



HAL
open science

Large-scale destratification in the Eurasian Basin thermocline and consequences on the Atlantic Water shoaling

François Challet, Christophe Herbaut, G. Meneghello, Marie-Noëlle Houssais

► **To cite this version:**

François Challet, Christophe Herbaut, G. Meneghello, Marie-Noëlle Houssais. Large-scale destratification in the Eurasian Basin thermocline and consequences on the Atlantic Water shoaling. Gordon Research Conference on Ocean Mixing, Jun 2024, South Hadley MA, United States. hal-04793431

HAL Id: hal-04793431

<https://hal.science/hal-04793431v1>

Submitted on 20 Nov 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

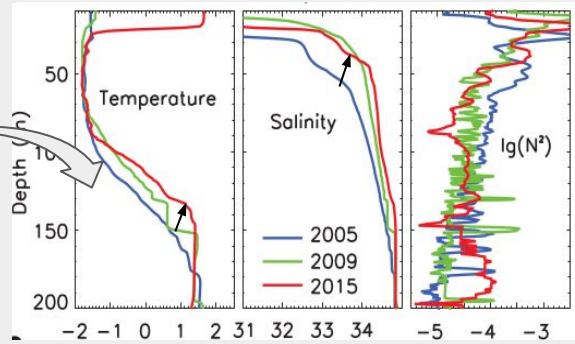
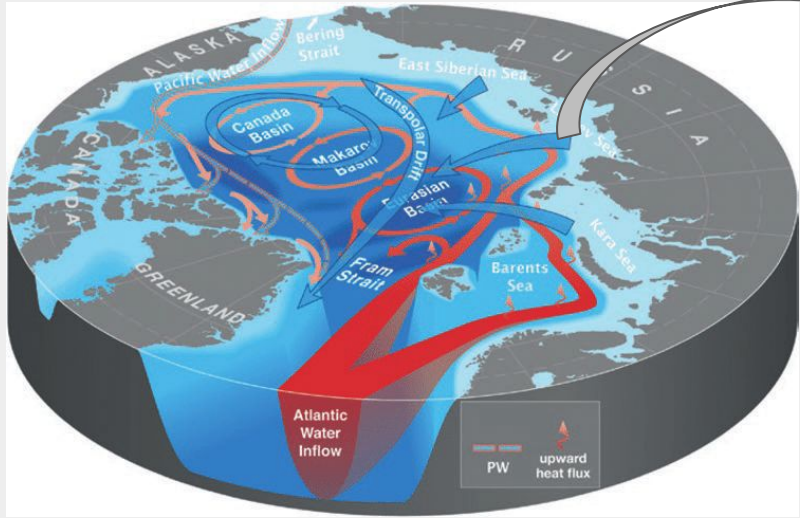
F. Challet¹, C. Herbaut¹, G. Meneghello² and M.-N. Houssais¹

