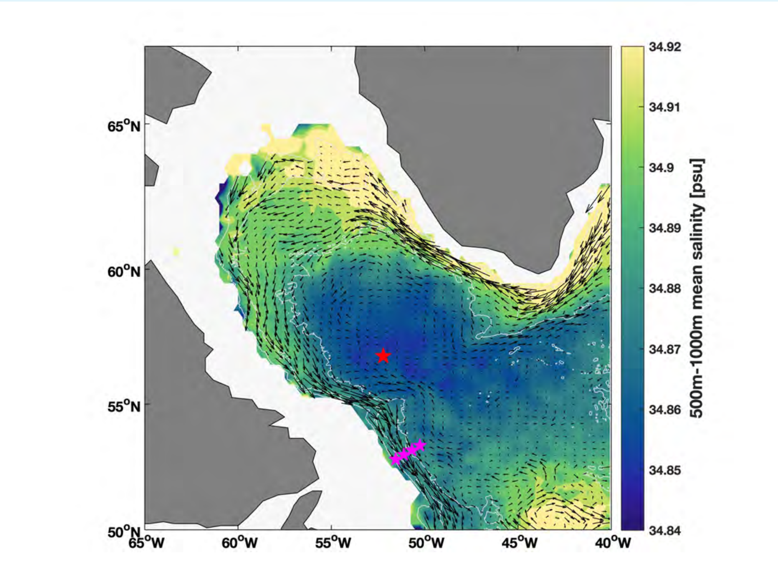
Gateway to the gateway to the Arctic: Oxygen export from the Labrador Sea

Jannes Koelling (j.koelling@dal.ca)

Dalhousie University, Halifax, NS, Canada

Labrador Sea Water (LSW) formation and ventilation



Salinity at 500-1000m depths, with mooring locations of 53N array (magenta) and SeaCycler (red)

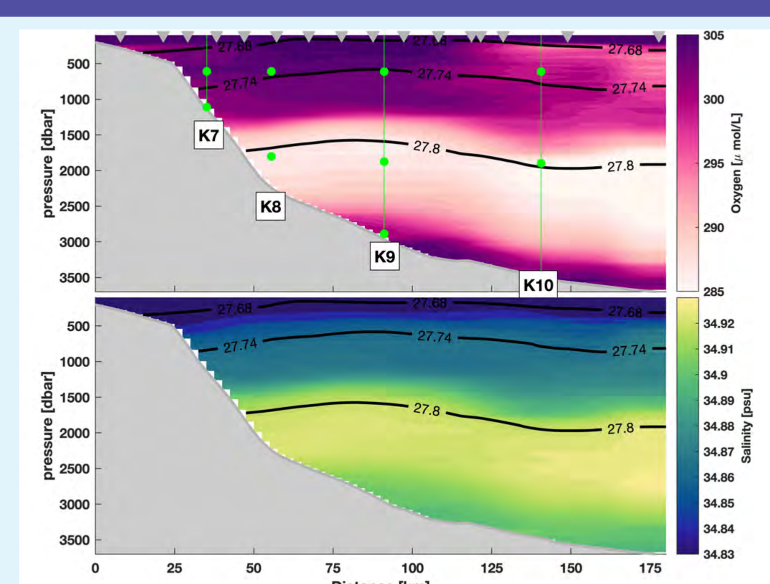
- Labrador Sea Water (LSW) formed by deep convection up to 2000 m during winter
- Intense oxygen uptake due to mixing with deep undersaturated water masses
- Southward export of LSW in the boundary current

