Responses to Reviewer #2's comments:

Reviewer #2 General comments: *The authors present an interesting study for the effect of mid-Holocene lakes. I believe this study and several other studies are still needed to understand the effect of those lakes on the climate of mid-Holocene Africa. As it currently stands, however, the manuscript needs considerable reworking before it is able to make a useful contribution to the compendium of literature on this topic.*

A: We thank the reviewer for his/her constructive comments and corrections that helped to significantly improve this manuscript. We have carefully revised it as described in detail below. We would like to acknowledge that we have made corrections to figures 1-4 and figures S4 and S8 to address a mistake in the seasonal calculation. Specifically, some of the previous results displayed the May-Oct mean instead of the Jun-Sep results. This initial discrepancy has no impact on our overall findings. For the corrections in the manuscript, we provide the line numbers from the revised paper with track changes.

Reviewer #2 Comment 1: (hereafter referred to as R2C1, R2C2…) ***Model choice and experiment setup:*** *The employed model resolution is T42 (280km) which is very very coarse by today's standards. Some climatic features do depend in a noticeable way on the model resolution. This therefore leaves a lot of questions, in my mind about the underlying results. Furthermore, the experiments have been spun-up for only 30 years and the results have been averaged over another 30 years, which is also not great. Considering the low resolution of the model, it should be possible to integrate it for a longer period of time.*

There are two further issues with the model, first being that it does not appear that the model has been run in a fully-coupled model (I am inferring this because it is not explicitly stated and because there are comments about initialization of ocean surface variables, but correct me if I am wrong). This leaves out important interactions with the ocean. Secondly, the SST, sea ice concentration, and the sea surface water isotope distribution are taken from an entirely different model. All these facts taken together present a very unsatisfactory picture of the experimental setup. I think the authors should revise their setup, or, provide sufficient evidence that their setup is not creating adverse results.

A: Thank you for your comments and concerns regarding our model choice and experiment setup. **Here, we answer the questions of the reviewer in detail one by one.**

"*low resolution of the model*"

Regarding the model resolution, we agree that T42 (280km) is a coarse resolution by today's standards. In terms of higher spatial resolution studies of the West African Monsoon (WAM) system using the isotope-enabled version of MIROC, there seems to be a lack of such studies. However, the latest PMIP4 MIROC-ES2L dataset for 6 ka also has a spatial resolution of T42. Steinig et al. (2018) used the Kiel Climate Model (KCM) to investigate the impact of spatial resolution on WAM precipitation, revealing that higher resolution models produce similar results to lower resolution models due to a reduction in convective (subgrid-scale) precipitation and an increase in large-scale precipitation. Furthermore, lower resolution models may shift the African Easterly Jet (AEJ) core towards the north and strengthen the Tropical Easterly Jet (TEJ). Thus, whether the impact of spatial resolution of MIROC on the convective and large-scale precipitation and the position and strength of the AEJ and TEJ, will influence our research findings need to be further investigated.

However, we agree that it would be interesting to investigate the sensitivity of the monsoon representation in MIROC to model resolution in future research. Hence, we added a statement about model uncertainty in discussion Line 516-518: "Additionally, while the main features of the WAM have been adequately captured, higher-resolution simulations are required to simulate finer convective activities and provide new insights at sub-grid scale (Joly, M., and A. Voldoire, 2009; Steinig, S., et al. 2018)." This spatial resolution was chosen based on the availability of the necessary components for our study, and also to allow for computationally feasible long-term integrations. We acknowledge that some climatic features may depend on model resolution, but we believe that our study still provides valuable insights into the potential impacts of dynamic lake changes on regional climate.

"*spun-up for only 30 years*"

In terms of the experiment setup, a 30-year spin-up period is sufficient to get a stable status in the Atmospheric GCM (AGCM). To confirm it, we have detected that the present 30-year spin-up has made the soil moisture of North Africa (Figure R1) and made sure it reaches stable conditions, which suggests the water balance conditions in North Africa.

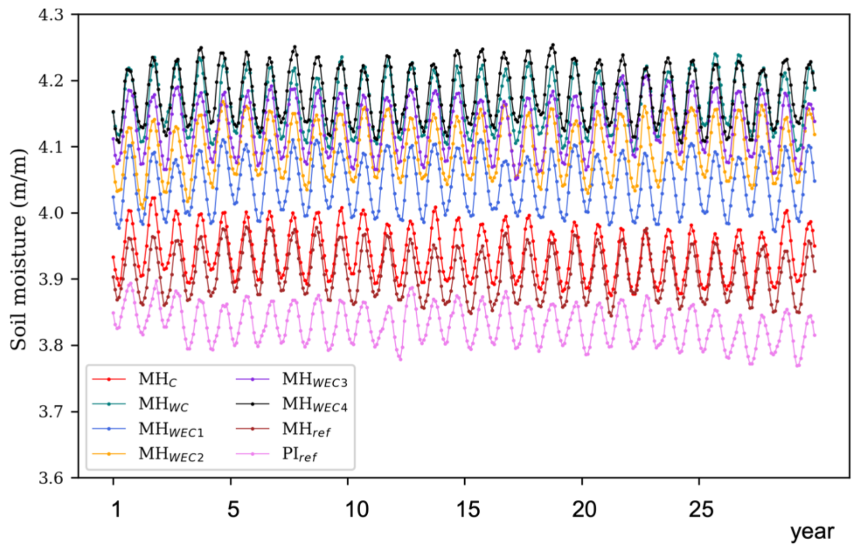


Figure 1. North African monthly soil moisture time series for all the experiments during the calculation period.

Thanks for your comments. In future studies utilizing an Atmospheric-Ocean General Circulation Model (AOGCM), we acknowledge the importance of extending the spin-up period to ensure a more robust initialization of the model.

"*fully-coupled model*"

We understand your concern about the lack of a fully-coupled model, and we agree that including ocean-atmosphere interactions would provide a more comprehensive representation of the climate system. However, the focus of our study was on the impact of dynamic lake changes on the regional atmospheric circulation. Therefore, we chose to use prescribed ocean boundary conditions to reduce the complexity of the model and allow for a clearer attribution of the changes to the lakes.

Overall, while we acknowledge the limitations of our experiment setup, we believe that our study still provides valuable insights into the potential impacts of dynamic lake changes on regional climate. We also add the limitations in the discussion part in Lines 498-500: "Furthermore, due to the absence of coupling with the ocean GCM, the model fails to consider the interactive effects of lake and SST or sea ice concentration, which are crucial to examine the teleconnection between the ocean and the WAM."

"*SST, sea ice concentration, and the sea surface water isotope distribution*"

We acknowledge that utilizing SST, sea ice concentration, and sea surface water isotope distribution from a different model (MPI-ESM-wiso) is not ideal. However, we deemed it reasonable for several reasons. Firstly, the SST and sea ice values obtained from MPI-ESM are in close agreement with the mean values of all the PMIP4 models (Brierly, C.M. et al., 2020). Secondly, the simulation differences among the coupled models are not substantial given that we are comparing MH and PI simulations, which are relatively similar. Thirdly, this approach was necessary by the unavailability of the required sea surface water isotope data for our study period. While these limitations exist, we believe that our approach is acceptable in detecting the dynamics of the water cycle in North Africa. Besides, Cauquoin et al. (2019) have already confirmed the reproducibility of the ocean with the δ18O$_{oce}$ proxy dataset. Since his model validation accuracy indicator (R^2=0.38 and RMSE =0.79 ‰) is quite similar to ours, we can confirm that using SST, sea ice concentration, and the sea surface water isotope distribution is acceptable in our study.

Brierley, C. M., Zhao, A., Harrison, S. P., Braconnot, P., Williams, C. J., Thornalley, D. J., ... & Abe-Ouchi, A. (2020). Large-scale features and evaluation of the PMIP4-CMIP6 midHolocene simulations. Climate of the Past, 16(5), 1847-1872.

Joly, M., and A. Voldoire, 2009: Influence of ENSO on the West African Monsoon: Temporal Aspects and Atmospheric Processes. J. Climate, 22, 3193–3210, https://doi.org/10.1175/2008JCLI2450.1.

Ohgaito, R., Yamamoto, A., Hajima, T., O'ishi, R., Abe, M., Tatebe, H., ... & Kawamiya, M. (2021). PMIP4 experiments using MIROC-ES2L Earth system model. Geoscientific Model Development, 14(2), 1195-1217.

Steinig, S., Harlaß, J., Park, W. et al. Sahel rainfall strength and onset improvements due to more realistic Atlantic cold tongue development in a climate model. Sci Rep 8, 2569 (2018). https://doi.org/10.1038/s41598-018-20904-1

R2C2: ***Methodology for analysis:*** *The authors investigate the contribution of the Western Sahara lakes by comparing the* MH_C *and* MH_{WC} *experiments, while the effect of Megalake Chad is studied by contrasting the differences between* MH_{WCE2} *and* MH_{WCE4} *I do not believe this is the right way of doing sensitivity studies for the effect of either of these two feature; this is because none of the lake maps employed in these simulations differ strictly with regards to those two features. There are several other differences between the lake maps that are all over the place. To some those differences* *very well may look small enough to ignore, but they don't look small to me (especially considering their aggregate effect over the entire North Africa) and the authors have not provided any evidence supporting their choice to overlook those differences. Rather than comparing MH_{WCE2} and MH_{WCE4} to study the effect of Megalake Chad, a more appropriate thing to do would be to compare the results from (let's say) MH_{WCE2} with another simulation in which only the employed surface map is the same one as that in MH_{WCE2} but with Megalake Chad removed. Similarly for studying the effect of western lakes (in this case the underlying lake maps MH_98 and MH_02 have lot of other differences over the northern parts of North Africa, Figure S2 of the manuscript).*

A: Thank you for your insightful critique of our methodology for analyzing the impact of Western Sahara lakes and Megalake Chad on the climate of North Africa.

While we acknowledge that the differences between the lake maps used in the simulations may have an aggregate effect on the results, we chose to compare the MH_{C} and MH_{WC} experiments to explore the contribution of Western Sahara lakes and to contrast the differences between MH_{WCE2} and MH_{WCE4} to study the effect of Megalake Chad. We understand that our approach may not align with your preference for sensitivity studies, but we believe it still provides valuable insights into the individual impacts of these lake features.

In our research, we opted to use the possible "true" lake maps in our simulations, as opposed to conducting ideal lake sensitivity experiments. This approach was motivated by our desire to provide new insights into the possible true lake-climate feedback. Besides, our decision to use LK_98 and LK_02 was based on previous studies that confirmed the influence of Western Sahara lakes on the northward monsoon movement (Specht et al., 2022), which can help us to compare with other research. Additionally, to clarify the lake aggregate effect, we further presented evidence supporting our choice of lake map comparison by including the LK1 and LK3 lake-climate response in Figures S9 and S10 of the supplemental materials (Figures S7 and S8 in the initial manuscript). Our analysis of these figures revealed that the low-mid-high level circulation and hydro-variables response showed similar response rules, and expansion trends along with the expansion of Megalake Chad in the LK1-4. This implies that on the lake-climate feedback mechanism that we focused on, the small lake aggregate effect has a negligible impact. In addition, the utilization of possible true lake maps (LK1-Lk4) enables us to reasonably demonstrate the effect of lake expansion. This approach allows for spatial and quantitative analysis of the role played by lakes in the region. Hence, by incorporating these true lake maps, we can enhance our discussions regarding the spatial distribution and magnitude of the lake's impact on the climate system.

We appreciate your suggestion for an alternative approach to study the effect of Megalake Chad by comparing the results from simulations with and without Megalake Chad. In future work, we will conduct such ideal experiments with the fully coupled model to explore the lake impact. We have also discussed the limitations of our approach in Section 4 Discussion and Conclusion Lines 486-492: "However, our lake sensitivity experiments may not comprehensively capture the impact of small lake aggregates, which may limit the scope of our findings. Here we have included the precipitation and isotope anomalies (Figure S12), as well as the SM, Evap, and T2 with the low-mid-high level circulation responses (Figure S13) for MH_{WCE1} and MH_{WCE3}. The similarity of these results with MH_{WCE2} and MH_{WCE} confirms that the small lake aggregate effect is negligible in the large-scale lake-climate feedback mechanisms. Nonetheless, conducting ideal sensitivity experiments in the future is necessary to confirm our findings and fully elucidate the impact of lakes on the regional hydroclimate during the mid-Holocene period."

Overall, we believe that our experimental design is appropriate for addressing our research questions and provides valuable insights into the role of lake changes in shaping the climate of North Africa. We thank you again for your valuable feedback, and we will consider your suggestions for future research.

R2C3: ***Isotope feature:*** *I do not follow how the isotope feature of the model is contributing to this version of the manuscript. The only real result discussed is the global-scale comparison with proxy derived isotope records, but the usefulness of that is lost on me as the subject of the paper is Africa/North Africa and there is only one δ18O proxy in all of Africa. It is in no way contributing to the understanding of the effect of mid-Holocene lakes over North Africa.*

A: We appreciate your comment and acknowledge the importance of model validation.

