Ocean Predict

SYMPOSIUM OP'24

In partnership with unesco Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

A physical-~~biogeochemical~~ hindcast for the Nordic Seas and Arctic 1950-2018

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NERSC NANSEN ENVIRONMENTAL AND REMOTE SENSING CENTER

Norwegian Meteorological Institute

DMI

Background

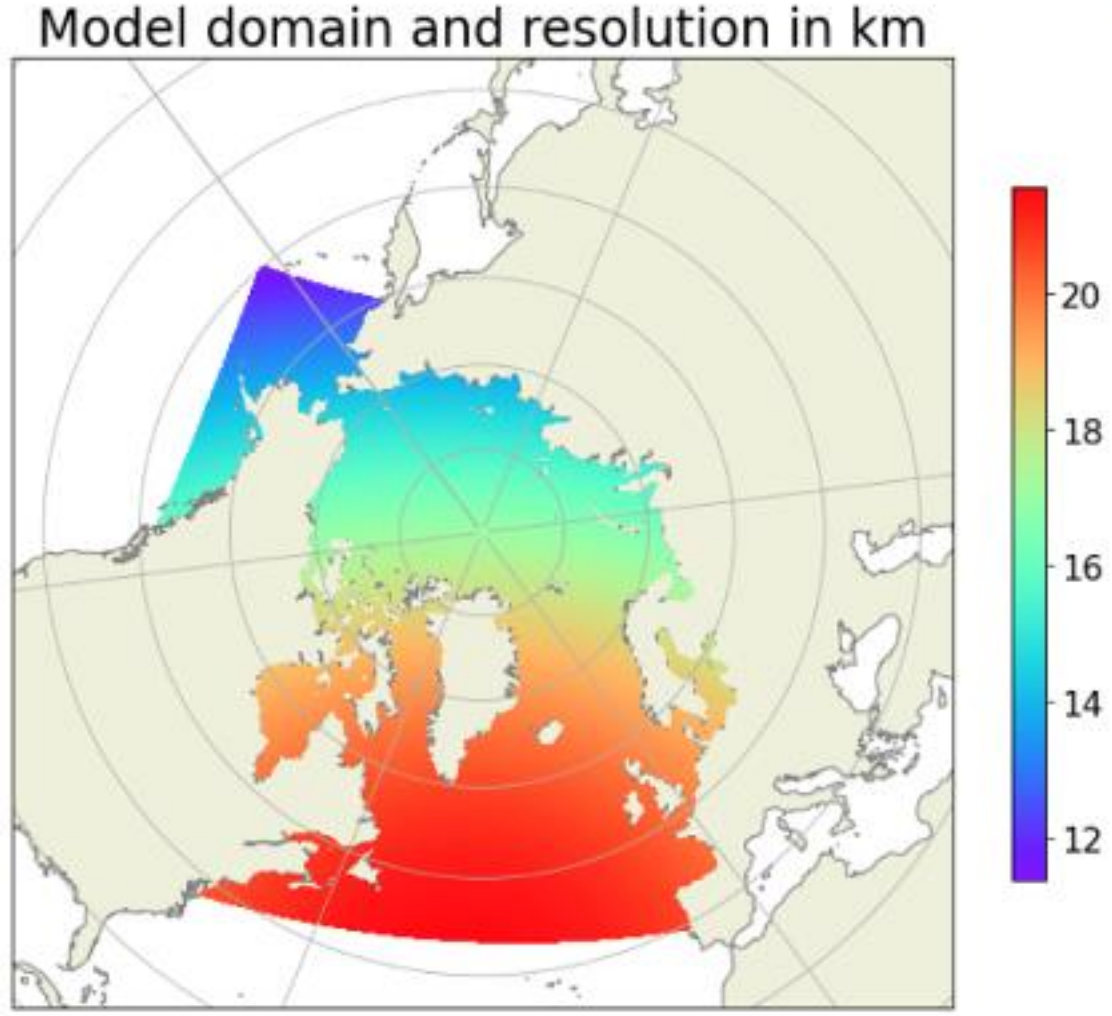
- In the context of climate change, we wish to understand future changes in physical and biogeochemical ocean conditions. To do this, a good understanding of past variability is essential.
- Past observations alone provide an incomplete picture, but model simulations of the past can help fill knowledge gaps and enhance our understanding of the processes involved.
- The challenge to providing these simulations is that there are few observations from the past to initialize and constrain the long-term simulations.
- Here, we present one attempt at a regional long-term simulation for the Arctic forced by atmospheric reanalysis and a climate prediction reanalysis on the lateral boundaries.
- The model has been evaluated with respect to climatology, trend, and variability.
- I will present fresh results and some recommendations for the road forward.

Model: HYCOM-CICE

- Hybrid Coordinate Ocean model, HYCOM (U. Miami)
- Hybrid coordinate
- Isopycnal in the interior
- Z-coordinate in the surface layer
- Sigma coordinates close to the coast (optional)

Prognostic variables:
u,v, t, s, dp (layer thickness)

