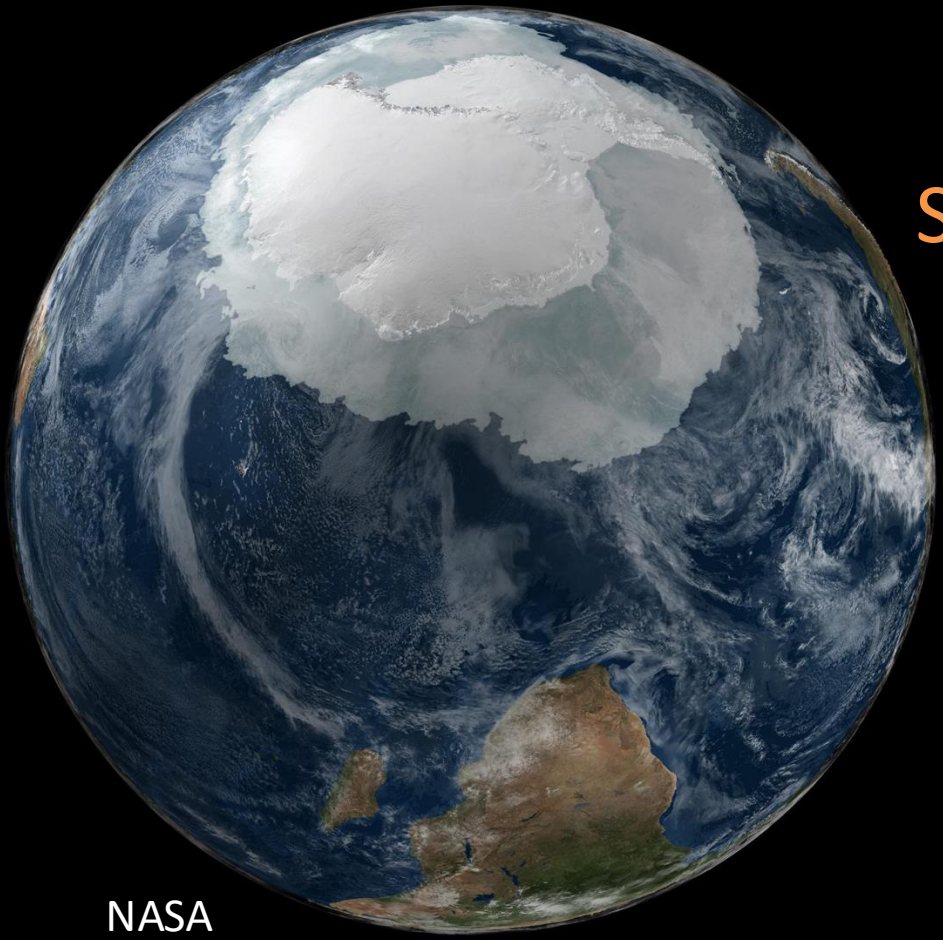
University of Southampton

esa



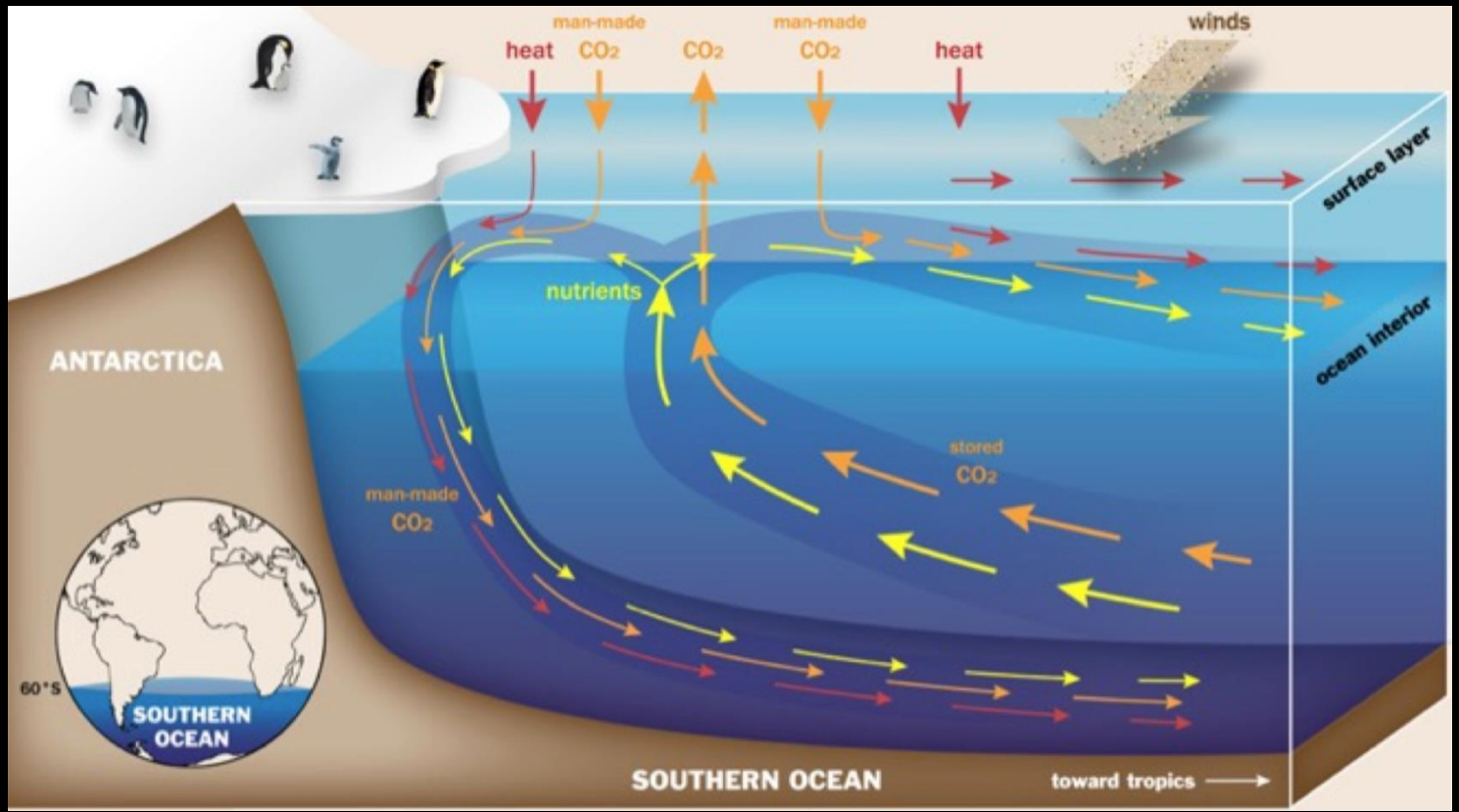
NASA

State of the art and gaps of Southern Ocean in-situ observations

Alessandro Silvano

Southern Ocean Overturning Circulation

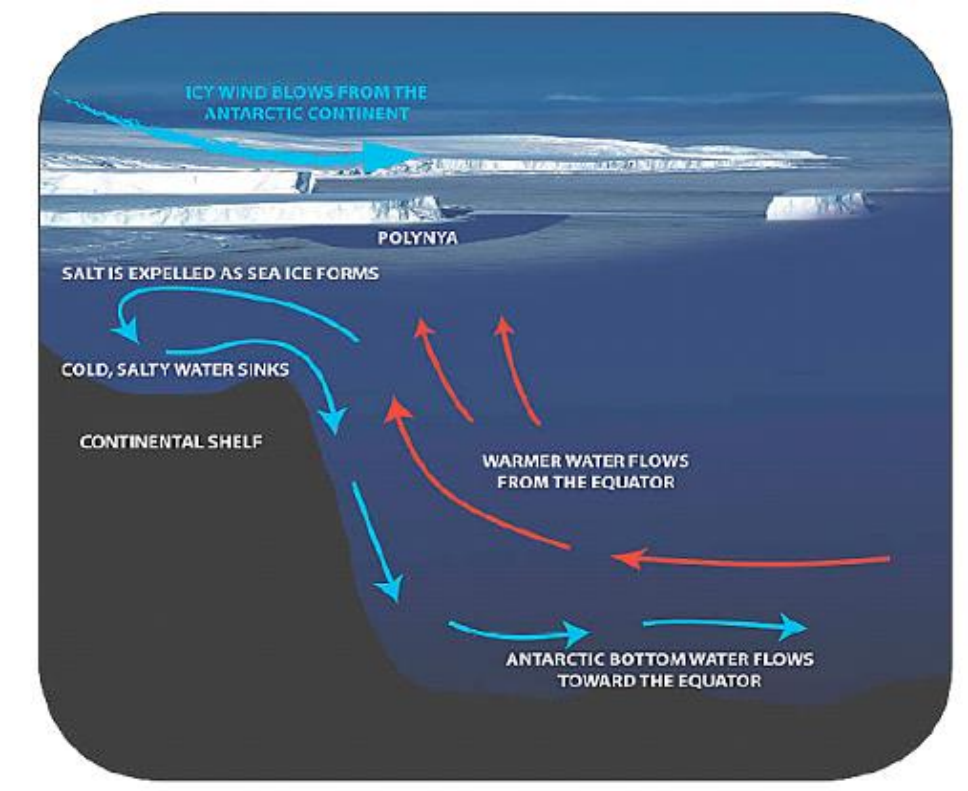
75% of heat and 45% of anthropogenic carbon ocean uptake



upper cell (2050-2100)

lower cell/ Antarctic Overturning (2100-2300)

