Reply to reviewer 2

We would like to thank Dr. Blöthe for his constructive comments, which we believe have improved the paper substantially. In our revision, we have accepted all of the reviewer's suggestions. We have made major revisions, rewrote/added many paragraphs in Introduction, Method and Discussion, we have modified some figures in the manuscript, and we have added other figures in Supplementary material. Our replies and changes to the original manuscript are embedded in the reviewer's comments (in blue colour). The new/modified text that will be included in the revised manuscript is shown here in *italic*.

Major comments

In their manuscript, Bertone et al. present a standardized workflow to integrate kinematic information into rock glacier inventories. Largely building their work on the guidelines proposed by the IPA action group on rock glacier inventories and kinematics, the authors test the integration of rock glacier kinematics as derived from InSAR data in eleven regions across the globe, for some of which they produce new inventories, but also using published data. In total, the study identifies more than 5000 moving areas that were then integrated in the respective inventories. The authors find considerable differences in the rock glacier kinematics for the eleven regions investigated, though these are only briefly attributed. Instead, the study focuses on the proposed workflow, also comparing two different delineation strategies for moving areas. The authors conclude that their study demonstrates the feasibility of integrating kinematic attributes into rock glacier inventories using a standardized procedure that reduces operator bias.

Overall, the manuscript is well written and presents an interesting contribution to global rock glacier research, though placing a strong focus on the technical details of the proposed workflow. In my view, shifting the focus on the results obtained from InSAR analysis in eleven regions worldwide would increase the impact of the manuscript. In any case, before acceptable for publication in TC, the authors need to address a number of general concerns, specific comments and technical corrections that I will outline in detail below.

Kind regards

The reviewer asked to shift the focus on the results obtained from InSAR analysis in eleven regions worldwide. This paper describes the recently published guidelines and shows preliminary results following incorporation of kinematic attributes into rock glacier inventories. We believe that our results cannot be conclusive. The systematic analysis and comparison of the eleven study regions would require a careful quantitative characterization of the climatic and geomorphometric conditions of each region followed by relevant multivariate analyses. These tasks are beyond the scope of the present work. On this premise, at this stage we are not concerned with the interpretation and critical comparison of the eleven regions. Rather, we discuss the advantages, limitations and potentials of the proposed standardized approach to support the integration of kinematic information in inventories at a global scale.

We have strived to address the above motivations in the manuscript. We have rewritten the last paragraph of the introduction (lines 81-91), also considering the reviewer1's comments. Accordingly, the new text reads as follows:

"*In this work, we present the guidelines developed within the ESA Permafrost_CCI project and in collaboration with the IPA Action Group (IPA Action Group - kinematic approach, 2020). Our main aim is to explore and demonstrate the feasibility of an international joint effort to include kinematic information in rock glacier inventories (RoGI). To achieve this goal, we apply the aforementioned guidelines in eleven regions of the world. Most existing inventories do not include kinematic information (Jones et al., 2018a), and here we are the first to derive quantitative standardized kinematic information on rock glaciers over as many regions as possible. This paper includes the description of the guidelines and a collection of results, as* *well as analyses, observations and considerations deduced from the results obtained. A product validation is also conducted with independent measurements on some specific cases. As this paper is the result of a large cooperative work and builds on recently published guidelines, it does not present definitive results and conclusions. On this premise, at this stage we are not concerned with the interpretation and critical comparison of the eleven investigated RoGIs. Rather, we discuss the advantages, limitations and potentials of the proposed standardized approach to support the integration of kinematic information in inventories at a global scale.*"

We have also moved the sentences L83-87 to line 80, and we have added in the discussion section (line 523):

"*Preliminary results show a number of challenges that need to be addressed by the scientific community. For this reason, it is not possible to conduct detailed interpretations and comparisons between the investigated regions, which would require further investigations. However, we can look at some considerations below*."

1) The authors focus their work on InSAR approaches for the derivation of kinematic attributes for rock glaciers, which is also clear from the title of their work. Still, the paper would benefit from a few additional details on other techniques that have been applied for obtaining kinematic data. This is only very briefly included in the manuscript, yet there is a huge potential to also include kinematic information from different techniques that can very well be integrated following the approach presented here (Line 440). Adding a few sentences on the potential to do so would broaden the scope of the work presented here.

The reviewer asked for additional details on other techniques potentially useful to obtain kinematic data and pursue the main objectives of this work. We have followed the reviewer's suggestion. Accordingly, we have modified/added the following sentences to line 465:

"*For example, feature tracking (Monnier and Kinnard, 2017) and image cross correlation (Kääb, 2002; Kääb et al., 2021; Necsoiu et al., 2016) conducted on high resolution optical imagery acquired from airborne or spaceborne platforms represent viable alternatives to obtain kinematic information on large areas. Similarly, the differencing of sequential high resolution DTMs has been successfully used to quantify surface displacement and vertical change in particular (Avian et al., 2009; Kaab, 2008). These techniques, although extremely useful for detecting large movements (i.e., topographic changes) with high accuracy over seasonal to annual and decadal time scales, rely heavily on the timing of costly repeat surveys, which typically have lower temporal resolution compared to SAR satellite-based acquisitions."*

2) Is there a technical reason why only velocity classes are included in the inventory, instead of using mean, median, or quantile values for the "moving areas"? Pressing data into pre-defined classes certainly has some advantages, but represents a loss of information at the same time. By using very broad groups, monitoring of dynamic changes could be both, disguised on the one hand and overstated on the other, if average velocities change across class boundaries. The authors should elaborate on the reasons for using defined class boundaries in order to make the process more transparent. Furthermore, it is also not clear to me, why only one kinematic category (moving area) can be included for each rock glacier unit (L272-274)? Is this also a technical limitation of the inventory?

