Drivers of interannual salinity variability in the Arctic Ocean

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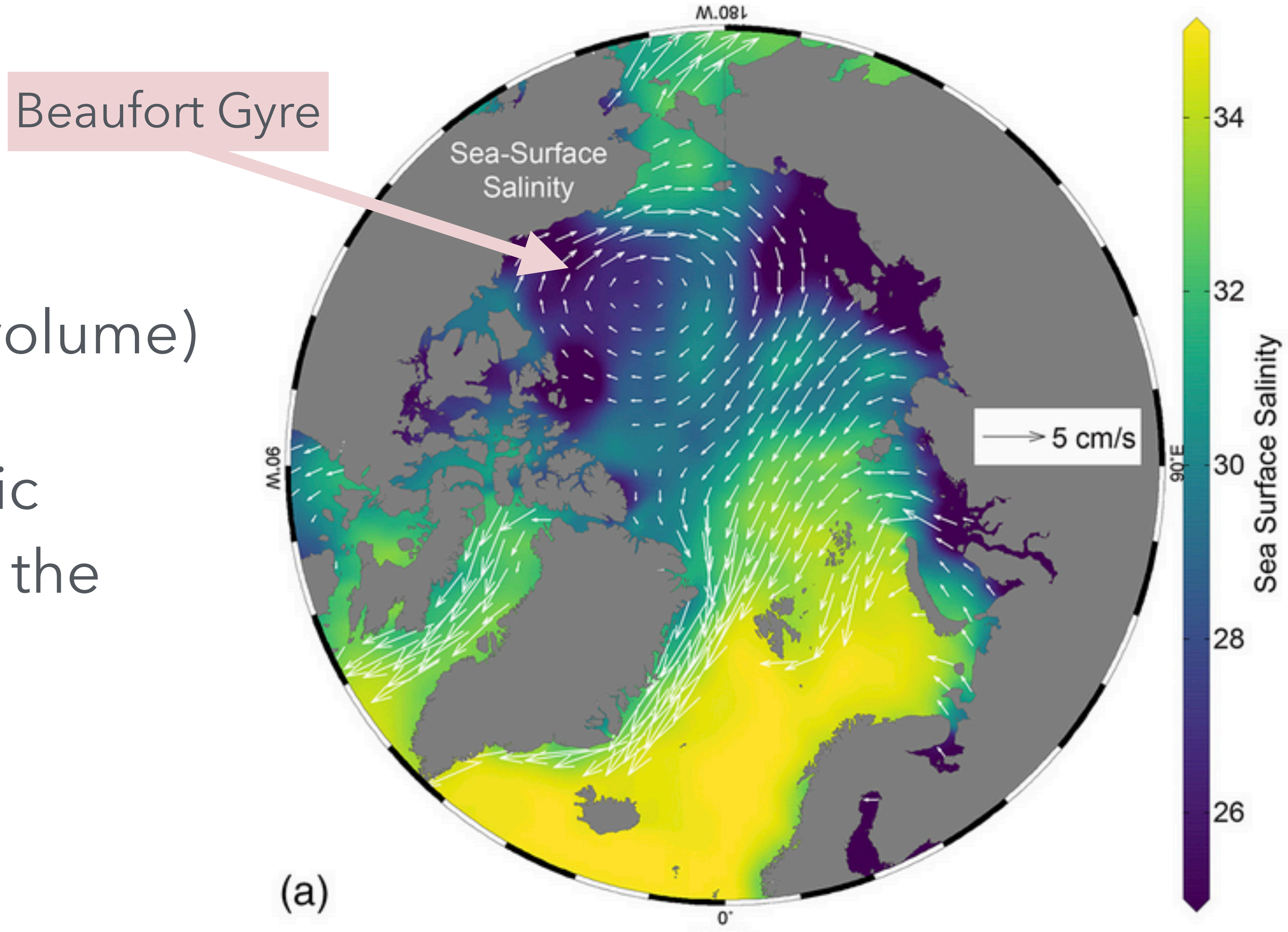
Motivation: Why studying salinity variations in the Arctic and BG ?

