Oxygen changes in the tropical North Atlantic in connection to meridional overturning circulation and subtropical cell variability

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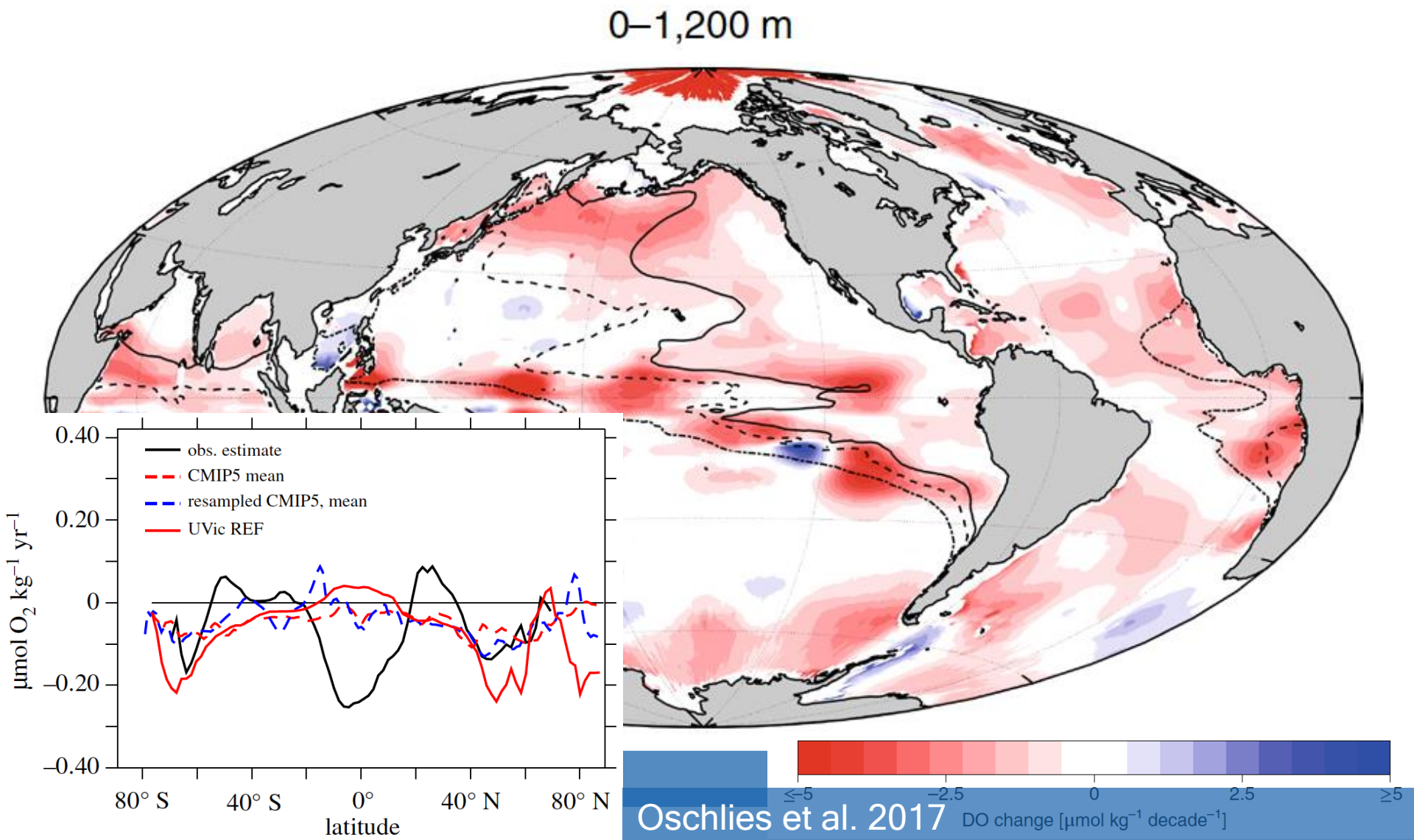
Oxygen Change in the Ocean (1960-2010)



Oschlies et al. 2017

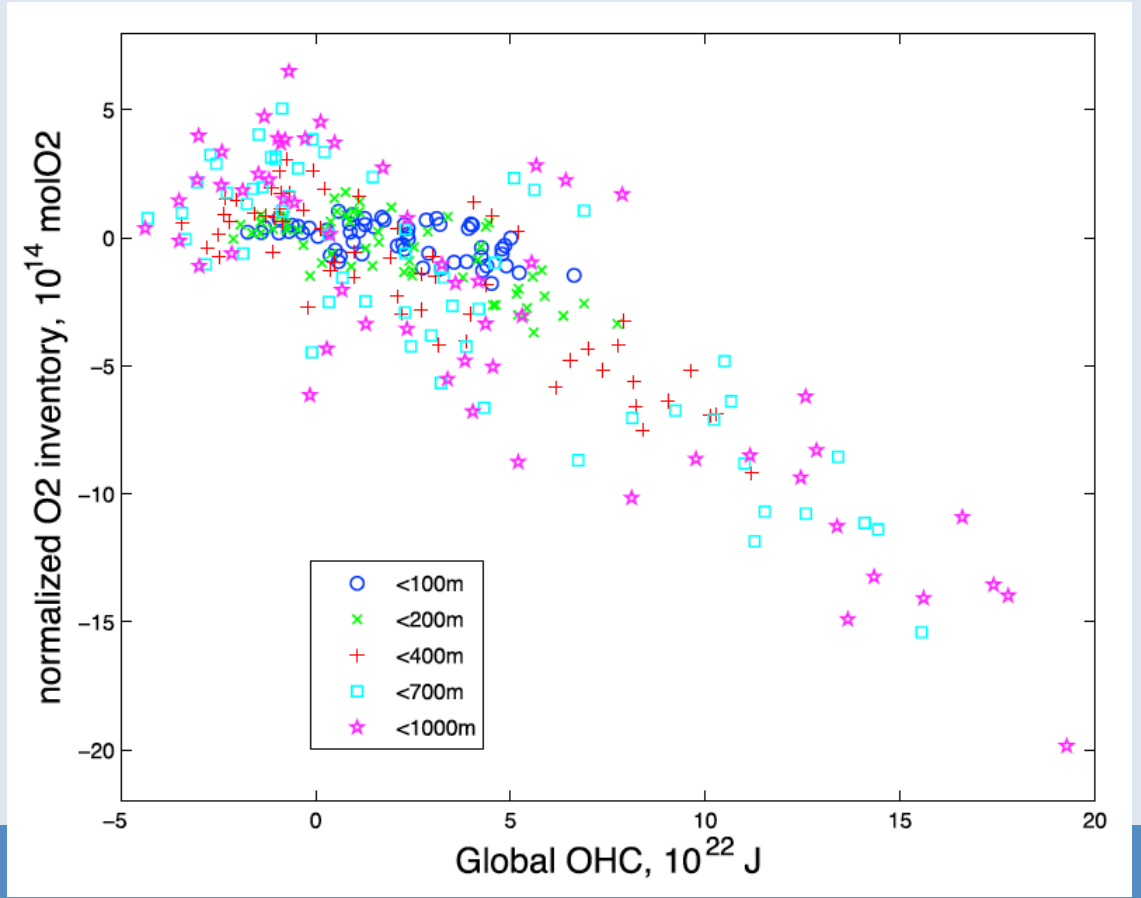
Oxygen Change in the Ocean (1960-2010)

- Global oceanic oxygen content decreased by more than 2% since 1960
- About 50% of changes in the upper 1000m can be explained due to warming induced solubility changes
- Changes in the deeper ocean may have their origin in basin-scale multidecadal variability, oceanic overturning slow-down and a potential increase in biological consumption

Schmidtko et al. 2017

Oxygen and Heat Content

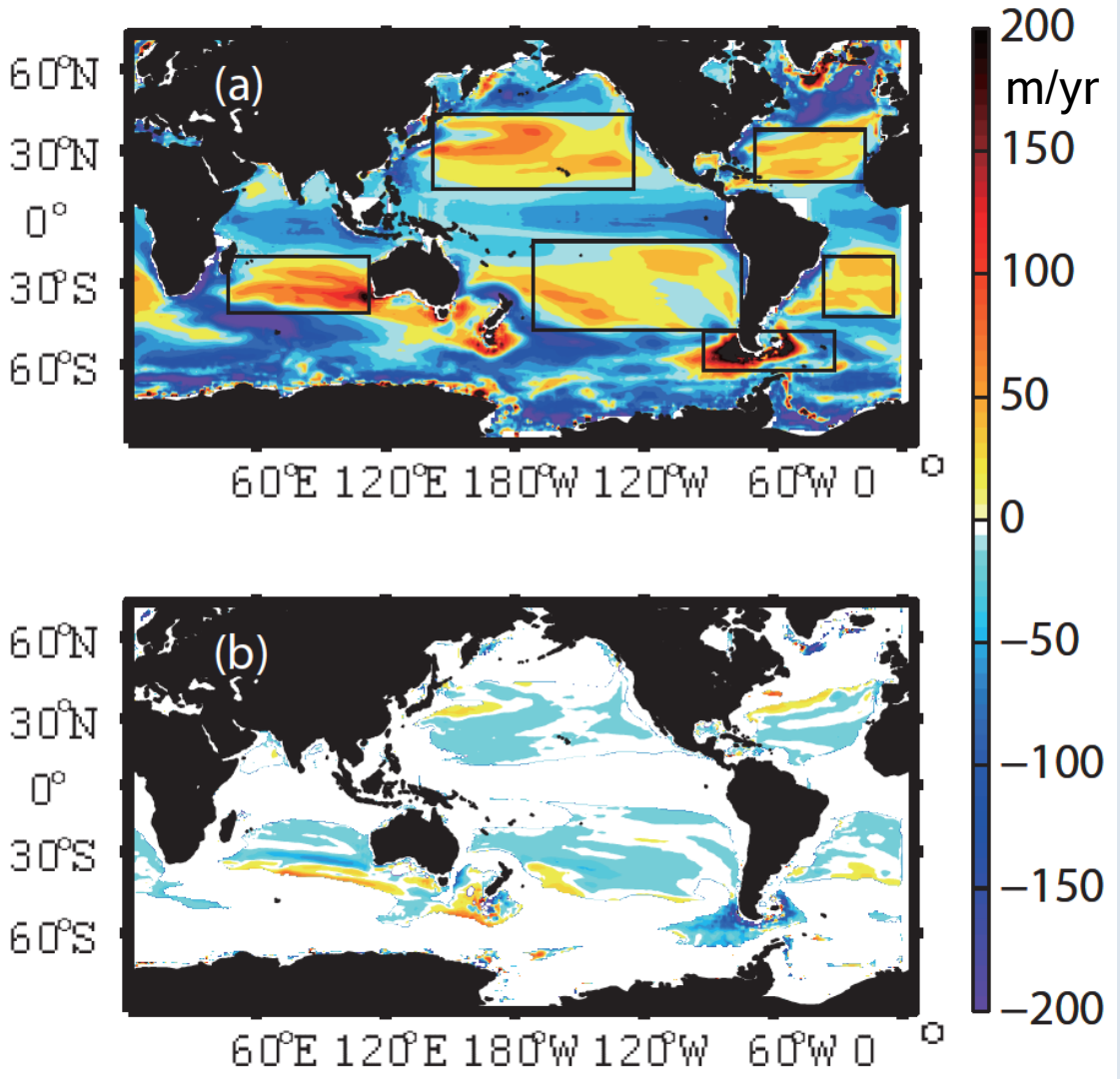
- Tight relationship between decreasing O_2 inventories and increasing ocean heat content
- Relationship at shallow depths consistent with temperature dependence of solubility
- In the thermocline and deeper layers, steeper relationship indicates that ventilation and circulation changes play a more important role



Ito et al. 2017

Subduction Rate and Response to Global Warming

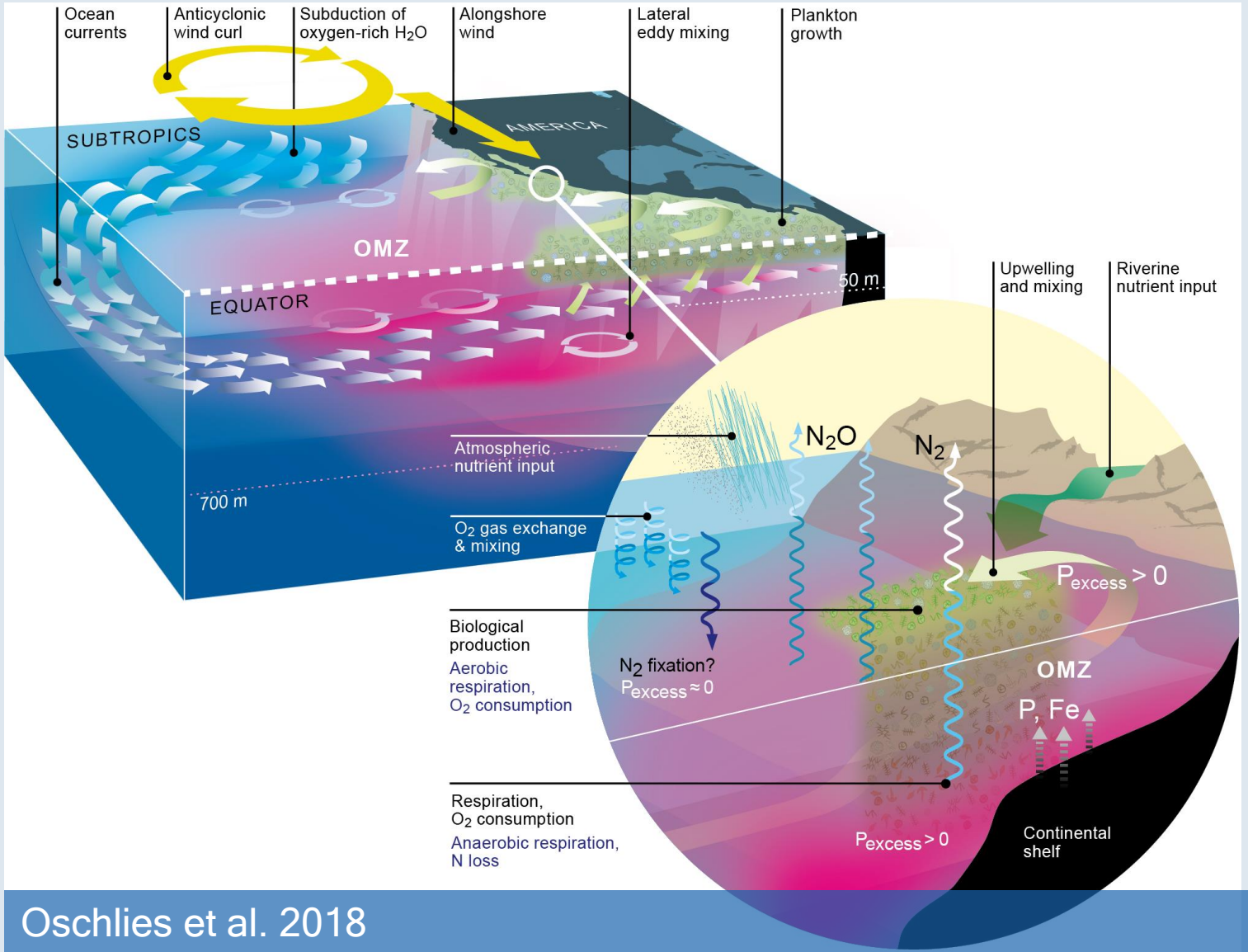
- IPCC AR4 model analysis
- Decreasing lateral induction due to a shallower winter mixed layer depth
- Also decreasing vertical pumping



Liu and Wang 2014

Thermocline Ocean Ventilation and O_2 Consumption

Weakening of Subtropical Cells in the Pacific associated with reduced oxygen along water mass pathways (Duteil et al. 2014)



Oschlies et al. 2018

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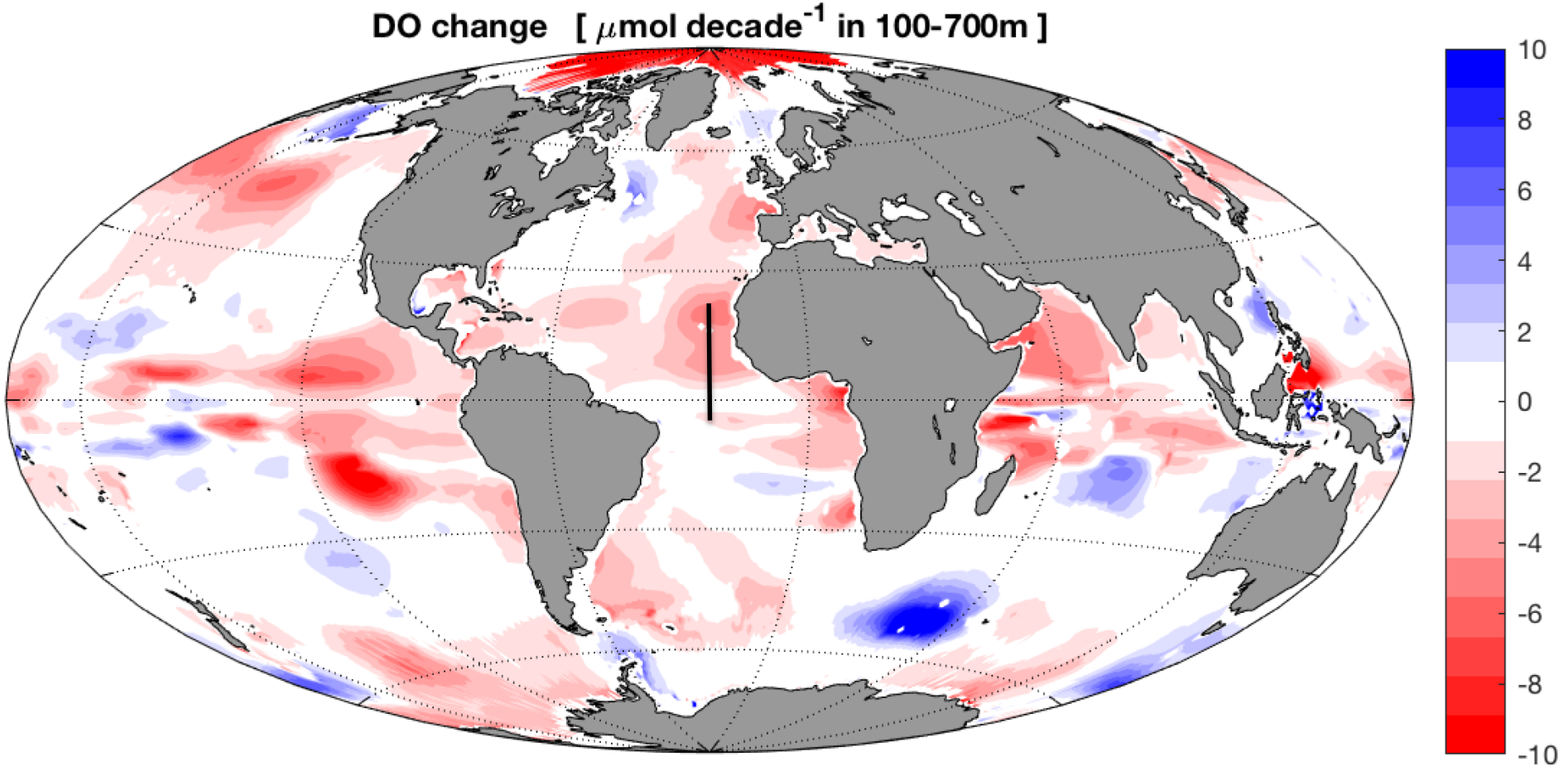
Oxygen Change in the Ocean (1960-2010)

