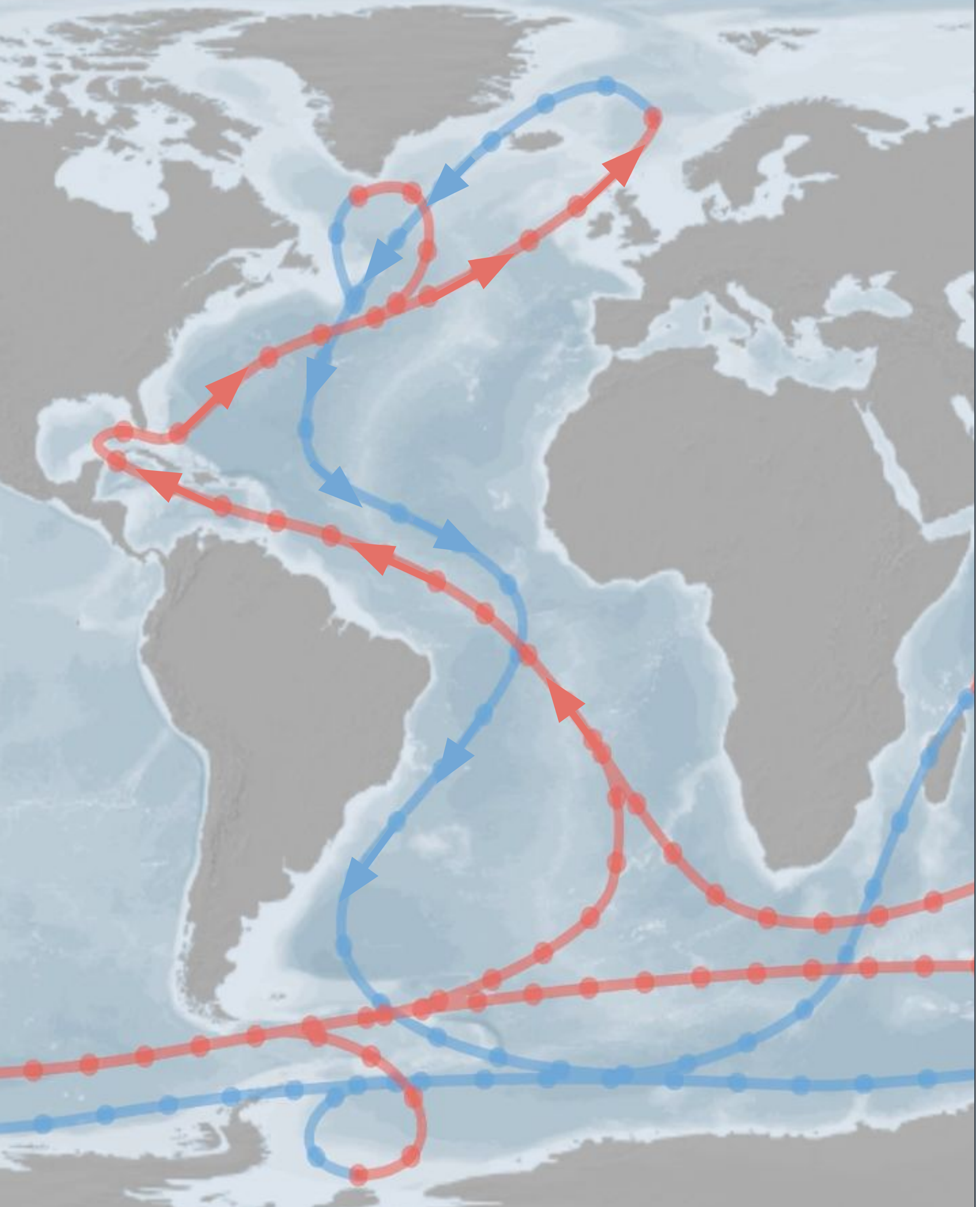


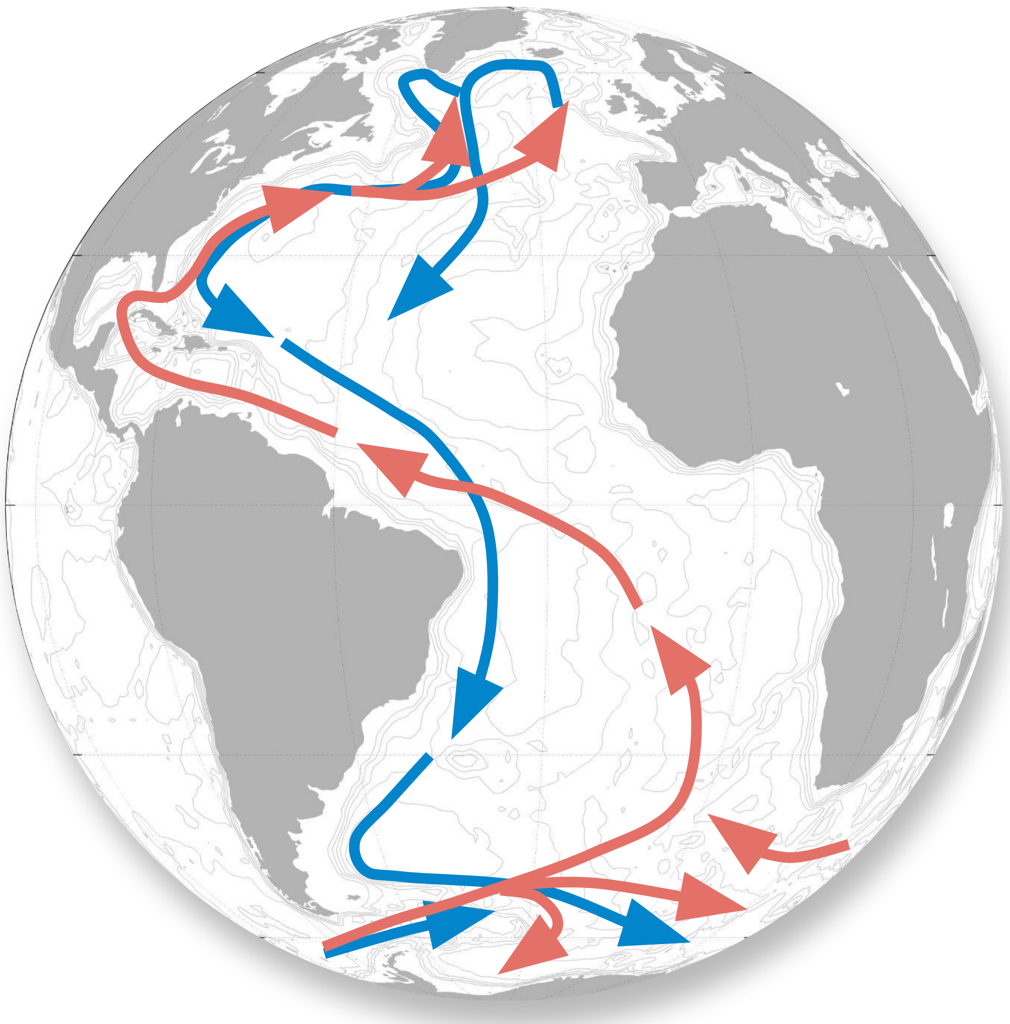
Graphic courtesy of Leah Chomiak and Shenfu Dong

Observed Variability of the Atlantic Meridional Overturning Circulation and the Deep Western Boundary Current along 34.5S

Renellys C. Perez[1], Shenfu Dong[1], Isabelle Ansorge[2], Edmo Campos[3], Maria Paz Chidichimo[4], Rigoberto Garcia[5,1], Tarron Lamont[6,2,7], Gavin Louw[6], Matthieu Le Henaff[1], Alberto R. Piola[8], Olga T. Sato[3], Sabrina Speich[9], F. Philip Tuchen[10], Marcel van den Berg[6], Denis Volkov[5,1]

[1]NOAA/AOML, USA; [2]Department of Oceanography, UCT, South Africa; [3]Oceanographic Institute, USP, Brazil; [4]CONICET, Argentina; Escuela de Hábitat y Sostenibilidad, UNSM, Argentina; [5]CIMAS, UMiami, USA; [6]Oceans and Coasts Research, Department of Forestry, Fisheries and the Environment, South Africa; [7]Bayworld Centre for Research and Education, South Africa; [8]Universidad de Buenos Aires, Argentina; [9]Laboratoire de Météorologie Dynamique, IPSL, Ecole Normale Supérieure, France; [10]UMiami Rosenstiel School, USA

Why measure the AMOC?



