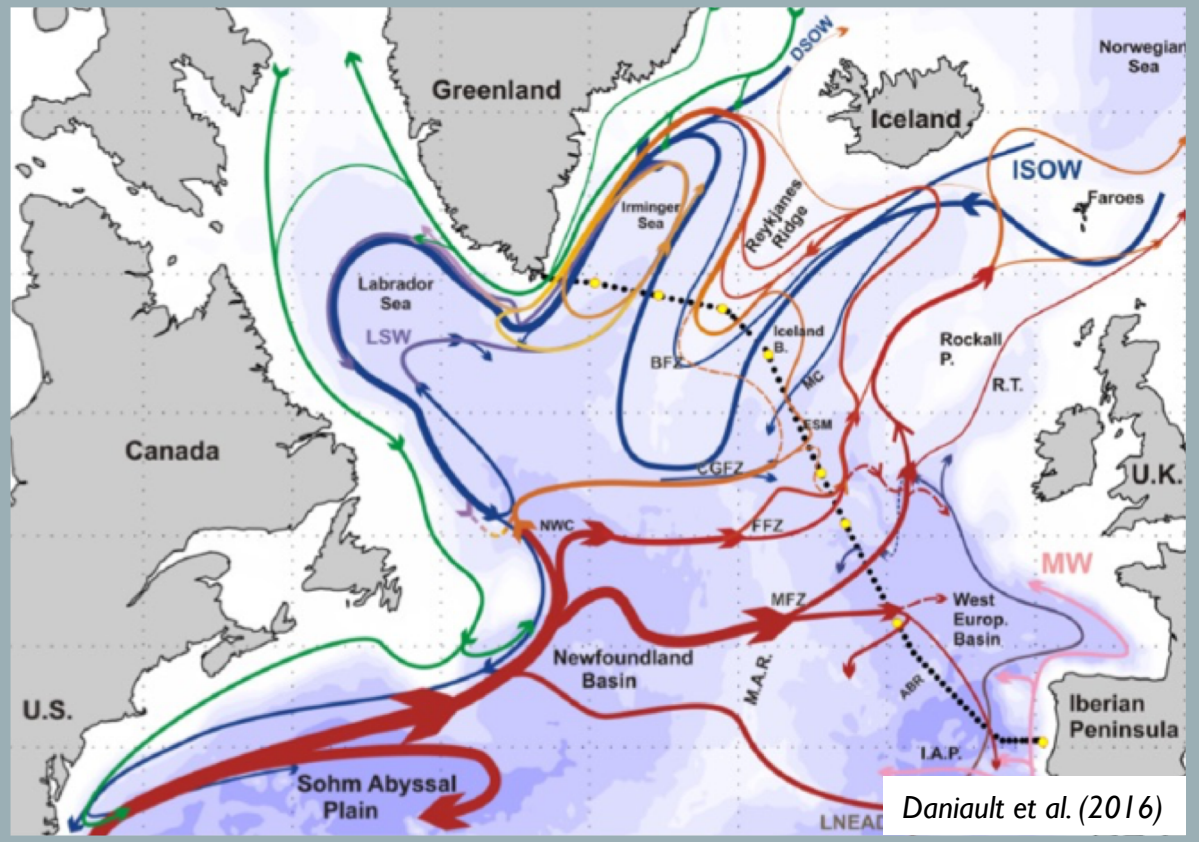
SHIFTING OCEAN CIRCULATION WARMS THE SUBPOLAR NORTH ATLANTIC SINCE 2016

Damien Desbruyères, Léon Chafik, Guillaume Maze + NOCS and LOPS collaborators



Daniault et al. (2016)