- Deoxygenation particularly in tropical oxygen minimum zones



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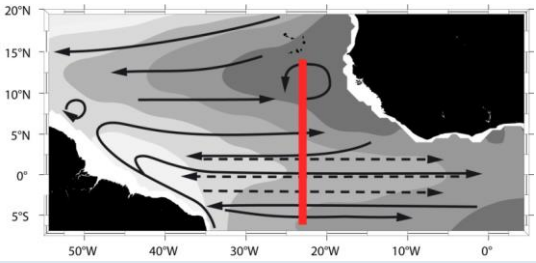
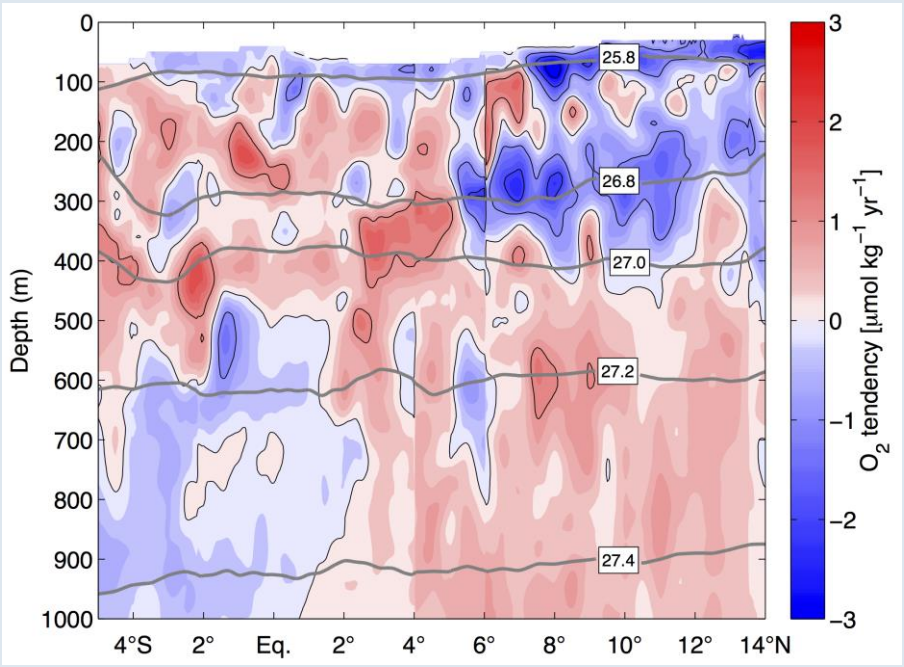
- During SFB754 we focused on 23°W section

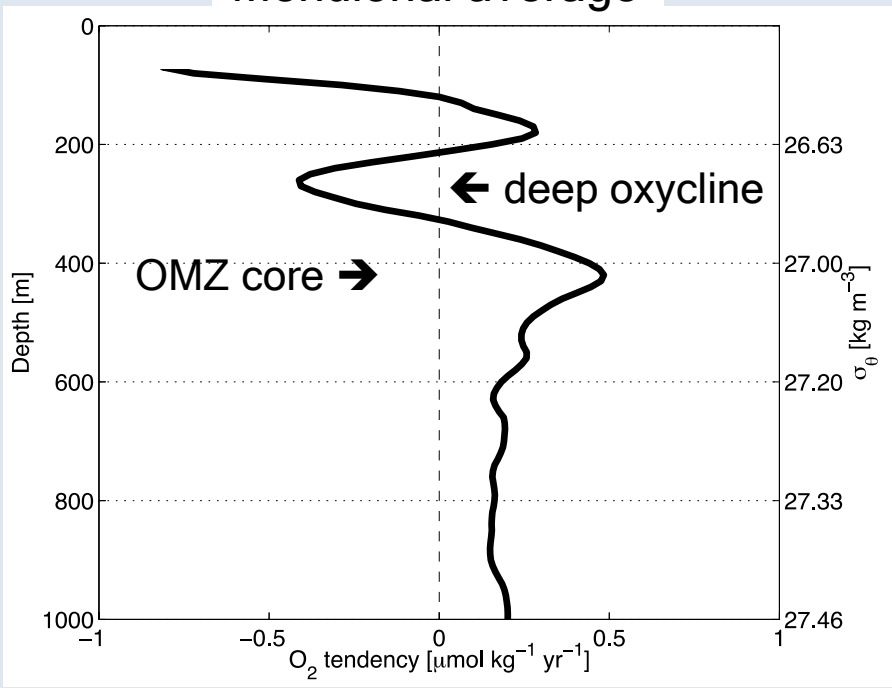
Oxygen Change along 23°W (2006-2016)



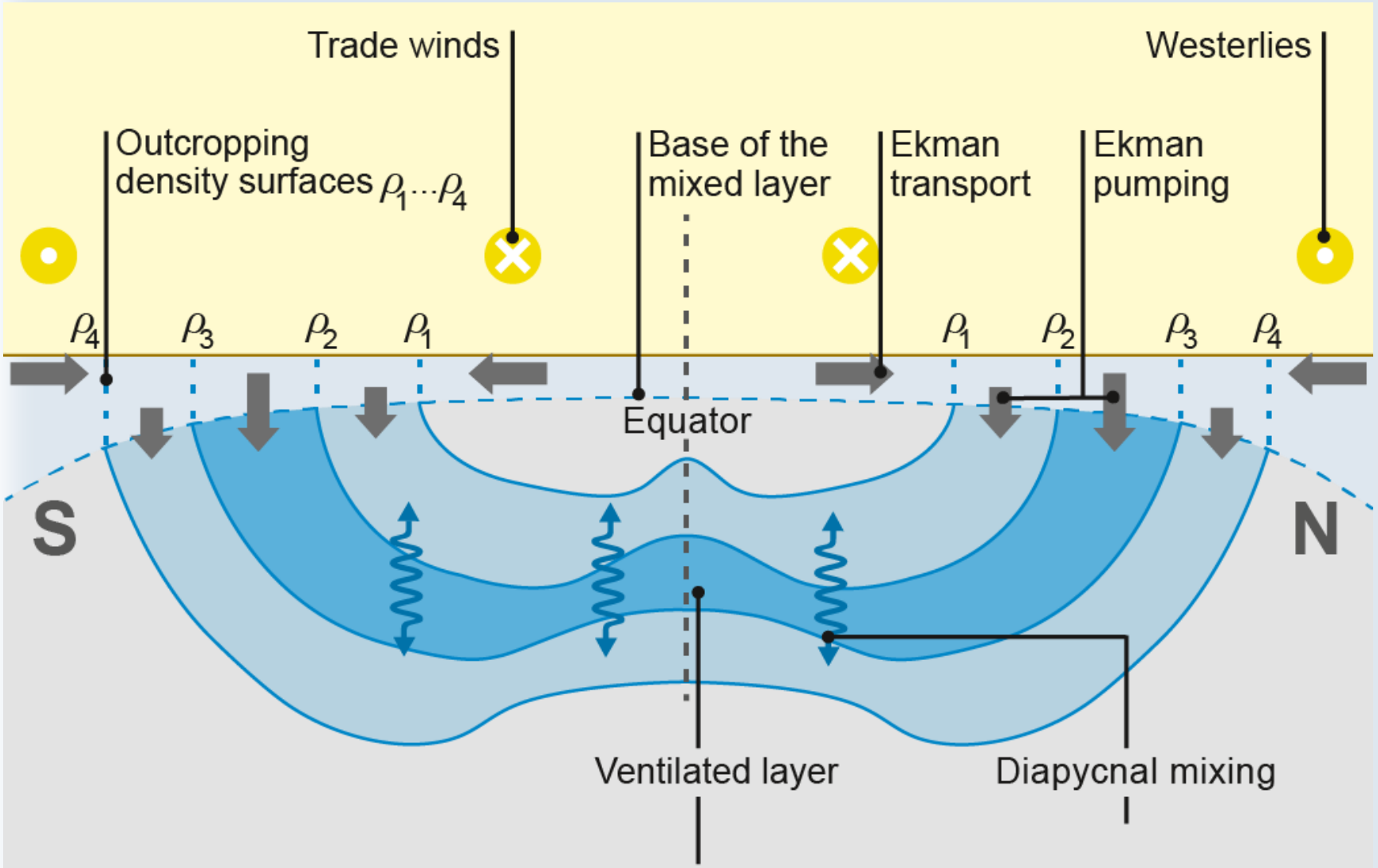
- O_2 reduction at the deep oxycline (shallowing of OMZ)
- O_2 increase above (150-200m)
- O_2 increase below 350m



