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Interactive comment on "Decapitation of high-altitude glaciers on the Tibetan Plateau revealed by ice core tritium and mercury records" *by* S. C. Kang et al.

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Interactive comment on "Decapitation of high-altitude glaciers on the Tibetan Plateau revealed by ice core tritium and mercury records" by S. C. Kang et al. Anonymous Referee #1 Received and published: 11 February 2015 With their paper "Decapitation of high-altitude glaciers on the Tibetan Plateau revealed by ice core tritium and mercury records" Kang and others provide data from two high elevation ice cores and relate these to presumably negative mass balance at those sites during recent decades. The paper is generally well written, clear and provides interesting results. It certainly deserves publication in the journal. Nevertheless, I am concerned regarding six major

issues, a series of smaller points and some deficiencies regarding figures. I recommend that these points are well looked after before final acceptance of the paper in TC.

Answer: We very much appreciated the constructive and detailed comments from this reviewer, and have incorporated all of them in the revised ms. Below we provide a point-by-point reply to the comments.

The six major points are the following: 1. Wording and Title: I think that the wording in the title and in subsequent phrases in the manuscript needs a little revision. To my understanding "decapitation" is in this case an inappropriate word that relates to killing of living creatures. In most circumstances, in civilization, people would associate a criminal offense with such kind of action. I don't think glaciology should make use of such martial wording. In contrast to this, climate is a physical system that does not act in the sense living creatures can act. Furthermore, a glacier is a dead body of frozen water. Regardless of the fact that it moves under the influence of gravity it is not a living thing that can be decollated. Therefore, and with respect for anything that is actually an animate being on the planet, I strongly recommend replacing the word "decapitation" with for example "loss of accumulation area" or "diminishing accumulation area" or something similar.

Answer: Agreed. The title has been changed to "Dramatic loss of glacier accumulation area on the Tibetan Plateau revealed by ice core tritium and mercury records"

2. Overall conclusions and generalization of results from only two sites to the whole region: Since both ice cores have been collected from sites at 5800 m asl you cannot really say anything regarding higher altitude accumulation areas above 5800 m asl. Therefore, maybe there is no complete loss of accumulation area since there might be remaining bits of accumulation areas further up. Therefore, I strongly recommend to be precisely saying that there has been a loss of accumulation area probably up to about 5800 m asl at the two study sites. Anything that's further up on the glaciers or

related to other glaciers in the area is - to my understanding - not covered by this study. In consequence, a complete loss of accumulation cannot be concluded from the study. That doesn't invalidate the study. It simply implies that - while "decapitation" shouldn't be used as a word anyway - even the complete loss of accumulation area is not a valid mature conclusion as long as it is solely based on the analysis of the two ice cores.

Answer: Agreed and we have avoided the use of "decapitation" throughout the revised ms.

3. In the section on methodology it is said that the ice cores were taken from slightly above or around the ELA (P421, L13) above the actual snowline. Isn't the area above the ELA part of the accumulation area? How can you obtain an ice core from above the ELA and at the same time reach the conclusion that there isn't any accumulation area on these glaciers since decades? If the latter would be the case the ELA should lie above the summit. Then it would not be possible to find any coring site above the ELA. Somehow this issue needs clarification. Answer: The ice core drilling site was chosen in the accumulation area according to the ELA (equilibrium line altitude) of 5570 m a.s.l. in the northern region of Mt. Geladaindong in 1970s reported by Zhang (1981). However, the coring site was in the ablation area when the ice core was retrieved in 2005. Yao et al. (2012) reported that continuous deficit mass loss occurred since the 1990s in the central Tibetan Plateau due to dramatic warming. Therefore, the accumulation area of the glacier in the 1970s (Zhang, 1981) had most likely changed to the ablation area since the 1990s. In the revision, we have clarified this.

References: Yao, T., Thompson, L. G., Yang, W., Yu, W. S., Gao, Y., Guo, X. J., Yang, X., Duan, K. Q., Zhao, H., Xu, B., Pu, J., Lu, A., Xiang, Y., Kattel, D., and Joswiak, D.: Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings, Nat. Clim. Chang. 2, 663-667, 2012. Zhang, L.: Glacier at the source region of Tuotuohe River in the upper reaches of the Yangtze River and their evolution. J. Glaciol. Geocryol. 3, 1-9, 1981.

