# The role of internal ocean dynamics and external forcings on the decadal-scale predictability in the North Atlantic: a large ensemble analysis

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# Rationale of the Study

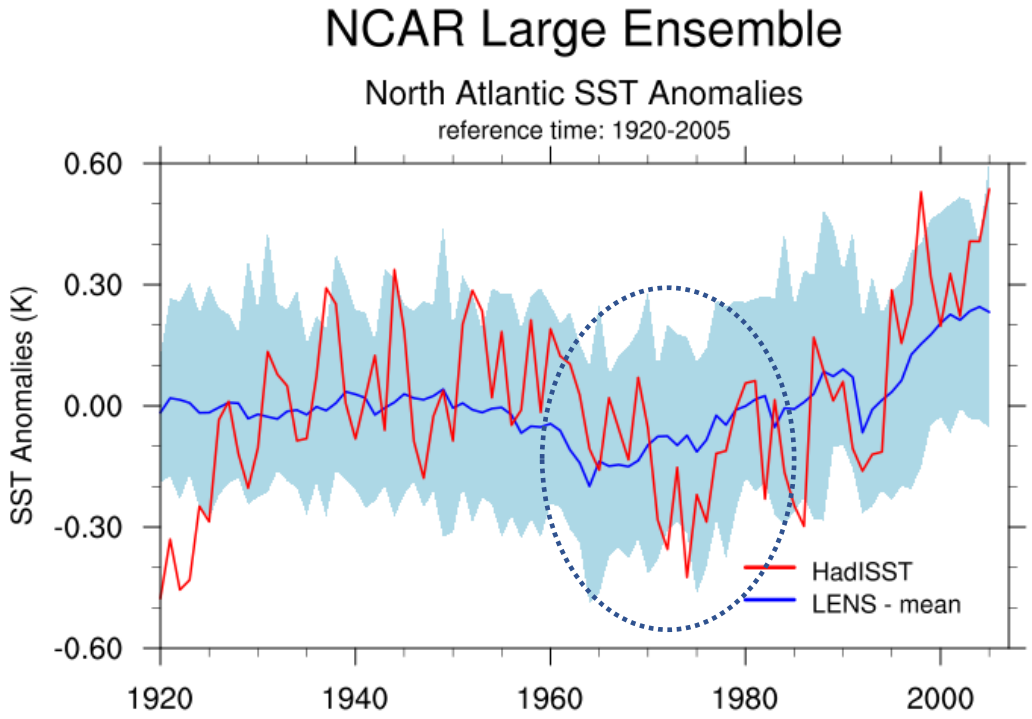
**Sea surface temperature** (SST) variability in the **North Atlantic** is known to be a **key source** of **decadal predictability** for the **Euro-Atlantic sector**. In this work we investigate the predictability of North Atlantic SST variability, with a special focus on the **1940-1975** “warm-to-cold” **transition**.

Several mechanisms and processes have been taken into account to explain the cooling in the mid of 20th century, ranging from a **slowdown of the Atlantic meridional overturning circulation** to an **increase in anthropogenic aerosol**.

This event is particularly interesting as it represents a well documented decadal-scale fluctuation of the observed climate record and can be used as a **suitable test-bed** to evaluate the **relative skill** of **initialized** versus **non-initialized** climate simulations. This is the reason why the same episode will be evaluated both in the NCAR-LENS and in the NCAR-DPLE systems.

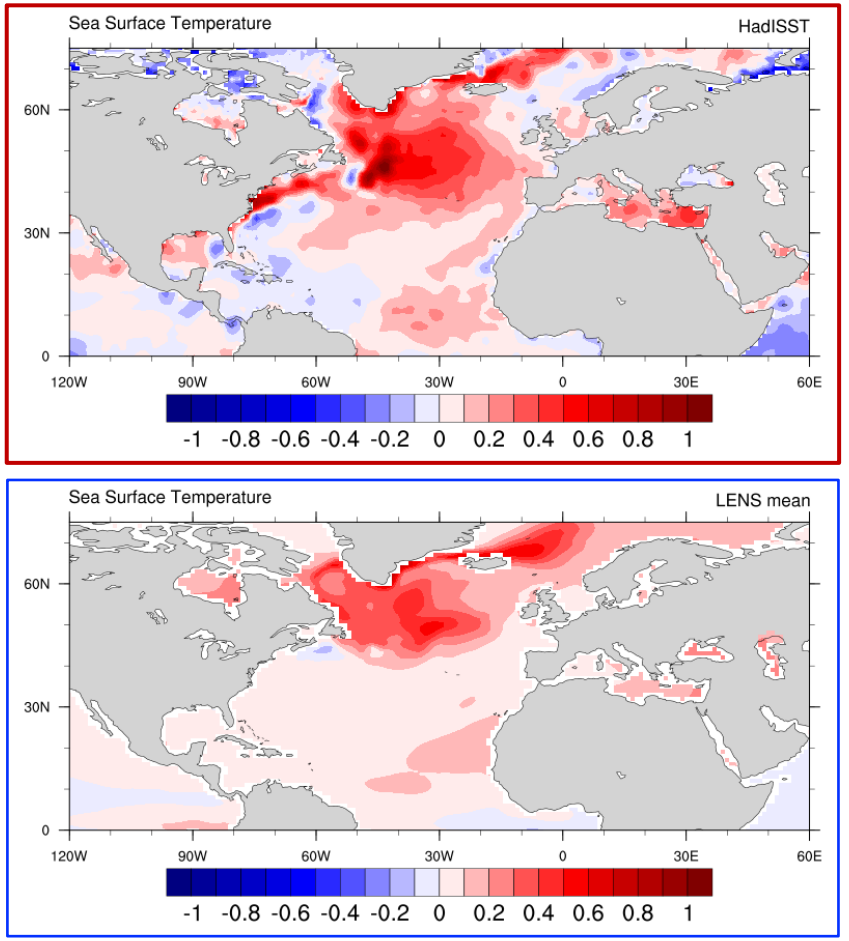
# The mid-20th century "warm-to-cold" transition