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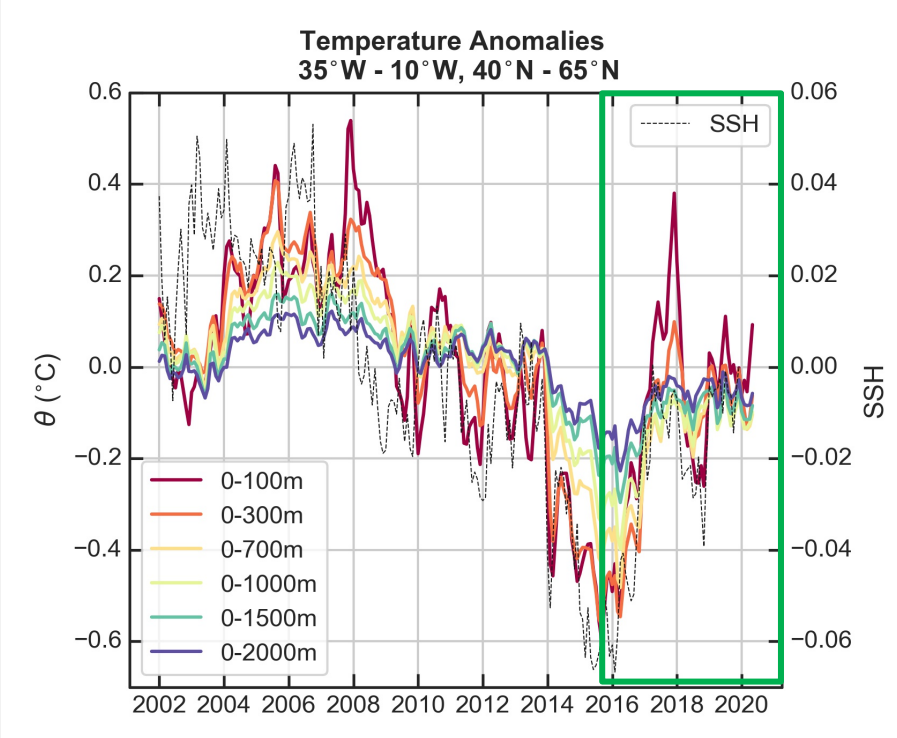
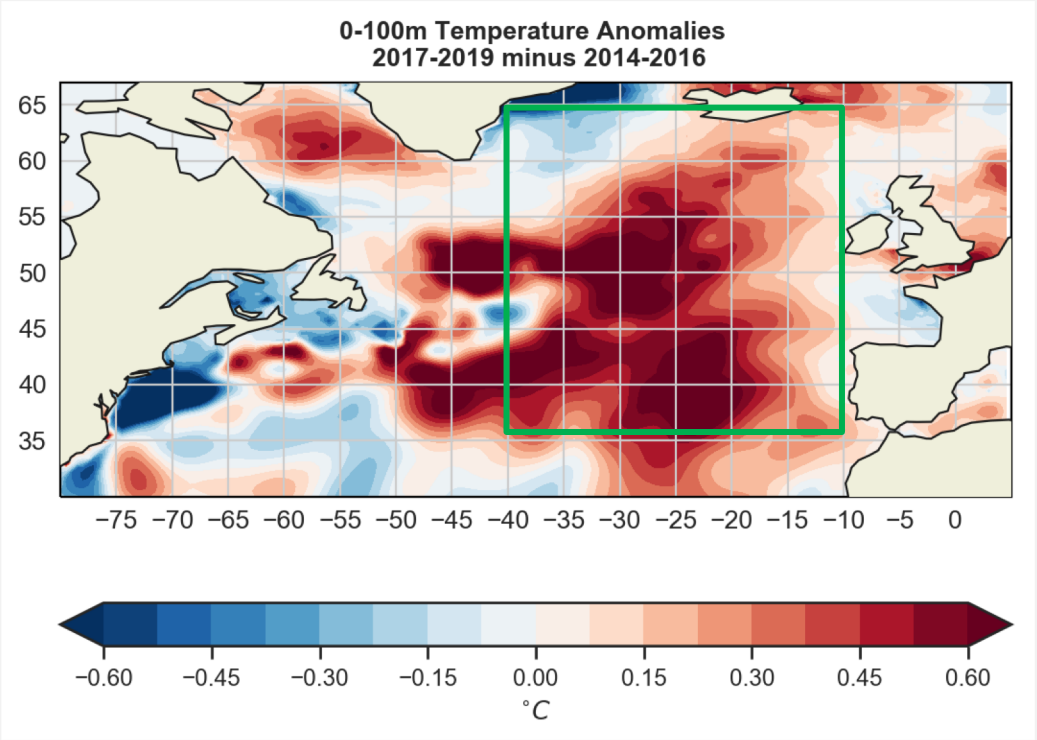
OS1.2

RECENT OHC CHANGES FROM ARGO



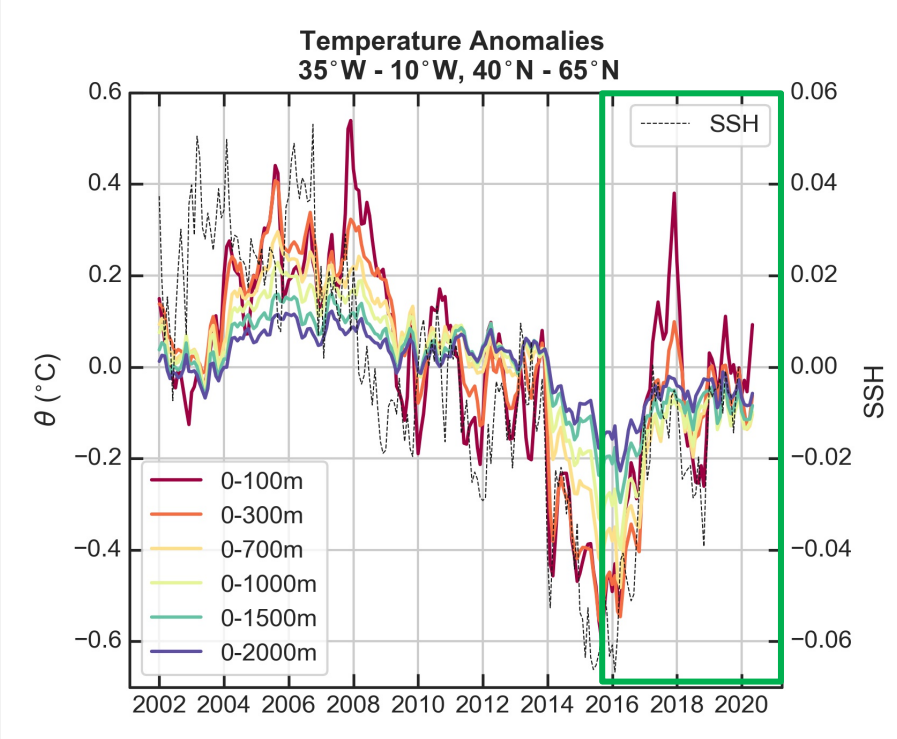
Depth-averaged θ anomalies in the eastern SPNA captured by the Argo array. Note the ***recent cooling-to-warming reversal in the mid-2010s.***



