

# Progressive Ventilation of AMOC waters in the subpolar North Atlantic

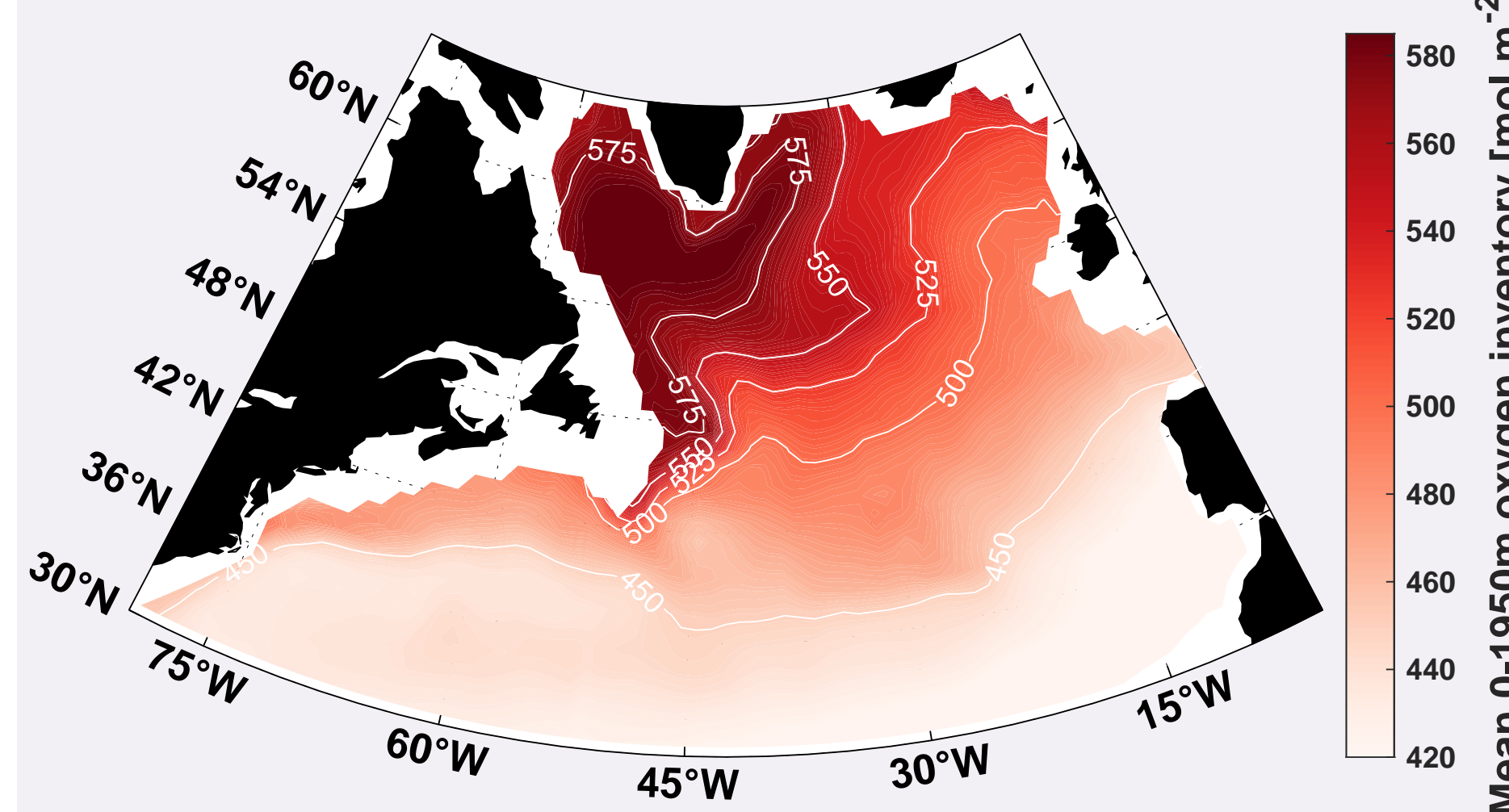


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## Introduction

### Mean oxygen inventory in subpolar North Atlantic



- Subpolar North Atlantic (SPNA) is a key area for ventilating the deep ocean
- Linked to Atlantic Meridional Overturning Circulation (AMOC) - northward-flowing surface waters are transformed into North Atlantic Deep Water (NADW), return equatorward at depth
- Previous work on ventilation has been focused on main deep water formation regions: Irminger and Labrador Sea