4. Counting annual layers backwards from the nuclear bomb horizon could imply that there are years without accumulation before 1982, in such that 1982 not necessarily needs to be the last year of positive accumulation. Maybe the last year with accumulation was later and there have been years without accumulation before 1982? Is it possible to constrain the Hg-records to better than +/- 10 years? Please at least discuss this issue.

Answer: We agree. Dating of counting annual layers was verified by the 210Pb dating which suggested that the top of the core was dated to 1982 $\pm$ 5 years as shown in our Fig. 3b. The resolution of Hg record is $\sim$ 5 yrs, thus the Hg records showed maximum values which referred to 1980s. One assumption in dating by counting annual layers backwards from the 1963 AD nuclear bomb horizon to 1982 AD is that there was annual net ice accumulation during this period. Uncertainties in the chronology will thus rise should there be no net accumulation in one or some of the years due to ice melt. This does not appear to be the case for the Geladaindong ice core, as the annual variation patterns and amplitudes in the main ion concentrations were similar upward and downward from the 1963 AD layer, suggesting no occurrence of strong melt (Fig. 4). Furthermore, the air temperatures were much lower before 1980s than those in the last three decades according to the data observed from the nearby meteorological stations such as Amdo. Indeed, the continuously deficit mass balance (cumulative negative mass balance) has only been reported since the 1990s in the central Tibetan Plateau (e.g., Xiaodongkemadi glacier (Fig. 6), near to the Geladaindong region; Yao et al. 2012), as well as in the northern neighboring region (e.g., Glacier No. 1 (Fig. S1), Tienshan Mts.; Zhang and others, 2014), due to dramatic warming in recent decades. Therefore, we might suggest that the mass loss of the coring site occurred mainly from the 1990s in the central Tibetan Plateau. Then, a continuous deficit mass balance caused the surface of the ice core up to 1980s. We have added discussions in the revision.

References: Yao, T., Thompson, L. G., Yang, W., Yu, W. S., Gao, Y., Guo, X., Yang,

X., Duan, K., Zhao, H., Xu, B., Pu, J., Lu, A., Xiang, Y., Kattel, D., and Joswiak, D.: Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings, Nat. Clim. Chang. 2, 663-667, 2012. Yao, T., Wang, Y., Liu, S., Pu, J., Shen, Y., and Lu, A.: Recent glacial retreat in high Asia in China and its impact on water resource in Northwest China, Sci. China (D), 47(12), 1065-1075, 2004. Zhang, G., Li, Z., Wang, W., and Wang W.: Rapid decrease of observed mass balance in the Urumqi glacierNo.1 Tianshan Mountians, central Aisa, Quatern. Intern. 349, 135-141, 2014.

5. Most of the time a DDF for snow will need to be used at high elevation sites that have almost permanent snow cover. DDFs of 3 to 8 mm/_C for snow seem to be reasonable to my knowledge, but certainly not DDFs above 10 mm/_C. Otherwise, please cite the references that justify a DDF for snow that is higher than 10 mm/_C. I think that the analysis of uncertainty regarding upper and lower limits of the melting according to the degree day modelling is not sufficient. You should provide three records of melting with the lowest, the middle and the highest reasonable DDF combined with the lowest, middle and highest reasonable temperature lapse rate - making up nine calculations at the least. This would provide the range of uncertainty with respect to the DDM. However, the uncertainty is much larger because a DDM is only a rough estimate of the melting since it does not fully cover all relevant physical processes. Further, the uncertainty in the precipitation estimate must be stated more clearly. The plus in precipitation at a high altitude site compared to stations further down in the forelands can easily reach 100%! Do not just give ranges but provide the full range of data in a Figure or a Table. The data provided in Figure 8 is not sufficient for this purpose.