Before the discussion, we apologize for the mistakes in showing Figure S3 with SISALv1 datasets and have now updated it with the latest SISALv2 dataset (Comas-

Bru, Rehfeld et al. 2020), consistent with the Dataset availability.

how the isotope feature of the model is contributing to this version of the manuscript

We would like to clarify that the use of an isotope-enabled model was primarily aimed at capturing these dynamics, rather than solely for model-data comparison purposes.

To address this point, we have made additional clarifications in both the Method and Result analysis. In section 2.1 Lines 102-104: "Such isotope-enabled climate models have proven to be valuable tools for tracing water vapor transportation and identifying the sources of precipitation changes (Tharammal, T. et al., 2021; Liu, X. et al., 2022)."

In the Result section, we further analyzed the stable oxygen isotope ratio in precipitation to differentiate the source of increasing precipitation from ocean and land. We also made additional revisions in section 3.3 Lines 426-435: "Positive $\delta^{18}O$ anomalies suggested the presence of an oceanic moisture source in addition to the local lakes, whereas negative anomalies indicated the influence of local water cycling. The $\delta^{18}O$ increase in the northern regions (Figure S10) suggests the moisture sources from the Atlantic Ocean are associated with westerly monsoon winds. Conversely, the equatorial land areas show decreases in $\delta^{18}O$, which are also current with weakened evaporation (Figure 3k) and warming effects (Figure 3l) in MH_{WCE4}. Further examination of the $\delta^{18}O$ decrease (Figure S10d) in the equatorial land areas in MH_{WCE4} suggested that the slight precipitation increment (Figure 2d) was not driven by the westerly monsoon winds. Instead, such a warming effect induced by equatorial lakes may link to the differences in lake heating during daytime and night (Thiery et al., 2015). Hence, while lakes in WAM regions tend to result in wetter and cooler climatic responses, lakes located elsewhere (such as the eastern lakes in South Sudan) may not impact the northward WAM movement."

These revisions emphasize that our use of an isotope-enabled model goes beyond model-data comparison and provides valuable insights into the water cycle dynamics and precipitation recycling processes in the region under study.

there is only one δ18O proxy in all of Africa

The use of isotopic features in the model allows us to validate our simulations against paleo-proxy records, avoiding bias from reconstructed datasets. While we acknowledge the limited availability of such records in Africa, the three African stations for which data is available showed good agreement with the modeled data. Furthermore, we have made additional efforts to supplement our validation in North Africa, as evidenced in R2C4.

R2C4: ***Comparison to proxies:*** *In contrast to the single $\delta^{18}O$ proxy in all of Africa, there are decent compilations of temperature and precipitation proxies over mid-Holocene Africa [Bartlein et al., 2010] that have been used for validation purposes in many studies. Why are the simulated temperature and precipitation not compared to those proxies?*

A: Thank you for your suggestions and for bringing up the issue of comparison to proxies.

mid-Holocene Africa [Bartlein et al., 2010]

Considering the limited scope of our study, we focused on comparing our results with the $\delta^{18}O$ proxy, which unfortunately lacks stations in Africa. We acknowledge that expanding the comparison to include another proxy datasets compiled by Bartlein et al. [2010] would enhance the robustness of our findings. However, we note that the proxy datasets provided by Bartlein et al. [2010] only cover the anomalies between 6ka-0ka, whereas our experiment shows the anomalies between 6ka-PI (1850y). Such difference between 0ka-PI would further bring ignorable bias to our comparison results in addition to the bias from constructed precipitation/precipitation datasets. Considering such bias, the comparison results show agreeable changing trends in annual mean precipitation and mean temperature in the warmest month in spatial distribution, but they do not address a good statistical relationship between the proxies and model data (Figure 2).

In terms of the comparison between precipitation data from our model (Figures R2a and R2b) and the proxy data, we observe good agreement in the central part of North Africa (NAf). However, in the northern region, our model underestimates precipitation compared to the proxy data. These results confirm that our model has limitations in simulating abundant precipitation in the northern region of NAf. Regarding the comparison of summer season temperatures (Figures R2c and R2d), our model generally underestimates temperatures in the central part of NAf but shows good agreement in the northern part. These validation results indicate that our model fails to capture sufficient precipitation in the northern part of NAf, while precipitation tends to concentrate in the central part with lower temperatures for the mid-Holocene. This discrepancy aligns with the challenge faced by many climate models in reproducing adequate precipitation over NAf. Considering the potential bias introduced by differences in the proxy datasets and the study period, we consider the validation results to be acceptable.

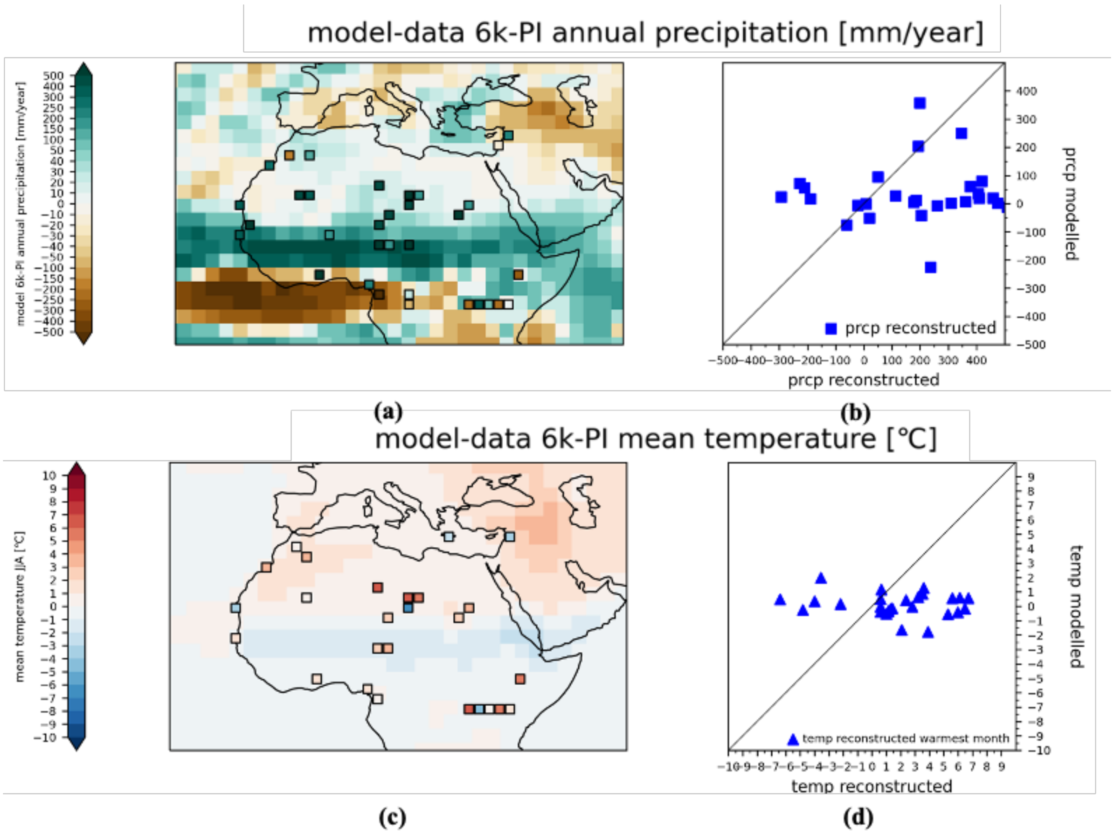
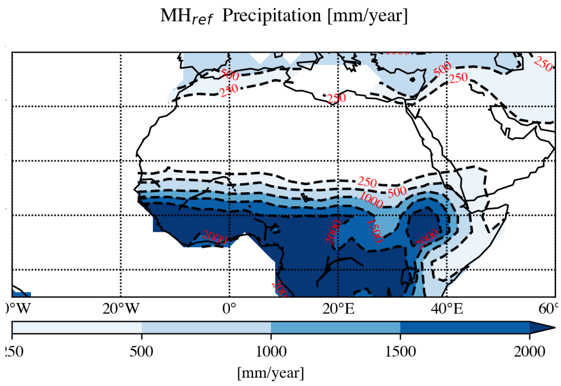


