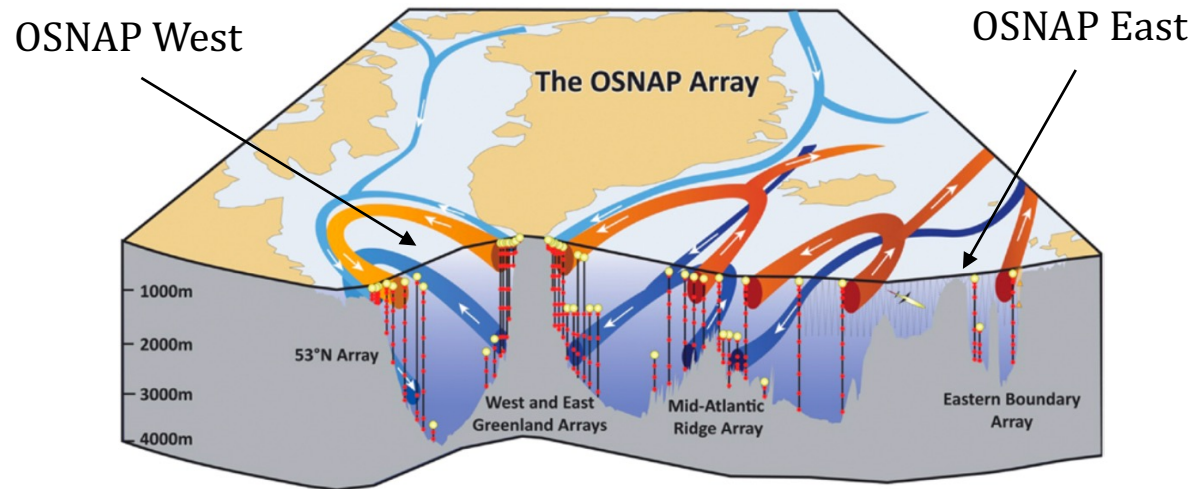
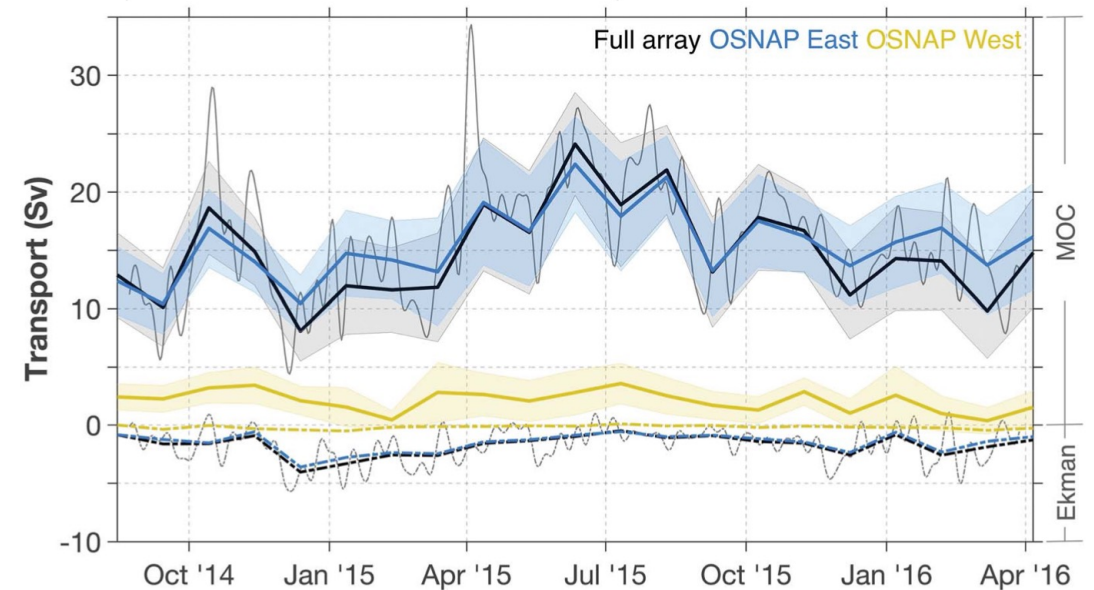


