The changing Greenland sea – From convection to stratification

Anne S. Haupt, anhau2837@uib.no
Polar oceanography, geof 338

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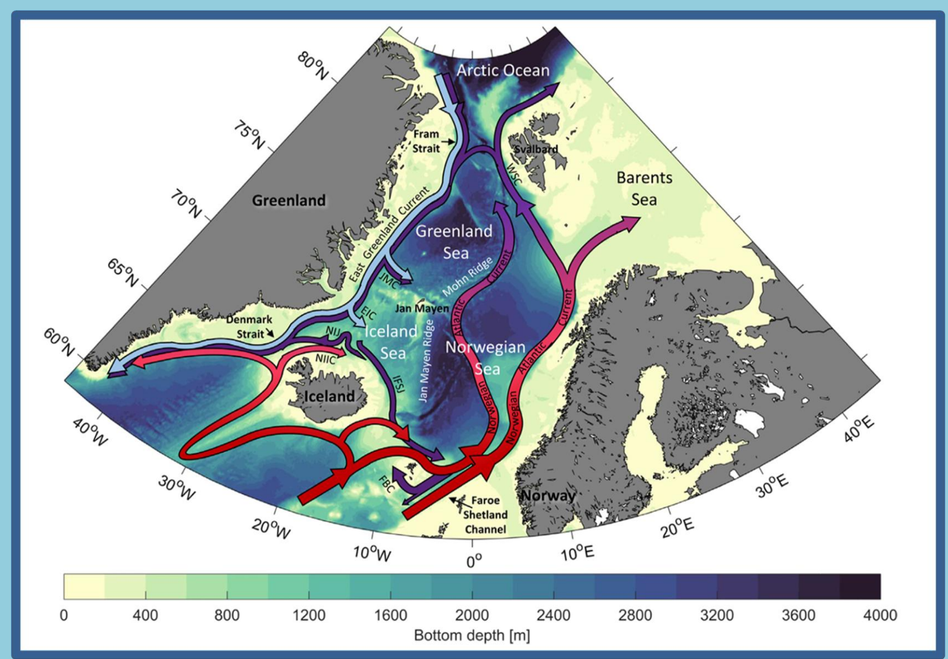
The Greenland sea

The Greenland Sea plays a critical role in the Atlantic Meridional Overturning Circulation (AMOC) by forming dense deep water through wintertime convection.

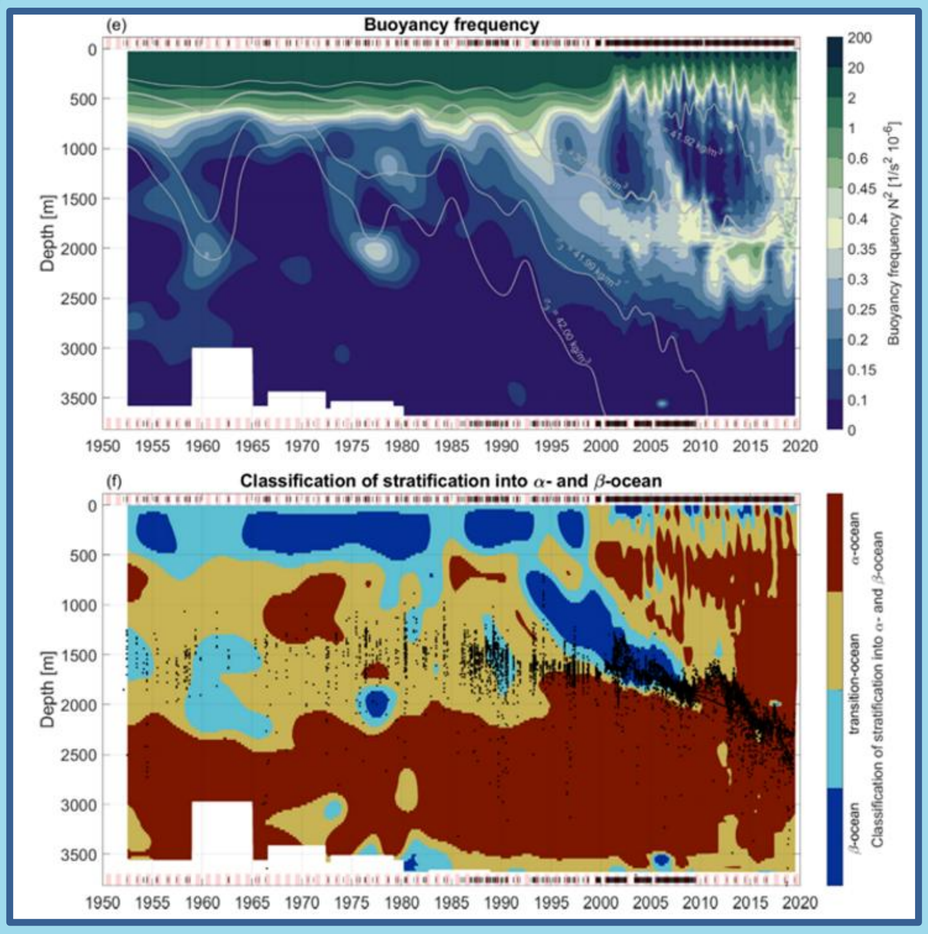
- Major site of deep-water formation, with the densest overflow waters to the Atlantic
- Supports the lower branch of the AMOC



Schematic of circulation in the Nordic Seas. (Brakstad et al)

Dense water formation

- In winter, sea ice forms and expels salt (brine rejection).
- This makes the surface water colder and saltier, increasing its density.
- Dense water over lighter water creates an unstable stratification.
- The water column overturns, triggering convection.
- Dense water sinks, driving vertical mixing and deep-water formation.

