RACE TP 1.1

Rolle des tropischen Atlantiks für Klimaschwankungen im atlantischen Raum

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In order to understand the role of the tropical Atlantic for climate variability in the Atlantic region, this subproject aims at investigating the variability of the western boundary current (WBC) system off Brazil as well as the Atlantic Meridional Overturning Circulation (AMOC) at 11° S. The assessed variability will then be related to the variability of the Subtropical Cells (STCs) as well as AMOC variability at other latitudes.

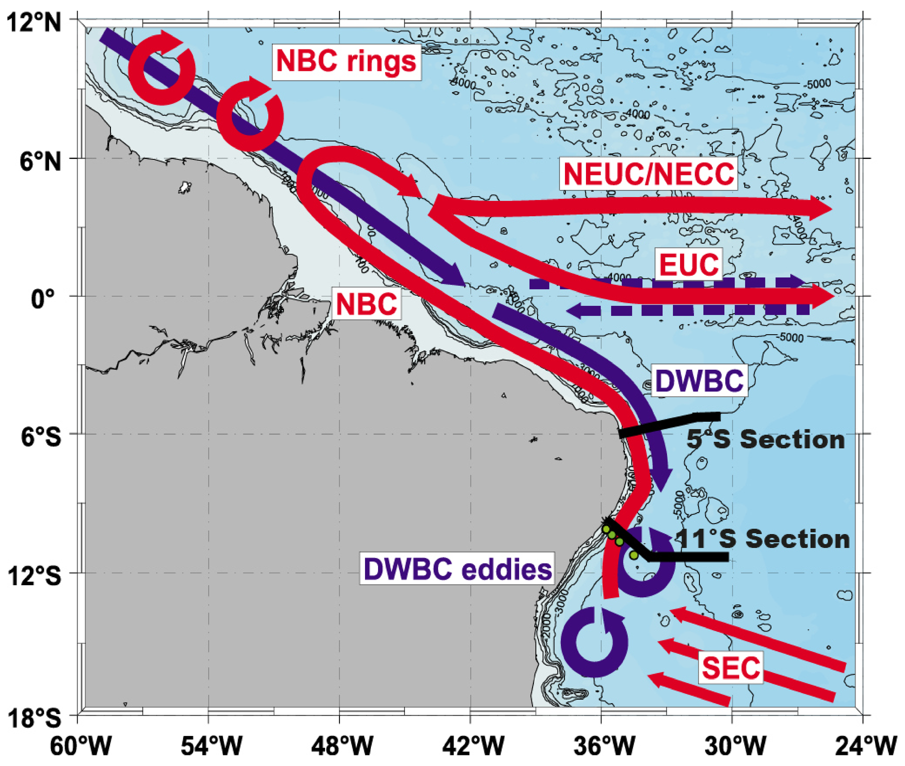


Fig. 1: Circulation scheme of the western tropical Atlantic (Dengler et al., 2004). Warm-(Cold) water routes of the AMOC are indicated in red (blue), hydrographic sections in black und moorings as green circles.

Observations of the WBC system:

- The WBC system is investigated with ship based observations and a mooring array (hydrographic as well as direct current observations).
- The variability of the WBC system, especially of the North Brazil Undercurrent (NBUC) and the Deep Western Boundary Current (DWBC) is investigated on time scales from intraseasonal to decadal.

