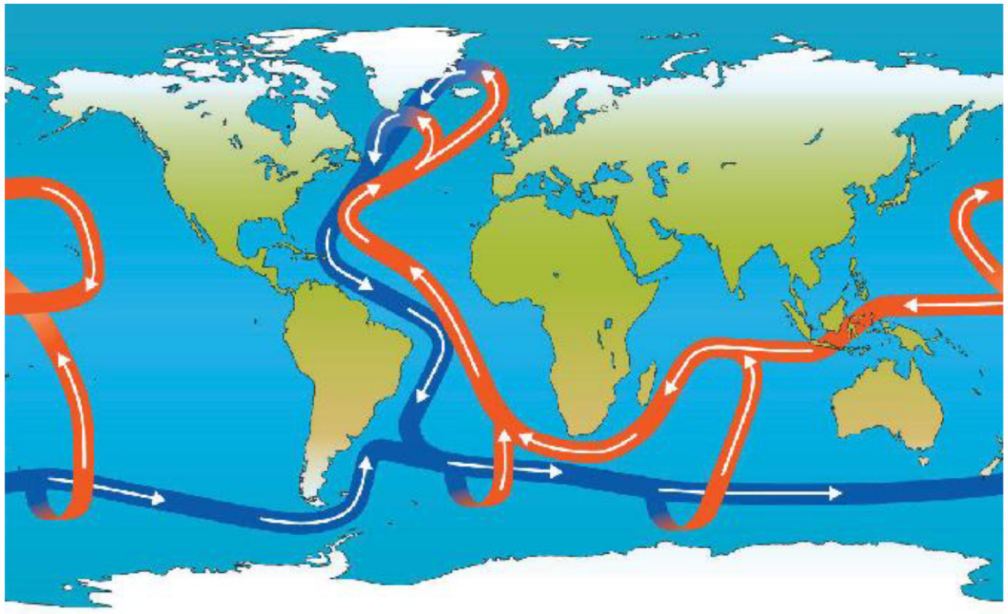
A 70-year perspective on water mass transformation in the central Greenland Sea

Anna-Marie Strehl, Kjetil Våge, Lars Henrik Smedsrud

Group Retreat 24th Mar 2022

Motivation



MetOffice, 2019

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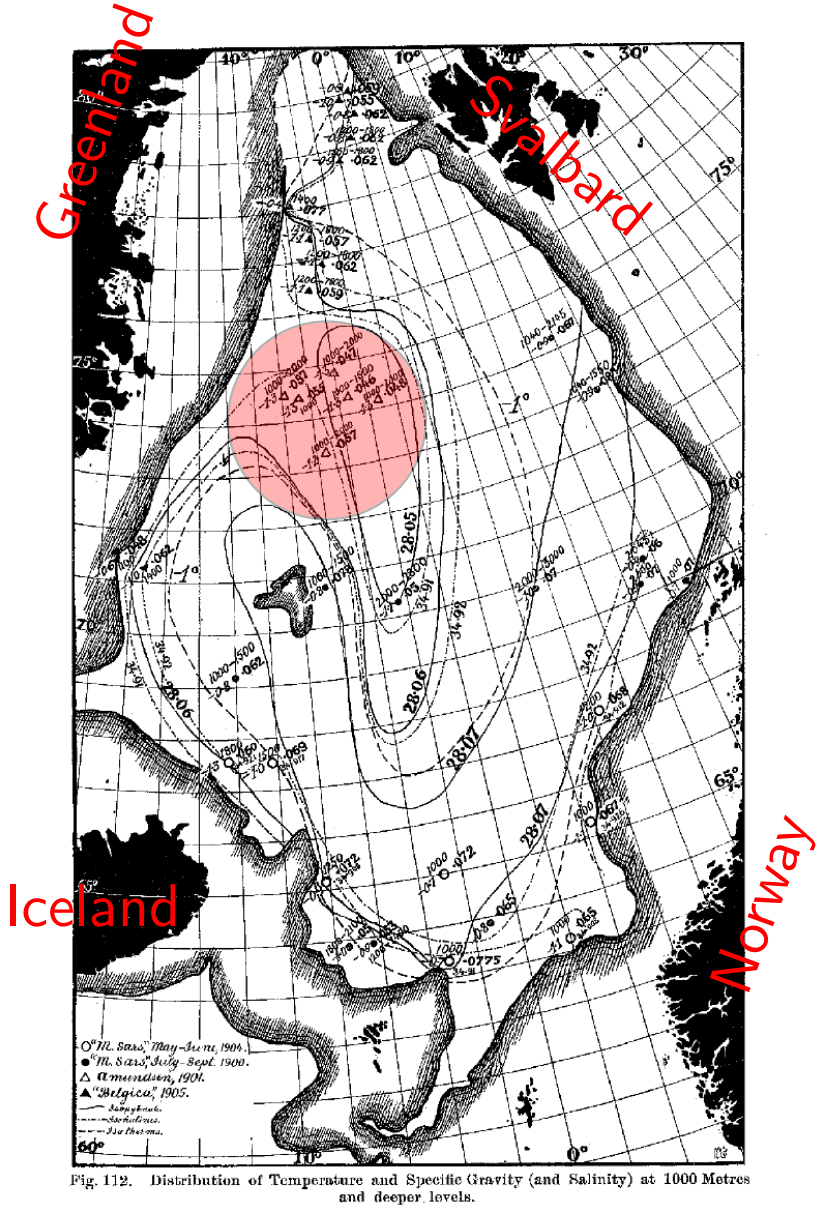

Fig. 112. Distribution of Temperature and Specific Gravity (and Salinity) at 1000 Metres and deeper levels.

- 1909, Helland-Hansen and Nansen: deep water production takes place in the Greenland Sea

Helland-Hansen and Nansen, 1909

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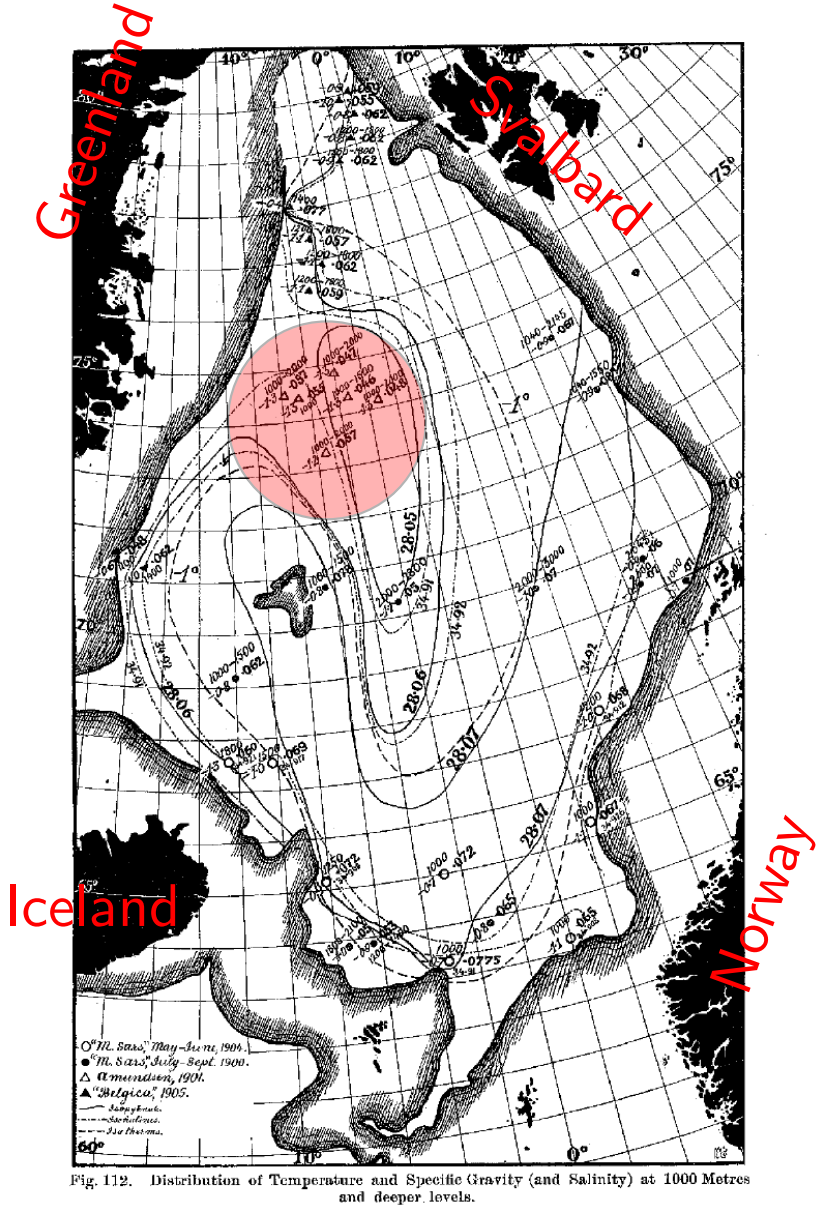

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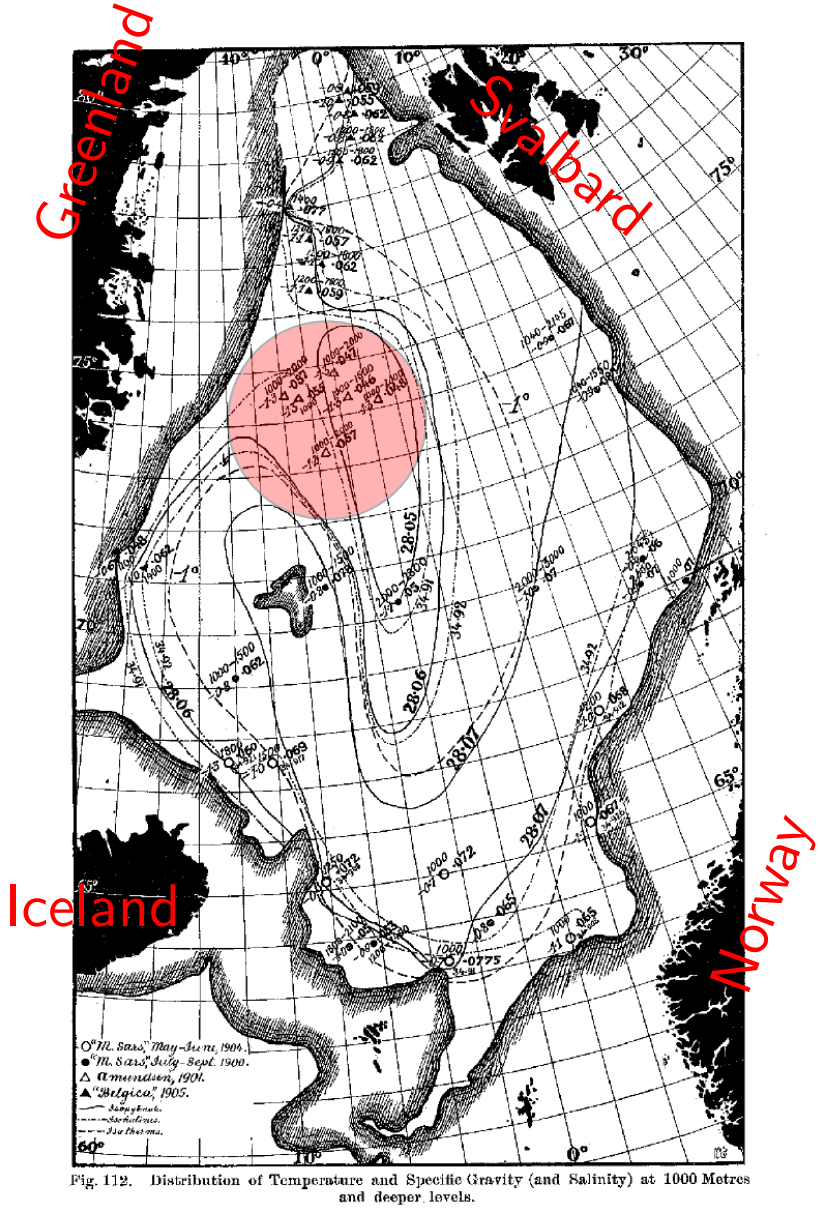

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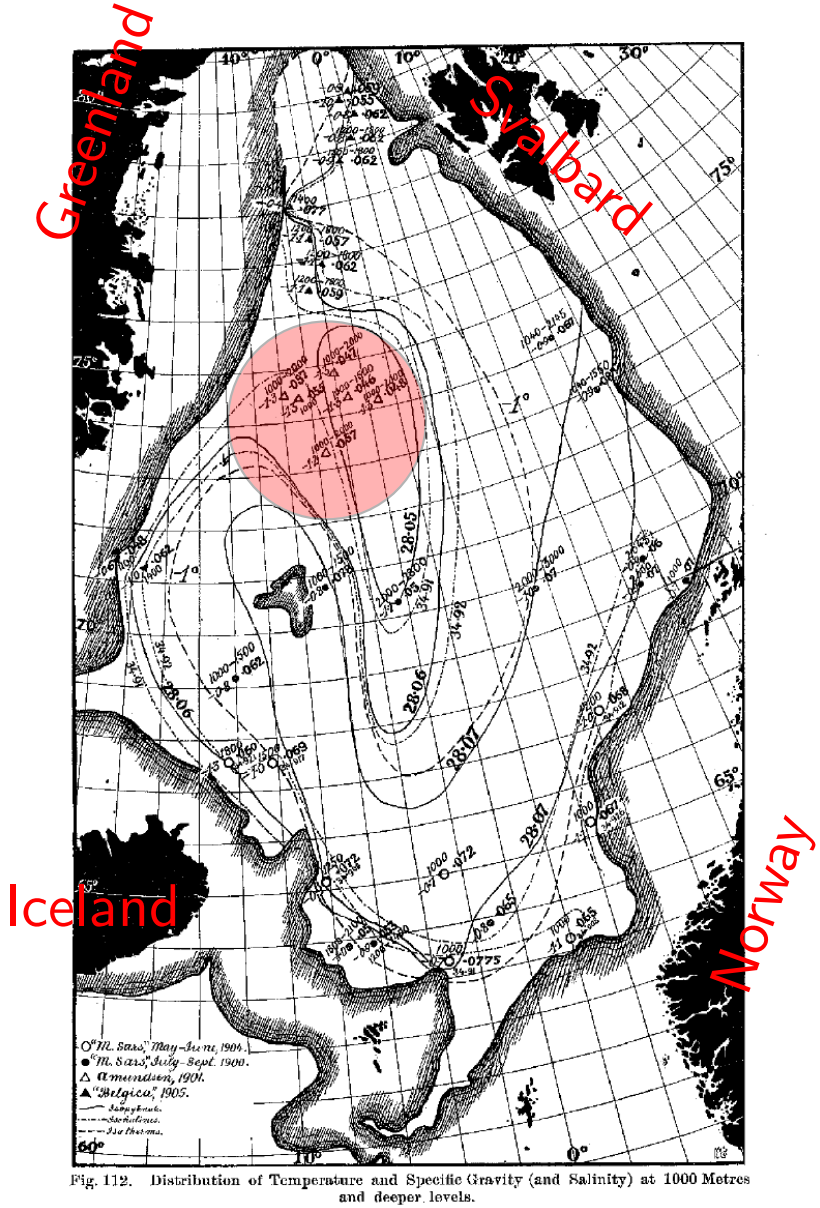

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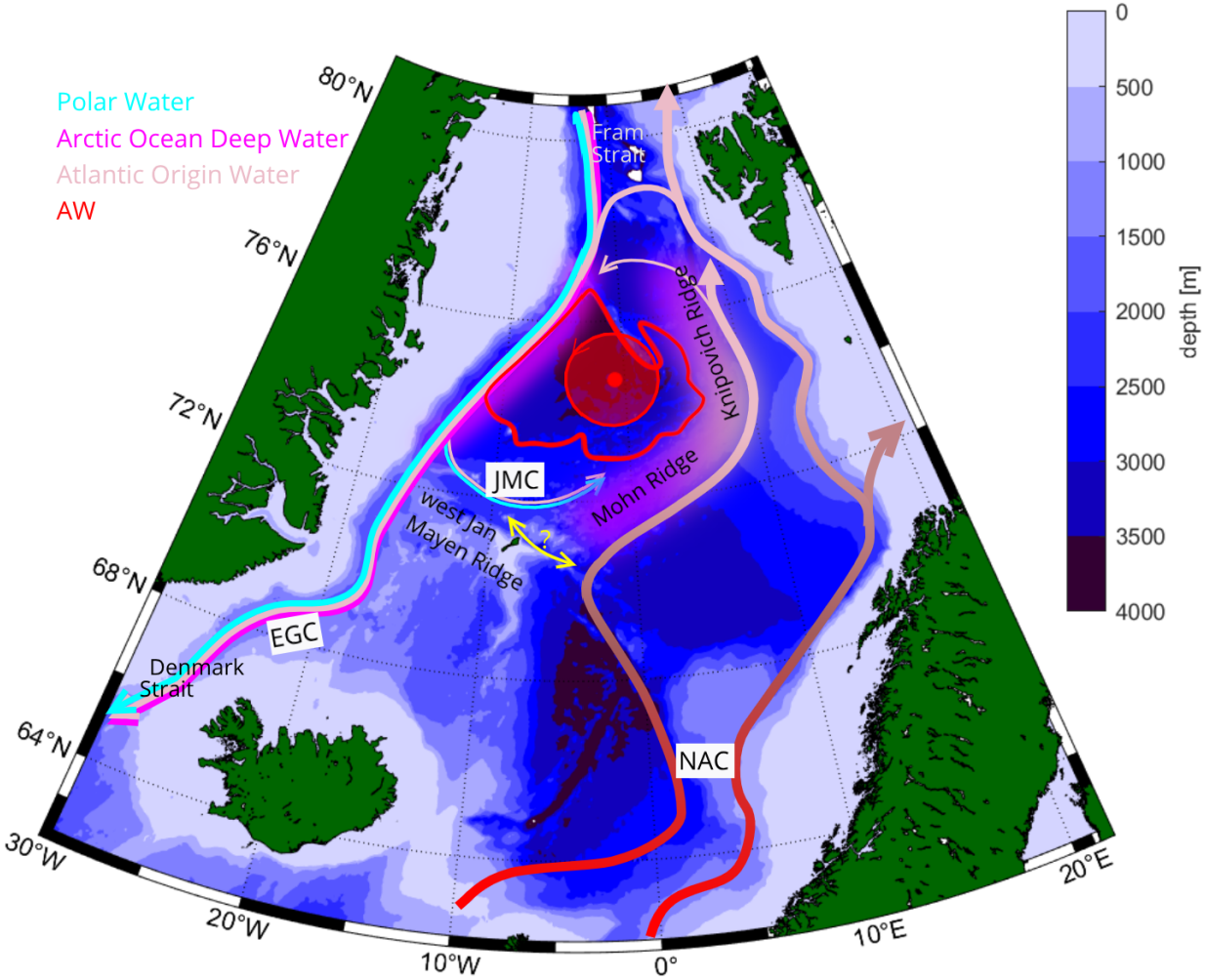
Helland-Hansen and Nansen, 1909

Overview - central Greenland Sea



changes in:

- hydrography
- convection
- seasonal variability

impacted by:

- surrounding water masses
- surface forcing
  - sea ice cover
  - heat fluxes

EGC: East Greenland Current
JMC: Jan Mayen Current
NAC: Norwegian Atlantic Current

