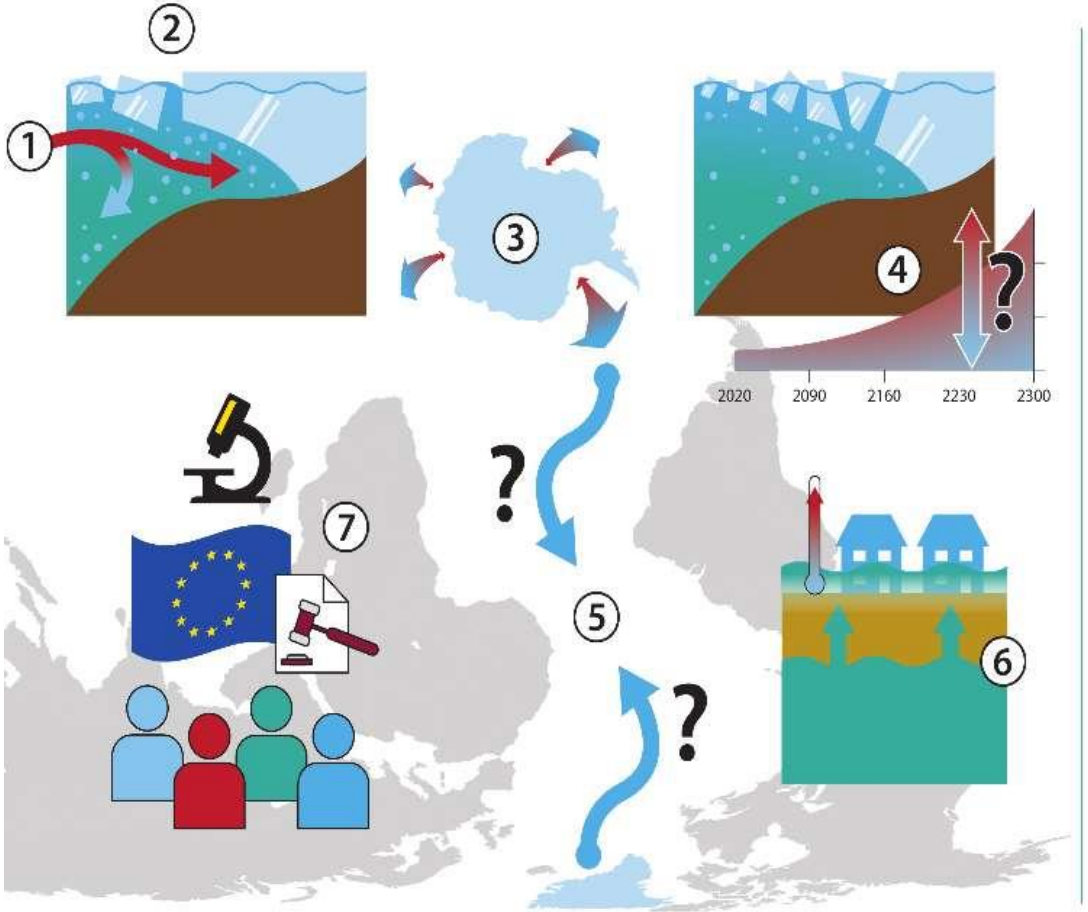
WP5 – Ice sheet impacts on global ocean circulation

ELAINE MCDONAGH & PETRA LANGEBROEK

(NORCE)

How sensitive is **ocean circulation** to changes in **freshwater fluxes** from the Greenland and Antarctic **ice sheets** ?



1. Ocean processes around Antarctica (WP1)
2. Antarctic ice sheet-ocean interactions (WP2)
3. Antarctic ice sheet modelling and freshwater fluxes (WP3)
4. Future fluxes and stability of Antarctic ice sheet (WP4)
5. Ice sheet impact on global ocean circulation (WP5)
6. Ice sheet-ocean-climate impacts and tipping points (WP6)
7. Scientifically and socially relevant impacts and dissemination (WP7-9)

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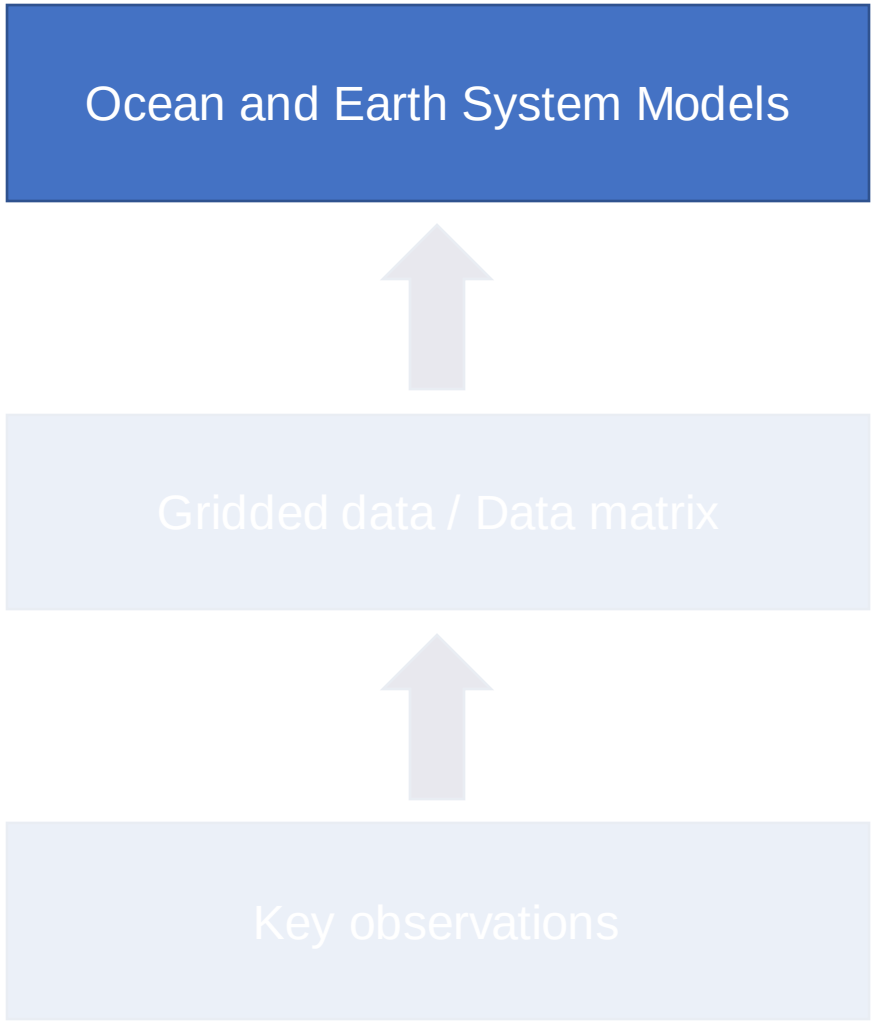
OCEAN:ICE



