

# Direct and indirect pathways of convected water masses and their impacts on the overturning dynamics of the Labrador Sea

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Utrecht University



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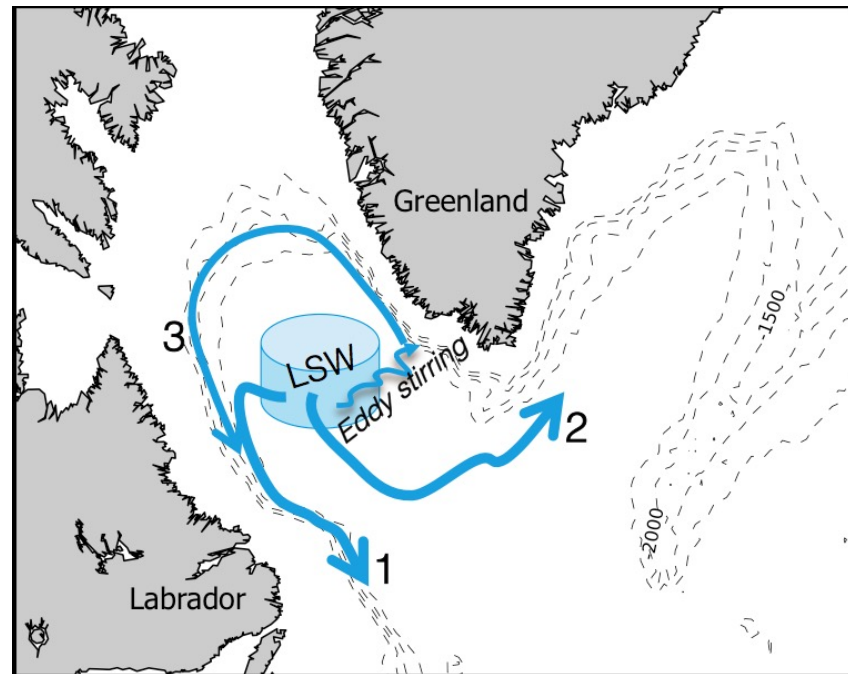


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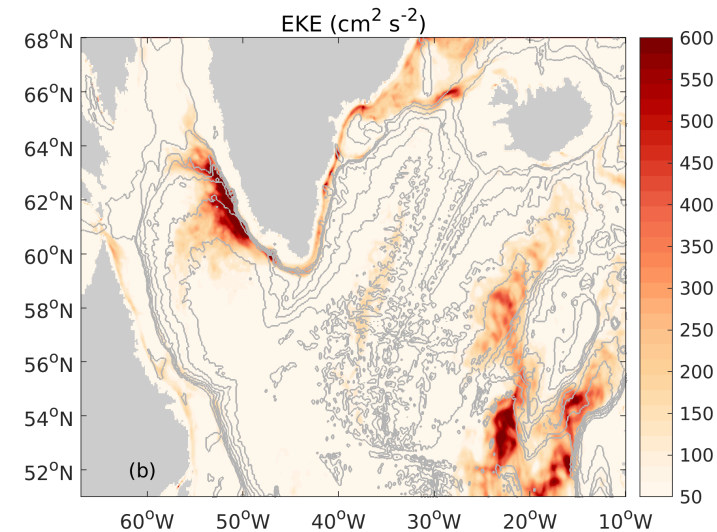
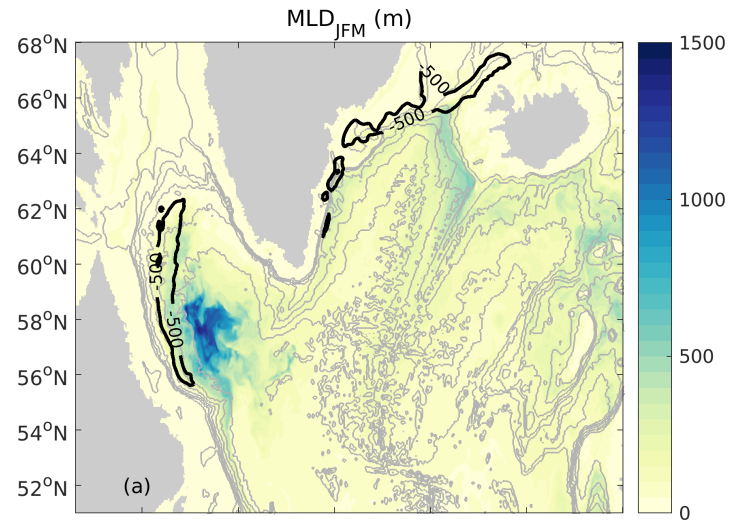
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Investigate the relative importance of the export routes of the convected water masses that might result in a complex relation between their formation and their export timescales, and the AMOC variability.