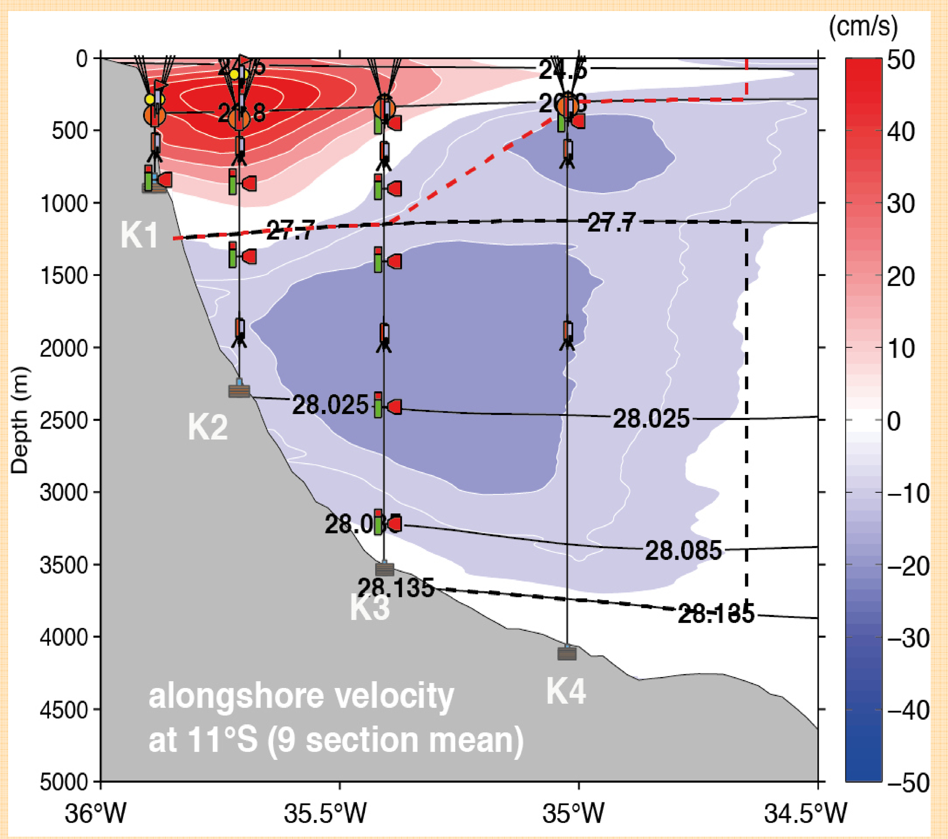
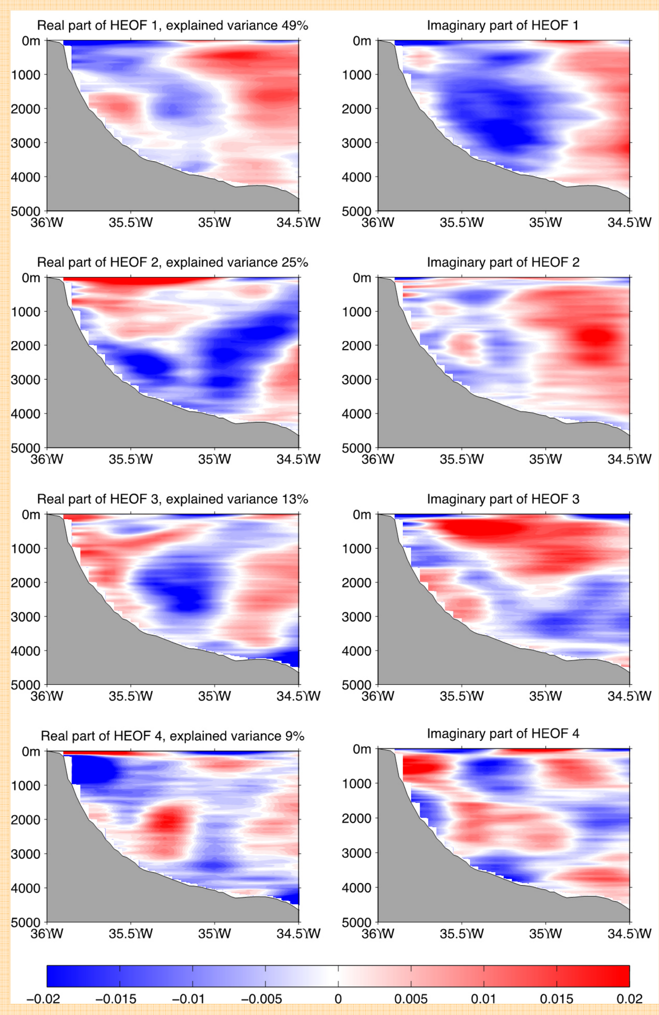


Fig. 2 Average section of alongshore velocity together with the mooring array design. Red/black dashed lines mark boxes for NBUC/DWBC transport calculations (Fig.3).

- In addition to the reconstruction of the velocity sections from moored observations by inter- and extrapolation (Fig. 3), the field will be reconstructed using a pattern regression method (Fig. 4). The reconstructed fields of the latter method can be directly compared to the observed fields and inferred transports of the shipboard observations.

Fig. 4: The real and imaginary part of the first four HEOF patterns calculated for the alongshore velocity of the 9 ship sections.



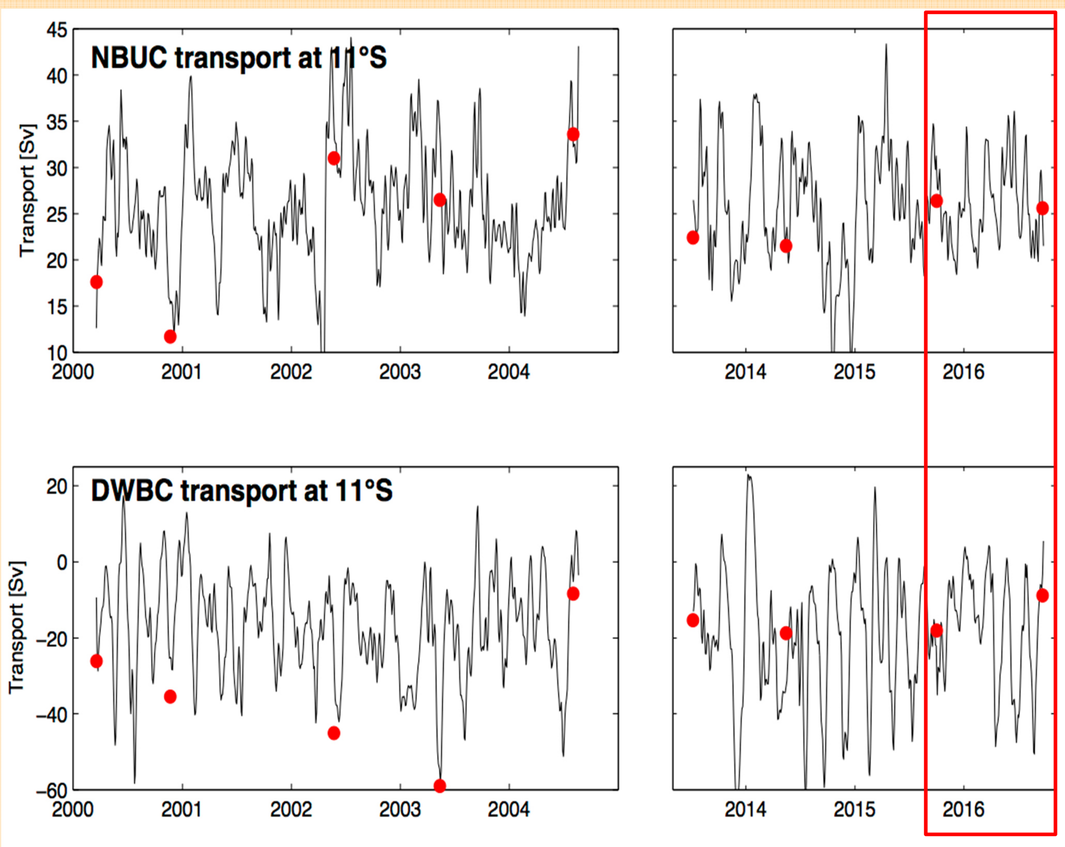


Fig. 3: Updated transport time series of the moored array for the NBUC (a) and DWBC (b). Red dots mark transports estimated from ship-board observations.

- Deep Eddies, which have been shown to accomplish the transport of NADW instead of a laminar flow and were predicted to disappear with a weakening AMOC (Dengler et al. 2004) are still present with similar characteristics (Fig. 1,3).
- The fourth cruise within RACE (M130) was performed in September/October 2016, when the third period of moored observations (red box in Fig. 3) could be recovered with an instrument performance of over 90%.
- The next and last cruises within RACE II is planned for March 2018.

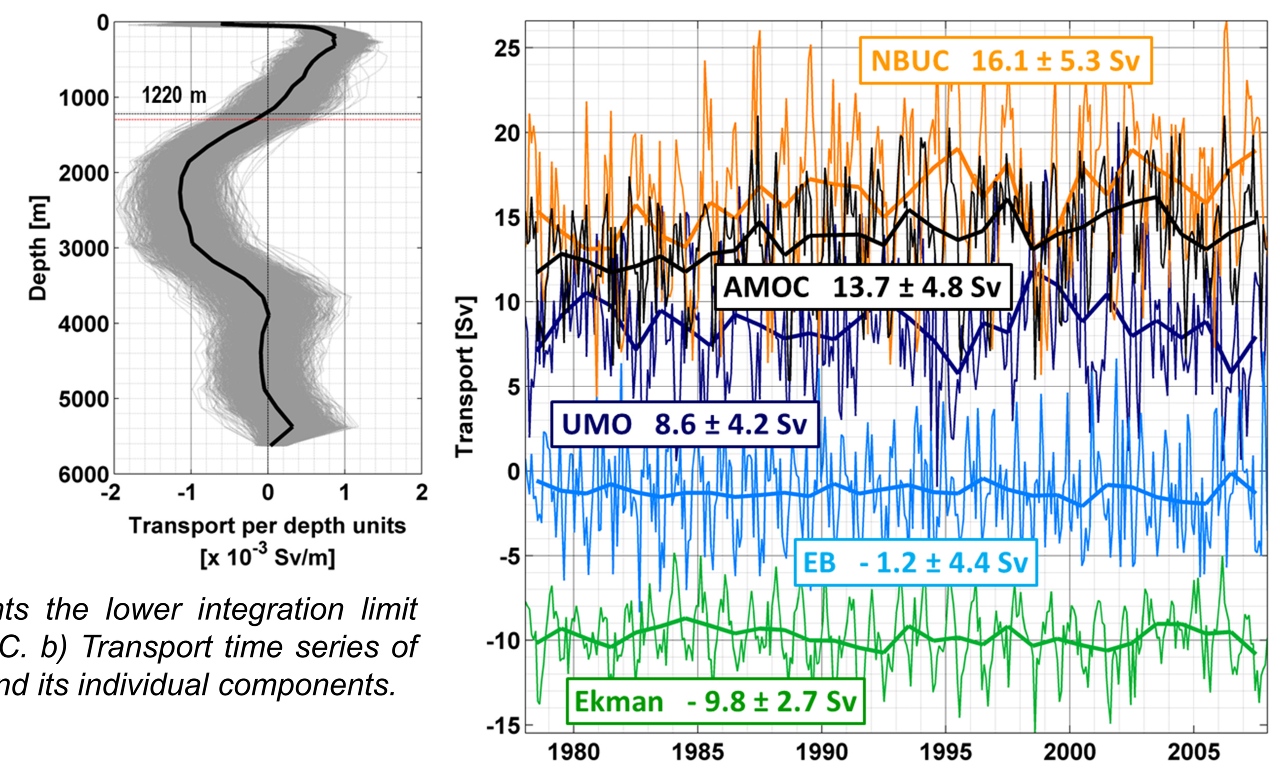
Variability of the AMOC at 11° S:

- The mean, and seasonal to interannual variability of the AMOC at 11° S will be determined by constructing a transport time series from numerous observations.
- The AMOC can be calculated by the sum of four meridional flow components (following assumptions of the RAPID setup; e.g. Kanzow et al., 2010; Chidichimo et al., 2010):

$$T_{AMOC}(t) = T_{UMO}(t) + T_{EK}(t) + T_{NBUC}(t) + T_{EB}(t)$$

- Currently, the INALT01 model (Durgadoo et al., 2013) with a 1/10° nest in the South Atlantic, is used as ‚testing area‘

Fig. 5 a) Vertical profiles of transport per depth unit at 11° S from INALT01 – every 5 days (grey) & averaged over 1978-2007. The zero-crossing represents the lower integration limit for the AMOC. b) Transport time series of the AMOC and its individual components.