Freshwater perturbations in ocean model NEMO and Earth System Model NorESM

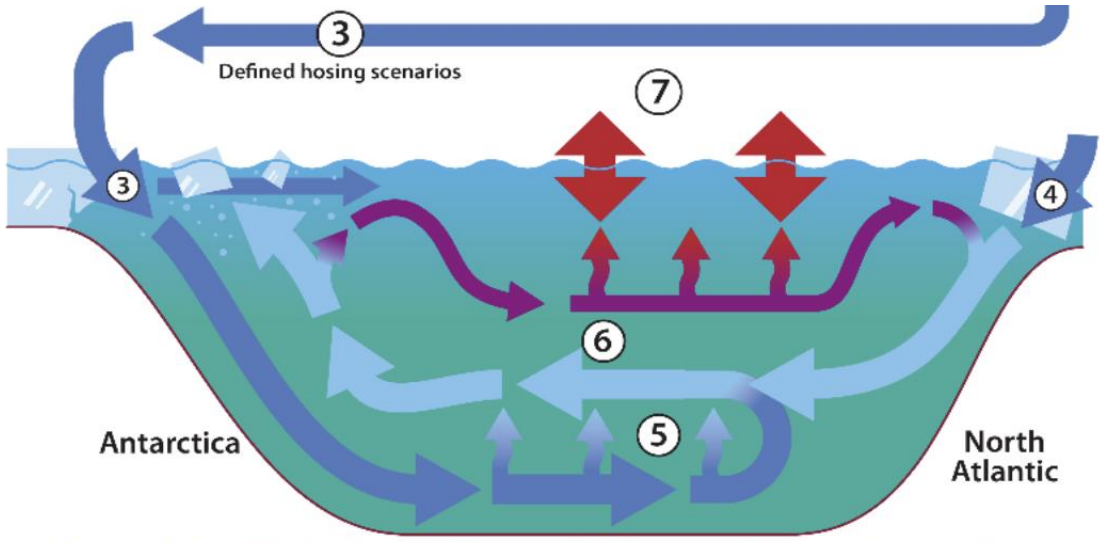


Figure 1.5: AIS freshwater flux projections and uncertainty and ocean model forcing. Section 1.2.4.3.

Freshwater perturbations

Casimir de Lavergne

Strategy:

› Long NEMO simulations at 1º resolution under climatological forcing plus freshwater perturbations.
› Passive tracers to tag and track northern and southern sourced deep waters.
› Analyse circulation and tracer changes due to freshwater perturbations.

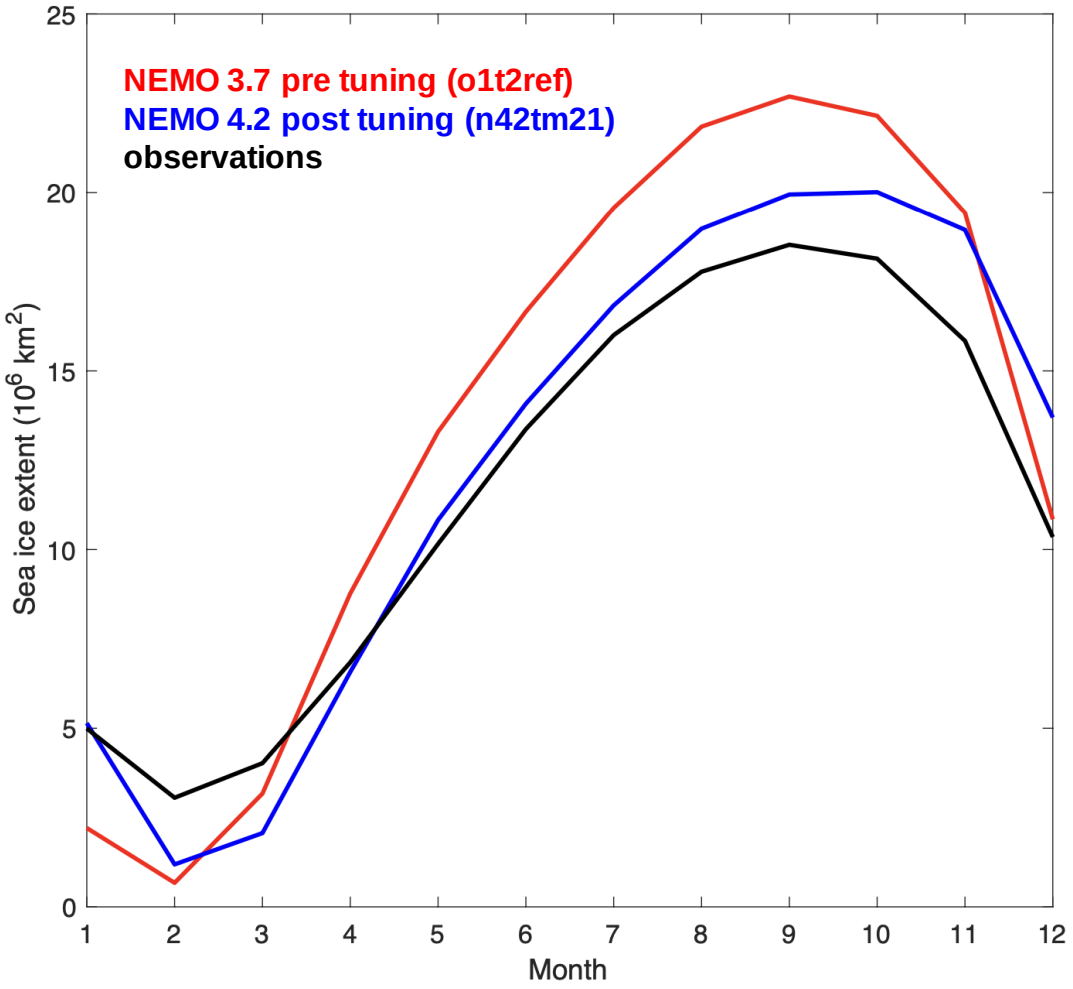
Methodology:

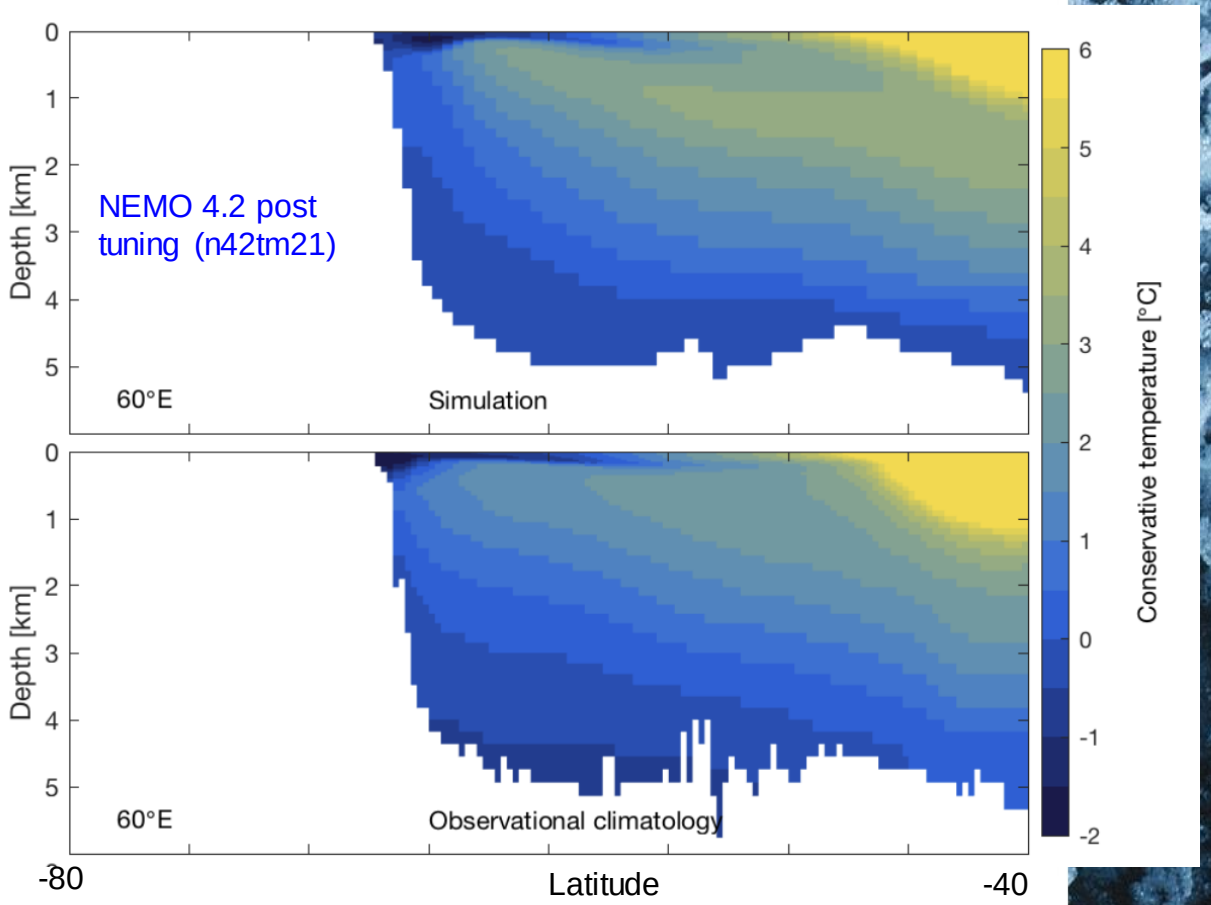
› Start from near-equilibrated NEMO simulations with COREII normal year forcing (and SSS restoring).
› Add several numerical dyes in deep water formation regions. Spin up the dye tracers offline.
› Convert the SSS restoring into a flux forcing.
› Run the model with online dye tracers for a few hundred years to obtain steady distributions.
› Run with the freshwater flux perturbation following some (extended) scenarios of ice sheet mass loss.
› Add dye tracers that track the new freshwater sources.

