

Interactive comment on “Improving estimation of glacier volume change: a GLIMS case study of Bering Glacier System, Alaska” by M. J. Beedle et al.

Anonymous Referee #3

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Comments are referenced to the manuscript by: (page,line)

General Comments

The paper describes a very painstaking analysis of volume change of a complicated glacier system with poorly defined boundaries. It is well organized with pertinent figures and tables; the English is quite good. The analysis is important work because the glacier system is very large and its recent volume change has made a substantial contribution to sea level rise.

Equal prominence should be given in the paper to what Bering Glacier has been doing,

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compared with what is given to the analysis methodology.

The term "template method" (182,2) was not used in the cited reference (Dyurgerov, 1996), so the authors ought to abandon it. A more readily intelligible term would be the $b_n(\text{AAR})$ method. Moreover, writing b_n/AAR (182,9 and 193,9-12) is very misleading because that means the ratio.

The paper is long and in places repetitive. Some sections would be more readable if they cited Tables 3-5 (which should be combined to promote perspicuity) instead of repeating so many numerical values in the text. Assigning short labels to the three models considered, as is done with the four hypsometries considered, could substantially reduce the wordiness of the paper. It should more consistently observe the convention of not using the article with glacier names; that is, for instance, "Steller Glacier" instead of "the Steller Glacier" (177,16). The prose would be smoothed by replacing "utilize" and "utilization" by "use" throughout the paper.

Specific Comments

How the $b_n(\text{AAR})$ method was applied to the hypsometry (182-9) needs to be explained. If a $b_n(z)$ was obtained and integrated over the hypsometry, it should be shown. The idea in Dyurgerov (1996) is that $b_n(t)$ could be found from $\text{AAR}(t)$, but here the authors presumably used a 1950-2004 mean AAR to get a mean $b_n(z)$. Lack of an explicit description of this, one of the three models considered, is a major omission.

Although it is not very clear on the point, the paper seems to imply (193,3-6) that the map-view shape of a glacier determines its area-altitude distribution. This is not true, unless an additional assumption is made concerning the slope of the glacier surface. Specifying a region on a map does not determine the topography within it.

The use of so many significant figures, three and sometimes four, is not warranted by the accuracy of the findings.

Because detailed information is lacking for the TH1 and TH2 outlines, the paper must

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explain how information about them can be used reliably.

Technical Corrections

- (172,19) Change "lead" to "led"
- (173,29) Change "culprits" to "contributors"
- (174,1) Change "by" to "over"
- (174,9) Change "parameters" to "characteristics" and define them, because (174,17) refers to them.
- (175,9) Table 2 says 1737.
- (175,16) Maybe these should be designated as just "Tangborn 1"¹ and "Tangborn 2"² to dispel confusion with the Tangborn (1999) in the references.
- (176,7) Table 2 says 1150.
- (176,16) It would be a good idea to refer to Section 3.3 here.
- (176,21) If "both modeling approaches" means the PTAA and AAR methods, it would be better to say "both the PTAA and AAR methods"
- (177,12) Fig.7 does not show Columbus Glacier
- (178,17) It should be "Making an outline of BGS necessitates..."
- (179,3) Change "subjective" to "subject"
- (179,10) Paul (2000) not in references.
- (179,26) It might be a good idea to describe the histogram method briefly here.