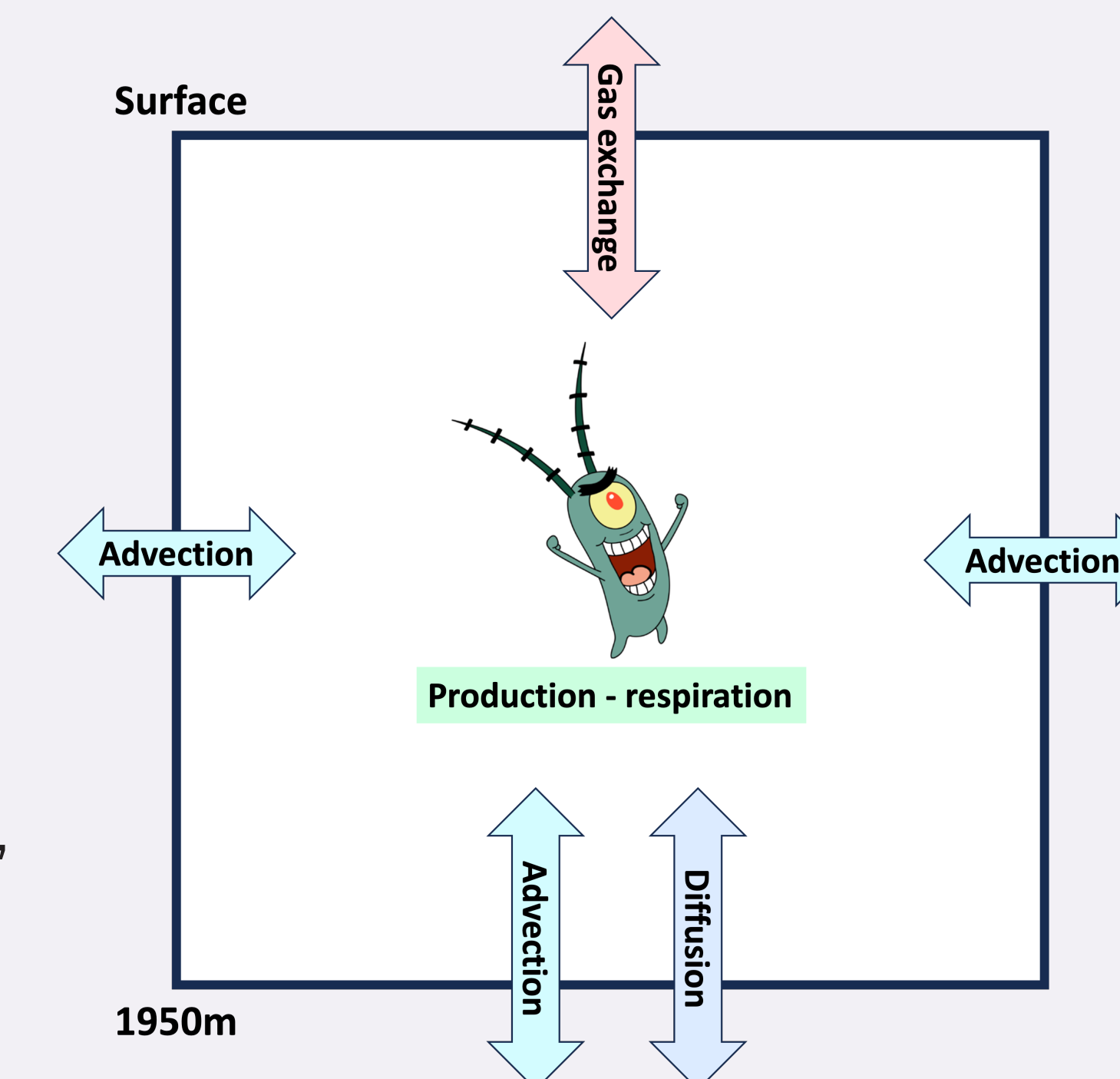
**Goal of this work: investigate patterns and magnitude of ventilation for the whole Subpolar North Atlantic**

