Answers to the Reviewer 5

We would like to thank the reviewer for his helpful and thoughtful comments and suggestions. Please, find below our response to your comments, on a point by point basis. Your comments are recalled in red and our responses are written in purple.

RC5: 'Comment on esd-2021-46', Anonymous Referee #5, 01 Oct 2021

Revision of "Weakened impact of the Atlantic Niño on the future equatorial Atlantic and Guinean Coast rainfall" by K. Worou, H. Goosse, T. Fichefet and F. Kucharski

General comments:

The article is a detailed analysis of the rainfall over the Guinean coast and the relation with Atlantic Niño using a pool of CMIP6 simulations in the historical period compared with observed data. The analysis is relevant, and the article convincingly shows that the rainfall will decrease over the Guinean coast as the Atlantic Niño variability will also decrease in the future.

The paper addresses relevant scientific questions and the conclusions are important for the climate science community.

I have, however, some suggestions for improving the paper from my point of view. I recommend shortening the article; I found a very large document with unnecessary figures. It is, however, good to see a lot of more information in the additional material. I have some ideas of how to reduce it below together with some typos and minor comments

specific comments and technical corrections:

- Typo in line 10 (and more). Please be aware that Bjerknes feedback is referred to Jacob Bjerknes, use Bjerknes feedback instead of Bjerkness feedback.

  Thank you for this correction, we will apply it everywhere in the revised manuscript.

- Line 31 (and also the abstract), You referred to the Atlantic Niño as ATL3, but the community usually defines ATL3 as an index (SST averaged over 20W-0, 3S-3N, Zebiak 1993). Please define the index first and then explain why you identify the Atlantic Niño with ATL3 (you could also use a different acronym).

  We will no longer use ATL3 for the Atlantic Niño mode. We will instead use the Atlantic Equatorial mode acronym (AEM) instead.

- Line 42, a reference should be added.

  This section will be rewritten in the revised manuscript, following the comments of the reviewer 1. We will add correctly references to support our statements.

- Table 2. It would be good to see the boxes within the map (for instance in figure 2)

  These boxes will be added to the figure 2 in the revised manuscript.

- Figure 3b and d, why ERA5 is used as a reference for the std when it is clearly biased in relation with the other observed SST datasets?, please explain in the text or in the figure caption.

We wanted to be consistent with one reference through our analyses, that is why we chose ERA5 as the reference in the Figure 3b and d. In the revised version of the paper, following the suggestion of the reviewer 1, we will keep only ERA5 to evaluate models performance. Additionally, we will remove the question of seasonality, so the Figure 3 will be added to the supplementary material.

- Line 132. Why do you remove the quadratic trend instead of the linear trend? It is quite clear the linear trend in the Atl3 SST in the historical period. Please show the trend of the rainfall and SST for the indexes to understand your choice.

