Seawater isotopes, salinity and the freshwater cycle
(CISE-LOCEAN database)

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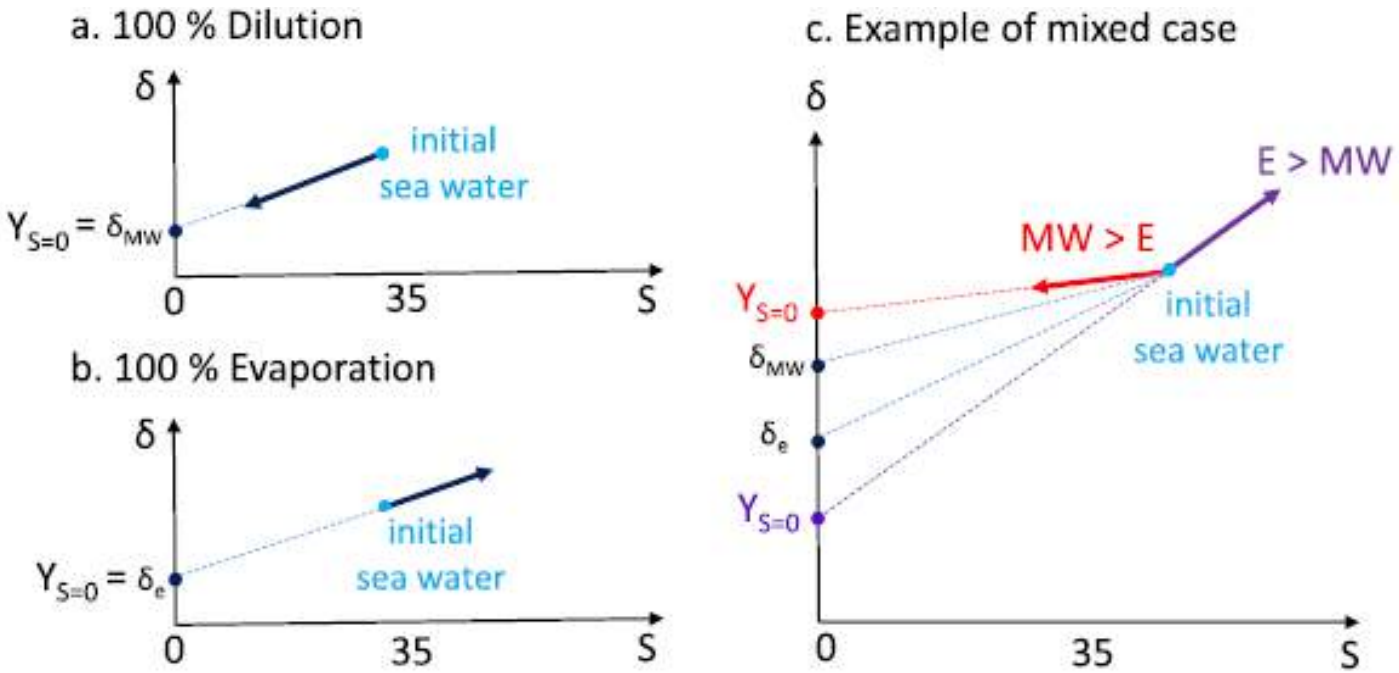
^{18}O / ^{16}O ($\delta^{18}O$) and ^{2}H / H (δD) nearly conservative in seawater to within 0.001 in $\delta^{18}O$

What does it record?