# Role of surface density and air-sea fluxes on the production of deep waters in the eastern subpolar gyre

Tillys Petit, M. Susan Lozier, Simon A. Josey and Stuart A. Cunningham

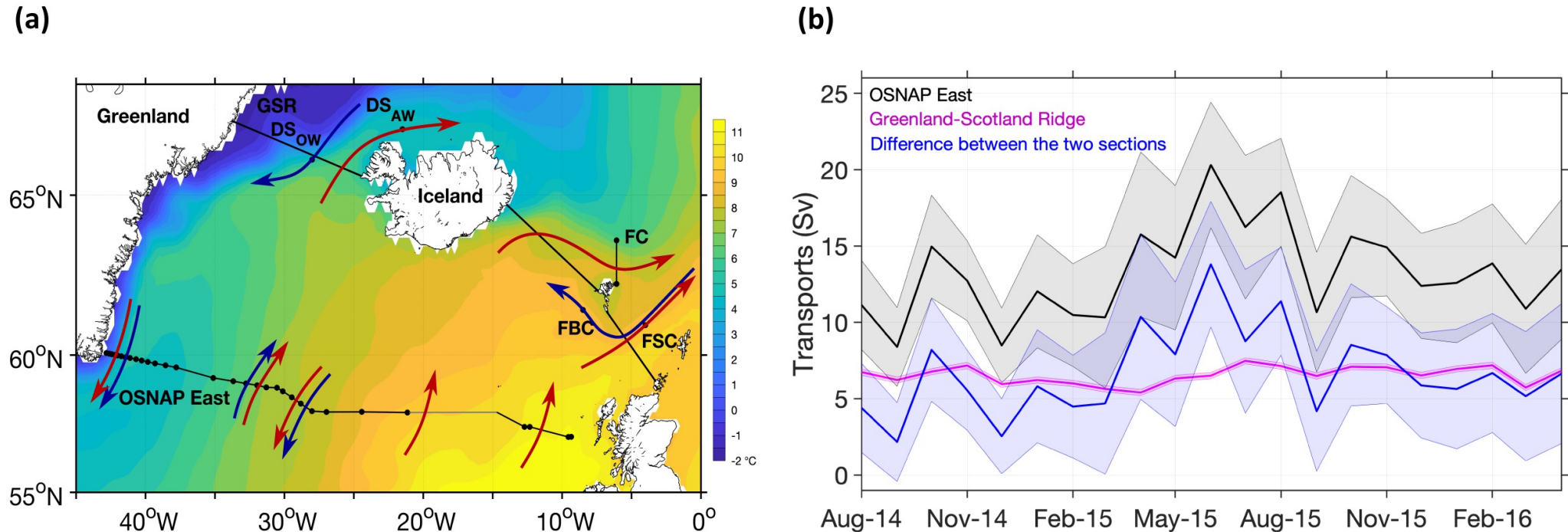


Lozier et al. (2017)



Lozier et al. (2019)

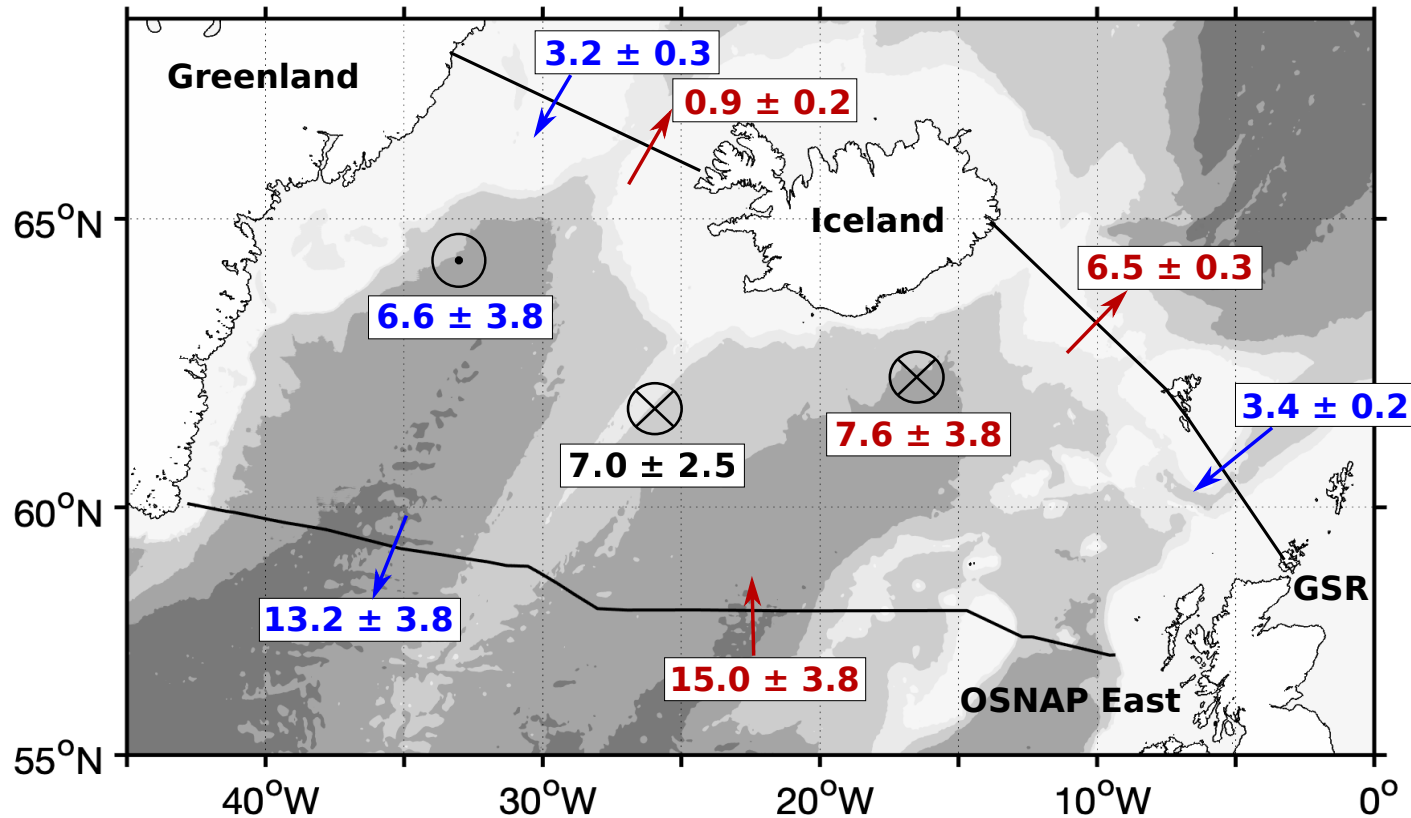
# What mechanism is responsible for producing deep waters in the eastern subpolar North Atlantic ?



