Review of: Li et al, 2023, Climate of the Past

April 26, 2023

Summary

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.

Major comments

1. 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.

2. 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).

3. 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 $\delta^{18}O$ proxy in all of Africa. It is in no way contributing to the understanding of the effect of mid-Holocene lakes over North Africa.

4. 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?

Other comments

5. 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]?

6. 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.

7. 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.

8. 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 metric.

9. 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.

- Line 239: What radiation is this? Longwave downwelling? Why does it increase with lake fraction?
- I do not follow lines 240–246.
- 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?
- Fig 4 caption: how can the units of radiation be "mm/day"? Where is the vertical axis for radiation data?
- 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.
- Line 264 "implying that ... wetter." this remark does not make sense when read within the full sentence.
- 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'?
- Line 279 What is this inverse pattern?
- Line 280 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?
- Line 283 What inverse warming effect?

10. 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?

11. 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).

12. 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.

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

Technical comments

The paper could use a through examination for grammar and clarity. Here are just some selected instances, but there are several more that I didn't have the time to put here.

14. **Line 81:** the hydroclimatic influence of ~~changes in~~ the presence of lakes
15. **Line 82:** two control simulations ~~as reference~~ for the
16. **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
17. **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.
18. **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.'
19. **Line 102:** MH_98 lake map~~s~~ .... with only ~~the~~ Megalake Chad
20. **Line 107–108:** Please rephrase the line "MH4 accounting...."
21. **Line 113:** ~~The~~ Megalake Chad's influence on NAF climate ~~was quantified~~ was assessed using ~~the~~ .....~~results~~.
22. **Line 120:** The~~y~~se are ~~reported~~ presented in Table 1
23. **Line 122:** which are reported in ~~Table 3 of~~ Risi et al 2010.
24. **Line 134:** component of the vertically integrated
25. **Line 136:** where u is the ~~horizontal~~ zonal wind
26. **Line 137:** The meridional component of the vertically integrated
27. **Line 154:** "verified based on" or "verified in"
28. **Line 155:** of global MH ~~experiments~~ characteristics using the MIROC-series
29. **Line 196:** What is SM? Soil Moisture?
30. **Line 263:** we further ~~estimated the~~ demarcated regions of precipitation...

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

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

References

Patrick J Bartlein, Sandy P Harrison, S Brewer, S Connor, B A S Davis, K Gajewski, J Guiot, T I Harrison-Prentice, A Henderson, O Peyron, Ian Collin Prentice, M Scholze, H Seppä, B Shuman, S Sugita, R S Thompson, A E Viau, J Williams, and Hanbo Wu. Pollen-based continental climate reconstructions at 6 and 21 ka: a global synthesis. Climate Dynamics, 37(3-4):775 – 802, 09 2010. doi: 10.1007/s00382-010-0904-1.

Deepak Chandan and W. Richard Peltier. African Humid Period Precipitation Sustained by Robust Vegetation, Soil, and Lake Feedbacks. Geophysical Research Letters, 47(21), 2020. ISSN 0094-8276. doi: 10.1029/2020gl088728.

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