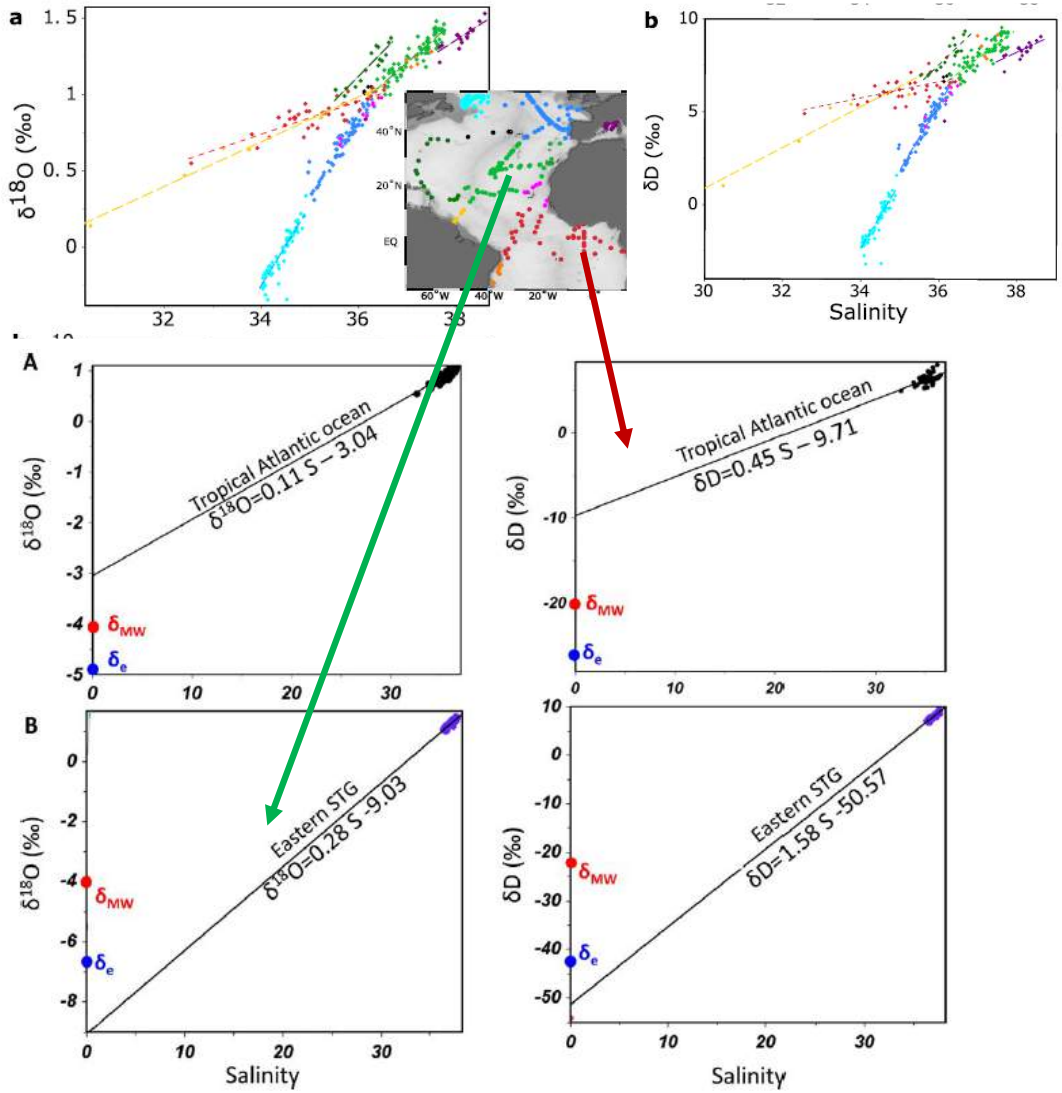
The hydrological cycle : E, P and rivers (MW)



δ_e and δ_{MW} are either measured or can be estimated (dependent respectively on the atmospheric boundary layer and atmospheric hydrological processes)