→ *D5.7: Report on initialisation and verification of NEMO configuration (M30, CNRS)*

Improvements & tuning

Casimir de Lavergne

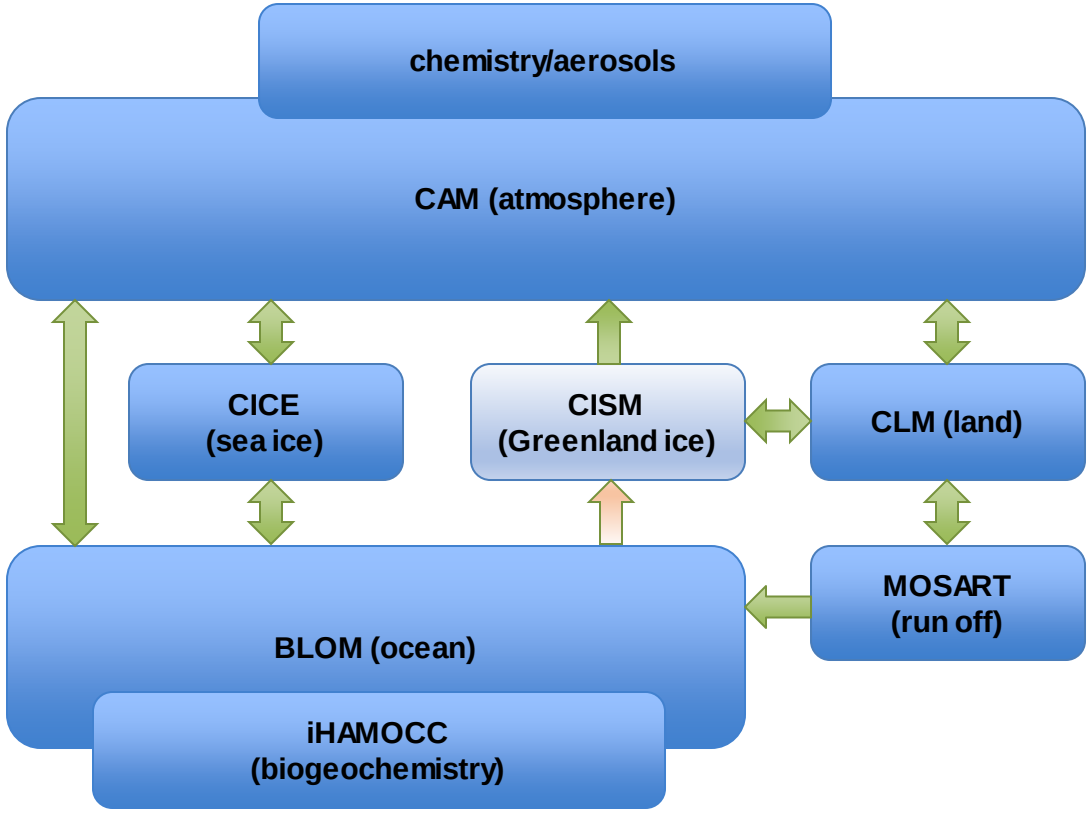




→ *D5.7: Report on initialisation and verification of NEMO configuration (M30, CNRS)*

Freshwater perturbations

Petra Langebroek



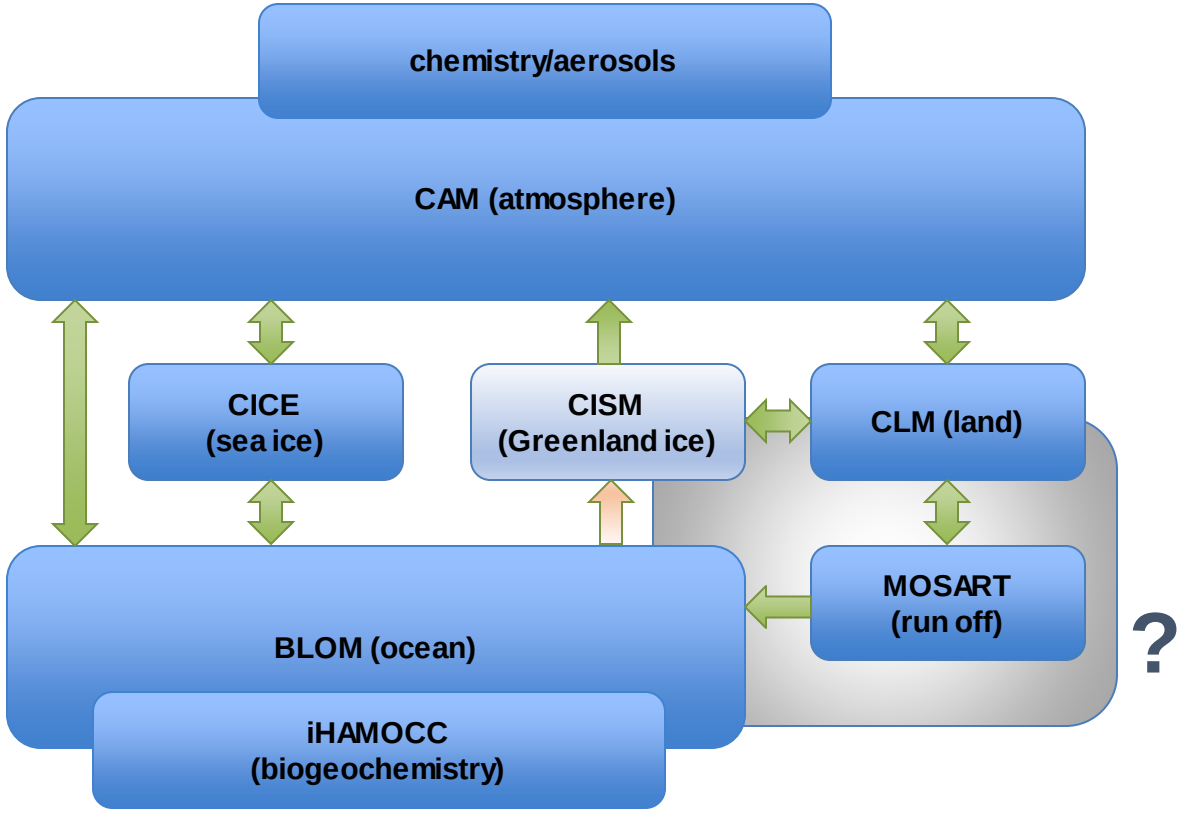
NEW: interactive Greenland ice sheet

- Atmospheric circulation changes due to changes in ice sheet topography
- Surface mass balance – height feedback
- Ocean thermal forcing, sub-shelf and frontal melting: Not yet, but addressed in Norwegian project (Heiko Goelzer)

NorESM2: Seland et al. 2020 CESM2: Danabasoglu et al., 2020

Freshwater perturbations

Petra Langebroek



NEW: interactive Greenland ice sheet

- Atmospheric circulation changes due to changes in ice sheet topography
- Surface mass balance – height feedback
- Ocean thermal forcing, sub-shelf and frontal melting: Not yet, but addressed in Norwegian project (Heiko Goelzer)
- **OCEAN:ICE** Freshwater fluxes influence the ocean circulation. HOW/MUCH?