The reviewer asked to better explain the reason why a certain set of velocity classes are chosen. This point is also connected to the point 5 of the reviewer's comments, where he asked to better explain the error assessment of the InSAR derived velocities. To address the reviewer's concern, we have modified and added sentences to the paragraph in lines 219-224, which now reads as follows:

"Standardized velocity classes are assigned to each moving area. They are meant to (i) facilitate the subsequent assignment of kinematic attributes to the rock glaciers, and (ii) reduce the error and the degree of operator's subjectivity in assigning a specific velocity. A small number of defined classes reduces the variability in choosing one class over another, despite generating a loss of information (i.e., precise velocities) and creating biased information when the velocities are close to the class boundaries. As the guidelines are intended to obtain as standardized results as possible, six main velocity classes are chosen to balance the above rationale. Following recent studies (e.g., Barboux et al., 2014), the velocity classes, listed in order of increasing velocity, include: "< 1 cm/yr," "1-3 cm/yr," "3-10 cm/yr," "10-30 cm/yr," "30-100 cm/yr," and "> 100 cm/yr." Two additional classes include: "Undefine" when velocity cannot be assessed reliably and "Other" when a more accurate velocity can be assigned. The boundaries between the classes are selected taking into account the investigative capabilities of the InSAR, as interferograms with shorter time intervals allow detection of fast movements, while interferograms with longer time intervals detect slower movements. For this reason, the velocity classes are related to the time intervals at which movements are detected by a coherent signal (for example, following Barboux et al., 2014, a coherent signal visible on annual interferograms of Sentinel-1 allows to detect velocities ranging from 0.2 cm/yr to 3 cm/yr). Moreover, the InSAR signals are frequently affected by large spatial and temporal variability (e.g., Figure 3c-3e). In order to reduce possible errors, the assigned velocity classes represent the mean movement rate in time (i.e., within the minimum observation time window and temporal frame defined above) and in space (i.e., within the outlines), and not a single intra-annual variation nor an extreme value. In this work, the moving areas with large variability of velocity are annotated."

We have also added the following sentences:

Line 285: "*These categories aim to obtain kinematic attributes as standardized as possible and reduce the operator's subjectivity*."

Line 167: "*Thus, a kinematic attribute represents the movement rate of a rock glacier, while the moving areas provide the detailed kinematics within the rock glacier*."

The reviewer asked to better explain why only one kinematic category can be included for each rock glacier unit (lines 272-274). We have strived to address this point. We have rewritten the text to make it less ambiguous (lines 271-276), also replying to specific comment about the existing text on lines 273-275. Here the new text reads as follows:

"*One kinematic attribute is assigned to each rock glacier unit, based on the characteristics (i.e., extent, velocity class and time interval of observation) of the moving area identified within each rock glacier itself (Table 2; IPA Action Group - kinematic approach, 2020). When a rock glacier hosts multiple moving areas (Sect. 3.3) a set of specific decision rules is followed. In case of two equally dominant moving areas, characterized by contiguous velocity classes, the class of the most representative moving area (e.g., the one closest to the front, according to Barsch, 1996) is favored for the attribution of kinematic attribute to the rock glacier. In the case of a higher number of equally dominant velocity classes on the same rock glacier, the median class is retained."*

3) Surprisingly, Figure 5 that presents the results from the semi-automated delineation of moving areas for Nordenskiöld Land shows numerous moving areas that containing one or few pixels. This seems contradictory to section 3.3, where in lines 206-207 moving area is defined as a part of the rock glacier surface that shows a uniform (spatially consistent) flow field. Lines 215-216 further explain that the signal of movement needs to cover at least 20-30 pixels. Furthermore, Figure 5 shows moving areas of few pixels that were integrated as kinematic information into the rock glacier inventory. Yet it seems some of these

rock glaciers are not attaining the minimum size of 0.01 km2 (Line 145). Here it would be helpful to show the outlines of mapped rock glacier units, as done in Figure 3.

The reviewer asked why some moving areas from semi-automated method fit only one pixel. We confirm that the result from the semi- automated delineation shows numerous moving areas that contain one or a few pixels only. We understand the reviewers' point and agree that the concepts, implementations and differences behind the semi- automated approach are not clearly exposed. To address this issue, we have strived to improve the description of the methods. In particular, we have added/rewritten text to clarify that the two methods are based on different criteria and, consequently, the pixel threshold is different.

The amended text now reads as follows:

Lines 215-216: "*Moving areas are identified and outlined by means of polygons, when the signal of movement is detectable on InSAR data*."

Lines 228-229: "*Clearly, the two methods are different and rely on different criteria. However, the relevant moving areas obtained share the same definition and the same velocity classes defined above. In this paper, we do not aim to compare the two methods; rather, we exploit the moving areas obtained with different methods (i.e., manual and semi-automated) to assign standardized kinematic attributes to rock glaciers."*

Line 242: "*As the manual method is based on a set of wrapped interferograms, focusing on single pixels risks to over represent small and striking patterns. To avoid unrepresentative patterns, moving areas are outlined when the signal of movement is detectable for at least 20 to 30 pixels of InSAR data.*"

Lines 254-255: "*The outputs of this processing are mean velocity maps with a resolution of 40 meters, on which moving areas are delineated. In particular, the velocity classes are then assigned exploiting the entire set of pixels, i.e., a merged raster map over the whole area. Each pixel provides a continuous coverage over time and therefore a single pixel is considered a reliable representative signal of movement. Compared to the manual approach, the interpretation effort is reduced, but several time-consuming calibration tests are required."*

In the discussion, we have also reshaped lines 497-506 to better explain the observed differences between manual and semi-automated methods, and their relations with the aim of this work:

"*In the study region, a total of 5,077 moving areas were inventoried. These provide information on surface deformation associated to rock glacier activity. Application of manual and semi-automated methods has yielded some difference. We observe fragmented moving areas outlines that reflect the jagged edges of pixels (down to single-pixel moving areas) in Norway and Svalbard (Rouyet et al., 2021), whereas smoothed outlines that fit the detected slope movements characterize the moving areas in the other study regions. Clearly, moving areas obtained in the semi-automated method (based on averaged unwrapped interferograms) are not directly comparable with manual counterparts (based on visual inspection of wrapped interferograms). The choice between manual rather than semi-automated methods should be made according to the region extent and the available time, favoring semi-automated methods mainly for very large regions, where manual approaches take too much time.*

Despite the slight differences detected in the moving area inventories, the kinematic attributes were successfully assigned to 3,666 rock glaciers, exploiting standardized rules to translate kinematic information from moving areas to rock glaciers."

