Reviewer#1:

The manuscript is much improved, and the separation into two sub-regions brings a lot more clarity to the results. However, some further improvements are needed before it is ready for publication. Note that line numbers are taken from the tracked changes version of the manuscript.

1. Some minor English proofreading required.

Answer: Thanks to the reviewer for the remark. Some English corrections have been added to the revised manuscript.

2. L36: Why are these coordinates given here?

Answer: Thanks to the reviewer for the comment. Indeed, we wanted to indicate the area where the residual term is most important. We will reformulate this point in the revised manuscript. The new text will be as follows: "The residual term on the northern part is important and provides a caveat when estimating dynamic and thermodynamic processes."

3. L40: Is this the spatial correlation between the two terms in that sub-region?

Answer: Thanks to the reviewer for his question. There is indeed a spatial correlation between the two terms. This point will be clarified in the revised manuscript. The new text will read as follows:: "This is confirmed by the high spatial correlation (r = 0.6) between the two terms compared to the other terms."

4. L213: 'has been identified' or 'was identified' is better than 'is identified' here, as it is a result of a previous study.

Answer: Done as suggested. Thank you. The new text will read as follows: "The increase in SSTs in the eastern Atlantic (Fig. 1a) has been identified as one of the causes of the positive precipitation anomalies over western central Africa in October 2019."

5. L215-218: I'm still slightly confused about the argument the authors are making here. I think that an increase in SSTs would increase rainfall via the thermodynamic term in the moisture budget (because of moister air advected from the ocean), but it is the dynamic term that dominates. Increased SSTs would not obviously increase the dynamic term, as the land-sea temperature gradient would be reduced.

Answer: ***We*** **understand the reviewer's concern. Although the increase in SSTs contributes to an increase in precipitation through the thermodynamic term, the moisture budget (see figure5 below) shows a domination of the dynamic term. This is because changes in wind (anomalies) are more significant than changes in humidity advected over the northern part of the domain. In addition, Figure 2 below shows that there was an anomalous meridional mean sea level pressure (MSLP) gradient over the Central Sahel with low pressure over the eastern Sahara and high pressure between 10 and 15°N which contributed to accelerating the meridional transport of moisture. This has been developed in the document, for example in the analysis of the moist static energy budget: "**Given the influence of the wind anomaly components on the displacement of dry enthalpy and latent heat, further decomposition of the $-\langle V'\cdot\nabla_h c_p T\rangle$ and $-\langle V'\cdot\nabla_h l_V \bar{q}\rangle$ terms along the zonal (Figs. 11b,e) and meridional (Figs. 11c,f) directions appear necessary. Figure 11a shows that the advection of dry enthalpy induced by the horizontal wind anomaly decreased over the area-averaged, with the highest values between 6°N and 14°N. The advection of dry enthalpy by the meridional wind anomaly (Fig. 11c) is particularly responsible for the decrease in the $-\langle V'\cdot\nabla_h c_p T\rangle$ term compared with the advection of dry enthalpy induced by the zonal wind anomaly (Fig. 11b), which is weak. For the transport of latent heat (Fig. 11d), the influence of the advection of $-\langle V'\cdot\nabla_h l_V \bar{q}\rangle$ term under the effect of the anomalous meridional circulation is the main term responsible for the supply of moist air to the northern part of the area, while the low contribution to the south is associated with a low input of moist air from the zonal wind anomaly (Fig. 11f). Analysis of the advection of dry enthalpy and latent heat by anomalous winds shows that the meridional wind anomaly had a significant impact compared with the zonal wind anomaly. In addition, the advection of the dynamic term associated with latent heat contributed significantly to the supply of MSE to West Central Africa compared to the advection of the dynamic term associated with dry enthalpy. One of the reasons would be because in addition to the warm Atlantic SSTs, there was also an anomalous meridional mean sea level pressure (MSLP) gradient in the Central African Sahel between a lower MSLP over the eastern Sahara and a higher pressure between 10 and 15°N. In addition, the trans-equatorial meridional wind fluctuated with the activity of the African easterly waves over the Gulf of Guinea (Nicholson et al. 2022)." **The warming induces an acceleration of the thermodynamic component over the ocean according to the Clausius Clapeyron relationship. However, for this to affect Central Africa, these fluxes have to be advected towards the continent through atmospheric circulation, indicating that the teleconnection between the ocean and Central Africa is located in the dynamic component.**

