A multi-model comparison of the ocean contributions to multidecadal variability in the North Atlantic

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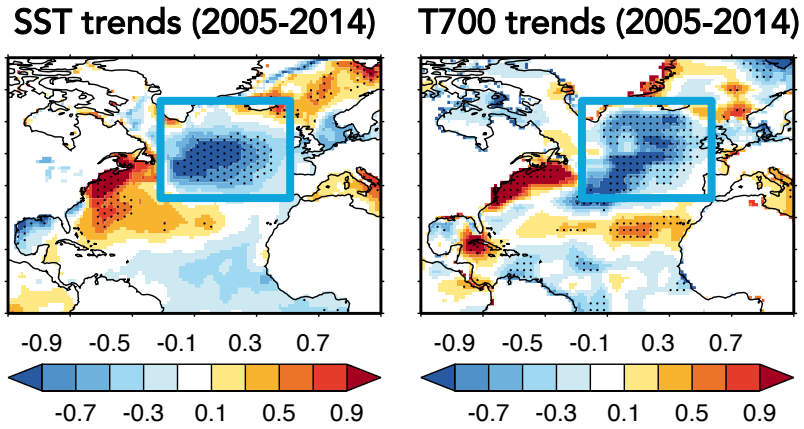
L. Hermanson, M. Menary (Metoffice, Exeter)
S. Yeager (NCAR, Boulder)

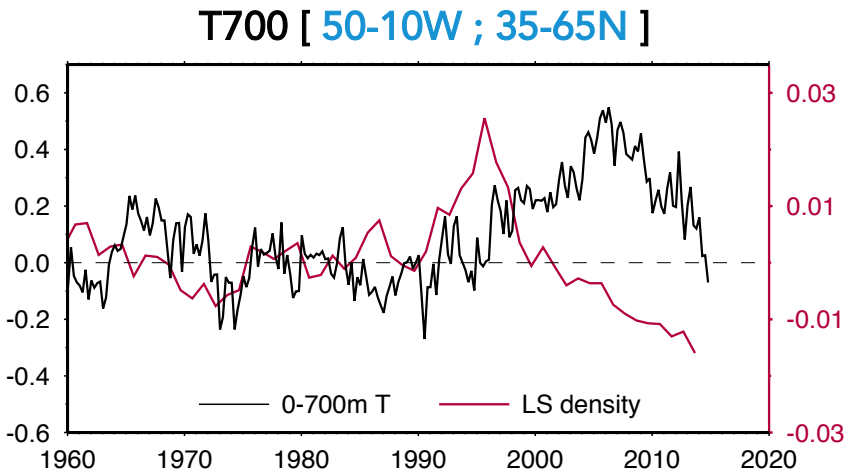
I. Context and Motivation

Origins of the cold-blob

Robson et al (2016)



A Labrador Sea density (LSD) decline preceded the occurrence of the recent cold blob in the North Atlantic



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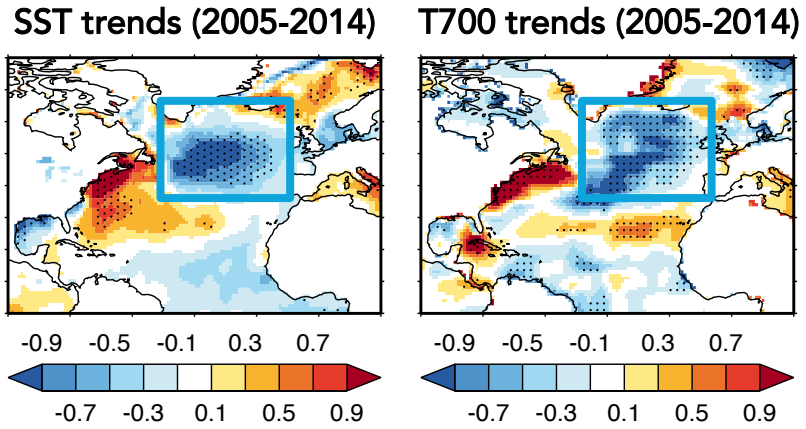

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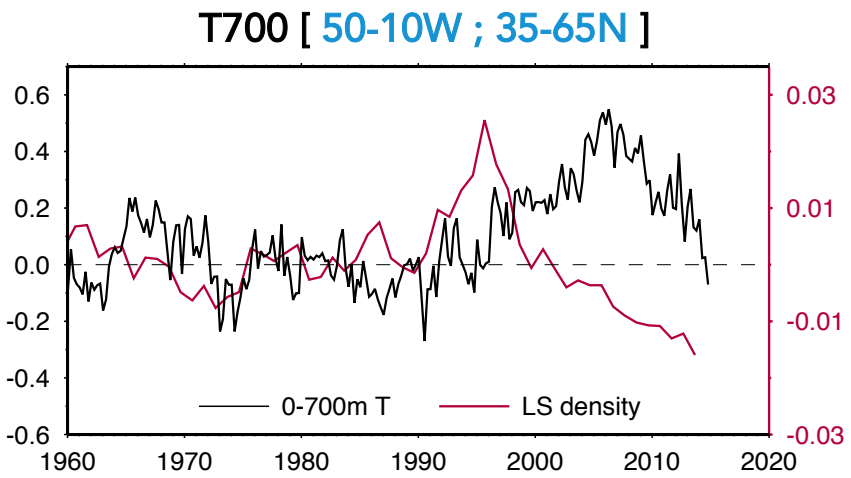

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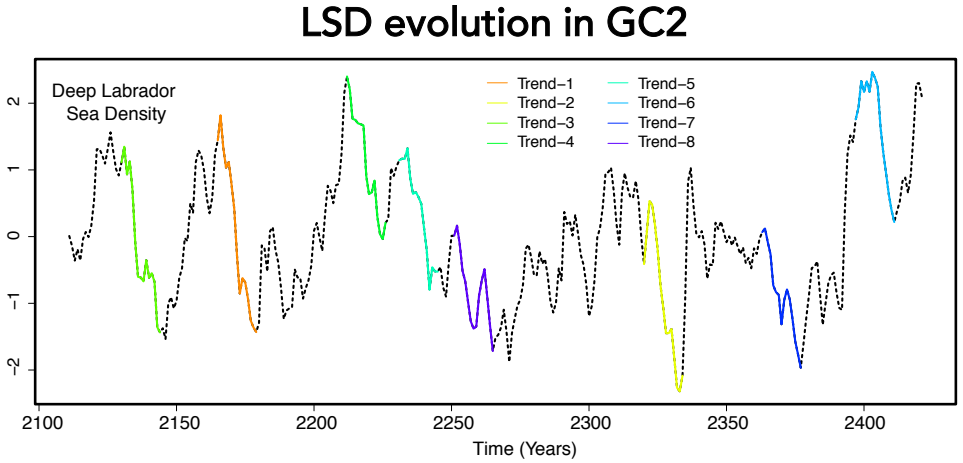
Preindustrial control experiment (310 yrs)

Eddy-permitting resolution (1/4° ocean)



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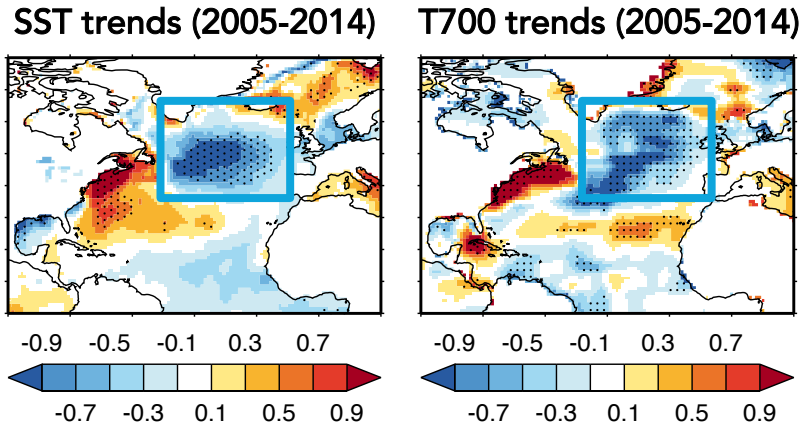

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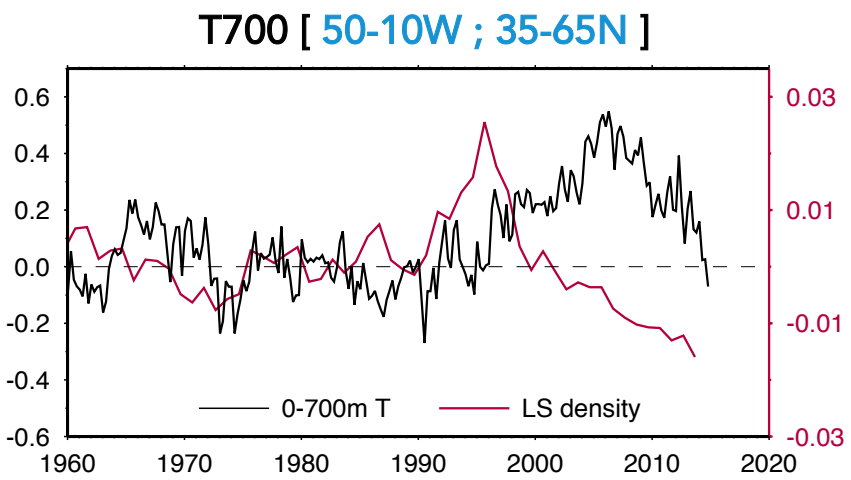
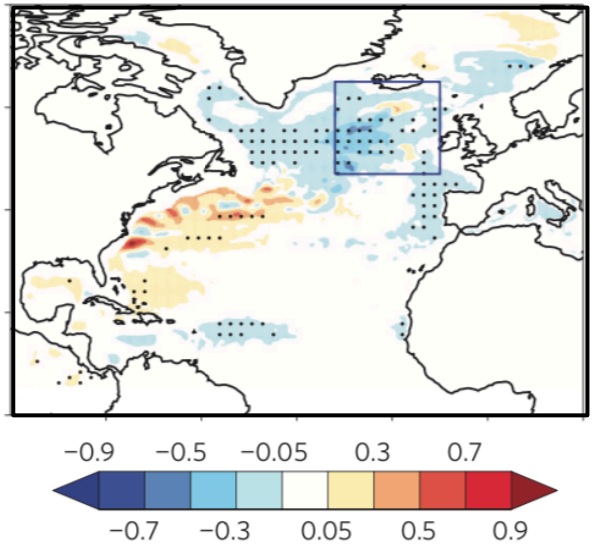


