

Comments on “The GAMDAM Glacier Inventory: a quality controlled inventory of Asian glaciers”, by T. Nuimura, A. Sakai, K. Taniguchi, H. Nagai, D. Lamsal, S. Tsutaki, A. Kozawa, Y. Hoshina, S. Takenaka, S. Omiya, K. Tsunematsu, P. Tshering and K. Fujita, submitted to *The Cryosphere Discussions*

Graham Cogley, June 2014

General Comments

This paper presents a large-scale glacier inventory covering all of High Mountain Asia, dated to the period 1999–2003 and relying on Landsat imagery and the digital elevation model of the Shuttle Radar Topography Mission (among other data sources). A huge amount of work has been done and documented carefully. Quality control and accuracy tests (leading to an estimate of region-wide accuracy in glacierized area of about 15%) are presented, and the new inventory is compared to an inventory of Bhutanese glaciers relying on ALOS imagery and to the recently published Randolph Glacier Inventory (RGI). The RGI is a global inventory, and in much of the present study area it is in fact the Chinese Glacier Inventory, which is the result of a major effort some 30 years ago based on surveys 20 to 40 years before the date of the new inventory.

Apart from the presentation of what will be a valuable regional-scale (and hopefully global-scale) resource, most readers will see the main result of the present submission as the finding of much less ice (30% less) in High Mountain Asia than is present in the RGI. The authors discuss this discrepancy for the most part reasonably, noting that the passage of more than 30 years will account for some of the difference and that there are quite serious ambiguities in the source imagery that are very difficult to resolve in the absence of field observations. However I am concerned by their apparent assumption that steep slopes which are bright in the imagery represent snow that will avalanche onto the surface of the “real” glacier in the valley below (so the steep slopes are not part of the glacier). This subject needs further consideration in the paper, but it should not be expected that the discrepancy can be resolved within the confines of the present study. My own instinct is to suspect that the exclusion of these steep slopes may in fact tend to underestimate the glacierized area, but I have to admit that is only a suspicion.

The paper is quite well written, and is commendably very short. There are some problems to do with clarity, and some of the Supplementary Information needs further work, but these criticisms are not fundamental. I think that this important new inventory should be documented in the literature, and subject to consideration of my comments below I would be happy to see it published in *The Cryosphere*.

Substantive Comments

P2800

L4 Why not give the exact number of scenes?

P2801

L13 The distribution of dates in the Chinese Glacier Inventory is actually from ~1956 to ~1983, with the median at about 1970. So repeated references in the paper to the 1970s should probably be to “the 1950s-1980s”, although space could be saved by saying here that “for brevity we refer to the Chinese inventory as being from the 1970s.”.

P2804

L13 This protocol for quality control is commendable and very impressive. One point about which more detail is required is the stage in which outlines were “if necessary, revised by a second operator”. Although the earlier part of the paragraph describes a sort of training programme, and introduces the delineation tests that are the subject of section 4.2, it sounds as though the final result was determined simply by the second operator. Given irreducible ambiguities of the kind discussed below (P2809 L28), this somewhat reduces confidence in the protocol (although it is not obvious how to improve it given that the final outline has to be the subject of a binary choice).

P2805 As described, the “unique” ID is non-unique. Each Landsat scene may contain hundreds of glaciers. Explain the ID more fully.