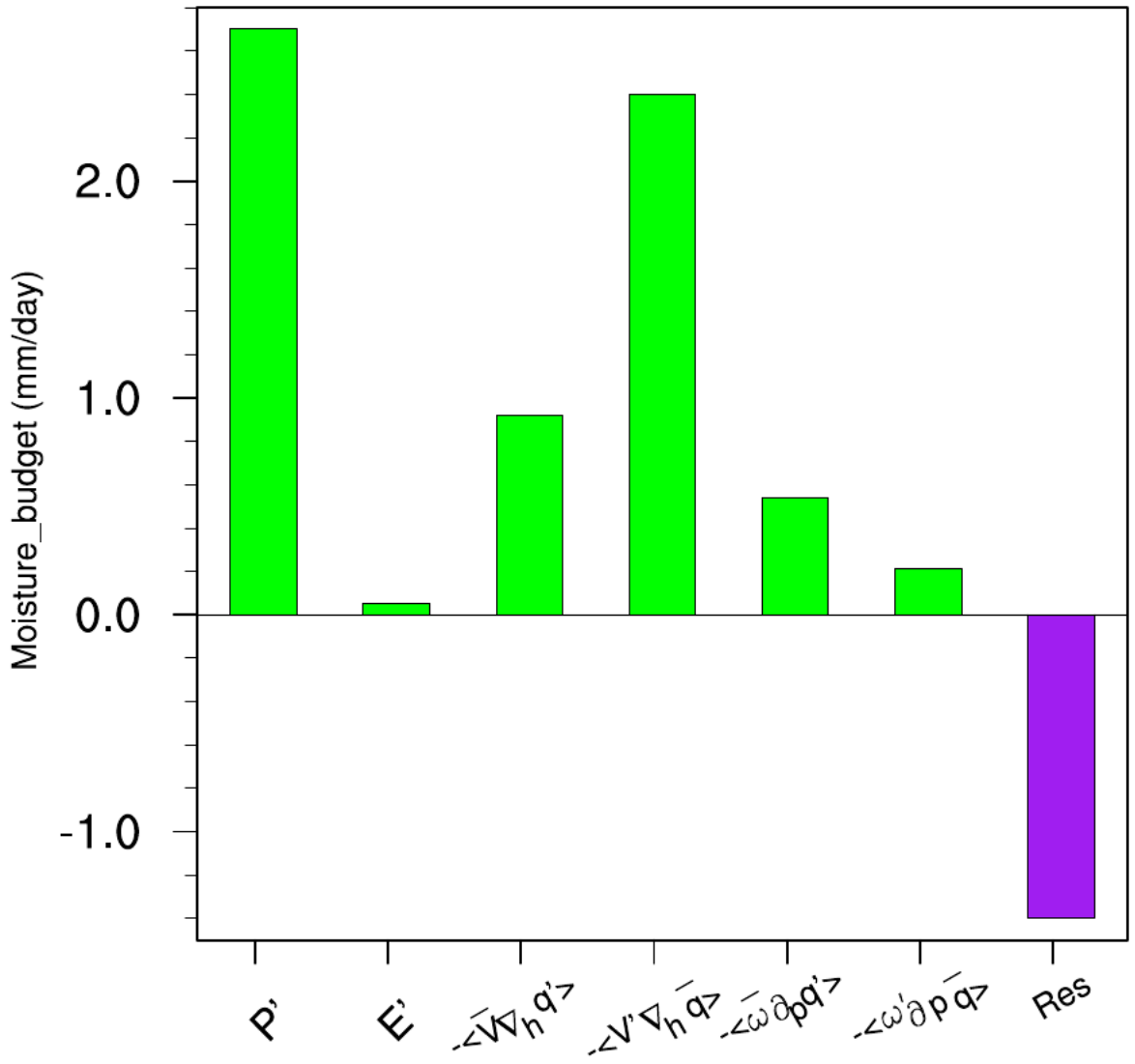

Fig. 5 Monthly mean anomalies in moisture budget for October 2019, averaged over the Northern part of West Central Africa (6°N-14°N, 6°-20°E).

