Divergence in climate model projections of future Arctic Ocean stratification and hydrography
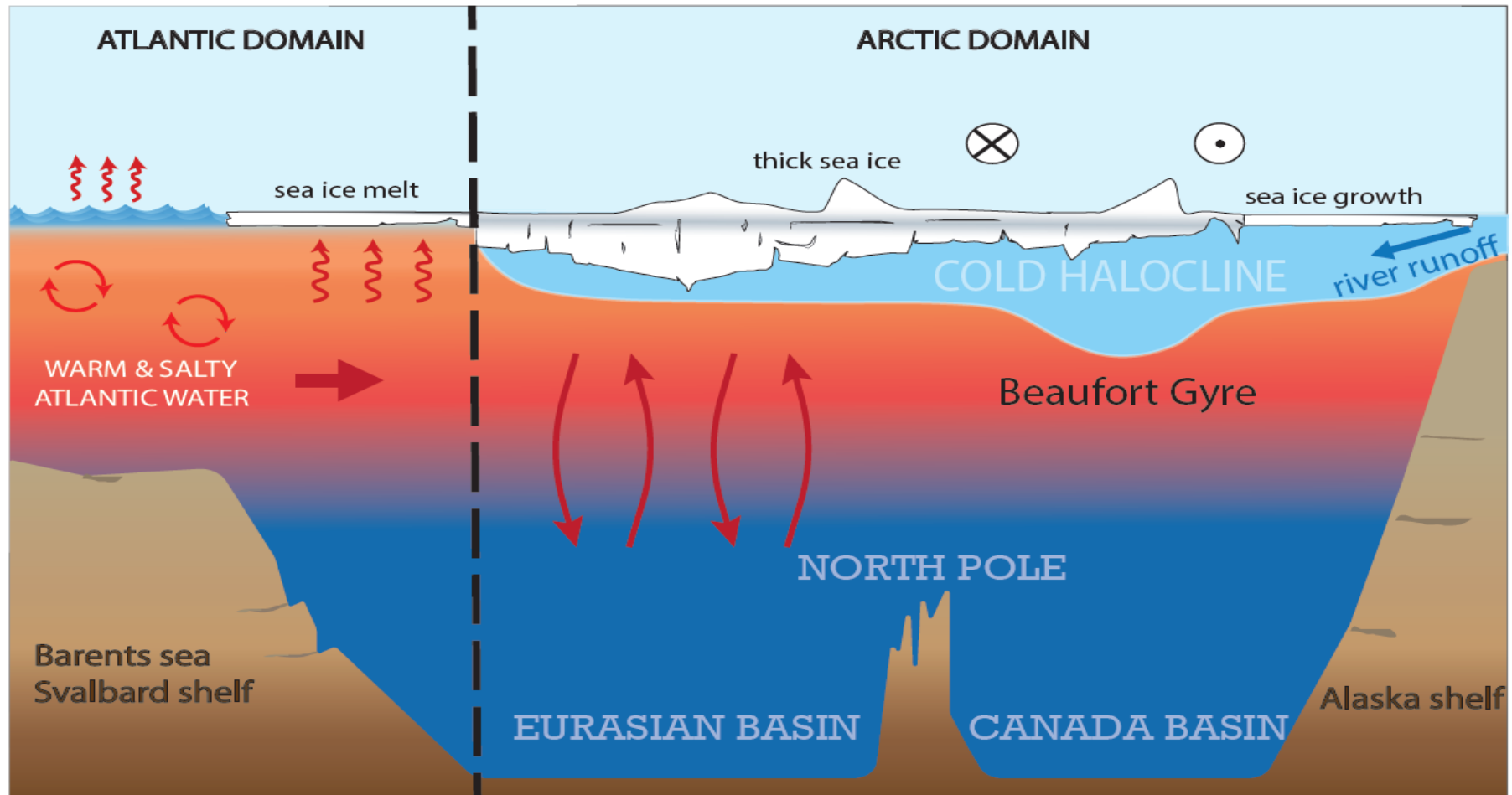
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Hannah Zanowski & Céline Heuzé

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- The Arctic Ocean is strongly stratified by salinity

- The stratification and halocline acts as an effective barrier for exchanges of Atlantic Water heat, nutrients and CO2

- Observations show that from 1970, the stratification in the Amerasian basin has strengthened, whereas, in parts of the Eurasian basin, the stratification has weakened (e.g. Polyakov et al. 2020).