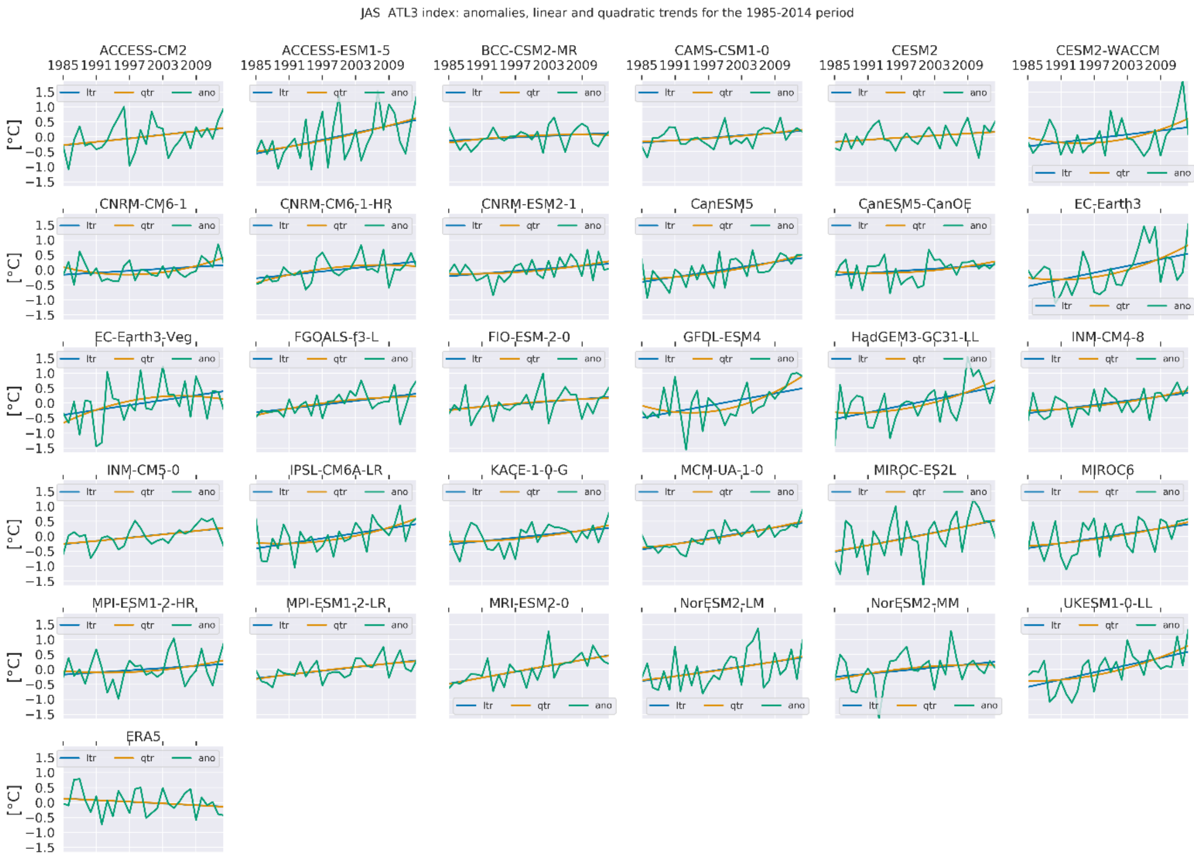

Figure R 1 SST indices of the Atlantic Niño: JAS mean of monthly SST anomalies averaged over the Atlantic Niño area (green curves), for the 1985-2014 period. The linear (blue curves) and quadratic (orange curves) trends are superimposed on each SST index. SST outputs from CMIP6 historical simulations (30 GCMs) and the ERA5 reanalysis are considered.

The linear in the JAS ATL3 SST is clear in ERA5, whereas in the CMIP6 historical period, it is roughly linear (Fig. R9). The apposition of both linear and quadratic trends in each SST index of the different models show cases where the quadratic trend departs from the linear trend (e.g. GFDL-ESM4). This motivated us to remove the quadratic trend from our data. However, in the revised manuscript, we will remove the linear trend instead of the quadratic trend, as the residuals from the detrended SST indices are similar in both cases (Fig. R10).

