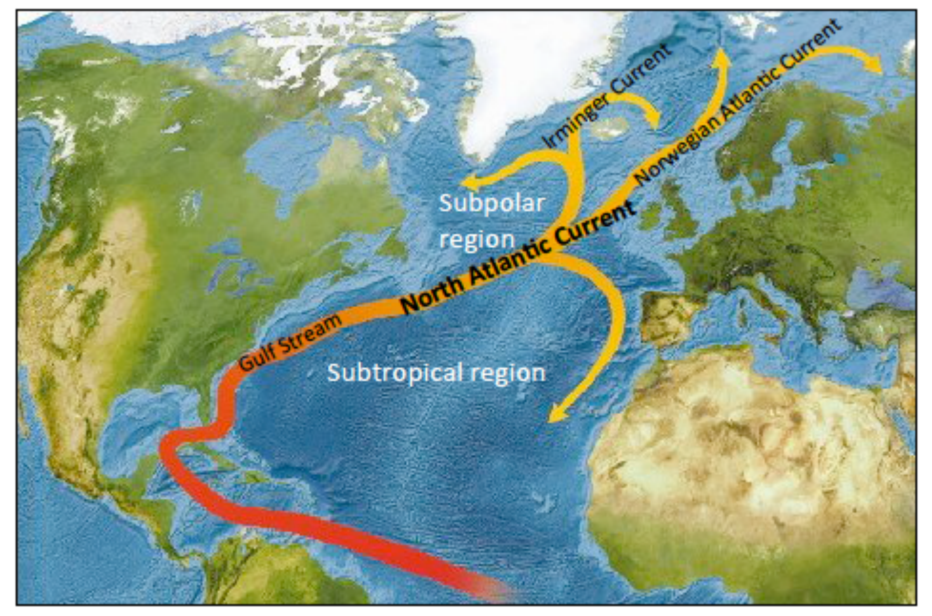


Atlantic water pathway

Mechanisms that give rise to predictability in the North Atlantic – Nordic Seas

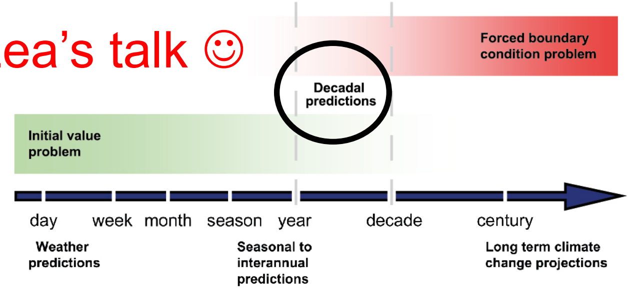
Helene R. Langehaug

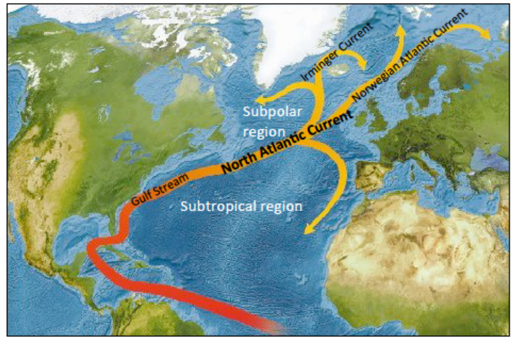
Nansen Environmental and Remote Sensing Center

Bjerknes Centre for Climate Research

helene.langehaug@nersc.no

See Lea's talk ☺





Outline

Background

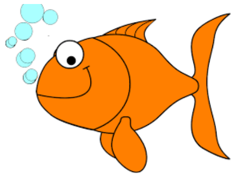
- › **Predictability** of North Atlantic SST and AMV
- › **Predictability** of SST in the Nordic Seas

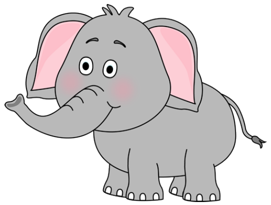
How to…

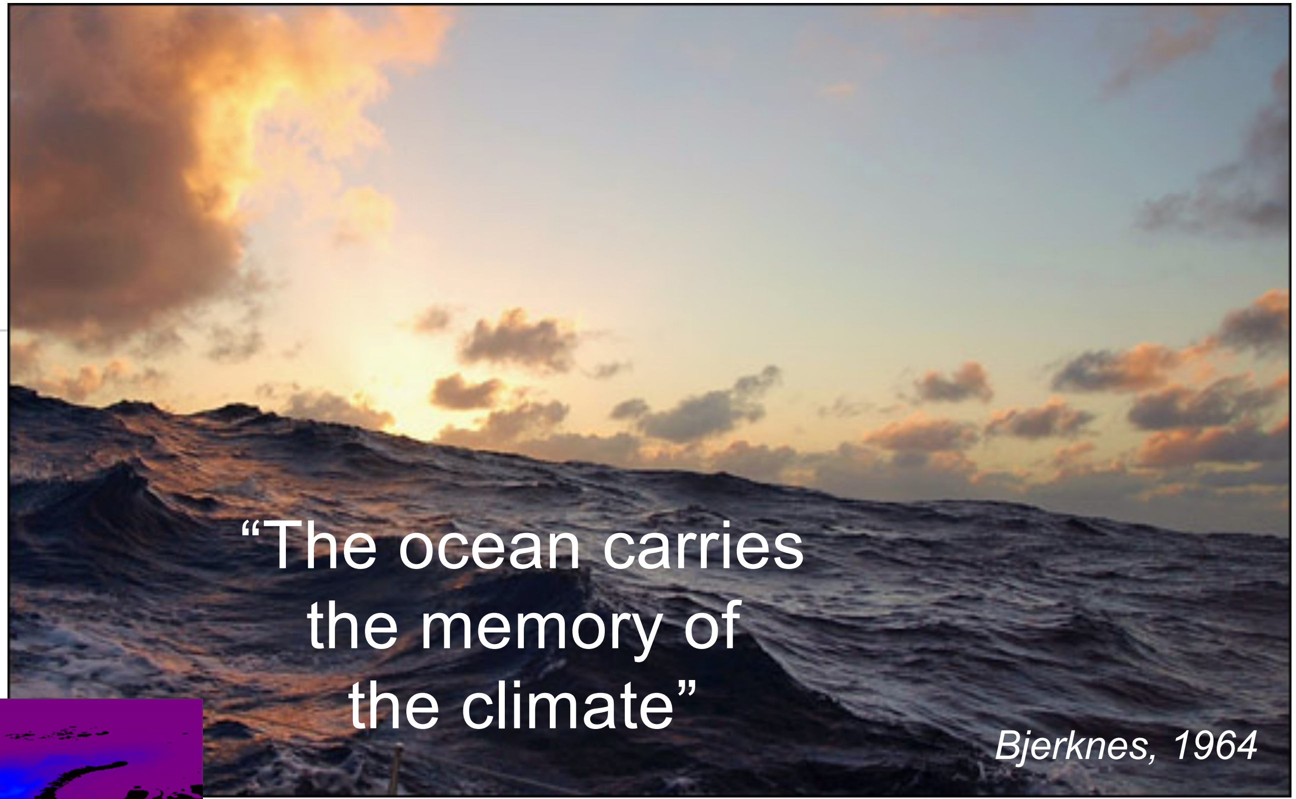
- › Assess **dynamical climate prediction system**
  - Use their predictions of the past to assess skill

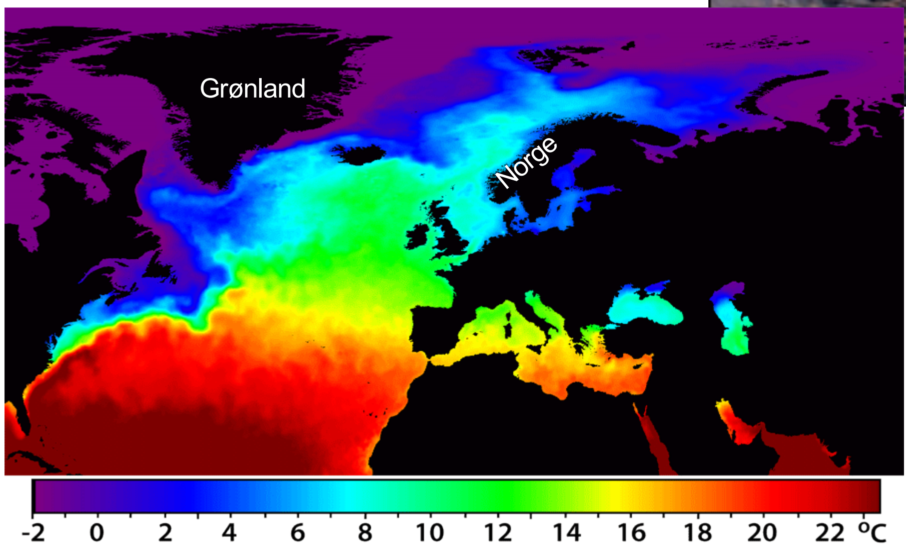
Main question for this talk

- › What is the **capacity** of current climate models to predict climate (e.g., SST) years to decades ahead?









Havoverflate-temperatur

Source: NOC from Met Office OSTIA data

See Odd Helge's talk ☺

Curr Clim Change Rep (2017) 3:112–127
DOI 10.1007/s40641-017-0064-z

DECADAL PREDICTABILITY AND PREDICTION (T DELWORTH, SECTION EDITOR)

Recent Progress in Understanding and Predicting Atlantic Decadal Climate Variability

S. G. Yeager[1] · J. I. Robson[2]

Predictability of North Atlantic SST and AMV

- Still many questions regarding the **physical mechanisms** that contribute to AMV
- A (dominant) understanding of AMV is the lagged relationships between deep water formation in the Labrador Sea, AMOC, and SST in the North Atlantic

AMOC – AMV

Curr Clim Change Rep (2017) 3:112–127
DOI 10.1007/s40641-017-0064-z

DECADAL PREDICTABILITY AND PREDICTION (T DELWORTH, SECTION EDITOR)

Recent Progress in Understanding and Predicting Atlantic Decadal Climate Variability

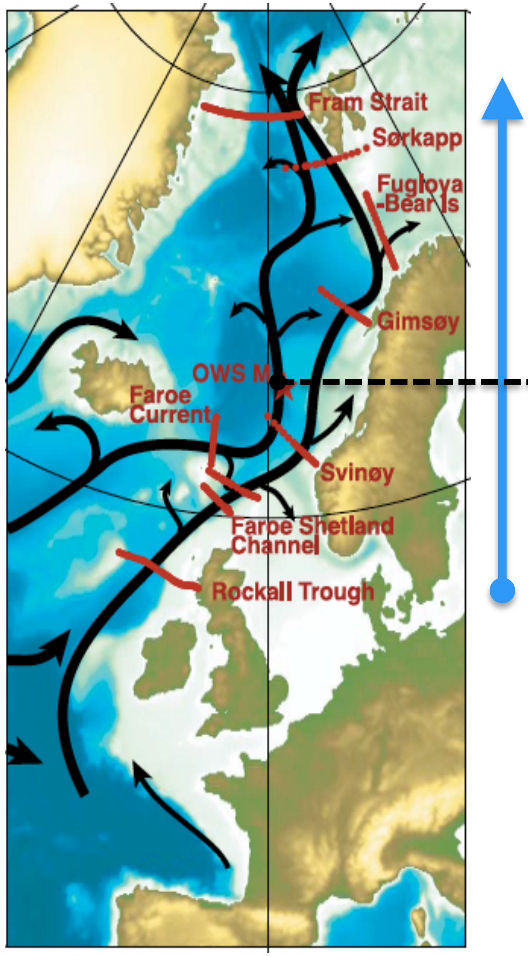
S. G. Yeager[1] · J. I. Robson[2]

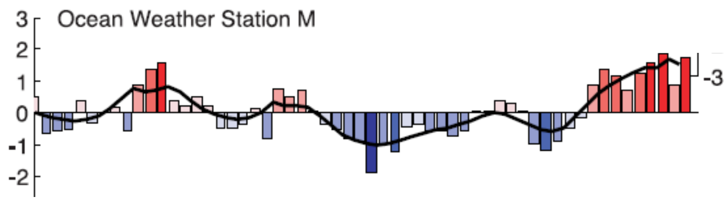
Predictability of North Atlantic SST and AMV

"Multi-model analyses highlighted the **subpolar North Atlantic** as a region of high potential predictability, with SST predictability related to, but generally less than, AMOC predictability"

AMOC – AMV

Predictability of SST in the Nordic Seas



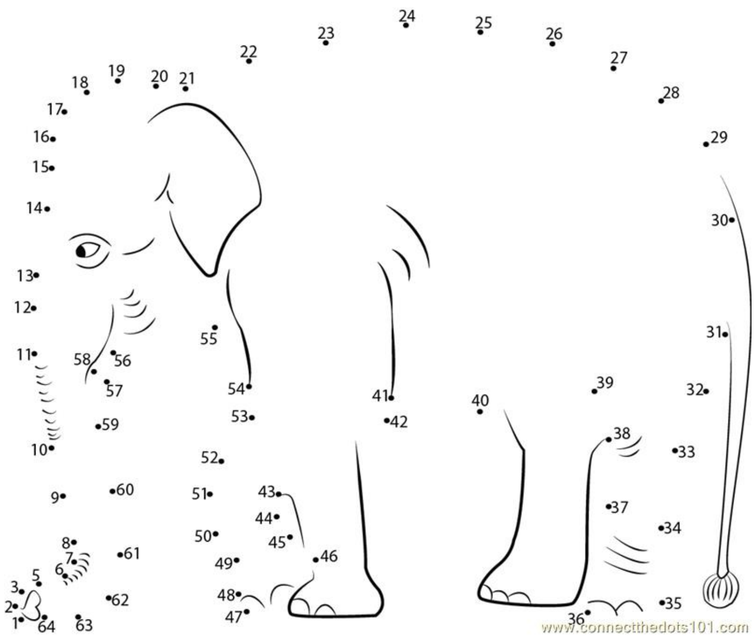


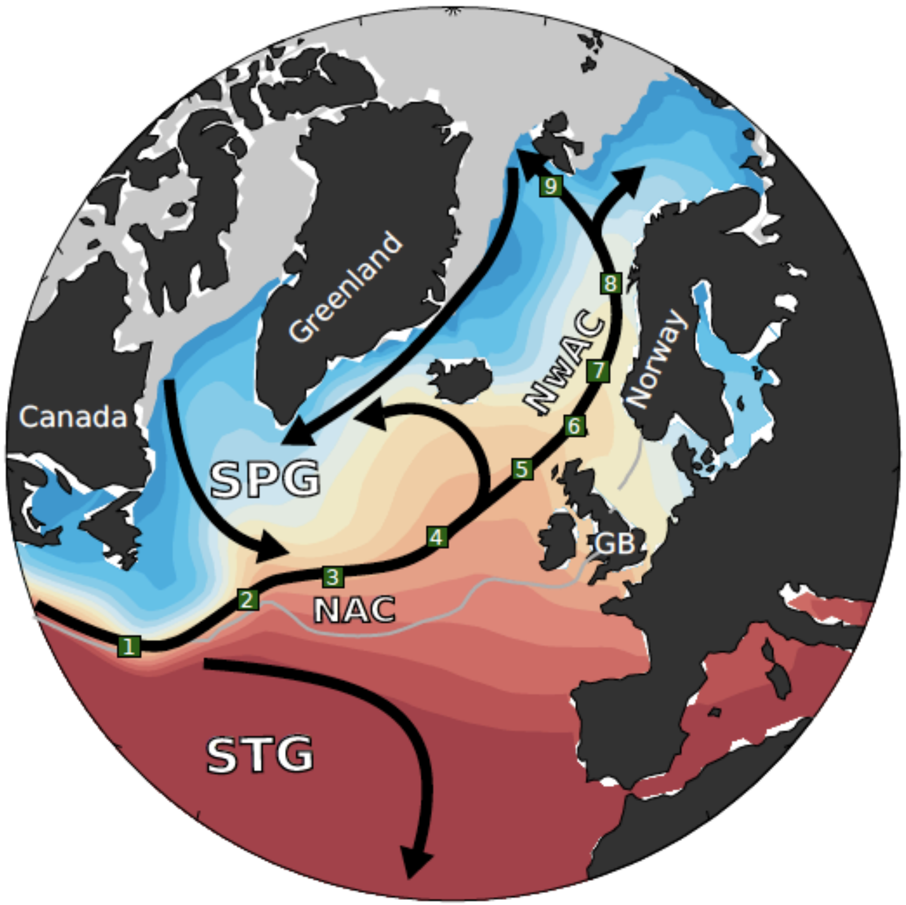
(e.g., Holliday et al. 2008; Eldevik et al. 2009)

Predictability of SST in the Nordic Seas

See Tore's talk ☺

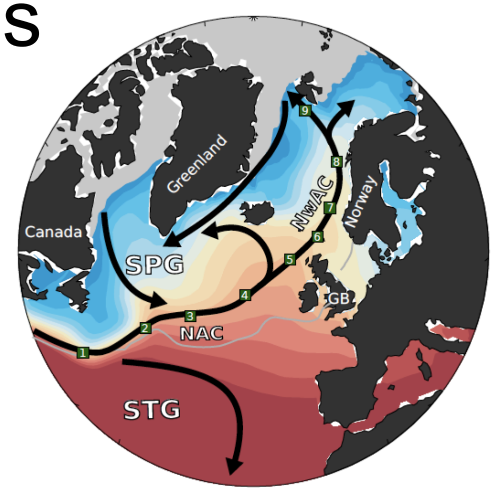
How is the stations connected?



