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Interactive comment on “Recent mass balance of Purogangri ice cap, central Tibetan Plateau, by means of differential X-band SAR interferometry” by N. Neckel et al.

Anonymous Referee #1

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Neckel et. al. provide a geodetic mass balance estimate of the largest glacier complex in the Tibetan Plateau, Purogangri ice cap. They employ two different methods to estimate glacier elevation changes from SAR data and compare the two. One method involves common DEM differencing using the InSAR DEMs and the second is an interesting attempt to difference the interferometric phase. A number of artifacts are described that are apparent in the elevation difference maps. Clearly, significant elevation changes are measured, especially on the lower glacier tongues. Higher up, it is not sure how the suggested artifacts are affecting the results. The results have the potential as important direct mass change estimates of the ice cap, and thus the relevance for the cryosphere is appropriate. However, the study/manuscript needs a considerable

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amount of work before becoming of acceptable scientific quality. For example, the text is short, and consequently, a large amount of details is missing which leaves the reader uncertain, sometimes confused, and unconvinced. The methods should be written in a way that it is reproducible and the data section could be expanded to describe fully the TerraSAR and TanDEM data. Moreover, it feels that this study is only half finished as a number of methodological concerns may significantly change the results and discussions in the manuscript. All in all, I hope my questions/considerations here will help fill in the gaps of this potentially nice study.

- The section describing the differential interferometric phase approach needs to be expanded greatly. I am still unclear exactly how this is done and whether I would be able to reproduce this study. It could be useful to have a flow diagram here to describe it. Thus it is also not clear how the errors in the X-band DEM will propagate in the results. In particular, how is the later phase unwrapping (P1125, L1) to convert the differential phase into absolute change affected? Then, could the co-registration be affected by errors translated from the DEM into the simulated SAR image (P1125, L12). Also, do both DEMs use the same datum and has there been any co-registration here, or are they perfectly aligned? I am guessing this would have a significant effect on a simulated SAR image. . . In summary, there are many gaps to fill in the methods section.

- A few comments about P1128, L4-12 and Figure 2. Satellite jitter and/or instrument shaking is easily visible on flat topography, as any slight resampling or mis-alignment between pixels will have little effect. However, in Figure 2, the differences that present patterns are mainly visible in the steeper topographic areas. This lets me suggest that these variations have some sort of resampling issue since the steeper the terrain, the larger the magnitude of error. Figure 5 then shows a section of relatively flat topography which exhibits a similar frequency at a much smaller magnitude that may be considered as jitter. However, it could be expected that jitter effects would be hidden in the noise of comparisons over steeper topography, the opposite effect of what is shown

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here. Similar effects can be generated within re-projection step of the processing (is a reprojection performed?), especially depending upon the type of resampling (nearest neighbor, bilinear, bicubic etc.) that is chosen. Furthermore, there is some similarity here as in the Gardelle et. al. (2012) paper about curvature related artifacts which suggests also a resampling artifact. One last point, is that the direction of pattern doesn't really seem to fit an along track or cross track direction, what could be the reason for this? I am not fully convinced yet that what is shown in Figure 2 is or is not related to the shaking of the arm.

- How exactly was the mass balance calculated from the elevation changes? The use of the zero elevation change as a proxy for the ELA is not correct (think about the surged glacier that is shown). Also, on some parts of your glaciers, this transverse artifact seems rather large, how does this affect your total mass balance estimate? Since the artifacts are clearly visible, it should be interesting to discuss this point. - Figure 2: Could be helpful to have the hillshade as a background for this map. Also, which year are your masks from, and are these the ones that are used for calculating volume change and geodetic mass balance?

P1120 -L18: Spell out “Tibetan Plateau (TP)” for the first use in the introduction

P1121 - L14: change to “First, ...” - L16-18: I am not sure “absolute” surface elevations is descriptive enough here. Maybe something more like “elevation changes were calculated by differencing the two (interferometrically or InSAR) derived DEMs...” - L25: What is the swath width of the C-Band? This to give context to the next sentence. - L26: change to “... which leads to large swaths of no data”

P1122 - Section 2.2. A deeper introduction to the terraSAR products would be useful for those readers that may not understand the potential quality and limitations of such data.

P1123 - L1: Does that mean the X-Band SRTM was used for orthorectification of the landsat? - L15-19: It is not how the SAR coherence images were used to delineate

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glaciers. Simple thresholding, band-ratio, classification as with the landsat scenes etc. ? Also, if these were also used for glacier delineation, can you compare landsat and coherence based outlines, since you generated both.

P1124 - Include the footnote in the text. - Last two sentences of the paragraph: It is not clear how exactly you converted phase difference to absolute height change. Which unwrapping technique or? Either way, Full descriptions of your steps here (and in the rest of the methods) will aid the reading and understanding of your paper, and moreover provide a more convincing paper to the readers.

P1125 - L3: Begin this sentence with, “before calculating phase differences...”. Otherwise, the reader must interpret when you do this step, and guesses that you did this before differencing the phases. - L18-20: One sentence for describing the differencing DEMs is rather un descriptive. How did you resample the DEMs, which interpolation, is the datum the same or did this require a conversion, were they co-registered, is there any elevation dependent biases etc. etc. ???

P1126 - L13: The zero elevation change contour is not necessarily the equilibrium line altitude. Especially in the case of your surge! Therefore, this approach is flawed. - L20-22: The second sentence of this paragraph says the same thing as the first. Consider combining in some way. - L5-7: Was the mean elevation difference in off glacier terrain used as a correction or just added to the error? I wonder how significant your mean difference is, and how well you may be able to estimate it?

P1127 - This section could use a table to aid the reader. - L0-1: How exactly did you calculate volume change? Was it using the curves (that are undescribed) in Fig 3 with the hypsometry? Or did you just take the mean elevation change? Which glacier outline did you use, older or newer? Or an average of the two? This is all important information as I am not sure how to compare your rates to estimates from other studies. - L1: Are the number provided here really absolute magnitudes, or are they rates (divided by the number of years)? I find the error bars rather small and wonder whether they really

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include the uncertainty of the mean bias between the DEMs. - L7: significant digits in the error estimate does not correspond to the area estimate?

P1128 - L2: This is the first time I see that the systematic error was much smaller for DEM differencing. Could be useful to have these numbers in a table, maybe a combined table with the glacier changes. Also, this point alone requires some discussion if you want to properly compare the methods. - L17: change to “the datasets used” - L18: “leading to unbiased results”. Yes in principle, what if the snow pack characteristics and depths are different in 2000 and 2012?

P1129 - The conclusions are short and un-descriptive. A more useful conclusion will aid the extraction of important information contained in this study.

Interactive comment on The Cryosphere Discuss., 7, 1119, 2013.

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