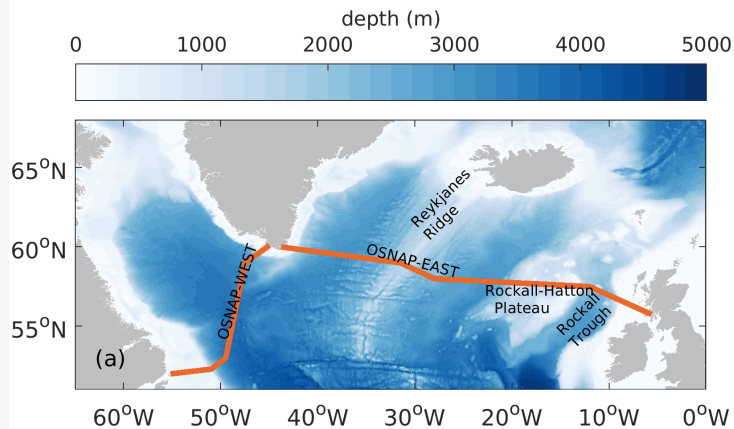


# 3 Modular Ocean Model (MOM)

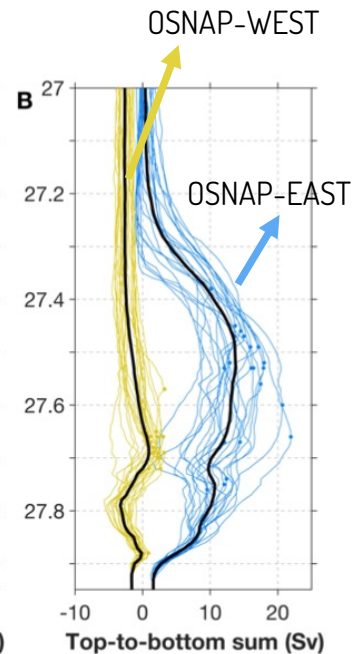
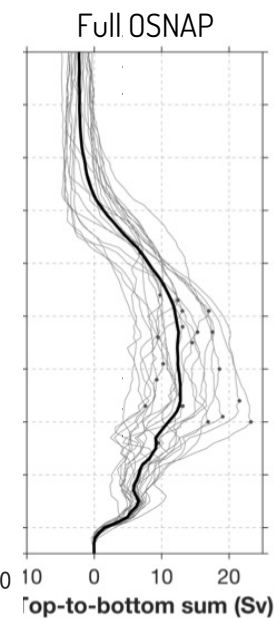
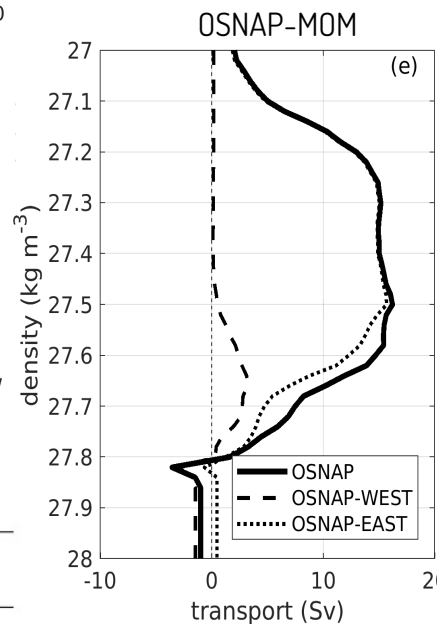
- ▶ global ocean-ice model (Spence et al., 2017)
- ▶  $0.1^\circ$  horizontal resolution
- ▶ 50 vertical layers
- ▶ normal year forcing (CORE-II)
- ▶ coupled sea-ice model