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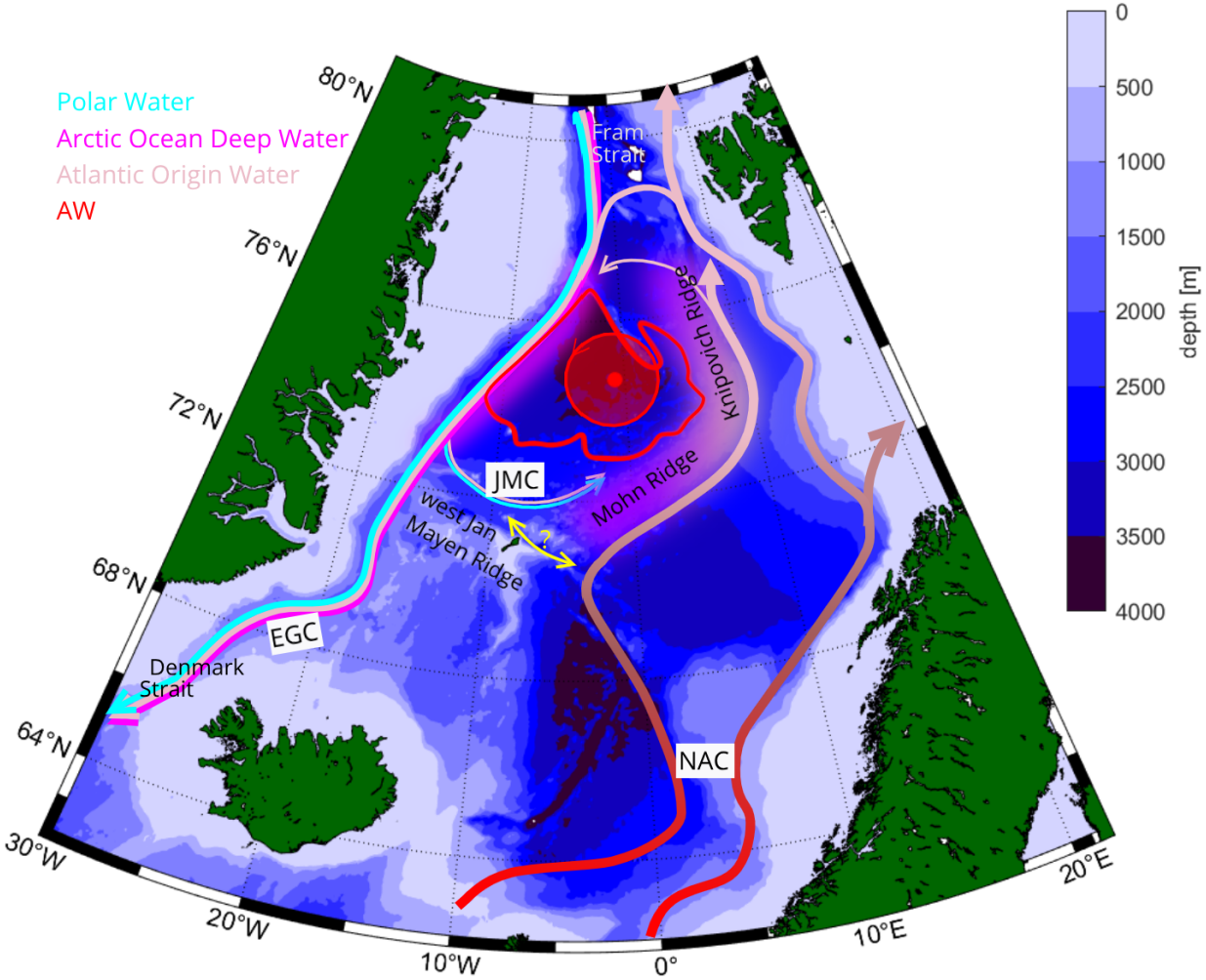

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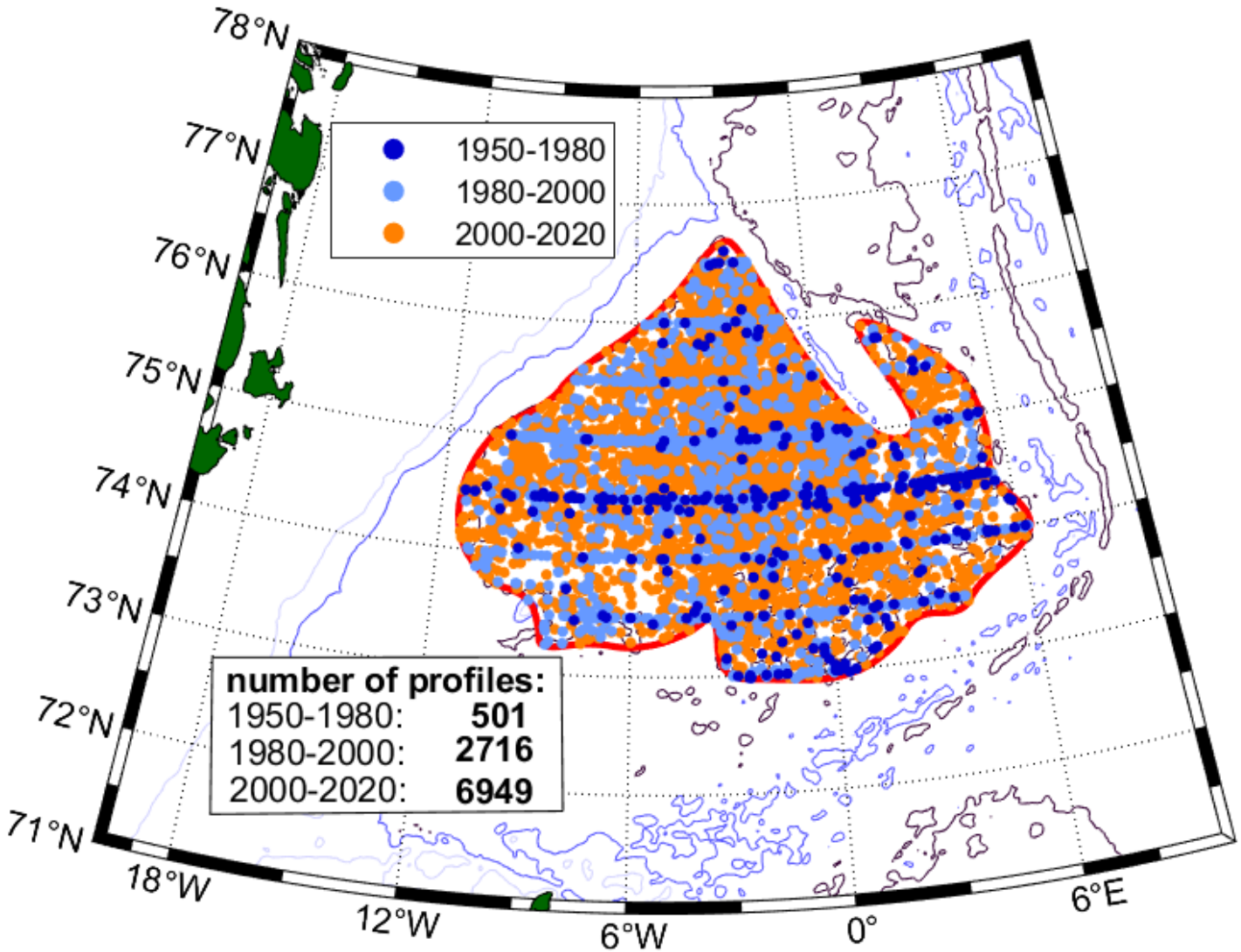

Brakstad et al., in prep, *Progress in Oceanography*

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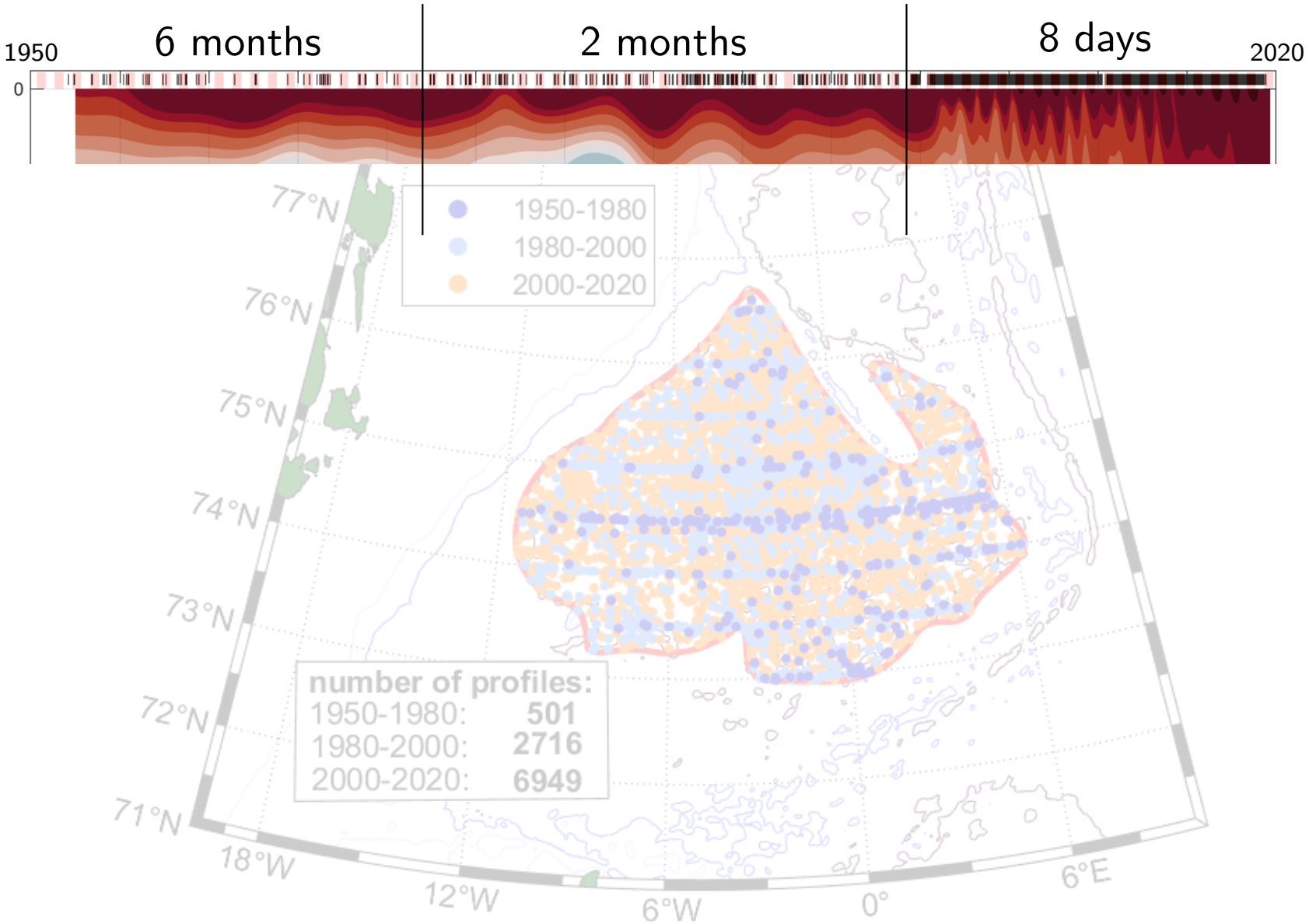

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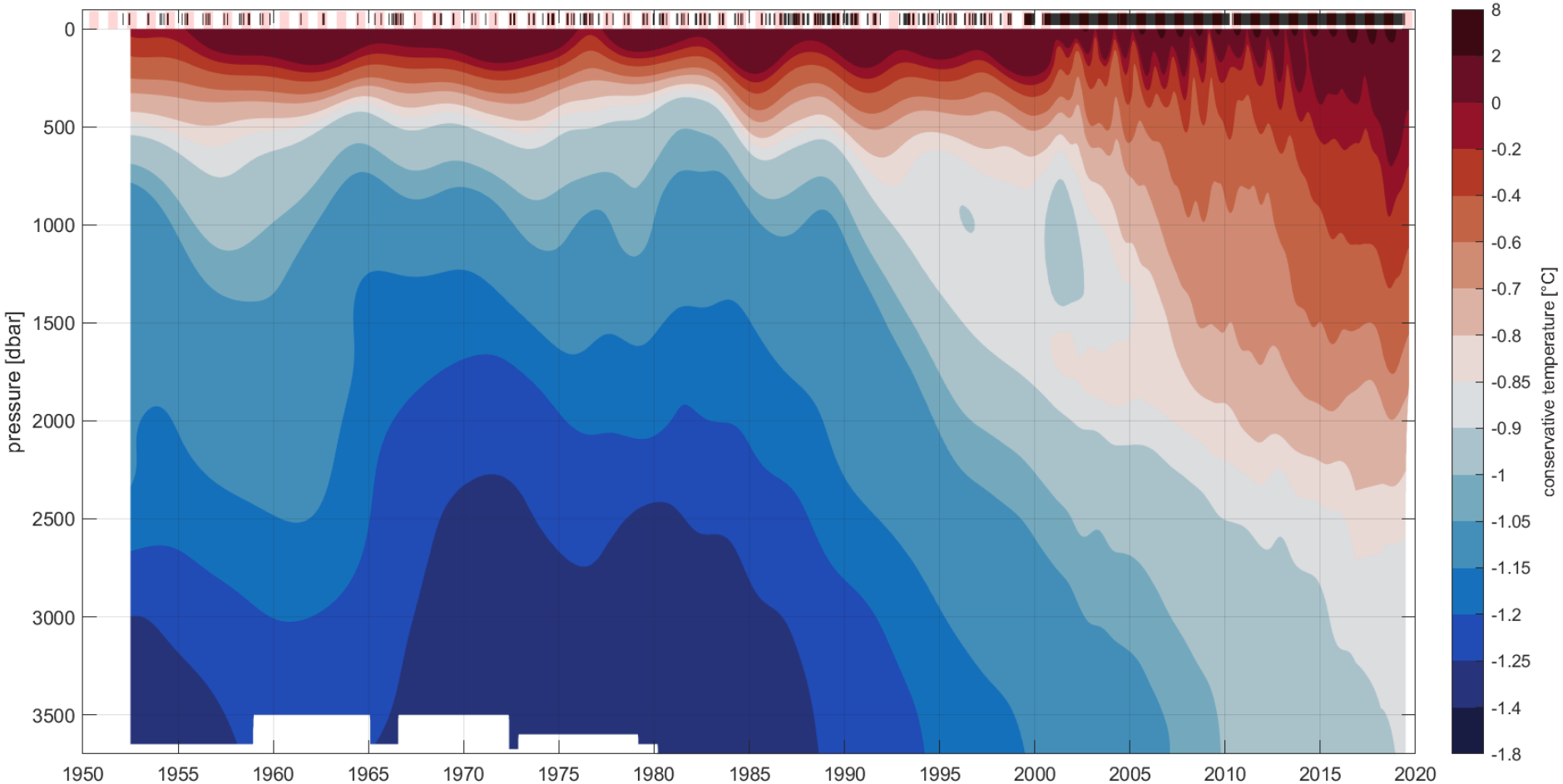
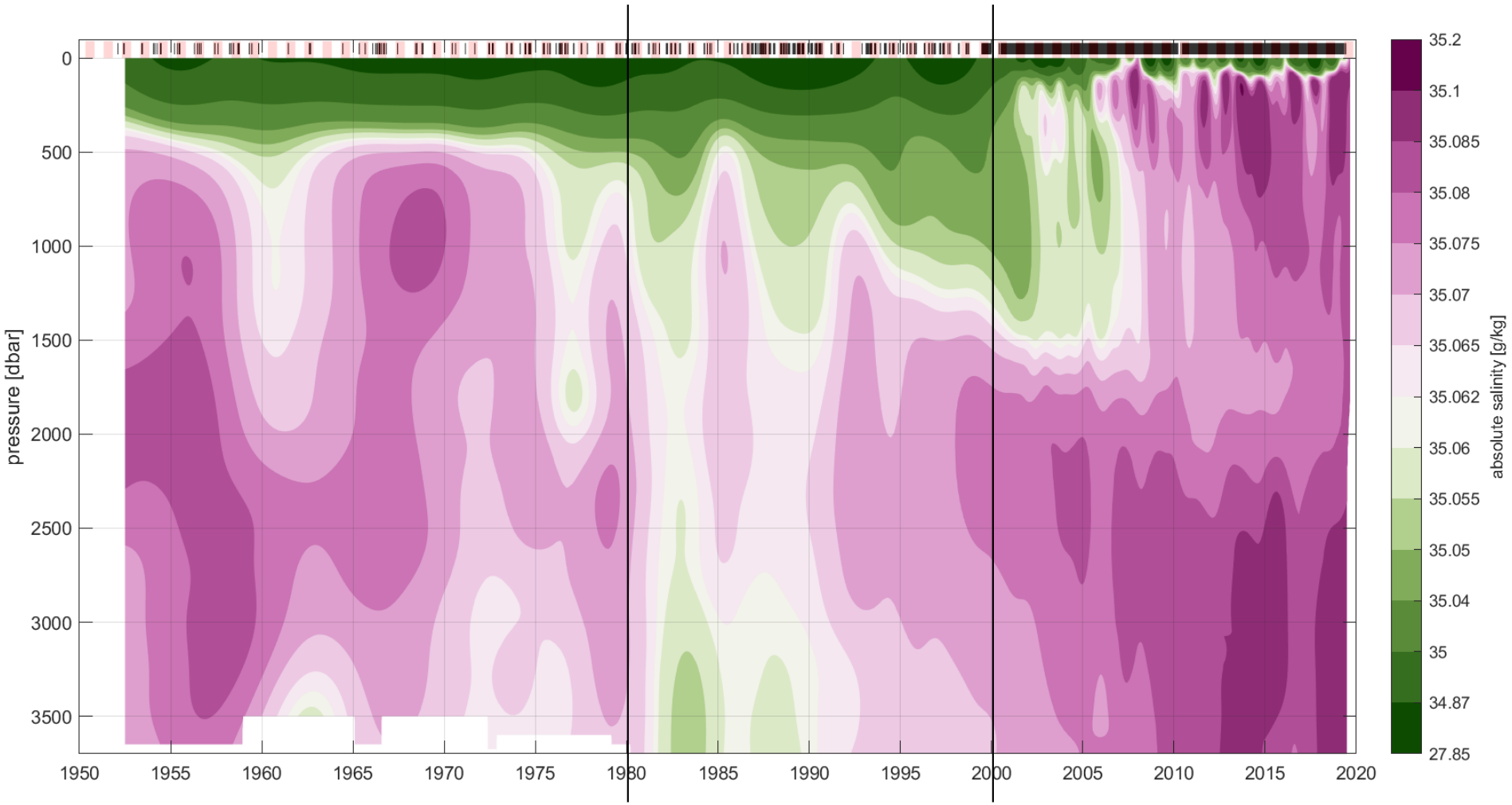
Temperature evolution



