SOMOVAR project: “Detection and understanding of the North-Atlantic Ocean Subtropical Gyre low-frequency Variability”

Focus on the 2005-2015 Eighteen Degree Water variability

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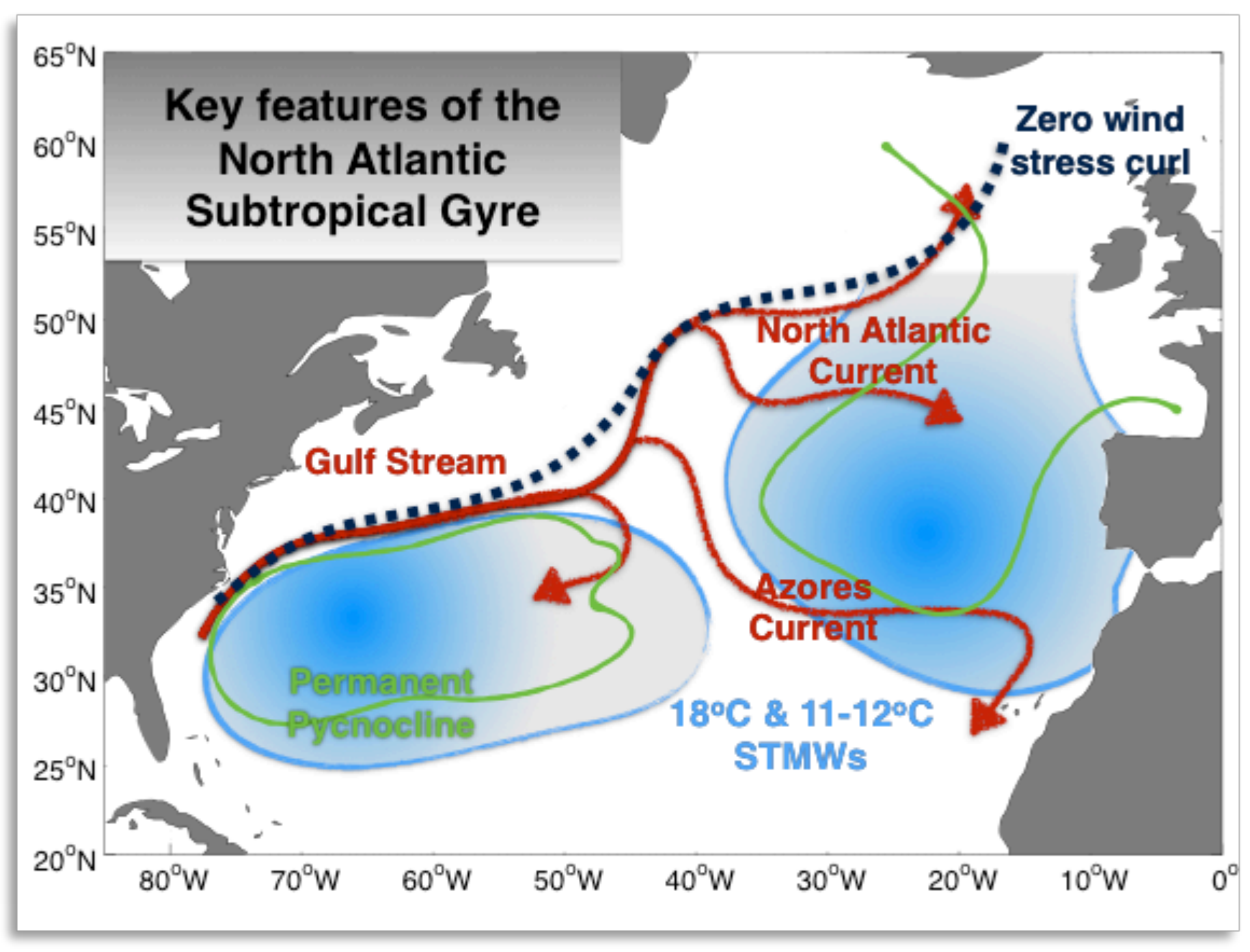
1/ THE PROJECT

The North Atlantic subtropical gyre holds the largest volume of warm water (say, temperature warmer than 10^{o}C) in the world's ocean mid-latitudes. It plays an important role for climate at the global (e.g. Kwon et al, 2010; Perez et al, 2013) and regional scales (e.g. Palter et al, 2015) through its participation in the meridional overturning circulation (e.g. Buckley & Marshall, 2015, Lique & Thomas, 2018), meridional heat transport (e.g. Trenberth and Carron, 2001; Williams et al, 2014), air-sea fluxes (e.g. Yu et al, 2008) and heat storage (e.g. Forget & Wunsch, 2007). It is thus crucial to know how the North Atlantic subtropical gyre (NATSG) has and will change in the face of climate change.