Petit et al. (2020)

Strong and variable overturning is observed in the Irminger and Iceland basins in comparison to the overflow transports at the Greenland-Scotland Ridge

# Atlantic Subpolar Gyre deep water is formed primarily in the Irminger and Iceland basins by local buoyancy forcing



Petit et al. (2020)

The **transformation** at the AMOC isopycnal matches remarkably well with our two estimations of overturning for the **Upper Layer** and **Lower Layer**

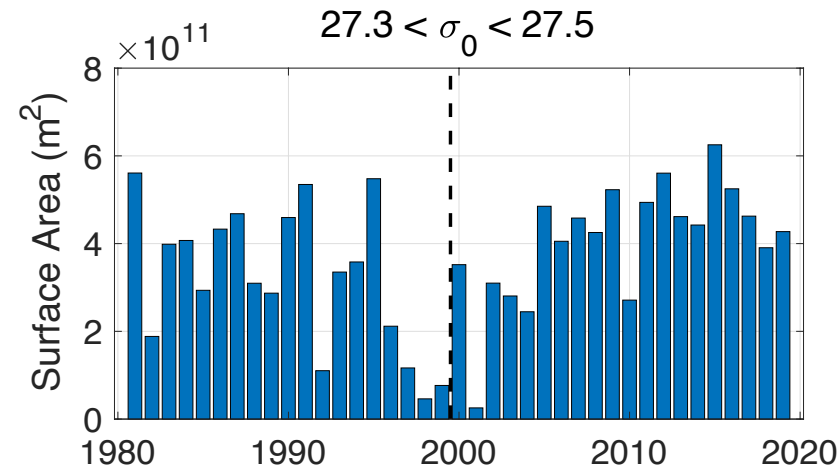
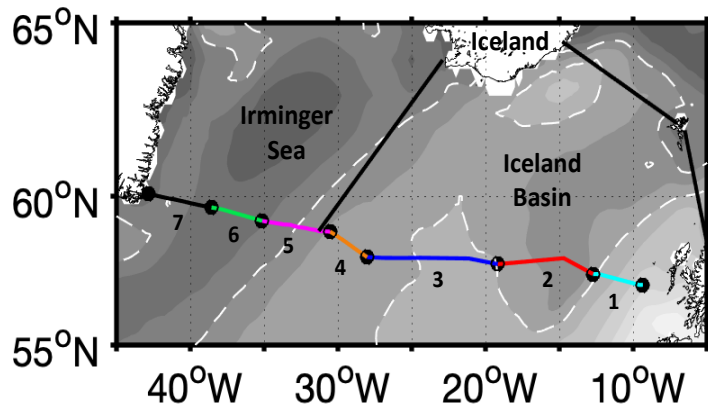
**What drives the strength and spatial pattern of the variance in transformation?**