Benetti et al., 2015, 2017, 2019

Low latitudes



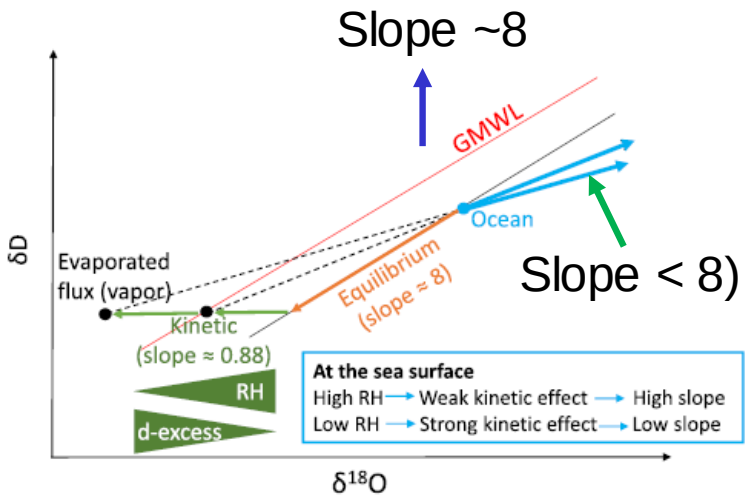
P/E ~ 2 sensitive to δ_{MW}

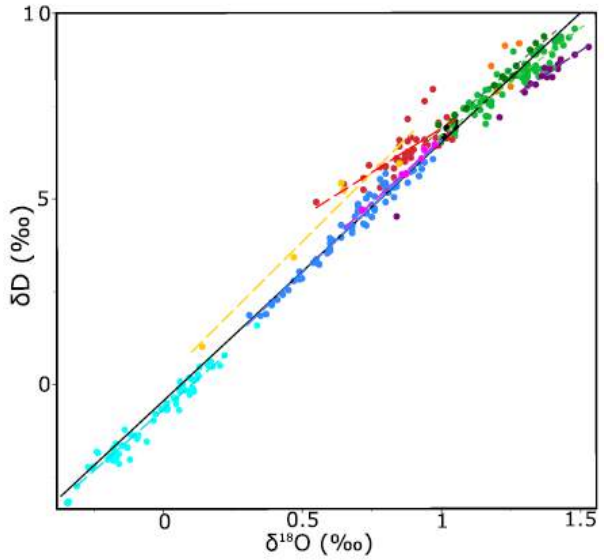
E/P ~ 2 sensitive to δ_e

box model:
Craig and Gordon (1965)

Benetti et al., 2017

D-excess (δD – 8 x $\delta^{18}O$)