Meridional average



Mechanisms of Thermocline Oxygen Changes



Oschlies et al. 2018

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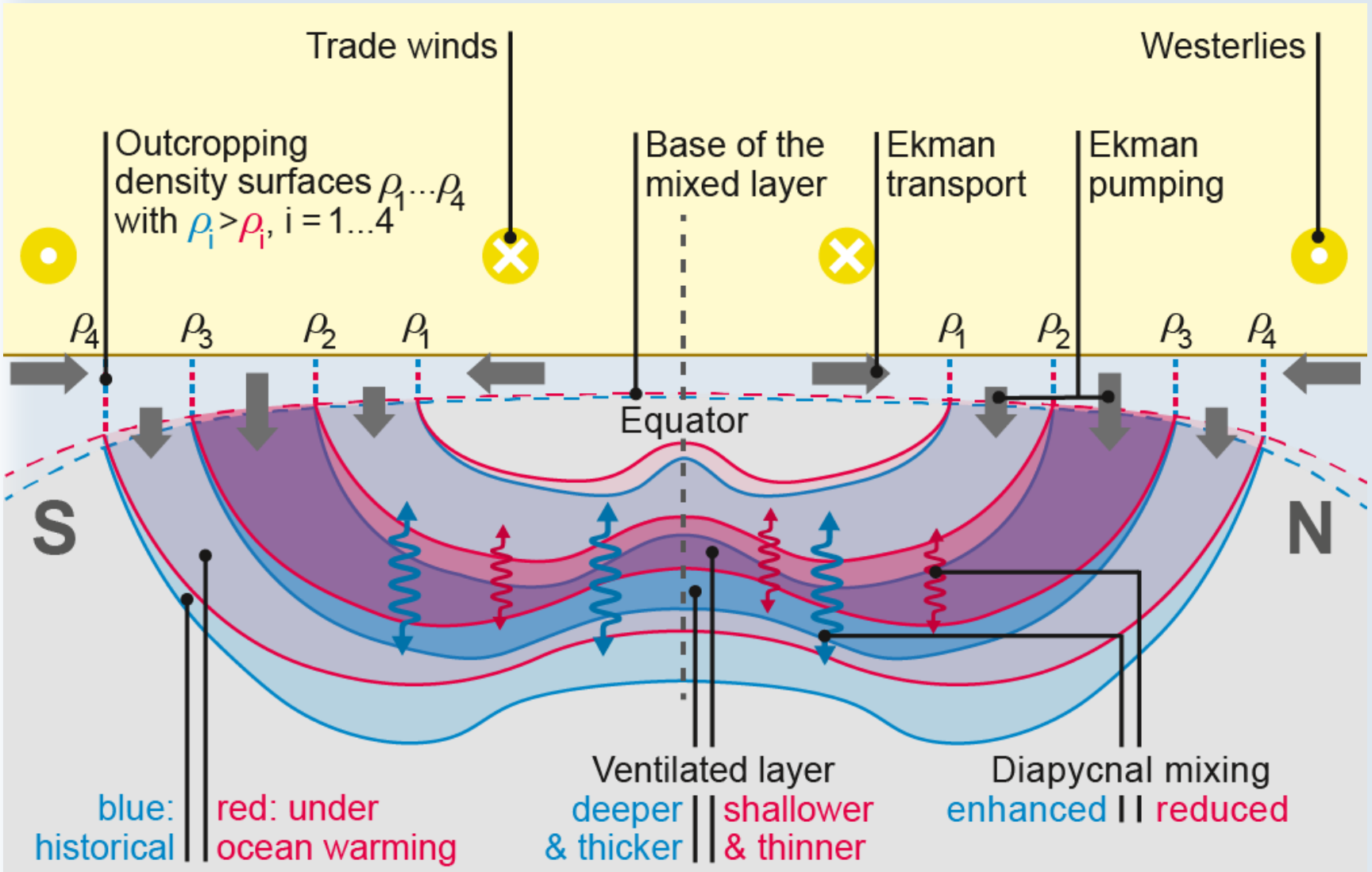

Oschlies et al. 2018

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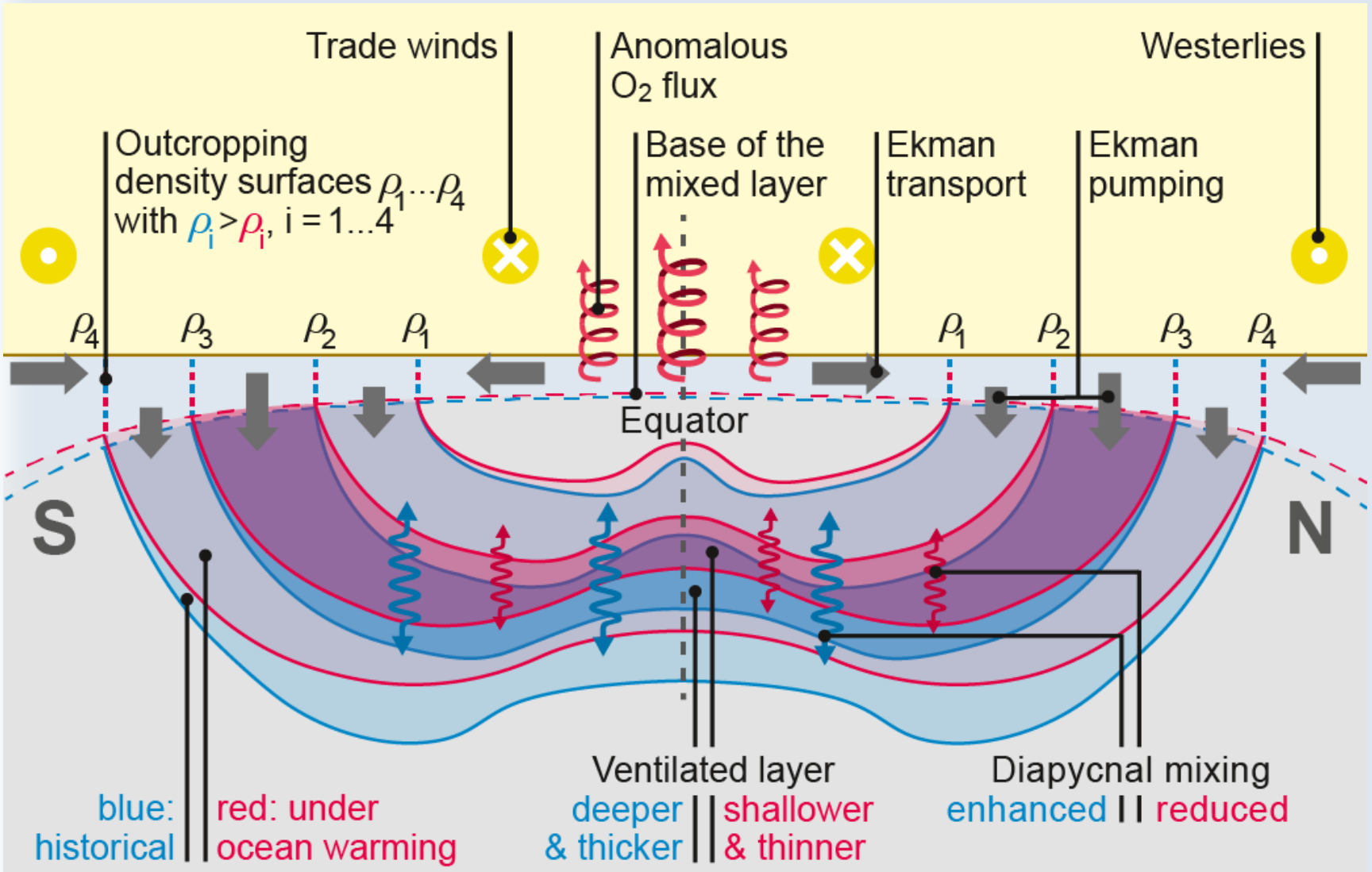

Oschlies et al. 2018

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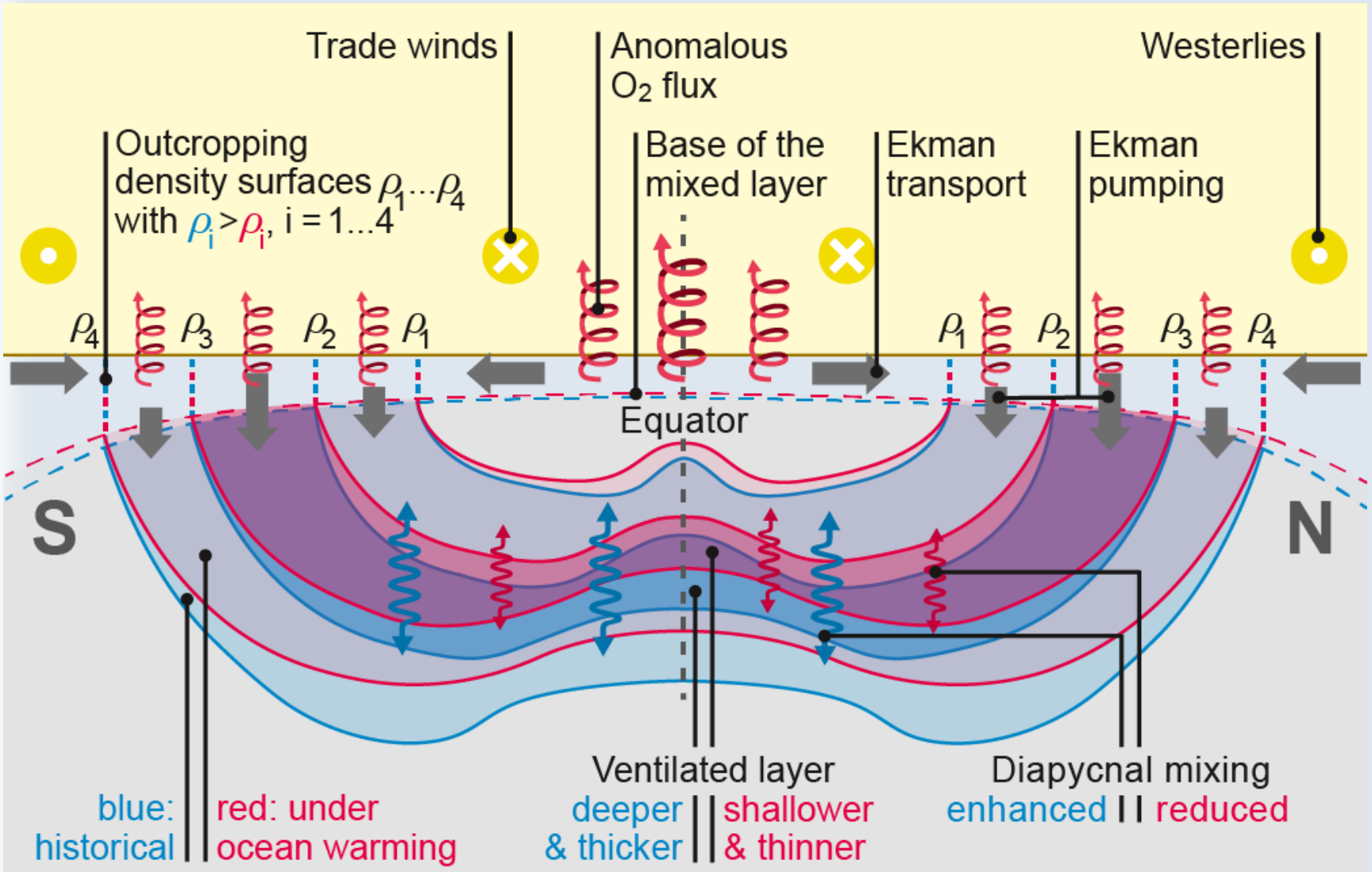
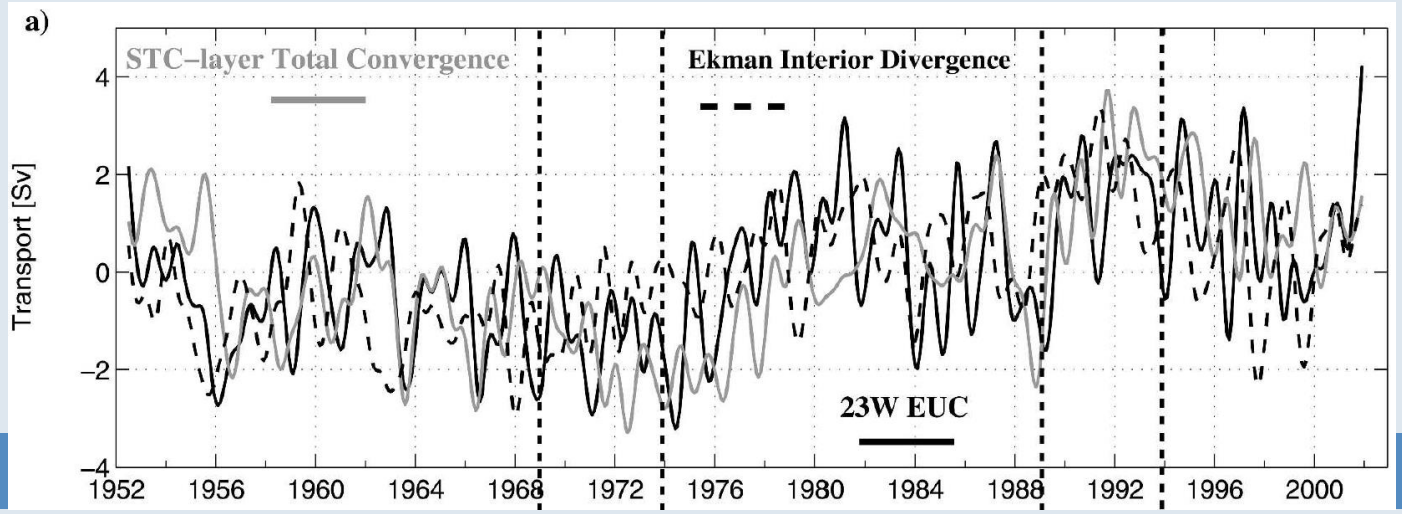


