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Climate of the Past Discussions

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Interactive Comment

Interactive comment on "Holocene vegetation and biomass changes on the Tibetan Plateau – a model-pollen data comparison" *by* A. Dallmeyer et al.

A. Dallmeyer et al.

anne.dallmeyer@zmaw.de

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We thank the Anonymous Referee 2 very much for his/her constructive critique and helpful suggestions.

Major comments:

Referee: *'Pg 1074, Line 11-14: These sentences state that the reconstructions primarily identify decreasing summer monsoon precip as the most important factor causing vegetation shifts and that the model changes in land cover all occur due to temperature changes. These statements greatly oversimplify what is presented in the text, as 2 out of the 4 reconstructions call upon temperature changes to explain vegetation shifts and*

1 out of the 4 sites in the model is strongly influenced by precipitation. There seems to be no great difference between reconstructions and model with regard to the climatic factors causing vegetation change and this conclusion should be deleted.'

Author: We agree. In the revised version of the manuscript we wrote: 'However, model and reconstructions often differ with regard to the climatic factors causing the vegetation change at each site. The reconstructions primarily identify decreasing summer monsoon precipitation and changes in the temperature of the warm season as the responsible mechanisms for the vegetation shift. In the model, the land cover change mainly originates from differences in warm/cold seasonal temperatures and only to a lesser extent from precipitation changes.'

Referee: *'Results: It would be possible (and preferable to the subjective approach given in the text) to statistically analyze the vegetation trends to determine whether they are significantly different from zero'.*

Author: We agree. To test the significance of the vegetation trends, we applied a simple statistical test: We calculated the standard deviation of the time-series (σ) and the difference between the mean value of the first 500years and the last 500year of the time-series (Δ covfrac). We assume a significant land cover trend, if $|\Delta$ covfrac$| > 2^*\sigma$.

We wrote in the revised manuscript (end of section 3.2): '..To test the significance of the simulated land cover trend, a simple statistical test is used. We assume a significant trend if the absolute differences in mean land cover between the first 500years and the last 500year is greater than two times the standard deviation of the entire time-series. Detailed results of this test can be seen in the Appendix (Table A1). According to this test, most land cover trends are significant. If a trend is not significant, this fact is mentioned in the text. . . .'

Referee: *' Table 1: It appears that there are no precipitation-related bioclimatic limits in the model, only temperature-related. In this case, how can you make any conclusions about whether vegetation shifts are due to temperature or to precipitation?'*

Author: The bioclimatic limits in JSBACH are, indeed, only temperature-related. Precipitation changes are only indirectly accounted for in the calculation of the plant productivity. For sites, where the simulated Holocene vegetation change can be attributed to temperature changes, we can see in our model results a clear change in the bioclimatic conditions, i.e. the bioclimatic conditions are outside of the climatic range of tolerance of the PFTs simulated for 6k and more favourable for another PFT. For sites, where we relate the simulated vegetation change to a precipitation change, the bioclimatic conditions are more or less the same during the entire simulation period, but the model show a strong change in precipitation and in the plant productivity. To make it more clear, we wrote in the revised version: '... Simulated changes in vegetation cover thus can be attributed to bioclimatic shifts (i.e. temperature changes), changes in plant productivity (related to precipitation) or changes in the frequency of disturbances. ...'

In the Appendix, we furthermore added figures showing the change in climate key-variables, bioclimatic conditions and the net primary productivity for all locations.

Referee: *' Section 5.3: Please place the total terrestrial carbon loss in perspective. Is this a large and important number, or a small and unimportant number? What is the significance of this finding?'*

Author: In our revised manuscript, we wrote: ' ...Projected on the total area of ca. 3.43 million km^2 (in the model), the terrestrial carbon loss adds up to 6.64GtC. These are approx. 7.5% of the simulated global terrestrial biomass loss during the Holocene. ...'

Referee: *'5. Summary and conclusion: The methodology used in this paper (analyzing dynamic vegetation) has some drawbacks compared to other approaches (specifically, offline vegetation modeling using an anomaly approach, eg, Wohlfahrt et al. 2008 Climate Dynamics, Miller et al. 2008 Journal of Ecology), as demonstrated in the issues the authors have with climate biases. Discussion of these different approaches would make a useful addition to this section.'*

Author: Using a coupled atmosphere-ocean-vegetation model instead of prescribing climate anomalies to a dynamic vegetation module has, indeed, drawbacks. The simulated climate has biases to the observations which could affect the vegetation distribution, particularly in climatic sensitive regions such as the Tibetan Plateau. However, the advantage of a coupled model is that it can take feedbacks between the vegetation and atmosphere into account. In our study, we are interested in the dynamics of the fully coupled system.