Feucher et al, 2018 and 2019 have suggested the difficulties to determine robust signals in the low-frequency variability of the subtropical stratification from ocean re-analysis. Here we tackle this challenge for the Eighteen Degree Water (Maze et al, 2009).



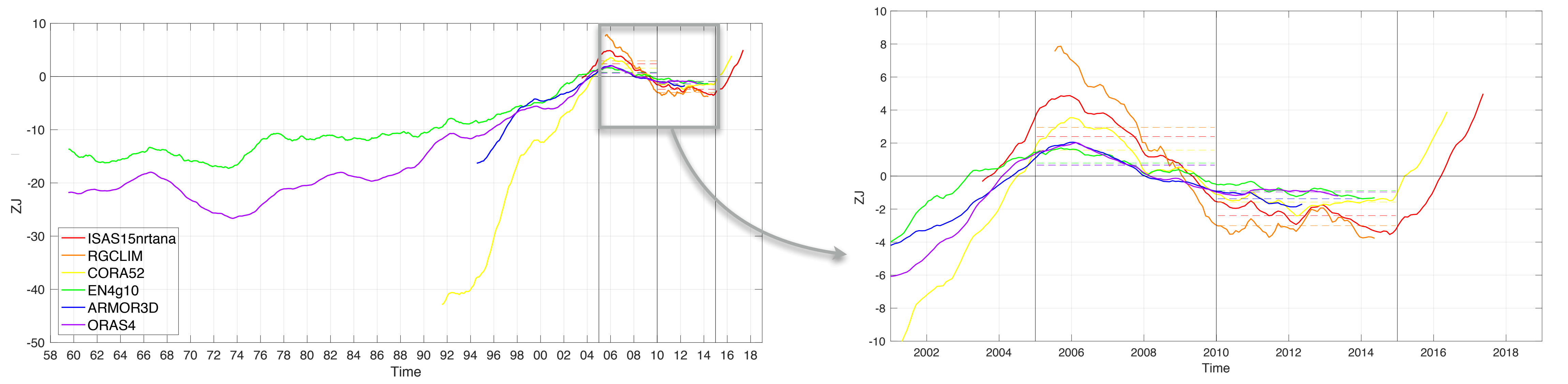
The objectives of the SOMOVAR project are to detect and investigate the mechanisms of variability of the North Atlantic Subtropical Gyre system at interannual-to-decadal time scales for the understanding of changes in observed oceanic heat content. It is organised around 4 work packages:

- **WP1: Observed variability of the NASTG.** ***This poster, where we focus on the Eighteen Degree Mode Water component of the NASTG.***
- **WP2**: Projected changes of the NASTG.
- **WP3**: Mechanisms of NASTG variability: process study. See Kenneth Lee Friday talk (abstract #27) on the Interannual impact of extreme wintertime weather on the North Atlantic subtropical stratification.
- **WP4**: A new perspective on WBC observed variability.

2/ RESULTS

North Atlantic 0-700m Ocean Heat Content (OHC700) for 6 state of the art ocean products