→ *D5.8: Report on Greenland ice sheet freshwater implementation in NorESM (M30, NORCE)*

Freshwater perturbations in ocean model NEMO and Earth System Model NorESM

From WP4

From NorESM

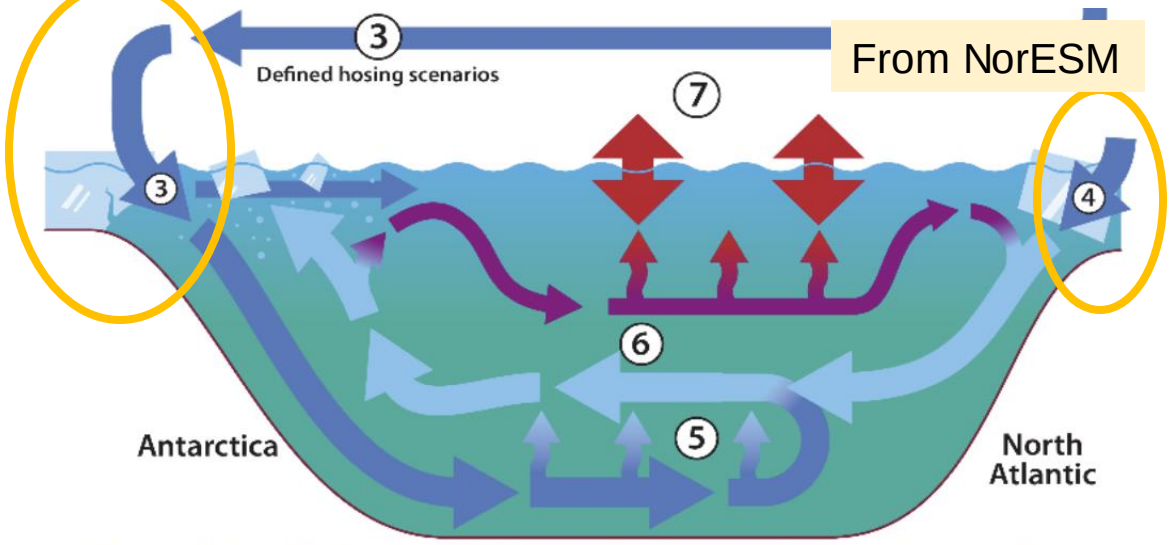
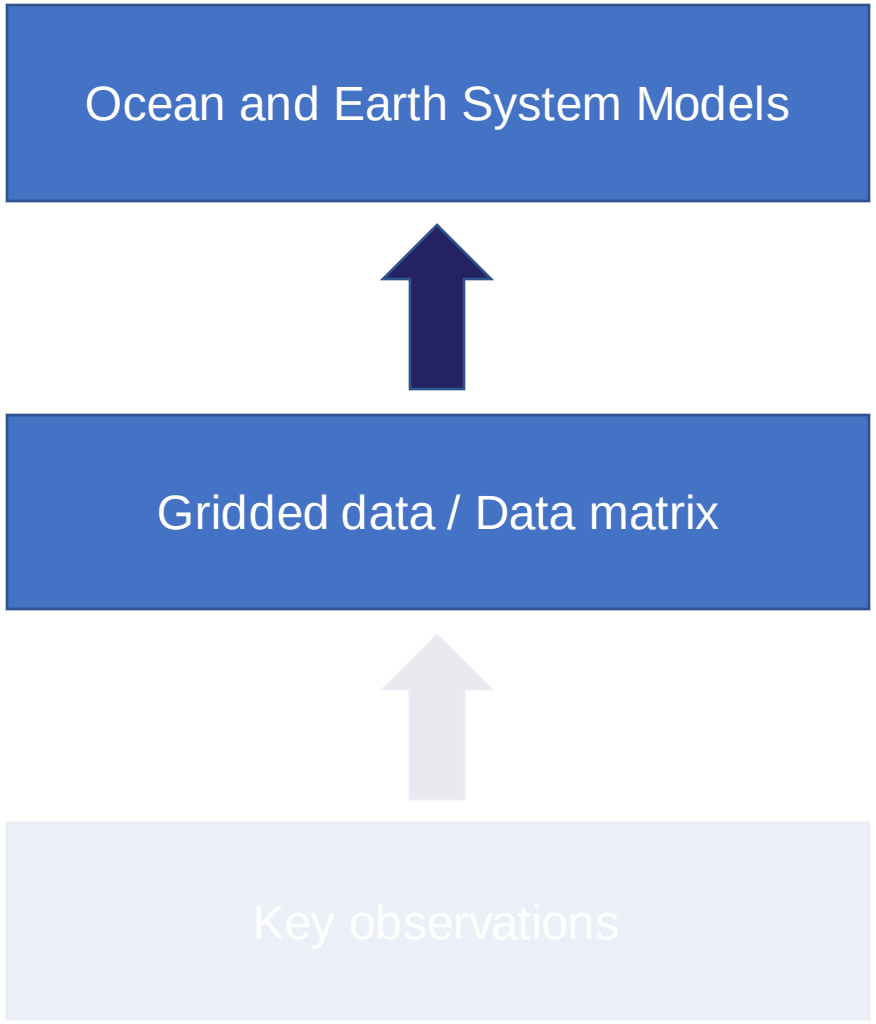


Figure 1.5: AIS freshwater flux projections and uncertainty and ocean model forcing. Section 1.2.4.3.

→ *D5.9: Report on impact of glacial freshwater forcing on ocean circulation in NEMO & NorESM (M42, NORCE&CNRS)*

How sensitive is **ocean circulation** to changes in **freshwater fluxes** from the Greenland and Antarctic **ice sheets** ?

