

## ***Interactive comment on “Fire, vegetation and Holocene climate in the south-eastern Tibetan Plateau: a multi-biomarker reconstruction from Paru Co” by Alice Callegaro et al.***

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Received and published: 9 July 2018

Anonymous Referee #1 General comments In this manuscript, A. Callegaro and colleagues present a multi-proxy investigation from a sediment core retrieved from a Lake on the Tibetan Plateau. They conducted relatively novel biomarker analysis to reconstruct past fire activity and vegetation in this area over the last 11 kyr. The paper is relatively well written and structured, and addresses scientific questions relevant to the scope of Climate of the Past. However the presentation of the results (figure) and more importantly the discussion and argumentation need to be improved and strengthened. I will highlight several cases under my “specific comments – major issues” where the

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argumentation was too superficial. Several possibilities for interpretation or explaining the discrepancies are often presented (e.g. fire activity, different transport, different fire temperature), which is good. But in the end the authors need to clearly state which one they favor and why. Looking at the figures, I mostly see discrepancies between the proxies. It may well be the case as the authors are comparing quite different indicators sometimes only marginally influenced by the parameter they are investigating (e.g. the effect of fire on n-alkanes). I strongly advise the authors not to go into too many directions, especially too many comparisons with other proxies or records that do not match. But rather make sure they have good arguments for their interpretation in the end. I would rather recommend showing a record of ISM intensity or temperature over the Holocene. The data are always presented with moving averages, which makes it difficult for the reader to appreciate for himself the original data obtained.

A: We thank Anonymous Referee #1 for useful comments that helped us improve the quality of the work. We substantially revised and rewrote great parts of the paper following your indications. We reply to specific comments below.

Specific comments Major issues: Page 9 line 2: I have to admit that I am quite skeptical about the high fluxes observed in both MAs and PAHs. As you state a few lines down, these high fluxes are the result of the higher sedimentation rate observed in the bottom part of the core. There is only one age point that is causing this high sedimentation rate, and no errors on this radiocarbon age are provided. Could it be that the sediment was distorted (stretched) during the coring process, causing these higher sedimentation rates. After checking Bird et al. (2014), it appears they dismissed a date which was much older (17.7 cal kyr) at 388.6 cm, as it was bracketed in between two ages in stratigraphic order. It could also be that your last one is a contamination during coring or bioturbation and that instead sedimentation rates were much lower in the bottom part of the core. Alternatively, the very high sedimentation rates could reflect an erosive event in the catchment. The TOM shows lower values for these older sediments. Erosion of catchment soil could bring also older fire biomarkers into the lake. Looking at the

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fluxes on figure 2b (ignoring the high peak), the MAs and PAHs don't show such similar patterns, except for the first maximum around 10.5 kyr BP and the following decrease to 10-9 kyr BP. You do make this statement further down on lines 23-24. You never actually explain this difference.

A: We agree with you the fact that the high sedimentation rate found in the deepest part of the core could have been derived by a distortion during the coring process or bioturbation, causing these higher fluxes of biomarkers. Due to this high uncertainty, we decided to discuss our biomarker's dataset only until 10.78 cal ky BP, as we state in our revised paper (P.6 L.12-14): "Since the deepest part of the core shows much higher sedimentation rate that cannot be clearly explained, with the possibility of data distortion, the subsequent description and discussion of the results exclude the samples aging 10.784-10.937 cal ky BP, limiting the dataset interpretation to the period between 1.347 and 10.768 cal ky BP". Moreover, as suggested by Anonymous Referee #3 we reanalyzed the samples for PAHs, including new target ions. The obtained results are different from the discussion paper and are shown in figure 2, that strongly changed.

Page 10 Line 25-26: You also never explain what could cause the difference between the 2 ratios L/M and L/(M+G), and which ratio is the more trustworthy, or which one you use for reconstructing the vegetation.