CICE: EVP sea ice model

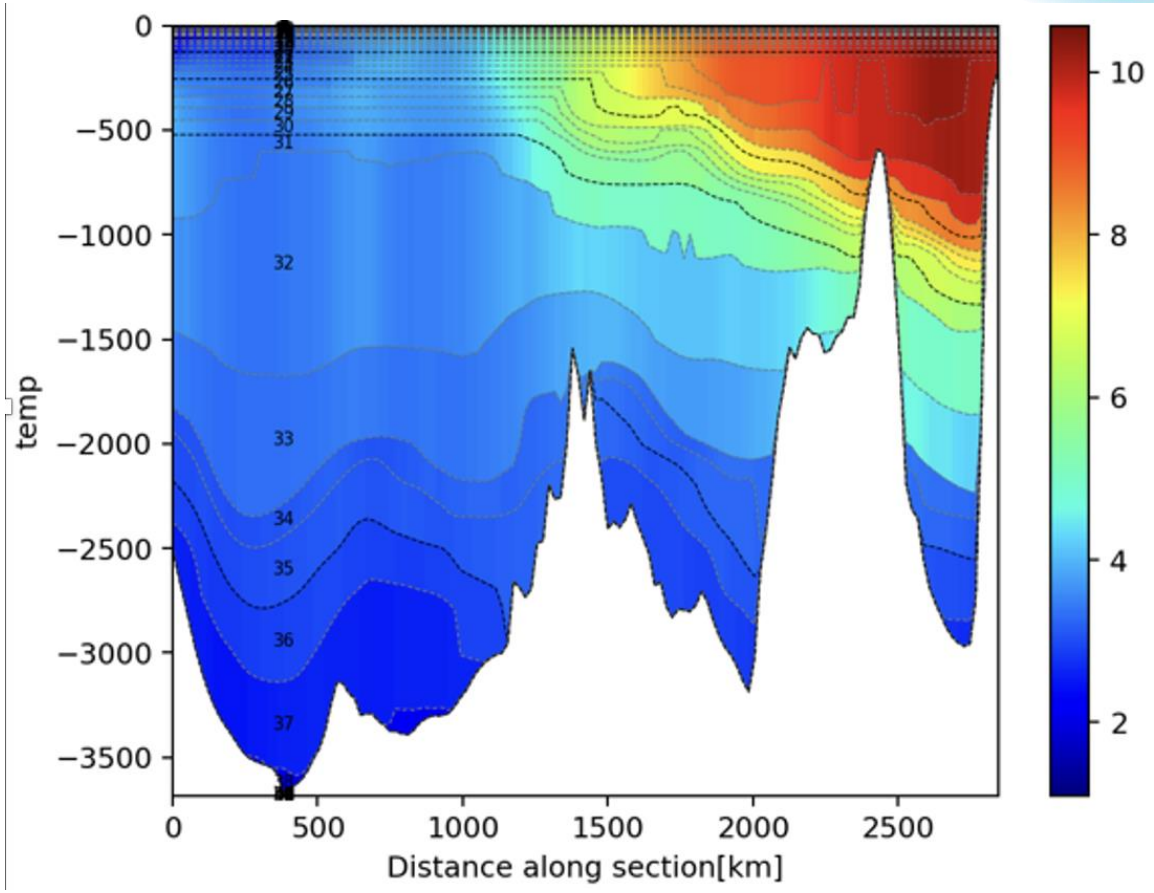


Model forcing and configuration

- Atmospheric forcing: ERA-5
- Lateral boundaries NorCPM – Norwegian Climate Prediction Model (1 member)
- River forcing: ArcticHype + Greenland runoff: monthly climatology.
- No tides
- No sea level pressure effect on sea level

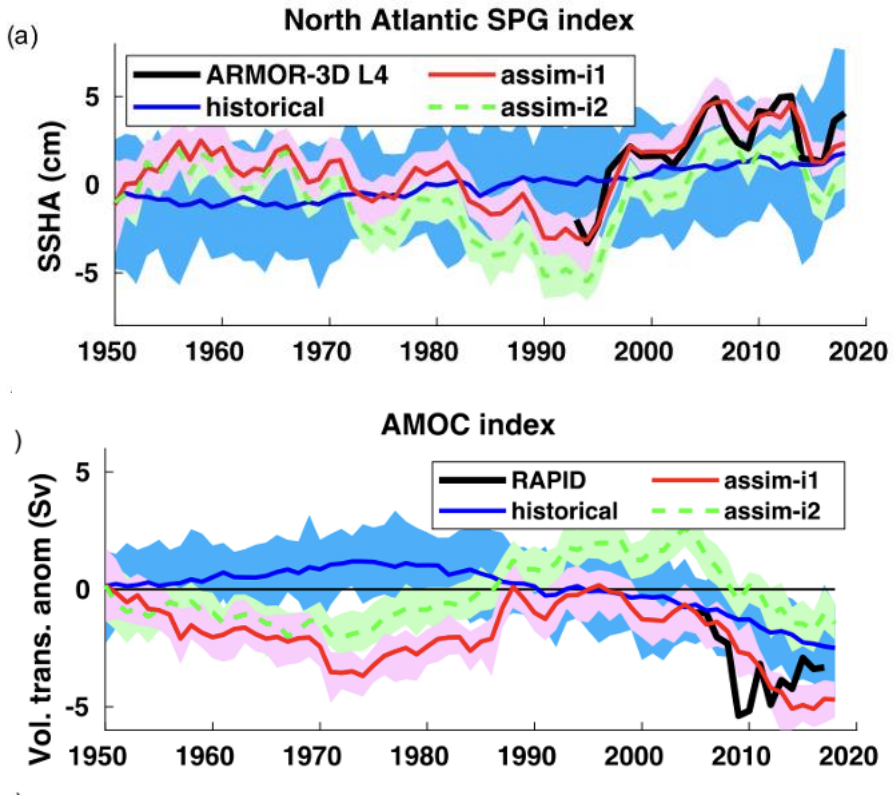
CICE
- Five sea ice thickness categories
- Freezing temperature is a linear function of salinity

50 vertical layers: 10 are fixed z-layers and 40 hybrid layers with density levels adjusted to represent the water masses in the Arctic.



