

# Observing the Atlantic Meridional Overturning Circulation

Isabela Le Bras

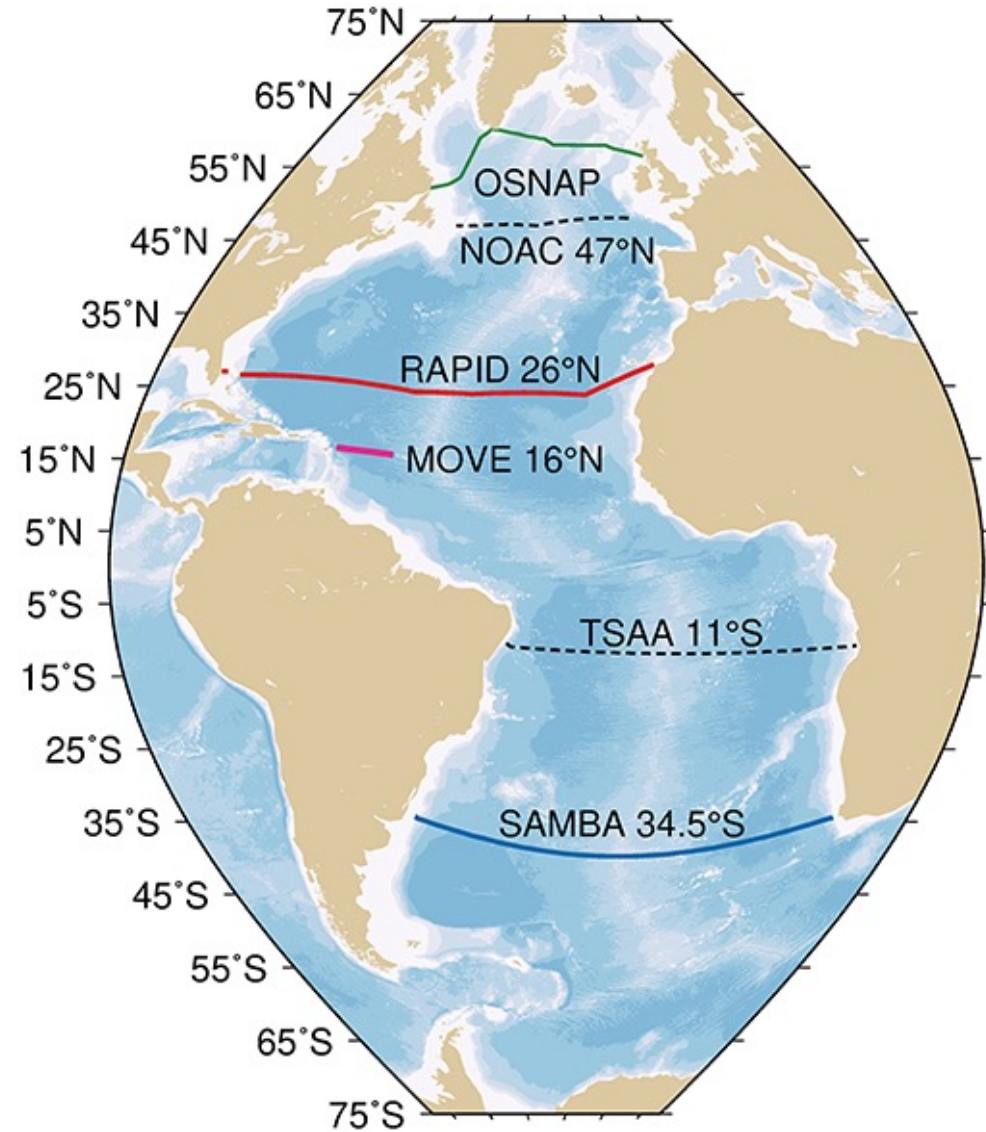
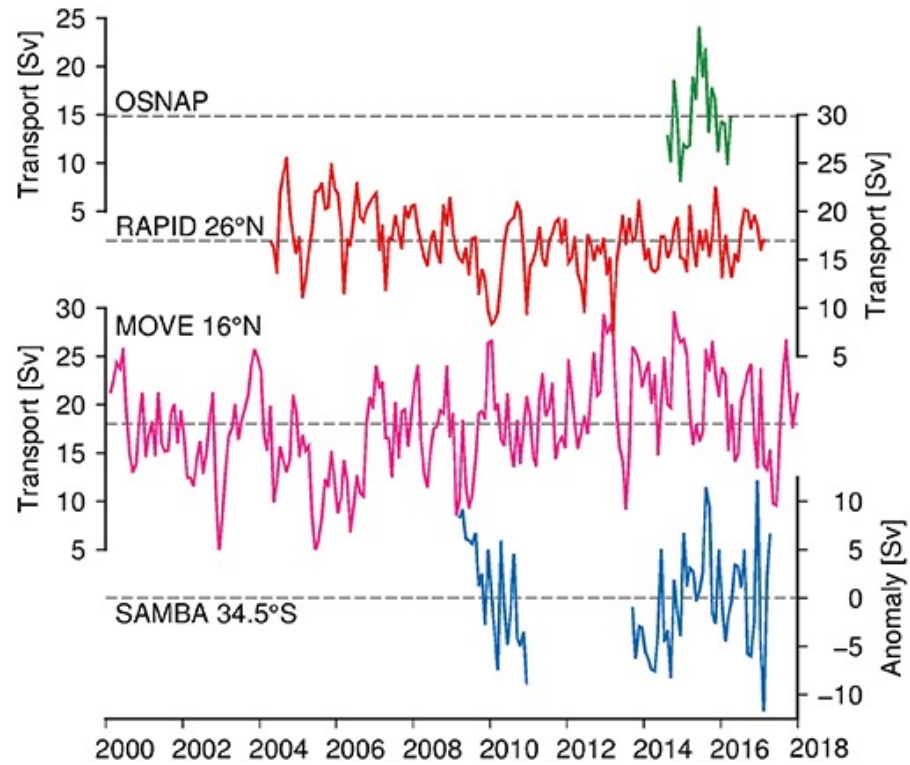
Woods Hole Oceanographic Institution

2023 US CLIVAR Summit

# Overview

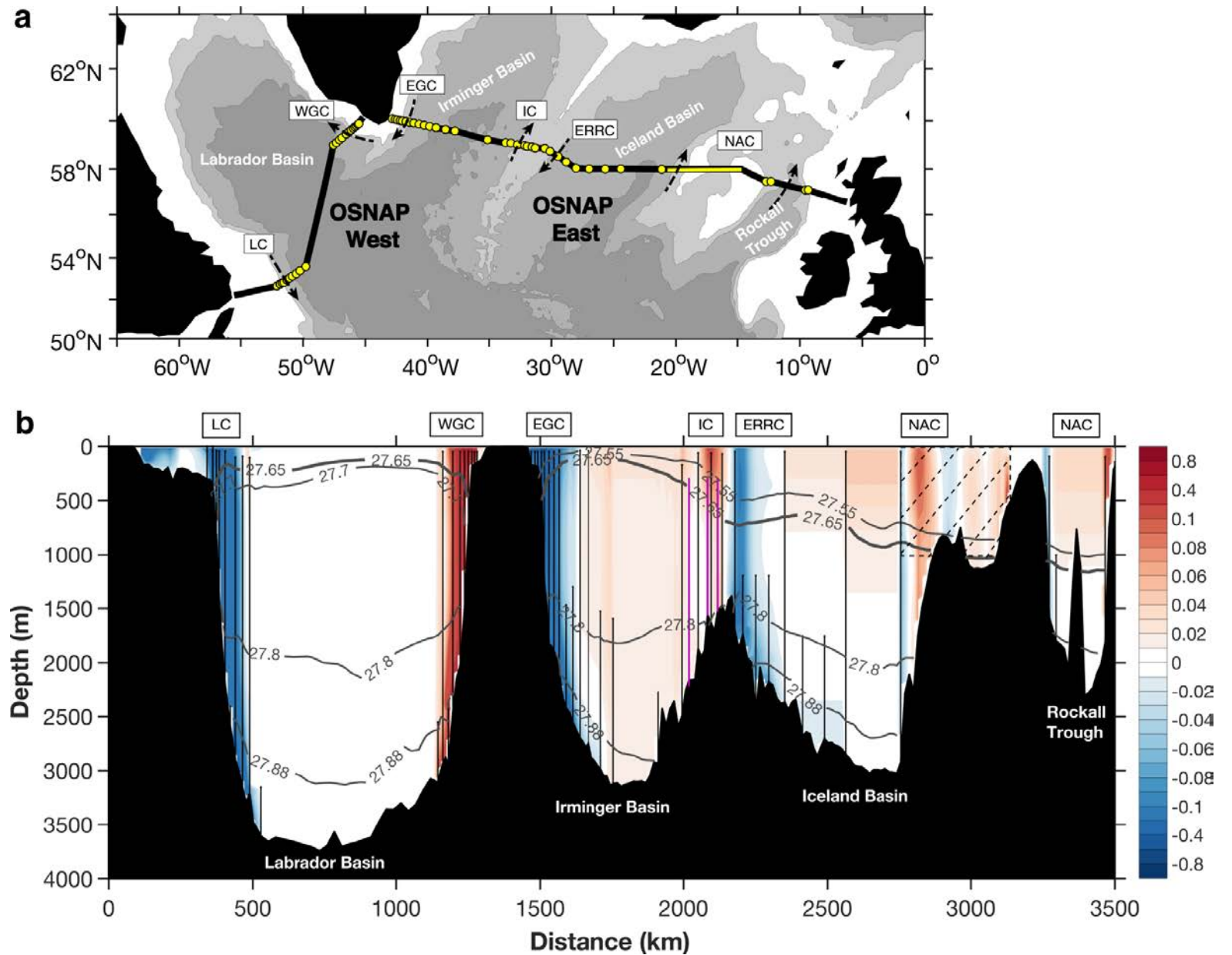
- Status of the *in situ* AMOC observing system
  - Overview of the arrays
  - Future plans (Funding? Scaling up/down?)
- Alternative AMOC observing methods (my work)
- Synthesize