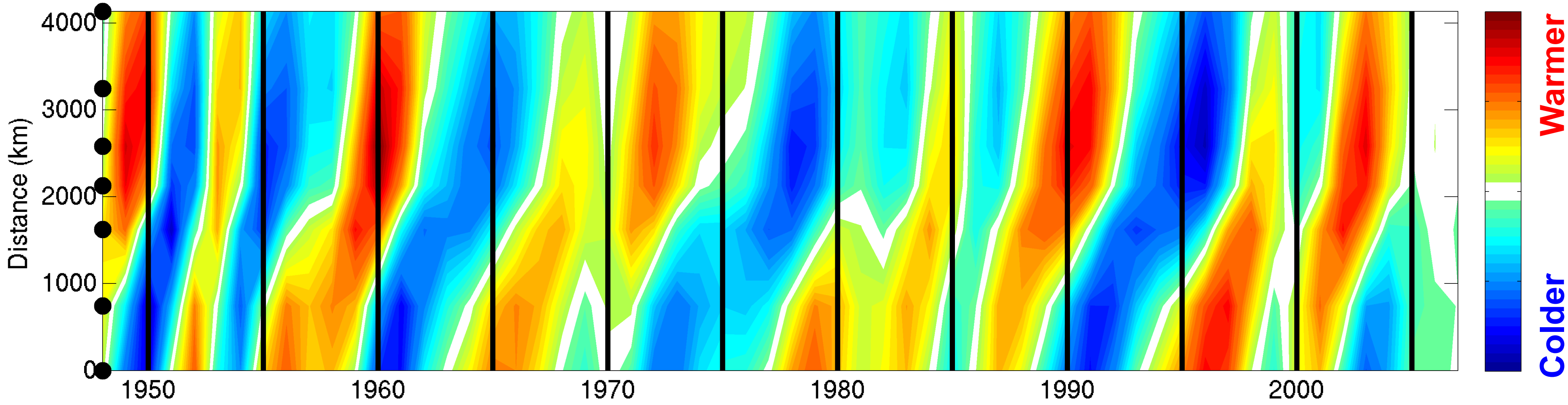


Årthun et al. 2017, Nature Communications

Predictability of SST in the Nordic Seas

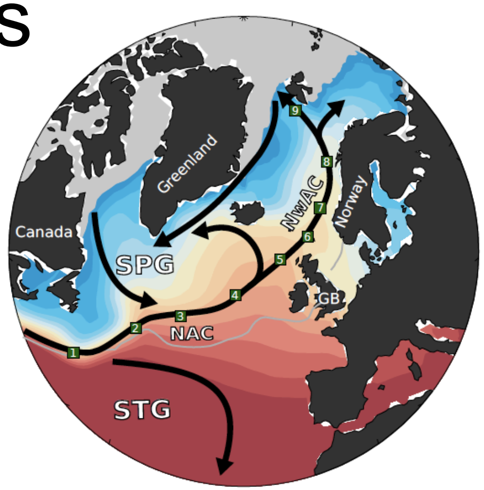


Variations in SST the last 60 years



Årthun et al. 2017, Langehaug et al., 2018

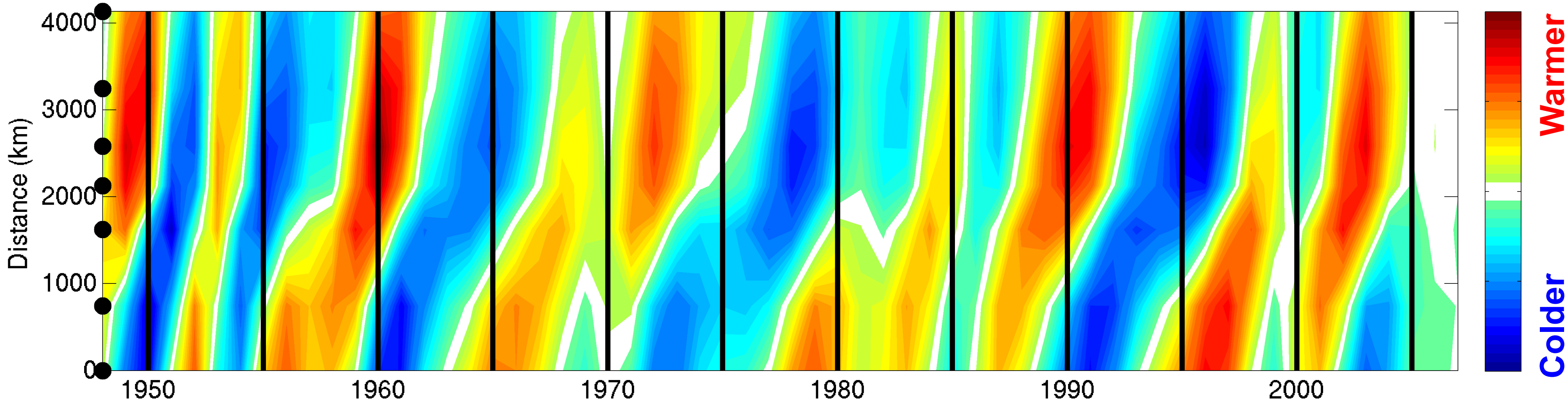
Predictability of SST in the Nordic Seas



Team Hardanger ☺

What are the main teleconnections that are already known?
→ This is a signal that travels in the ocean

Variations in SST the last 60 years

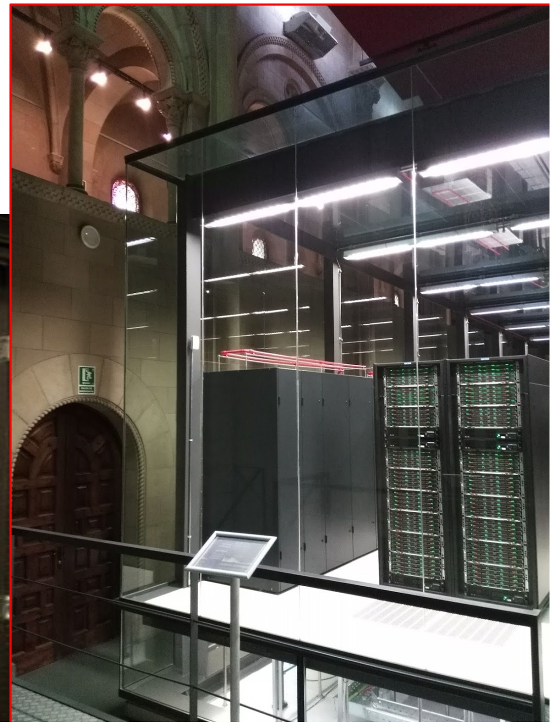


Årthun et al. 2017, Langehaug et al., 2018

See Yiguo and Madlen's talks ☺

Dynamical climate prediction system

› e.g., the Norwegian Climate Prediction Model
  - Similarities to a numerical weather model
  - With advanced methods to initialize the model
  - Large computational power is required
    › Large number of ensemble members
    › Several start dates



Bjerknes Centre for Climate Research

How to assess prediction skill?

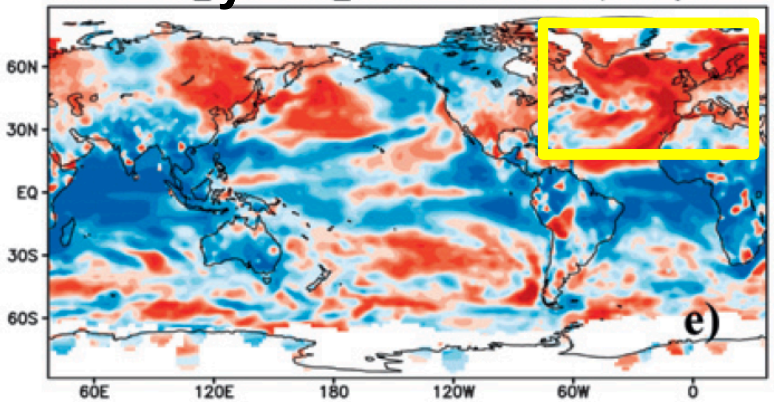
- “**Hindcast**”
  – predicting the past (e.g., with NorCPM)

- **But**, we do not know that the same prediction skill holds for the future…

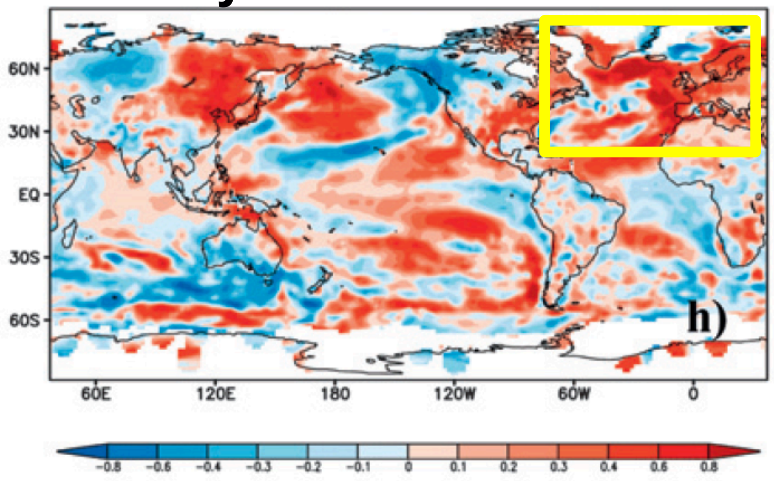
Main question

Predictive skill of SST in the subpolar North Atlantic

2-5 yrs after initialization

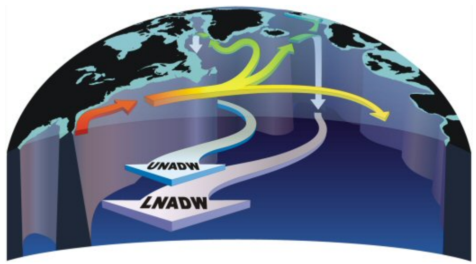


6-10 yrs after initialization



The subpolar North Atlantic is consistently the region with the largest relative improvement in SST skill due to initialization.

The skill is related to the northward advection of warm (and saline) subtropical water by AMOC.

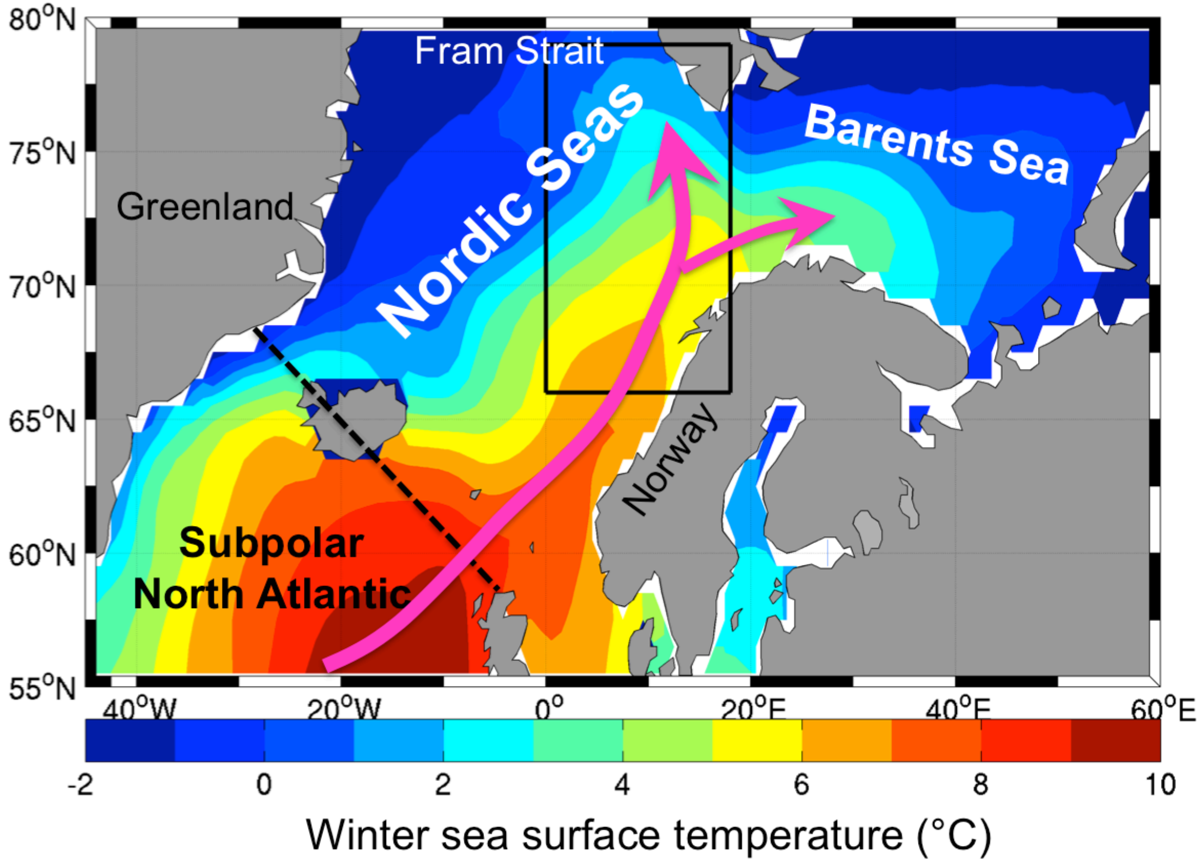


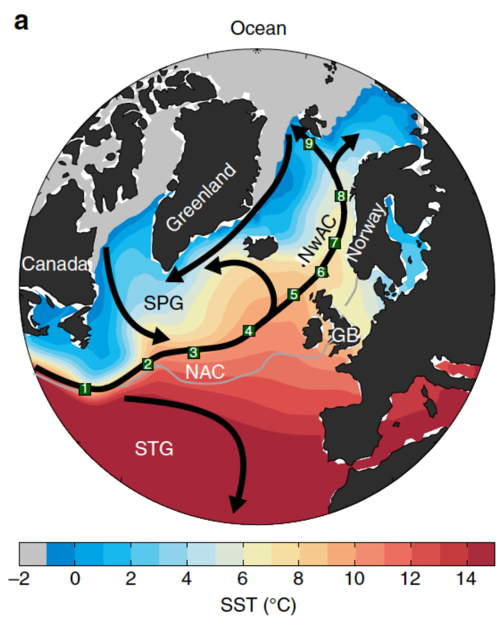
(e.g., Matei et al., 2012, Robson et al. 2012; Yeager et al. 2012; Msadek et al. 2014)

Main question

Predictive skill of SST in the Nordic Seas

Is it possible to predict changes some years ahead (with CMIP5 models)?