Salinity evolution



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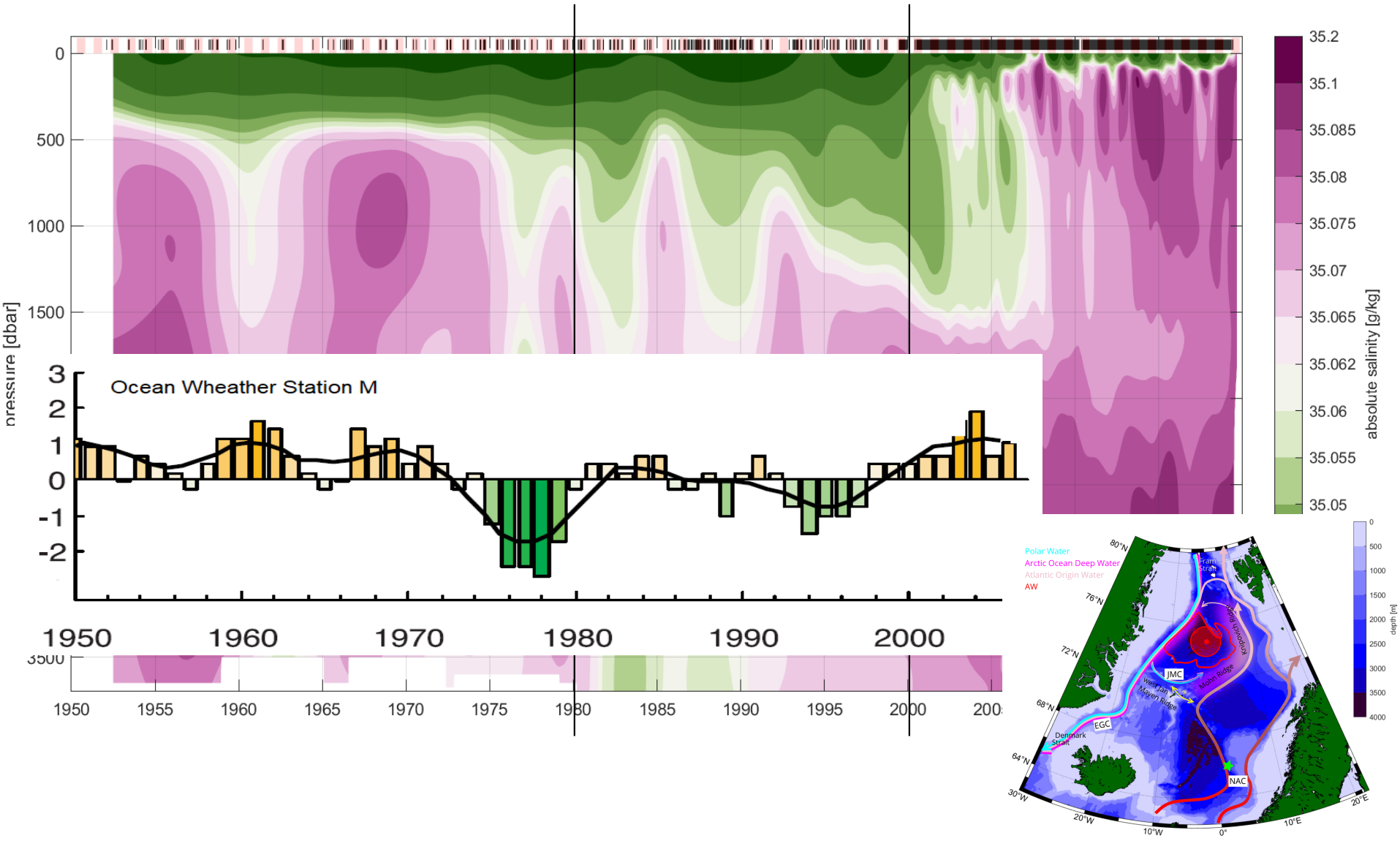
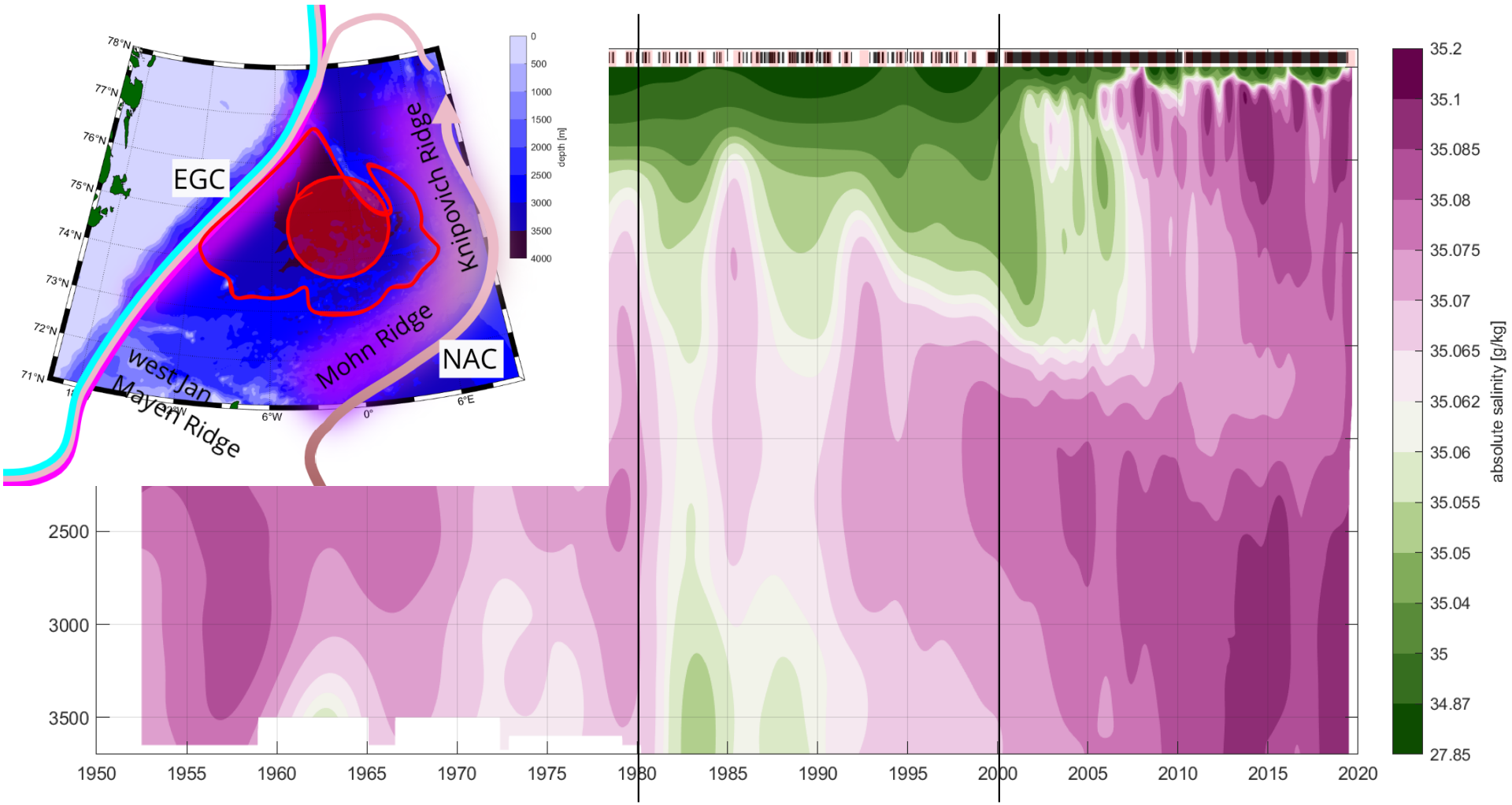
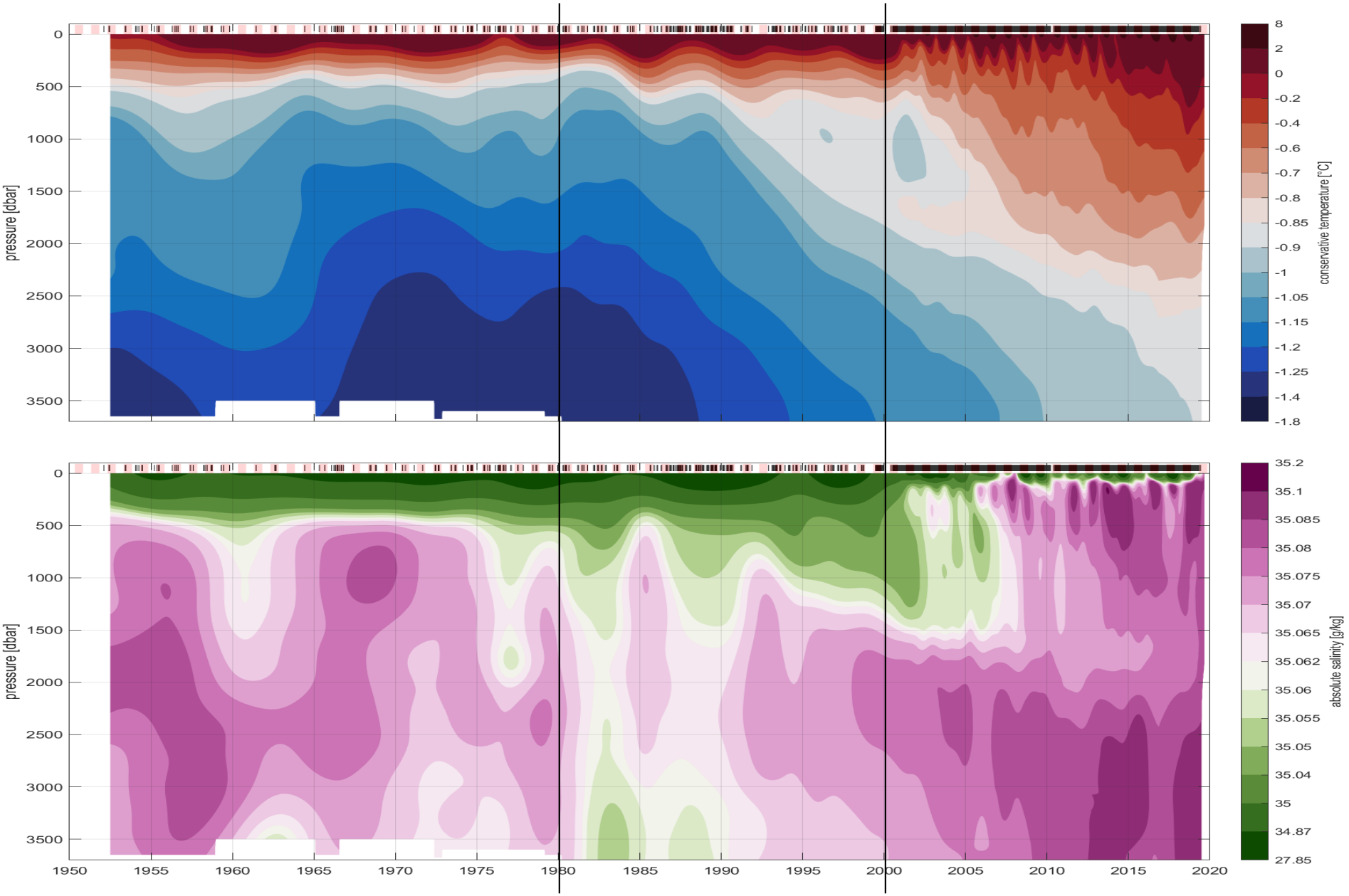


Holliday et al., 2008, *Geophysical Research Letters*

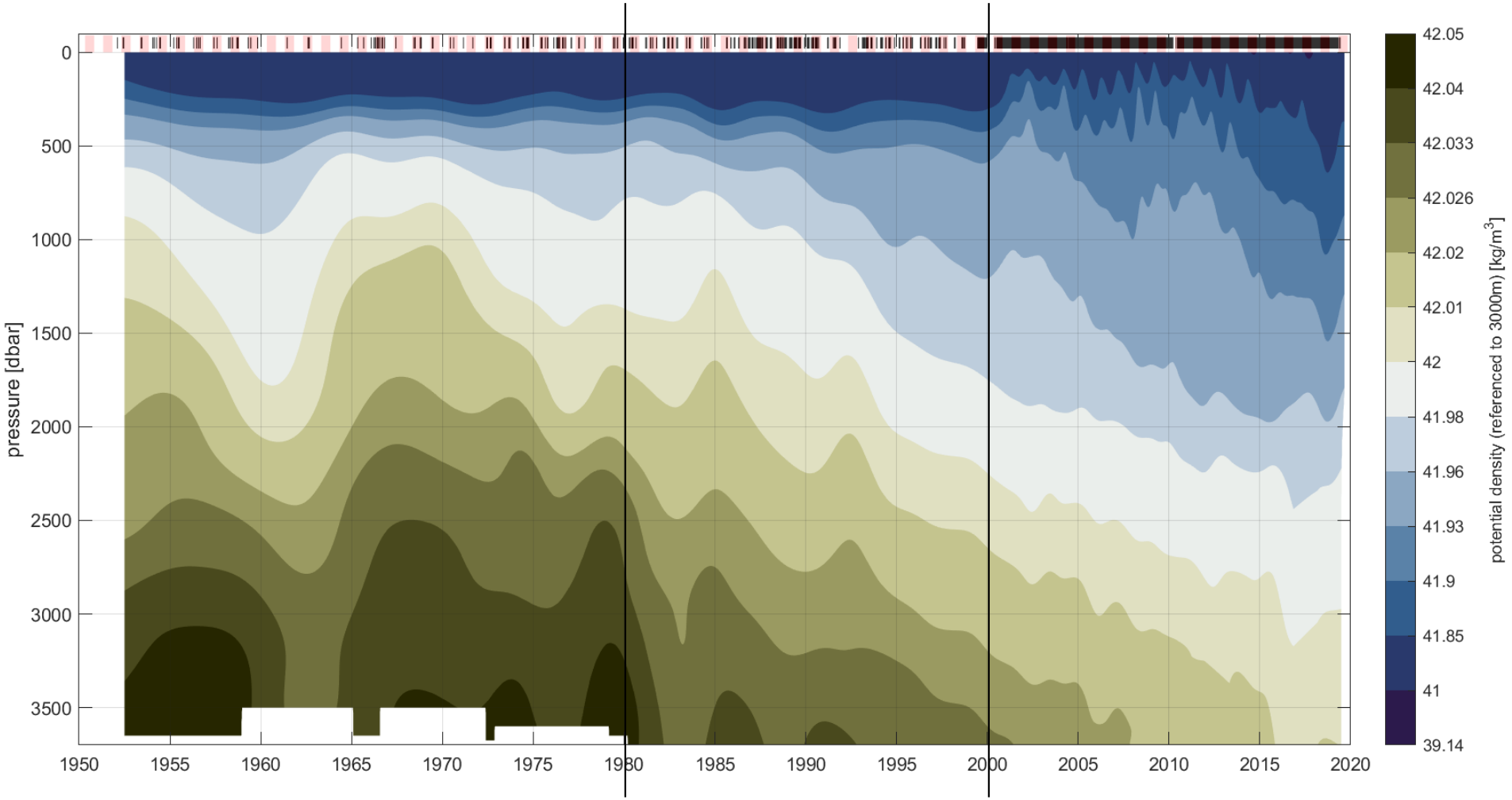
Salinity evolution



Temperature + salinity evolution



Density evolution (referenced to 3000 m)



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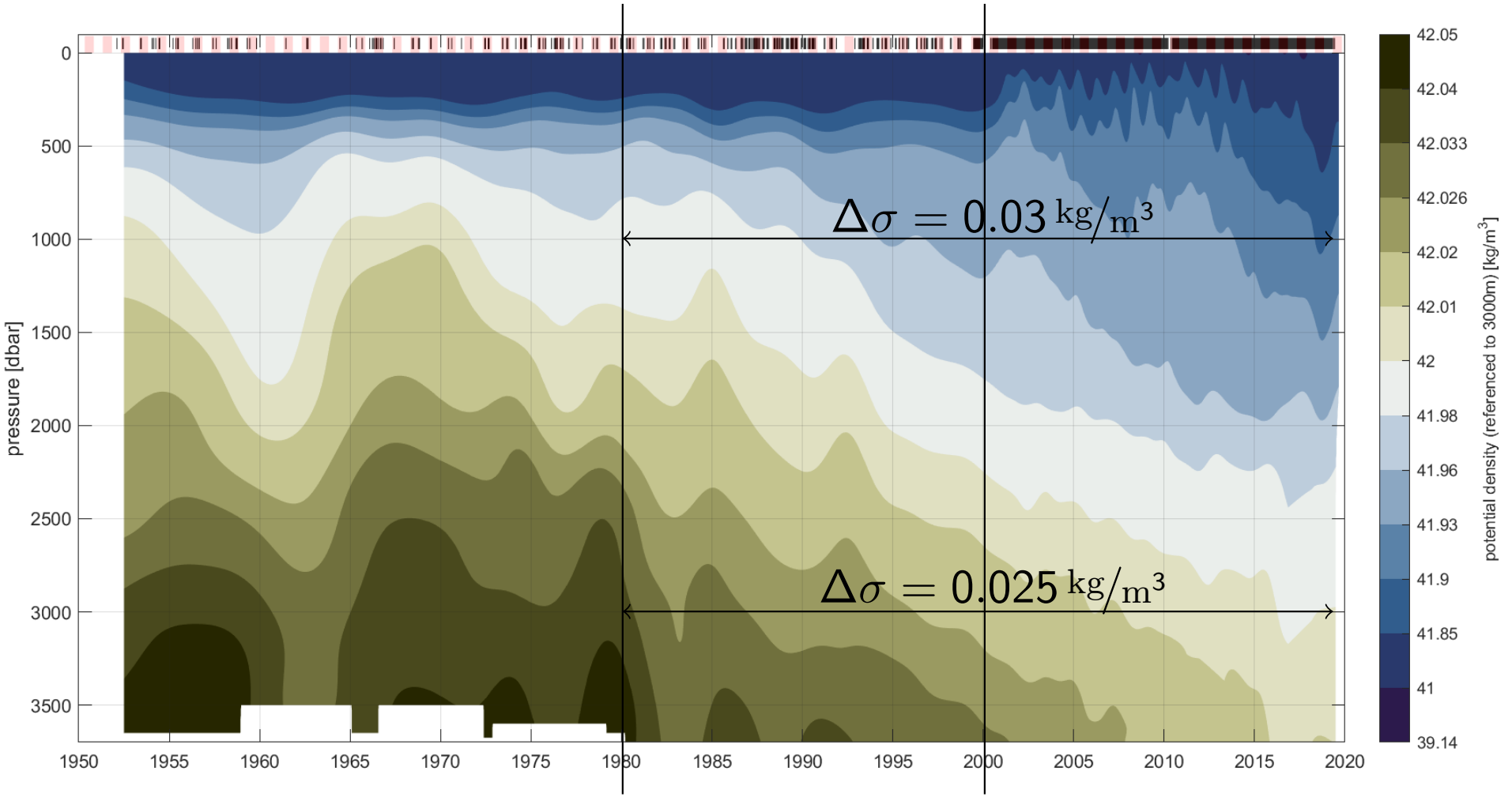
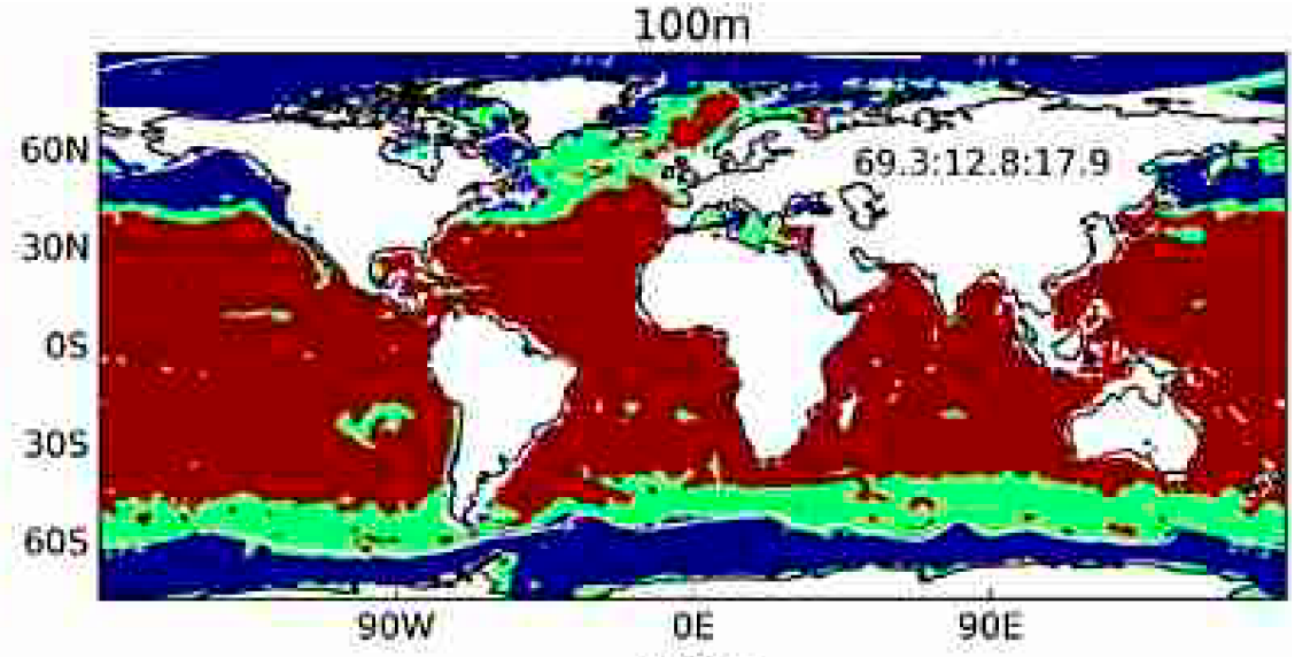