some skill in North Atlantic SST predictability is found in the NCAR Large Ensemble (LENS)
cooling signal found in the **ensemble mean**: possible influence of external forcing?




OBS

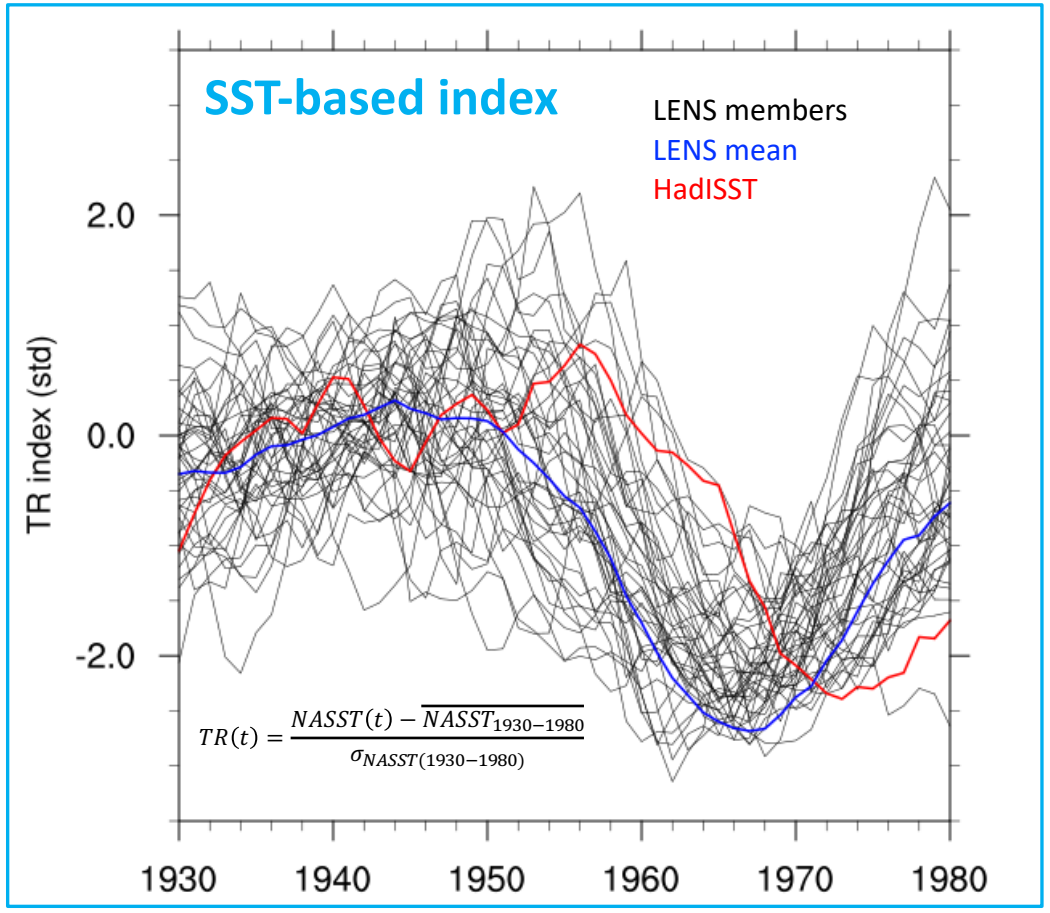
LENS MEAN



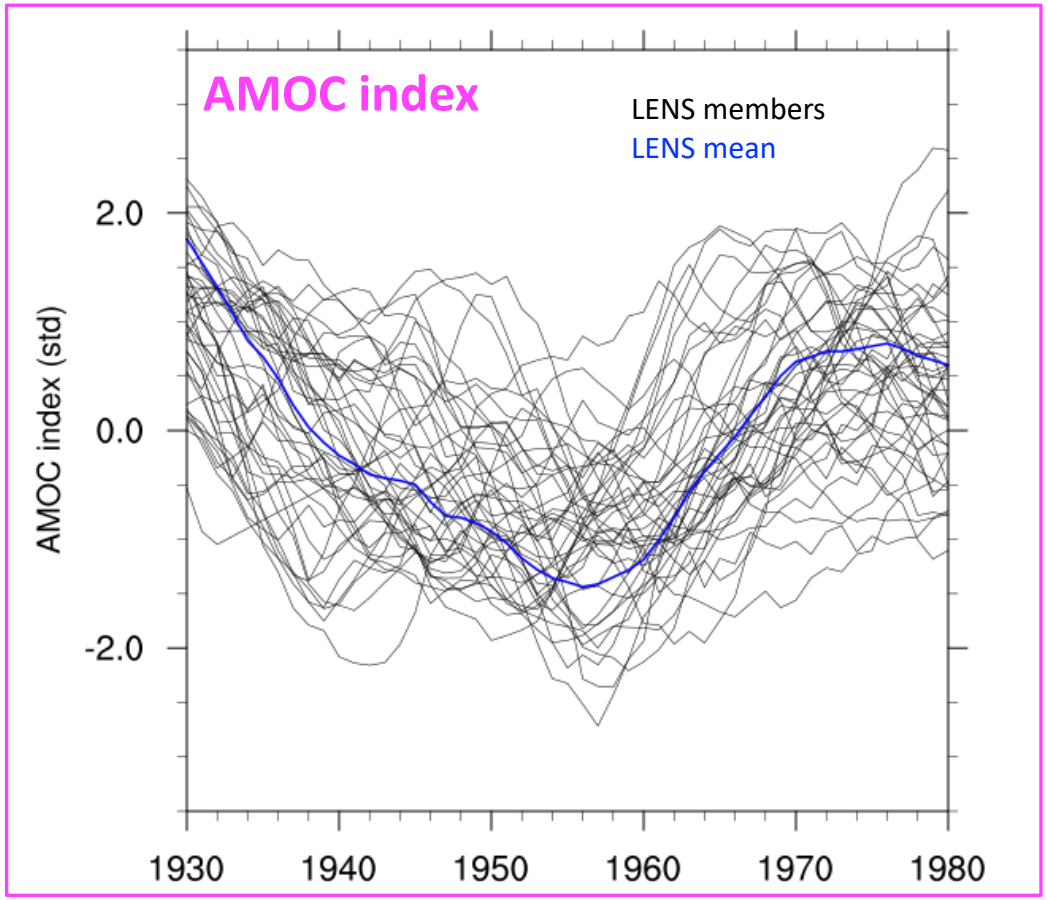

'Warm – Cold' composite:
Positive anomalies = cooling
Negative anomalies = warming

Composite 1930/1950 - 1960/1980