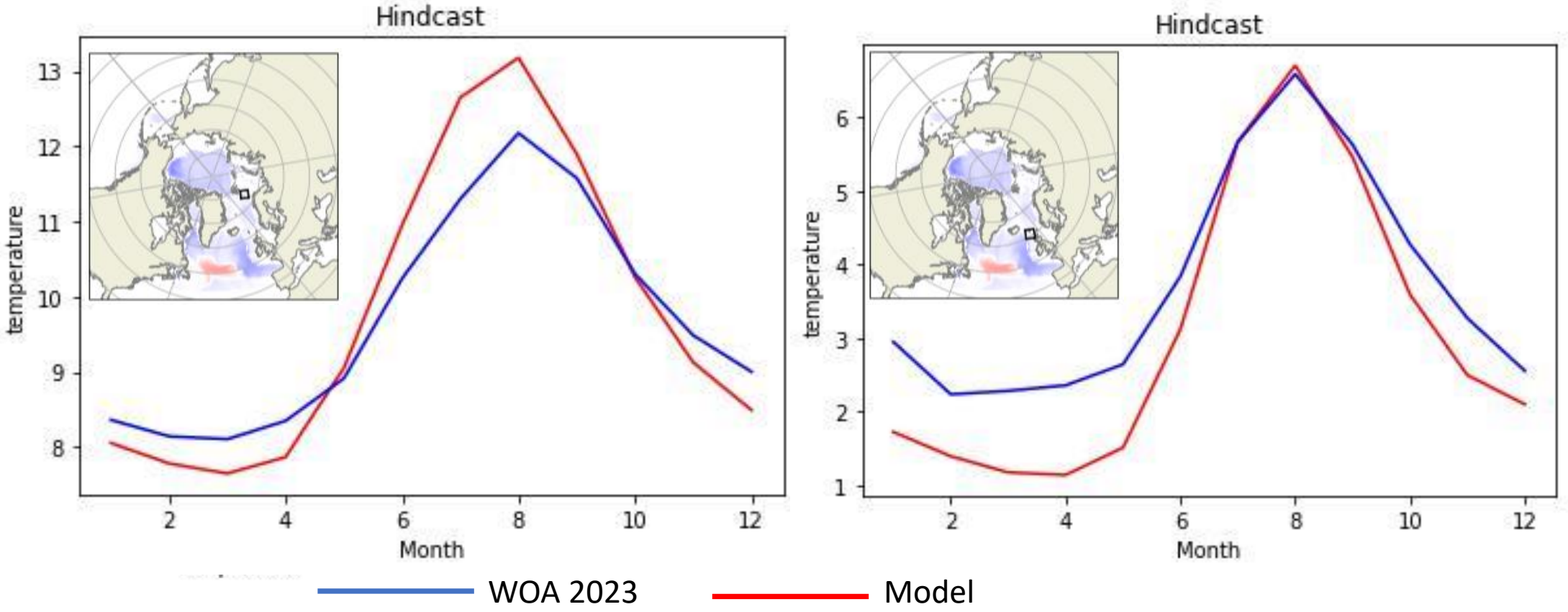
Initialization and bias correction

- NorCPM is run as a climate model until 1950, then run with assimilation of T and S anomalies. Updates sea ice.
- The model was initialized in September 1940 using the bias-corrected climatology based on NorCPM 1940-1949.
- Lateral boundaries nudged to monthly NorCPM with constant bias correction:
  - Delta method based on climatology 1981-2010.
  - Monthly bias correction destroyed the seasonal cycle on the Pacific side.
- Analyzed results 1950-2018.