- (180,2) What is the accuracy of the DEM?
- (181,21) What is done?
- (183,9) It should be said where the 5173 km² value was published, perhaps by Molnia and Post (1995) as (186,15) says.
- (183,13) It should be said that the BH area is what 557 km² is 15% of.
- (184,8) Readability of Section 4.2 would be considerably enhanced by combining Tables 3-5 and confining this section to discussing the results more in words, instead of quoting so many numbers that are readily apparent in the combined table.
- (184,11) Change "Each integration between one of the three mass balance models...of results" to "Integration over each of the four hypsometries of the b_n function of each of the three models reveals the same pattern:"
- (185,13) The ± 330 km² error is symmetric, and thus lacks bias. Perhaps "heavily biases" should be replaced by "contributes heavily to."
- (185,17) The error cannot include an outline. Perhaps "includes" should be replaced by "reflects uncertainty about."
- (185,18) Does "overly conservative" mean that the ± 330 km² is probably too large or too small? Be specific, using more objective language.
- (187,21) Presumably "other glaciers" means elsewhere in the world. Be specific.
- (188,2) Fix the sentence: glacier definitions do not stem from the use of tools.
- (189,10) Section 5.2.1 is largely redundant with Section 4.2
- (190,25) Mayo (1989) missing from references. Presumably "2-6 m" means 2 to 6 m.

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- (191,2) It should be clarified whether the discrepancy refers to the entire $b_n(z)$ profile (which is published in USGS reports for many individual years) or to its integral over the glacier hypsometry.
- (191,6) State basis for comparison of "more negative PTAA results"
- (191,26) If emergence velocity of the ice is the dynamical process in question, say so.
- (192,1) Explain how Post inferred an ablation rate from a comparison of surface elevations of lobes with and without debris cover.
- (192,9) Not only is outlining the region of debris cover necessary to determining ablation rates, but so is knowing its thickness.
- (192,26) Calling Gulkana and Wolverine triangular would be more descriptive. Pies are round. Also (193,2) and (193,4).
- (193,16) What is meant by "similar adjusted PTAA model"?
- (193,25) Augment "...1972 to 2000." to "...1972 to 2000, or $-2.3 \text{ km}^3/\text{yr}.$ "
- (194,2) Move reference to Table 4 to earlier in the sentence, because it does not give the total SLE values. Moreover, they are total 54-year SLE rise, not total SLE.
- (194,15-16) The sentence needs to be clarified, identifying the comparison better, explaining how the 0.1463 mm value is arrived at.
- (194,19) It is meant that *having* the outlines and hypsometries is imperative.
- (194,23) Ranges should be identified as from using the adjusted PTAA model (Table 4).
- (195,4-5) Identify sources for 1720 and 6200 km^2 areas and say "This new outline (BH)..."

- (195,13) Cite reference for 5000 km² area for Malaspina, presumably Molnia (2002).
- (196,3) Add mention of importance of hypsometries.
- (199) Should Quintino Glacier also be in first section of Table 1? The section "Portion of Bering ..." appears to be incomplete.
- (200) Headnote of Table 2 should define AH, T1H, BH, T2H, DCH.
- (201) Because Tables 3-5 are so similar in composition, they would profitably be combined, to ensure that their contents could all be viewed simultaneously. The addition of a column giving the total 1950-2004 contribution to SLE would be very beneficial. Headnote should refer to Table 2 for codes AH, T1H, etc.
- (204) On Fig.1, Wolverine Glacier is misplaced and Anchorage also has a star. Because Malaspina Glacier is mentioned often in the text, it should be indicated here.
- (205) Debris cover looks grey, and dark green appears to be vegetation on Fig.2. Label Malaspina Glacier.
- (207) In its caption, Fig.4 needs to be better coordinated with earlier Figs. The caption should also refer explicitly to the panels in terms of panel labels. It should also explain how the thickness of the debris cover can be discerned.
- (208) Fig.5 needs to be related in caption to Fig.2 and its color scheme needs to be defined. The caption can be considerably shortened by combining first two and last sentences.
- (209) Fig.6 color scheme needs to be defined. Should mention of Fig.2 be of Fig.5?
- (210) Is vertical exaggeration in Fig.7 only 3:1?

- (211) Fig.8 curve labels can be defined by reference to Table 2 if suggestion (200) is adopted. Vertical scales need a label, and balance panel needs thinner curves.
- (212) See (211) concerning Fig.9 curve labels. In caption, change "relatively consistent amount of area within elevation bins" to "relatively equal area within 150-m area bands (Fig.8)"

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