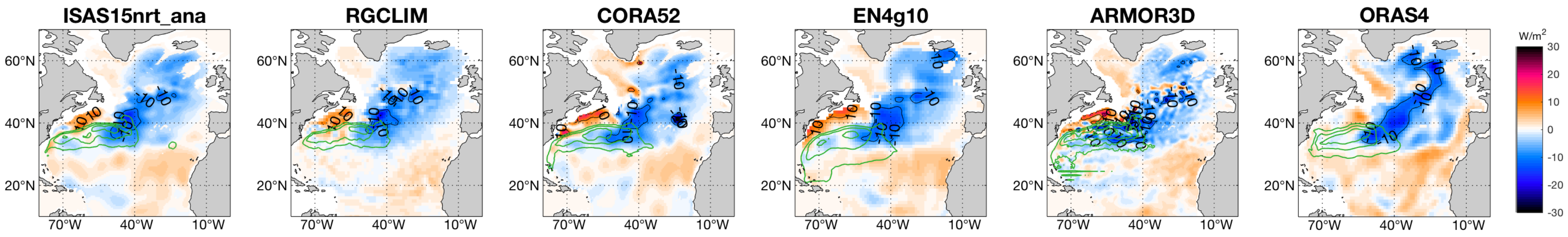
Seasonal cycle removed, time series low passed with a 3 years moving average. Reference baseline 2005-2014.



The amplitude of the signal differ from one product to the other, but there is a systematic reduction in OHC700 observed from 2005 to 2015 that looks unprecedented since the early 70s.

Spatial distribution of 2005-2015 OHC700 changes

Difference between OHC700 averaged over [2010-2014] minus [2005-2009]. Green contours indicate EDW thickness standard deviation.



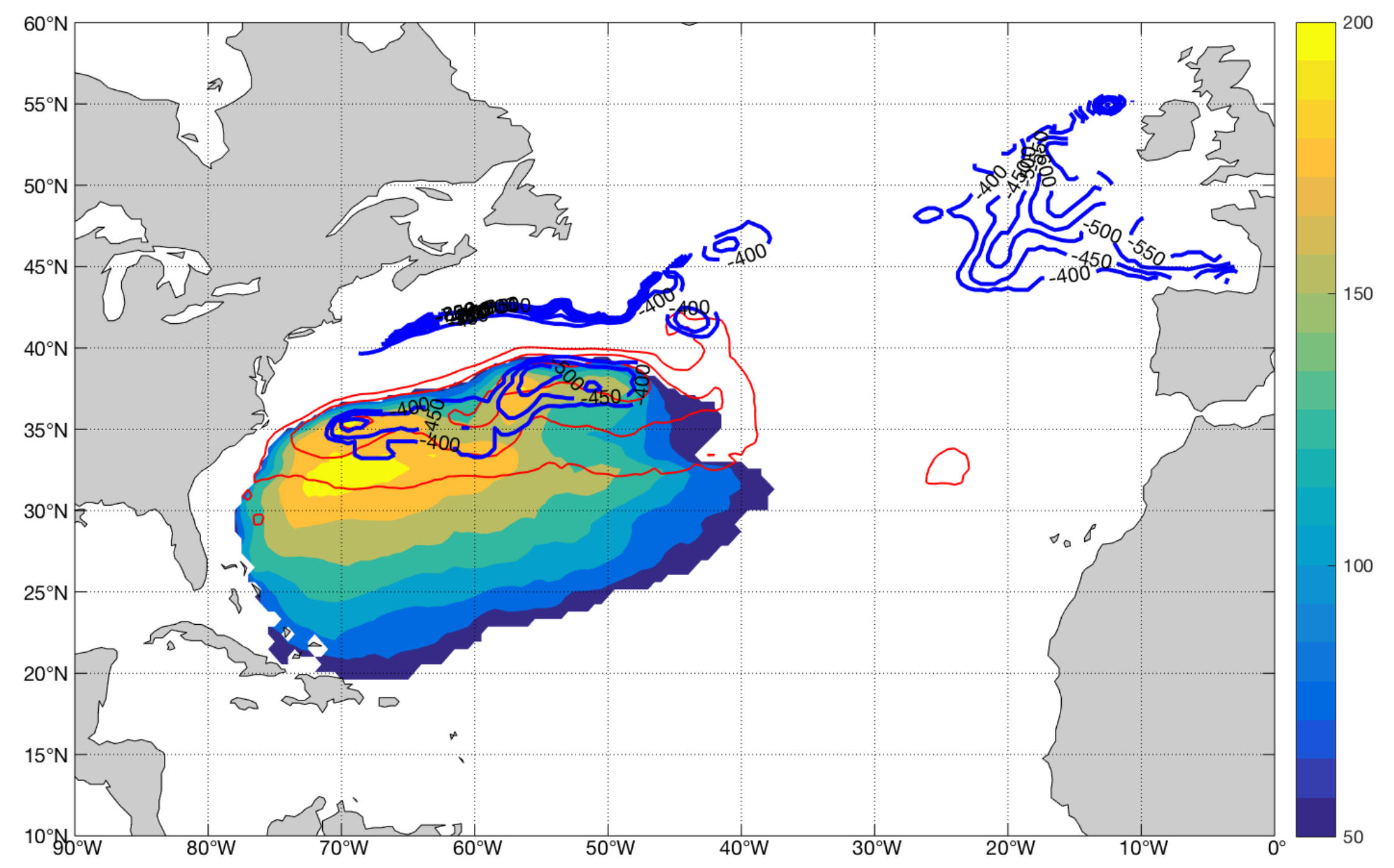
All products show a similar OHC change pattern dominated by a large reduction from 55W/30N to Iceland and smaller warming elsewhere (20N/30N band, Labrador Sea, North of the GulfStream).

