

Interactive comment on “A glacier inventory for the western Nyainqentanglha Range and Nam Co Basin, Tibet, and glacier changes 1976–2009” by T. Bolch et al.

Anonymous Referee #2

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Review for manuscript: “A glacier inventory for the western Nyainqentanglha Range and Nam Co Basin, Tibet, and glacier changes 1976–2009” By Bolch et al.

The manuscript focuses on glacier changes in the last four decades in the south-eastern Tibet using a combination of satellite imagery (Hexagon, Landsat TM/ETM+, MSS), aerial photos and GIS techniques. This is an important contribution for helping to fill the gap in the understanding the spatial patterns of glacier changes in the Himalayas, where glaciologic data are scarce. I particularly appreciate the author’s use of standardized semi-automated methods, and the detailed description of methods for constructing the glacier inventory. While the paper is well written in clear English,

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some improvements could be made in the structure of the paper as well as the language. Some paragraphs are very dense at times, and need to be revised. Some sections have a little too much detail, making it hard to follow. Re-organization, and sub-headings are needed in other places. It is hard to extract the big picture about glacier changes in the different areas, and what governs those changes. I suggest focusing on making the trends become more obvious. Some points need to be stressed, for example that retreat rates were overestimated by previous studies, or that there are differences between the north vs south of the study area. I also recommend shortening the paper. I recommend accepting the manuscript with minor revisions. Specific comments are offered below.

Abstract: Line 9: replace Landsat MSS (year 1976) with “1976 Landsat MSS, similarly throughout the manuscript. Line 11: Insert what exactly the manual adjustment was done for, ie. “Manual adjustment was especially necessary for georeferencing the panchromatic Hexagon data and for delineating the debris-covered glaciers.”

Line 14, end: remove “a”

Lines 16-17: ‘The glacier area decreased between 1976 and 2001 by about ..’ Re-order the words, split the phrase in two (long phrase), and revise the language, ie: “The glacier area decreased by xx% between 1976 and 2001. This is less than the change reported in previous studies.” Line 18; same as comment above on line 9 -replace “topographic maps from the 1970s” with “1970s topographic maps; similarly for Landsat, throughout the manuscript. This shortens the phrases a bit.

1. Introduction p.430, Lines 25-26- The importance of glacier runoff in the Himalayas is generally overstated in the literature (and the media), with little evidence offered. Glaciers are certainly important in the hydrologic cycle in the Himalaya, but some clarifications are needed. Do you mean people living close to the glacier terminus and depending on glacier runoff directly? Or people living downstream? Please clarify and provide some references- otherwise, I suggest revising the statement.

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p.431, line 1: “Like in many other parts of the world. . .” I suggest being more specific- do you refer to global temperatures? Give references for other mountainous parts of the world where increases in temperatures have been reported. Give the rates of increase in temperature reported in these studies. The trends are different at high altitudes vs low altitudes (more increase at high altitudes in the TiP). However, in other parts of the world such as the Andes, this trend is reversed, ie less increase in temperature at higher elevations (see Vuille et al 2000 and 2003 papers). Please revise/clarify.

Lines 1-6: The phrase is too dense, I suggest splitting in two parts: one for temperature/precipitation trends, and one for glacier changes reported in the TiP.

Line 6: replace “This trend is also confirmed “ With: “Similar trends have been reported..”

Lines 7 – 15- The paragraph doesn’t tie together well, the ideas need to be re-ordered. The discussion about the importance of glaciers is not so much needed here, this is well known. Also, mentioning GLOFs could be omitted. I suggest revising this paragraph, i remove lines 7 -15 and re-phrase to something shorter like: “There is a concern about increased GLOF potential [refs] and decreased water resources in the long run. This poses a need for glacier monitoring in this area, etc etc..” This provides a good lead into second paragraph on p. 432, the need for remote sensing studies (see my comments below).

Lines 16 – 22- again, change the focus of the paragraph here- you might want to emphasize that climate data are scarce, which makes glacier change studies difficult. Lines 19-22 belong to study area. Lines 22- 20 on p. 431 and 1 -3 on p. 432 also belong to the study area, rather than introduction. This is redundant with lines 10 – 20 on page 434.

p.432, line 1- as far as I know, Ageta and Higuchi refer specifically to Nepalese glaciers as ‘summer-accumulation type”. Can you provide some other reference that supports the statement that glaciers in your study area also belong to summer-accumulation

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type? Is it based on your analysis of climate data, or previous studies?