The central Greenland Sea - something in between



β-ocean
(salinity stratified)

transition ocean

α-ocean
(temperature stratified)

$$N^2 = g\left(\alpha\frac{\partial\theta}{\partial z} - \beta\frac{\partial S}{\partial z}\right)$$

Stewart and Haine, 2016, *Journal of Physical Oceanography*

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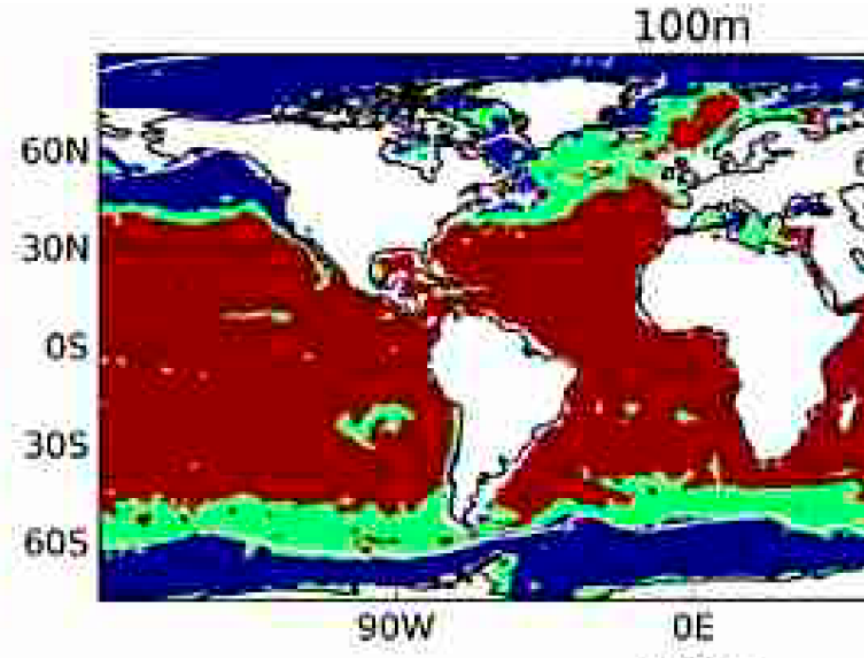

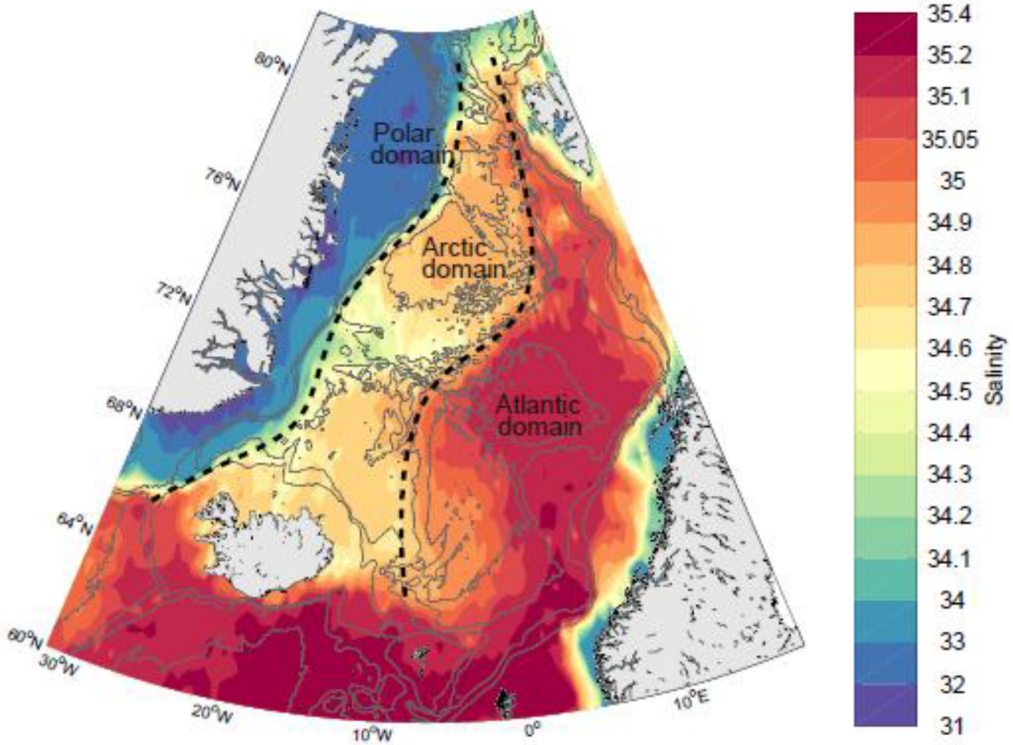

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from L. Håvik, 2018

α-/β-ocean classification

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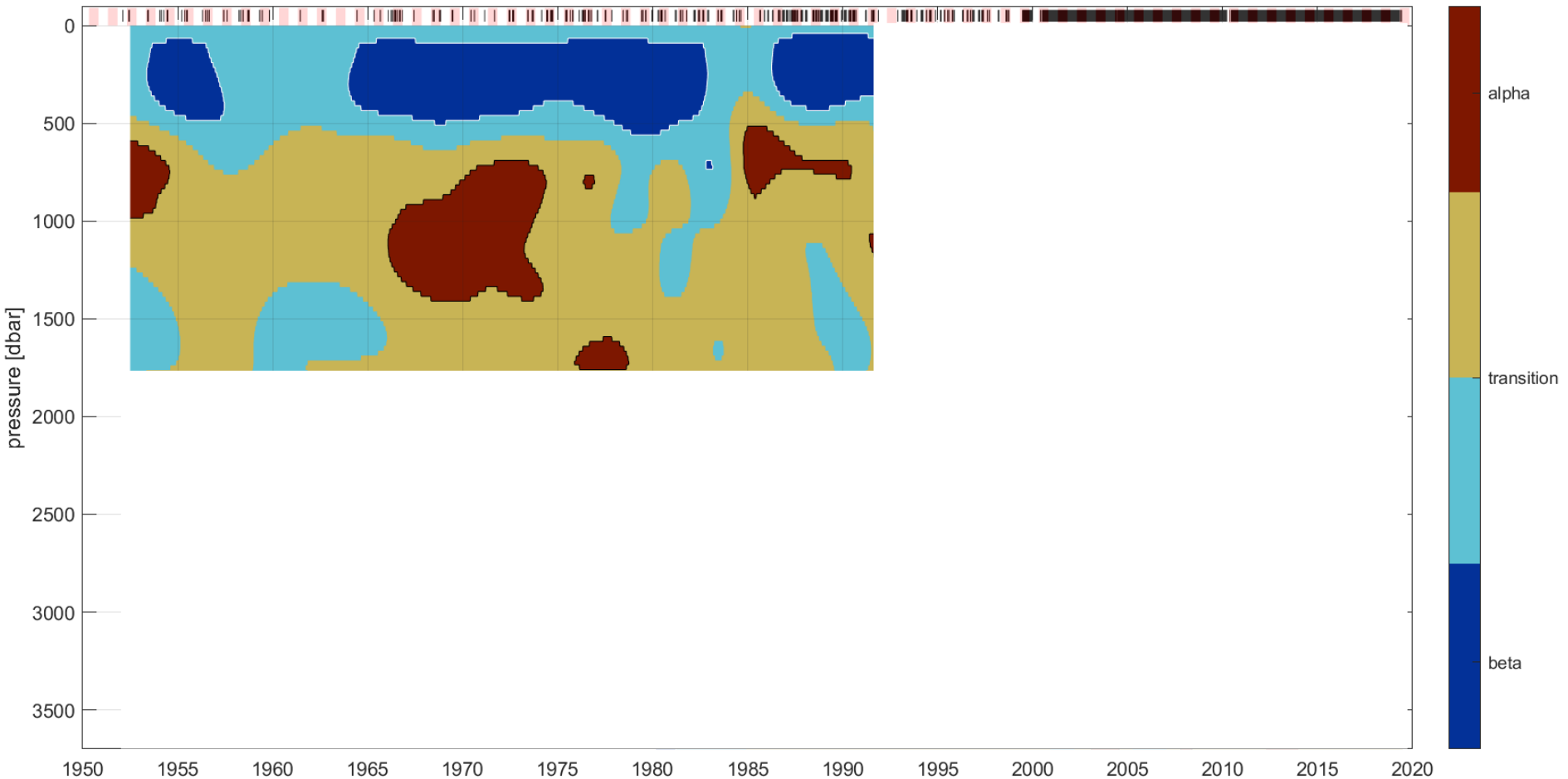

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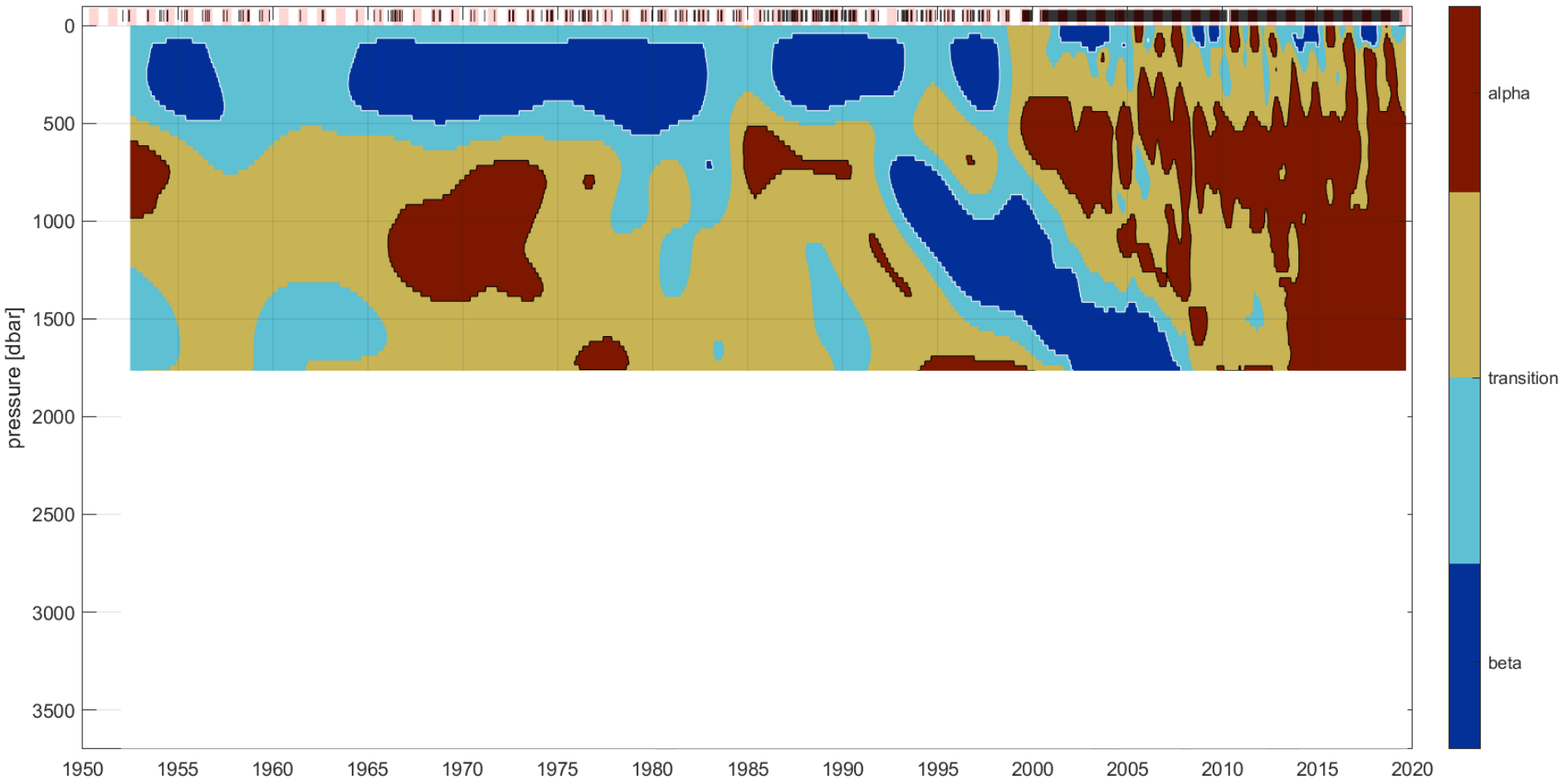
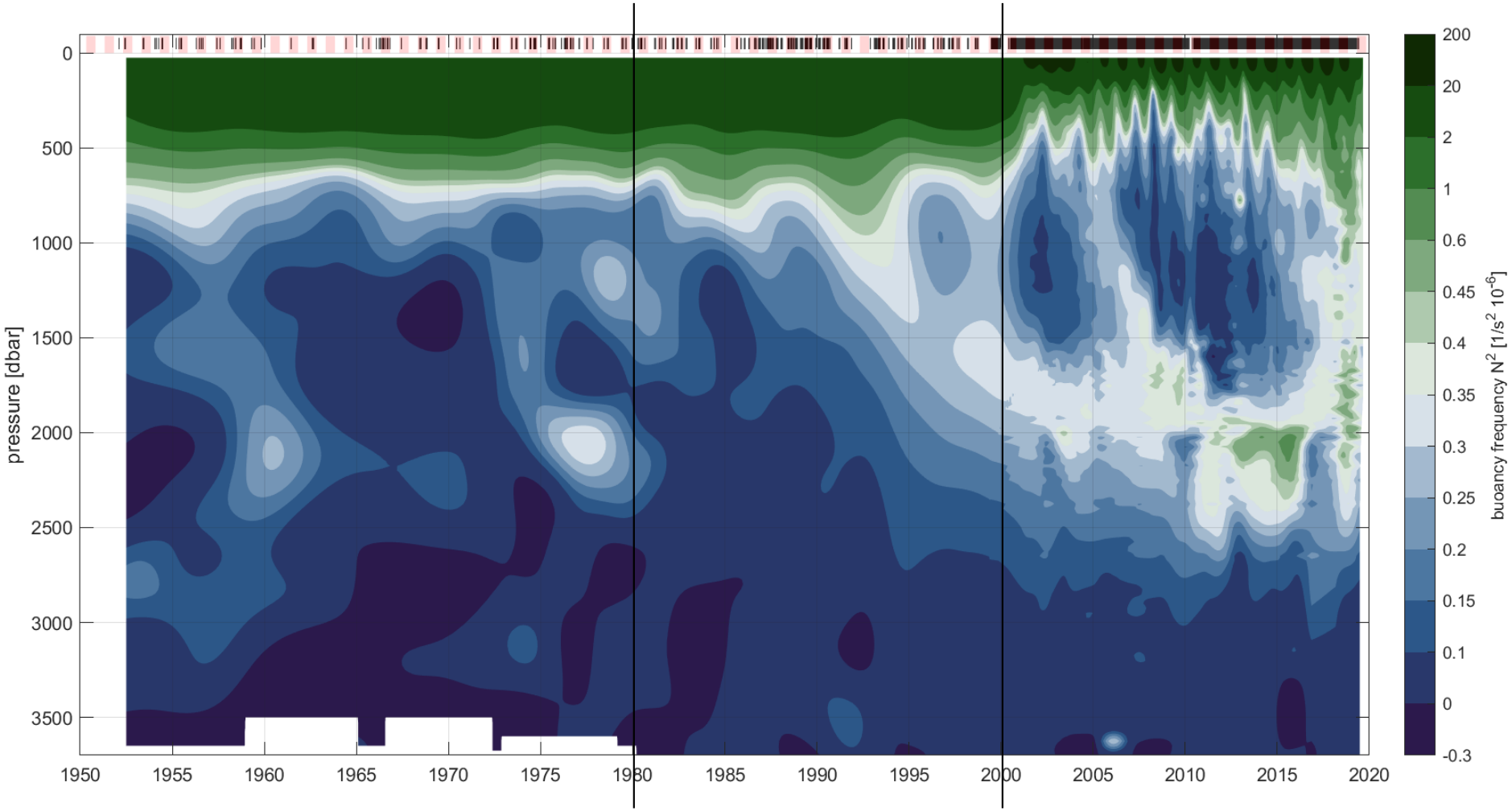
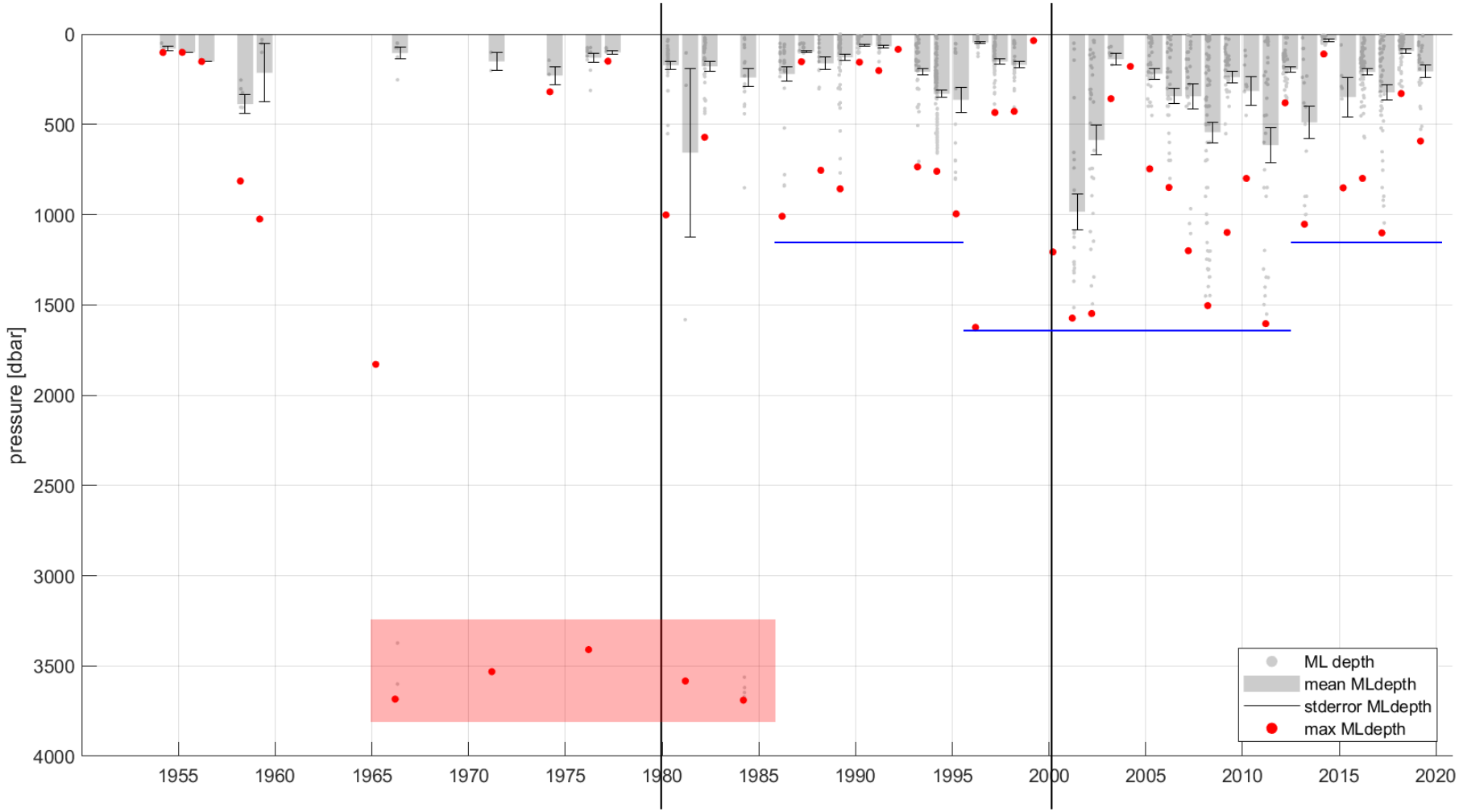