# External Forcing vs. Internal Variability




lag between observations and model, with **LENS mean SST** *leading* the observed transition by about ten years.
Consistent with previous studies, emphasizing the driving role of external forcings (aerosol, GHG).




huge spread in **AMOC signal**, but a consistent behaviour is found in the ensemble mean:
forced signal mediated by ocean dynamics?

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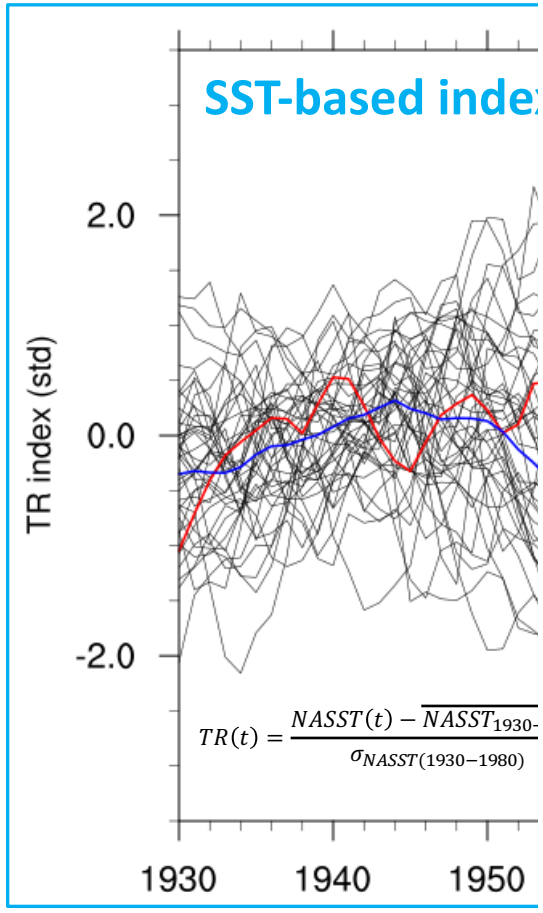