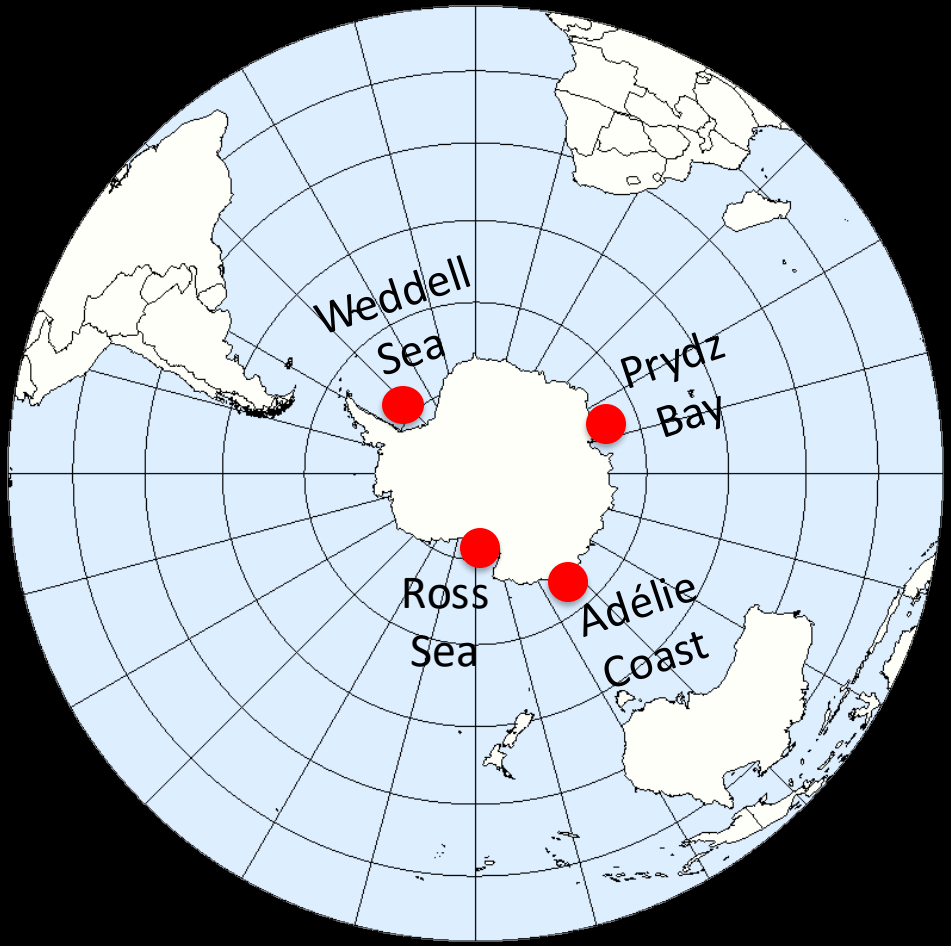
The Lower Cell (Antarctic Overturning Circulation)



