Interannual to Decadal Predictions of Thermohaline Anomalies and Air-Sea Interaction in the Subpolar North Atlantic and the Nordic Seas

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Motivation

This work is a PhD Project at the University of Bergen that started this year. Thus, suggestions about the methodology and research questions are most welcome.

- The poleward propagation of temperature and salinity anomalies in the North Atlantic is believed to be a source of climate predictability (Årthun et al. 2017; Langehaug et al. 2018);
- Improvements of climate predictions are important to provide more accurate information for decision makers in areas like water management, agriculture, control of diseases, and Atlantic cyclones frequency;
- Good skill due to initialization in the Subpolar North Atlantic (SPNA) for lead times up to 10 years (Matei et al. 2012; Yeager et al. 2012; Müller et al. 2014);
- In the Nordic Seas the models are not as skillful as demonstrated in SPNA, lead times of 1-3 years (Langehaug et al. 2017);

SPNA *x* Nordic Seas

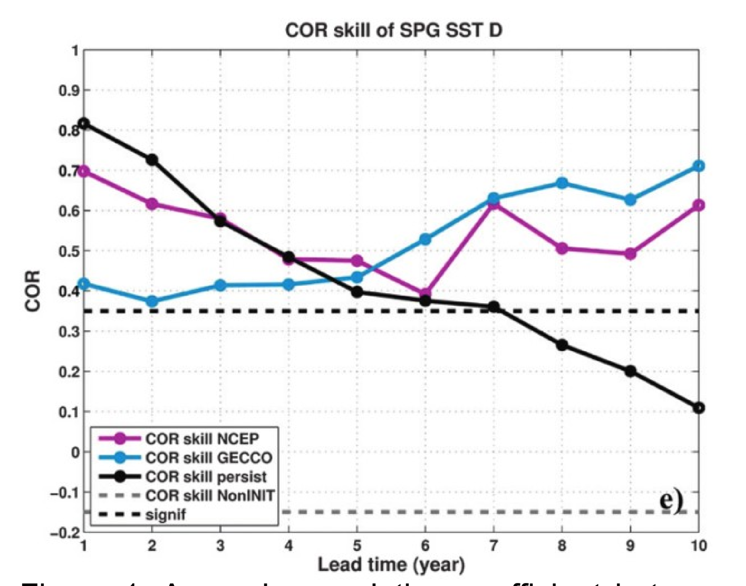


Figure 1. Anomaly correlation coefficient between the linearly detrended SPNA SST in observations (from HadISST) and hindcasts at lead times 1 to 10 years from the NCEP system (violet) and GECCO system (blue). The predictive skill of persistence forecast is shown in solid black and of NonINIT experiments in dashed gray. Source Matei et al. (2012).

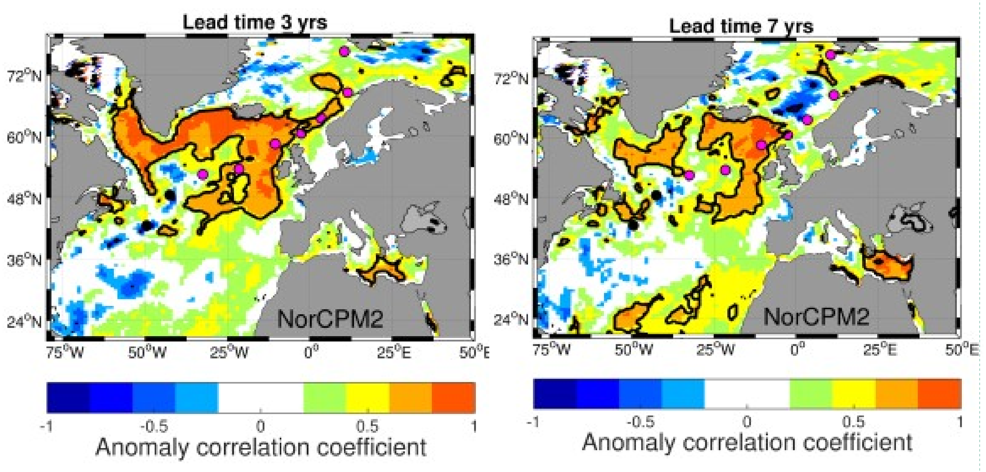


Figure 2. Anomaly correlation coefficient, point-by-point, of winter (Jan-Apr) SST between HadISST2 data and the ensemble mean of the NorCPM version 1c at lead time of 3 and 7 years. Source: Courtesy Helene R. Langehaug.