  1. Anomalous inflow of warm/saline Atlantic Water and an expansion of the Atlantic domain **"Atlantification"**

  2. Surface freshening and advection of fresh Pacific Water

From Polyakov et al. 2020
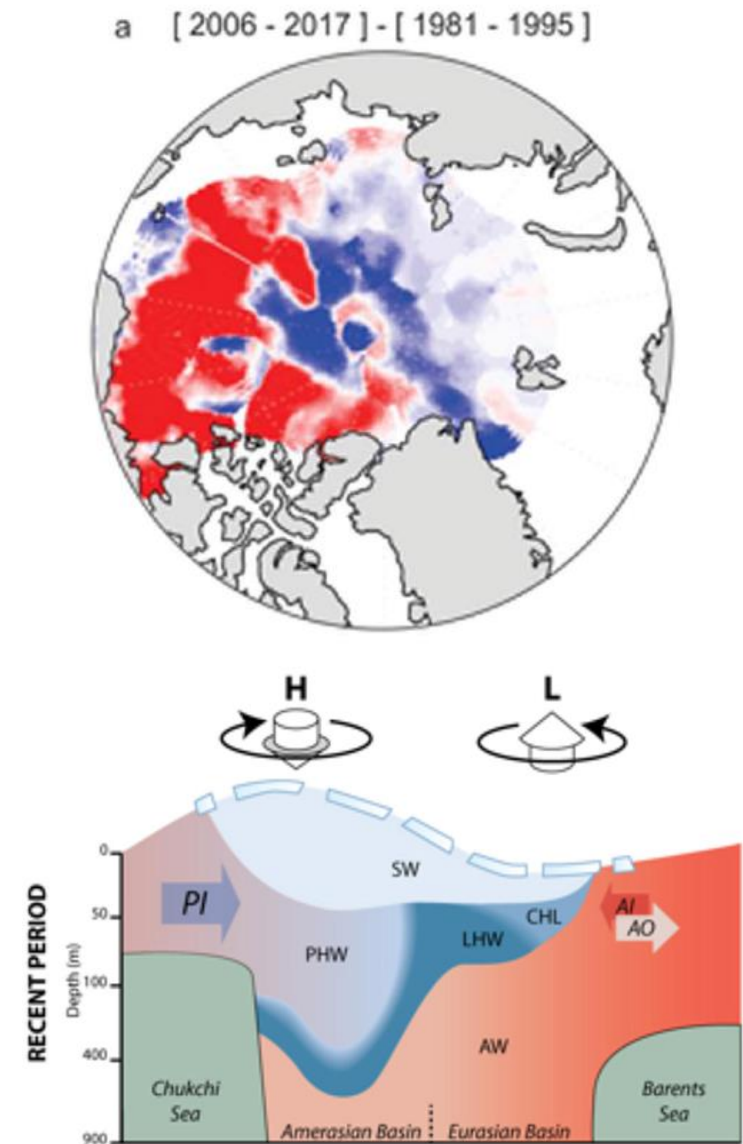
Research gap:

It is unknown how the stratification will change in the future due to opposing mechanisms in the different regions. Will the stratification increase due to increased freshwater fluxes or will Atlantification spread eastward?
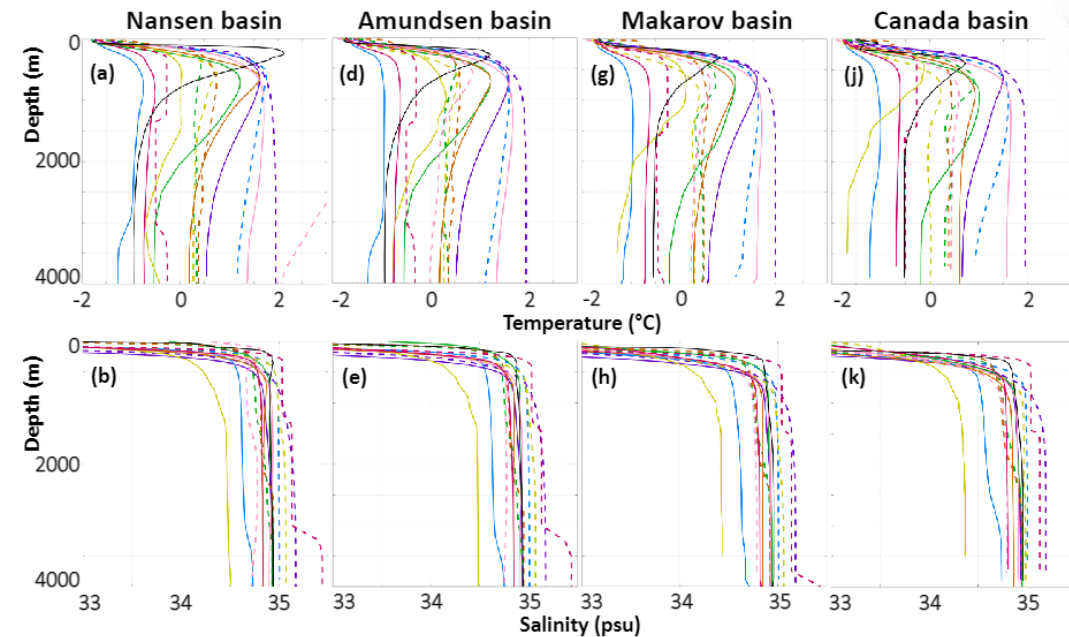
Objective

Provide an overview of the changing Arctic stratification using 14 CMIP6 models

The major challenge:

- CMIP6 models have crucial biases in simulated Arctic hydrography

  (e.g. *Heuze et al. 2022, Koshravi et al. 2022, Zanowski et al. 2021*)

- Challenging to define a "halocline"

Example from Heuze et al. 2022

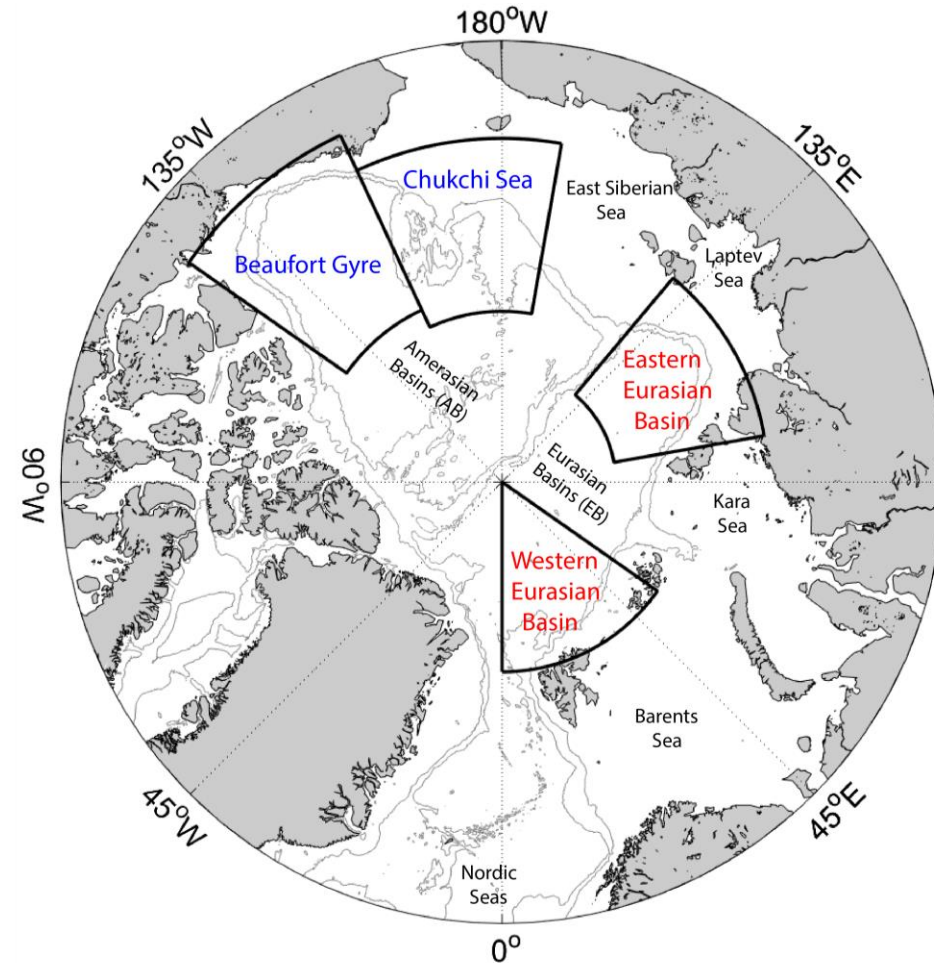# We present a new indicator of stratification

➢ *Despite biases the models can still provide insight in how various water masses change relative to each other*

"Work" to overcome stratification (ΔPE)

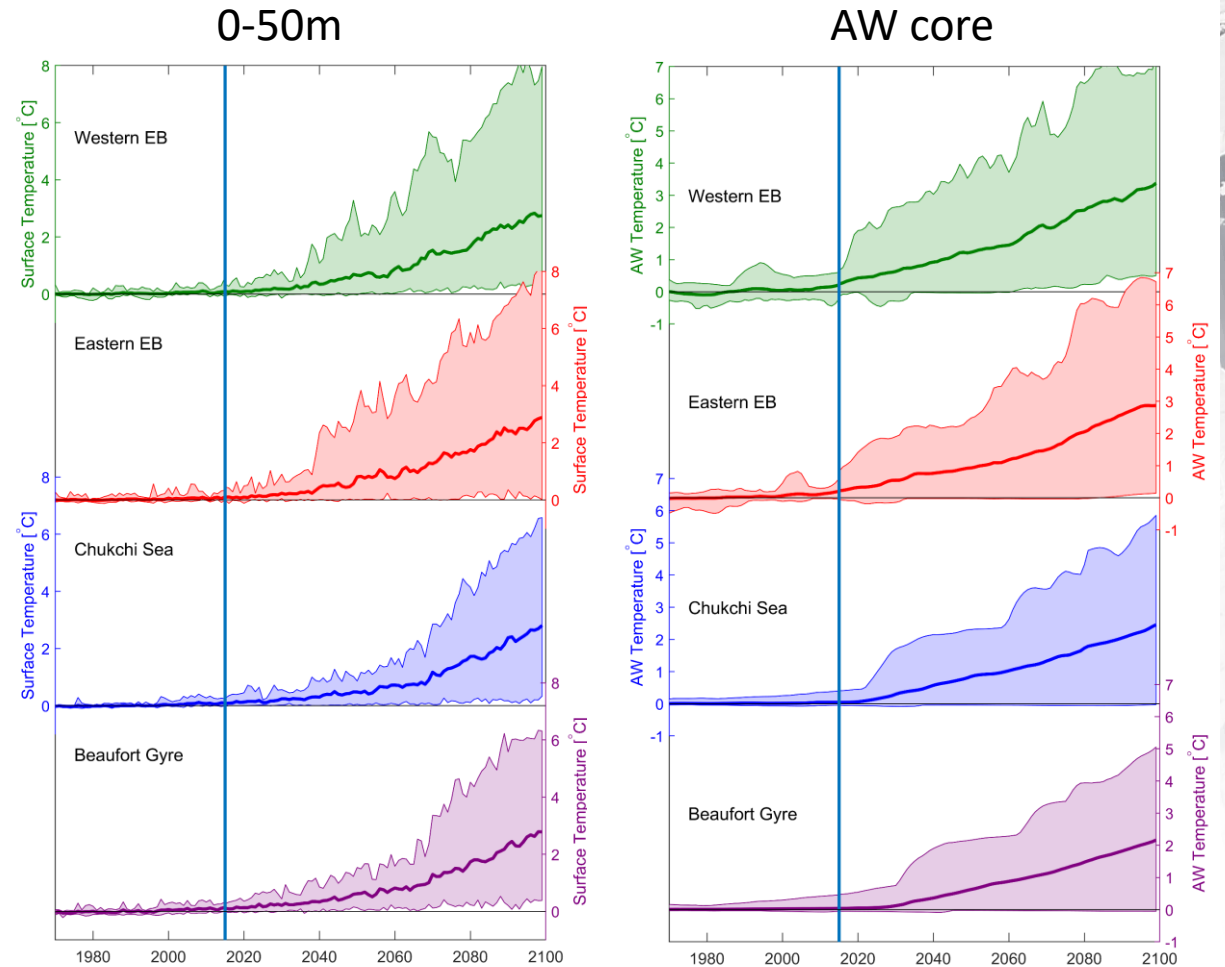An integral of the energy needed to fully mix the water column to a certain depth