# Highly variable surface area of SPMW over 40 years

Two variables are key to transformation estimates: the air-sea fluxes ( $Q, E, P$ ) and the surface densities ( $\sigma$ )

$$F(\sigma^*) = \frac{1}{\Delta\sigma} \iint \left[ -\frac{\alpha}{C_P} Q + \beta \frac{S}{1-S} (E - P) \right] \Pi(\sigma) dx dy$$

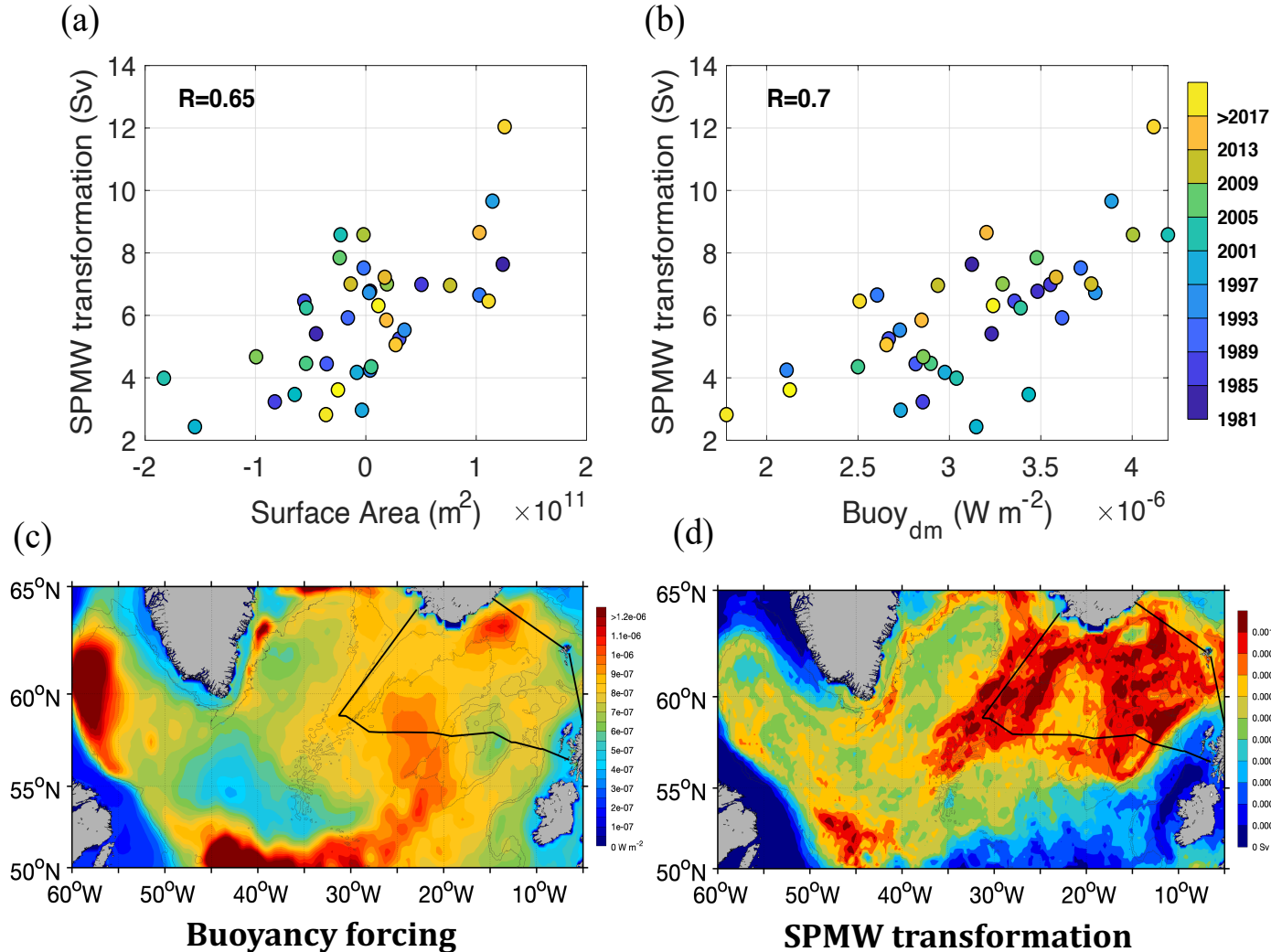
$$\Pi(\sigma) = \begin{cases} 1 & \text{for } |\sigma - \sigma^*| \leq \frac{\Delta\sigma}{2} \\ 0 & \text{elsewhere} \end{cases}$$



