AMOC and eddy analysis across the Labrador Sea in a 1/60th degree configuration of NEMO

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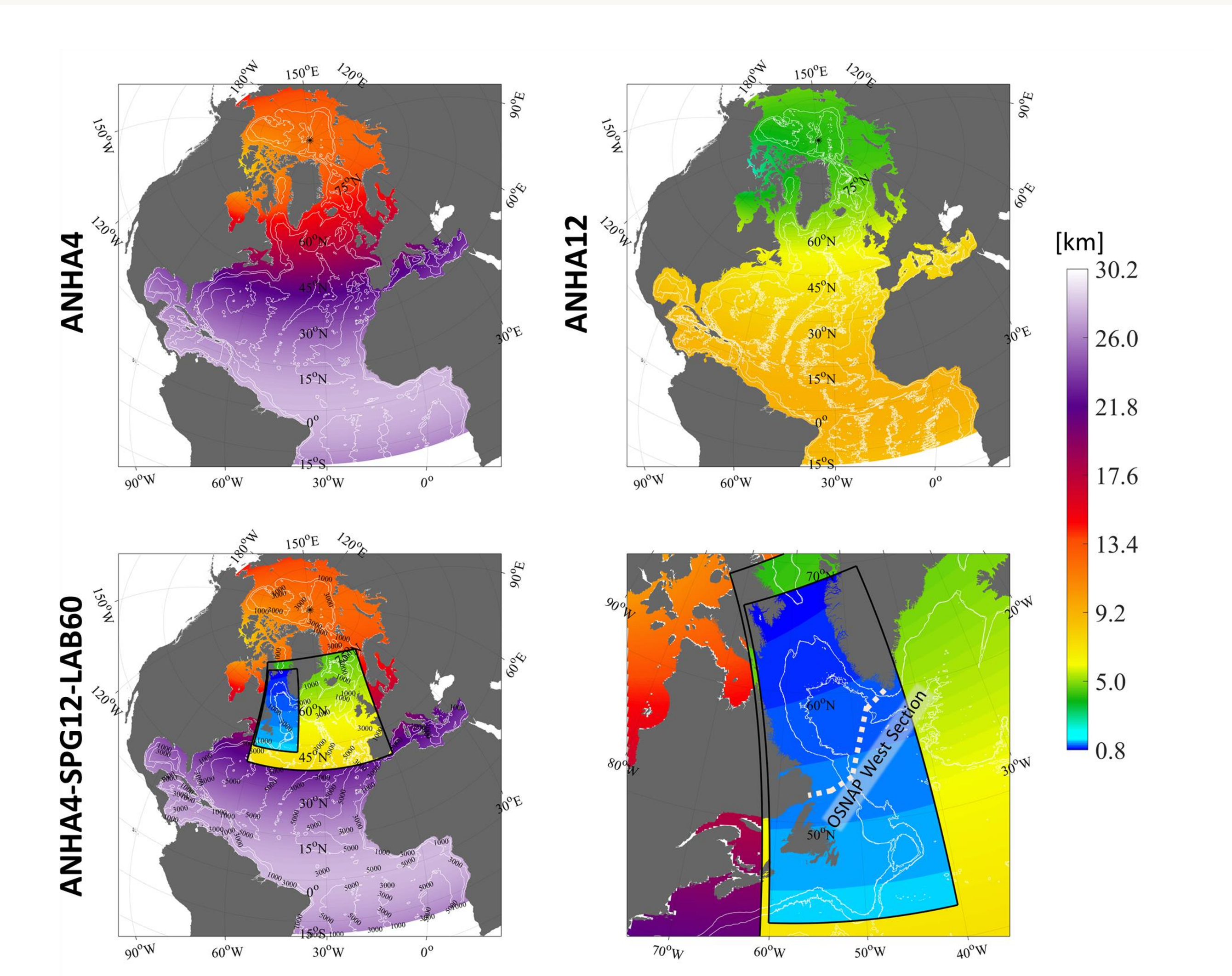
I. Motivation