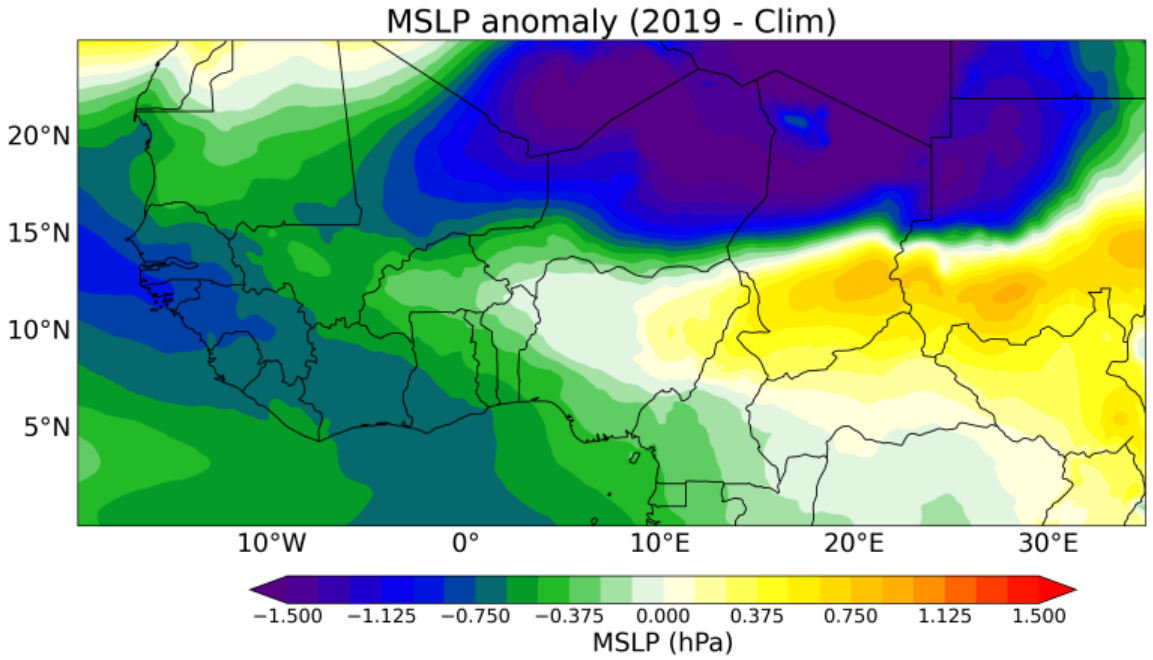

Fig. 2. Mean sea-level pressure anomalies (MLSP) during October 2019 vs long-term mean (1987-2017).

6. L289-291: This argument still doesn't make sense to me. The changes in winds are not obviously a response to increased moisture advection, and there is no evidence presented here of a link to global warming. Warmer Atlantic SSTs could be due to anthropogenic forcing, but the authors cannot conclude that from the evidence presented here.

Answer: ***We*** **understand the reviewer's concern. This conclusion has been deleted from the revised manuscript.**

7. L315-316: From Fig. 7g it appears that the residual term is concentrated in the Sahel region, and probably includes a nonlinear interaction between wind and moisture changes in this region.

Answer: We thank the reviewer's remark, we have reworded this in the revised manuscript. The new text will read as follows: "The residual term could influence the estimation of dynamic and thermodynamic distributions in the water budget, and its high values in the Sahel region would be associated with a non-linear interaction between wind and changes in humidity."

8. Fig. 5 and Fig. 6 should be combined as two sub-figures in a single figure. Same for Fig. 9 and Fig. 10.

<u>Answer:</u> suggestion taken into account. Figures 5 and 6 have been combined, and figures 9 and 10 as well (see figures below). All edited in the revised manuscript.