This OHC change is driven by a reduced AMOC (Smeed et al, GRL 2017).
We wonder what is the impact of this particularly large OHC change onto the North Atlantic subtropical stratification ?

Since the OHC change pattern affects the EDW formation region, we focus on the impact on this mode water

The Eighteen Degree Mode Water (EDW) is defined as all water parcels with the following properties:

$$\begin{aligned}\sigma_\theta &= 26.4 \pm 0.2\, kg\, m^{-3}\\ \theta &= 18 \pm 1\, ^oC\\ Q &\leq 1.5 \times 10^{-10} m^{-1} s^{-1}\\ H &\geq 50\, m\end{aligned}$$

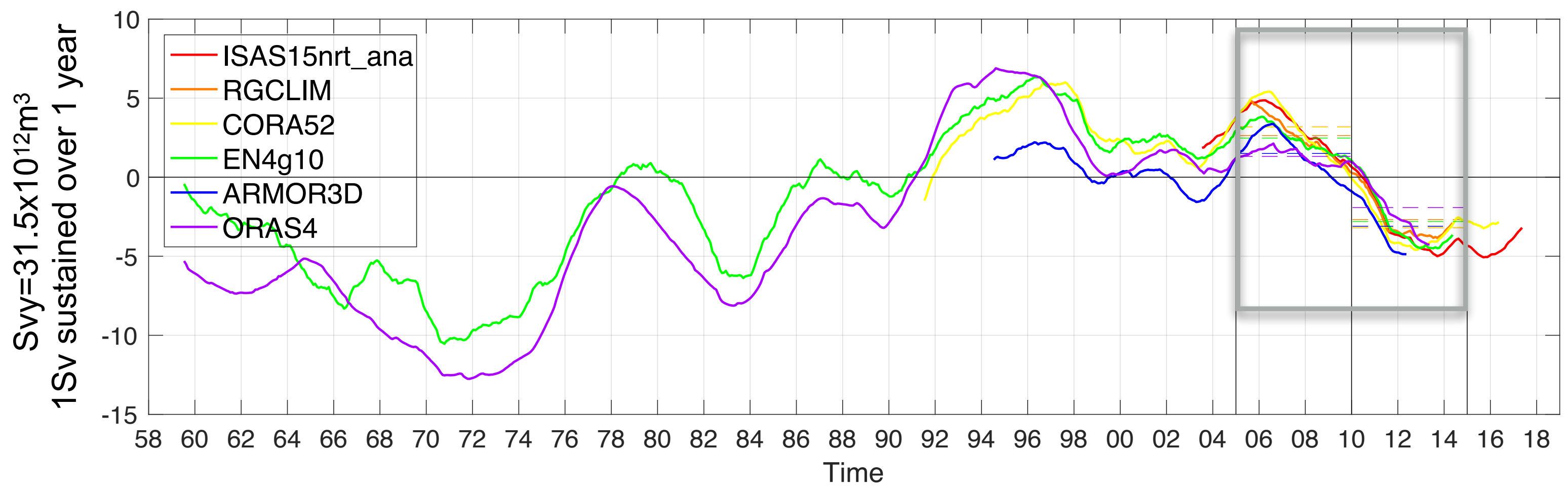


EDW mean thickness (color) with its std (red). Deepest mixed layer depth in blue contours.