Considering this, the main purpose of this work is to investigate thermohaline anomalies and air-sea interaction in the SPNA and in the Nordic Seas using different versions of the Norwegian Climate Prediction Model (NorCPM).

Methodology

- We will use 3 different versions of the NorCPM;
- Different observation-based data for comparison;
- Other state-of-the-art models from the Coupled Model Intercomparison Project Phase 6 - Decadal Climate Prediction Project (CMIP6 DCPP) for comparison;

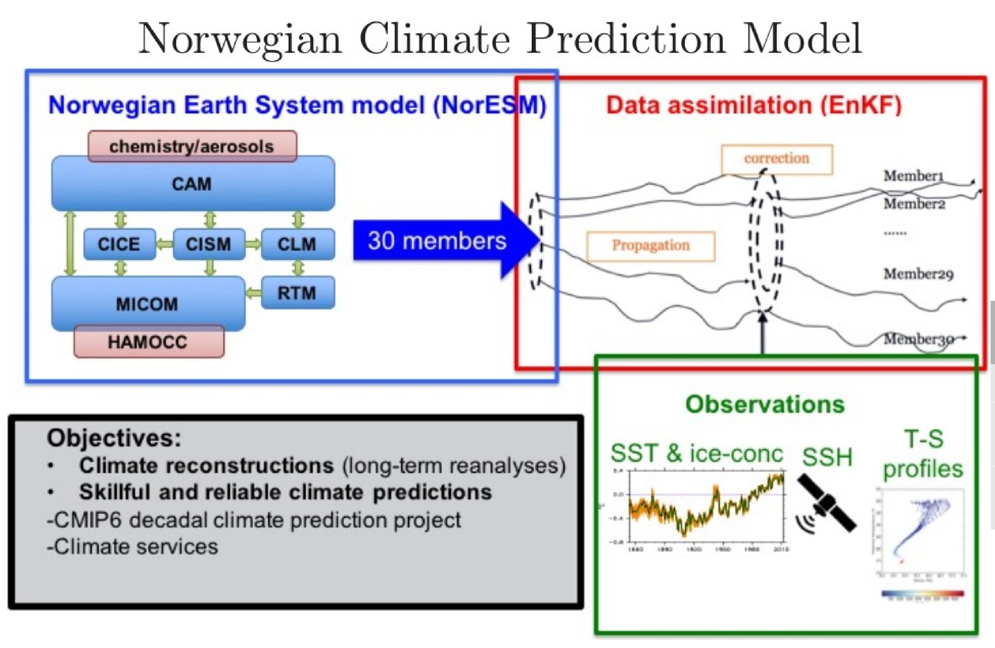


Figure 6. NorCPM escheme. Source: Counillon et al. (2016).

