since 2016, following the cold SPNA period since mid-2000s, a shift in ocean circulation is reported to have initiated a new warming phase.
- **<u>Motivation:</u>** To understand
  - the chain of mechanisms that activated this **enhanced influx of subtropical heat since 2016** from observations.
  - the degree to which **southward communication of deep density anomalies** is involved in driving this recent warming.

T' trends (2007-2015)

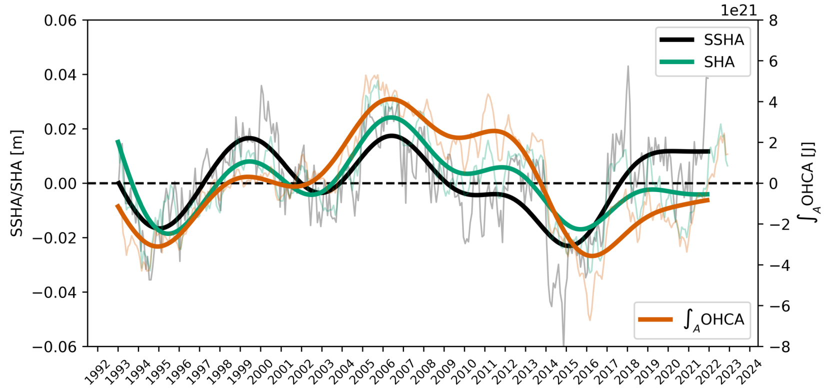


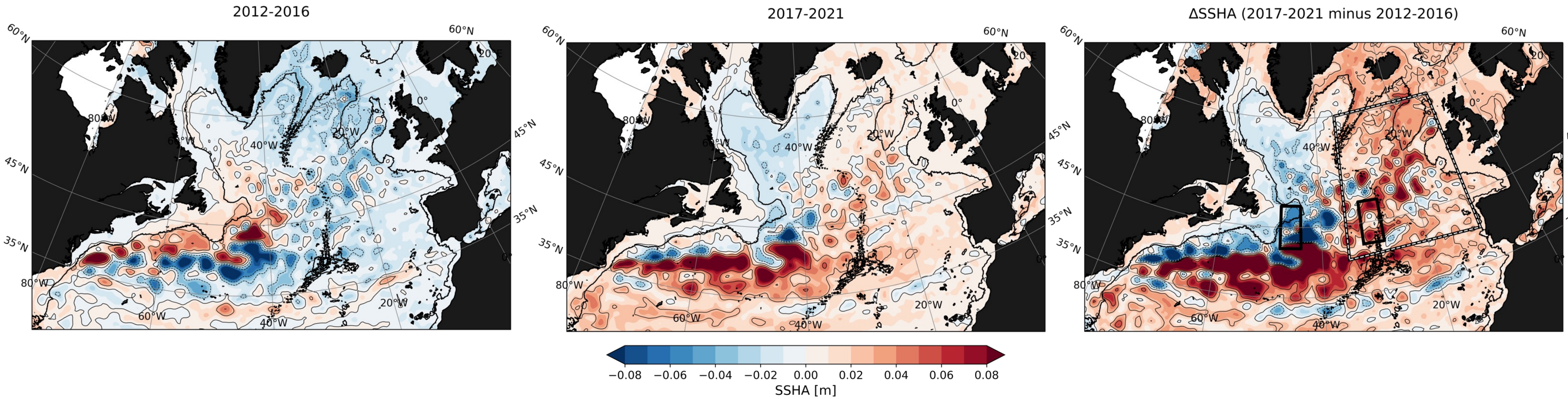
Jackson et al. (2022)



Desbruyères, Chafik, and Maze (2021)

