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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.

**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 #2 Received and published: 5 March 2015 Glacier volume loss through high-elevation thinning is a major research conclusion, and the strength of this paper lies in expanding the already documented Himalayan glacier thinning to other locations in the Tibetan Plateau. The revision of the paper should concentrate more on this point, which may require significantly shortening the paper. The research adds valuable additional locations demonstrating high-altitude glacier thinning and therefore contributes



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to our scientific understanding of current freshwater volume stored in Tibetan Plateau glaciers.

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.

Comment 1: I am not convinced by the chronology of the Geladaindong ice core, as Figure 4 demonstrates what is likely a melt layer immediately deeper than the AD 1963 radioactivity peak. This likely melt then influences the comparison of Hg records in Figure 5. Do modern studies demonstrate a seasonal deposition of Ca2+ on these ice fields? Is there any evidence for melt above AD 1963? If the top of this glacier is thinning due to melt, it is likely that the melt influenced the upper strata of the glacier ice. Such melt may explain the offset in Hg records, where the Geladaindong Hg spike appears to occur 5-10 years earlier than the NamCo Hg spike (the geographically closest Hg record with which to compare the results). While comparing Hg records is an interesting approach, the errors associated with this approach (Figures 4 and 5) need to be expressly addressed throughout the paper.

Answer: 1) Based on the three snowpit records in the Guoqu glacier, Mt. Geladaindong, Zhang et al. (2007) reported seasonal variations in the concentration of Ca2+ and other major ions in snowpits, with higher values during the winter half year. At the Geladaindong ice core site, there were firn layers (snowpit) with a depth of 78 cm. The bottom of the snowpit was glacier superimposed ice, indicating one year transferring from snow to ice. Thus, melt could happen during the summer but seasonal signals were still reserved in the ice layers. In other words, the melt water (or percolation) should not disturb the layers deposited in previous years as other studies suggested (Namazawa and Fujita, 2006; Eichler et al., 2001). 2) The temperature was much lower before the 1980s than in the last three decades observed from the nearby meteorological stations (such as Tuotuohe and Amdo). The continuous deficit mass balance (i.e., cumulative negative mass balance) only happened since the 1990s in the central Tibetan Plateau (e.g., Xiaodongkemadi glacier, near to the GL region) as reported by Yao et al., (2012) (Fig. 6) due to dramatic warming (Fig. 7). There is another example: the longest mass balance observation from Glacier No. 1 at the headwater of the Urumqi River (see Fig. S1 below), Tienshan Mts., China, suggested that the mass balance was fluctuating during 1950s to 1970s, and more deficit mass balance appeared in the 1980s, while almost continuously negative mass balance occurred since the mid-1990s (Zhang et al., 2014). Therefore, it is highly possible that the mass loss of the coring site occurred mainly from the 1990s in the central Tibetan Plateau, and this continuous deficit mass balance caused the surface of the ice core up to the 1980s. 3) The resolution of the Hg records from the Nam Co lake sediment is around 5 year, thus the timing of the peak may not exactly match that of the ice core records.

We have included these discussions in the revised ms.

References: Eichler, A., Schwikowski, M., Gäggeler, H.: Meltwater-induced relocation of chemical species in Alpine firn, Tellus B, 53 (2), 192-203, 2001. (DOI: 10.1034/j.1600-0889.2001.d01-15.x) Nakazawa, F. and Fujita, K.: Use of ice cores from glaciers with melting for reconstructing mean summer temperature variations, Ann. Glaciol., 43, 167-171, 2006. 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. 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. Zhang, Y., Kang, S., Zhang, Q., Cong, Z., and Zhang, Y.: Snow/ice records on Mt. Geladaindong in the central Tibetan Plateau, J. Glaciol. Geocryol., 29(5), 685-693, 2007. (In Chinese with English abstract)

Major points: P. 423 and Figure 2: You mention that some samples at 31 m were contaminated with tritium during sampling. How were the samples contaminated? Please define. This contamination needs to be explained because otherwise these elevated tritium concentrations at 31 m significantly affect the findings and conclusions.

Answer: The elevated tritium concentration (29.1 TU) at 31 m of the Nyainqentanglha ice core is clearly not representing the horizon from the atmospheric nuclear bomb testing between 1953 and 1972. Only one isolated sample has a tritium concentration elevated compared to the background (Figure 2). If this sample would represent the 1963 bomb horizon, the tritium concentration would have to be much higher (>200 TU), and the spike would need to be much broader as the atmospheric nuclear bomb testing occurred over more than a decade; all the samples from above (younger than) the 1963 bomb horizon would need to have a tritium concentration of 10 TU. This is clearly not the case. Tritium contamination in the laboratory can be excluded; no other sample showed elevated tritium concentrations, and the depth horizon at 31 m was re-sampled later with the similar tritium concentration confirmed.