Stratification is controlled by salinity (« β » ocean)

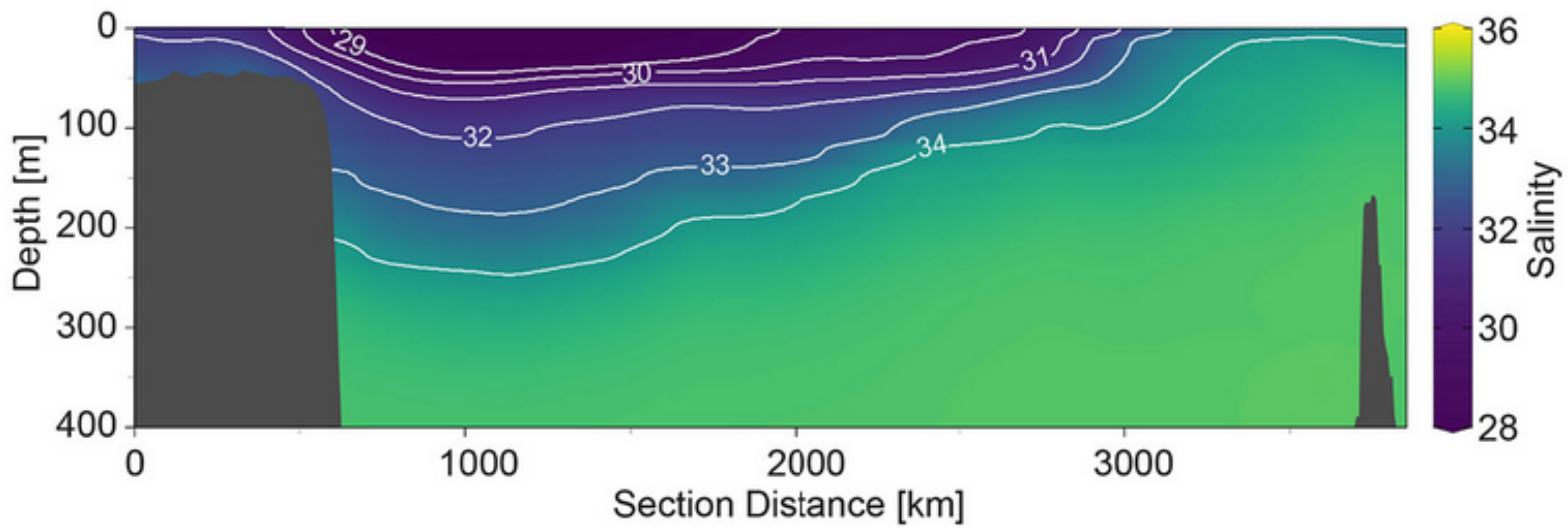
Arctic Ocean receives ~11% of all river runoff (for 1% volume)

Arctic Freshwater may be exported to the North Atlantic convection regions (e.g. Karcher et al. 2005), influence the AMOC and the global climate