Insights into the evolution of the recent warming in the eastern SPNA since 2016



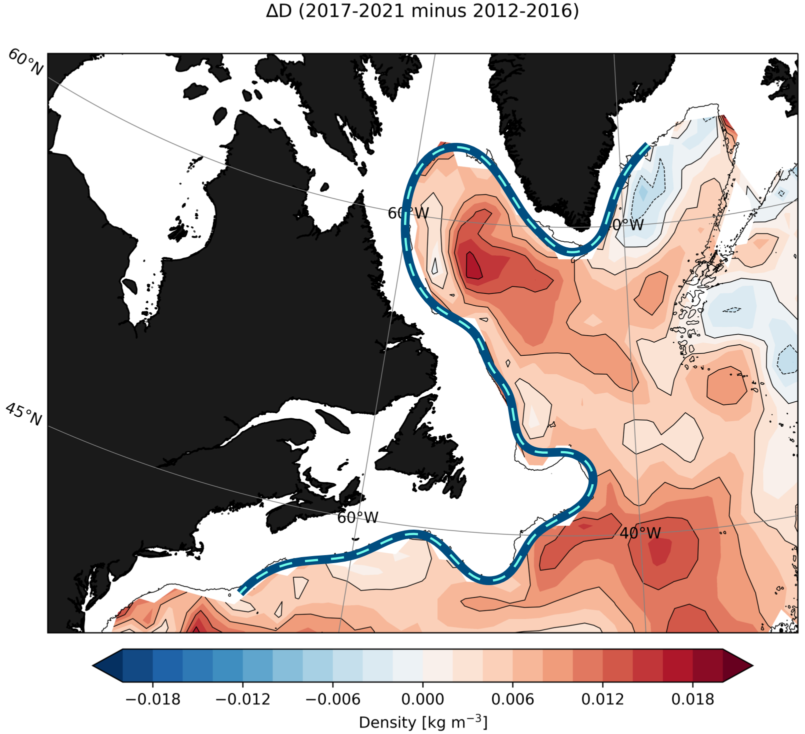


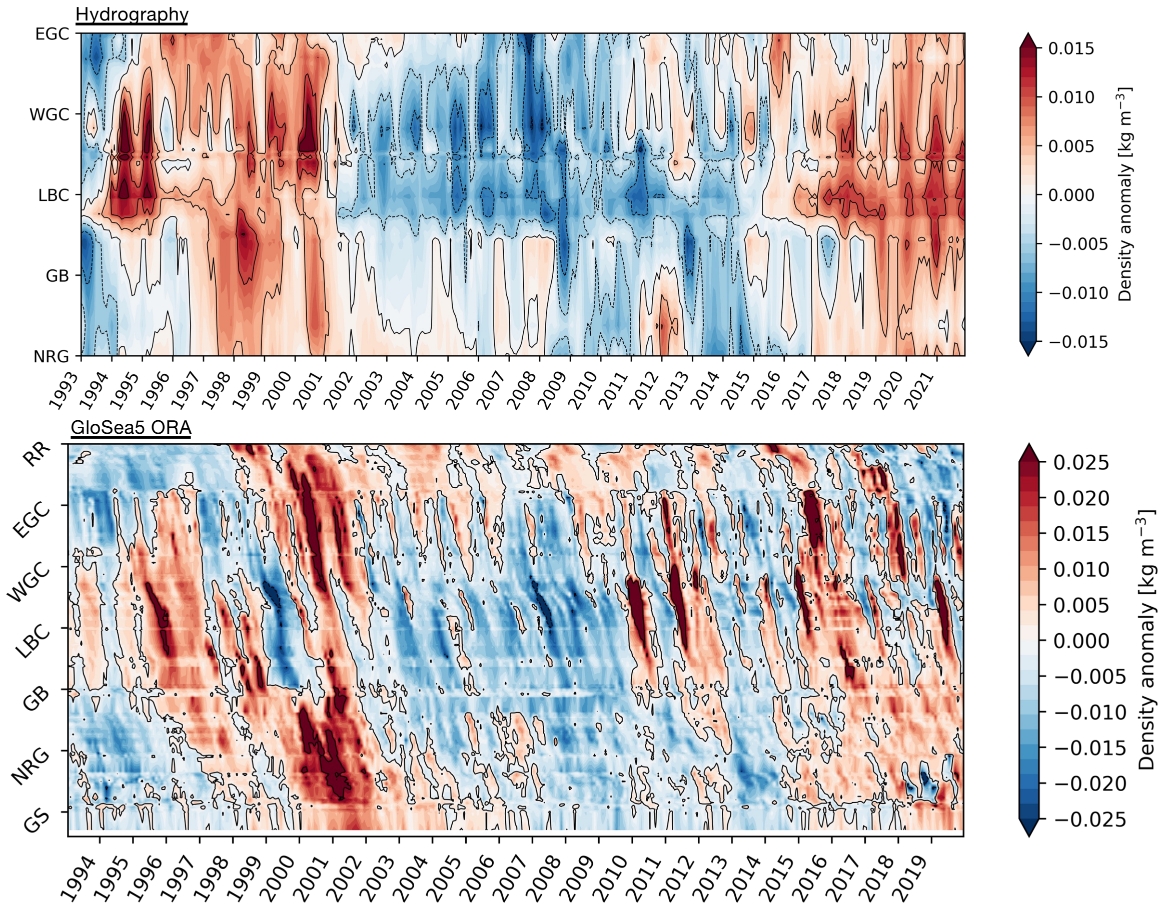
- Cooling and enhanced watermass transformation
- Weak northward geostrophic flow by the NAC and decreased ocean heat supply to the eastern SPNA

