Climate of the Past Discussions

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Comment on cp-2021-17

Anonymous Referee #1

Referee comment on "Mid-Holocene monsoons in South and Southeast Asia: dynamically downscaled simulations and the influence of the Green Sahara" by Yiling Huo et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-17-RC1, 2021

The authors use dynamically downscaled simulations to assess the impact of a vegetated Sahara on the South Asian and Southeast Asian monsoon region under mid-Holocene (MH) greenhouse gas (GHG) and orbital conditions. They couple the regional climate model WRF with the regional ocean model CROCO and drive this coupled model by output of the global model UofT-CCSM4 GCM. An ensemble of experiments is conducted using different convection schemes in WRF and different PI and MH boundary conditions.

Due to a better representation of the complex orography in South and Southeast Asia, the regional precipitation and temperature distributions are resolved in more detailed in the regional model. The MH forcing leads to an enhancement of the monsoon systems and an increase in precipitation in northern South and Southeast Asia. On the Indo-Chinese Peninsula and on the Tibetan Plateau, precipitation is rather decreased. The MH forcing furthermore leads to shifts in the monsoon season. In both areas, the monsoon onset is delayed and the withdrawal is postponed. Anomalies due to the MH forcing are generally more pronounced in the regional model than in the global model and show a better agreement to pollen-based reconstructions. However, both models are not able to capture the reconstructed mid-Holocene precipitation pattern in South China and the dry central Asian regions.

The incorporation of a vegetated Sahara enhance the precipitation response to the mid-Holocene orbital and GHG forcing and generally leads to a positive precipitation anomaly in South India, along the northern flank of the Tibetan Plateau and in North China beeing more in line with the pollen-based reconstructions. In addition, the simulations with Green Sahara only show a sligth shift in the monsoon season compared to pre-industrial times.

The authors have taken great effort to compare the regional and global model simulations. They visualise their results with many, easy-to-read illustrations, which are described in detail and comprehensibly in the text. Unfortunately, however, the analysis rarely goes beyond these descriptions. Results are not quantified and not analysed in detail. Also, with

the large number of illustrations and descriptions, the main guiding question about the influence of the green Sahara on the monsoons in the regional model is lost. I also miss a comparison with results of model studies (regional and global models) that have already been carried out on the Asian monsoon during the mid-Holocene. Since the core question is very interesting and the study could make a major contribution to better understanding and quantifying the interactions between the West African and Asian monsoons, I still recommend considering publishing the manuscript. However, major revisions are needed.

Main comments to the authors:

a) I understand that the monsoon precipitation distributions may strongly be influenced by the convection scheme in the model, since most rainfall stems from convective cloud cluster. However, in the context of this study, a comparison of the simulations with the different convection schemes seems to me to be too extensive. It is more a ‚disruption‘ than a significant contribution to underline the core message. Perhaps one could simply discuss an ensemble mean from the simulations in the main text and, for example, include the uncertainties in plots about the precipitation mean over the two regions. A comparison of the different simulations could then be presented in the supplement or appendix. Omitting the comparison would also help the paper to focus more on the main question.

b) It is useful to compare the results with palaeo-reconstructions. Since the pollen-based reconstructions cover a larger spatial variability, it makes sense to concentrate on these reconstructions and not to discuss the cave records. On the one hand, it is still not entirely clear what the cave records recorder at all (whether changes in wind direction or changes in precipitation), and on the other hand, they are located very unfavourably, precisely on the border between positive and negative anomalies in the model. In the meantime, there is also a new pollen-based data set by Herzschuh et al. (2019) that mainly covers China. It would be interesting to see whether the deviations from the models to the reconstructions also show up in a comparison with these new reconstructions. Please use a metric to quantify your findings. Just per eye it can hardly be seen that e.g. the regional model fits better to the reconstructions than the global model for Mh_{ref}.