Beaufort gyre= Largest freshwater reservoir in the Arctic

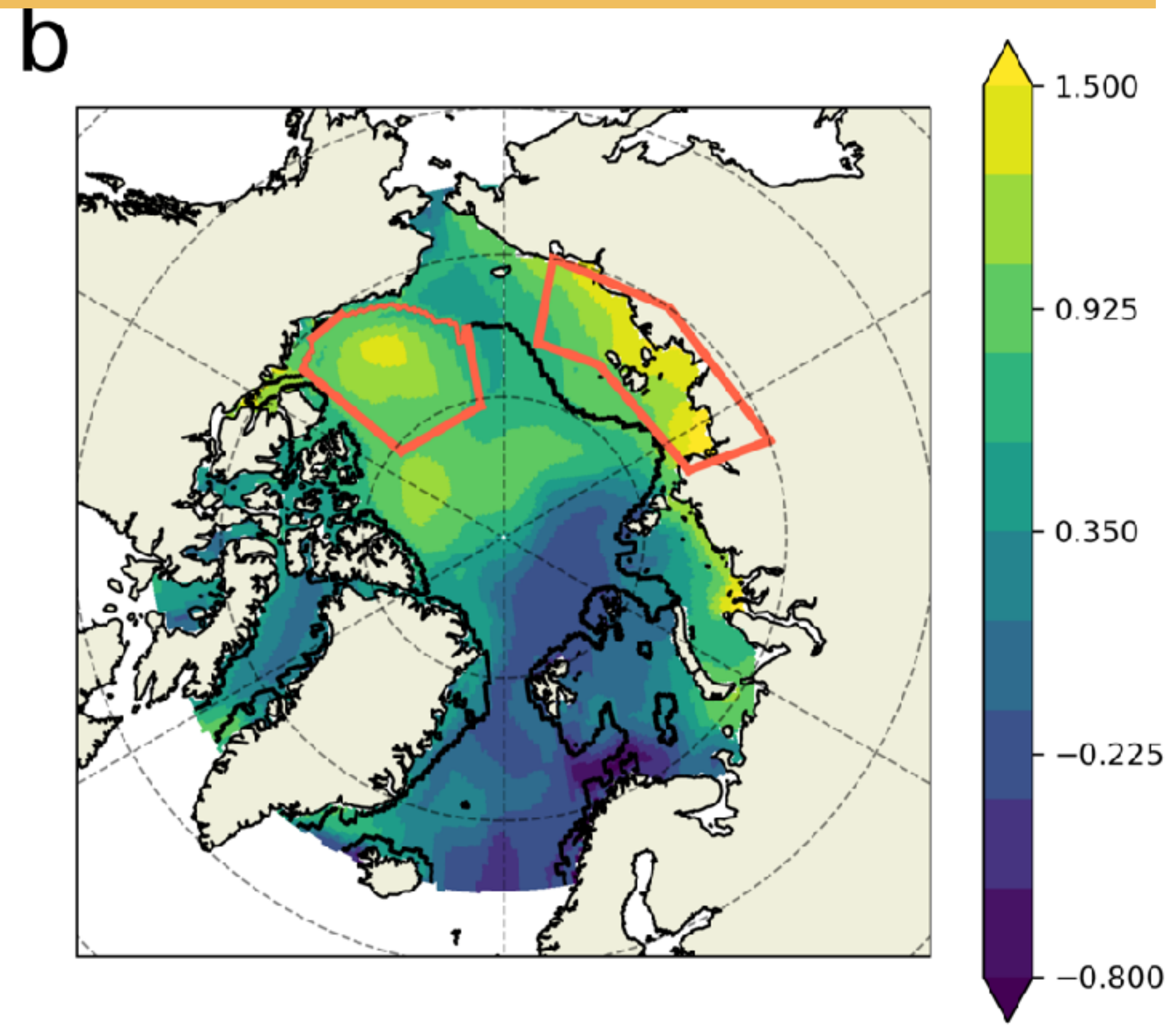


Timmermans et al. 2020



Motivation: Why studying salinity variations in the Arctic and BG ?

Time mean (1993-2014) of the vertical Integral of the interannual S variance $\mathrm{psu}^2 \cdot \mathrm{m}$ in ECCO



- BG has a strong interannual variability

- Its mechanisms have only been studied in idealised numerical models

What are the mechanisms of salinity variability in realistic configurations of the Arctic Ocean ? In the BG and in other regions ?

Method: salinity variance budget

Variance (~squared « Amplitude ») of interannual salinity variations

$$\frac{1}{2}\frac{\partial \overline{S'^2}}{\partial t} = \text{ADVECTION} + \text{DIFFUSION} + \text{FRESHWATER FLUXES}$$

Effect of oceanic circulation

Parametrized mixing

Effect of Precipitation, Evaporation

River runoff sea-ice melt/freeze

Right hand side term > 0 –> acts to increase the amplitude of salinity variations SOURCE

Right hand side term < 0 –> acts to decrease the amplitude of salinity variations SINK