The reviewer asked to show the outlines of mapped rock glacier units in figures 4-6. Unfortunately, we cannot address this point, because some rock glacier inventories only contain the rock glacier location (indicated as dots) and the outlines are not available.

4) The authors have obtained kinematic information from eleven regions across the globe. While devoting a lot of discussion to the technical details, there is only a few sentences that discuss the significant differences within this data set. This is surprising, as there is huge potential to gain valuable insight into rock glacier behaviour on a global scale that remains unexploited. In connection to my general comment 2, it would be very interesting to see the full distribution of displacement velocities obtained from all regions. Figure 9 indicates sharp contrasts between the regions, but velocity classes mask very interesting details.

Please see our reply to the first general comment at the beginning of this document. We have strived to better show the comparison between the assigned kinematic attributes. We have reorganized the figure 7, 8b and 9, and we have removed relict rock glaciers from figure 9b. Below the new figures.

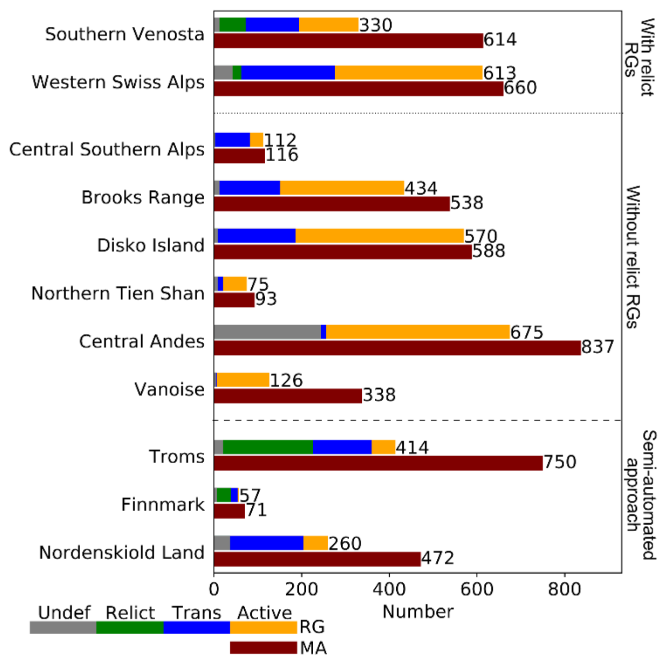


Figure 7. Number of inventoried moving areas (brown bars), and rock glaciers classified as undefined (grey bars), relict (green bars), transitional (blue bars) and active (orange bars) for each investigated region. The length of the bars is proportional to the number of observations (x axis). Numbering indicates the total number of moving areas and rock glaciers. Regional inventories that include relict rock glaciers are separated from those that do not and from those investigated with a semi-automated approach. Detailed information on assigned moving area velocity classes and rock glacier kinematic attributes are included in Table S3 and S4 of Supplementary material.

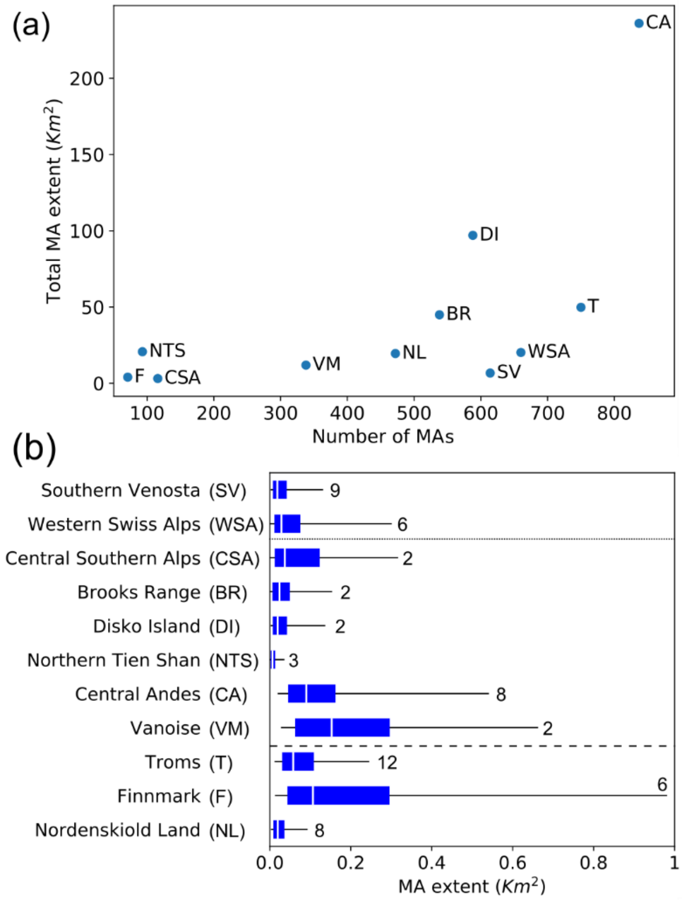


Figure 8. (a) Scatterplot of the total area covered by the moving areas (y axis) as a function of the number of mapped moving areas (x axis). (b) Boxplots show the area distribution of the moving areas. Bars enclose interquartile ranges, whiskers show 5 and 95 percentile. On the right, the maximum number of MAs associated with one RG for each region. Regional inventories that include relict rock glaciers (top) are separated from those that do not (centre) and from those investigated with a semi-automated approach (bottom).

