

***Interactive comment on* “Comparing modelled fire dynamics with charcoal records for the Holocene” by T. Brücher et al.**

Anonymous Referee #2

Received and published: 29 January 2014

This manuscript describes a study to investigate the causes of changes in large-scale biomass burning over the mid- to late preindustrial Holocene. The authors use an earth system model of intermediate complexity (CLIMBA) that simulates climate at very low spatial resolution and that is partially coupled through climate (unidirectional) and the carbon cycle (bidirectional), to a dynamic global vegetation model (JSBACH) that runs at somewhat higher spatial resolution. The JSBACH model includes a moderately complex wildfire module that is driven by fuel availability and climate, and produces, among other variables, estimates of burned area and carbon emissions. With this model setup, the authors run a single experiment covering the most of the preindustrial Holocene, from 8ka to 200 BP. Simulated burned area and carbon emissions are then evaluated against paleoenvironmental archives of past biomass burning from the Global Charcoal Database (GCD), both through direct comparison, and after translating the model

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[Discussion Paper](#)



outputs into Z-scores that, in theory, should be more comparable to the homogenized charcoal database. Overall the results are satisfactory, with some correspondence between CLIMBA-JSBACH and the GCD in most continents and most times, with the notable exception of Europe and Monsoon Asia. In Europe, inferred fire activity shows little long-term trend over the preindustrial Holocene, while model simulations simulate a strong decrease over time, with GCD Z-scores greater than the model simulations in the mid-Holocene and lesser in the more recent past. In Monsoon Asia the long-term trend looks similar for both the data and model simulation, but the observations show much greater variability, particularly after 3ka. One explanation for these discrepancies between models and data-based reconstructions could be human activities, which were not considered in the current study.

Overall this is a solid manuscript describing a reasonably well-designed study. The topic and results will be of clear interest for much of the readership of *Climate of the Past*. There are, however, several points that need further consideration before final publication, and several confusing or poorly written sentences in the manuscript. With moderate revision I would be pleased to recommend this article for final publication.

General comments:

My first major comment relates to the substantial spatial mismatch between the resolution of the climate and fire models and the point observations in the charcoal records. The charcoal data are not distributed in a spatially homogenous way within a geographic region, but when comparing model simulations with data at both zonal and regional scales, as far as I understand from the methods, the model timeseries are presented as gridcell averages, area-weighted across the region. There is a real risk in the analysis the way that it is currently presented that the model is weighting over a larger, potentially different area than what is represented in the data. For example, there is almost no data from India in the GCD (based on Fig. 1 in Marlon et al., *Quat. Sci. Rev.*, 2013) but the “Asia monsoon” region being averaged across in the model simulations includes the Indian subcontinent. The zonal comparisons only exaggerate

[Interactive
Comment](#)

this mismatch further, comparing a equally weighted model zonal model result with a data synthesis that will be heavily biased to the parts of that zone where there is the most data. Therefore, the area represented in the model is very different than the area represented in the data. It would have made much more sense to compare simulated burned area from only those 3.75 degree JSBACH gridcells where charcoal observations were present. Even this relatively coarse resolution of the fire model presents a huge scale mismatch compared to what is recorded in charcoal records, but at least it would avoid some of the spatial biases.

The authors should discuss the results of their model-data intercomparison in the context of the recent study by Molinari et al. (Global Ecology and Biogeography, 2013), who also performed a comparison between modeled paleoclimate, vegetation, and anthropogenic land cover change, and charcoal records, albeit only for Europe. How are the conclusions in the current study different or similar to what Molinari et al., suggest were the most important drivers of change in wildfire over the preindustrial Holocene?

One of the reasons given for the increase in biomass burning over the preindustrial Holocene period simulated by the model is the simulated increase in biomass as a result of increasing CO₂ concentrations in the mid- to late-Holocene. This Holocene CO₂ fertilization effect seen in JSBACH is a characteristic common to many DGVMs, however, it could be overestimated as there is little independent evidence for enhanced plant growth over this time period. It would be helpful to comment on what the simulations might be like if the vegetation model did not respond so sensitively to the Holocene CO₂ rise.

Finally, this manuscript needs a careful editing job by a technical editor or native English speaker (of which there are some among the authors). There are many confusing and/or awkward sentences in the text that made reading this manuscript laborious. I have made several remarks below in my specific comments on sentences I found strange, but please try to improve the language in the manuscript overall before resubmitting.

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Specific comments:

Page 6436, lines 4-5 Does this sentence imply that there are no biogeophysical feedbacks between land and atmosphere in CLIMBA? How might changes in burned area affect climate locally? I suppose that the very coarse CLIMBER-2 grid is too coarse to realize any biogeophysical feedback as a result of changes in burned area, but this issue should be commented on, either here or in the discussion section.

Page 6437, lines 5-9 If anthropogenic emissions of CO₂ as a result of land cover change are not considered in the current study, this sentence can be removed, as it describes something that was not part of the study and is a potential source of confusion, as it strays from the main message of the manuscript.

Page 6438, lines 21-22 As commented above, because the charcoal data are not uniformly representative of a region, model-data mismatch could be a result of data processing. This statement should be modified to acknowledge this fact.

Page 6439, lines 8-10. This sentence is awkward and confusing and might better be broken into two. Please revise.

Page 6440, line 2 Inappropriate Germanized usage of the word “until”, revise.

Page 6440, line 13-34 The sentence starting with “Regions. . .” is awkward. Revise.

Page 6440, line 26 Replace “wide spread” with “widespread”

Page 6444, lines 16-18 The sentence beginning with “Since. . .” is poorly worded, please revise. Also, it is not clear how changes in vegetation fraction are estimated given the authors own admission that both the climate (and probably the land model) are not sufficiently detailed in spatial resolution to really say much about this region. I suggest not trying to draw these kind of conclusions based on the limitations in the model setup the authors describe.

Page 6444, lines 27-29 These two sentences should be revised to avoid colloquial

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Discussion Paper



language and delete extraneous words, e.g., “. . .as the a member...”.

Page 6445-6446, Paragraph beginning on p. 6445, line 12 This paragraph is confusing and it is not always clear what quantities are being discussed. For example, “JSBACH simulates an increase [in what?] in all regions. . .”, or “. . .the highest number [of what?] is found. . .”. The discussion switches between “increase” and “decrease” frequently and I had to read the paragraph several times and refer back to the figures to understand what was being described. I should not have had to do this. The phrase starting with “the Z-score transformed values show an opposite trend. . .” doesn’t make any sense at all. Please revise this entire paragraph to improve clarity and emphasize the main message the authors want to convey.

Page 6446, lines 16-17 Again, please improve the clarity of this awkwardly worded sentence.

Page 6447, lines 6-8 The sentence starting with “Close to the overall. . .” does not make sense. I think the authors are trying to compare total burned area with Z-scores, but am not sure. If a comparison between charcoal Z-scores and burned area is intended, I doubt the validity of any implied causal link, because changes in Z-score do not have to be caused by changes in burned area, fire return interval being rather more important, so this is not really be an appropriate comparison. The authors acknowledge this point, however obliquely, on page 6448, lines 16-20.

Page 6448, line 2 Remove the comma in “shows, that”

Page 6448, lines 16-20 Please improve the wording of the very awkward and long sentence starting with “So, neither. . .”

Page 6456, Figure 3 All of the panels in this composite figure are too small to make a meaningful interpretation of the results. Please replot in larger size or split into separate figures or both.

Interactive comment on Clim. Past Discuss., 9, 6429, 2013.

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