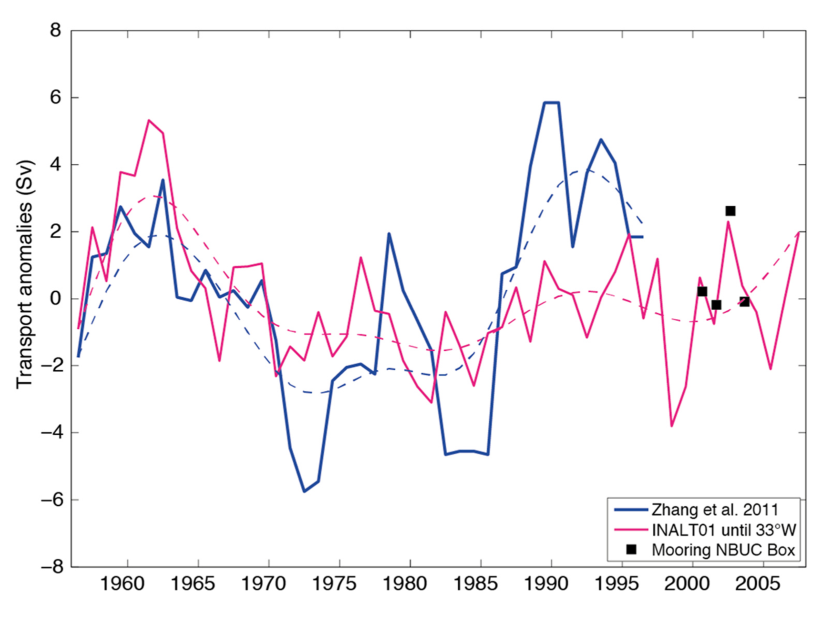
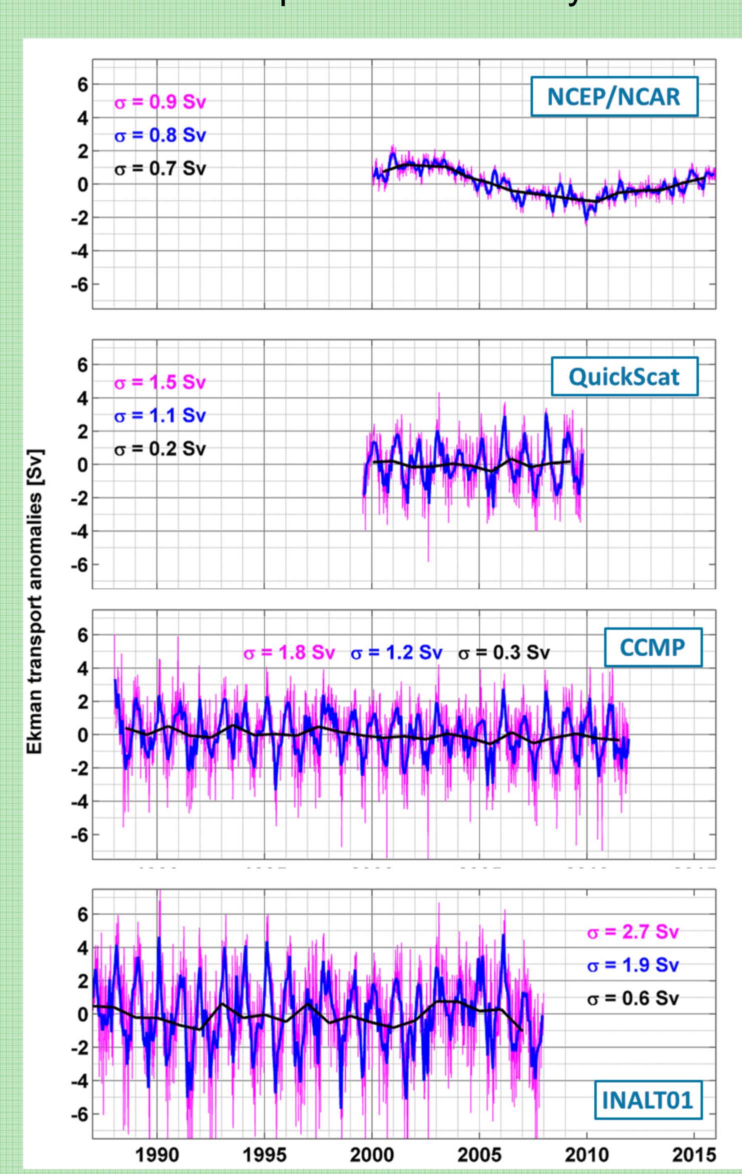


Fig. 6: NBUC transport anomalies, where 15, 16 and 25 Sv were subtracted (INALT01, geostrophic transports and moored observations).