Composite T700 trend
5 year after LSD declines



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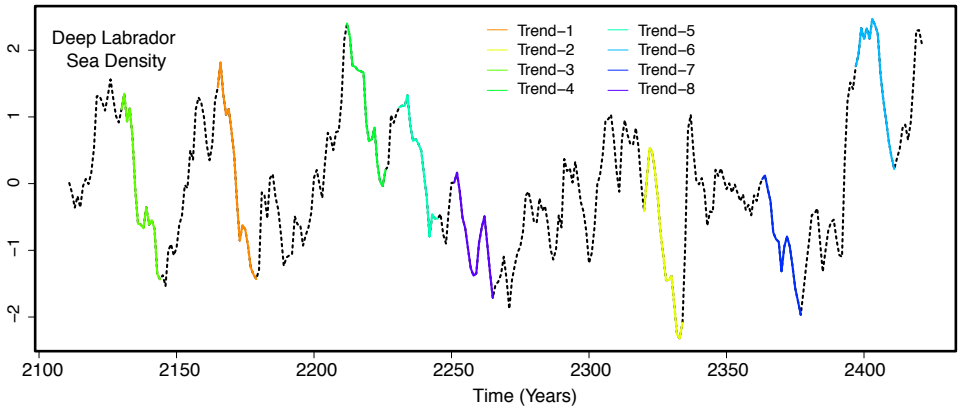

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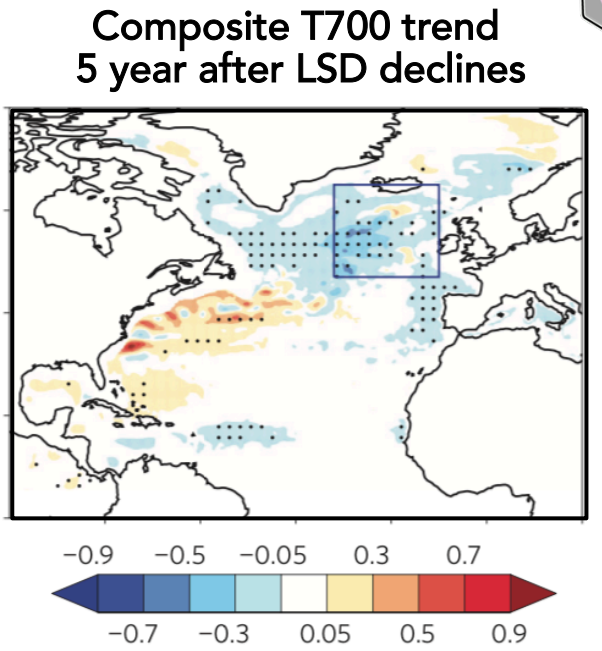

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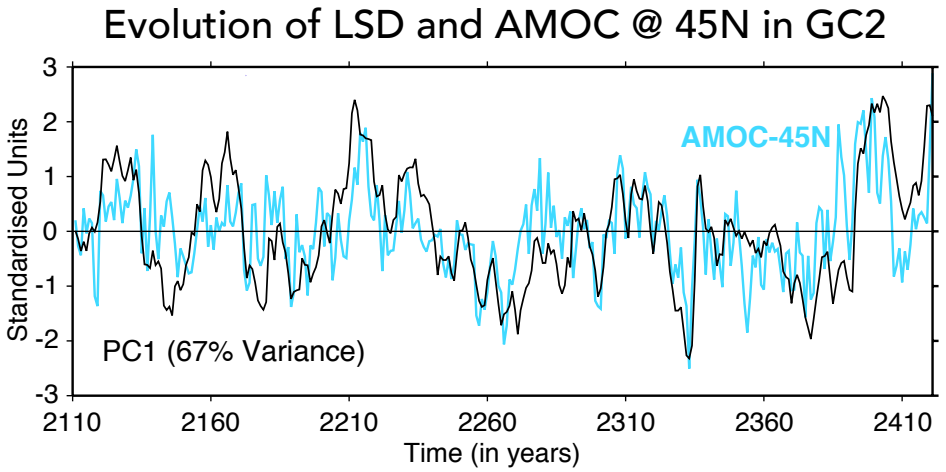

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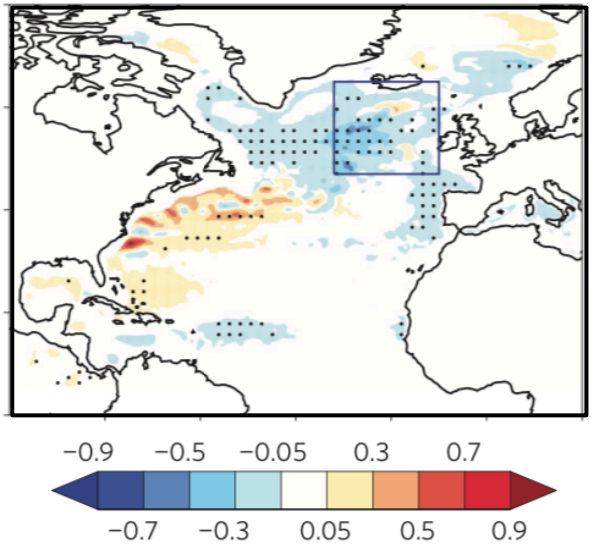
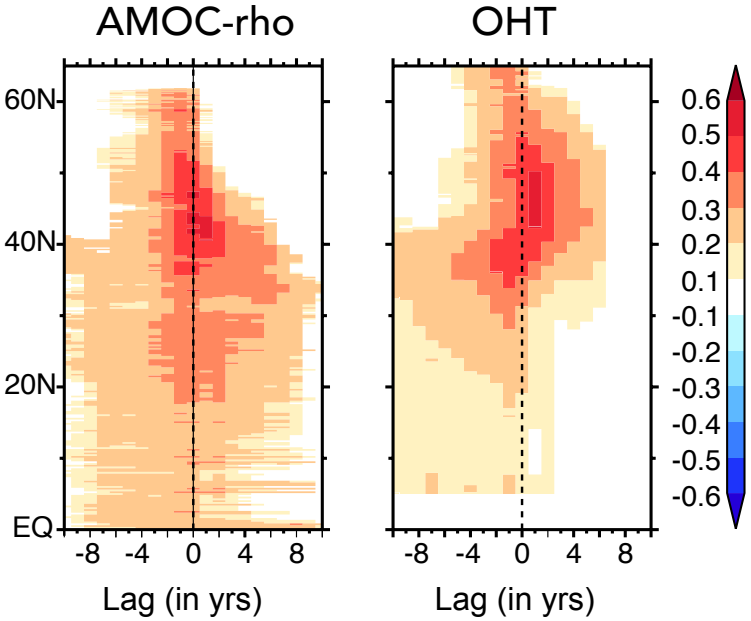


Cross-correlations with LSD Index



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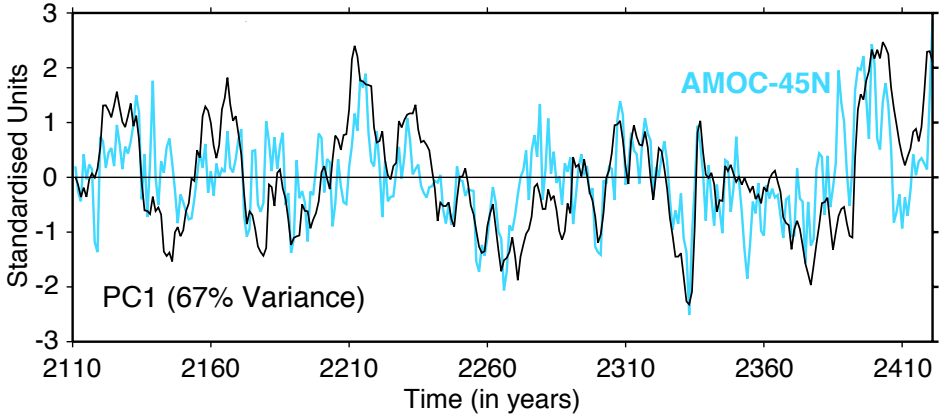

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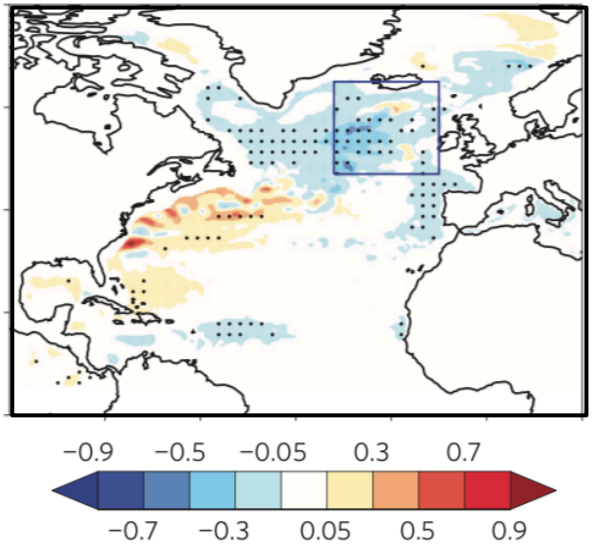

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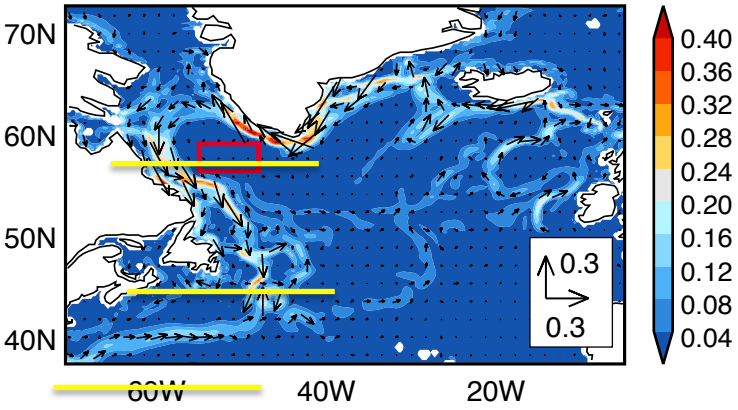
Mean ocean currents @ 1000m



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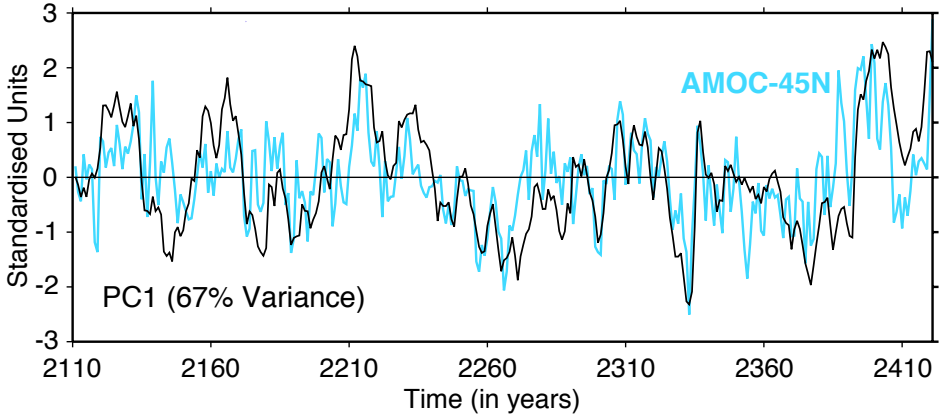

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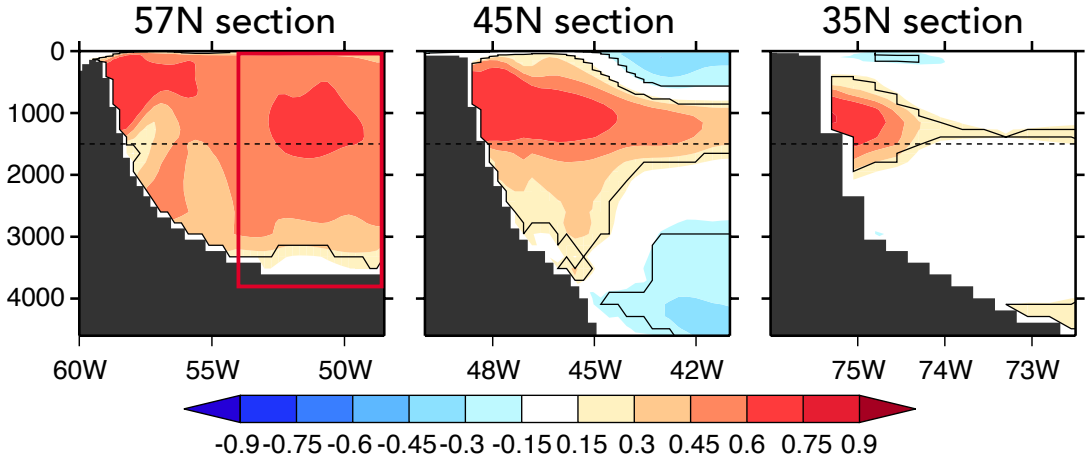
As Labrador Sea densities **propagate southward along the western boundary**, they enhance the AMOC via **thermal wind balance**, increasing the **heat transport to the North**

In-phase correlations: density vs AMOC @ 45N



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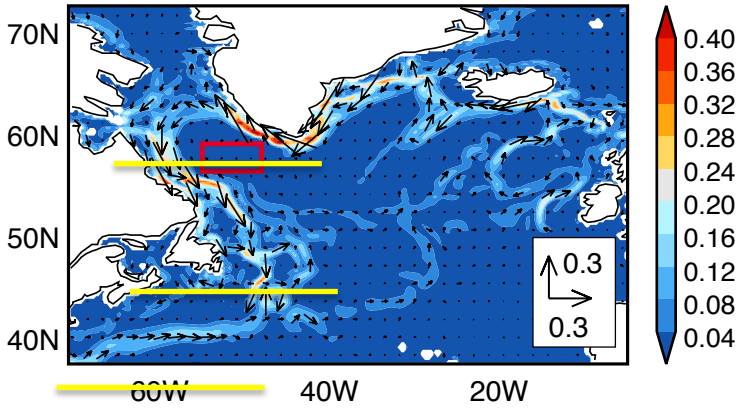

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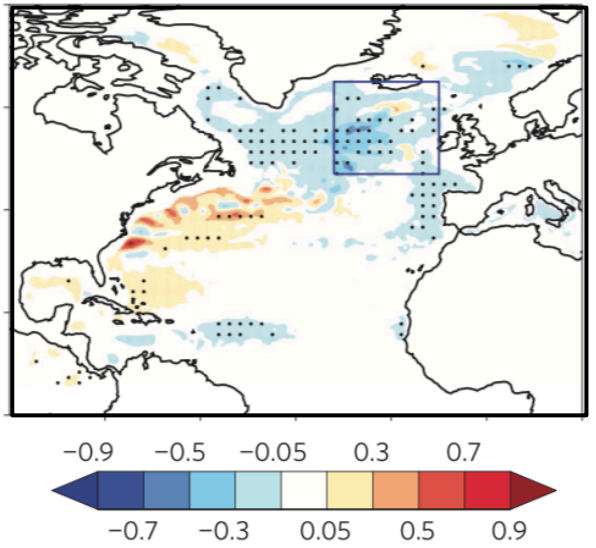

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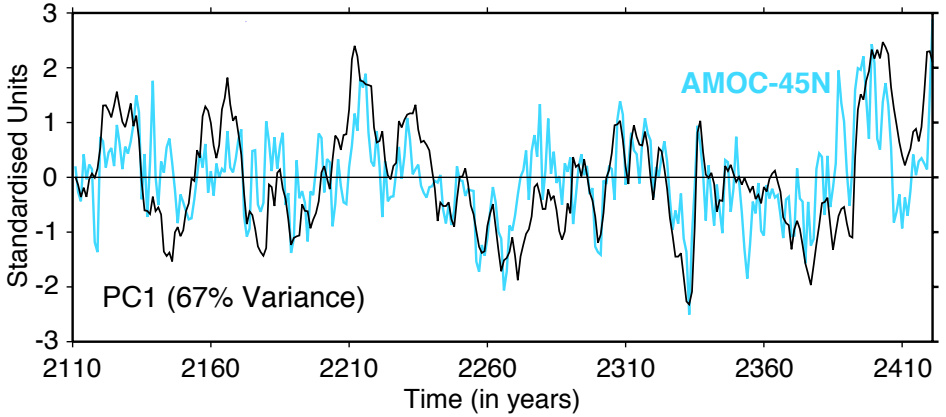

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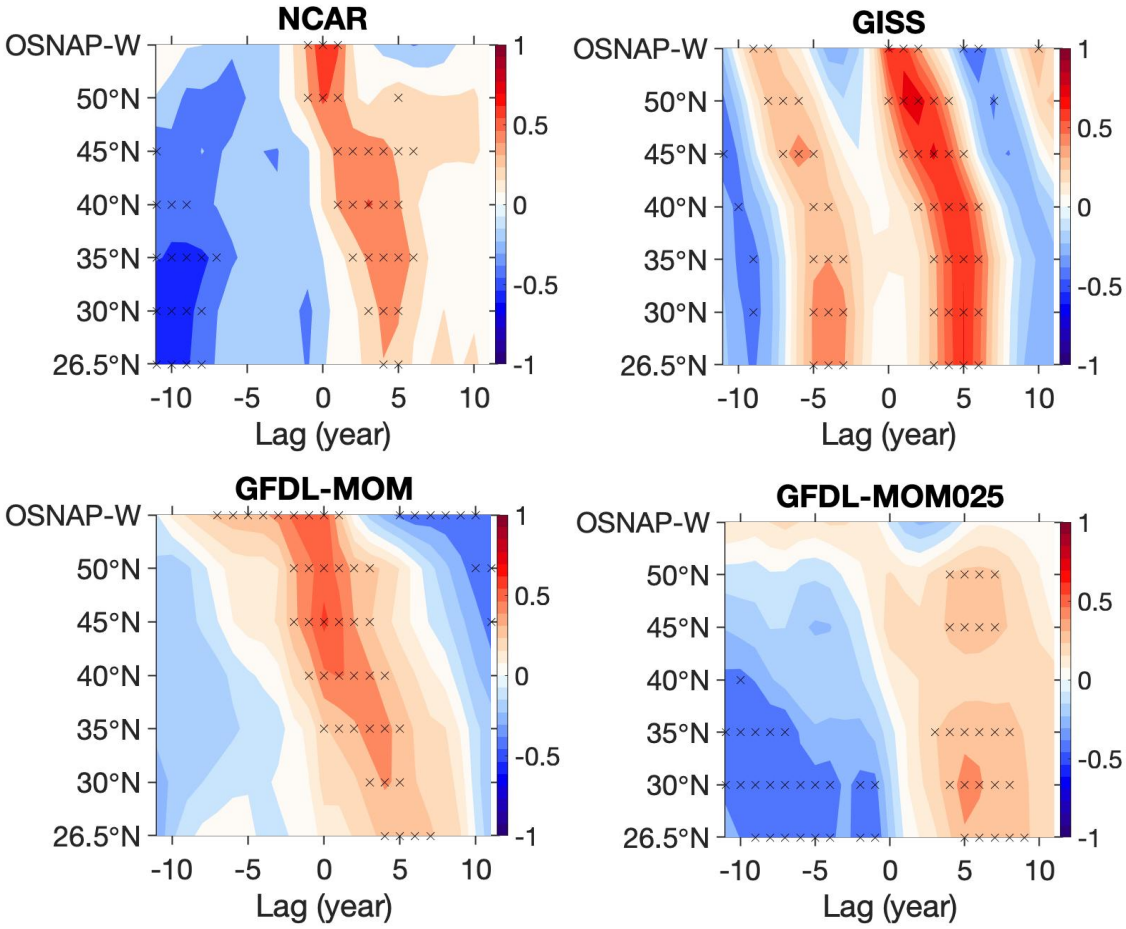
Li et al (2019)

