What causes the Atlantic Niño mode to vary on decadal timescales?

Ioana Ivanciu[1]*, Joke F. Lübbecke[1,2] , Peter Brandt[1,2]

[1]GEOMAR Helmholtz Center for Ocean Research Kiel, Germany
[2]Christian-Albrechts-Universität zu Kiel, Germany
* iivanciu@geomar.de

1) Timescales of tropical Atlantic variability

- Atlantic Niño mode variability on both interannual and decadal (12 years) timescales
- Highest Atlantic Meridional Mode (AMM) variability at 12 years
- Highest South Atlantic Anticyclone (SAA) variability on decadal timescales

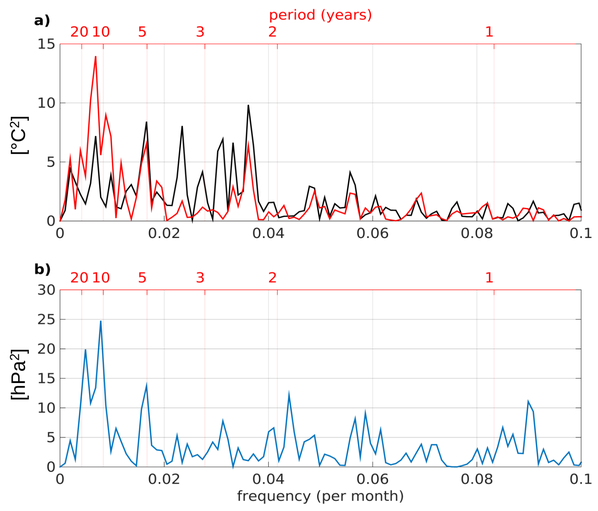

Fig. 1: *Power spectrum of **a)** the Atl3 index (black), the AMM index (red) and **b)** the SAA index.*

2) SST variability induced by the South Atlantic Anticyclone

Interannual

- The SAA weakens (strengthens) 1-2 months before an Atlantic Niño (Niña)
- Atl3 SST anomalies are the response to wind changes in the west
- Equatorial Rossby and Kelvin waves travel across the basin and generate the SST anomalies through the thermocline feedback[1]

Decadal

- The SAA weakens (strengthens) one year before positive (negative) Atl3 SST anomalies
- Anomalous SAA winds extend into the Northern Hemisphere with a lag of one year
- AMM SST pattern develops
- The Atl3 SST anomalies are part of the broad AMM SST pattern
- The AMM projects its decadal variability onto the Atlantic Niño mode

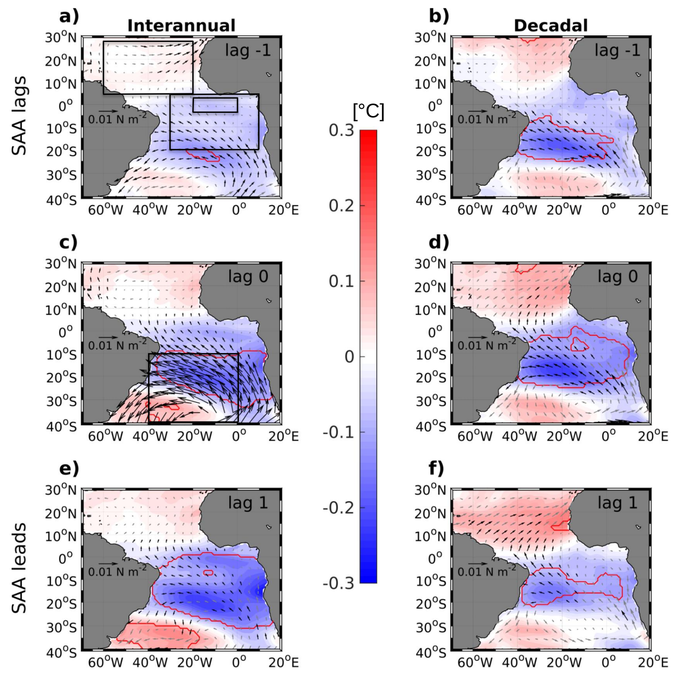

Fig. 2: *Lagged regression of COBE SST anomalies (color shading) and 20CR wind stress anomalies (arrows) onto the SAA index on interannual (**a)**, **c)**, **e)**, lags in months) and decadal (**b)**, **d)**, **f)**, lags in years) timescales for the time period 1960-2007. The black boxes mark the regions used for the Atl3, AMM and SAA indices.*