"Final stop" for water masses modified in the SPNA

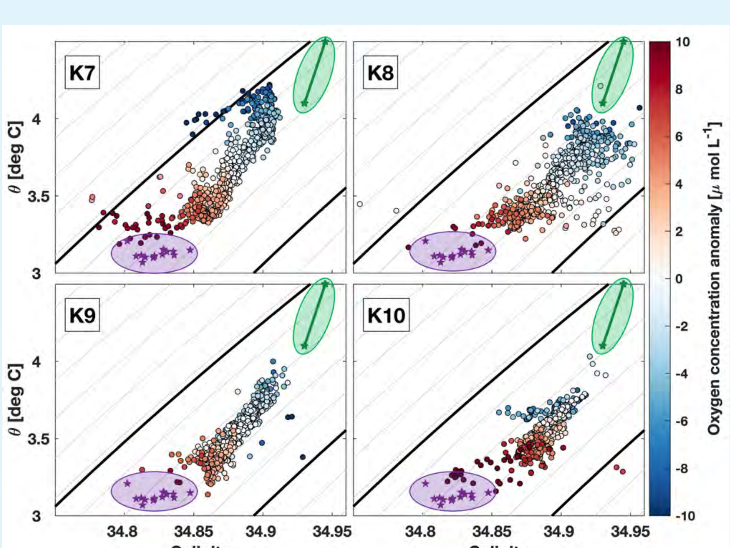
The 53N array

- Mooring array deployed at exit of the Labrador Sea
- Primarily measures strength of the boundary current, in operation since 1990s
- Oxygen sensors added in 2016 to study O2 export

First time series of oxygen concentrations in Labrador Sea outflow



Water mass changes

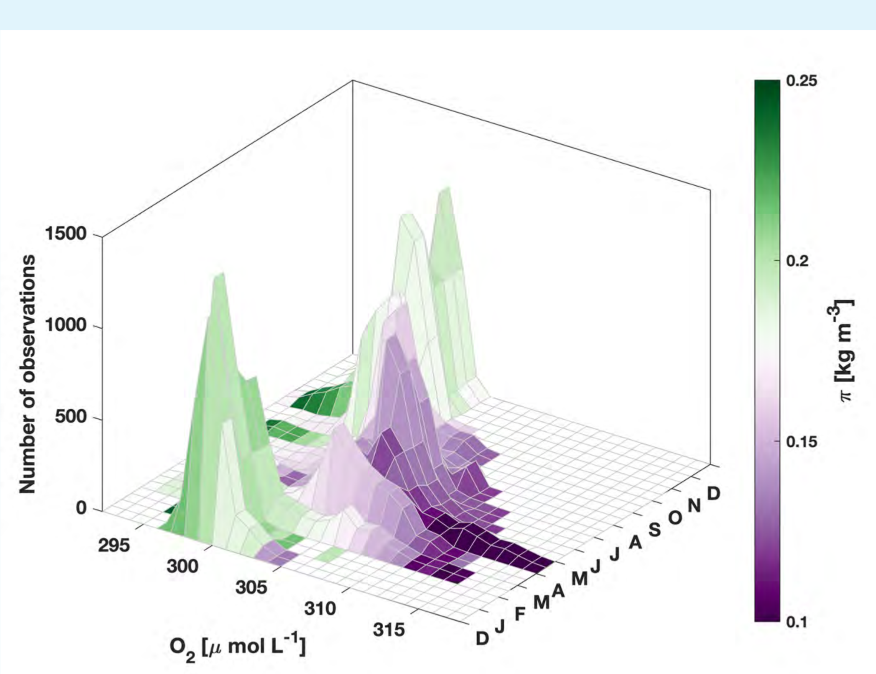


T/S plot at the four mooring locations. Colors show O2 anomaly. Purple (LSW) and green (IW) colors show typical water mass properties in the region

- Properties at the mooring locations lie along mixing line of LSW (purple) and Irminger Water (IW, green)
- T/S values closer to LSW are associated with higher oxygen concentration