# Model performance: OSNAP array in MOM

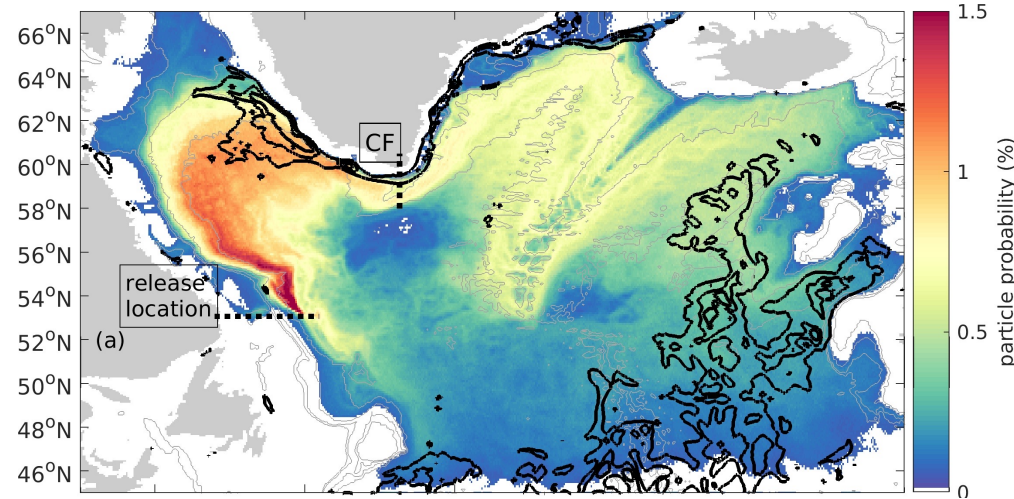


| section     | MOM<br>(Sv) | MOM<br>( $\text{kg m}^{-3}$ ) | observations<br>(Sv) | observations<br>( $\text{kg m}^{-3}$ ) |
|-------------|-------------|-------------------------------|----------------------|----------------------------------------|
| OSNAP array | 16.2        | 27.50                         | 14.9                 | 27.66                                  |
| OSNAP-EAST  | 15.7        | 27.50                         | 15.6                 | 27.53                                  |
| OSNAP-WEST  | 3.2         | 27.66                         | 3.3                  | 27.70                                  |



Lozier et al. (2019)

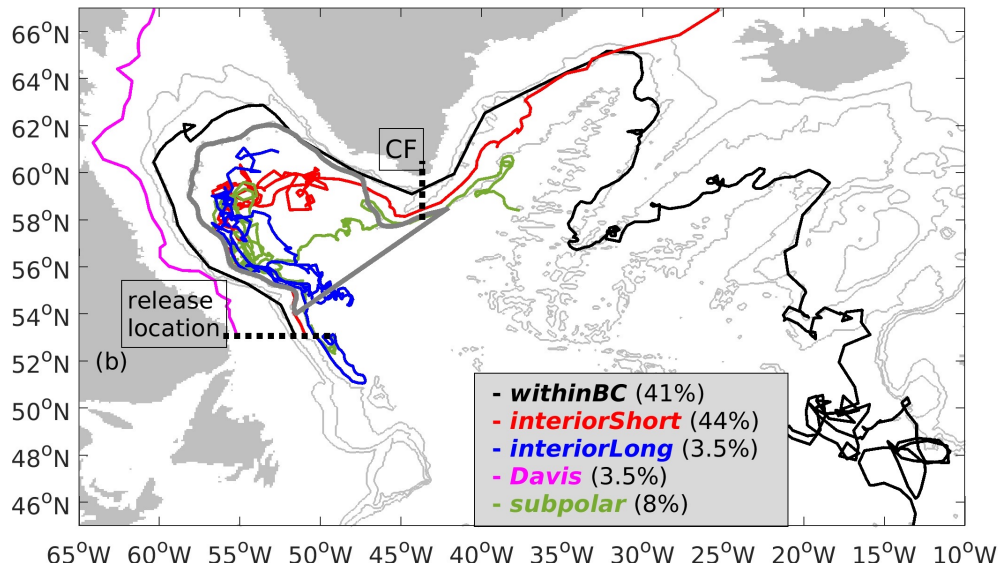
- ▶ Release particles at 53°N over depth
- ▶ Backwards tracking
- ▶ Each particle is tagged with a corresponding transport
- ▶ 6 years advection time
- ▶ Particles are advected offline in 3D velocity fields using the Connectivity Modeling System (CMS, Paris et al., 2013)