$$PE(H) = \int_{H}^{surface} g(z)\rho(z)z\,dz$$

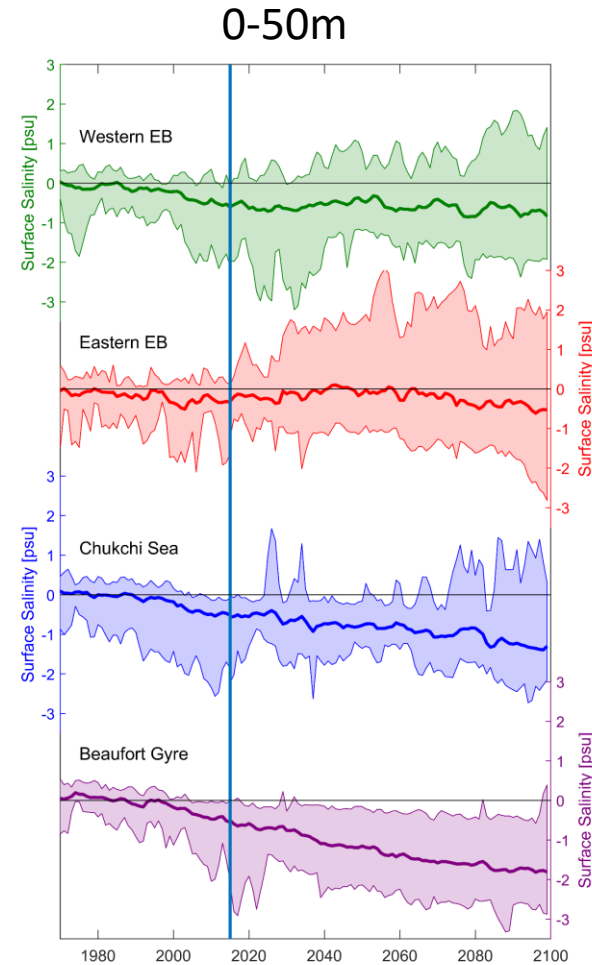$$\Delta PE(H) = PE(H) - PE(H)_{mixed}.$$

CRiceS

Future changes in hydrography (ssp585)

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0-50m

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2. All models project a freshening of the surface layers in the Amerasian Basin