3/ RESULTS

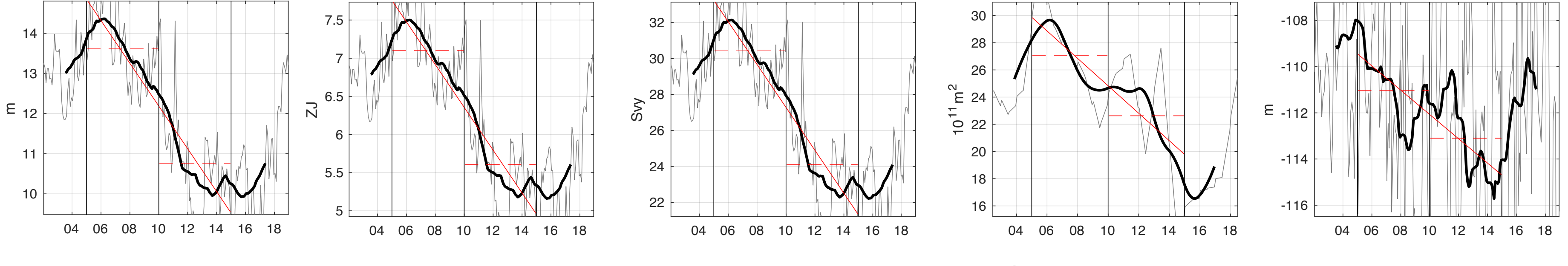
North Atlantic EDW volume for 6 state of the art ocean products

Seasonal cycle removed, time series low passed with a 3 years moving average. Reference baseline 2005-2014.

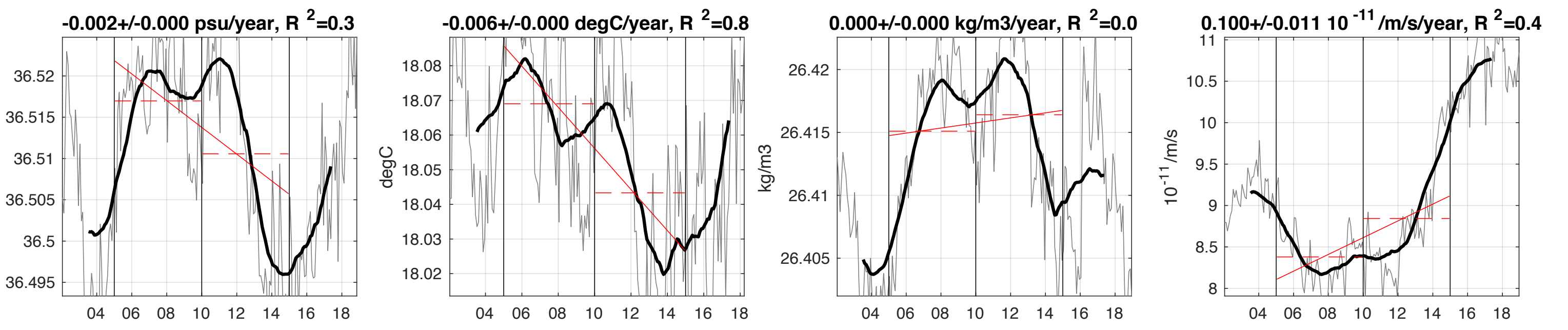


The EDW shows a robust volume reduction over 2005-2014. This reduction amplitude has only been seen 4 times in 60 years.