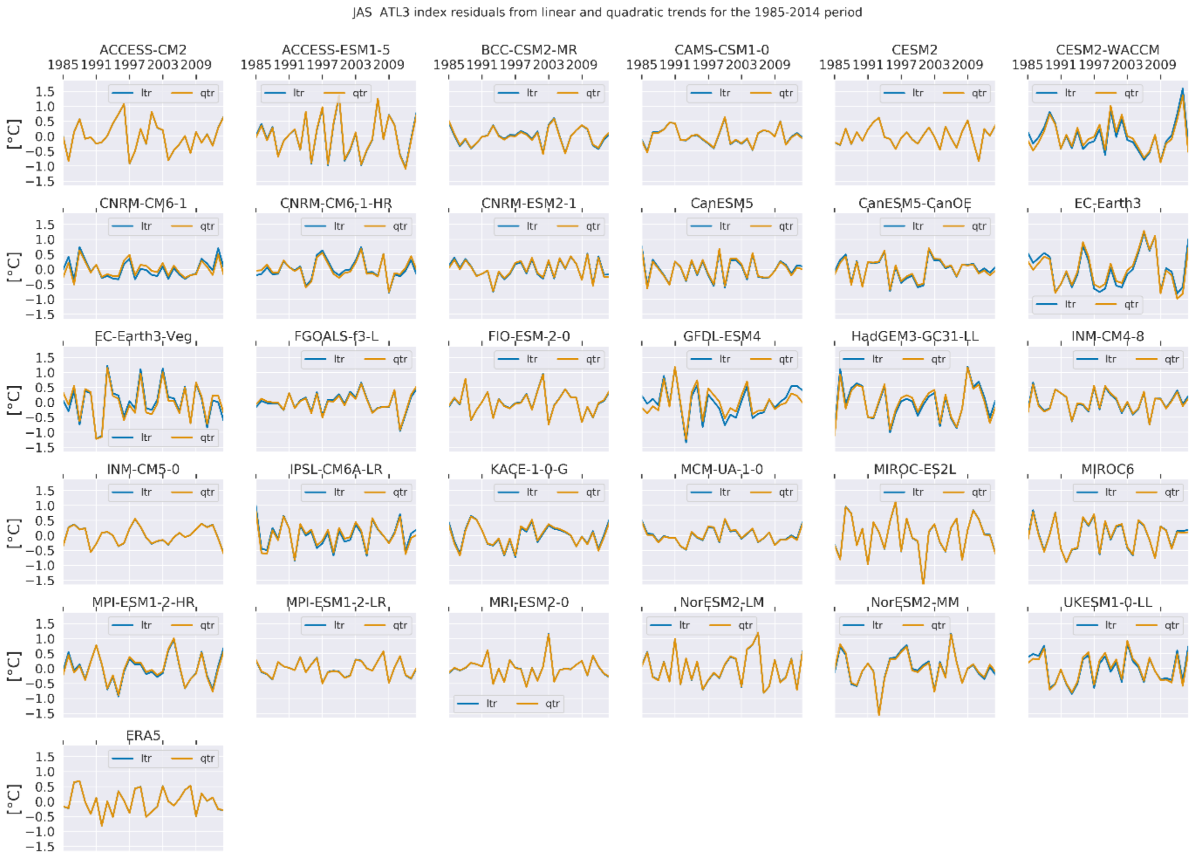

Figure R 2 Residuals of the JAS ATL3 SST index after removing the linear trend (blue curves) and the quadratic trend (orange curves). The indices are computed from 30 CMIP6 data and ERA5 for the 1985-2014 period.

The analysis of the rainfall time series of the Guinea Coast also shows that in most of the cases, the rainfall trends can be considered as linear (Figure R11). In the case of CESM2-WACCM for example, the two trends are slightly different. However, the residuals from the detrended time series do not exhibit a strong difference in the interannual variability (Figure R12). Therefore, we will consider the trend as linear in the revised manuscript.

