Clim. Past Discuss.,
doi:10.5194/cp-2016-67-RC2, 2016

Climate of the Past Discussions
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Interactive comment on "Holocene biome changes in Asia – an analysis of different transient Earth system model simulations" *by* Anne Dallmeyer et al.

Anonymous Referee #2

Received and published: 28 September 2016

In this manuscipt, Dallmeyer et al. use BIOME4 to simulate Asian vegetation changes from the mid-Holocene (6 ka BP) to present. They first calibrated the model to better simulate the present vegetation in the Asian region, and then applied it to the Holocene. To assess the uncertainties in simulating Holocene vegetation, the authors use the output from 5 transient Holocene simulations with different earth system models (ESM) as the climate forcings for BIOME4. The BIOME4 results indicate an easterward (southward) shift of the desert-steppe-forest (forest-tundra) boundary in the transitional monsoon zone (Arctic) from the mid-Holocene to present. This trend is robust in spite of the climate forcings used for BIOME4, and is in general consistent with the proxy data retrieved from these regions. However, there are large uncertainties in the magnitude

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and temporal variation of these vegetation shifts among the BIOME4 simulations using different ESM output, which is difficult to be compared with the available proxy data. Some discussions on these issues are offered in the manuscript. In general, the manuscript is innovative in its effort of using multi-ESM output for modeling vegetation and assessing model uncertainties, and also in its effort of modeling vegetation changes throughout the mid-Holocene which can be compared with proxy records on time dimension. The manuscript is written in a clear and logic way, but there are still some aspects that may be improved.

Major comments:

1. A clearer explanation of the rational of the methods is needed:

(1) What's the resolution of BIOME4? Although we could speculate the resolute of BIOME4 in this study is 0.5x0.5 degree according to the resolution of CRU TS3.1, it should be better if the author could state this clearly and explain why 0.5x0.5 degree is sufficient? Would higher resolution of BIOME4 be beneficial?

(2) It is said that "The differences between the monthly mean climatologies (long-term averages of 120 years) simulated for each time-slice and the simulated pre-industrial climate have been added to the reference dataset. " How do authors calculate the differencse? Is it absolute difference or relative difference? Do the author use the same methods for all the climate variables?

(3) Some of the ESMs used in the study also include dynamic vegetation (e.g., COMOS, COSMOSacc, and PLASIM). Have the authors checked how the vegetation changes in these fully couple runs? Are they consistent with the offline simulations using BIOME4? BIOME4 simulations using output from COSMOS and COSMOSacc seem to exhibits the largest difference between mid-Holocene and present day. Is this partially related to the fact that vegetation feedbacks have been included in COSMOS and COSMOSacc runs?

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2. I suggest more discussion on the temporal variation of Asian vegetation in the proxy and in the model, which is one of the key aspects in this study.

(1) The decline of forest biome from 6k to 0k in Daihai record can be related human activity. The author should separate possible human induced changes from climate driven changes so as to better compare with the model results which is purely climate driven changes. For instance, based on Figure 11, the proxy record implies a strong decline of forest biome from 3500 to 2500 BP in Daihai. Can this be caused by human activity?

(2) The potential linkage of vegetation changes between the monsoon region and the Arctic region. From mid-Holocene to present, a southward shift of forest-tundra boundary in the Arctic (colder Arctic) corresponds to a eastward shift of desert-steppe-forest boundary in the transitional monsoon region (weaker East Asian summer monsoon). Does this relation between Arctic and monsoon vegetation change also exist in a shorter time scale in both proxy and the model results?

(3) Why the temporal changes of vegetation from 6k to 0k is non-linear in both proxy and model results? Does this related to orbital forcing or internal feedbacks?

(4) The shift of desert-steppe-forest boundary in the transitional monsoon region is shown to be linked to precipitation changes in this region, but is it also linked to East Asian summer monsoon strength? It would be interesting to see if the shift of desert-steppe-forest boundary is in line with the changes of the East Asian summer monsoon strength from 6k to 0k.

Specific comments:

Introduction: An introduction of existing vegetation simulations for the mid-Holocene in Asia may be useful.

Line 200: “medium” should be “intermediate”

Line 277-278: Why cold season temperature decrease in the tropical region in mid-

Holocene?

Line 327-329: rephrase the sentence to be clearer: Should “westward of 118” be “eastward of 118”?

Line 342, Line770: "Fig.D" does not exist?

Line 418-419: references need to be added for the statement

Summary and Conclusion: can be shortened.

Table 3: Please add information on whether the models use dynamic vegetation.

Figure1: Please explain the rational for the lightblue line in the figure? How do you define the extent of the Asian monsoon region? Please specify which climate dataset or reference the summer circulation at 850 hPa in the figure is based on? The sketch of the summer circulation may be oversimplified and thus misleading to the reader.

Figure2: Why there is no vegetation cover over India and South East Asia in the reference map? Please explain.

Figure6,7,8,9,10: Please use different color or line type to represent each individual simulations.

Figure9: While the caption says (a) is absolute difference in annual mean temperature, the figure title of (a) have unit “%” suggesting relative difference? Which one is true?

Figure11: The label of time axis is better to be consistent with previous figures (using minus values for year?). It would be better if each individual simulation can be shown in the figure to see which simulation is in the best agreement with the proxy data.

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