Årthun et al. 2017

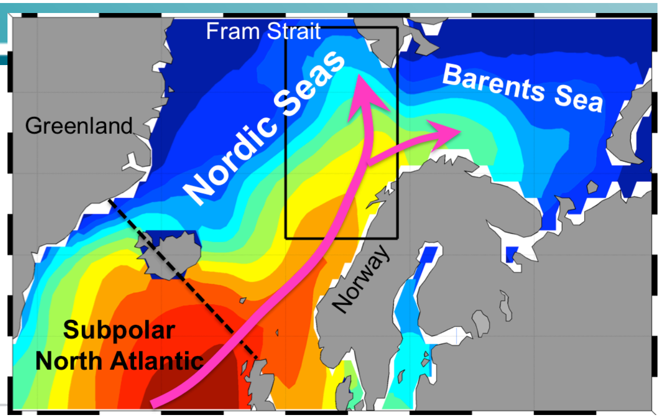
(e.g., Yeager et al., 2015; Langehaug et al., 2017)

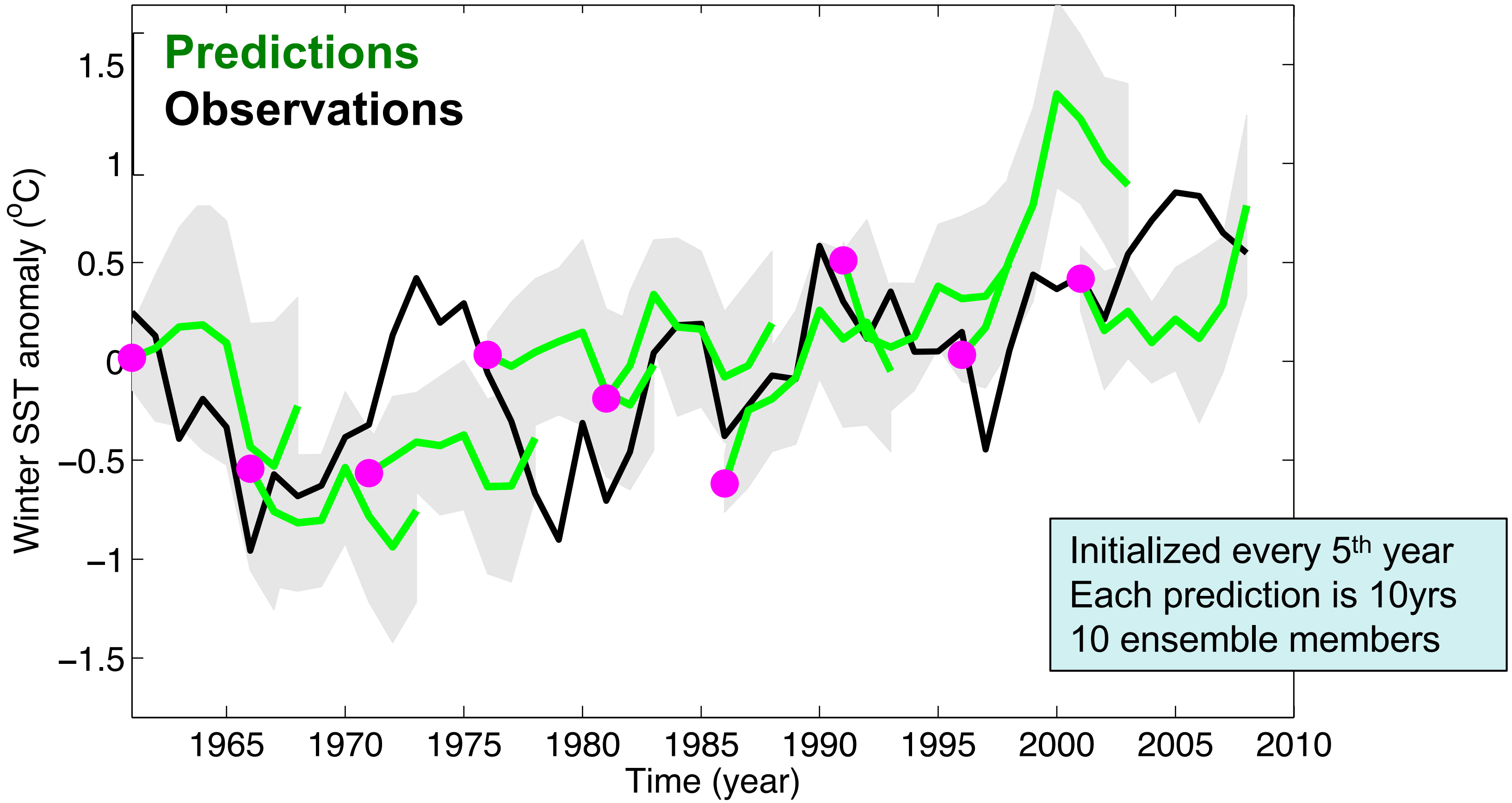
CMIP5

→ What do we expect from climate models in this particular region?

CMIP5

Initialized hindcast experiments or retrospective predictions





- *Initialization: model is corrected with ocean observations; model must start from a realistic climate – a warm or cold ocean*

Some information about the **CMIP5** model experiments

- 16 models that contribute with decadal **initialized hindcast experiments** (or retrospective predictions) to the CMIP5 data archive

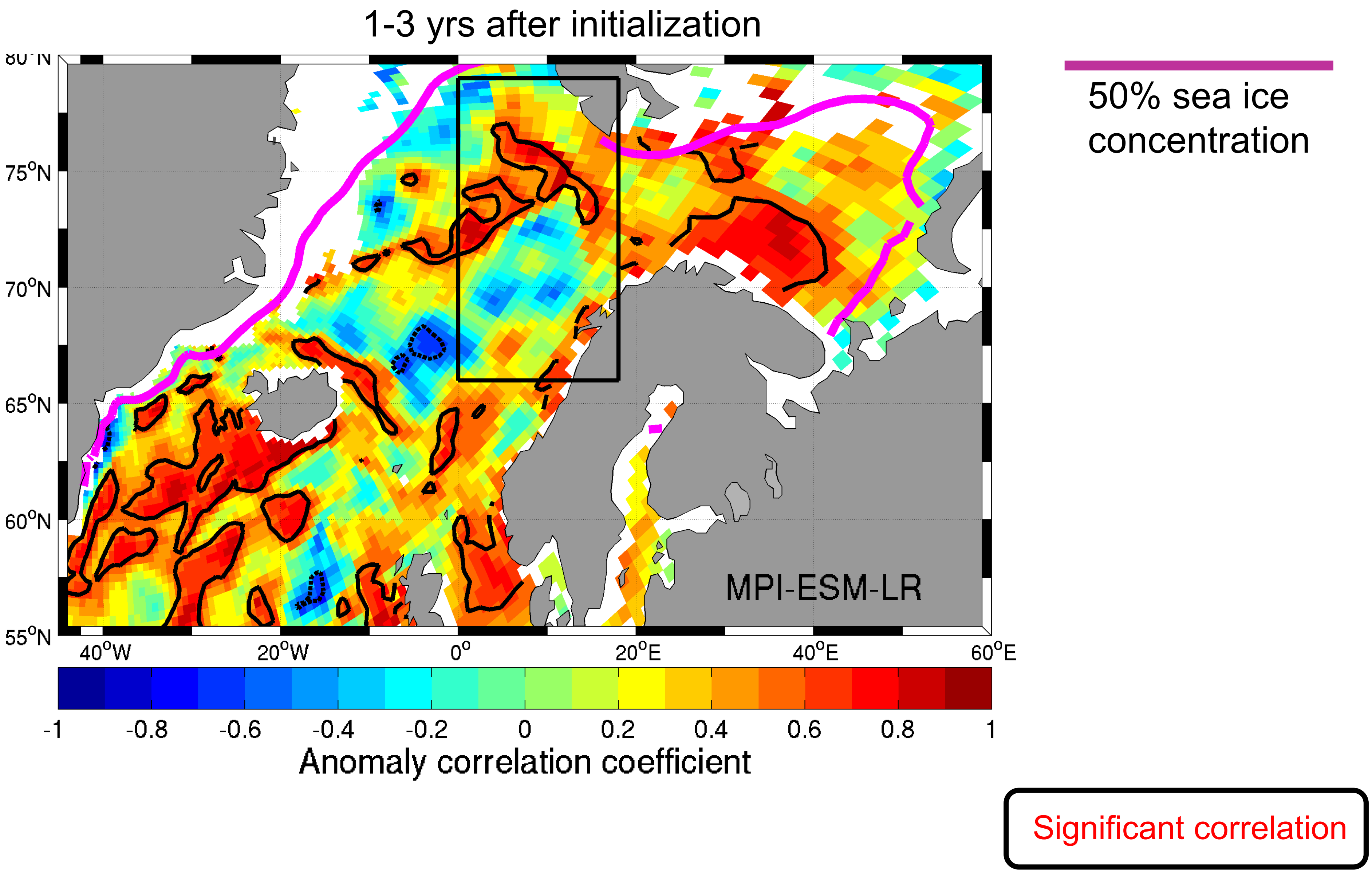
- We are focusing on **three** of these models: MPI-ESM-LR, CNRM-CM5 and IPSL-CM5

- It is in a modelling and dynamical aspect of interest to analyse models that differ, thus representing **a range of different model climates**

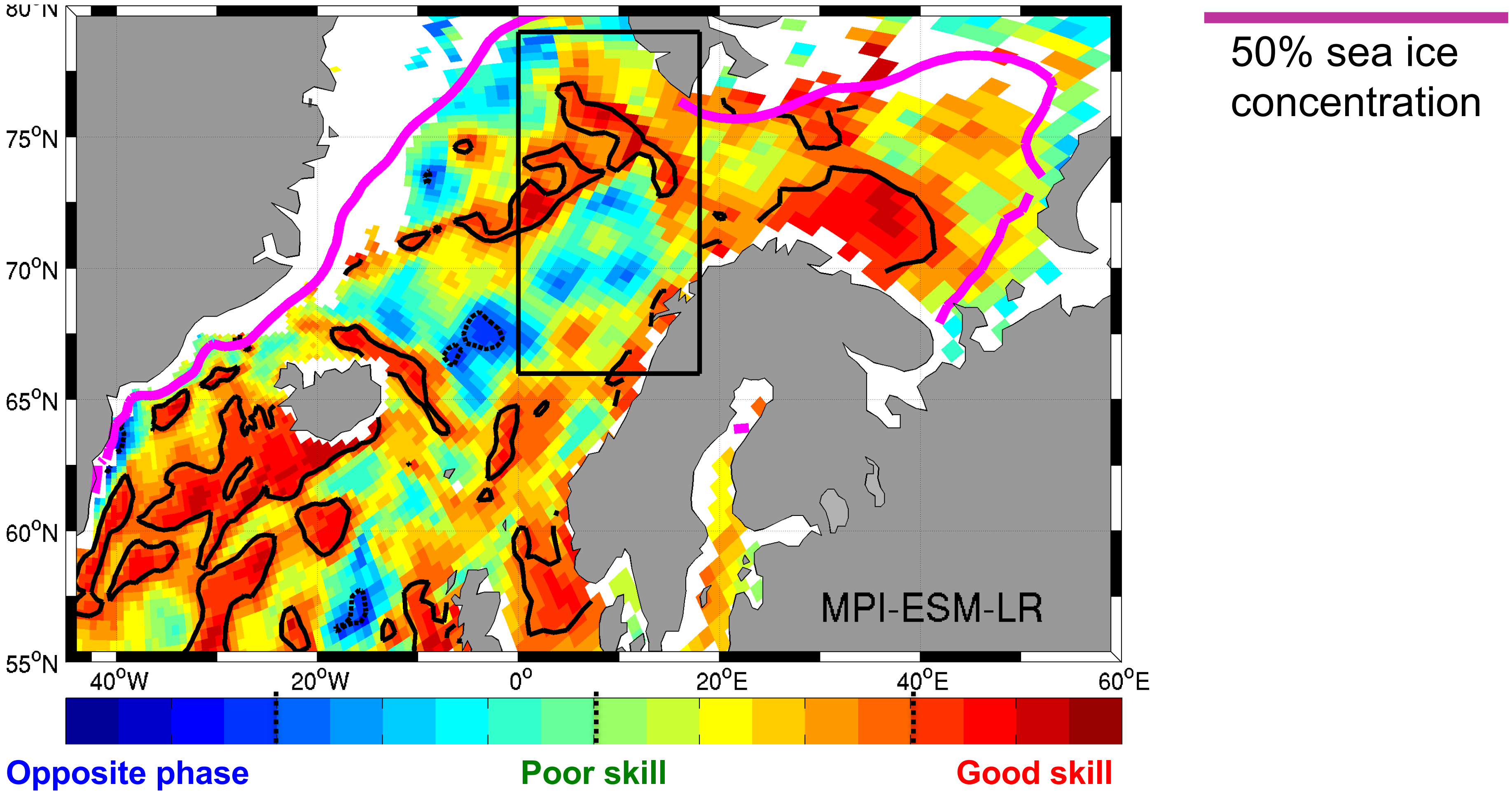
- Each model provides several ensemble members, which have been initialized **every fifth year** between 1960 and 2010

