First of all, my apologies for this late review.

*Thank you for your objective, helpful and constructive comments, which will certainly help to improve our study.* Please find our answers in blue in the text.

The paper is one of the first publication comparing the evolution of rock glacier kinematics for a set of landforms located in a single catchment area over a period of more than 60 years. The analysis is mostly based on historical aerial photographs and more recent airborne laser scanning data made available by the authors team. It permits to capture the evolution of rock glacier kinematics at roughly at a decadal time step.

This is a very interesting paper suffering however from several weaknesses, which I strongly recommend to improve in order to consider it for publication. The paper is relatively long and needs to be significantly shorten, either via the text content or the concision of some sentences or paragraphs. Any repetition must be avoided. I agree that this is a difficult exercise. The content of the illustration is mostly excellent, but usually much too small, what is deserving the paper. Some very important results are lost in large figures (e.g. evolution of the velocity flow field) and must be highlighted. Maybe some additional figures are needed.

*This was noted in the same way by all other referees. We will restructure and shorten the study. Furthermore, we will omit the chapter on special cases and only briefly address it in the discussion and try to generalise the results.*

The structure of the paper must be revised. The description of all rock glaciers, including their spatial flow pattern and connection to upslope unit must come in entrance. It helps the eventual splitting of some rock glaciers in distinct sub-areas to be envisaged. Then the results are presented. Finally a distinct discussion section must come. At present results and discussion are mixed. The discussion must avoid to be too hypothetical.

*As noted by referee 1, we will present the results of the rock glacier inventory and the more detailed characterisation of the rock glaciers studied at the beginning of the results section. In the following, we will present the results of the flow velocity, surface elevation change (former 3D Distance) and the volume change analyses. Only then will we discuss the results.*

*Since this will substantially change the structure and length of the individual passages, it is also possible that some passages noted in the comments will be removed. Wherever we retain the passages, we will take the comments into account, as detailed below.*

The methodology to calculate the rock glacier flow rate (single value) is unclear. It looks to be a mean of all parts of the rock glacier where any data is available, whatever the kinematic behavior. What is the sense of doing so ? Marginal areas, not moving homogeneously with the main rock glacier body, should not be taken in consideration. In addition, for some rock glaciers, it looks that calculating a mean velocity for the entire landform has no sense regarding the heterogeneity of the kinematic behavior over both space and time. Separating some rock glaciers in two or several kinematic sub-aeras could provide results (and conclusions) differing from the current ones.

*After reading your comment and thinking about it, we understand your concern about calculating the mean value of the entire rock glacier, as is done in many studies, as this is not* *representative due to the multimodal distribution of the velocities on some rock glaciers. Therefore, we would propose to keep Figure 4 (boxplot with mean and LoD) and Figure 6 (mean of flow velocities and influencing factors) for the comparison of the rock glaciers among each other. However, in a new figure, we will present the maps of flow velocity and the corresponding violin plots or density plots of flow velocity to illustrate the heterogeneity and the change of the different kinematic zones on the individual rock glaciers over time. In addition, we will make a figure showing the area of the rock glaciers whose flow velocity is above the LoD and above the maximum LoD of all time slices (proportion of "active" area). In this way, we believe that the heterogenity and change in the "active" area can be well represented. In this context, active means detectable as active with our method, which we will also describe this in the text.*

The "3D displacement" is not one, meaning it is not a displacement in xyz coordinates, but an inadequate terminology to define somehow a vertical movement only, but not exactly. What is the interest of applying such an approach (movement normal to the surface)?

*We agree that 3D displacement is a misleading term, which shoud discribe a point cloud based surface elevation change. Although this approach can be advantageous in complex trains (c.f. Lague et al. 2013) , we will replace the analysis with a DoD analysis in the revised version, as Referee 2 noted that the calculation of the volume by gridding of the point cloud based surface elevation changes is not correct. Although this will just very slighly change the results, this approach may be easier to understand and provide better comparability with other studies that largely follow the classic 2.5 D (DoD) approach.*

Both abstract and conclusions must be revised accordingly. They have not been reviewed, because they may change after having adapted the analysis procedure.

Since about L500, I have not performed an in-depth review.

The additional references indicated in my review are suggestions only.

The location of all rock glaciers must be provided.

*In addition to figure 1, which shows the locations of the rock glaciers in the study area, we will add a kmz file with the locations of the rock glaciers studied in the supplementary merterial part of the study.*

Detailed comments :

Title : I guess it is more the multi-decadal kinematics of the rock glacier which is analyzed and not the morphodynamics

*We Agree. We will change the title accordingly.*

L14 : nine or eight ? Weird statement.

*In the case of the point cloud based surface elevation change there are nine and for the flow velocity analysis there are eight. The ninth could not be considered for the flow velocity* *analysis due to shadowing and lack of surface structure which made image correlation impossible. This is specified in more detail at the end of the introduction and in the methods section.*

L33: “or pure ice”. To be avoided. This would be a debris-covered glacier.

*We will remove “or pure ice” from the sentence.*

L38: “in part” can be omitted. Ice build-up within the ground might be the dominant process and the embedding of external (e.g. glacier, snowpatch) ice might be inexistent.

*We will delete this passage due to the requested restructuring of the introduction of Referee 1.*

L42: Active layer is consisting of unconsolidated debris (not only “boulders”)

*We will correct this.*

L43: I don’t see the causal relationship between the thermal regime driven by freeze-thaw cycles and the air-filled porosity of the active layer. There is also air and water advection. Are there some references to propose ?

*We will remove this sentence from the manuscript as reviewer 1 requested that we shorten the very general introduction to rock glaciers up to line 55 and go more into their (recent) kinematics.*

L43: “These”, but which ones ?

*By these we mean the previously mentioned freeze-thaw cycles and the air convection. This sentence will also be deleted in the revised version, due to the requested shortening of the general introduction by Referee 1.*

L46: No, the debris size is not smaller, but the proportion of coarser debris per volume is less.

*We will correct this.*

L51: What does mean "long-term"?

*Since the previous sentence talks about seasonal changes, by long-term we mean the change in thermal forcing over several years. We will specify this.*

L51-54: See also Cicoira et al. 2021 - A general theory of rock glacier creep…

*We will add this reference.*

L.54 : The shear zone is maximally a few meters thick.

*We will specify this.*

L57ff: This is only valid in the European Alps.

*We will limit the validity of the statement to the European Alps.*

L59. Velocity decrease since the 1990s. Which of the mentioned studies are reporting this ? I agree that some rock glaciers are decelerating, but the general trend is a significant continuation of the acceleration (e.g. PERMOS 2019 in the Swiss Alps… must not be very different in the Austrian Alps, a couple of tens kilometers eastward)

*We did not want to talk about a general deceleration of rock glaciers following the acceleration in the 1990s, but to show that there were phases (years or multiple years), in which constant or decreasing velocities were measured. This is also partly reflected in our study, in RG 01, 03, 06, 08. In these examples, lower flow velocities were measured in the period 2006 - 20012 than between 1997 - 2006 and 2012 - 2017. At least in two of the metioned studies this is also the case (e.g. Kellerer-Pirklbauer and Kaufmann, 2012 - for three rock glacier in the Hohen Tauern Range, Austria or Kenner et al. 2020 - for Schafberg rock glacier in the Swiss Alps). We will formulate this more clearly and also note your comment about annual measurements and that this is mainly due to the deceleration drop in 2005/06.*

L70. No one of both mentioned references is showing this, but Delaloye et al. 2013 – Rapidly moving rock glaciers… - and Eriksen et al. 2018 - Recent Acceleration of a Rock Glacier Complex, Ádjet ...- are doing so. About destabilization, see also Marcer et al. 2019 - Evaluating the destabilization susceptibility of ...

*We agree that in the studies mentioned a maximum of 4m/yr is given. In an earlier version we had Vivero & Labiel 2019, which give 60-75 m in about a year, in the citation, this had to be deleted due to the limit of 80 references in the cryosphere.*

*We will add "…up to sveral tens of meters…" and include Vivero and Lambiel (2019) and Marcer et al. (2019) into the citation.*

L83 I would suggest "e.g." because there are other studies, sometimes difficult of being accessible. Maybe also Kummert et al., (under final review in ESPL) - Pluri-decadal evolution of rock glaciers surface velocity and its impact on sediment export rates towards high alpine torrents. See also Kääb et al. 2020 - Inventory, motion and acceleration of rock glaciers... for an example outside of the Alps

*We agree. We will insert e.g. in the citation.*

L85. There is something wrong in this sentence

*We will rephrase this sentence.*

L89. Are the rock glaciers the same, so 8 of 9 ?

*Yes, we will specify this. The reason was already given in a previous answer.*

L94. Never begin a chapter with a figure. But besides, it would good to precise what are the used coordinates, what is the unit (m ?) and to add (or replace them by) lat/long coordinates.

*The coordinate system used is ETRS89 / UTM zone 32N EPSG:25832 and the unit is meter. We will mention this in the caption.*

L97. m. a.s.l.

*We will correct this.*

L108. Anthropic influence on the rock glacier as well ? Which ones precisely ?

*Yes, there is also anthropogenic influence on a rock glacier due to the construction of the glacier road between 1979 and 1982, which intersects rock glacier RG03. We will mention this here.*

L110. Inactive rock glaciers. How was this classification done ? On which parameters ? Does it fit with the IPA Action Group Rock glacier inventories and kinematics definition ?