## Methods

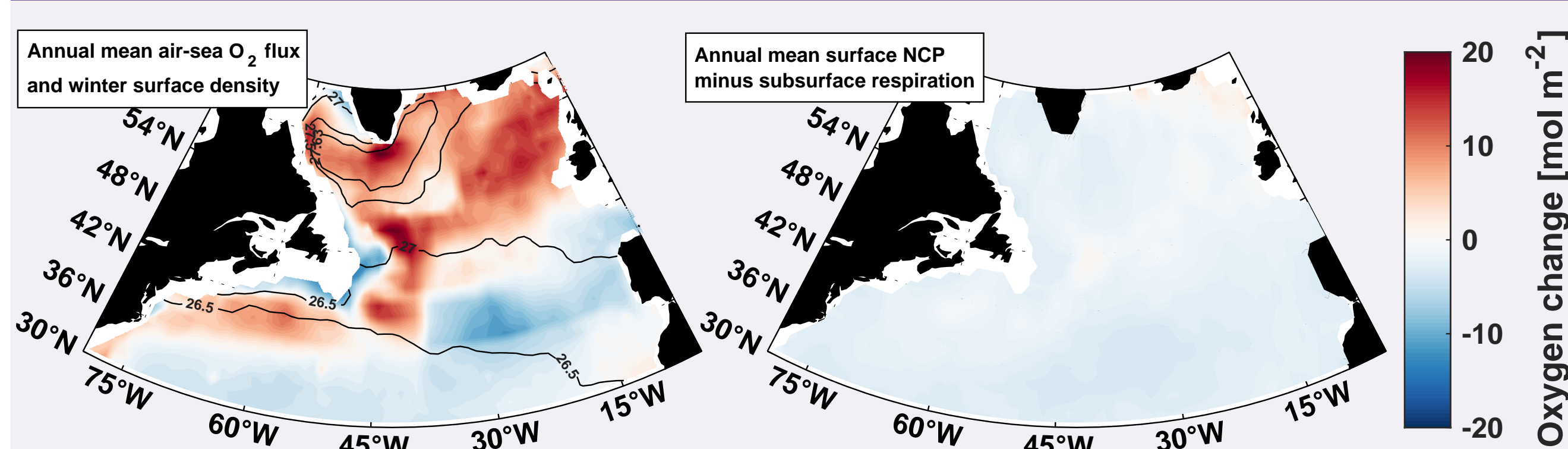
- Use GOBAI-O2 (Sharp et al., 2023): global, depth-resolved, monthly maps of oxygen concentration based on BGC-Argo and GLODAP
- Construct oxygen budget for 0-1950m at each grid point:

$$\frac{d}{dt} O_2 inv = \text{Gas exchange} + \text{Biology} + \text{Physics}$$

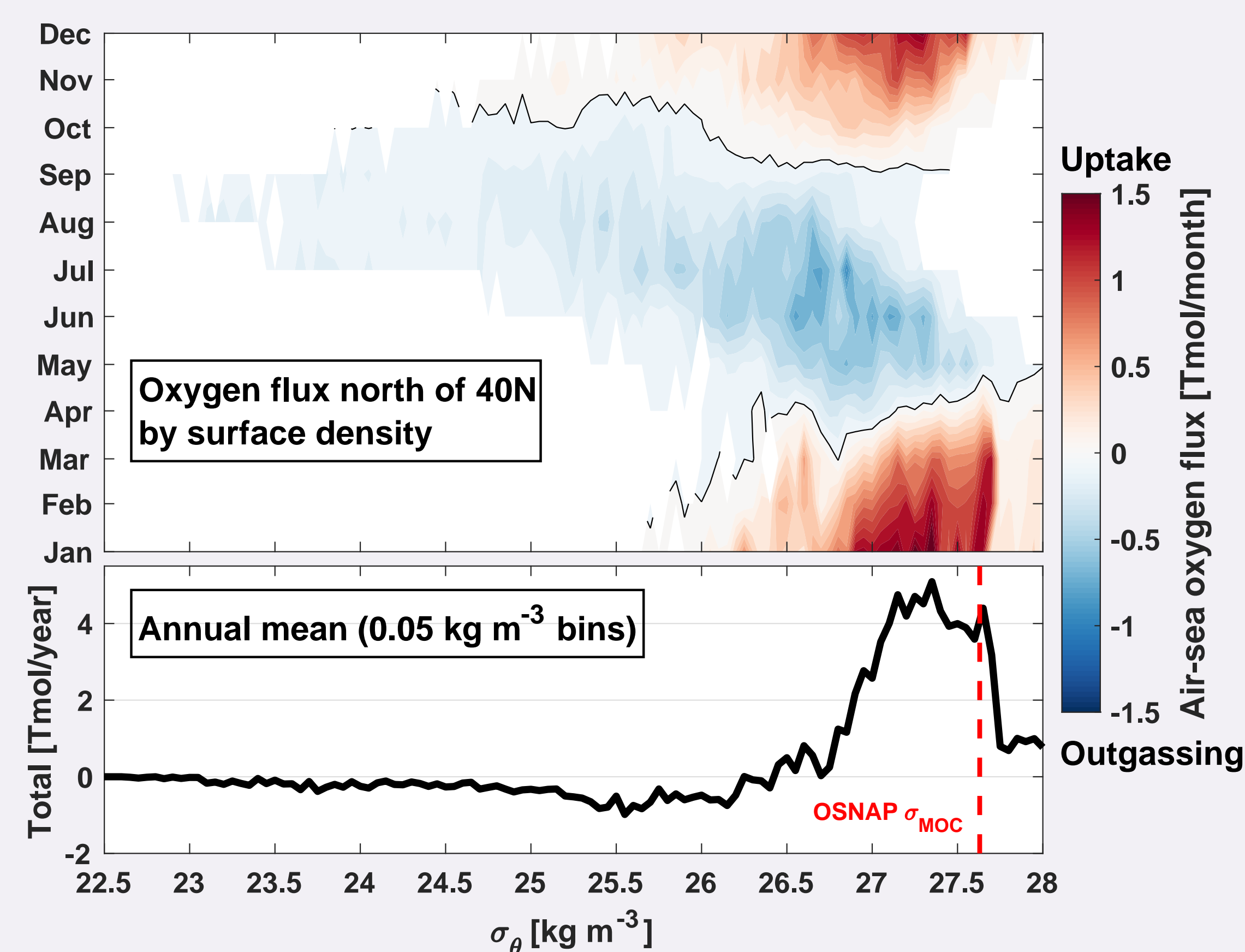
- When integrated over mean seasonal cycle,  $\frac{d}{dt} O_2 inv = 0$
- Gas exchange parameterized using Liang et al. (2013), with bubble parameters adjusted by  $\beta = 1.5$
- Biology: Mixed layer NCP from MOBO-DIC (provided by M. Cornec), assume mean respiration below
- Estimate physics as residual between other terms