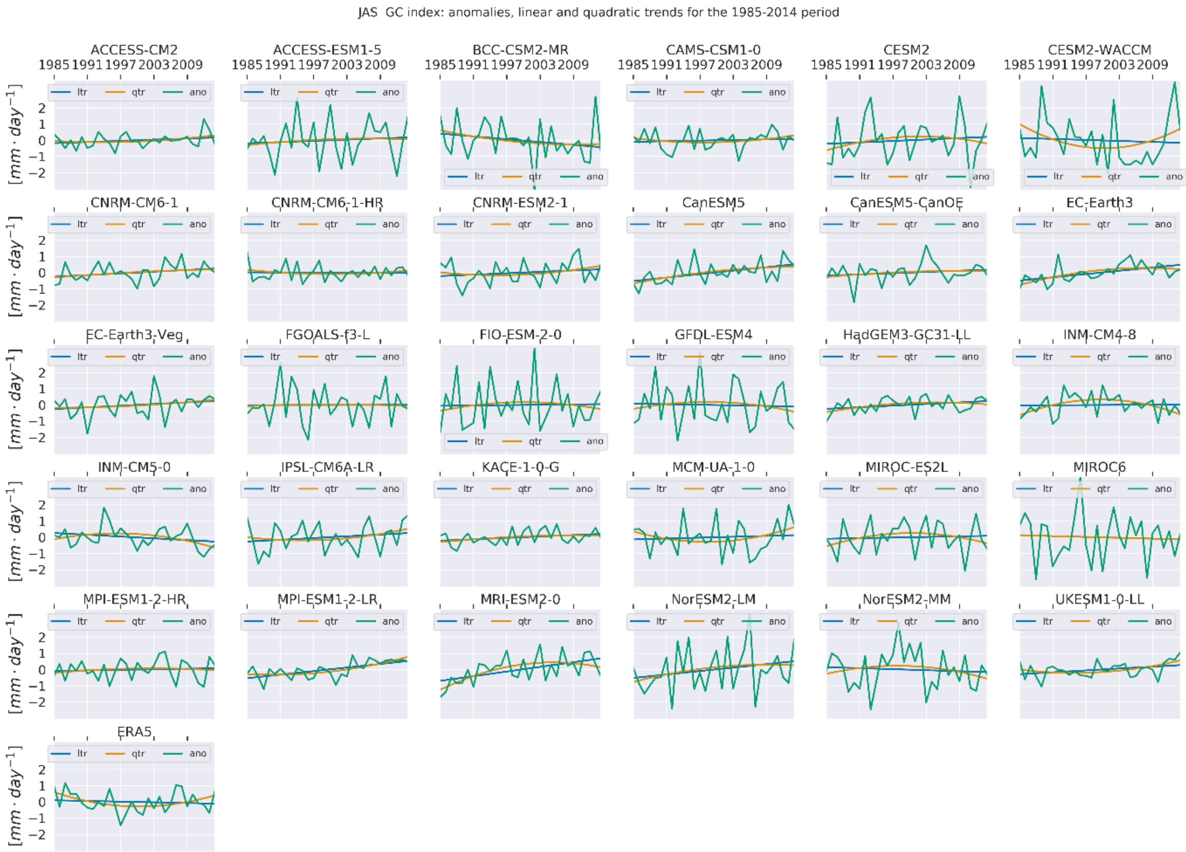

Figure R 3 JAS rainfall index of the Guinea-Coast over the 1985-2014 period. Linear and quadratic trends (blue and orange curves respectively) are superimposed on each rainfall index. Indices are computed from 30 CMIP6 models and ERA5