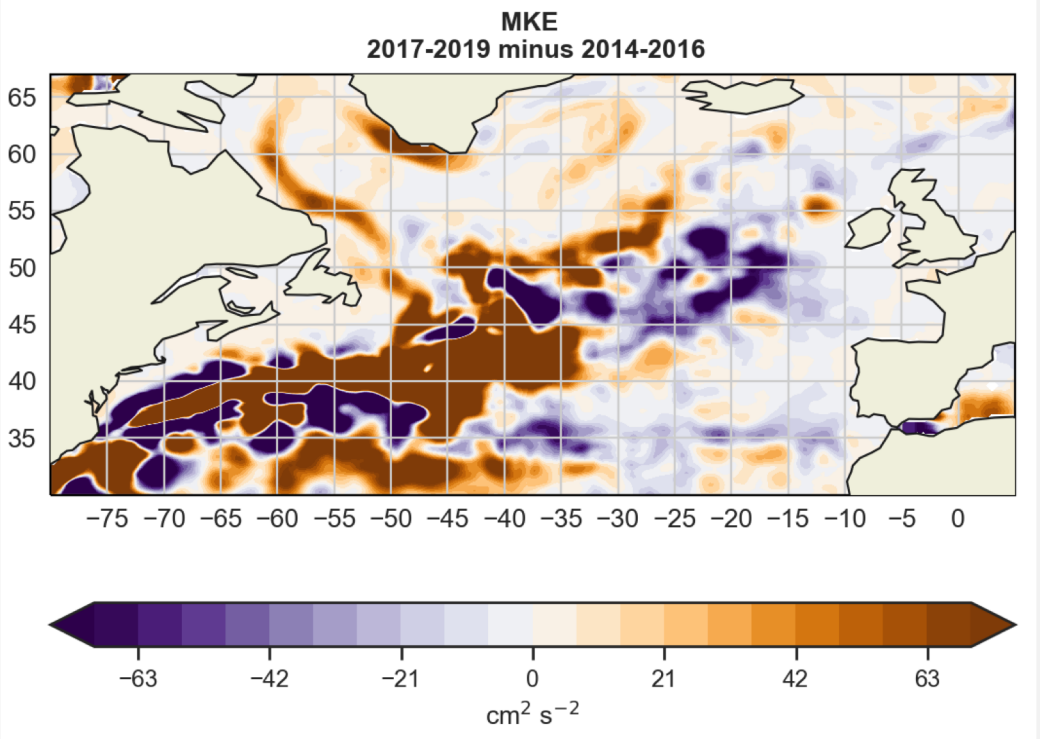
θ difference (0-100m) between 2014-2016 and 2017-2019. ***Note the large-scale extent of the recent warming.***

See related modelling analysis: *e.g. Robson et al 2016, Piecuch et al 2017, Desbruyères et al 2015.*

RECENT CIRCULATION CHANGES FROM ALTIMETRY



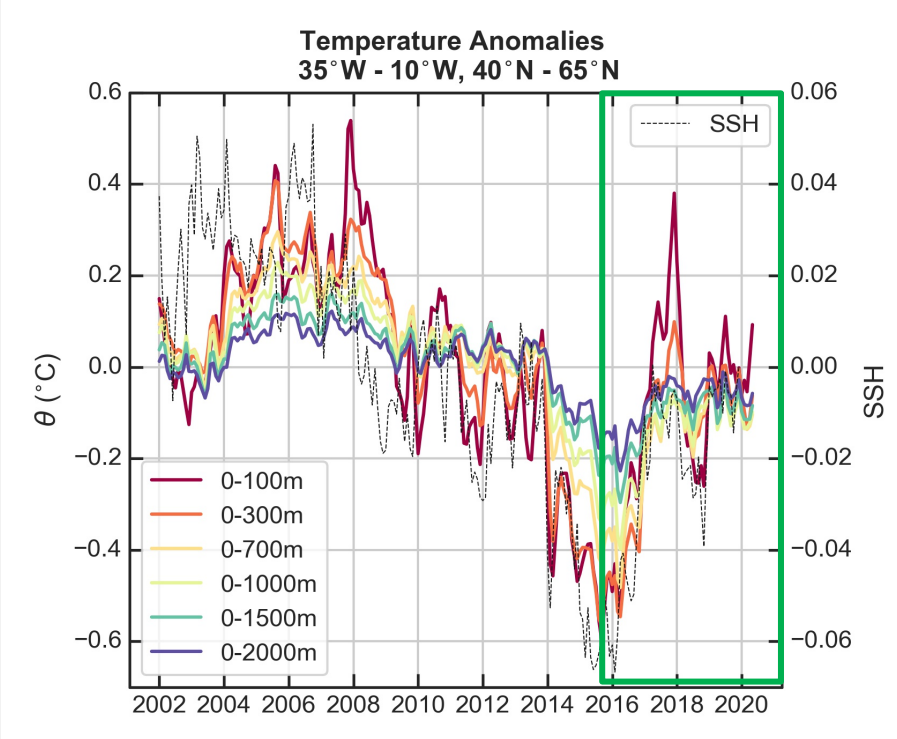
Depth-averaged θ anomalies in the eastern SPNA captured by the Argo array. Note the ***recent cooling-to-warming reversal in the mid-2010s****.*