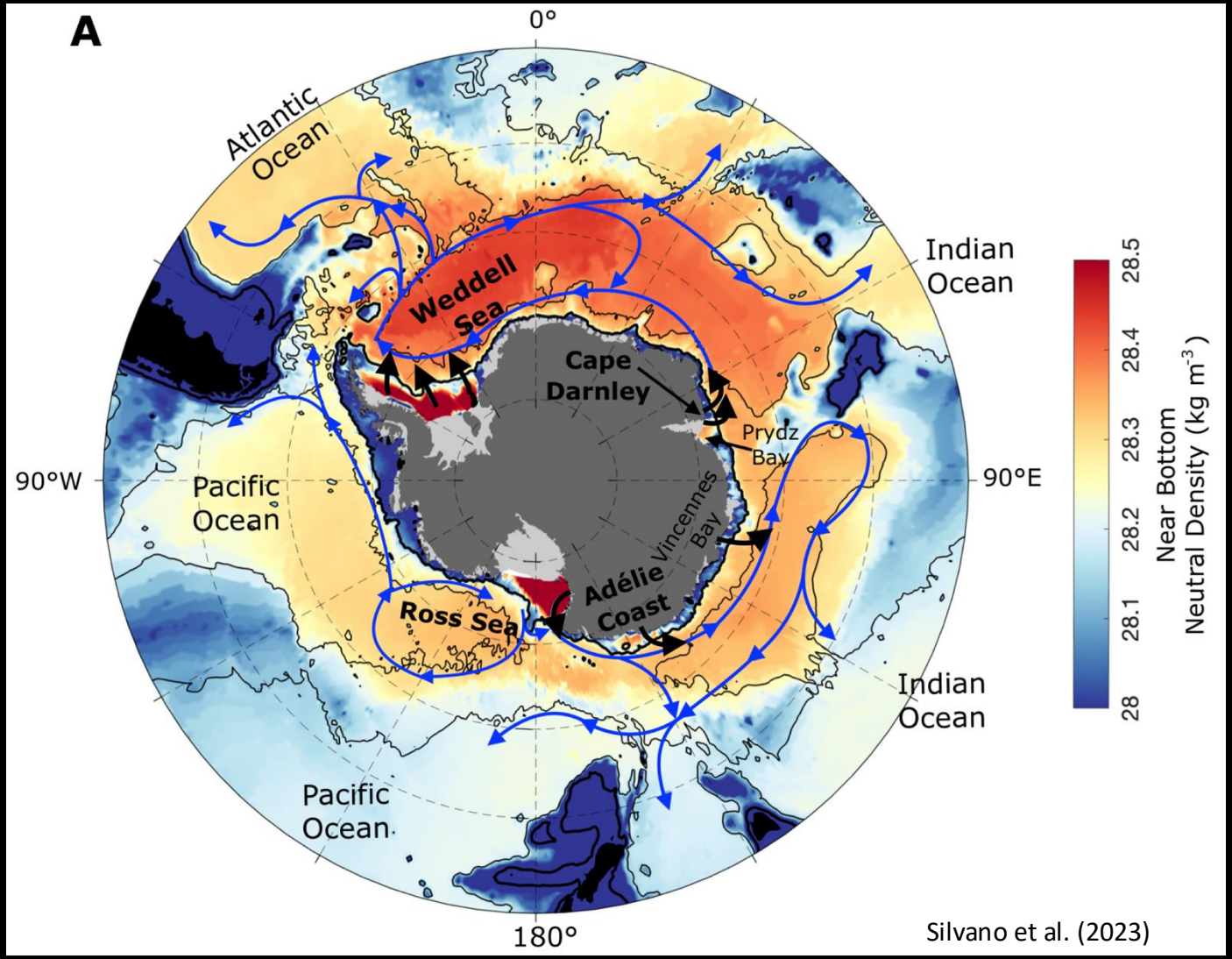
UNSW website, Matt England

Antarctic Bottom Water (AABW) stores heat and carbon in the abyss for centuries

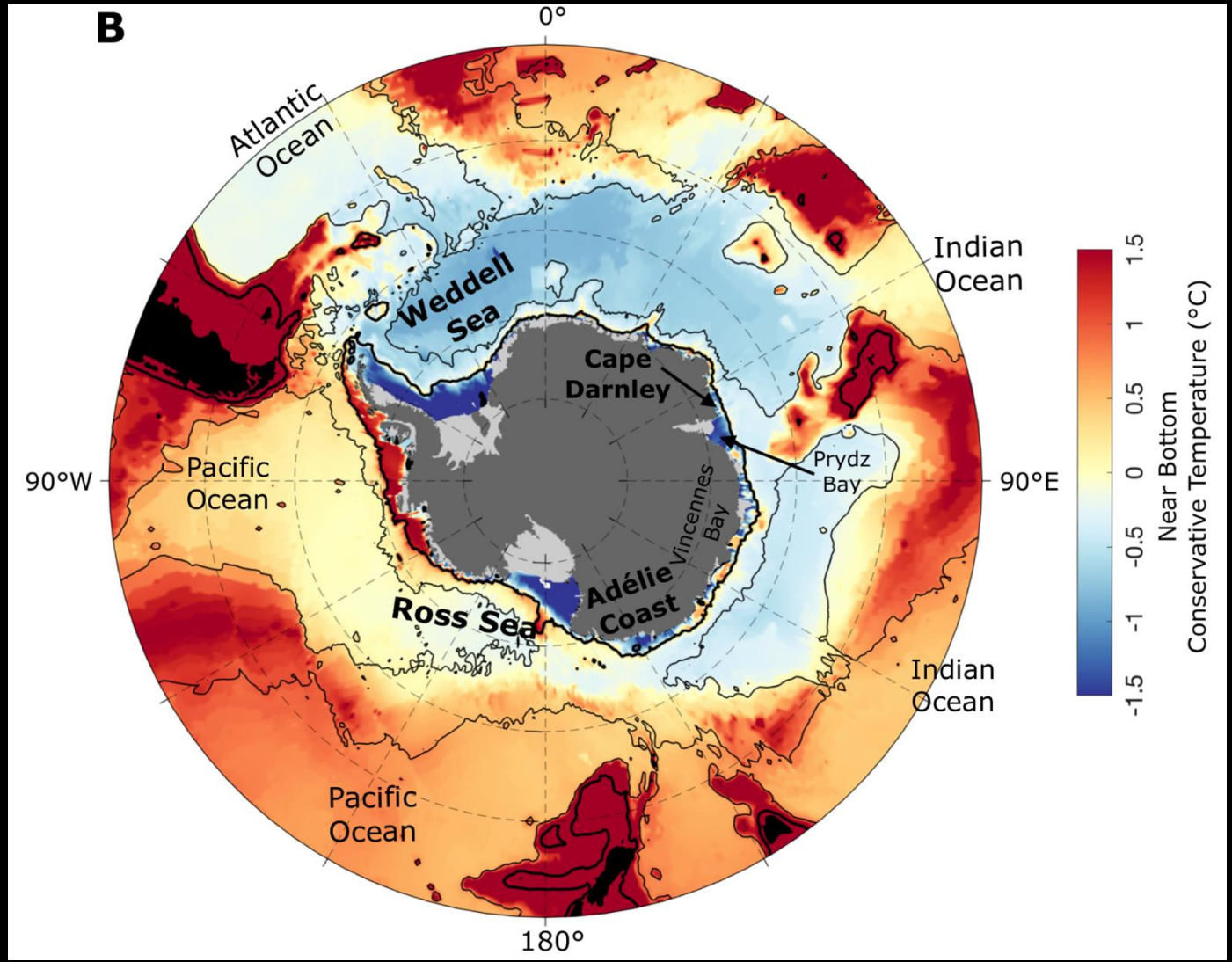
AABW formation sites



AABW circulation



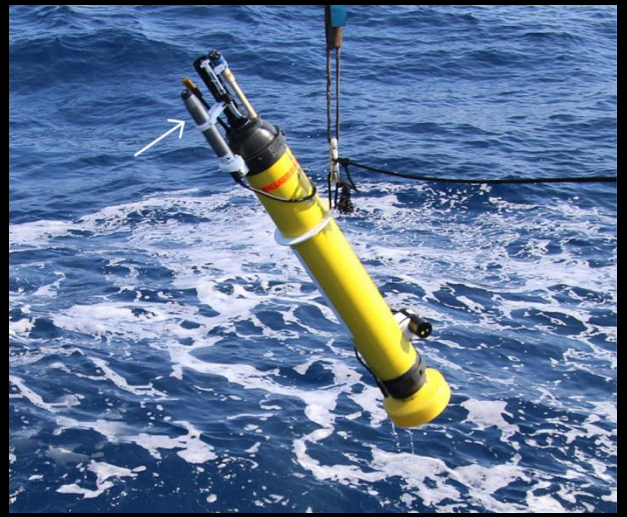
Silvano et al. (2023)


B
0°
Atlantic Ocean
Indian Ocean
Weddell Sea
Cape Darnley
Prydz Bay
90°W
Pacific Ocean
90°E
Vincennes Bay
Adélie Coast
Ross Sea
Indian Ocean
Pacific Ocean
180°
1.5
1
0.5
0
-0.5
-1
-1.5
Near Bottom Conservative Temperature (°C)

In-situ observations

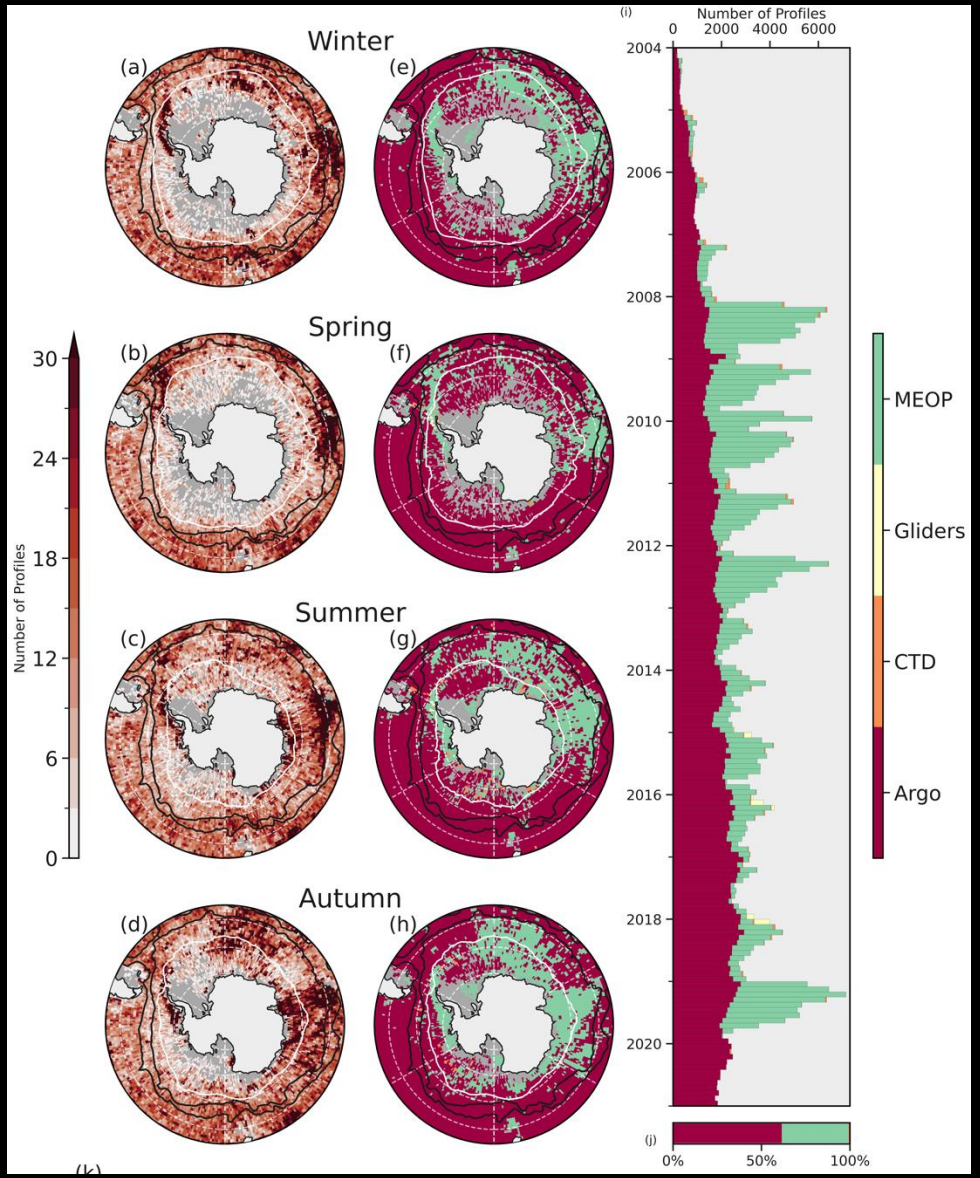
Ships (summer) + year round moorings

Under ice floats (year-round)