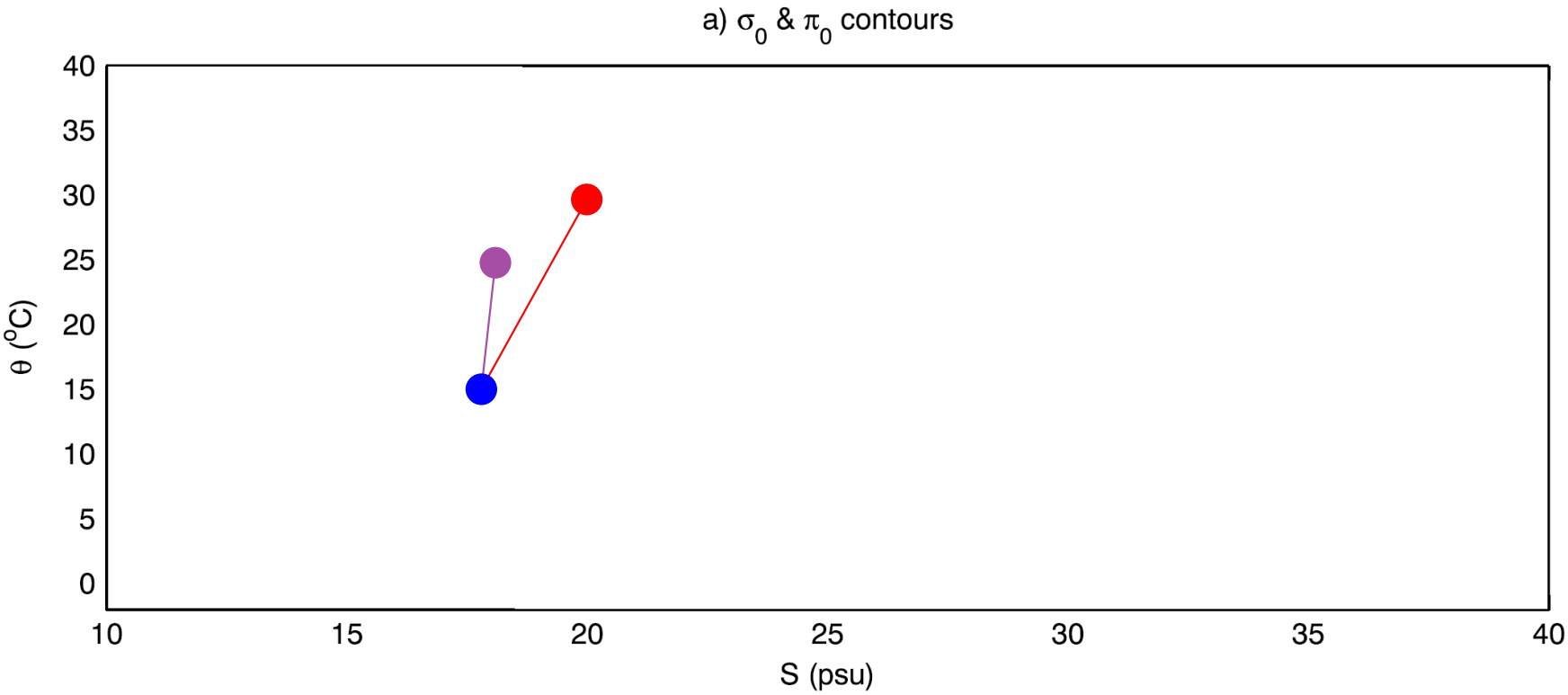
Stratification (buoyancy frequency) evolution



Mixed layer depth



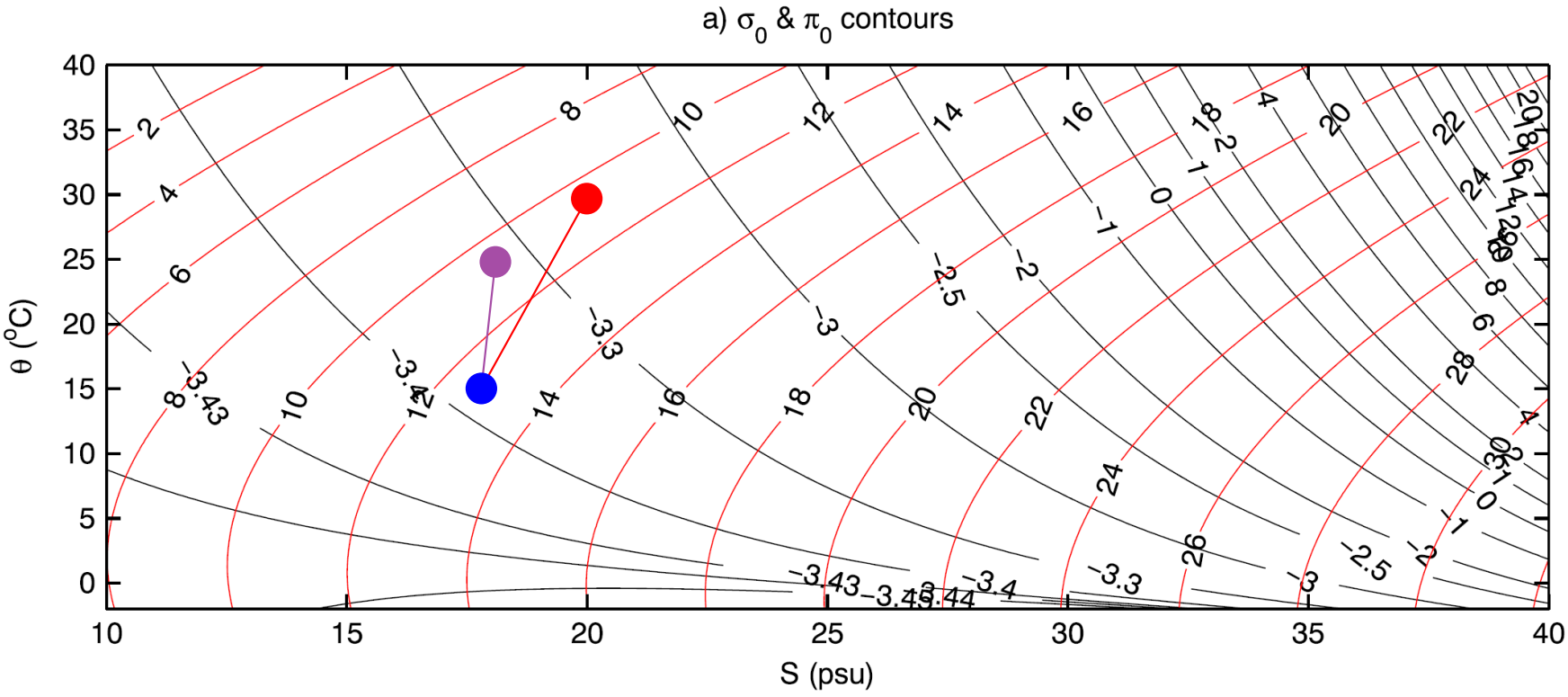
σ-π distance



Huang, Yu, and Zhou, 2018, *Journal of Geophysical Research: Oceans*

σ-π distance

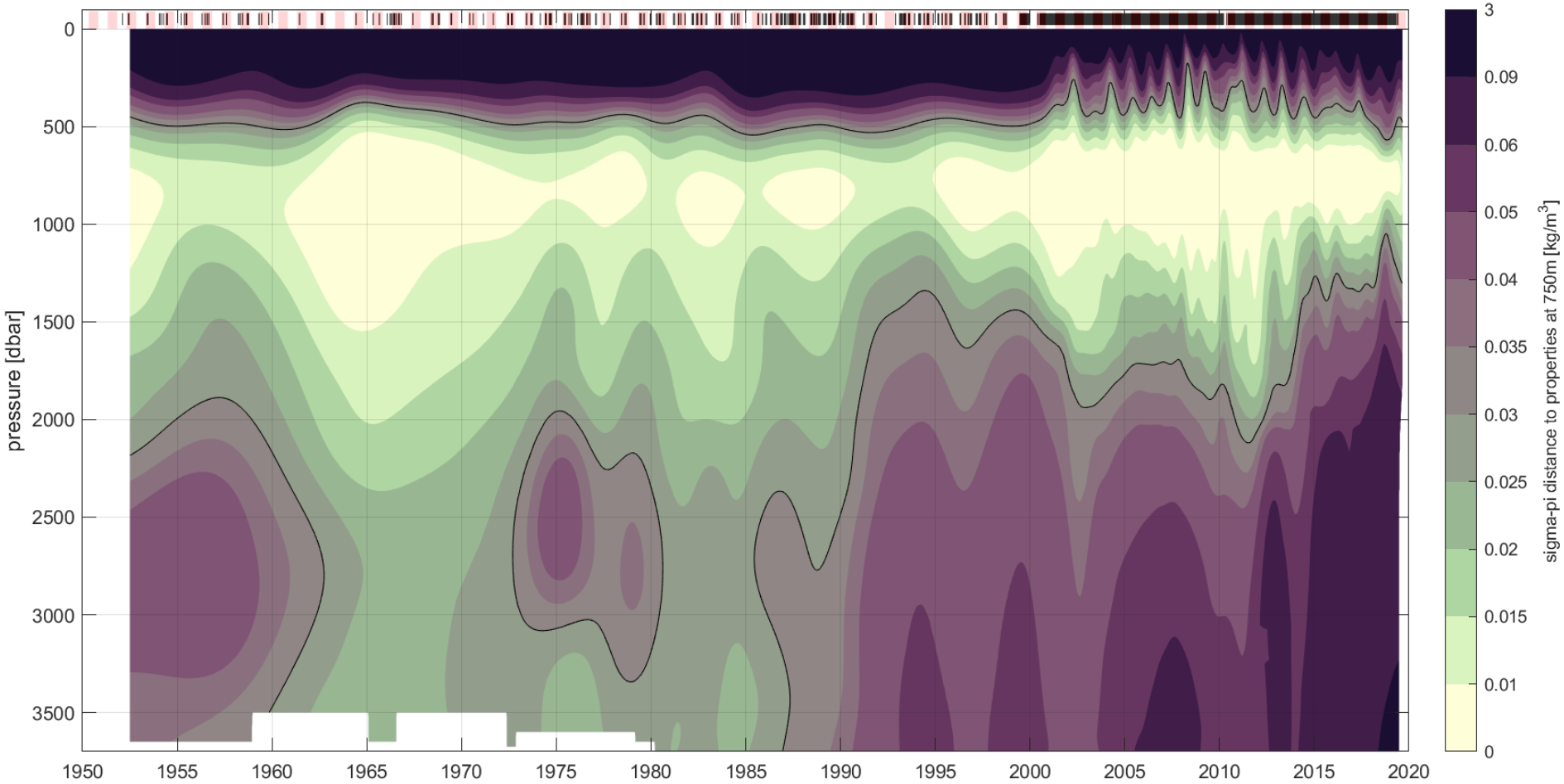
σ : density π : spicity



change coordinate system from θ-S to σ-π

Huang, Yu, and Zhou, 2018, *Journal of Geophysical Research: Oceans*

σ-π distance to 750 m



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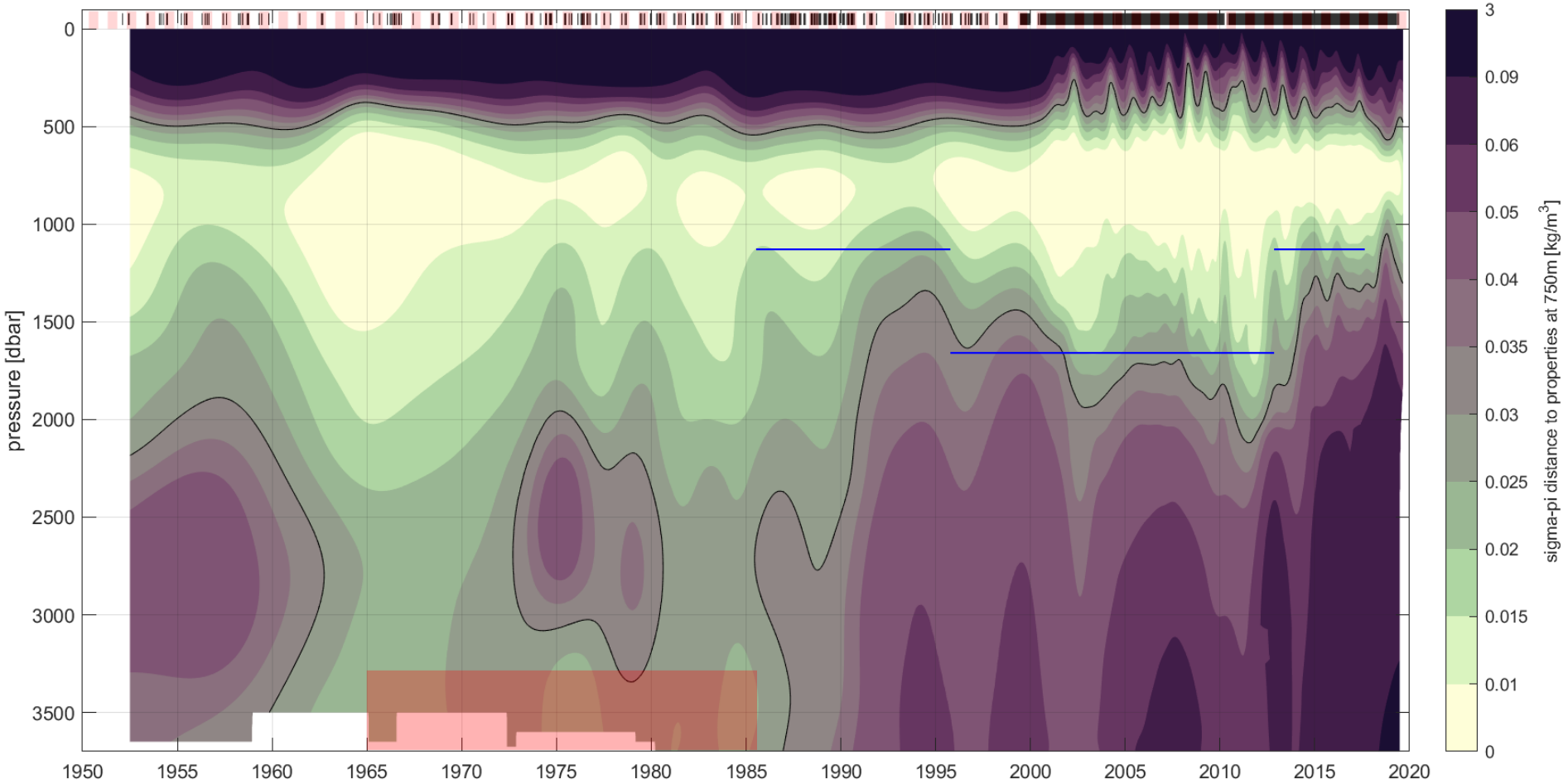
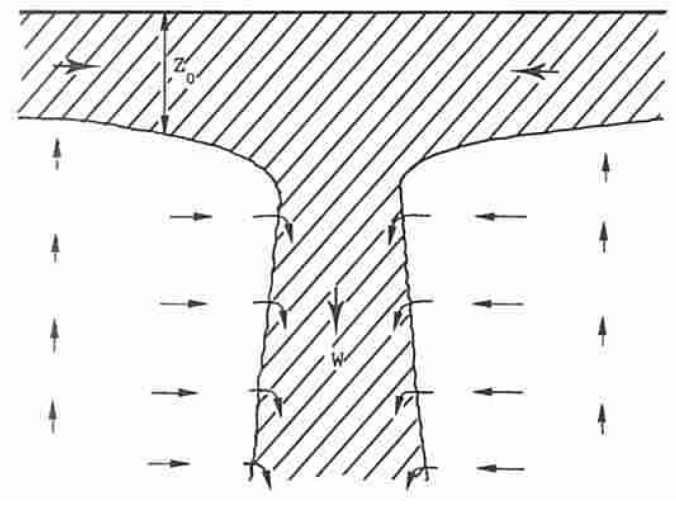
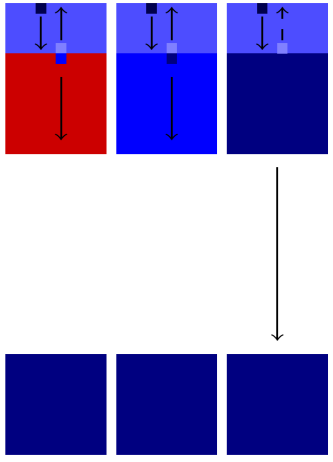
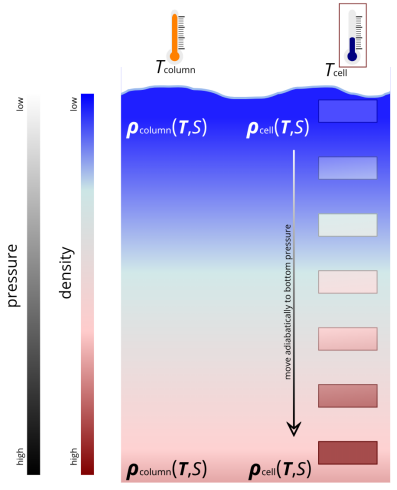


convective mechanisms

haline convection	**thermal convection**	**double diffusive convection + cabbeling**	**thermobaric convection**
mixed layer convection		internal convection	bottom reaching convection