Figure R2. Precipitation and temperature model-data comparison for the reference mid-Holocene simulation in North Africa. (a) shows the simulated global pattern of annual mean precipitation between the MH_{ref} and PI_{ref} climate (background colors) and the observed annual mean precipitation changes (squares) between MH_{ref} and the present climate. (b) is a scatter plot showing a comparison of observed precipitation changes with simulated precipitation anomalies at the same location. (c) and (d) are the same as (a) and (b) but for the seasonal mean temperature model [Summer (JJAS)]-data [warmest month] comparison.

To further validate the MIROC5-iso performance in North Africa, we conducted a comparison with Figure 4a of the study by Larrasoaña et al. (2013). Our findings indicate that the MIROC5-iso simulation has difficulty in shifting the zone with precipitation less than 1000 mm/year northward, but it exhibits good agreement with the reconstructed map in the zone with precipitation exceeding 1000 mm/year. This comparison shows the simulation bias of the MIROC5-iso model in North Africa, specifically in terms of the northward movement of the monsoon system.



(a)

Figure R3. North African annual precipitation comparison. (a) The spatial annual precipitation for MH$_{ref}$.

This part of the comparison has been added in section 3.1 Lines 249-256: "To further examine the model performance in North Africa, we compare our precipitation result with Figure 4a in the study conducted by Larrasoaña et al. (2013). From Figure S4a, our results indicate that the MIROC5-iso was hard to reproduce the northward shift of the zone with precipitation less than 1000mm/year, but show good agreement with the reconstructed map in the zone with precipitation exceeding 1000mm/year. Besides, we also compared our result with precipitation and summer season temperature anomalies between 6ka-0ka, as provided by Bartlein et al. (2010) (Figure S4b-e). This comparison also revealed precipitation underestimation in the northern NAf and lower temperatures in the central NAf. These comparisons collectively suggest a simulation bias of the MIROC5-iso model in North Africa, particularly concerning the northward movement of the monsoon system."

Larrasoaña, J. C., Roberts, A. P., & Rohling, E. J. (2013). Dynamics of green Sahara periods and their role in hominin evolution. PloS one, 8(10), e76514.

Why are the simulated temperature and precipitation not compared to those proxies?

Such isotope-enabled climate models could provide more accurate validation directly with proxy data directly, avoiding bias from reconstructed datasets. While we acknowledge the limitation of our proxy data station in North Africa, it should be noted that, as described in section 3.1, our model was able to successfully capture the critical components of the West African Monsoon (WAM), which are particularly relevant to our study of the lake-climate mechanism.

Hence, even though there are limitations in our regional-scale validation, we believe that our simulation of the mid-Holocene climate of North Africa is acceptable.

R2C5: *Line 45: Chandan and Peltier [2020] did not use the 'small-lake map' of Hoelzmann et al. [1998]. The Hoelzmann map prescribes a small uniform lake fraction for nearly all of Sahara, this aspect was not utilized in their paper. Furthermore, the Hoelzmann map includes a sizeable region of wetlands covering >70% grid cell south-east of Megalake Chad which is not included in the Chandan and Peltier land surface. Actually, on this matter, I wonder why these wetlands are not included in your Hoelzmann map considering that you say in the manuscript that you treat wetlands as lakes? I am also curious why your Hoelzmann map differs noticeably from what is shown in Plate 3 of Hoelzmann et al. [1998]?*

A: Thank you for your comment and for pointing out these important issues.

In Lines 46-47, we want to claim that Chandan and Peltier [2020] supplied more Megalakes based on the 'small-lake map' of Hoelzmann et al. [1998]. We apologize for the confusion caused by this error and further clarified them.

Regarding the Hoelzmann map, our study only uses the lake map, not the wetland map in Plate 3b of Hoelzmann et al. [1998]. In order to compare with the research of Specht, Claussen et al. (2022), we directly used their processed small lake map (Hoelzmann, Jolly et al., 1998) and maximum lake map (Tegen, Harrison et al., 2002) and the details can be found in the data availability and Table S1. We acknowledge that there must be some discrepancy due to the upscaling process.

Additionally, we clarified in the manuscript that only the latest high-resolution one (Chen, Ciais et al., 2021) includes both the wetland and lakes. However, due to our model limitation, the wetland module only accounts for wetland-related processes in middle and high-latitude grids with snowmelt, as described by Nitta et al. (2015, 2017). Hence, these model features were considered in prescribing and treating wetlands as lakes in MIROC5-iso when simulating the LK1-4 maps. Given that the wetland and lake mechanisms are different, such kind of simplified assumption may introduce certain limitations. So, we will further elucidate the distinct roles of the wetland and lake in the land-climate system in the future.

To further clarify this point, we made some revisions on:

Section 1 Lines 77-78: "…… and the recently-updated high-resolution lake and wetland reconstructions maps (Chen et al., 2021) over the NAf during the MH."