- Atlantic Meridional Overturning Circulation (AMOC) plays a crucial role in the global thermohaline circulation, influencing the mean climate state and its variability.
- The Labrador Sea is an important region predisposed to deep convection and formation of water masses in its interior. This water mass potentially contributes to the AMOC by feeding the dense southward Atlantic deep circulation.
- An accurate representation of the AMOC is essential for reliable predictions of climate patterns and understanding oceanic changes.
- Recent pronounced Greenland mass loss, driven by polar amplification, has increased freshwater flux into the Subpolar North Atlantic, potentially impacting the AMOC.

II. Methods and Model



Horizontal grid spacing focusing on the Labrador Sea

NEMO ocean model coupled with Sea-Ice model

	Configuration			
	ANHA[a]		ANHA4-SPG12-LAB60	
Experiment	ANHA4	ANHA12	LAB60-GLM	LAB60-NoGLM
NEMO ocean model version	3.4	3.4	3.6	
Horizontal Resolution	1/4 °	1/12 °	1/4 ° horizontal resolution with 1/12 ° nest covering Subpolar North Atlantic and 1/60 ° inner nest covering LS	
Vertical levels	50	50	75	
Atmospheric Forcing	CGRF[b]	CGRF	CGRF (to 2007), DFS[c] (to 2017), and ERA5[d] (to 2019)	
Initial and Boundary Conditions	GLORYS2v3[e]	GLORYS2v3	GLORYS1v1	
Greenland Melt	Yes	Yes	Yes	No

AMOC is represented by the maximum of the Atlantic overturning streamfunction in density space, $\max[\psi(\sigma,t)]$ [1]:

$$AMOC(t) = \max[\psi(\sigma,t)] = \max[\int_{\sigma_{min}}^{\sigma}\int_{x_1}^{x_2} v(x,\sigma,t)dxd\sigma]\ (Sv)$$

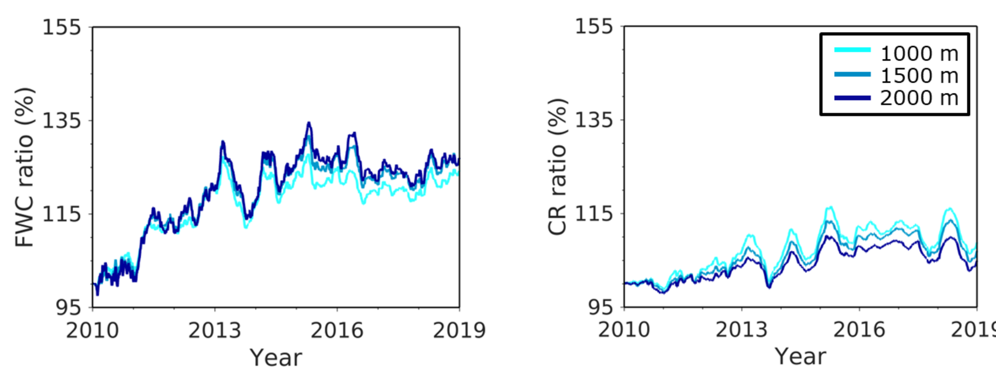
Eddy Kinetic Energy (EKE) represents the strength of eddy activity:

$$EKE = \frac{1}{2}(u'^2 + v'^2)\ (cm^2/s^2)$$

$$(u',v') = (u-\bar{u}, v-\bar{v})$$

III. Impact of pronounced Greenland melt freshwater on the Labrador Sea

$$ratio = \frac{LAB60\_GLM}{LAB60\_NoGLM} \times 100$$



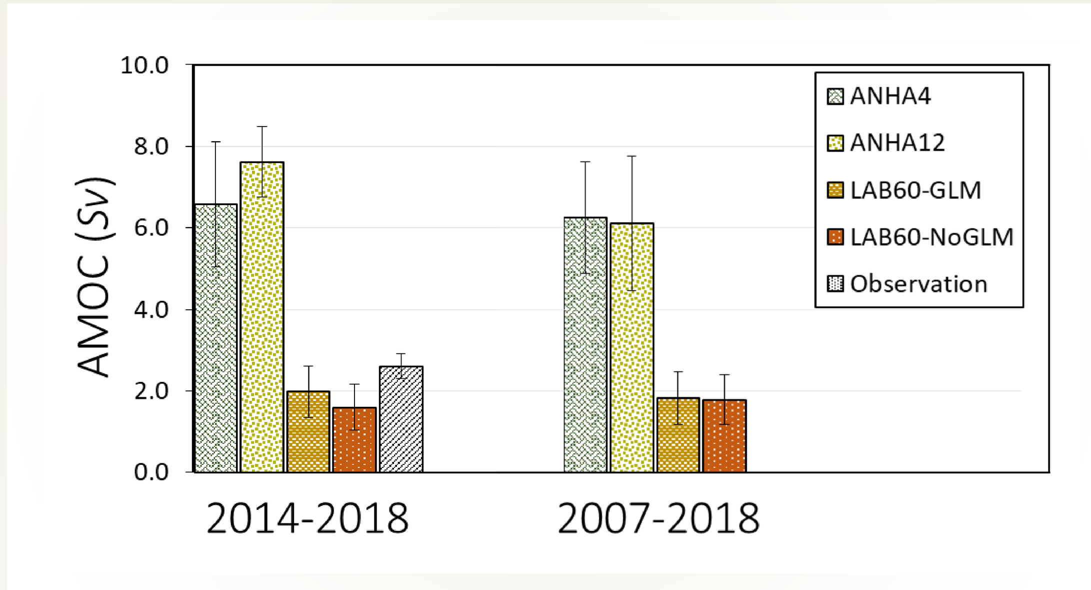
Freshwater content and convective resistance ratios over Labrador Sea with reference depths of 1000, 1500, and 2000 m

- Increasing trend in freshwater content ratios over time
- Increasing trend in convective resistance ratios indicates the intensified Labrador Sea stratification over time

Abbreviation

a. ANHA: Arctic and Northern Hemisphere Atlantic
b. CGRF: Canadian Meteorological Centre (CMC) Global Deterministic Prediction System (GDPS) reforecasts
c. DFS: Drakkar Forcing Set
d. ERA5: European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis v5
e. GLORYS: Global Ocean Reanalysis and Simulations
f. OSNAP: Overturning in the Subpolar North Atlantic Program