# AMOC arrays

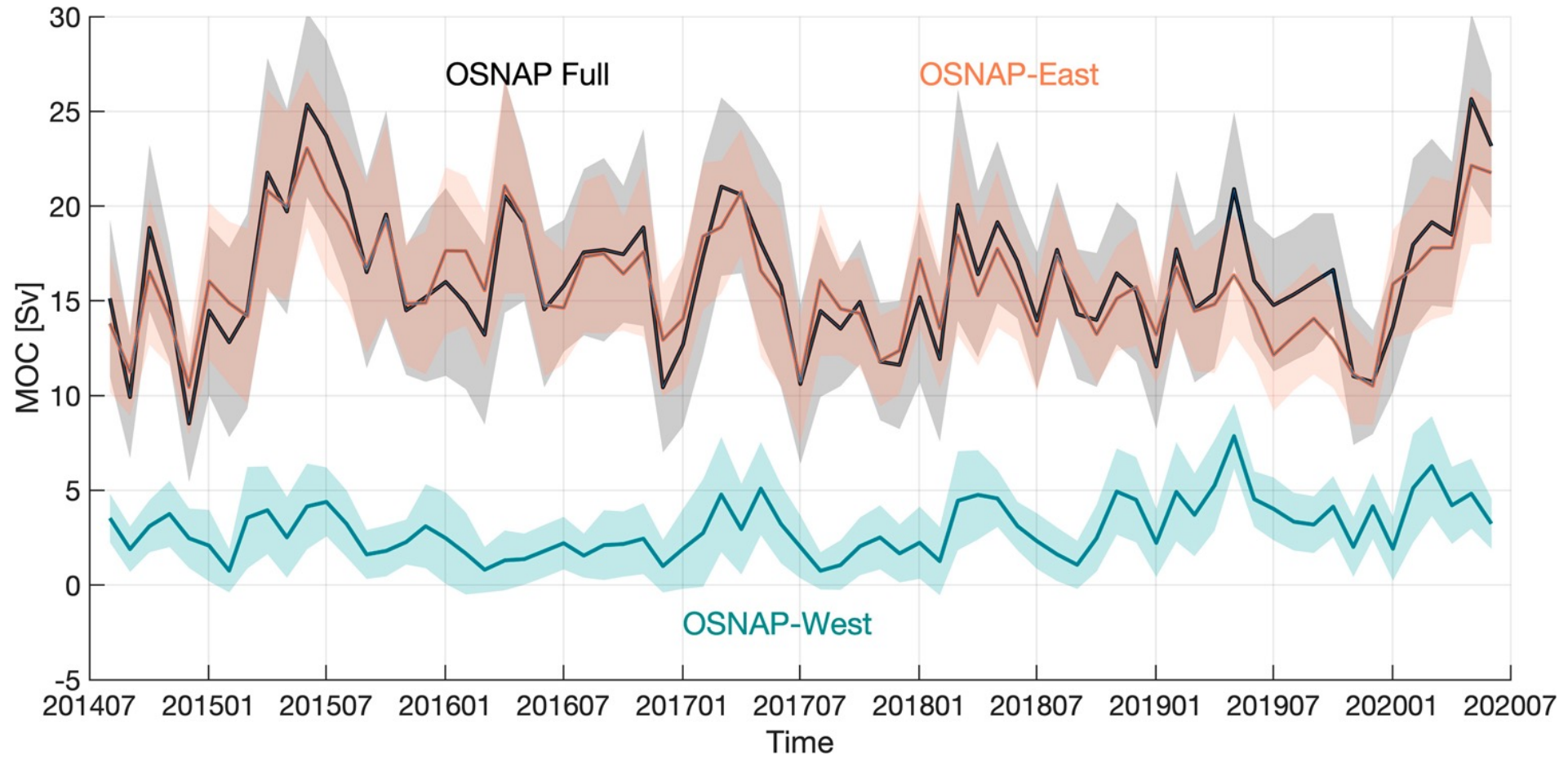


# OSNAP (Overturning in the Subpolar North Atlantic Program)

2014-present



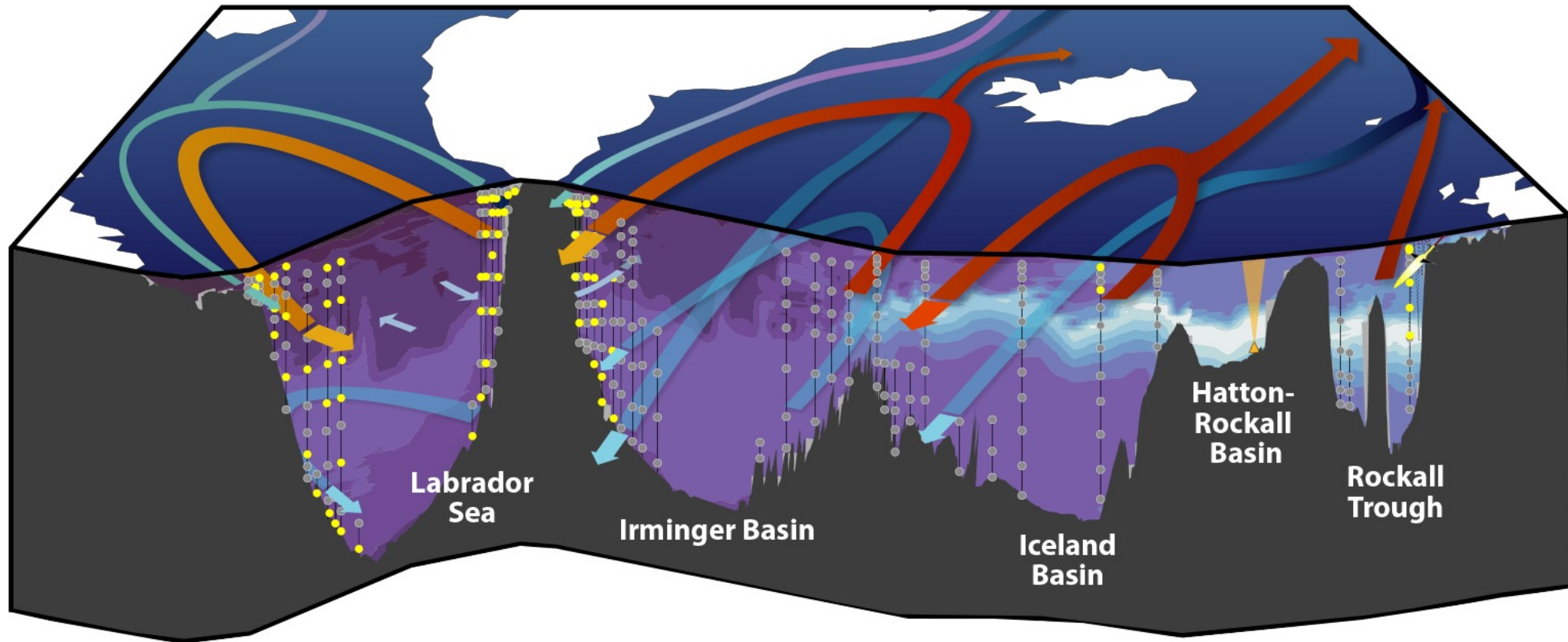
# Latest OSNAP time series



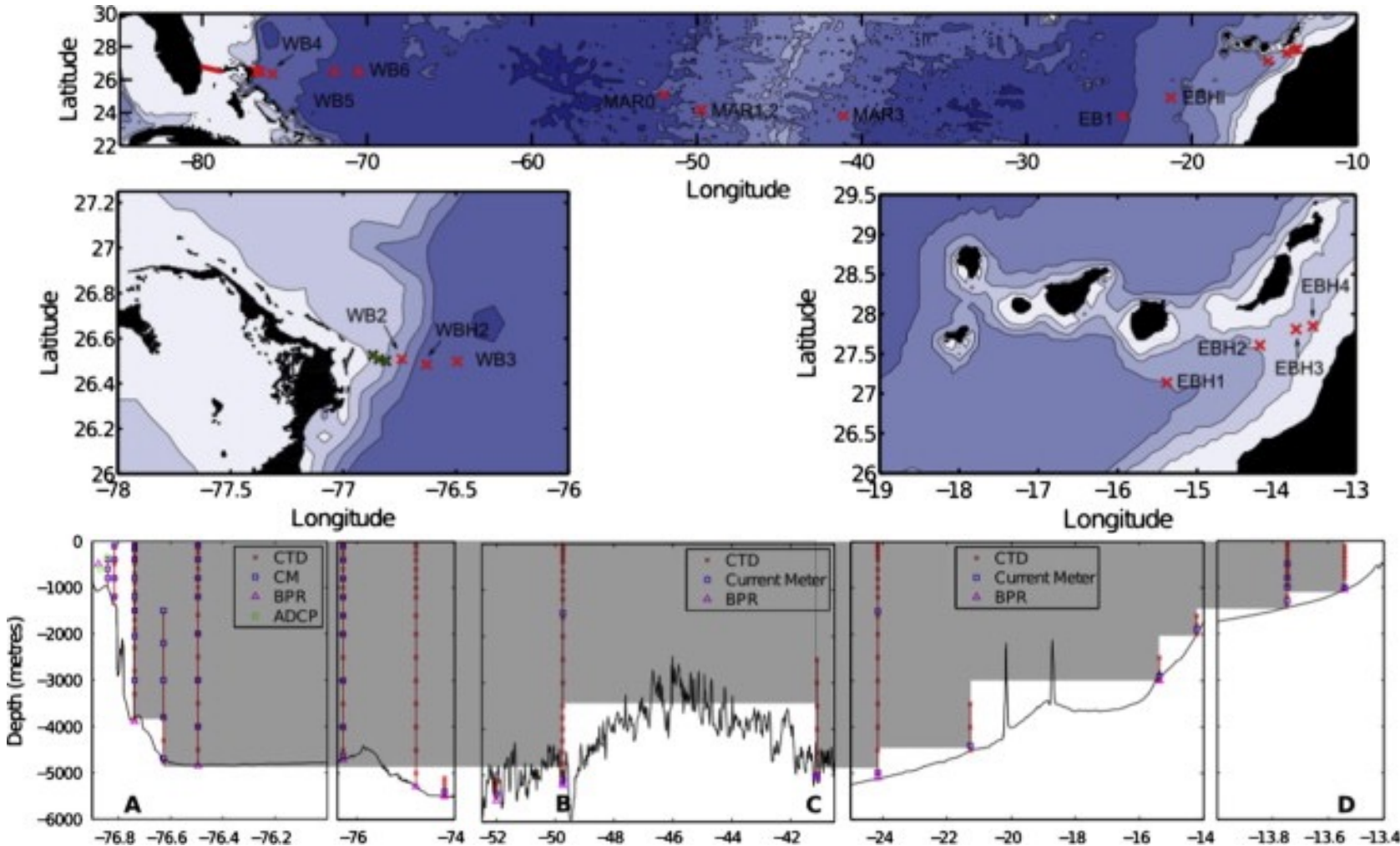
# OSNAP future plans

- Funded through 2024 (ten year time series)
- Likely to continue at least two years past 2024, potentially scaled down
- International collaboration (US, UK, Germany, Netherlands) requires extensive coordination
- New focus on carbon/oxygen?