EDW properties for the ISAS15 product



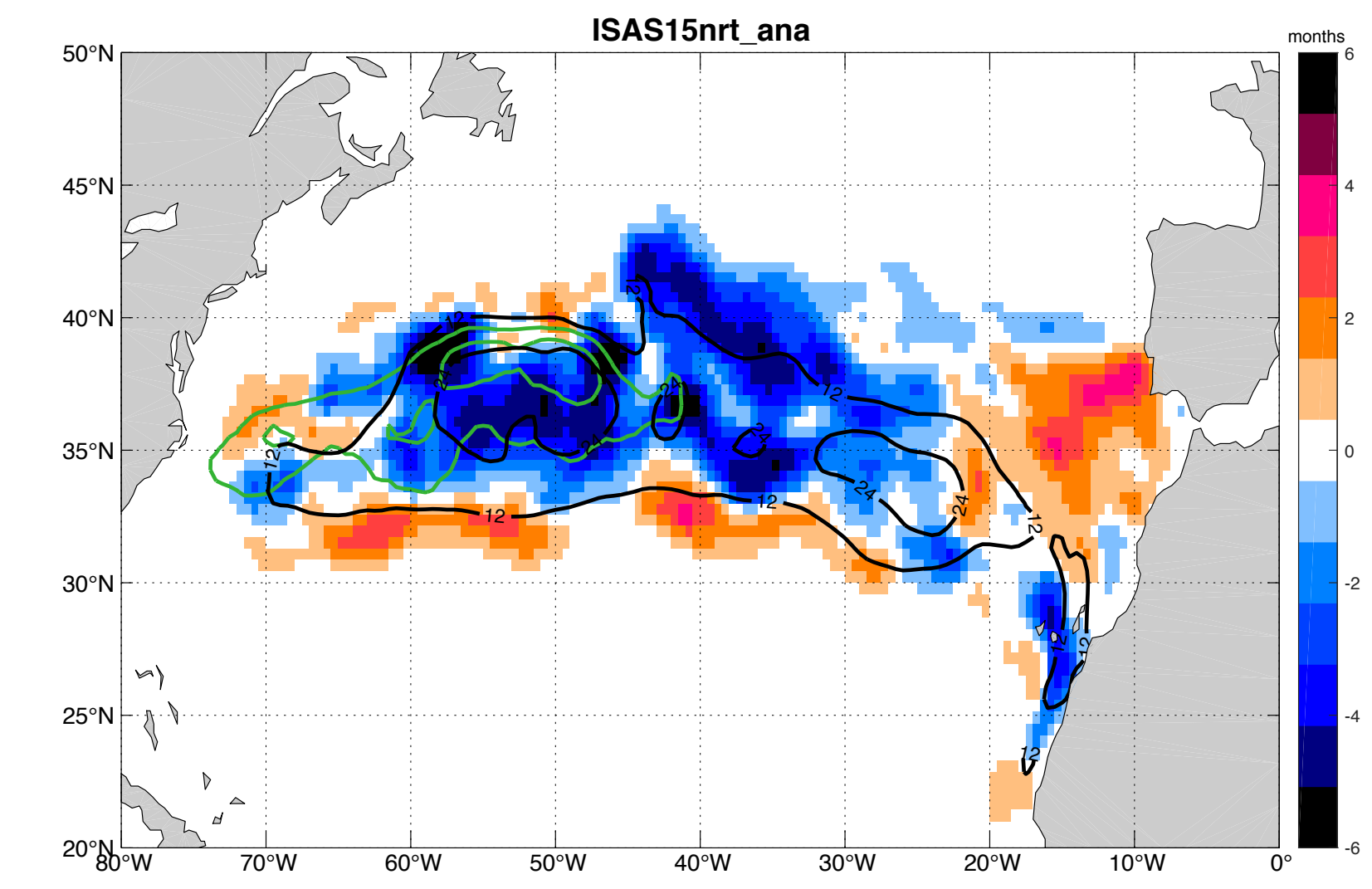
The EDW sees its thickness, heat content, outcropping surface and winter mixed layer depth to decrease significantly over 2005-2014.



The EDW also sees its temperature and salinity to decrease, but changes are compensated in density. PV is increasing because the EDW thickness is decreasing, which lead to a more stratified more water. Thickness reduction drives the volume reduction, compare to horizontal extent.