For  $\Delta\sigma = 27.3-27.5 \text{ kg m}^{-3}$

- Mean surface area of  $3.67 \cdot 10^{11} \text{ m}^2$
- Standard dev. of  $1.53 \cdot 10^{11} \text{ m}^2$

# Do air-sea fluxes play a major role in determining the strength and spatial pattern of the transformation?

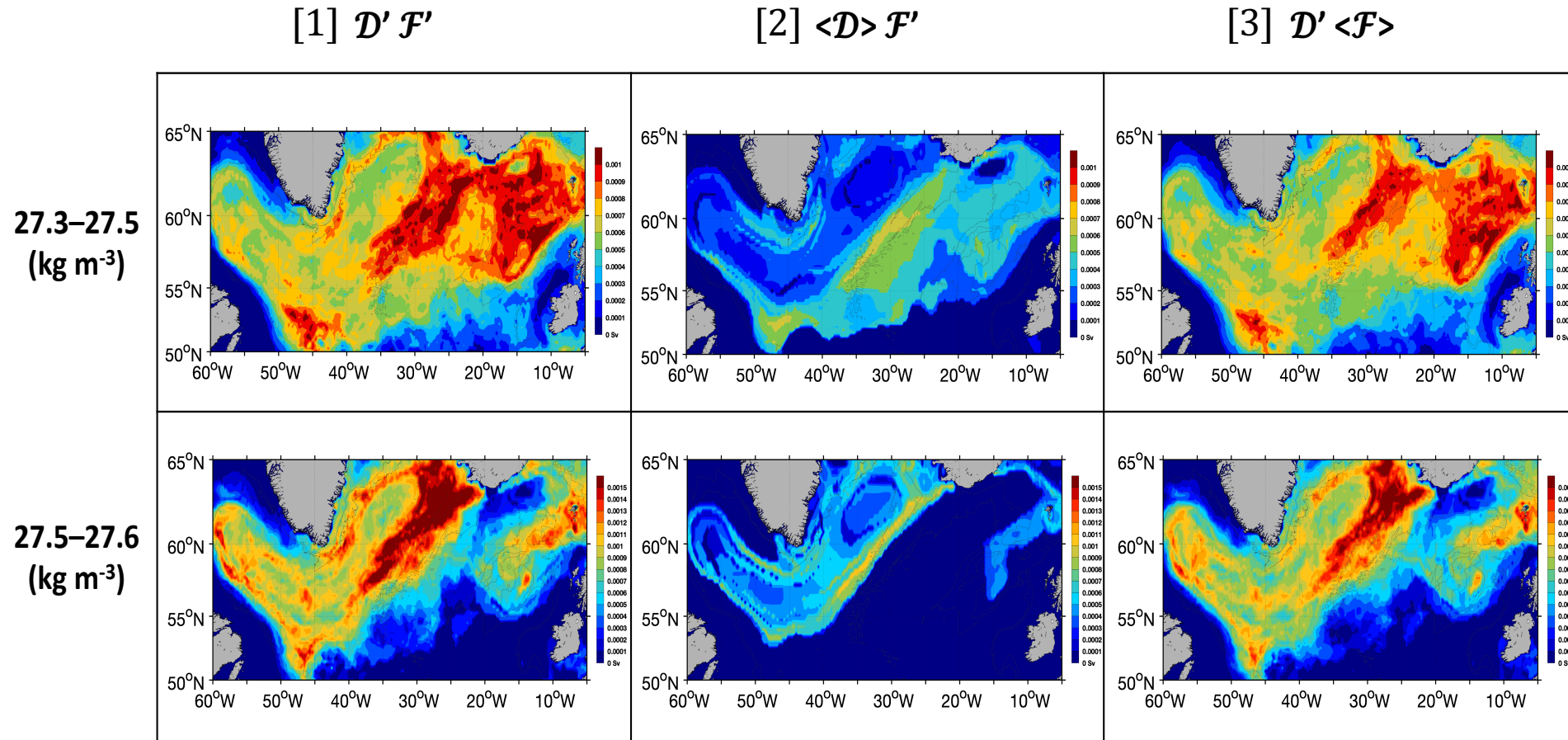


➤ The buoyancy flux and the surface area are both strongly related to the SPMW transformation over the Iceland Basin;