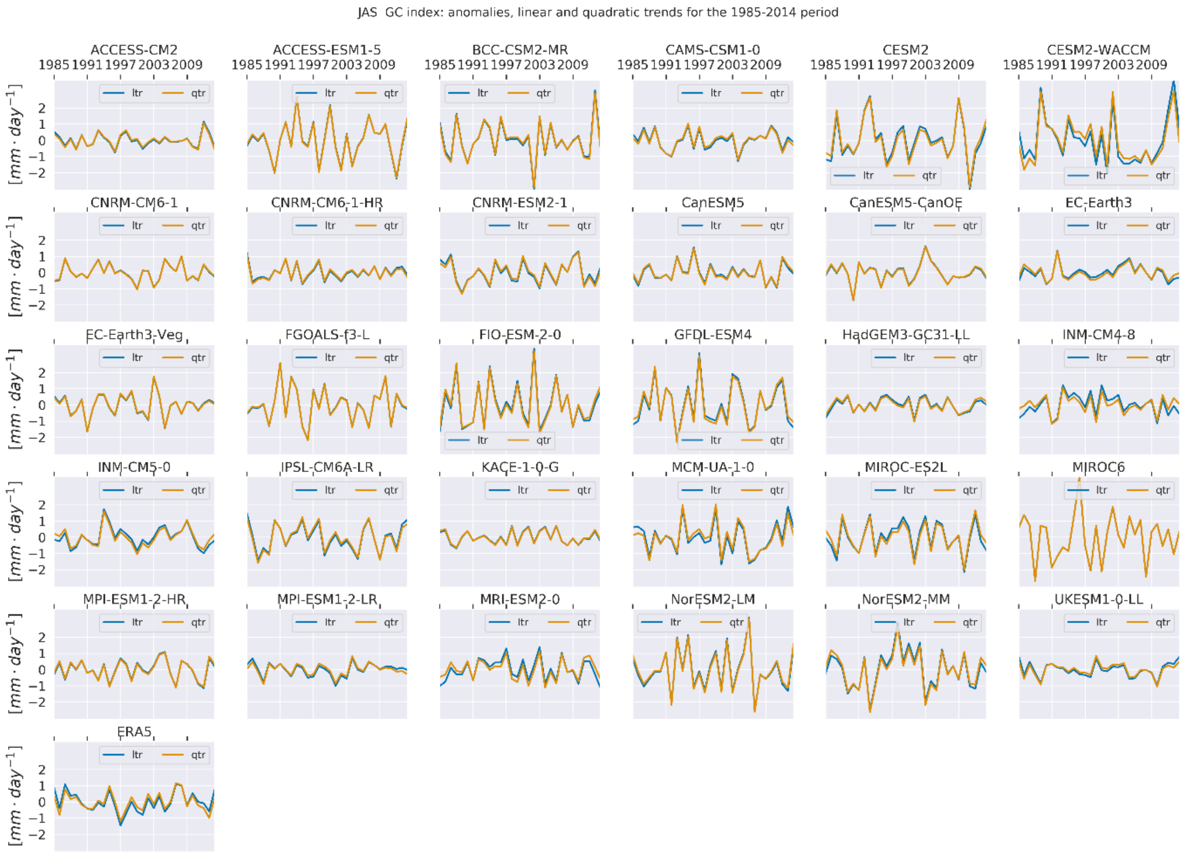

Figure R 4 Residuals of the linearly (blue curves) and quadratically (orange curves) detrended JAS Guinean Coast rainfall indices. Indices are computed from 30 CMIP6 models and the reanalysis ERA5 for the 1985-2014 period.

- Figure 4a and line 255. From figure 3b and the observations, it is clear the main season for Atl3 would be JJA, why do you decide to compare the observed and simulated Atlantic Niño in JAS? It would be useful to show correlation between SST and rainfall indexes for different seasons to realize which of the seasons is more realistic (maybe in the observation the maximum correlation is between Atl3 SST index in JJA and precipitation GG in JAS).

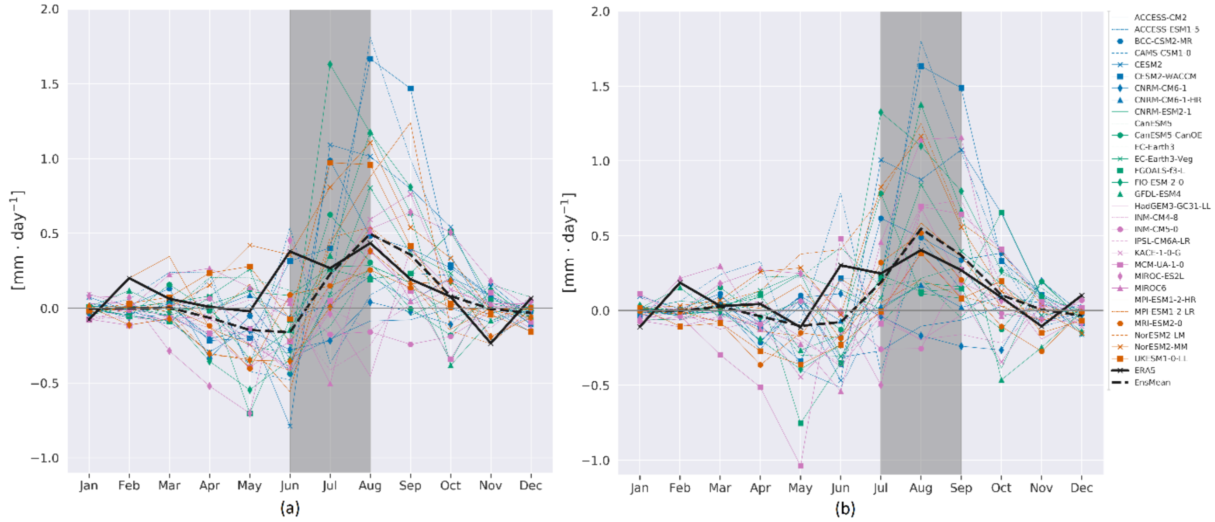

Figure R 5 Monthly stratified rainfall anomalies regressed onto the standardized JJA (a) and (JAS) ATL3 index in 30 CMIP6 models and in ERA5 over the 1985-2014 period. The vertical gray band shows the considered season of the ATL3 index.

