

Manuscript: Dynamic interaction of lakes, climate and vegetation over northern Africa during the mid-Holocene

Response to Reviewer 2

Major remarks

The authors investigated the effect of large lakes in the Sahel and Sahara on the West African summer monsoon during the mid-Holocene. In order to ensure consistency between the lake expansion and the simulated climate and the associated water balance, they developed a dynamic endorheic lake (DEL) model and implemented it into the atmosphere-land model ICON-JSBACH4. Their mid-Holocene simulations showed that both, lake and vegetation expansion during the mid-Holocene caused a precipitation increase over northern Africa, while the lake-vegetation interaction is somewhat counteracting the overall effect with a relative drying response over the entire Sahel. The study is well written and contributes valuable insights into mid-Holocene dynamics and land-atmosphere interactions over northern Africa.

We would like to thank the reviewer for taking the time to read through our manuscript and for giving us such constructive feedback. Below we will respond to the author's comments point by point. We respond with "Ok." if we would correct the manuscript exactly as suggested.

I have only one major remark that is related to Fig. 11. It shows only relatively small areas where the lake depth is changed. However, the results show a comparatively large effect. Can't it be that the effect is related to natural variability? In order to consider this, you may separate your 150-200 years evaluation period into 30-year time slices and check whether the impact of the lake depth change is a robust feature or has a larger natural variability.

Thanks a lot for your suggestion. Regarding the idealized lake-depth experiment (mH-mHL10) as show in Fig. 11 b) the lake depth, as well as vegetation and lake extent is prescribed and therefore does not change throughout the simulation. We expect that natural variability should not play a role for these results.

However, we will compute the standard deviations of lake depth and precipitation to get an idea whether or not the changes seen in Fig. 11 a) are significant and induce significant changes in precipitation.

I suggest adding a table with regional averages (e.g. Sahel and Sahara) in precipitation for the different experiments that would allow an easy comparison of the different precipitation changes (see also my comment to Line 323-325).

We will provide the regional precipitation averages for the individual basins over northern Africa in an extra table in the appendix.

I also suggest a thorough proof reading as the current version of the manuscript comprises several typos. Below I suggested correcting those I found.

We will correct the typos as suggested.

In summary, I suggest accepting the paper for publication after minor revisions are conducted.

Minor remarks

In the following suggestions for editorial corrections are marked in Italic.

Line 11: ... Basin, the lake area is slightly ...

Ok.

Line 16: ... lake expansion that is dominated by the expansion ...

Ok.

Line 16-18: Sentence is somewhat difficult to read. Please rephrase, e.g. separate into two sentences!

We will rephrase this sentence as the following: "Accordingly, the surface temperature increases over the region of Lake Chad and causes local changes in meridional surface-temperature gradient. These changes in the meridional surface-temperature gradient are associated with a reduced inland moisture transport from the tropical Atlantic into the Sahel, which causes a drying response in the Sahel."

Line 54: ... treated, all previous simulation studies prescribe ...

This statement seems to be too general. I guess you mean studies with GCMs? With regard to hydrology, there are several studies that use climate forcing to simulate lake area expansion in the mid-Holocene, e.g. Coe 1997; Stacke 2011.

Coe, M.: Simulating continental surface waters: An application to holocene Northern Africa, J. Climate, 10, 1680–1689, 1997.

Stacke, T. (2011). Development of a dynamical wetlands hydrology scheme and its application under different climate conditions. Phd Thesis, Hamburg: University of Hamburg. Berichte zur Erdsystemforschung, 99.

Yes, this statement seems to be in fact too general or even misleading and therefore needs to be rephrased. We here wanted to refer to studies that investigated the effect of North African lakes on the mid-Holocene climate using GCM only. We would therefore rephrase the sentence as the following: "Apart from the difference in how the vegetation is treated, previous simulation studies all prescribe the mid-Holocene lake extent over the Sahel and Sahara from reconstructions to investigate their effect on the mid-Holocene climate (Li et al., 2023; Specht et al., 2022; Chandan and Peltier, 2020; Krinner et al., 2012; Broström et al., 1998; Coe and Bonan, 1997)."