OCEAN:ICE



Surface water isotope reconstruction

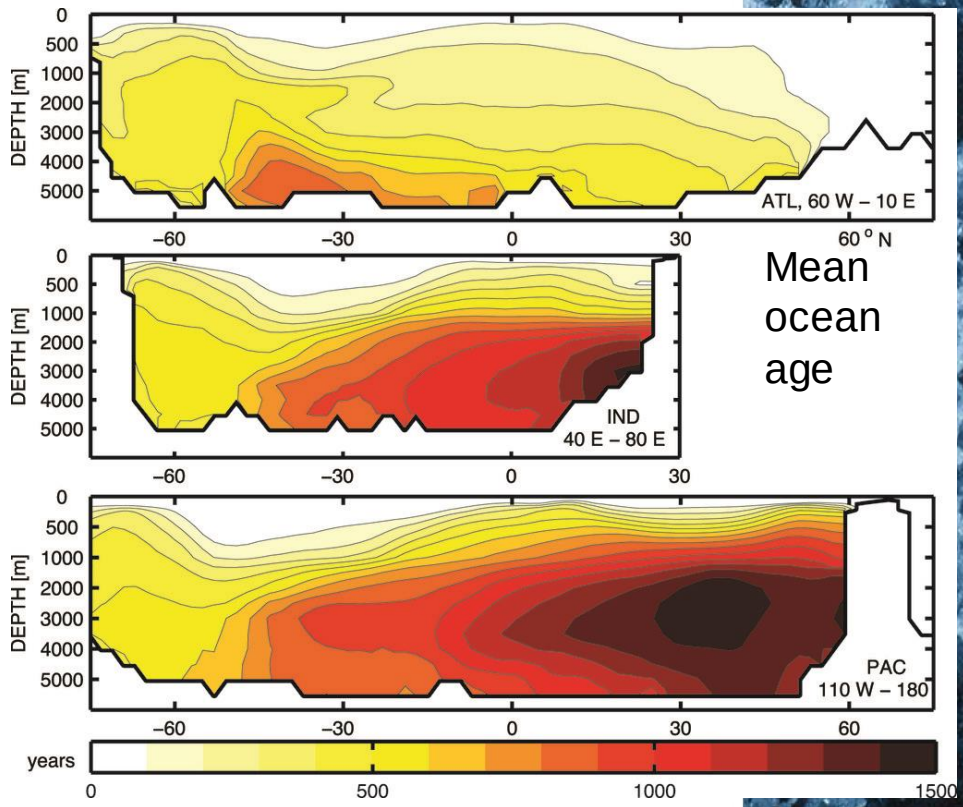
Elaine McDonagh Michael Meredith

- Green's Function:
  interior distribution – steady state circulation – surface properties

- Total Matrix Intercomparison (TMI)
- Uses temperature, salinity, oxygen, nutrients, oxygen isotopes and carbon-14 (Gebbie & Huybers, 2011, 2012)

In Ocean:Ice WP5:

- TMI Green's Function and interior distribution of oxygen isotopes to reconstruct surface boundary conditions
  - Decorrelation scales
  - Reconstruction
  - Interpretation in terms of meteoric water and sea ice contributions



Mean ocean age

Gebbie & Huybers, 2012

→ *D5.5: Report on temporal and spatial length scales in δ18O observations (M18, NORCE, UKRI-BAS)*
→ *D5.6: Reconstruction of global surface δ180 and salinity (M30, NORCE, UKRI-BAS)*

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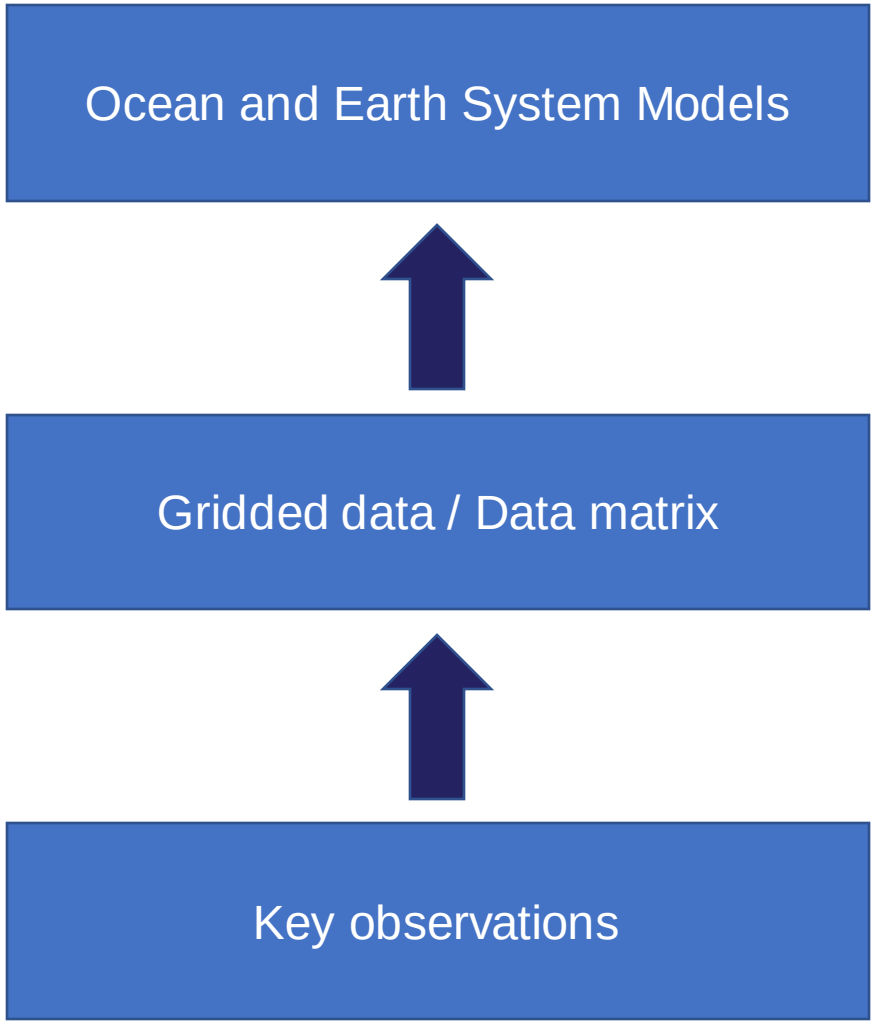
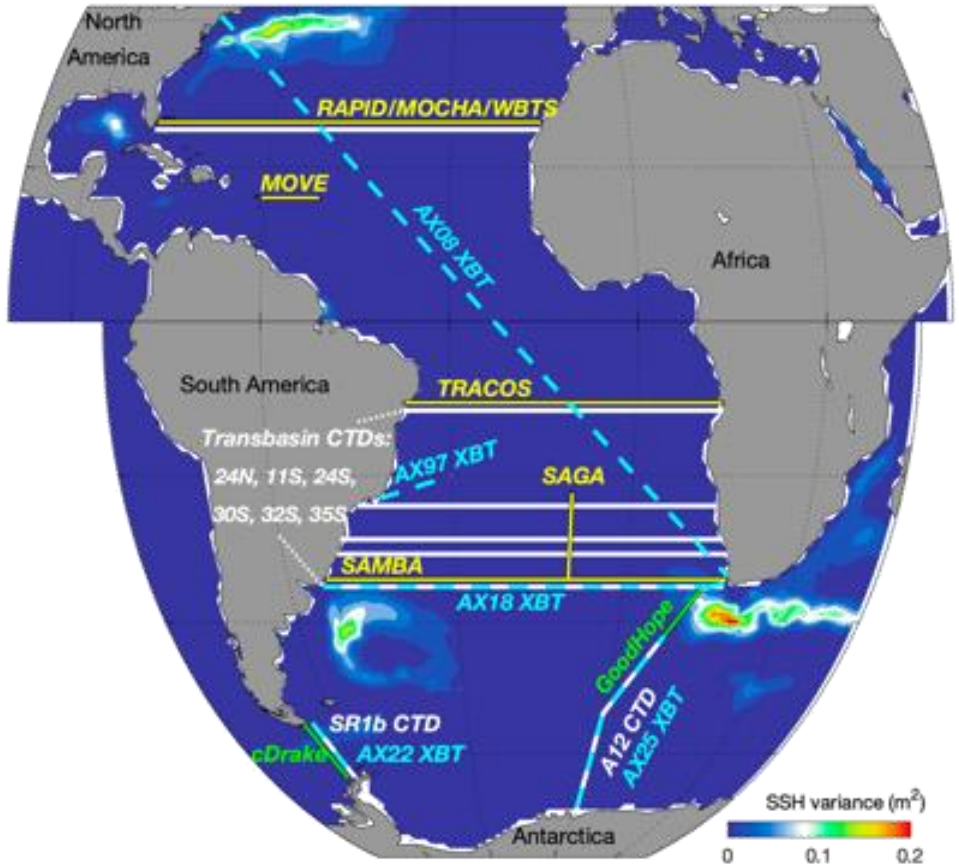
OCEAN:ICE