O2 linked to T and S

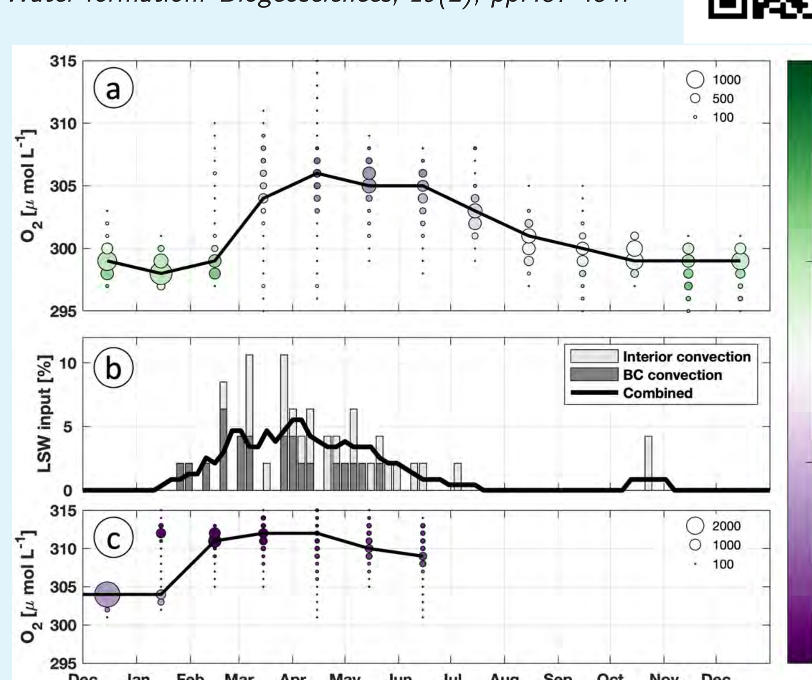
Annual cycle of oxygen



Annual cycle of oxygen concentration, color shows water masses, LSW (purple) and IW (green)

- Oxygen increases by almost 10 μM during April–September
- Changes associated with water masses; switch from predominantly IW to LSW

Koelling, J., Atamanchuk, D., Karstensen, J., Handmann, P. and Wallace, D.W., 2022. Oxygen export to the deep ocean following Labrador Sea Water formation. Biogeosciences, 19(2), pp.437-454.

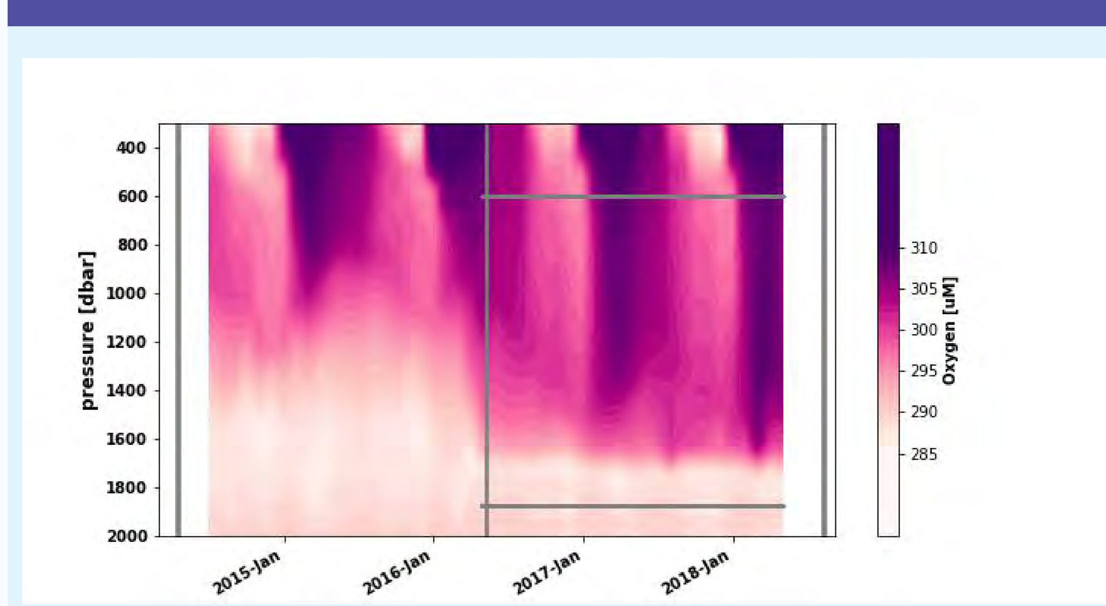


Annual O2 cycle at K9 (top) and interior (bottom), and LSW input (middle)

- Arrival of LSW preceded by increased input of LSW (estimated from Argo) and increased O2 in interior
- Suggests that the increase is caused by export of newly ventilated LSW
- Associated increase in oxygen transport estimated as 1.6 Tmol