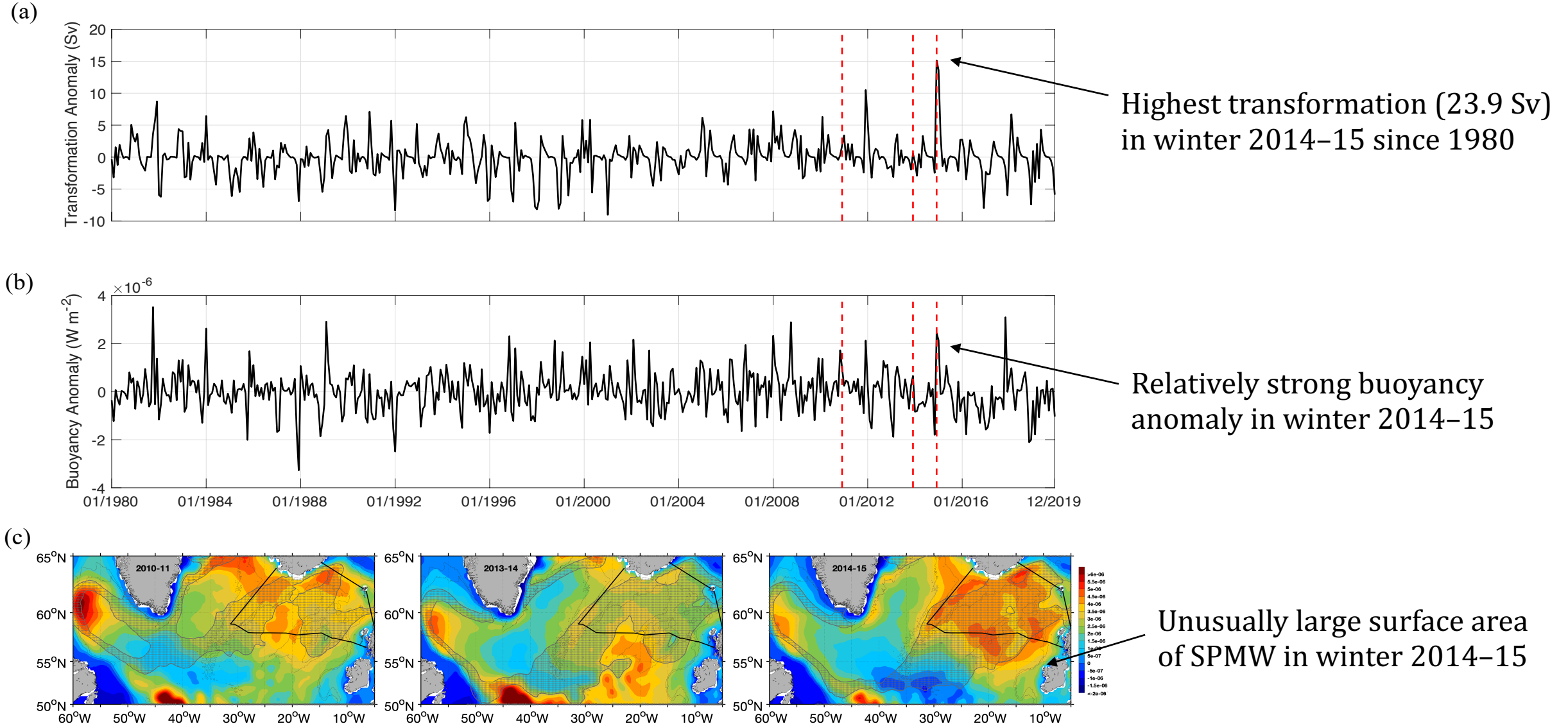
➤ However, the spatial distribution of the variance in buoyancy flux does not match the variance in SPMW transformation.

# The variance in SPMW transformation is primarily driven by the surface density

The variance in SPMW transformation are estimated with [1] variable surface density ( $\mathcal{D}$ ) and air-sea fluxes ( $\mathcal{F}$ ); [2] climatological surface density and variable air-sea fluxes; [3] variable surface density and climatological air-sea fluxes



