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 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.

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.

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.
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.)
L10	I do not think you can refer to a model first described in 1997 and 1999 as "recently developed".
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.
L25	Change "a few dozen" to "a few hundred", and cite either or both of Dyurgerov (2010) and Cogley (2009).
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.
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?

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).

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).

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).

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.

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.

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 R^2 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).

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)?

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

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".

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).

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	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

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