# GOHSNAP (Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic Program)



# RAPID/MOCHA/WBTS at 26.5N (2004-present)



- From Bill Johns (U Miami)
- US maintains western boundary, UK eastern boundary
- Mid-Atlantic Ridge moorings discontinued in 2020
- Western boundary array pared down in 2023
- PIES used more extensively, looking into gliders, other alternatives
- Funding secure through 2027 and outlook is optimistic



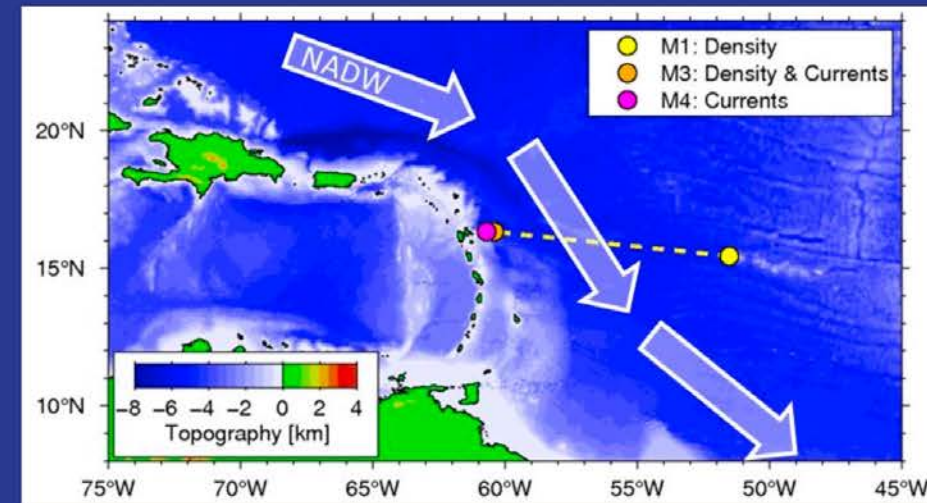
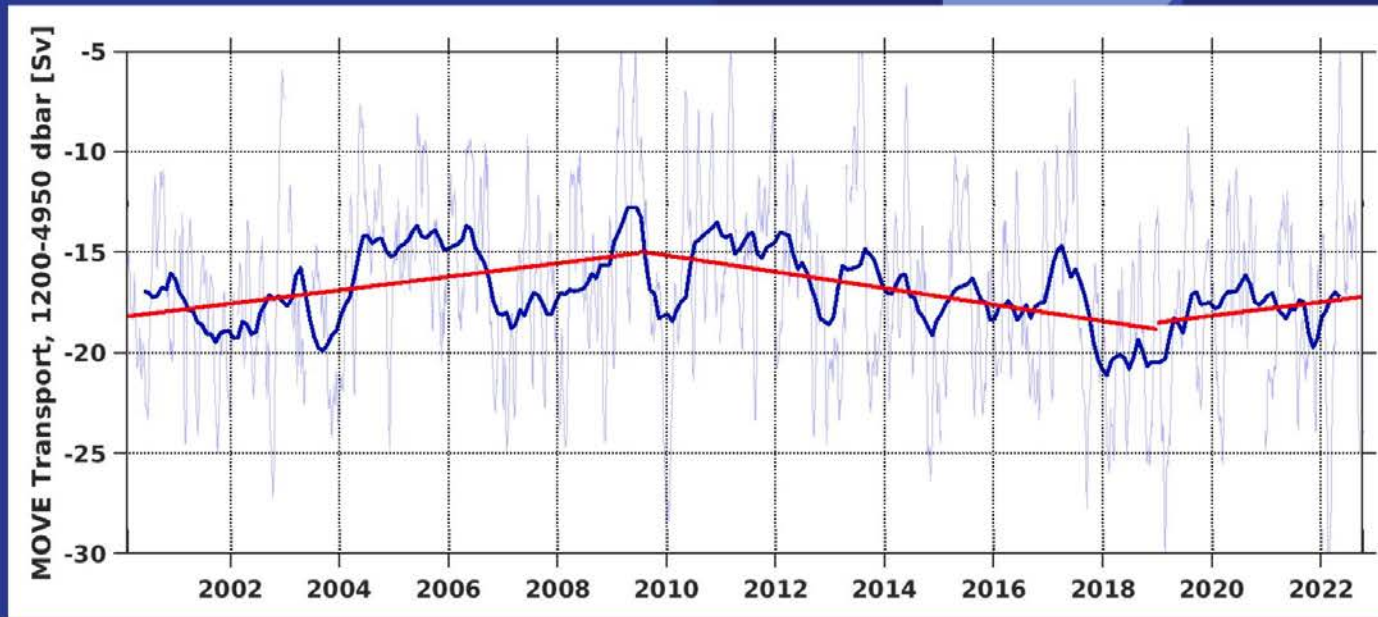
# MOVE (16°N)

