Role of Equatorial Basin-Mode Resonance for the Seasonal Variability of the Angola Current at 11°S

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Moored velocity observations of the Angola Current

- No steady southward flow of the Angola Current
- Pronounced intraseasonal to seasonal variability, potentially induced by coastally trapped waves

Kopte et al. (2017)
Variability of the Angola Current at 11°S

- Dominance of annual and semiannual oscillations, intraseasonal at 120-day and 90-day Semiannual cycle
- Annual cycle
- Longer periods show increasingly baroclinic structures

What drives Angola Current variability at **annual** and **semiannual** frequencies?

Remote equatorial vs. Local forcing!

OFFSHORE ADCP: Reconstructed annual (top) and semiannual (bottom) cycle:
Concept of resonant equatorial basin modes

- **Equatorial Basin Modes**: Standing modes in a zonally bounded basin involving equatorial wave propagation and reflection

- Theoretical resonance period $T_n$:

  $$ T_n = \frac{4 \cdot L}{m \cdot c_n} $$

  - $L$ ... Basin width
  - $n$ ... Baroclinic mode
  - $c_n$ ... Gravity wave speed
  - $m=1$ ... Gravest basin mode
  - $m=2$ ... Second basin mode

- Linear dynamics: Can be studied in a linear Shallow-Water Model

- Gravest basin modes of the 4th and 2nd baroclinic modes explain substantial parts of equatorial circulation seasonality

**Basin mode impact on eastern boundary circulation?**

*Courtesy of M. Claus*

_Cane and Moore (1981), Greatbatch et al. (2012), Claus et al. (2016), Brandt et al. (2016)_
Approach: Multi-mode Shallow-Water Model

- First 5 baroclinic modes
- Oscillating forcing separately at annual and semiannual frequencies

- Zonally uniform zonal forcing restricted to the equatorial band
- Only remote equatorial forcing!
- Annual and semiannual components of JRA-55 reanalysis wind stress
- Local forcing off Angola is included!

Wind forcing projection coefficients – **Not assumed a priori!**
Model-computed amplitudes need to be fitted to suitable observations

- Zonal velocity time series at 23°W-Equator allows modal decomposition
- Used for scaling of model-computed modal amplitudes
Horizontal structure of (semi-)annual oscillations

- **Gravest basin modes:**
  - Mode 4 / Annual cycle
  - Mode 2 / Semiannual cycle

- **Neighboring baroclinic modes:**
  - Similar structures
  - Less amplitude

Meridional amplitudes of dominant baroclinic modes indicate importance of equatorial forcing at 11°S-Angola!

Kopte et al. (2018)
Semiannual cycle of the Angola Current

- Large discrepancies in EF-only in terms of amplitude and phasing
- Slight improvement of the phasing when forcing (EF+LF) is included
- Yet: Lack of amplitude at mid-depth

Further investigations suggest missing amplitude of 4\textsuperscript{th} baroclinic mode / semiannual cycle

Potential causes for underestimation of the 4\textsuperscript{th} mode / semiannual cycle?
Why does the model underestimate the 4th mode / semiannual cycle?

- **4th baroclinic mode / semiannual cycle:**
  
  **Second Basin Mode**
  
  - Two amplitude maxima along the equator
  - 23°W-Equator is located close to the nodal point!
  - Alternative scaling location: 35°W-Equator
    - Only few data → Larger uncertainties
    - Similar scaling factor as 23°W-Equator

Discrepancies in model-computed semiannual cycle cannot be resolved using a different scaling location!

**Other potential reasons?**

- Bad representation of wind stress curl off Angola? *(Problem of the forcing)*
- Wave scattering, Interactions with topography? *(Not included in the model)*
- Non-linear processes? *(Not included in the model)*
Annual cycle of the Angola Current

- Annual cycle is already well-reproduced by EF-only
- Only minor modifications including local forcing (EF+LF)
- Dominated by the gravest basin mode of the 4th baroclinic mode, 3rd and 5th baroclinic mode important for the phasing

Annual cycle appears to be essentially controlled by the remote equatorial forcing
Summary and conclusions

- Strong intraseasonal to seasonal variability of the boundary circulation off Angola

- Shallow-Water Model simulations with different forcing to investigate the role of remote equatorial and local forcing for the seasonality of the Angola Current

- Large parts of the Angola Current’s annual cycle and – with some reservations – semiannual cycle appear to be essentially controlled by linear wave dynamics!

Paper recently published: