Clim. Past Discuss., 7, C966–C990, 2011
www.clim-past-discuss.net/7/C966/2011/

Climate of the Past Discussions

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

Received and published: 1 July 2011

We would like to thank the Anonymous Referee 1 for his/her constructive comments that helped to improve our manuscript.

Referee: *'p. 1075, lines 8-12. North Africa and Middle East can not be called "surroundings". I suggest reformulating this sentence. The Taklamakan Desert and Dzungar Desert are conventionally used names'*

Author: We agree, changed the names of the desert like suggested by the reviewer and wrote in the revised manuscript: 'The large amount of air pumped up in the atmosphere above the Tibetan Plateau due to high convective activity diverges near the

tropopause and subsides in North Africa, Central Asia and the Middle East. Thereby, the large-scale subsidence forces and forms dry climates and deserts such as the Sahara, Taklamakan Desert and Dzungar Desert. (Rodwell and Hoskins, 1996; Ye and Wu, 1998; Duan and Wu, 2005).'

Referee: *'line 20. What is the source of snow?'*

Author: The source of snow is mainly wintertime and early springtime precipitation. The snow depth and coverage has a strong variability. Changes in snow cover can affect the atmospheric circulation in the following summer, see e.g: Qian et al., Int. J. Climatol., 23, 593-613, 2003).

Referee: *'lines 25-30. Introduction is mainly concerned about how the TP influences climate of the surrounding regions. However, the area of the plateau itself is large, settled by people and gives the origin of several great rivers. It would be fair to say a couple of sentences on what is influencing the TP climate and environments. For example, what causes above/below-normal rain or snow.'*

Author: We agree, the Tibetan Plateau is not only a key-player in the regional climate system, but also the source region of several large rivers supplying fresh-water for billions of people. This is an important fact with regard to future climate change on the Tibetan Plateau. We decided to mention only processes by which the Tibetan Plateau affects the regional and global climate to point out the decisive role of the Tibetan Plateau's land surface on the atmospheric circulation. The major aim of the study was to critically assess the performance of ECHAM5/JSBACH-MPIOM with respect to this aspect. The detailed atmospheric processes forming the climate on the Tibetan Plateau are irrelevant for this study. To keep it as simple as possible, we therefore only mentioned in the introduction of each study site which planetary-scale circulation system affect the site. In former studies about vegetation on the Tibetan Plateau, changing monsoon precipitation has been suggested as the primary driver of vegetation changes during the Holocene. Therefore, the geographical position of the sites relative to the major circulation systems is most important for understanding the precipitation changes at the sites. The variability of precipitation is strongly related to the variability of the monsoon systems.

Referee: *'p. 1076 line 19. I suggest to mention Kleinen et al. 2011 paper, which is available online in The Holocene.'*

Author: done.

Referee: *'p. 1077 lines 1-4. Do you mean changes in natural vegetation/carbon storage here? If so, you need to say this more clear.'*

Author: Yes we do, this model version can only calculate potential vegetation. Anthropogenic land cover changes are not taken into account. In the revised manuscript, we wrote:

'...For this purpose, we compare pollen-based vegetation reconstructions for different sites on the Plateau with the simulated potential vegetation trend in the surrounding areas. Anthropogenic land use changes are not taken into account by the model. Secondly, we want to identify the specific climatic parameters that caused the past vegetation changes. Thirdly, we quantify the total changes of simulated vegetation carbon storage for the entire Tibetan Plateau. '

Referee: *'Lines 6-10. You already mentioned part of this earlier.'*

Author: Yes, some information has already been given in the introduction. We repeated it here, because the complex orography and the height of the Tibetan Plateau and adjacent mountain ranges have an important impact on the climate of the Tibetan Plateau. The local climate strongly depends on the local orography. Therefore, we kept this paragraph in the revised manuscript.

Referee: *'I recommend to keep the structure of the 2.1 section more clear, i.e. starting with monsoon circulation mention its summer and winter features, total, summer and winter precipitation, and temperatures. In your case, precipitation story is interrupted*

by the temperature.'

Author: We agree and restructured this section. We wrote in the revised manuscript:

' ... Following the general decrease in altitude, near-surface air temperature and precipitation increase from the north-western to the south-eastern part of the Plateau. In summer, the Plateau is characterised by near-surface air temperatures up to 19°C in the south-east and ca. 6°C in the north-west (Sun, 1999). Winter temperatures are around 5-10°C in the south-east and 25°C in the north-west (Cui and Graf, 2009). Due to the strong insolation during daytime, near-surface air temperatures experience strong diurnal variations. Surface soil temperature varies up to 50°C (during spring) between day and night (Cui and Graf, 2009). Annual precipitation amounts ranges from approximately 700mm in the south-eastern part to less than 100mm in the north-western part (Sun, 1999), but precipitation strongly varies in time and space (Ueno et al., 2001). Besides the orography, precipitation distribution on the Tibetan Plateau is strongly determined by the large-scale atmospheric circulation. The southern and eastern parts are affected by the Asian summer monsoon (Fig.1a) that provides more than 80% of the annual total precipitation (Cui and Graf, 2009). The northern parts are affected by the westerly wind circulation bearing less precipitation. The diverse climate conditions lead to a unique land cover on the Plateau. ... '

Referee: *'Summer monsoon provides 60% of the annual precipitation. . . I thought it should be more. What is the source/amount of winter precipitation?'*

Author: We have taken this value from the publication of Cui and Graf, 2009. This value is only an estimate of the contribution of the monsoon precipitation to the annual total on the entire Tibetan Plateau. The Tibetan Plateau is located at the fringe area of the Asian monsoon domain, but there are also large parts that are not characterised by a monsoon climate. In the monsoon affected regions, summer monsoon provides more than 80% of the annual precipitation. The non-monsoonal regions also get winter and spring precipitation (up to ca. 90mm). This precipitation is related to Rossby-wave disturbances.

In the revised manuscript we modified this statement: Besides the orography, precipitation distribution on the Tibetan Plateau is strongly determined by the large-scale atmospheric circulation. The southern and eastern parts are affected by the Asian summer monsoon (Fig.1a) that provides more than 80% of the annual total precipitation (Cui and Graf, 2009).

Referee: *'p. 1078 line 1. 700 mm/year is not a small amount'*

Author: We agree and wrote in the revised manuscript: ' ... Annual precipitation amounts ranges from approximately 700mm in the south-eastern part to less than 100mm in the north-western part (Sun, 1999), ... '

Referee: *'line 10. intensive logging. You need to specify when. In the past 20 years large areas were reforested.'*

Author: We revised this text: 'Present-day vegetation along the wet and warm south-eastern and eastern margins of the Tibetan Plateau is dominated by montane conifer and broad-leaved forests. However, loss of natural forest since at least during the past 2000 years and even more intense since the 1950s is attributed to anthropogenic forest clearance as a consequence of the high timber, grazing and agricultural ground demand of a constantly growing population (Studley 1999; Zhang et al. 2000; Dearing et al. 2008; Wischnewski et al., 2011). Only during the last three decades reforestation programs and a logging ban stopped the further forest loss in these areas (Zhang et al. 2000; Fang et al. 2001).'

Referee: *'Lines 23-28. This jump to the global circulation is confusing. I recommend to reserve chapter 2.1 for the general climate, providing more precise (uniform) climate information for the four pollen sites'.*

Author: For the understanding of the Holocene vegetation change at the four sites on the Tibetan Plateau, it is necessary to mention the dominant large-scale atmospheric

circulation system at the sites. We think, it is reasonable to provide this information right next to the description of the site-specific climate, since the climate is strongly related to the large-scale circulation system.

Referee: *'In the current version climate and environments descriptions are taken from former publications, therefore not easy to compare. In your case, I would use advantage of having modern climate data in hands (I assume, grids are better than meteostation data) and summarize sites names, coordinates, and climate variables used in this study in a separate table. Satellite MODIS information would be helpful to present for the selected grids, as it will help to understand structure of modern vegetation cover. This will also save space, as you do need to repeat all numbers in the text.'*

Author: The commonly used gridded datasets (such as products of the Climate Research Unit) are based on meteostation data. The highest resolution of these datasets is 0.5°x0.5°, i.e. a grid-box size of roughly 2500km^2. Thus, the size of the grid-boxes is much larger than the surface area of most lakes we considered in this study. Therefore, it is very likely that a nearby located meteorological station can represent the local climate at the study sites more appropriately than the gridded data. We decided to use the same values for the climate variables as given in the original publications. We kept them in the revised version of the manuscript. To summarise the information in a table is a very useful suggestion. We added a table including site names and simulated and observed elevation and climate in the discussion section (see also comments below). The structure of vegetation cover on the Tibetan Plateau is summarised in Fig.1b.

Referee: *'p. 1079 MAT is common in the Chinese publications, but I rather would like to see mean July and January temperatures which are more relevant for plant growth/biome simulation.'*

Author: July and January temperatures are, indeed, important for the plant growth. We therefore added the mean temperature values, when available, for these month in the revised manuscript in case they have also been mentioned in the original references of the reconstructions. We wrote for:

Lake Qinghai: The nearby climate station (Yeniugou, 99.58°E, 38.42°E, 3320 m a.s.l.) records a mean annual temperature of -2.5°C, a mean July temperature of 10°C and a mean January temperature of -16.3°C.

Lake Naleng: The mean July temperature at the lake is ca. 7.4°C. Mean annual temperature is approximately 1.6°C .

Lake Zigetang: According to Naqu climate station (90.02°E; 31.48°N, 4500 m a.s.l.), mean annual temperature is -0.6°C, mean July temperature is 9.5°C and mean January temperature is -12°C.

Lake Bangong: 'Temperature ranges from -15.8°C in January to 11.9°C in July and are ca. 1.5°C in the annual mean.'