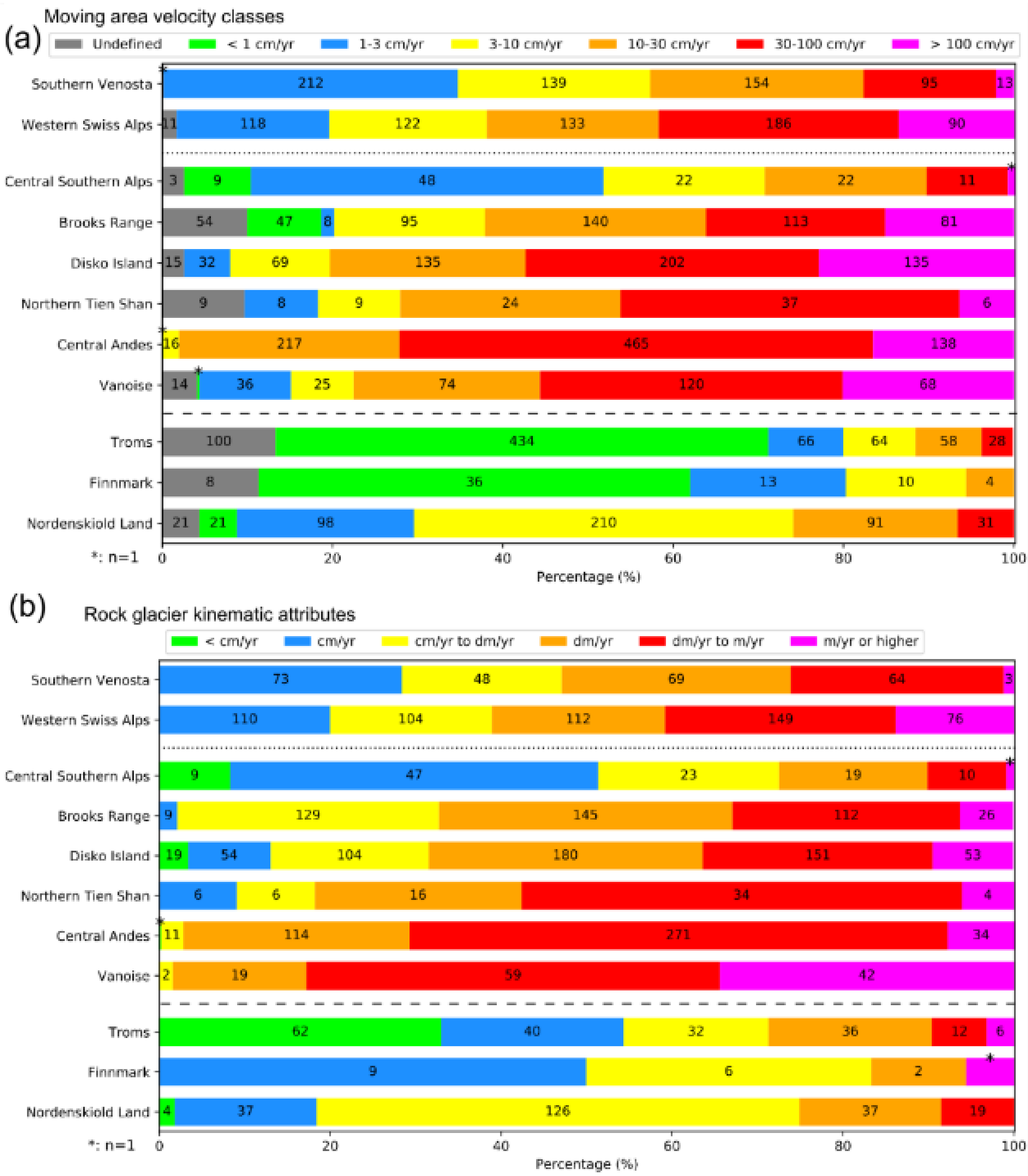


Figure 9. Assigned moving area velocity classes (a) and rock glacier kinematic attributes (b) for each investigated region. Relict landforms are not showed in panel b. The length of the bars is proportional to the percentage (x axis), the values inside the bars indicate the numbers for each category. Regional inventories that include relict rock glaciers (top) are separated from those that do not (centre) and from those investigated with a semi-automated approach (bottom). Detailed information on assigned moving area velocity classes and rock glacier kinematic attributes are included in Table S3 and S4 of Supplementary material.

5) A final point to consider is the error assessment of the InSAR derived velocities. The manuscript does not present much details on the errors associated with the method itself, nor with assigning moving areas to pre-defined velocity classes. In Lines 223-224 it is described that the velocity classes reflect the “spatio-temporal mean movement rate”. In my view, this deserves a bit more detail. Naturally, and also visible in the Fig. 3 c-e, there is significant variability in surface velocities within moving areas. How precisely is the

distribution of values used to obtain the "mean movement rate"? Do you differentiate between moving areas with very narrow distributions from those with large scatter in velocities? This would be especially relevant, when the mean movement is close to class boundaries.

The reviewer asked additional details on the spatio-temporal mean movement rate of velocity classes. To address this point, we have modified and added sentences to lines 219-224, please see the new text in our reply to point 2.

The reviewer asked additional details on the errors associated with the method itself, and with assigning moving areas to pre-defined velocity classes. The errors and subjectivity were evaluated during an intercomparison exercise of the ESA Permafrost_CCI project, and the main outcomes have been described within one section in discussion (5.1 Subjectivity of the method). According to the reviewer's suggestions, we have improved this part by adding the following sentences in:

Line 427: "*Despite the guidelines adopted, some degree of subjectivity can still occur. A large heterogeneity is often related to large spatial and temporal variability of the InSAR signal – interpreted in different ways by the operators – or to errors*."

Line 436: "*Two examples are included in this paper (Fig. 11) to show the contrast between a simple rock glacier and a more complex one, characterized by higher variability of InSAR data.*".

To illustrate this spatial variability, we have added Fig. 11, in conjunction with additional figures in the supplementary material.

