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The Cryosphere Discussions

Interactive comment on "Glacier changes in the Pascua-Lama region, Chilean Andes (29° S): recent mass-balance and 50-year surface-area variations" *by* A. Rabatel et al.

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Substantive comments

Referee #2: J.G. Cogley comment:

P2308 L22 Explain "arid diagonal", or remove the reference to it.

Authors reply:

This expression define one of the Earth's driest region. It is commonly used in papers dealing with glaciology, hydrology and climatology in this region. However, the wording has been changed to be more explicit and a reference was added: "the so-called "South

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America Arid Diagonal" (23-28°S, Schwerdtfeger, 1970)."

Referee #2: J.G. Cogley comment:

P2309 L24 The definition of "glacieret" should be referenced in more detail. I am a bit surprised that small size is not part of the definition, and the Pascua-Lama glacierets do not seem to fit the definition anyway.

Authors reply:

The definition has been slightly modified on the basis of the Glossary of mass balance and related terms. It is now expressed as follow: "The term "glacieret" defines a very small ice body, typically less than 0.25 km2 in extent, with no marked flow pattern visible at the surface, usually occupying sheltered parts of the landscape and formed primarily by drifting snow and (Cogley et al., 2011)" Yes, glacierets of the Pascua-Lama region fit well the definition, they are small in size (most of them < 0.1 km^2), they occupy a sheltered position and are mainly formed by drifting/blowing snow.

Referee #2: J.G. Cogley comment:

P2310 L17 On which glacier was the speed of 2.0 m a-1 measured? Provide an address for Golder

Authors reply:

This was measured on Guanaco Glacier. It has been specified in the text. An e-mail address of Santiago de Chile, Goder Associates office has been mentioned in the references.

Referee #2: J.G. Cogley comment:

P2310 L18-20 Explain how the thicknesses were measured, and give mean as well as maximum thicknesses in Table 1 if they are available.

Authors reply:

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Mean thicknesses are not available. Thicknesses were measured by Golder Associates using a Ground Penetrating Radar. The sentence has been modified as follow: “Ground Penetrating Radar measurements made by Golder Associates (2009) on Guancaco, Estrecho and Ortigas 1 glaciers and Esperanza, Toro 1 and Toro 2 glacierets show that the ice is generally thin on the glacierets but can reach several tens of metres for the glaciers (Table 1).”

Referee #2: J.G. Cogley comment:

P2313 L17 Presumably this should be “(root of the quadratic sum ...”.

Authors reply:

Yes, it has been changed

Referee #2: J.G. Cogley comment:

P2314 L15-18 Perhaps “halting melting” should be “inhibiting melting”. I do not understand “isolating the glacier ... ice temperature”. It should be “isolating the body of the glacier ...”, but the rest of the clause is unclear.

Authors reply:

“halting melting” has been replaced by “inhibiting melting” The other sentence has been reformulated and is now: “and by isolating the body of the glacier from incident radiation and thus allowing a rapid decrease in ice temperature”

Referee #2: J.G. Cogley comment:

P2315 L2 “Figure 3 presents”: these data are sufficiently important that they ought also to be tabulated, in full.

Authors reply:

A new table has been added to present these data: Table 4 in the final draft.

Referee #2: J.G. Cogley comment:

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P2315 L9 Define the coefficient of variation briefly.

Authors reply:

It has been done by adding a short definition in the sentence: “the coefficient of variation which measures the dispersion of a distribution, CV, is...”

Referee #2: J.G. Cogley comment:

P2316 L13 What is ? It looks like (1–p), where p is the probability that r differs from zero. p would be a more usual way to present this information.

Authors reply:

It has been corrected according to your remark.

Referee #2: J.G. Cogley comment:

P2316 L14 Change “decreasing with altitude” to “increasing with altitude”. Ablation is implicitly a negative quantity in all of the graphs.

Authors reply:

Done

Referee #2: J.G. Cogley comment:

P2316 L16-17 I would have thought that shelter from high winds might discourage melting. It would certainly favour deposition of windborne snow. Why cannot stronger melt at low elevation be due simply to higher temperatures (i.e. more time spent above the freezing point)?

Authors reply:

For more clarity, this sentence has been changed as follow: “Lower parts of the ice bodies may be more sheltered from high winds (which favours sublimation instead of melting), receive increased long wave radiation from surrounding valley sides, and

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experience longer time spent above freezing point at a daily time scale, all favouring melting during the ablation season."

Referee #2: J.G. Cogley comment:

P2316 L24 Change "This means" to "This suggests", to reduce the strangeness of the sums exceeding 100%. Consider also deleting the parentheses and ending the sentence with "while for the glacier the corresponding percentages are 64% and 51%"; the parenthesis trick saves space, but it also reduces readability and impact.

Authors reply:

The sentence has been changed according to your remark.

Referee #2: J.G. Cogley comment:

P2317 L19 I do not understand "elevation-driven temperature-dependent contrast". Expand and clarify what is being referred to.