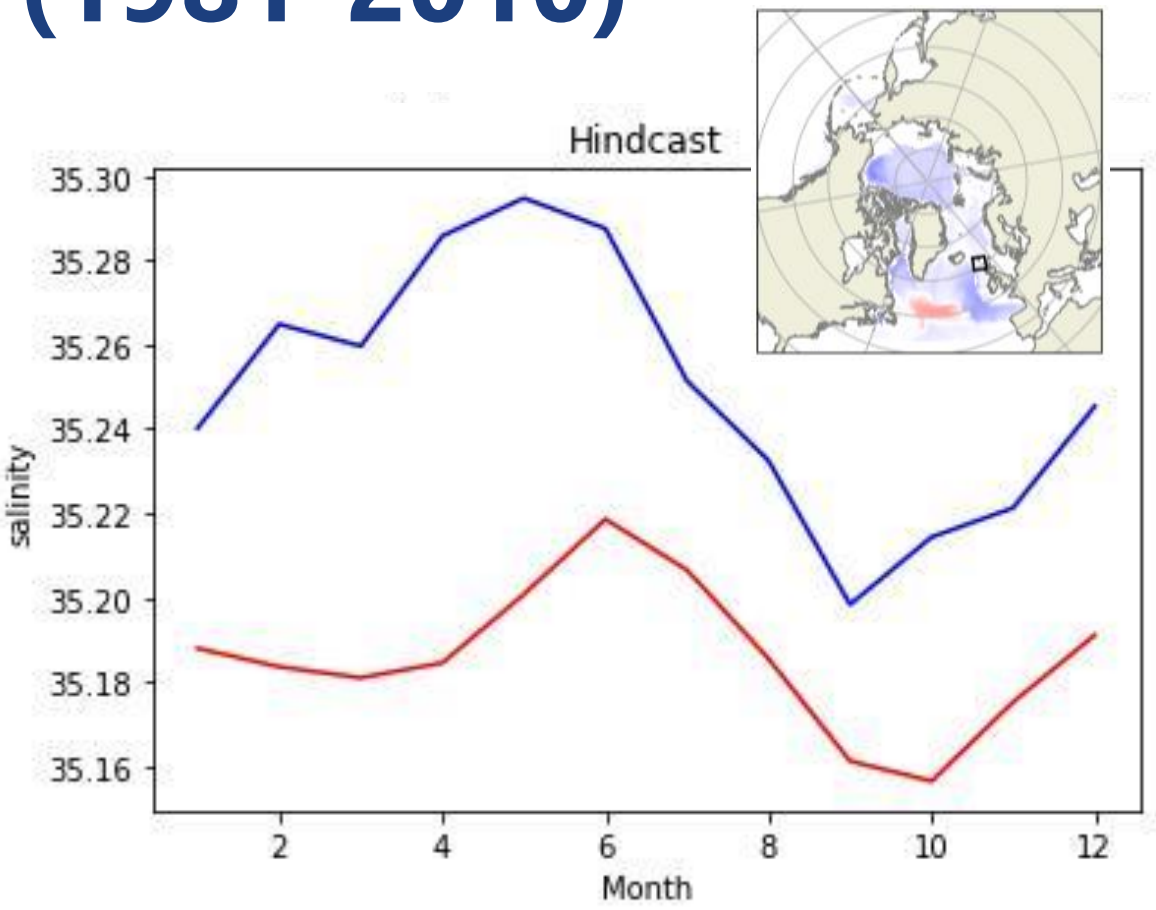


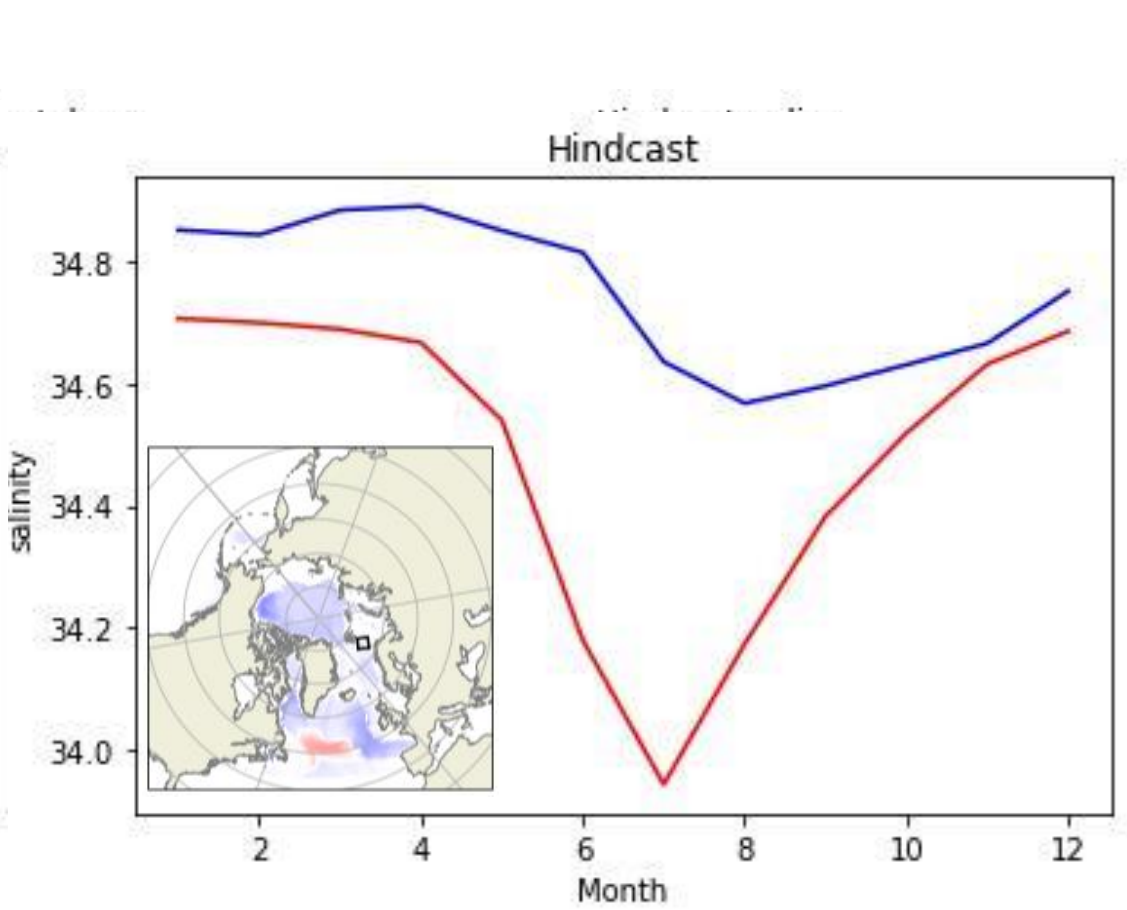
Figures from Bethke et al., 2021

Comparison to climatology: temperature (1981-2010)



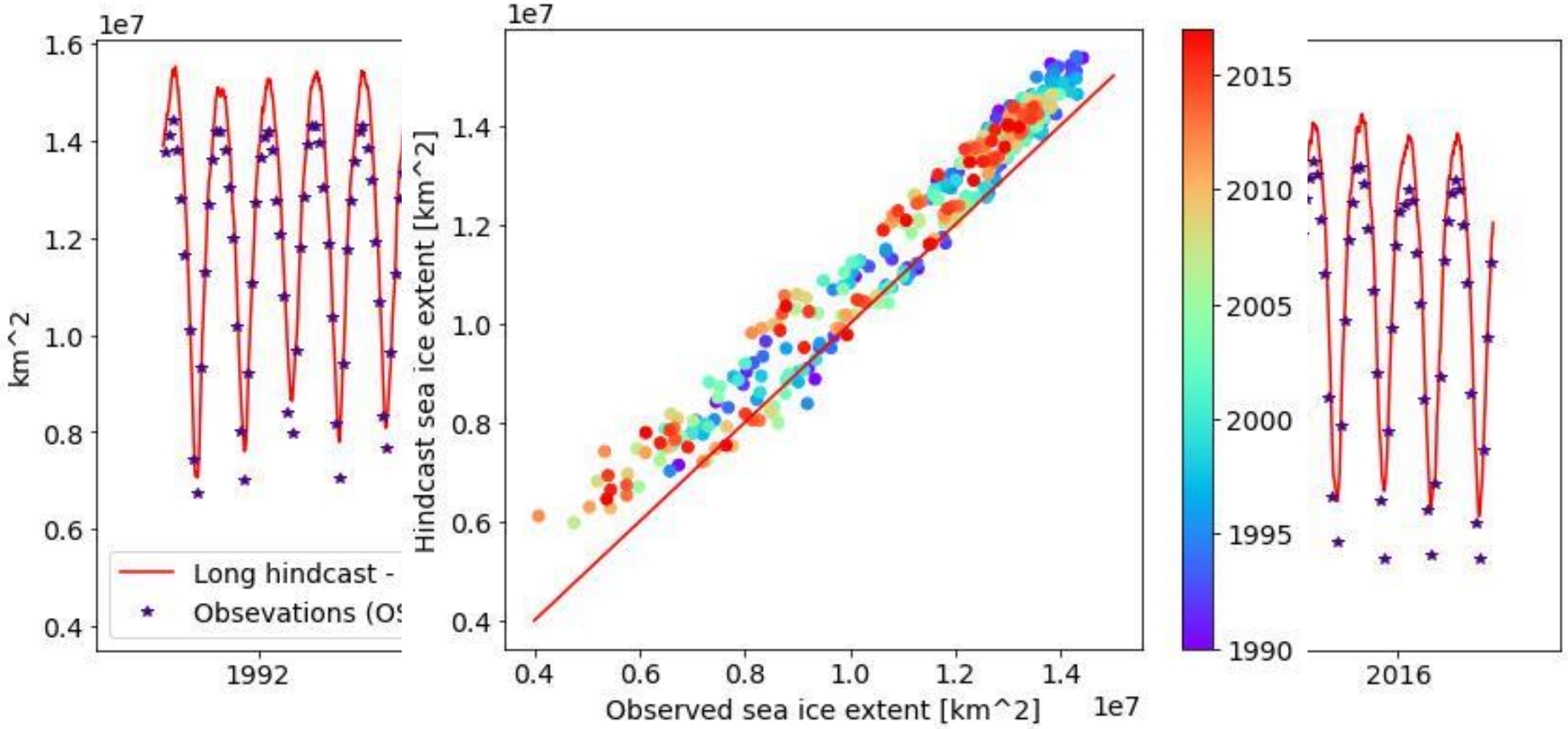
Comparison to climatology: surface salinity (1981-2010)