The cross-correlation between the JJA and JAS ATL3 index and the monthly rainfall indices of the Guinea Coast indicate a strong ATL3-rainfall covariability during July, August and September in the CMIP6 models (Fig. R13). This result indicates that the amplitude of the rainfall response in the models is maximum in JAS, with a similar order of magnitude, whether the ATL3 index is computed over the JJA or the JAS season. As we are interested in the impact of the Atlantic Niño mode on the rainfall in Guinea-Coast in the CMIP6 models, we will consider the JAS season.

We also note that in the two cases (i.e. JJA and JAS ATL3 index), the CMIP6 ensemble mean rainfall response in June is weak compared to ERA5. Moreover, in ERA5, the rainfall responses to the JJA and JAS Atlantic Niño indices are quite similar and stronger during JJAS (June to September).

- As you exposed in the introduction, deconstructive interaction of Atlantic Niño and ENSO events onto the WA rainfall in some time-periods can conduct into a dipole or monopole of the rainfall anomalies (Losada et al 2012). It would be nice to see how many of those simulated and observed Atl3 indexes are correlated with Niño3 index. Thus, the rainfall pattern in figure 5 could be a mix between local and remote SST drivers.

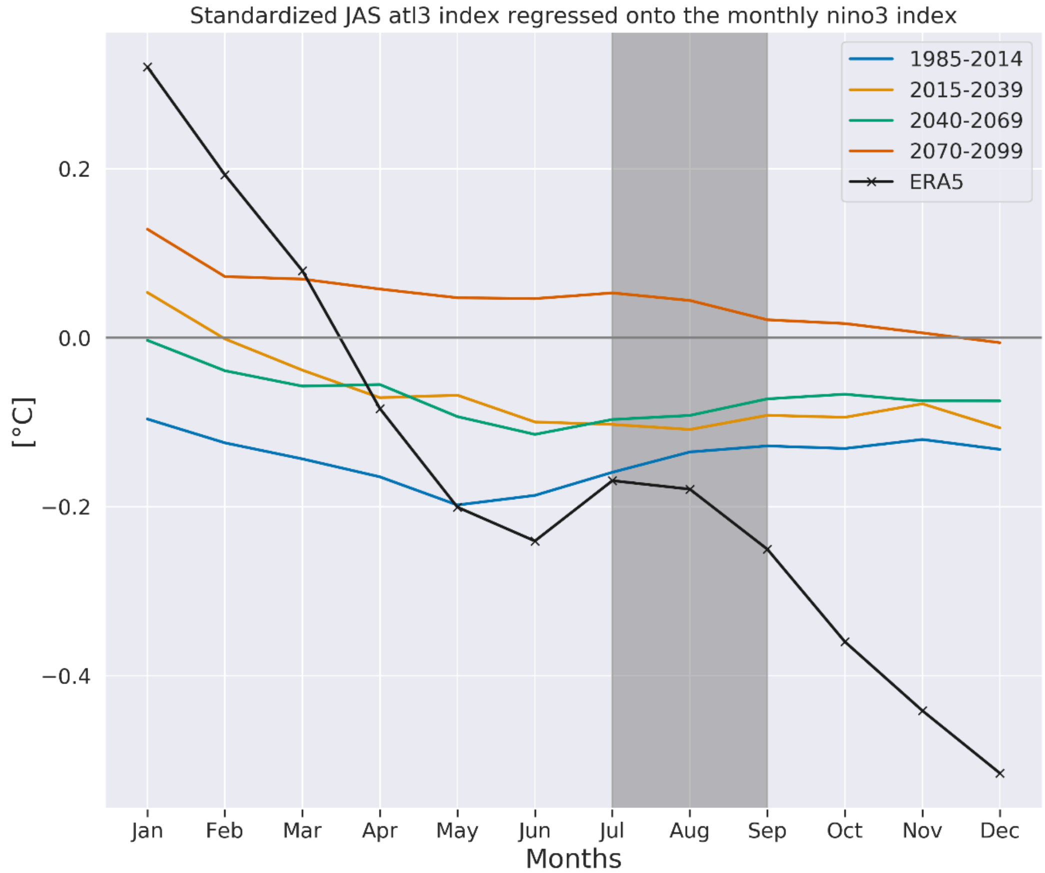

Figure R 6 Monthly stratified Niño3 index regressed onto the standardized JAS ATL3 index for different periods. The 1985-2014 period is considered for ERA5 (black curve). The other curves correspond to the ensemble mean response of 30 CMIP6 models over four different periods.