*Here we follow the classical classification into active - motion (from image correlation) inactive - ice contained; no measurable motion (melting, visible on DoDs) and fossil (e.g. Krainer & Ribis 2012). The methodology is described in chapter 3.1 Rock glacier inventory (P6L133-141). We will describe the classification in more detail in the methods chapter on the rock glacier inventory.*

L113. Replace by something like : Finally, eight active rock glaciers representing different characteristics and conditions were investigated in detail regarding flow velocities and one more regarding vertical displacements

*We agree that the formulation is clearer this way and will adopt the sentence in a similar way.*

L121. The rock glacier moving downwards, it does not make sense to write that it reaches the “highest elevation”. Would it not be that it is located at the highest elevation range among the nine selected rock glaciers ?

*We will put the description in the results section, as Referee 1 asked us to put the results of the inventory in the results section. We will take this comment into account when we rewrite the manuscript.*

L129. Is the layer below the ice rich permafrost body really ice free ? Because it is very difficult to conceive an active rock glacier which is only frozen in its upper part. Where is the shearing zone developing on the long term ?

*Here we describe the results of the geophysical investigations of Hausmann et al. 2012 at the Ölgruben rock glacier (RG 01). Since we are not experts in the interpretation of geophysical surveys, we can only report the results of the study as published.*

151-153. There was a paper in 2008 (Delaloye et al. - Recent interannual variations of rock glacier creep in the European Alps) showing that there was an almost good similarity of interannual variations of rock glacier velocity over the entire European Alps, confirmed a decade later by Kellerer-Pirklbauer et al. (2018) at EUCOP - Interannual variability of rock glacier flow velocities in the European Alps. There was also a short communication at ICOP 2016 by Staub et al. - Rock glacier creep as a thermallyâ€‹ -driven phenomenon: A decade of inter-annual observations from the Swiss Alps - showing that the interannual variations are basically driven by shifts in mean ground surface temperature for a period of about 2.5 years. For sure this is also influencing the liquid water content within the permafrost.

*This is why we write liquid water availability and not precipitation, the increased liquid water availability can have several causes, which according to Kenner et al. (2020) is mainly controlled by the ground temperature and the onset and duration of the snow cover. This is described in the introduction (P3L66-63). We will remove the explanation in the methods section, as Referee 1 noted that this should be explained in the introduction.*

153-155. The effects of liquid water availability and snow cover on rock glacier morphodynamics must be precised. Does it mean on-set and melt-out of the snow cover influencing the ground surface temperature or water equivalent of the snow pack which will melt out in spring/suemmer and directly influencing the rock glacier hydrology. Or both ?

*The influence of various drivers of rock glacier flow velocity is nicely displayed in Kenner et al. (2020), Figure 5. Although they just derive this from the study of one rock glacier, we think this is a very good overview and we are following it to some extent in our discussion of climate factors.*

*Both. As the influence of GST indiectly influences water availibility as well. The onset of winter snow cover determines the winter cooling intensity, which in turn influences the timespan with liquid water in the active layer. The strongest influence, however, is shown by the timing of snow melt, but less by the snow water equivalent (Kenner et al. 2020).*

Finally, the paper is focusing on decadal velocity changes. What relation to short-term (less than annual) changes ?

*We do not know exactly to which passage this comment refers, as we are now in the method section in cronological order. We refer to findings about short-term change and their relation to decadal velocity changes in the discussion.*

L276ff. This is not a 3D displacement, but something else (the surface change normal to the surface). But what is the interest of doing so and not calculating simply the vertical displacement? What are the advantages on a rock glacier ?

*See previous answer.*

L323 “showed good agreement”. Please, provide values, figure or table.

*A “hard” quantitativ comparison of values seems difficult to perform, as methedology and time spans differ. Nevertheless, we will include a table in the appendix.*

L.326 Is the stable area so stable? In principle, bedrock is more suited to be stable than a debris slope.

*We agree that bedrock can generally be considered more stable than a debris solpe. However, on bedrock, which usually has lower roughness, the errors are underestimated, especially in the image correlation analysis. Since we know the change from our point cloud based surface elevation change analysis in these areas, we know that they are stable.*

L361-363. The introductive part of the sentence could be avoided.

*We will correct this.*

L.367. A significant trend cannot be calculated over 11 years only. What is this data meaning ? Is it a difference between the mean of the two periods or a trend in 11 years as expressed in the two previous sentences.

*The two previous sentences describe the trend over 65 years at the Obergurgl-Vent and Nauders stations. The one meant compares the increase in the mean value in the last two epochs of the study, including the Weißsee station. We will make this clearer when rewriting the results and discussion section.*

L370. Precise what are these seasons, e.g. spring is MAM, summer JJA ?

*We will precise this in the methods section where we describe the meteorological analysis and in the caption of the corresponding illustration.*

L371-372 Conditions causing heat waves in future is not the purpose of this paper looking back into the past. The sentences could be removed.

*Agreed. We will remove this sentence.*

L388. +152 mm in 65y. Is it a lot or not ? What is the annual value ?