IV. Mean AMOC Strength across the OSNAP West Section

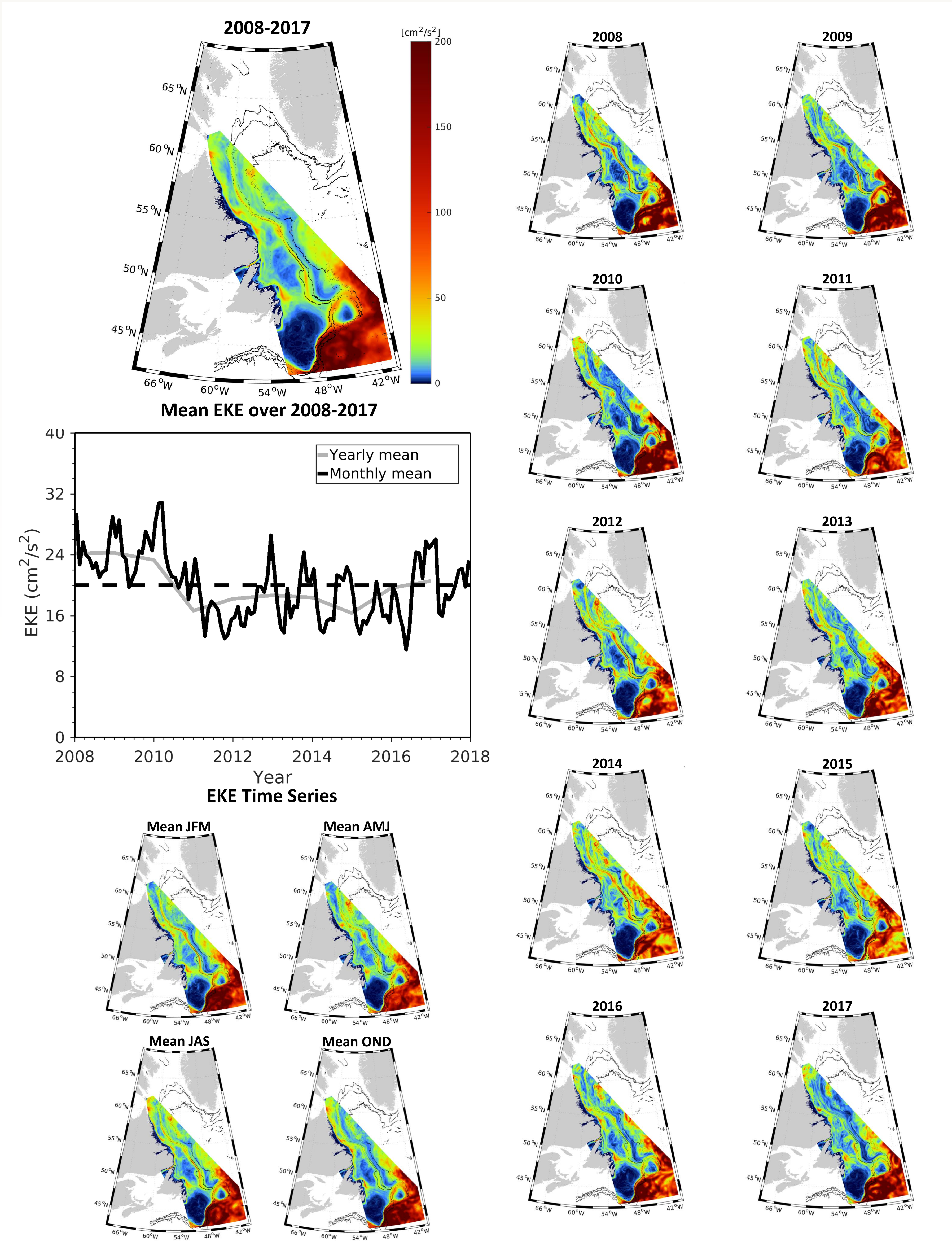


Mean AMOC Strength

	Date	Configuration				OSNAP Observations [1]
		ANHA		ANHA4-SPG12-LAB60		
Experiment		ANHA4	ANHA12	LAB60-GLM	LAB60-NoGLM	
Mean	OSNAP[g] Period	6.58±1.53	7.62±0.87	1.98±0.63	1.59±0.56	2.6±0.3 Sv
AMOC_{σ} (Sv)	2007-2018	6.25±1.38	6.11±1.65	1.82±0.65	1.78±0.61	-

- The OSNAP estimates of mean AMOC are best predicted by the eddy-rich high-resolution configuration.
- Increased Greenland melt freshwater inflow contributes to stronger stratification in the Labrador Sea, yet no significant impact on the AMOC strength.

V. Eddy Kinetic Energy analysis



Seasonal variability of EKE

Interannual variability of EKE

VI. Next Steps

- How do the barotropic and baroclinic instabilities of Labrador Current vary seasonally and interannually?
- How do the eddies and instabilities of Labrador Current influence the stratification within the Labrador Sea?
- How do turbulence schemes impact the seasonal and interannual variability of Labrador Current instabilities?

References

1. Li et al., Nature communications 12, no. 1 (2021): 3002.
2. Hoshyar et al., Ocean Modelling 187 (2024): 102307.
3. Pennelly et al., Geoscientific Model Development 13, no. 10 (2020): 4959-4975.

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