- All hindcasts have a time length of **10 years**

Correlation between model data and HadISST in each grid cell

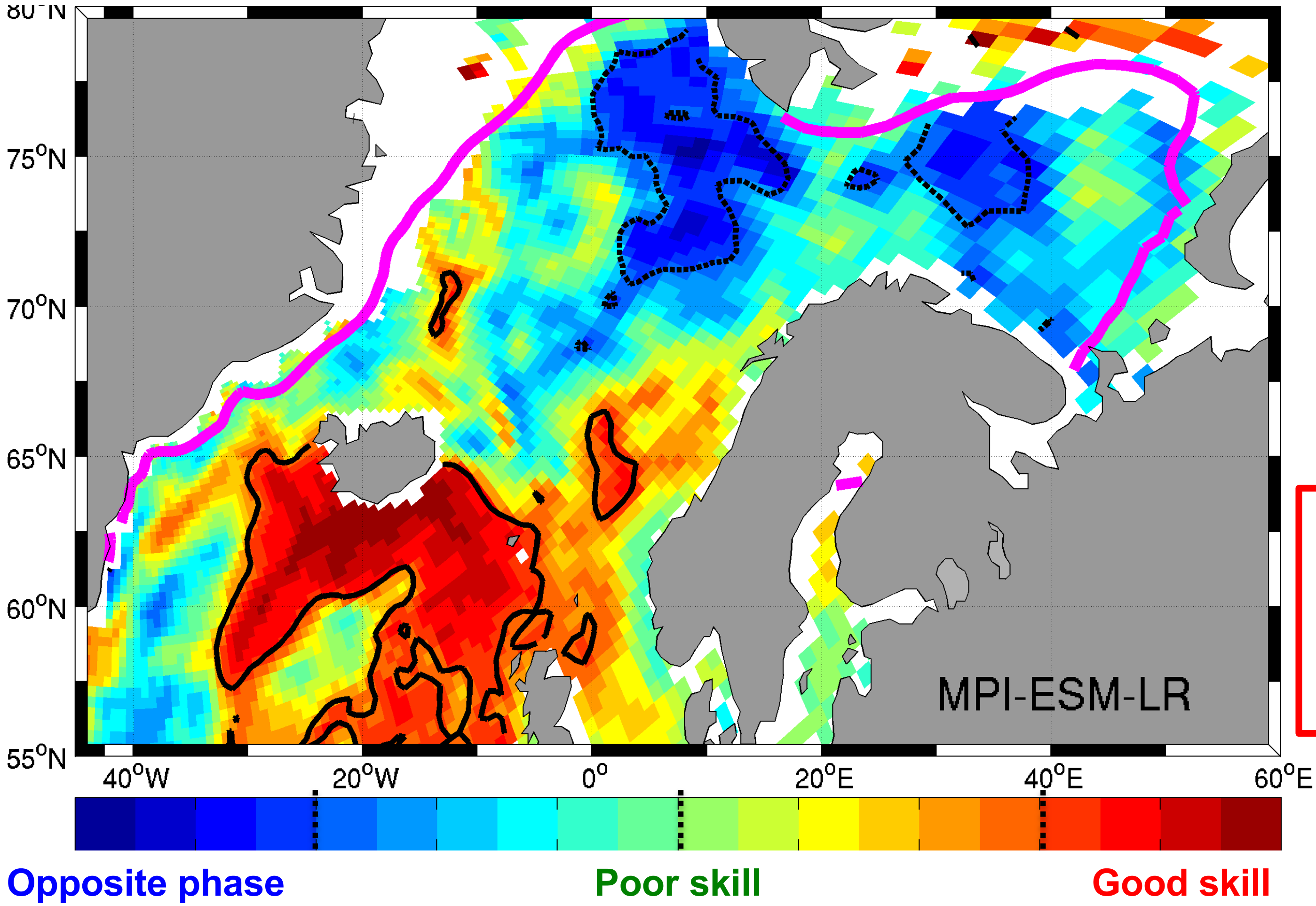


1-3 yrs after initialization



Predictive skill is poor in the Nordic Seas and Barents Sea

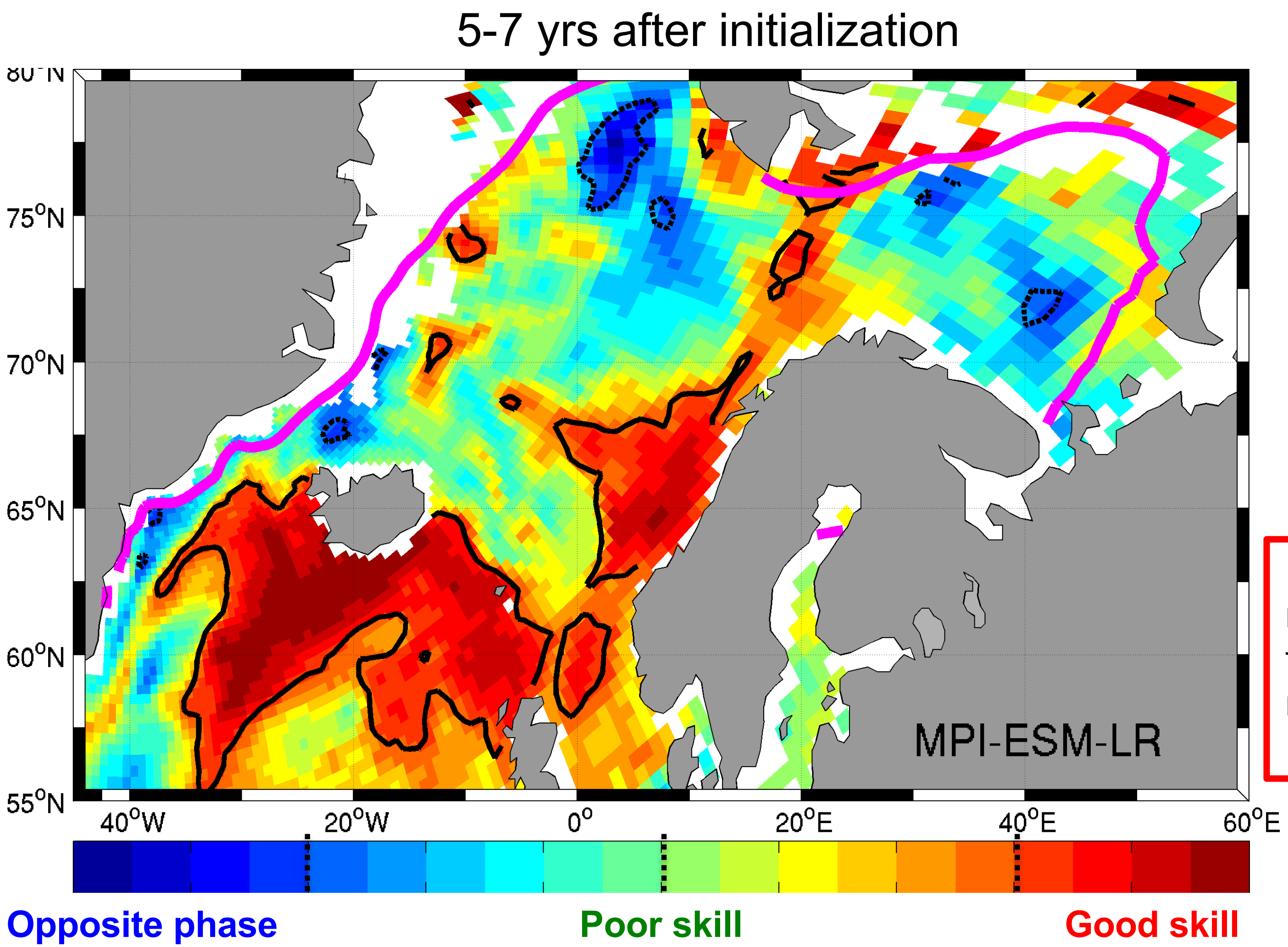
4-6 yrs after initialization



However…

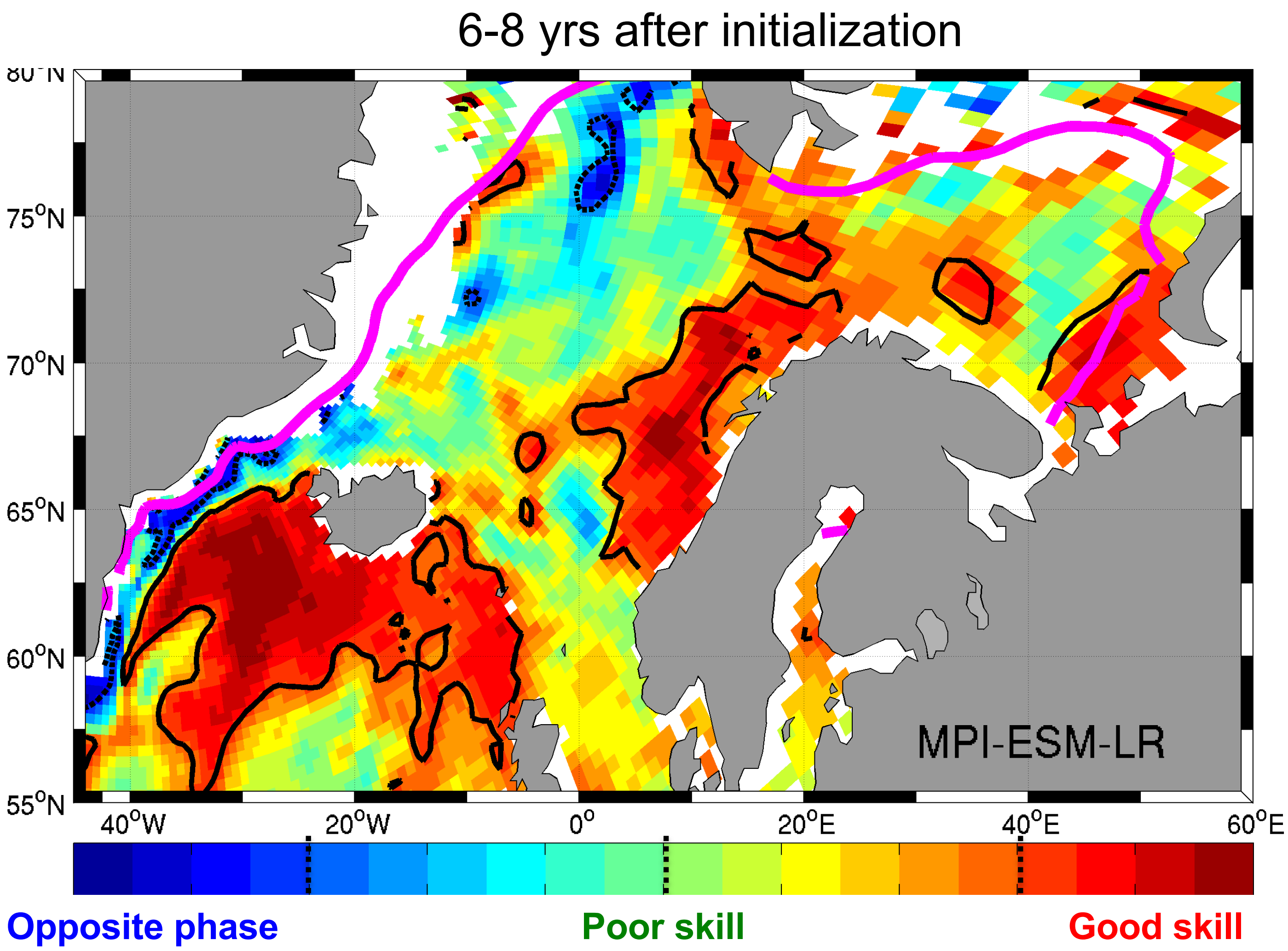
Progression of regions with high skill from the subpolar region and into the Nordic Seas…

Predictive skill in the eastern Nordic Seas
– along the pathway of Atlantic Water

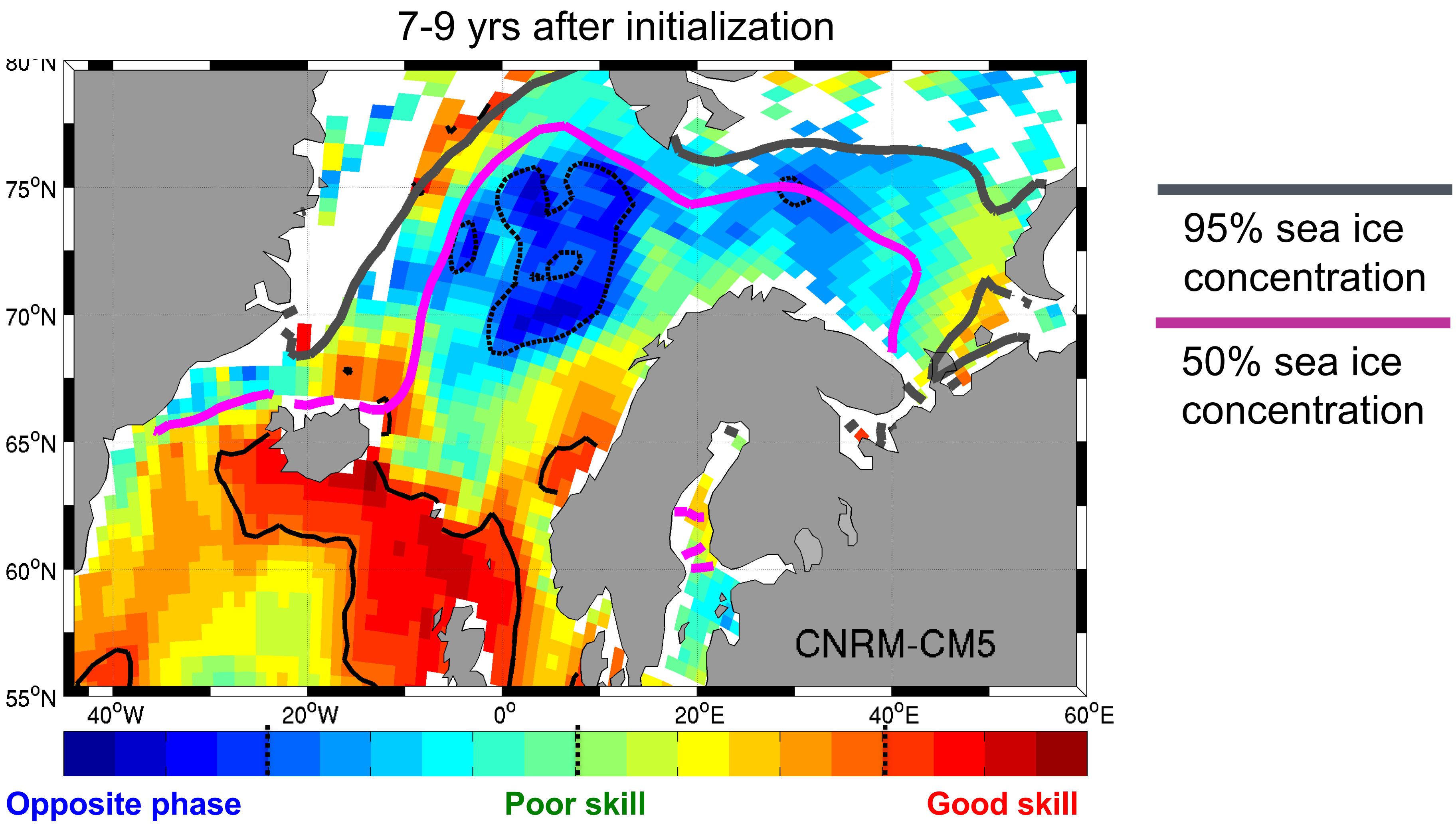


Progression of regions with high skill from the subpolar region and into the Nordic Seas…

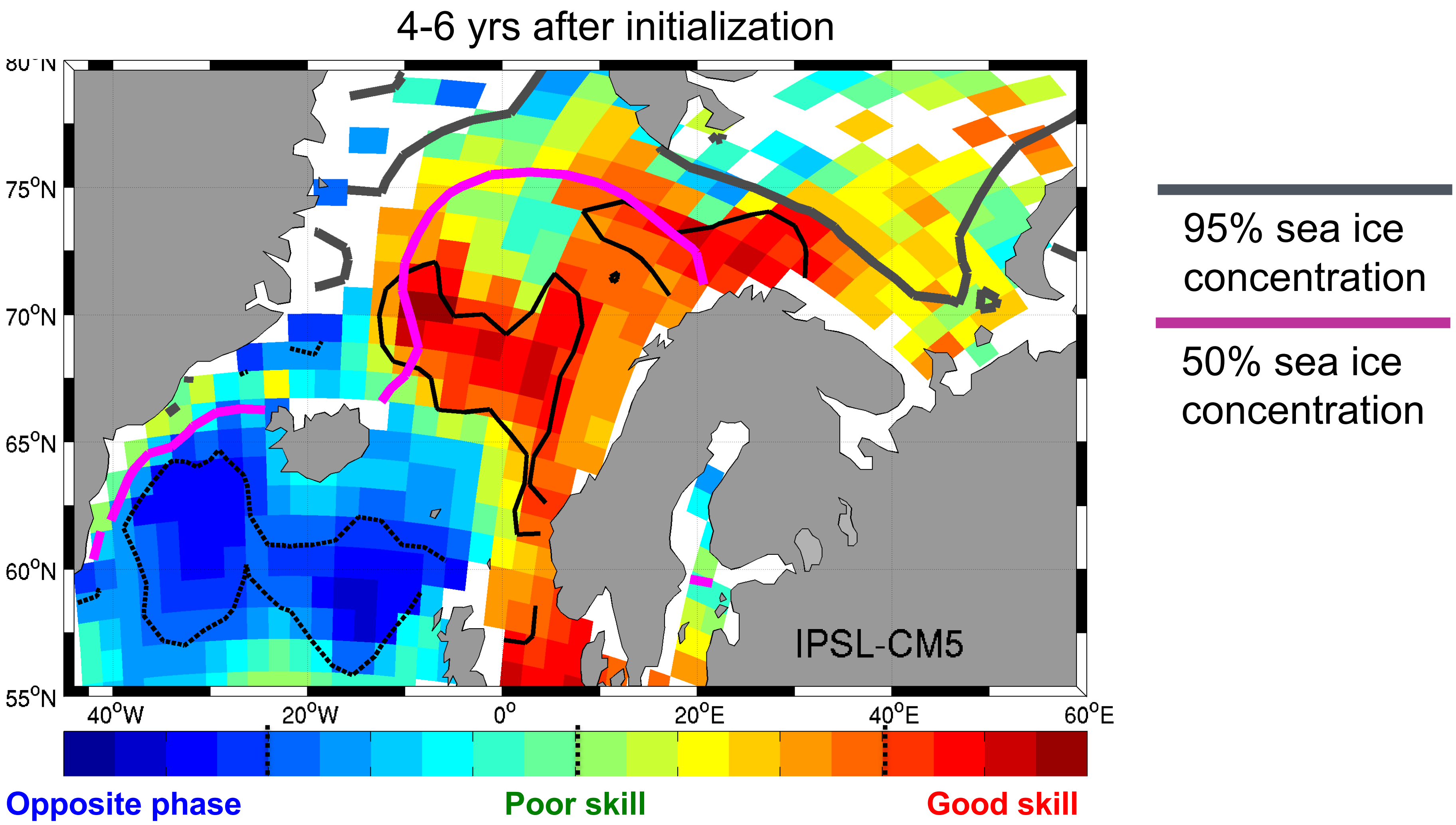
Predictive skill spread towards Barents Sea and Fram Strait