*We give the mean annual precipitation value for the study period in the next sentence (931 mm/yr). In the previous sentence we give the range of trends for all the stations studied (53 mm - 241 mm). A positive trend of 152 mm in 65 years is already quite a lot in our view.*

L393-395. This sentence about precipitation predictions could be removed (not of interest for this paper)

*Agreed. We will remove this sentence.*

L408. Snow melt trend: How much ? What are the starting dates and durations ?

*Referee 1 has noted that the small decreases in the snow parameters are not a trend. We will therefore delete the sentence. In addition, we will reanalyse the snow parameters and add the onset of a significant snow cover (>50) and the complete snow melt as parameters.*

L420. Provided max flow values are valid for a single period or as a mean for 1953 to 2017 ?

*These values are for the whole period of inverstigation (1953 – 2017). We state this in the beginning of the sentence: "For the whole period of investigation…"*

L421. How is the mean value spatially calculated ? How is delimitated the area taken into consideration for the calculation ? It looks from the figures that they comprise marginal areas (with velocity close to 0) to sectors moving much faster. Why not to split into sub-areas and perform a comparative temporal analysis ? See also the definition of moving areas within the IPA Action Group Rock glacier inventories and kinematics -

https://www.unifr.ch/geo/geomorphology/en/research/ipa-action-group-rock-glacier/ - documents (kinematics as an optional attribute in rock glacier inventories)

*As described in the general comments, we will show the change in the "active" areas (areas above LoD and LoDmax). In addition, we will show the flow velocities of the individual time periods as a violin plot or density plot as these representations highlight the heterogeneity and its changes.*

L.421. A mean velocity of 3.5 cm/year is rising some questions about the accuracy and reliability of the results (in particular changes over time). Is such a low value significant ?

*As described in the general comments, the mean values play a subordinate role in the revised version, as the development of flow velocities over the entire rock glacier is better shown in the boxplot and future violin or density plots. The value mentioned represents the mean value for RG 03 in the time slice 1970-1982. In this time period, maximum movements of 1.51 m (0.089 m/yr) were measured and the significance value of the measurements is 0.027 m/yr with about half of the measurements exceeding this value. It can therefore be said that significant movement on the rock glacier can be measured in this time slice. In the revised version, as described, we will refer less to the mean values of the entire rock glaciers and take a better look at their uncertainty.*

L424. One should note that the period 1997-2006 is marked by the peak of 2000-01 (described for instance by Ikeda et al. 2003 - Rapidly moving small rockglacier at the lower limit of the mountain permafrost belt… - and 2008 - Fast deformation of perennially frozen debris in a warm rock glacier…) and the famous 2003-04 peak (e.g. Delaloye et al. 2008), The period 2012-2017 is embedding the extreme peak of 2015 (e.g. Kellerer-Pirklbauer et al. 2018, PERMOS 2019), whereas the period 2006-2012 contains no peak of activity.
L431. 2006 is often a low, the period with the lowerst velocity recorded since 2000 (e.g. PERMOS). More generally the sentence is difficult to understand unambiguously.
L431-433. You could refer to Delaloye et al. 2008 for the low in 2006 in the European Alps and to PERMOS 2019 for the description of the entire period.

*We have tried to include studies with higher temporal resolution in explaining the change in our epochs (e.g. P17L429-433 and P18L470-73). We will improve content and sentence structure with the help of the literature listed here.*

L434. RG 04 : A detailed spatial analysis (of the morphodynamics) is necessary, with the help of (time-lapsed) maps. It should be the same for the other rock glaciers.

*Referees 1 and 2 have requested that the detailed analyses of the individual rock glaciers be greatly shortened and that we rather focus on general similarities and differences in the revised version. But we will describe the general trends, simialrities and differernces of the spatial development. The development of the individual rock glaciers can then be examined by the reader in the flow velocity maps and newly added violin or density plots.*

L435-7. “Many studies mentioned periods of slight decrease or constant flow velocities following the strong acceleration in the 1990s”. Not really. This is mostly related to the deceleration drop in 2005-06. Read the related papers (already mentioned earlier), and in particular the PERMOS reports.

*We will revise the passage with the help of the literature mentioned.*

L437-9. There are various examples of recent deceleration (or absence of acceleration), particularly in the Swiss Alps (e.g. Aget – see PERMOS 2019 – or Dirru – see Delaloye et al. 2013 – Rapidly moving rock glaciers…- Cicoira et al. 2019 - Water controls the seasonal rhythm of rock glacier flow – and Kummert et al. (under final review in ESPL) Pluri-decadal evolution of rock glaciers surface velocity and its impact on sediment export rates towards high alpine torrents). Probably Val Sassa and Val dal'Acqua rock glaciers in the Swiss national park have done so, but on a longer term since the end of the LIA (e.g. when comparing Chaix 1923 - https://www.persee.fr/docAsPDF/globe_0398-3412_1923_num_62_1_5609.pdf - p.11 and more recent measurements ba the National parc - https://www.parcs.ch/snp/pdf_public/2016/33398_20160921_121930_Sassa_Aqua_Bericht_2012.pdf, the movement rate appears to have been divided by 20 along the last century) . There are also some examples in Roer's PhD (2005). See Roer et al. 2005 - Rockglacier acceleration in the Turtmann valley (Swiss Alps): Probable controls

*Of course we agree with your statement. However, the second half-sentence is decisive for the statement, which says:"... relative to the speeds at the beginning of the 1950s". We are not aware of any studies that have measured lower or constant flow velocities in recent years than in the 1953 - 1970 epoch. However, we have to put the statement into perspective, since the uncertainty of the mean value only allows the conclusion that the flow velocity remain constant.*

What is the mean velocity of RG04 ? This must be given. What is the uncertainty of the values.