A: The difference between the 2 ratios is the inclusion of galactosan in the calculation. However, due to the fact that galactosan seems to show a different degradation pattern, we decided to discuss only L/M, as we state in the new version of the paper (P.10 L.2-4): "Due to the fact that galactosan presents a different biodegradation behaviour, the application of L/(M+G) ratio may be inadequate (Kirchgeorg, 2015). For this reason, we limited the discussion only to L/M ratio results."

Page 11, GCD results: I don't quite follow your argumentation. Why did you compile charcoal records over such a vast area? Are you expecting similar climatic trends

C3

over the Holocene, over this entire area 1000s of km across? If yes, then you should make it clear why (monsoonal systems etc). If no, then it doesn't make much sense to compile all of these into one record. You should also discuss in more details the different temperature of production of charcoal and levoglucosan, what does it imply? What explains different fire temperature, and what fire would you then expect to explain your data.

A: We agree with your observation on the fact that an area of 1000 km could be too wide to be considered as reference for Paru Co. Due to the fact that also Anonymous Referee #2 commented on this topic, we decided to exclude this part of the work from the new version of the paper due to the fact that this confrontation with GCD was not improving the data interpretation.

Page 13: It would have been useful to show a record of changes in monsoon strength (e.g. precipitation) along your own records.

A: As suggested, we added dD per mill of C27 and C29 figure 4(a) and lithics% in figure 5(b), retrieved from Bird et al. (2014), which are used as Indian Summer Monsoon indicators. Figures 4 and 5 are now strongly different respect to the previous version of the paper.

Page 13: If you would rather not trust your PAH record as a fire record, then you should make it much clearer earlier on, and mention that you will then only discuss MAs. Given the high variability of your PAHs, it may be your best option.

A: Since we reanalyzed all the PAHs fractions, we found new interesting results and we were also able to calculate Ant/(Ant+Phe), IP/(IP+Bghi) and FluA/(FluA+Pyr) diagnostic ratios. Therefore, we improved the discussion and the comparison between PAHs and MAs (section 5, from P.10 of the new version of the paper).

Page 14 line 7: Are you now arguing that the MAs peak at 5.6 is due to transport, and not fire activity? A bit earlier you were discussing the Bond Event 4 and monsoonal

C4

precipitation. This is somewhat confusing. If both could play a role, you should add a summary sentences stating that.

A: In the new version of the paper we removed the association between MAs and Bond Event 4. On the contrary, we improved a lot the discussion of long-range transport, with a new paragraph called "5.4 Atmospheric transport" in which we tried to explain how one of the most probable source of levoglucosan seems to be atmospheric transportation from the South.

Smaller issues: Title: I recommend adding "Lake" to Paru Co

A: The new title is "Fire, vegetation and Holocene climate in a south-eastern Tibetan lake: a multi-biomarker reconstruction from Paru Co".

Abstract, line 24: I would briefly explain why PAHs decreases but MAs remain high. What is the distinction to the intense biomass burning during the early Holocene where both were high?

The new data show that high molecular weight PAHs peak in the early Holocene, and we address this fact to intense local fires and elevated burning temperatures. We explain this fact in the discussion section (P.11 L.1-2): "The high concentrations of higher molecular weight PAHs during the early Holocene could be explained with local fires of greater combustion temperatures, due to the fact that higher number of rings requires greater burning energy (Denis et al., 2012) [...]" .

Page 2, line 5: In the sentence just before you state that fire contribute to greenhouse gases, this contradicts the end of the sentence here.

A: We agree and revised accordingly, now the sentence sounds as: "The impacts of greenhouse gases and associated global climate change on the frequency, intensity, duration, and location of biomass burning are not well understood and the contribution of fire emissions to past and future atmospheric composition are also unclear (IPCC, 2014)".

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Page 2, line 6: Why do you use "therefore"? I don't see a clear link into this last sentence. It makes sense that these sentences are in the introduction, but there is not much flow, or logical order to these sentences. They just seem to be put together. Please improve the argumentation.