WOA 2023 Model

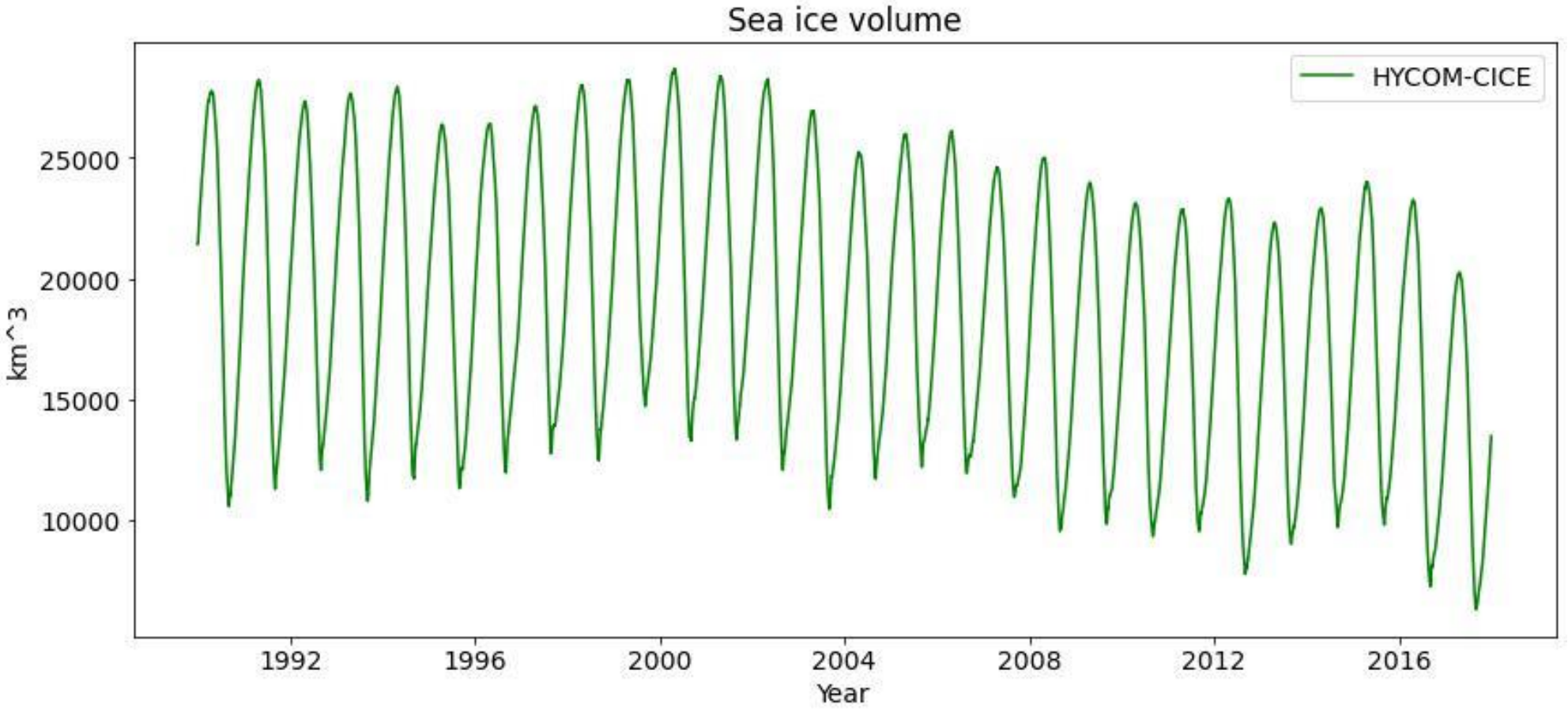
Sea ice variability



Sea ice extent has a persistent positive bias, but with similar interannual variability to the observations

Sea ice volume has a reasonable value and decreases with time

Sea ice variability



Sea ice extent has a persistent positive bias, but with similar interannual variability to the observations

Sea ice volume has a reasonable value and decreases with time

Sea level variability

Comparison with:

- tide gauges northward of 45°N

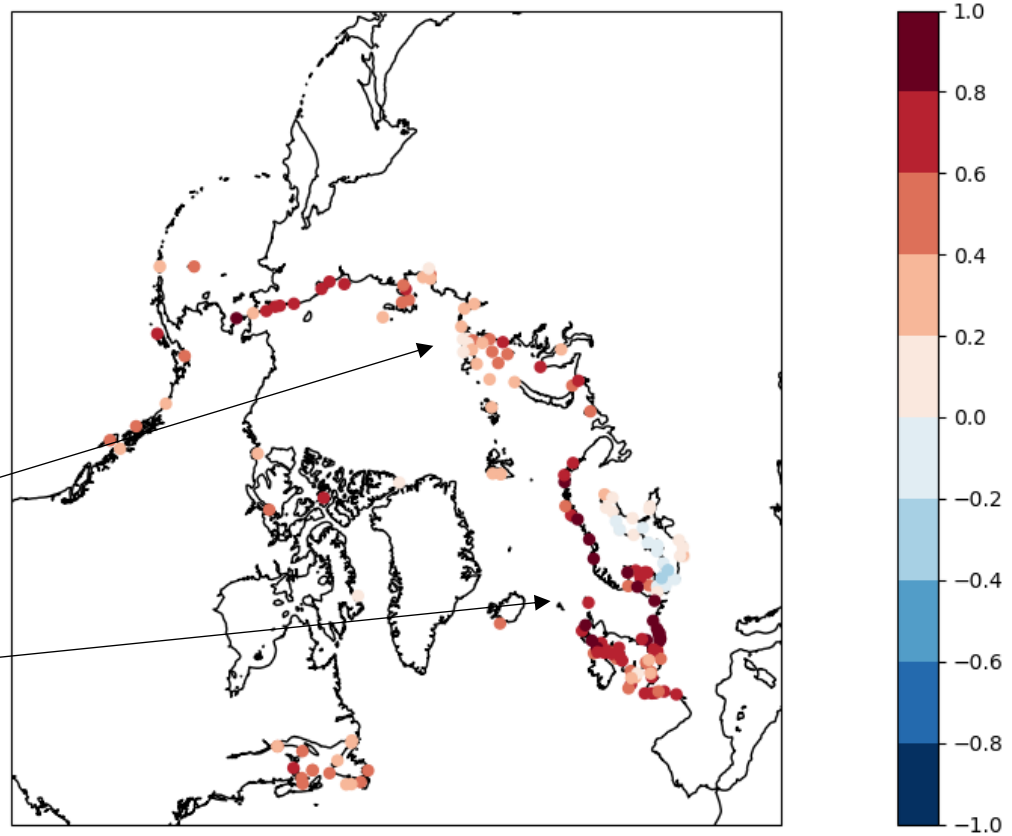
through linear correlation of:

- detrended
- deseasoned

sea surface height.

Mixed results with correlations even:

- between 0.0 and 0.2
  (between Kara and Laptev Seas)
- higher than 0.8
  (mostly northern Europe)



Temperature trends (at 5m depth)

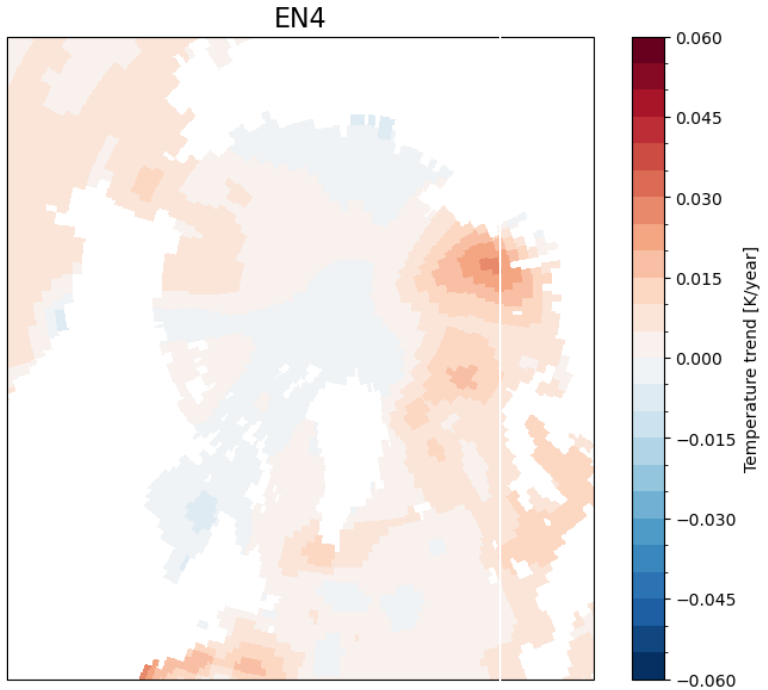
Model trends compared to EN4
Computed based on 1950-2017
Partial agreement:

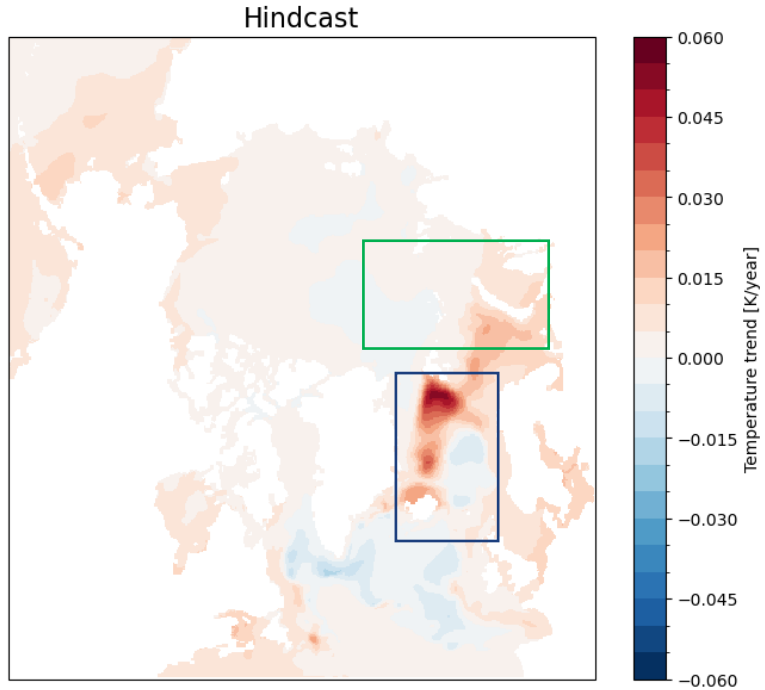
- in the Arctic

Hindcast mainly differs in:

- Kara Sea
  (anomalously low trends)
- Greenlands Sea
  (anomalously high trends)

- Agree on warming in the Barents Sea

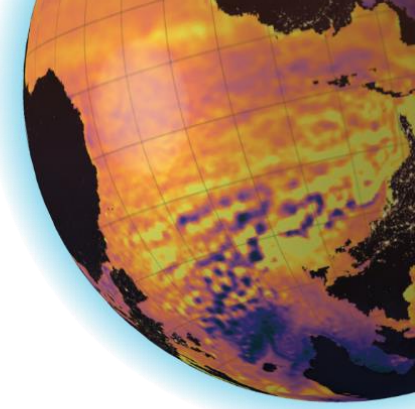




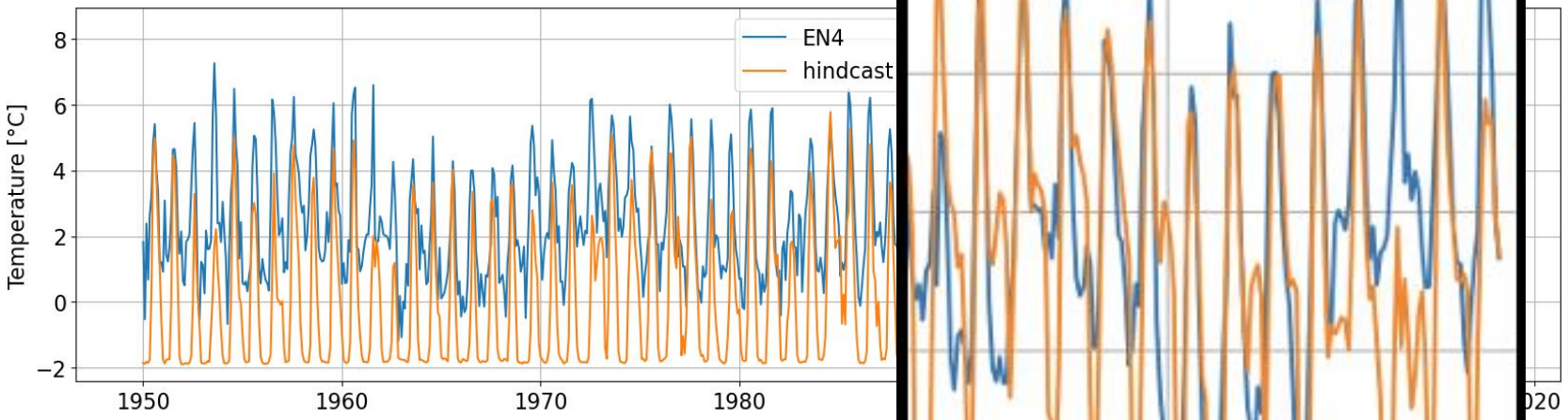
EN4: doi:10.1002/2013JC009067.