Rudels, 1990, *Deep Sea Research Part A. Oceanographic Research Papers*

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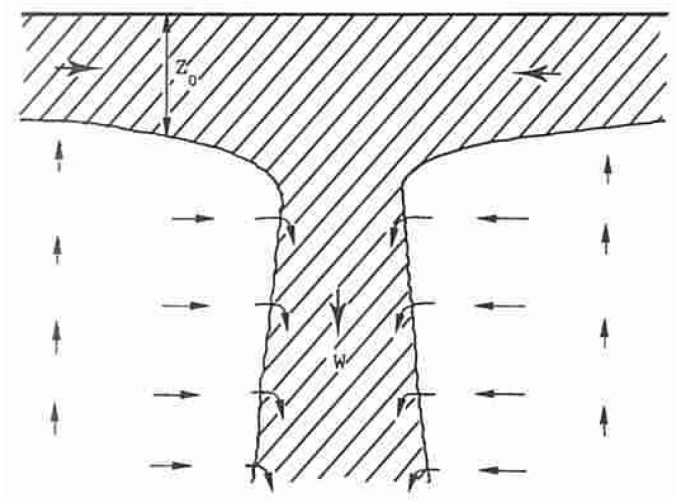

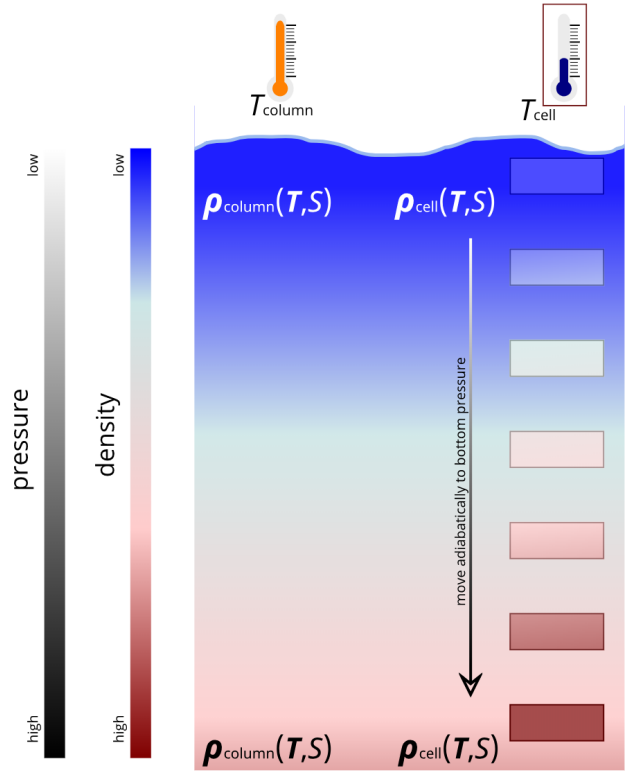

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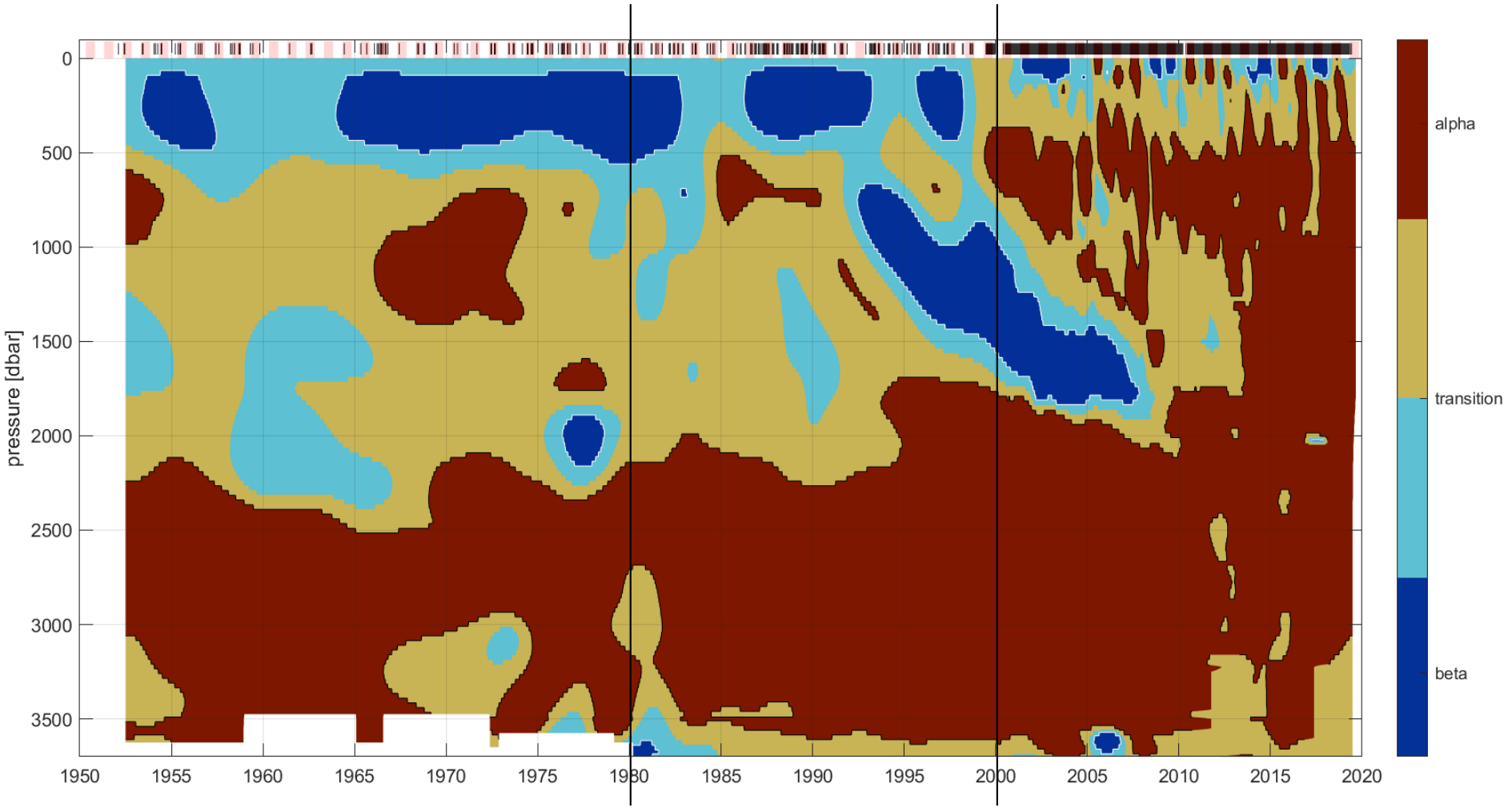
α-ocean: temperature-stratified β-ocean: salinity-stratified



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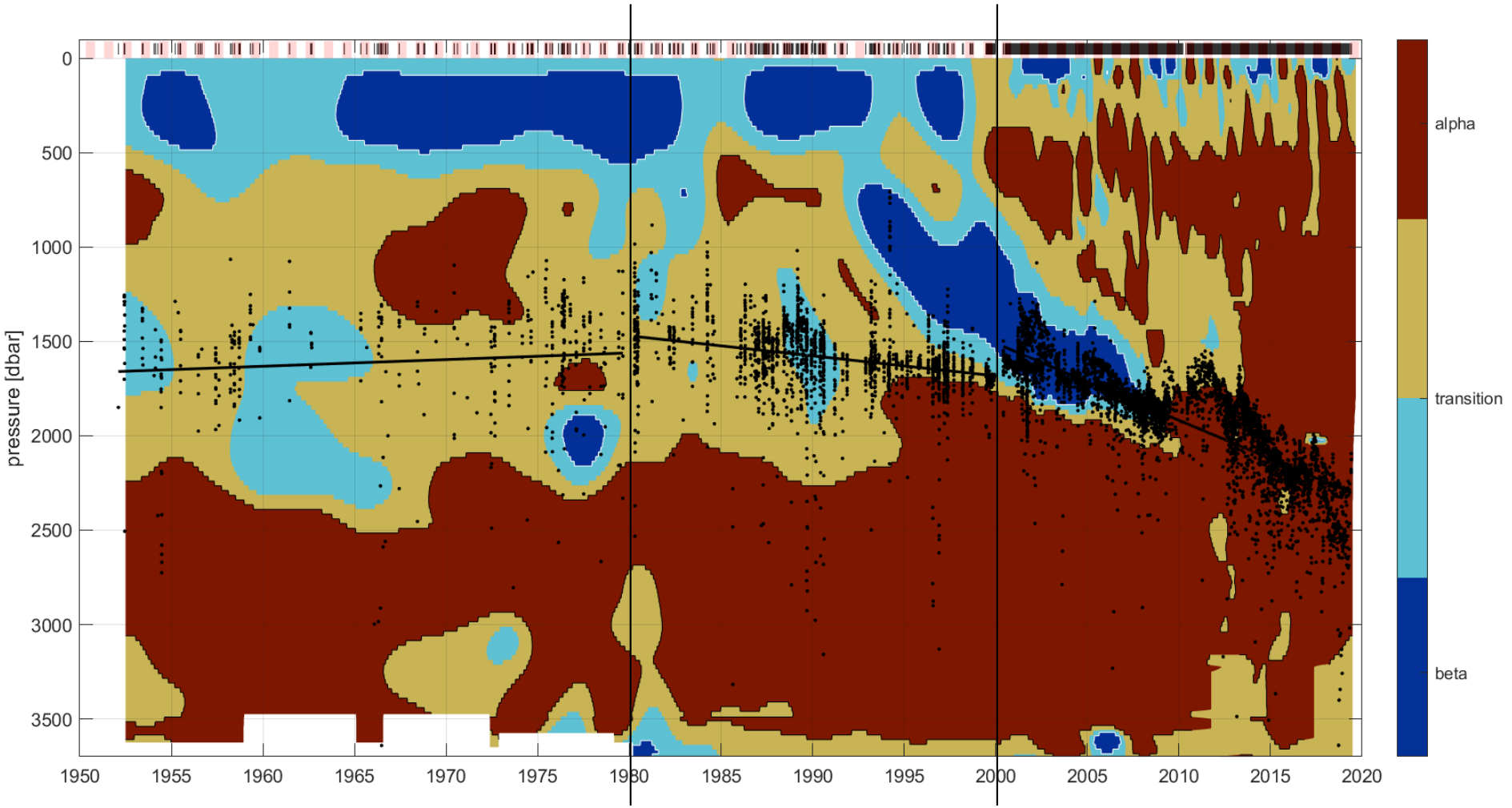

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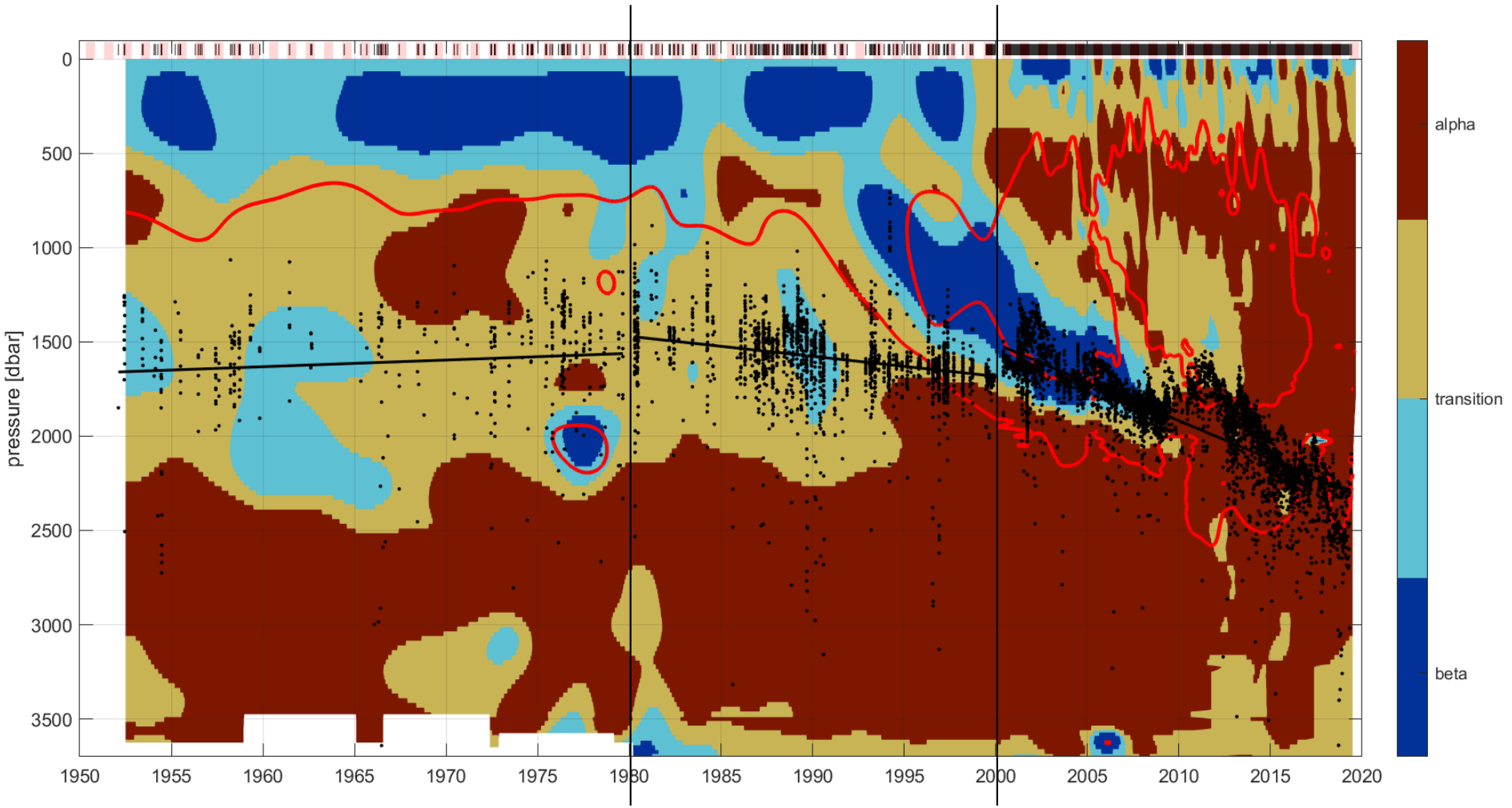
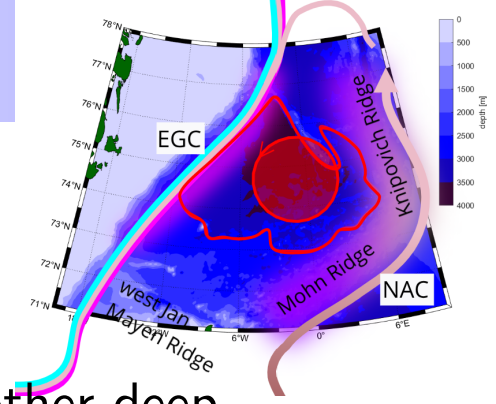


Summary - changes in the central Greenland Sea

Hydrography:

- intermediate variability probably driven by variability in the NAC
- deep variability caused by convection and import of other deep water masses



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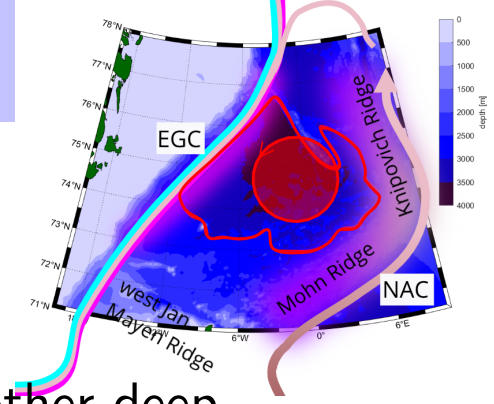

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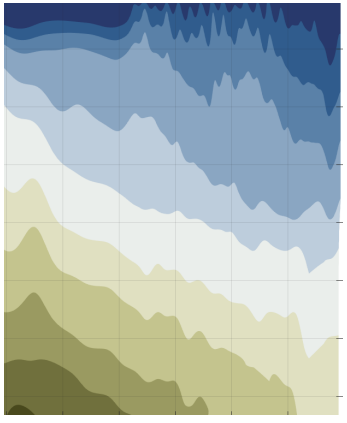
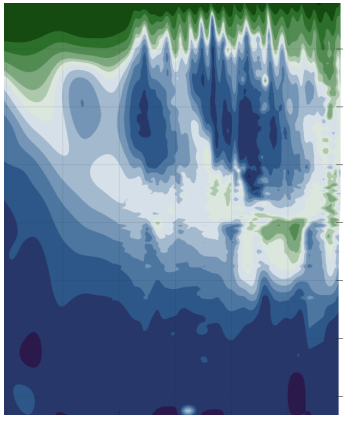
- ↑ increase of temperature and salinity
  ↓ decrease in density
- formation of stratified layer separates intermediate from deep ocean





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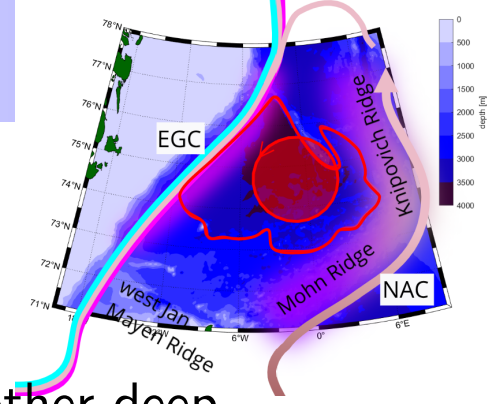

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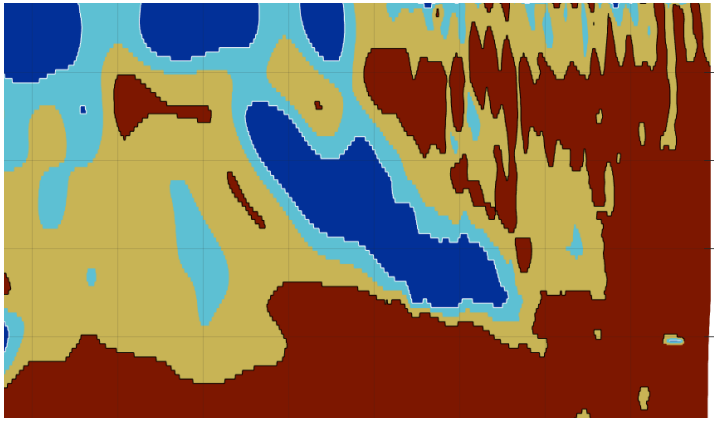

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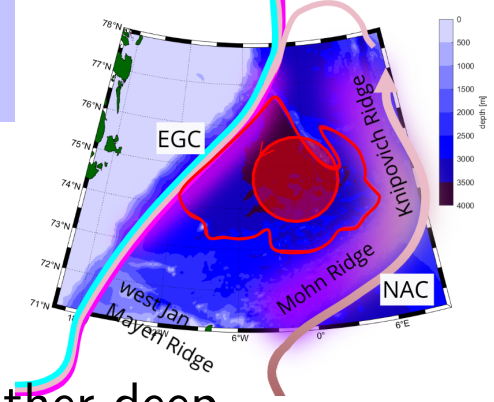