3. In the Eurasian Basin, however, some models project a salinification of the surface layers

4. Additionally, almost all models project a freshening of the Atlantic layer
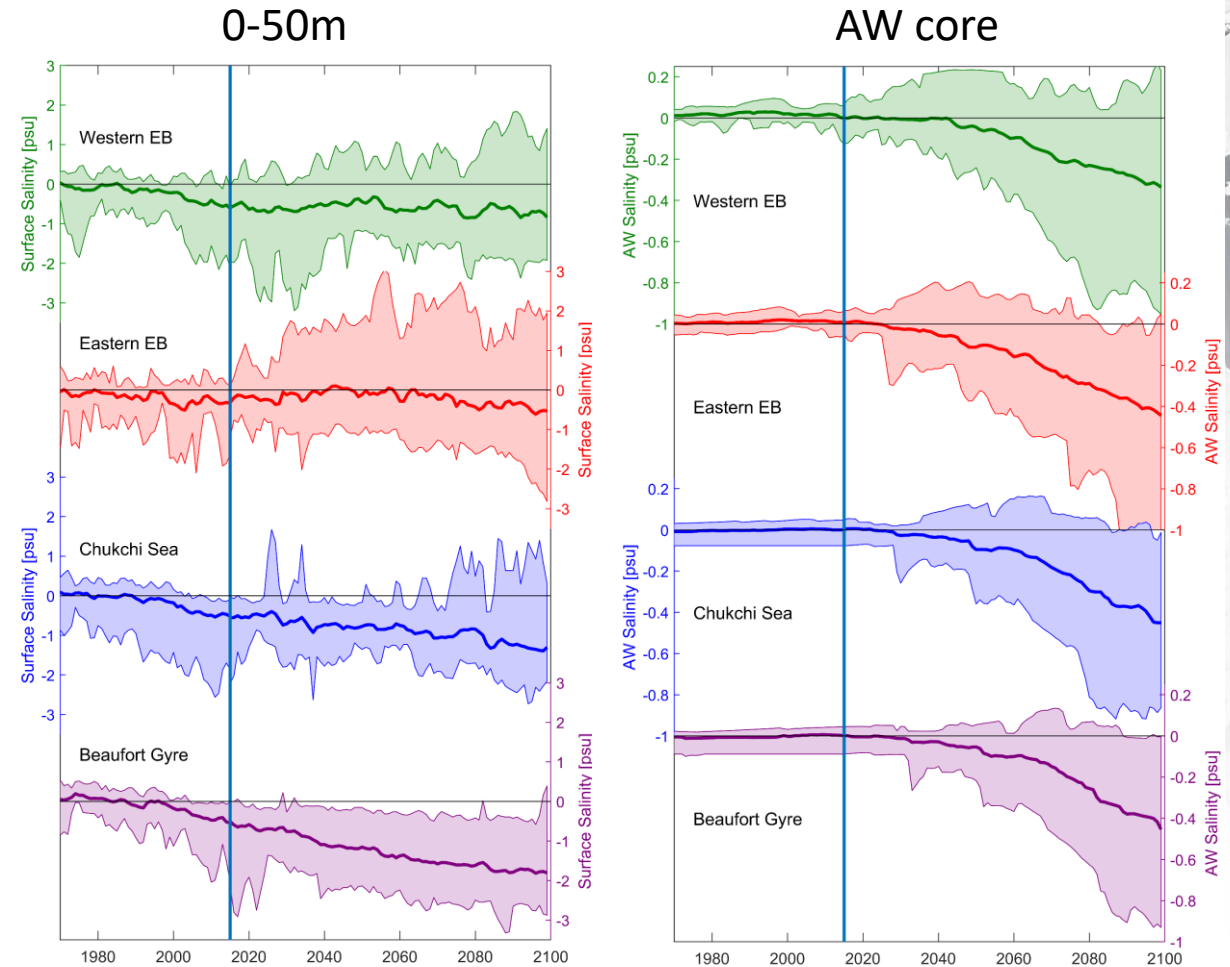
Future stratification (ssp585)

1. Agreement on strengthened stratification in the Amerasian basin in the future. (Atlantification will not spread eastward)