Referee: *'p. 1080 3.1 Reconstruction section needs to be clarified. "Standard" is not correct expression here. There were several publications on pollen-based biome reconstruction in China (after Yu et al. 2000), which all present different biome-taxa matrixes.'*

Author: We agree and deleted the term 'standard'.

Referee: 'Moreover, biomes which are presented in the current study are different from Yu et al. and classical biome scheme of Prentice et al. I would suggest to present here a table, attributing all pollen taxa from the four pollen records and 112 surface pollen sites to the respective pfts and biomes'.

Author: We agree with the reviewer. We now present the following biome-taxon matrix used in this study in Table C1 in the Appendix of the revised manuscript.

Referee: *'I would also name this section 3.2 Vegetation reconstruction, and put it after the General model section.'*

Author: We changed the section heading to 'Vegetation reconstruction' like the referee

had suggested and also changed the structure of the method section.

Referee: *'line 23. instead of writing "reasonable" I would suggest to express results of this study (for the relevant biomes) in a quantitative way.'*

Author: We agree and added the following text: 'A test of this method with a modern pollen data set of 112 lake sediment-derived pollen spectra from the Tibetan Plateau yielded a correct assignment of 100% of temperate desert sites, 75% of temperate steppe sites, 84% of alpine steppe sites, 79% of alpine meadow sites (Herzschuh et al., 2010a). Patchy forest sites intermixed with alpine shrublands were mostly assigned to temperate or alpine steppes as no shrub biome was considered in this study.'

Referee: *'p. 1081. 3.2. should be 3.1 (see my previous comment). I would name this section 3.1. Model and experimental design'*

Author: We chose the heading 'General model setup and experimental design' to distinguish the part of rather general model information from the detailed description of the dynamic vegetation module. We therefore kept this heading.

Referee: *'Line 24 ". . . have no influence." On what? Please, edit this sentence.'*

Author: We agree and wrote: ' . . .During the entire transient run, atmospheric composition stayed constant. The calculated climate change, thus, can be attributed to orbital forcing alone. Biogeochemical processes have no influence on the climate change. . . .'

Referee: *'Lines 25-30. This part is very important, but is not easy to understand from a very scarce description provided here. Could you explain it more clear? It would be helpful to present a table with the average climate/vegetation characteristics for the grids attributed to each study site. In this case the readers themselves would be able to compare modern actual and experimental characteristics at the study sites.'*

Author: We agree and extended the information. We wrote in the revised manuscript: ' ...Instead we chose two to three grid-boxes in the vicinity of each lake showing an analogue vegetation trend (Fig.2). The grid-boxes have been selected by applying the following criteria: a.) The averaged climate in the grid-boxes represents the local climate at the study site more appropriately (e.g. Lake Qinghai, Lake Zigetang); b.) The grid-boxes are located upstream of the study sites with respect to the atmospheric circulation system effecting the site (e.g. Lake Bangong, Lake Naleng, Lake Zigetang) . . .'

A comparison of the climate at the sites and the surrounding grid-boxes is given in Table 2 (see comment below)

Referee: *'Line 26 "may differ". In your case I would write just "differ".'*

Author: done.

Referee: *'p. 1082. 3.3 section. Does it need to be a separate or can be merged with the 3.1 model setup?'*

Author: We think, separating the general model description and the detailed description of the dynamic vegetation module help to improve the readability of the text. We therefore did not merge the sections to one section in the revised version.

Referee: *'I have one major criticism to this section. It is extremely poorly referenced. Could you add some references where appropriate.'*

Author: In this section, indeed, only a few references are used. The dynamic vegetation module is a very new component of the model JSBACH. So far, neither a published documentation nor other publications describing the model exist, except the publication of Brovkin et al, 2009. We therefore decided to provide a detailed overview on the dynamic vegetation module in this study. We mentioned all existing references which are relevant.

Referee: *'p. 1083. Lines 16-18. This paragraph citing Brovkin et al must be in the beginning.'*

Author: We agree and wrote in the revised manuscript: 'The dynamic vegetation mod-

ule used in this study (Brovkin et al., 2009) distinguishes eight plant-functional types (PFTs), i.e. plants. . .'

Referee: *'Lines 19-21. Be aware that you must apply the same (or similar) treatment to the pollen-derived vegetation units. Therefore, biome-pft-taxa table suggested earlier is absolutely necessary.'*

Author: Please, see next comment. We included a table showing the assignment of the pollen-taxa to the major vegetation types used in the model in Table C1 of the revised manuscript.