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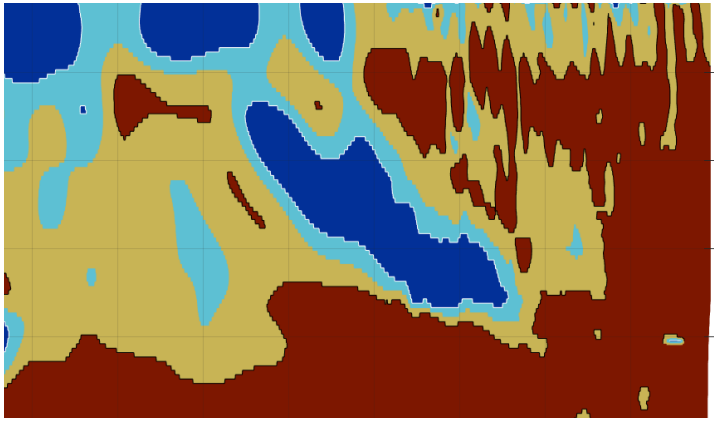
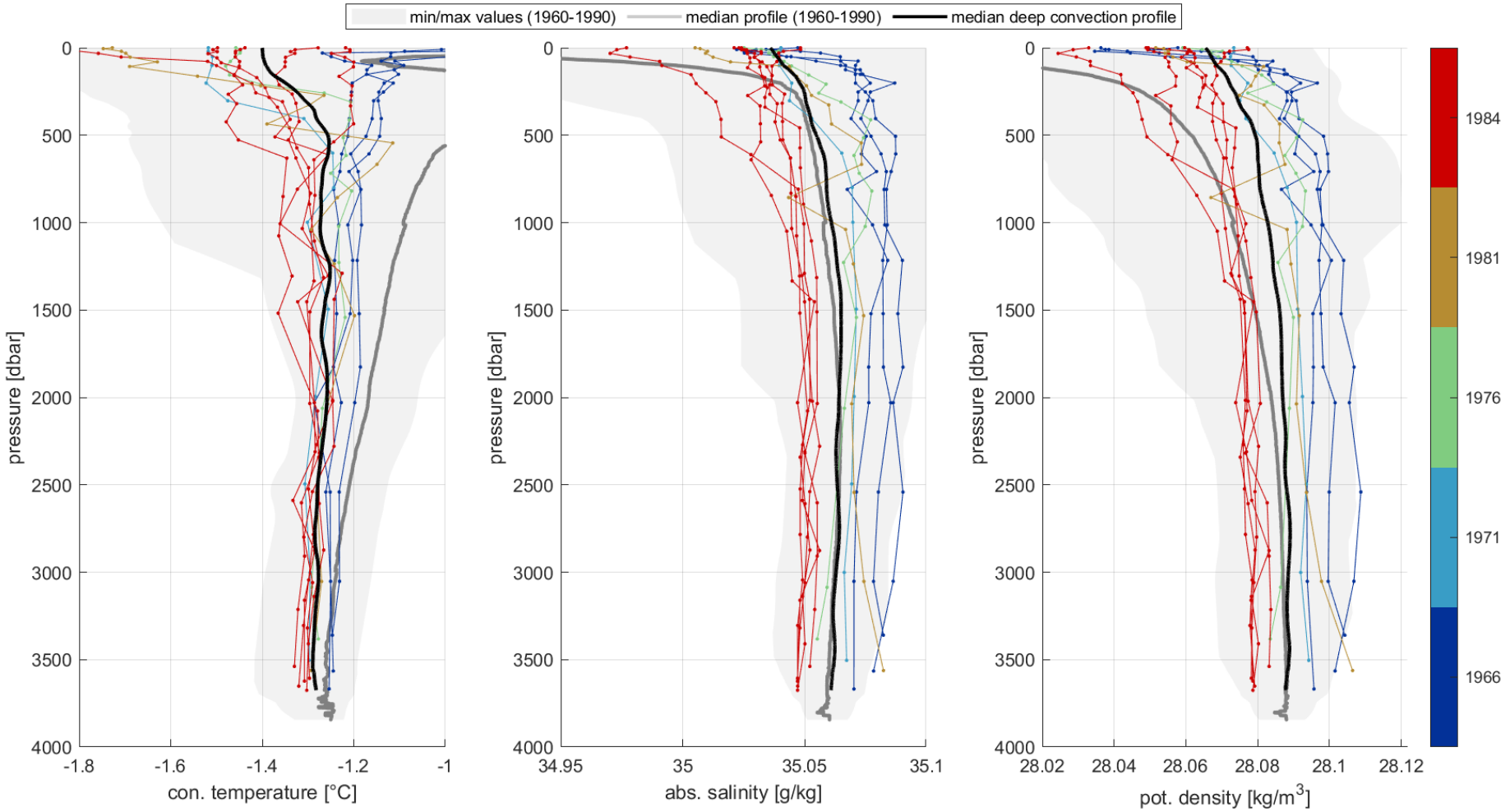


Convection:

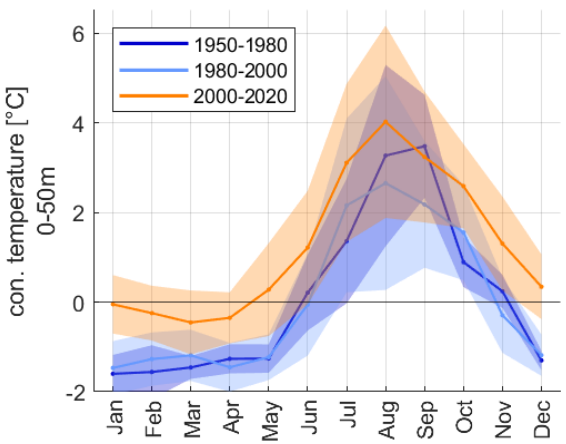
- deep convection until 1985
- intermediate mixed layer depth increased during formation of GSAIW
- since the early 2010s even the intermediate convection became shallower

deep convection profiles

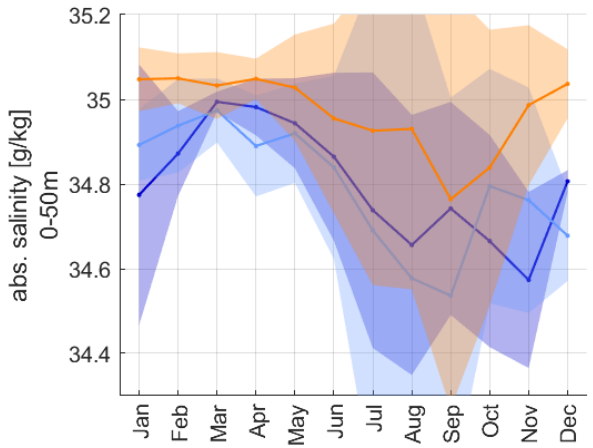


Seasonal Variability of surface properties

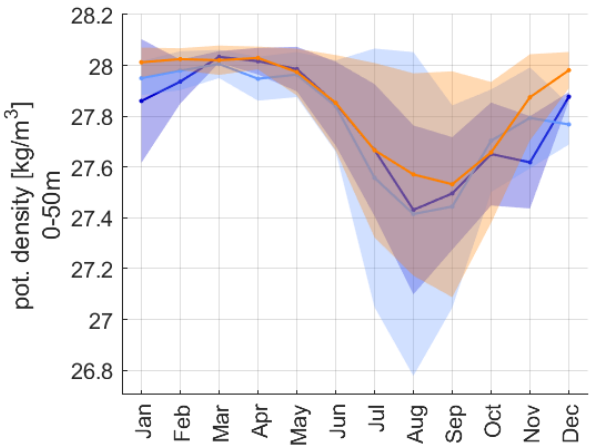
temperature



salinity

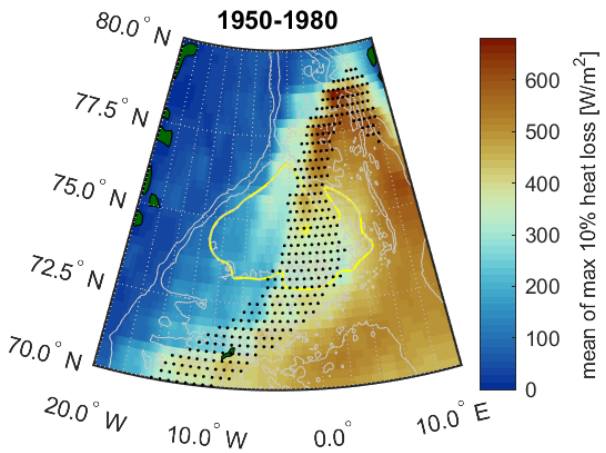


density



Typical heat fluxes and the MIZ

black points: MIZ (marginal ice zone, 15 % – 50 % ice coverage),
colour: composite mean of the max. 10 % of heat loss



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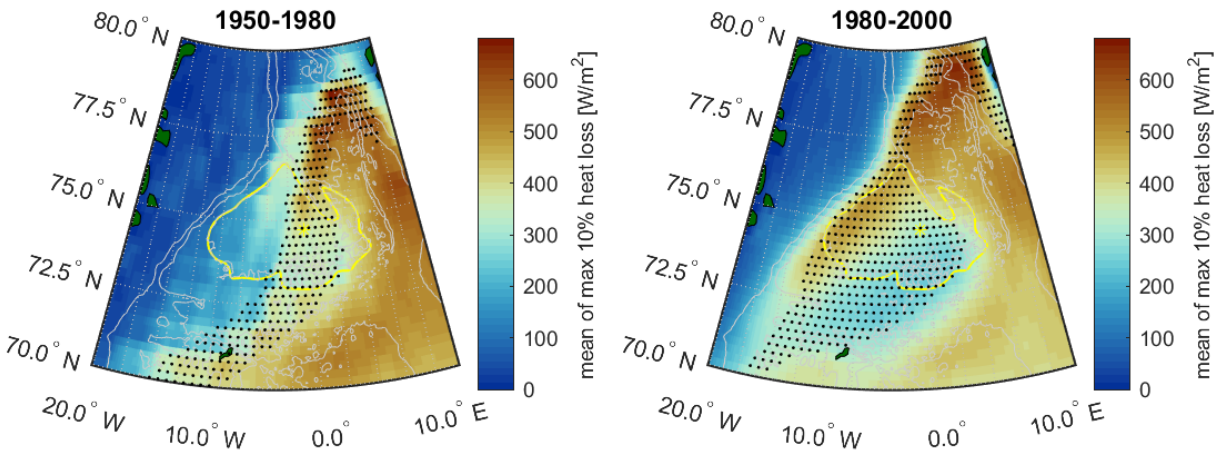

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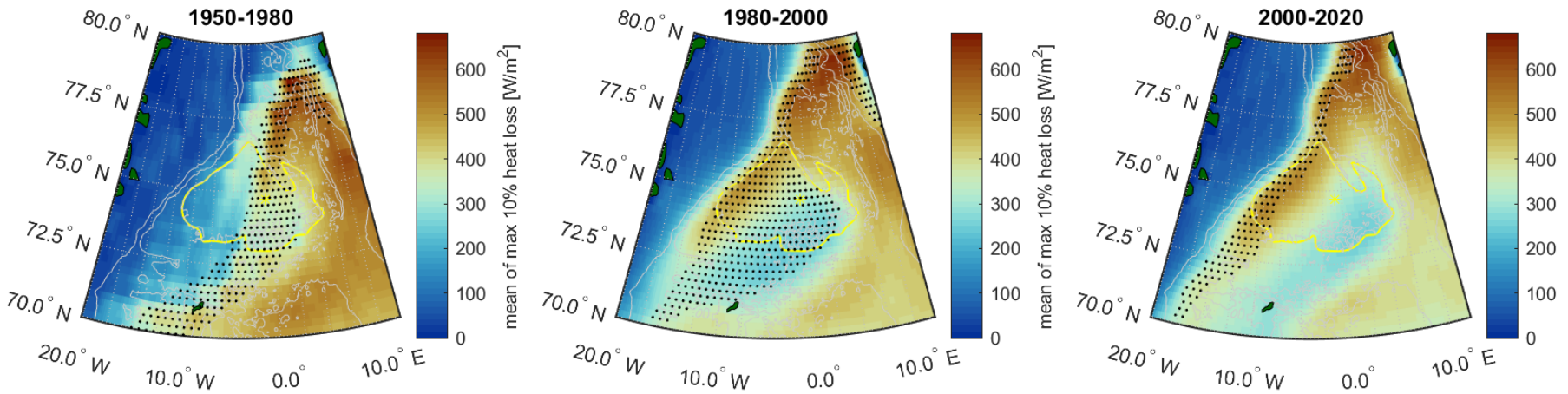
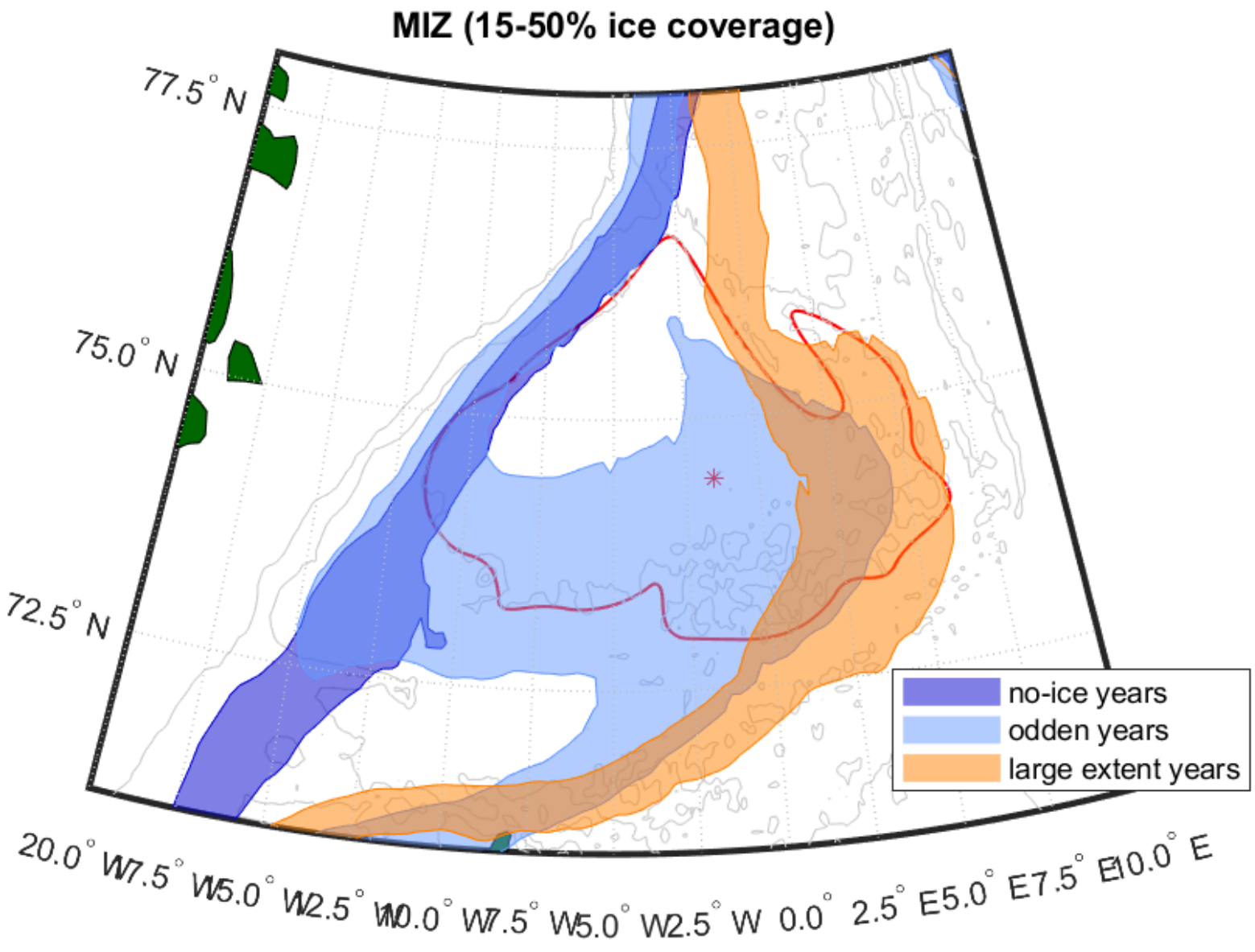
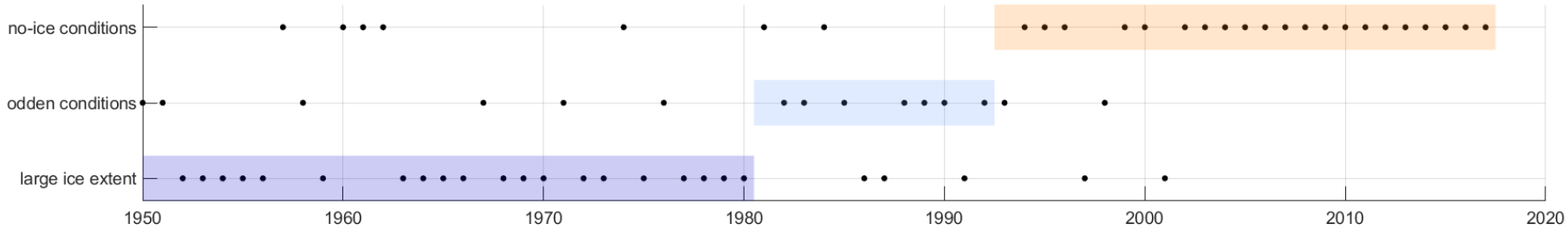
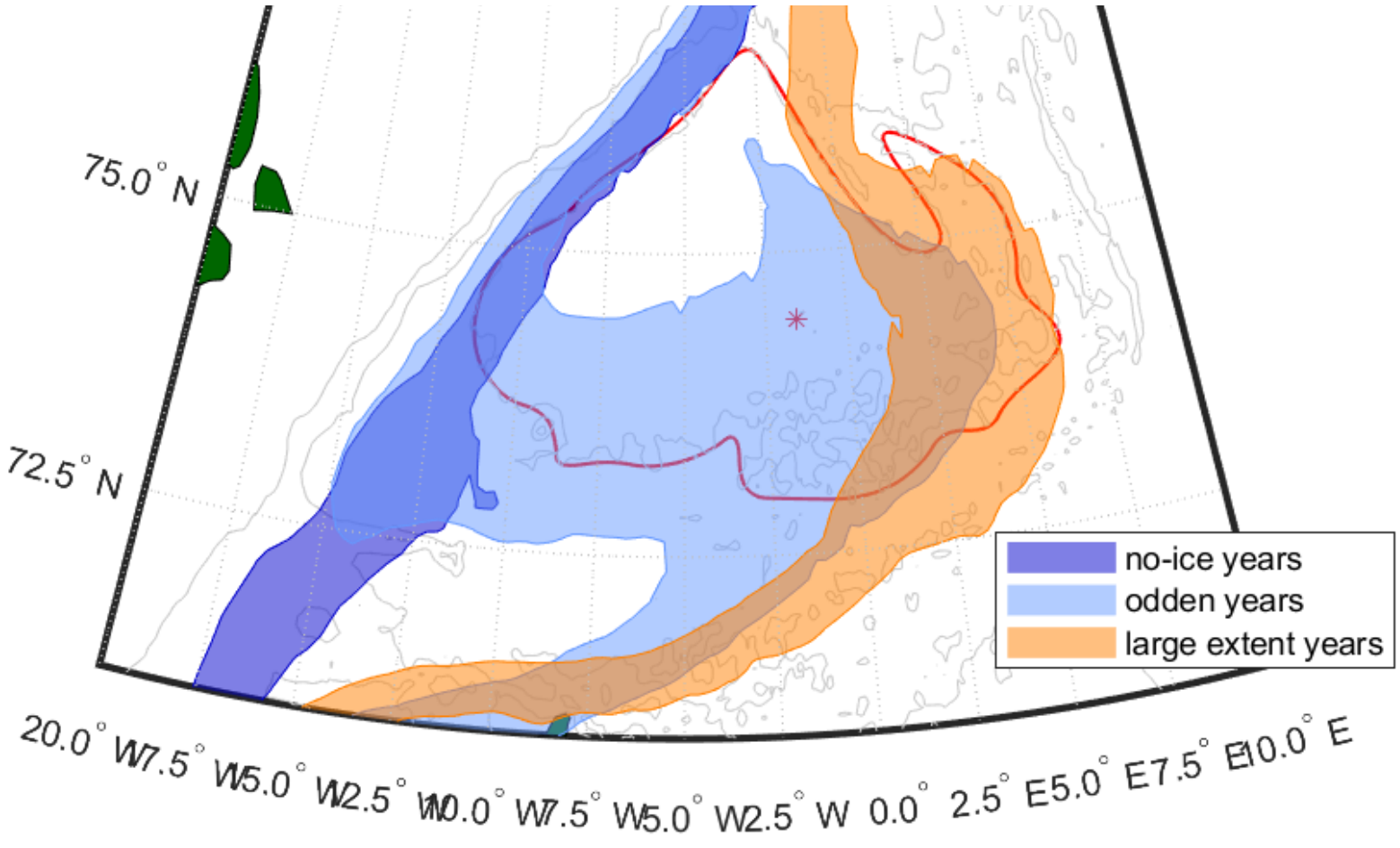