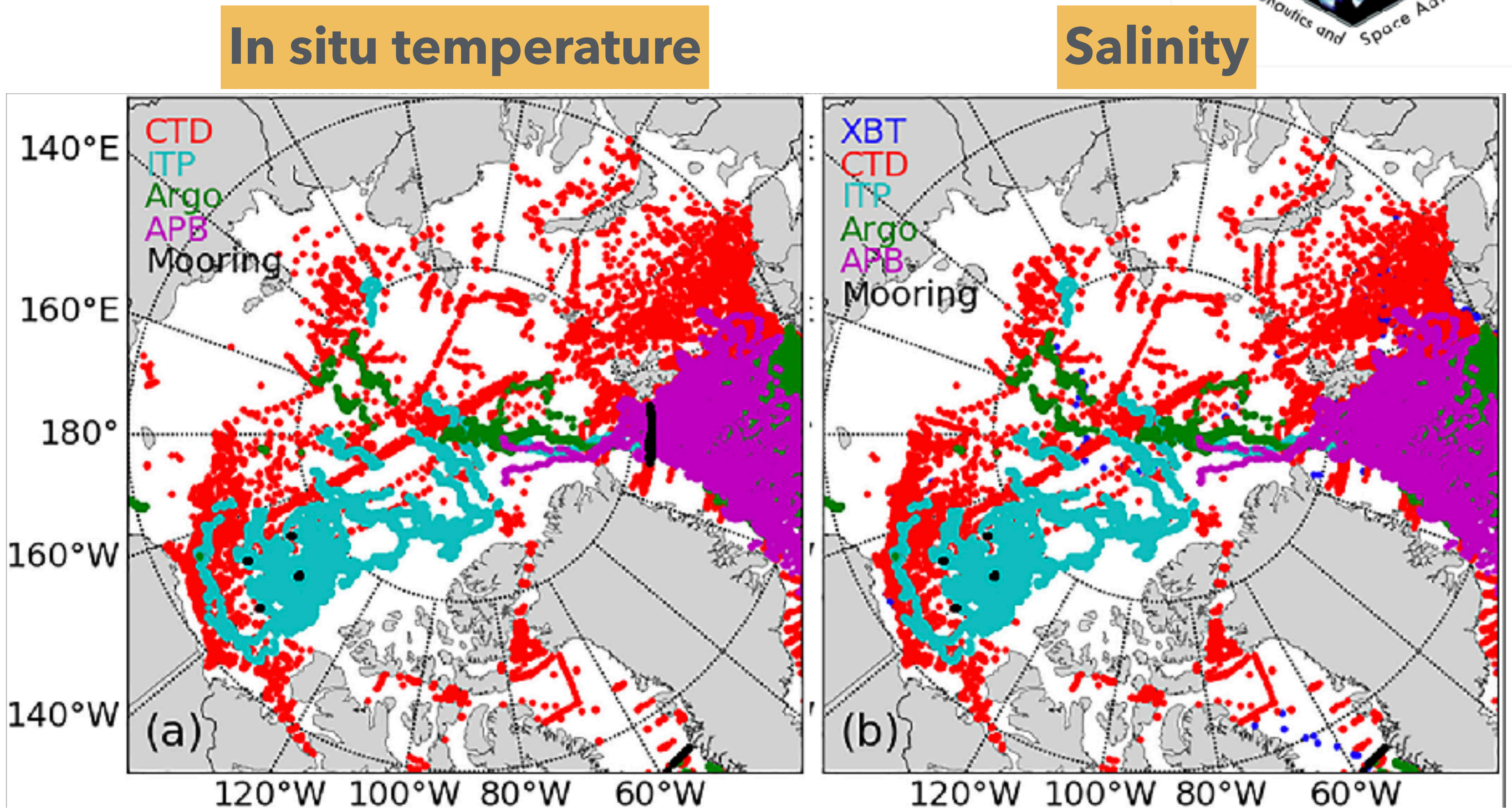
Data: ECCO v4

ECCO v4 = global ocean numerical simulation constrained by a set of available observations over the period 1993-2014

horizontal resolution ~40km at high latitudes 50 vertical levels –> mesoscale turbulence is parametrised