## Air-Sea gas exchange and biology



- Air-sea gas exchange dominates relative to biological activity
- Most uptake occurs upstream of the traditional "ventilation regions"
- Net uptake for  $\sigma_\theta > 26.5$  of 72.9 Tmol; 60.2 Tmol (83%) at densities corresponding to the upper branch of the AMOC ( $\sigma_\theta < 27.63$ )

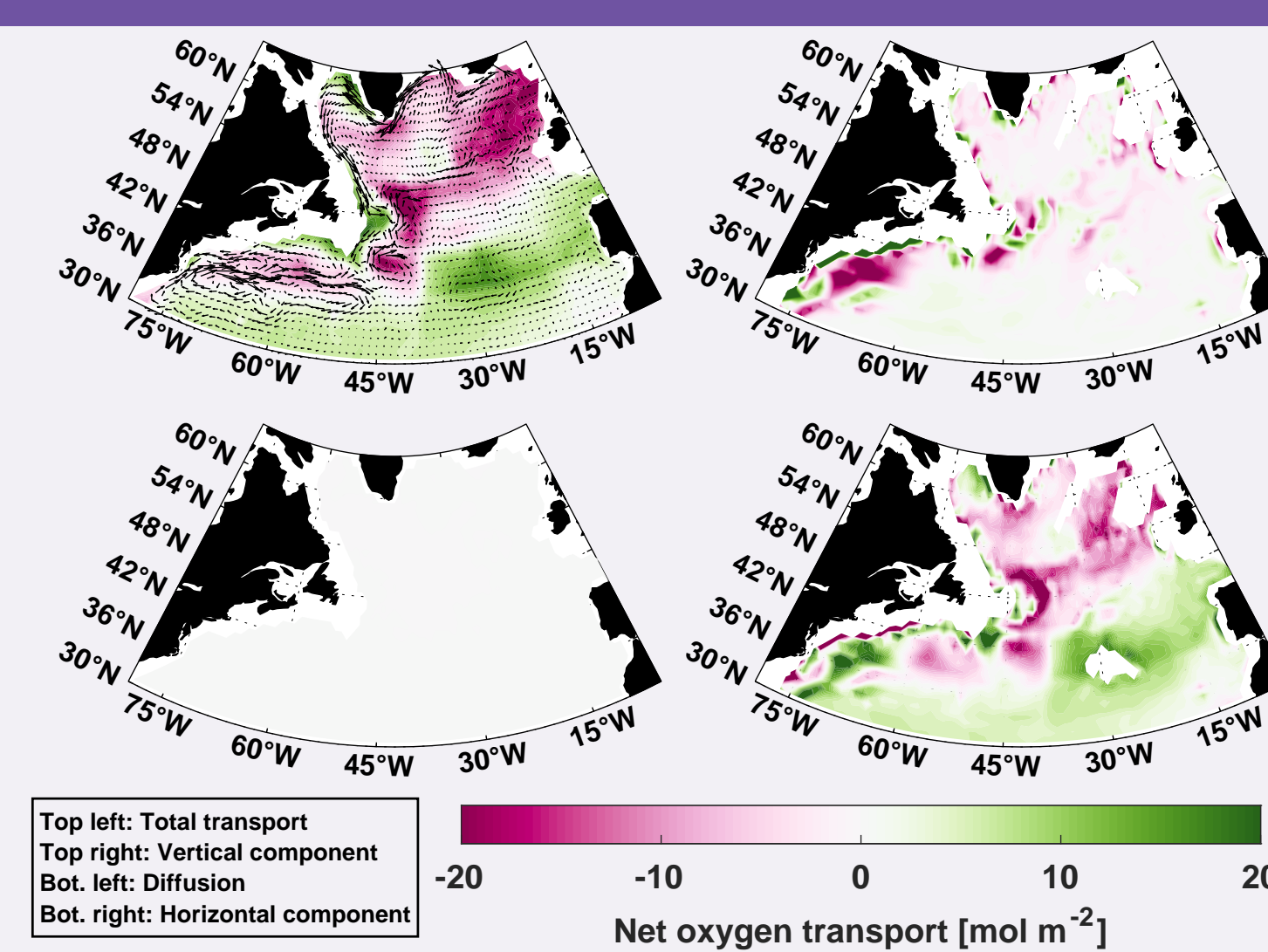


**Most oxygen uptake in SPNA occurs in upper AMOC limb**

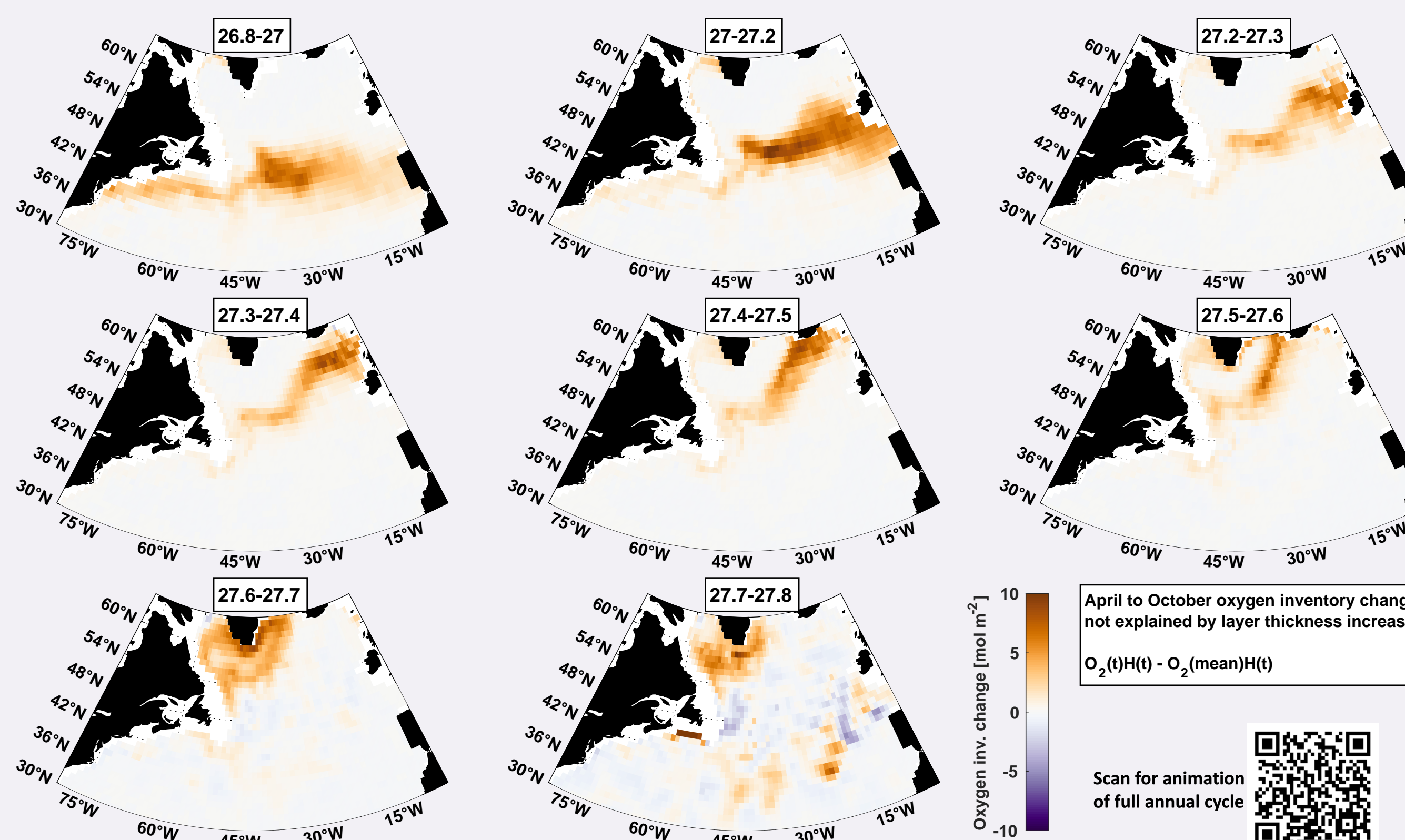
## Oxygen transport and inventory change

- "Physics" can be further separated into horizontal and vertical advection, and diffusion:

$$\int^z \vec{u}_H \cdot \nabla O_2 + \int^z w \frac{\partial O_2}{\partial z} - \kappa_z \frac{dO_2}{dz}$$



- Net oxygen uptake is balanced by physical export, mostly through horizontal advection; high export areas align with ocean circulation
- Oct-Apr  $O_2$  inventory increase in regions of mode and deep water formation; matches areas of strong uptake

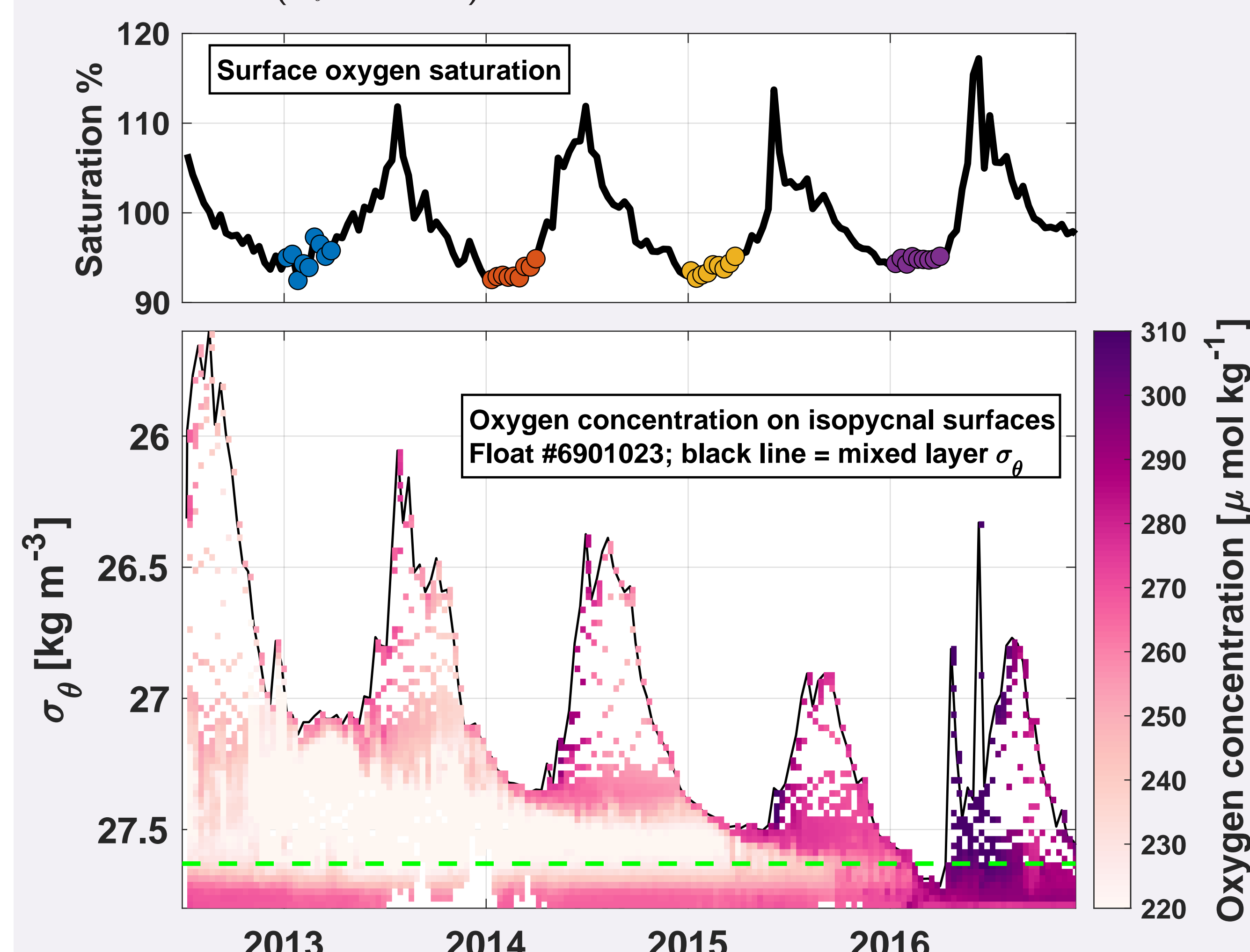


**Ventilation of mode/deep waters in winter**

## Oxygen changes following Argo float trajectory

- AMOC pathways connect eastern and western SPNA; example from Argo float following this pathway
- Winter mixed layer undersaturated in  $O_2$  due to mixing and cooling

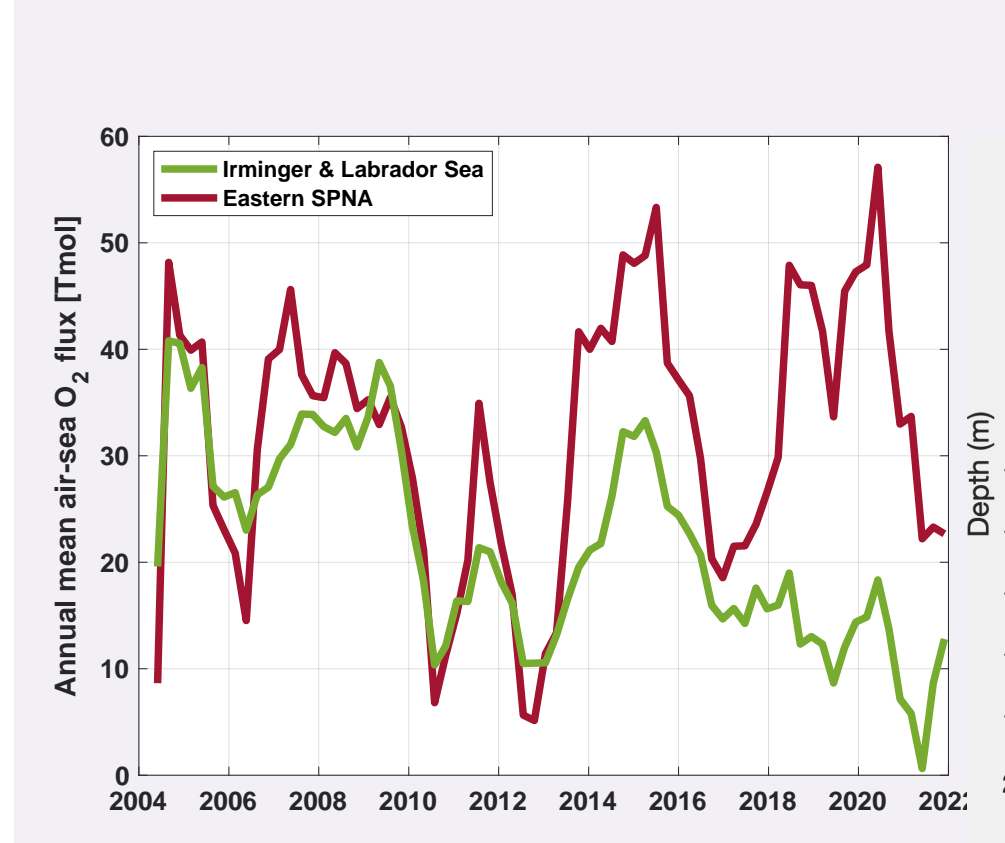
- Ventilation is evident in winter by increasing  $O_2$  at lowest density
- Each year, previously formed mode water is progressively modified, increasing oxygen and density
- In 2016, the mode water ( $\sigma_\theta < 27.63$ ) is further modified into Labrador Sea Water ( $\sigma_\theta \approx 27.72$ )