Line 4: Before talking about remote sensing, I suggest introducing previous glacier inventories (the Chinese inventory) and the problems associated with it (lines 20 – 29 on p. 243 and 1- 10 on p. 244 here). Also introduce uncertainties associated with this inventory to transition to the need for RS.

Line 19: a) “continental climate” - Which winds do you refer to here? b) replace “comprehends” with “comprises of” c) replace “one glacier where mass balance measurements were started” with “one glacier with mass balance measurements”. Remove “and” after Kang et al and start a new phrase. Replace “that is” with “which is”.

p. 433, line 1. Place “there is” after “currently”, and replace “paper” with “study”

2. Study area Line 12: Break phrase after Nyaingqetanghla, and replace “which is” with “The area is” Line 20” replace “few is” with “little is” Replace “on the” with “about the” Lines 10 – 20: consolidate with paragraph from p. 431.

3. Data and methods This section is quite dense and there is a lot of detail. I suggest thinning it quite a bit.

p. 434, line 22; replace “the glacier inventory are” with “this glacier inventory IS” p.436 : “level (1T)- explain or omit The use of the “deviation” (eg line 2 1, 8 on p.435, so on) is not appropriate throughout the manuscript. Replace with “difference”, “horizontal shifts”, or RMSE, as needed. Line 6; remove “time around” The use of the verb tense is not consistent. Sometimes past tense is used, other times present tense. I suggest checking this throughout the manuscript and using the past tense. line 13: “SLC-off”- needs to be explained if included. This is too much detail. When the word ‘resolution’ is used, please specify if you refer to “spatial”, “spectral” or “temporal, ie. line 25.

Lines 1 – 25- this is too dense, try to shorten and include only essential information. p. 436, line 16 -17: “However, the quality of the ASTER GDEM..”- I suggest removing, for sake of being more concise. I think the quality of the GDEM is the same for now. line

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23- can you comment on the quality/accuracy of the various versions of SRTM in this area?

Line 15; holes... "are common for DEMs derived from ASTER... due to availability of few scenes"- CONFUSING. Specify that holes are due to difficulty in stereo-correlation procedures in steep mtn terrain.

3.2 Glacier identification Line 25; remove "Due to the size....coverage". Start with "We applied..." and move the idea at the end, ie, semi-automated approaches are appropriate for large study areas, etc.. Add the reference Racoviteanu et al, 2009- Annals of Glaciol after Paul et al, 2009.

p. 437, line 18: replace "could" with "were".

Lines 24- 29- it seems to me that this belongs to section 3.3 (at the end of that section on p.438), since these glaciers were selected for a detailed change analysis.

3.3 Glacier inventory and change analysis p. 438, Line 13: replace 'had to be' with "were". Same comment as the use of 'could' . Also, avoid the use of "correct" (lines 16, 23), since this cannot be proven. Replace with "accurate" or "accurately".

Lines 15 – 23- reduce the detail here. Such difficulties are discussed in the Annals paper, you can refer to it.

3.4 Error analysis

Move this section as part of the discussion section, and merging with lines 1 – 8 on p. 444, which also refer to error analysis.

4. Results p. 439, lines 20 – 23- too much detail here, this phrase could be removed. Line 25: avoid the use of "little less" , or "little higher" , "little lower" (line 19 – 20 on p. 440) and quantify where possible, or replace 'little' with 'slightly' p. 440. Line 3- does glacier orientation reflect the wind circulation patterns? Line 16- too many numbers, I suggest referring to the table and just giving the rates of retreat. Line 25: insert "The"

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before “Analysis” Line 27, end of phrase- refer to Table, and give numbers, ie xx % loss for smaller glaciers vs xx% loss for larger glaciers.

p.441, line 1: there is a small tendency that glaciers ..lost relatively more area...’ revise the language to: “Glaciers with lower median elevation tend to lose relatively more area...” Line 4. Break the phrase after (Fig. 7B).

A few suggestions for further analysis: -it would be useful to have the change in glacier termini (Z min)for the entire range as well as the selected glaciers -also, a correlation analysis between % change and median elevation, min. elevation, orientation, glacier area, debris cover respectively to better understand the changes. -an estimate of % debris cover would be useful, as well as the change in area for the debris-covered glaciers only

Do you conclude that the selected glaciers are representative of the entire range? If so, state this at the end of section 4.2. How do selected glaciers compare to the entire range in terms of glacier area and debris-cover?