Section 2.1 Lines 147-150: "It should be noticed that the water body delineated in LK_98 and LK_02 lake maps only pertain to the lake but the LK1-4 lake maps include both the wetland and lakes. Generally, lakes and wetlands are persistently saturated or near-saturated areas that are regularly subjected to inundation or shallow water tables in the absence of human disturbances (Tootchi et al., 2019). In this study, wetlands are also treated as lakes in our climate model."

R2C6: *Please revise/rewrite the content between lines 60 and 66. It is not quite clear what discrepancies you are trying to highlight in these lines.*

A: Regarding lines 60-66, we want to explain the discrepancies in the literature regarding the mechanisms of lake-climate interaction in the NAf monsoon system and concluded that the lake-climate mechanism to maintain the Green Sahara condition is still unclear.

The related sentences in Section 1 Lines 65-73 have been revised as: "Recent studies have explored the mechanisms of how various components of the NAf monsoon system, including the Sahara Heat Low (SHL) and Sahara Highs in western Sahara, the African Easterly Jet (AEJ) in the middle atmosphere (600 hPa), and Tropical Easterly Jet (TEJ) in the upper atmosphere (200 hPa) influence the near-surface westerly flow northward and rainfall (Biasutti & Sobel, 2009; Claussen et al., 2017; Kuete et al., 2022). However, discrepancies exist regarding the effects of these components on what. Chandan and Peltier (2020) suggested that such a cooling effect could weaken the SHL and local convection, reducing the precipitation. Conversely, Specht et al. (2022) found that a weakened AEJ enhanced inland moisture transportation, leading to a northward and prolonged rain belt. As a result, the mechanisms of lake-climate interaction in the NAf monsoon system remain unclear."

R2C7: *There are too many names in the paper that start with MH and which refer to both simulations and lake maps. This makes reading the paper rather confusing as I easily mix up lake map names with experiment names. I suggest keeping the experiment names as they are and renaming the lake maps to LK (or something else). For example, MH_98 lake map becomes LK_98.*

A: Thank you for your comment and suggestion.

We have taken your suggestion into consideration and made appropriate changes to the naming conventions used in the paper to avoid confusion. As you suggested, we have renamed the lake maps by changing 'MH' to 'LK' in both the main text and supplementary materials. This should make it easier for readers to differentiate between the simulations and lake maps.

R2C8: *Provide more information on the Budyko aridity index in section 2.3.2, including but not necessarily limited to how it should be interpreted, what is the physical basis for this metric and what are the caveats of using this metri*c.

A: We appreciate your suggestion to include more information on the Budyko aridity index in section 2.3.2.

The supplement sentences in Section 2.3.2 Lines 231-237 are as follows:
"The annual mean of net radiation and precipitation were used in the analysis. A higher Budyko aridity index indicates a drier region due to the available energy being high relative to the amount of water, whereas a lower index indicates a more humid region due to the available energy being low relative to the amount of water. In our study region, six climate regions are classified by Budyko aridity index: Tropical Humid ($I \leqslant 0.7$), Humid ($0.7 < I \leqslant 1.2$), Semi-Humid ($1.2 < I \leqslant 2.0$), Semi-Arid ($2.0 < I \leqslant 4.0$), Arid ($4.0 < I \leqslant 6.0$) and Hyper-Arid ($6.0 < I$). The equation suggests that changes in the dryness index within a region are more indicative of shifts in the hydroclimatic regime over the long term rather than intra-annual variability, such as individual drought events."

R2C9: *Section 3.3 is very difficult to follow. I suggest a complete re-write of this section. Here are some of my comments for that section.*

A: Thank you for your feedback and suggestions regarding Section 3.3. We appreciate your input and agree that the section could benefit from a rewrite to improve its clarity and readability. The details revision are provided according to your comments as follows:

- *Line 239: What radiation is this? Longwave downwelling? Why does it increase with lake fraction?*

A1: The net surface radiation, which is the sum of net longwave radiation (LW) and net shortwave radiation (SW), is a key factor that affects climate. To understand the changes in radiation, we analyzed the changes in LW and SW separately. As shown in Figure 4Ra, $LW^{\uparrow}$ decreases (downward LW increase) as the temperature cools following the positive relationship of T^4 ($LW^{\uparrow} = \varepsilon\sigma T^4$). However, only a small increase in $SW^{\downarrow}$ ($SW^{\downarrow} = (1-\alpha)SW^{\downarrow}$) related to the surface albedo changes (Figure R4c). For instance in Figure R4b, in the MH$_{WCE4}$ experiment, the areas where $LW^{\uparrow}$ decreases correspond to the cooling and humidifying areas, suggesting that such cooling and humidifying areas show larger absorption in the incoming LW.