Ocean-forced experiments 1°–1/4°

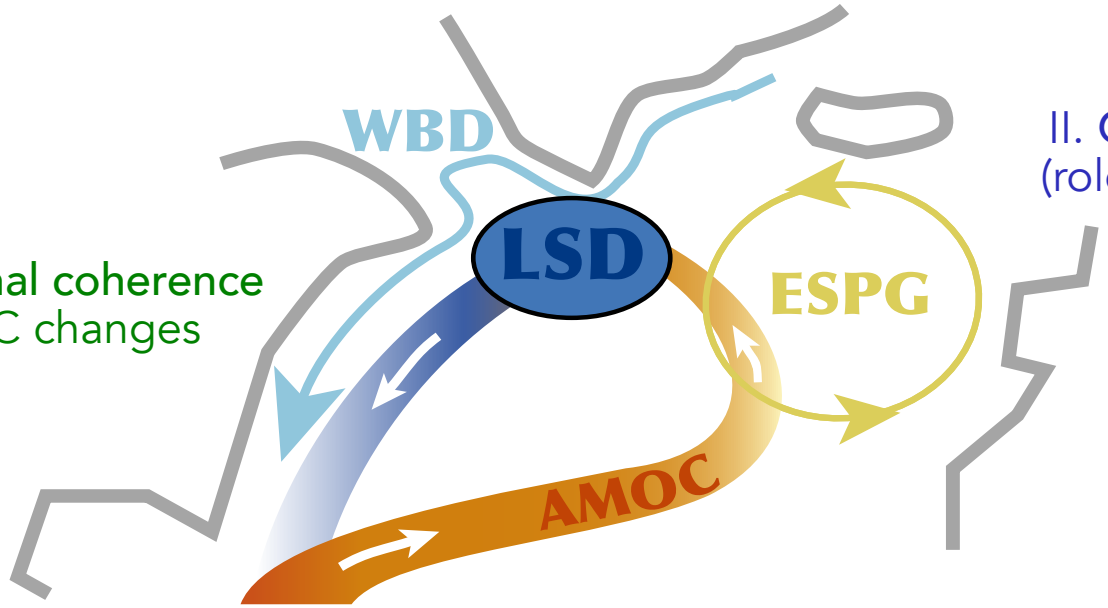
Cross-correlations: LSW density vs AMOC



No **coherent relationships across models** between the **AMOC** and the density of newly formed **Labrador Sea Waters** on interannual-decadal timescales

I. Context and Motivation

I. Consistency of the LSD relationships across an ensemble of climate models



II. Causes of the inter-model spread (role of some climatological features)

III. Latitudinal coherence of AMOC changes

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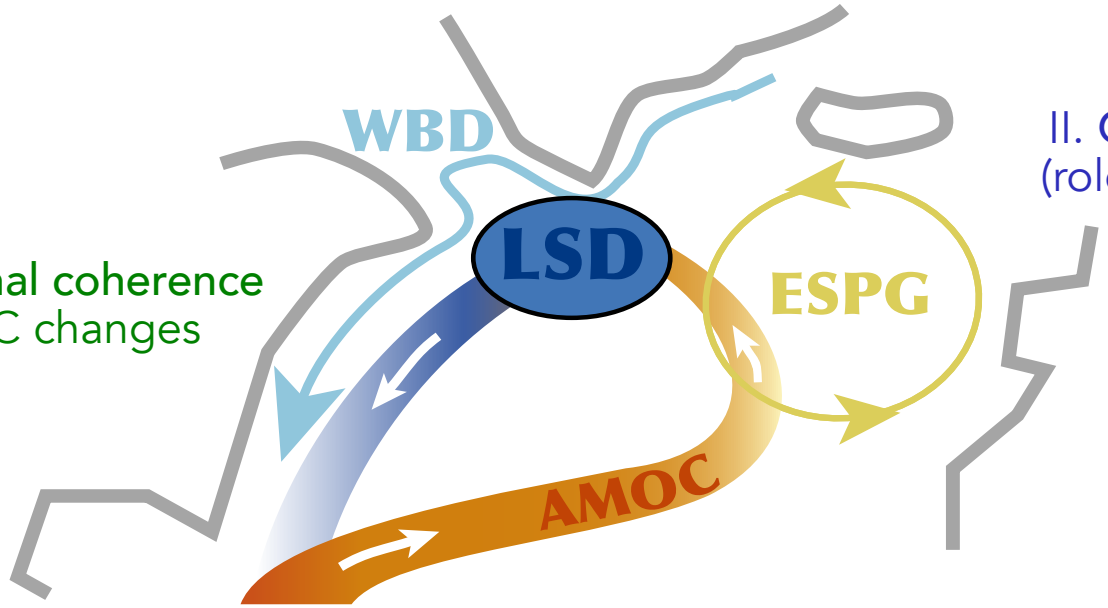
III. **Latitudinal coherence** of AMOC changes



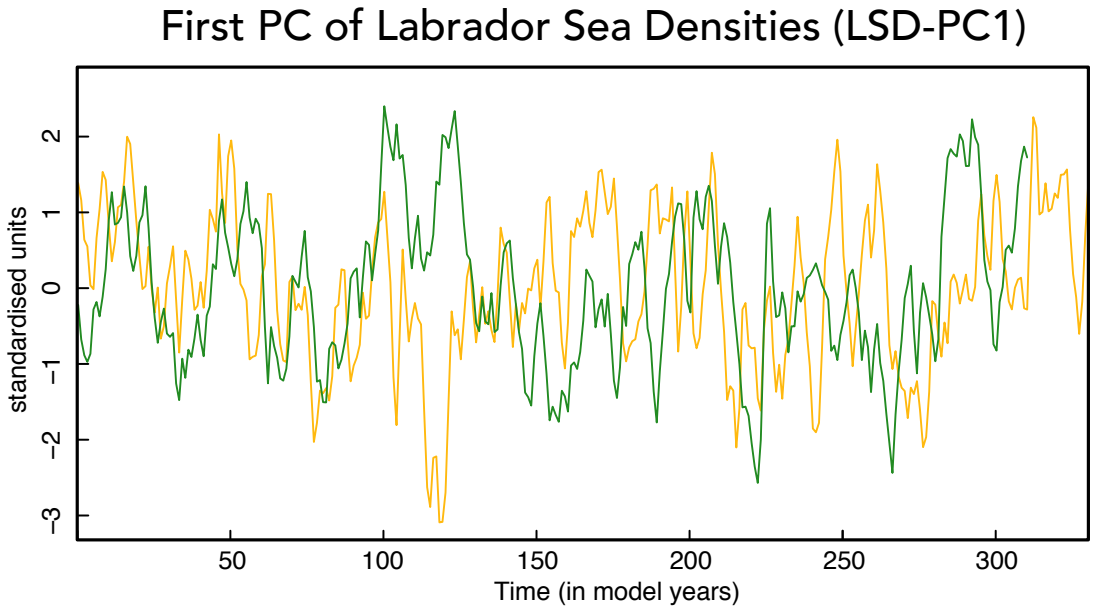
II. Experimental Setup

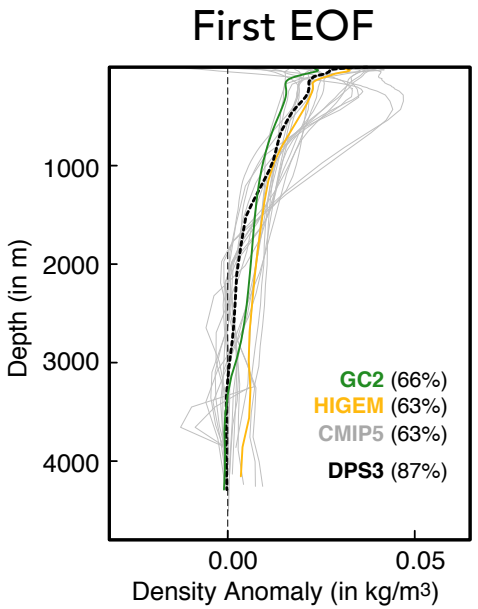
A set of coupled preindustrial control experiments