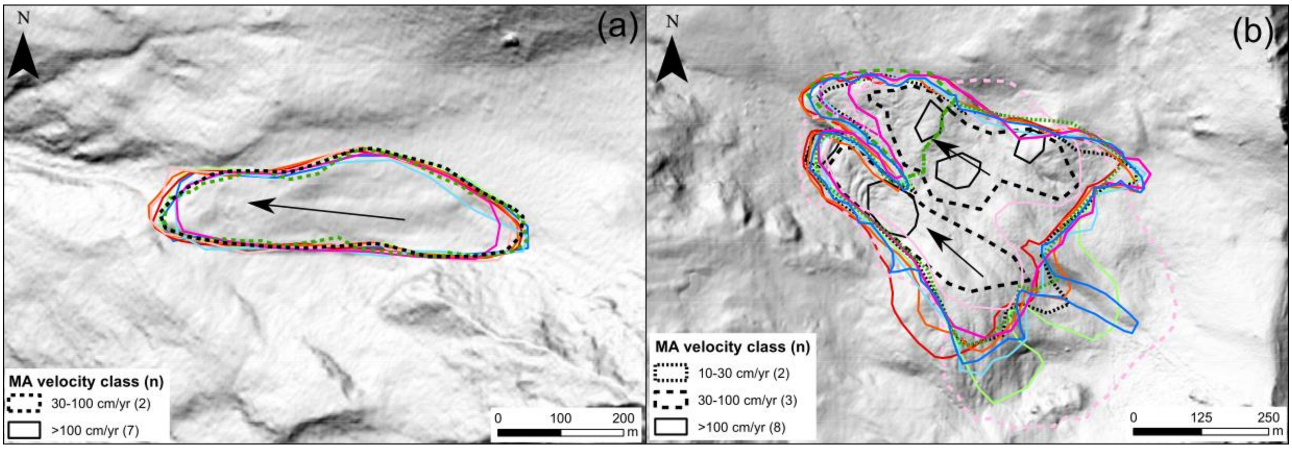


Figure 11. Two examples (a and b) of moving areas delineated by nine operators. Hillshade as background. The outlines drawn on the simple rock glacier (a) are very similar, and moving areas are classified as ">100 cm/yr" by seven operators and as "30-100 cm/yr" by two operators, because of the temporal variations in velocity. According to the mapped moving areas, this rock glacier is classified as "m/yr or higher" by seven operators and as "dm/yr to m/yr" by two operators. Greater heterogeneity is observed on rock glacier affected by larger temporal- and spatial- variations in velocity (b), with more heterogeneous outlines of moving areas and different assigned velocity classes (">100 cm/yr", "30-100 cm/yr" and "10-30 cm/yr"). However, despite the larger heterogeneity, this rock glacier is classified as "m/yr or higher" by six operators and as "dm/yr to m/yr" by three operators. Some interferograms are included in Figures S2-S4 of Supplementary material.