Answer: We have added more detailed info re DDM in the revised ms, including two new tables (Tables 1 and 2). Daily temperature and positive cumulative temperature at the two sites were calculated based on the minimum (0.5 âĎČ/100 m) and maximum (0.72 âĎČ/100 m) temperature lapse rate reported by Li and Xie (2006) and Yang et al. (2011), respectively, for the Tibetan Plateau (Tables 1 and 2, Fig. 7). The Medium value was set as the global average of 0.6 âĎČ/100 m. Due to the differences in the

surface energy-balance characteristics of snow and ice (including albedo, shortwave penetration, thermal conductivity and surface roughness), reported DDFs vary greatly among regions and times. Based on previous work in the southern and central Tibetan Plateau (Wu et al., 2010; Zhang et al., 2006), we selected DDF values of 3.0 (minimum for snow), 5.3 (medium for snow), 9.2 (medium for ice) and 14 (maximum for ice) mm âĎČ-1 d-1, respectively (Tables 1 and 2). The change rate of precipitation ranged from 0.87 to 11 mm /100 m in the high elevations of the Qilian and Tienshan Mts. (Liu et al., 2011). However, there are no observed data available for the central Tibetan Plateau. Thus we assumed that precipitation was the same at the coring site as at the nearby station when using DDM, although in reality it might be higher at the coring site than that at the nearby station. References: Li, Q. and Xie, Z.: Analyses on the characteristics of the vertical lapse rates of temperature- taking Tibetan Plateau and its adjacent area as an example, J. Shihezi University (Natural Sci.), 24(6), 719-723, 2006. Liu, J., Chen, R., Qin W., and Yang, Y.: Study on the vertical distribution of precipitation in mountainous regions usingTRMM data, Advances in Water Science, 22(4), 447-454, 2011. Wu, Q., Kang, S., Gao, T., and Zhang, Y.: The characteristics of the positive degree-day factors of the Zhadang Glacier on the Nyainqêngtanglha Range of Tibetan Plateau, and its application, J. Glaciol. Geocryol., 32(5), 891-897, 2010. (in Chinese with English abstract) Yang, X., Zhang, T., Qin, D., Kang, S., and Qin, X.: Characteristics and changes in Air Temperature and Glacier's Response on the North Slope of Mt. Qomolangma (Mt. Everest), Arct. Antarct. Alpine Res., 43(1), 147-160, 2011. Zhang, Y., Liu, S. Y., and Ding, Y.: Spatial variation of degree-day factors on the observed glaciers in western China, Acta Geographica Sinica, 61(1), 89-98, 2006.

6. It may be a possibility that there were some warm years that removed the nuclear signal from the accumulation area while after that other years still had a positive mass balance. I understand that the Hg-record is a further indication that this is not the case. However, the temporal constraint of the Hg-record is not so clearly provided in the text. I would argue that the authors should more cautiously discuss any possible

flaws in their chain of arguments so that the reader gets a better understanding of the reasoning behind the conclusion. There is a chance that overall the case is not quite as simple as it appears according to the manuscript. I believe it would strengthen the paper quite a bit if you could elaborate on this in more detail.

Answer: As per our reply to Comment 4 above, strong melt (or mass loss) might have been happening since the 1990s according to the observed continuous deficit mass balance in the central Tibetan Plateau. We suggest that the nuclear bomb signal can be reserved in the deposited layers. In the revised ms, we have clarified that the surface age (1982) had an uncertainty as indicated by 210Pb dating.

Smaller points that still need consideration: P419, L11; P420 L15, P424, L26, P427, L20, P428, L6: replace "glacier decapitation" and similar wording with more appropriate wording – see my comment above Answer: We have replaced "glacier decapitation" throughout the revision.

P420, L1: insert "the before "last decade".

Done.

P420, L9: "marker horizons" not "maker horizons".

Done.

P424, L6: "Faïn" instead of "Fain".

Done.

P424, L17: "Hylander" instead of "Hyland".

Done.

P424, L25-27 and hereafter: The conclusions or rather generalizing statements based on only few measurement sites should be avoided. I would strictly limit the statement to findings refereeing to the investigation sites of this paper since individual glaciers in

the same region may heterogeneously respond to climate forcing.

Answer: We agree and have revised the ms accordingly.

P425, L10: "in the order" instead of "on the order".

Done.

P424, L20: replace "tracks" with "matches" or "agrees".

Done.

P425, L25: replace "at" with "of".

Done.

P 425, L19: "Since 1995, the cumulative mass loss reached 5000 mm with an annual mass loss rate of about 300 mm w.e.": What is the end date of the period in which mass loss piled up to 5000 mm?

Answer: The period is from 1995 to 2010 for the observation of Xiaodongkemadi glacier mass balance. We have added this info in the revised ms.

