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Climate of the Past Discussions

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.

Anonymous Referee #1

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This paper discusses the general atmospheric circulation patterns that led to a time-transgressive termination of Green Sahara conditions in their 7850-year transient simulation with MPI-ESM1.2. The paper is well-written, carefully organized, and very detailed. The scientific questions addressed in this paper are well-motivated and the results are logically laid out and backed by supporting evidence. The findings of this paper present important conclusions and significant advances to our understanding of climate dynamics that contributed to the end of the African Humid Period.

The main result from this study is an assessment of the atmospheric circulation changes that brought about regionally diverse terminations of the African Humid Pe-

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Discussion paper

riod between 8ka and the Pre-industrial era. The authors highlight that changes in West African monsoon dynamics and occurrence of extratropical troughs are the dominant mechanisms by which local regions experienced an end to humid conditions during the Holocene. The description of their transient Earth system model simulations is detailed and clear, with the exception of their description of how vegetation is treated by the model, which is covered in greater detail below.

This paper significantly contributes to the field of Holocene African climate dynamics, and I certainly recommend it for publication. However, I have listed some clarifications and modifications below that will help strengthen the quality of this publication.

Page 4, Line 110 and 3.2 Vegetation distribution: One challenge of using a transient climate simulation with dynamic vegetation during the African Humid Period is ensuring that the vegetation-climate interactions are being simulated accurately and that the vegetation does not die off or grow too rapidly. It appears that these simulations have successfully simulated African vegetation throughout the last 8ka; however, there needs to be more detail here on how vegetation is treated in the model. What was the initial condition used for vegetation in North Africa at the start of the climate simulations (at 8ka)? What are the moisture thresholds for changing between vegetation types and ultimately drying out the land surface for an end to the AHP? Vegetation is incredibly important for simulating Holocene North African hydroclimate, so it is important to add these descriptions either to the Methods or in 3.2 Vegetation distribution. These details may be present in some of your cited literature (e.g., Dallmeyer et al., 2019 or Bader et al., 2019), but I believe it necessary to include the important details here in this paper as well.

Page 4, Lines 125-128: When discussing the orbital-induced insolation changes taking place in the transient simulation, it would help for understanding of the simulation setup to explain how often these vary. Are the values changing year-to-year (so year 7001 has very slightly different values than 7002) or are they fixed values for a certain time span (i.e. step-wise changes; fixed orbital values for years 7001-7050 then different

values for 7051-7100)?

Page 4-5, 2.1 The transient simulation: In addition to added detail regarding model treatment of vegetation, it is important to understand how the model was spun-up for a simulation start at 8ka. Please add a brief description of the process undertaken to spin-up the model in Section 2.1. Again, this information may be present in Bader et al. (2019), but I believe that mention of this process is important for clarity on model setup.

Page 5, Line 143-144: I understand that the periods 7k, 5k, 3k, and 0.3k are selected as periods with low volcanic activity; however, they also seem to provide and be used as a four-part snapshot of decreasing orbital precession and North African humidity. It may be useful to add further description on the use and motivation for using these time-slices to analyze changes in atmospheric circulation throughout the transient simulations.

Page 6, Lines 166-167: The following sentence was somewhat ambiguous to me: “In a few cases, records that were deemed too short to properly identify the decline in precipitation (i.e., because of deflation), were excluded.” If I understand this correctly, this sentence is describing that there are too few data points available in these records to identify a robust decline, so therefore these records were not used. If this is not the intended purpose of this sentence, please update to improve clarity.

Page 9, Lines 260-261: The phrase “In the region north of 7°N” is somewhat ambiguous for this calculation. I recommend you make this region more well-defined so it is clear where this calculation is taking place.

Page 10, Lines 316-319: The bipolar convergence pattern is somewhat difficult to discern in Figure 8, especially because the listed reference (Fig. 8a) is not a difference plot. I would recommend adding description to this section to more clearly define where this bipolar change is occurring – either by including a description of a well-defined region or by placing a dotted box in Figure 8c, which appears to be the difference plot

being referenced.

Page 14, Lines 430-434: Instead of describing that “The AHP . . . is still present in pre-industrial times”, could the description instead state that parts of this equatorial region are not impacted by the orbital precession-fueled swings in monsoonal rainfall, like the other listed regions are, due to the fact that its rainfall comes from a variety of patterns, only one of which is monsoonal? This is just a suggestion that may make this section read more smoothly.

Figure 3: Showing how types of vegetation evolve in four different grid cells throughout the transient simulation is a very interesting way to analyze how the AHP termination varies! The grid cells chosen here are clustered in a fairly small meridional arrangement, however. It might be more informative to expand these grid cells to show this same vegetation time-evolution for grid cells further north and further south to provide more context of vegetational changes. However, if these do not provide novel vegetation change results, then this would be unnecessary.

Figure 3: d) shows the simulated minimum desert fraction during the Holocene, but it is unclear at what point of the simulation this distribution comes from. I would suggest that a description is added to define when this distribution occurred.

Figure 4: The explanation of c) – e) is somewhat confusing. I interpreted this as - c) Model: orange dots experience AHP end first (before all other colors) and green dots last (after all other colors) - d) Records: orange dots experience AHP end first (before all other colors) and green dots last (after all other colors) - e) Orange dots are where the Model dots were earlier than the Record dots, Green/Blue dots are where the Model dots were later than the Record dots, and grey dots are where the Model and Record dots were the same. If this interpretation is correct, one suggestion for improving clarity could be to add a different color bar for e) so the absolute and difference plots do not have the same color bar. This may make the colors of the dots more intuitive and help understanding.

Purely technical corrections are listed below:

Page 2, Line 50: “Neeling” should be changed to “Neelin”, I believe.

Page 7, Line 212: There is a reference to BIOME6000, Harrison, 2017. However, I was unable to reconcile this in-text citation with the References at the end. Please update the citation in the References. Perhaps this is supposed to be Harrison, 2014? Or a paper not listed?

Page 10, Line 315: There is a reference made to “Fig. 8b” here, but the previously stated description does not appear to be in reference to what I see in Figure 8b. I believe it may be in reference to Figure 8e instead?

Page 13, Line 407: There is a reference to “Fig. A4”, but this figure does not appear in the paper. Please update this reference.

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