*The mean values range from 0.08 m/yr (1997-2006) to 0.06 m/yr (2012-2017). So we agree that we should not really speak of a decrease in mean velocity, but rather of a constant mean velocity, considering uncertainty. What is decreasing, however, are the maximum velocities. As stated above in the revised version we will give uncertainty values for the means.*

L452 (and others around). Why to be so precise in the values, taking into account their uncertainty?

*We agree. We will reduce the value by a maximum of two decimal places and also indicate the uncertainty when giving the values.*

L.451-453. Increase of the 2012-2017 velocity in comparison to which period ? Note that a pluri-decadal acceleration by a factor 2 to 10 has been observed in the Swiss Alps as well (PERMOS 2019 or other related documentation), e.g. Gemmi/Furggentälti, Grosses Gufer, Tsarmine.

*Compared to the epoch 1953/54-1970/71. We write this in the introductory sentence to this chapter (P18L444-446). We will include the PERMOS report and relativise the statement to: "...one of the highest relative changes in flow velocity compared to other studies."*

L.453-454. About rock glacier destabilization, see also Delaloye et al. 2013, Eriksen et al. 2018, Marcer et al. 2019 (already mentioned earlier in this review) and Marcer et al. 2020 - Investigating the slope failures at the Lou rock glacier front…

*We are aware of these publications, but the maximum number of references on the cryosphere is limited to 80. However, we will check whether the publications mentioned are more appropriate than those already cited.*

L.456-458. Agreed, but this must come in the discussion part and must be explain in details (provide maps/topographical profiles, etc.)

*We will take this into account in the complete revision of the results and discussion part of the paper.*

L.459. “The relative changes regarding the remaining rock glaciers ranges between 23.45% and 271.87%” is a huge difference ! 23% means about constant velocity and 271% an acceleration by a factor close to 4 ! This is not the same behavior.

*We do not state that the behaviour is the same, but only present the range of values that the other rock glaciers show. However, we will emphasise the big difference and the resulting diversity of behaviour.*

L.459-460. I don’t understand the sense of the sentence… If you remove RG04, because it has a very low slope, then one could say that higher elevated rock glaciers (in the set) are steeper, but not that they change their relative flow velocity to a greater extent. If they do so, this is then because of their elevation (and eventually thermal state/structure) or steepness ?

*We will remove this sentence as referee 1 has noted that this statement is not valid due to the small sample size.*

L.463. What are these “topographic factors” ?

*Here we mean the topographical factors listed in Table A1 (exposition, slope, elevation). We will specify this in the revised version.*

L.464. “On rock glaciers RG 01 and RG 08, higher flow velocities have been measured between 1953/54 and 1970/71 compared to the subsequent periods”. Be more precise. What are the subsequent periods ?

Agree... but there was then an increase since the 1990s.

*By the following epochs we mean the epochs 1970/71 - 1982 and 1982 – 1997 for RG 01. Regarding RG 08, the highest maximum flow velocities (by manual mapping) of the entire study period were measured between 1953 and 1970.*

*We will precise this.*

L474-476. “These peaks might not be found on the other rock glaciers due to superimposing effects over the long time steps and indicate a slightly different sensitivity, response or response time of individual rock glaciers to intra-annual, inter-annual or multi-annual fluctuations in external forcing parameters.” Obscure sentence, which must be either precised, or removed.

*We will precise this sentence.*

L476. “the three investigated rock glaciers”. Which ones ? There were only two mentioned at the beginning of the paragraph

*It must say two. We will correct this.*

L474. “differing substantially in the other characteristics measured”. I do not understand.

*Here we wanted to express that the rock glaciers are the two with the lowest elevation, but differ in size, slope, exposure.... We will discuss this in more detail.*

L479. « higher error ». To be precised.

*The mean error for the 1997-2006 epoch is 0.08 m/yr. In comparison, it is 0.02 m/yr for the 2012-2017 epoch. We present this in chapter 4.1 but we will also specify it here.*

L481-2. “analyzed for altitudinal zones of 20 meter ». Why to do so ? And not comparing central to marginal zones, or else ?