P426, L3: skip the word "to" in "confirm to widespread glacier : : :". The statement anyway is a bit strong since from your study you can only draw conclusions for the two study sites. Maybe better say that mass loss is in "in agreement" or "consistent" with your finding but refrain from drawing an overall conclusion for the whole region.

Answer: We agree and have revised the conclusion accordingly.

P426, L20: skip "of glacier area" in "may occur at the higher elevations of glacier area compared with : : :"

Answer: We agree and have revised the conclusion accordingly.

P226, L25: skip "the" in "according to the previous works : : :".

Done.

P427, L3: "mass loss" instead of "mass losing".

Done.

P427, L15: change to “oF glacierS during the last decade ranging from THE Himalayas : : :”.

Done.

P427, L16: "northwestern TP" instead of "northwestern of the TP"

Done.

Figures: Fig.1: Number the three parts of the figure (e.g. a,b,c) and give proper explanations in the figure capture. Insert a color legend in the uppermost map. You should overlay altitude lines so that the reader can see the topography and general altitude. Please provide a coordinate system and glacier outlines for the glaciers interesting for your study in the two lower pictures. The lower right picture is of bad quality. Choose a better satellite image. Please use consistent naming of the glaciers (e.g. Xiaodongkemadi in the map and Dongkemadi in the figure caption).

Answer: We have modified the figure.

Fig. 6: Clearly indicate in the figure caption if these are measured or modelled mass balance data. Change "Mt. Nyainqentanglha" to "western Nyainqentanglha Mts."

Answer: Done.

Fig. 8: This figure gives no additional information because the numbers are already given in the text. I suggest removing this figure. The definition of Min and Max is confusing. Min should be more negative, but in your case it is the least negative (most positive) mass balance.

Answer: We have deleted Fig. 8 and added Tables 1 and 2 concluding calculated results.

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/9/C450/2015/tcd-9-C450-2015-supplement.pdf

Interactive comment on The Cryosphere Discuss., 9, 417, 2015.

Tables

Table 1 Calculated annual net mass balance (mm w.e. yr^{-1}) during 1966-2013 AD based on various degree-day factor (DDF) values (mm ℃$^{-1}$ d^{-1}) and temperature lapse rates (℃/100 m) at the Geladaindong ice core site. Negative values represent deficit mass balances.

Table 2 Calculated annual net mass balance (mm w.e. yr^{-1}) during 1966-2013 AD based on various degree-day factor (DDF) values (mm ℃$^{-1}$ d^{-1}) and temperature lapse rates (℃/100 m) at the Nyainqentanglha ice core site. Negative values represent deficit mass balances.

Table 1

DDF[a, b] / Temperature lapse rate	Minimum 3.0 (snow)	Medium 5.3 (snow) 9.2 (ice)	Maximum 14.0 (ice)
Minimum (Tr1)[c] 0.5	-386±220	-1025±369 -2108±625	-3441±944
Medium (Tr2) 0.6	-121±192	-925±576	-2203±811
Maximum (Tr3)[d] 0.72	132±157	-109±247 -518±408	-1021±610

a: Wu et al., 2010; b: Zhang et al., 2006; c: Li and Xie, 2006; d: Yang et al., 2011.

Table 2

DDF[a, b] / Temperature lapse rate	Minimum 3.0 (snow)	Medium 5.3 (snow) 9.2 (ice)	Maximum 14.0 (ice)
Minimum (Tr1)[c] 0.5	-469±249	-1189±400 -2410±663	-3912±992
Medium (Tr2) 0.6	-2.57±212	-671±538	-1733±791
Maximum (Tr3)[d] 0.72	336±150	234±207 60.4±313	-153±450

a: Wu et al., 2010; b: Zhang et al., 2006; c: Li and Xie, 2006; d: Yang et al., 2011.

Fig. 1.

Figures

Figure S1

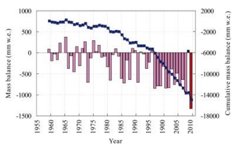

Fig. S1 The annual (pink bar) and cumulative (blue line) mass balance of the Urumqi glacier No. 1 located in the astern Tienshan Mts. (Zhang et al., 2014).

Revised Figure 1

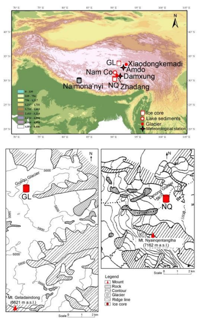

Fig. 2.