A: We modified the sentences according to your suggestion. The new sentences sound as: "However, a recent study found that the synthesized Holocene fire record in eastern monsoonal China strictly tracks global atmospheric CO<sub>2</sub> concentration from Antarctica (Xue et al., 2018), but it is still not clarified which one between fire and CO<sub>2</sub> triggered the other. Therefore, more studies would be needed to improve human knowledge about past and present biomass burning events, which need to be characterized and accurately mapped in order to investigate interactions with weather, climate, and landscape dynamics over a range of spatiotemporal scales."

Page 2, line 13: (and throughout the manuscript) List references in chronological order, the oldest one first, the most recent one last)

A: Thanks for the indication, however, Climate of the Past does not require chronological order for the in-text citations, as it is explained in the website [https://www.climate-of-the-past.net/for\\_authors/manuscript\\_preparation.html](https://www.climate-of-the-past.net/for_authors/manuscript_preparation.html): "In terms of in-text citations, the order can be based on relevance, as well as chronological or alphabetical listing, depending on the author's preference". We have chosen the alphabetical order and we checked to be consistent throughout the manuscript.

Page 2 line 16: Can you specify what type of ecosystem processes?

A: We modified the end of the sentence, that now sounds as: "and other environmental processes such as vegetation growth, detrital influx, volcanic eruptions".

Page 2, line 18: Ice cores from where, also the TP?

A: In order to be more clear, we completely rewrote the sentence in this way: "Within the Tibetan Plateau (TP), only a few studies examine past biomass burning by using

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charcoal (Herrmann et al., 2010; Miao et al., 2017) or black carbon. Polycyclic aromatic hydrocarbons (PAHs) are reported in the lake sediments from the Tibetan Plateau (TP) spanning the last 2 centuries (Yang et al., 2016). Monosaccharide anhydrides (MAs), ammonia and black carbon in ice cores have been used as combustion proxies and indicators of fire on or influencing the Tibetan Plateau, but these records only cover the last century (Kaspari et al., 2011; Ming et al., 2008; Shugui et al., 2003; Xu et al., 2009; You et al., 2016b)".

Page 2 line 26: I don't see what you mean by specific environmental conditions?

A: The specific environmental conditions are explained after in the text, concurrently with the more detailed description of every class of biomarkers.

Page 2 line 31: I would clarify here that the following list of marker you are discussing are Mas

A: We agree and revised the sentence in this way: "Within the listed biomarkers, MAs are specific tracers of vegetation combustion".

Page 4 line 25-26: Please rephrase this sentence: the first part of the sentence is about difficult access to paleoclimate archives and then you mention few investigations into species diversity and plant communities. Where is the relationship?

A: We rephrased the sentence, that now sounds as: "However, its remote nature restrains access to possible paleoclimate studies, resulting in relatively few investigations of past species diversity and plant community changes".

Page 5 line 19: Define ecosystem functions or use another word, e.g. vegetation distribution?

A: We incorporated your change in the sentence as following: "More recently, human activities and related climate change have significantly altered the regional hydrology and vegetation distribution of the plateau, with degeneration of plants that led to desertification and frequent dust storms (Wang et al., 2008)".

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Page 5 and Figure 1: It would have been more useful to have a more precise catchment map showing these features than the large google map on figure 1 or the satellite picture showing only the lake.

A: In the new version of the paper we added a focus on atmospheric transport to the Tibetan Plateau. That is why in our opinion figure 1(a) is important to understand the continental position of the lake within the neighboring geographic areas. We have just zoomed in on the study region.

Page 6 Line 8: The  $^{137}\text{Cs}$  determination method is not cited here, whereas the radio-carbon is.

A: We added the expression "determined by direct gamma counting" in order to specify the  $^{137}\text{Cs}$  determination method.

Page 8 line 7: How did you obtain wet density?

