Observing the Boundary Currents and AMOC at 11°S

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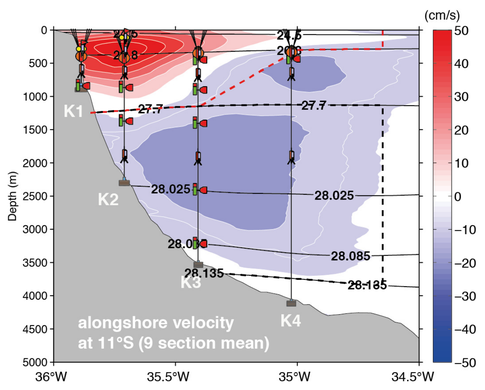
The tropical Atlantic plays an important role for climate variability in the whole Atlantic region. Especially, the western basin constitutes a key region for the exchange of water masses, heat and salt between the Southern and Northern Hemispheres. Therefore, it is a good place to monitor water mass signal propagation, changes in the transports of the Western Boundary Currents (WBC) and the Atlantic Meridional Overturning Circulation (AMOC).

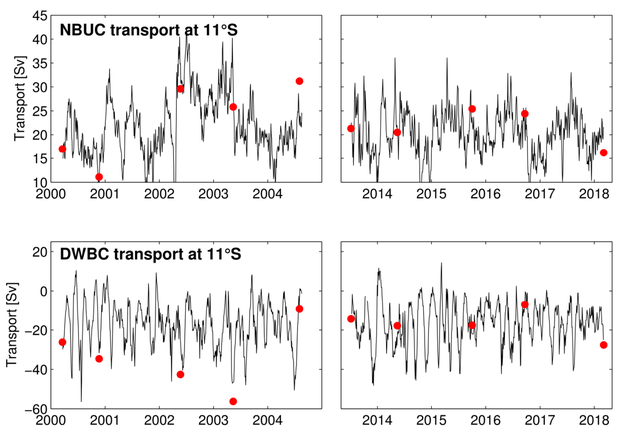
The observational program at 11°S developed historically: Parts of it already started in the early 1990s during WOCE, were continued during 2000-2004 within the German CLIVAR program with ship-sections along 5°S and 11°S. Simultaneously, a first mooring array was deployed at 11°S to observe the variability of the western boundary current (WBC) regime off the Brazilian coast (Schott et al., 2005). Instead of a laminar flow, Deep Eddies have been found to accomplish the DWBC transport at 11°S (Dengler et al. 2004). Observational and model studies show that AMOC signal on inter-annual to decadal time scales can directly be identified within transport and/or salinity variations of the NBUC (e.g. Biastoch et al. 2008; Zhang et al. 2011; Rühs et al., 2015).

The WBC Array off Brazil



- Inter-annual to decadal NBUC variability is similar to results from nested ocean model INALT01 (Durgadoo et al., 2013).
- Two decades of ship-based hydrographic measurements confirm observed long-term water mass changes in the Brazil Basin (e.g. Hummels et al., 2015; Herrford et al., 2017).
- Next maintenance cruises (M159) in Oct. 2019 and proposed for 2021.

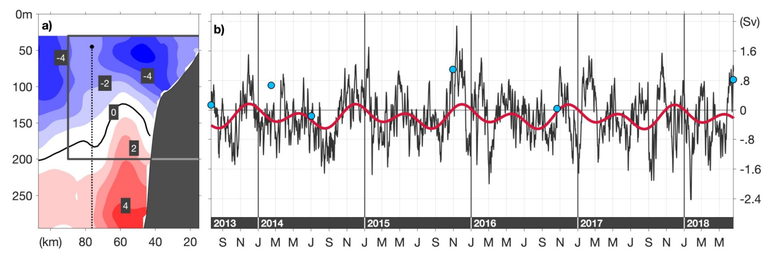
- The North Brazil Undercurrent (NBUC) & the Deep Western Boundary Current (DWBC) off Brazil are observed with
  - 4x tall current meter moorings (2000-2004; 2013-today)
  - ship-based observations (10 sections)
- Mean transports did not change significantly between 2000-2004 and 2013-2017 (Hummels et al., 2015).



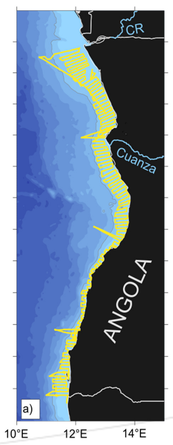
Updated from Schott et al. (2005) & Hummels et al. (2015).