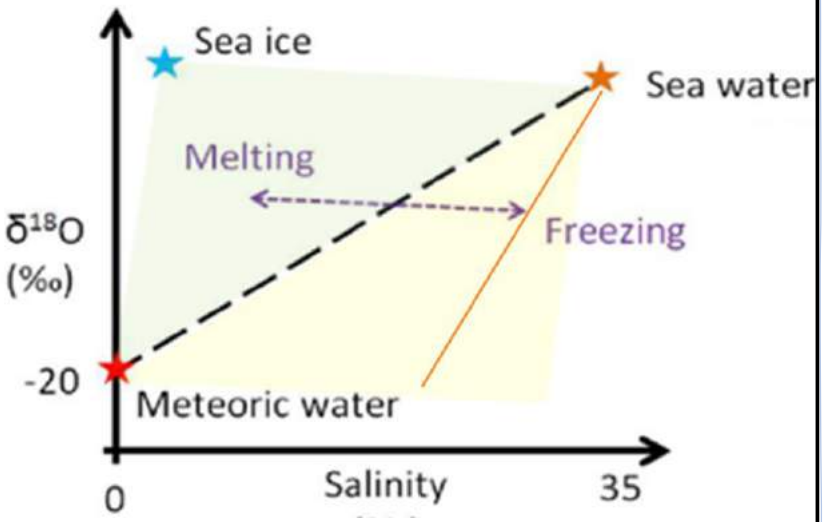


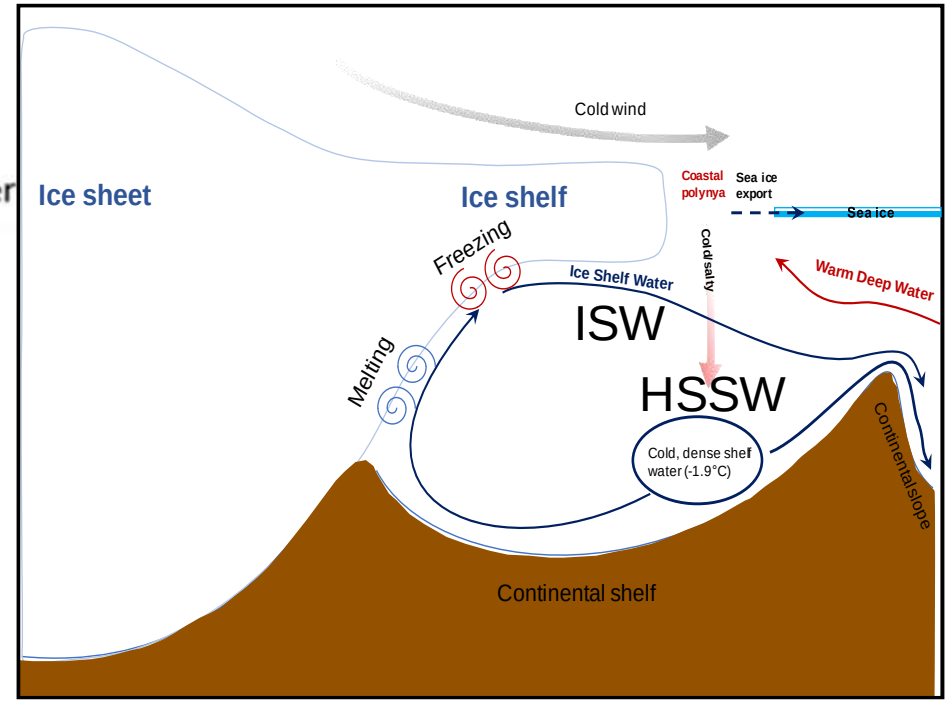
- Med sea (and eastern subtropical gyre) low humidity – high kinetic effect – low slope
- Tropical Atlantic rainfall almost in equilibrium with air (low re-evaporation)

Benetti et al (2017)

The hydrological cycle

Continental ice versus sea ice…

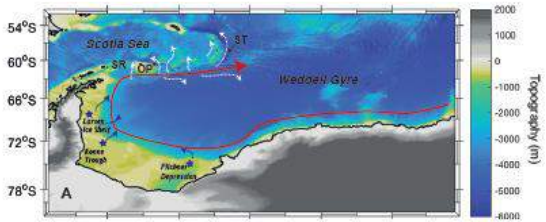




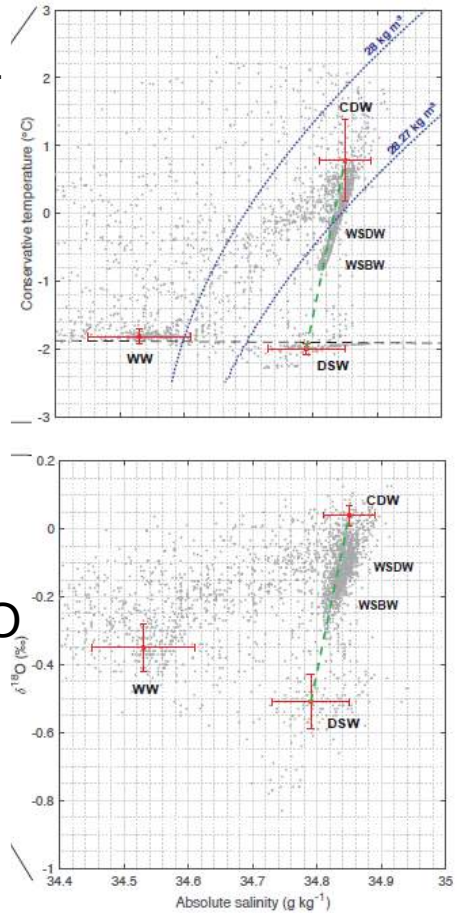
If Meteoric water from ice-shelf; notice also:
Meltwater from Ice-shelf: low T (partial refreezing) and high O_2