3) Interaction with the southern subtropical cell

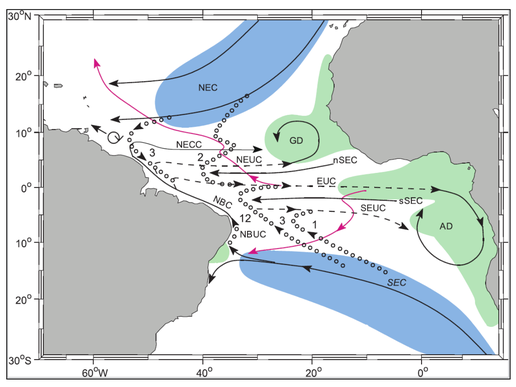

Fig. 3: *Schematic of the Atlantic STC showing the subduction areas (blue), the upwelling regions (green) and the main currents. From Schott et al., 2004[2].*

- Anomalous SAA winds trigger changes in the Ekman transport at 10°S
- The equatorial upwelling is altered and the EUC transport responds with a lag of one year[3]
- Significant relationship on timescales above 2 years:
  - Ekman transport at 10°S & EUC transport at 23°W one year later
  - EUC transport & Atl3 SST in the previous year
  - SAA index & EUC transport one year later
- The southern subtropical cell (STC) provides a second mechanism for decadal Atl3 SST anomalies

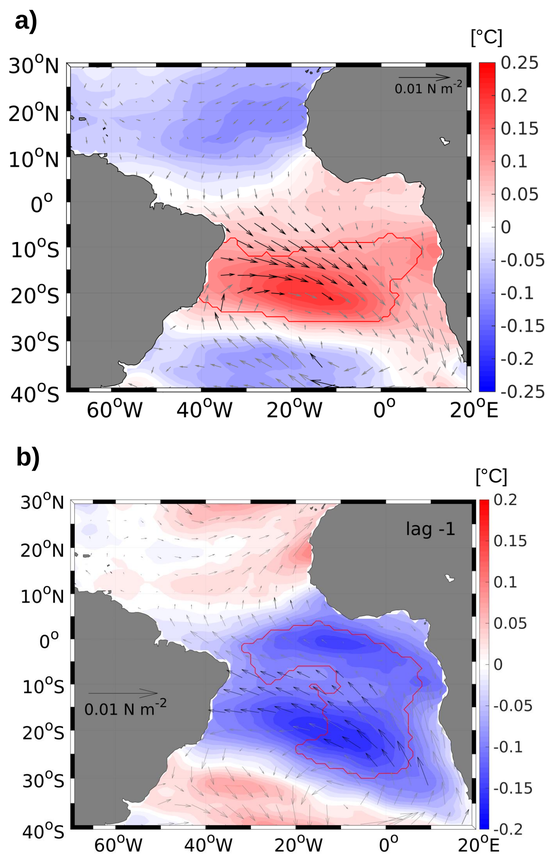

Fig. 4: *Decadal regression of COBE SST anomalies (color shading) and 20CR wind stress anomalies (arrows) onto **a)** the 20CR Ekman transport at 10°S in the same year and **b)** the SODA 2.2.0 EUC transport at 23°W in the following year for the time period 1960-2007.*

4) Modulation by the Atlantic Multidecadal Oscillation

- The relationship between the strength of the SAA and the Atl3 SST anomalies is modulated by the AMO phase

Negative AMO

- Atlantic Niño develops in response to changes in the SAA strength
- Summer Atl3 SST anomalies significantly correlated with the SAA index in the previous spring

Positive AMO

- No clear change in the SAA can be seen, in contrast to recent findings[4]
- Summer Atl3 SST anomalies and spring SAA index not correlated
- Wind anomalies in the western equatorial Atlantic driven from the north