Predictive skill only reaches the southern Nordic Seas at longer lead-time



Predictive skill not found in the subpolar North Atlantic
– but in the eastern Nordic Seas



Conclusions

In CMIP5, SST predictability is…

› in general limited in the Nordic Seas in comparison with the subpolar North Atlantic

› found in parts of the Nordic Seas and Barents Sea 1-3 yrs after the initialization

› found on longer lead-times (not in all models)
→ underlining the potential role of ocean dynamics/advection of SST anomalies

› diverging among the three CMIP5 models

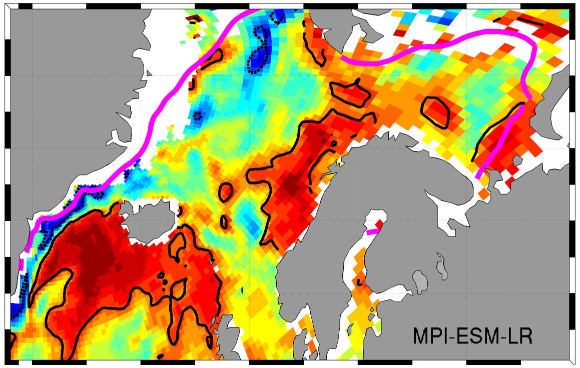
Langehaug et al., 2017

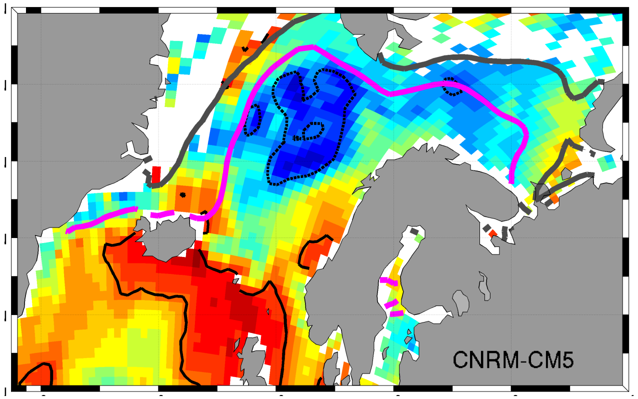
Conclusions

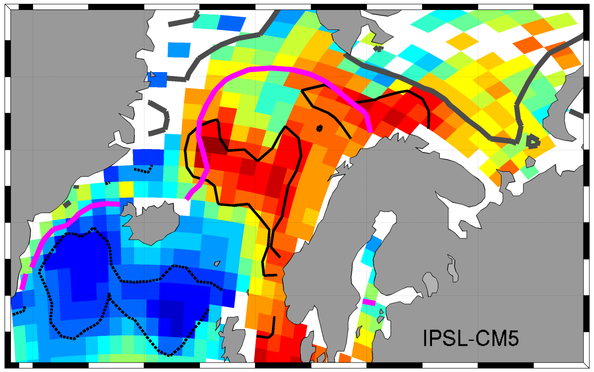
Potential sources for differences:

1. Horizontal resolution of ocean part
2. Initialization process
3. Mean state of sea ice
4. Link and time lag with AMOC at 48°N

How are surface anomalies carried northward in the models?





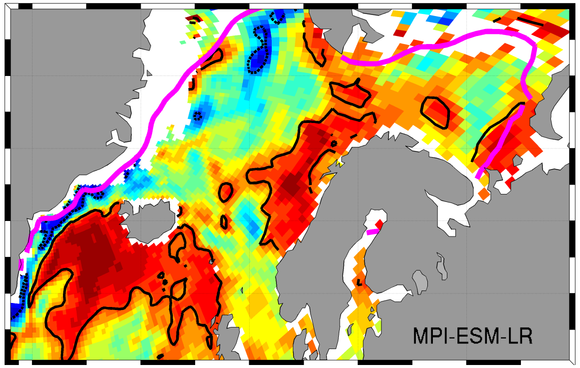


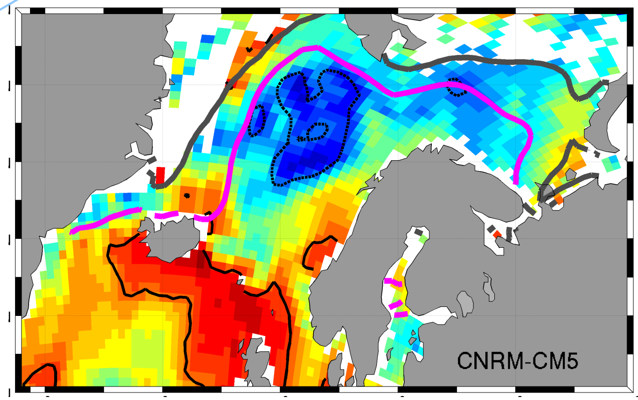
Langehaug et al., 2017

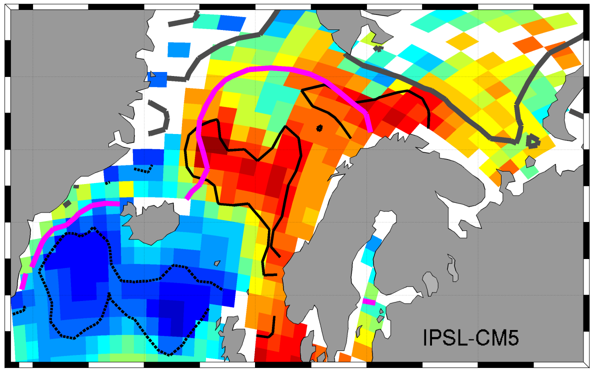
Conclusions

Team Fjord View ☺

Which model and predictions are the most relevant?
→ Each model has good and less good features.
→ To use several models will help you to have a better understanding.





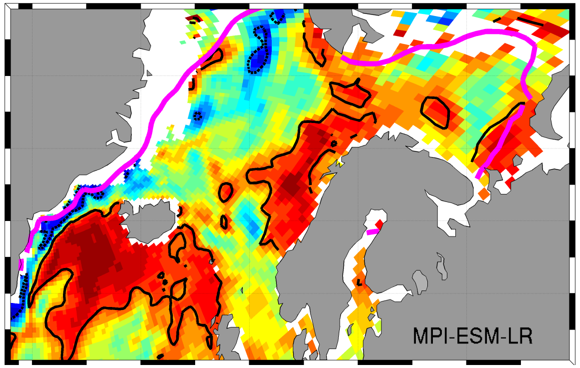


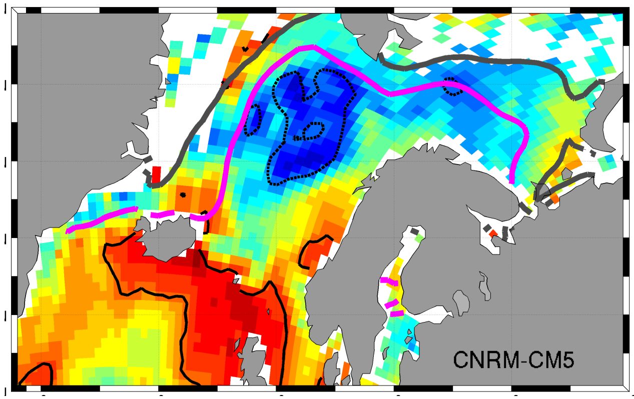
Langehaug et al., 2017

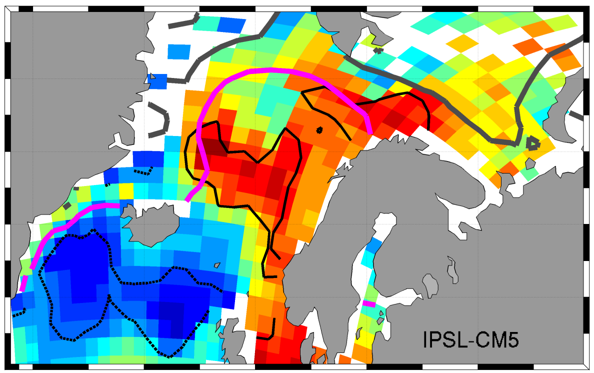
Conclusions

Group 4 ☺

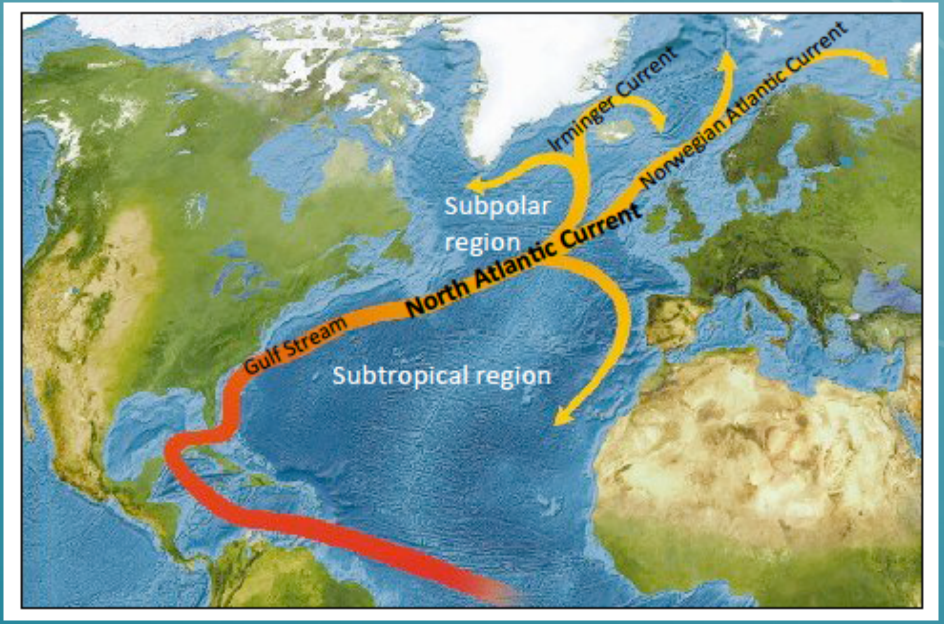
What is the state of the art tools?
→ ESMValTool (Earth System Model Evaluation Tool)
→ See Shuting's talk







Langehaug et al., 2017



Confront model and predictions with mechanism identified in observations

– Using forced NorESM and NorCPM –

Systematic model errors are a major challenge in climate prediction

- We confront the following systems with mechanisms identified in observations:

1) Forced global ocean-sea ice model (1948-2007) **NorESM**

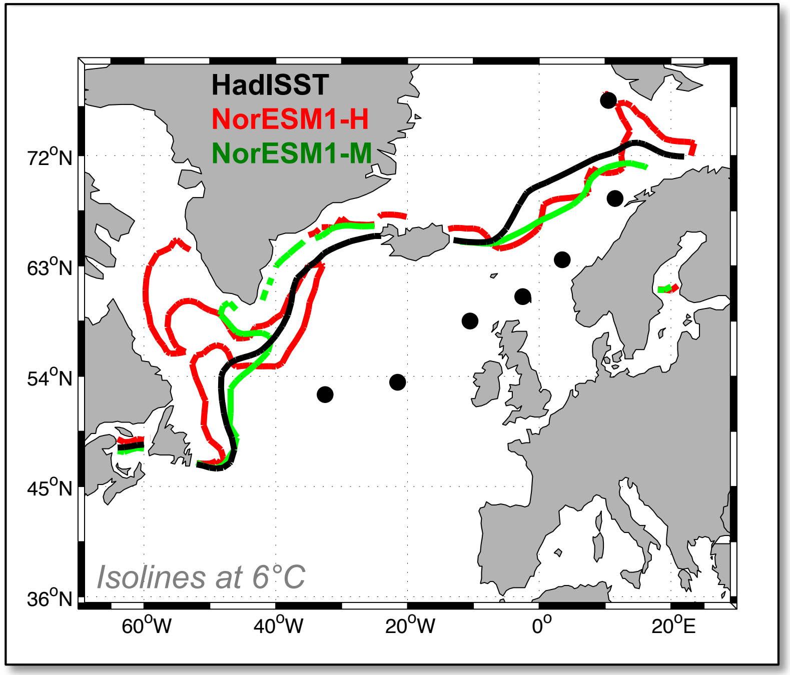
2) Dynamical climate prediction model (1960-2011) **NorCPM**

Comparison of two model versions of the NorESM

Both versions forced with COREv2 atmospheric reanalysis for the period 1948-2007.

› **NorESM1-M (Medium resolution):**
- **1 degree** horizontal resolution of ocean model
- Run for five cycles (300 model years)

› **NorESM1-H (High resolution):**
- **0.25 degree** horizontal resolution of ocean model
- Run for two cycles (120 model years)

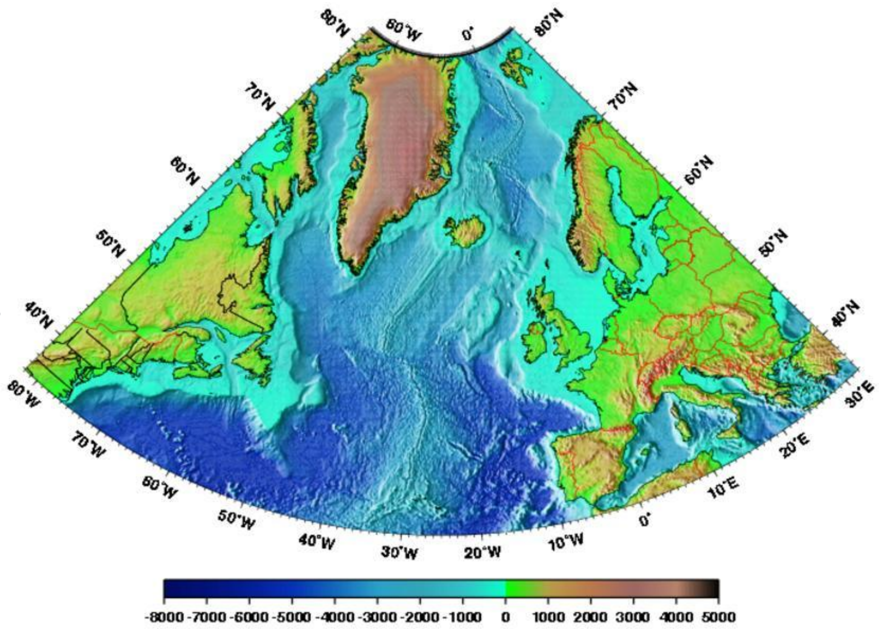


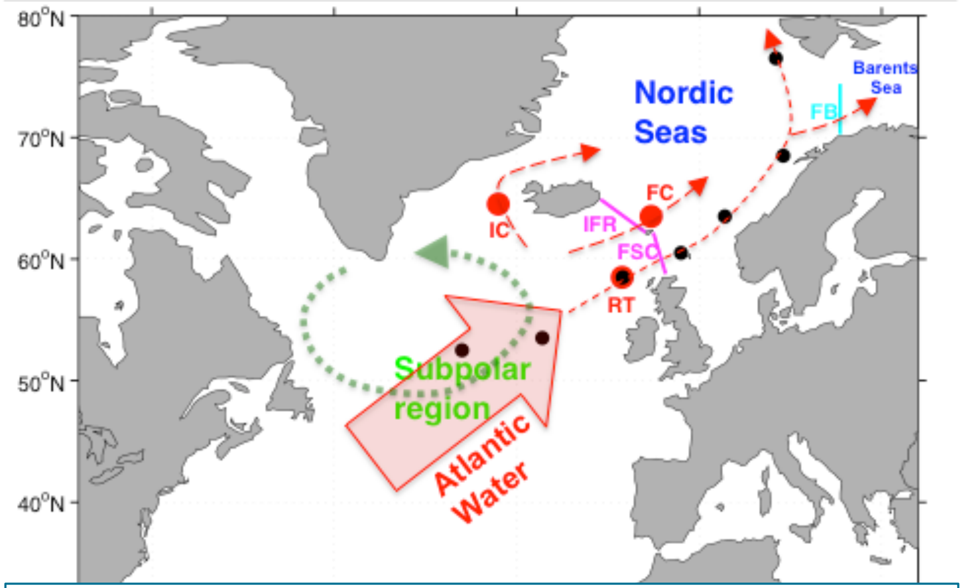
Atlantic Water in high resolution:
– further west in subpolar region
– further north in Nordic Seas

Why do we expect improvements with a higher resolution model?