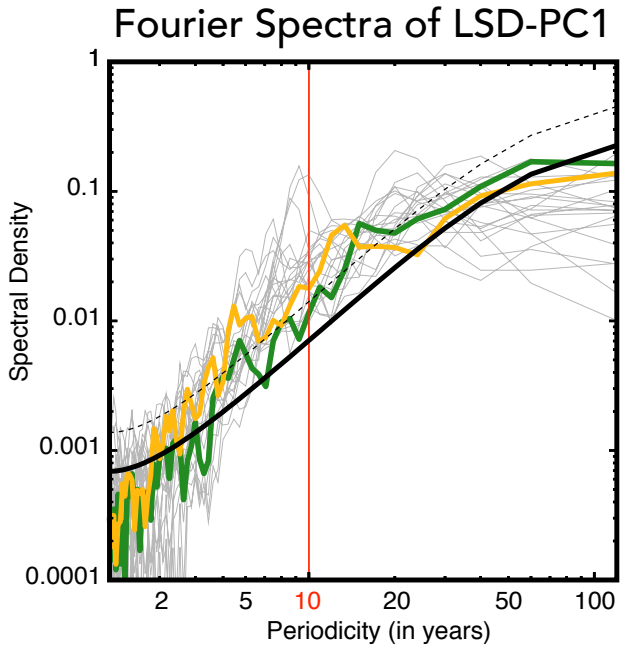
GC2	310 yrs	1/4° Orca grid
HiGEM3	340 yrs	1/3° ocean
CMIP5 ensemble	19 experiments	1° ocean or lower resolution

DPS3-Assimilation	1960-2016	1/4° Orca grid	Reference

III. LSD as an index of multidecadal variability







The **first mode** of LSD variability **consistently** describes **a red-noise** process with **enhanced variance between 10-30 years.**

The associated EOF also shows a **coherent structure** across models, with larger density values near the surface that decrease gradually with depth

III. LSD as an index of multidecadal variability

Rest of the analysis is focused on **decadal trends** (with 10 year running windows)

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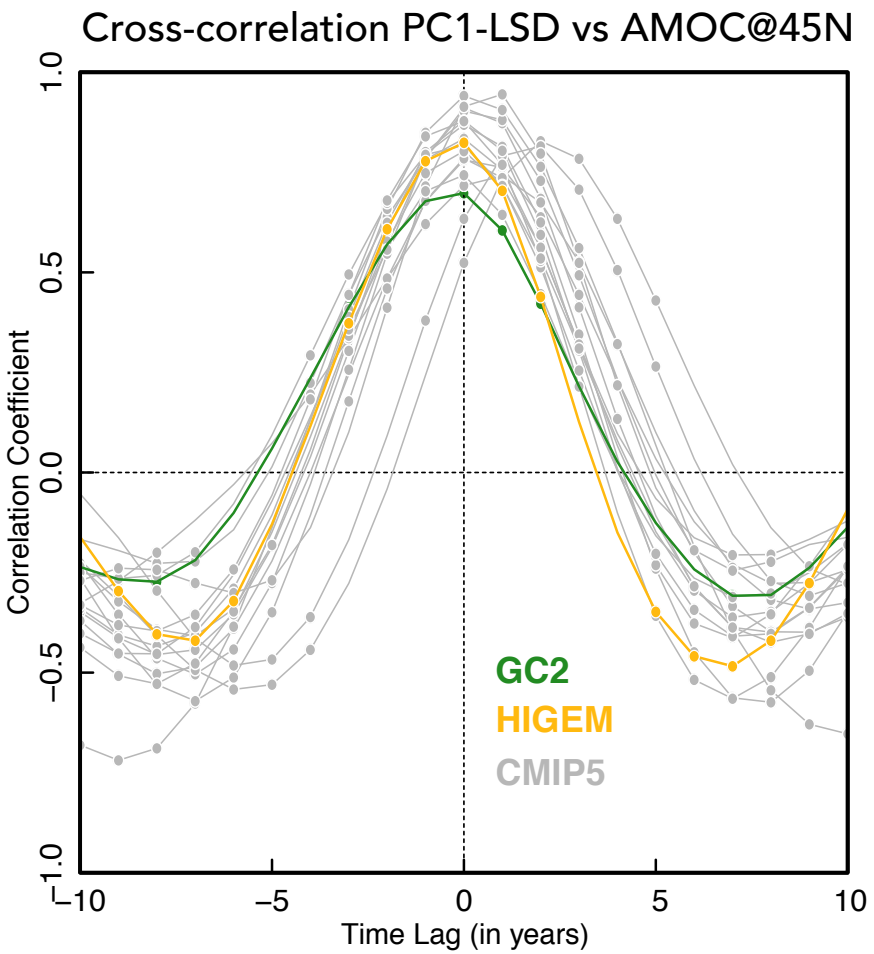

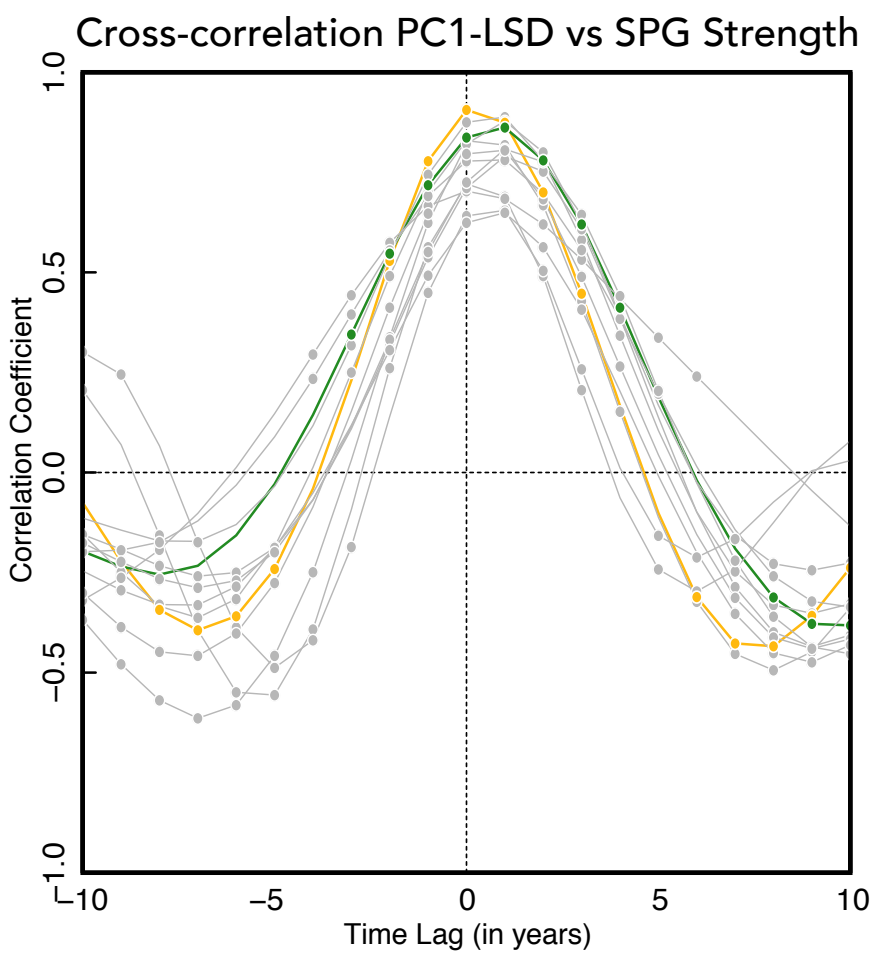

The trends in **LSDs are consistently** linked to enhancements of the **subpolar AMOC and the of the subpolar gyre circulation**