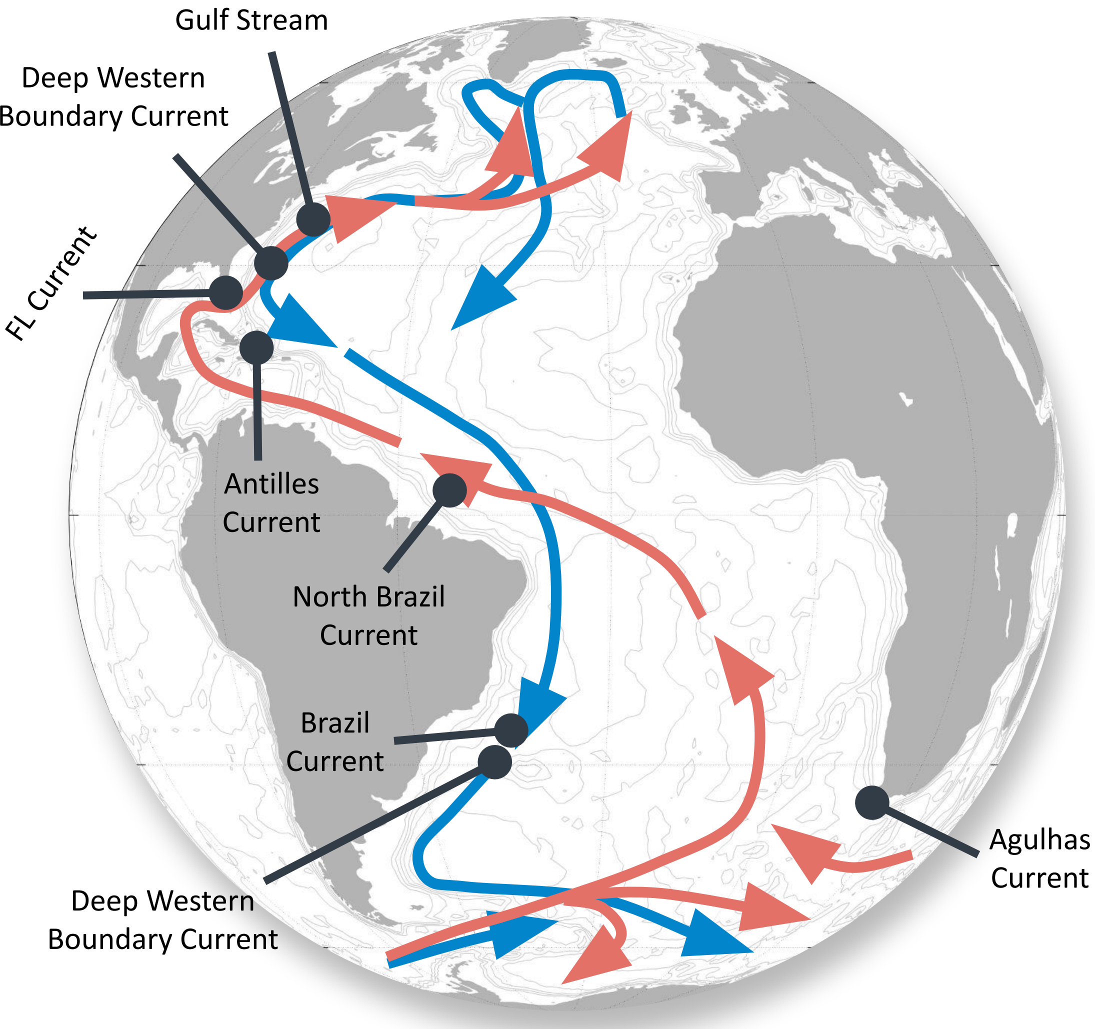
Measure, describe, and understand the pathways and variability of the upper and lower limbs of the AMOC, including future weakening and distance to tipping point

Assess the role of AMOC in redistributing heat and salt in the ocean, and how it affects regional and coastal sea level changes

Study the relationship between AMOC and extreme weather events, including monsoons, heat waves, hurricanes, flooding and droughts

Slide courtesy of Leah Chomiak and Shenfu Dong

Why measure boundary currents?