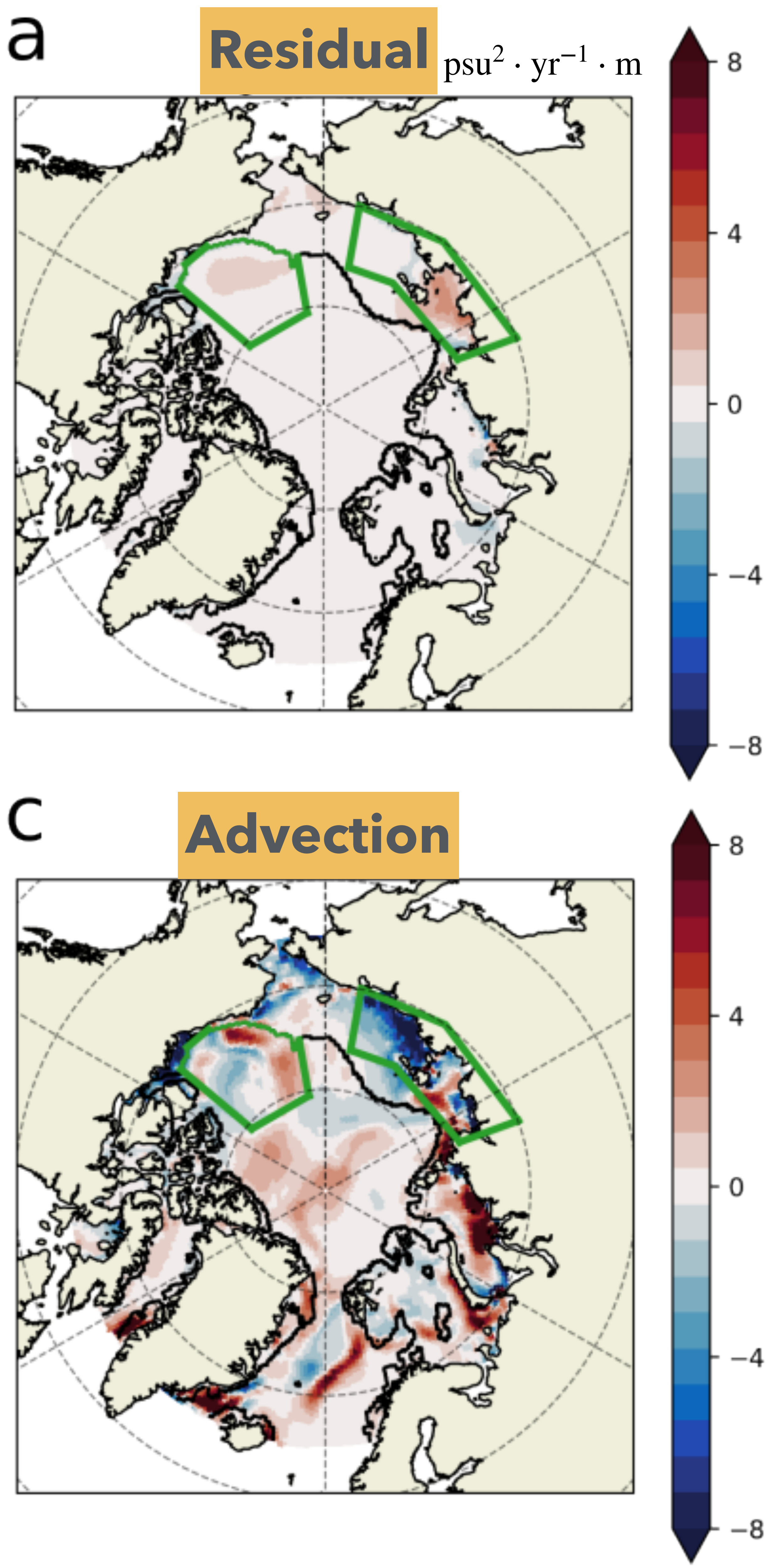
Why using ECCO ?