Matthias Lankhorst  
and Uwe Send



UC San Diego

- 22+ years duration
- Deep AMOC limb
- Decadal variability
- Recent methodological improvements:
  - Validation of long-term trends against GRACE satellite gravimetry
  - Improved salinity corrections
  - Near future: drift-corrected seafloor pressure sensors
- Funding: NOAA GOMO



Images: Volkov et al., BAMS 2023 (submitted); Send et al., GRL 2011 (DOI:10.1029/2011GL049801)

Some interesting RAPID-MOVE comparisons: Frajka-Williams et al. 2018, Danabasoglu et al. 2021

# South Atlantic MOC (SAMOC)

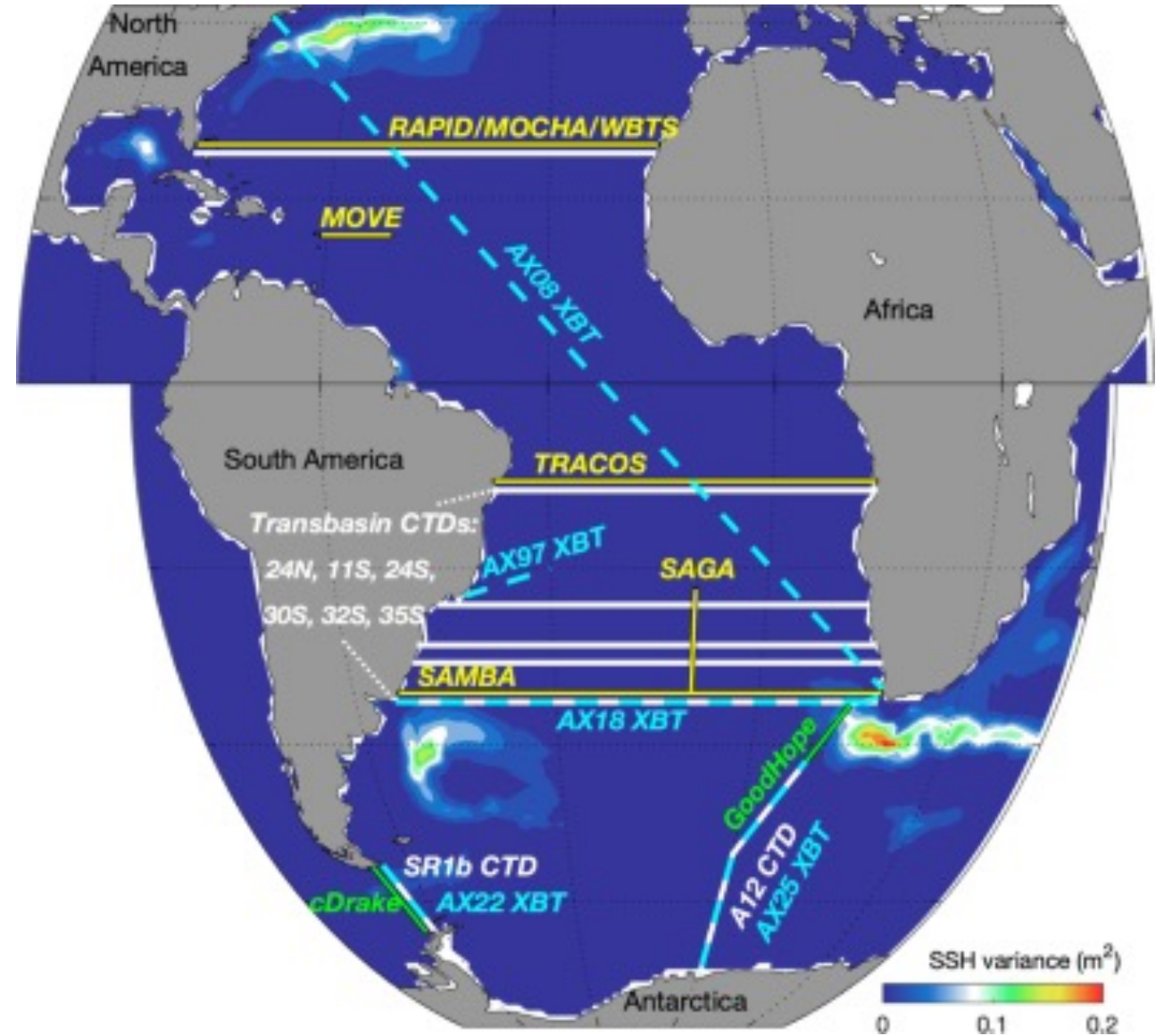
Countries: Argentina, Brazil, France, Germany, Mexico, Norway, Spain, South Africa, United Kingdom, United States, and Uruguay

**SAMBA**: South Atlantic MOC Basin-wide Array

**TRACOS**: TRopical Atlantic Circulation and Overturning at 11S

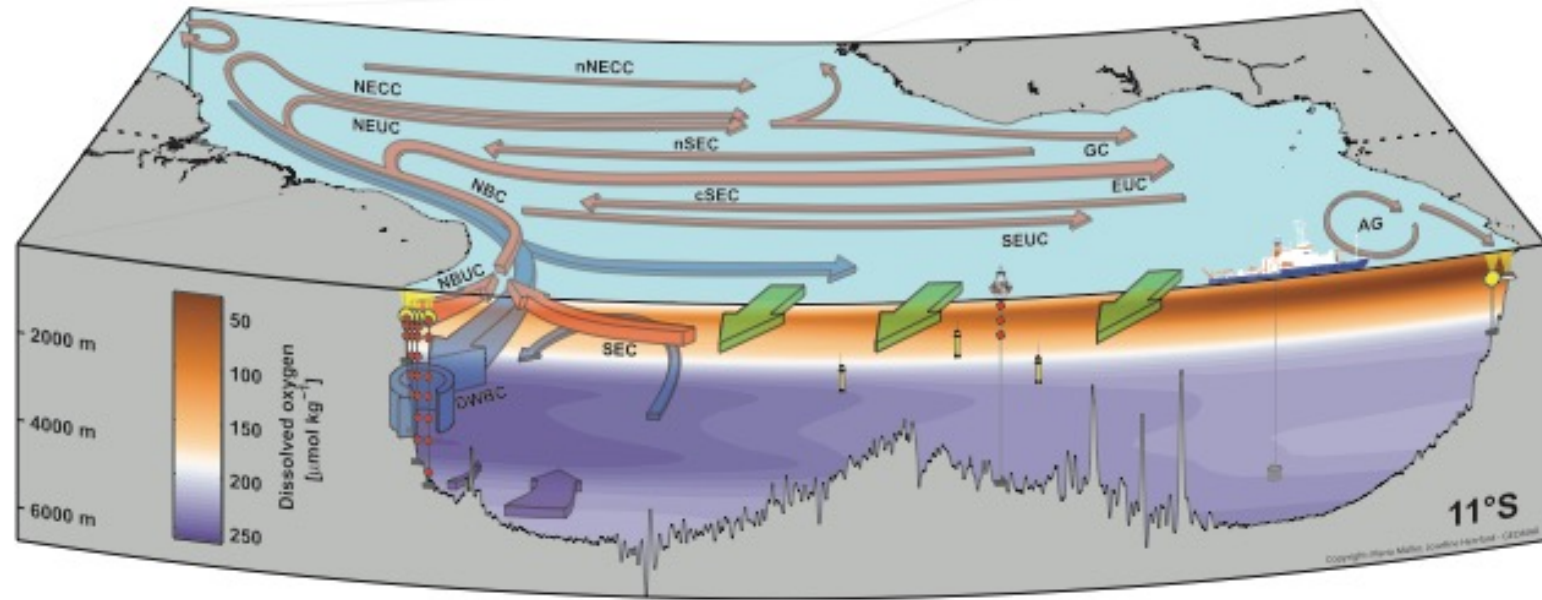
**SAGA** : South Atlantic Gateway Array  
Trans-basin & interocean XBT & CTD transects