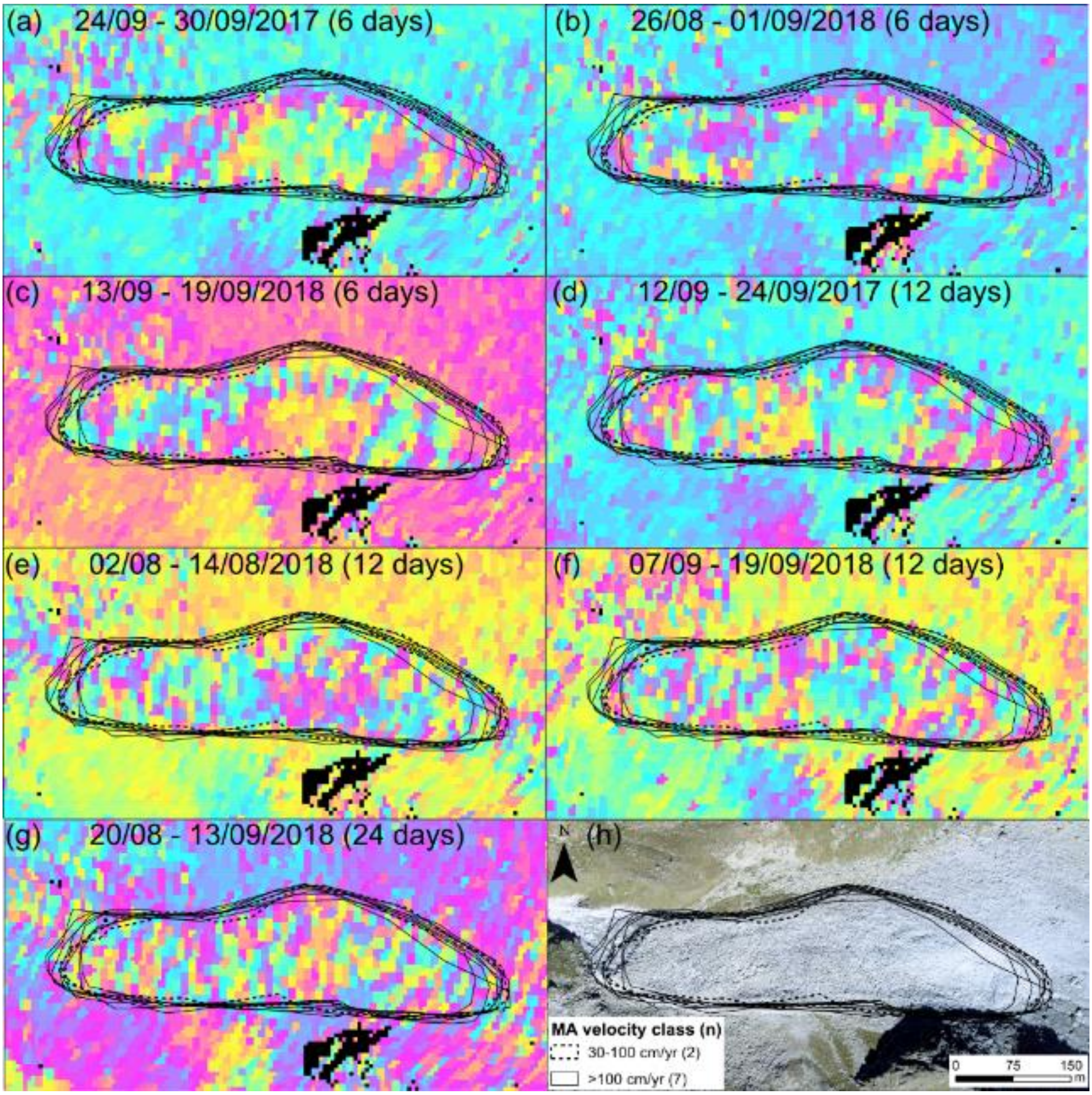


Figure S2. Sentinel-1 interferograms at 6 days (a-c), 12 days (d-f) and 24 days (g) show the temporal variability of the InSAR signals. Orthoimage (h) from © Google Earth 2019. The outlines of moving areas (black polygons) drawn by nine operators on a simple rock glacier case mostly agree with the observed InSAR signal; large discrepancies between the outlines are not observed, while both velocity classes ">100 cm/yr" and "30-100 cm/yr" are assigned due to temporal variations in velocity. According to the mapped moving areas, this rock glacier is classified as "m/yr or higher" by seven operators and as "dm/yr to m/yr" by two operators.

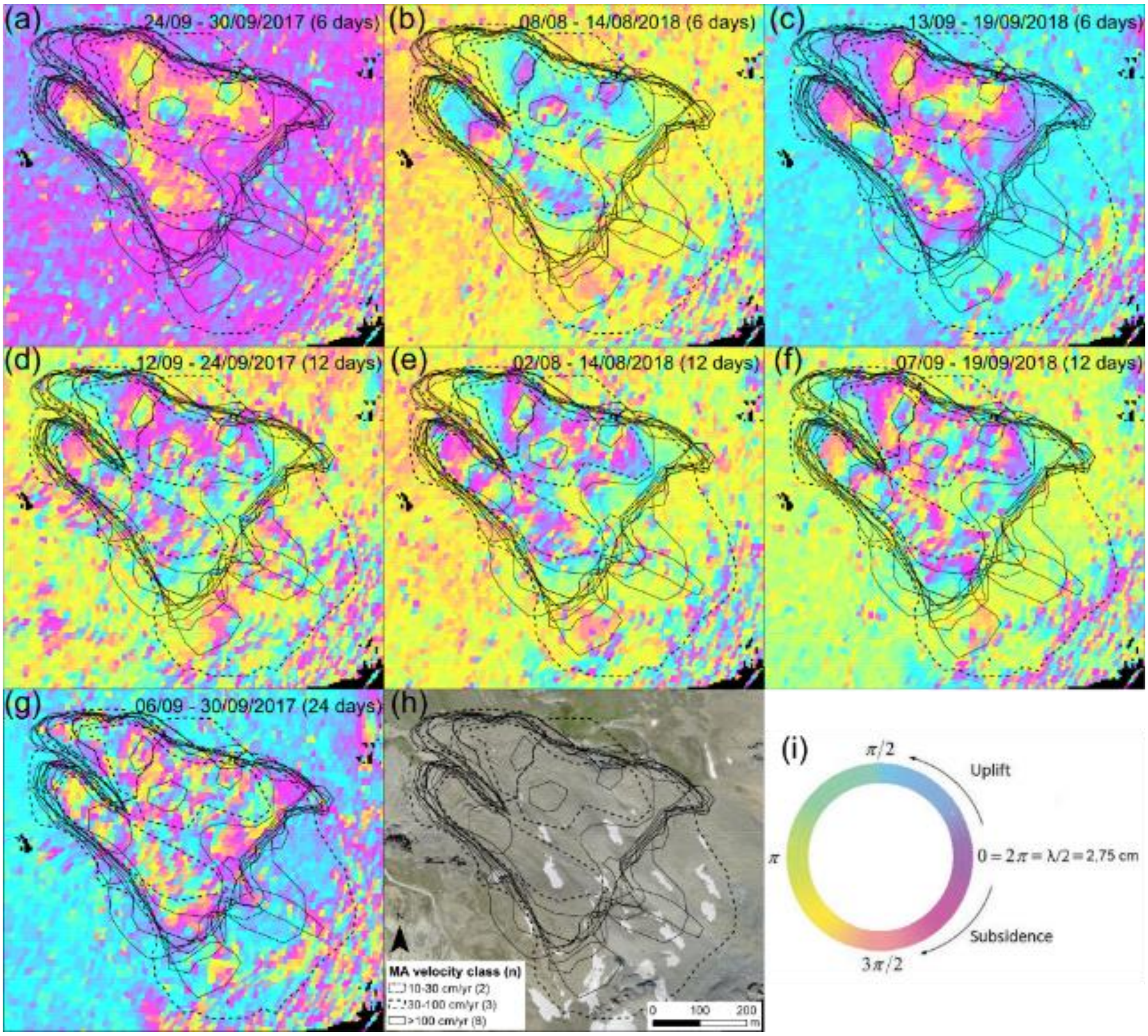


Figure S3. Sentinel-1 interferograms at 6 days (a-c), 12 days (d-f) and 24 days (g) show the temporal and spatial variability of the InSAR signals. Orthoimage (h) from © Google Earth 2019. The outlines of moving areas (black polygons) drawn by nine operators on a complex case of rock glacier show quite large heterogeneities; several velocity classes (">100 cm/yr", "30-100 cm/yr" and "10-30 cm/yr") are assigned due to large temporal and spatial variations in velocity. However, this rock glacier is classified as "m/yr or higher" by six operators and as "dm/yr to m/yr" by three operators. Phase cycle for Sentinel-1 in panel i. The single outlines are visible in Figure S4.