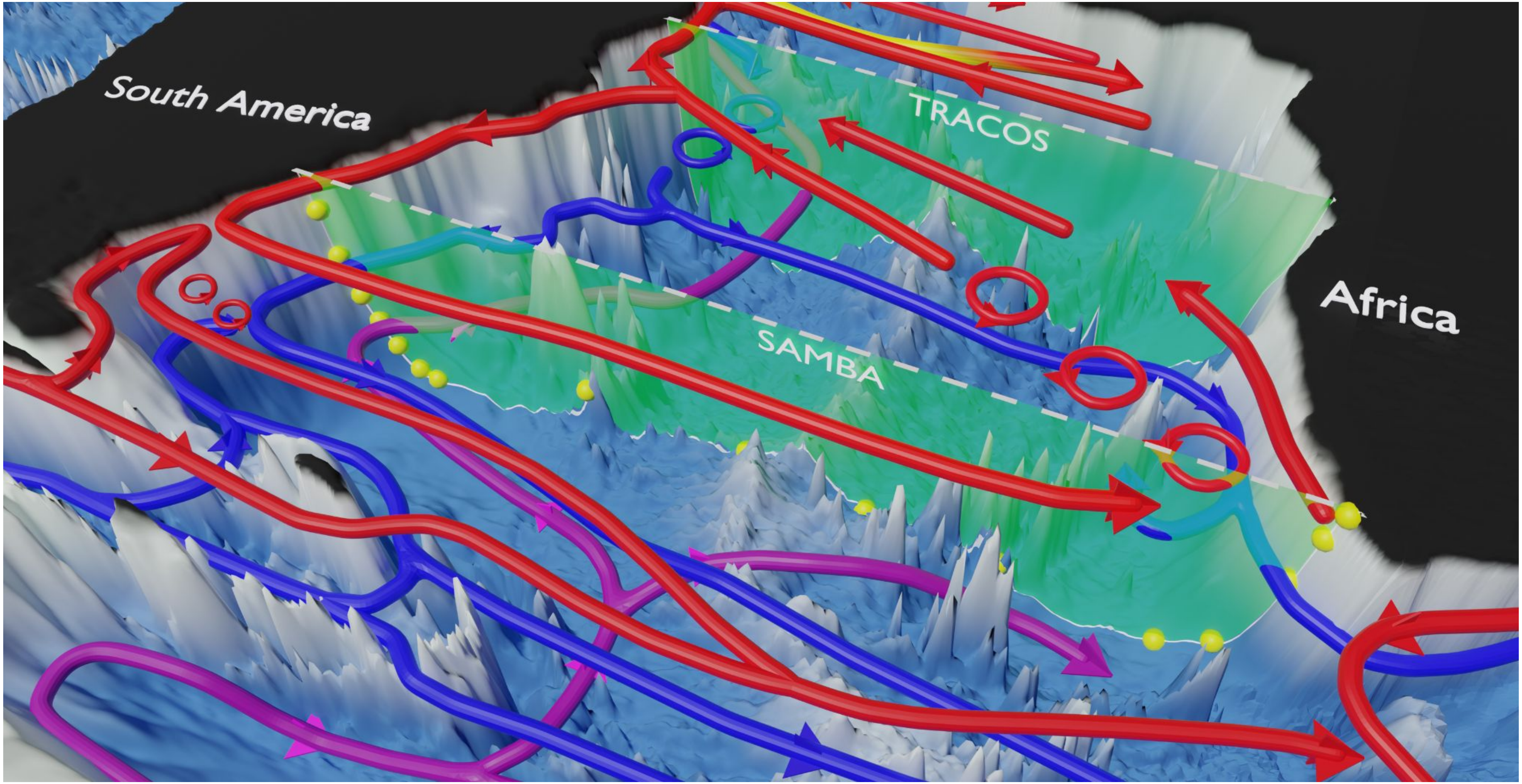


Within the AMOC, these currents are the main carrier of heat, mass, salt, and biogeochemical constituents

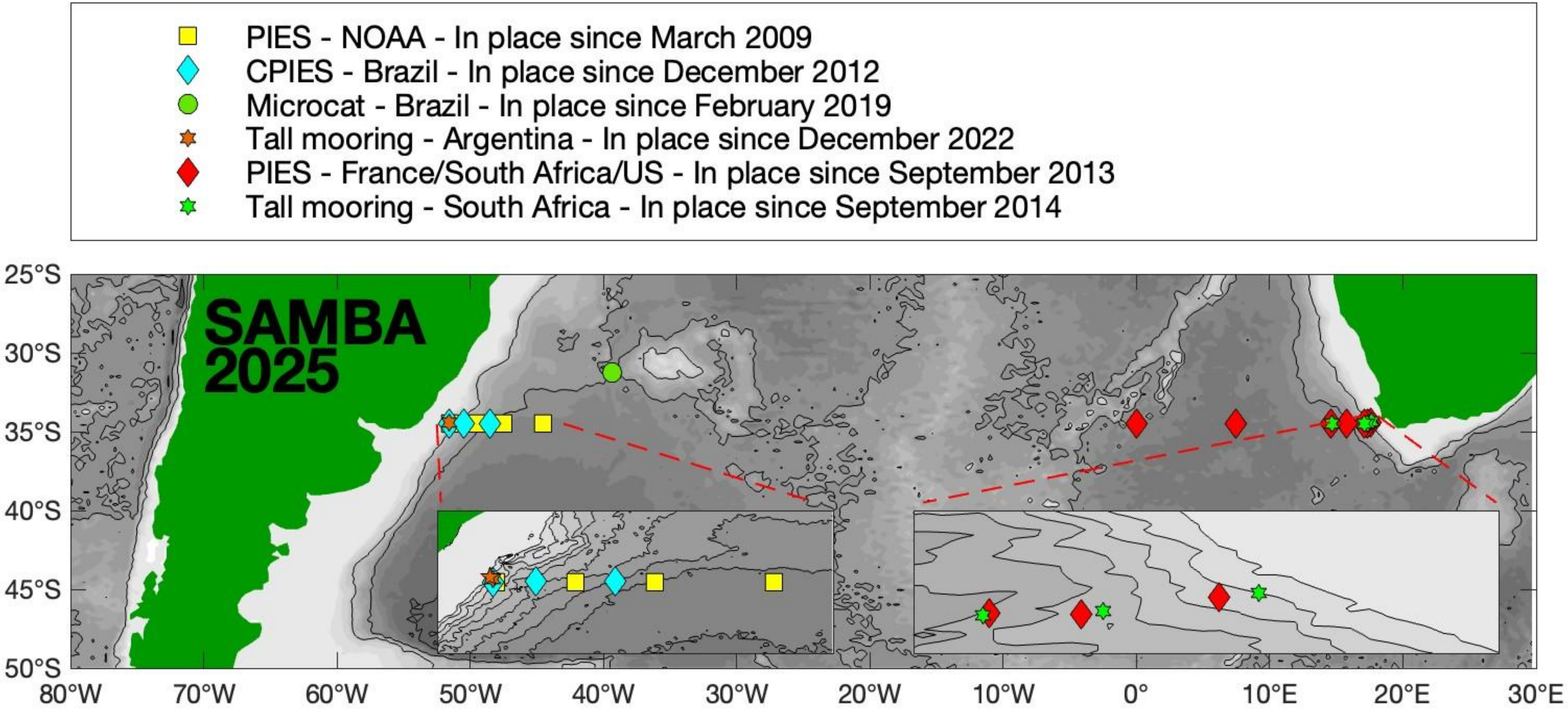
Boundary currents play key roles in coastal and open ocean exchanges
(shelf ecosystem health and productivity)

Release large amounts of heat and moisture to the atmosphere, playing a critical role in the climate and weather

