The coupling between the ocean and the atmosphere in the equatorial Atlantic seasonal cycle

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Motivation

Annual cycle eastern Tropical Atlantic
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Annual cycle eastern Tropical Atlantic

Atlantic Cold Tongue (ACT)
Motivation

Annual cycle eastern Tropical Atlantic

Atlantic Cold Tongue (ACT)

West African Monsoon (WAM)
How important is the coupling between the upper ocean and the atmosphere in the equatorial Atlantic seasonal cycle?
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1- To what extent does the seasonal cycle in equatorial Atlantic SST influence that of the atmosphere?
How important is the coupling between the upper ocean and the atmosphere in the equatorial Atlantic seasonal cycle?

1- To what extent does the seasonal cycle in equatorial Atlantic SST influence that of the atmosphere?

2- How much of the seasonal cycle of equatorial Atlantic SST can be explained by wind variations not driven by local SST?
AGCM sensitivity experiments

- Version 4.0 of the Community Atmospheric Model (CAM4) low-top, 1.25°x0.9° and 26 vertical layers.
- Historical run: from Jan 1982 to Dec 2013.
- 2 AGCM experiments with prescribed SST as boundary conditions.
Methods

AGCM simulations

AGCM sensitivity experiments

- 2 AGCM experiments with prescribed SST as boundary conditions.

  **climSST** - seasonally varying SST. No interannual variability

  **eqmeanSST** - time independent SST at the equator (10S-5N) and seasonally varying elsewhere
OGCM sensitivity experiments

- NorESM ocean component based on MICOM model.
- Historical runs: from Jan 1948 to Dec 2009.
- 4 OGCM experiments forced with reanalysis and CAM4 simulations output data.
OGCM sensitivity experiments

- 4 OGCM experiments forced with reanalysis and CAM4 simulations output data.

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Forcing data</th>
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<td>CTL</td>
<td>COREv2 interanually varying forcing data</td>
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<td>CORE_clim</td>
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<td>CAM4_climSST</td>
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OGCM sensitivity experiments

- 2 OGCM experiments forced with CAM4 simulations output data.

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OGCM sensitivity experiments

Simulation

CAM4_climSST

CAM4_eqmeanSST

Forcing data

CAM4_climSST simulation output

CAM4_eqmeanSST simulation output
Results CAM4

Seasonal cycle of the winds

Regions: WEA (40-20W, 4S-4N) Western Atlantic
       EEA (16W-4E, 4S-4N) Eastern Atlantic
Results CAM4

Seasonal cycle of the winds

- **U WEA**
  - Module (m/s)
  - climSST
  - eqmeanSST
  - JRA

- **U EEA**
  - Module (m/s)

- **V WEA**
  - Module (m/s)

- **V EEA**
  - Module (m/s)

Regions: WEA (40-20W, 4S-4N) Western Atlantic
EEA (16W-4E, 4S-4N) Eastern Atlantic
Results CAM4

Variance not explained by eqSST

Squared correlation of climSST - eqmeanSST
Results CAM4

Variance not explained by eqSST

Squared correlation of climSST - eqmeanSST
Take home points

- The model simulates a seasonal cycle in the atmosphere when forced with non-varying equatorial SSTs.
Take home points

- The model simulates a seasonal cycle in the atmosphere when forced with non-varying equatorial SSTs.

- The coupling between ocean and atmosphere is stronger in the western equatorial Atlantic.
Results MICOM

Seasonal cycle of SST

Atlantic SST (EQ) CAM4climSST run

Atlantic SST (EQ) CAM4eqmeanSST run

Time (months)

Longitude

SST (°C)
Results MICOM

Seasonal cycle of SST

Model

Atlantic SST (EQ) CAM4climSST run

Time (months) vs Longitude

Observations

Atlantic SST (EQ) HadISST

Time (months) vs Longitude
Results MICOM

Seasonal cycle of SSH
Results MICOM

Seasonal cycle of SSH and TAUX
Conclusions and future work
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- CAM4 simulates a seasonal cycle in the atmosphere when forced with non-varying equatorial SSTs.
Conclusions and future work

- CAM4 simulates a seasonal cycle in the atmosphere when forced with non-varying equatorial SSTs.

- MICOM reproduces a significant amount of the seasonal cycle variability at the equator when forced by winds not produced by local SST.
Conclusions and future work

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La Santa waves
Thanks for your attention
Muchas gracias

La Santa waves
Extra slides
Results CAM4

Seasonal cycle precipitation

(c) PRECT climSST WEA

(d) PRECT climSST EEA

(g) PRECT eqmeanSST WEA

(h) PRECT eqmeanSST EEA
Results CAM4

Coupled ocean-atmosphere modes

**Equatorial SST mode** = MCA of the climSST-eqmeanSST difference

**FOLLOW NAD´S SUGGESTIONS!!!**
Takatama et al. (2012) approach for near-surface wind-divergence budget

\[
-U_x - V_y = \left[ + \frac{\varepsilon}{\varepsilon^2 + f^2} \nabla^2 P + M_1 P_x + M_2 P_y \right] \\
+ \left[ -\frac{\varepsilon}{\varepsilon^2 + f^2} \frac{\nabla \cdot \vec{\tau}(Z)}{Z} - \frac{f}{\varepsilon^2 + f^2} \frac{\nabla \times \vec{\tau}(Z)}{Z} \\
-M_1 \frac{\tau^x(Z)}{Z} - M_2 \frac{\tau^y(Z)}{Z} \right] \\
+ \left[ -\frac{\varepsilon}{\varepsilon^2 + f^2} \nabla \cdot \vec{A} - \frac{f}{\varepsilon^2 + f^2} \nabla \times \vec{A} \\
-M_1 A^x - M_2 A^y \right],
\]

Pressure adjustment mechanism

Downward momentum mixing

Advection
Results CAM4

Wind convergence – SST connection

- (SST Laplacian)

SLP Laplacian

Wind convergence

The Lindzen and Nigam mechanism
Results MICOM CORE Seasonal cycle of SST and SSH
Results MICOM CORE

Seasonal cycle of SSH and TAUX

- Atlantic TAU (EQ) CTL run
- Atlantic TAU (EQ) CORE_clim run

- Atlantic TAU (EQ) CTL run
- Atlantic TAU (EQ) CORE_clim run

(Time (months) vs. Longitude)
Observations

Seasonal cycle of SSH and TAUX