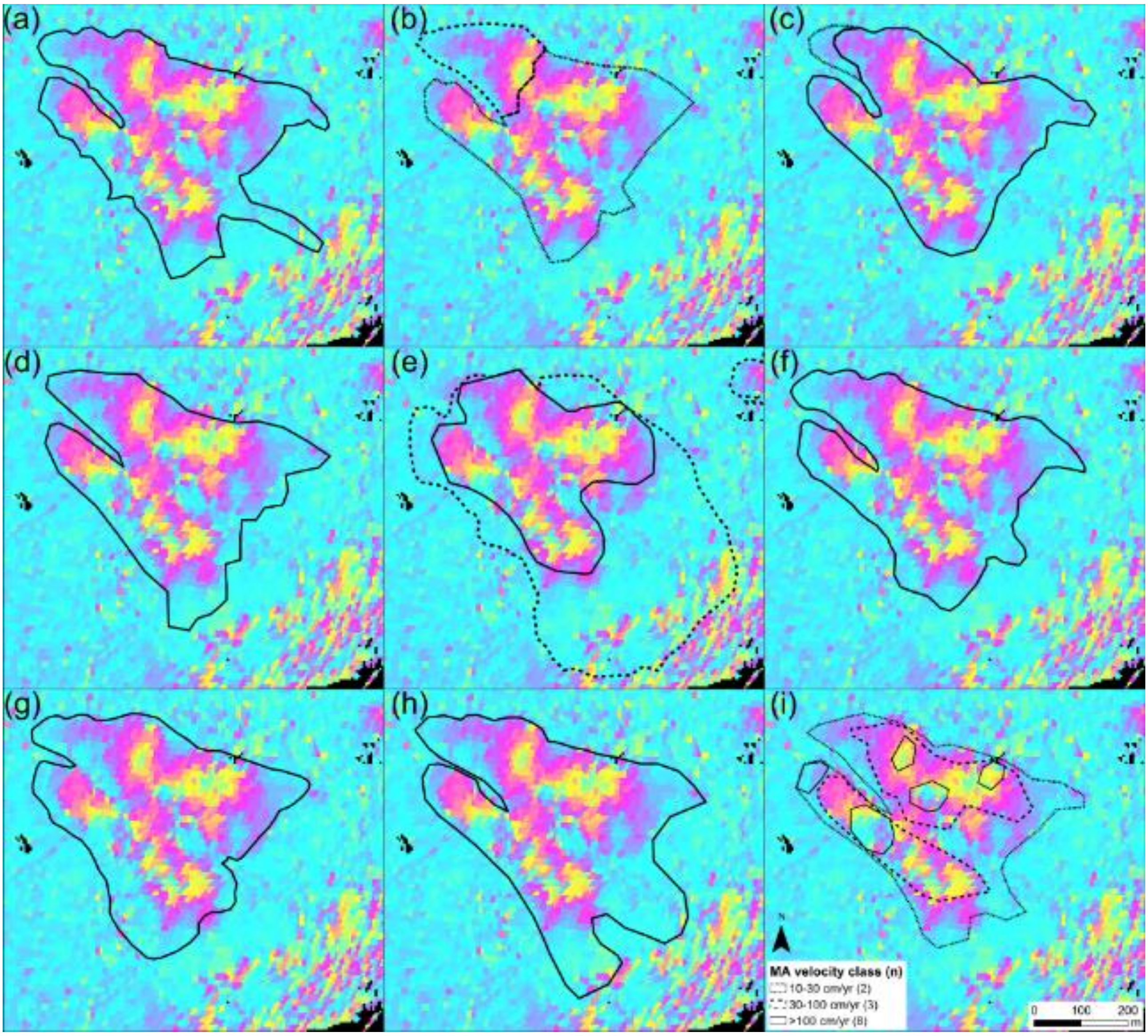


Figure S4. Each panel (a - i) shows the outlines of moving areas (black polygons) drawn by nine operators on a complex case of rock glacier. Sentinel-1 interferogram at 6 days (13/09/2018 – 19/09/2018) as background.

The error assessment of the InSAR derived velocities has been evaluated/discussed by qualitative comparison with DGNSS and feature tracking measurements in the manuscript (L405-410 and 533-541). We observed a good agreement with the assigned kinematic attributes. The validation effort was focused on the assigned kinematic attributes (aim of this work), without paying specific attention to the velocity classes of the moving areas. To clarify this point, we have increased this part by adding sentences in:

Line 406: “*The assigned moving area velocity classes sometimes do not fully cover the velocity ranges recorded by DGNSS measurements (Table 3)*.”

Line 535 “*With reference to the main objective of this work, that is assigning a robust and reproducible kinematic attribute to rock glaciers, our classification resulted being correct in most cases*.”.

Specific comments

L1-3: In what regard are the results presented here preliminary? In L520, 531, L553 preliminary refers to the completeness of inventories, while in the Abstract (L34) preliminary seems to be referring to the InSAR data itself? In the manuscript, this should be clarified to avoid confusion. As for the title, I am unsure if the word preliminary sends the right message here?

Comment accepted. Following the reviewer's suggestion, we have proposed a new title: "*Incorporating InSAR kinematics into rock glacier inventories: Insights from eleven regions worldwide*". We have removed "*preliminary*" on L34. We have replaced "*preliminary*" with "*first*" on L531. We have improved the meaning of the results in the introduction section (as per our reply to the first general comment, the last paragraph of the introduction has been rewritten).

L24: As rock glaciers not only depend on, but contain permafrost, maybe the authors could rephrase their statement here?

Comment accepted. We have modified the sentence: "*Rock glaciers contain permafrost and thus their sensitivity to climate variability and change makes the spatial distribution of these landforms critical for managing water resources and geohazard potential in periglacial areas*."

L36: Does this statement refer to the IPA action group, or to the study presented here?

To address the reviewer's concern, we have clarified this sentence (line 36-38) as also requested by the reviewer #1: "*This is the first internationally coordinated work that incorporates kinematic attributes within rock glacier inventories at a global scale*."