# Unusually large SPMW transformation in winter 2014–2015



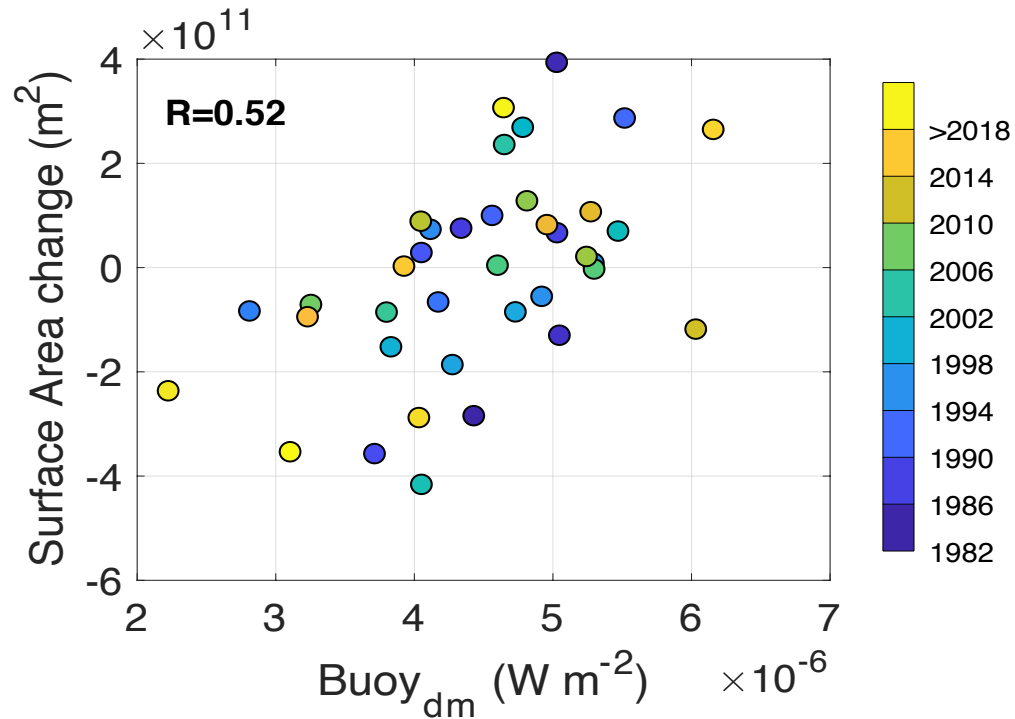
# Unexpected key role of the surface density on the overturning variability over the eastern subpolar gyre

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- The interannual variability of this transformation is largely driven by the variance in the surface density, as expressed by the outcropping area for the associated isopycnals;
- Unusual conditions in both air-sea fluxes and surface area of SPMW during winter 2014–2015 induced the largest SPMW transformation in 40 years

➤ **What sets the surface density over the Iceland Basin ?**

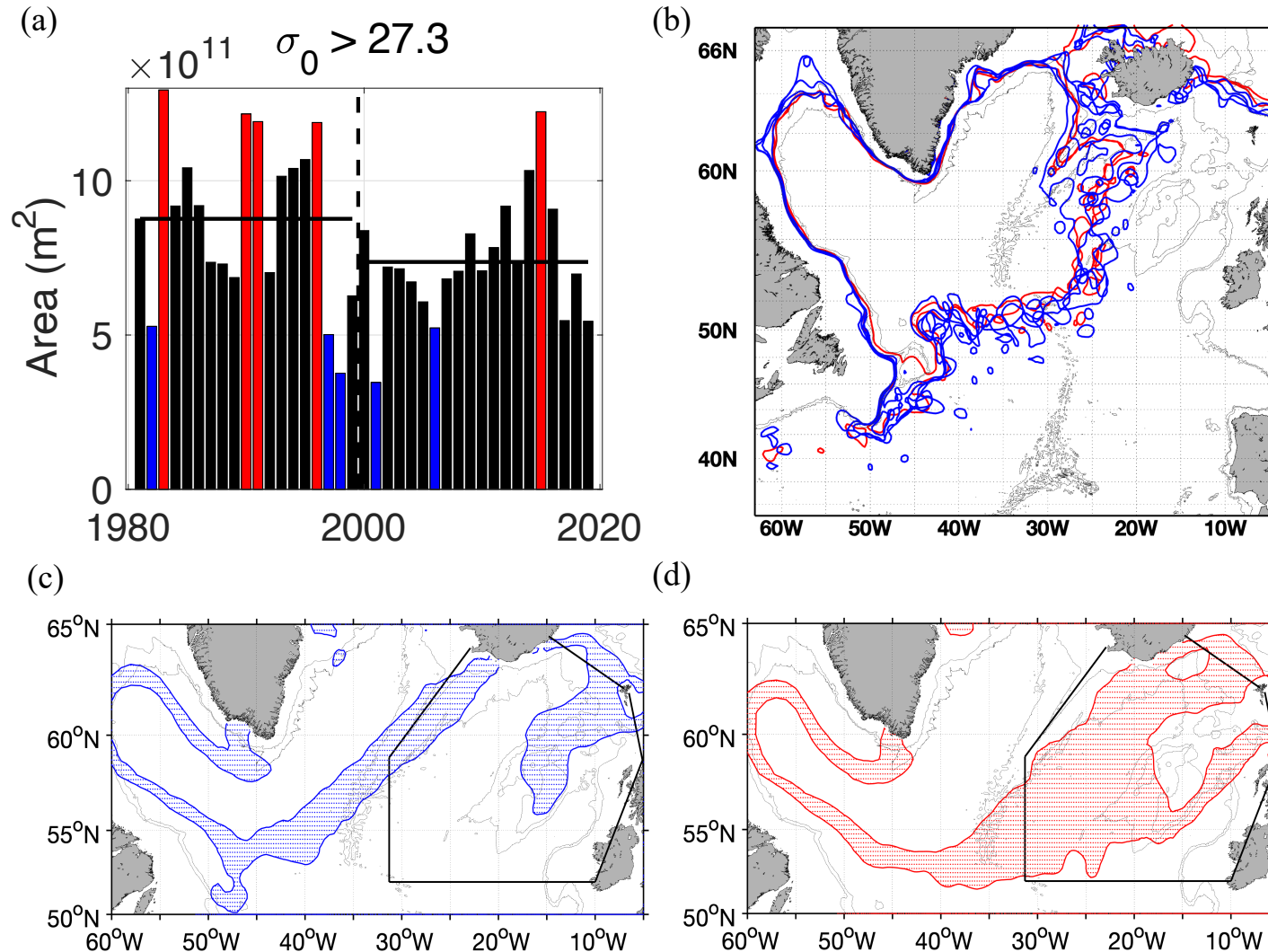
# What sets the surface density over the Iceland Basin?