Oschlies et al. 2018

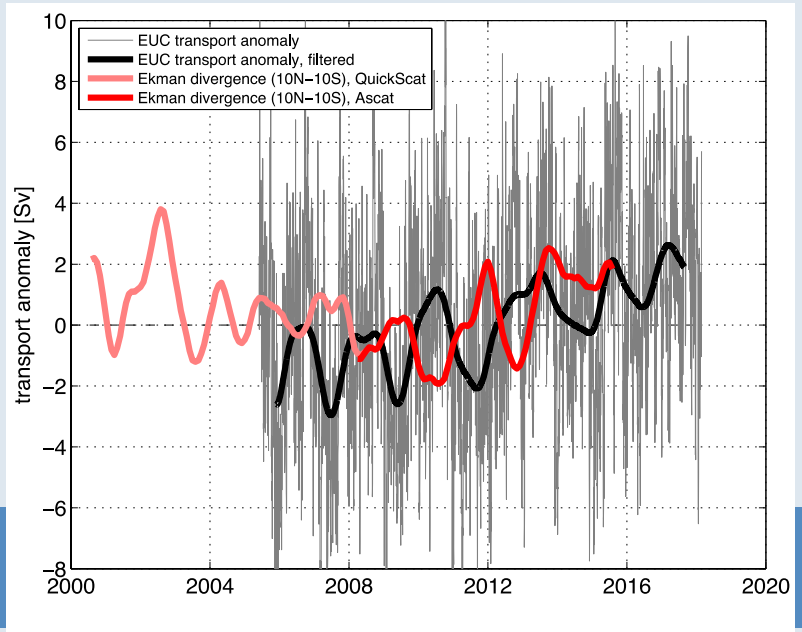
Atlantic STC variability

- STC in GECCO assimilation
- Multi-decadal variability with possible impact on upper 250m

Rabe et al. 2008



- Moored EUC measurements at 23° W show strengthening of EUC of about 2.5 Sv per decade
- Ekman divergence show similar variability (depending on the wind product)



EUC transport update Brandt et al. 2014

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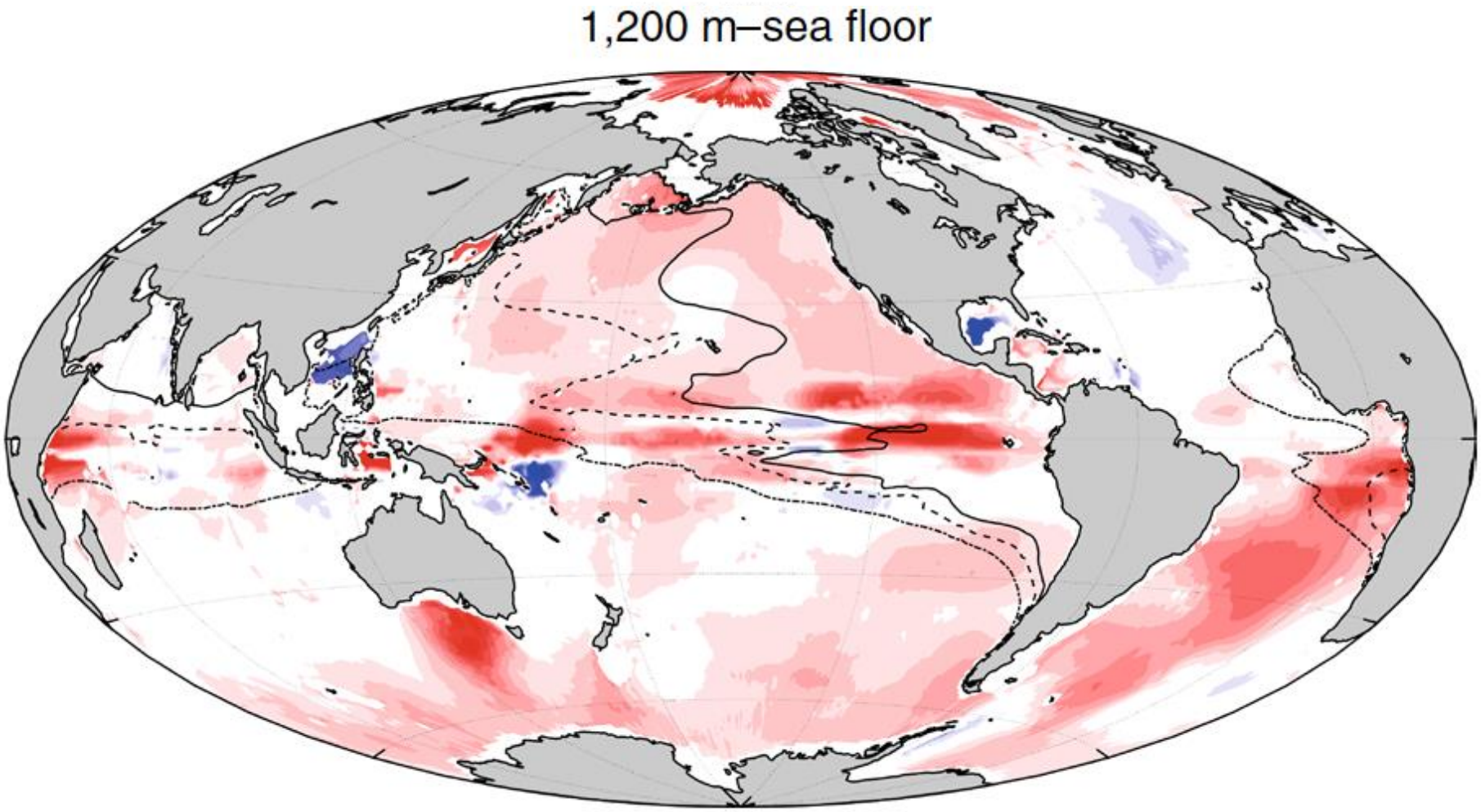
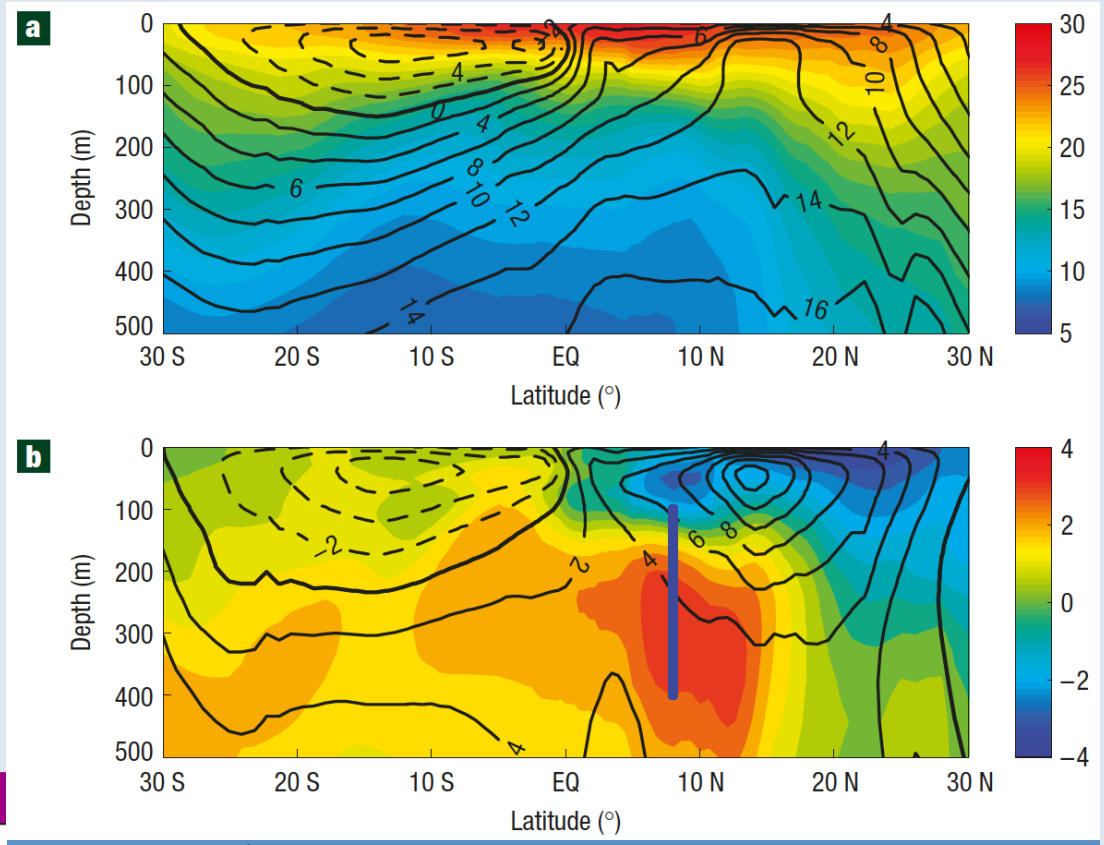
Oxygen Change in the deep Ocean (1960-2010)



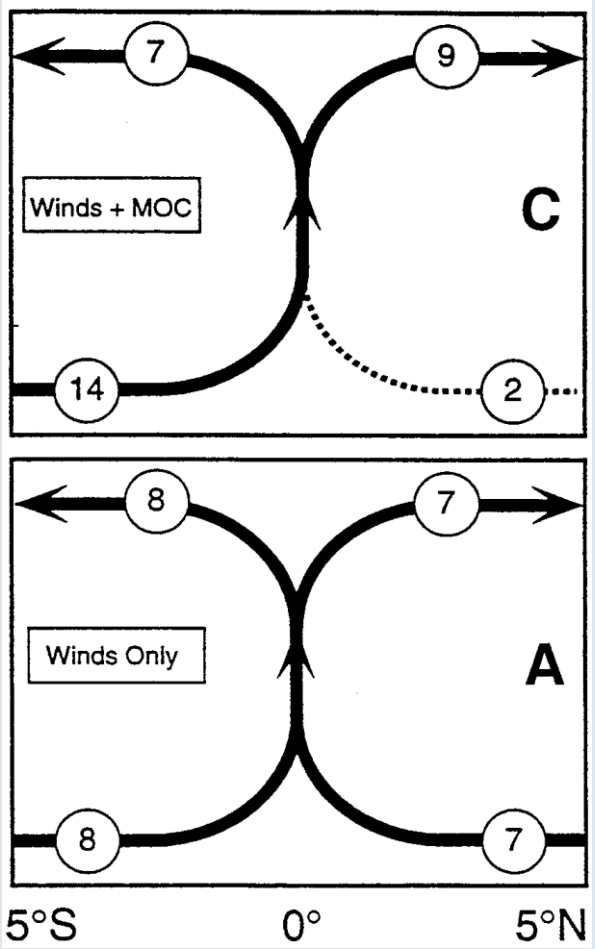
Oschlies et al. 2018

Effect of AMOC on Atlantic STCs

- Without AMOC: almost symmetric STCs in the Atlantic
- Thermocline warming due to AMOC weakening in water housing experiment

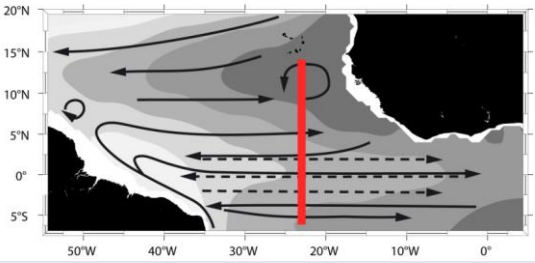


Chang et al. 2008



Fratantoni et al. 2000

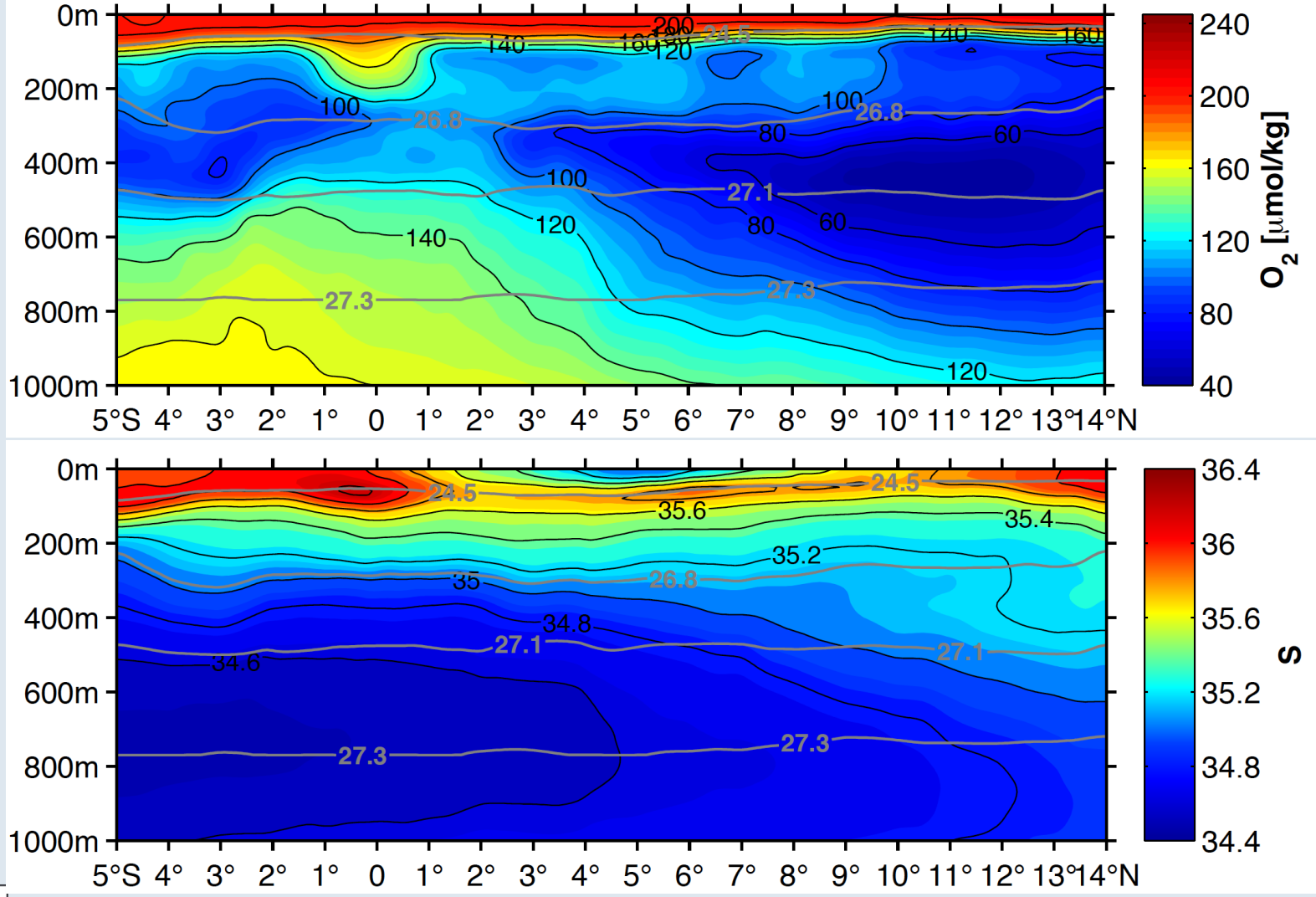
Mean 23°W Section



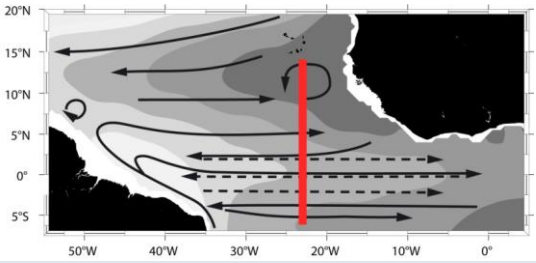
Equatorial oxygen maximum

Deep oxycline at about 300m or σ_θ=26.8 kg/m^3

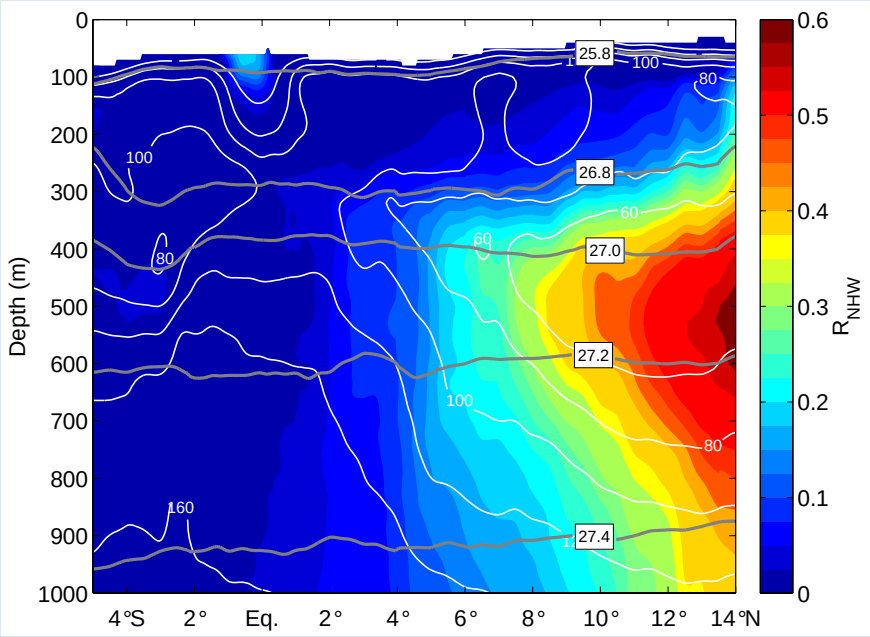
Southerm hemisphere water reaches far into the North Atlantic