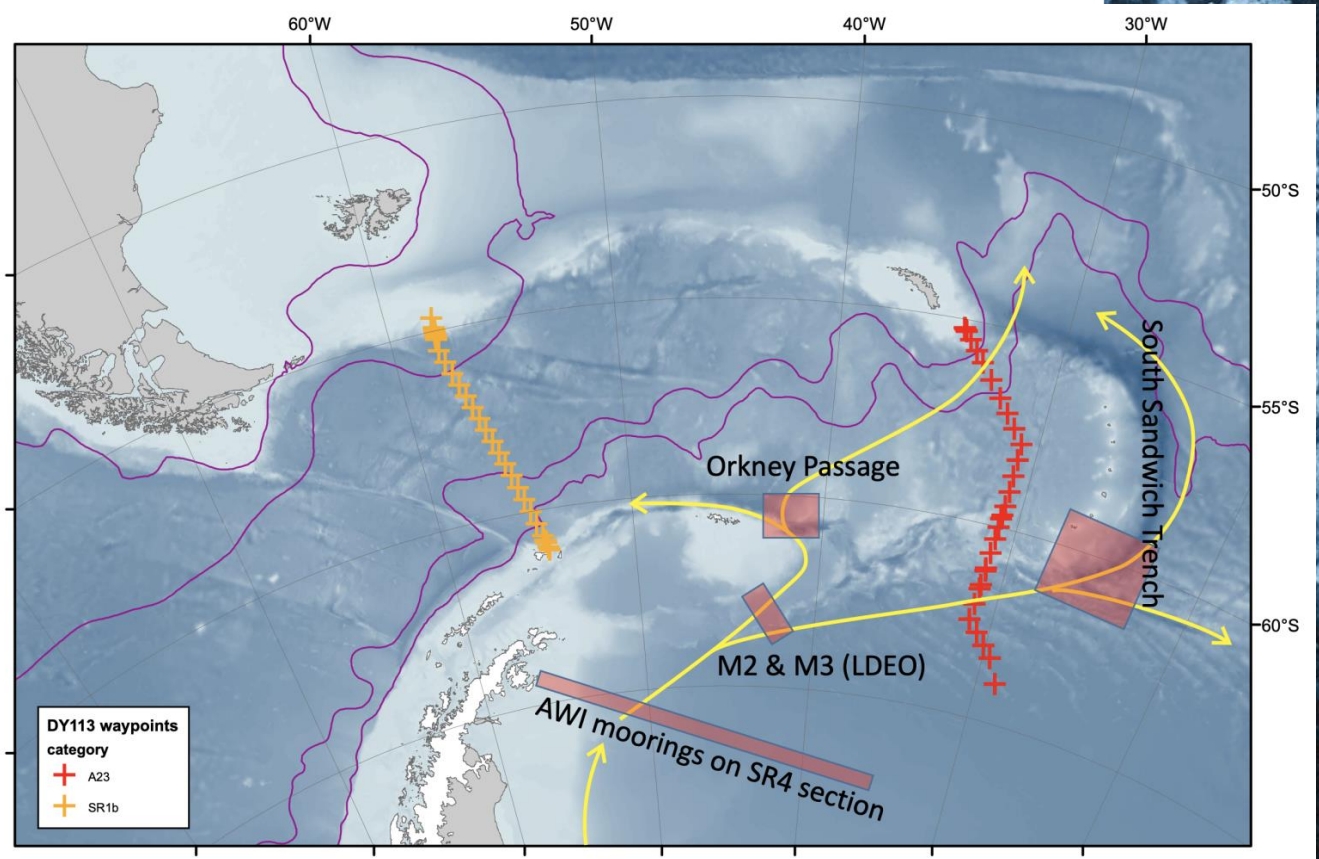


Key observations: focus on AABW export

South Atlantic MOC Basin-wide Array (SAMBA)

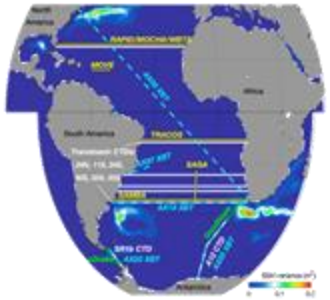


Orkney Passage & South Sandwich Trench



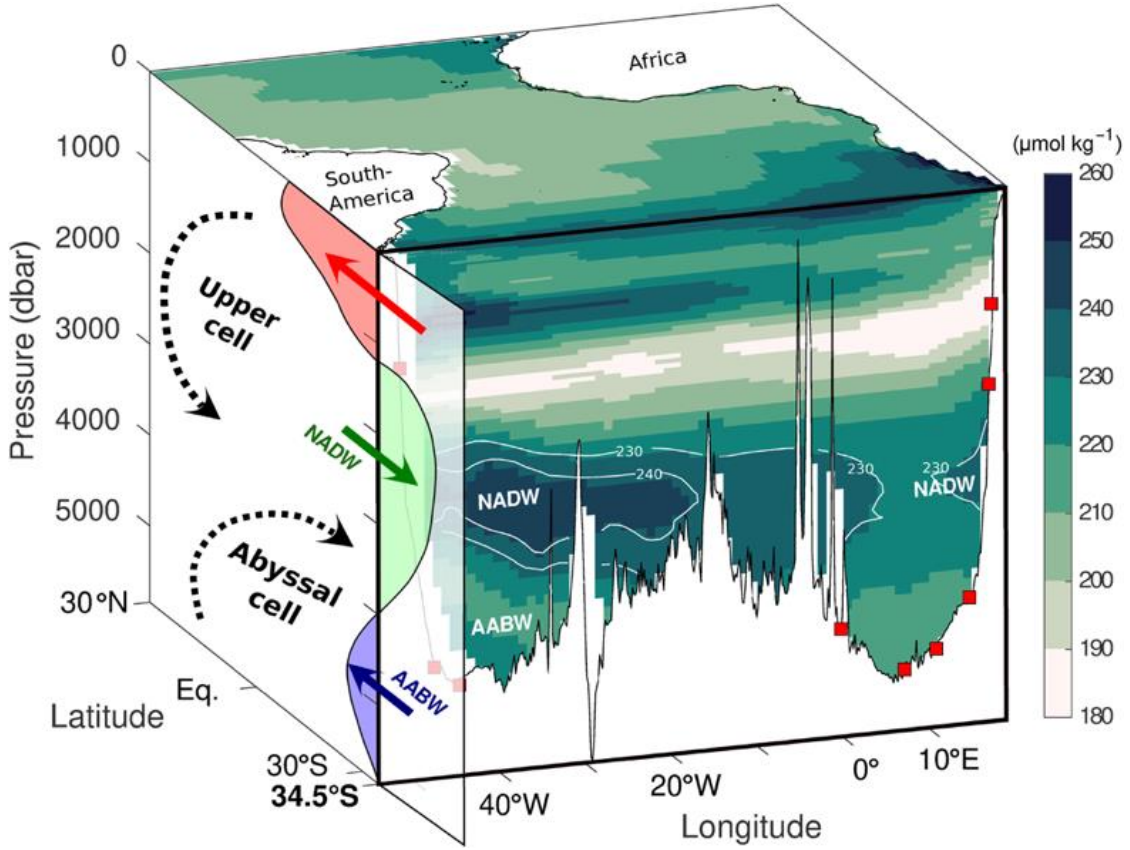
SAMBA

Sabrina Speich

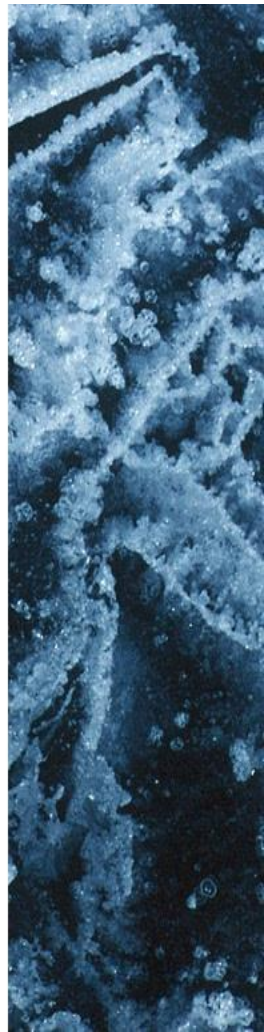


Focusing on the Abyssal cell of the AMOC

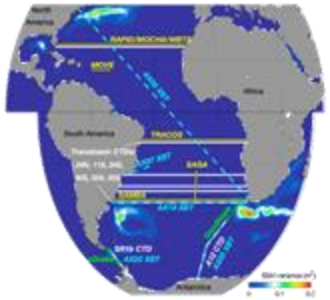
- Adding complements to SAMBA (6 MicroCATS in bottom waters)
- Analyzing historical & SAMBA observations, as well as reanalysis data
- Testing impacts from theory, academical and Earth System Models