- ▶ Categorize particles based on:
  - ▶ the location where they enter in the Labrador Sea
  - ▶ the path they take within the Labrador Sea
- ▶ Focus on: lateral exchanges between boundary current and interior → separation criterion: 3000 m isobath

# Pathways from MOM

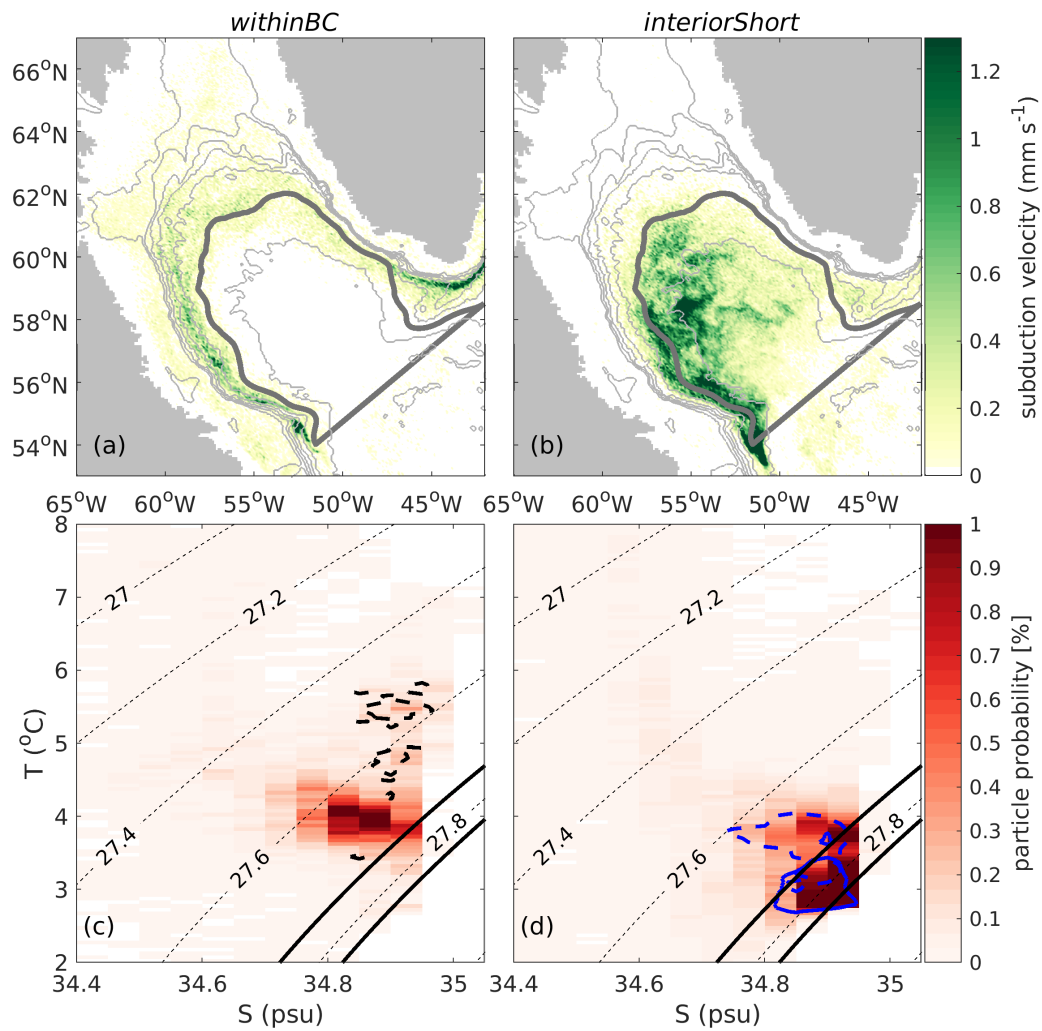
- ▶ *withinLoop* particles: enter through Cape Farewell (CF) & onshore the 3000m isobath (grey contour line):
  - ▶ *withinBC*: stay onshore of 3000m
  - ▶ *interiorShort*: entering the interior
- ▶ *subpolar* particles: enter through Cape Farewell (CF) & offshore the 3000m isobath (grey contour line):
- ▶ *Davis* particles: entering from the Davis Strait
- ▶ *interiorLong* particles: still in the basin after 6 years