ice coverage of the central Greenland Sea



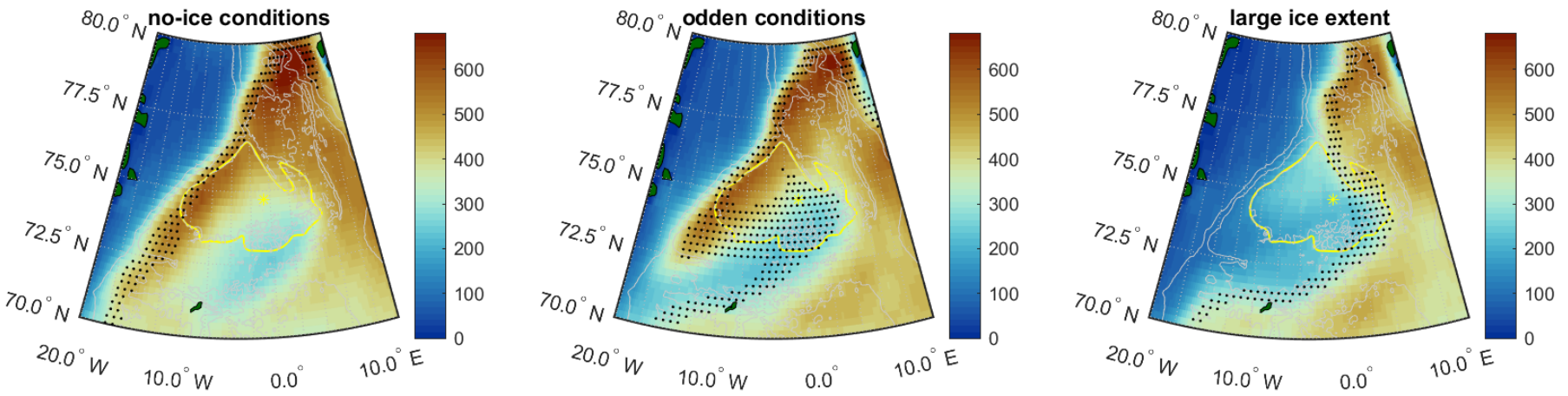
ice coverage of the central Greenland Sea



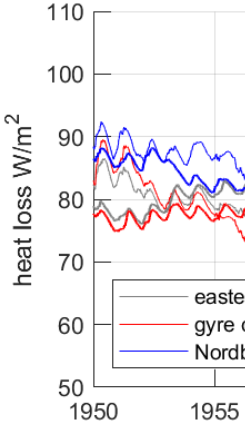


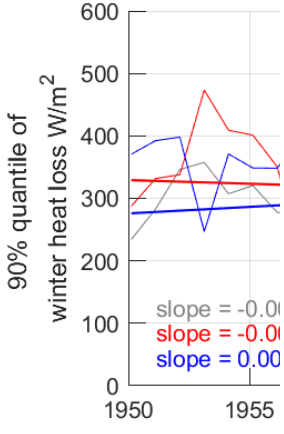
Typical heat fluxes for the different ice states

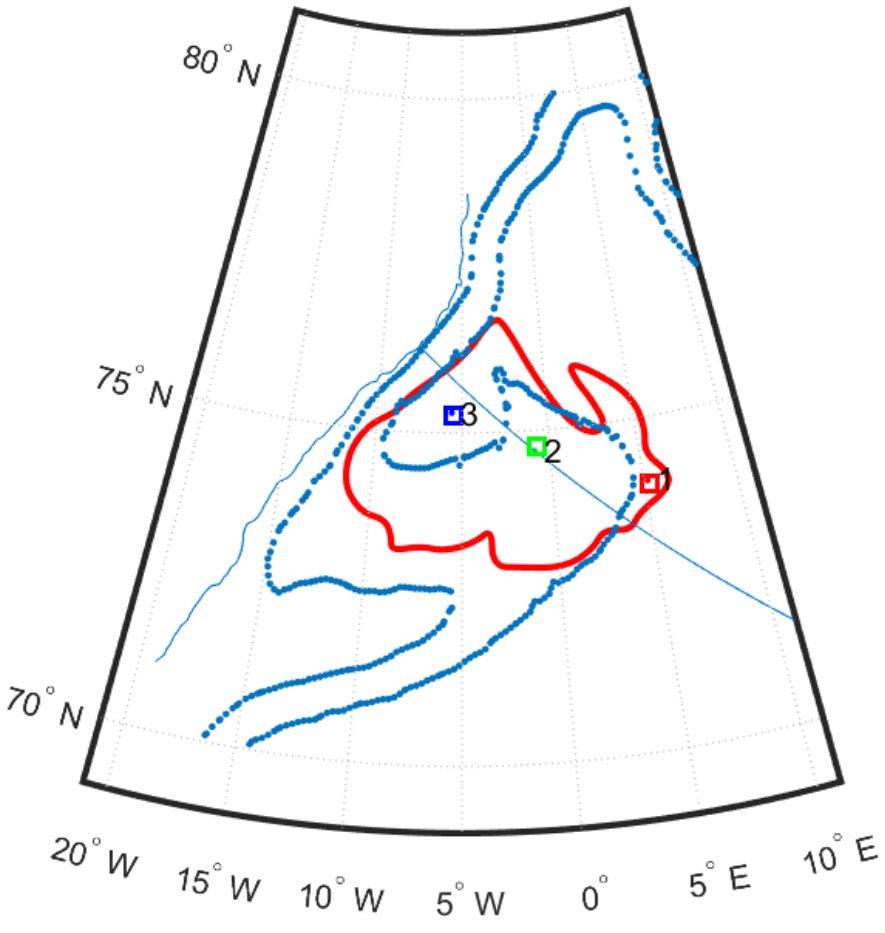
black points: MIZ (marginal ice zone, 15 % – 50 % ice coverage),
colour: composite mean of the max. 10 % of heat loss

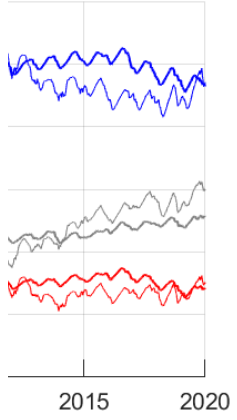


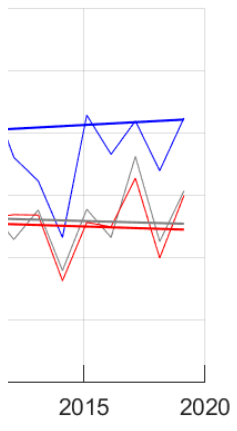
heat flux trend at different locations



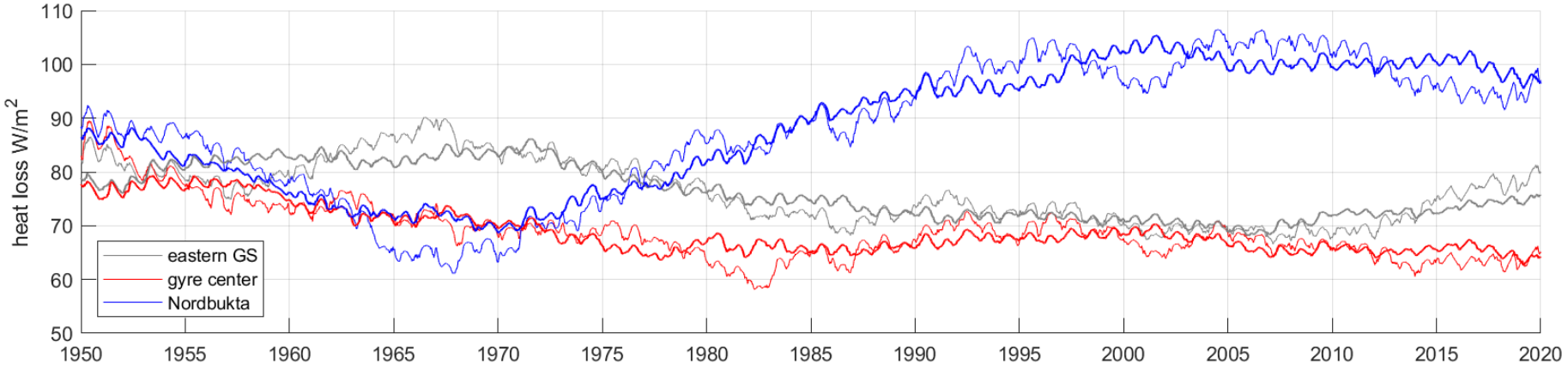


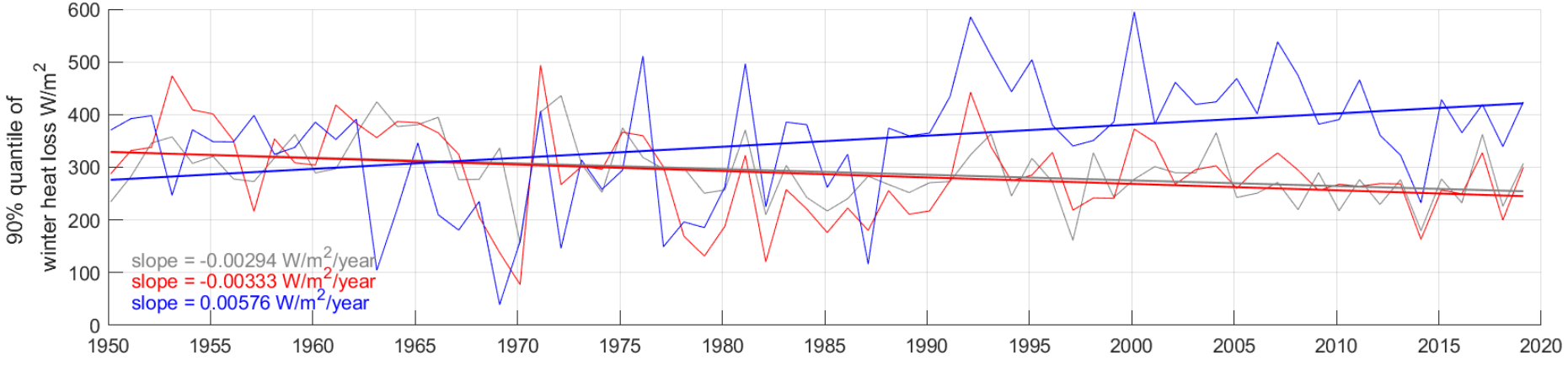




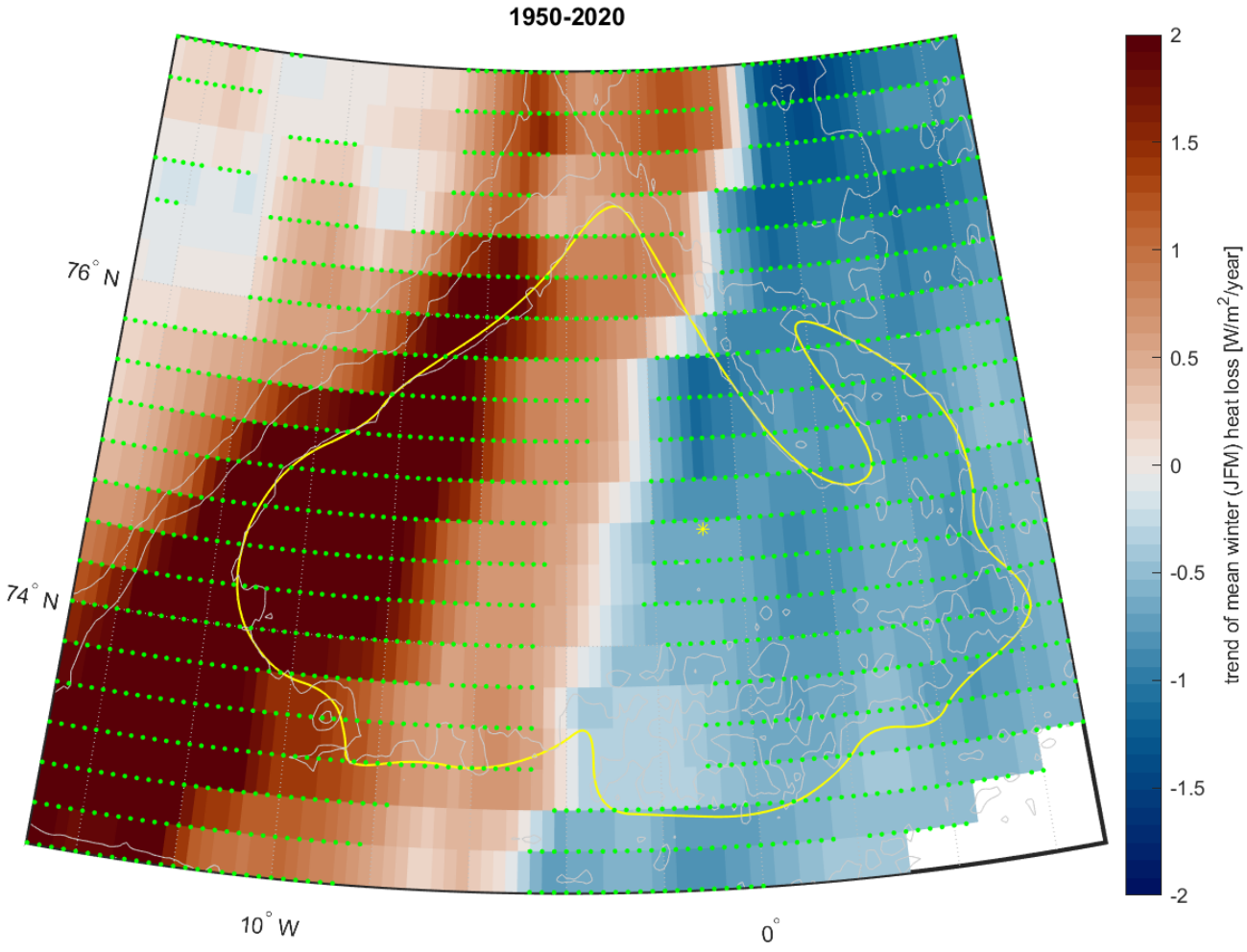


heat flux trend at different locations

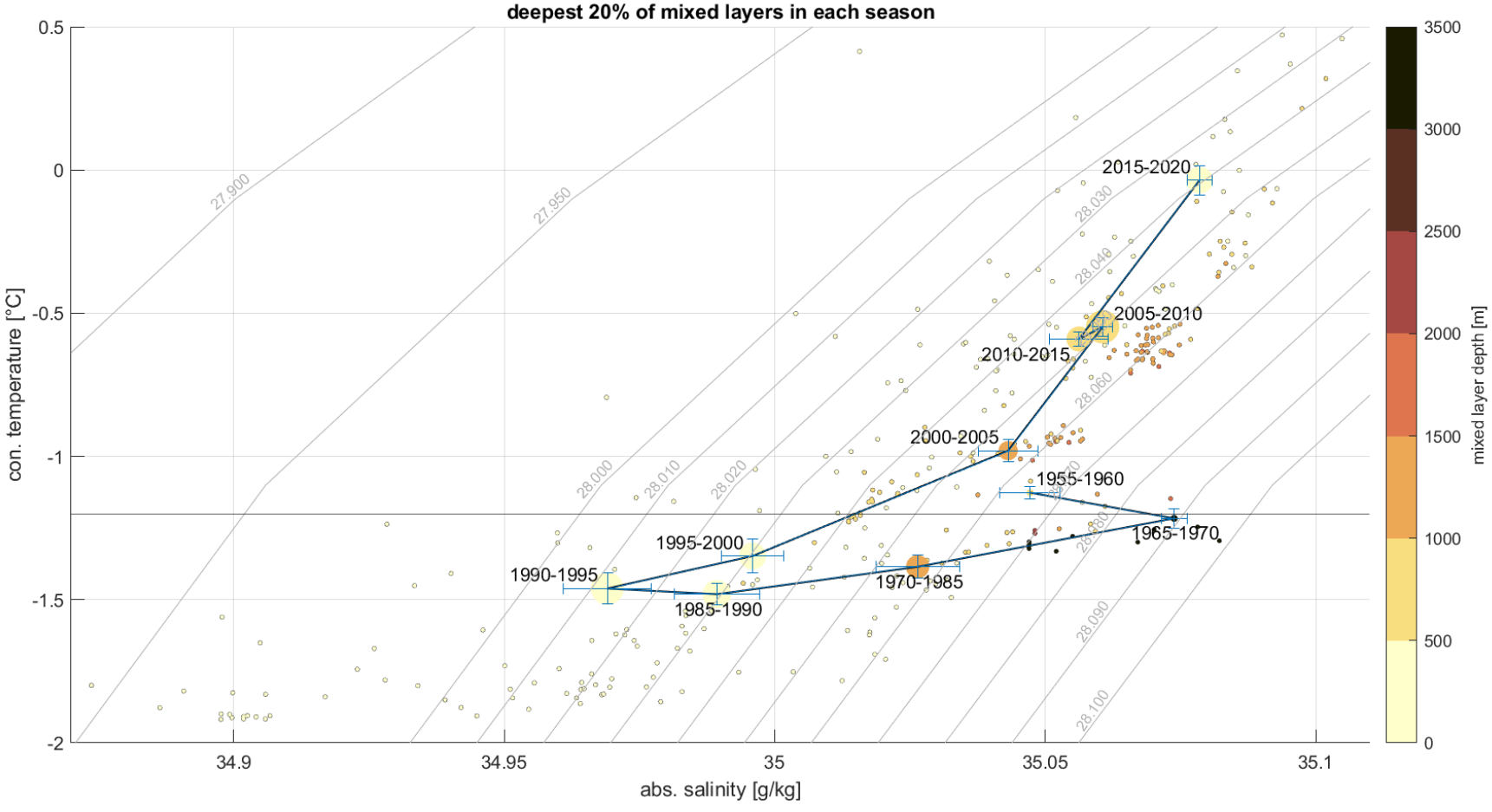




heat flux trend



Mixed Layer properties



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