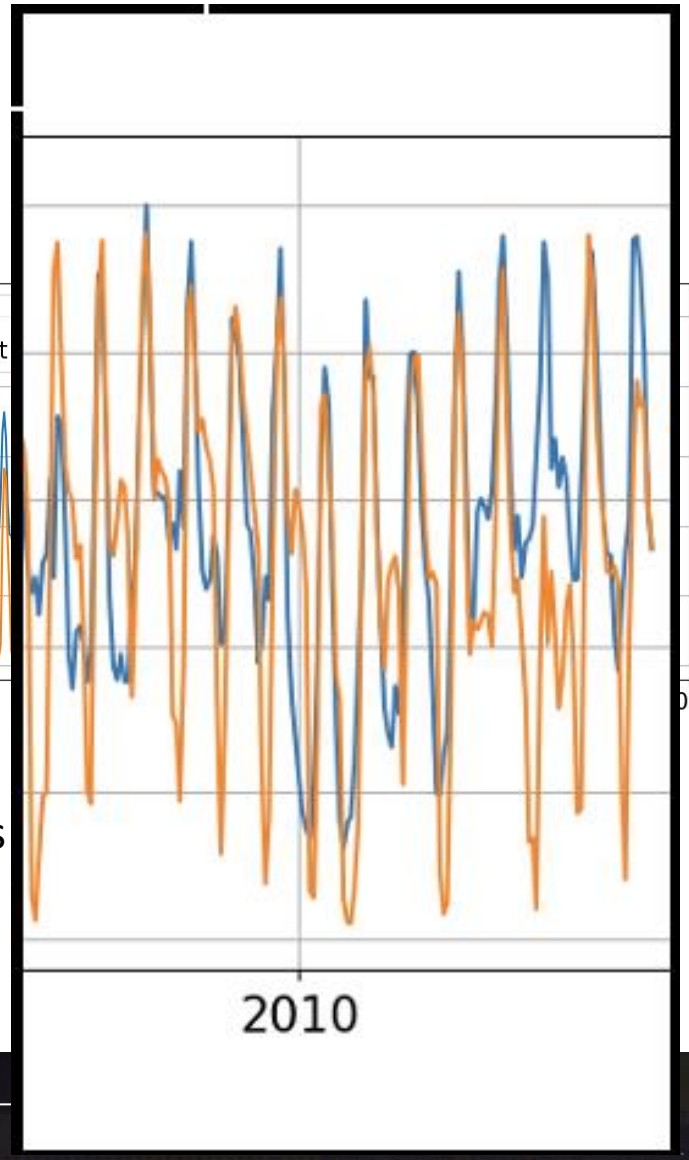
WOA 2023 Model

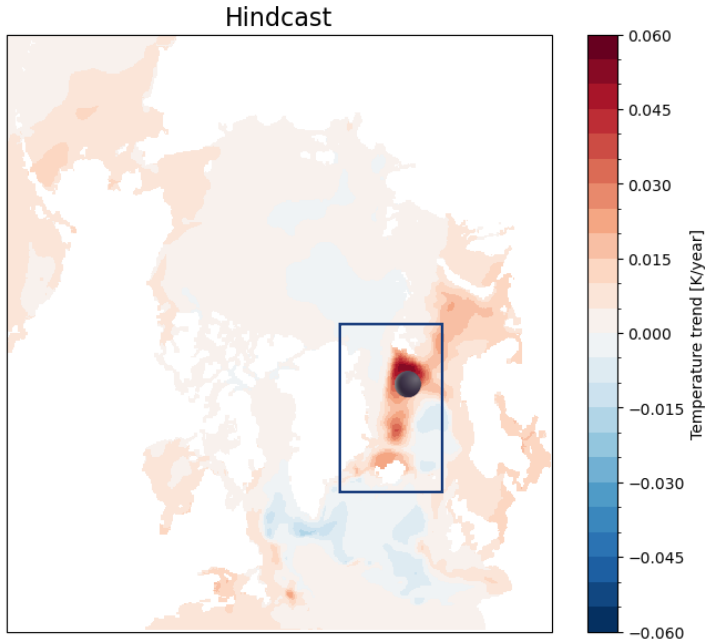
Example: Greenland Sea



grid point south-east of Svalbard
(~ 77N and 12E)







Maybe, hindcast with:

- wider sea-ice edge than in observations
- up early 2000s
- better agreement since early 2000s

on inter-annual timescales.

EN4: doi:10.1002/2013JC009067.

Salinity trends (at 5m depth)

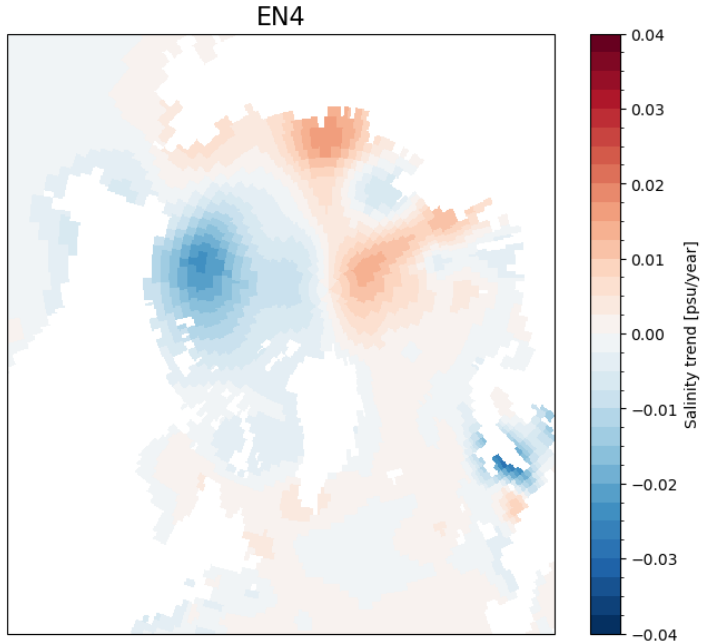
Model trends compared to EN4
Computed based on 1950-2017

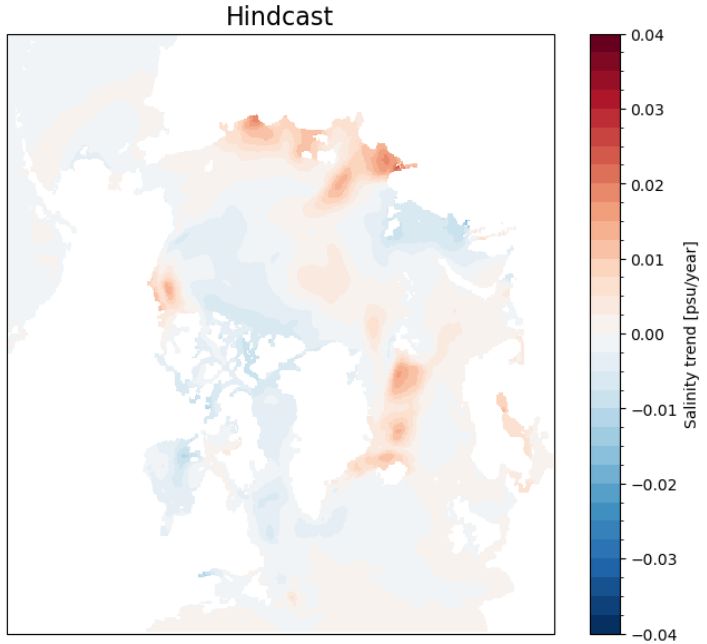
Beaufort Sea freshening:

- not captured by hindcast.

Problem as:

- Arctic circulation mostly controlled by salinity
- freshening might have repercussions on north Atlantic circulation





EN4: doi:10.1002/2013JC009067.

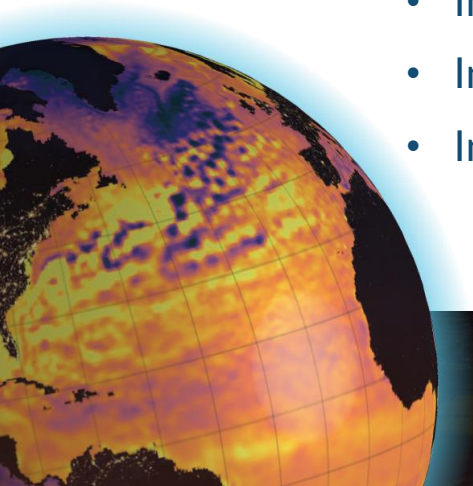
Summary & future work

Summary:

- A first attempt on a long hindcast to simulate trends and variability in the Nordic Seas and the Arctic.
- Quality is variable:
  - 😖 Salinity bias in the Arctic, which will impact circulation
  - 😊 Surface variability in sea ice and temperature (after 2000) appears realistic

Furture work

- More in-depth analysis of the results, including water-mass distribution in the surface and at depth.
- Runs with several ensemble members of NorCPM and
- Improve initial conditions
- Interannual river forcing from 1979 (GloFAS)
- Include and evaluate the biogeochemical



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Thank you!