Authors reply:

The whole sentence has been modified for more clarity. It now written as follow: "This more negative summer mass balance might be partly attributable to the distribution of stakes on the glacierets, which extends to a lower elevation than on the glacier, but, as the altitude-dependence of ablation is very weak (section 4.1.3; Figure 5), and temperatures are persistently sub-zero at this elevation, additional explanations to an elevation dependancy based on vertical temperature gradients are needed to explain the difference in summer balance between the glacier bodies."

Referee #2: J.G. Cogley comment:

P2317 L20-21 Surely the penitents could be a result of enhanced ablation?

Authors reply:

In this environnement, sublimation consumes most of the available energy. Penitents

are caused by differential ablation. Ablation (through sublimation) has a minimum on the penitent's peaks and a maximum on the troughs (through melting). Thus, penitents enhance ablation by favouring melting in the hollow.

Referee #2: J.G. Cogley comment:

P2317 L24 "The consistent formation of penitents": this argument seems illogical to me, or at least not thought out in sufficient detail.

Authors reply:

The sentence mentioned by the referee "The consistent formation of penitents" does not appear in the orignal text. We mention: "The systematic observation of penitents on the glacierets in summer...". However for a sake of clarity, we slightly modified the text and added a explanation: "The systematic observation of penitents on the glacierets in summer is probably linked with: i) widespread surface dust deposits, as they are small ice bodies and therefore a larger portion of their surfaces can be influenced by dust deposition from the unglaciated surroundings; and ii) penitents of the glacierets are taller than on glacier and can reach several meters high, because there are not only snow penitents but ice penitents which maintain from one year to another (Figure 7)." A new figure (Figure 7) presenting photos of penitents on Guanaco Glacier and Toro 1 Glacierets has been added to illustrate the text.

Referee #2: J.G. Cogley comment:

P2319 L11 Make the red and blue boxes in Figure 7 two (or four) standard deviations high, and explain the height in the caption.

Authors reply:

The PDO index has been removed from this Figure.

Referee #2: J.G. Cogley comment:

P2319 L27 "These data reveal ...": I do not agree, and suggest deleting this and the

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next sentence. In fact, the PDO could be removed from the paper altogether. I cannot see the connection.

Authors reply:

The PDO has been removed from the discussion.

Referee #2: J.G. Cogley comment:

In Figure 7, the cumulative balances for Echaurren Norte and Guanaco should both be set to zero at the same reference date, probably 2003/04.

Authors reply:

Done.

Referee #2: J.G. Cogley comment:

P2320 L8 Explain why the geodetic balance for 2002/03 on Guanaco has lower accuracy than the corresponding glaciological balance for Echaurren Norte.

Authors reply:

The following sentence has been added to explain the uncertainties on the geodetic method computed from GPR measurements: “because of: i) the uncertainties on the GPR measurements; and ii) the error resulting from the spatialisation at glacier scale of the measurements made on a few GPR profiles (2 or 3 per ice body)”

Referee #2: J.G. Cogley comment:

P2320 L13 I doubt the value of this long semi-quantitative discussion of links with the PDO. At the least, it should be shortened by focussing on the numbers (Pascua-Lama shrinkage rates, and average Echaurren Norte balance rates and PDO indices for periods that are synchronized as closely as possible with the dates of Pascua-Lama imagery).

Authors reply:

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The PDO has been removed from the discussion.

Referee #2: J.G. Cogley comment:

P2321 L9-10 The value of the remark about standard deviations is doubtful. About one in 40 should be in excess of $\pm 2\sigma$ if the precipitation anomalies are distributed normally, but it is clear that the distributions are not normal.

Authors reply:

This remark has been removed

Referee #2: J.G. Cogley comment:

P2321 L16 This paragraph about the lack of dependence of balance on temperature would be stronger if correlation coefficients and slopes (i.e. dB/dT) were presented.

Authors reply:

Both correlation coefficients and slopes for the dB/dT relationship have been added. The text as consequently been modified as follow: “In contrast, no link between glacier mass balance and summer temperatures, nor between glacier surface area loss and temperature evolution over the last fifty years emerges. Considering annual mass balances and mean summer temperature for the November-March period (January-March period) at Frontera AWS (Figure 1), the correlation coefficient and slope are respectively 0.14 and 0.03 (0.37 and 0.19). Considering summer mass balances, the same parameters for the same period are respectively 0.31 and 0.14 (0.08 and 0.08).”

Referee #2: J.G. Cogley comment:

P2321 L16 I am surprised that the trend of +0.19°C/decade is not significant, because it accumulates to a T that is higher by 0.9°C in 2007 than in 1958.

Authors reply:

Due to the strong interannual variability of temperatures the trend that appears is actu-

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ally not significant, the sentence has been completed in that sense.

Referee #2: J.G. Cogley comment:

P2323 L1 This conclusion could be deleted.

Authors reply:

This conclusion has been deleted.

Referee #2: J.G. Cogley comment:

P2329 Table 4 I would expand this table to give the important facts: the area of each ice body at each of up to four dates.

Authors reply:

This has been done. The table presents now the surface area for each available date for each ice body.

Stylistic comments

Authors reply:

All the stylistic comments have been carefully considered. Especially, every hyphen has been checked.

Interactive comment on The Cryosphere Discuss., 4, 2307, 2010.