Slide courtesy of Leah Chomiak and Shenfu Dong

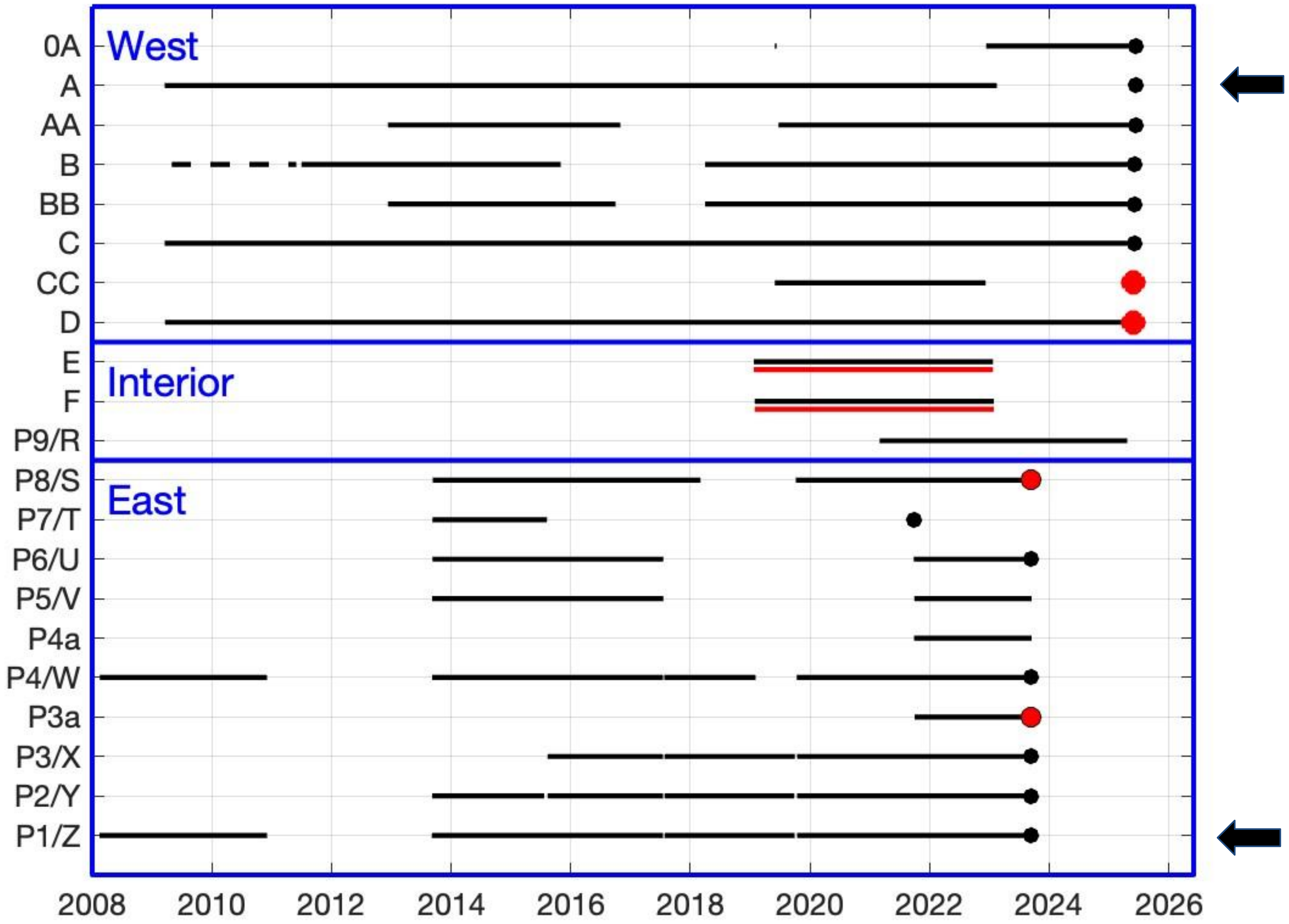


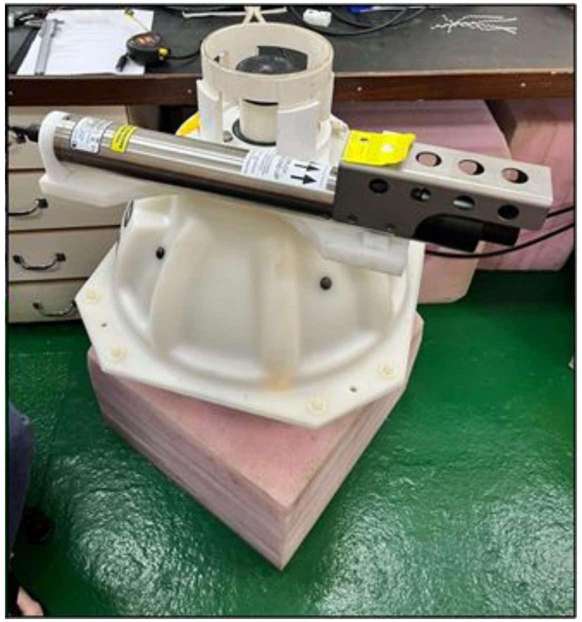
Graphic courtesy of Bertrand Dano



PIES - NOAA - In place since March 2009
CPIES - Brazil - In place since December 2012
Microcat - Brazil - In place since February 2019
Tall mooring - Argentina - In place since December 2022
PIES - France/South Africa/US - In place since September 2013
Tall mooring - South Africa - In place since September 2014
SAMBA
2025
25°S
30°S
35°S
40°S
45°S
50°S
80°W
70°W
60°W
50°W
40°W
30°W
20°W
10°W
0°
10°E
20°E
30°E

SAMBA PIES/CPIES time line





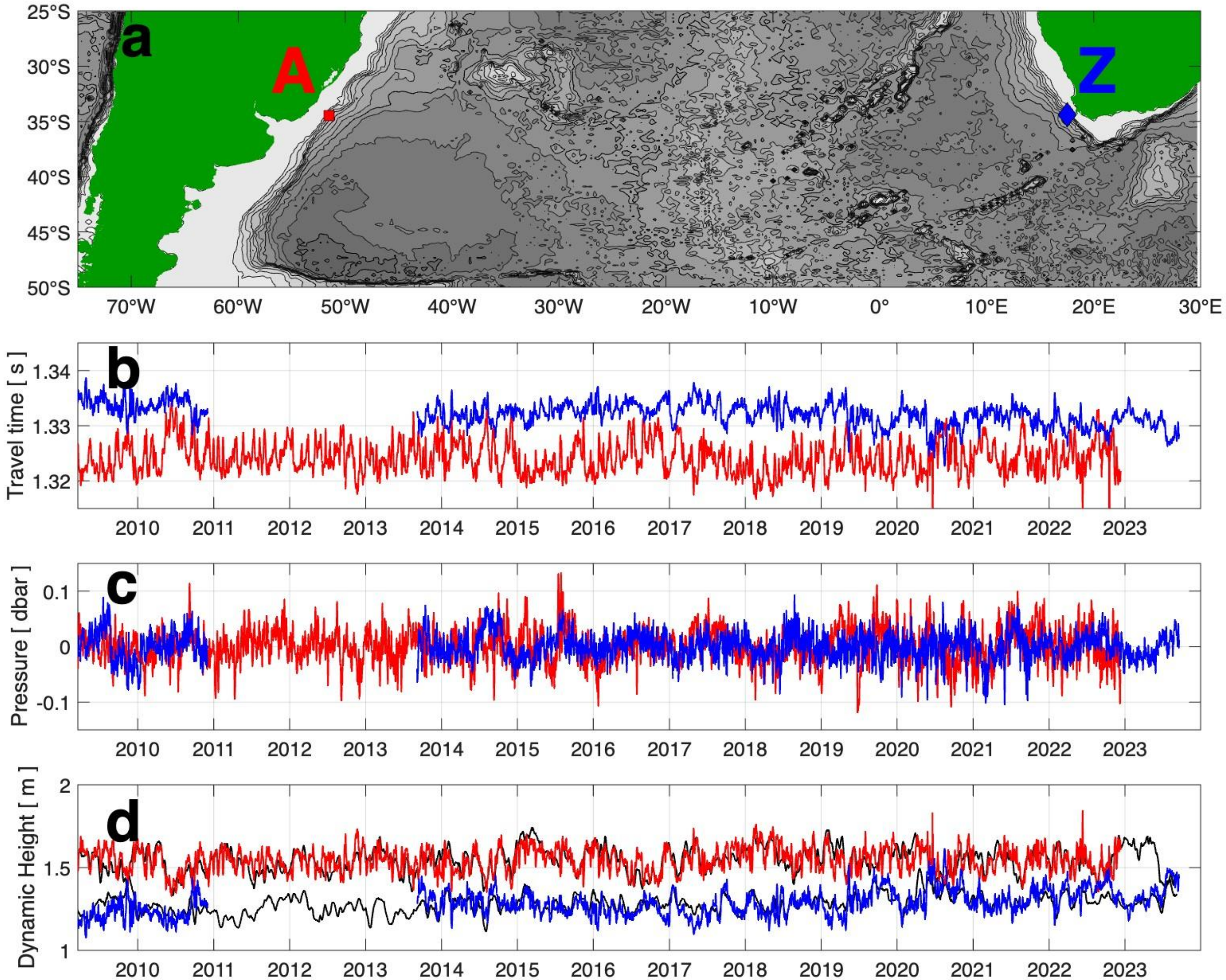
What does a PIES mooring measure?

Vertical acoustic travel time
Bottom pressure (temp)

Combined with hydrographic data and empirical relationships, PIES data provide time series of **dynamic height.**

Differencing dynamic height and pressure between adjacent PIES provide **baroclinic** and **barotropic geostrophic velocity,** respectively across each pair of PIES.

We integrating velocity zonally (east-west) and vertically to estimate volume transport of AMOC.

