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Interactive comment on "What glaciers are telling us about Earth's changing climate" *by* W. Tangborn and M. Mosteller

W. Tangborn and M. Mosteller

wendell@hymet.com

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Comments on "What glaciers are telling us about Earth's changing climate", by W. Tangborn and M. Mosteller, submitted to The Cryosphere Discussions Graham Cogley, July 2014 General Comments

This paper, which is exceptionally well written and is also commendably brief, describes studies with the PTAA model, a temperature-index model of mass balance introduced in the 1990s, of a number of glaciers in Alaska, Austria and elsewhere. The PTAA model itself is described, but only in outline. Results obtained so far are assessed and summarized, and are placed in the context of a larger project which will rely on the PTAA

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model as its primary tool. It is fair to say that the results are mixed. Correlations between balances measured and simulated over several decades range from quite good to indistinguishable from zero. The paper concludes with a section on communication of the project results to the public.

The PTAA model is welcome as an independently-developed addition to the currently available set of models of climatic forcing of glacier mass balance. It has been around for some time, but the most detailed description of it, now 15 years old, leaves unanswered a number of questions of detail, for example about the calibration procedures. Some of those questions are answered here, but I think that the authors need to present a more thorough description of the model than has appeared to date. This is the first time I have had occasion to read Tangborn (1999) in detail, and I have to say that the PTAA model seems vulnerable to the criticism that it is not very parsimonious. There are 14 free parameters (that is, "knobs to twiddle"), which may explain why it requires the elaborate simplex optimization described briefly in sections 3.2 and 3.3. By comparison, the model of Radić and Hock (2011) has seven parameters of which only one is allowed to vary during calibration.

AR: A more detailed description of the model is provided in the revised version of the article. There is a more recent description in Tangborn (2013) that demonstrates its successful application to the Bering Glacier in Alaska. The criticism that the PTAA model is not very parsimonious (it has too many coefficients and too few equations) indicates a serious misunderstanding of how it works. Admittedly this is mostly due to an incomplete description of the model in this paper that will be remedied in the next version. However, the cited Bering Glacier paper givers enough detail on the model structure and calibration and provides sufficient information for a basic understanding of how the model works.

There is a great difference between the PTAA model and other models such as Radic and Hock (2011). First of all it does not have "14 knobs to twiddle" in the calibration process. There are 15 coefficients that simultaneously and automatically convert weather

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observations to snow accumulation and snow and ice ablation. But these coefficients are unchanged for each day of the full period and for each elevation interval. Therefore, the same coefficients are applied over 2 million times during the calibration. (the main difference between the PTAA and other models that is likely the cause of much misunderstanding is that it operates on a daily time increment and 10-30 meter area altitude distributions).

Unfortunately I cannot advise publication of this paper. The important section on public communication could well become the basis of another paper, but is out of place here, and the remainder of the paper needs to be recrafted to present more details about the model and about its successes (and failures) during calibration and validation. A future version should also reflect better awareness of the current literature on glacier–climate modelling.

AR: Current literature on glacier-climate modeling does not provide a precedent for the ablation-global temperature approach presented in this paper, therefore, no references are cited.

Substantive Comments

P3475 Title The title exaggerates the scope of the paper, which is about tests of a glacier–climate model applied to a small number of glaciers.

AR: The paper is not about testing a glacier-climate model to a small number of glaciers. It is an application of a GC model to demonstrate what glaciers are telling us about climate-change on a global scale.

P3476 L3 Pfeffer et al. (2014) found 198,000 glaciers, and showed evidence that the real number could be more than twice as great. (References are at the end.)

AR: Some of the difference is likely due to the definition of a glacier.

L10 I do not think you can refer to a model first described in 1997 and 1999 as “recently developed”.

AR: “Recently developed” has been removed.

L21 Delete one of the synonyms “size” and “extent”. More importantly, it would be wonderful if change of extent were indeed “a measure of mass balance”, but I know of no successful estimates of the latter from the former.

AR: Size and extent removed

L25 Change “a few dozen” to “a few hundred”, and cite either or both of Dyurgerov (2010) and Cogley (2009).

AR: If we are referring to glacier balances made manually (stakes and snow pits), then a few dozen is correct.

P3477 L1 How is the representativeness of the forty glaciers determined? There is a substantial literature about this question, Fountain et al. (2009) being notable as an example because they showed that South Cascade Glacier, one of the archetypal “representative” glaciers, is an outlier. AR: South Cascade Glacier is arguably the most studied glacier on the planet. One reason it was selected for study is because it is easy to get around on. For this reason it can be called an outlier. There may be a similar bias for most manually measured glaciers that is not present in these forty glaciers that were selected more on the basis of data availability than physical constraints, so likely are more representative than manually measured glaciers.

L11-12 Surely the PTAA model is a temperature-index model , and must therefore resemble a degree-day model in its simulation of ablation as a function of temperature? And does it not require “manual” balances for validation if not for calibration? 2 AR: It resembles a degree day model but only in its data requirements and not for calibration. Of course it requires manual balances for validation (how else would this be done). This comment suggests that the PTAA model has not been adequately described and is not understood. L15 It would be appropriate here to cite as well the early work of the Juneau Icefield Research Project, summarized for example by Miller and Pelto (1999).