CTD-instrumented seals (year-round

Gliders and AUVs

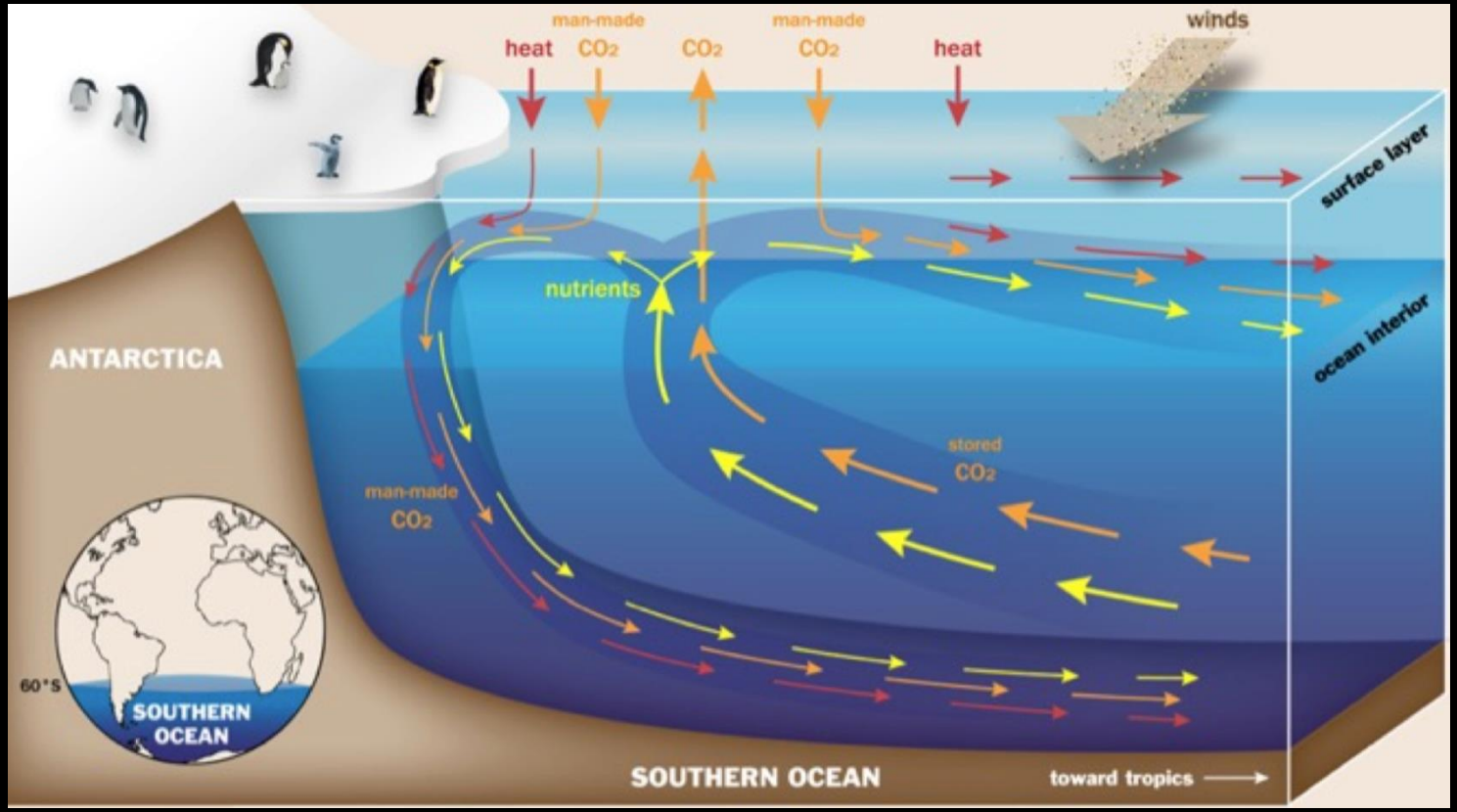


In situ observations since 2004

- Argo and marine mammals (MEOP) have changed the way we observe the Southern Ocean
- Polar Southern Ocean (where AABW forms) still poorly sampled
- **Continental shelf particularly poorly observed**
- Summer bias

Spira et al. (under review)

Need for long term AABW observations



upper cell (2050-2100)

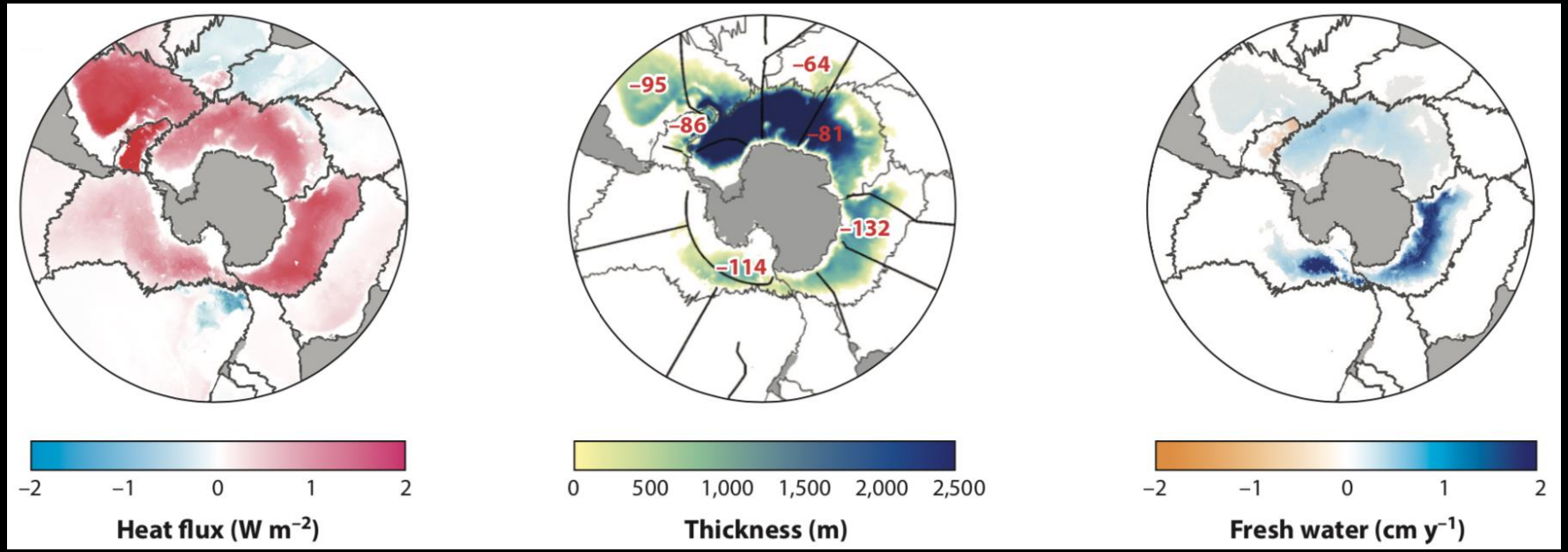
lower cell/ Antarctic Overturning (2100-2300)

Multidecadal changes based on repeated CTD sections and mooring observations

warming

contraction

freshening



AABW trends between the 1980s and 2000s
(sections every 10 years)

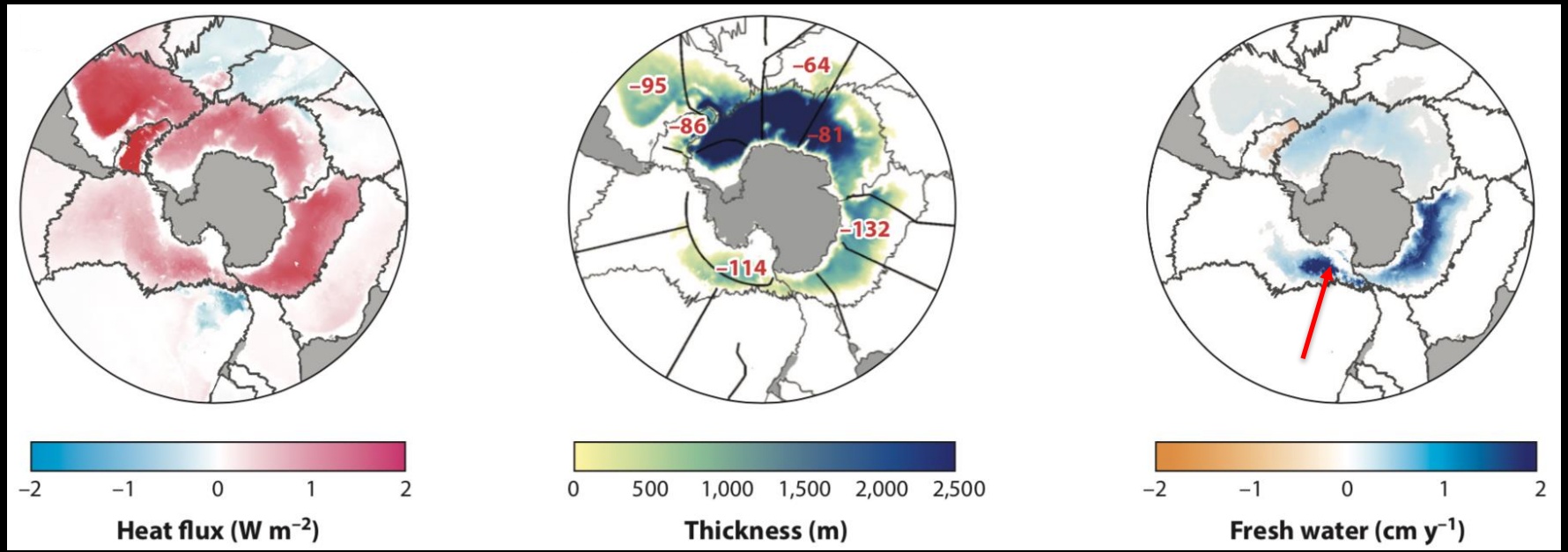
Purkey et al. 2017
Rintoul 2007
Menezes et al. 2017