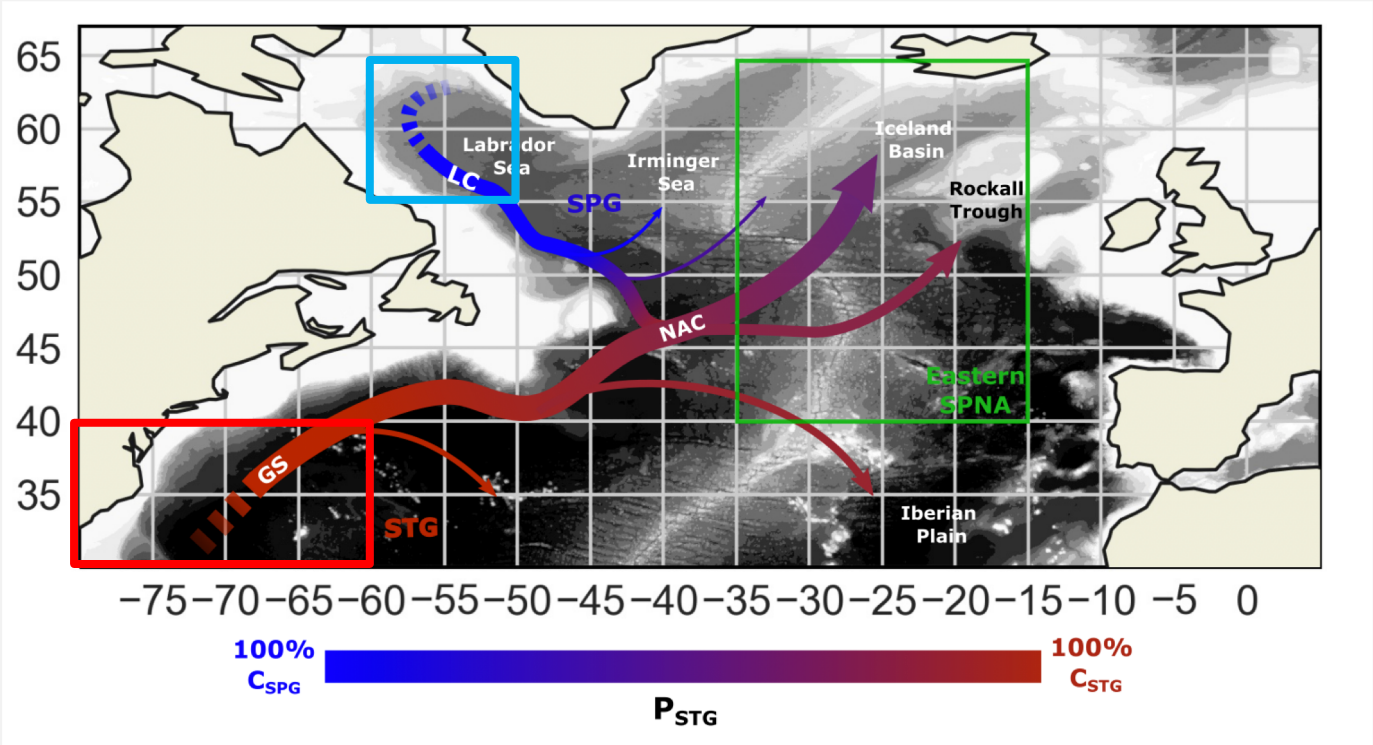


Mean Kinetic Energy (MKE) difference between 2014-2016 and 2017-2019 from satellite altimetry. ***Note the intensification of the intergyre NAC flow****.*

See related modelling analysis: *e.g. Robson et al 2016, Piecuch et al 2017, Desbruyères et al 2015.*