The air-sea fluxes explain only ~30% of the surface density change in winter over the Iceland Basin

- The rest of the ~70% reflects other mechanisms that can impact the surface density, including changes in ocean circulation and wind-driven upwelling

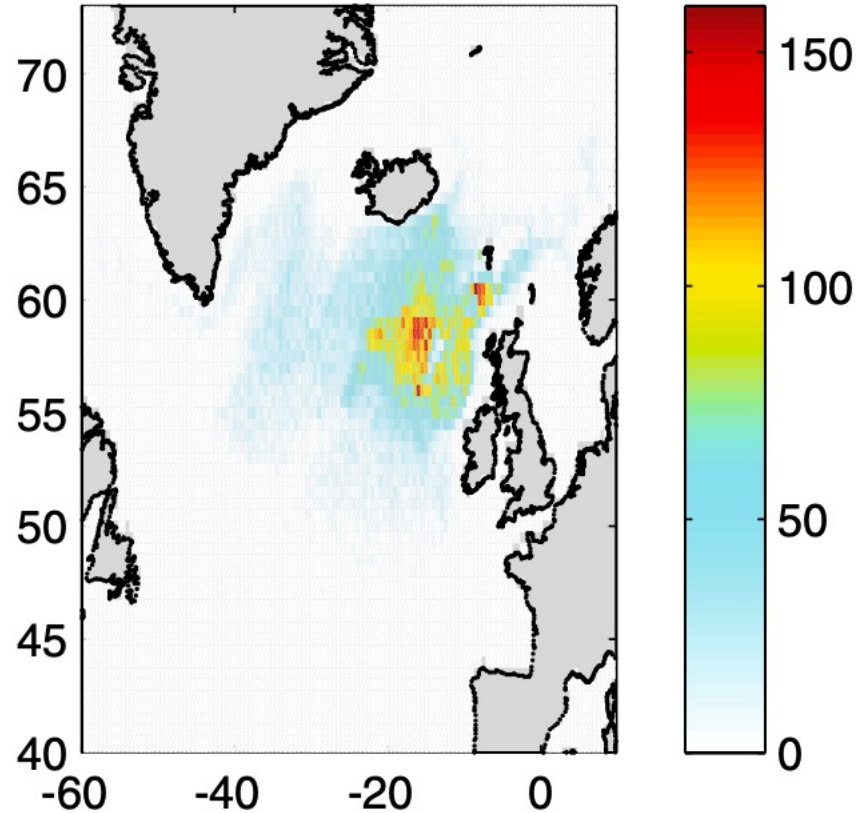
# What sets the surface density over the Iceland Basin?



- The source area is mainly localized over the Reykjanes Ridge and the Rockall Plateau during “small” winters;
  - The isopycnal 27.3  $\text{kg m}^{-3}$  shifts north of the Charlie-Gibbs Fracture Zone during “small” winters;
- “small” or “large” surface areas cannot be attributed to specific positions of the gyre

# What sets the surface density over the Iceland Basin?

(c) Distribution of reemerging particles



Grist et al. (2016)

Grist et al. (2016) analyzed the long-term impacts of anomalous SPMW formation on regional climate and found that some of it will undergo reemergence the following autumn/winter