*We looked at the altitude zones because we wanted to see if there was an altitude-dependent trend. As described above, we will show the active area and its change. Additionaly we will display flow velocity in violin or desity plots to better visualise the different reactions.*

L482-4. “rock glaciers do not move uniformly, but have zones with higher and lower flow velocities”. It must come at the beginning... and frame the velocity analysis of the previous sections.

*We will state this at the beginning of the section of flow velocity results.*

L484-5. in the terminal section of the rock glacier ? In the front would mean in the frontal (talus) slope.

*Yes, we mean the terminal part of the rock glacier. We will correct this.*

L489. Relative instead of « percentage »

*We will correct this.*

L491-2. “This could point to the fact that from 2006 to 2017 higher elevated rock glaciers enter an unstable state as a reaction of changes in the external forcing”. This is a very tricky interpretation, which in any case must be moved to the discussion section.

*As mentioned earlier, we will restructure the results and discussion section and will take this into account when doing so.*

L493. There is no lag to permafrost temperature. What temperature is talked about ?
L.494. “temperature limits or similar”. I do not understand.
L.494. Time lack or time lag ?
*Here we wanted to express rock glacier RG 05 only shows a significant increase in flow velocity from 2006 onwards, especially in the higher altitude parts of the rock glacier. The assumption was that the delayed acceleration in comparison to the other rock glaciers*

*examined occurs due to the higher elevation. However, as Referee 1 also pointed out, our sample is too small to be able to prove this. We will therefore remove this hypothesis.*

L500. Figure 5. Great figure… if made larger. This is obvious here that most rock glaciers are not moving uniformly both in space and time. The multi-decadal kinematic analysis must imperatively be conducted on rock glacier sub-areas separately.

*We will respond to your proposal as described above. Although we have already tried to highlight the different kinematic zones and their development in the text, we will try to make this even clearer.*

Unit of the color scale ?

*The unit of the color scale ist given in the figure for every rock glacier individually in the map of the 2012 – 2017 epoch. Admittedly, this is a bit small and will be enlarged in the revised version.*

L.501. Section 4.4 is mostly an hypothetical discussion, not results.

*In the revised version, this chapter will be included in the discussion section, more systematically supported by literature.*

L579. Figure 7. Never start a chapter with a figure. Moreover, I don't understand what is this 3D displacement. Is it the vertical shift at fixed locations ?

*Admittedly, 3D displacment is not the correct term. The method is outlined in Figure A1. It is an established method to calculate the changes between two point clouds. It is commonly known as M3C2 (c.f. Lague et al. 2013). Since we did not use the M3C2 algorithm implemented in CloudCompare, but rather followed Fey and Wichmann (2017) and calculated this in SAGA LIS, we do not call the procedure M3C2, although it is very similar.*

*As described above, we will work with DoDs in the revised version. Tests have shown that this will hardly change the results, but we think it will make the results more accessible and easier to compare with other studies.*

L582. "0.031". Unit ? How is such a value calculated ? What is then its meaning for the rock glacier geometry change ?

*The unit is m/yr. This value is derived by calculating the mean of all surface elevation changes and than deviding it by the number of years beween measurements. Since there was hardly any subsidence due to extension or ice melting on RG 05 until 2006, the positive value could be due to debris input from the steep south-western adjacent slopes or to erroneous measurements. We will redo the analysis of the surface elevation changes and the volume changes and take better account of the errors and uncertainties.*

L592. This is not a mass balance, as the value looks not to be computed over the entire landform, which is also changing in geometry.
L608. Figure 8. How is this calculated ? How to take into account the geometry change ? The quality of the figure is poor (labels are much too large for instance).

*The values were calculated over the entire rock glacier, by gridding the point cloud based surfaces elevation changes, only snow patches were excluded. What is true, however, is that the calculation of the volume from the point cloud is not quite trivial. We will replace the volume calculation with a classic DoD volume calculation and improve the associated figure.*

L614-5. This is a setting, not a result. This should come before any kinematic (or morphodynamic) analysis. In addition, the aspect is for sure very different as well. What about the connection to the upslope unit ?

*We will include a small chapter in the results section describing the results of the rock glacier inventory and, in more detail, the characteristics of the rock glaciers studied.*

L616. "These changes are mostly spatially clustered, but in some cases they also show a clear temporal clustering". I guess, this is what is explained in the next paragraphs? If not, please do so.

*Yes, this is described in the next paragraphs.*

L.618. "Overall, the picture already described for the general trends is confirmed." That is.. ? What is this picture ? What are the general trends ?

*The general trends are described in the previous chapter. These are: the values are predominantly in the negative range; For most rock glaciers the mean values of the point cloud based surface elevation change in the first epoch are very close to zero and show a sharp shift to the negative in the epoch 1970/71-2006 or 2006-2012; almost all rock glaciers show values of the point cloud based surface elevation change in the negative and the positive range. We will redo the surface elevation change and volume calculations and will take this into account in the complete revision of the results and discussion section.*

L620 (and elsewhere). Avoid all "clear" and "when looking"... You have to show/express for the reader what is so "clear" "when looking", but not let him figure out.

