

Reply to reviewer #3

Review for manuscript esd-2017-58 "Equatorial Atlantic interannual variability and its relation to dynamic and thermodynamic processes" by Jouanno et al.

The authors analyze different regional model runs to determine the relative contribution of the dynamic and thermodynamic forcing to interannual variability of the equatorial Atlantic sea surface temperature.

The manuscript is well written and addresses relevant scientific questions within the scope of Earth System Dynamics. The substantial and novel scientific results about the role of the thermodynamic forcing of interannual climate variability in the tropical Atlantic are timely and present a valuable contribution to the community interested in tropical climate dynamics.

I think that the manuscript should be publishable after the authors have addressed my concerns mentioned below. My major remarks are (1) the results of a recently published study by Planton et al. 2017 (Main processes of the Atlantic Cold Tongue Interannual Variability, Climate Dynamics, published online.) are very similar to the results of the REF run discussed in section 3. Many aspects, such as a mixed-layer heat balance analysis for Atlantic Nino and Nina events, ocean-atmosphere fluxes during these events, are discussed in detailed in that paper but remain unreferenced here. (2) section 2.3 explaining in detail how the biased runs were constructed is hard to follow. I would appreciate a more detailed explanation of how the forcing for these runs was constructed. (3) I would appreciate if the authors could also include a discussion about predictability in their discussion and conclusion section. What do the new findings mean for the predictability of interannual climate variability in the tropical Atlantic by state of the art climate models?

Following your suggestions we complete the manuscript :

- 1) The paper by Planton et al. [2017] was not available when we submitted this manuscript, but we add reference to their study and discussion when required (in Introduction, Result, and Discussion-Conclusion Sections).
- 2) We provide more details on how the biased simulations were built.
- 3) We add a discussion on predictability (see details below)

I am offering some details to the remarks above and some minor remarks below.

Page 3, Line 13: Insert "out" after carried.

Inserted. Thanks.

Page 3, sentence in lines 19-21 sounds strange: I would suggest changing it to: "This strategy allows to specifically remove the dynamical contribution of the interannual winds. However, thermodynamic contributions of wind variability (i.e. latent and sensible heat) are allowed to vary interannually."

Indeed it sounds better. Thanks.

Page 3, 3rd paragraph of section 2.3: I find it difficult to follow this paragraph and I would appreciate if additional information on how the forcing for BIASED and BIASED-tauclim runs were constructed. E.g., were the atmospheric variables taken directly from the coupled model (CNRM-CM5) and interpolated onto your grid? Was anything else done with the forcing? How does the CNRM-CM5 model compare to other CMIP 5 models, particularly in respect to the SST bias ?.

We now provide additional information on the methodology used to build the BIASED forcing.

CNRM-CM5 model exhibit a marked equatorial Atlantic warm SST bias typical of the CMIP5 ensemble mean warm bias [Richter et al. 2008, Voldoire et al. 2014]. This was already mentioned.

Page 3, Line 36, mixed layer balance equation: the meridional advection term (2nd term on the right hand side) is wrong.

It should say: $-\hat{n}_l \cdot \mathbf{v} \cdot \partial_y T \hat{n}_l$.

Thanks, this has been corrected.

Page 5, line 10, "...but at levels that remain in an acceptable range": What is an acceptable range? I find this statement very subjective and suggest removing it.

This has been removed.

Page 5, line 10, "s.t.d.": The abbreviation is not introduced. Also, I find the sentence in which the abbreviation is mentioned hard to understand. Please explain "interannual monthly s.t.d."?

The sentence has been replaced by "interannual standard deviation"

Page 5, whole sentence starting in line 24: The fact that net atmospheric heat flux anomalies are of elevated during cold ACT events and reduced during warm ACT events have been noted earlier. E.g. Planton et al, Main processes of the Atlantic Cold Tongue Interannual Variability, Climate Dynamics, published online, 2017, discuss this in some detail.
We add reference to Planton et al. [2017] when discussing this point.

Page 5, Paragraph from line 27 to 38: The results presented here are convincing. However, they are very similar to the results presented by Planton et al., 2017, who also analyze the mixed layer heat balance during Atlantic Nino and Nina events. In addition, they discuss interannual wind anomalies (i.e. τ_{aux}) in March to May being relevant for Atlantic Nino, Nina events that seem to agree with the results shown in your figure 3.
Indeed, they are similar and we add reference to Planton et al. [2017]

Page 6, line 18, “than in REF.” sounds wrong. I think it should say “as in REF”. Page 7, line 8: add an “s” to suggest.
Corrected.

Page 7, line 9: no comma before “that”; “mode” must be capitalized.
Corrected.

Page 6-7, discussion and conclusion section: After reading the conclusions I was wondering about predictability. If in coupled climate models the dynamic response is too weak, then short term (1-3 month) predictability originating from equatorial wave propagation would be underestimated, right? Could the authors include some statements about predictability in their conclusions? After all, this is a major focus of the PREFACE project.

We agree and complete the discussion-conclusion section as follows :

“From a climate modelling perspective, and although a set of fully coupled simulations would be required to confirm our findings, our results are suggestive that a reduction of the mean and seasonal model biases in the Tropical Atlantic (in particular from the atmospheric component) would strongly benefit to the representation of the interannual variability. The variability of the Atlantic Cold Tongue exerts a significant influence on the climate of the surrounding regions and more specifically on the West African monsoon [Okumura and Xie 2004, Caniaux et al. 2011] or on rainfall variability in the northeast of Brazil [Kushnir et al., 2006]. In terms of predictability at seasonal time scale of these phenomena, our results suggest that the ability of the climate models to maintain a realistic stratification and east-west tilt of the thermocline is key in correctly representing the response of the summer coupled system to spring wind anomalies.”