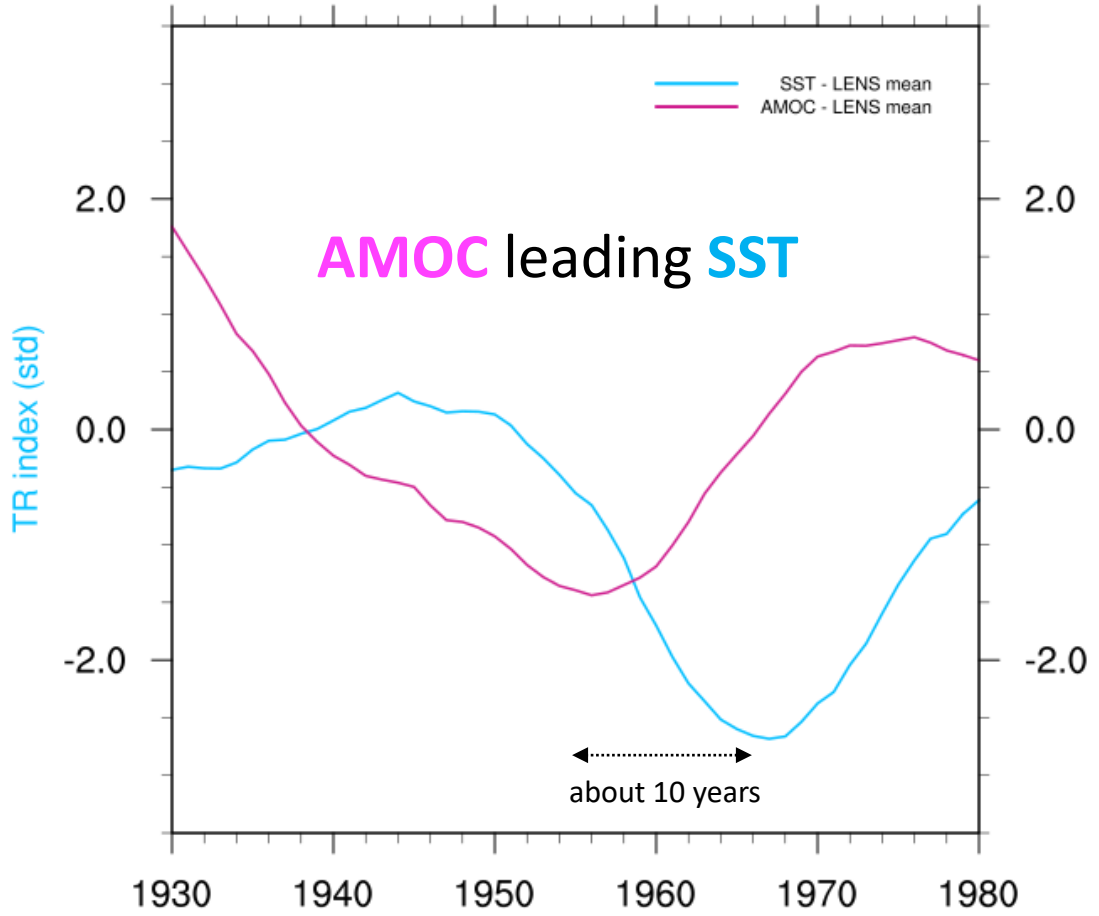


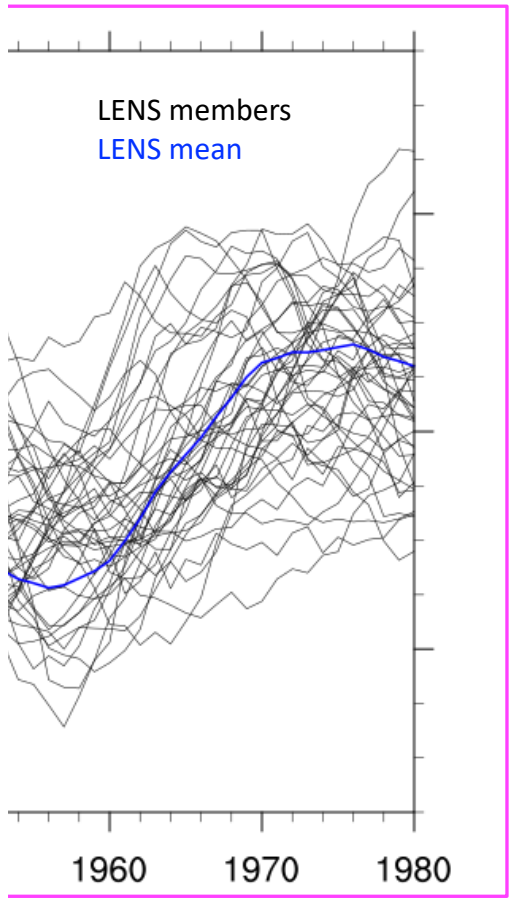


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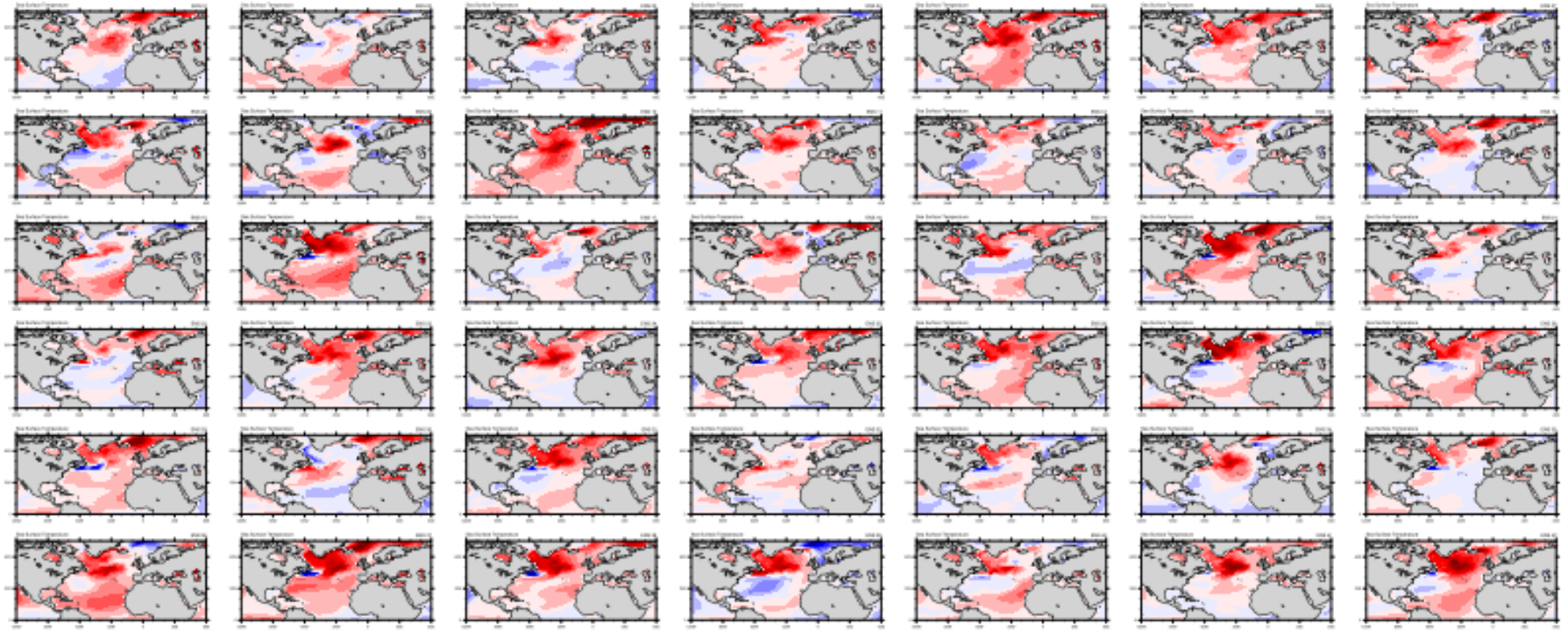
# Beyond the ensemble mean…

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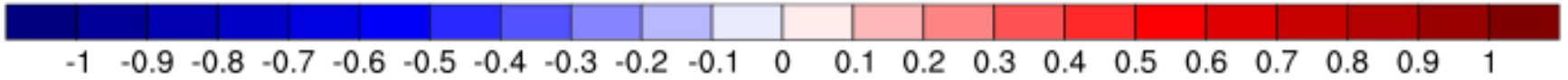


**inter-ensemble diversity** , with the observed horseshoe pattern not present in all the members:
*clustering* based on the distance from the observed pattern