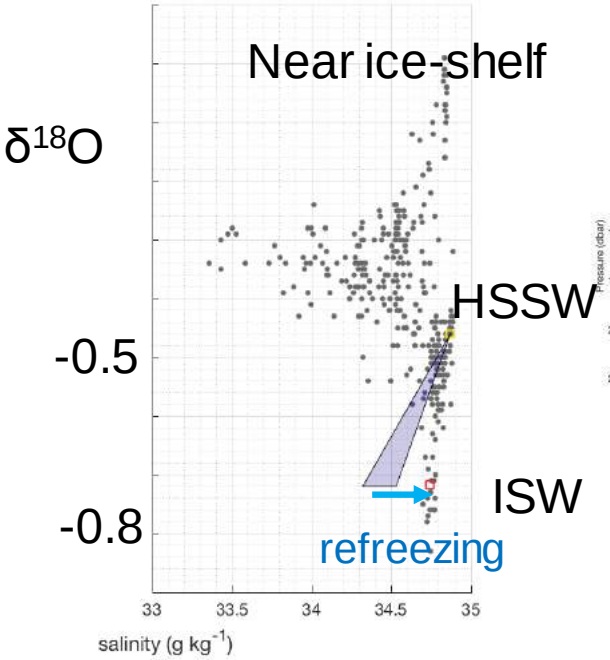
Application to Wapiti cruise and Weddell Sea (*Akhoudas et al, 2020, 2021*)

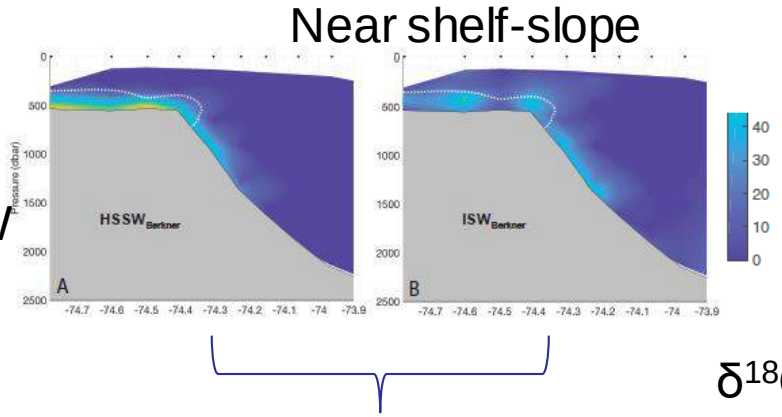
Weddell Sea – ISW formation – bottom waters



In Weddell Sea







Dense plume cascading (together, DSW)