In situ & altimetry synthesis estimates

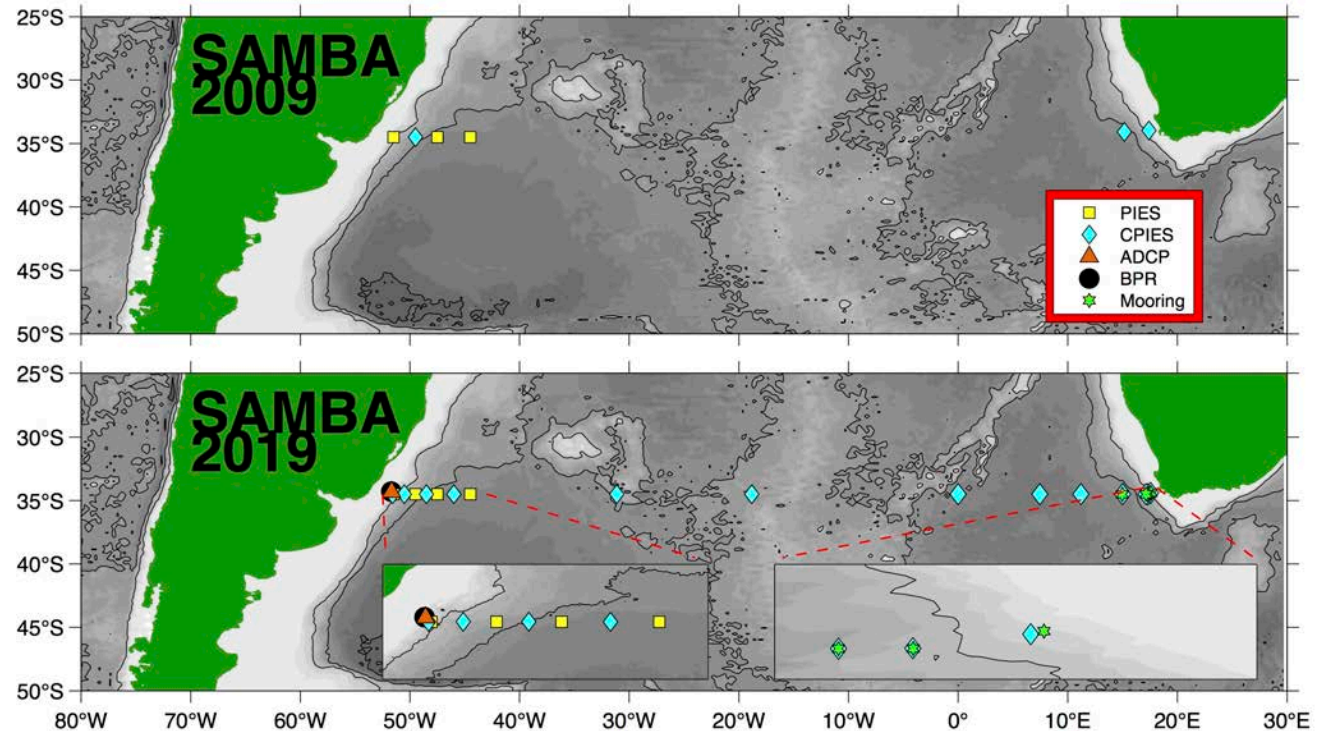


# TRACOS

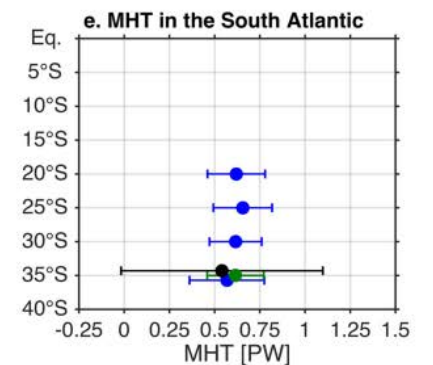
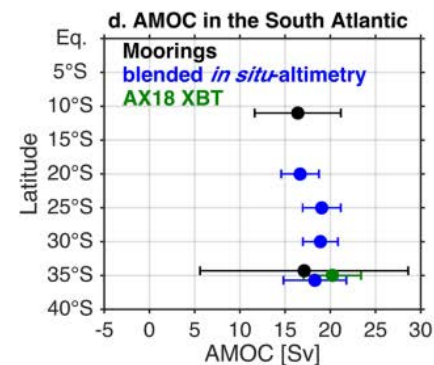
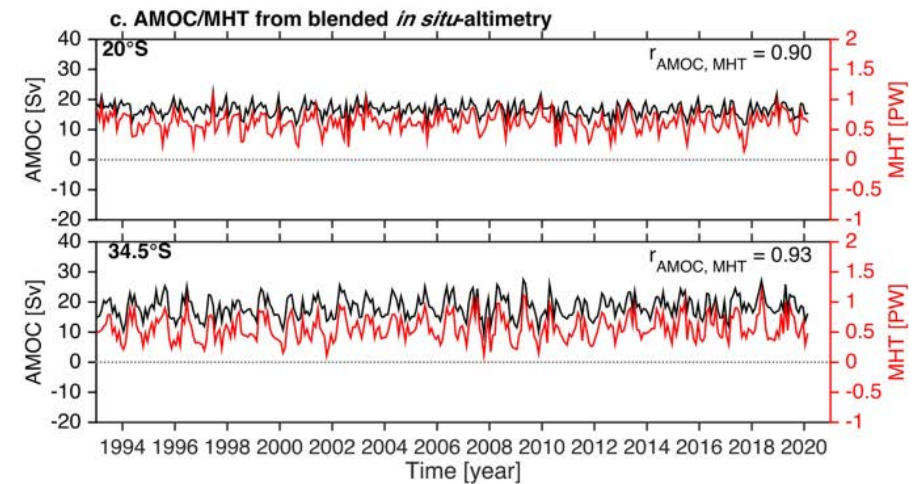
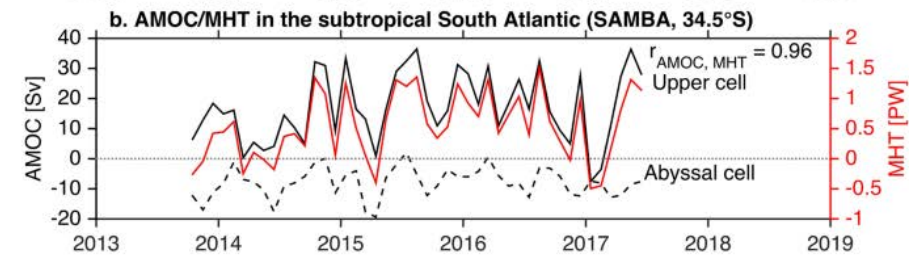
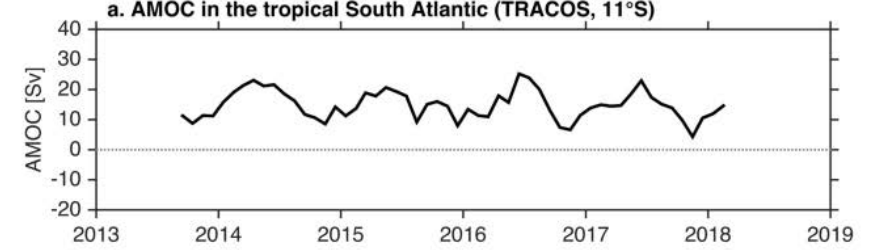
Tropical Atlantic Circulation and Overturning at 11S will be maintained until at least 2025 (Germany, Brazil)



