

Clim. Past Discuss., referee comment RC1
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Comment on cp-2021-75

Anonymous Referee #1

Referee comment on "Effect of nitrogen limitation and soil biophysics on Holocene greening of the Sahara" by Jooyeop Lee et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2021-75-RC1>, 2021

Review of "Effect of nitrogen limitation and soil processes on mid-Holocene greening of the Sahara" by Lee et al.

In this work Lee et al. present a range of numerical modelling results aimed at investigating the effects of nitrogen limitation and soil processes on the vegetation expansion in North Africa during the mid-Holocene. This is an important question as the authors demonstrate they would have contributed significantly to the greening of the Sahara.

The authors used an advanced ESM, while the model configuration may have some flaws. Multiple global simulations of 8000 years ago were performed with different model set-up targeting different combinations of soil carbon, nitrogen, and lake area, etc. Some simulations require additional model input such as the mid-Holocene soil carbon and nitrogen in North Africa, and the authors have made plausible assumptions.

The results highlight the albedo- and evapotranspiration-precipitation feedbacks related to soil biophysical properties and soil nitrogen limitation, and they can potentially explain why current ESMs fail to realistically simulate a Green Sahara.

I think this is an interesting study and it is easy to understand its scientific message. However, I suggest some points, mostly regarding the methodologies, be addressed or be clarified before it is considered for publication, as follows.

1. I feel the MH period that is used in this study (8 ka) should be more clearly stated in

the title or abstract. Since 8 ka is a less common model setup compared to 6 ka, some limited efforts would be beneficial to the modelling community to quantify the differences in climate/ecosystem response between 8 ka and 6 ka.

2. The term "Earth system model" (widely used in the text) is confusing. As I read in Sec 2.2, there is neither description on the ocean/sea-ice model component that was employed, nor how the ocean state was prescribed. The authors might have used a model configuration of only dynamic atmosphere and land surface, which can cause serious caveats. Ocean dynamics plays an important role in amplifying the orbitally induced strengthening of WAM (e.g. Braconnot et al. 1999).

3. The model spatial resolution (4 deg in N-S direction) is very coarse. For a range of the whole simulations, the vegetation extent only shifts a few gridcells (e.g. only one gridcell from extreme cases of 0K to 8KCNS, no shift from 0K to 8K or from 8KCN to 8KCNS). With such a coarse resolution, is the division of three boxes (the overlap takes up half of the box) necessary? Is it feasible that the authors repeat some representative simulations (e.g. 8K and 8KCNS) with higher resolution? Also, how can the authors estimate 2 deg shift (Line 192) from 4 deg model output?

4. It is quite puzzling as the authors reported that the model does not simulate increased vegetation fraction or GPP even with increased precipitation in 8K (Fig. 4). Are the vegetation fraction, GPP and dominant land cover type annual mean or JJAS mean (not clearly stated for soil water, albedo, etc.)? Could there be a mismatch? Could it be related to the coarse spatial resolution? It is also not easy to understand when the dominant land cover type is unchanged as bare soil, the vegetation fraction and GPP changes over these gridcells can be quite large (e.g. Fig. 4 8K vs. 8KCN).

5. It can be more informative for earth system modelers if the authors can do an estimate for the relative contribution from each process to the greening of North Africa. It should not be difficult if the authors create an index to quantify the vegetation condition within a box and assume all the factors (MH boundary conditions, soil texture, nitrogen limitation) can be added up linearly.

Technical:

L32 platform -> example

L33 respects -> aspects

L101 iss -> is

Fig. 8f Please explain more on the sand fraction used here.

Ref:

Braconnot, P., Jousaume, S., Marti, O., & De Noblet, N. (1999). Synergistic feedbacks from ocean and vegetation on the African monsoon response to mid-Holocene insolation. *Geophysical Research Letters*, 26(16), 2481-2484.