For questions, contact me at
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Gimsøy section

Consider Section B:

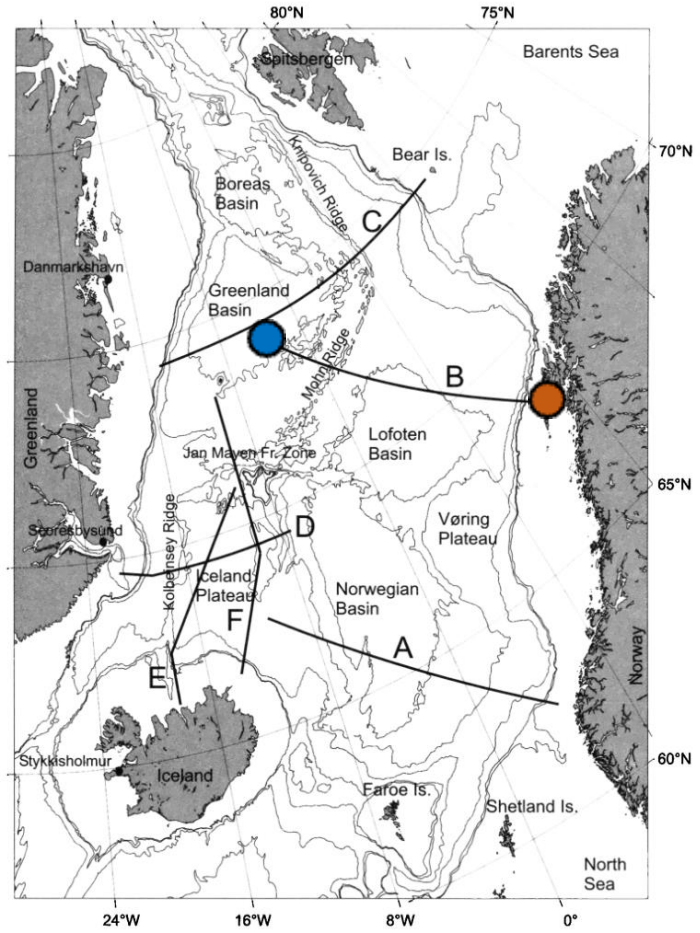
- 74.0°N, 5.0°W
- 68.4°N, 14.0°E

(Lofoten Basin & part of Greenland Basin)

Interesting as it captures:

- Arctic Front

Blindheim and Østerhus (2005)



Gimsøy Section: June 1999

Observations show:

- water from Greenland Sea (S<34.9)

intruding under:

- Atlantic Water

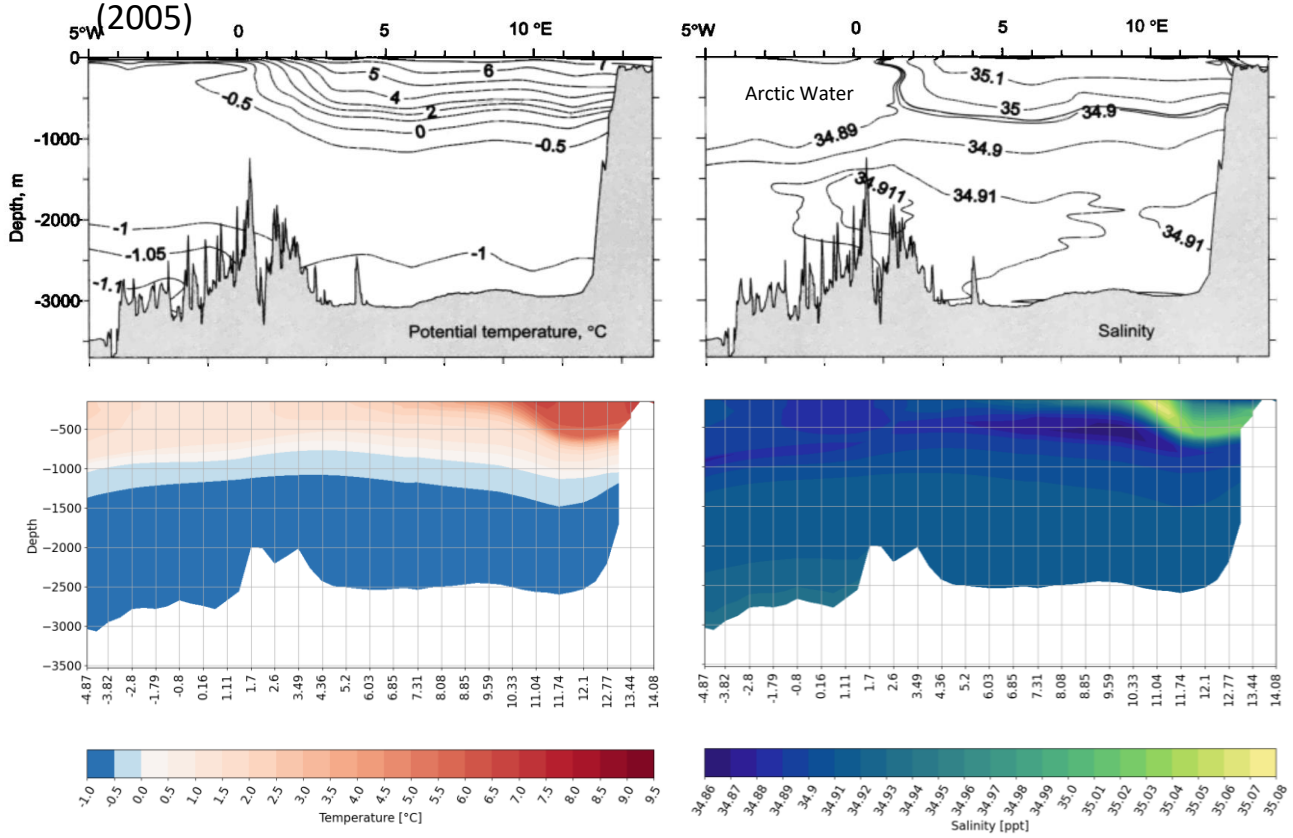
at circa 1000m depth.

Comparable salinity values:

- in hindcast

at same, intermediate level.

Readapted from Blindheim and Østerhus (2005)



Observations

Hindcast