Formation of Weddell Sea AABW

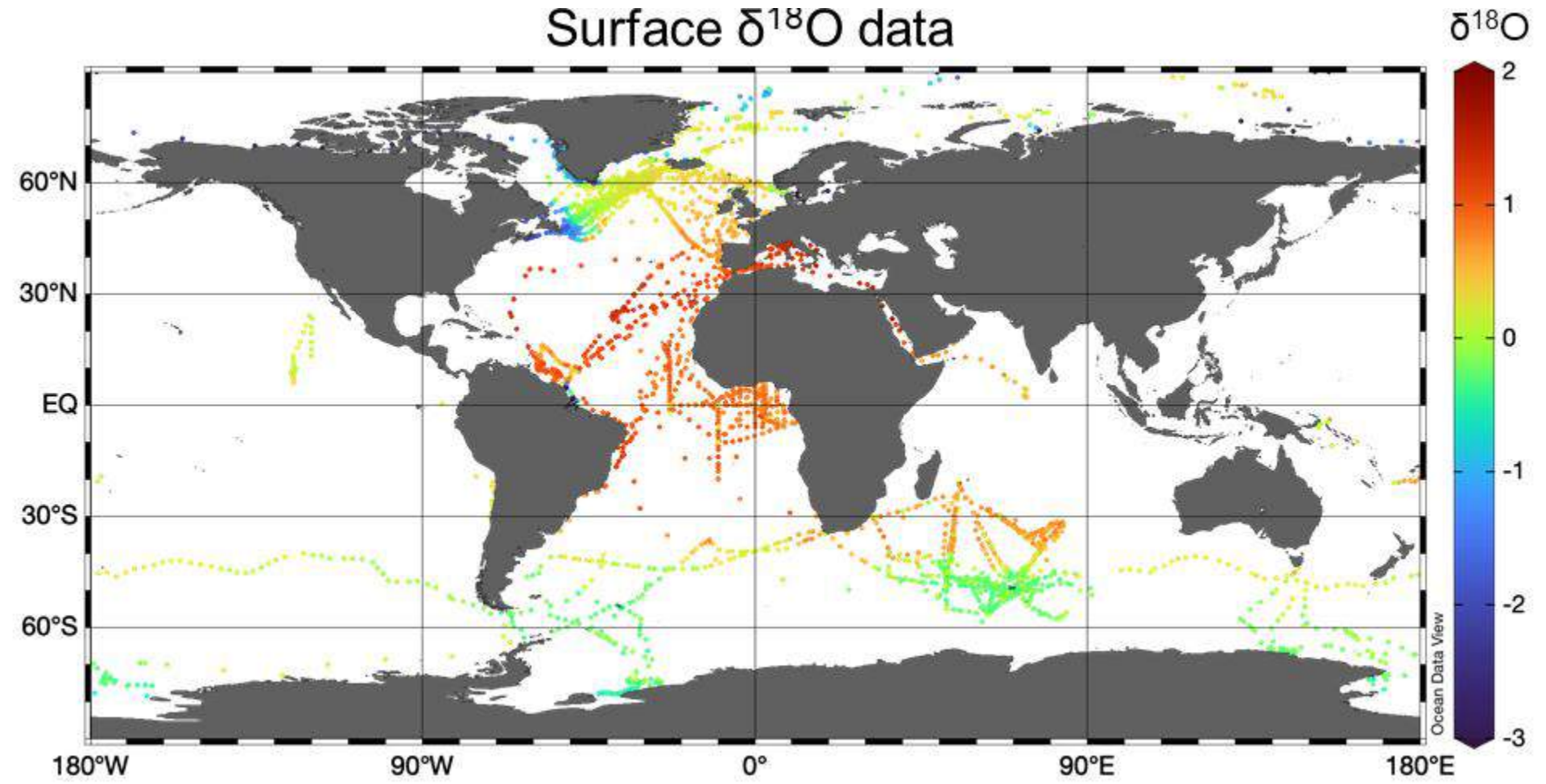
Shelf processes result in:

conversion of 3.4 Sv of CDW in DSW

+ entrainment of 3.9 Sv of CDW in dense plumes

Akhoudas et al, 2020, 2021

The CISE-LOCEAN dataset (V1)



- 8000 $\delta^{18}O$; > 6000 δD ; more than half in ‘surface’ layer
- ~15-23 years North Atlantic SPG/tropical; South Indian Ocean

Data issues

- Collection-storage: supected exchange through cap in 11.3%, detected from anomalous d-excess.
- Errors during measurements (random + effect of salt)

  < 0.05 ‰ in $\delta^{18}O$; 0.15 ‰ in δD
- Internal reference materials.

  Possible drifts up to 0.03 ‰ in $\delta^{18}O$; 0.15 ‰ in δD
- Internal consistency (deep watermasses):

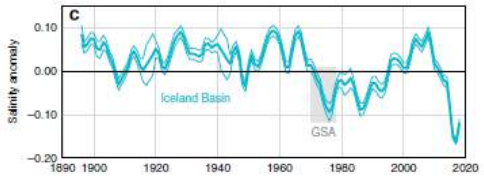
  0.035‰ in $\delta^{18}O$ and 0.15 ‰ for δD
- Comparison to other data sets/data providers

  - Three sets of duplicate samples : suggest rms error 0.035 to 0.05 ‰ in $\delta^{18}O$