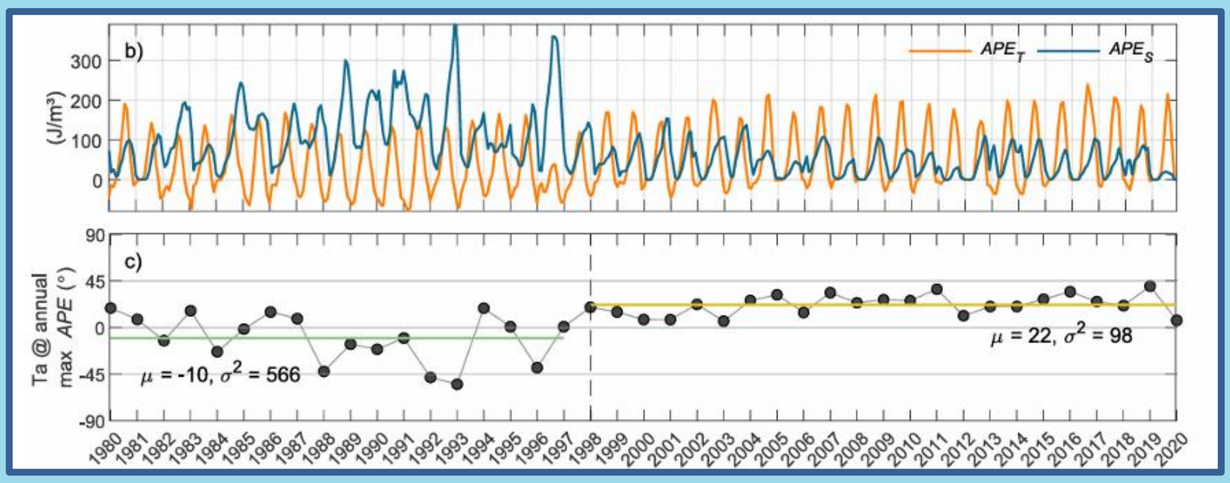


Buoyancy frequency and classification of stratification over a period of 70 years in the Greenland sea. Strehl et al (2024)

Changes over time

The Greenland Sea has experienced a significant shift from deep convection to a more stratified thermal ocean state. Increased freshwater input has led to a more stable water column, reducing convection and shifting the ocean from a haline stratified (β) ocean to a thermal stratified (α) ocean.

α-ocean dominating — Shallow convection — N^2 ↑ Stronger stratification — ! Shift in 1998



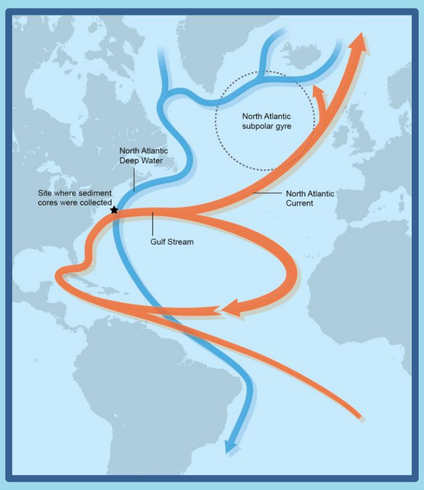
Time series of thermal (APE_T) and haline (APE_S) contributions and turner angle at annual maximum stratification (APE). Gjelstrup and Stedmon (2024)

AMOC

Reduced convection in the Greenland Sea contributes to less dense water formation, weakening the lower branch of the AMOC.

Effects of weakened AMOC:

- Change global heat distribution
- Slow down in uptake of atmospheric carbon
- Disruption of regional climate
- Feedbacks -> limit future convection & increase stratification.



AMOC & the subpolar gyre. Praetorius (2018)

Conclusion & Future perspective

- The Greenland Sea has transitioned from a deep convection site to a stratified basin forming intermediate waters.
- Long-term weakening of convection could permanently change the deep-water formation.
- Future changes in sea ice cover, freshwater input, and atmospheric forcing will be critical in determining whether deep convection can resume.

References:
Brakstad et al (2023) Formation and Pathways of dense water in the Nordic seas based on a regional inversion, https://doi.org/10.1016/j.pocean.2023.102981
Strehl et al (2024) A 70-year perspective on water –ass transformation in the Greenland sea, https://doi.org/10.1016/j.pocean.2024.103304
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Summer K. Praetorius (2018, North Atlantic circulation slows down, doi: https://doi.org/10.1038/d41586-018-04086-4

UNIVERSITY OF BERGEN
Faculty of Science and Technology