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AR: Reference to Pelto (2012) has been added to revised article.

L23 The authors are apparently unaware of a good deal of recent literature on large-scale analysis of mass balance, both measured and modelled. A revised version of this paper should be based on consideration of the work of (among others, and in addition to sources cited above) Gardner et al. (2013), Leclercq et al. (2011), Marzeion et al (2012) and Radić et al. (2014). Some of this work has been reviewed by Cogley (2012). AR: The correlation shown between ablation of the Wrangell Range glaciers and global temperature anomalies compiled by the Hadley Climate Center does not have a precedent publication to cite. There are many publications such as those mentioned here that show large scale analysis of mass balance but not any that would lead to a glacier ablation-global temperature finding demonstrated in our paper. I would appreciate if someone would direct me to a published paper that demonstrates an ablation-global temperature model that uses a daily time interval, which I could then reference. P3478 L1 Rignot and Thomas (2002) is 12 years old. Cite a more recent paper, perhaps McMillan et al. (2014) or Shepherd et al. (2012).

AR: New reference added

L18 A rain/snow threshold slightly above 0°C is common in other temperature-index models. The reason for this choice should be discussed briefly.

AR: There is no value in comparing threshold temperature values of two models that are so dissimilar.

P3470 L6-7 This is not an adequate description of the simplex optimizing system. I know nothing about it, but some informative comments have already been made about it by Cameron Rye. AR: Further comments have been published by the author in Cryosphere Discussions regarding the Cameron Rye comment about the simplex. L12 The authors should consult the 2011 Glossary of Glacier Mass Balance and Related Terms, endorsed by the International Union of Geodesy and Geophysics, for updated terminology and notation (http://unesdoc.unesco.org/images/0019/001925/192525e.pdf). Some particular points are that lower-case symbols are (still) recommended for balance quantities at points and in elevation bands, that c and a are (still) preferred for accumulation and ablation respectively, and that the term "net balance" has been retired, for reasons discussed at length in the Glossary. P3480 L3 The greater R2 is 0.67 on P3477 and in Table 1. L7 The first author must know a lot more about field measurements on Columbia Glacier than I do, but I have in my records a single field measurement of annual balance derived from Mayo et al. (1979).

AR:: There is only one manual field measurement for the Columbia and it is controversial (the summer surface in 1978 was mis –identified). Furthermore, one manual measurement is not enough for a comparison of measured and PTAA annual balances.

L9 How do the results of Tangborn and Rana (2000) compare with those of the recent modelling study of Langtang Glacier by Immerzeel et al. (2013)?

AR: I could not find a Langtang glacier model for comparison.

L13-19 I was unable to access the web address cited for Tangborn (2012), but the statistical basis for the "These results indicate . . ." sentence sounds shaky to me. What is the distribution of sample correlations between the 7000 weather-station temperature series and their global mean? How many of them are "significant"? And of course the extremely poor performance of the PTAA model at replicating measured total balance (see L28-29) should suggest a more cautious appraisal; as a minimum, "glaciers are more sensitive" should be modified to "ablation on the Wrangell Range glaciers appears to be more sensitive". P3481

AR: Extremely poor performance compared to what? Please show me results for other glacier balance models (that do not mix in manual balance measurements), that produce annual balances based on routine weather observations, for 50-60 years, for several glaciers, and show R2 results similar to those in Table 1, and for the glaciers shown on the www.ptaagmb.com website.

L1-4 In addition to Das et al., the work of Arendt et al. (2013), comparing GRACE results with field measurements from Gulkana and Wolverine Glaciers, is also relevant for investigating the reasons for poor model performance in southern Alaska. L5 It is odd to come across a new section about the Wrangell Range glaciers after the extended discussion of them in section 3.4. That discussion should be moved to here. L17 “a cause and effect mechanism is not apparent”: this is puzzling. There is a very well understood chain of causes and effects leading from increases in greenhouse gases to the greenhouse effect (an increase of downwelling longwave radiation from the atmosphere) to greenhouse warming at the surface, and from warming to increased ablation on glaciers. I do not understand why increased concentrations of greenhouse gases should be a direct cause of increased ablation. The glaciers are invaluable indices of climatic change because they are independent of what is measured at the weather stations (thermometers are not used in mass-balance measurements), but I think it is a mistake to look for a “common cause”. 3

L19 The communication of results about glacier changes to the public is very important, but this section sits uncomfortably with the technical content of the preceding sections. It could perhaps become the basis of a different paper, following up the analysis of Davies and Glasser (2014).