Multidecadal changes based on repeated CTD sections and mooring observations

warming

contraction

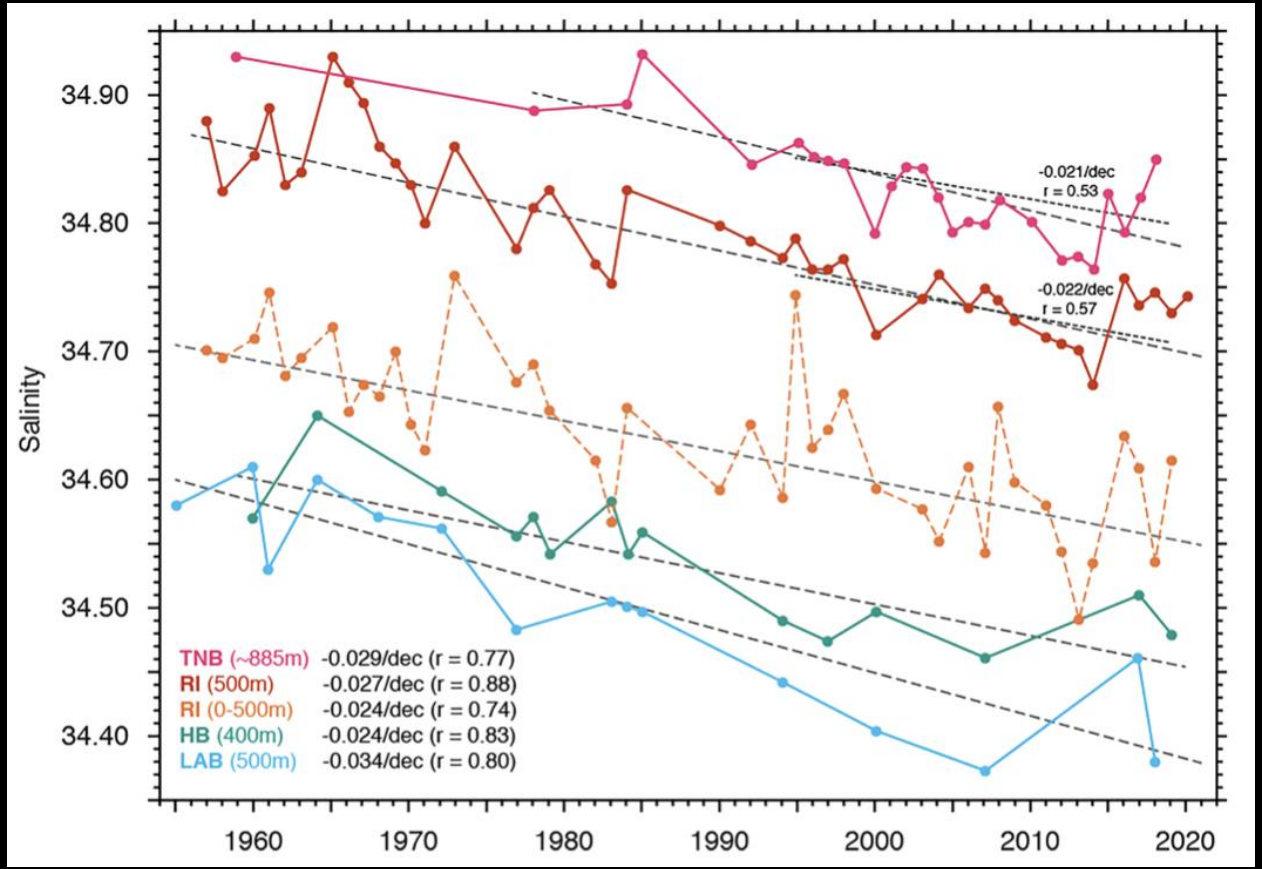
freshening



AABW trends between the 1980s and 2000s

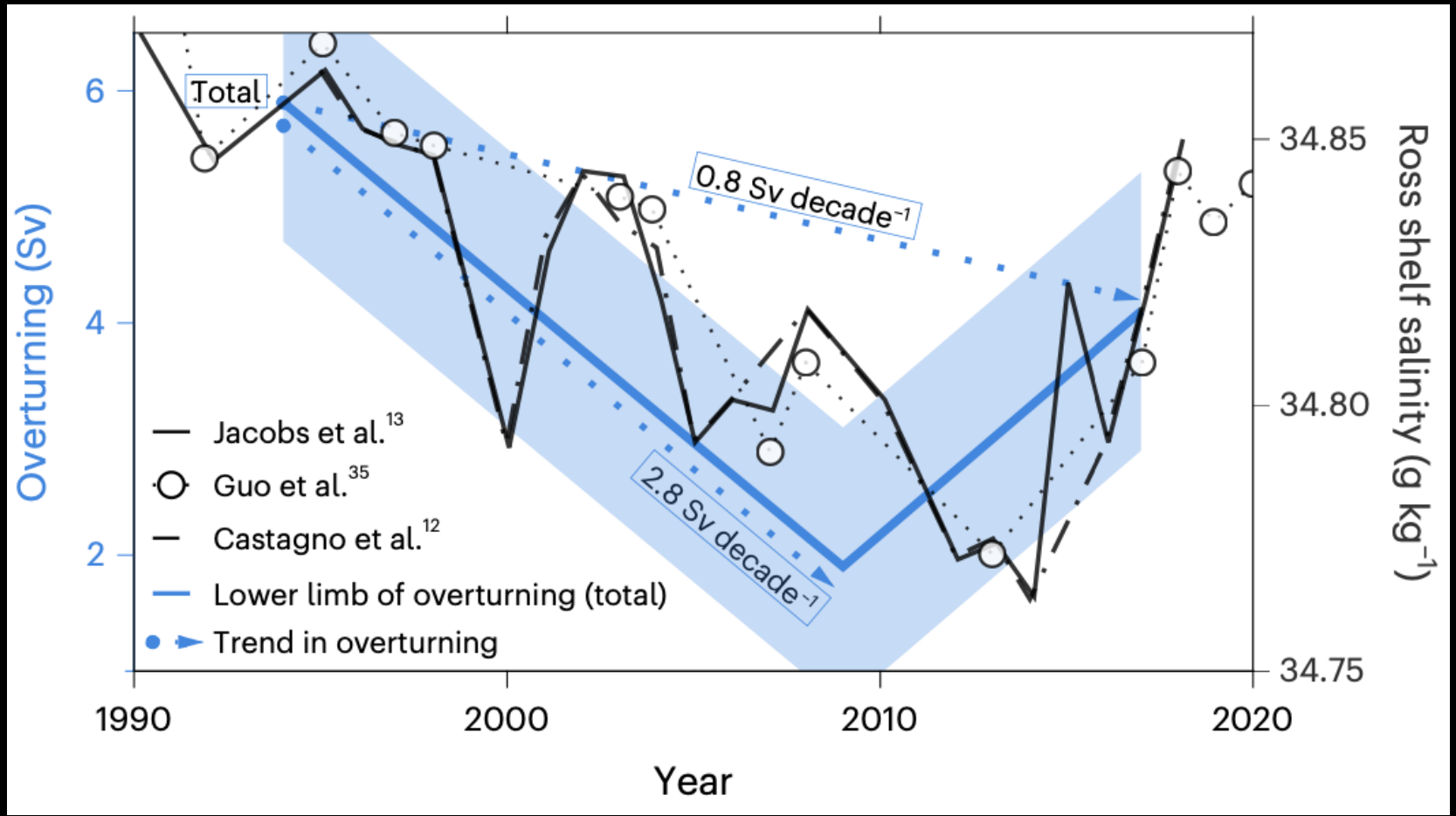
Purkey et al. 2017
Rintoul 2007
Menezes et al. 2017

Multidecadal freshening in the Ross Sea



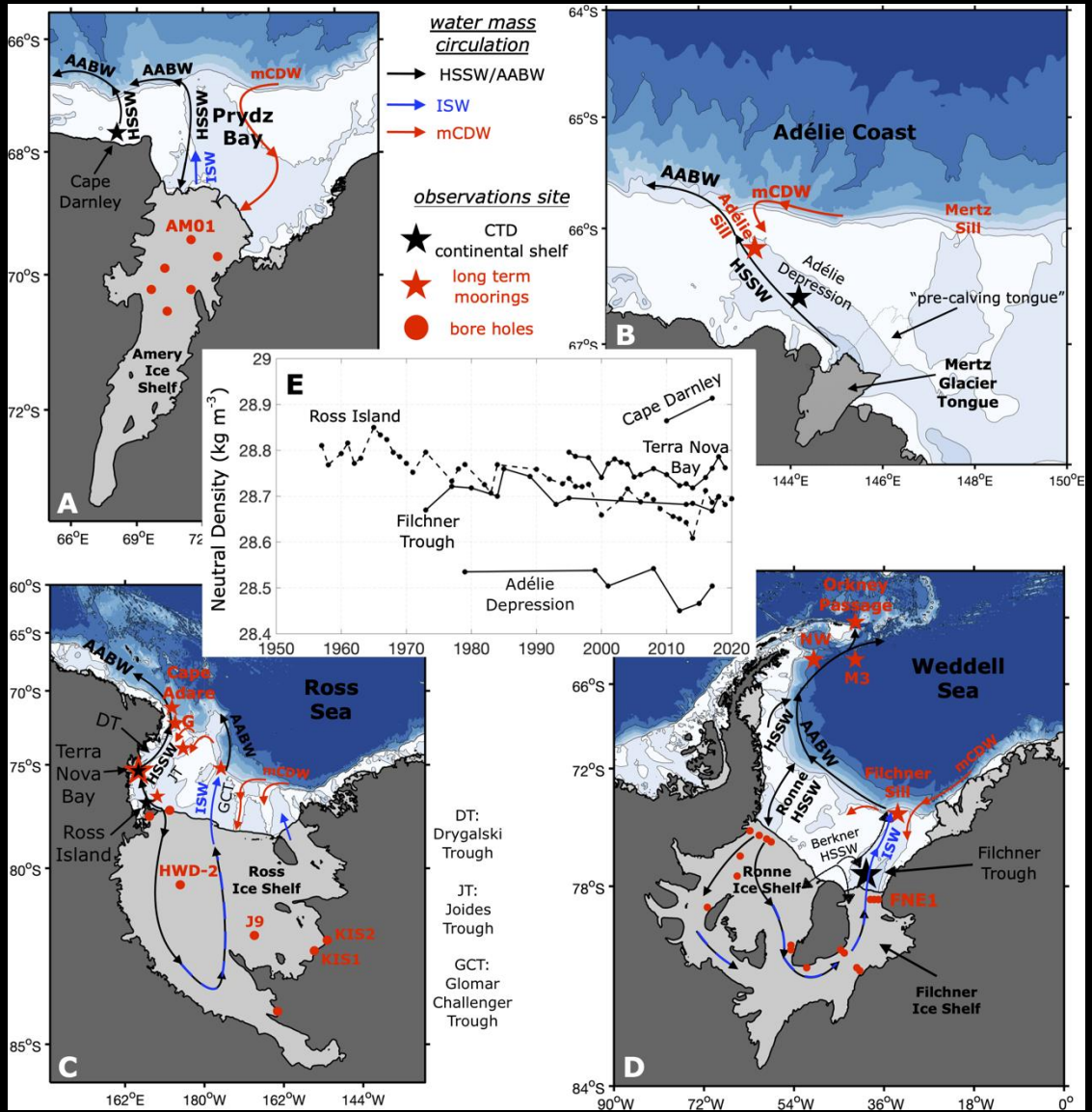
Jacobs et al. (2022)