# Water mass transformation

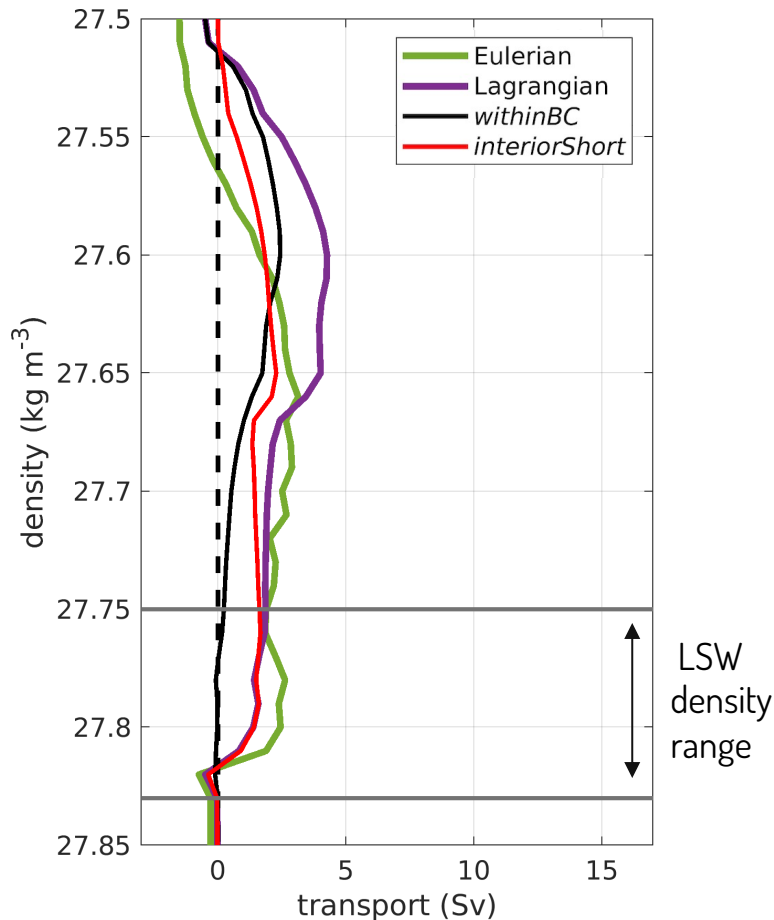
From the total subduction in the Labrador Sea:

- ▶ 46% occurs within the boundary current
- ▶ 54% occurs in the interior of the basin
- ▶ Denser water masses are formed in the interior of the basin