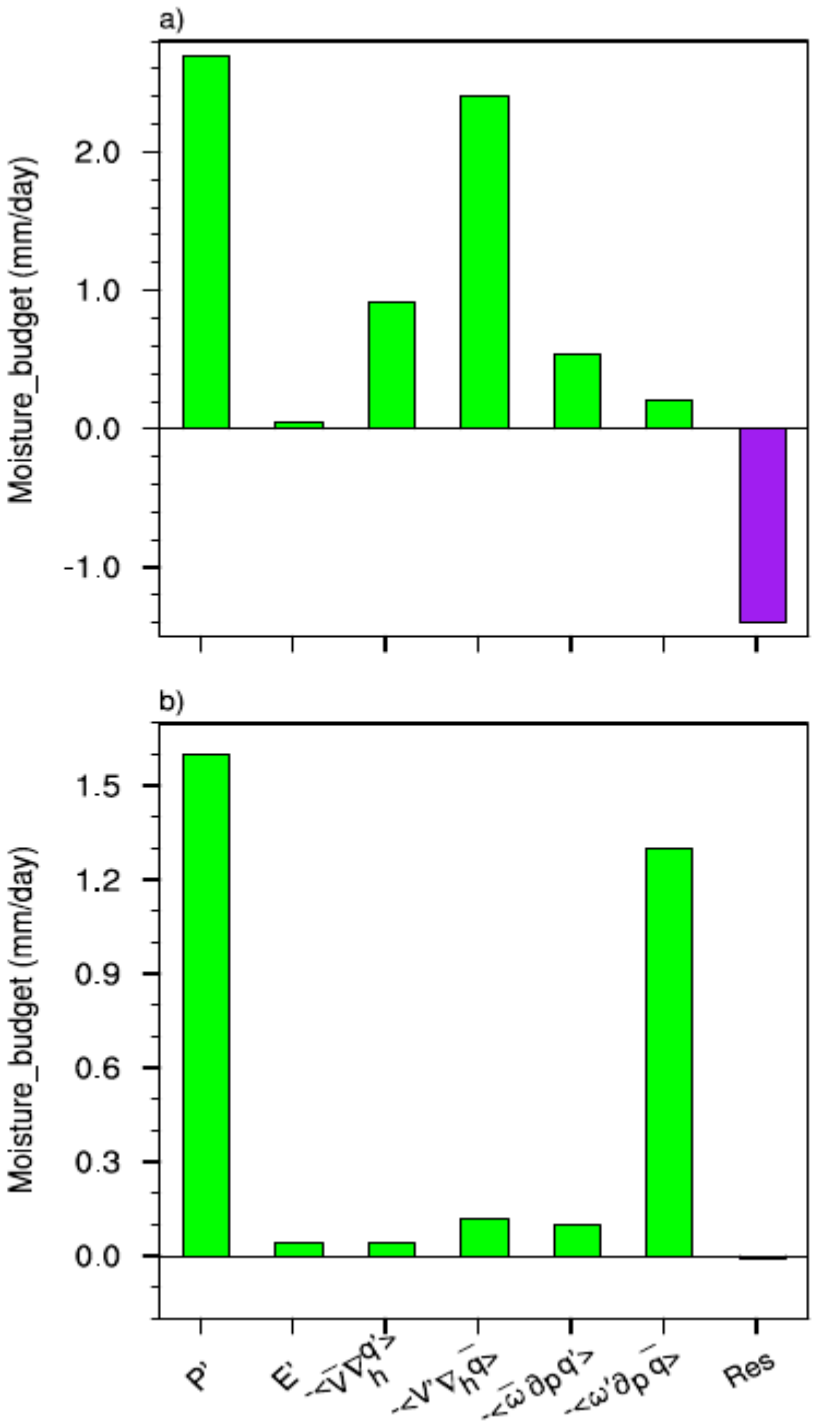

Fig. 5 Monthly mean anomalies in moisture budget for October 2019, averaged in a) over the Northern part of West Central Africa (6°N-14°N, 6°-20°E) and b) over the Southern part of West Central Africa (6°S-5°N, 6°-20°E)