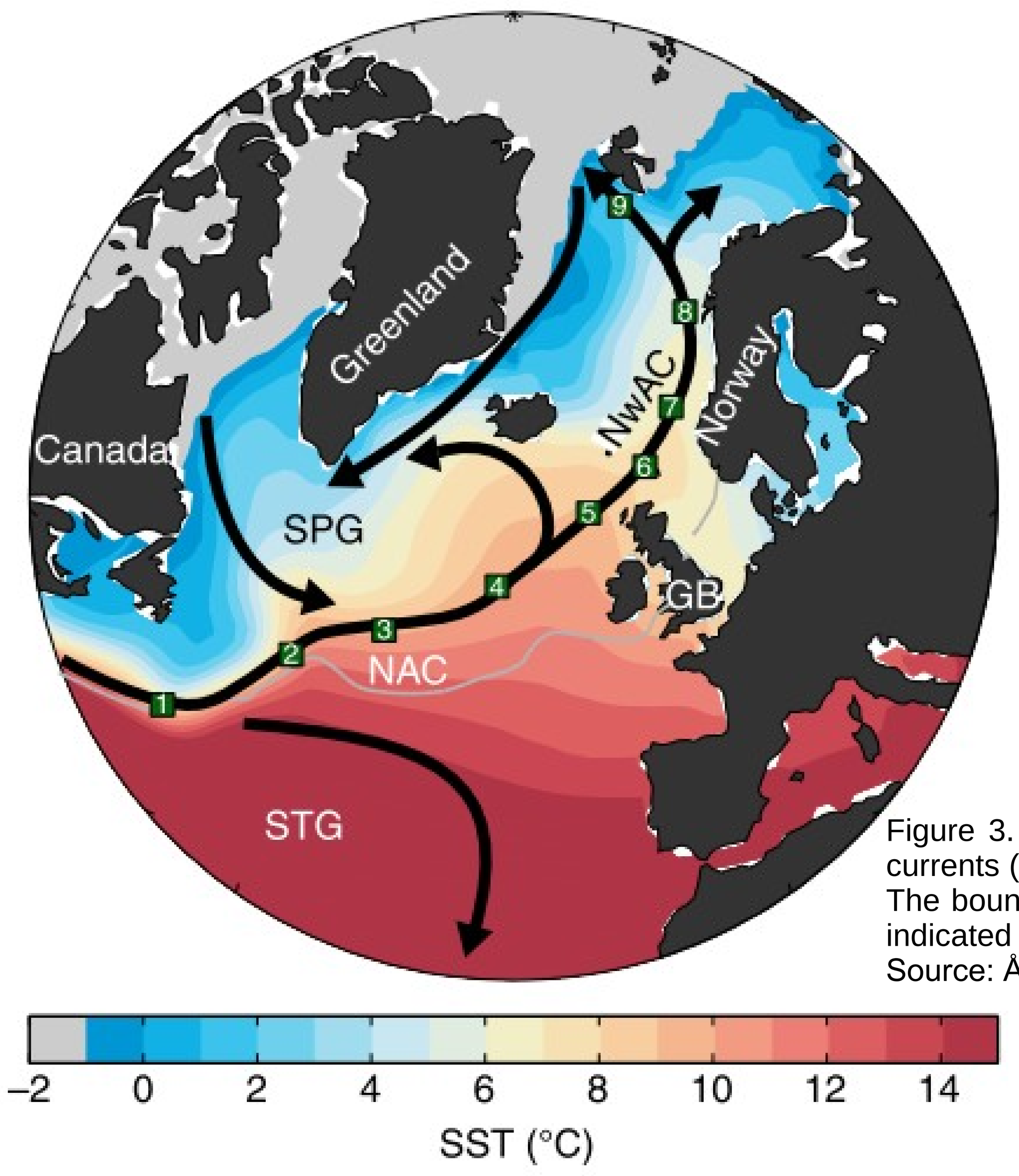
Table 1: Versions description of the NorCPM simulations that will be used in this PhD Project.

Versions	Data Assimilated	CMIP Forcing	Assimilation Method
Version 0	SST (HadSST2)	CMIP5	Weakly Coupled
Version 1c	SST (HadSST2) Hydrographic data (EN4)	CMIP5	Strongly Coupled
Version 1DCPP	SST (HadSST2) Hydrographic data (EN4)	CMIP6	Strongly Coupled

For skill analysis we will use:

- Statistical metrics like bias, mean absolute error and correlation;
- Complex Principal Component (CPC) and Empirical Orthogonal Function Analysis (EOF);
- Physical oceanographic comparisons like water mass analysis, eddy kinetic energy, heat content, AMOC strength, wind stress, volume and heat transport;

Background – based on observations



- The North Atlantic Current (NAC) carries salt and warm water poleward;

Figure 3. Climatological SST (colour) and major ocean surface currents (black arrows). Sea ice is indicated by the grey shading. The boundary between the subtropical gyre (STG) and SPNA is indicated by the time-mean zero SSH contour (grey line). Source: Årthun et al. (2017).

- Thermohaline anomalies propagation with a speed of 2 cms-1 and a characteristic time scale of 14 years;

- Possible drivers:
  - Ocean advection (Sutton and Allen 1997; Årthun and Eldevik 2016);
  - Local air-sea heat fluxes (Mork et al. 2014);
  - Large scale atmospheric circulation anomalies (Krahmann et al. 2001; Foukal and Lozier 2016);