- Warming associated with increased advection of subtropical waters
- Positive ΔSSHA at the intergyre boundary and strengthened NAC

- Supports the notion of anomalous surface heat advection into the eastern SPNA by the NAC, *but there is more to the story…….*

Southward spreading of deep density anomalies

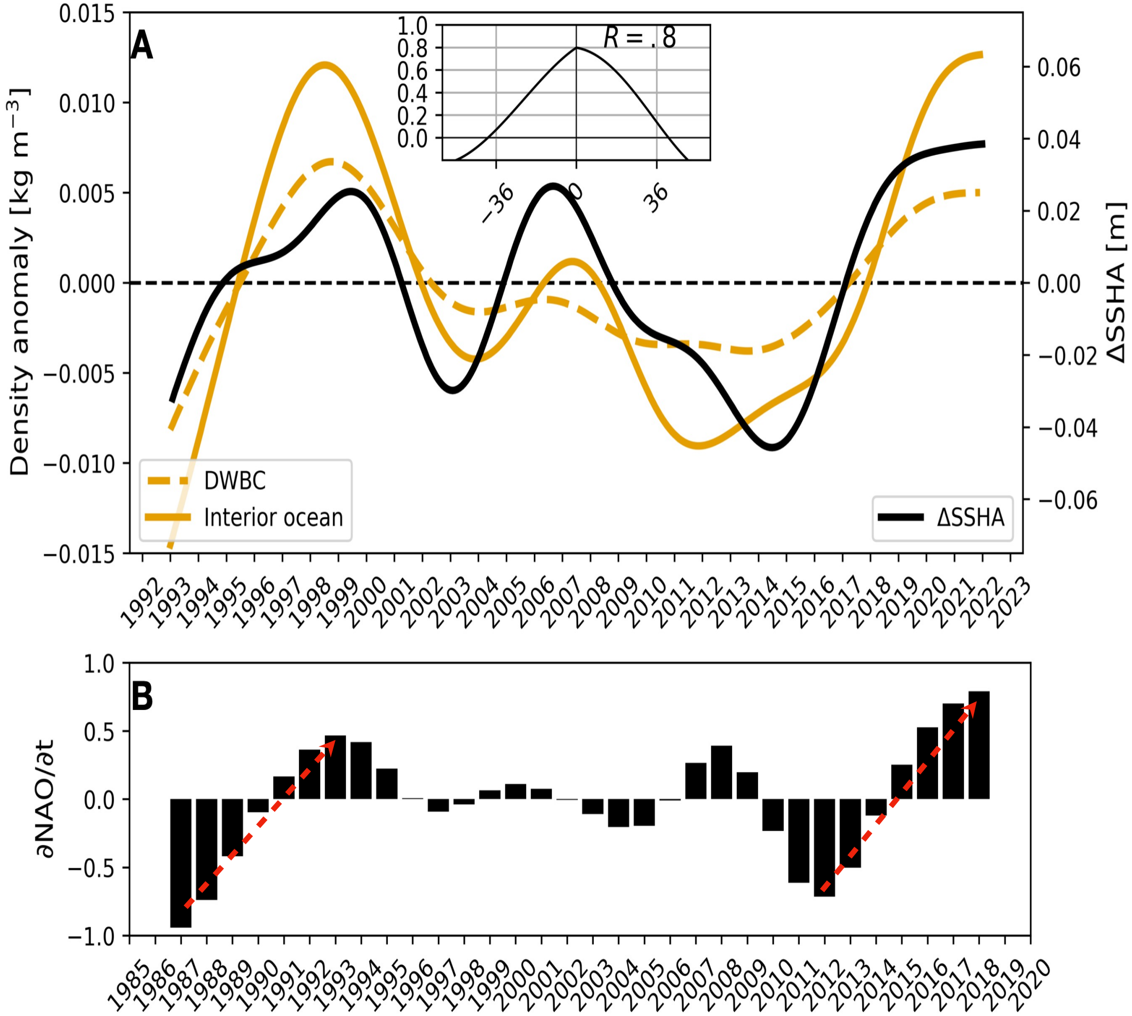




- A notable basin-wide increase of positive density anomalies along the entire western boundary
- These deep density anomalies drive NAC transport anomalies by inducing large-scale SSH gradients
- The increased influx of heat into the eastern SPNA since 2016 by the NAC can thus be related to the *progressive increase in the deep density anomalies along the western boundary*.