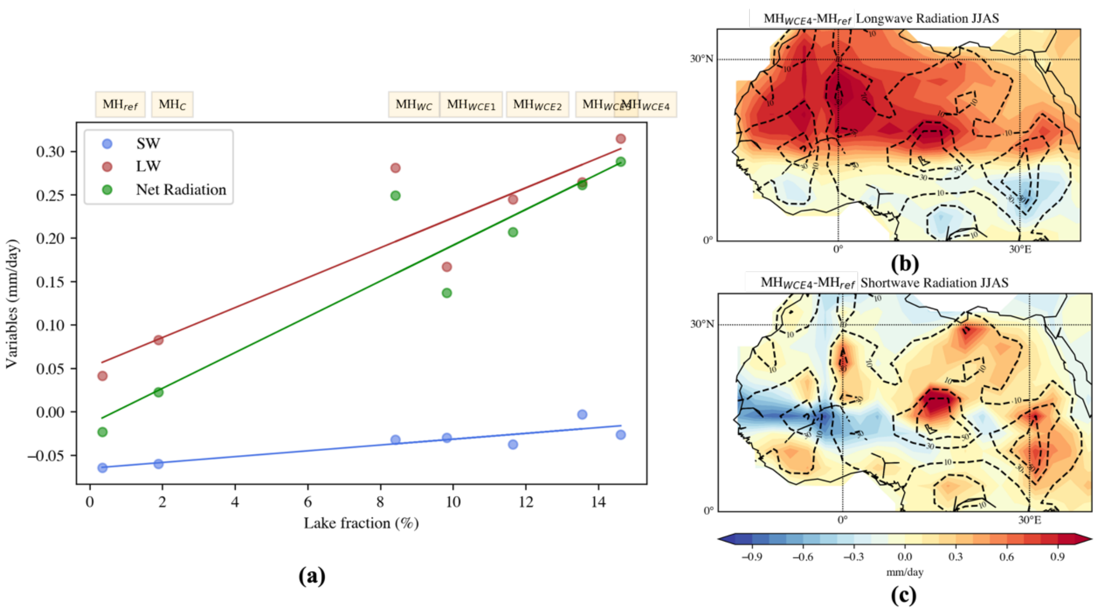


Figure R4. (a) Statistical relationship between regionally averaged radiation variables anomaly and averaged grid lake fraction over Northern Africa (20°W–40°E, 0–35°N) for MH lake experiments anomalies (relative to PI$_{ref}$) on the annual (circle) averages. The radiation variables include net surface shortwave radiation (blue), net surface longwave radiation (red), and net radiation (green). Simulated mid-Holocene climatological JJAS mean anomalies MH$_{WCE4}$ with respect to MH$_{ref}$: (b) net surface longwave radiation (shades), (c) net surface shortwave radiation (shades). For maps (b) and (c), The lake fraction [%] contours of the respective lake sensitivity experiment are shown with the black dashed lines. All the radiations units have been transferred from [W/m^2] to [mm/day] based on the equation: $W/m^2 = 1000(kg/m^3) \times 2.5\times10^6(J/kg) \times$ 1mm/day (1/86400)(day/s) $\times$ (1/1000)(mm/m).

To further clarify this part, we added the following explanation in section 3.3:
Lines 346-353: "To provide further insights into the changes in radiation (Rad), we examined the relationship between net longwave radiation (LW) and net shortwave radiation (SW) in relation to the lake fraction (Figure S6a), positive downward). Take MH_{WCE4} experiments as an example, Our analysis revealed that the increase in Rad can be attributed to two factors: the increase in downward LW in the cooling and humidifying areas (Figure S6b) and the slight increase in downward SW in the regions with higher lake fraction, which is associated with changes in surface albedo (Figure S6c). These findings suggest that the humidifying and cooling areas experienced greater incoming LW radiation absorption."

- *I do not follow lines 240–246.*

A2: My apologies for any confusion I may have caused.

The purpose of these lines was to explain how the variables are affected by changes in lake expansion. Specifically, we found that in summer, the expansion of the lakes had a stronger impact on hydrological changes, resulting in wetter and cooler conditions in the lake sensitivity experiments. However, in winter, there was no clear correlation between the variables and lake expansion, although there was still a cooling effect (represented by downward green triangles in Figure 4) with a standard deviation of approximately 0.1. However, in summer, the MH_{WC} experiments had higher anomalies compared to the MH_{ref} experiment (shown as upward triangles in Figure 4), indicating that the lake position had a greater impact than the lake fraction.

The related sentences have been revised in section 3.3 Lines 345-346: "The annual mean values of Precipitation (Prcp), Evap, and Radiation (Rad) increase with lake fraction, whereas T2 decreases (crosses in Figure 4)." Lines 354-361: "Additionally, seasonal analysis shows that during summer, there are considerable differences between the lake sensitivity experiments and the PI_{ref}, with positive anomaly offsets for Prcp, Evap, and Rad and negative anomaly offsets for T2 (upward triangles in Figure 4). Whereas, during winter, these variables are not significantly related to the lake expansion (standard deviation = ~0.1), but a cooling effect is still observed (downward green triangles in Figure 4). Therefore, the lake expansion mainly affects hydrological changes in summer, leading to wetter and cooler conditions in the lake sensitivity experiments compared to the MH_{ref}. However, the unusually high anomalies observed during summer in the MH_{WC} experiments suggest that the position of the lake may play a more important role than the proportion of lakes in moistening the Sahara regions."

- *The text says that Figure 4 shows zonally averaged quantities but that is clearly not the case. What averaging is being done in Fig 4?*

A3: I apologize for the confusion in the text.

In Figure 4, the zonally averaged quantities = sum of all grids' values/ grid numbers, meaning that the values are the result of averaging the relevant variables within the study region, rather than being zonally averaged. To clarify, we change the 'zonally averaged' to 'regionally averaged' in Line 363 and Figure 4 caption.

- *Fig 4 caption: how can the units of radiation be "mm/day"? Where is the vertical axis for radiation data?*

A4: In the calculation of Radiation, we convert its unit from W/m^2 to mm/day. The equation is as follows:

$W/m^2 = 1000(kg/m^3) \times 2.5\times10^6(J/kg) \times$ 1mm/day $(1/86400)(day/s) \times$ $(1/1000)(mm/m)$

The equation has been added in the legend of Figure S6.

Hence, the radiation shares the same vertical axis with precipitation and evaporation.

- *What do 'precipitation scarcity' and 'precipitation surplus' mean? Scarcity and surplus with respect to what? Please define them clearly. How are figures S5b and S7 showing these quantities generated? How are the numbers presented in line 165 and shown in Fig 5a computed? I cannot make sense of these results because you haven't defined the two phrases.*

A5: We apologize for any confusion caused by the lack of clarity and have made revisions to improve the manuscript's presentation of these concepts.

'precipitation scarcity' and 'precipitation surplus' mean

Precipitation scarcity and surplus refer to the regions in North Africa that receive less or more precipitation than the semi-humid climate zone threshold, respectively. We have revised the relevant sentence in the manuscript to provide a clearer definition in section 3.3 Lines 393-394: "By comparing the simulated precipitation with the semi-humid climate zone threshold, the regions receiving less than the threshold are considered as scarce and regions receiving more are considered as surplus."

figures S5b and S7 showing these quantities generated

The figures S5b and S7 show the spatial patterns of precipitation scarcity and surplus, respectively, and are generated based on the same threshold mentioned above for each grid.

numbers presented in line 165 and shown in Fig 5a computed

The numbers presented in Line 395 and shown in Figure 5a are computed by summing the precipitation deficits or surpluses in the regions of scarcity and surplus, respectively, over North Africa.

- *Line 264 "implying that ... wetter." this remark does not make sense when read within the full sentence.*

A6: This sentence has been deleted. The sentence in Lines 391-393 has been revised as: "Hence, we further demarcated regions of the precipitation scarcity and surplus based on the threshold of semi-humid climate zones (I = 2)."

- *Line 267 ""The spatial pattern showed .... modes." What mode? I don't see any (dynamical) mode here, it is just the northward extent of the WAM which starts from the south. Did you mean to say a 'precipitation pattern'?*

A7: We apologize for the confusion. Lines 398, the correct term is "precipitation pattern" rather than "mode".

- *Line 279 What is this inverse pattern?*

A8: Thank you for raising this question. To clarify, the inverse pattern refers to the north-south inverse pattern of surface temperature anomaly observed in MH_{WCE2} and

MH$_{WCE4}$. Despite the increased precipitation in the near-equatorial regions, surface temperatures still show a warming effect. To investigate this phenomenon further, we analyzed stable oxygen isotopes in precipitation and found evidence of an oceanic moisture source in addition to local lakes. This analysis helped us explain the different water cycle mechanisms in equatorial lakes and shed light on the role of lake location in influencing the monsoon.