- P2806
L2-3 These biases are ambiguous. With respect to what reference? The other DEM (in which case they are differences, not biases)?
- P2808
L2 It would be helpful to give the equivalent RGI area for comparison. Its uncertainty is of the order of 10%, so there is a clear discrepancy.
- P2809
L3-5 This is not true of the RGI coverage of China, only of non-Chinese parts of High Mountain Asia (in the Altai, Tien Shan, Pamir and Himalayas).
- L12-13 The assertion that there are no RGI glaciers in the western part of High Mountain Asia surprises me. As accurately as I can read Figure 11b, the bright red pixel in northern Pakistan is at (72.0,35.5) (southwest corner) on the Chitral–Swat divide, and in RGI version 3.2 that 0.5-degree cell contains lots of glaciers, including several valley glaciers.
- L28 “high-relief headwalls”: an important reason for the greater glacierized area in the RGI than in the GGI must be the ~30-year difference in their dates (P2810 L3-5), but the assumption in this sentence that high-relief headwalls ought *not* to be included raises a complex and open question which needs further discussion in the paper.
One has to decide, usually on the basis of a single satellite image, whether the steep slope is ice-covered; commonly this decision is unreachable because the slope is snow-covered, and a further decision is required about whether the slope is so steep that all the snow will fall off between the image date and the end of the mass-balance year. If it were to do so, and whatever was beneath the snow were thus exposed (and observed, which is unlikely), the question would have an answer. Short of this ideal, I think there is genuine ambiguity given the present state of observational knowledge. Perhaps there is a role for time-lapse photography of steep valley walls in resolving the problem.
A further difficulty is that it is not clear how those who worked on the Chinese Glacier Inventory approached the problem, or even whether the problem was recognized at the time.
- P2810
L5 Shangguan et al. 2007 offer only weak support for glacier shrinkage as an explanation of the RGI/GGI discrepancy (10 km² of shrinkage, or 0.4% of an initial glacierized area of more than 2700 km² in the Kun Lun, in 31 years). Possible alternatives with broader geographical scope are Li, X., et al. 2008 (*Global and Planetary Change*, **62**, 210-218) and Ding, Y.J., et al. 2006 (*Annals of Glaciology*, **43**, 97-105).
- L16 “since the 1970s”. But which discrepancy is being discussed here? If it is the discrepancy with Bajracharya and Shrestha 2011, “the 1970s” should be “about 2000”.
A related point, which also diminishes the usefulness of Table 3, is that the numbers in Bolch et al. 2012 derive largely from the RGI.

Stylistic Comments

- P2800
L2 Delete “the” before “High Mountain Asia”, and make this change throughout the text.
- P2801
L15 “Pfeffer”.
- L26 “... error respectively in these regions”.
- P2803
L16 “identification of glacier divides”.
- L21-22 Change “glacier area” to “ ‘glacier’ ”.
- P2804
L20 “glacier boundaries were misidentified”.
- P2805
L7 Change “attribute datasets” to “attributes”.

L12 P2806	Change “are” to “is”.
L5 L9 P2807	The English spelling is “Karakoram”. Change “less” to “lesser” and “field” to fields”.
L20	These percentages are ambiguous. The consistency should be described in terms of a percentage difference between the inventories, making sure that the reader knows which is which.
P2808	
L6 L16	“grid cell”. Make this change throughout the text, e.g. at L19 and frequently later. “overestimated”, not “over-delineated”. This too needs to be changed throughout, as well as “under-delineated”.
P2810	
L7 L9 L17 L25	“glaciers”. “over the Himalaya”. “summaries”. Figure 10a, not 10c. Change “in parts of” to “in most of”. In the RGI only small parts of Chinese territory (e.g. part of the Nyainqentanghla Range) are more recent than the Chinese inventory.
P2816	
Table 2 P2817	Add “inventory” after “(2011)”, and right-justify all columns but the first.
Table 3 P2827	Move “the” to follow “and”.
Figure 10	End the first sentence at “boundaries”, then say “Glacier outlines are from the RGI (red) and the GGI (green).”.

Supplementary Information

The supplementary information is not adequately documented. The filenames should ideally include the name of the first author and the date, and in any case should be reproduced accurately in the table headers. The main PDF file should begin with full bibliographic data (full list of authors, title of the paper, etc.).

Figure S1	This is potentially quite valuable, but needs further documentation.
a:	Add an outline of the steep headwall, which I cannot find. If it is the bright white patch at right centre, I need more information before accepting its exclusion from the glacier; it looks like an ordinary accumulation zone to me.
c:	Define “true-colour” and “false-colour” (as in the main text, in terms of Landsat bands), and say which panel is which. In fact, say which panel is which in each of b to g.
d:	Is the lake in the right panel really “non-glacial”? It looks like a <i>supraglacial</i> lake.
f:	The scales appear to differ between the two panels. I can only guess that the orange rectangle in the left panel represents the extent of the right panel, and I do not know what conclusion I am being invited to draw – that the blue patch on the left is or is not a glacier.
g:	“... in Google Earth imagery of appropriate date.”; the typically high resolution of Google Earth imagery is of little value for distinguishing seasonal snow from perennial snow or firn. On the left of the north-south divide in the left panel, the larger of the two green glacier outlines omits a grey (i.e. not brown) patch that seems to be part of the glacier in the right panel. Why?
Figure S2	Again potentially valuable, but I do not know which colours represent right and which represent wrong decisions about delineation.

- a: In the deep shadow on the south side, I would accept the orange outline (following the topographic divide) as correct, and I can see no basis for the decisions marked in red, green and blue.
- b: Here I would also reject the red, green and blue decisions. The main paper seems to suggest that they correctly exclude a lateral moraine, but I am not sure of the basis for this.