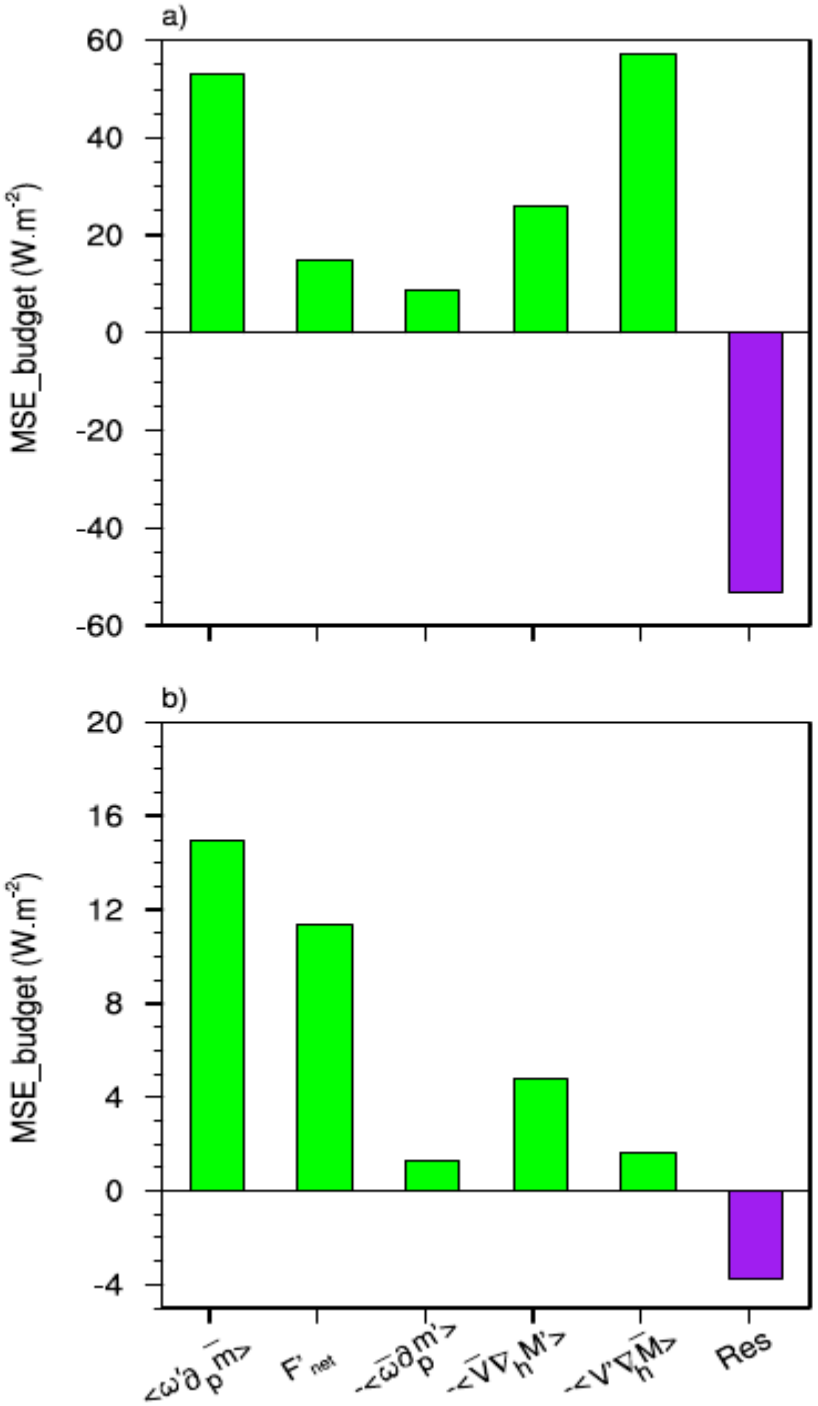

Fig. 8. Different terms of the Moist Static Energy (MSE) budget averaged in a) over the Northern part of West Central Africa (6°N-14°N, 6°-20°E) and b) over the Southern part of West Central Africa (6°S-5°N, 6°-20°E).

9. L351-353 and L602-605: I don't agree with this. A proper attribution method is required to determine the contribution of global warming to this event. Speculation without evidence is not useful.

Answer: We understand the reviewer's concern. We have reworded this in the revised manuscript. The new text will read as follows: "Thermodynamic effects reflect the change in the thermal state of the atmosphere associated with the October 2019 rainfall extremes over West Central Africa. However, changes in the thermodynamic effect, although not the key factor responsible for the October 2019 events, contributed up to 35% of the total effect (the sum of dynamic and thermodynamic contributions) on the northern part and 15% on the southern part of the domain." **and** "We proceeded by decomposing the water balance and MSE equation, separating the associated dynamic and thermodynamic effects. Changes in atmospheric circulation are behind dynamic processes, while changes in water vapor are behind thermodynamic processes. This approach provides a better understanding of the mechanisms behind rainfall anomalies. The main findings can be summarised as follows:"

10. L416: Typo here – remove 'bove'.

Answer: Done as suggested.