- Bathymetry varies largely along the Atlantic Water pathway
- It is particularly complex from the subpolar region to the Nordic Seas
- Flow of Atlantic Water partly follows the bathymetry

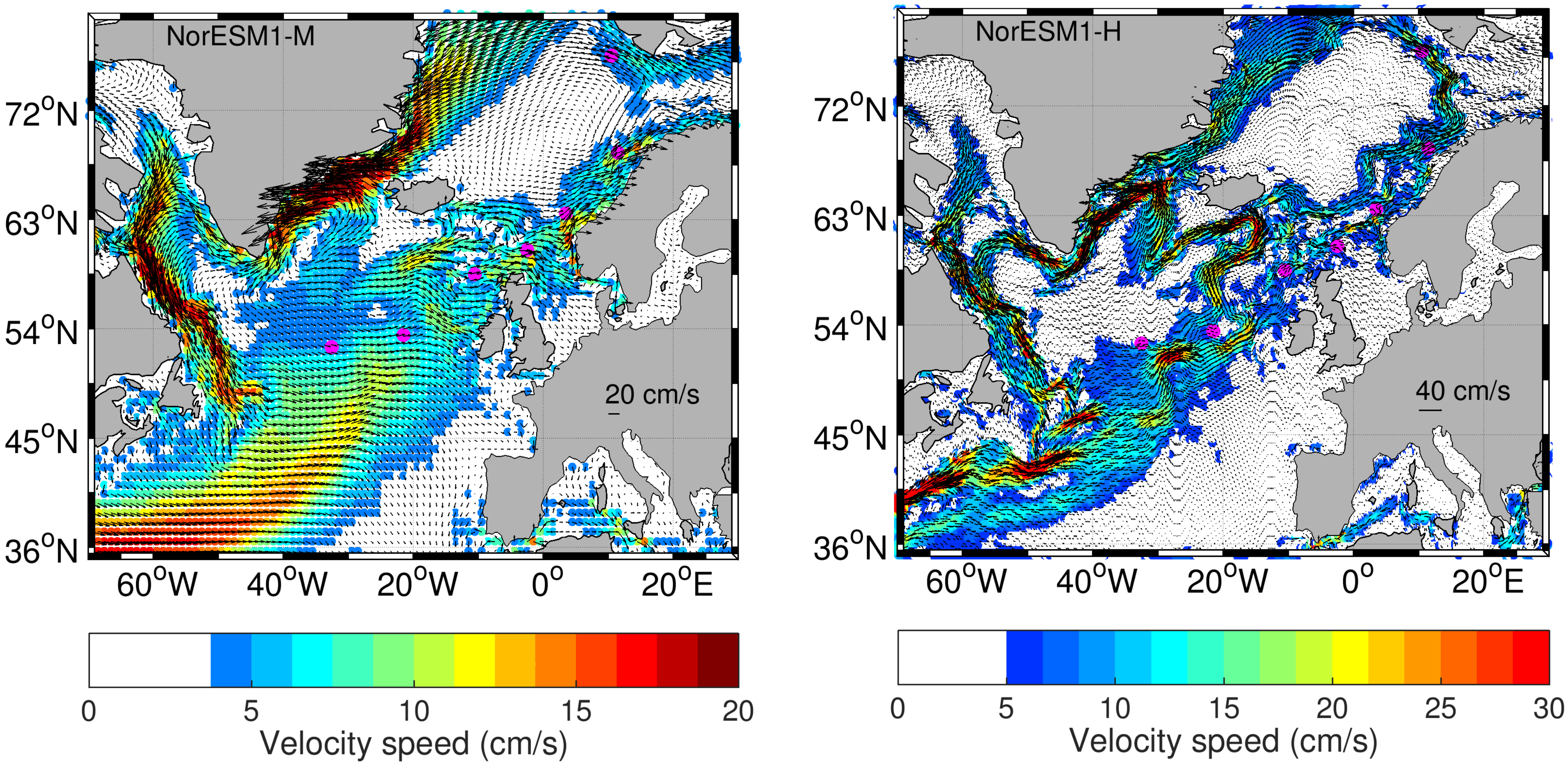
Potentially better represent the transport of mass and heat across the ridge, allowing thermohaline anomalies to be communicated

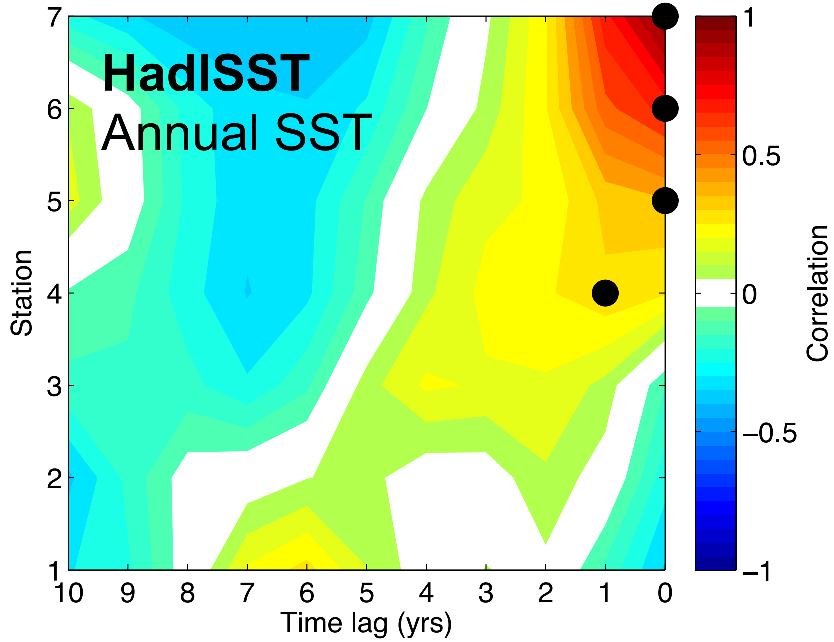


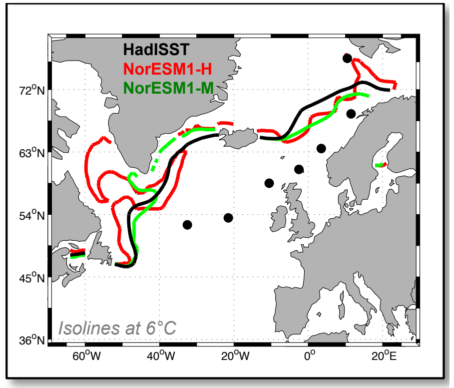


Improved mean heat transport in the high resolution for FSC and FB (1948-2007)

Surface circulation related to the North Atlantic Current is improved in high resolution