The related sentences in section 3.3 Lines 407-426 have been revised as:
"Specifically, SM and Evap showed positive anomalies with a cooling effect in the north of 10°N and minor or negative anomalies but with a warming effect in the south of 10°N over NAf. However, such near-equatorial (around 0°–10°N) warming effect can not be explained solely by the reduced precipitation in MH$_{WCE2}$ and MH$_{WCE4}$ as the enhanced precipitation belt covered the entire tropical area (0°–20°N), in contrast to being concentrated in the WAM regions (around 10–20°N) in MH$_{WC}$. To identify the inverse temperature anomalies pattern in MH$_{WCE2}$ and MH$_{WCE4}$, we analyzed the stable oxygen isotope ratio (δ^{18}O) in precipitation (Figure S10)."

- *Line280 There is nothing new in the finding that the moisture source is largely oceanic along with some contribution from local moisture recycling. Is the isotope analysis contributing anything new?*

A9: The stable oxygen isotope ratio (δ^{18}O) analysis of precipitation in MH$_{WCE2}$ and MH$_{WCE4}$ did confirm an oceanic moisture source in addition to local lakes in the monsoon regions. Meanwhile, further analysis revealed a decrease in δ^{18}O with weakened evaporation and warming effects in the equatorial land areas, suggesting that the precipitation increment was irrelevant to the westerly monsoon winds. This inverse warming effect induced by equatorial lakes may be related to their special equatorial location with heating differences during the daytime and night.

Hence, based on the isotope analysis, this study found that lakes located in the West African Monsoon (WAM) regions exert wetter and cooler climatic responses, while lakes outside of the WAM regions, like the eastern lakes in South Sudan, do not affect the northward WAM movement.

To further make this part clearer, we revised the paper at Lines 426-435: "Positive δ^{18}O anomalies suggested the presence of an oceanic moisture source in addition to the local lakes, whereas negative anomalies indicated the influence of local water cycling. The δ^{18}O increase in the northern regions (Figure S10) suggests the moisture sources from the Atlantic Ocean are associated with westerly monsoon winds. Conversely, the equatorial land areas show decreases in δ^{18}O, which are also current with weakened evaporation (Figure 3k) and warming effects (Figure 3l) in MH_{WCE4}. Further examination of the δ^{18}O decrease (Figure S10d) in the equatorial land areas in MH_{WCE4} suggested that the slight precipitation increment (Figure 2d) was not driven by the westerly monsoon winds. Instead, such a warming effect induced by equatorial lakes may link to the differences in lake heating during daytime and night (Thiery et al., 2015). Hence, while lakes in WAM regions tend to result in wetter and cooler climatic responses, lakes located elsewhere (such as the eastern lakes in South Sudan) may not impact the northward WAM movement."

- *Line 283 What inverse warming effect?*

A10: In Line 405, the phrase 'inverse warming effect' refers to the phenomenon that even though there is an increase in precipitation over the near-equatorial regions, the surface temperature still shows a warming effect in MH_{WCE2} and MH_{WCE4}. The following analysis of the stable oxygen isotope ratio in precipitation helps to explain this phenomenon and the different water cycle mechanisms in equatorial lakes. The related paragraph has been revised in reply to the above two questions.

R2C10: *Line 302–303: I am not sure it is correct to say that Chandan and Peltier [2020] underestimated the contribution of lakes (similar sentiment regarding Line 47). In their study, the lakes do have quite a bit of contribution in the 10–15N latitudinal band which is the same region where precipitation effect is greatest in your simulations. If you look at Figure 3 of that paper, the influence of lakes, determined by the zonal mean difference between MHV and MHVL, can be as high as 200mm or more in that latitudinal band, and while a spatial difference between those two simulations was not shown in that paper, I am quite sure it would be very similar to the spatial patterns shown in your Figure 2. Are you able to compute an equivalent zonal precipitation mean to compare with CP2020's Fig 3 and thus argue that the lake influence in their lake experiment is decidedly lower than in yours?*

A: Thank you for your suggestion.

Based on your comments, we have also estimated the zonal changes in precipitation over the North African land [20°W–35°E, 0–35°N] in our study (Figure 5). Our MH_{C}

experiments indicate precipitation anomalies of up to 300 mm/year, which is in agreement with the findings of Chandan and Peltier [2020] shown in Figure 3 since their lake maps only consider the Megalakes. However, our MH_{WC} experiments show higher precipitation anomalies of up to 600 mm/year, and MH_{WCE4} experiments show even higher precipitation anomalies of up to 800 mm/year. Additionally, we observed that the peak precipitation values for each experiment shifted northward as the lake area expanded. Based on these results, we can conclude that the influence of lakes in our study is greater than that of Chandan and Peltier [2020].

We have added this part in Section 4 Lines 474-476: "Besides, compared with our simulations (Figure S11), Chandan and Peltier (2020) underestimated the contribution of lakes, approximately close to MH_{WC} results, by supposing that the weakened SHL induced by the surface cooling effect would reduce precipitation."