Referee: *'4. Results. Again, I like to stress that this biome classification is different from anything published by Yu et al. and Prentice et al. Differences between the modelling and pollen based techniques should be mentioned in the method section. For example, model takes desert as non-vegetated area, while pollen-based reconstruction definitively uses pollen/plant taxa for this land cover category.*

Author: The general biomization method used in this model is very similar to the method of Prentice et al. In this study, vegetation is only grouped in a kind of mega-biomes so that it fits best to the plant functional types. Furthermore, we added the following text to the reconstruction method section (3.3): 'We are aware of differences in the handling of vegetation in the model and in the reconstructions. These differences have historical and technical reasons. Whereas the reconstructed vegetation is usually assigned to plant functional types (PFT) and then to biomes, simulated vegetation is grouped in plant functional types. These or the specific combinations of them then serve as major vegetation types. Nevertheless, we think it is most reasonable to compare pollen-based biomes with model-derived PFT coverages than to directly compare pollen-based PFTs with model-derived PFTs. The advantage of this method is particularly obvious in the case of model-proxy comparisons of deserts or of forested areas. The biome desert, for instance, contains vegetation such as Ephedra and Chenopodiaceae that can survive in extremely dry climatic conditions and are therefore representative for a desert environment and reach up to 100% here. In the model, no such vegetation type exists and the land cover type 'desert' is only represented by the non-vegetated area (bare ground). Thus, to compare the pollen-based desert biome to the model bare ground (which also includes only seasonally bare ground) is most reasonable as the same bioclimate is assumed for these vegetations. In forest biomes, pollen-PFT-biome assignment also account for vegetation growing in the understorey such as herbs of Rubiaceae. Thus, vegetation cover can exceed 100% (due to more layers). In the model, vegetation competes for 100% of the grid-box and has to be arranged side by side, herb (Grass PFT) does only out-compete trees due to bioclimatic limitations.'

Referee: *'Line 25. Explain, why 20 year average is taken. Is this comparable with pollen averages?'*

Author: The pollen-based reconstructions usually have a much coarser temporal resolution (100years and more, depending on age). However, in this study, a sediment core of Lake Qinghai is used that has the very high temporal resolution of roughly 20-30 years in the upper layers. We decided to choose the same resolution. We added this information in the revised version: ' ... Fig.4 shows the corresponding simulated vegetation trend as averages over 20 years which is the highest temporal resolution occurring in the reconstructions. ...'

Referee: *'p. 1084 lines 3-8. Again, reference to the table where MODIS values of vegetation cover for the chosen areas would be very helpful for evaluating the results.'*

Author: The main observed vegetation types can be seen in Fig.1b in the manuscript.

Referee: *'line 13. How to explain this? I thought that simulated trends, which favor decrease in tree cover would also cause increase in desert fraction.'*

Author: Trees are not necessarily replaced by bare-soil in the model if climate conditions get worse. A decrease in tree cover can also lead to an increase in shrubs and

grass. This is the case on the North eastern Tibetan Plateau.

Referee: *'Line 26. Why? Is this also supported by any other data?'*

Author: 'A strong fluctuation in the modelled vegetation trend indicates an occasionally recovering tree fraction.' With this sentence, we describe the vegetation change in our transient model simulation. The reason for the fluctuation is given in the discussion section: '...With increasing winter insolation, the cold season becomes warmer and frost events rare. Given a higher NPP in the model, raingreen shrubs are then able to successively replace the evergreen trees. However, the vegetation cover fluctuates, because frost events still occur with lower frequency.' (p1089,1090 l.28-3).

Referee: *'p. 1085 line 12. vegetation decline. What does it mean? Please, edit this sentence'.*

Author: For better understanding we wrote in our revised manuscript: 'The pollen record of Lake Bangong from the western Tibetan Plateau depicts a regional reduction of vegetation during the last 6000 years.'

Referee: *'Differences between Fig. 3 and Fig. 4 must be stated in this section. For example results for Qinghai show good correlation, for Naleng – almost opposite (worse of all), and are moderately good for the other two sites.'*

Author: We decided to use the result section for a qualitatively comparison of the simulated and reconstructed vegetation trend. Agreements as well as differences are mentioned for each site. Potential reasons for the partial disagreement have been discussed in the discussion section (5.1). The reconstructions present the vegetation trend and composition only qualitatively. One can infer the dominant land cover type and the general trend, not more. Given that, the reconstructed and simulated trends are in good agreement. To point this out, we added the following information to the reconstruction method section: 'The pollen-based reconstructions describe the vegetation trend qualitatively. The dominant vegetation type and the general trend can be inferred, but no conclusions on vegetation fraction and ratios can be made.' Furthermore, we concluded the result section of the revised manuscript with: 'Overall, the reconstructed and simulated vegetation trends are in agreement, albeit some systematic differences appear. The potential reasons for these differences are discussed in the following section. '

Referee: '*p. 1086 lines 1-10. I am surprised why Qinghai is taken as example. It shows best correlation between model and data. Could this 1. factor be tested with the modern data? I would understand reference to the general studies, if nothing else is available from the region. It is not the case here. Why not to use top core samples from the four pollen records discussed in the current study and to see whether it is true and in which way results are biased?'*

Author: Large lakes are, despite of its potential problems with far-transported pollen (which we found is small), most suitable for comparison with climate models, as they have source areas that are rather similar to the size of model grid boxes. Furthermore, no other continuous and high-resolution records are available from the north-eastern Tibetan Plateau that cover the transition area between steppe vegetation and forest in its source area. The uppermost samples of Qinghai Lake, Zigetang Lake and Naleng Lake were assigned to steppe/meadow and of Lake Bangong to desert which fits the vegetation observations.