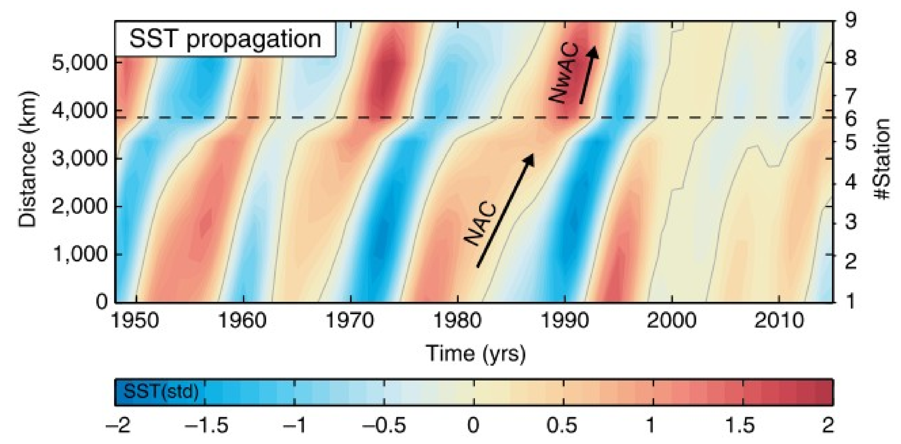


Figure 4. Temporal development of the leading mode of SST propagation. The dashed line indicates the boundary between the subpolar North Atlantic and Nordic Seas. Source: Årthun et. al (2017).

- Ocean and Atmosphere play different roles for specific events (Asbjørnsen et al. 2019);

- The relation with dominant atmospheric patterns in the North Atlantic region (e.g. NAO) remains poorly understood and represented in current climate models (Yeager and Robson 2017).

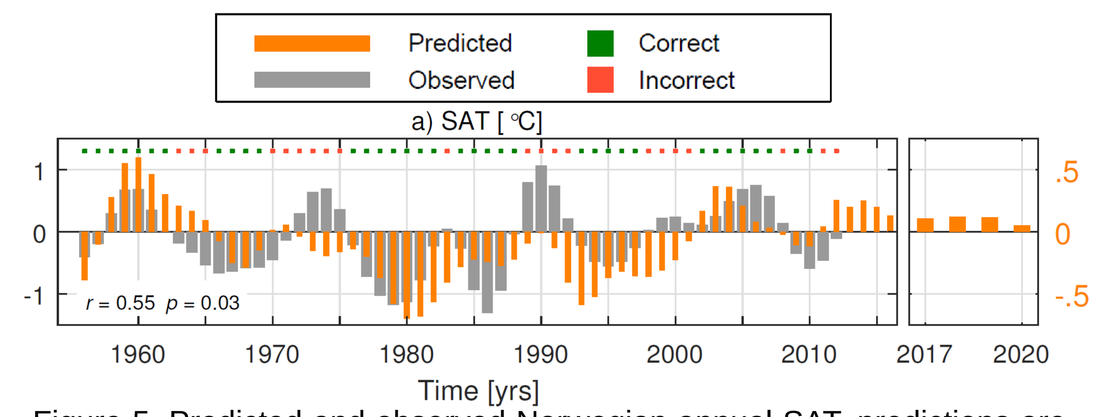


Figure 5. Predicted and observed Norwegian annual SAT, predictions are based on 5-year low-pass filtered SST in the subpolar North Atlantic between 1948 and 2013, with a prediction horizon of 7 years. Predictions for 2017–2020 are highlighted in the panels to the right. Source: Årthun et al. (2017).

Research Questions

1) What is the effect of different initialization over thermohaline anomalies in the SPNA and Nordic Seas?

2) To what extent is the improvement in ocean skill communicated to the western Europe climate?

3) What are the strengths and weaknesses of NorCPM compared to CMIP6 DCPP in the SPNA and Nordic Seas region?

References (Main)

Årthun et al., 2017: Skillful prediction of northern climate provided by the ocean. *Nat. Commun.*

Counillon et al., 2016: Flow-dependent assimilation of sea surface temperature in isopycnal coordinates with the Norwegian Climate Prediction Model. Tellus, Ser. A Dyn. Meteorol. Oceanogr.

Langehaug et al., 2017: On model differences and skill in predicting sea surface temperature in the Nordic and Barents Seas. *Clim. Dyn.*

Langehaug et al., 2018: Variability along the Atlantic water pathway in the forced Norwegian Earth System Model. *Clim. Dyn.*

Matei et al. 2012: Two tales of initializing decadal climate prediction experiments with the ECHAM5/MPI-OM model. *J. Clim.*

Müller et al., 2014: Decadal climatepredictions for theperiod1901–2010 with a coupled climate model. *Geophys. Res. Lett.*

Yeager et a., 2012: A Decadal Prediction Case Study: Late Twentieth-Century North Atlantic Ocean Heat Content. *J. Clim.*