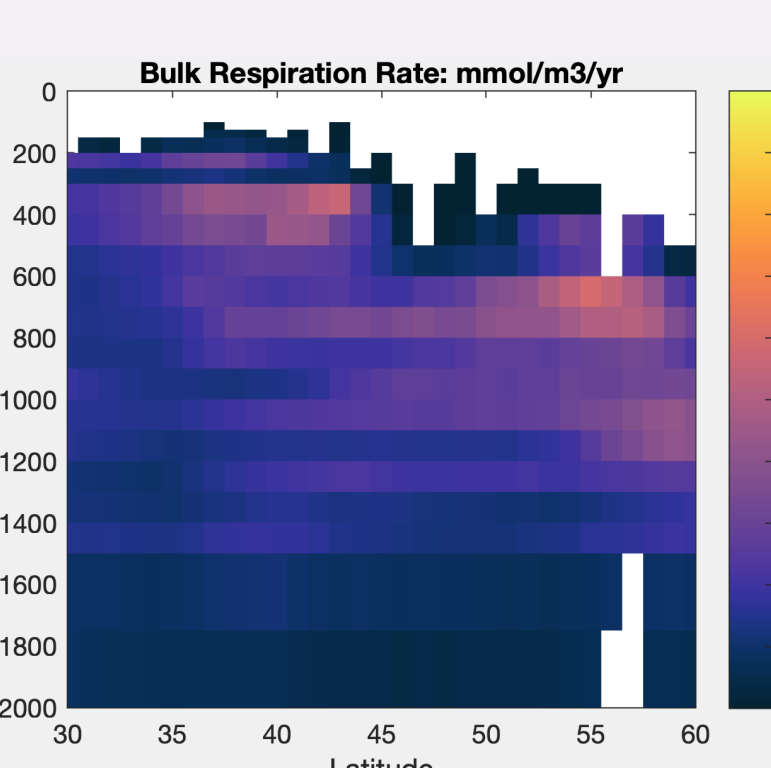
**$O_2$  taken up accumulates along AMOC pathway**

## Future Work

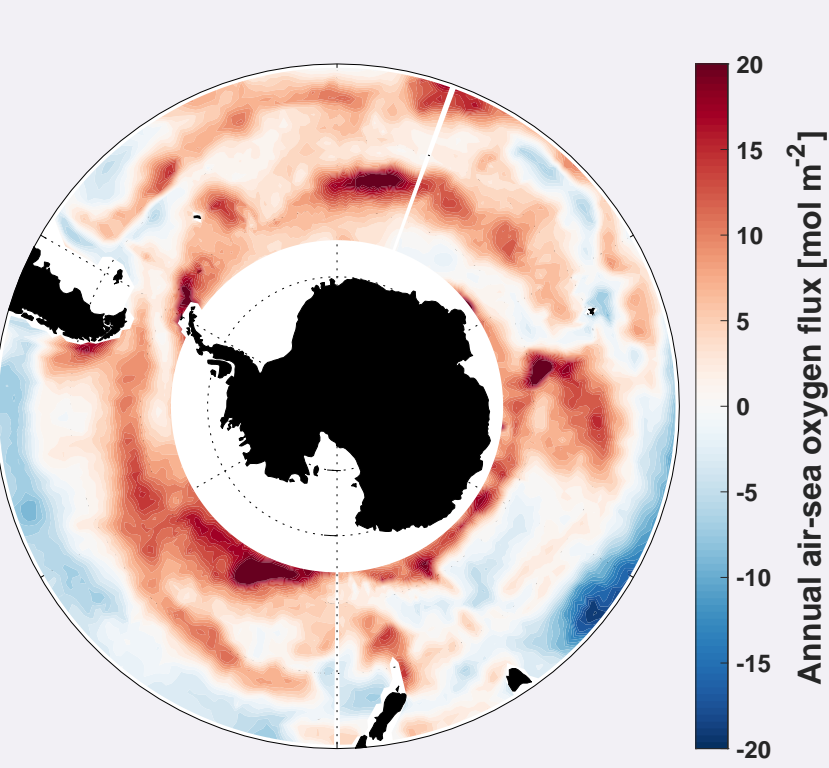
### Interannual variability



### Improve representation of "biology"



### Southern Ocean ventilation



## Take-Home Message

Northward-flowing AMOC waters are **progressively ventilated** with oxygen in the SPNA **before** being transformed into deep waters and returning south

