

The Cryosphere Discuss., author comment AC1  
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## Reply on RC1

Benjamin Aubrey Robson et al.

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Author comment on "Glacier and rock glacier changes since the 1950s in the La Laguna catchment, Chile" by Benjamin Aubrey Robson et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-200-AC1>, 2021

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Thank you very much for your constrictive and helpful comments, and your positive feedback on the manuscript. Our responses to your comments are listed in the table below.

Best regards,

Benjamin Robson (on behalf of the authors).

### Reviewer comment

The authors followed a method similar to Falaschi et al. (2019b?) to quantify glacier elevation change and mass balance errors. However, it is unclear how to compute the error of penetration depth ( $E_r$ ) in equation (4). The accounting of penetration error as an independent source may be questionable in equation (4). Given that the error of penetration depth affects the calculation of elevation changes which are then propagated to the error of mass changes,  $E_r$  is not independent from  $\Delta h$  in this case.

### Our response

We have now clarified in L 188 – 191 that a linear correction was applied, where 0 m correction was applied at the firn line, increasing to 5 m correction at the top of the glacier. The reason we have  $E_r$  as a separate error term is that it is only included in the DEM pairs that involve the SRTM DEM. We recognise that there are various different corrections possible for radar penetration, and we have tried to list them in the text. The reason we chose this method is that it had been applied in other South American studies. We hope that by incorporating the radar correction into  $\Delta h$  we can present our results and demonstrate their significance. We have also clarified now that we follow the approach of Falaschi et al 2019b.

The glacier mass change estimation in this study was compared to that of Braun et al., 2019 and Dussaillant et al., 2019, which used different sources of DEMs. A new global estimation of glacier mass balance (and elevation change maps) is published in Hugonnet et al. (2021). It is necessary to update the comparisons with this dataset to see whether the disagreement persists.

Thank you for the update, we have now compared our study to that of Hugonnet et al, 2021 both in the text and the figure.

In line 350, the figure (Figure 8, comparison of glacier velocities) does not match the contents about comparing with in-situ glacier mass balance. Quantitative information from our interpretation of the field survey is therefore missing.

We have updated the text to refer to figure 7. We also calculated the median deviation, which is substantial, and as such validates our interpretation that the relation is weak.

Rock glaciers seem to be in an overall equilibrium (Table 5) between 2012 and 2020 in contrast to the noticeable thinning of Tapado Glacier with debris-covered and clean-ice sections (Table 4). In addition to velocities and evident elevation changes on different parts of rock glaciers, any extended comments or discussions regarding the overall state of rock glaciers? I.e., is the equilibrium state indicative of the insensitive response of glaciers to climate forcing?

This is a good point. We have expanded on this point in the discussion. It is hard to compare a glacier surface that is stable with a stable rock glacier surface. The former indicates a mass balance close to zero, but the latter can indicate either that the rock glacier is in equilibrium or conversely that there is little permafrost to thaw in the rock glacier. We have emphasized this point more in the manuscript and we now suggest that surface elevation changes combined with ice rock glacier deformation rates is the best way of assessing if rock glaciers have lost ice.

Line 95: Please simply describe the annual temperature level and precipitation amount in the study region in this paragraph. We have now added in this information

Line 160: 'Third order polynomials were fitted to elevation biases...'. According to Figure 2, six-order polynomials was used for across-track correction? Thanks for spotting this. You are right, sixth-order polynomials were used for along-track, and third order for across track and elevation dependent. This has now been fixed.

Line 195: 'We opted to follow the same methods as Falaschi et al. (2019) who utilized...'. The reference is unclear, Falaschi et al. (2019a) or Falaschi et al. (2019b)? This has now been fixed.

Line 251: When describing glacier area changes, keep the number (positive/negative) consistent to avoid confusion. The sentence can be revised to '...the glacier area decreased at a rate of  $5910 \pm 1060 \text{ m}^2 \text{ a}^{-1}$  ( $0.35 \pm 0.30 \% \text{ a}^{-1}$ ), which increased to  $6818 \pm 24202 \text{ m}^2 \text{ a}^{-1}$  ( $0.60 \pm 2.28 \% \text{ a}^{-1}$ )...' This has been revised

Line 251 Page 12: '-5910  $\pm 1060 \text{ m}^2 \text{ a}^{-1}$  ( $-0.35 \pm 0.30 \% \text{ a}^{-1}$ )', missing space between units ( $\% \text{ a}^{-1}$ ). This kind of error is widely found throughout the manuscript (i.e., line 256, 315, 316). Do proofreading and correct the missing or surplus spaces. Thanks, we have now fixed this

Line 265: '()' missing references? Thanks, we have now fixed this

Line 278: '...between 2012 to 2015' revise to 'from 2012 to 2015' This has now been fixed

Tables: The format of tables (number format, border lines, etc.) needs to be revised to improve the reading and be in line with the journal's requirements This has now been fixed

Table 5: The table is long, moving to the appendix or supplementary? This has now been fixed

Figure 1: It is not clear about the extent of debris-covered sections in (b). This information is necessary for a better interpretation of Figure 5. Try set the shade of rock glacier extent more contrasted in (a). Figure 3. The location of the (c) is not described in the figure caption. For a concise presentation, (b) and (c) can be aligned horizontally rather than vertically with (a). This organization also applies to Figure 3. Thank you for the feedback. We have now altered the symbology for the rock glaciers, debris-covered section, and clean ice. We have changed the orientation of Figure 1 and

Figure 4: The legend covers up (blurs) part of the line drawings. This has now been fixed

Figure 8: The figure does not match the contents discussed. It is about the validation of glacier velocities rather than glacier surface elevation changes from the field survey We will move the figure up so that it fits better in the text

Figure 11: To improve visual geolocation, set the scale of the same place consistent across different panels (a, b, c) We have now made the scale consistent