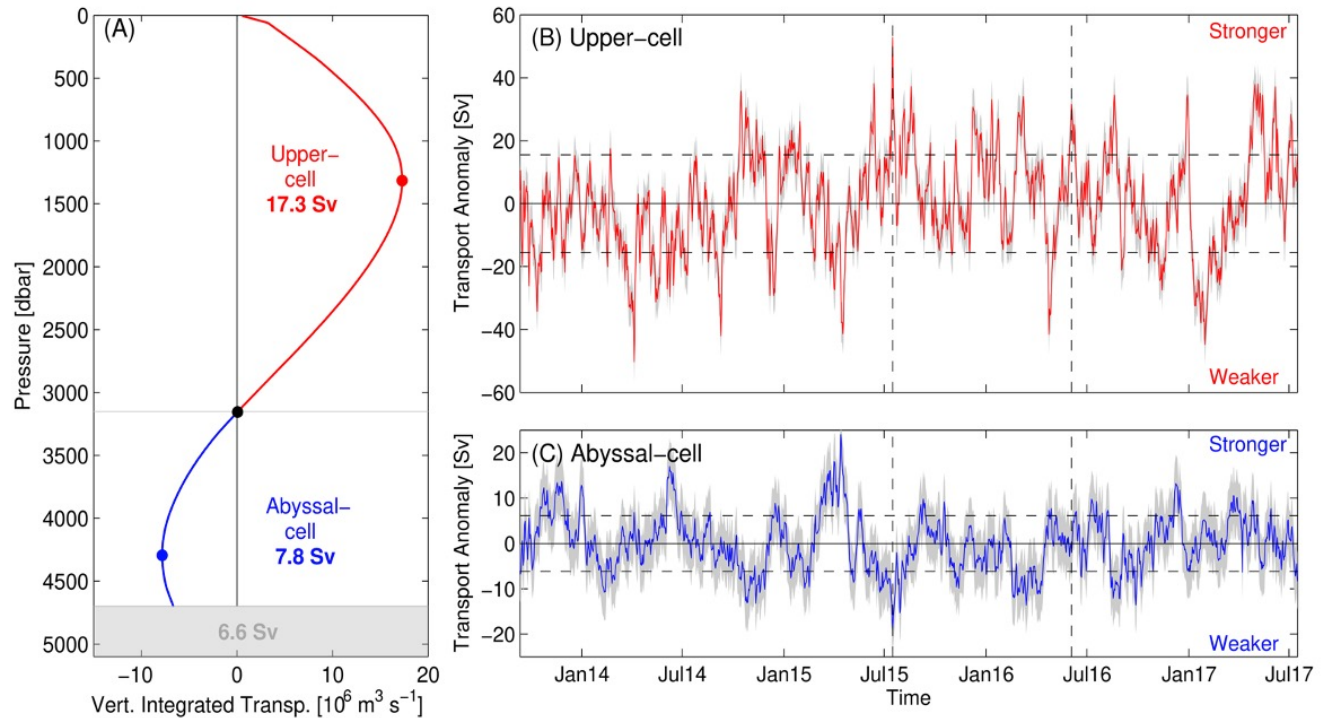
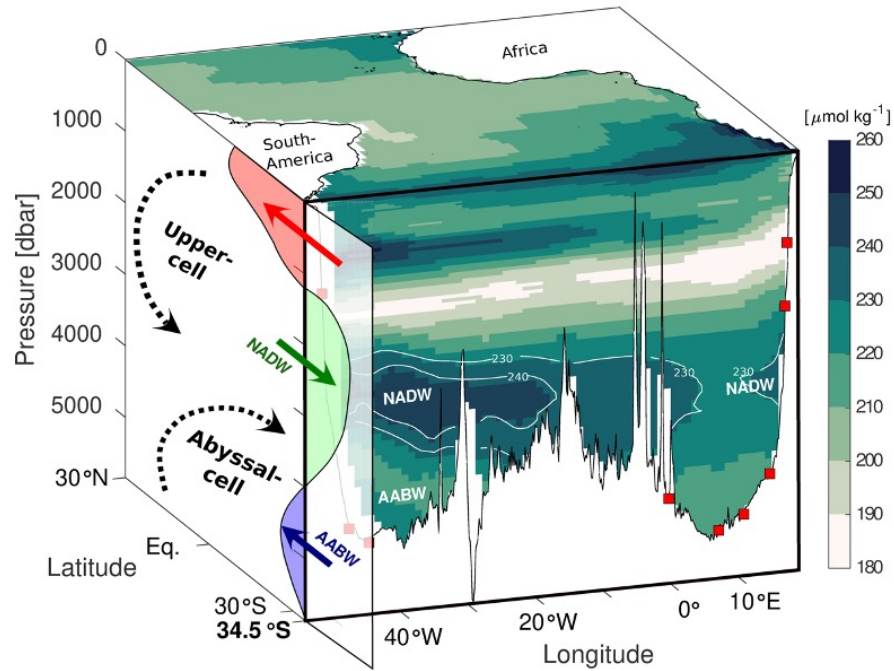
**SAMBA** SAMoc Basin-wide Array (34.5S) makes extensive use of PIES, which can be deployed 4+ years at a time. Now have about 20 sites (US, Brazil, Argentina, South Africa, France, Spain)



- South Atlantic is the only basin with equatorward heat transport
- Gateway to other Oceans
- Variability increases from 11S to 34.5S
- AMOC and MHT strongly correlated



# SAMBA 9-site Daily MOC Time Series

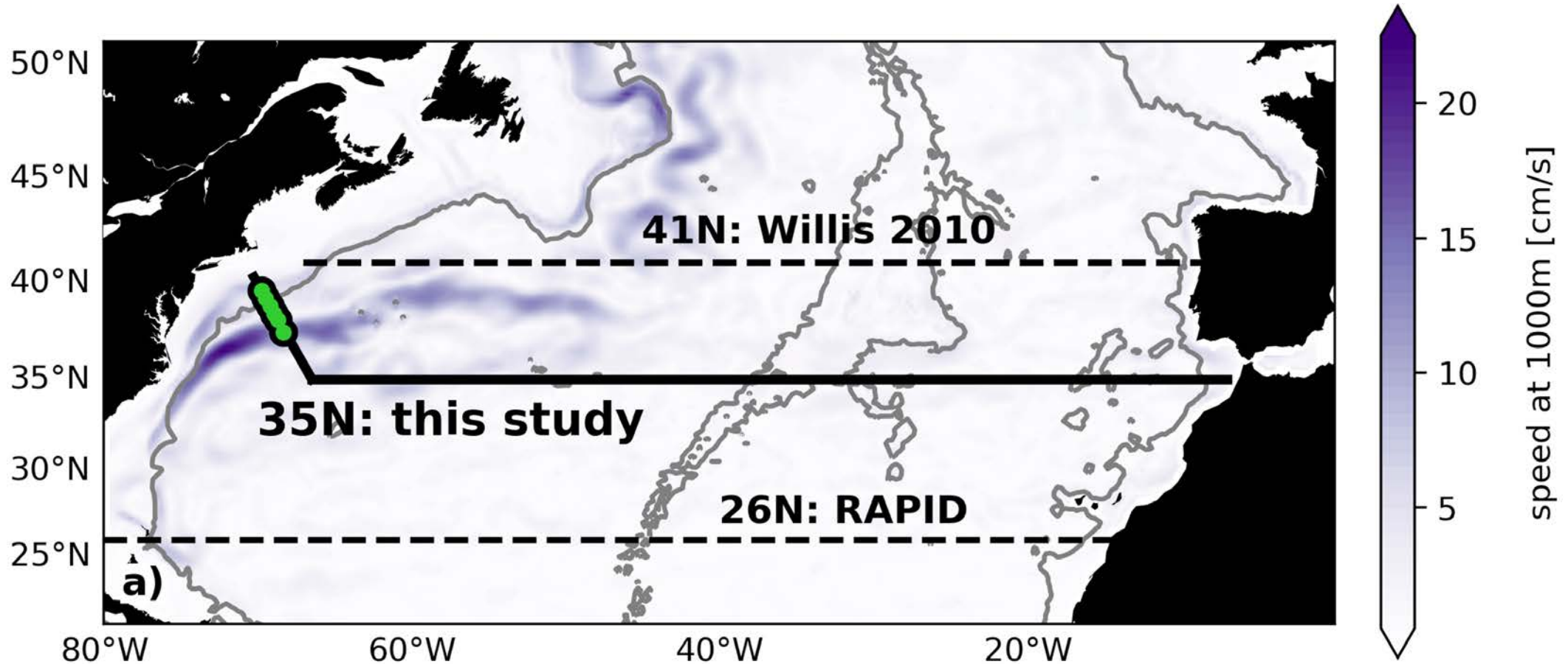


- Highly energetic overturning circulation in both upper and abyssal cells
- Abyssal-cell variability is largely independent of the overlying upper-cell transport variability