CONSTRUCTING A SIMPLE MODEL

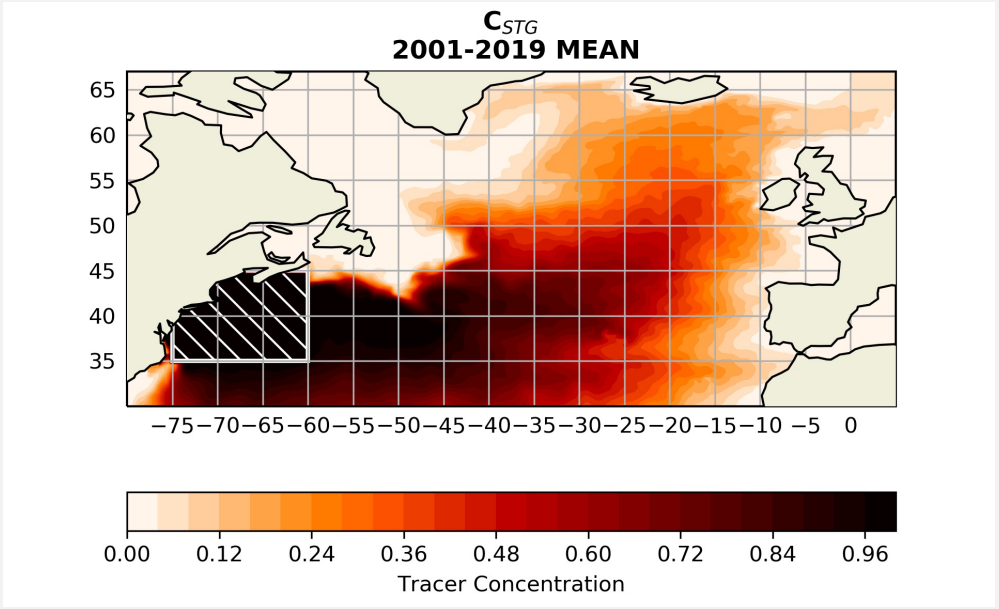




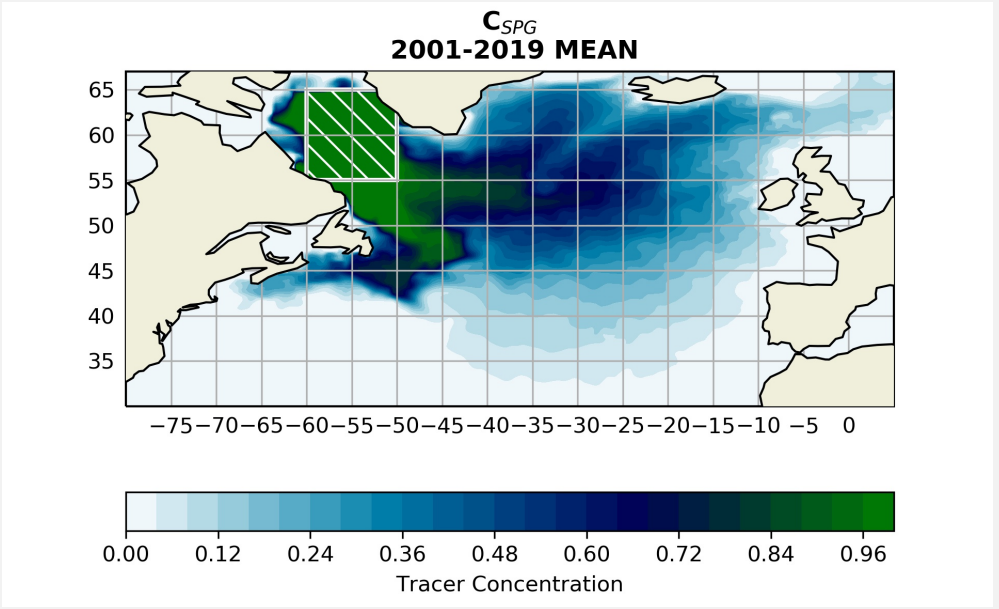
$$\frac{\partial C}{\partial t} = -\langle v \rangle . \nabla C + \kappa . \nabla^2 C$$

A simple model for the advection-diffusion of a passive tracer representing eastern SPNA source waters can be built from altimetry-derived surface geostrophic velocities (v). It enables to extract from surface Eulerian velocities (and mesoscale eddy diffusivities) a **Lagrangian decomposition of the eastern SPNA water mass origins**.

SUBTROPICAL AND SUBPOLAR WATER PATHWAYS

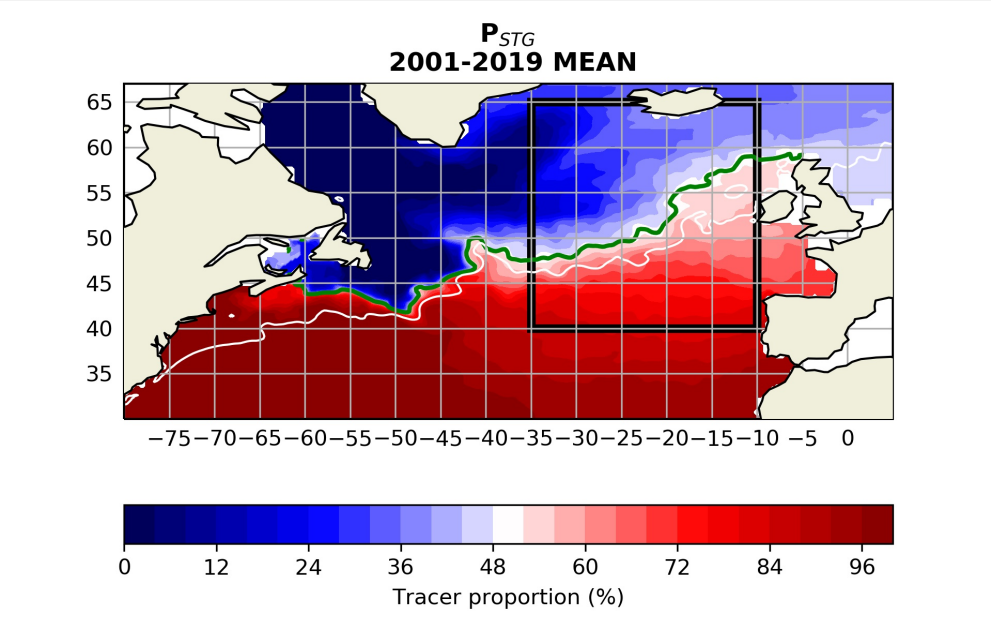


Distribution of subtropical tracer after 3 years of advection within time-mean altimetry-derived surface currents



Distribution of subpolar tracer after 3 years of advection within time-mean altimetry-derived surface currents

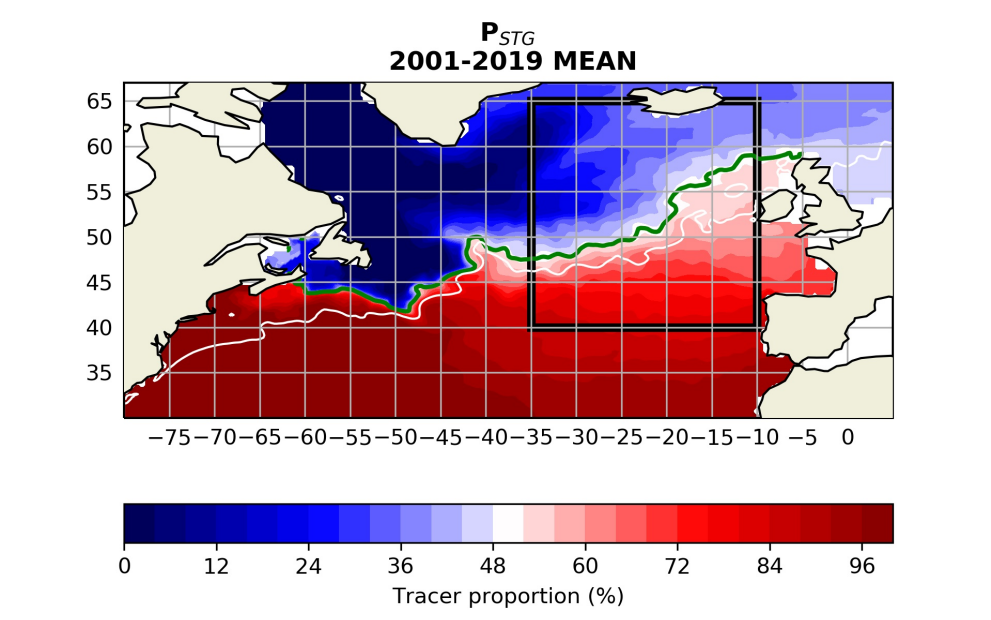
SUBTROPICAL AND SUBPOLAR WATER PROPORTIONS



*Distribution of subtropical **tracer PROPORTION** (P_{STG}) after 3 years of advection within time-mean altimetry-derived surface currents*