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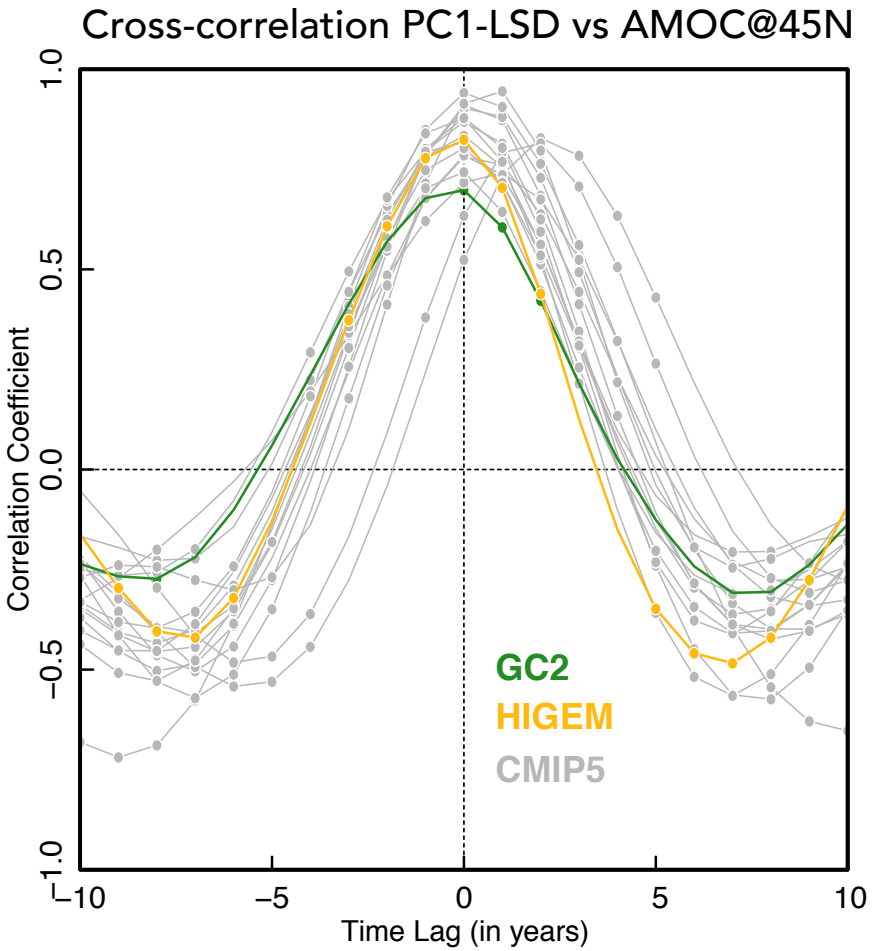
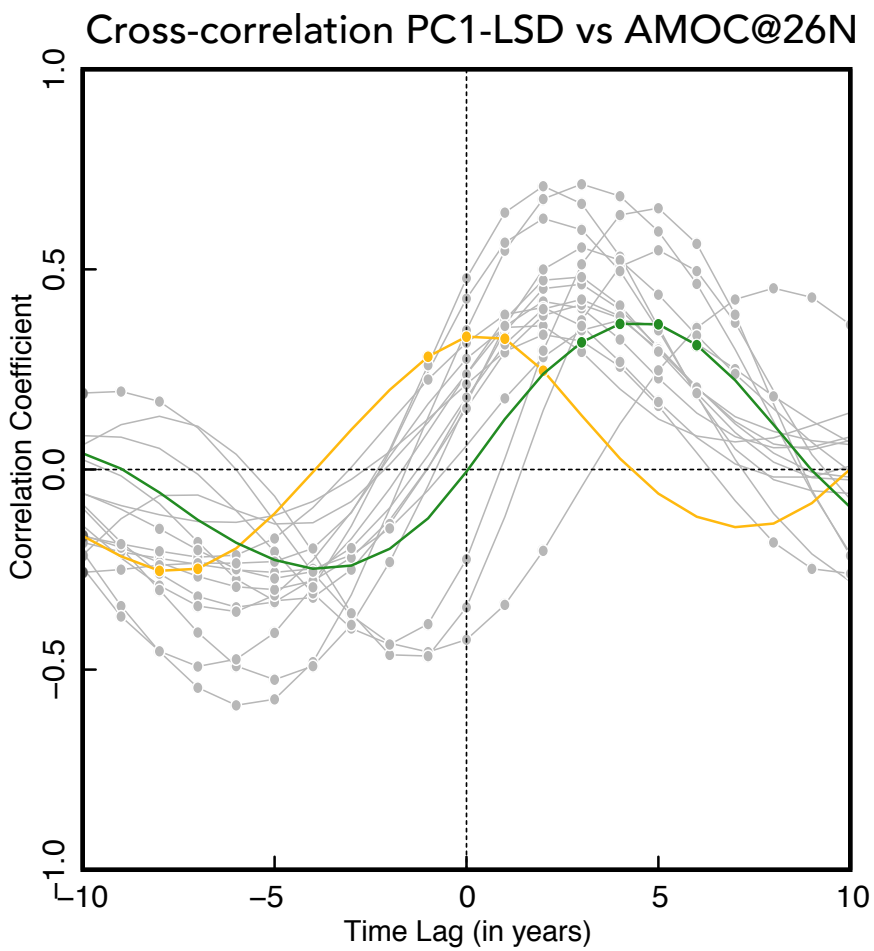
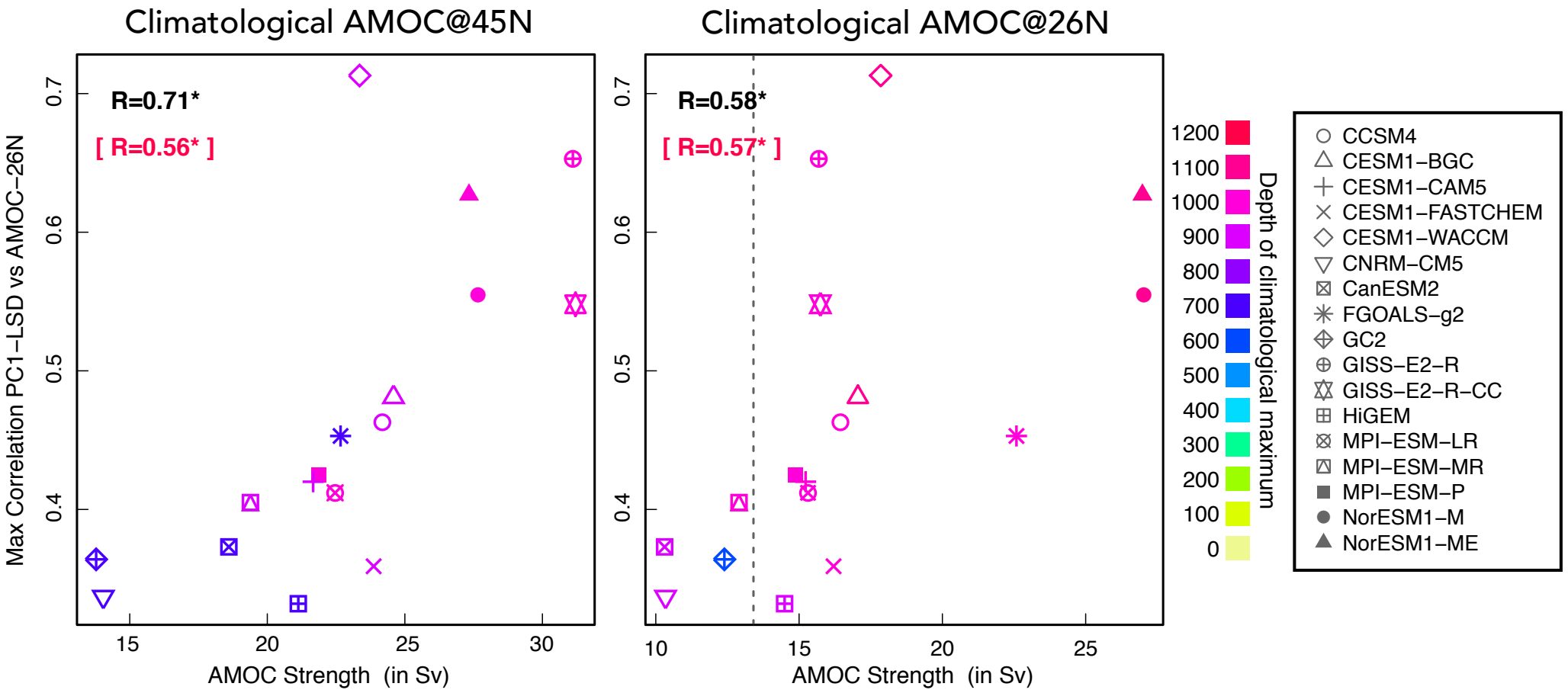




The link with the AMOC at 26°N is much weaker, and the intermodel spread is larger (in particular regarding the lag of the max correlation)

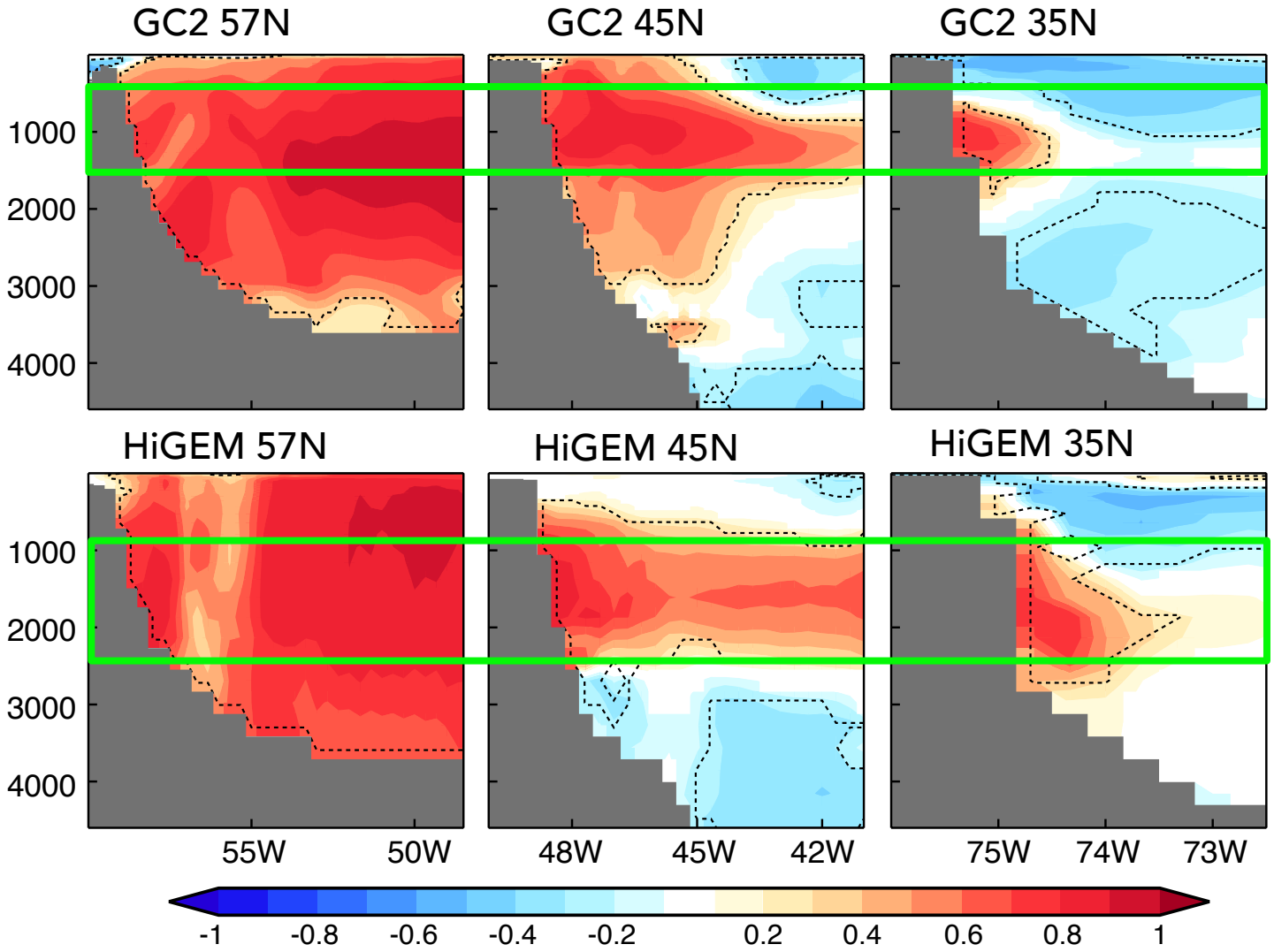
IV. Characteristics of the inter-model spread