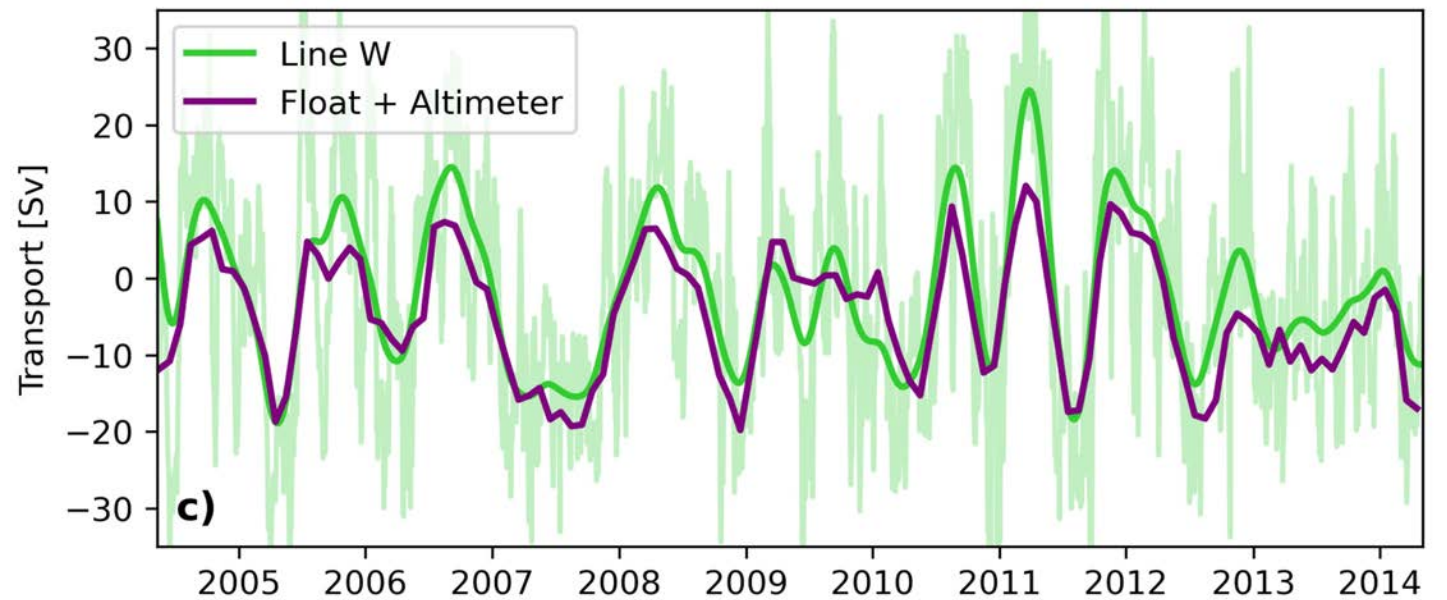
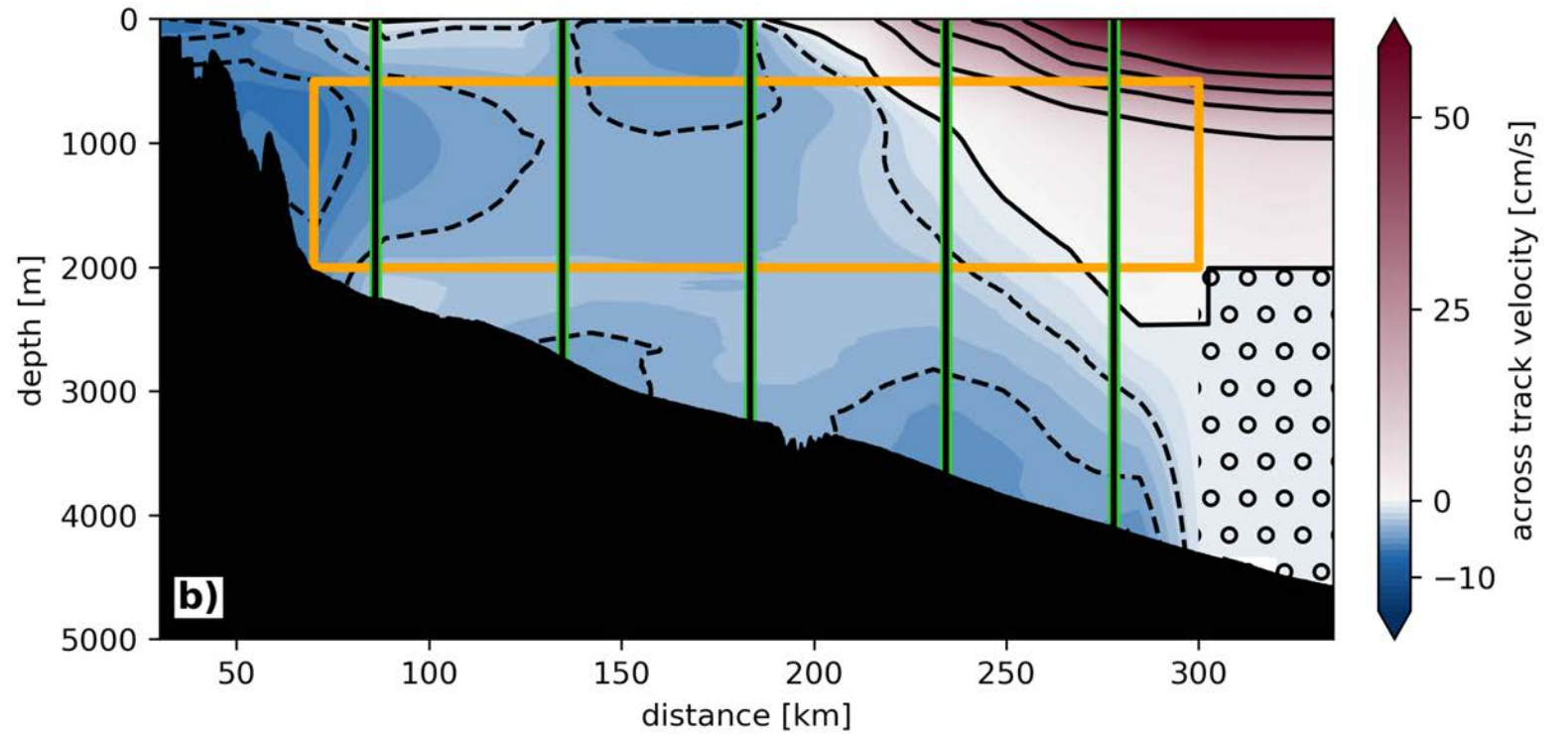
*Kersalé et al. (2020)*

Thanks to Shenfu Dong and Renellys Perez

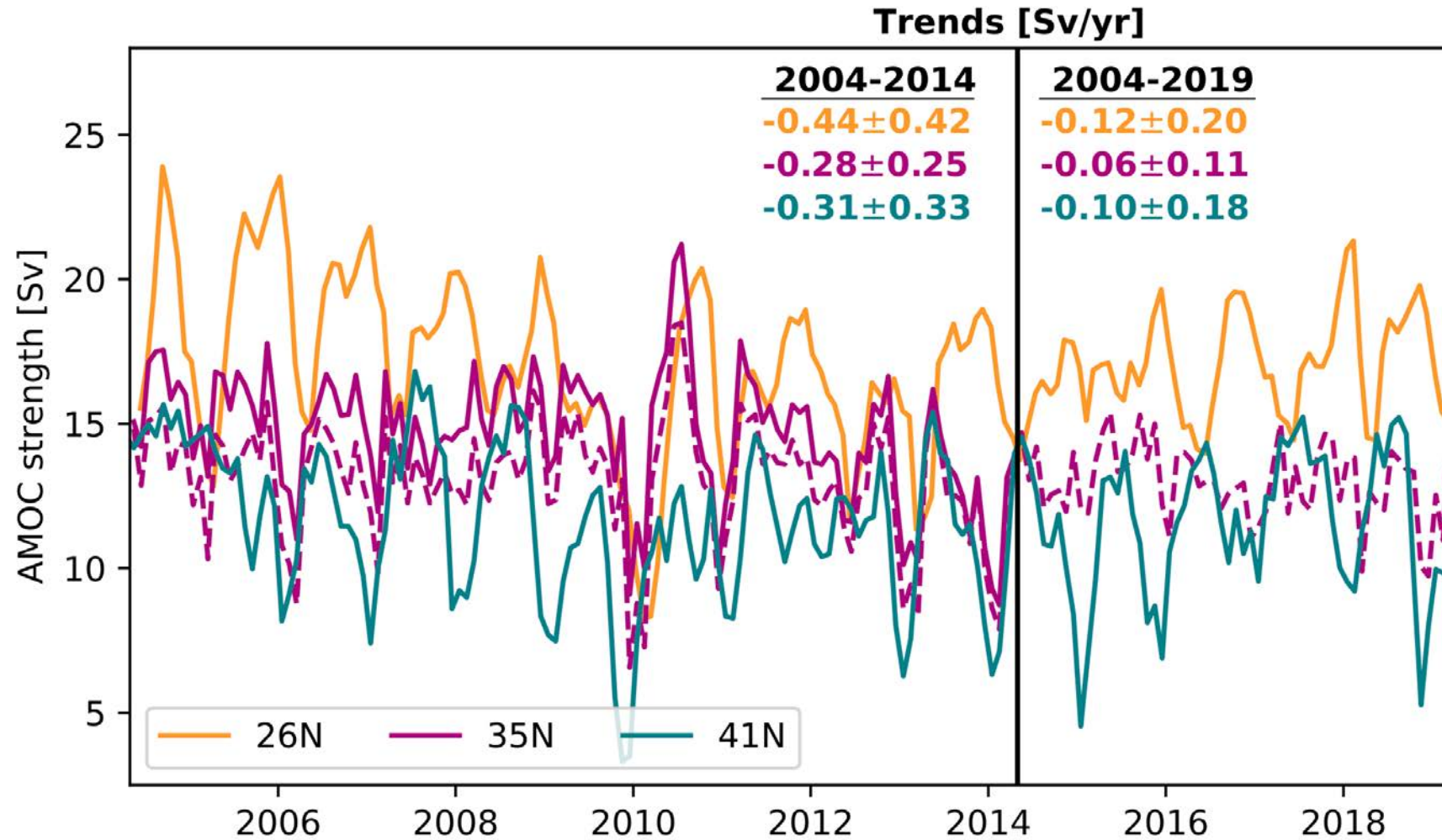
# AMOC at 35N from Line W mooring data, floats and altimeter motivated by deep flow decline