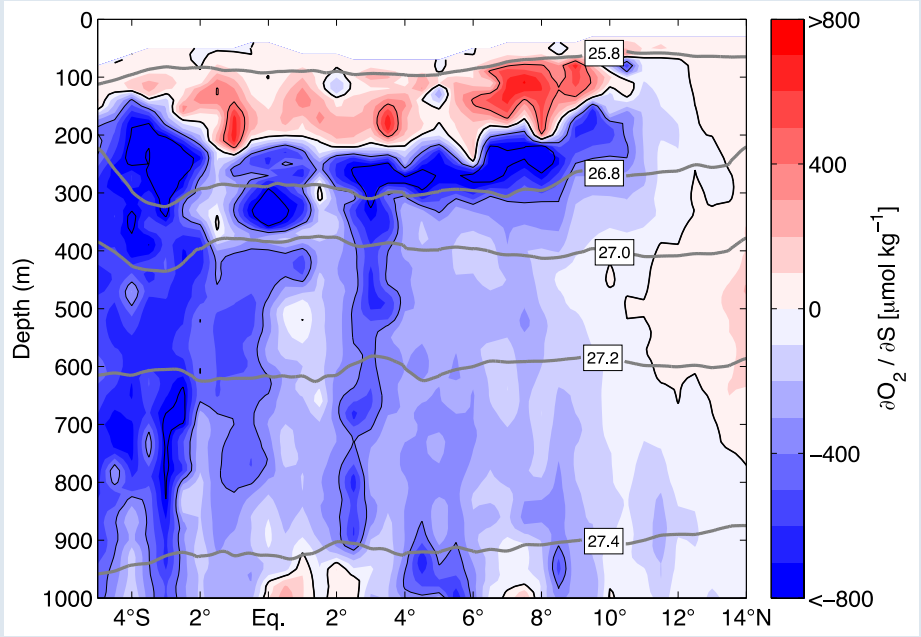


Water mass distribution and ventilation



- Tropical North Atlantic is dominantly ventilated from the southern hemisphere due to presence of AMOC

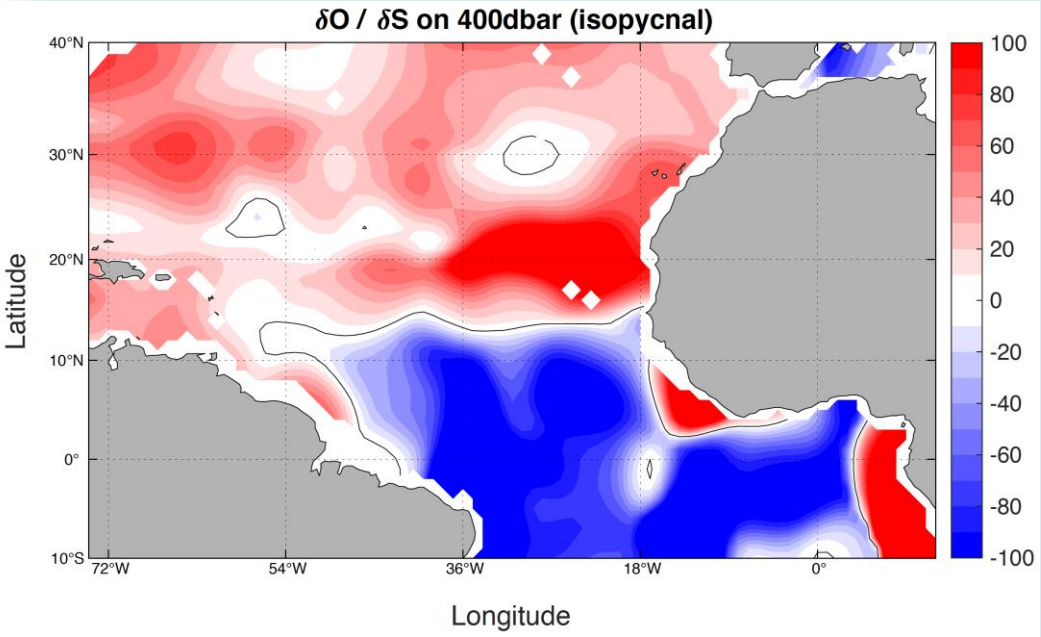




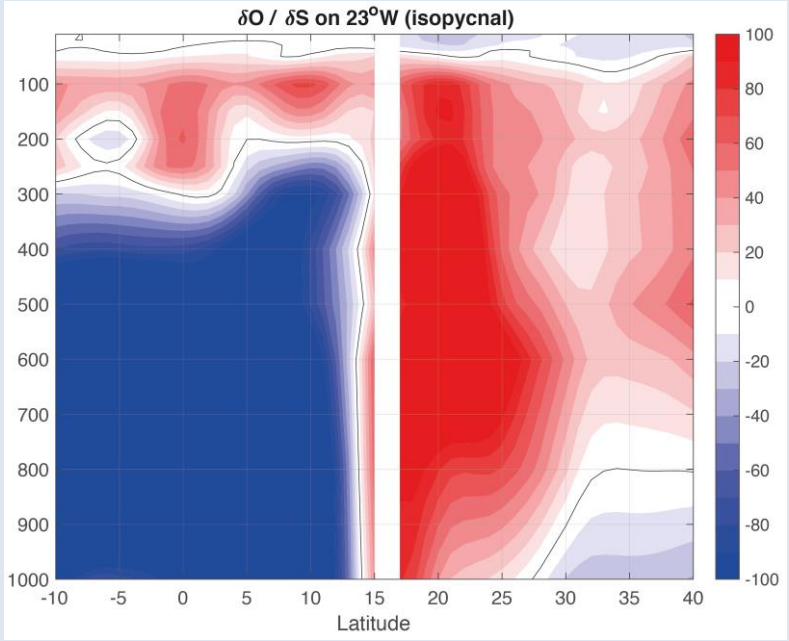
- Portion of NA water:
  - red: more NA water
  - blue: more SA water
- Oxygen-Salinity relation:
  - red: more oxygen, more salinity
  - blue: more oxygen, less salinity

