

Interactive comment on “Holocene biome changes in Asia – an analysis of different transient Earth system model simulations” by Anne Dallmeyer et al.

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Referee #1 (R1)

R1: "Model tuning/validation are using inconsistent information for 0K reference run, e.g. period for climate data, CO₂ concentration, and biome. Author chose the averaged climatology of 1960-2000 from CRU TS3.1 dataset, and drove BIOME4 model with pre-industrial 280 ppm CO₂-concentration, rather than the mean CO₂ concentration of 1960-2000. However, the reference observed biomes for comparison is from modern data. To be simplify, author is using Modern climate + PI CO₂ to simulate Modern biomes. I understand that author hope to show model's performance in lower CO₂ environment. However, in BIOME4 model, CO₂ has been treated as a very im-

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portant factors for biome distribution. Thus you cannot ignore the effect of change CO₂ concentration from 280ppm to 345ppm or the mean level during 1960-2000. It would be helpful and more convinced if the author could add the following information:

a) A detailed logic about using pre-industrial CO₂ concentration (280 ppm) and modern climate, but comparing with modern biome data

A: We fully agree, that this is misleading. There are several reasons why we chose this constellation. a) modern climate data is the only observed (and model independent) data that exist and we want to have a reliable reference climate. b) Most climate models fixed the CO₂ concentration to pre-industrial values (i.e., 280ppm) and we want to calculate the vegetation distribution consistent to the climate data c) we compared the reference simulation with potential vegetation, that is probably not in equilibrium with the current, fast changing, atmospheric CO₂-level d) Simulations using CO₂-level of 280ppm or 360ppm differ only slightly on Macro-Biome-level (at 2108 out of 33800 grid-boxes, i.e.6.24% of the grid-boxes).

We have revised our manuscript by writing in the chapter about the reference simulation: "As reference simulation for the modern biome distribution (named pre-industrial or 0k in the following), we forced BIOME4 with the modern monthly mean climatology (1960-2000) taken from the University of East Anglia Climatic Research Unit Time Series 3.10 (CRU TS3.10, University of East Anglia, 2008, Harris et al., 2012) providing a more reliable climate background than pre-industrial climate reconstructions or simulations. Though, we prescribed pre-industrial atmospheric CO₂-concentration (280 ppm) to be consistent to the transient Holocene climate simulations and to partly come up with the fact, that modern vegetation is supposed to be not in equilibrium with the fast changing atmospheric CO₂-level. The differences between the reference simulation using 280 ppm and a simulation prescribing 360 ppm can be seen in the Appendix (Fig. A3)."

R1: "b) Quantify the CO₂ effects on modern biome distribution by comparing simula-

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tion using mean CO₂ concentration during 1960-2000 with simulation using prescribed 280ppm. The similarity of the two simulations would support the choice of using 280 ppm CO₂ concentration. "

A: On Macro-Biome-level, simulations with 360ppm or 280ppm differ only slightly. In the region of interest, the simulation with 360ppm shows slightly more temperate forest in Eastern China and also more cool forest in Central-Western Asia. This has no effect on the results and conclusions of our manuscript. We added a figure showing the simulated 0k biome distributions using 280ppm and 360ppm, respectively, to the Appendix (Fig. A3)

R1: "c) If using modern CO₂ concentration did generate some difference, would it affect the adjustment of BIOME4 model, e.g. LAI, NPP and soil moisture limits, and other bioclimate limits? I think this is very important. Because here the model is highly tuned with today's observation. The choice of modern climate and CO₂ data would affect this tuning. The change of those modified climate (and other) limits would have impact on the transient MH simulation."

A: The choice of using 280ppm has no effect on the general conclusions drawn in this manuscript. Most of the slight adjustments (such as bioclimatic limits) are independent of the CO₂-level. Therefore, we do not expect an impact on the results for the mid-Holocene vegetation change.

R1: "Author mentioned that BIOME4 is an equilibrium vegetation model, and also attributed the failure of simulating modern Arctic tundra with deciduous taiga and boreal woodlands by this equilibrium issue. This also caused the inconsistent short-term variability between simulation and pollen-reconstructed biomes. Does this mean the climate change during each 500 years are either too big variation or too short period to be treated as equilibrium? And how big the influence is for the transition zone simulation?"

A: We are not sure, if we understand this comment correctly. The short-term variability revealed by the reconstructions can not be seen in the model, because the temporal

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resolution of the BIOME4 simulations are 500 year time-slices, only. The here used reconstructions have a much finer resolution. The climate forcing data for the time-slices are considered to be at equilibrium conditions.

R1: "One of the main targets of this paper is "to test the robustness of the simulated vegetation changes and quantify the differences among the models". As pollen-reconstructed biomes can be used another way for climate model-data comparison, it would be much more interesting if some more analysis/discussion about the evaluation/quantification about effects from uncertainties and bias of climate models in terms of model components, forcing setting. And this would also be more relative to this paper's subtitle "an analysis of different transient Earth system model simulations".