Encouraging  
correspondence  
for merging  
products



# Similar decadal variability but no long-term decline

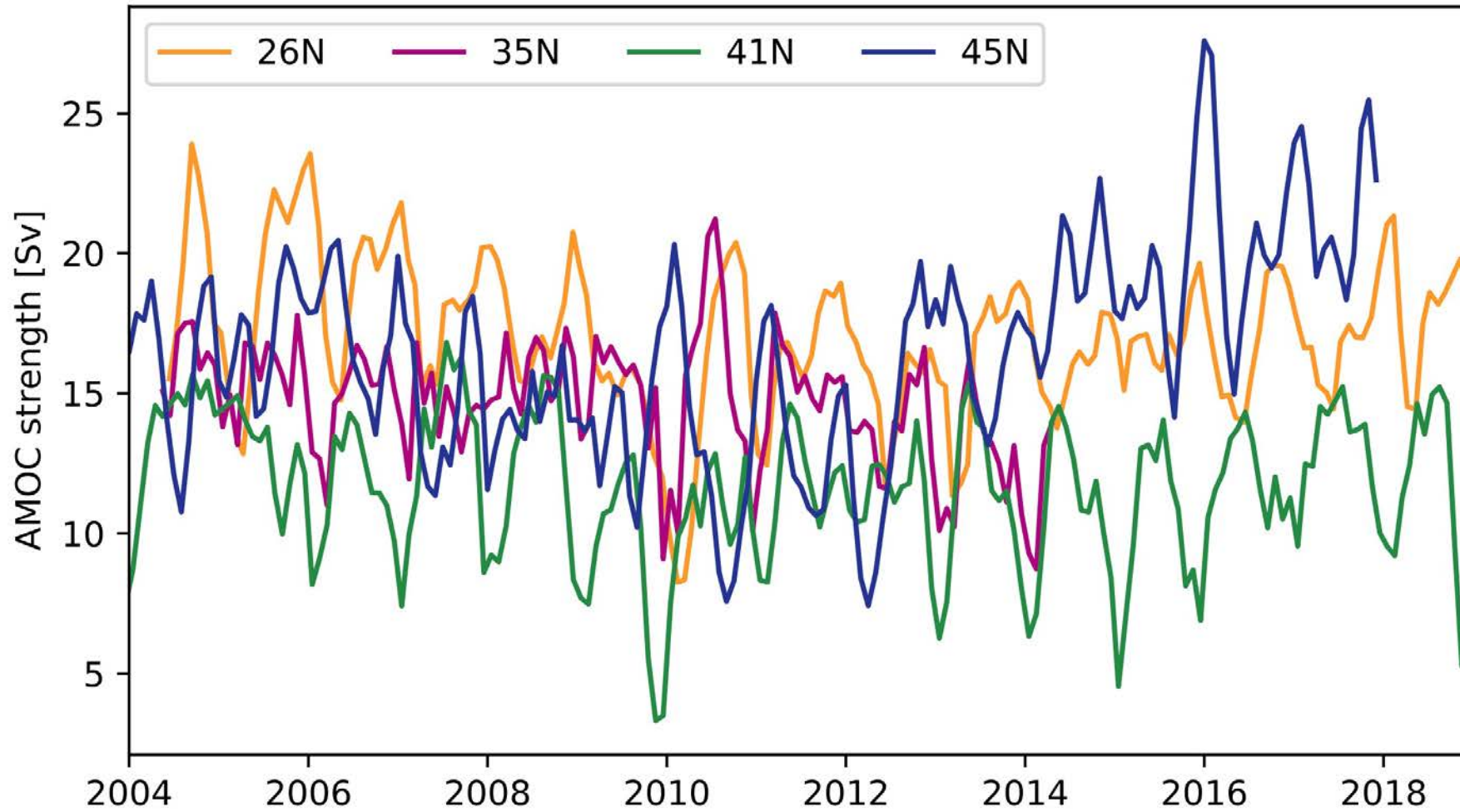


Note: Caesar et al. (2021) estimate 0.04 Sv/yr 1950-present

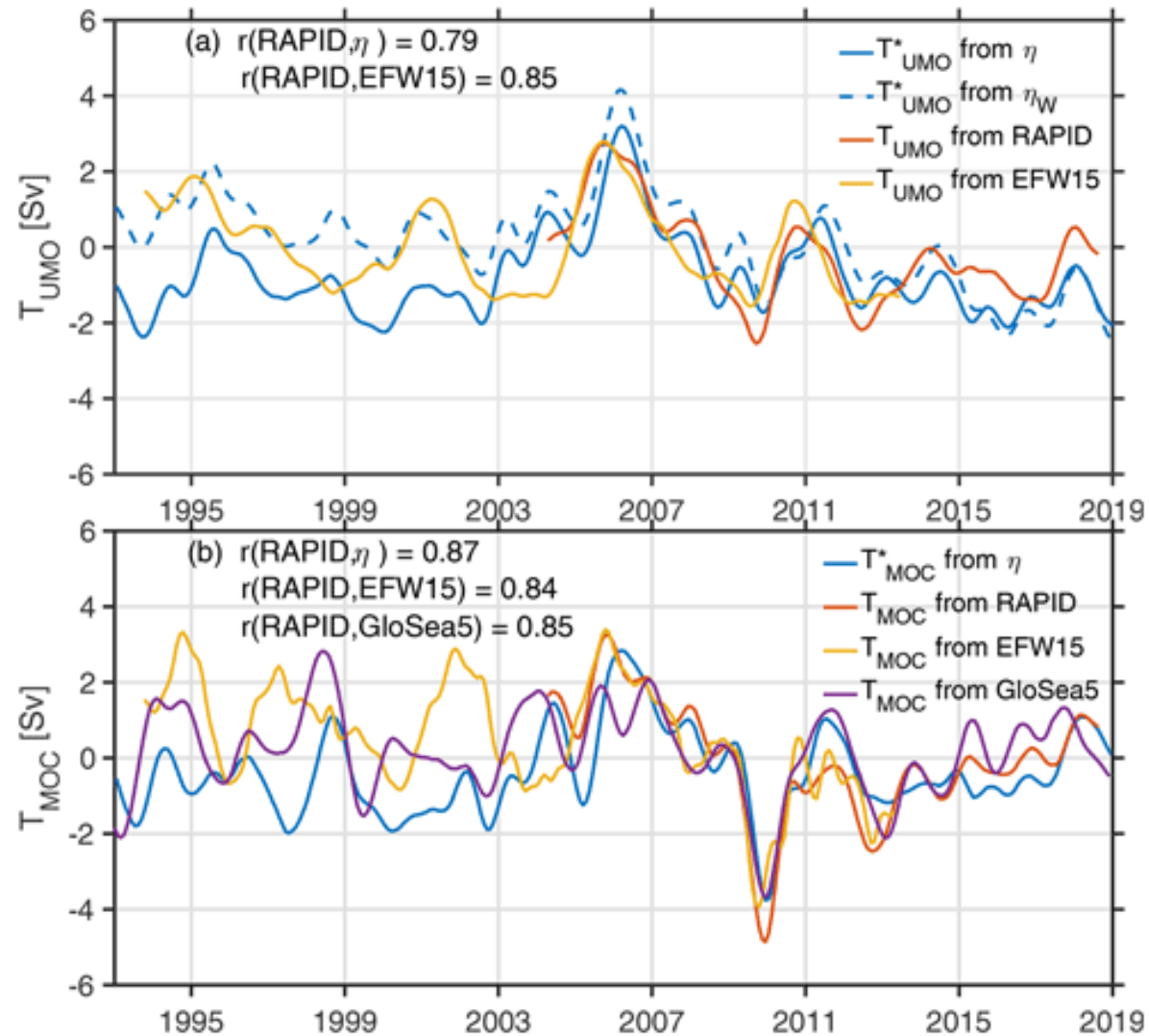
Moat et al. 2022, Willis 2010, Le Bras et al. 2023



# Contradicting changes at the gyre transition



# Reconstructing RAPID from altimeter



# Synthesis

- AMOC observing systems are
  - Important baselines for comparison with ocean/climate models
    - Some are now two decades long!
  - Becoming more cost-effective
  - Providing new insights on AMOC-relevant processes and dynamics
- Alternative AMOC observing methods can be used to investigate
  - Meridional AMOC structure
  - Critical elements of AMOC observing (what are the minimum requirements)