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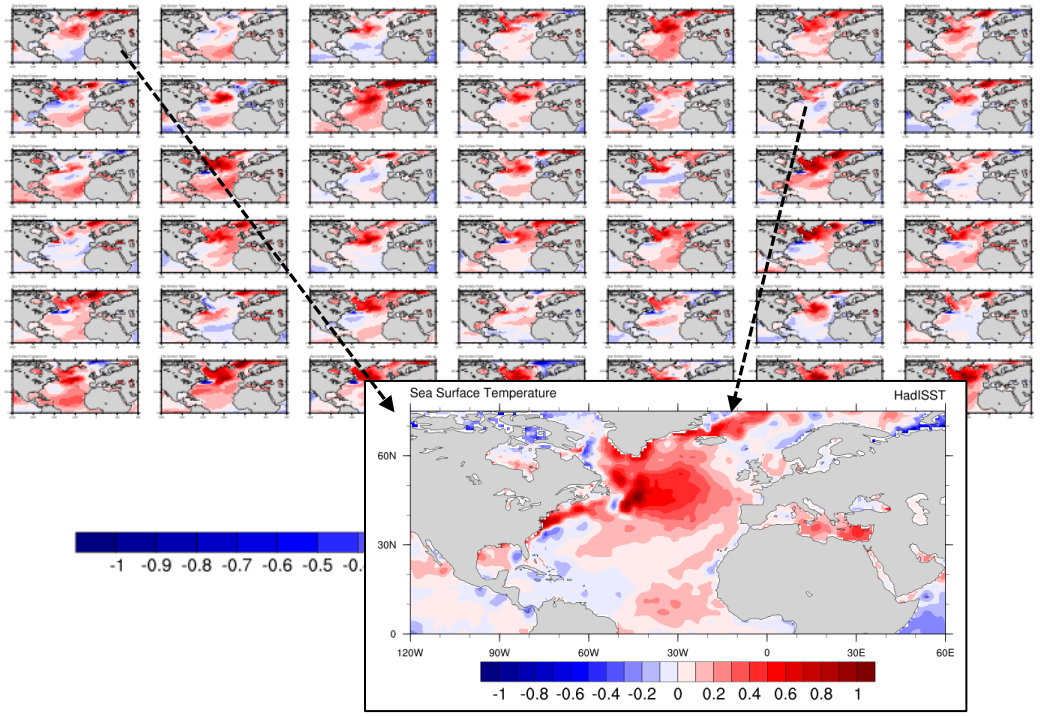
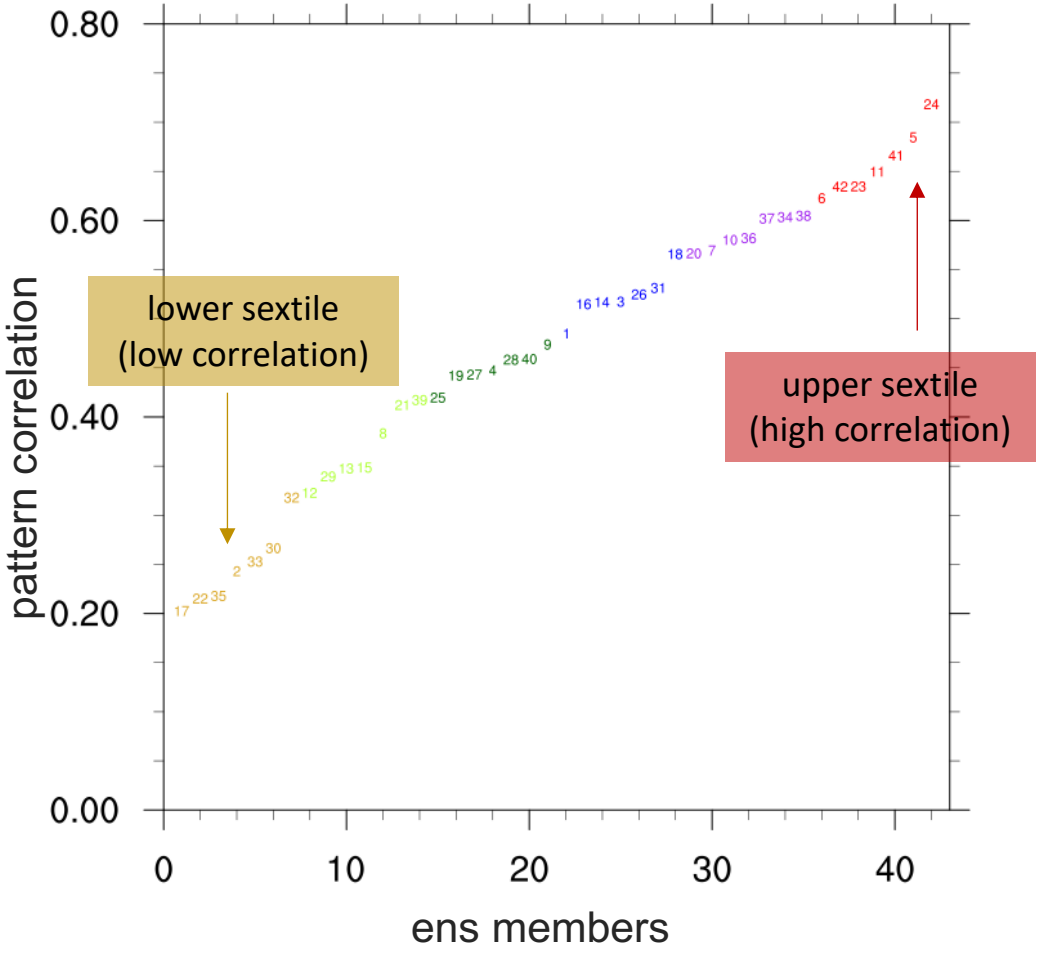