P. 423 and Figure 2: In the figure caption, you note that the peak in Northern Hemisphere tritium is mid-1963. However, on page 423, you mention that this peak is "during the thermonuclear bomb testing era" which also includes the 1950s. It is essential to be more explicit of the actual years in the paragraph on page 423, as all resulting chronologies are dependent upon this assumption. Also, Figure 2 could be greatly improved if you visually separated the three records.

Answer: We agree and have edited the statement accordingly. Fig. 2 has been modified.

Figures 4 and 5: The annual layer counting in this figure is completely based on the Ca2+ peaks. While the d18O, Cl- and Fe variations can help support this information, it is not correct to say that they form the annual layer counting. What do the dust records show at the peak at 6 m depth? Is there any evidence of melt and refreezing that causes this large increase in Ca2+, Cl- and Fe? If so, the dating below 1963 AD may be incorrect. If this dating below 1963 AD is incorrect, then the comparison in Hg records in figure 5 may also be flawed.

Answer: We agree that there was melting in the summer at the coring site. However, as per our answer to Comment 1 above, we believe the melt water (or percolation) did not disturb the layers deposited in previous years.

Minor points: Figure 1: The map in the upper panel needs to show much more detail: (ie topographic lines, country borders, cities, etc.) that help the reader place the ice core sites into context. Such details are especially important since the meteorological stations are approximately 2000 meters lower than the ice core sites, as well as the fact that the authors extrapolate in to regional applications in the conclusions section. Answer: We have revised Figure 1. It is around 950-1500 meters between the ice core sites and the nearby stations.

P. 421 Line 1: This sentence contains two separate ideas that are not linked (as they currently are in the paper). Yes, the Tibetan Plateau influences the intensity of the monsoon. The monsoon itself is a reversal of weather patterns, but this reversal happens regardless of the intensity of the monsoon. Perhaps you would like to stay that the increasing the spatial extension of the monsoon may change weather patterns in regions (ie to the north) that are currently not influenced by the monsoon?

Answer: We have corrected the sentence in the manuscript as follows: "The plateau is also a major forcing factor on the intensity of the Asian monsoons, and mainly influenced by the Indian monsoon during the summer season."

P. 424 Lines 5-10 and Figure 2: All of these assumptions are based on the fact that mercury has an atmospheric lifetime of months. This long lifetime needs to be explicitly stated, so that the reader knows that these assumptions are valid. Answer: The lifetime of mercury is about 0.5-2 years. We have added this and corresponding reference in the revised text.

P. 425 Lines 25-26: Are these mass losses total mass losses for all glaciers? Or mass loss over a region? Or for a specific glacier?

Answer: It was an averaged mass loss per year over the central Tibetan Plateau (Neckel et al., 2014). In the study, glaciers were grouped into eight compact sub-regions where they assumed climatologically homogeneous conditions. The eight sub-regions are covered relatively well by the ICESat dataset (Neckel et al., 2014).

References: Neckel, N., Kropacek, J., Bolch, T., and Hochschild, V.: Glacier mass changes on the Tibetan Plateau 2003-2009 derived from ICESat laser altimetry measurements, Environ. Res. Lett., 9, doi: 10.1088/1748-9326/9/1/014009, 2014.

427 Lines 6 to 10. This sentence is confusing. In the previous paragraphs you suggest that ice and snow have different surface energy-balance characteristics both from each other and from surrounding non-glaciated terrain, which are both true. However, you need to expressly then mention these aspects if you move into the "possibly larger lapse rate in the glacier regions" argument. Or is the possibly larger lapse rate mentioned in the cited publication?

Answer: The larger lapse rate occurred in the glacier regions when comparing with the global average of 0.6 °C (100 m)-1 which was observed by other researchers (Yang et al., 2011). Note that we have revised the DDM section with more detailed info according to the suggestion from reviewer 1.

Miscellaneous: P. 419 Line 13: Please define the altitude(s) of the summit regions.

Answer: The altitudes of the summit regions are up to about 5800 m a.s.l. We have added this in the revised ms.

P. 419 Line 14: Define "this" at the beginning of the sentence. E.g. "This mass loss"

Answer: We have corrected this.

P. 419 Line 17: Please omit the abbreviation "TP" for "Tibetan Plateau" throughout the paper. You are not limited for space. It is easier and more clear to read sentences without acronyms.

Answer: We have corrected this.

P. 419 Line 24: Define “several percent”. 2%? 20%?

Answer: “several percent” is about 4.8%. We have clarified this in the revision.

P. 419 Line 22: Replace “retreating” with “retreat”.

Done.

P. 419 Line 24: Include “Tibetan Plateau” after “central”.

Done.

P. 419 Line 26: Include “the” before “last”

Done.

P. 420 Line 13: Add “thinning” after “this”.

Done.

P. 420 Line 16: This is not “Ice accumulation chronology”. The major point is that the ice is not accumulating over timescales of more than the seasonal surface snow. A better phrase could be “timing of ablation”. Done

P. 420 Line 18: Omit these acronyms from the entire paper. These acronyms only serve to confuse the reader. Your goal is to be as clear as possible, and the acronyms work against you.