11. L494-495: More analysis is still required here to properly understand what is happening. Which component of Fnet is responsible for this? Is it surface latent heat flux, sensible heat flux, or radiative fluxes?

Answer: Appreciation to the reviewer for the suggestion. We conducted further analyses and a new Figure 10 (see below) is added to the manuscript. This result reveals that the latent (Fig. 10a) and sensible heat (Fig. 10b) flux anomalies are minor while the radiative flux anomalies (Fig. 10c) are large, showing that this dominated the energy balance during the October 2019 event. The new text will read as follows: "The difference between the net energy balance for 2019 and the climatology (Fig. 9e) shows low positive values in the north and south of the region respectively. Such an increase (mainly to the south of the area) is associated with a strengthening in the vertical structure of the MSE anomaly through ascending currents and, consequently, an increase in precipitation. A further analysis of the net energy balance (Fig. 10) shows that during October 2019, the latent heat flux (Fig. 10a)

decreased mainly over the Sahel and to the south of the domain. Sensible heat, on the other hand, increased slightly, with values of around 1.5 $W \cdot m^{-2}$. Analysis of the radiative flux anomalies shows strong positive values over the Sahel and the southern part of the domain (up to 50 $W \cdot m^{-2}$), showing that this is the main factor responsible for the increase in the energy balance during the exceptional event of October 2019."

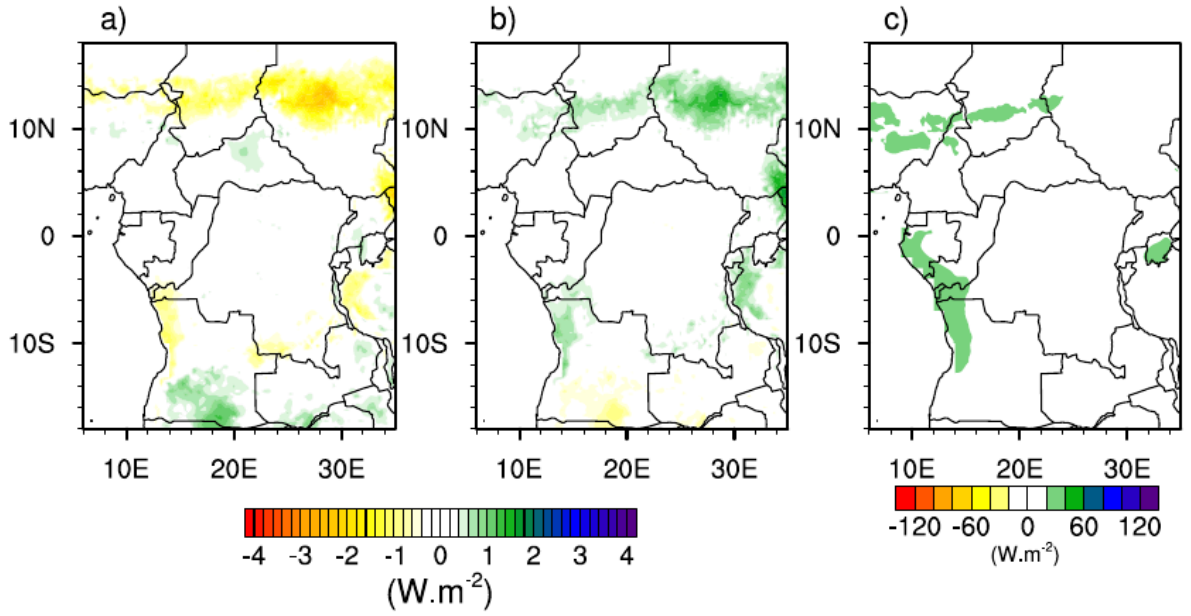

Fig. 10. Spatial distribution of a) latent heat, b) sensible heat and c) radiative flux anomalies in October 2019 over western equatorial Africa.

12. L561-566 and L585-586: The increased PMSL gradient between the Sahara and Sahel could favour enhanced northward meridional winds, but I don't see why increased Atlantic SSTs would have this same effect?