Referee: *'Lines 13-16. Again it is much more convenient to use examples from the analyzed areas/records in addition to the more general references.'*

Author: We added Herzschuh et al. (2010c) as reference; here the representation of Tibetan vegetation in the pollen spectra is discussed.

Referee: '*Lines 18-28. I do not see your reason clear. Biome is also a great simplification.'*

Author: We do not understand the question here. We fully agree with the referee that

biome is a great simplification and have also mentioned this in the manuscript (see p.1086 ll 17-19).

Referee: *'What is 'biome flickering'? Could you explain this or provide a reference?*

Author: We replaced this phrase "biome flickering" with an explanation: "Biomisation of fossil pollen assemblages from such non-forested areas often faces the problem of that neighbouring samples were assigned to different biomes despite no shifts in the pollen signal are obvious. This rather reflects ecological noise than a true biome shift because the assignment of the dominant biome is very sensitive to small variations of affinity scores between pairs of closely matched biomes such as desert, steppe or meadow. We face this problem by presenting the affinity score differences between the most important biomes at each site."

Referee: *'p. 1087 Line 9. What is 'the strong relief'? Edit, please. In general the TP is rather flat and the relief is less complex than that of the Alpes, for example.'*

Author: In the revised manuscript, we changed this sentence: The Himalaya and the Kunlun Mountains, as well as other mountain ranges, vanish. In reality, the strong spatial variance in orography (e.g. at Lake Naleng) implies a high heterogeneity of regional climate and vegetation, which cannot be captured in the model and may lead to discrepancies between the model results and reconstructions.

Referee: *'Lines 12-17. I would suggest to present simulated values in the table (not only in figures) for comparison with modern data and for facilitating discussion.*

Author: We added a table with the simulated and observed (station data) values for temperatures and precipitation to the site-specific discussion section (5.2, see comment below).

Referee: *'. . . is too warm (up to????)' Please add value.'*

Author: The value is already given in the text, to clarify we wrote in the revised version: '. . .simulated climate is too cold on the central and south-eastern Tibetan Plateau (up to 2.8°C) and too warm on the northern Tibetan Plateau (see Fig.5). Maximal positive temperature anomalies of up to 7.2°C occur on the north-western Tibetan Plateau.'

Referee: *'p. 1088 lines 1-5. This paragraph needs more attention. Nomads are living at high elevations, whilst low elevations are shared between nomads and pastoralists, each group may influence vegetation in different way. Please, make it clear in the paragraph and extend this paragraph by adding more references to the appropriate environmental/archaeological/historical studies of the region.'*

Authors: Almost the whole area that we consider within the climate model and all sites of pollen studies are not suitable for pastoralism. That is why we considered only information on nomadic land use in this overview study here. We are not aware of further archaeological overview studies that provide information on the extend of the human impact. There are several more speculative studies around, which discuss the potential human impact based on regional palaeoecological studies – out of them we cited Schlütz Lehmkuhl (2009) and Herzschuh et al. (2010a) that at least provide continuous records.

Referee: *'Lines 17-21. If this values are simulated for the study region, then they must be in the table in order to facilitate comparison with the observed climate.'*

Author: We put these values in a table (Tab.2):

Referee: *'p. 1089 lines 9-10. How this conclusion was obtained. What are the taxa-indicators for reconstructing human activity in this area?'*

Author: For a detailed discussion please see the cited publication by Herzschuh et al. (2010a).

Referee: *'Line 27. What are raingreen shrubs? This pft should be clarified in the biome-pft-taxa table.'*

Author: 'Raingreen shrubs' is a plant functional type used in the model JSBACH. This pft has the following physical properties: height: 1m; roughness length: 0.5m;

maximum leaf area index: 3m^2/m^2; albedo$_{vis}: 0.05; albedo_{NIR}: 0.25;$

Raingreen shrubs are not frost-resistant. For further details on the bioclimatic limitation of this model-PFT see Tab.1 in the manuscript.

Referee: *' p.1090 lines 5-9. This statement is not clear to me. Why modern vegetation must be forest? Does this statement has support from MODIS or botanical observations. Please, explain.'*

Author: This sentence is, indeed, not easy to understand. The major disagreement in the simulated and reconstructed vegetation trend is the vegetation type that replaces the decreasing forests. The reconstructions show an increase of steppe/meadow, the model shows an increase of shrubs. The simulation of increasing shrub vegetation is a result of the Holocene temperature change. During mid-Holocene, simulated winter temperatures were lower than at present-day. Frost events occur regularly. As defined by the bioclimatic limits in the model, the model-PFT 'raingreen shrubs' is not frost-resistant, it can not survive when the temperatures of the coldest month fall below 0°C. Since the model simulates an increase of cold season temperatures during the course of the Holocene, shrubs are decreasingly limited by this bioclimatic threshold. However, due to the underestimated orography in the model, the simulated present-day temperatures at this site are much too high (11° instead of 1.6°). If the model had had no temperature bias, it would have calculated frost-events in present-day and shrubs would not have survived in the model. Under these circumstances, the model would have calculated no Holocene vegetation change at this site, and the present-day vegetation type in the model would primarily be forest.