CLUSTERIZATION

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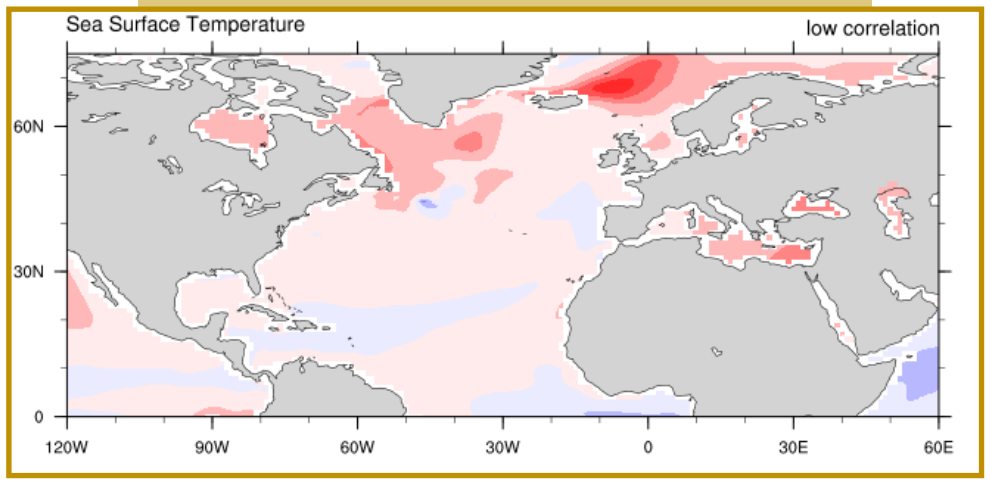
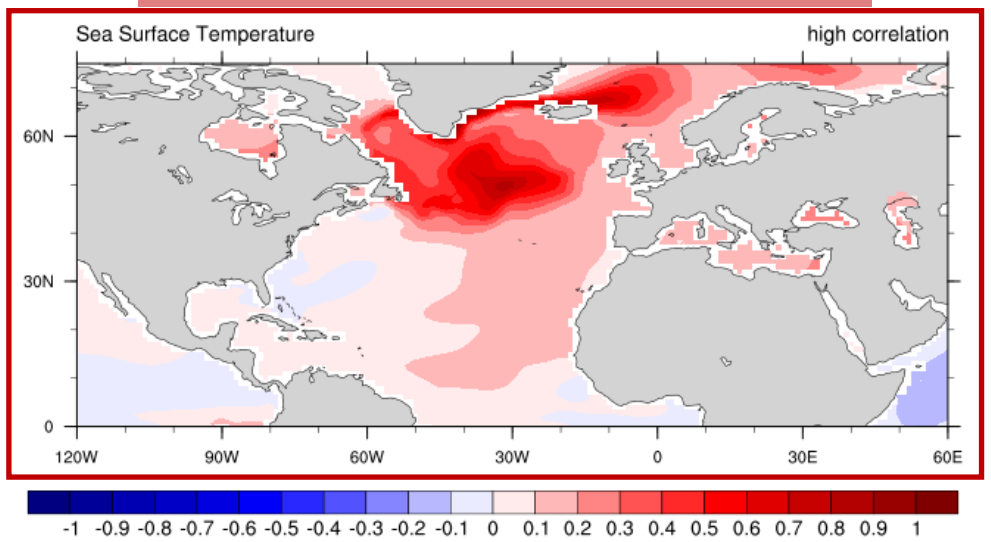
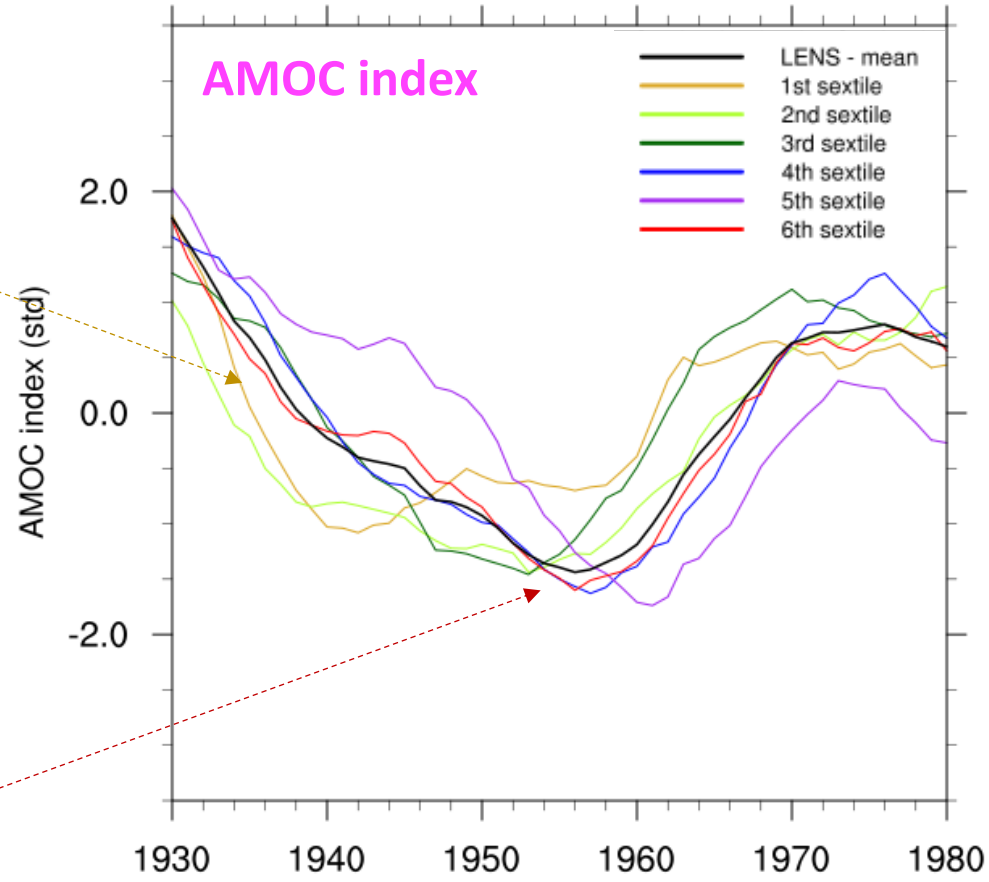
# Clustering of LENS members

LOW CORRELATION PATTERN
(average of the 1st sextile)




HIGH CORRELATION PATTERN
(average of the 6th sextile)

