Reply to Comments of Referee 2 to the Manuscript of Jungandreas et al. "How does the explicit treatment of convection alter the precipitation-soil hydrology interaction in the Holocene African humid period?"

Thank you very much to the very helpful comments!

General comments

My main comment is about the presentation of the implications of the results, which are very relevant for the modelling of the GS. The main finding of the paper highlights the importance of considering the precipitation-soil moisture interaction when high resolution simulations are used. I have the impression that this is not sufficiently highlighted in the abstract and in the introduction, when the objective of the paper is stated.

For instance, in the abstract the authors could add a few lines to briefly explain how run-off influences soil moisture instead of referring to a previously published paper. And make a more logical link with the following sentence.

Similarly, in the Introduction, after the description of previous results by Jungandreas et al. (2021), a clear statement is needed of what is missing in the previous paper and what the present paper aims at.

We will modify and improve the abstract and the introduction.

Specific comments

L14: I don't understand how to connect the conclusions on the role of precipitation type in this sentence with the conclusions on the role of soil moisture in previous sentences. Please make a clearer logical link.

We will reformulate the last paragraph by mentioning the results found in the simulations with constant soil moisture in the previous paragraph and by more clearly explaining the meaning of the constant-soil moisture simulation. We begin a new paragraph with the sentence starting in line 14, which summarizes not the discussion regarding the simulations with constant soil moisture, but the overall result of our study.

L82-87: I believe that you should not summarise here your findings. You could outline here the content of the next sections.

We can reformulate the introduction by shortening the text as suggested.

L110: why do you use 5 km for simulating explicit convection? Usually in CPM/storm resolving setups, 2-3 km resolution is used. Running the simulations at higher resolution would change your results?

We had to limit the downscaling simulations to maximum 5 km as the finest horizontal resolution because of computational restrictions. We do not expect qualitatively different results, when going to a finer spatial resolution. First, our simulations at 10km horizontal resolution (using resolved and parameterized convection, respectively) yield not the same, but very similar results. Second, the large mesoscale convective systems of the West African monsoon can be nicely resolved using models with 5km horizontal resolution.

L130: this sentence is unclear to me. Do you simulate land cover by using IFS or do you use the same land cover used in IFS (as I guess)? Please clarify.

We checked this again carefully: We use present-day land surface cover generated by the German Weather service (DWD) by combining GLOBCOVER2009, Harmonized world soil database (HWSD), GLOBE & Lake Database. We will revise this in the manuscript explicitly.

L132-135: I don't understand how you use MPI-ESM Holocene simulations, desert fraction and the present-day vegetation to build your GS land cover. Please rephrase and clarify.

The present-day land cover is the same as the one used by the land model TERRA, which is used by the DWD for their weather forecast.

The MPI-ESM performed 6000 year-long transient Holocene simulations with dynamic vegetation cover. One minus the (dynamic) vegetation fraction gives the desert fraction during the mid-Holocene.

We use this desert fraction to know how far north vegetation reached and to determine the main vegetation gradient for our GS-simulations i.e. the lower the desert fraction the higher the vegetation cover. The vegetation gradient we prescribe in our GS-simulation consists of five vegetation types: closed broadleaved evergreen forest , closed to open shrubland, closed to open herbaceous vegetation, sparse vegetation and bare area (desert)(see Fig.2b and d).

However, a specific present-day vegetation type cannot always be transformed into the same GS-vegetation type.
For example: present-day deserts can be transformed into close broadleaved evergreen forest or sparse vegetation in our mid-Holocene simulations, depending on the latitude or region you are looking at. Therefore, we cannot only use the desert fraction to prescribe mid-Holocene vegetation cover, but also need to specify the present-day vegetation type in each grid cell and its location.

We will clarify this part in a revised manuscript.

L144: which version of ERA? ERA5?

Yes, we use ERA5. We will mention this explicitly in a revised manuscript.

L182: in the discussion of the changes in the heat fluxes at the surface, you mention the changes in cloud cover, which are not presented anywhere in the paper. A figure is needed to illustrate cloud cover changes.

We will add a figure in the Appendix.

L187: moisture is not limited with regard to what? Do you mean "abundant"? Please clarify.

Yes, moisture is not limited so that evapotranspiration is not hampered. We will clarify this.

Section 3.1.2: a map showing the differences in the lon-lat projection would be helpful in illustrating the changes in horizontal transports.

We will add a map of horizontal moisture transport in the Appendix.

L243: please add brief descriptions of CAPE and CIN.

We will add a brief description.

L246: LFC is not defined.

We will define it in the revised manuscript.

Section 3.1.4: this section is not very clear in my opinion. At L252, you state that the increase of vegetation in the coastal region leads to a decrease of precipitation, which I find rather counterintuitive. I'd say that the decrease in precipitation is mostly lead by the change in the thermodynamical gradients due to the dramatic increase in vegetation in the Sahara-Sahel, in turn leading the changes in the dynamics, which you also highlight at the end of the section. Please rephrase to clarify these aspects.

That is correct, the decrease over the coastal region is mainly caused because of the dynamical shifts of the monsoon further north.
We will clarify this in the revised manuscript.

Technical corrections

L75-78: the sentence does not read very well, please revise the location of commas.

L150: We.

L335: please check this sentence, something is wrong/missing.

The technical corrections will be implemented in the revised version.