

The Cryosphere Discuss., referee comment RC2  
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## **Comment on tc-2021-208**

Anonymous Referee #2

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Referee comment on "Glacier–permafrost relations in a high-mountain environment: 5 decades of kinematic monitoring at the Gruben site, Swiss Alps" by Isabelle Gärtner-Roer et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-208-RC2>, 2021

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The study provides a) a review of existing measurements at the well investigated Gruben site in the Swiss Alps, b) extends the existing surface elevation change and velocity measurement to the recent time, c) presents some new in-situ measurements, and d) discusses based on the long term data the glacier-permafrost relation. This is one of the most comprehensive study on this topic presenting of the longest and most detailed time series on rock glaciers and is therefor of high interest and well suited for the journal. The study should ultimately be published, but there are several shortcomings which need to be addressed before publication.

### *General comments*

Rock glacier vs. rockglacier: I understand the reason behind using rockglacier in one word and I am also fine with that. However, internationally writing "rock glacier" is much more common and I will use this spelling in my review.

### Sections 1&2 (Intro and Study site)

The introduction section and Gruben site section should be better structured and in particular the section about the Gruben site could be more focussed. Some information about the study site is in the intro some in the specific section. However, some of the information of the Gruben site are needed to understand the rational of the study. Many information in the Gruben site section is quite old and probably already captured in Haeberli et al. (2001). My suggestion is to shorten the Gruben site section and focus on the relevant information for this specific study. It would also facilitate the understanding if the overview figure 1 and the geomorphological figure (Fig. 4) would be shown side by side. Maybe the permafrost zonation can be included in Fig. 4 (though you would need to change the colours) or shown in the supplement.

It is also not clear how you distinguish between the debris-covered glacier, the glacier affected rock glacier and the periglacial rock glaciers. A clarification is crucial are there are different options regarding the rock glacier origin as the authors are well aware of. Some relevant information is given in the results section but the information is needed earlier to be able to understand.

### Section 3 (Methods)

The methods need to be more in depth described and quantitative uncertainty estimates provided (and not just referenced to other studies). Only with an uncertainty assessment you can state that the obtained results are within the "range of measurements uncertainty" (L. 241f) or are significant. The uncertainty/accuracy should be assessed by investigating the results over stable terrain, and for the recent time by comparison to existing in-situ measurements.

It needs also be clearly stated what was done in this study and which is based on earlier work. Please also clarify why you start in 1994 while the study by Käab et al. (1997) provided data until 1995. How do the data from 1994 and 1995 match?

### Section 4 (Results)

A quantitative uncertainty estimate is also beneficial for the results section where at least the most important numbers should be given along with the uncertainty range. The values given should also be more precise where possible (e.g. "are in about the same range of -0.1 to -0.5 m/a" – is there any difference at least in tendency or remained the surface lowering the same?, but this is only one example, there are several others)

### Section 5, Discussion

The discussion would benefit from putting the results more into the context of the current rock glacier research worldwide. One example from Tien Shan is given but there are several other suitable examples from other parts of the world (though not from one of the authors).

Moreover, I ask the authors also to consider work by other researchers on the similar study site. I am aware of the different opinions about the origin of rock glaciers by different groups. In particular therefor it is important not to disregard but discuss relevant work by others (e.g. Whalley, W. B.: Gruben glacier and rock glacier, Wallis, Switzerland:

glacier ice exposures and their interpretation, Geogr. Ann. A, 102, 141–161, doi:10.1080/04353676.2020.1765578, 2020.) but critically

I have not counted in detail, but there are many self-citations. This is okay as the authors have done most of the work at the study site but putting the own work better into the context of existing knowledge would also reduce the self-citation ratio.

#### *Detailed comments*

Title: Write "5" in letters "five"

L.54: There have been many more recent studies related to rock glacier creep. Please cite one or two more recent ones in addition to Roer (2007)

- 55: Be more specific: Are the typical depths of the shear horizon of around valid for the rock glaciers on Earth or for the Swiss Alps where measurements are available?

L 88: "periglacial and glacier-affected parts": This should be explained in the introduction to be able to understand the purpose.

L94f: I suggest to first summarise the most important characteristics of the Gruben site and then refer to Haeberli et al. (2001) for more details (see also my general comment above).

- 104f: Provide a reference for the statement of the temperatures during LIA and the precipitation.

Figure 1: This is a key figure to understand the situation. It is in general good, but could and should be further improved. I suggest including a legend with the most important symbols/letters (e.g. the lines) of the figure (or write the letter and numbers in a table associated to the figure. This would make the figure more easily understandable. Moreover, I suggest to add some symbols (e.g. to indicate the rock glacier fronts etc.). I can imagine that it is for a non expert no easy to identify to which form the letters are referring to exactly (or show the figure side by side with Fig. 4, see above). Moreover, how was the approx. LIA extent and the flow during LIA determined?

Figure 2: Please include the letters, numbers and lines in the legend. Indicate the elevation of the mountain peaks. Also include the rock glacier and glacier outlines as this is very important information. See also my general comment above.

- 124: What are the modelling results of the two global models for the site? Please include the sites with BTS measurements and clearly mention how well they fit to the models.

L148: Are these permafrost landforms in Fig. 1? If yes, please refer to it more clearly. If not: Include in Fig. 1.

L155: Who determined the 0.15 times surface velocity at the front?

L169ff: The reference is now 45 years old. Others are also now the most recent ones. Please state critically if the statements are still true considering the temperature increase the last decades.

L210ff (section 3 data and methods): it is not clear from the section what was actually done within this study and which data was already processed by earlier ones (e.g. Kääh, 2005; Roer et al., 2005a; Brunner, 2020). Please clarify. Moreover provide the most important information about the processing steps also in this study. Most important: provide quantitative estimation of the accuracy. See also general comment above.

Figure 5: I recommend the most common colour coding convention and present surface lowering in red and elevation gain in blue. I ask to provide a more detailed subdivision of the elevation changes, so that more details are visible (e.g.  $>1.0$ ,  $1.0-0.75$ ,  $0.75 - 0.50$ ,  $0.50-0.25$ ,  $0.25 - 0.10$ ,  $0.10 - -0.10$ ,  $-0.10 - -0.25$  ...). I do not see any white colour. I suggest showing and not show this range transparent. Please add the info about where are the different parts of the glacier and rock glacier. I ask you also to show the elevation change outside the glacier and rock glacier area which enables to visually assess the accuracy (either in this figure or in the supplement). It would certainly also of high interest to know how the parts of the south-eastern moraine (where the road leads to) changed over time (e.g. if there is an ice core I would expect at least some surface lowering)

L259: What is the mean vertical change and what does "almost constant surface lowering" mean? Constant within the uncertainty? Or is there a period with significant differences?

Figure 8: Add uncertainty/error bars. You may enlarge the y-axis for better visibility of the

changes and error bars. Why is there only an indication of 1994 in the x-axis, but the caption states "to 1995". This related to my earlier comment of the periods "until 1995" and "from 1994".

L305ff (section 4.3): The general information about the debris-covered glacier should be given in the into/study site section. The section would also be benefit from more quantitative details. These are probably available in the master thesis most readers will not understand as it is German. Provide the link to the thesis in the reference list.

L321: Just as a reminder: add uncertainty ranges to all numbers.

L325: The range given is quite large. Be more specific.

L 330ff (Section Gruben glacier)

The numbers provided here are also quite vague and important information is missing (e.g. how was the retreat measured, where is information about the surface lowering available). Moreover, more detailed information should be provided (retreat and elevation change per period). Indicate in one of the figures the comparison to the measured thickness (mentioned in the last sentences.)