Clim. Past Discuss.,
https://doi.org/10.5194/cp-2019-86-AC2, 2019

Interactive comment on "The end of the African humid period as seen by a transient comprehensive Earth system model simulation of the last 8000 years" *by* Anne Dallmeyer et al.

Anne Dallmeyer et al.

anne.dallmeyer@mpimet.mpg.de

Received and published: 18 October 2019

We thank Referee#2 for carefully reading the manuscript and helpful comments that improve the manuscript.

Summary: The authors present analysis of the African Humid Period (AHP) in a transient earth system model simulation of the mid to late Holocene. They focus on characterizing and understanding the termination of the AHP (wet to dry transition) across northern Africa. They show that wet mid-Holocene conditions were primarily confined to western and central regions of the Sahara, and that the transition to present-day aridity in these regions was time transgressive, consistent with proxy interpretation. Based

on analysis of modeled daily precipitation events and subtropical jet stream characteristics, they find that tropical-extratropical interactions in the form of tropical plumes enhanced mid-Holocene rainfall in western regions of the Sahara, prolonging wet conditions there. The tropical plume hypothesis helps to explain the spatial differences in AHP termination date across the Sahara. The paper adds to our understanding of the AHP in two important ways. First, it confirms earlier hypotheses and simplified modeling results that tropical-extratropical interactions shaped the AHP using an advanced, state of the art coupled climate model simulation. Second, it presents the tropical-extratropical interaction mechanism in the context of the spatially and temporally heterogeneous termination of the AHP. The analysis is well done and straightforward and the manuscript is well-written. I recommend the manuscript be considered for publication in Climate of the Past, and only have a few minor comments for the authors.

Minor comments

R: Please discuss the suitability of the T63 resolution for studying tropical plumes. Can MPI-ESM1.2 accurately simulate these fairly narrow, transient events?

A: In T63 (i.e. approx.1.875° on a gaussian grid), clouds can not be resolved. Cumulus convection is parametrized. Thus, tropical plumes - in their original meaning – may not be accurately represented in the model, but the typical atmospheric circulation and the precipitation pattern associated with tropical plume events can be simulated. To demonstrate this, we have included and discussed Fig.6 in the original paper which shows a strong event in the model simulation.

R: There are several instances when the authors reference Skinner and Poulsen (2013), but the reference should be Skinner and Poulsen (2016).

A: Thank you. This was indeed a mistake.

R: Lines 148-149: Please provide evidence (references) that the use of the bare soil fraction is an appropriate indicator for moisture availability in the Sahara. I imagine that this depends strongly on the dynamic vegetation module.

A: Following the suggestion of Referee #1, we included a short description of the vegetation dynamics in JSBACH in the revised version of the manuscript. There, we explained the calculation of the BSF, which strongly depends on the NPP of the PFTs, which in turn is a function of the moisture availability.

R: Can you provide a discussion of why the Eastern Sahara does not see a substantive increase in precipitation like the Western Sahara in MPI? Why does the monsoon enhancement remain constrained to the west? This is the opposite of what we see in CMIP5 projections for the 21st century in response to elevated GHG forcing, so it may have relevance for understanding future climate.

A: In our simulation, the precipitation enhancement during Mid-Holocene is not constrained to the Western Sahara. The precipitation and vegetation cover is also increased in the Eastern Sahara, except for the Libyan Sand Sea which presumably remained a desert in the mid-Holocene according to reconstructions. The western part experiences a much stronger increase in precipitation and vegetation which can be explained by the fact, that the West African monsoon system is mainly active in the western part of North Africa, for instance, the Saharan heat low is located in the western Sahara. The isohyets are strongly declined in North-west to South-east direction. Furthermore, the orbital forcing and the GHG forcing differ, leading to different response pattern (see e.g. Claussen et al. 2003 or D'Agostino et al. 2019).

Claussen M., Brovkin V., Ganopolski A., Kubatzki C. & Petoukhov V. (2003): Climate change in northern Africa: the past is not the future. Climatic Change, 57 (1), 99 –118.

D'Agostino, R., Bader J., Bordoni S., Ferreira D., Jungclaus J. (2019), Northern Hemisphere monsoon response to mid-Holocene orbital forcing and greenhouse gas-induced global warming, Geophys. Res. Lett. doi: 10.1029/2018gl081589.

R: Line 407: The authors reference a Figure A4, but it was not included in the draft.

A: We changed this reference to Fig.10.

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2019-86, 2019.