Observations off Angola

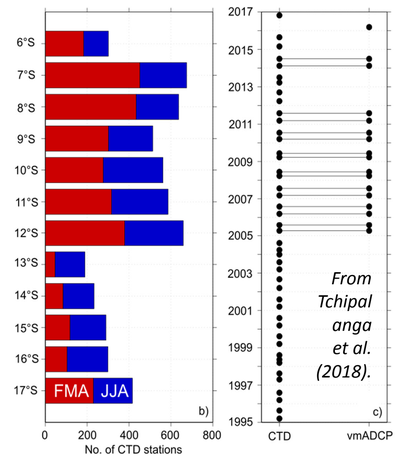
Updated from Kopte et al. (2017).

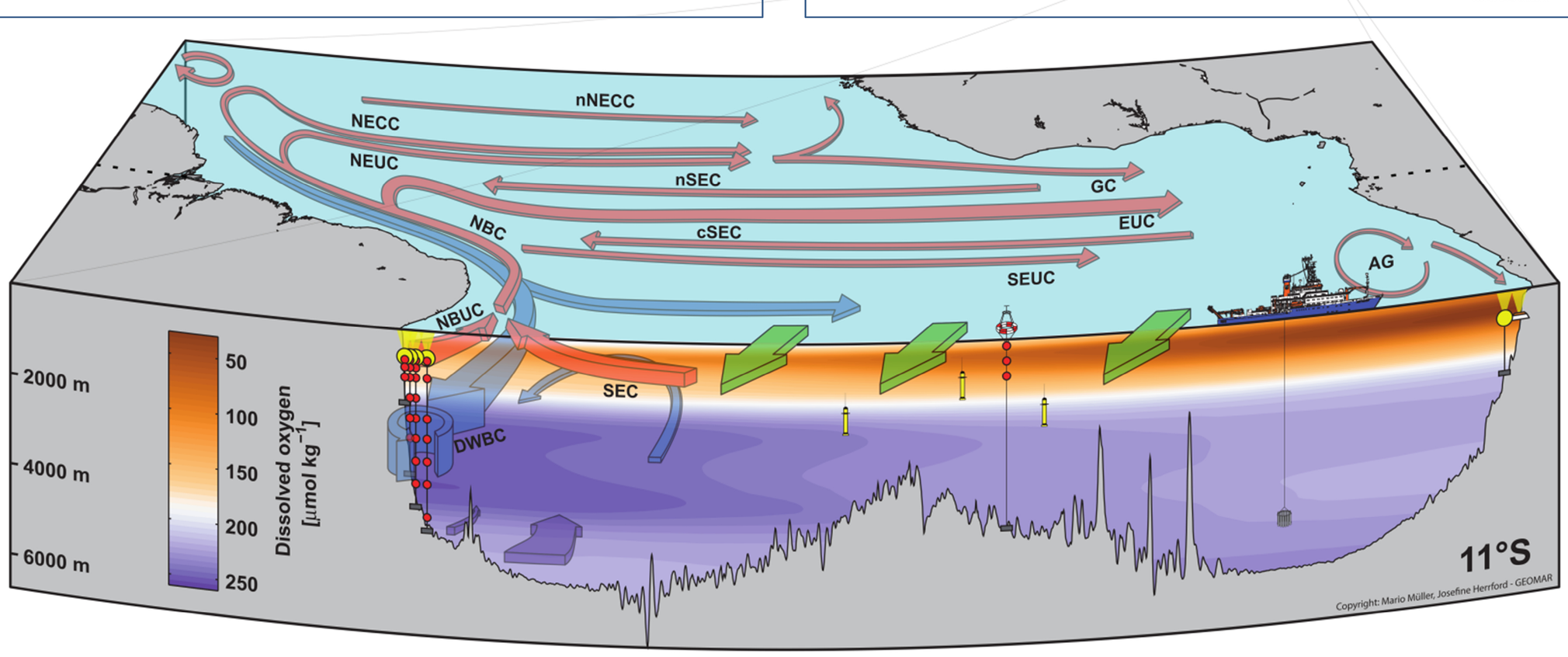


- The Angola Current (AC) is observed with moored current meter measurements since 2013.
- AC transport is weak & dominated by seasonal variability associated with remotely forced waves (Kopte et al., 2017; 2018).
- Maintenance cruises (M158) now and in spring 2021.