We agree, to point out pros and cons of our approach are a very useful addition to our manuscript. We added in the Discussion section (5.1) of the revised version:

'(3) To avoid large climatic biases to observations, vegetation studies are often conducted by prescribing a biases-corrected climate (i.e. sum of simulated climate anomaly and observed mean climate) to a vegetation model instead of using a dynamically coupled atmosphere-ocean-vegetation model (e.g. Wohlfahrt et al. 2008; Miller et al. 2008). This anomaly-approach is particularly useful in climate impact studies but has the drawback of not taking feedbacks between the climate and vegetation into account. Previous climate modelling studies suggest that vegetation and land-surface feedbacks with the atmosphere could have enhanced the orbitally-induced Holocene climate change in monsoon regions (e.g. Claussen und Gayler, 1997; Broström et al., 1998, Diffenbaugh and Sloan, 2002; Levis et al. 2004; Li and Harrison, 2009). In ECHAM5/JSBACH-MPIOM, the overall contribution of the vegetation-atmosphere interaction to the Holocene climate change in the Asian monsoon region is small (Dallmeyer et al., 2010). However, in regions showing a strong land cover change (e.g. in parts of the Tibetan Plateau or the present-day monsoon margin), the Holocene vegetation change has a significant effect on the simulated climate. Therefore, we decided to use a coupled atmosphere-ocean-vegetation model in the current study to account for nonlinearities in the climate system, albeit this method may lead to biases in land cover trend.'

Referee: *' A reconstruction that is not discussed, but should be, is Co Ngion (Shen et* *al. 2008 Ecology). This site is very close to Lake Zigetang, but shows distinct meadowsteppe ecotone fluctuations quite different from either the Zigetang reconstruction or the model. The Co Ngion record, at the very least, is a good reminder that we might not get the entire picture from one reconstruction.'*

Author: The biomisation used in our approach has been adjusted to the modelling approach. We find fluctuations in the Artemisia/Cyperaceae ratio (finally what has also been found by Shen et al., 2008) too and this has been discussed in Herzschuh et al., 2006. However, the ratio between steppe and desert, what has been discussed in this manuscript, was rather stable.

Minor comments:

Referee: *' Some spelling and grammar errors in abstract, eg, Line 16 change "is shrinking" to"shrunk" and Line 18 change "Gras" to "grass."'*

Authors: In the revised version, we wrote: 'shrinks' instead of 'is shrinking' and 'Grass' instead of 'grass'

Referee: *' Pg 1074, Line 18: Grass fraction 38.9% does not match number presented in text (38.1%).'*

Author: This is a mistake. 38.1% is the correct number. We changed it.

Referee: ' Introduction pg 1075: Ideas not ordered into logical paragraphs. Difficult to read.'

Author: The structure in the Introduction is the following:

1. Short notice on topography 2. General influence of the Tibetan Plateau on climate, including examples 3. Role of the land surface 4. Summary of the Holocene land cover change on the Tibetan Plateau 5. Motivation and summary

In the revised manuscript, we tried to improve the readability of the introduction by separating the examples of the climatic impact of the Tibetan Plateau from the rest of

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the text. The examples are now presented as a bullet-point list.

Referee: ‘ *Pg 1077, line 24: I don’t understand “(spring).” Do you mean to say “during spring?”’*

Author: Yes we do. It is ‘during spring’, We corrected it.

Referee: *‘ Pg 1079, line 13: Do you mean “approximately” rather than “presumably?” I don’t understand why the mean annual temperature is presumed to be 1.6 degrees C.*

Author: The value 1.6°C is an estimation. There are meteorological stations only in lower elevations. We agree, ‘approximately’ is more appropriate. We corrected the sentence.

Referee: *‘Table 2: Too many numbers for a table (with too many significant digits). This would be better shown in a figure’.*

Author: We agree and reduced the digits.

Referee: *‘Pg 1091, line 7-8: “Therefore, the annual temperature sum is not high enough to fulfil [sic] the limit of growing degree days in the model.” What limit do you mean, the limit between trees and shrubs?’*

Author: We rephrase this sentence more precisely: Therefore, the annual temperature sum is not high enough to exceed the bioclimatic limit of growing degree days needed to get woody vegetation in the model.

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