Climate of the Past Discussions

Clim. Past Discuss., author comment AC2
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Reply on RC2

Huan Li et al.

Author comment on "Comparison of the green-to-desert Sahara transitions between the Holocene and the last interglacial" by Huan Li et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2022-27-AC2, 2022

Reply to reviewer # 2 (Qiong Zhang)

We thank the reviewer for providing constructive comments on our manuscript. Below we have replied to all her comments (in italic font).

- There are more proxy evidence on the green Sahara during Holocene, while less reporting on a green Sahara and the abrupt transition from green to desert during LIG from the proxy aspect. Line 85 cited three papers on such evidence, it would be good to provide more detailed information on their findings , such as what kind of proxy, the location and what do the data imply.

REPLY: This is a good point; we will provide in the revised manuscript the information proposed by the reviewer.

- In model description, more information on the physics of the atmospheric model ECBilt should be provided, since the manuscript mainly discuss the changes in precipitation. When coupled to the LPJ-GUESS module, it also uses could cover as one climate input, the description on relevant physics such as the cloud and convection of the model would be helpful to understand the simulated precipitation and climate and how they further influence the vegetation simulation. For the model resolution T21, would be good to provide the grid distance in kilo-meters as a reference to paleoclimatologist who are not familiar with the spectral grid.

REPLY: Much of this information was provided in our previous paper Li et al. (2020), but we agree with the referee that more information on ECBilt and the coupling to LPJ would be useful for the reader. We will provide this information in the revised manuscript.

- For the coupling to vegetation model, climate input for LPJ-GUESS is the monthly mean, while VECODE uses annual mean temperature, precipitation and GDD0 (Line 132). We know that the changes in seasonality due to orbital forcing are the major cause for changes in African monsoon, the authors need to comment the potential effect by using annual coupling with dynamic vegetation model VECODE.

REPLY: We thank the reviewer for this suggestion. In the revised manuscript, we will discuss the potential impact of using annual temperature and precipitation as input for VECODE. Please note that VECODE receives some seasonal information through the GDD0 *(growing degree days above 0°C).*

- In line 150, it is mentioned that pre-industrial vegetation from the CMIP LUH2 dataset is upscaled and used as the prescribed vegetation in PI_FIX, it would be helpful to show this pre-industrial vegetation map, and mention what information from the vegetation map is read by the ECBilt (albedo, evaporation?). Also good to compare this vegetation pattern with the simulated ones in PI-VEC and PI_LPJ, this would help to image and understand the changes in vegetation cover in Fig3.

REPLY: We will include one or two maps showing the PI vegetation used in the experiments with fixed vegetation. The vegetation maps are used to infer land surface albedo and the maximum water volume in the bucket model.

- When present the area averaged vegetation cover and climate parameters for north Africa in Fig1 and Fig2, should mention the domain for the average. If they are averaged over the entire region north of equtor showed in fig3, it includes the equatorial African region and African monsoon region, which are known as wet and vegetated even today when Sahara is desert. One might wonder what happens in these regions from 121K when vegetation cover is close to zero in Fig2, even equatorial and monsoon region became desert?

REPLY: This is a good point that was also commented on by reviewer 1. The used domain has as limits 10W-35E and 15-30N, so covers the present-day Sahara region and part of the Sahel. The modern African monsoon region is not included. We will clarify this in the revised manuscript.

- I understand the variables showed in Fig1 are annual mean. Following the given insolation in summer, one might wonder why the annual mean temperature has warming trend when the summer insolation has the decreasing trend in the case of no vegetation feedback. Even though the authors mentioned in Line 225 that this warming trend is also seen in other simulations, would be good to explain what cause the warming trend, it can not be due to the GHG forcing since GHG is fixed.

REPLY: *This point was also raised by reviewer 1. In LIG_FIX, the vegetation is fixed to desert in the entire experiment, so there are no changes in albedo as in the experiments with dynamical vegetation. Even without the albedo effect, the precipitation in Northern Africa was still significantly higher in the early part of the interglacial due to the enhanced summer monsoon, forced by elevated insolation values. This enhanced precipitation resulted in relatively humid soils and enhanced evaporation, leading to evaporative cooling in the first part of the LIG relative to the end of the LIG_FIX experiment. This created the positive temperature trend that is also seen in other LIG experiments without dynamical vegetation (e.g., Bakker et al. 2014). We will clarify this in the revised paper.*

- Fig3 showed an interesting anomaly pattern in vegetation cover, I am curious if such a pattern in supported by the proxy data or other model simulations. the authors mentioned in line 297-298 about the spatial complexity in two references, would be nice to provide more information from these findings.

REPLY: As suggested by the reviewer, we will provide in the revision some more information on spatial patterns found in other studies.

- The manuscript focuses on the interaction between the climate and vegetation, it would be helpful to show the spatial anomaly pattern of precipitation, temperature and soil moisture, in order to understand how the climate anomaly pattern affect the vegetation anomaly pattern in Fig3.

REPLY: As proposed by the reviewer, we will provide some maps showing the spatial distribution of climate variables. We suggest putting these maps in the supplementary information as background information.

- In Fig.4 the simulation for HOL_VEC did not show the full simulation period and stopped at 2000, and HOL_LPJ stopped at 3000 yr BP, what is the reason? Something strange happened in the late periods?

REPLY: Nothing strange happened, we just focused on the results showing the transition, which ended before 3 ka BP.

Fig 6, can you explain why the model simulate more precipitation during Holocene than during LIG, e.g., when insolation is the same, despite with fixed or coupled vegetation. According to Fig1, insolation declined below 460 W/m2 after 121 K during LIG and after 3 K during Holocene, in Fig2 almost no vegetation after 119 K but some 5-10% remain after 3K in coupled VECODE, please comment on what cause these differences. Please also comment on the possible reason for an accelerated increase in precipitation during LIG when insolation greater than 480 W/m2

REPLY: Differences in ocean surface temperature are likely to play a role here. The monsoonal precipitation is depending on the thermal contrast between the ocean and continent. The ocean was slightly warmer in the LIG than in the Holocene, which could partly explain a stronger precipitation in the Holocene with the same summer insolation. In addition, vegetation-climate feedbacks play a role. For example, as can be seen in Figure 1, the insolation was similar at 122 ka and 8 ka. However, Figure 3 shows that the vegetation cover is more extensive at 8 ka than at 122 k, which enforces the precipitation through the vegetation climate feedbacks. We will elaborate on this in the revised version of the manuscript.