ECCO has no un-physical term in the salinity evolution equation –> can be used to study processes



Adapted from Fournier et al. 2020: data used to constrain ECCO-v4 in the Arctic

Results: ECCO v4



Freshwater fluxes → SOURCE

Diffusion → SINK

Advection → SINK / SOURCE

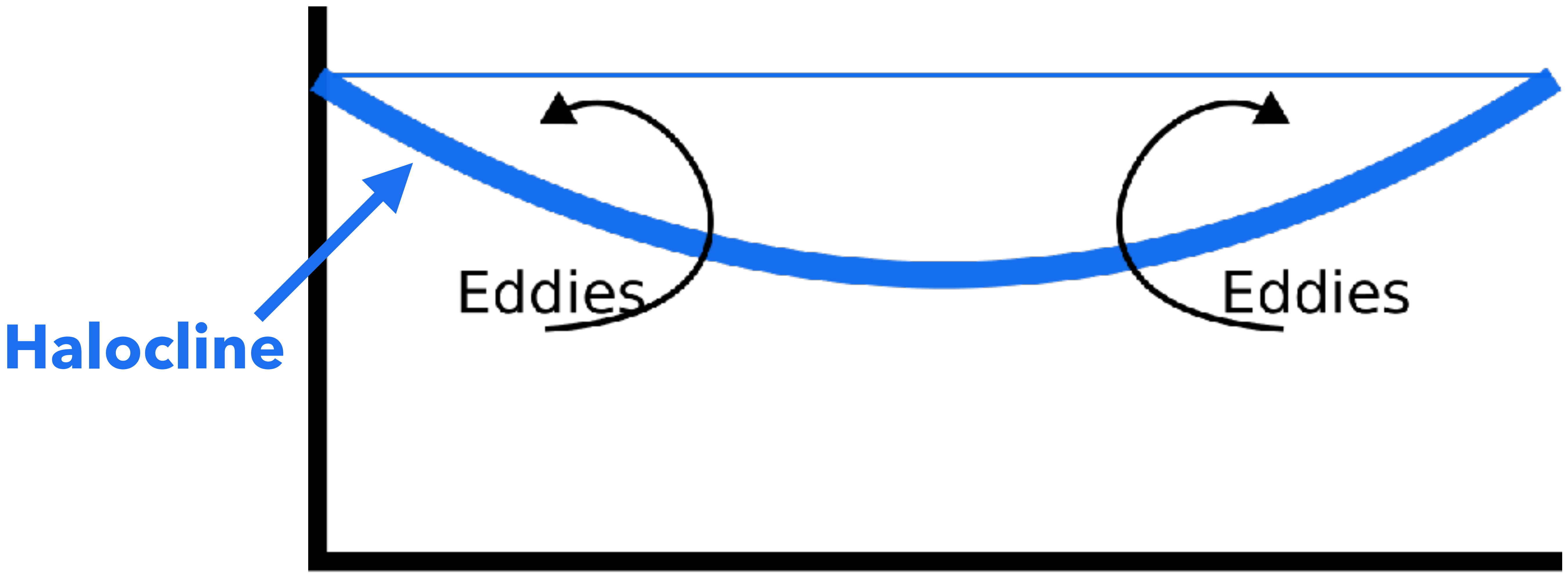
Diffusion
+
Freshwater fluxes
+
Advection
≈
0