A: We calculated wet density with this formula:  $\text{dry density (g/cm}^3\text{)} + (\text{water content (\%)} * \text{water density (g/cm}^3\text{)})$ .

Page 8 line 11: for the other ratios you clearly state what they are useful for. You should do the same with the ACL, what can it tell you?

A: We briefly added the significance of ACL. The sentence now sounds as: "the average chain length (ACL), representing the composite of longer and shorter n-alkanes between the chain length range of 21 to 33 and indicating the prevailing length".

Page 8 line 29: please provide these latitude and longitude ranges. How many records did you compile in total?

A: Since we removed the comparison with the GCD, this information can be neglected.

Page 9 line 7: or you had erosion of older compounds in the catchment (soil).

A: Thanks for the suggestion. As already specified earlier in the responses, in the new

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version of the paper we decided not to discuss the data of the deepest part of the core.

Page 9 line 30: Why didn't you look at the correlation between BiSi and PAHs and TOM and PAHs?

A: The correlation between PAHs and TOM was indicated at page 10 line 14 in the discussion paper. However, due to the fact that the new PAHs data are different, we did not consider in the discussion these correlations.

Page 9 line 33: It would have been good to summarise here how the link ISM-BiSi works.

A: Thanks for the tip. In the new version of the paper, BSi is not used as indicator for ISM. Instead, we used lithics(%), inserted in figure 5(b), because more intense rainfall result in greater lithic deposition (Bird et al., 2014).

Page 10 line 1-9: These correlations should be presented when you first describe similar trends of both PAHs and MAs, at the beginning of the section!

A: We agree with the comment and, in the new version of the paper, we present the correlation values at the beginning of the result section.

Page 10 line 2: the (negative) correlation between MAs and TOM was larger than this (-0.54) and with a more significant p-value. Maybe there is something to discuss there, even though it is not positive as you expected.

A: Thanks for the comment. The correlation at page 10 line 2 was between PAHs and MAs. The correlation between TOM and MAs was at page 9 line 29.  $r = -0.54$  was referred to the correlation between MAs and BSi, not to MAs and TOM. For this reason your question is not totally clear to us. By the way, we were not expecting positive correlation between MAs and TOM, because it would have been signified a relationship of MAs with organic matter.

Page 10 line 5: how does it vary? Does it vary with time, depending on the main

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climate?

A: That sentence was removed from the paper. However, an explanation about MAs catchment area is given in the new section 5.1 (paleofire activity) where we say that "MAs are capable of travelling hundreds of kilometres (Schüpbach et al., 2015; Zennaro et al., 2014)".

Page 10 lines 5-9: These last two sentences should probably be moved to the discussion section.

A: Thanks for the comment, we incorporated your changes in the new version of the paper. Now, section 4 is dedicated only to the mere description of the results.

Page 10 line 7: Unfortunately we don't see the original concentration in your figures, only the fluxes.

A: The new figures strongly changed due to the facts that we have some new data and that we decided to use concentrations instead of fluxes, because data discussion is focused between 1.347 and 10.768 cal ky BP, when sedimentation rate is constant.

Page 10 line 8: can you specify what you mean by "biogenic origin"? combustion of biomass is also biogenic for me

A: In the new version of the paper we the confrontation between PAHs and TOM was not considered for the data interpretation, so that sentence is no more present.

Page 10 Line 13-15: I don't fully understand this sentence, can you rephrase it to be more clear?

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 10 line 15: Is the statistic done only for this interval, or for the entire core? please specify

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A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 10 line 19: please provide some examples of these changes in the terrigenous environment.

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 10 line 28: It would be useful to either state the published range in the text, or in the figure. Are those ranges for L/M, or for L/(M+G)

A: As you suggested, we incorporated a better description of the L/M ranges in the new version of the paper, in the new section 5.2 "Combustion sources", where we state, for example: "In addition to the PAH ratios, L/M ratios can also help determine combustion sources. L/M emission ratios ranging between 0.6–13.8 may be due to softwood combustion, while ratios between 3.3–22 depict hardwood burning, and ratios 2.0–33.3 may be due to burning grasses".