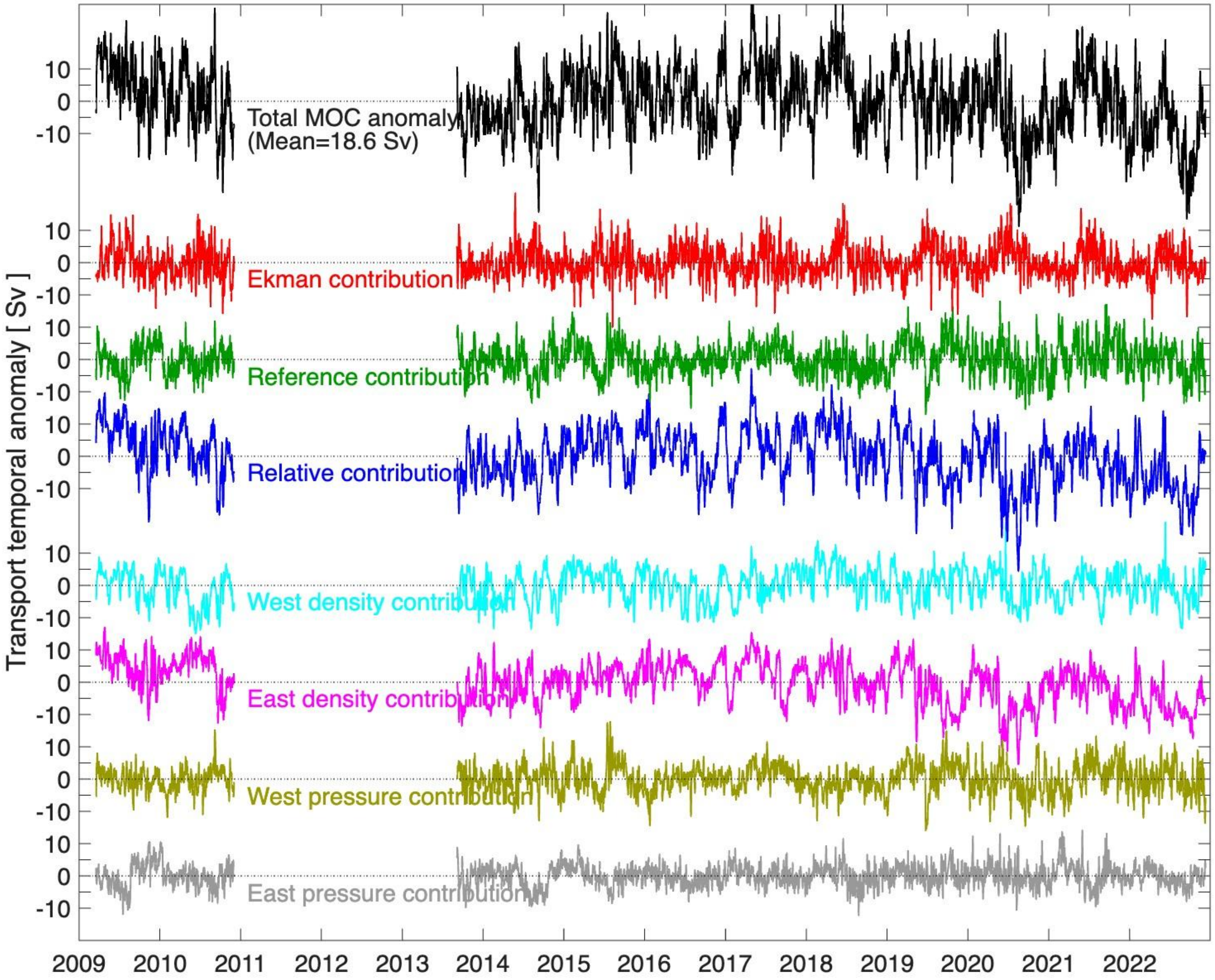


SAMBA A&Z: AMOC time series

Multi-year record: 2009-2022
Mean: 18.6 Sv
Standard Deviation: 10.4 Sv
Trend: -0.58 Sv/yr

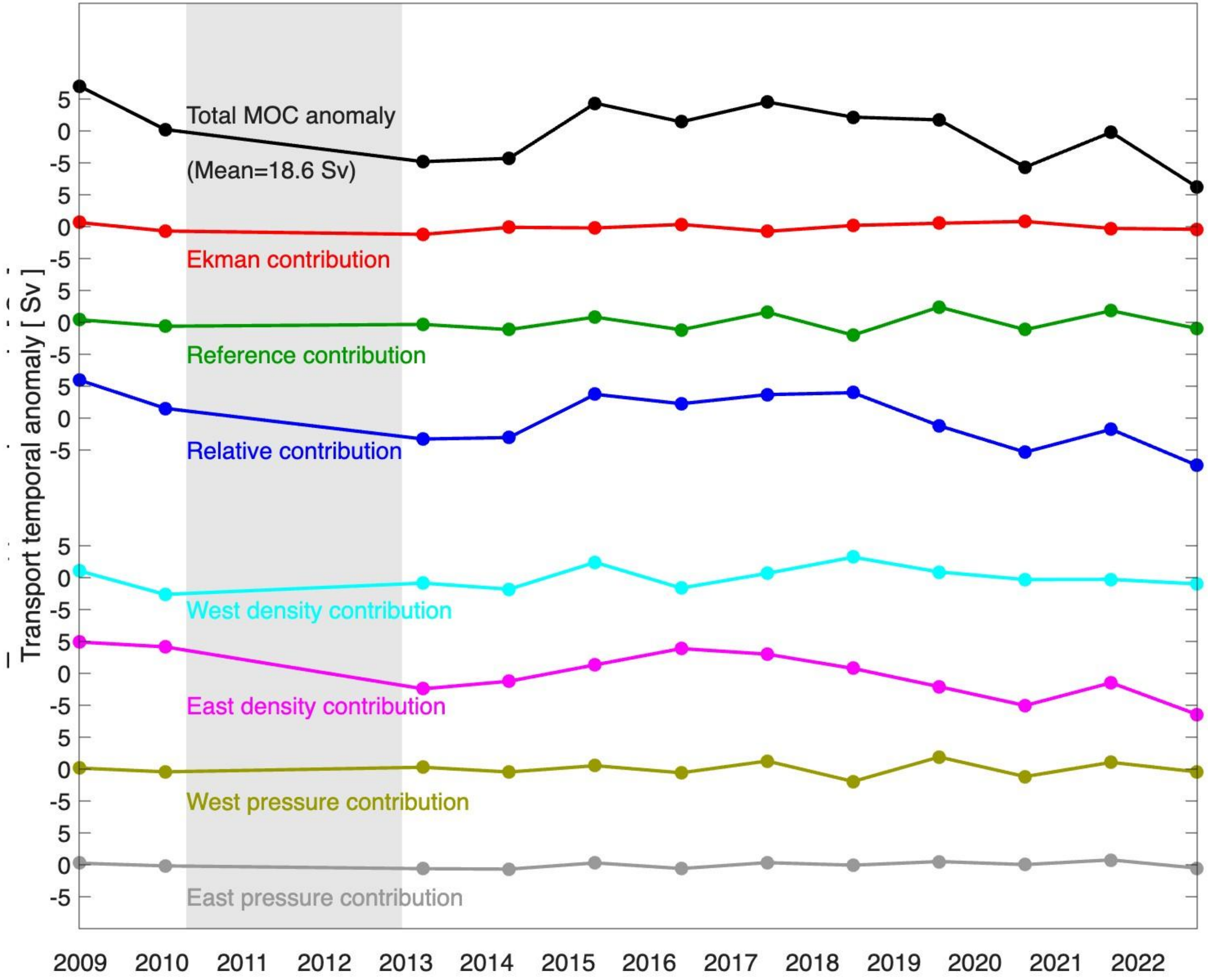
Density-driven changes are the largest source of variability (**blue**), followed by pressure (**green**) & Ekman (**red**) contributions

Eastern boundary density (**pink**) and western boundary pressure (**khaki**) variations are largest contributors to those changes.