AR: I have no response to the above and following comments because this referee does not understand the PTAA model and how it has been applied. But this is mostly because it is not explained clearly in the TCD article. I suggest waiting until the revised version of this article is published and commenting on that. The revision uses an application of the PTAA model to the Wrangell Range glaciers to explain its operation and to demonstrate how the mass balances were calculated. Stylistic Comments P3476 L20 I would change “making” to “suffering” or “experiencing”. P3477 L22 “Haeberli”. “Zemp et al.”. See also Dyurgerov (2010) and Cogley (2009). P3479 L14-15 It would be simpler to say “the area-weighted balances of all altitude intervals”. L18 Delete the repetitive parenthesis. L21 “developed”. (The “l” is missing from my copy.) P3482 L4-6

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Interactive Comment

Do not hyphenate "low elevation" or "lapse rate". "together they will reveal". P3488 Figure 1 L3 There seem to be ~250 iterations in the graph, so "250" here should probably be "235". P3489 Figure 2 A brief explanation of why only south-facing glaciers are presented would be appropriate. P3490 Figure 3 L3-6 Delete this sentence, which repeats material in the text at P3481 L15-17 (on which see my comment above). References
Arendt, A., S. Luthcke, A. Gardner, S. O'Neel, D. Hill, G. Moholdt and W. Abdalati, 2013, Analysis of a GRACE global mascon solution for Gulf of Alaska glaciers, Journal of Glaciology, 59(217), 913-924. Cogley, J.G., 2012, The future of the world's glaciers, in Henderson-Sellers, A., and K. McGuffie, eds., The Future of the World's Climate, 197-222. Elsevier. Cogley, J.G., 2009, Geodetic and direct mass-balance measurements: comparison and joint analysis, Annals of Glaciology, 50(50), 96-100. Davies, B.J., and N.F. Glasser, 2014, Analysis of www.AntarcticGlaciers.org as a tool for online science communication, Journal of Glaciology, 60(220), 399-406. Dyurgerov, M. B. (2010), Reanalysis of glacier changes: From the IGY to the IPY, 1960–2008, Materialy Glyatsiologicheskikh Issledovanij, 108, 5–116. Fountain, A.G., M.J. Hoffman, F. Granshaw and J. Riedel, 2009, The 'benchmark glacier' concept – does it work? Lessons from the North Cascade Range, USA, Annals of Glaciology, 50(50), 163-168. Gardner, A.S., G. Moholdt, J.G. Cogley, B. Wouters, A.A. Arendt, J. Wahr, E. Berthier, R. Hock, W.T. Pfeffer, G. Kaser, S.R.M. Ligtenberg, T. Bolch, M.J. Sharp, J.O. Hagen, M.R. van den Broeke and F. Paul, 2013, A reconciled estimate of glacier contributions to sea level rise: 2003 to 2009, Science, 340, 852-857. Immerzeel, W.W., F. Pellicciotti, and M.F.P. Bierkens, 2013, Rising river flows throughout the twenty-first century in two Himalayan glacierized watersheds, Nature Geoscience, 6, 742-745. Leclercq, P.W., J. Oerlemans and J.G. Cogley, 2011, Estimating the glacier contribution to sea-level rise for the period 1800-2005, Surveys of Geophysics, 32(4), 519-535.Miller, M.M., and M.S. Pelto, 1999, Mass balance measurements on the Lemon Creek Glacier, Juneau Icefield, Alaska 1953-1998, Geografiska Annaler, 81A(4), 671-681. Marzeion, B., A.H. Jarosch, and M. Hofer, 2012, Past and future sea-level change from the surface mass balance of glaciers, The Cryosphere, 6, 1295–1322. 4

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Mayo, L.R., D.C. Trabant, R. March and W. Haeberli, 1979, Columbia Glacier stake location, mass balance, glacier surface altitude, and ice radar data: 1978 measurement year, Open File Report 79-1168, U.S. Geological Survey. McMillan, M., A. Shepherd, A. Sundal, K. Briggs, A. Muir, A. Ridout, A. Hogg and D. Wingham, 2014, Increased ice losses from Antarctica detected by CryoSat-2, Geophysical Research Letters, 41, 3899-3905. Pfeffer, W.T., A.A. Arendt, A. Bliss, T. Bolch, J.G. Cogley, A.S. Gardner, J.O. Hagen, R. Hock, G. Kaser, C. Kienholz, E.S. Miles, G. Moholdt, N. Mölg, F. Paul, V. Radić, P. Rastner, B.H. Raup, J. Rich, M.J. Sharp and the Randolph Consortium, 2014, The Randolph Glacier Inventory: a globally complete inventory of glaciers, Journal of Glaciology, 60(221), 537-522. Radić, V., A. Bliss, A.C. Beedlow, R. Hock, E. Miles and J.G. Cogley, 2014, Regional and global projections of 21st century glacier mass changes in response to climate scenarios from global climate models, Climate Dynamics, 42(1-2), 37-58. Radić, V., and R. Hock, 2011, Regionally differentiated contribution of mountain glaciers and ice caps to future sea-level rise, Nature Geoscience, 4(2), 90–94. Shepherd, A., and 46 others, 2012, A reconciled estimate of ice-sheet mass balance, Science, 338(6111), 1183-1189.

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