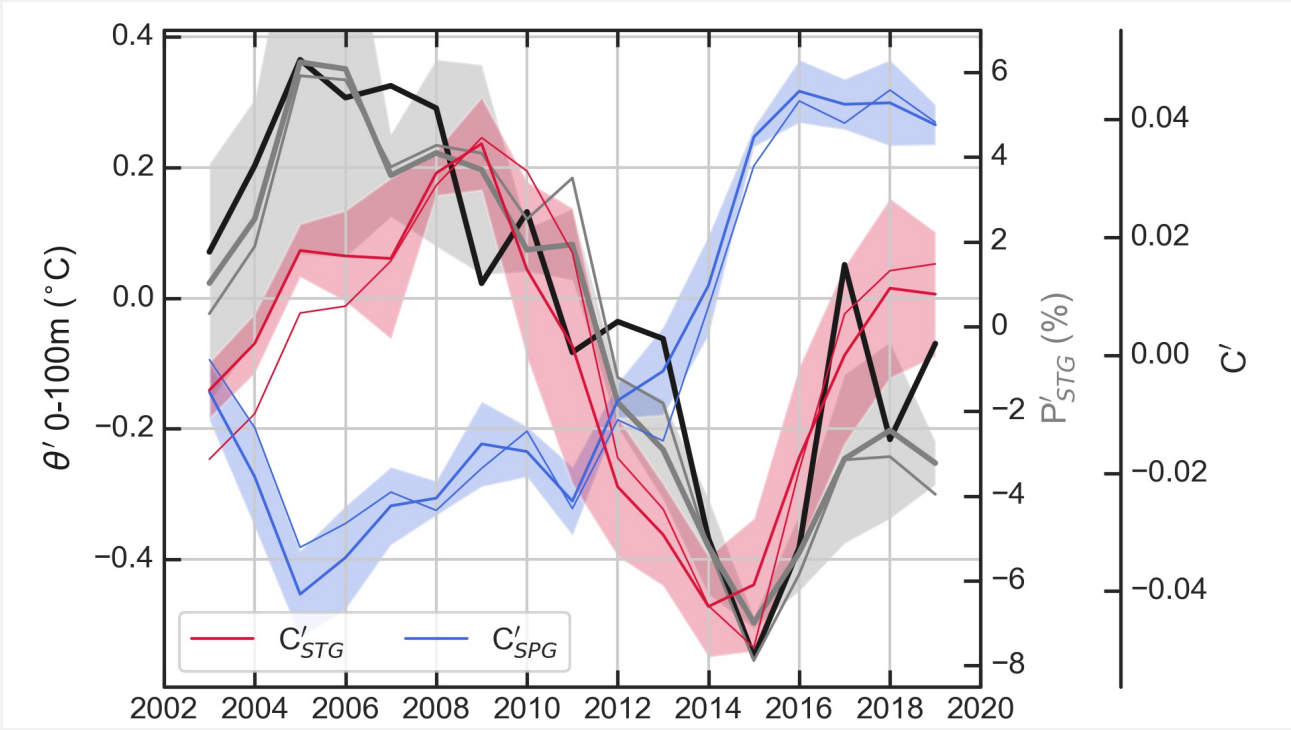
We repeat the experiment with successive (and overlapping) N-year windows to monitor P_{STG} during 2002-2019

PROPORTION CHANGES VS. TEMPERATURE CHANGES



*The changes in subtropical **tracer PROPORTION** in the SPNA is well correlated with temperature changes.*

The sharp and ongoing warming of the SPNA is largely driven by a shift in ocean circulation (increased penetration of warm subtropical waters).