AMOC annual means

On interannual timescales, density-driven changes (**blue**) are largest source of variability, with eastern boundary density (**pink**) variations providing the largest sources of those changes.



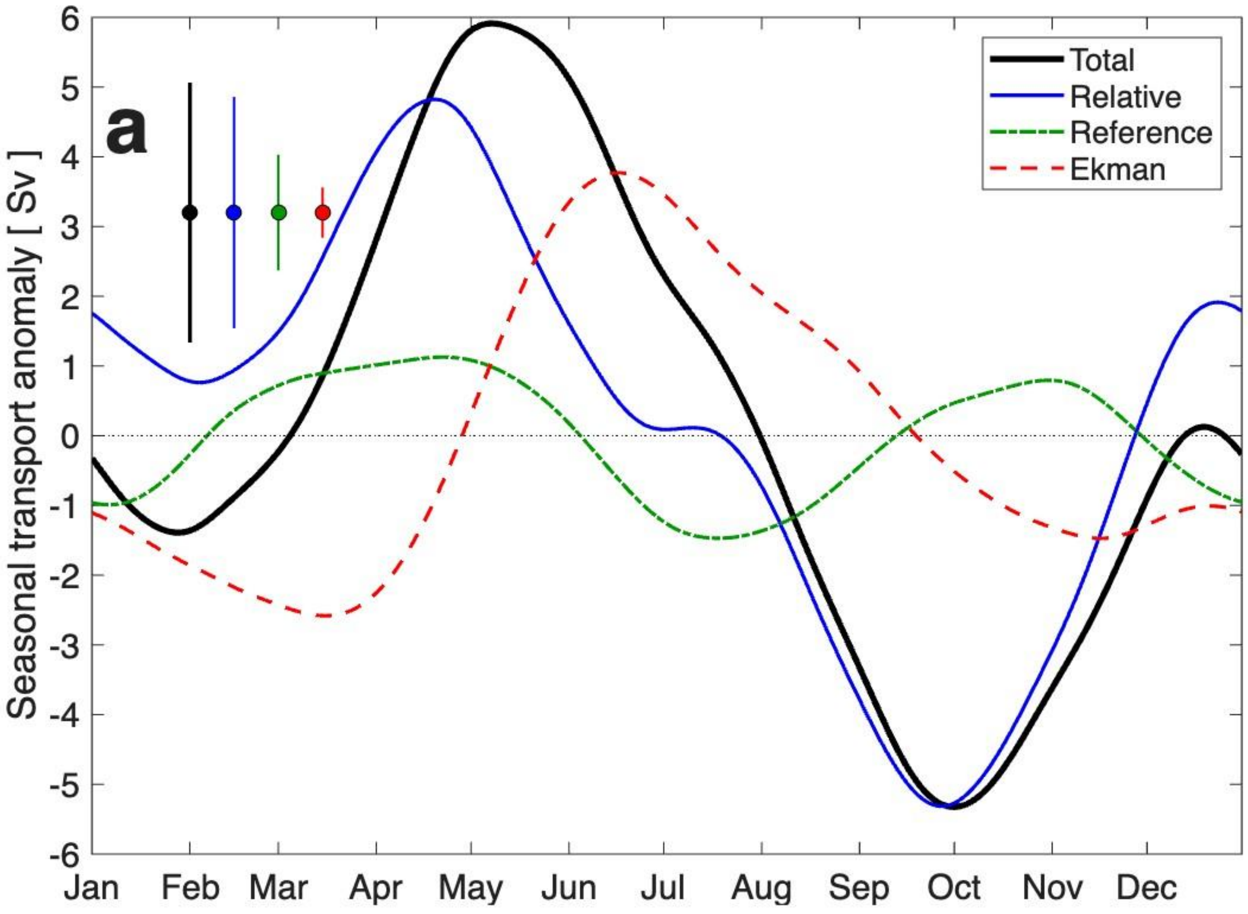
AMOC seasonal cycle

AMOC seasonal cycle has a range of +/- 6 Sv (standard dev = 3.3 Sv)

The seasonal cycle of the density contribution (**blue**) is the largest.

Ekman (**red**) and pressure (**green**) contributions are semi-annual and out of phase and partially cancel each other out.

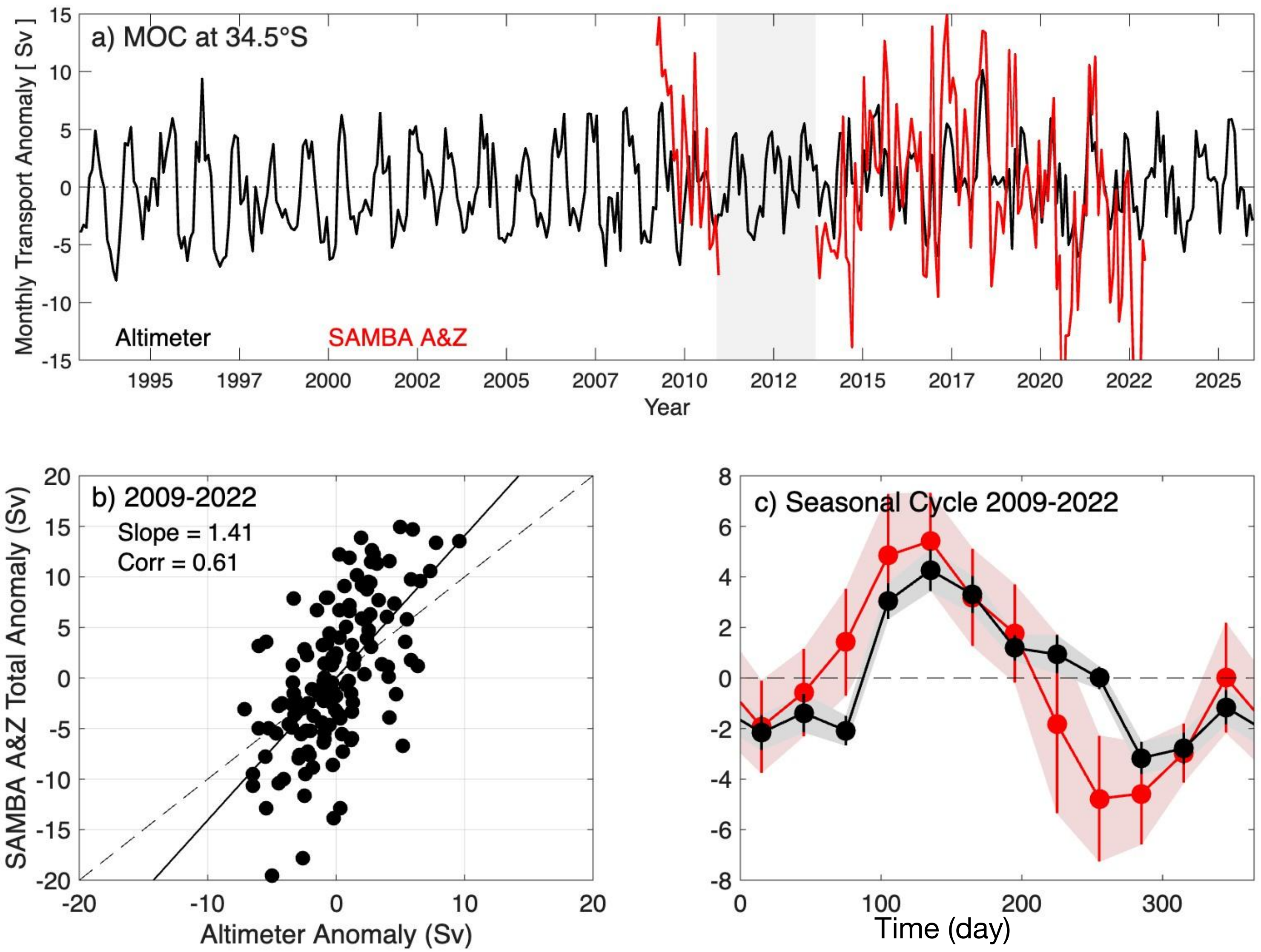
All three components are needed to resolve seasonal cycle.