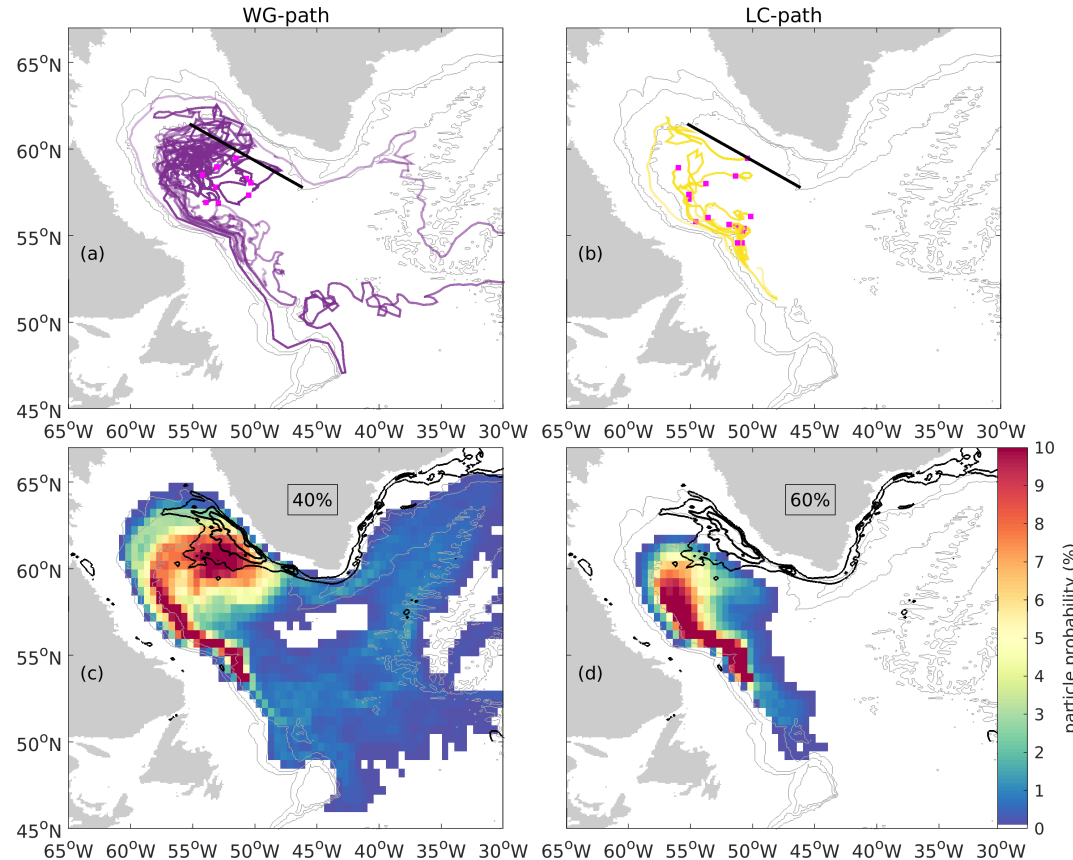
# Overturning in the Labrador Sea (Lagrangian view)

- ▶ Total Lagrangian overturning (purple line)
    - ▶ based on the summed transports carried by the *withinBC* and *interiorShort* particles
    - ▶ 4.3 Sv at  $\sigma=27.60 \text{ kg m}^{-3}$
  - ▶ Only the overturning associated with the *interiorShort* particles (red line) shows significant contributions in the LSW density range
- 
- ▶ Denser waters are formed in the central-LS, whereas convection along the boundary current results in lighter waters