- In a first attempt, the AMOC and its four components are directly calculated from the velocity field (Fig.5 b))
- Interannual NBUC variability as assessed from moored observations between 2000-2004 is consistently found in the output of INALT01 (Hummels et al., 2015). Decadal NBUC variability is similar in INALT01 and geostrophic transport estimates from Zhang et al. (2011).
- The mean eastern boundary transport is small, but similarly contributes to the AMOC variability on seasonal timescales

Ekman transport variability:

- Different wind products (NCEP/NCAR, QuickScat, CCMP, INALT01 wind stress) and observations (e.g. Fu et al., 2016) are compared at 11° S regarding the mean Ekman transport and variability on different timescales



- Seasonal variability is dominant, but differs in amplitude between products
- Spurious decadal variability is found in NCEP/NCAR

Fig. 7: Ekman transport anomalies [Sv] calculated from different wind products/INALT01 wind stress forcing on a weekly (magenta), monthly (blue) and annual (black) basis.

Aims during RACE II:

- **Assessment of the transport variability of NBUC, DWBC und the AMOC at 11° S on intraseasonal to decadal time scales**
- **Investigation of the relation between transport variability at the western boundary at 11° S (warm and cold water route) and the variability in the subpolar North Atlantic with respect to signal propagation within the AMOC**
- **Analysis of the spreading of water mass anomalies within the AMOC, which can e.g. originate from the variability in the inflow of saline waters from the Indian to the Atlantic ocean**
- **Investigation of the relation between NBUC variability at 11° S and EUC variability at 23° W, its impact on heat and freshwater balances of the mixed layer, resulting ocean-atmosphere interactions and rainfall variability over West Africa.**

1) Chidichimo, M. P., T. Kanzow, S. A. Cunningham, W. E. Johns, and J. Marotzke, 2010: The contribution of eastern-boundary density variations to the Atlantic meridional overturning circulation at 26.5° N. Ocean Sci., 6, 475–490, doi: 10.5194/os-6-475-2010.
2) Dengler, M., F. A. Schott, C. Eden, P. Brandt, J. Fischer, and R. J. Zantopp (2004), Break-up of the Atlantic deep western boundary current into eddies at 8 degrees S, Nature, 432(7020), 1018–1020.
3) Durgadoo, J. V., B. R. Loveday, C. J. C. Reason, P. Penven, and A. Biastoch (2013), Agulhas leakage predominantly responds to the Southern Hemisphere westerlies, J. Phys. Oceanogr., 43(10), 2113–2131.
4) Fu, Y., J. Karstensen, and P. Brandt, 2017: Meridional Ekman transport in the tropical Atlantic. I Ocean Sci. Discuss., doi: 10.5194/os-2016-98. In review.
5) Hummels, R., P. Brandt, M. Dengler, J. Fischer, M. Araujo, D. Veleda, and J. V. Durgadoo, 2015: Interannual to decadal changes in the western boundary circulation in the Atlantic at 11° S, Geophys. Res. Lett., 42, doi:10.1002/2015GL065254.
6) Kanzow and Coauthors, 2010: Seasonal variability of the Atlantic meridional overturning circulation at 26.5° N. J. Climate, 23, 5678–5698, doi: 10.1175/2010JCLI3389.1.
7) Zhang, D., R. Msadek, M. J. McPhaden, and T. Delworth (2011), Multidecadal variability of the North Brazil Current and its connection to the Atlantic meridional overturning circulation, J. Geophys. Res., 116, C04012, doi:10.1029/2010JC006812.

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