Comparison with altimetry-synthesis product

The monthly SAMBA A&Z (**red**) and altimeter-based (**black**) AMOC time series show best agreement (r>0.7) between 2015 and 2019, with differences linked to SAMBA density-driven variations.

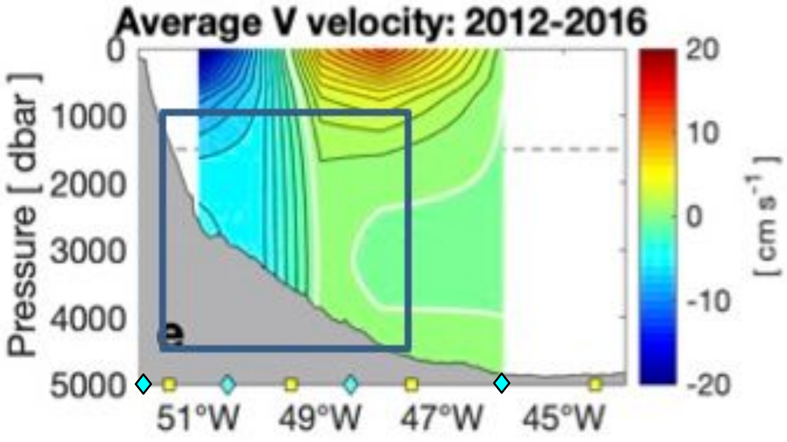
While the seasonal cycles agree well in phase and magnitude, the SAMBA estimate is more energetic.

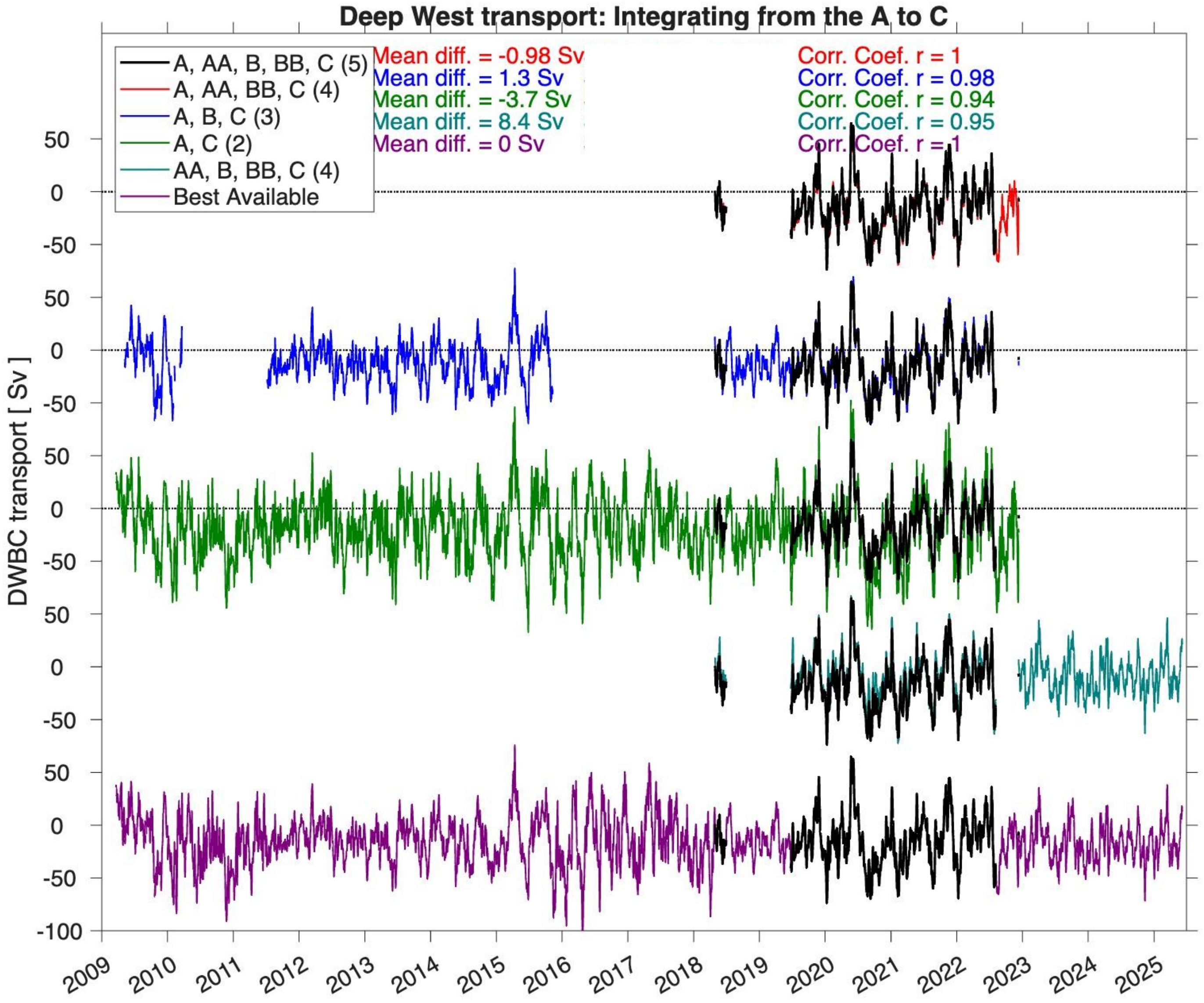


Updated from Dong et al. (2021)

“Best Available” DWBC time series

We construct a continuous 16-year DWBC times series, free from temporal gap, using all available PIES data between A & C. This captures offshore expansion and meandering of the DWBC.