Thank you for this suggestion. We regressed the monthly Niño3 index onto the standardized JAS Atlantic Niño index for 30 CMIP6 models and ERA5 (Fig. R14). In ERA5, the JAS ATL3 index is negatively correlated with the Niño3 index from April to December. This opposite phase relationship is stronger in November and December. In the January to March, an in-phase relationship is observed. The CMIP6 models ensemble mean response shows an anticorrelation between the JAS ATL3 index and the Niño3 index for all the months during 1985-2014. Thus, the effect of SST in both basins would lead to rainfall anomalies of the same sign over Guinea Coast. In the future, a general decrease of the Niño3-ATL3 relationship is obtained in the 2015-2039 and 2040-2069 period. However, the sign of the correlation between both indices is reversed in the long-term period (2070-2099). This means that in the 2070-2099 period, two rainfall anomalies with opposite signs will interact over Guinea Coast during, and this would reduce the rainfall amplitude associated with the Atlantic Niño.

For the 1985-2014, 2015-2039, 2040-2069 and 2070-2099 periods, there are, respectively, 9, 7, 9 and 7 models which show a significant correlation between the JAS Niño3 and ATL3 indices (Fig. R15). This correlation is not significant for ERA5 during JAS. These results will be added to the revised manuscript.

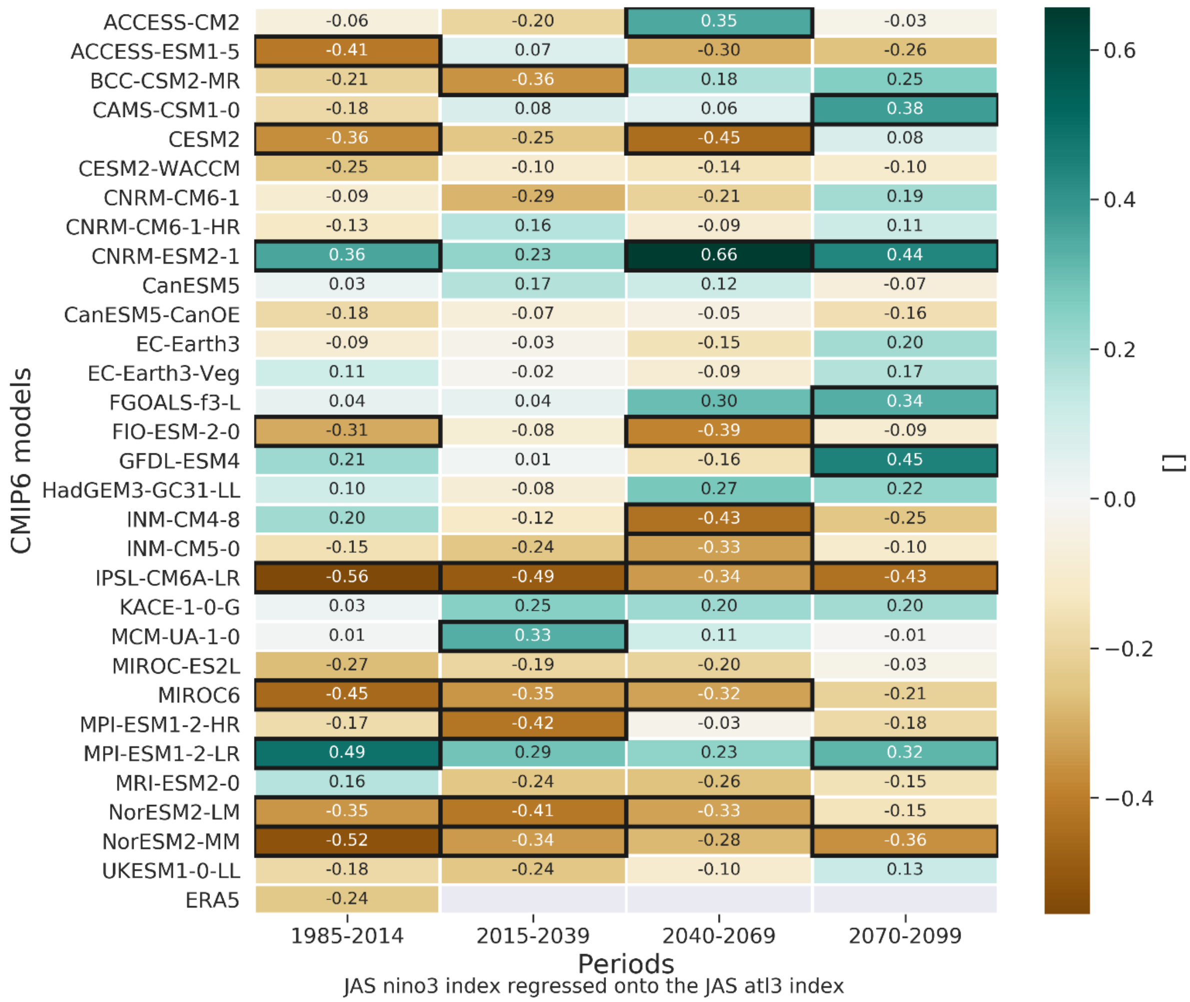

Figure R 7 JAS Niño3 index correlation with the JAS ATL3 index over four different periods. 30 CMIP6 models and the reanalysis ERA5 are analyzed. Significant regression coefficients at 90% confidence level (Student test) are highlighted with a black box.

- Line 264. Stronger correlation between Atl3-SST and SSH in models than in ORAS5 implies stronger Bjerknes feedback in the models, which I did not expected from CMIP5 models analysis (for instance Dippe et al 2018, DOI 10.1007/s00382-017-3943-z). It would be nice to see surface wind superimposed on figures 6 u-x to illustrate the 3 elements of the Bjerknes feedback.