Manta et al., 2021



SAMBA

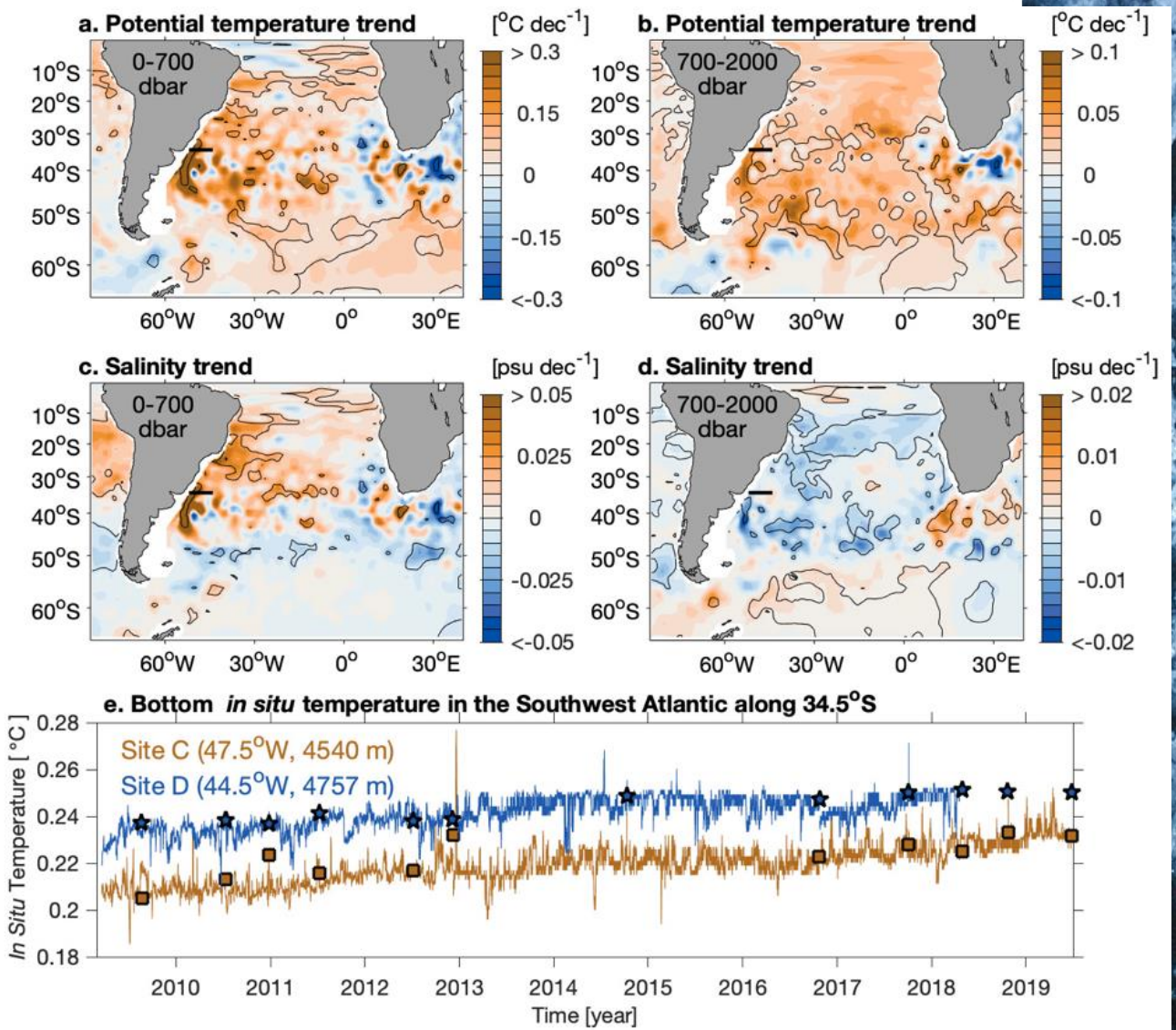


Measured trends in the South Atlantic

› Clear warming of the upper 2000 m

› Around & below: a clear signature of freshening
(unclear interpretation of meteoric water and sea ice contributions)

› Clear warming of bottom waters
What about salinity?