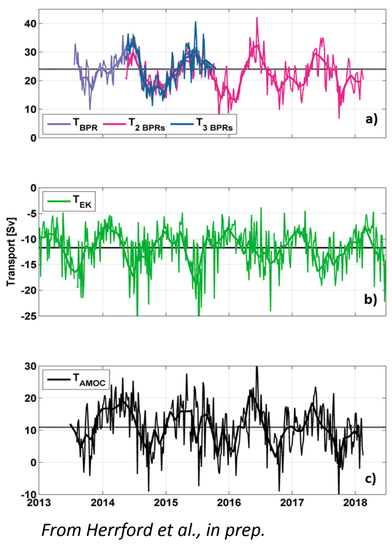
- Within the EAF-Nansen program an extensive set of repeated, quasi-regular biannual ship surveys was performed since 1995.
- Seasonal water mass changes could be quantified.
- Strong inter-annual to decadal variability of subsurface heat content was identified and related to central waters of different origin competing with varying AC transport (*Tchipalanga et al., 2018*).





Bottom Pressure observations

Bottom Pressure (BP) observations on both sides of the basin (at 300m & 500m) can be used to estimate seasonal AMOC variability at 11°S.



From Herrford et al., in prep.

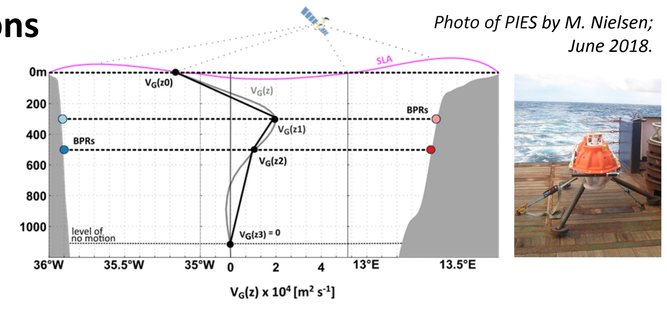


Photo of PIES by M. Nielsen; June 2018.

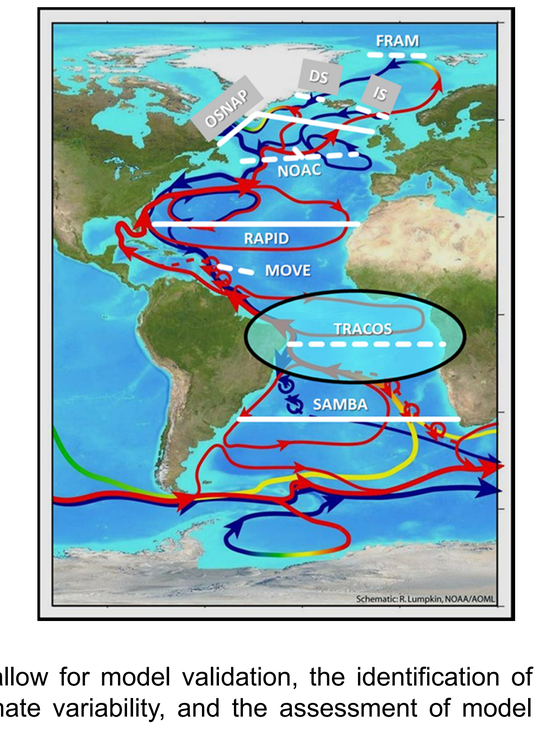
- From the pressure difference between the eastern and western boundaries basin-wide geostrophic transport variations above 1000m (T_{BPR}) can be derived.
- Adding the local, wind stress forced Ekman transport (T_{EK}) gives AMOC transport variations:

$$T_{BPR} + T_{EK} = T_{AMOC}$$

- In the Tropics, T_{AMOC}, as well as all BP & wind-stress time series, are dominated by the annual and semi-annual cycles. Seasonal AMOC variability is in good agreement with the INALT01 model (Herrford et al., *in prep.*).
- New mooring setup is planned off Angola with BP measurements at 1000m.

Work in progress/Outlook

- All available hydrographic measurements in the tropical South Atlantic will be combined to extend time series of the WBC system & AMOC and investigate longer-term variability.
- In a synthesis phase, the assessed variability of the WBC system & AMOC at 11ºS will be related to
  - variability of the equatorial circulation and its impact on rainfall over Africa based on observations near the equator, specifically at 23°W
  - AMOC variability in the Subtropics of both hemispheres
- The spreading of water mass anomalies within the AMOC and their long-term changes, which can originate from the South or North Atlantic, will be analyzed.



- The analysis of observations & models will allow for model validation, the identification of key processes of observed circulation & climate variability, and the assessment of model prediction skill.

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