Results: decomposition of the advective term

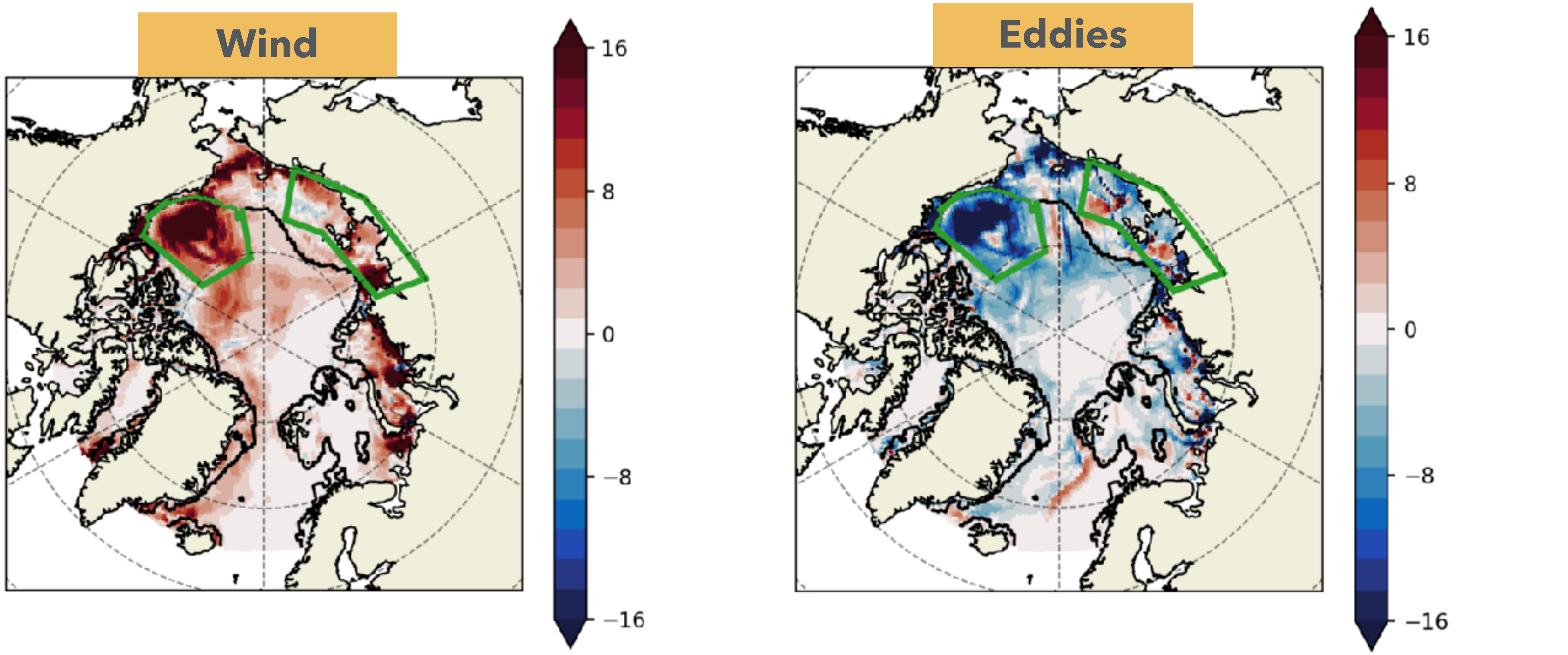
ADVECTION = WIND + EDDIES + (OTHER TERMS)

Effect of mesoscale eddies

Effect of interannual wind variations on velocities (Ekman balance) mediated by sea ice



Results: decomposition of the advective term



In the Beaufort Gyre : **WIND** + **EDDIES** ≈ 0

Results are in agreement with the mechanisms derived from idealised configurations of the Beaufort Gyre (e.g. Davis et al. 2014, Yang et al. 2016, Manucharyan & Spall 2016)

Summary

- A new methodology is introduced to investigate the mechanisms of salinity variability in the Arctic in realistic configurations

- Two regions display large inter annual salinity variability: the Beaufort Gyre and the Eastern Siberian Shelf