2. Divergence in model projections of stratification in the Eurasian basin
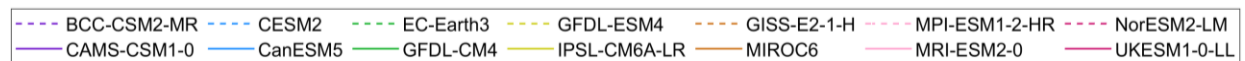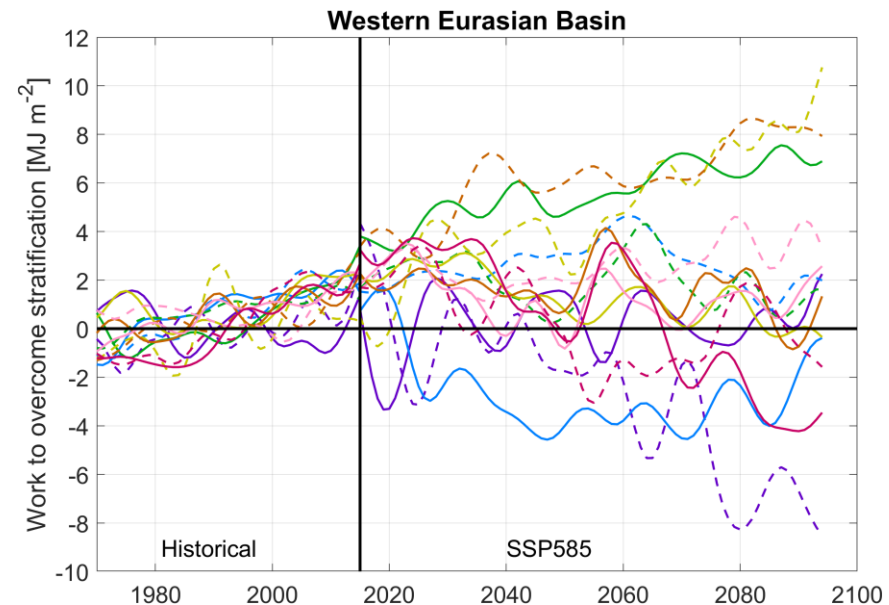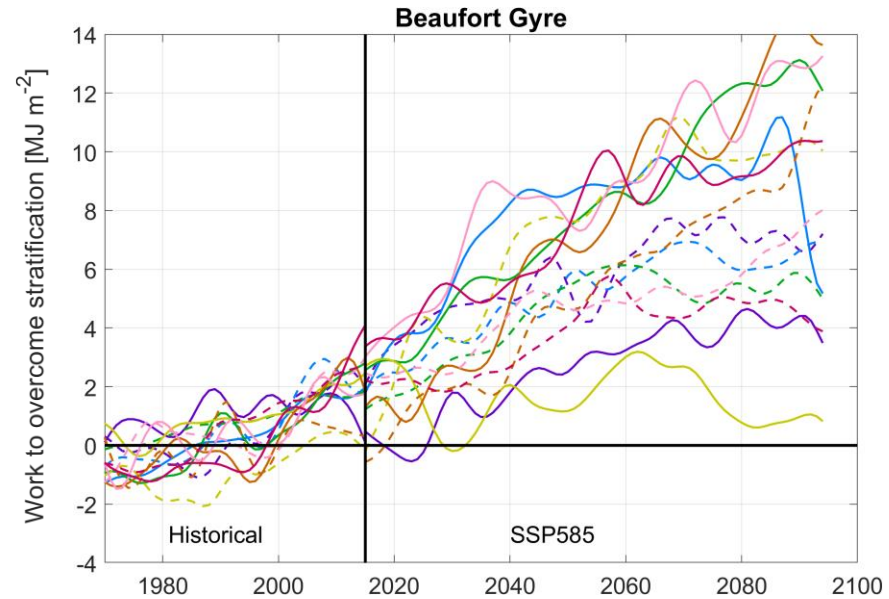
Concluding remarks and consequences

1. Of the models we analyzed, half of the models predicted a strengthening of the Eurasian basin stratification.

2. Opposite pathways are due to different balances between trends in the upper ocean, and trends at depth, related to fluxes through Fram Strait

3. Our study highlights the importance of a multi-model approach for studies of the future Arctic Ocean. Given large biases and opposite trends, relying on a single or just a few model systems is insufficient and may result in misleading conclusions.

4. However, it is important to analyze and interpret the models individually, not as a multi-model mean.

CRiceS

Thank you for your attention
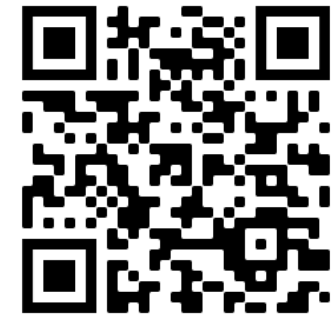
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