The Cryosphere Discuss., 5, C1287–C1291, 2011
www.the-cryosphere-discuss.net/5/C1287/2011/

The Cryosphere Discussions

Interactive comment on "A minimal model for reconstructing interannual mass balance variability of glaciers in the European Alps" *by* B. Marzeion et al.

Anonymous Referee #1

Received and published: 9 November 2011

This paper presents a minimal glacier mass balance model for the reconstruction of long-term time series for Alpine glaciers over the last 200 years using the HISTALP data base. The authors perform a careful validation of their parsimonious model against 15 long-term mass balance series and quantify model uncertainty. By separating influences of temperature and precipitation on Alpine glacier mass balance, geographical patterns of the main drivers of glacier mass change are derived.

I enjoyed reading this well written manuscript that presents a simple and straightforward modelling framework that is purely based on readily available data. I think this paper will be a valuable contribution to scientific literature as the methodology op-

timally makes use of the information contained in the HISTALP data base regarding glacier behaviour. Although the method is simple, it takes into account the most important physical processes and therefore has a higher justification than pure statistical correlations.

Nevertheless, I have a number of comments that should be addressed by the authors, and might contribute to a further strengthening of the conclusions. My major concerns are given below:

1. **Glacier terminus:** In their simple model, each glacier is attributed an elevation to which the temperature is extrapolated. The authors assume – without any discussion – that the elevation of the *glacier terminus* is indicative for the entire glacier. Why? Is the elevation of the glacier terminus really the variable that best integrates glacier geometry, and is representative for the entire glacier? A low-lying glacier terminus could be explained by high accumulation, as well as a large high-elevation accumulation area. The authors definitively need to provide more details on why the glacier terminus altitude was chosen as the connection of the glacier with climatological variables and not, for example, the median elevation, the ELA, the elevation range, or the glacier area.

2. **Determination of SSC parameters:** It is not completely clear to me how C_T and C_P were determined. For example, why are positive values for C_T, and negative value for C_P found for individual months? A positive C_T indicates that higher air temperature leads to more positive mass balance. Can this be explained physically?

3. **Comparison to the SSC model:** A comparison of the model skill with the less parsimonous SSC model is performed and it is found that the SSC model performs worse although 24 parameters have been calibrated compared to only two in the present approach. I asked myself, if this comparison is 'allowed'. As

the authors state (page 2810, line 5), the SSC model is calibrated differently than in its original presentation (Oerlemans and Reichert, 2000). What is the impact of the simplified approach to calibrate the SSC parameters chosen here on the uncertainty in the parameter values?

4. **Inner-alpine glaciers:** An intriguing result of the analysis is that inner-alpine glaciers (receiving less precipitation) are more sensitive to precipitation changes than glaciers with high accumulation at the flanks of the Alps. However, small and very small glaciers (they are mostly characterized by high precipitation amounts, and are often situated at low elevation) are known to show a strong dependence on precipitation variability (see e.g. Kuhn, 1995, ZGG). This contradicts the findings presented here. I would expect glaciers with very high accumulation rates to be sensitive to changes in these, as a few percent precipitation decrease would result in a significant loss in total accumulation in m w.e. a^{-1}.
   The question that needs to be addressed by the authors is whether the results based on their model are significant (and can be explained), or their results are artefacts of a model that was not constrained with separate measurements for accumulation and ablation.

5. **Table 1:** When looking at the values of $a_{\text{optimized}}$ and $\mu_{\text{optimized}}$ for the individual glaciers quite some spread emerges. Could the author explain possible reasons for these differences? e.g. a obtained for Sarennes differs by almost a factor of 2 from Wurtenkees. The parameter μ is almost double for Careser compared to Gries (both glaciers are in a relatively similar climatological setting). Furthermore, is there an explanation why the rmse is relatively low (around 200-300 mm ww.e.) for glaciers in the Eastern Alps, and above 400 mm w.e. for glaciers outside of Austria. Is this related to (i) the quality of the HISTALP data base, (ii) to the model setting that works best for the climatological conditions in the Eastern Alps, (iii) to the quality of the mass balance measurements, or (iv) length of the data series?

6. **General focus of the paper:** The authors decide to focus their paper on the presentation and the validation of their model, and to provide only one exemplary application. This application is very interesting though, and I expected some more discussion of it. Rather than just focussing on the sometimes a bit lengthy presentation and validation of the model, I would suggest to emphasize the application and the interpretation of the results.

Detailed comments:

- **page 2801, line 3:** Just a general remark: I am not sure whether a study that only relies on the modelling of annual mass balance values, can claim to *investigate* the interaction between glaciers and atmosphere.
- **page 2802, line 27:** What other kinds of analysis (that are not performed in this paper) would this data set also allow for?
- **page 2803, line 1-13:** This part could be shortend or even be omitted to save space.
- **page 2804, line 23:** This statement is actually not understandable at this point of the paper – it rather appears puzzling. Either provide an explanation here, or move it completely to the discussion at the end of the paper.
- **page 2805, line 4-5:** "the amount, ... ". Unclear. What is done exactly?
- **page 2806, line 3:** Isn't rather Cogley (2005) meant here?
- **page 2806, line 21:** I understand how one parameter (e.g. μ) can be minimized using eq. 3. But now, the equation contains two unknowns (a and μ). What is the procedure to minimize both of them? Equation 3 does not apply then anymore.

- **page 2807, line 9:** Can some details about the auto-correlation lag time be given? I have troubles understanding what has been done here exactly.
- **page 2810, line 1:** The parameters of the SSC model were obtained based on multiple regression. I do not completely understand the procedure. Can the annual mass balance anomaly really be used to obtain a temperature sensitivity for e.g. the winter months? Some more details about the justification of the method applied here to determine SSC parameters might be helpful.
- **page 2811, line 14-19:** This paragraph is important, but I do not completely get it. What exactly is $r_{SSC,fitted}$?
- **page 2815, line 13:** How significant is the correlation of glacier terminus altitude and precipitation / temperature dependence of the glaciers? When looking at Fig. 12 it looks as the statement is only valid for very few data points, and for the vast majority of the glaciers no elevation dependence at all emerges.
- **page 2818, line 18:** It might be helpful to shortly describe what reference-surface balances are, rather than just providing a reference. Many readers might not be familiar with this term.
- **page 2820, line 9:** This paragraph is useful to discuss the value of the model results, and addresses a very important question: How well are mean mass balances reproduced. I suggest providing even more discussion. For example, what can be learnt from the bias shown in Figure 13? How can it be interpreted? e.g. the small biases for the glaciers in the Eastern Alps, and the huge bias for Aletschgletscher? What does a positive bias mean? Model too negative/positive?

Interactive comment on The Cryosphere Discuss., 5, 2799, 2011.