Enhanced oxygen export due to LSW input

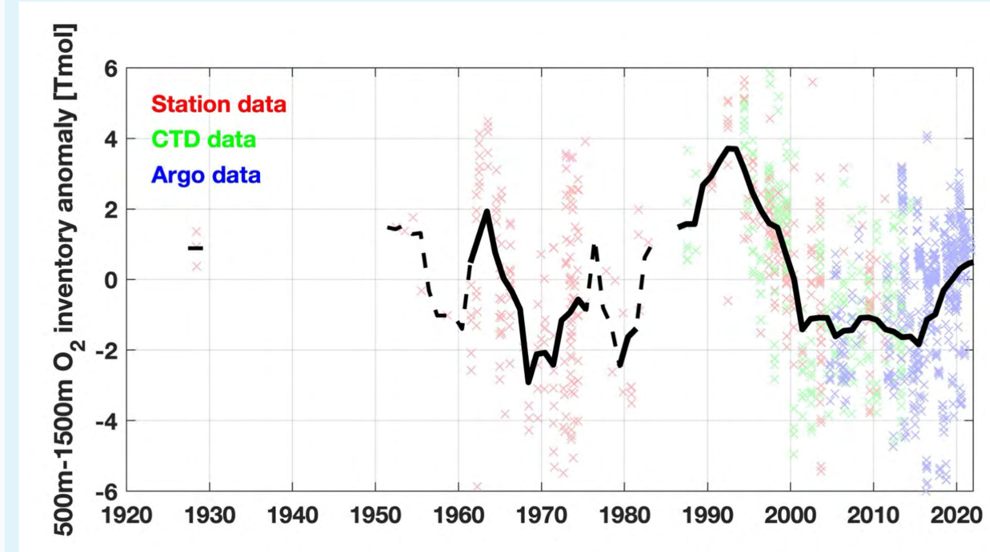
Interannual changes



Oxygen concentration at K9 over 4 years, reconstructed using gridded T/S

- Interannual variability reconstructed from a gridded T/S product using a neural network
- Increased extent of high-oxygen LSW layer starting in 2016
- Coincides with reinvigorated convection, deeper and denser LSW in interior

Decadal variability



Time series of oxygen in the interior Labrador Sea

- Decadal variability in interior Labrador Sea oxygen inventory
- Budget is not in steady state; periods of accumulation (export > uptake) and removal (export < uptake)

Suggests decadal variability in uptake and export

Link to Arctic Circulation

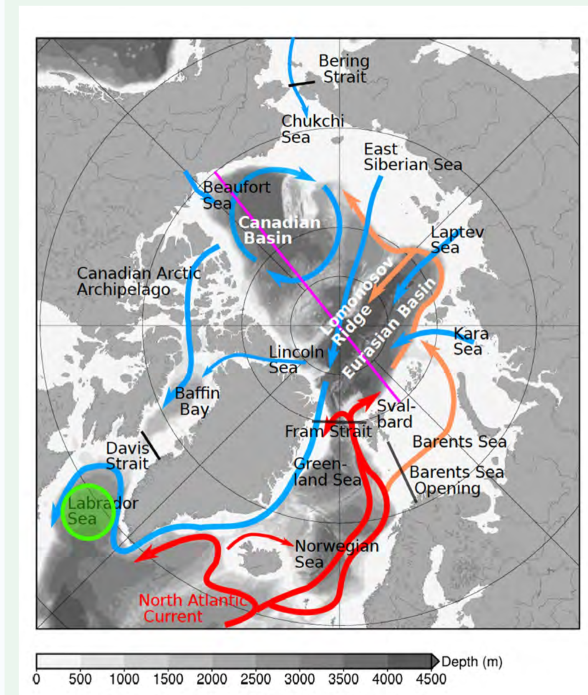
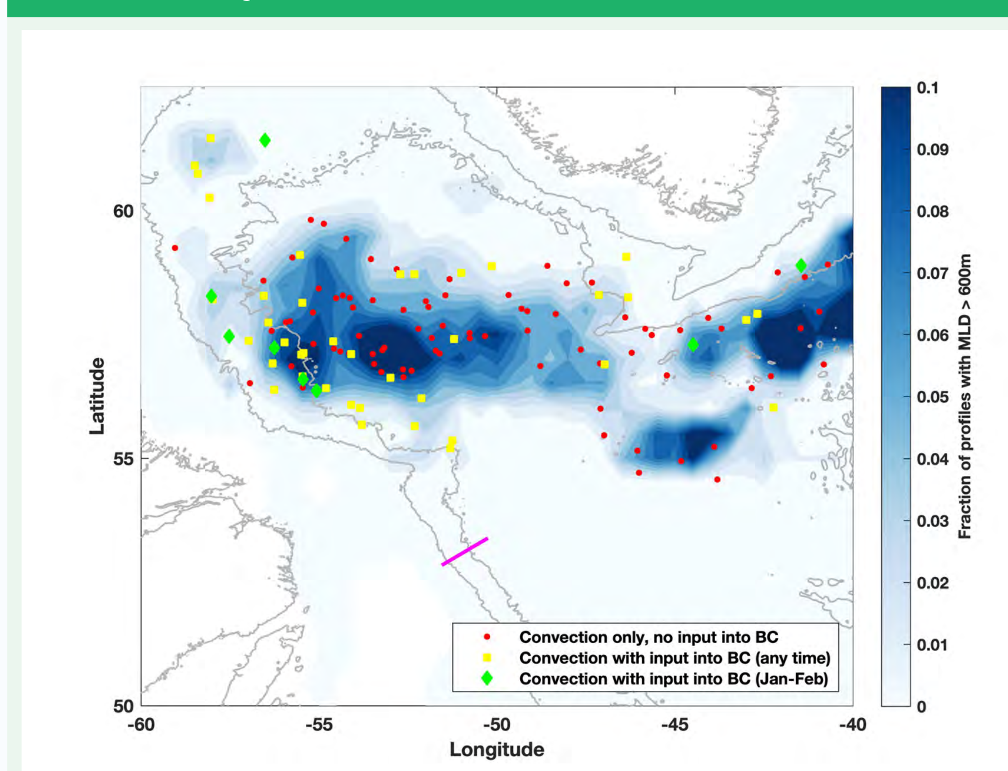