We wrote in our revised manuscript: '...This difference in vegetation trend may partly result from the strong temperature bias of the model. The simulated annual mean temperature in SETP is nearly 10°C higher than observed and well above the freezing point. Given the observed annual mean temperature (Tann = 1.6°C), frost would still limit the occurrence of shrubs and growing of shrubs would probably have been impossible during the entire 6000 years. Simulated present-day land cover would, then, primarily be forest. . . .'

Referee: *'p. 1091 line 14. 'low pollen assemblages' What do you mean by this?'*

Author: We reformulated this sentence: ,. . .reveal at least a low pollen contribution from these vegetation types '

Referee: *'Line 16 'pollens' should be pollen grains or pollen types representing low-elevated vegetation! The whole paragraph needs editing. By the way extensive pollen literature from China provides examples of arboreal pollen being transported to the low elevations by the streams (i.e. Herzschuk et al. 2004). This feature deserves to be mentioned.'*

Author: We agree, 'pollens' should be pollen grains. We wrote in the revised manuscript: '. . .These pollen grains represent low-elevation vegetation and have apparently been transported from far regions by atmospheric wind circulation. This extra-regional pollen component is slightly higher during the late Holocene, when the regional vegetation is characterized by more openness as indicated by the increase ruderal and desert plants such as Brassicaceae. . . .' According to this argumentation, we do not assume fluvial transport from higher elevation; also the relief is rather flat in the surrounding of Lake Zigetang.

Referee: *'p. 1092 line 18. I do not understand this technique. Since it is not a strait forward to the readers, I would suggest to explain the method in the method section above. It also seems to me that the 'cut' area of 3.43 million km2 is by 1 million km2 larger than original area of the Tibetan Plateau mentioned at page 1074. How this is possible?'*

Author: We have not used a special technique, but made an ad hoc definition in line with our model world. The model has a very course grid, i.e. ca. 3.75° corresponding to ca. 400km on a great circle. The orography as averages over areas of roughly

400km x 400km yield a model orography as shown in Fig. 2. This is a standard interpolation used in all climate models. We decided to take all grid-boxes with a height exceeding 2500m in the model, because this limit yields an area approximately resembling the Tibetan Plateau. For example, a limit of 3km yields a much smaller area as the observed one. We wrote in the revised manuscript: 'Tab.3 illustrates the averaged simulated vegetation and biomass change on the Tibetan Plateau, which we ad hoc defined as those grid-boxes exceeding orographic height of 2500m in the model (cf. Fig.2). This area has a size of approx. 3.43 million km^2. '

Referee: *'28.3% is covered by forest in the model. Could this value (and other simulated values) be compared with the MODIS or any other observational data from the same region? This will give more credit to your modelling results'*

Author: The model only calculates potential vegetation. Therefore, one can not compare it with satellite-derived present-day land cover directly. A comparison of present-day tree cover based on MODIS data and simulated present-day forest fraction that was modified to account for anthropogenic land use change can be seen in Brovkin et al., 2009. In the revised version, we added the following sentence to the beginning of section 5.3: 'Due to the underestimated orography in the model, the simulated fraction of potential vegetation cover on the Tibetan Plateau is probably overestimated and, therefore, not comparable with the present-day observed, anthropogenic effected distributions. However, as we are not aware of other modelling studies concerning the Holocene land cover change on the Tibetan Plateau, we use our model simulation to assess the total Holocene vegetation and biomass change in this region. . . .'

Referee: *' Again, it surprises me that there are no other references in this section? Does it mean that nobody performed such simulations before? If so this must be clearly stated as the advantage of the current work? If not, the results must be discussed against the other simulations and differences are mentioned and explained, if possible.'*

Author: This is indeed an important point. In the revised version, we pointed out that no other modelling studies exist assessing the total Holocene vegetation and biomass change on the Tibetan Plateau (see last comment)

Referee: '*I believe that many readers would like to see not only the absolute simulated values, but also how much the TP changes in biomass contribute to the global values during the Holocene.*'

Author: This would, indeed, be interesting. We calculated the global values. The total terrestrial carbon loss adds up to ca. 89.7 GtC. Thus, the vegetation change on the Tibetan Plateau is responsible to ca. 7.5% of the simulated Holocene global terrestrial biomass loss. Another strongly contributing region is the Sahara-Sahel. In contrast, there are also regions showing more terrestrial biomass in 0k as in 6k (e.g. large parts of South America) We added this information to the manuscript and 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: *'p. 1093 lines 25-28. Here I see a contradiction to the figures 3 and 4 in the results section (see my comment above).'*

Author: The reconstructed and simulated trends are in agreement except for Lake Naleng. Part of the feeling that reconstructions and model results disagree may arise from the way of presenting the trend in Fig. 3 and 4. The reconstructions show the trend qualitatively (see comment above), they have no unit. To further point this out, we deleted the numbers in the labelling of the x-axis of figure 3 and replaced them with the more qualitative labelling 'less ↔ more'. We furthermore modified the statement on p.1093 l.25-28: '...In general, the simulated and reconstructed vegetation trends are in agreement for most sites but reveal differences with respect to their climatic causes. The results of ...'