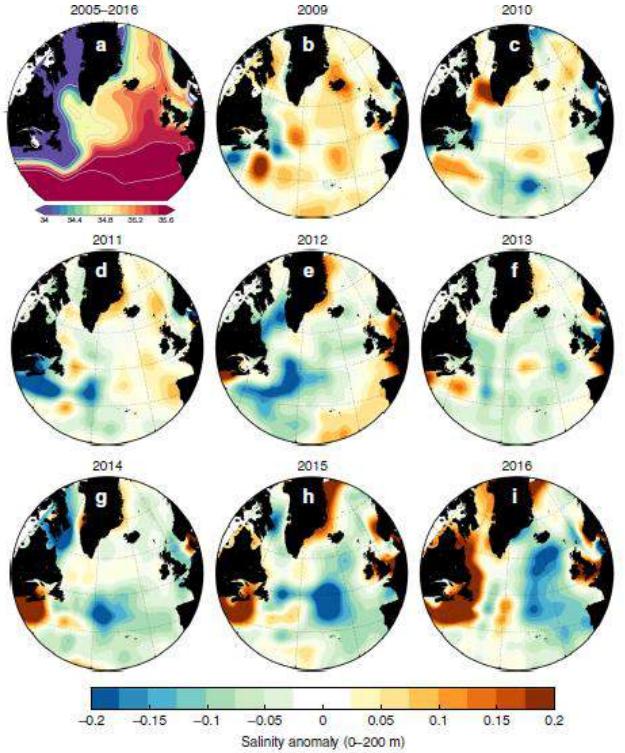
  - Large scatter in a set of 18 comparisons with data of different groups (rms: 0.055 ‰ in $\delta^{18}O$) and average difference (0.082 ‰ in $\delta^{18}O$)