(reference: Herzschuh, U. et al.: *Nature Communications*, *10*: 2376, 2019 doi:10.1038/s41467-019-09866-8).

c) I think you could reduce the number of figures. For instance, you could show the SST and continental surface temperatures in one plot (Fig. 4 + 5). You could show the topography of both models together with the names of the geographical regions. Please think about which plot is really necessary and which do not help to underline what you want to say in your paper.

d) The paper would benefit on a detailed discussion which processes are connecting the Green Sahara and South and Southeast Asia. Please already summarize in the Introduction, why the land-surface in North Africa may affect the Asian monsoon, how this teleconnection work and which dynamical circulation systems may be involved. To me it is e.g. not clear, why a greener land-surface outbalances the monsoon season shifts seen in the MH_{ref} simulation. It would e.g. be helpful to show and discuss the precipitation pattern and the atmospheric circulation in the global model for the entire region, North Africa + South/Southeast Asia.

e) The Introduction is very detailed, but you present a lot of information that is not really necessary to understand your paper (at least one has the feeling that it does not help to understand the paper). I recommend to re-structure the Introduction and pushing the individual parts more towards the main topic. For instance, in the first part (ll. 30 to 42) you stress the importance of the Tibetan Plateau on the Asian monsoon. Afterwards you talk about the population. I think, it would be more target-oriented to connect the importance of the Tibetan Plateau with the need to use a high spatial resolution in climate models to better represent the effect of the Tibetan Plateau on the monsoon. In global models, the Plateau is usually very flat, so why should global models capture the effect of the Plateau on the regional circulation? And this is one reason why it is so important to downscale the simulation.

Try to shorten the Introduction by beeing more precise and always keep your main topic in mind. You want to „convince" everybody that it is necessary to use regional models to analyse and understand the effect of a Green Sahara on the South and Southeast Asian monsoon. It is also important to highlight the advantages of the regional model for analysing the effect of the Green Sahara on the South and Southeast Asian monsoon.

f) Some sentences are really long. Please try to keep sentences short (e.g. ll 13.-17)

g) It is often annoying when too many methods are not explained, but instead reference is made to other articles. Please think about explaining the main methods and giving essential informations on the models directly in this paper.

Minor comments:

L 22: Decreased surface temperatures during mid-Holocene monsoon seasons may to a large part also result from the evaporative cooling of the surface due to enhanced precipitation.

LL81-92: This method part could be shifted to the end of the Introduction. It disturbs the story here.

L.93: The Green Sahara is not only a ‚climate difference'.

L.155: It is not clear if you name the regional simulations or global simulations or both with $MH_{Ref.}$

L. 159: I somehow miss a description of the land-surface conditions in Asia. Are they also prescribed according to mid-Holocene climate conditions? Does the global model includes dynamic vegetation? East Asia is also greener during mid-Holocene and this also affects the Asian monsoon circulation.

L. 186-189: You could check if SST records are available for the region and if they indicate the same pattern

L.203: Please explain!

L.211-213: ‚most of SA experiences wetter climate...' In the plot most regions are yellow which means reduced precipitation during MH.

L.221: ‚substantial differences between global and regional model...attest to the importance of high resolution modeling….' Both models more or less agree to the reconstructions, but it is not clearly visible which model performs better.

LL.224-228:Why do increased temperatures downstream of the monsoon circulation result in more precipitation, please explain!

L.239: Please discuss the change in East Asian monsoon circulation and its effect on the precipitation in East China.

L.244-245: it's ‚Fig.6a and 6b'

L.245: Speleothems do not always recorder total precipitation.

L.260-272: I would delete this part or move it to the Appendix.

L.273: It's Figs. 6c and 7f.

L.308: Please explain the consequences of a reduced cooling over the northeastern Arabian Sea and southern BOB.

L. 356: Please also discuss the large-scale circulation, including Northern Africa.

L. 436: The changes in precipitation as response to the Green Sahara forcing may also feed back to the South and Southeast Asian monsoon circulation. Please comment on this.

Fig. 1: You do not really need this figure since you hardly explain it.

Fig. 3: The black contours are difficult to see. The monsoon circulation is also determined by the cross-equatorial temperature gradient and the SSTs in the Southern Indian Ocean. Please explain, if this fact affects your results infered by the regional model that does not include these areas.

Fig. 8c) It seems that in both regions the MH_{GS} simulations reveal higher temperatures year round (or at least during most of the year) compared to the $MH_{REF.}$ Please explain why and how this affects the precipitation distribution.

Fig. 9c) Why is the precipitation increased in MH_{GS} in the post-monsoon season. It would be helpful to show an anomaly plot MH_{GS}-$MH_{REF.}$

Fig. 11E: heading: it is SEA instead of SA

Fig.12: Please also show the global model results and the circulation changes over Northern Africa.