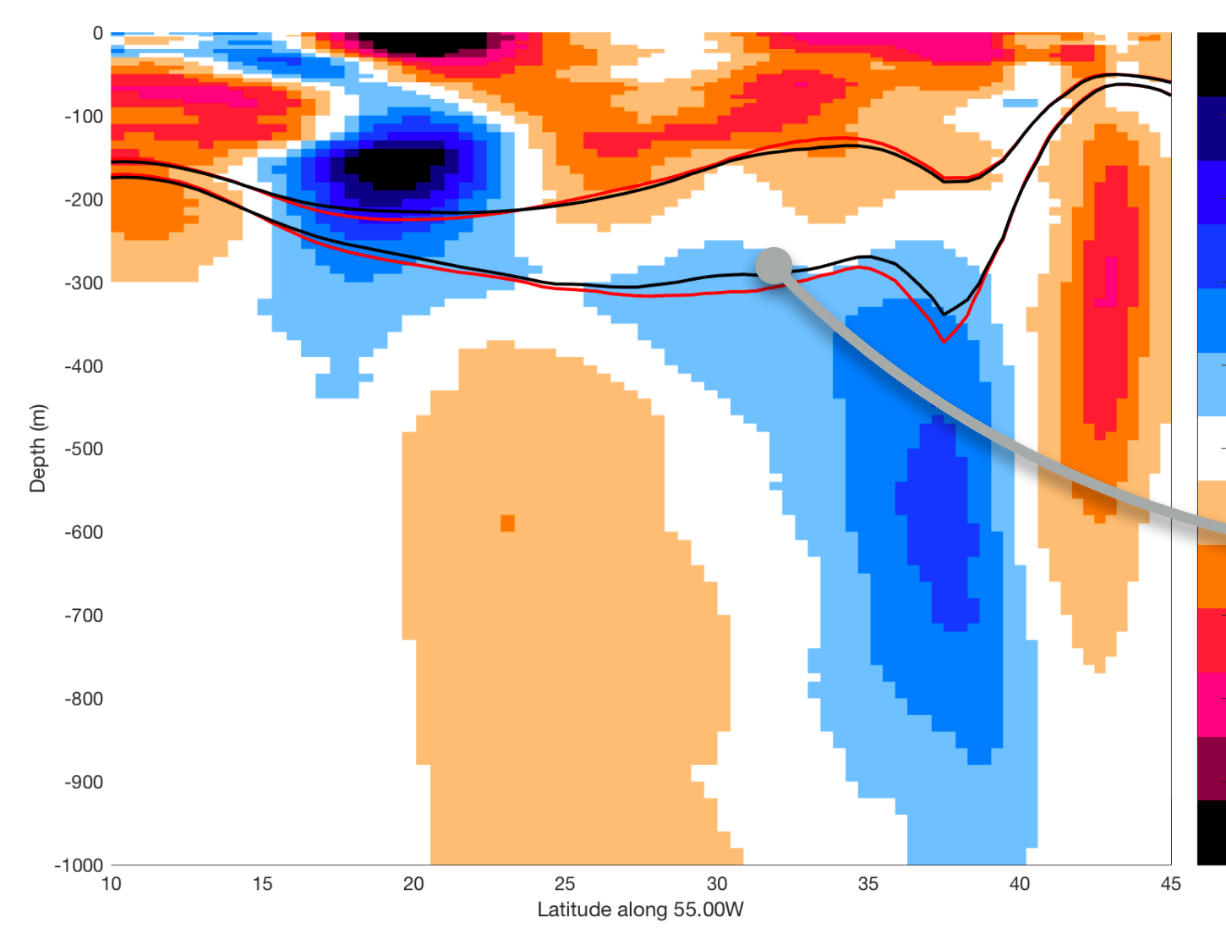
Outcropping change

Local outcrop occurrences over 5 years
(contours: mean state, shading: [2010-2014] vs [2005-2009]



Potential density change along 55W

Contours: 26.3-26.5 isopycnal
Red [2005-2009], Black:[2010-2014]