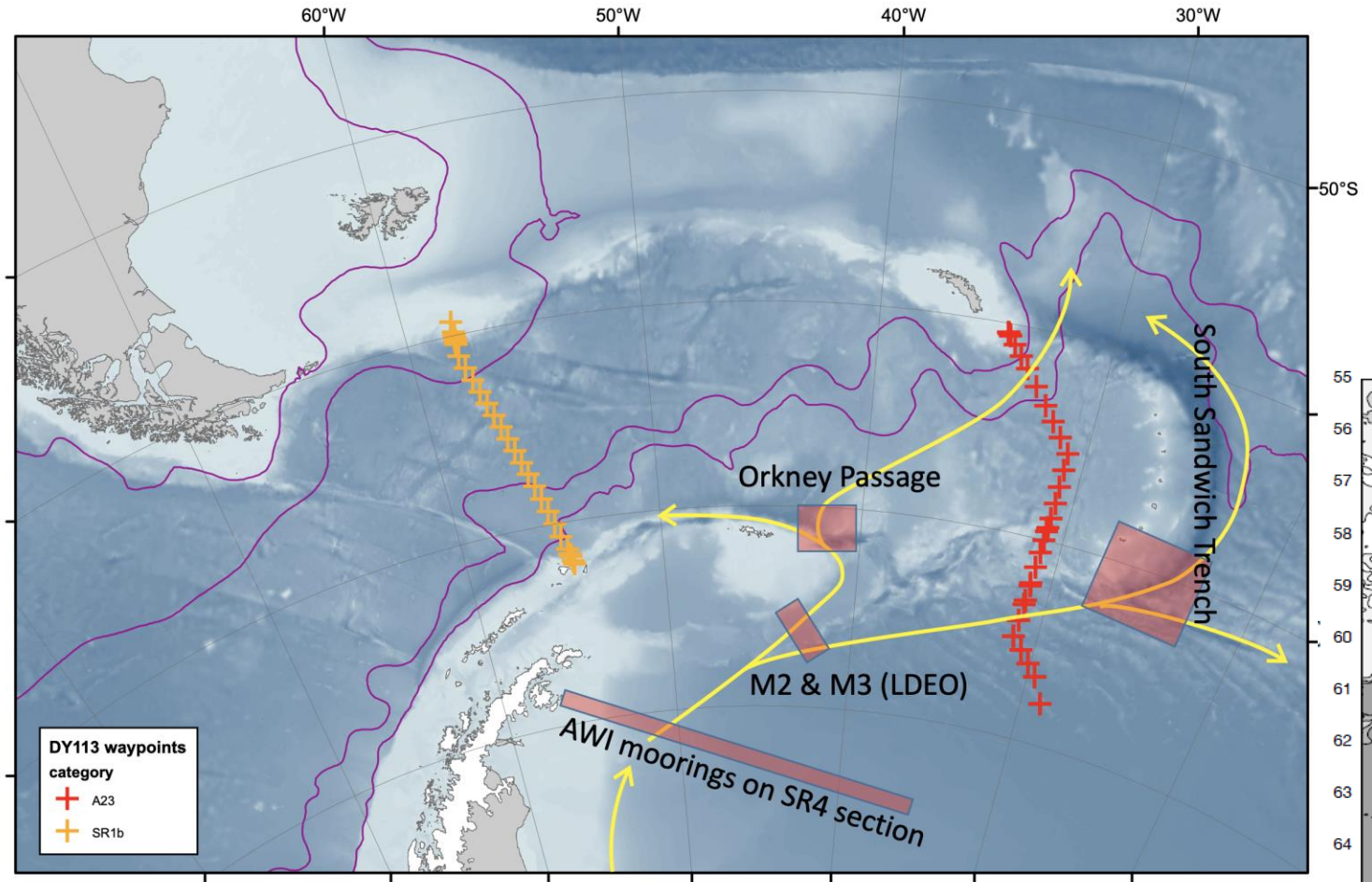


Chidichimo et al., 2022, in press

→ *D5.3: Calibrated, quality-controlled dataset of near-bottom sensors on SAMBA array (M36, ENS-LMD)*
→ *D5.4: Paper on deep and bottom water masses from SAMBA observations (M44, ENS-LMD)*

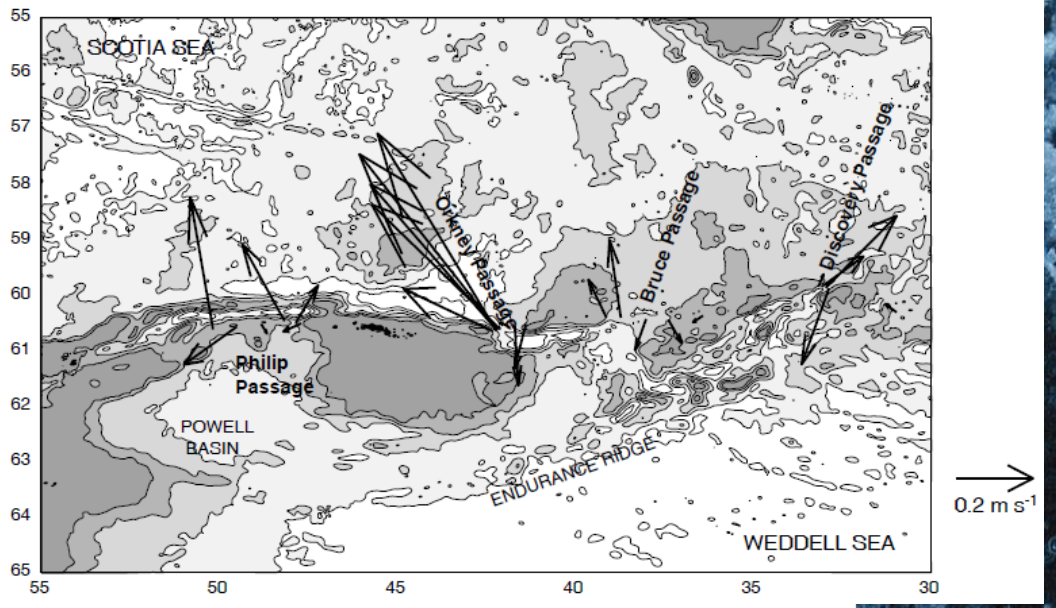
Orkney Passage & South Sandwich Trench

Povl Abrahamsen Michael Meredith Alberto Naveira Garabato



Key region for export of Weddell Sea Deep Water, a precursor to Antarctic Bottom Water

Strong northward currents



Naveira Garabato et al., 2002

Orkney Passage & South Sandwich Trench

Plans for 2022-2023

- Cruise DY158: BAS Ecosystems and Polar Oceans cruise on RRS Discovery
  - Depart Montevideo 22 Dec 2022
  - Krill work near South Georgia
  - A23 section repeat
  - Orkney Passage/M2/M3 mooring recovery and turnaround
  - Arrive Stanley 29 Jan 2023
- Two moorings in Orkney Passage will not be redeployed
- If all goes well: return with net surplus of instrumentation and hardware, some of which can be used in South Sandwich Trench
- RISK: ship not ice strengthened. RRS Sir David Attenborough can possibly recover as contingency, but redeployments unlikely

Orkney Passage & South Sandwich Trench

Plans for 2023-2024

- Finalize mooring designs after end DY158
- Procure remaining mooring equipment in spring/summer 2023
- Ship equipment to Cape Town late summer 2023
  - Risk: Logistics from Europe to South Africa unreliable/slow at present
- Deploy moorings in South Sandwich Trench from SA Agulhas II in 2023-2024 season
  - Risk: Very short planning timescale for cruises

Plans for 2024-2025

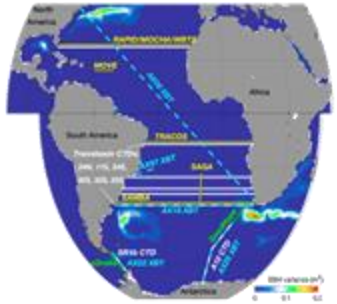
- Mooring cruise to Orkney Passage/M2/M3 on RRS Sir David Attenborough through BIOPOLE
  - Requested dates: Jan-Mar 2025
  - Risk: ship availability/readiness

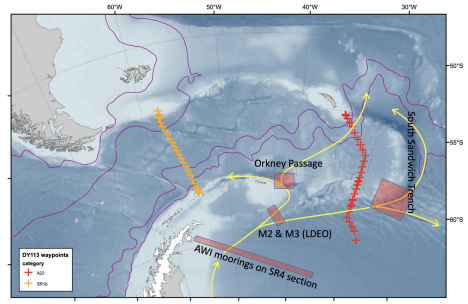
→*D5.1: Calibrated, quality-controlled mooring dataset from South Sandwich Trench (M36, UKRI-BAS)*
→*D5.2: Paper on South Sandwich Trench data, incl. Orkney Passage comparison (M45, UKRI-BAS)*

WP5 – Ice sheet impacts on global ocean circulation

New key observations

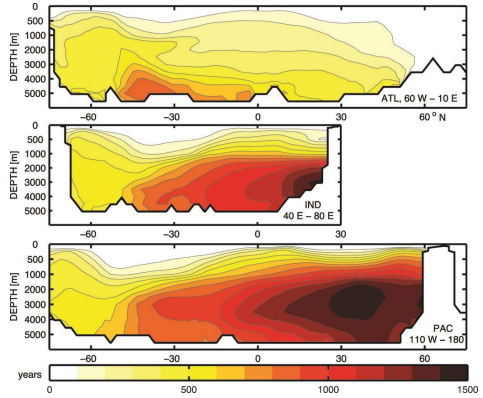
› Currents, temperatures, salinity, etc. at Orkney Passage, South Sandwich Trench & SAMBA





Data matrix

› Using state-of-the-ocean to reconstruct surface boundary conditions (meteoritic water and sea ice)



Ocean and Earth System modelling

› Understanding of impact of freshwater on ocean circulation, using NEMO and NorESM

THANK YOU!

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People involved

- Elaine McDonagh
- Petra Langebroek
- Povl Abrahamsen
- Sabrina Speich
- Mike Meredith
- Alberto Naveira Garabato
- Casimir de Lavergne

- Several (3-4) recruitment positions