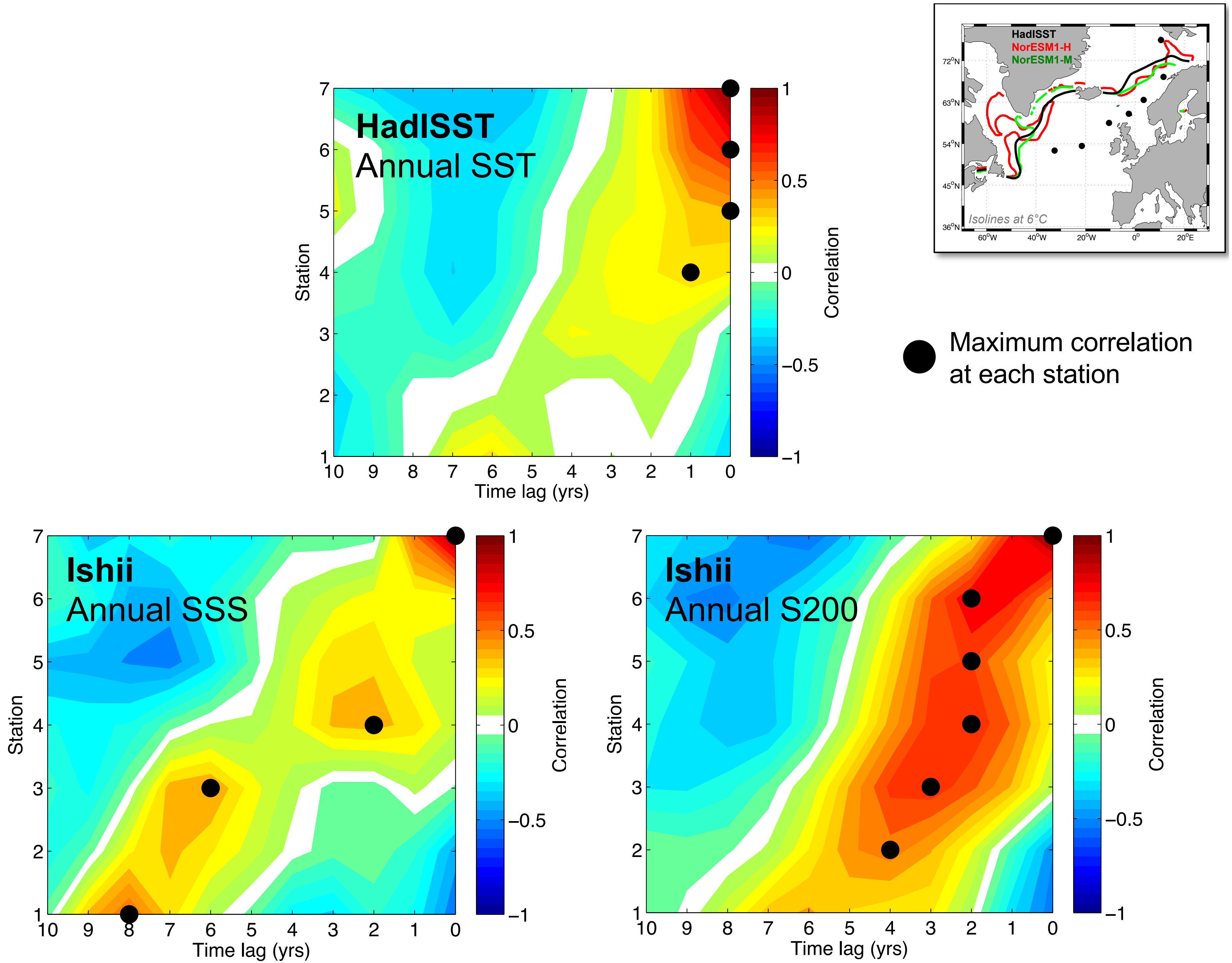




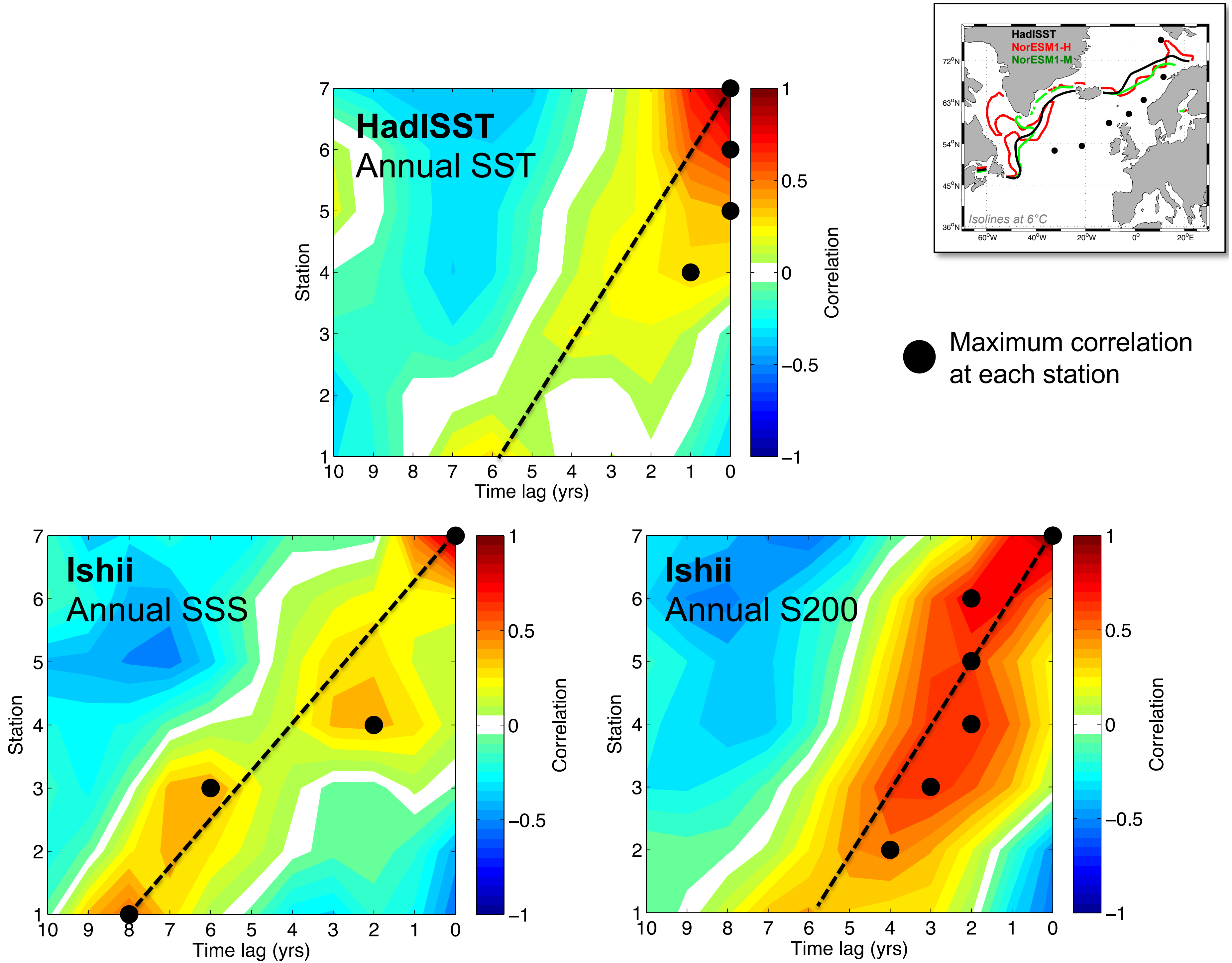


Maximum correlation at each station

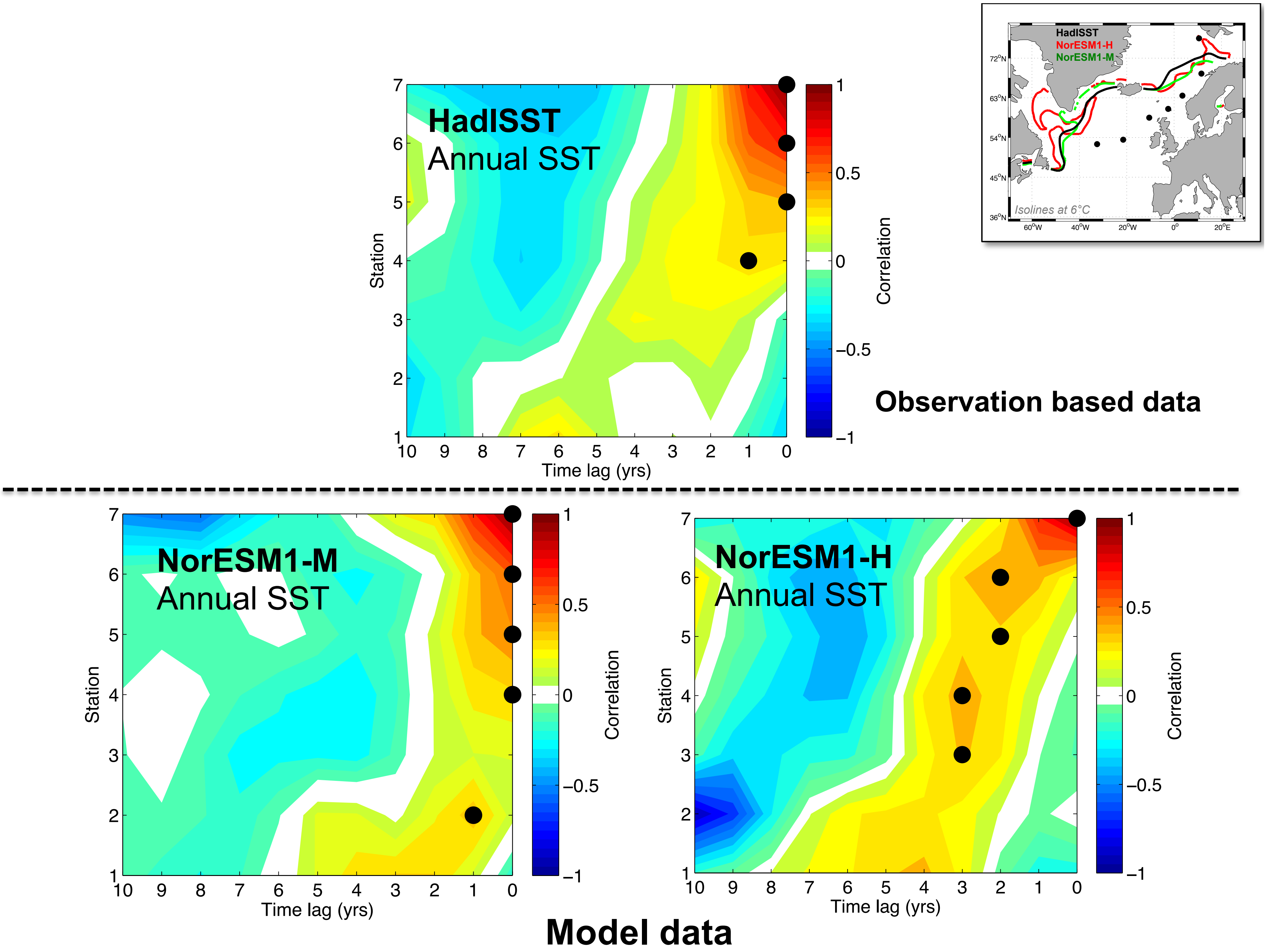
Only observation based data

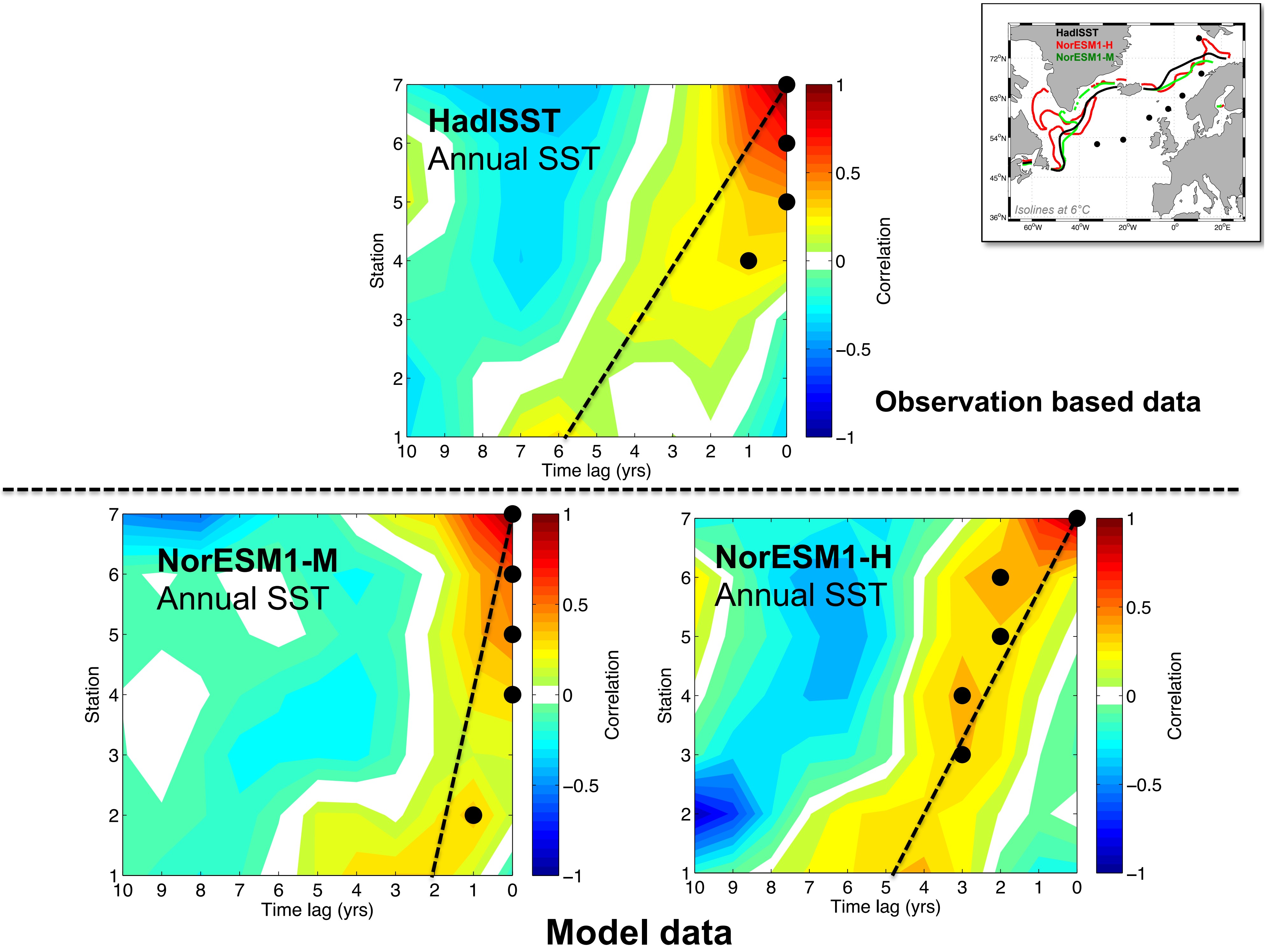


Only observation based data



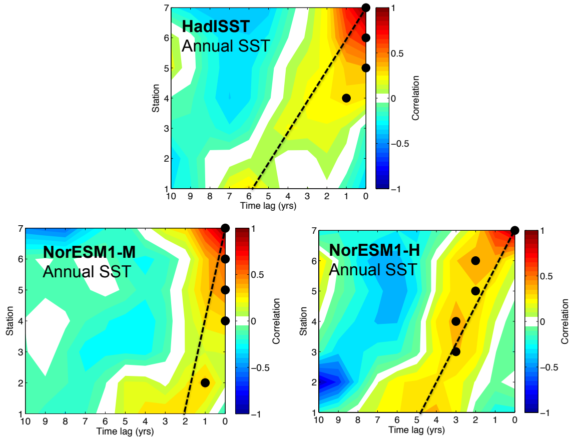
Only observation based data

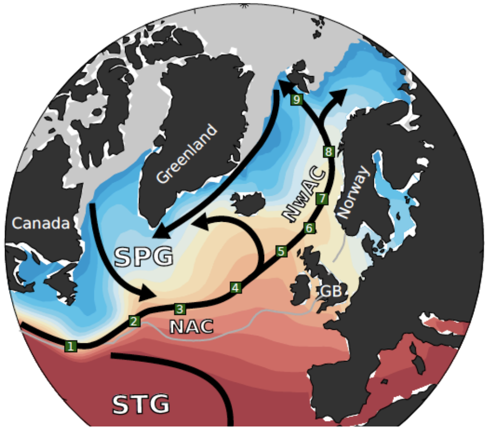

HadISST
NorESM1-H
NorESM1-M
Isolines at 6°C
72°N
63°N
54°N
45°N
36°N
60°W
40°W
20°W
0°
20°E
HadISST
Annual SST
Station
Time lag (yrs)
Correlation
Observation based data
NorESM1-M
Annual SST
Station
Time lag (yrs)
Correlation
NorESM1-H
Annual SST
Station
Time lag (yrs)
Correlation
Model data



HadISST
Annual SST
Station
Time lag (yrs)
Correlation
HadISST
NorESM1-H
NorESM1-M
Isolines at 6°C
Observation based data
NorESM1-M
Annual SST
NorESM1-H
Annual SST
Model data

Conclusions





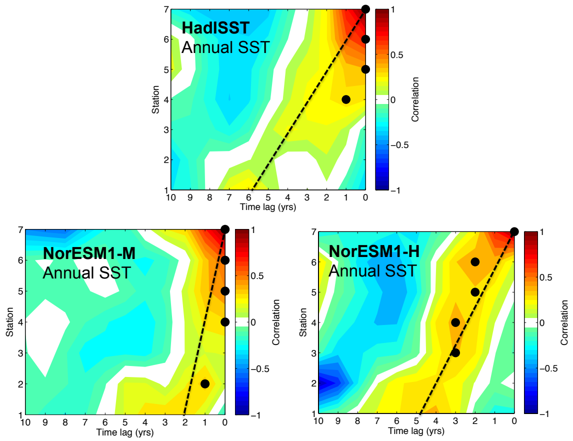
Årthun et al. 2017

Higher horizontal resolution (from 1° to 0.25°) improves the communication of warm and cold anomalies from the subpolar region to the Nordic Seas

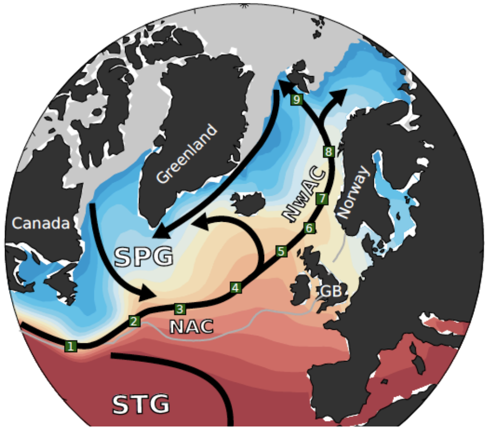
We propose to use similar diagnosis as presented here on coupled climate models that are used for climate predictions

This observation-based diagnosis (Årthun et al., 2017) is tailored to test mechanisms related to the Atlantic Water pathway, and can be particularly useful in attribution source of skill in climate predictions

Langehaug et al., 2018



Conclusions



Årthun et al. 2017

Higher horizontal resolution (from 1° to 0.25°) improves the communication of warm and cold anomalies from the subpolar region to the Nordic Seas

Group 2 ☺

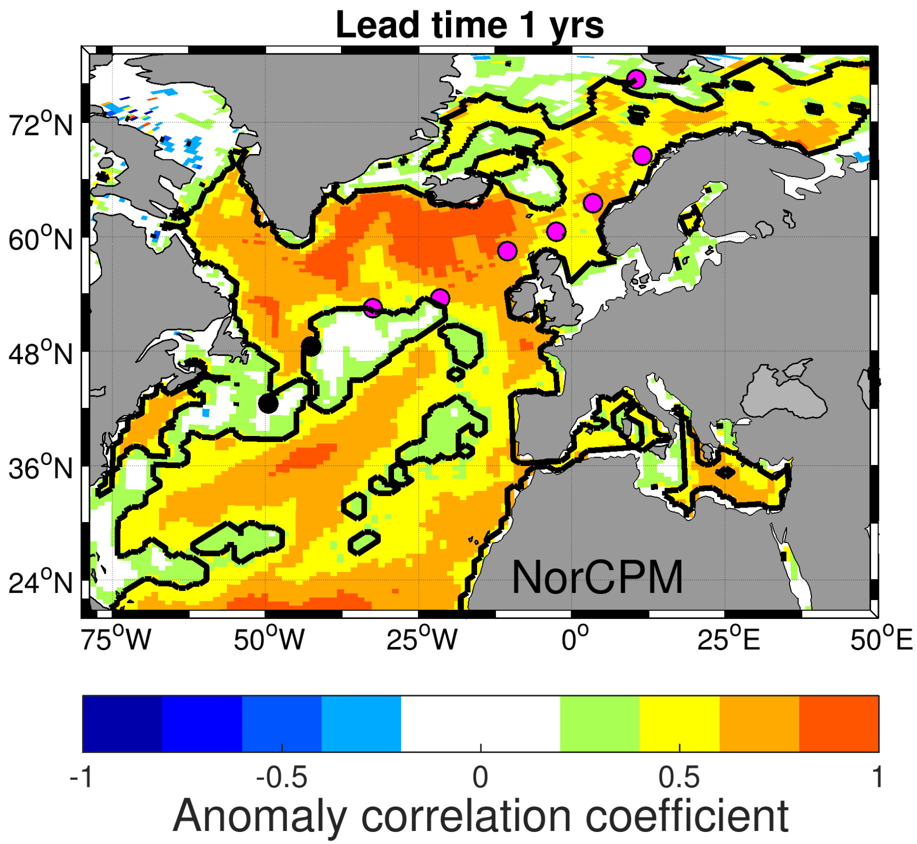
How well do models represent teleconnections and what is the importance of model resolution?
→ Here higher resolution leads to a more realistic circulation and thereby also better time lag.