¹LOCEAN, Sorbonne Université, CNRS, IRD, MNHN, Paris, France

²LMD, Ecole Normale Supérieure, Paris, France

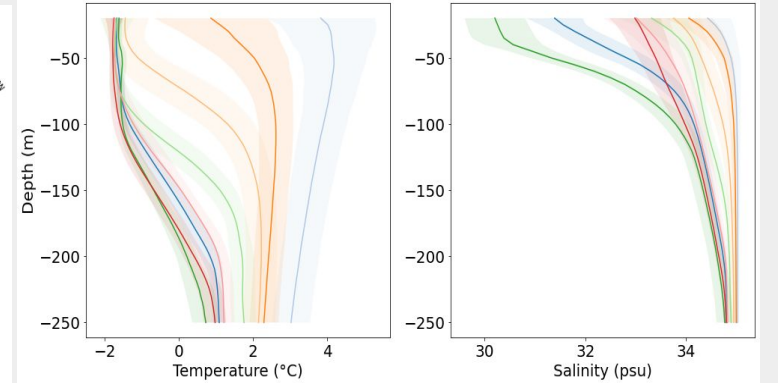
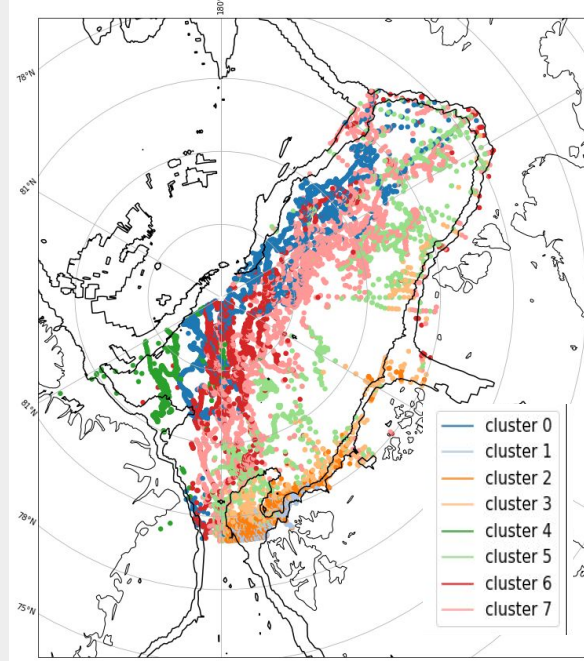
Context: an uncertain future for the Eurasian Basin (EB) stratification

CTD data from the Eastern Eurasian Basin (EEB - Polyakov et al., 2017)

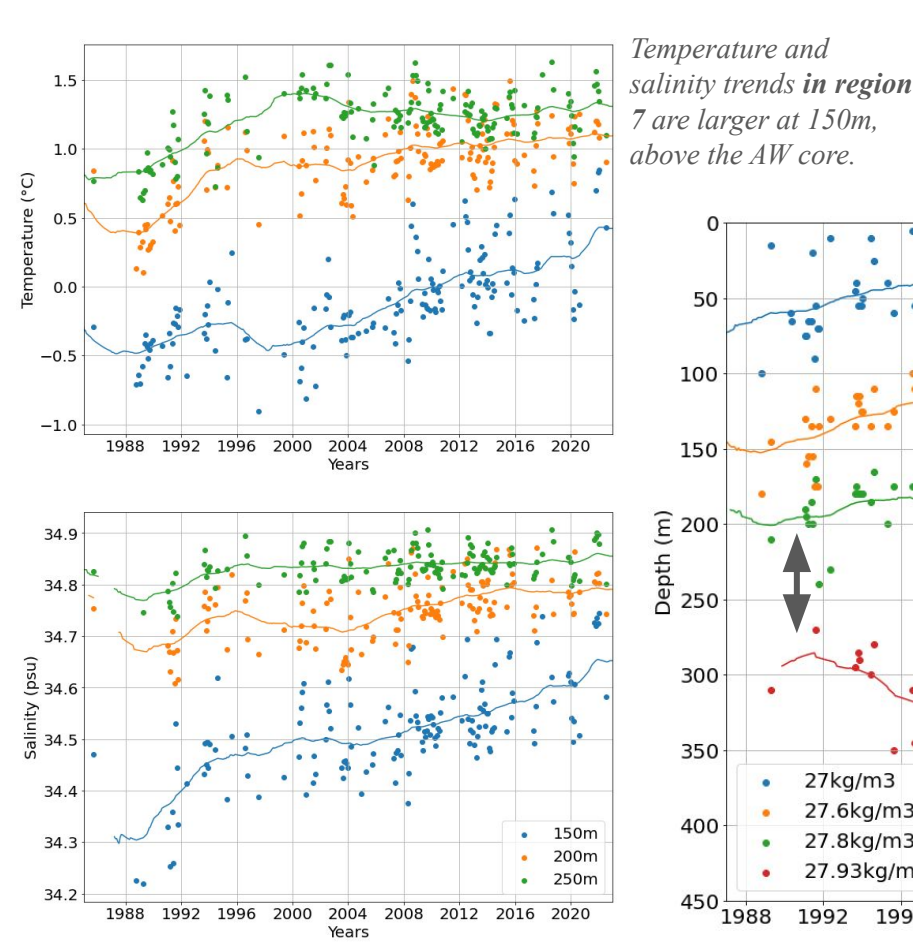


- ❖ Halocline destratification and Atlantic Water (AW) shoaling have been observed locally in the EEB.
- ❖ This might slow down sea ice formation during the cold season.
- ❖ No model agreement on the large-scale trends in the basin (Mulwijk et al., 2023).