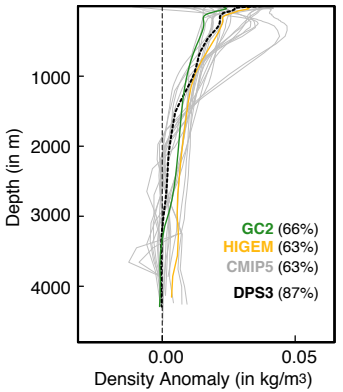
Models with **stronger LSD link with AMOC@26°N** are those where the **climatological AMOC is stronger and deeper**

IV. Characteristics of the inter-model spread

Correlations LSD-PC1 vs Boundary densities



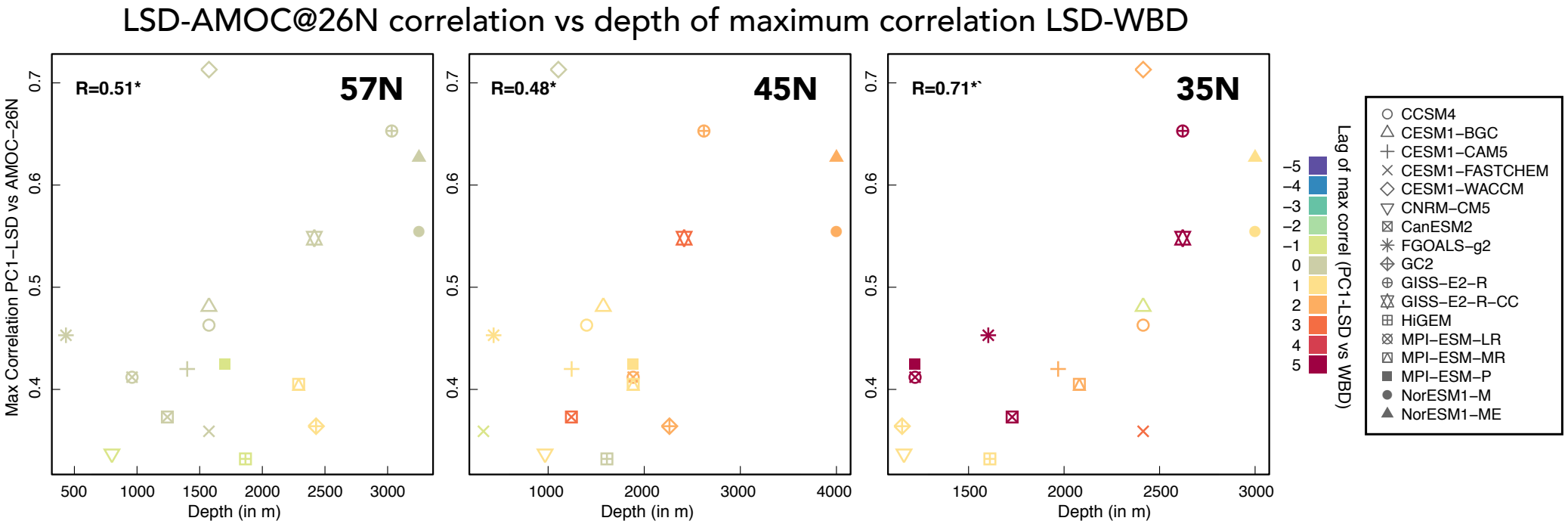
EOF LSD



Despite having EOFs of LSD of similar structure, **GC2** and **HiGEM** show **different connection between LSDs and boundary densities downstream**

IV. Characteristics of the inter-model spread

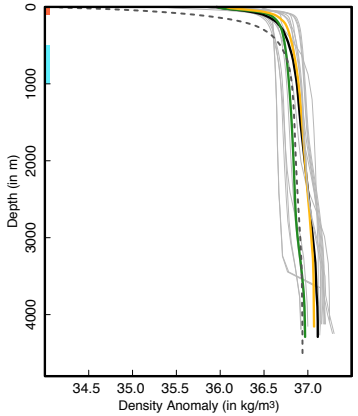
These differences can actually explain part of the spread in the LSD - AMOC26°N relationships



Models with the **strongest LSD-AMOC@26N** connection tend to show **deeper boundary densities** propagating across all latitudes

IV. Characteristics of the inter-model spread

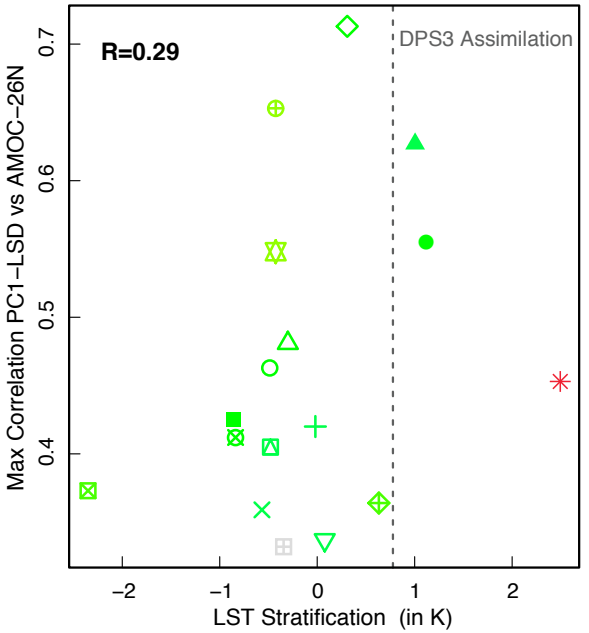
LSD mean profile



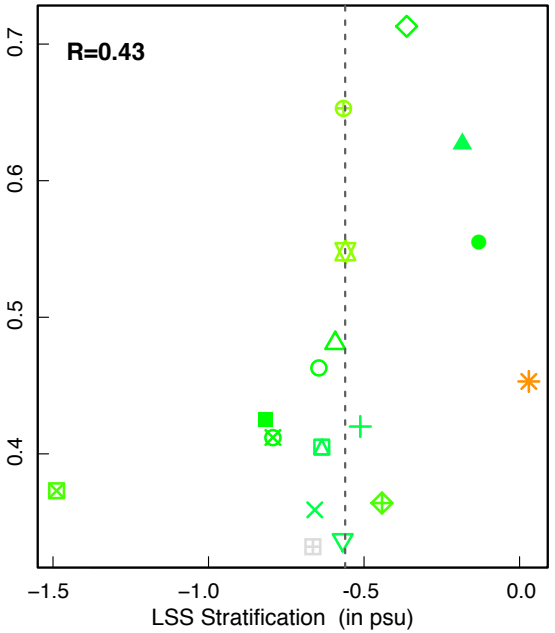
Role of Labrador Sea stratification

Stratification Index: [Average 0-100m] – [Average 500-1000m]

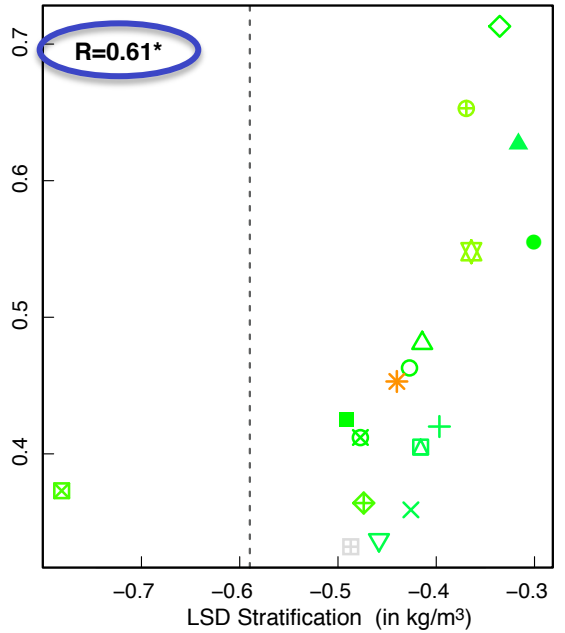
Labrador Sea Temperature

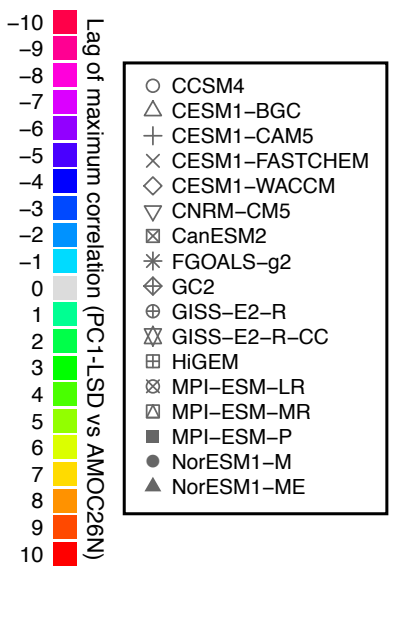


Labrador Sea Salinity



Labrador Sea Density





Model spread (in PC1-LSD vs AMOC26N relationship) seems to be also partly affected by **differences in Labrador Sea density stratification**