Figure modified from Wang et al. (2018); green area shows convection region

- Input of arctic water masses into the Labrador Sea
  - Arctic inflow through Bering Strait into the Labrador Current
  - Flow through Fram Strait and Irminger Sea into West Greenland Current
- Boundary-interior exchange brings signal into LSW formation region

Arctic inflow affects LSW properties

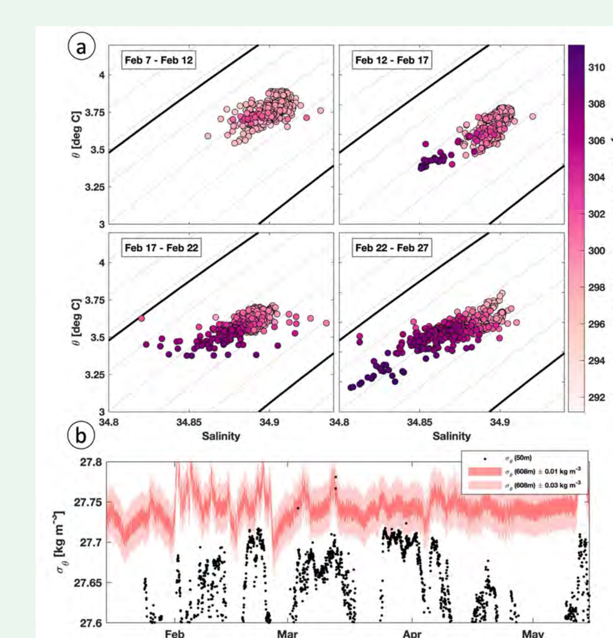
Boundary current convection



Location of last ventilation for Argo floats measuring export

- Convection occurs in "classical" region in interior of basin, but also within the boundary current
- Long residence time in interior; quick export for boundary current convection
- Mixes water column including cold, fresh water near the surface

Importance of Arctic inflow for LSW due to formation in boundary current?



Top: Progressive T/S diagrams at K8 mooring with color showing O2. Bottom: Density at 50m and 600m

- Arrival of high oxygen signal at 53N in February; inconsistent with advection from interior
- No sign of local instability, suggesting upstream convection
- Interior convection likely only contributes after March

Main points

- Annual cycles of oxygen measured at exit of Labrador Sea
- Summertime increase due to newly ventilated LSW, associated with 1.6 Tmol export
- Interannual and decadal variability in export
- Properties of LSW, including oxygen, affected by processes in Arctic
- Convection occurs in boundary current as well as interior; important to understand upstream variability

References & Acknowledgements

Wang, Q., Wekerle, C., Danilov, S., Wang, X. and Jung, T., 2018. A 4.5 km resolution Arctic Ocean simulation with the global multi-resolution model FESOM 1.4. *Geoscientific Model Development*, 11(4), pp.1229-1255.

This research has been supported by the Canada Excellence Research Chairs, Government of Canada (Ocean Science and Technology grant), the Canada First Research Excellence Fund (Ocean Frontier Institute grant), the Horizon 2020 (Blue Action (grant no. 727852) and EuroSea (grant no. 862626)), and the Bundesministerium fÃ¼r Forschung und Technologie (RACE grant). Jannes Koelling was funded by the Ocean Frontier Institute through the International Postdoctoral Fellowship.