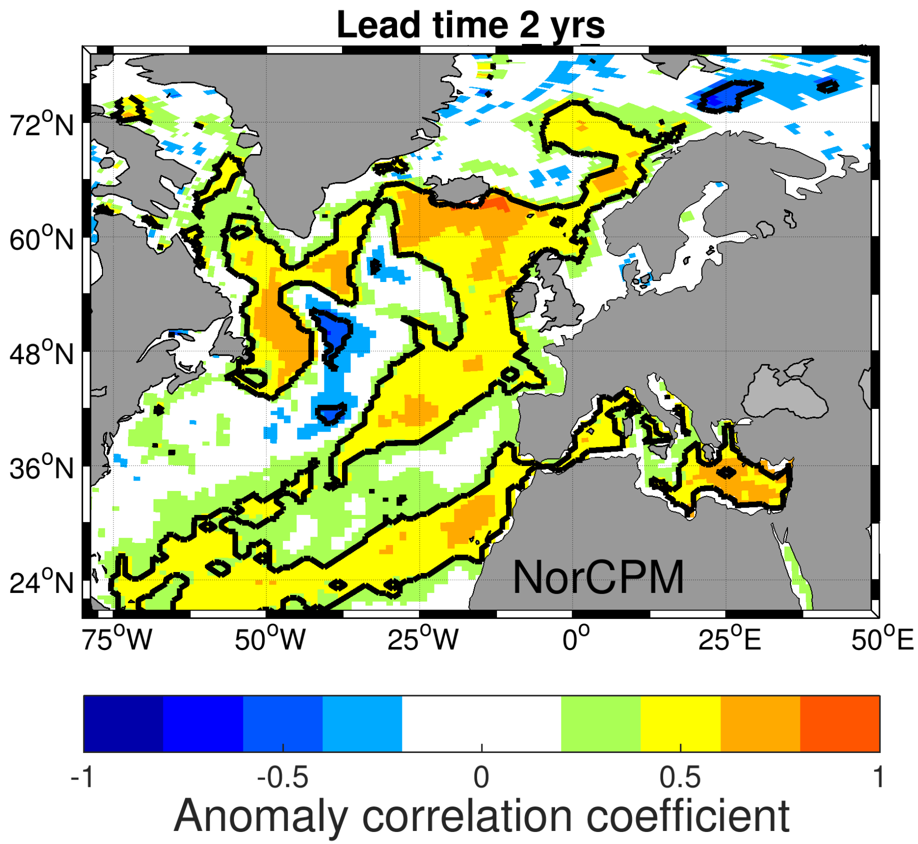
Langehaug et al., 2018

Work in progress…

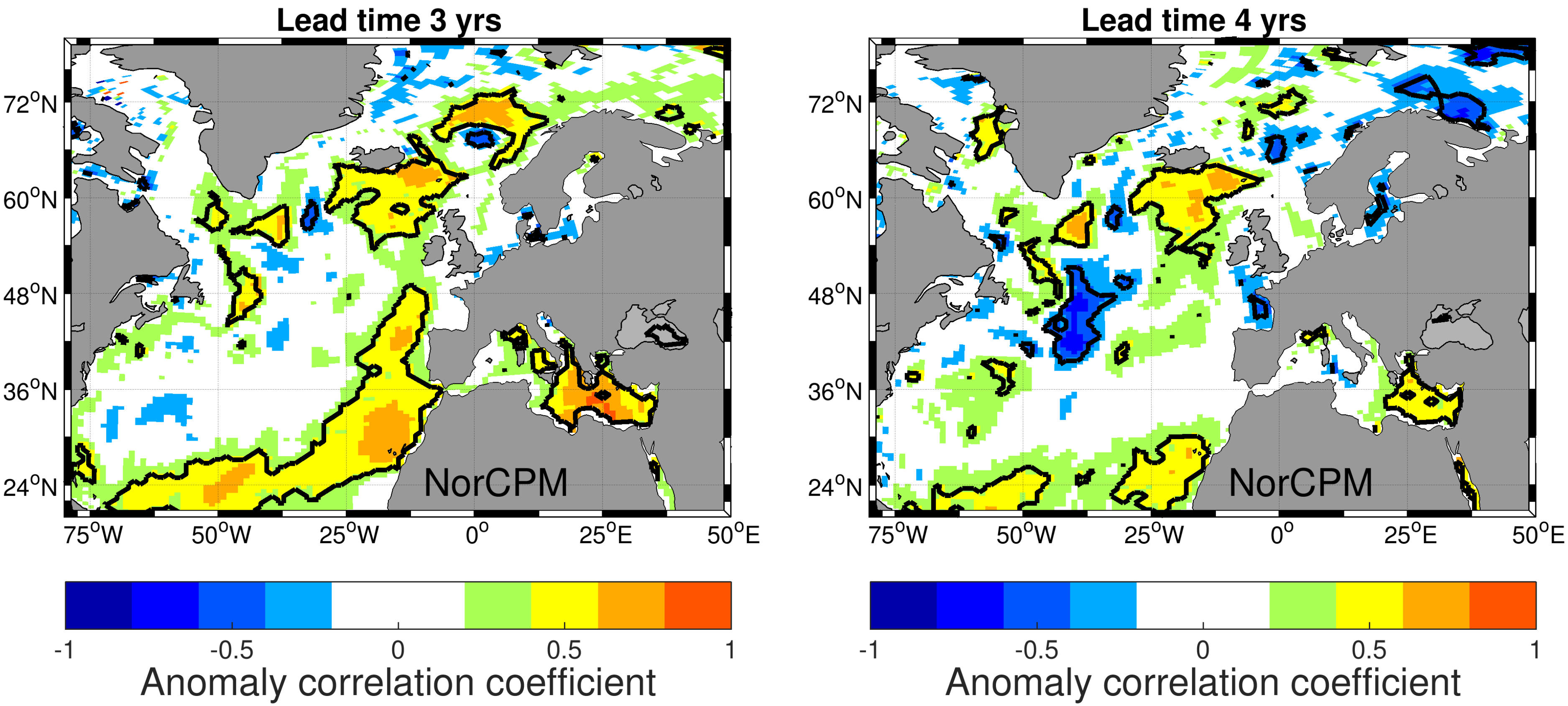
Objective

Assess winter SST and underlying mechanism in a ***prediction system***



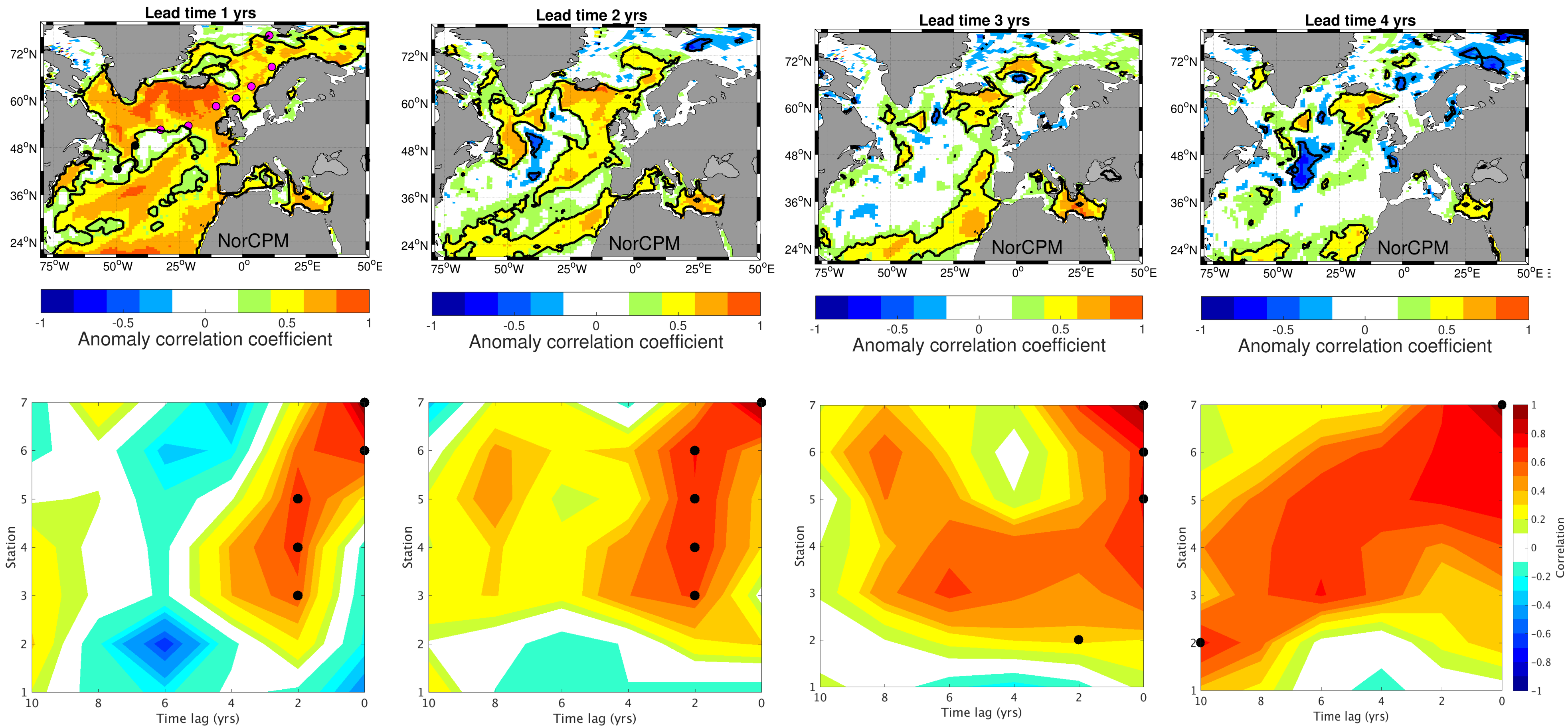


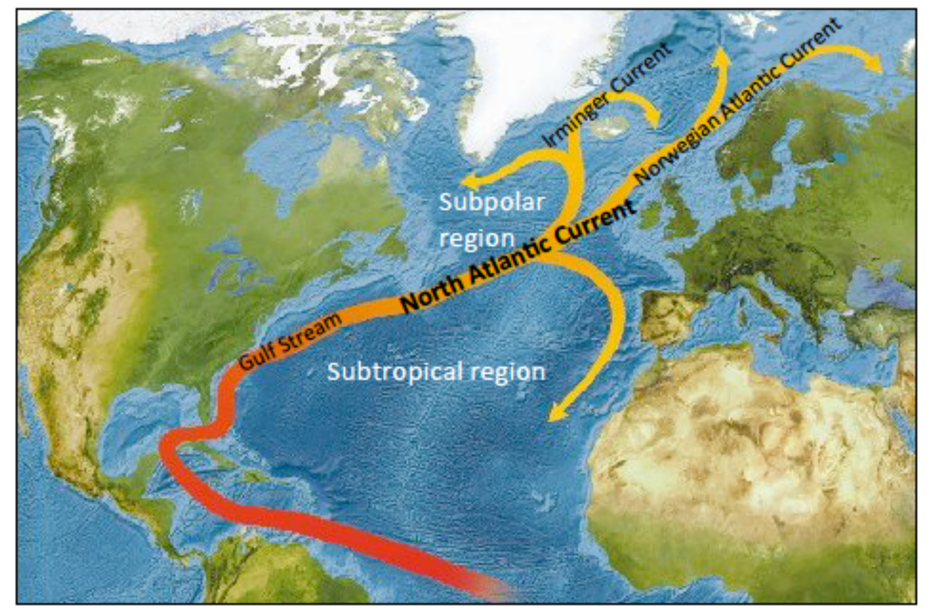
Norwegian Climate Prediction Model



Norwegian Climate Prediction Model

Confronting the prediction system with mechanism identified from observations





Mechanisms that give rise to predictability in the North Atlantic – Nordic Seas

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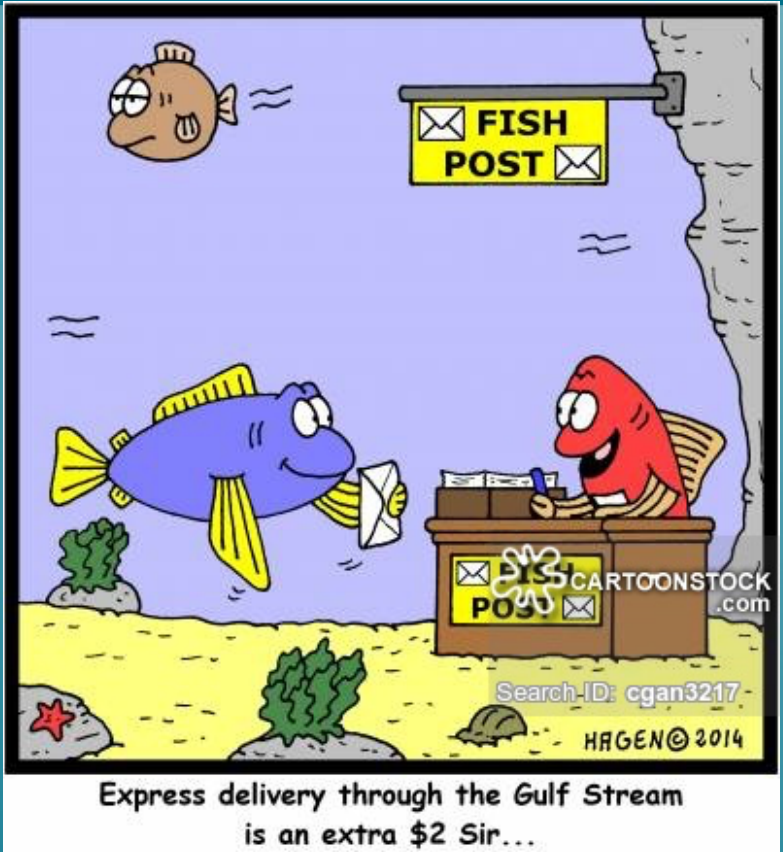

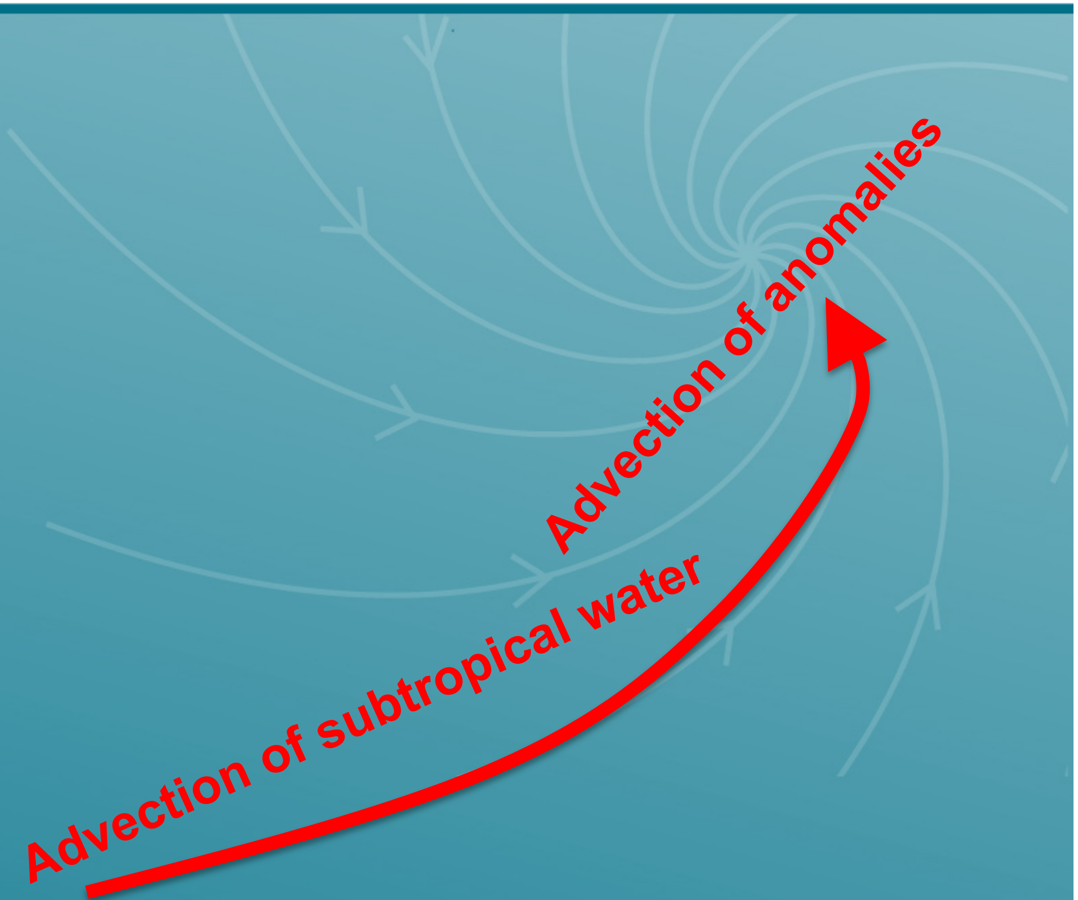

Ocean dynamics has an important role in climate prediction in the North Atlantic – Nordic Seas

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