*Agree. We will take this into account in the complete revision of the results and discussion section.*

L621. "Therefore, the characteristic topography for rock glaciers is formed". I do not understand.

*Here we wanted to express that in the negative and positive patterns of the point cloud based elevation changes one can recognise the development of the flow bulges through compression and extention. We will formulate this differently.*

L622. "or the rock glacier advances". It does. It has been shown before. But how is this scattering looking like ?

*Here we wanted to express that the rock glacier advance can also be seen in the patterns of the point cloud based surface changes. We will reformulate this.*

L622. « changes in activity ». Activity in what ? A vertical displacement is in particular the sum of the downslope movement of the rock glacier, the strain pattern (compression/extension), aggradation/melt of excess ice. If the flow rate of the rock glacier is increasing, the related component of the vertical movement is increasing proportionally.

*Activity is the wrong term in this context. Here we wanted to express that the patterns and magnitude of negative and positive changes are changing spatially and temporally. We will rephrase this.*

*As we show in chapter 4.7 and figure 10, flow velocity and vertical movement do not necessarily change proportionally. This was also shown for seasonal changes by Ulrich et al. 2021.*

L625. “inactive”. The activity must be related to the flow rate, not the vertical movement.

*Here we refer to the flow rate. We agree that we need to precise this because this chapter is mainly about point cloud based elevation changes.*

L627. “show hardly any 3D displacements » Is it not a question of scale ? More generally, what about the uncertainty ?

*Yes, of course it is a question of scale, but the rock glaciers mentioned hardly show any values above the error (LoD) value. We will reformulate the sentence: "...show hardly any significant point cloud based elevation chenages." in addition to the error value (from stable surfaces), we will perform an uncertainty analysis following Anderson (2019).*

L628. Where to look at on the figure ?

*This can be seen in Figures 7, 8 and 9. In Figure 7, this is evident from the shift of the median towards more negative values in most cases. In Figure 8, the volume balances become more negative in most cases, and Figure 9 shows this spatially on the point cloud-based surface elevation change maps.*

L628. “Here”. Where ?

*By "here" we mean in the case of the other rock glaciers mentioned in the previous sentence. We will rephrase this.*

L629. What are these active and inactive areas ? I guess the terminology is inappropriate.

*Yes, the therminology is not correct here. We mean areas with higher and lower changes in the point cloud based surace elevation change. We will rephrase this.*

L629. “eleveation dependency”. Absolute or relative to the rock glacier extent?

*By this we mean that the investigation of the altitude zones on the respective rock glaciers shows no altitude-dependent change. We will make this clearer.*

"Looking" at the figures, it becomes obvious that aggradation has frequently occurred at the front, whereas subsidence is systematic in the rooting zone, no ?

*If one considers all time periods and rock glaciers, we believe that this requires a more differentiated interpretation.*

L632. "show very clear activity in subsidence". How much, please ?

*The mean annual surface elevation change for RG 05 decreases from -0.019 m/yr in 1970 - 2006 to -0.023 m/yr in 2012 - 2017. This is also reflected in the volume changes (Figure 8) and spatially better resolved in the elevation classes in Figure 9. We will carry out this analysis again with DoDs and will give values in the revised text.*

L.635ff. Figure ? Where to see that ? Could it be else (than what has been observed) ? How is a null or a positive balance possible ? There should be a feeding of the rock glacier, which is equaling or exceeding the melt of excess ice at the front. For most rock glaciers, it cannot be reached because the motion rate is too fast (should be only a couple of cm/year maximally for most landforms) or there is no connection with any active feeding mechanism (for all glacier forefield-connected rock glaciers or when a small glacier occupied the rock glacier rooting zone during the Little Ice Age, what should be the case for most rock glaciers of concern by this study).

The methodology to calculate the volume balance must be explained, as well as its limitations and uncertainties.

*The slighly positive values are due to the errors and uncertaunties in the measurements. We will make the analysis of the surface and volume changes based on a DoD analysis and determine the errors and uncertainties based on Anderson (2019) - Uncertainty in quantitative analyses of topographic change: error propagation and the role of thresholding.*

A volume balance cannot be calculated for a rock glacier unit, which is not entirely covered by the data.

*The data cover the entire area of the rock glacier, although snow lies on the surface of the rock glacier in some small areas, as this would lead to bias in the results, the areas in which snow lies in one epoch were excluded for all epochs. Therefore, in our opinion, this approach is valid for the comparative analysis of volume changes.*

L637-8. Provide figure.

*We refer here to figure 8. We will include a reference to this figure.*

L650. Figure 9. The figure is very interesting, but too complicated, too small, and almost impossible to read

*We will split the figure and make one figure with the diagrams and one with the maps.*

L657. Provide illustration, map, figure.