Page 11 line 1: the second part of this sentence is rather vague. n-alkanes do not record all organic input inot the lake, and they also record organic production within the lake.

A: We revised the sentence according to your suggestion: "Past vegetation changes can also be derived by variations in n-alkane ratios, as n-alkanes can record the organic input into and within the lake".

Page 11 line 15: Here you should list the other FeSts, especially those that would have indicated the presence of humans.

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 11 Line 16-17: Are there other information (e.g. archeology) which could support

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this finding? No known settlement in this area, too high elevation, ...?

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 11 lines 19-23: All this first part should be in the method section.

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 11 line 31: I only counted 3 colour bars where the arrows go in the same direction, that's pretty bad as a similarity...

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 12 line 31: I wouldn't call this composite record regional, it's almost continental

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 13 line 5: How do these different burning temperature occur? You need to discuss this point in further details. Would we then have low or high temperature fire during this interval, and why, what caused this type of fire?

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and you would see that references to different combustion temperatures are made frequently throughout the text. For example: "If we assume that low molecular weight PAHs degrade at 500 °C, we have to assume that MAs may also degrade at this temperature, as maximum concentrations occur at burning temperatures centred around 250 °C".

Page 13 line 14: The PAHs show a clear minimum at 8kyr. The Sum of MAs show a peak from 8 to 9 kyr BP. The 8.2 cal ky BP was a short and abrupt event, if the ISM was peaking then, I would not expect a 1000 year long dry interval.

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A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 15 line 4: that warm period would fall right into the 8.1 to 7.2 cold intervals (1-2 degrees cooling) you are mentioning a few lines up...that's contradictory

A: We agree and revised the sentence in order to be more clear. The new sentence sounds as: "However, within this warm period, the climate had a sudden, intense change between 8.1 and 7.2 cal ky BP with temperatures 1-2 °C below early and mid-Holocene levels and forests retreating downslope."

Page 15 lines 6-7: please specify the time interval here. As you were just mentioning relatively young intervals (<2.7 kyr BP) where you don't have fire records it is confusing. Do you mean for the early Holocene?

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 15 line 18-19: I wonder which one (forest or shrub) tend to have more fire? I also wonder if the presence of forest or shrub has an influence on the fire temperature?

In general, woody fires tend to have higher temperatures (350-550 °C) respect to grass fires (120-250 °C). Due to the fact that forest and shrubs are both woody plants, there is no much difference between them, but it depends mostly on the weather/climate. Fire temperatures are influenced by both quantity and quality of the fuel. In woody vegetation, backfires frequently burn longer and deeper but headfires are hotter.

Page 15 line 22-24: In this sentence is is hard to follow what the observations where, and what are the suppositions, could you reformulate more clearly what has been observed, and what is assumed?

A: We clearly reformulated the sentences, that now sound as: "After 5.2 cal ky BP, lake levels decreased, probably causing opposite fluctuations in both ACL and Paq, suggesting diminished ISM rainfall, reduced clastic deposition, and lowered lake levels,

C13

which leading to an invasion of the littoral zone on the core site and an increase in sand deposition (Bird et al., 2014). The fluctuations in both ACL and Paq are consistent with these lake level changes (Figures 3 and 4)."

Page 15 line 32-33: I don't follow your argumentation. How can you infer that this mechanism would also occur in the sediments?

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 16 line 1-2: leaf waxes can also be abraded and transported by the wind, as well as in streams in suspended sediments, leaves are not necessarily requested for their transport and deposition

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 16 line 6: I don't understand what you insinuate here? What details would you look into? Please be more specific and/or provide examples.

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

Page 16 line 25: No, they can also be transported quite far by winds.