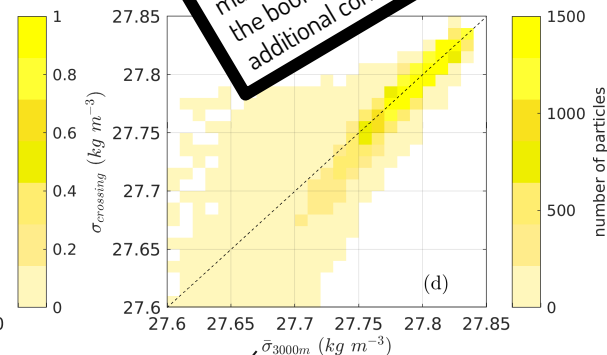
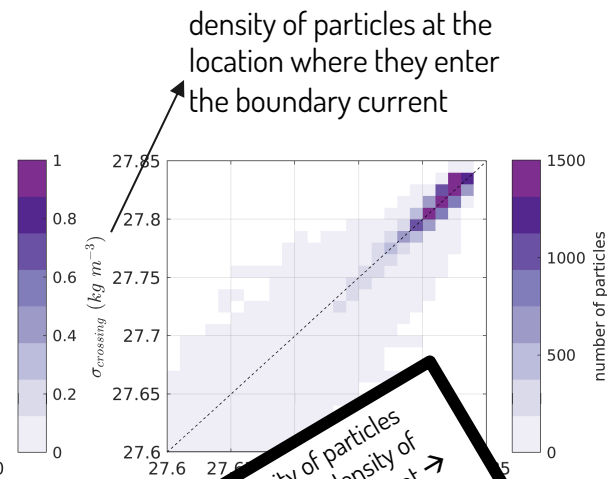
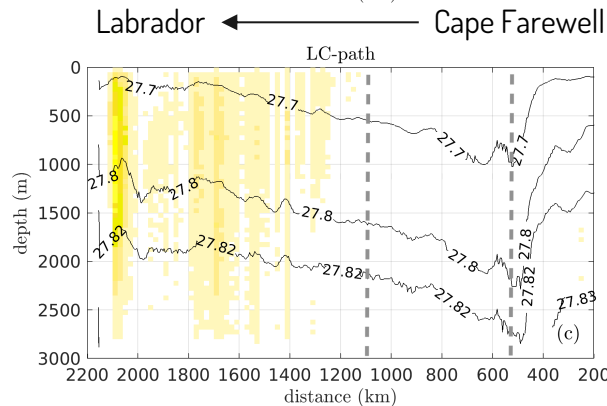
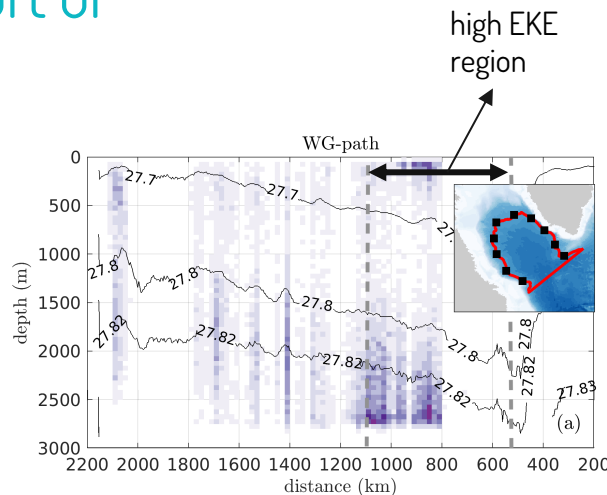
# Pathways of convected water masses

- ▶ Focus on the *interiorShort* particles that subduct in the interior of the basin
- ▶ Pathways after subduction:
  - ▶ **WG-path**: particles that move towards the high EKE region (Northeast of the black line →  $EKE > 200 \text{ cm}^2\text{s}^{-2}$ )
  - ▶ **LG-path**: particles that move towards the Labrador side



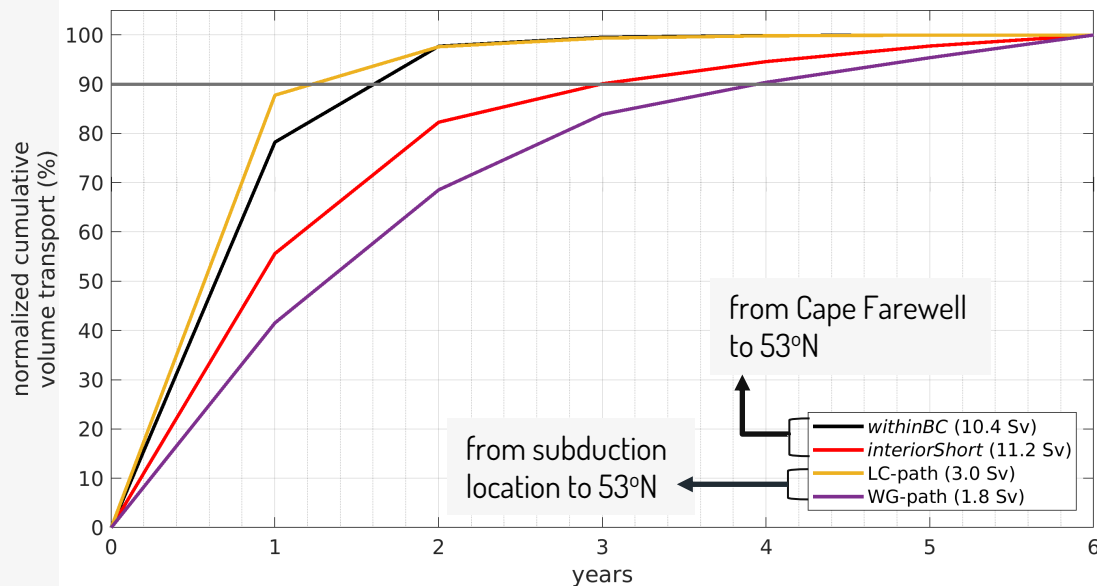
# 3-D view on the export of convected waters

- ▶ Location & depth at which the particles re-enter the boundary current
- ▶ **WG-path** particles:
  - ▶ re-enter at the high EKE region
  - ▶  $\sigma_\theta > 27.82 \text{ kg m}^{-3}$
- ▶ **LG-path** particles:
  - ▶ farther downstream the high EKE region
  - ▶  $\sigma_\theta < 27.82 \text{ kg m}^{-3}$



mean density of the boundary current

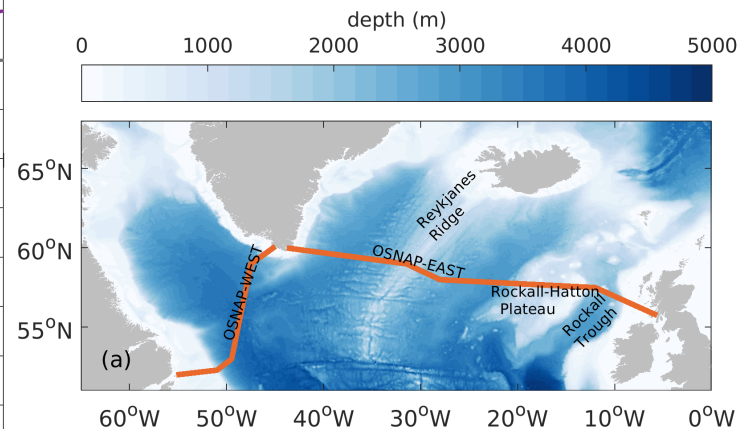
# Export timescales



densest water masses → WG-path  
Export timescales more than 4 years



delayed arrival of the LSW at the sites where the AMOC variability is observed



- ▶ 85% of the total transport carried by the launched particles follow either the boundary current (*withinBC* particles) or a more complex route that involves boundary current-interior exchanges (*interiorShort* particles) from Cape Farewell to 53° N within a 6 year period
- ▶ The denser water masses formed in the central-LS first follow an eddy-driven path towards the West Greenland coast (WG-path), while the lighter water masses that formed in the central-LS and are rapidly exported at the Labrador side (LC-path)
- ▶ Complex three-dimensional view of the LSW export → the interior-boundary current exchanges are crucial for the LSW pathways and export timescales
  - ▶ **The boundary current-interior exchanges should be considered when attempting to find connections between the processes occurring in the Labrador Sea and AMOC variability**

Available for discussion @ live chat on Friday  
30<sup>th</sup> April at 13:00-15:00 CET

OS1.2-The North Atlantic: natural variability and global change

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