*As all referees are in favour of shortening the whole paper and referees 1 & 2 suggest deleting the chapter on special cases, we will only mention this briefly in the discussion. We will nevertheless add the road to the maps of the rock glacier in Figures 5 and 9.*

L660. What about local loading (by displaced debris) ?

*This might be an explination as well. We will discuss here this.*

L664. Provide values !

*We will insert them in the text and refer to the corresponding figures. In addition, we will indicate the uncertainties in the revised version.*

L665. But most rock glaciers in the European Alps accelerated since the 1990s ! Why to state here specifically that "a strong increase in flow velocity was measured since 1997, which makes a delayed reaction of the rock glacier to the road construction 17 years before very likely". This is tricky and even false (i.e. no specific reaction).

*We do not mean the acceleration of the rock glacier in general since 1997, but, as described before, the rather unusual change in the flow pattern. The highest velocities occur at the in the area of the front in the time beween 1953 and 1982, after construction of the road the highest flow velocities are found below the road. Maybe the explenation of this is a bit speculative, we will only mention the possible antropogenic influence of the rock glacier in the revised version, in which the entire chapter will be shortened significantly.*

L.667. "It is known". Add reference(s)

*We will add references e.g. Ikeda and Matsuoka (2002).*

L667. "both factors". Which factors ?

*The topographical effects and the loss of ice mentioned in the sentence before. We will precise this.*

L669. Slope, altitude and ice occurrence are not an internal forcing. They are almost not changing over time. The ice/water content ratio does it.

*We will correct this accordingly.*

L669. "It is evident". ???

*We describe this in the following sentences for RG 04 and RG 08.*

L690. Thermokarst lakes "become a more common feature on rock glaciers due to warming and degradation of permafrost ». But there are not so frequent ! And only where massive (glacier) ice is embedded in the rock glacier.

*We agree. If we retain the passage, we will add "…where massive glacier ice is embedded in the rock glacier".*

L.693. "shifted its location". Or evolved in size and location consecutively to rapid ice melt at its margins.

*Of course the lake evolved in size and location consecutively to rapid ice melt at its margins, but it also shifted its location due to rock glacier flow.*

L705ff. This section must be heavily synthetized. See also comments on vertical movement in 4.x.x. Has not been reviewed, because the 3D displacement is somehow an obscure concept to me in this paper.

*We will redo the analysis of surfave elevation changes and volume changes as described before. Having done this, we find this aspect of linking flow velocity and surface elevation change interesting. There is only one study (Ulrich et al. 2021) that deals with this in a seasonal context and there are no studies on this yet for a long-term consideration.*

*However, we agree that this chapter can be shortened. In addition, we will change the figure by removing the interquantile range and instead show the uncertainty ranges of the surface elevation and the flow velocities.*

Figure 10 looks very interesting, whereas it should be adapted to rock glacier sub-areas. The insert in the upper right is not fully necessary.

*We will remove the insert.*

Table A1:

Elevation: I've tried to identify the rock glaciers on Google Earth. I don't know how these elevations have been determined, what do they represent. In particular, the max elevation appears to be often exaggerated.

*We will include a kmz file with the rock glaciers in the supplementary material to make them easier to find on Google Earth. The elevations were calculated from our ALS dataset from 2017. This is available in the coordinate system ETRS89 / UTM zone 32N (EPSG:25832). In this coordinate system the ellipsoid GRS 1980 is used, so the elevations are m above GRS 1980. Google Earth uses the WGS 84 / Pseudo-Mercator (EPSG:3857) coordinate system. This uses the ellipsoid WGS 84, which may be the reason for inconsistencies.*

Connection to the upslope unit : Reference and abbreviations ?

*The classification was done according to the IPA Action Group: Rock glacier inventories and kinematics - Baseline Concepts  Inventorying Rock Glaciers. We will  insert the reference and explain the abbreviations.*

RG 01 : I would say GFC for the main unit.

*We agree. However, one lobe is also TC, so we will keep this but change the order.*

RG 03: GFC. There is no glacier in connection with the rock glacier at present.

*We agree. We will change this.*

RG 04: GFC. There is no glacier in connection with the rock glacier at present.

*We agree. We will change this.*

RG 05: Not sure about the site. The rock glacier I guess is RG-05 is TC, but maybe it is another one.

*No you are right. We will change this.*

RG 06: But for sure with a glacier in the rooting zone during LIA, as attested by the thermokarst lake development in probably glacier ice embedded into the rock glacier.

*We know that there is clear evidence that a glacier must have been in the root zone during the LIA. However, the glacier inventory (Fischer et al. 2015) does not show a glacier here. We will add a note that there must have been a small glacier there.*

RG 09: GFC. Why TC ?

*Since in our understanding it is a poly-connected rock glacier.*

Connection to the upslope unit and area covered by 1850 glacier extent : These two characteristics show that the rock glaciers cannot be treated all in the same way. This is extremely important.

*We will take these two characteristics more into account when revising the discussion.*