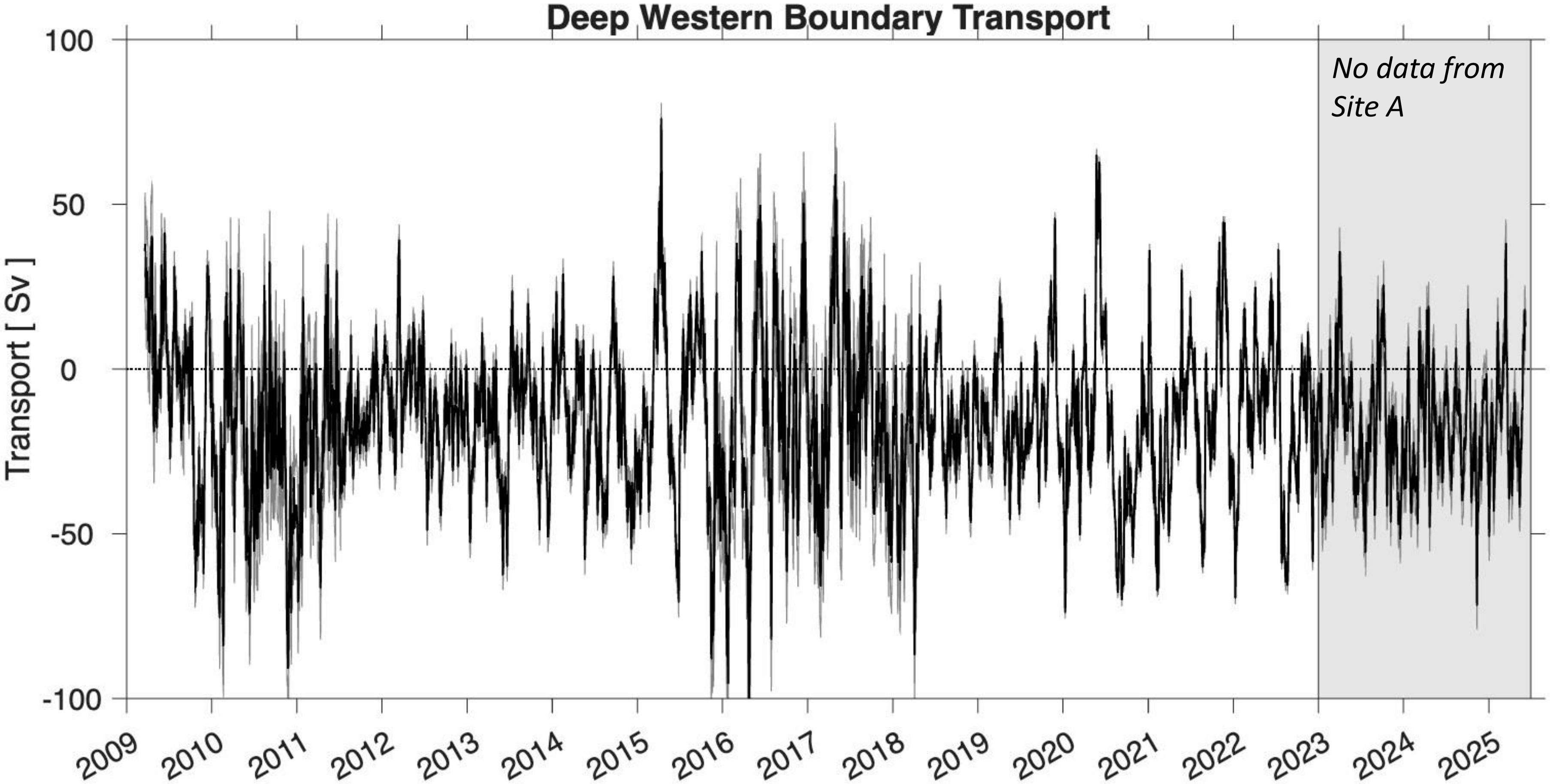


Sixteen-year DWBC time series

DWBC is energetic on short time scales from 20-to-220 days.

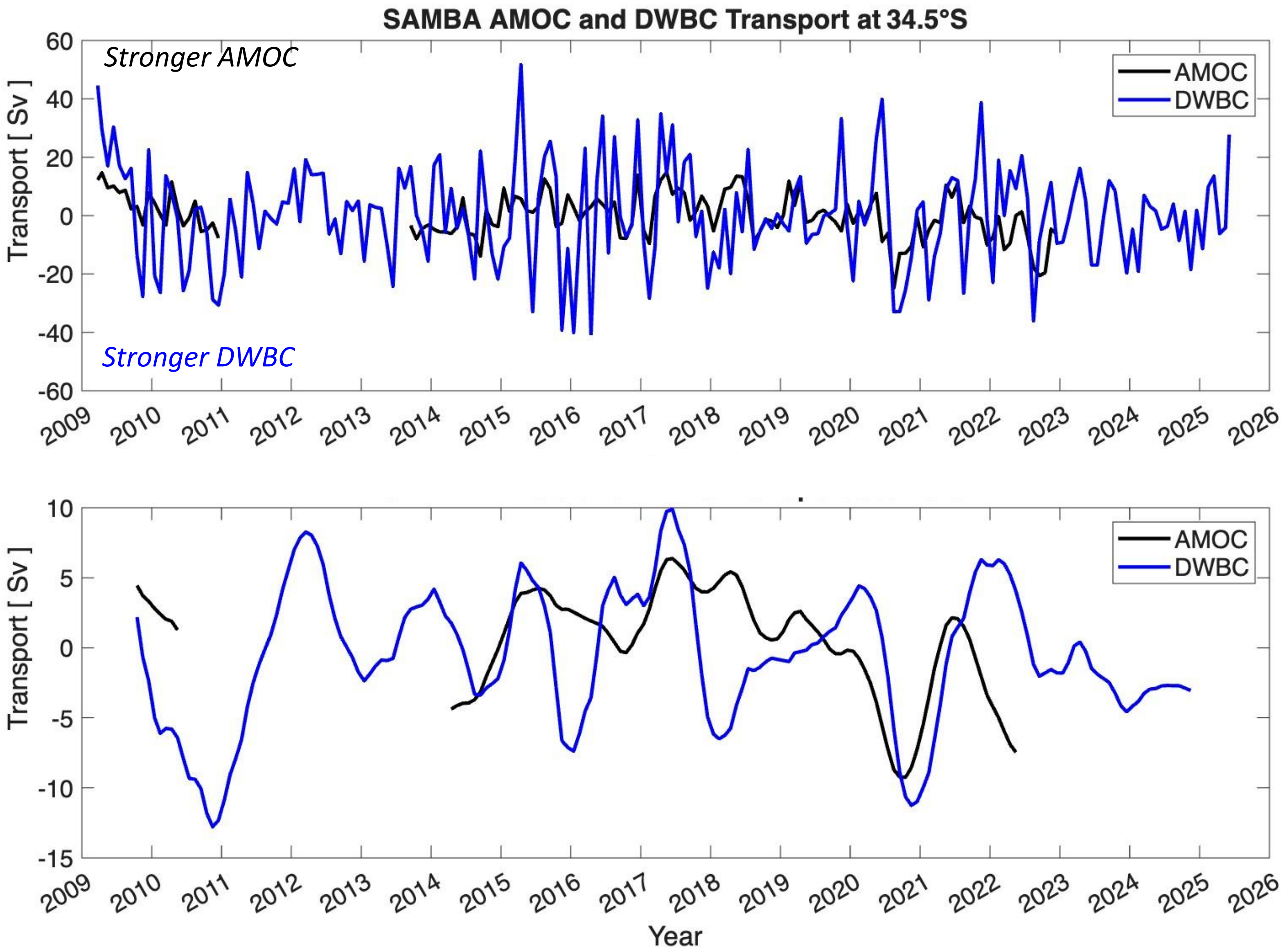
Mean: -15.6 Sv
Standard Dev: 22.4 Sv

There is a significant negative trend (-0.17 Sv/yr between 2009-2025; -0.25 Sv/yr between 2009-2022)



DWBC and AMOC covariability at 34.5S

AMOC and DWBC show a modest positive correlation (monthly ~0.4, annual ~0.5): a weaker AMOC corresponds to stronger DWBC anomalies (i.e., stronger southward transport anomalies).



Key Takeaways

01 Observations show the northward AMOC transport is weakened during 2009-2022, while the southward DWBC is strengthened.

02 Despite larger amplitudes, there is good agreement between the SAMBA A&Z AMOC transport and altimetry-based transports, especially on seasonal time scales.

03 Monthly and annual DWBC and AMOC transport anomalies do exhibit modest covariability, despite AMOC being dominated by density variations and the DWBC by pressure variations.