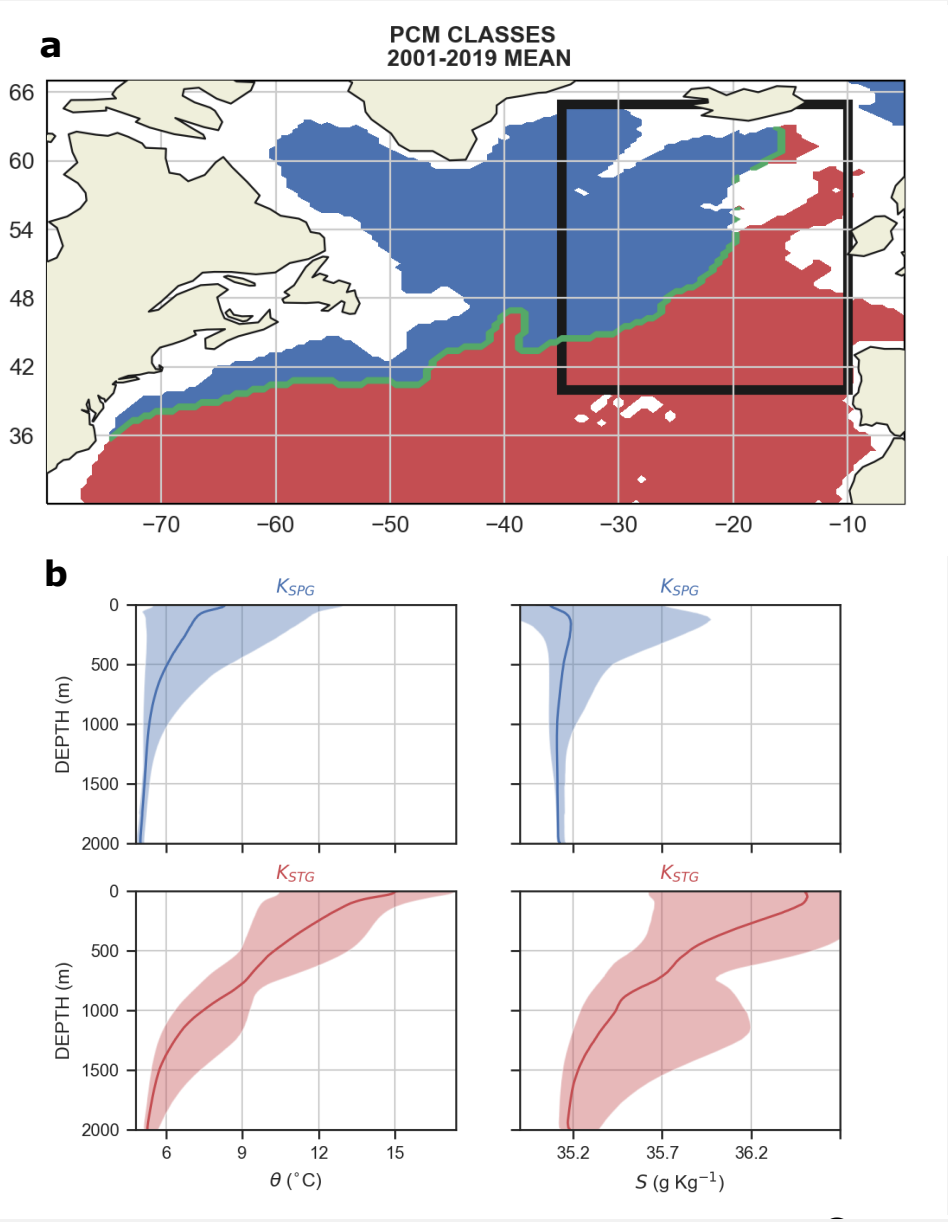
Temperature of the upper layer

Proportion of subtropical waters

Subtropical tracer concentration

Subpolar tracer concentration

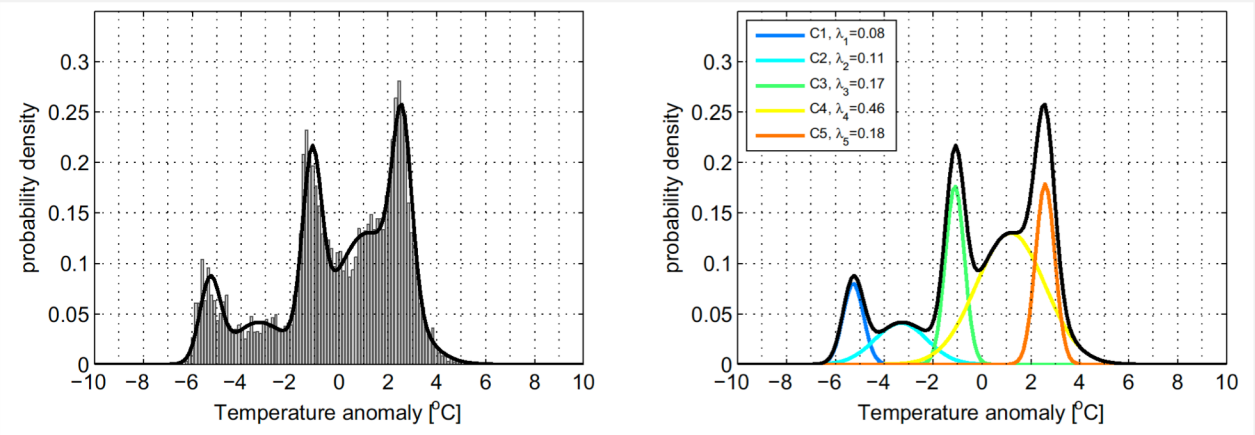
BELOW THE SURFACE: PROFILE CLASSIFICATION



Profile Classification Model (PCM) applied to Argo (gridded) profiles is used to objectively define a subtropical and a subpolar ocean region with unique vertical stratification pattern.

An PCM example from Maze et al (2017)

Observed PDF (gray), 5-class PCM PDF (black) and its decomposition (colors)