  The 850 hPa horizontal wind will be added to the SSH maps in the Figure (6), and we will also refer to Dippe et al 2018, to compare the strength of the Bjerknes feedback in CMIP5 and CMIP6 models.

- Paragraph from line 280 please reduce or suppress, I do not see that OC+ models are explaining important differences from GC+ models. Remove (or reduce) and explain later in the text (beginning of section 5.2)

The text from the lines 280 to 305 will be suppressed, and the OC+ group will be removed from the main discussions.

- Figure 8 is a very interesting and illustrative view of the processes and the trends, however, Figure 9 is not necessary (figure 9a is certainly illustrative of where the mean change occurs but figure 9 overall is redundant). From my point of view figure 9 should be removed or put in the additional material. Conclusions on this part could be explained with figure 8 alone.

  Figure 9 will be put in the additional material, thank you for the suggestion.

- Line 380 should start a new section 5.2

  The section 5.2 will start from the line 380 as suggested.

- Line 397 typo zonal

  Thank you for this correction.

- I found all the discussion about figure 10 of OC models very unnecessary, indeed in your abstract you don't mention such differences. The main result about this in the abstract is "higher confidence in the reduction of the rainfall associated with atl4 over the Atlantic Ocean than over the Guinea coast". It is appreciated the detailed analysis of the different model flavours but It doesn't give any light into the main conclusion. I will leave the GG models alone, and the OC models in the additional material. Also, figure 11 b is not necessary for the conclusions, I would go for 11a alone. Please enlarge Figure 11a.

  We agree with the comment. We will remove the OC categories from the Figure 10 and we will put them into the supplementary material.

  The reviewer 1 suggests removing the discussion about the extension of the Sahara heat low to the tropical north Atlantic. We will then move the enlarged Fig. (11a) to the supplementary material, and the Fig. (11b) will be suppressed.

- Line 471 remove more

  Thank you for the correction. It will be taken into account.