Method: a clustering algorithm to define regions with coherent profiles

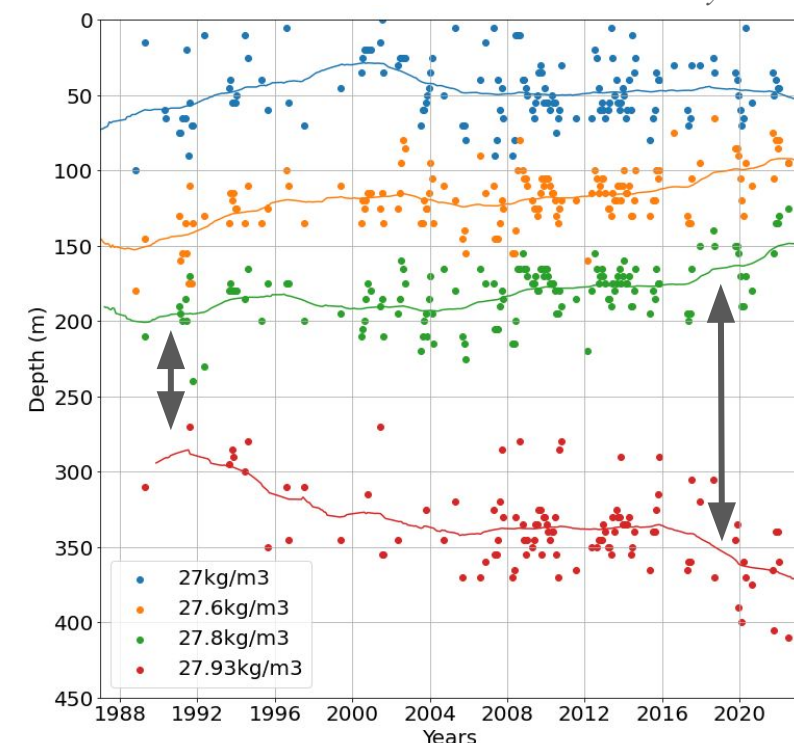


- ❖ Few temperature and salinity time series are available due to the lack of continuous measurements.
- ❖ Clustering allows to best regroup and compare data from different locations.
- ❖ Realistic time series are reconstructed in each region.



