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Interactive comment on "Climate regime of Asian glaciers revealed by GAMDAM Glacier Inventory" *by* A. Sakai et al.

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SUBSTANTIVE COMMENTS This is a very interesting article, and very timely as many people are concerned about melting glaciers in High Mountain Asia and their effects on river flow. A frequent problem with such policy-relevant research is the lack of background knowledge: High Mountain Asia is an enormous area with highly diverse climate and glacial conditions, and this study could have been made much easier in the Alps, for purely scientific purposes, where more data are available. Despite this, the paper makes very good use of available data and significantly extends our knowledge of glacier-level precipitation across High Mountain Asia. Such knowledge is needed for modelling the response of glaciers to changing climate as we know that the climatic sensitivity of glaciers depends on the precipitation/climate regime.

The paper is wide in scope and has an enormous reference list covering the literature of (a) precipitation climatology in High Mountain Asia, (b) estimation of proxy glacier ELA, and (c) climate at the ELA. Topic (a) is well discussed but not used as a basis for the analysis, while (b) is partly covered in the companion paper by Nuimura et al (2008) but extended with respect to glacier median elevation which is a reasonably good proxy to balanced-budget ELA (Braithwaite and Raper, 2009). The substantive contribution of the present paper is to (c) climate at the ELA.

The basic methodology of estimating ELA, extrapolating climate data to the proxy ELA, calculating the snow melt at the proxy ELA, and equating snow melt to snow accumulation at the proxy ELA (or annual precipitation) has quite a long history. e.g. from Ahlmann (1924) to Ohmura et al (1992). I understand that the approach was widely discussed on the Soviet literature (Kotlyakov and Krenke, 1982).

Despite the claimed antiquity of the climate-at-the-ELA field above, this paper makes significant new findings that well justify its publication. Aside from the up-to-date datasets, the main innovation in the paper is the different ways of aggregating the median elevations of the glaciers giving G-, L- and W-median elevations. I should say here that there is much confusion in the glacial geology literature about glacier median elevations, and some respected textbooks even mistakenly define it as the average of maximum and minimum glacier elevations. The GAMDAM Glacier Inventory correctly defines the median glacier elevation as splitting the area of the individual glaciers into equal halves, i.e. applying an accumulation-area ratio of 0.5.

Looking at the discussion on pages 3635-3637, I think the authors should use the terms G-average elevation, L-average elevation and W-average elevation to make clear that these are different ways of averaging the median elevations of individual glaciers within each 0.5 by 0.5 degree grid square. The glaciers are characterised by size (area), and the different averages G-, L- and W- take account of different effects of local precipitation, avalanching etc.

Important parameters in the classic glacier inventories like the First Chinese Glacier Inventory (Shi, 2008) are primary classification of glaciers, e.g. ice caps, outlet-, valley- and mountain-glaciers, and aspects of ablation and accumulation areas but these do not appear to be evaluated in the GAMDAM Glacier Inventory. Aspect has a well-known control on the ELA itself and local precipitation conditions expected there (Evans, 1977 and 2006). Similarly, the primary classification of a glacier has a strong control on both glacier size and precipitation conditions. If these two parameters are not evaluated in the GAMDAM inventory it would be worth considering an update to the inventory.

MINOR ISSUES The paper is generally well arranged in sufficiently good English to understand the main points. There are, however, many "micro-errors" that need correction by an English language specialist. This includes missing or superfluous definite and indefinite articles, verb agreements with nouns etc. I make specific small points on the following:

P. 3631 line 3: I assume you mean "Almost all datasets. . ."

P. 3631 line 29-30: The sentence "However, the estimated ELA has a large discrepancy with glacier distribution" needs rephrasing as it is presently meaningless.

P. 3633 line 4: "Hamper" should be "Harper".

P. 3634 line 6 to 9: This would probably read better as "Most precipitation in the interior of High Mountain Asia originates from recycled evaporation, and such a proportion of continental recycling cannot be found in the other continents"

P. 3635 line 9: I suggest ". . .the few observed ELA with . . ."

P. 3635 line 25: I suggest ". . .by area-weighted averages of median elevation for individual glaciers".

P. 3637 lines 16-17: I find "The glacier mass balance, however, usually is calculated from only direct precipitation as an input meteorological data" nearly meaningless. Are you talking about mass-balance models?

P.3637 lines 27 to 28: I suggest "If calculated, W-median elevation is less than or equal to L-median elevation".

P. 3638 line 17: Kondo (1990) is not listed in reference list.

P. 3642 lines 3 to 4: Fujita and Ageta (2000) may have said what you say, but they are over-simplifying as there will be different ablation rates for ice, snow and debris-covered ice, so ablation must depend upon precipitation as well as air temperature and solar radiation.

P. 3642 line 24: You quote Braithwaite et al. (2006) but Braithwaite (2008) would also be a useful reference.

P. 3643 line 5: Braithwaite (2008) is a useful extension of the paper by Ohmura et al. 1992) as it takes account of the different climate settings of the glaciers with a family of curves.

P. 3643 line 19. I once tried (unpublished!) to map glacier precipitation across High Mountain Asia using the degree-day model extrapolated to the median elevation in the World Glacier Inventory, and I found problems in especially the Mount Everest region. This was because air temperatures were too low to give any meaningful melt at the ELA in this region. Presumably zero balance at the ELA is maintained by relatively large sublimation.

P. 3644 lines 20 to 25: It is interesting that you adjustment ratios less than unity in some parts of your region. Braithwaite et al. (2002) compared "glacier precipitation" with precipitation from a gridded climatology ("regional precipitation") and found ratios of about 2 to 2.5 for many regions, but the ratio was closer to 1:1 for the Alps. Braithwaite et al (2002) suggested that the Alpine part of the climate dataset contained relatively higher-lying stations than other parts of the dataset. Could that be true of the regions where you find a lower adjustment ratio?

P. 3645 line 27: You probably mean < 1 km2 here?

Pages 3647 to 3652 Reference list. I have checked your reference list and only missing item is Konto (1990).

P. 3653: Nice map!

P. 3654: To what do the coloured dots refer? Are these decade averages of observed ELA? On how many glaciers?

P. 3657 Fig. 5: I cannot see much difference between these three maps. What about mapping (a) differences L-median minus G-median, and (b) W-median minus G-median?

P. 3658 Fig. 6: It is interesting (and important) that (a) misses the high precipitation in SE High Mountain Asia.

P. 3660 Fig. 8: Note that Figure 5 in Braithwaite et al (2008) shows how the Ohmura dataset can be split into high- and low-accumulation situations using annual temperature range.

P. 3661 Figure 9: Very good! Do you discuss why you use 40% summer precipitation and not 25% or 50 %?

P. 3662 Figure 10: Interesting!

P. 3663 Figure 11: Please confirm that there are some places where adjustment ratio can be 15 to 20 times.

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Interactive comment on The Cryosphere Discuss., 8, 3629, 2014.