How much do you mean with "quite far"? In the new version of the paper we found that CPI and L/M have a slight positive correlation ( $r = 0.31$ ,  $p\text{-value} = 0.03$ ) suggesting that both local and regional sources are possible.

Page 17 line 1: what do you mean by paleoreconstruction information, this is too vague, could be paleotemperature, paleoprecipitation...

A: Due to the substantial modifications in the results, section 4 and 5 of the new version of the paper are completely changed and this sentence is no more present.

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Page 17 line 27: You should not discuss something for the first time in the conclusion. This expansion of Bronze Age civilization should have been mentioned earlier. In the text, you mention 4.2k as the collapse of Chinese Neolithic cultures

A: Due to the substantial modifications in the results, also section 6 of the new version of the paper is completely changed and this sentence is no more present.

Page 31 – figure 5: Your lake is located at 30N, why do you use the insolation at 40N?

A: All the figures from 2 to 5 have strongly changed. Now we used insolation a 30° N in figure 4(e).

Page 31 – figure 5: There are dots in between the Paq and the ACL graphs, to which graph do they belong to?

A: All the figures from 2 to 5 have strongly changed. Paq and ACL are now shown in figure 4(b,c).

Page 31 – figure 5: I wonder what signal you would obtain if you were to use the same 5pt moving average on the Paq and the ACL. It seems to me that the Paq data without moving average show a signal similar to the sitostanol

A: All the figures from 2 to 5 have strongly changed. Paq and ACL are now shown in figure 4(b,c) and compared to lake level changes from Bird et al. (2014).

Page 31 – figure 5. I am not quite convinced by the insolation driven trend. Or at least I don't think this is the signal you should be looking for in your n-alkanes data over the Holocene. I am also not convinced by your green bars highlighting similar oscillations in Norm 31 and sitostanol. The youngest peak is relatively coeval, the one before is already almost opposite (sitostanol peak is closer to the Norm31 minimum than to its maximum). The third Norm31 peak is not coeval with any peak in Sitostanol. And the 4th peaks are again quite offset.

A: All the figures from 2 to 5 have strongly changed. The comparison between Norm31

C15

and Sitostanol was removed, since it was not considered significant within the new data interpretation.

Page 32 Figure 6: The figure is of poor resolution. The blue dots on the map in panel a are not described/explained. If not used these should be removed. The oscillations in panel b (charcoal) can barely be seen. The curve and its envelope (dotted curves) are not explained. I suggest deleting “resulted” and “analysis” from the figure caption. The figure caption should also describe what the blue green and red arrows are for.

A: Figure 6 was removed, since the GCD comparison was no more informative within the new data interpretation.

Technical corrections Page 2, line 11: delete provided

A: We agree and revised accordingly, the new sentences sounds as: “Lake sediments archive high-resolution histories of sediment flux, as well as climatic, hydrological and ecological changes, as long as the lakes preserve sediments through time”

Pag 2 line 28: delete "in buried sediments"

A: We agree and revised accordingly, the new sentences sounds as: “Significant concentrations of these compounds are present in soil and sedimentary archives with ages older than 10 cal ky BP”.

Page 2 line 31: You could add “and longer timescales” after “the Holocene”

A: We agree and revised accordingly, the new sentences sounds as: “suggesting that degradation, if happening, is a low-kinetic process (Battistel et al., 2016) and that these compounds resist over the Holocene and longer timescales”

Page 3 line 17: I would here mention “diverse distribution of chain length”

A: We agree and revised accordingly, the new sentences sounds as: “Different types of plants have diverse distribution of n-alkanes chain-lengths”.

C16



Page 4 line 1: replace “anthropological” with “archeological”?

A: With “anthropological” we mean a wider evidence of human presence (FeSts, human-related pollens, ...) respect to “archeological”, that is only related to archeological findings.

Page 4 line 2: replace “quantification” with “determination” (I wouldn't say that we can truly quantify the presence of humans. We are not there yet.