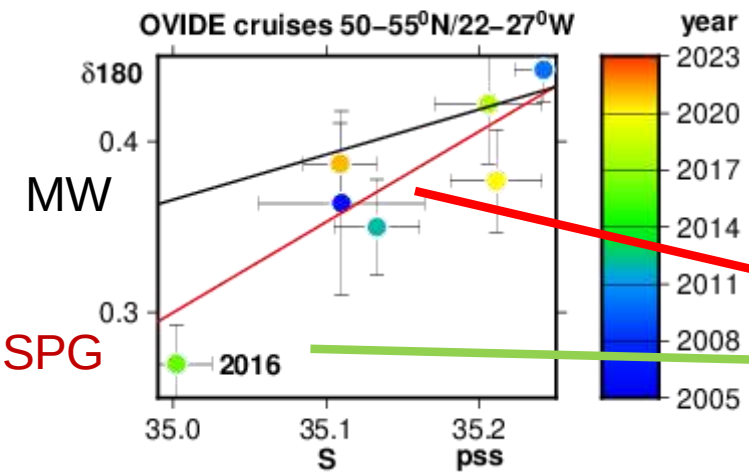
Reverdin et al., 2022

Great salinity anomaly 2016 eastern subpolar NA

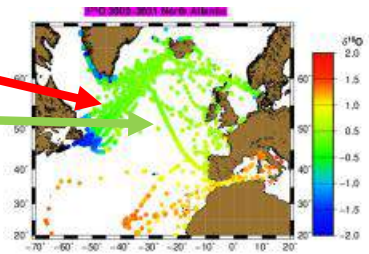


Holliday et al., 2020

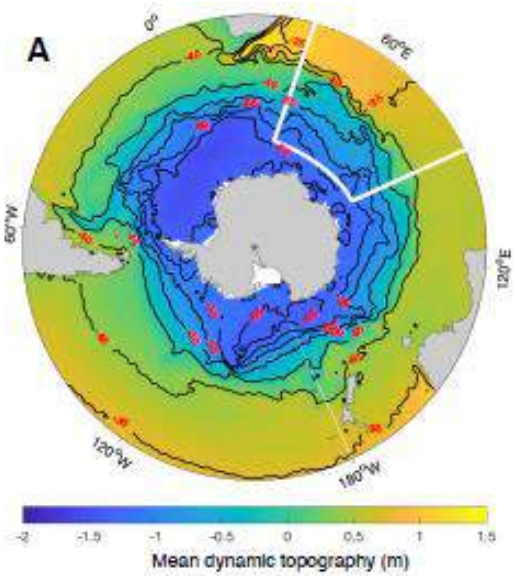


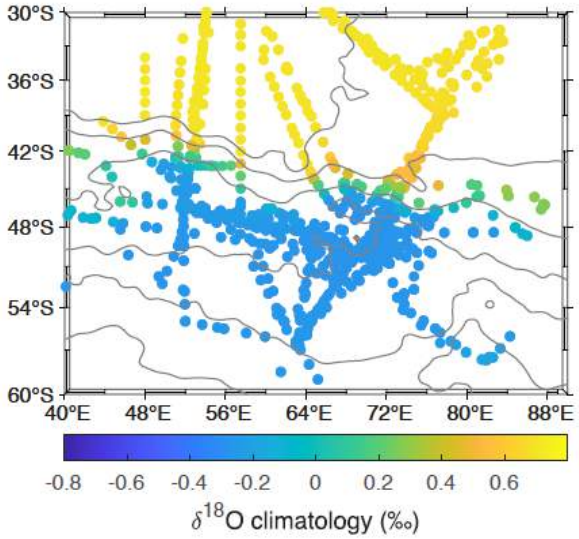


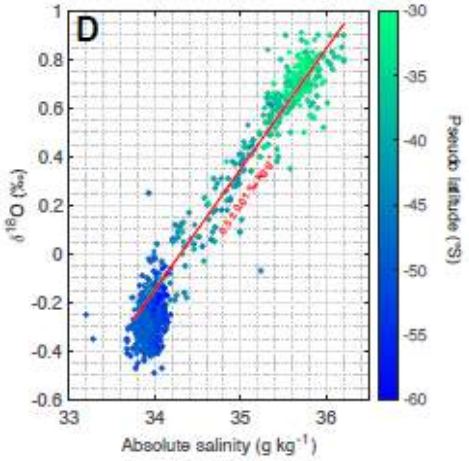
Western SPG

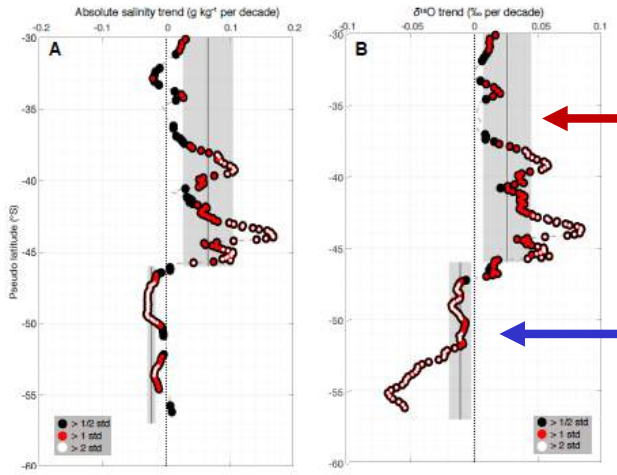


South Indian Ocean (trends 1993-2021)



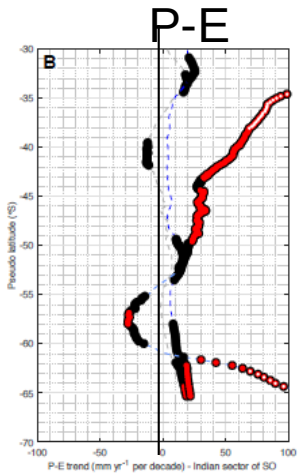






P-E trend : -95.3±29 mm yr dec
$\delta^{18}O$ P-E : -7.3±1 ‰

P-E trend : 51.8±4.5 mm yr dec
$\delta^{18}O$ P-E : -8.4±1 ‰



Akhoudas et al., 2022

Perspectives

Large interest to consider simultaneously

S and seawater stable isotopes for investigating changes in the hydrological cycle

- Need to boost intercomparison of data from different data providers – and datasets
- Need to consolidate international archives
- earlier efforts GISS, local databases
- PAGES CoralHydro2k (Delong et al., 2022)
- Proposal of a SCOR WG: MASIS