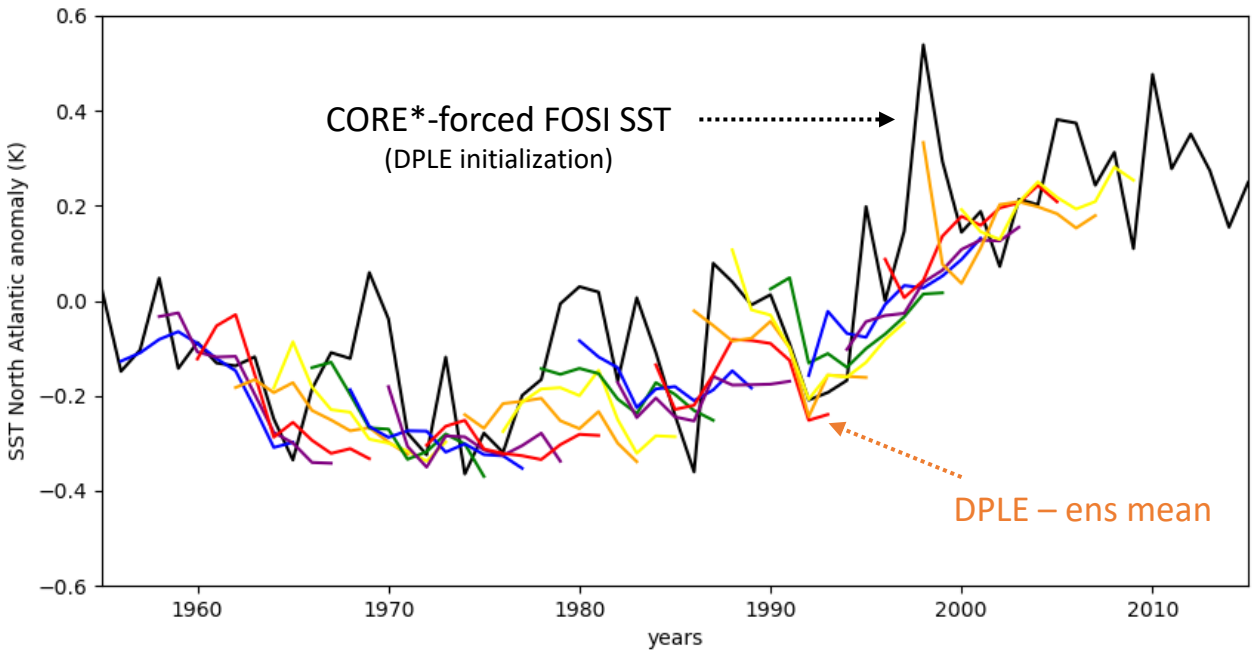



Applying the SST-based clusterization on the AMOC index a clear phase-shift emerges, with the clusters more distant from observations displaying an anticipated minimum

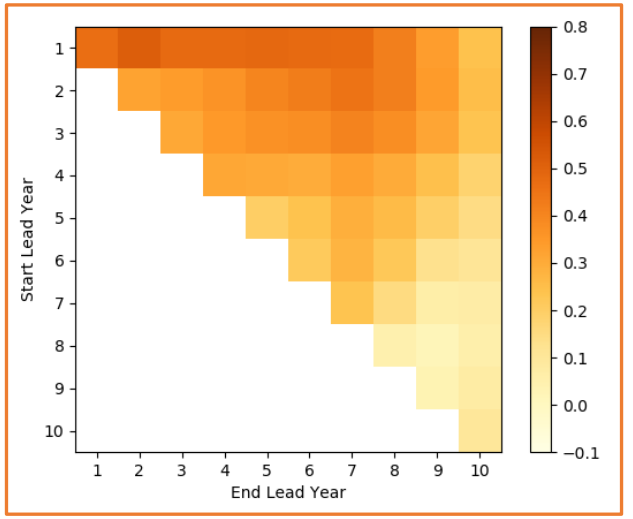
# Next steps: the mid century transition in the DPLE

North Atlantic SST Anomalies in the NCAR-DPLE

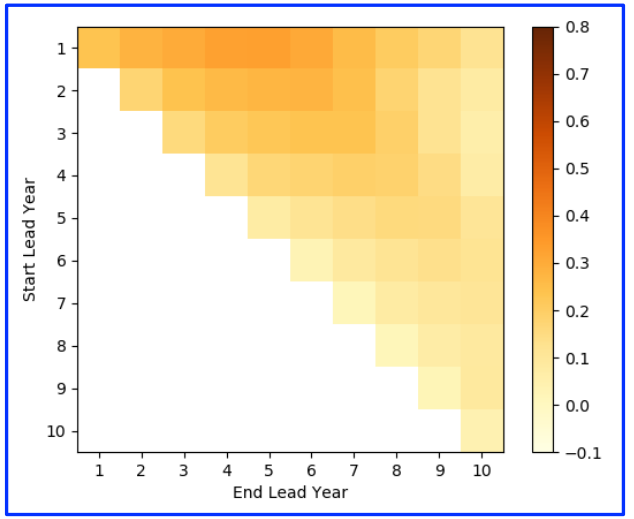



The DPLE reproduces the cooling episode,
with an **enhanced skill** compared to the LENS

ACC over the North Atlantic region (1955-1980)




DPLE




LENS

# Summary and future plans

The aim of this work is to analyze the mid 20$^{th}$ century North Atlantic cooling both in the NCAR-LENS and in the NCAR-DPLE systems, in order to investigate the relative contribution of external forcing and internal variability, and hence to assess the role of initialization.

- Even without initialization, the NCAR-LENS shows some skill in capturing the North Atlantic SST transition, suggesting a crucial influence of external forcing in shaping the observed variability in the North Atlantic.

- The fingerprint of the cooling transition emerges also in the Atlantic meridional overturning circulation, with the AMOC signal leading the SST one.

- In the future the main focus will be on the analysis of this event in the NCAR-DPLE, which from a preliminary insight shows an enhanced skill compared to the NCAR-LENS in representing the mid 20$^{th}$ century SST variability over the North Atlantic.