We think the suggested citations (Coe 1997; Stacke 2011) would rather contribute to the statement at line 38-41, since these studies focus on modelling the mid-Holocene surface water extent using a prescribed mid-Holocene climate/hydrological forcing.

Line 69: In the end of sect. 1, an outline about the following sections is missing. The last sentence only describes the content of Sect. 2.

We are sorry for the missing outline. We will correct the numbering of the individual sections as follows: 1. introduction, 2. methods, 3. results and 4. conclusions. At the end of the introduction, we will give a brief overview of the following section: This could read as follows:

“In the following methods section, the concept of the dynamic lake model and the structure of the present-day and mid-Holocene simulations is described. In the results section, the simulated present-day lake extent is briefly evaluated by comparing it with observational data. Similarly, we compare the simulated mid-Holocene precipitation increase as well as the lake and vegetation extent with mid-Holocene reconstruction data. Additionally, we look at the individual and synergistic effect of the mid-Holocene lake and vegetation extent on the North African climate and how the depth of the lakes influences the mid-Holocene climate over North Africa. Finally, we discuss our results in relation to former studies in the conclusions part.”

Line 91: ...applied over northern Africa.

Ok.

Line 142: ... concept of the endorheic ...

Ok.

Line 214: ... represented as a mixed ...

Ok.

Line 228: ...orography is used ...

Ok.

Line 242: ... less sensitive to ...

Ok.

Line 245: ... growth and shrinking of ...

Ok.

p.12 – Figure 5 caption – last sentence: It is written: “The black boundary in subplot c) ...” I assume you mean panel d) not c)? In addition, I suggest writing ‘panel’ instead of ‘subplot’ throughout the paper.

Yes, we mean panel d), not c). Sorry for the confusion. We will replace "subplot" with "panel" throughout the document as suggested.

Line 272: Considering these large ...

Ok.

Line 313: ... presence of dynamic lakes in the ICON-JSBACH4 ...

Ok.

Line 324: ... to the total ...

Ok.

Line 323-325: I suggest providing some values (e.g. averaged over the Sahel) to allow an easy comparison of the precipitation changes.

We will provide these information in an extra table or as part of figure A1 in the appendix.

p. 16 – Fig. 8 caption: Simulated a) lake extent changes ...

Ok.

Line 333: In fact, the comparison ...

Ok.

Line 340: ... the different scaling).

Ok.

Line 355 and 357: There are no arrows in Fig. 9c. Please correct!

We realized that Fig. 9b) is systematically referred to as 9c) by mistake. We will correct this error.

Line 373-376: Sentence is too long and difficult to read. Please rephrase into two sentences.

We agree that this sentence is hard to understand. Therefore, we will rephrase it as the following: „This circulation response includes a near-surface easterly wind acceleration above Lake Chad that decreases the inland moisture transport (Fig. 9d-e) and, thus, rainfall at around 12 °N. Additionally, the circulation response includes a dipole-like zonal wind response in the mid-troposphere above Lake Chad that corresponds to a southward shift of the African Easterly Jet (Fig. 9d-e) and, thus, a southward shift of the rain belt’s northern boundary.“

Line 385: However, the simulated ...

Ok.

Line 391: ...contributes a large ...

Ok.

Line 402: ... updrafts, which occurs ...

Ok.

Line 406-408: Sentence is difficult to read and understand. Please rephrase!

We will rephrase the sentence accordingly: “This interaction caused a 3,000-year time-lag between the orbital-forced summer insolation maximum and the maximum lake extent during the mid-Holocene (Lézine et al., 2011b). This time lag is due to the fact that the aquifers over North Africa filled up in the early Holocene until the water table reached the overlying lake basins, leading to the formation of larger lakes. As precipitation over northern Africa decreased towards the end of the African Humid Period, the lake basins continued to be fed by the aquifers and, therefore, regressed with a delay to the orbitally-forced precipitation changes.“

Line 417: ...relates to the known dry ...

Ok.

Line 447-457: This paragraph comprises the same or similar sequence of references several times. Please rephrase and avoid redundant use of the same references if possible.

Line 465: ... over northern Africa.

Ok.

Line 466: ... effect of exorheic ...

Ok.