5. Discussion

5.1 Images and methodology

This would fit better at the end of discussion in an errors/accuracy assessment along with the discussion of the Chinese inventory. I suggest starting section 5 with the discussion of glacier changes (section 5.2) Also, there is some redundancy here with material from the introduction (eg lines 10 -18 on p. 442) , please revise. I suggest moving Table 1 to section3, Data and methods, and refer to it there. Also, this section could be shortened. 5.2 Glacier changes

p.442, line 26: “The study reveals a long-term trend of glacier changes..” revise to something like: “This study found a long-term trend..” Also, what do you mean by long-term? Define here- decades?

First give the rates of retreat, again, and then interpret here.

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p.444, line 3: it is not correct to refer to ELA here- but instead, refer to the median/mean elevation. Phrase is too long, separate after “ELA”.

Line 6: replace “in line’ with “in agreement”

Line 7. Insert “the’ before “southern”

Line 10: remove “and above”; remove decimal from 10.0 m a-1; replace “significant’ with “significantly” Line 11: insert ‘the” before ‘debris-covered’ The result is interesting, this is not a typical pattern- usually debris-covered glaciers (with thick debris) show slow rates of retreat. Comment on this, and offer some potential explanations for the behavior of Xibu. Lines 12- 12: “..show that negative balance values occur since 2005” Remove “that”, “occur” and insert “mass” before “balance”

Can you say what % of the glacierized area is covered with debris? Line 17: ‘This study results in lower values” Replace”results in ’ with “found” Line 18: “..reveal similar values”.. Insert “to previous studies” Lines 20 – 29 on p.443 seems like it belongs to the introduction Lines 1-9 on p.444 belongs to error analysis (as suggested, this would be better at the end of discussion) p.443, line 29- replace “deviation: with ‘difference’

p.444- lines 1-2 “Our results ..seem to be reliable”- remove this, it is subjective line 9-10- redundant with paragraphs above, compress into one paragraph. Break line after Li et al, 2008. Lines 14- 19 would fit better in conclusions; however, this is rather vague, I suggest removing these to keep the paper more concise.

Lines 20 onwards: the Climate discussion needs a subheading in the discussion, it is buried in the discussion of glacier changes. Line 20: “None of the five glaciers..’ – this is already stated. Line 22: “mean annual rates’- which rates? area? Length? Line 27- remove “cells”- it is too technical

p.445- lines 1-4 – long phrase. What do you mean Liu and Chen assumed a higher increase at higher elevation? Was this based on data? Please explain. p.445: lines 22 – 17- this looks like material in the introduction, remove or revise line 6; ‘increase of

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annual precipitation”- replace “of” with ‘in” line 8- “stable fluctuations in precipitation”- what do you mean here? If it’s fluctuating, then it cannot be stable. Please rephrase.

6. Conclusions

p.446- Line 4: remove ‘precise’- again, this is subjective line 7: ‘the correction of the outlines. . . .concentrate on debris-cover correction”- redundancy. Replace with “Future steps will involve..correction of debris cover..” line 13 “In addition, this enables to show the consistency of the data’- this is vague- which data are you talking about? Line 25 is wordy. I suggest removing “In this respect the advent of”, and start with “Gridded data”. Line 28 “This kind of investigations is currently followed by the authors”- awkward phrasing, revise to something like “further studies are conducted..”

Tables: these could be consolidated/simplified.

Table 1: move to Data/methods

What kind of data is USGS, are you referring to topo maps? The site where data are archived/ also, need to explain DLR and GCLF in the table heading. These are not discussed in the data section

Table 2- Need to specify these regions in the Study area or methods. You have 5 regions here, however, in the text you only focus on 3 of those-

add “Number of glaciers” to table column “Number”

Table 3 caption – ‘extends’ should be ‘extents” You could add the area from Table 4 to this table, since this table is about basic stats. Table 4 would be more manageable.

Fig 4: doesn’t seem so essential. Fig 5 caption: reverse “covered area to ‘area covered”
Fig 7: reverse axis, is is easier to see.

Interactive comment on The Cryosphere Discuss., 4, 429, 2010.