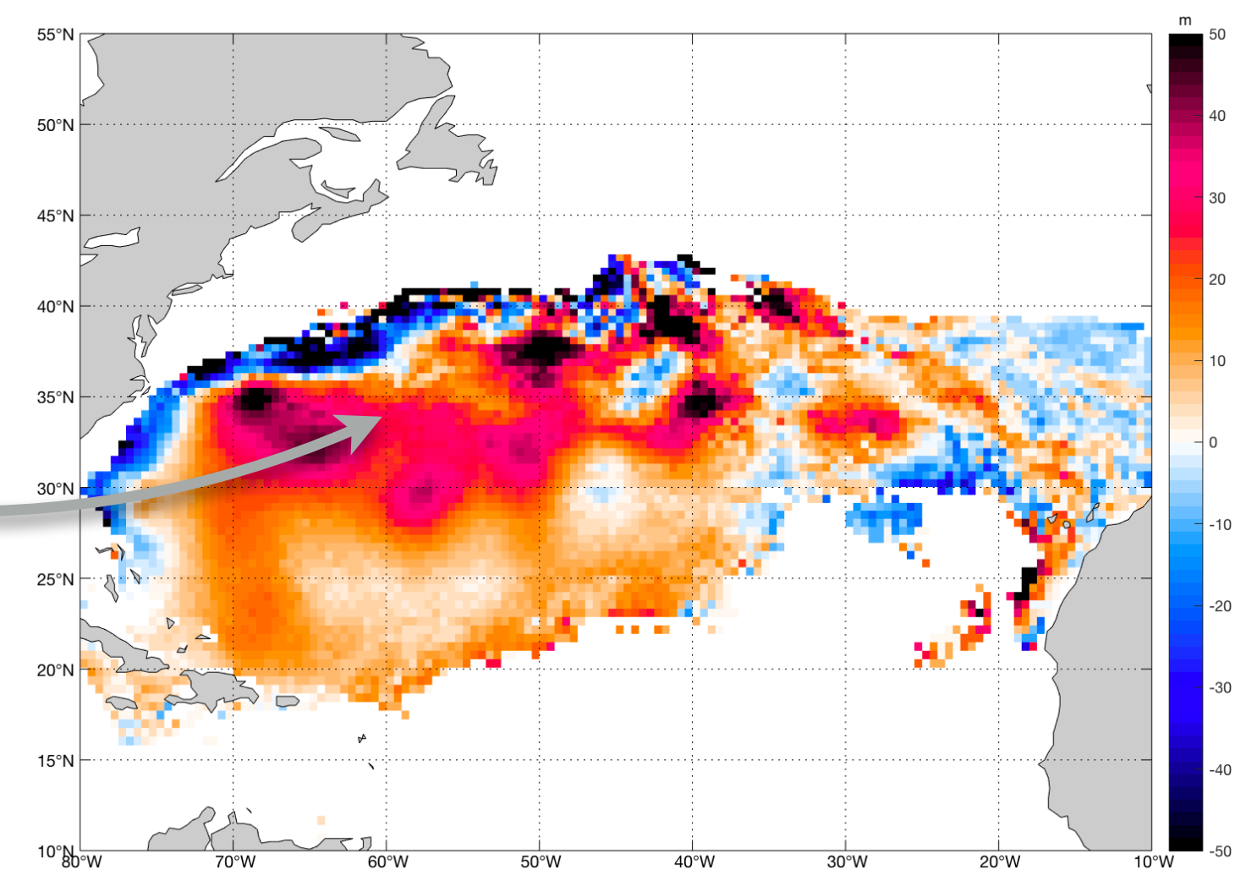
EDW Heat Content change decomposition

[ZJ]	dHC	V*dT	dV*T
Total	-1,598	-0,008	-1,585
Interior	-1,399	-0,007	-1,388
Outcrop	-0,199	-0,049	-0,172

The EDW outcrop less frequently but its heat content change is driven by an interior volume reduction.
This volume reduction is due to the uprising of the EDW bottom isopycnal:

EDW bottom isopycnal depth change

[2010-2014] minus [2005-2009]



REFERENCES

Kwon et al, 2010 (10.1175/2010JCLI3343.1); Perez et al, 2013 (10.1038/ngeo1680); Palter et al, 2015 (10.1146/annurev-marine-010814-015656); Buckley & Marshall, 2015 (10.1175/JCLI-D-14-00579.1), Lique & Thomas, 2018 (10.1038/s41558-018-0316-5); Trenberth and Carron, 2001; Williams et al, 2014 (10.1175/JCLI-D-12-00234.1); Yu et al, 2008; Forget & Wunsch, 2007 (10.1175/JPO3072.1); Feucher et al, 2018 (10.17882/56503) and 2019 (10.1029/2018JC014526); Maze et al, 2009 (10.1175/2009JPO3985.1); Smeed et al, 2017 (10.1002/2017GL076350).

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