Referee: *'p. 1094 line 10. You state that there are discrepancies between simulation and observation at 0ka, but what can you say about the past. How large these*

discrepancies should be expected? What is general credibility of your results?'

Author: The underestimated orography in the model probably also induces a bias in the simulation of mid-Holocene Asian climate. Nevertheless, we think that the simulated vegetation trends at the sites used in this study are not affected by this bias, except at Lake Naleng, for which we discussed this point. At Lake Qinghai, simulated present-day climate and observations are very similar so that there is probably also no strong bias in mid-Holocene climate. At Lake Zigetang, simulated climate is too harsh in mid-Holocene and present-day. Therefore, a bias of a few degrees in the model would have no effect on simulated vegetation composition. The simulated vegetation at Lake Bangong is mainly independent of the temperature. Paleoclimate reconstructions are sparse, often derived from pollen reconstructions and also represent the mid-Holocene climate only qualitatively and in relation to the present-day climate. Therefore, a detailed comparison of the modelling results with independent paleoclimate reconstructions is not possible at the moment. The model is able to simulate general climate trends such as the decrease of the summer monsoon strength and the decrease of precipitation in large parts of the Asian monsoon regions as reported by e.g. speleothems (e.g. Wang et al. 2005). In the revised manuscript, we discussed the simulated climate change in more detailed in the Appendix B and also point to this fact: ' ...In all regions, the model calculates a decreasing Holocene precipitation trend that is probably related with the generally weakening of the Asian summer monsoon since the early- and mid-Holocene reported also in vegetation-independent reconstructions such as cave records (e.g. Fleitmann, 2003; Wang et al. 2005; or Maher, 2008). ... '

Referee: *'Line 20. Surprisingly reconstructed temperatures appear here? Where do they come from? The paper presents only pollen-based vegetation reconstructions. Please, insert climate reconstruction to the results or change your text.'*

Author: 'We took this statement from the original manuscript of Kramer et al.2010. We added the reference to the text: ' The vegetation degradation around Lake Naleng (SETP) is probably caused by changes in temperature between mid-Holocene and present-day. According to reconstructions, decreasing summer temperatures lead to a downward shift of the treeline and therefore to less forest vegetation around Lake Naleng (Kramer et al.2009). The reduction of forest fraction in the model . . .'

Referee: *'References. I mentioned that several parts of the manuscript would benefit from better referencing. On the first quick view several important papers are missing, e.g. Kleinen et al., 2010, 2011; Gaillard et al., 2010, Ren and Beug, 2002; Wanner et al., 2008.'*

Author: We agree and added the following references in our revised manuscript: Kleinen et al., 2011 (in the Introduction) and Gaillard et al., 2010 (in the Summary). Instead of mentioning Ren and Beug's study we refer to Ren, 2000 which is more appropriate for our study. Wanner et al. only mention the Tibetan Plateau with respect to the glacier advances in the 1st and 2nd millennium AD which is not the subject of our manuscript.

Referee: '*Table 2. Please, check that the number size is not too small'.*

Author: In our revised manuscript, we increase the size of the numbers and reduce the numbers after the decimal point.

Referee: *'Figure 1. Please, check that all references are provided for the figure.'*

Author: Fig.1a is based on observations, we added this information to the figure caption.

Referee: *'Figure 2. Actually, why the topography in the model is so different from the reality? As I mentioned before, the topography is flat in the central regions of the TP. Could be topography corrected?*

Author: This is related to the course numerical resolution of the model (see answer to comment above)

Referee: *'Figures 6-9. I do not see a reason, why not to present complete set of the*

key climatic variables for the four regions discussed in the article, and not only one-two selected parameters from each region?'

Author: We decided to show only the climatic parameters that are relevant for the vegetation change in the model to reduce the number of figures in the manuscript. In the revised version, we added the complete set of key climate variables for the four regions in the Appendix B and also discussed the change in climate in more detailed.

References

Brovkin, V., Raddatz, T., Reick, C.H., Claussen, M., and Gayler, V.: Global biogeophysical interactions between forest and climate. Geophys. Res. Lett., 36, L07405, doi:10.1029/2009GL037543, 2009.

Dearing, J.A., Jones, R.T., Shen, J., Yang, X., Boyle J.F., Foster, G.C., Crook D.S., and Elvin, M.J.D.: Using multiple archives to understand past and present climate–human–environment interactions: the lake Erhai catchment, Yunnan Province, China. Journal of Paleolimnology, 40, 3–31, 2008.

Fang, J., Chen, A., Peng, C., Zhao, S., Ci, L.: Changes in forest biomass carbon storage in China between 1949 and 1998. Science, 292, 2320, 2001.