Water mass distribution and ventilation

- Regional pattern at OMZ core: ventilation from southern hemisphere up to 12°N



Calculated from the MIMOC climatology in µmol kg^{-1}



- Oxygen-Salinity relation:
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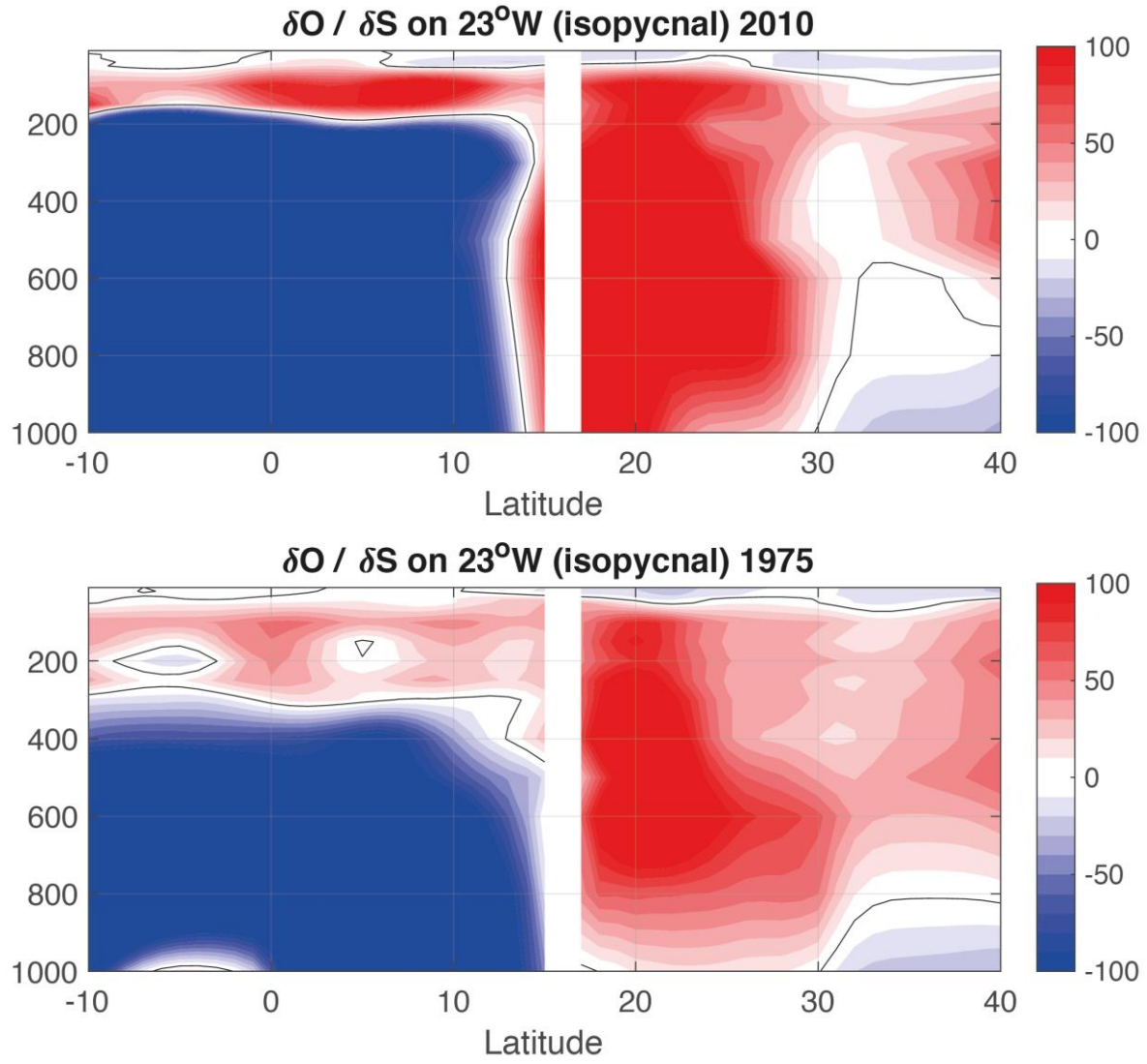
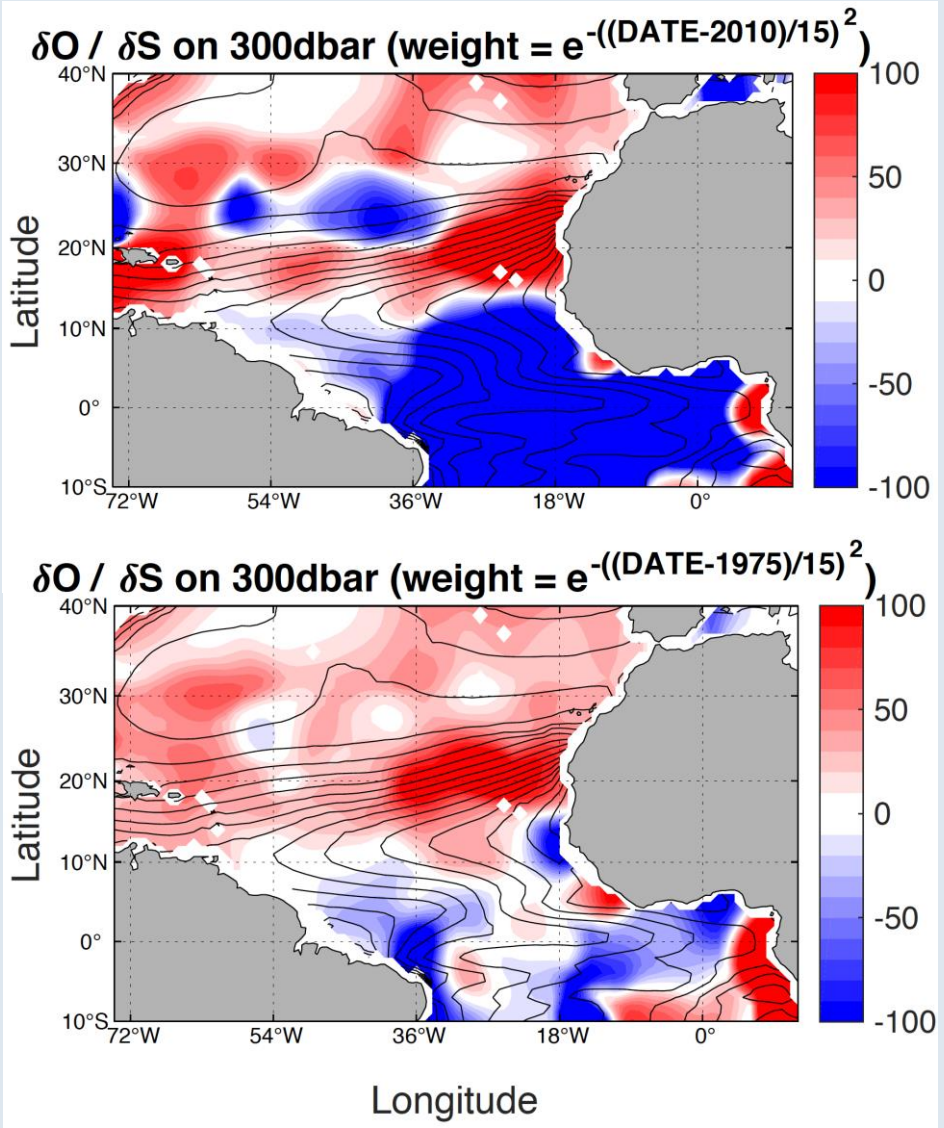
Decadal ventilation changes

- Do the oxygen-salinity relation changes for different decades?



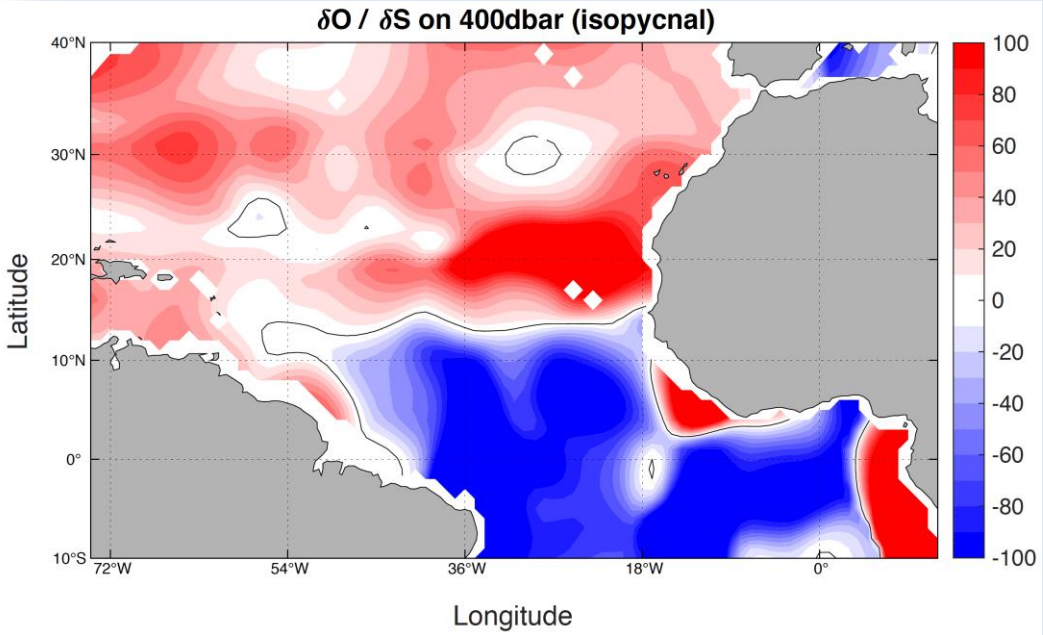
Decadal ventilation changes

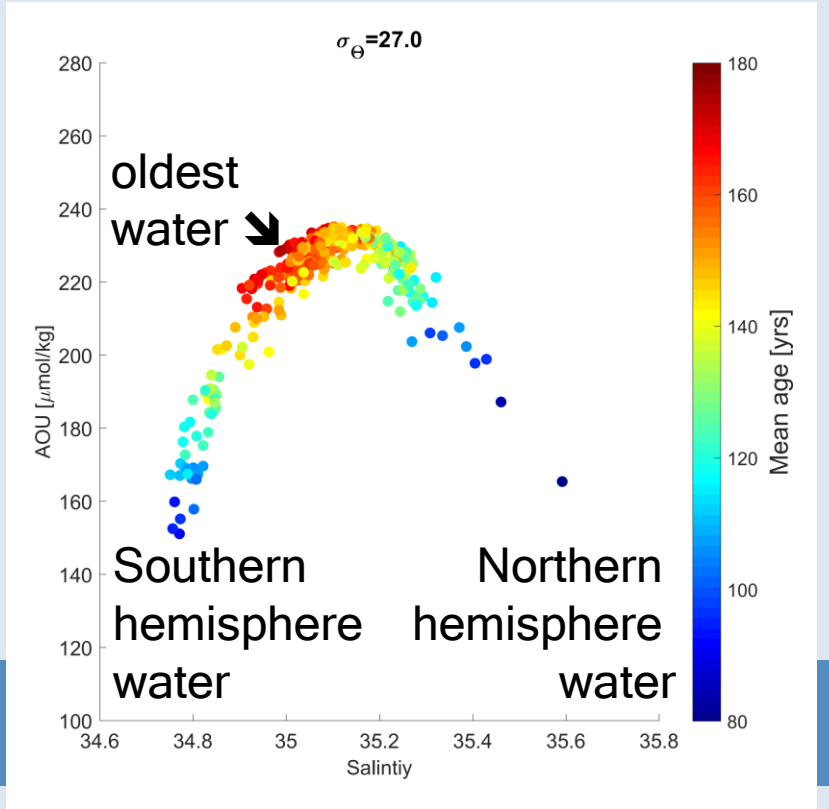
- During the recent decade ventilation in the upper 300m of the tropical North Atlantic south of about 12°S seems to be associated with low-saline waters, while around 1975 ventilation with high-saline waters reaches far more south



Water mass distribution and ventilation

- Southern hemisphere water is older but higher in oxygen
- AMOC weakening: age decreases but O_2 reduces?





- Portion of NA water:
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  - blue: more SA water

Stöven et al. in prep.

- Mean age (tracer age, CFC-12, SF-6)

Conclusion

- Large number of processes result in oxygen changes on different timescales
- AMOC and STC likely to have strong impact on ventilation pathways and oxygen content in the tropical Atlantic
- Comparison of observed mean O_2 distribution and its changes and model simulations: prospects for improving model dynamics and parameterizations