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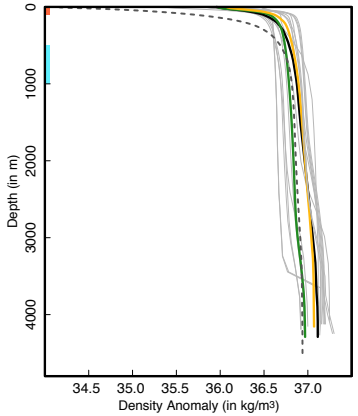
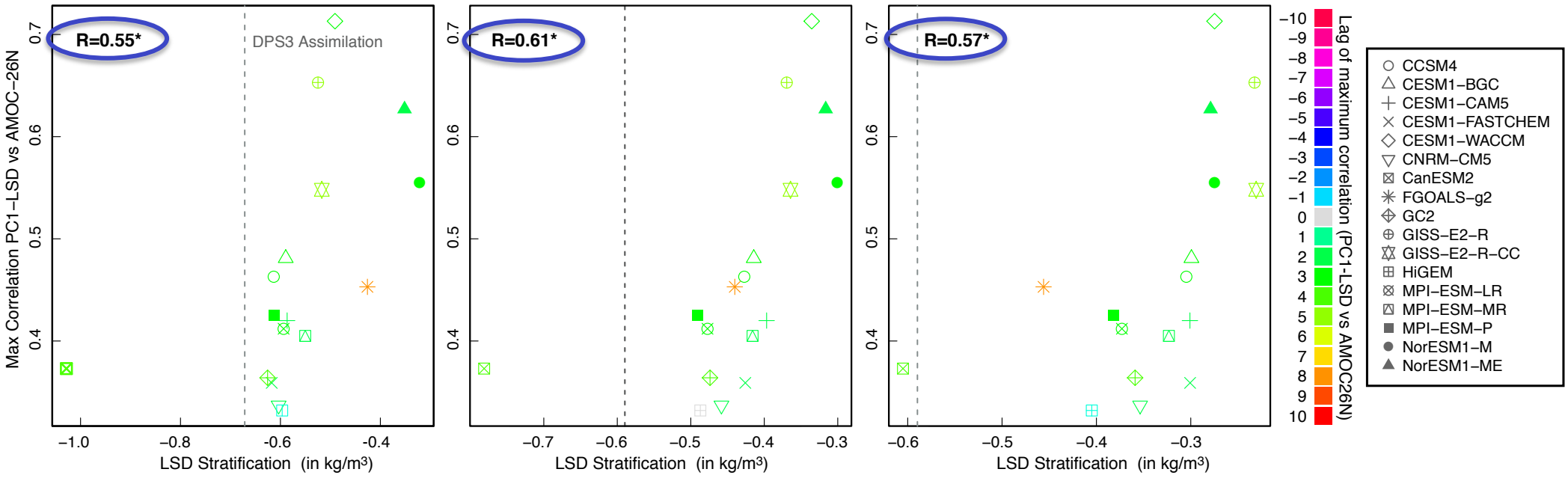


Role of Labrador Sea stratification

Stratification Index: [Average 0-100m] – [Average 500-1000m]

LSD (0-50 vs 400-500m) **LSD (0-100 vs 500-1000m)** **LSD (0-200 vs 1000-2000m)**



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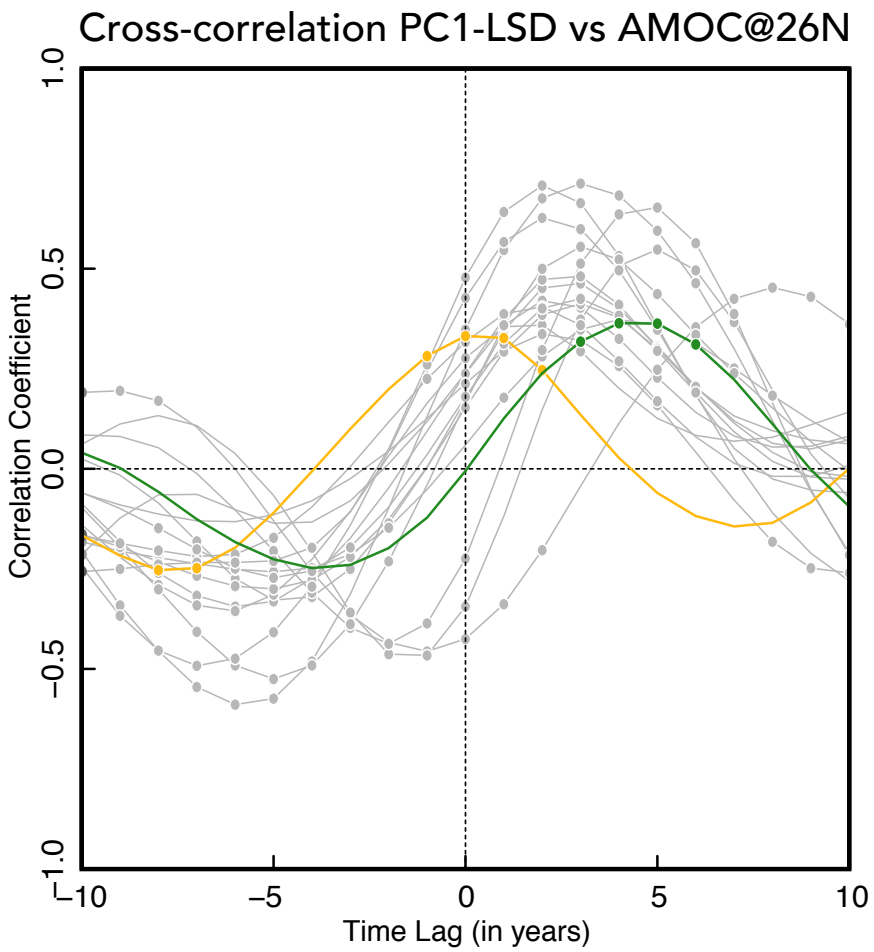
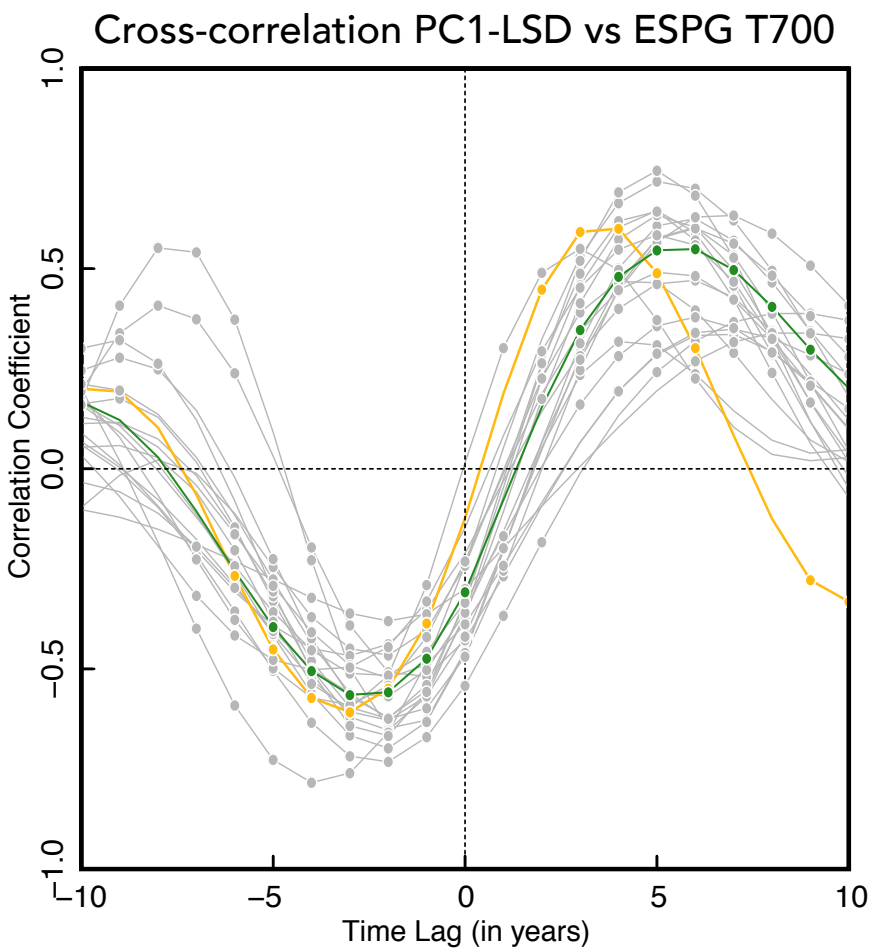
V. Consequences of the inter-model spread

The different representations of LSD-induced AMOC changes across latitudes can impact the associated impacts.





The lagged link between the LSDs and the Ocean Heat Content in the Eastern SPG shows substantial differences in magnitude and lead time.

Take home messages…

- All the simulations analysed show clear multidecadal variability in the Labrador Sea densities, and support a close link with the strength of subpolar AMOC and SPG circulation

- However, their ultimate link with the boundary densities, and cross-latitudinal coherence seems to be model dependent

- This spread appears to be partly linked to the different biases in the Labrador Sea stratification and how LS densities propagate downstream across the boundaries

- It is still to be determined if and how these different model representations can affect the oceanic and continental impacts of LSDs and the AMOC, and thereby their predictability

Thanks for your attention!!