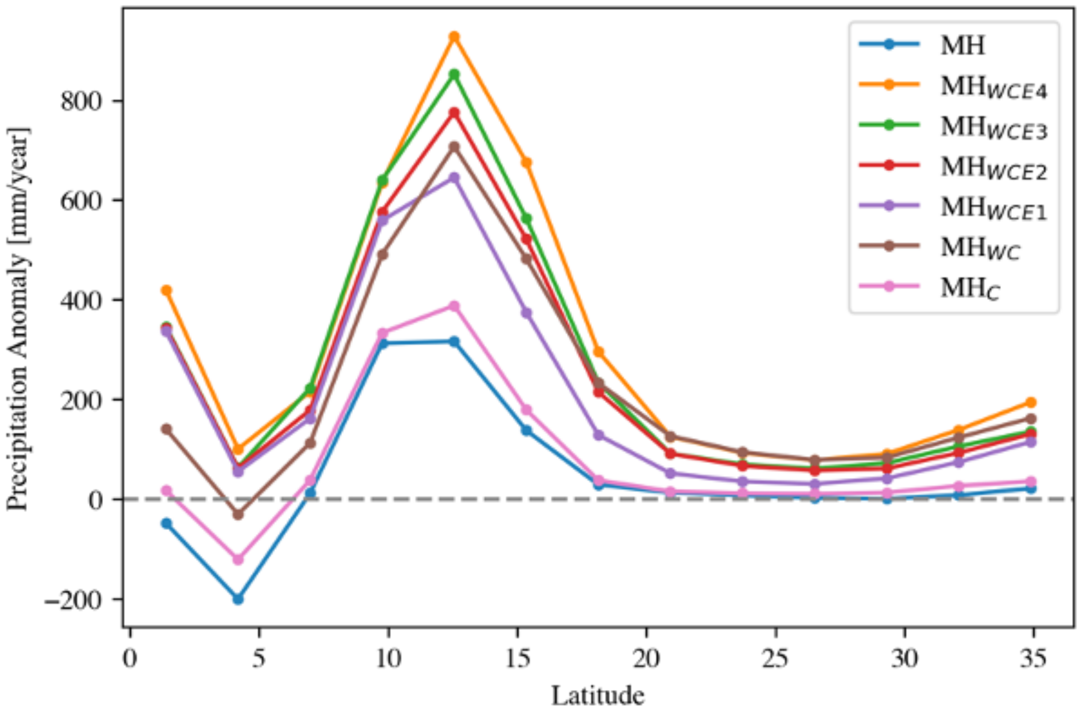


Figure R5. Zonal means, over "North Africa" land [-20°W–35°E, 0–35°N] of annual precipitation anomalies of the mid-Holocene experiments with respect to PI_{ref}.

R2C11: *Line 309: "we suggest that western lakes and Megalake Chad should be located in the WAM regions to induce the monsoon movement" I am not sure what you mean by that. One doesn't get to choose where any lake is located, it is located where it is (or was).*

A: We apologize for any confusion caused by our wording. What we meant to say is that based on our simulation results, we suggest that the presence of western lakes and Megalake Chad located in the WAM region could have had an impact on inducing the monsoon movement in the Sahara region during the mid-Holocene.

The sentence in Section 4 Lines 482-483 has been revised as: "…, we suggest that both the western lakes and Megalake Chad located in the WAM regions may have played a crucial role in inducing the monsoon movement."

R2C12: *Figure S2: For sub-figure (g), how is the lake fraction defined? Is it lake_area_africa/area_global? Or is it lake_area_global/area_global? Why not just use lake_area_africa/area_africa? I don't see the need for anything 'global' in calculating lake fractions as everywhere outside of North Africa the lake map is unchanged. Furthermore, lake fraction in terms of the area of Africa (say north of equator) yields a number that can be better compared to other numbers in the literature. Please also address the sentence on lines 109–110 based on your revision.*

A: Thank you for your comments. In sub-figure (g) of Figure S2, the lake fraction is defined as lake_area_africa/area_global, as we wanted to examine the contribution of the North African lakes to the global lake area. However, we understand your point about using lake_area_africa/area_africa for better comparison with other numbers in the literature. Hence, we have revised the figure caption and labels accordingly.

Regarding the sentence on Lines 145-147, we have revised it as: "The average main lake fraction over the NAf region according to these different reconstructions varies from 1-10 % compared to the total land areas of NAf (Figure S2g)". We have also modified the Figure S2 caption to read: "(g) The fraction (circle size) of all the prescribed lakes experiments compared to the total land areas of North Africa."

R2C13: *Figure S5: The description for sub-figure (b) is wrong.*

A: It has been corrected: "(a) The spatial distribution of six climate regions and (b) The spatial distribution of precipitation scarcity and precipitation surplus over Northern Africa for MH_{ref} experiments."

Technical comments

A: Thank you for bringing up these issues with the grammar and clarity of our paper. We have carefully reviewed the paper and made several revisions to improve its readability and overall coherence. The detailed revisions are as follows:

Line 81: *the hydroclimatic influence of ~~changes in~~ the presence of lakes*

Done (L.105).

Line 82: *two control simulations ~~as reference~~ for the*

Done (L.105-106).

Line 90: *sea surface provided by MPI-ESM-wiso ~~PI and MH simulations .... MIROC-iso~~ (Cauquoin et al., 2019) as boundary conditions for our PI and MH simulations*

Done (L.118-119).

Line 92–93: *It doesn't make sense to say you "found few lakes existed in NAf", because of course very few lakes exist in the NAf today. Please re-phrase.*

A: The sentence in Lines 113-115 has been rephrased as: "In MH_{ref} and PI_{ref} experiments, the presence of lakes in North Africa (NAf) is minimal, using the global lake fraction map from the ETOPO5 as in MIROC5 standard simulations (Figure S1). In contrast, the other experiments show highly varied lake fractions, indicating a much higher lake fraction in those cases."

Line 91–94: *Please move the remark starting on this line (i.e starting from 'Figure S1a shows...') immediately before the sentence on line 87 which starts with 'Each experiment was run.'*

Done (L.113-115).

Line 102: *MH_98 lake map~~s~~ .... with only ~~the~~ Megalake Chad*

Done (L.139).

***Line 107–108**: Please rephrase the line "MH4 accounting...."*

A: The sentence in Lines 144-145 has been rephrased as: "LK4 has the largest lake proportion in the western, eastern, and Megalake Chad regions, and differs from MH2 primarily in its representation of Megalake Chad (Figure S2d, S2f)."

***Line 113:** ~~The~~ Megalake Chad's influence on NAF climate ~~was quantified~~ was assessed using ~~the .....results~~.*

Done (L.152).

***Line 120:** The~~y~~se are ~~reported~~ presented in Table 1*

Done (L.158).

***Line 122:** which are reported in ~~Table 3 of~~ Risi et al 2010.*

Done (L.159).

***Line 134**: component of the vertically integrated*

Done (L.215).

***Line 136:** where u is the ~~horizontal~~ zonal wind*

Done (L.218).

***Line 137:** The meridional component of the vertically integrated*

Done (L.219).

***Line 154:** "verified based on" or "verified in"*

Done (L.246).

***Line 155:** of global MH ~~experiments~~ characteristics using the MIROC-series*

Done (L.247).

Line 196: *What is SM? Soil Moisture?*

A: In Line 299, the term "SM" has been changed to "soil moisture (SM)".

Line 263: *we further ~~estimated the~~ demarcated regions of precipitation...*

Done (L.392).

Line 274: *The ~~boarding line~~ border between regions of precipitation scarcity zones and precipitation surplus zones...*

Done (L.404-405).

Line 288: *Difficult to follow. Please re-write this sentence.*

A: In Lines 437-438, the sentence has been rephrased as: "We used the MIROC5-iso model with different GS lake maps to investigate the influence of Western Sahara lakes and Megalake Chad on the northward movement and eastward expansion of WAM, leading to the humidity in Sahara region."