A: We agree, that more investigations on the uncertainties and biases related to the different model forcing and model components would be interesting, but to quantify this, more simulations (using different model components and forcing) are needed, which are very expensive and consume much computational power. We added a short discussion on the differences in interactive model components between the models and their potential effects on vegetation simulation: 'At least partly, the discrepancies in simulated climate may be related to the differences in interactive model components used in the climate model, i.e. some models include dynamic vegetation some do not. To test the influence of dynamic vegetation on the simulated Asian climate, sensitivity simulations have to be undertaken. An appropriate set of experiments only exists in the COSMOS-setup (cf. Dallmeyer et al., 2010.). According to these simulations, interactive vegetation has a negligible effect on the mid-Holocene to pre-industrial precipitation change in the desert-steppe-forest transition zone. Vegetation feedbacks contribute to the warmer mid-Holocene climate in the high northern latitudes, but the interactive ocean has a much stronger impact on the climate change. Therefore, the lack of interactive vegetation in KCM and ECHO-G may partly lead to biases in simulated climate change, but we do not expect an effect of this on the general results of this study.'

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R1: "in Figure2, it is clear that there is discrepancy for desert, shrubland, and grassland between observation and simulation for desert-stepper-forest transition zone (Region 1 in Figure1). Would it have effects on the 6k simulation?"

A: The main difference in the 0k simulation is the occurrence of a dry shrubland belt between the desert region and the steppe-region. In the observations, this shrubland belt is rather located in between the desert region. This 'separated' biome belts are also seen in the 6k simulations. However, as we group the biomes 'dry shrubland' and 'desert' into the Macro-Biome 'desert', and discuss the transient biome changes on the basis of the Macro-Biomes, only, we do not expect an effect of the differences between the reference dataset and the 0k model simulation on the the general results and conclusions of this study.

R1: "When the GCM output is interpolated into 0.5, whether elevation is considered? Would elevation have impacts on BIOME4 simulations using different GCM model outputs. Because different models have different spatial resolutions, which would deliver different elevation to the same 0.5 grid cells."

A: As we use the anomaly method to calculate the biome distribution, the elevation - or more precisely - the climate gradients resulting from the elevation are preserved from the CRU reference climate. Implicit in this widely used downscaling approach is the assumption that the temperature lapse rate does not change with climate. This is a fair assumption, if not drastically different climate states (e.g. glacial vs. interglacial climate) are considered. However, different spatial resolutions lead to different representations of the elevation in the models, which may have an impact on the climate change during the Holocene. We added this information to the Discussion (II 422-427).

R1: "500-year window length was applied for time slice analysis, and 120-year long-term mean was used to represent the climate status for each time slice. However, it is still not very clear, whether the 120 years are starting from the first year of each window or these 120 years are evenly distributed around the starting year of the window.

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A: We agree, this is not mentioned in the text. We use the years 1 – 120 (or 12) of each climate model simulations for 6k, year 501-621 (50-61) for 5.5k, etc. and the last 120 (12) years for 0k. We added this information in the revised manuscript (ll.226-227).

R1: "In Figure6b, how can the precipitation be negative value ζ ‘

A: "The figure shows the differences in precipitation to the pre-industrial value“

R1: "And please also check the data for Figure 6. The ensemble mean precipitation of 30mm/day for a desert-stepper-forest transition zone should be too big.“

A: "Many thanks, the unit was wrong, it is mm/year! We corrected it.

R1: "line 472, could the author explain the meaning of temporal “linear”, and why should we expect it should be linear or non-linear ζ ‘

A: We agree, this is misleading, we now write: "The expansion of desert during the Holocene back to modern distribution is not uniform and varies spatially.“

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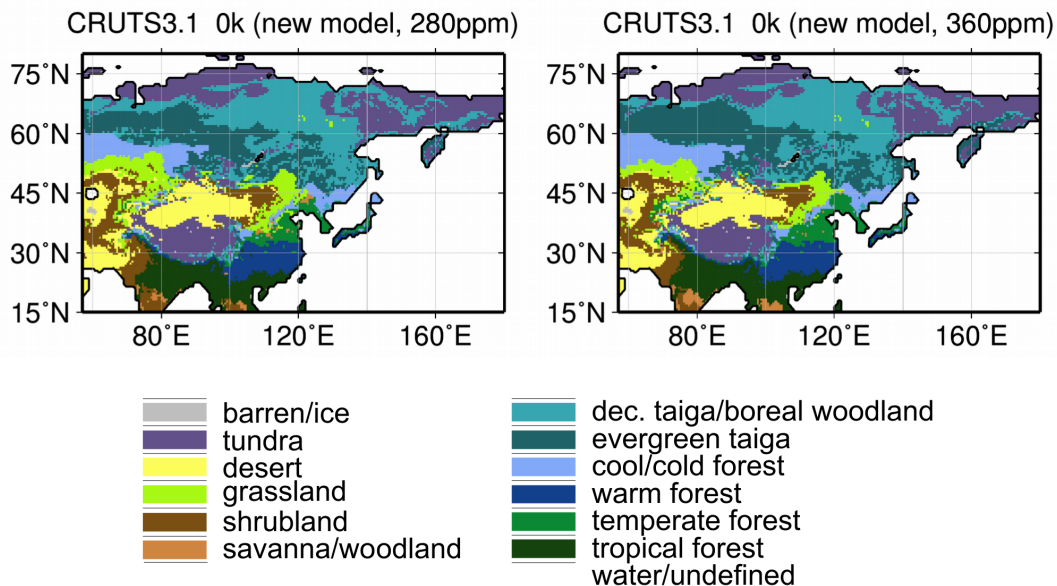


Fig. 1. Biome distributions for the modern climate (CRUTS3.10 0k) simulated in the modified BIOME4-version (new model) using atmospheric CO₂-level of 280ppm (pre-industrial) and 360ppm (modern), respectively.

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