A: We agree and revised accordingly, the new sentences sounds as: “Revealing human presence in lake catchments often relies on anthropological evidence, but advances in proxy development during the past two decades now allows determining of the presence of humans or pastoralism through steroid fecal biomarker concentrations”.

Page 5 line 5: You could mention the Younger Dryas & Bolling Allerod in your text.

A: We agree and we added “in the context of Bølling–Allerød and Younger Dryas events in the region” to the sentence.

Page 5 line 12: You could maybe use “superimposed on these oscillations” instead of “even with these oscillations”.

A: We agree and revised accordingly, the new sentences sounds as: “Superimposed on these oscillations, the general temperature trends affecting the TP include warm and humid climate in the early to mid-Holocene, as registered in sediments and dust deposits”.

Page 8 line 3: I would rather use data “analysis” instead of “elaboration”

A: We agree and revised accordingly. The title of the section is now “3.4 Data Analysis”

Page 8 line 9: Replace “significant” with “significant”

A: We agree and revised accordingly, the new sentence sounds as: “In order to help data interpretation, 2-tailed Pearson's correlations were calculated in R with a 95%

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confidence interval (Supplement S3) with statistically significant results when p-values are  $< 0.05$ ”.

Page 8 line 11: what do you mean with “useful for work”? I would rather say “useful for our study, or for our interpretation”

A: We agree and revised accordingly, the new sentence sounds as: “N-alkanes ratios useful for our study include [...]”.

Page 8 line 30: Here you should refer to the figure presenting this data

A: Due to the substantial modification of the paper, this part is no more included in the new version.

Page 9 line 17: use “up to” instead of “touching values till”

A: Due to the substantial modification of the paper, this part is no more included in the new version.

Page 9 line 21: remove the comma

A: Due to the substantial modification of the paper, this part is no more included in the new version.

Page 13 line 27: delete the second “not”

A: Due to the substantial modification of the paper, this part is no more included in the new version.

Page 15 line 2: Is there a word missing? (“a limited abrupt to”???)

A: Due to the substantial modification of the paper, this part is no more included in the new version.

Page 15 line 13: I would rather use another verb, for instance “place the Paru Co...”

A: Due to the substantial modification of the paper, this part is no more included in the

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new version.

Page 15 line 15: specify the time interval considered

A: Due to the substantial modification of the paper, this part is no more included in the new version.

Page 15 line 26: I would rather call this "long term trend" than "millennial scale".

A: Due to the substantial modification of the paper, this part is no more included in the new version.

Page 15 line 29: can you indicate by how much on average?

A: Due to the substantial modification of the paper, this part is no more included in the new version.

Page 15 line 30: same here, by how much? is it significant?

A: Due to the substantial modification of the paper, this part is no more included in the new version.

Page 16 line 4: "it seems that"

A: Due to the substantial modification of the paper, this part is no more included in the new version.

Page 16 line 11: slash and burn -> at which time?

A: We added "over the past 4600 years (Miehe et al., 2006)" in the sentence.

Page 16 line 11: Please indicate Lhasa on Figure 1.

A: We agree and revised accordingly.

Page 16 line 12: where exactly? Please show on the map.

A: We agree and revised accordingly.

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Page 16 line 16: compared to (or "with respect to")

A: Due to the substantial modification of the paper, this sentence is no more included in the new version.

Page 16 line 32: Comparing data that resulted from (or originated from)

A: Due to the substantial modification of the paper, this sentence is no more included in the new version.

Page 16 line 33: "processes that happened"

A: Due to the substantial modification of the paper, this sentence is no more included in the new version.

Page 19 line 6: The journal and pages are missing.

A: We checked and added the correct missing details.

Page 29: Specify in the figure caption that the BSi axis is inversed

A: Thanks for the observation, but now BSi is no more used in our graphs.

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Interactive comment on Clim. Past Discuss., <https://doi.org/10.5194/cp-2018-19>, 2018.

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