Decrease (30%) in the abyssal overturning since the 1990s



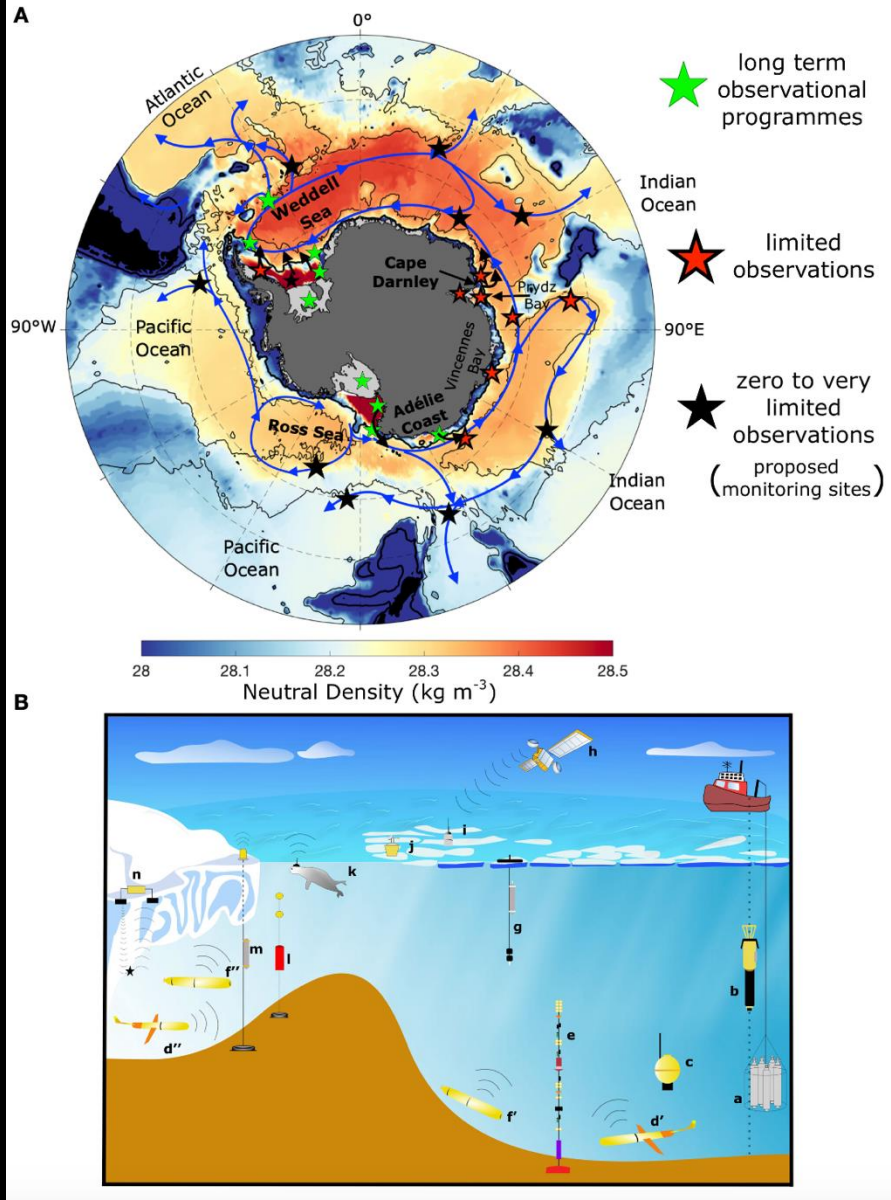
Gunn et al. (2023)

Observations at the four AABW formation sites



Silvano et al. (2023)

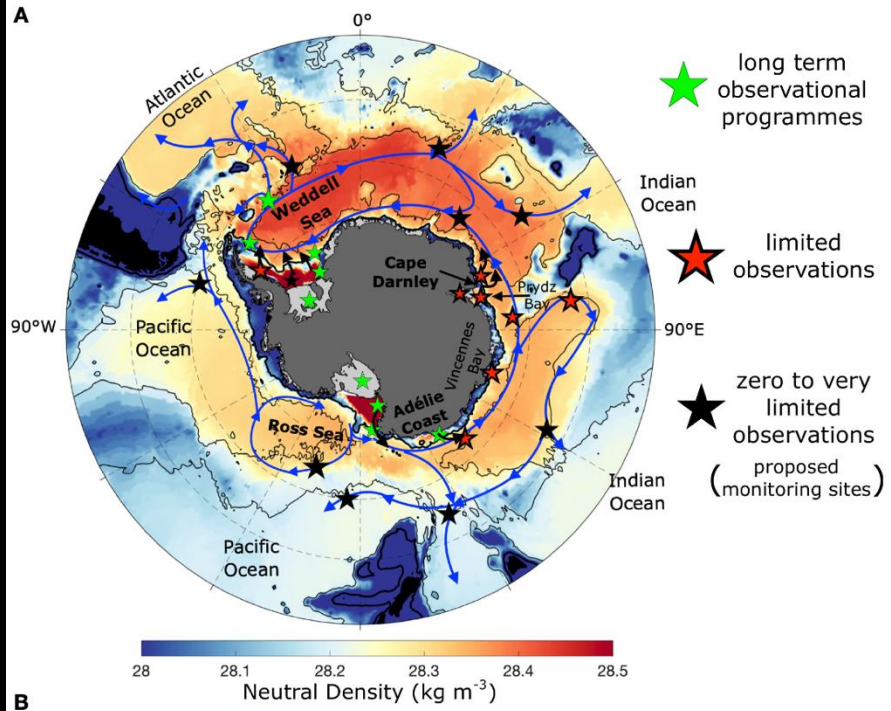
An observing system for the lower cell

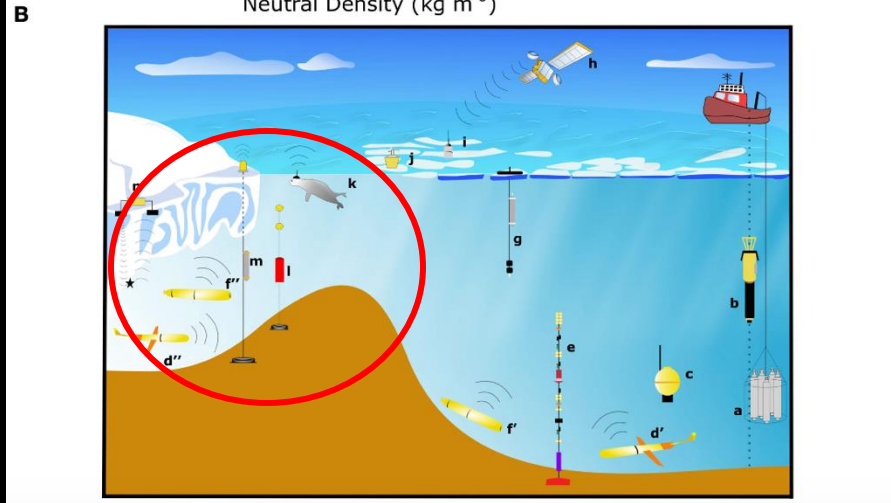


Silvano et al. (2023)

An observing system for the lower cell

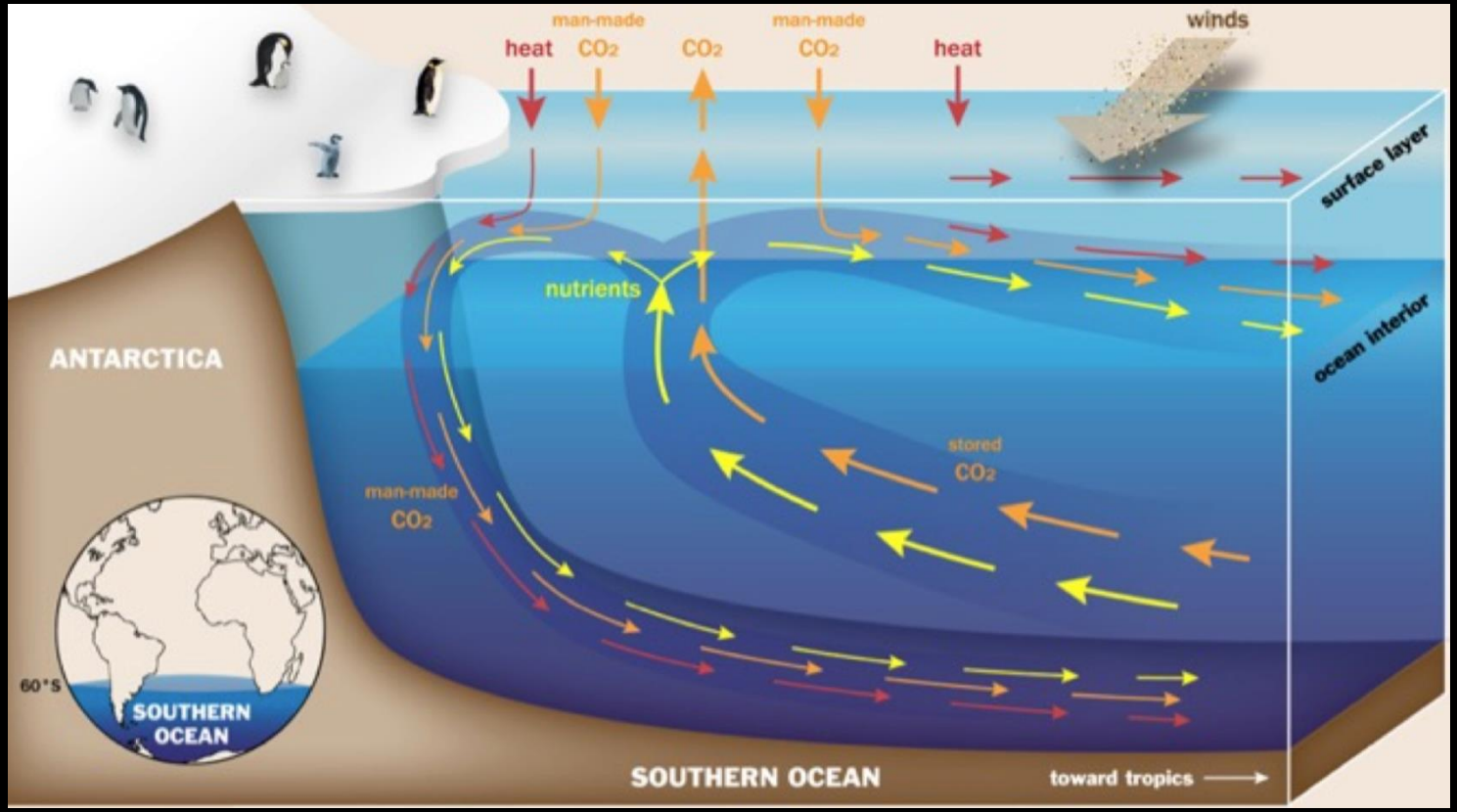
→ Key to measure the Antarctic continental shelf and slope





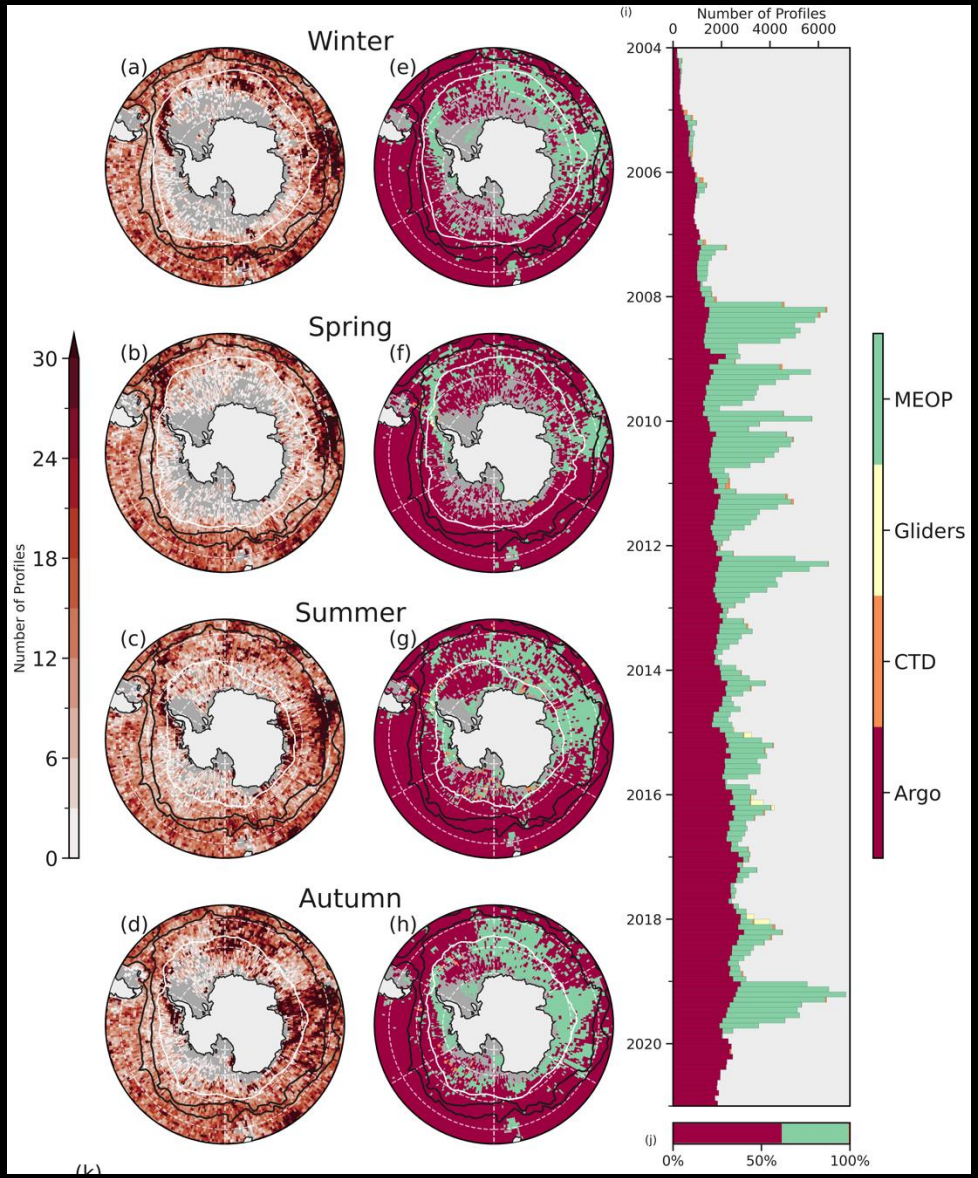
Silvano et al. (2023)

Upper Cell



upper cell (2050-2100)

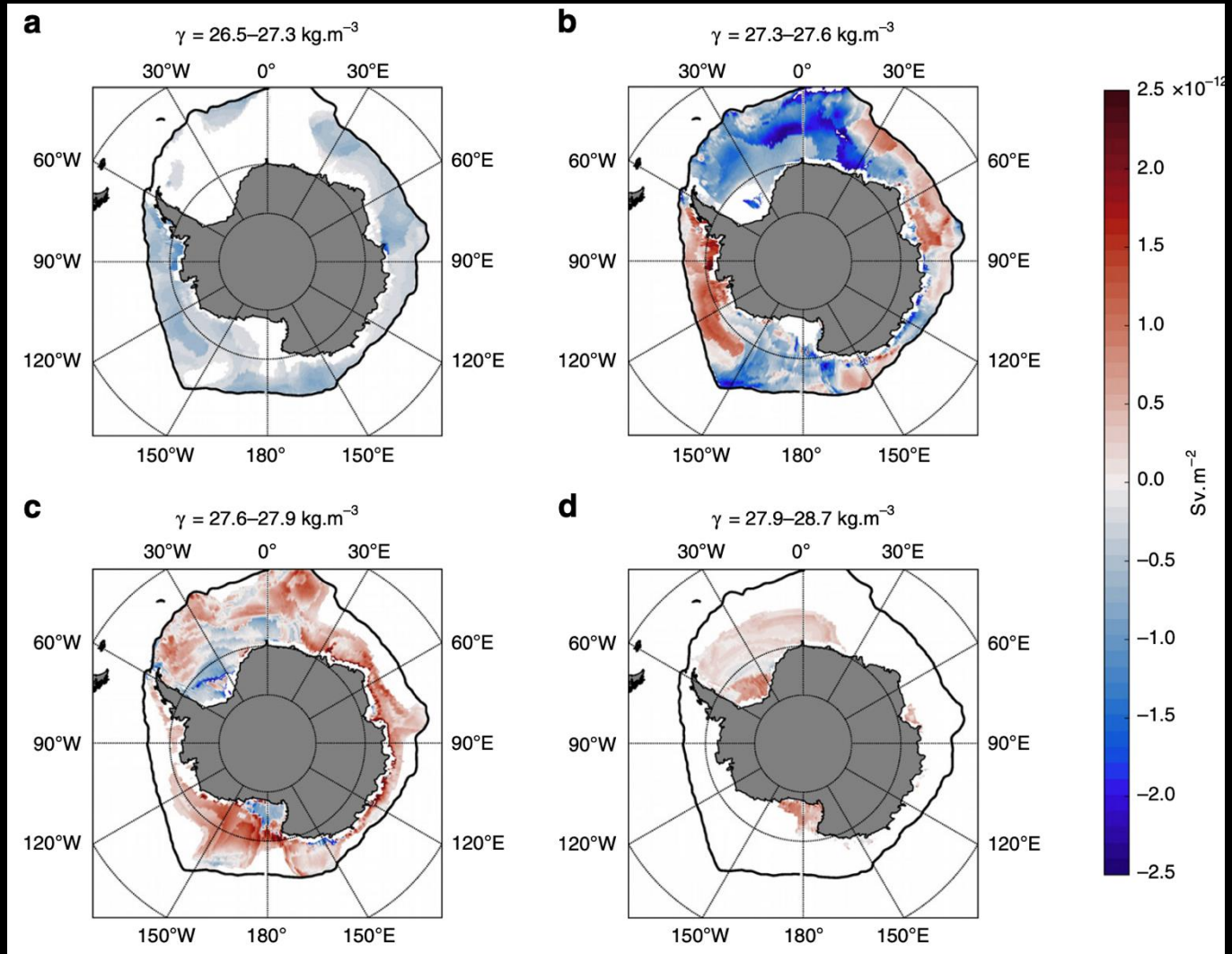
lower cell/ Antarctic Overturning (2100-2300)