Gaillard, M.-J., Sugita, S., Mazier, F., Trondman, A.-K., Broström, A., Hickler, T., Kaplan, J. O., Kjellström, E., Kokfelt, U., Kuneš, P., Lemmen, C., Miller, P., Olofsson, J., Poska, A., Rundgren, M., Smith, B., Strandberg, G., Fyfe, R., Nielsen, A. B., Alenius, T., Balakauskas, L., Barnekow, L., Birks, H. J. B., Bjune, A., Björkman, L., Giesecke, T., Hjelle, K., Kalnina, L., Kangur, M., van der Knaap, W. O., Koff, T., Lagerås, P., Latałowa, M., Leydet, M., Lechterbeck, J., Lindbladh, M., Odgaard, B., Peglar, S., Segerström, U., von Stedingk, H., and Seppä, H.: Holocene land-cover reconstructions for studies on land cover-climate feedbacks, Clim. Past, 6, 483-499, 2010.

Kleinen, T., Tarasov, P., Brovkin, V., Andreev, A., Stebich, M.: Comparison of modeled and reconstructed changes in forest cover through the past 8000 years: Eurasian perspective. The Holocene, doi: 10.1177/0959683610386980, 2011. Maher, B.A.: Holocene variability of the East Asian summer monsoon from Chinese cave records: a re-assessment. The Holocene, 18, 6, 861-866, 2008.

Qian, Y.F., Zheng, Y.Q., Zhang, Y., Miao, M.Q.: Responses of China's summer monsoon climate to snow anomaly over the Tibetan Plateau. Int. J. Climatol. 23: 593–613, 2003.

Studley, J.: Forests and environmental degradation in SW China. International Forestry Review, 1, 260-265, 1999.

Wang, Y. J., Cheng, H., Edwards, R.L., He, Y.Q., Kong, X.G., An, Z.S., Wu, J.Y., Kelly, M.J., Dykoski, C.A., and Li, X.D.: The Holocene Asian monsoon: Links to solar changes and North Atlantic climate. Science, 308, 854-857, 2005.

Wischnewski, J., Mischke, S., Wang, Y., and Herzschuh, U.: Reconstructing climate variability on the northeastern Tibetan Plateau since the last Lateglacial – a multi-proxy, dual-site approach comparing terrestrial and aquatic signals. Quaternary Science Reviews, 30, 1-2, 82-97, 2011.

Zhang, P., Shao, G., Zhao, G., Le Master, D., Parker, G., Dunning, Jr. J., Li, Q.: Ecology: China's forest policy for the 21st century. Science, 288, 2135, 2000.

Interactive comment on Clim. Past Discuss., 7, 1073, 2011.

Tab. C1: Assignment of the pollen-taxa to the major vegetation types in the model.

	forest	shrub	steppe/meadow	desert
Alnus	1	0	0	0
Betula	1	0	0	0
Juniperus	1	0	0	0
Picea	1	0	0	0
Pinus	1	0	0	0
Quercus	1	1	0	0
Salix	1	1	0	0
Thalictrum	1	1	0	0
Rubiaceae	1	1	1	0
Berberis	0	1	0	0
Hippophaë	0	1	0	0
Rhododendron	0	1	0	0
Fabaceae	0	1	0	0
Potentilla type	0	1	0	0
Spiraea	0	1	0	0
Apiaceae	0	0	1	0
Bupleurum type	0	0	1	0
Artemisia	0	0	1	0
Chichorioidae	0	0	1	0
Crassulaceae	0	0	1	0
Cyperaceae	0	0	1	0
Gentianaceae	0	0	1	0
Lamiaceae	0	0	1	0
Liliaceae	0	0	1	0
Poaceae	0	0	1	0
Rumex/Rheum	0	0	1	0
Polygonum bistorta type	0	0	1	0
Aconitum	0	0	1	0
Ranunculus acris type	0	0	1	0
Trollius type	0	0	1	0
Stellera	0	0	1	0
Anthemis type	0	0	1	1
Aster type	0	0	1	1
Saussurea	0	0	1	1
Papaveraceae	0	0	1	1
Brassicaceae	0	0	0	1
Caryophyllaceae	0	0	0	1
Chenopodiaceae	0	0	0	1
Ephedra distachya type	0	0	0	1
Ephedra fragilia type	0	0	0	1
Calligonum	0	0	0	1
Tamarix	0	0	0	1
Nitraria	0	0	0	1

Fig. 1.

Site	Location	H_{real} [m a.s.l]	H_{mod} [m a.s.l.]	p_{ann} [mm/yr]	$p_{ann,mod}$ [mm/yr]	t_{ann} [°C]	$t_{ann,mod}$ [°C]
Qinghai	36.55°N, 100.1°E	3200	4008	250	230	-0.7	-1.8
Naleng	31.1°N, 99.75°E	4200	2600	630	1850	1.6	11.1
Zigetang	32°N, 90,9°E	4500	4330	300-500	743	-2.6 - -0.3	-4.8
Bangong	33.42°N, 79°E	4200	1898	70	250	-1.5	16.5

Fig. 2.