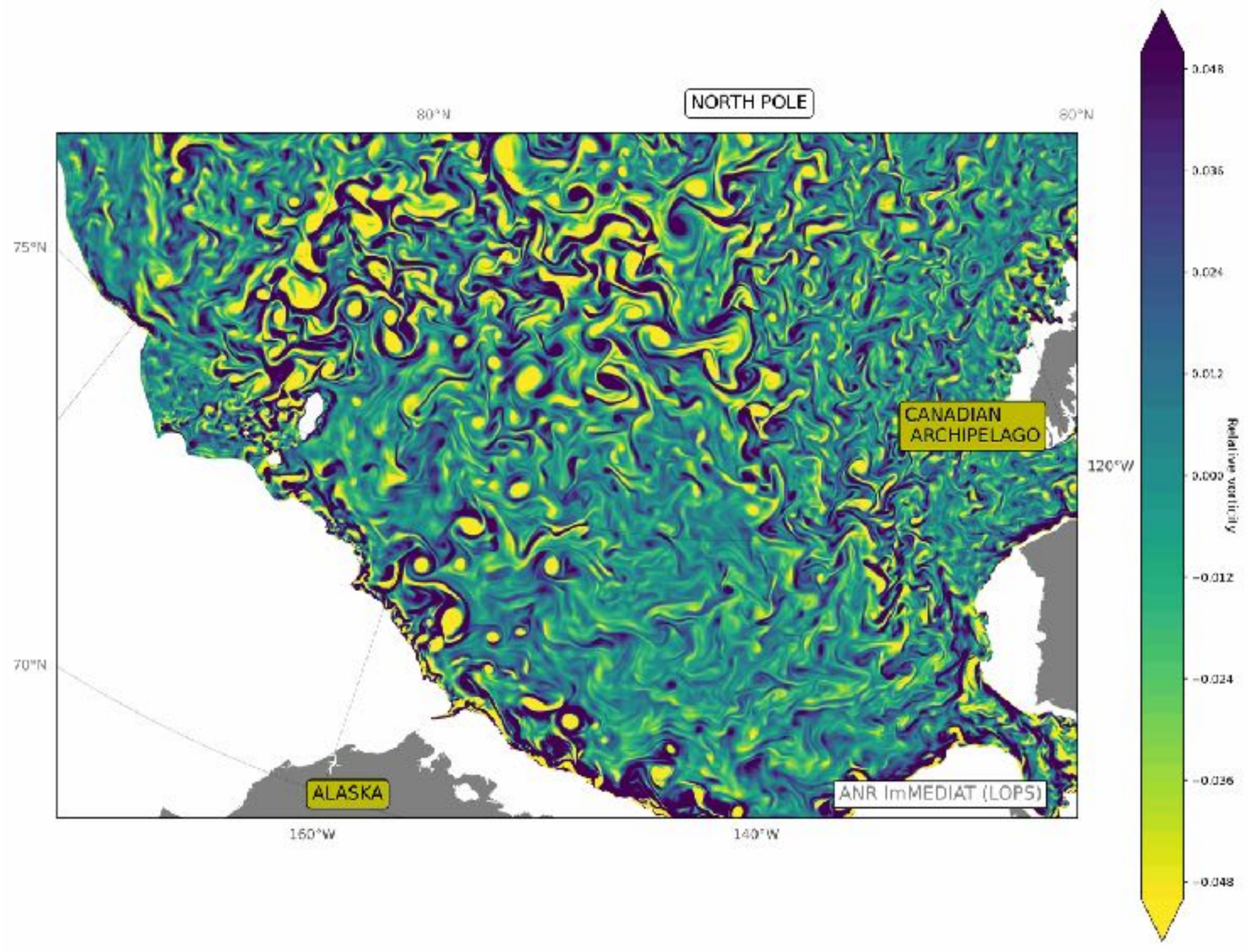
- In the BG the main source is linked to the salinity flux through mean salinity surfaces (84% of all sources), sustained by fluctuating winds via Ekman balance. The main sink is associated to the parameterisation of eddy fluxes (86% of all sinks).

- In the ESS the largest source is linked with sea ice melt/freeze (61% of all sources) and the largest sink to the parameterisation of eddy fluxes (46% of all sinks)

Hochet et al. 2024 *Drivers of interannual salinity variability in the Arctic Ocean JGR: Oceans*

Perspectives

- Apply the same framework to an eddy resolving configuration of the Arctic
- The framework can be used to study the mechanisms of variation of different variables on different timescales
- Use the same methodology to study the effect of climate change on the mechanisms of interannual salinity variability in the Arctic using climate models



Talandier & Lique 2023 SEDNA simulation

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