In situ observations since 2004

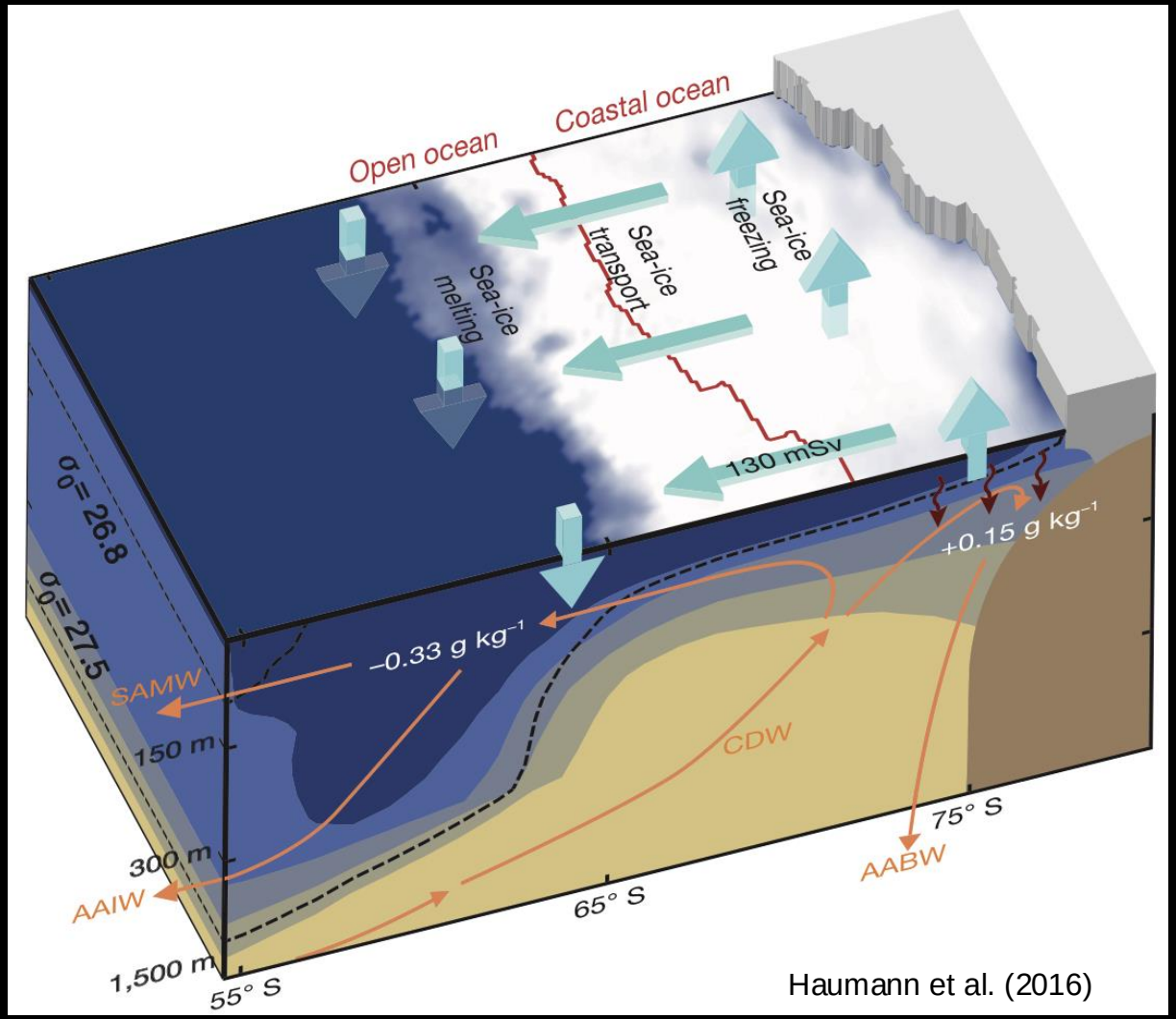
- Summer bias
- But now we have some winter observations!

Spira et al. (under review)



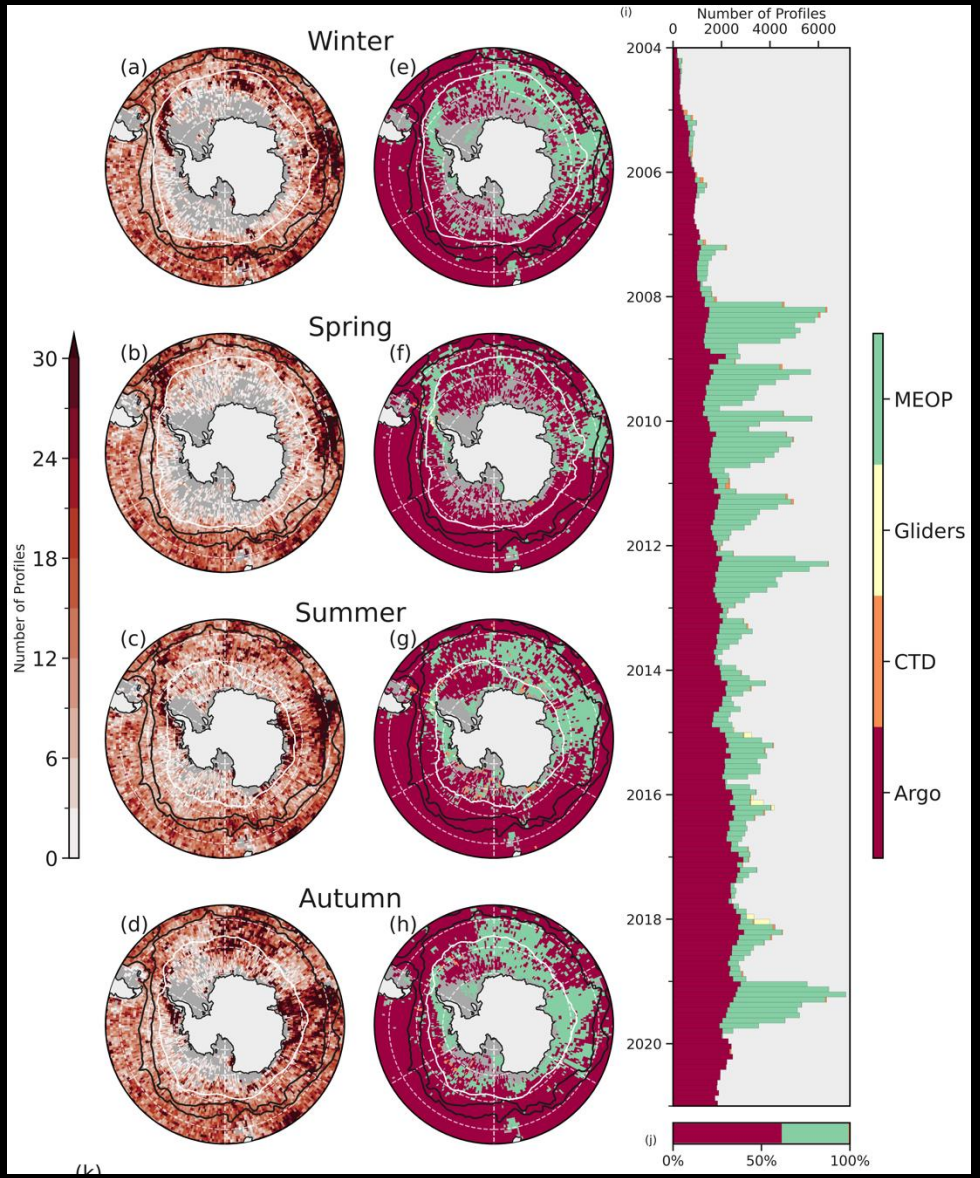
Observation-based water mass transformation

Pellichero et al. (2018)



Haumann et al. (2016)

The upper cell is influenced by sea ice processes



Sustained observations needed for the upper cell

- ARGO and MEOP essential
- More high resolution, year round glider and AUV campaigns (Antarctica InSync)

→ upper ocean processes under sea ice (marginal ice zone and winter)

→ Detect and understand interannual to decadal changes

→ Any circulation changes associated with recent sea ice decline?

Spira et al. (under review)

In situ observations are not enough!!!!

- Satellite derived observations (SST, SSS, sea ice volume and drift, sea level, ice sheet freshwater fluxes) need to be improved in the polar Southern Ocean

- Ice-ocean-atmosphere coupled models

- (improve in situ and satellite-derived air sea fluxes!)


SOOS
SOUTHERN OCEAN OBSERVING SYSTEM


INTERNATIONAL SCIENCE COUNCIL
SCAR
SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH
International Council for Science
SCOR
Scientific Committee on Oceanic Research