Done.

P. 420 Lines 24 and 25: Replace “Climatically the southern and central TP is influenced primarily” with “The southern and central Tibetan Plateau is climatically influenced by”.

Done.

P. 420 Line 27: Omit “respectively”.

Done.

P. 421 Line 5: Change to: “by drilling to the bedrock depth of 124 m”.

Done.

P. 421 Line 17: Change “frozen” to “in a frozen state”.

Done.

P. 421 Line 21: Describe how much of the ice core was scraped away during the decontamination process.

Answer: Approximately 1 cm of the outer sections was scraped away. We have added this in the revision.

P. 421 Line 21: Replace “parts” with “sections”.

Done.

P. 421 Line 24: Place “the” before “outer”.

Done.

P. 421 Line 26: Place “of” before “the samples”.

Done.

P. 422 Line 12: Replace “showed good agreement of differences within 15%” to “agreed within 15% of each other”.

Done.

P. 422 Line 25: Place “bomb” after “thermonuclear”.

Done.

P. 423 Line 7: Place “the” before “central”.

Done.

P. 424 Lines 5-10: All of these assumptions are based on the fact that mercury has an atmospheric lifetime of months. This long lifetime needs to be explicitly stated, so that the reader knows that these assumptions are valid.

Done

P. 424 Line11: Replace “emissions” with “concentrations”. Done.

P. 424 Line 27: Please replace “experiencing shrinkage” with “retreating”.

Done.

P. 425 Line 3: Please omit “where ice cores were retrieved for reconstructing paleoclimate”.

Done.

P. 425 Line 6: Omit “hoever”.

Done.

P. 425 Lines 9-10. Replace “Suggest that the annual mass losses from upper glacier areas are at least on the order of several hundred millimeter water equivalent (mm w.e.) with “This data suggests that the glaciers have a net loss of at least several hundred millimeters water equivalent (mm w.e.) each year.

Done.

P. 425 Line 24: Please replace “they” with “these authors”.

Done.

P. 425 Line 26: The total mass loss?

Done.

P. 426 Line 4: Please replace “to” with “with”.

Done.

P 426 Line 8: Replace “DDM” with “DDMs”. Done.

P 426 Line 10: Place “as” before “the”.

Done.

P. 426 Line 16: Replace “station” with “stations”.

Done.

P. 426 Line 25: Replace “the previous works” with “the previous work”.

Done.

P. 426 Line 27: Please replace “ shows a dramatic increasing trend in positive accumulated temperature” with “shows a dramatic positive trend in increasing temperatures”.

Done.

P. 427 Line 3: Replace “glacier mass losing” with “glacier mass loss”.

Done.

P. 427 Line 15: Replace “glacier” with “glaciers”.

Done.

P. 427 Line 16: Replace “northwestern of the TP” with “northwestern section of the Tibetan Plateau”. Done.

P 428 Line 1: What do you mean by “inland” ? Do you mean the southern section of the Tibetan Plateau?

Done.



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P 428 Line 5: Replace “outburst” with “outbursts”.

Done.

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/9/C462/2015/tcd-9-C462-2015-supplement.pdf

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

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**Figures**

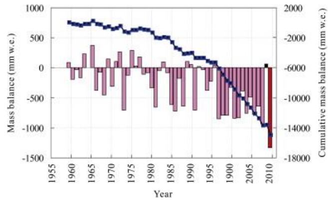


Fig. S1. The annual (pink bar) and cumulative (blue line) mass balance of the Urumqi glacier No. 1 located in the astern Tienshan Mountain (Zhang et al., 2014).

The revised Fig. 2.

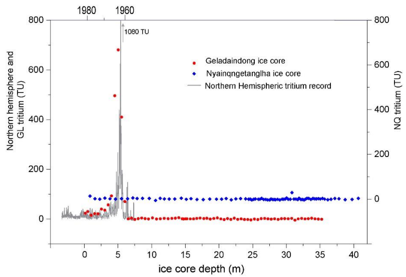


**Fig. 1.**



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The revised Fig. 1.

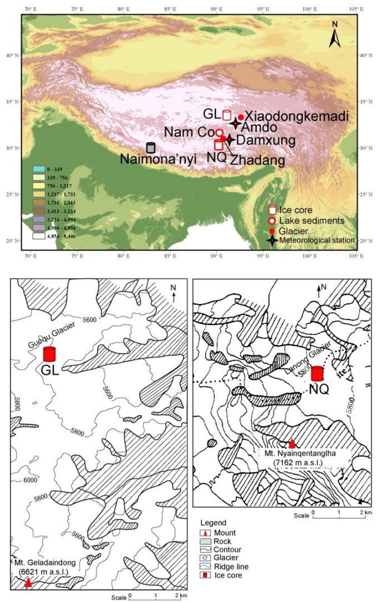


**Fig. 2.**



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