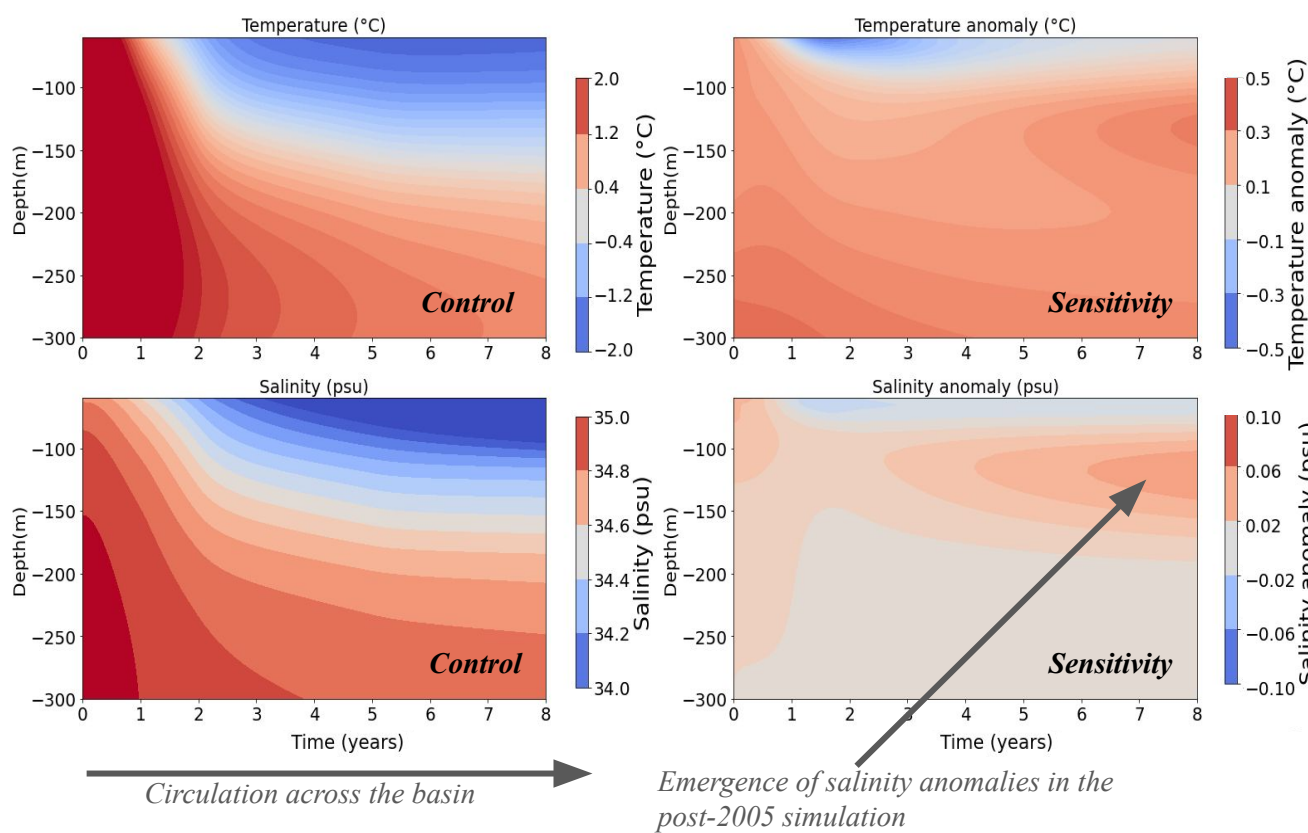
Results: AW shoaling and destratification

Vertical migration of isopycnals in region 7: AW stratification decreased by 50%.



- ❖ Positive temperature and salinity trends over the period 1986-2022 are visible in the thermocline, above the AW core.
- ❖ They are associated with an upward migration of isopycnals in the thermocline up to the halocline base.
- ❖ Isopycnals below the AW core are moving down.
- ❖ This induces a strong destratification in the thermocline and the AW layer (-50% in 40 years).
- ❖ These results are obtained in most regions.

Analysis: coupling between the salinity and stratification anomalies



- ❖ A 1D-model simulates the vertical diffusion of a T-S anomaly along the journey of a water column across the EB (from cluster 1 to cluster 0).
- ❖ Restoring terms are diagnosed from a control simulation initialized with pre-2005 T-S conditions at the entrance of the EB.