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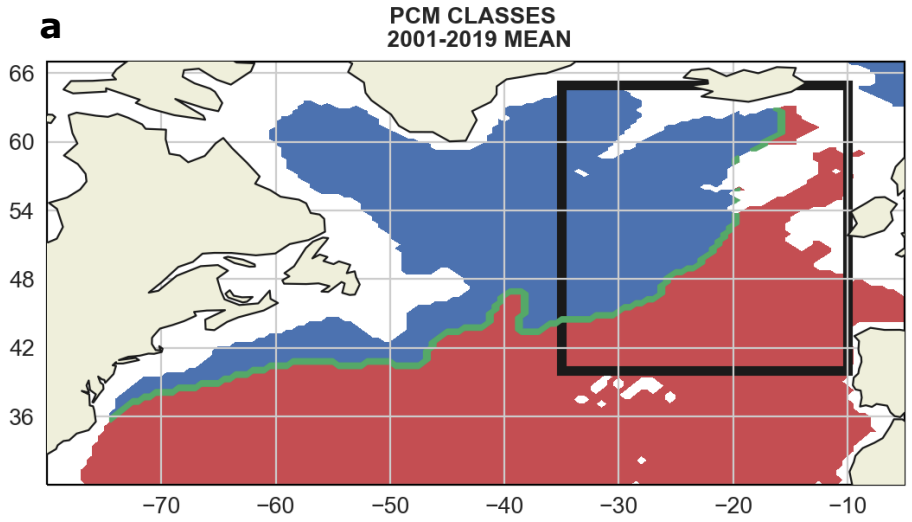
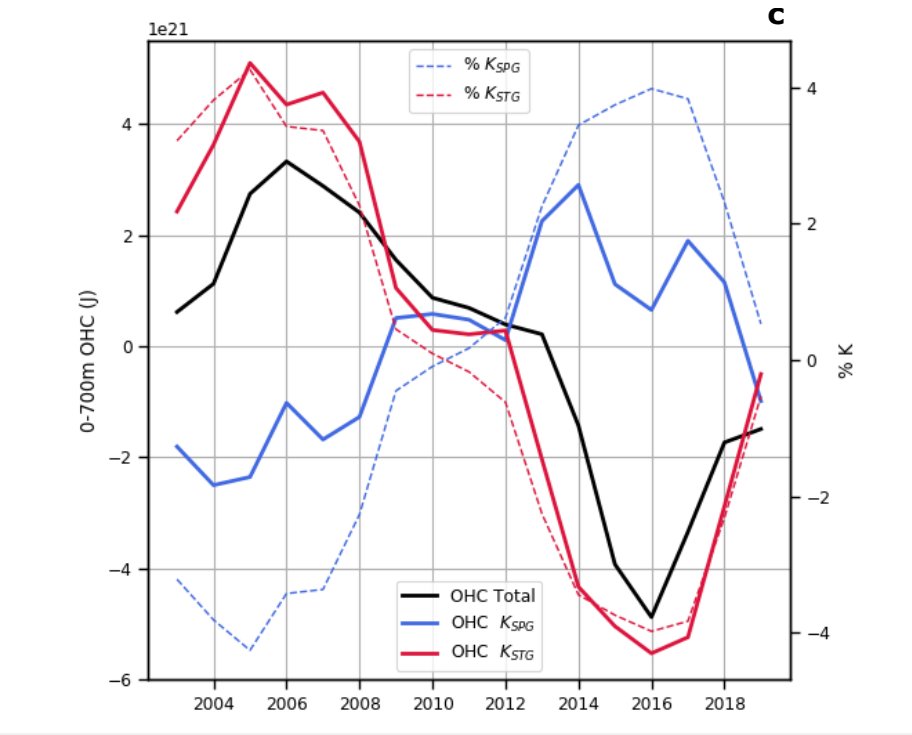




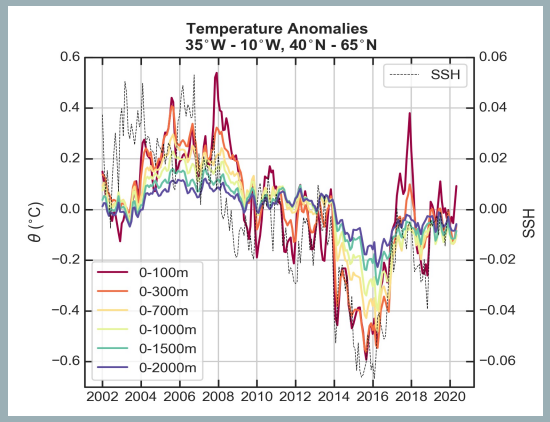
Profile Classification Model (PCM) applied to Argo (gridded) profiles is used to objectively define a subtropical and a subpolar ocean region with unique vertical stratification pattern.

Changes in subtropical and a subpolar cluster extent and associated OHC (0– 700m) variability confirms the altimetry-derived mechanism for recent trend reversals.

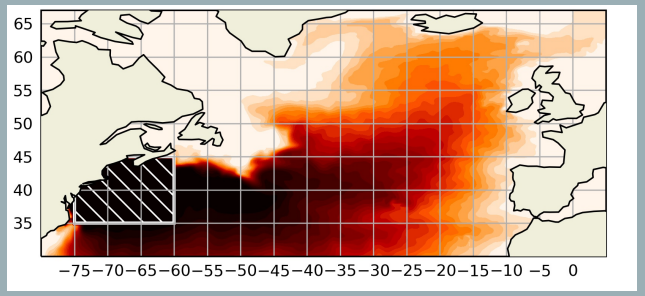
$$OHC_K(t) = \iint_{x,y} p_K(x,y,t)[\int_{z=700m}^{0} \rho_0 C_p \theta(x,y,z,t)dz\,]dxdy$$

TAKE-HOME MESSAGES

1. **Following a gradual cooling of the SPNA that was persisting since 2006, a surface intensified and large-scale warming sharply emerged in 2016.**



2. **Both surface-based index (altimetry) and stratification-based index (Argo) of source water pathways point out an increased penetration of warm subtropical waters into the eastern SPNA as the dominant driver.**



3. **The proposed mechanism is consistent with a possible intensification of the AMOC at the southern exit of the SPNA since the mid-2010s**
(cf Desbruyères et al 2019, OS)

More in Desbruyères et al (2021) - Communications Earth & Environment

Thanks !