<u>Answer:</u> We understand the reviewer's concern. Indeed, the increase of anomalous meridional mean sea level pressure (MSLP) gradient over the Central African Sahel reinforced the meridional transport of moisture. Furthermore, Figure 1 of the revised manuscript (see below) shows that the increase in SSTs (Fig. 1a) is associated with a strong advection of moisture (Fig. 1b) from the ocean towards the Sahel.

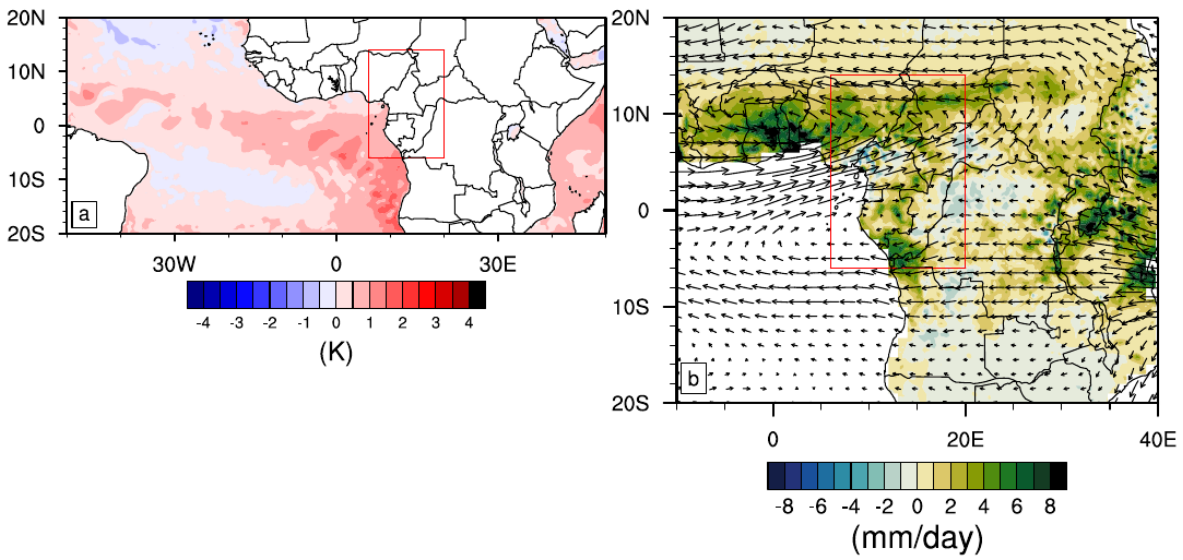

Fig 1. SST a) and rainfall b) anomalies during October 2019. The vectors represent anomalies of vertically integrated atmospheric moisture flux. The red box indicates the Central West Africa area.

13. L644-648: Have Atlantic Ninos been previously linked to strengthened northward winds over the northern part of the domain used here? The authors consistently link the warm Atlantic SST anomalies to the anomalous northward winds, but the mechanism for this is not obvious to me, and has not been explicitly stated in the manuscript.

Answer: We understand the reviewer's concern. Previous work by Nicholson et al (2022) highlighted that the increase in equatorial Atlantic SSTs associated with the late retreat of the West African monsoon played an important role in precipitation anomalies in the Sahel. In addition, Figure 1 below is taken from Vallès-Casanova et al (2020) and the authors showed as summarize that, Atlantic Niño is typically characterized by warm sea surface temperature anomalies (SSTAs) and positive sea surface height anomalies (SSHAs) in the eastern equatorial Atlantic and westerly wind anomalies in the western basin (e.g., Carton & Huang, 1994; Philander, 1986; Zebiak, 1993). Some Atlantic Niño events are also responsible for the failure of the West African summer monsoon and increased frequency of flooding in the West African countries bordering the Gulf of Guinea and the Sahel.