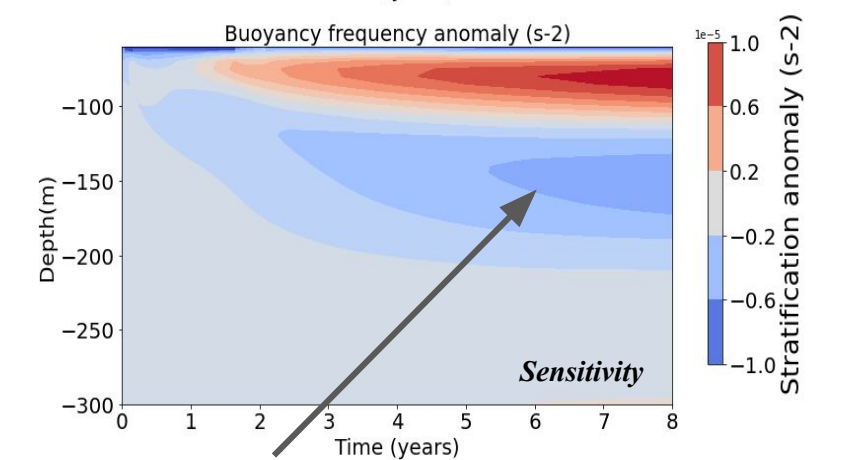
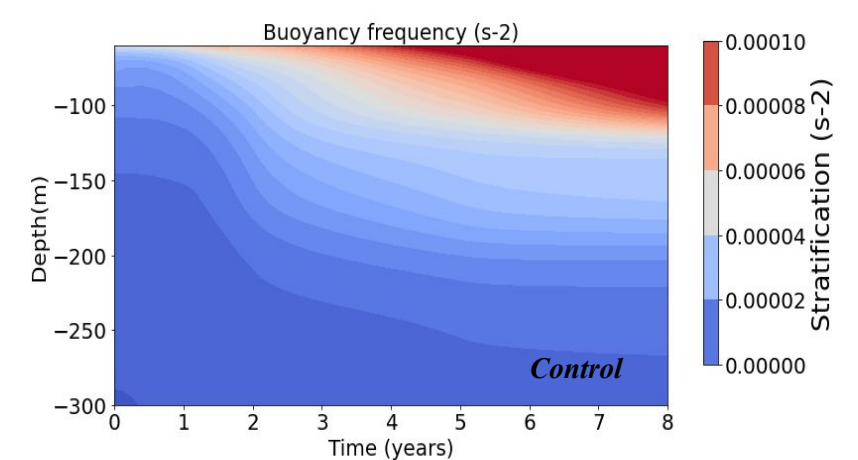
$$\frac{DT}{Dt} = \Gamma \frac{\partial}{\partial z} \left(\frac{\epsilon}{N^2} \frac{\partial T}{\partial z} \right) - \alpha(T - T_{ref})$$

$$\frac{DS}{Dt} = \Gamma \frac{\partial}{\partial z} \left(\frac{\epsilon}{N^2} \frac{\partial S}{\partial z} \right) - \alpha(S - S_{ref})$$

$$N^2 = - \frac{g}{\rho_0} \frac{\partial \rho(S, T)}{\partial z}$$

Time-dependent restoring profiles (stratification changes inside the EB)

- ❖ The sensitivity experiment is initialized with post-2005 average profiles at the entrance of the EB. This post-2005 simulation replicates qualitatively the observed structure of T-S anomalies and destratification further in the EB.



Amplification of an initial destratification in the post-2005 simulation

Conclusions:

- ❖ A significant destratification trend ($p < 0.05$) was found in the thermocline and upper AW layer in most of the EB over the past four decades.
- ❖ It can be explained by the coupling between the salinity and stratification profiles.
- ❖ This coupling could have amplified a weaker initial stratification at the Fram Strait after 2005.
- ❖ The impact of these trends on the heat fluxes to the surface to be further investigated.

References:

Carmack, E., and Coauthors, 2015: Toward Quantifying the Increasing Role of Oceanic Heat in Sea Ice Loss in the New Arctic. *Bull. Amer. Meteor. Soc.*, **96**, 2079–2105, <https://doi.org/10.1175/BAMS-D-13-00177.1>.

Polyakov, I. V., Pnyushkov, A. V., Alkire et al. (2017). Greater role for Atlantic inflows on sea-ice loss in the Eurasian Basin of the Arctic Ocean. *Science*, 356(6335), 285–291. <https://doi.org/10.1126/science.aai8204>

Mulwijk, M., A. Nummelin, C. Heuzé, I. V. Polyakov, H. Zanowski, and L. H. Smedsrud, 2023: Divergence in Climate Model Projections of Future Arctic Atlantification. *J. Climate*, **36**, 1727–1748, <https://doi.org/10.1175/JCLI-D-22-0349.1>.