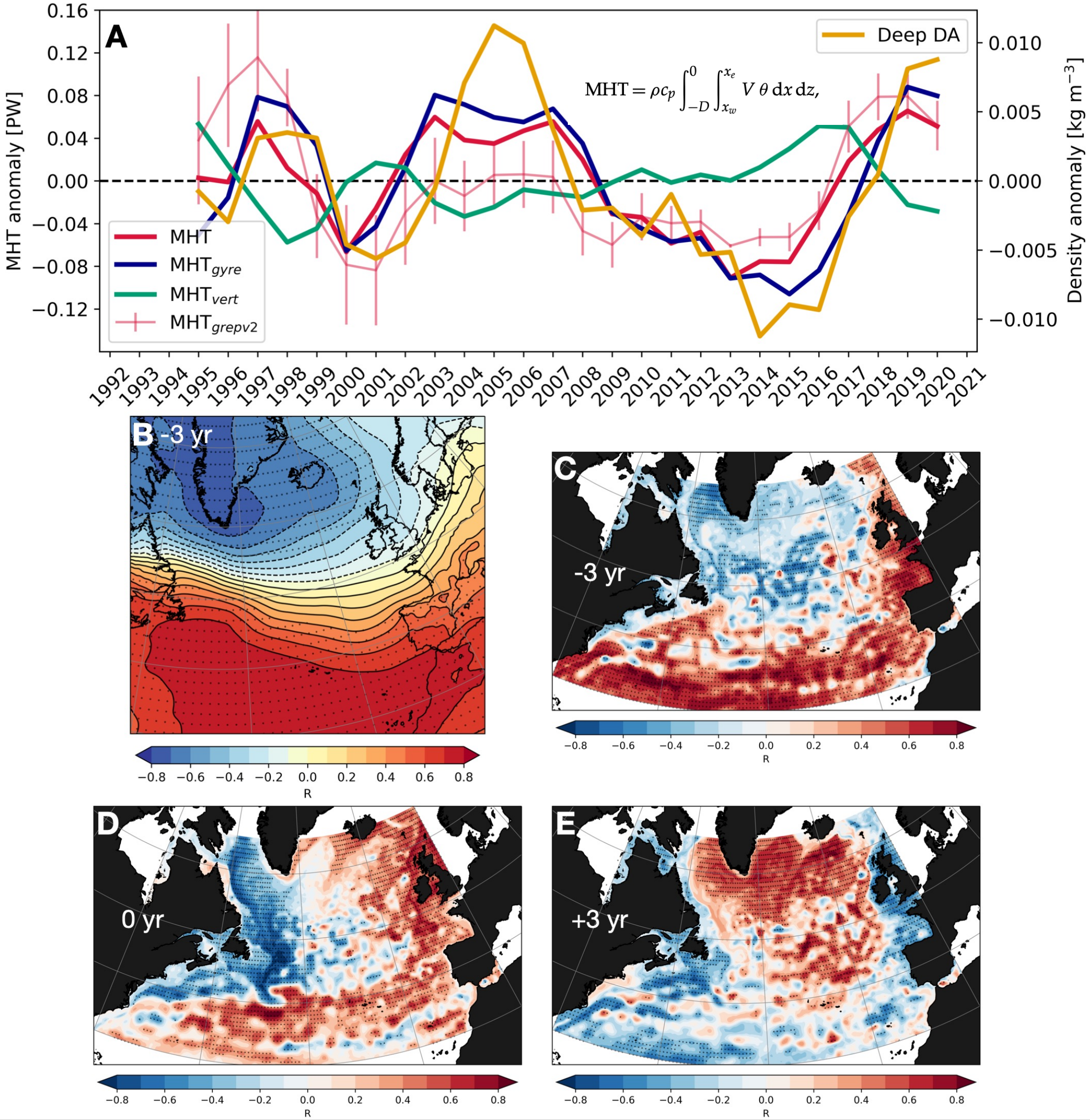
Deep Western Boundary Current density and relationship to NAC strength

- WBC density exhibits a clear decadal variability coinciding with the strength of the NAC and hence the thermal reversals characterizing the SPNA.
- This is linked to NAO tendency and increased watermass transformation in the SPNA
- *NAC strength variations at the intergyre boundary are a response to changes in the subpolar overturning circulation and associated southward spreading of deep density anomalies along the western boundary.*



Meridional heat transport at the intergyre boundary: variability and linkages

- Increase in the total MHT at the intergyre boundary since ~mid-2010s in ORAs
- MHT variability is predominantly driven by anomalous changes in MHTgyre (accounts for 84% of the explained variance)
- MHTgyre shows a strong connection with deep density anomalies; it corresponds with their arrival to the intergyre boundary
- Anomalous increase in MHT and deep density anomalies at the intergyre boundary is primarily driven by NAO forcing that leads by ~3 yrs
- MHT variability notably imprints on SSH anomalies
- The main driver of the horizontal circulation and MHT is due to changes in the ocean density structure.



Summary

- We examined the mechanisms activating the warming in the eastern SPNA since 2016.
- This warming phase since 2016 is a result of intense subpolar overturning in the preceding years driven by the NAO.
- This coupling is accomplished by southward propagation of deep density anomalies along the western boundary; an essential element in these interactions.
- Changes to ocean density structure at the intergyre boundary is the main driver behind this event suggesting that wind forcing was not the primary cause.

*Chafik L, Penny Holliday N, Bacon S, Baker JA, Desbruyères D, Frajka-Williams E, Jackson LC. 2023 Observed mechanisms activating the recent subpolar North Atlantic Warming since 2016. Phil. Trans. R. Soc. A **381**: 20220183. https://doi.org/10.1098/rsta.2022.0183*