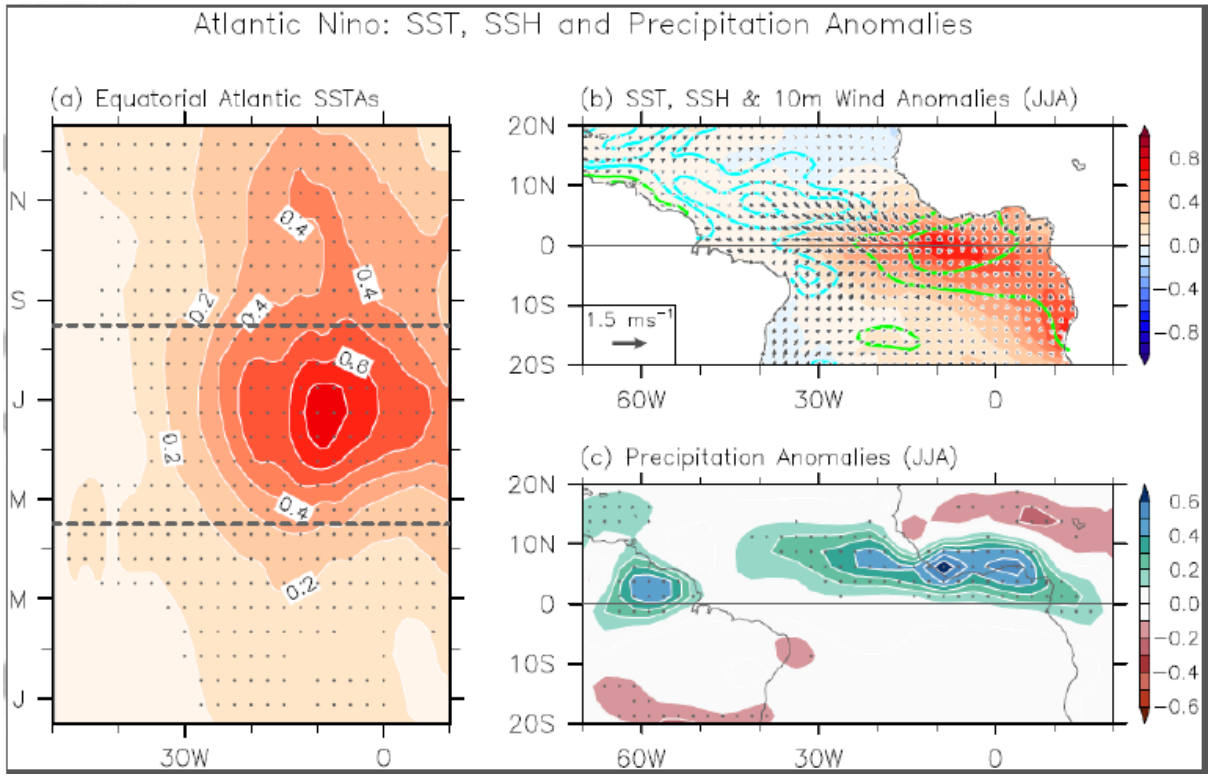

Figure 1. (a) Time-longitude plot of composite mean equatorial Atlantic SSTAs, averaged between 3°S and 3°N, from January to December derived from observed Atlantic Niño events. Significant SSTA values at 99% or above based on a Student's t-test (two tailed) are indicated by gray dots. (b) Composite mean tropical Atlantic SST (shades), SSH (contours) and 10-m wind (vectors) anomalies, and (c) precipitation anomalies during June-August derived from observed Atlantic-Niño events. Positive and negative SSHAs are indicated by green and cyan contour lines, respectively in (b). Significant precipitation anomaly values at 95% or above based on a Student's t-test (two tailed) are indicated by gray dots in (c). The units for SST, SSH, winds and precipitation are in °C, m/s cm, and mm /day, respectively. The contour interval for SSH anomalies is 0.5 cm.

Reviewer#2:

I thank the authors for their revisions. I appreciate the extra analysis and improved figures (and the robustness check with an additional reanalysis product).

I have a few remaining points, so I'm happy to recommend publication after these minor revisions.

L176: If you're not showing an explicit example of that (eg, a supp docs time series figure of dq/dt or q), then it would be worth providing a citation for this.

Answer: We thank the reviewer's remark, A citation will be included in the revised manuscript.

L191 / Eq 6: there's still an error here, like I said in my last review, this should be Lvq (or m) in the time-varying term on the left-hand side.

Answer: We thank the reviewer's remark, we have reworded this in the revised manuscript.

Data section: Since you're showing MERRA2 results in the supp docs now, it would probably be good to include a reference to that in your Data section (2.1)

Answer: We thank the reviewer for pointing this out. A reference has been included in the Data section (2.1).

L316: could you please put a paragraph break here? At first reading I didn't fully realize we were now talking about a different regional subset.

Answer: suggestion taken into account.