Climate of the Past Discussions

Clim. Past Discuss., referee comment RC1
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Comment on cp-2021-16

Anonymous Referee #1

Referee comment on "Mid-Pliocene West African Monsoon rainfall as simulated in the PlioMIP2 ensemble" by Ellen Berntell et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-16-RC1, 2021

The authors investigate the climatic changes in the West African monsoon area during the mid-Pliocene warm period. For this purpose, they use the ensemble of climate simulations for Pliocene and pre-industrial times conducted in different models within the PlioMIP2 project. They analyse changes in precipitation and circulation, including the surface temperature, sea level pressure and the monsoon flow.

Since the mid-Pliocene warm period may be an analogue of near-future climate states, the results are related to possible future climate scenarios inferred by the CMIP5 project and are additionally set in the context of different model sensitivities.

The ensemble indicates a robust enhancement of the West African monsoon during the mid-Pliocene warm period. The monsoon rainbelt penetrates deeper into the Sahara desert than at pre-industrial times and the monsoon withdrawal is delayed. In contrast to the CMIP5 simulations that show regional differences in the rainfall response with a drying in the western Sahel, the PlioMIP2 ensemble presents a regional uniform rainfall increase north of approx. 7°N. This anomaly pattern is robust among the models, but they differ with respect to the strength of the rainfall increase.

The authors have carefully analysed the model simulations and presented the results clearly, precisely and comprehensibly. The topic was very well introduced and placed in the context of current research. The focus and main aims of the study were clearly formulated and the manuscript was logically organised and well structured. I fully recommend the publication of the manuscript in Climate of the Past and have only minor comments:

a) The main explanation for the increase in monsoon precipitation is seen in the increased atmospheric CO2 level in this study. However, the modern atmospheric CO2 content is at

the same level and observations show a precipitation band in North Africa that does not extend very far north and also nowhere near as high precipitation rates as shown in this study for the mid-Pliocene. The question therefore arises as to what extent other causes might be (at least partly) responsible for the area-wide increase in precipitation. It would be helpful to introduce and discuss other boundary conditions that may affect the monsoon rainfall. Land surface changes are only briefly addressed. These certainly contribute to an increase in precipitation, but are there other factors? In this context, I would suggest showing a map with the prescribed vegetation pattern and maybe also a map for the vegetation anomaly simulated by COSMOS. And I recommend to discuss the vegetation influence in more detail.

b) Some parts of Africa receive significantly high amounts of precipitation during June and also during October and some of the models simulate a strongly increased precipitation at mid-Pliocene during October. I understand that, with respect to the analysis of the monsoon flow etc., the core summer monsoon season is taken for the calculation of the mean distributions. But, I think the prolongation of the monsoon season is one of the most interesting aspects in the results. Therefore, I recommend to either include both month (or at least October) into the mean, or (if the atmospheric dynamic is significantly different between October and JAS) to present and discuss additionally a plot on the October precipitation and atmospheric circulation.

specific comments:

L73: model studies or reconstructions?

Fig.1: The different colours are not easy to distinguish, maybe you can think about using different line types for similar colours. In the right panel, the line for the observation can not be seen, it would help to plot the MMM and modern line on Top of the others.

Fig.1: One of the most interesting question is the WAM progression into the Sahara desert. Please think about including also a seasonal cycle plot for the Sahara (e.g. 20°N-30°N, 20-30°E).

Fig.1: In the modern precipitation distribution, the isohyets are tilted, i.e. on the same latitude, rainfall is higher in the western part than in the eastern part of North Africa. Due to this, the region used for analysing the seasonal cycle is often limited to 10°W-10°E.

L129: I'm not sure about the quality of the CRU TS v4 data for the early period (1901-1930), because weather stations and the data coverage was and is still very rare in this region. Maybe you can check if there are large differences to the 1960-1990 period, and if you can see interpolation residues.

LL143-151: For better comparison, you could mention the observed PI rainfall rate.

Fig.2: The colours of the colour-bar are difficult to distinguish and it is not entirely clear which colour stands for which value. The pattern correlation value is very small. You could save space in the panel plots by omitting the coordinates in the individual plots. The land sea mask can be used for orientation and the coordinates can also be estimated from the MMM plot. This would make it possible to enlarge the plots without increasing the size of the overall plot.

Fig.2: I think it would be interesting to discuss and analyse in more detail, why some models produce a very strong increase in rainfall and some do not. Is there a relationship to the prescribed boundary conditions or specific model physics. Is it just the sensitivity?

L159: WAM instead of WAS?

Fig.3: Please define the region "Sahel" again in the caption of the plot so that you can read the plot without reading the other figure captions or the text.

L226: the word 'anomalies' is doubled.

Sec. 4.2: I think the pattern correlation for the modern precipitation distribution is not the best way to prove and summarize model performances, because North Africa has a very zonal and uniform precipitation pattern. Are there any climatic reconstructions that could be used to estimate whether the precipitation distribution calculated for MMM is correct and the increase in precipitation is of the right order of magnitude?

L.327: "...our results support a future strengthening of the WAM and rainfall increase over West Africa and Sahel in a high CO2 scenario." I think that it is not necessarily possible to conclude from the analyses for the mid-Pliocene warm period how the WAM will change in the future. The future will experience much higher CO2 levels and it is not guaranteed that this will lead to a permanent expansion of vegetation. This depends on very different factors.