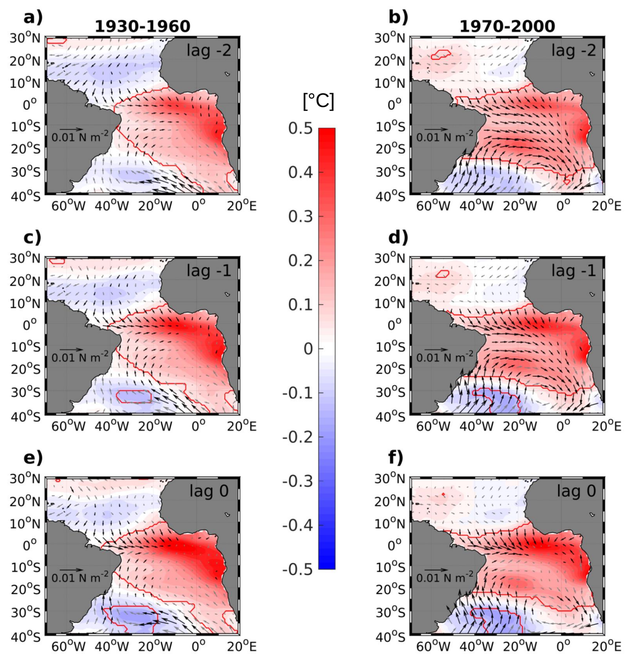

Fig. 5: *Lagged regression of COBE SST anomalies (color shading) and 20CR wind stress anomalies (arrows) onto the Atl3 index for positive (**a)**, **c)**, **e)**) and negative(**b)**, **d)**, **f)**) AMO. Lags are in months.*

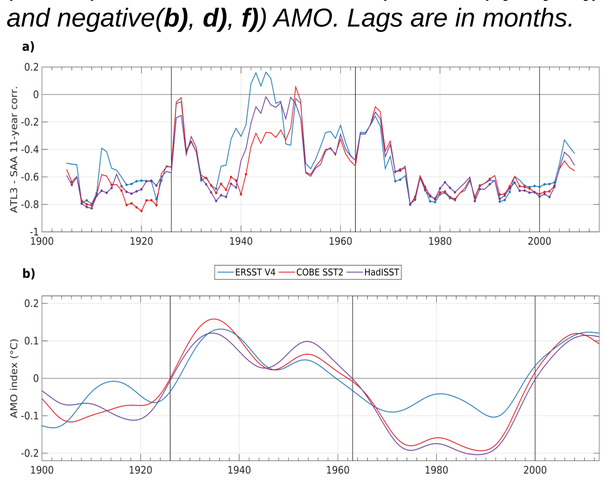

Fig. 6: ***a)*** *11-year running correlation between the JJA Atl3 SST anomalies and the MAM SAA index for NOAA ERSST (blue), COBE SST (red) and HadISST (magenta) **b)** The AMO index for the time period 1900-2012.*

5) Summary

- The Atlantic Niño mode varies on decadal time scales, with a period of 12 years, in addition to its well known interannual oscillations
- Changes in the strength of the SAA trigger both interannual and decadal SST anomalies in the Atl3 region
- On decadal timescales SAA fluctuations lead to AMM events which alter the Atl3 SSTs and the decadal AMM variability is projected on the Atlantic Niño mode
- The SAA fluctuations also impact the Alt3 SSTs by modifying the strength of the southern STC on decadal timescales
- The AMO modulates the ability of the SAA to induces Atl3 SST anomalies. The relationship between the SAA and the Atlantic Niño is strong only during negative AMO

References

[1]Foltz, G. R., and McPhaden M. J. (2010). Interactions between the Atlantic meridional and Niño modes. *Geophys Res Lett*, 37:L18604.
[2]Schott, F., McCreary, J., and Johnson, G. (2004). Shallow overturning circulations of the tropical-subtropical oceans. Earth`s Climate: The ocean atmosphere interaction, *Geophysical Monograph Series* 147, AGU, Washington D.C.
[3]Rabe, B., Schott F. A., Köhl, A. (2008). Mean circulation and variability of the Tropical Atlantic during 1952-2001 in the GECCO Assimilation Fields. *J Phys Oceanogr*, 38:177-192.
[4]Martín-Rey, M., Polo, I., Rodríguez-Fonseca, B., Losada, T., and Lazar, A. (2018). Is there evidence of changes in Tropical Atlantic variability modes under AMO phases in the observational record? *J Clim*, 31(2):515-536.

HELMHOLTZ SPITZENFORSCHUNG FÜR GROSSE HERAUSFORDERUNGEN