L40-42: I think this should be stated with a bit more precision. Many landforms could be "detected" based on "front, lateral margins, […]". Here, it seems the authors want to say that the landform outlines can be mapped along these features? If this is intended as a list of diagnostic criteria for the identification of rock glaciers, this should be elaborated.

To address the reviewer's concern, we have modified the sentence with "*Rock glaciers are creeping masses of frozen debris in the mountain periglacial landscape. Morphologically, they are characterised by a distinct front, lateral margins, and often by ridge-and-furrow surface topography.".*

L44: might want to cite: Corte A. 1976. The hydrological significance of rock glaciers. Journal of Glaciology 17: 157 – 158.

Comment accepted. We have added the suggested reference.

L52: as this is a long list already, Krainer, K. and Ribis, M. 2012. A rock glacier inventory of the Tyrolean Alps (Austria). Austrian Journal of Earth Sciences, 105, 32-47.

Comment accepted. We have added the suggested reference.

L76-80: Is there a way to elaborate here, why the ESA project solely focused on the inclusion of InSAR approaches into rock glacier inventories?

The inclusion of InSAR approaches into rock glacier inventories is only one part of the ESA project. To address the reviewer's concern, we have modified "*In this context, a part of the ESA Permafrost_CCI project called CCN2 (https://climate.esa.int/en/projects/permafrost/; last access: 10 October 2021) – following the baseline concepts proposed by the IPA Action Group (IPA Action Group - baseline concepts, 2020) – developed specific guidelines (IPA Action Group - kinematic approach, 2020) to systematically integrate kinematic information within rock glacier inventories, exploiting spaceborne interferometric synthetic aperture radar (InSAR) data*.".

L81-83: At this point, but also throughout the manuscript (e.g. L66), it is difficult to discern what the authors did in this study and what the contribution of the IPA action group was. I think the clarity could be greatly enhanced by incorporating a sentence here that illustrates the relation between IPA action group and the author collective.

Comment accepted. As per our reply to the first general comment, the last paragraph of the introduction (lines 81-91) has been rewritten.

L87-89: Not clear what the "irregularities and differences" refer to here

We have strived to address this point. We have rewritten the last paragraph of the introduction (lines 81-91), please see the new text in our reply to the first general comment at the beginning of this document.

L109: I am sure the authors took great care of this, but still it would be good to explain here shortly how snow-free conditions were assured.

Comment accepted. We have rewritten this sentence *"As snow cover is a severe limitation for InSAR (Klees and Massonnet, 1998), only snow-free periods are considered (from July to September and from January to March for Northern and Southern Hemisphere, respectively). Any residual snow periods are identified by exploiting the interferometric evidence on InSAR data (e.g., extended interferometric decorrelation, Touzi et al., 1999)."*

L162-163: Here it is not clear how moving areas are included within inventories. I suggest to shortly elaborate this here.

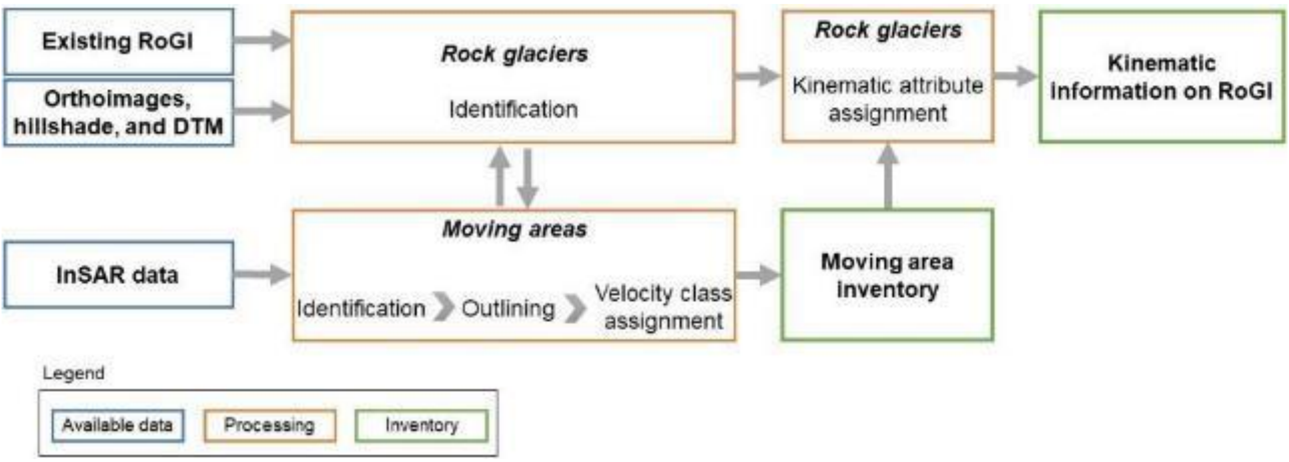
Comment accepted. We have rewritten this sentence "*Moving areas are included within inventories using polygons*".

L176: "[…] we present the standards of moving areas […]" is unclear. I think the authors want to express that below they will describe details on the standard procedure to identify and include moving areas?

Exactly. To address the reviewer's concern, we have rewritten this sentence "*Subsequently in Sect. 3.3 we describe the details of the moving areas and the interferometric methods used to produce the moving area inventories.*"

Figure 2: The authors might want to use boxes of similar size here. Standing in very small boxes, the reader might get the impression that e.g. InSAR and Moving area inventory are subordinate to much larger boxes. Also, the outlines are very thin and differences might be better visible, if these were thicker?

Comment accepted. Below the new figure



L266-267: Please specify "on a significant part of its surface" here.

Comment accepted. We have rewritten *"It is assigned only when spatially representative of the rock glacier, i.e., when the rock glacier is documented by consistent kinematic information on a significant part (i.e., at least half) of its surface*."

L273-275: This seems to be arbitrary. Why should an area closer to the front of the rock glacier be more representative by definition? Is there a technical reason that forecloses the inclusions of multiple moving areas? (see general comments)

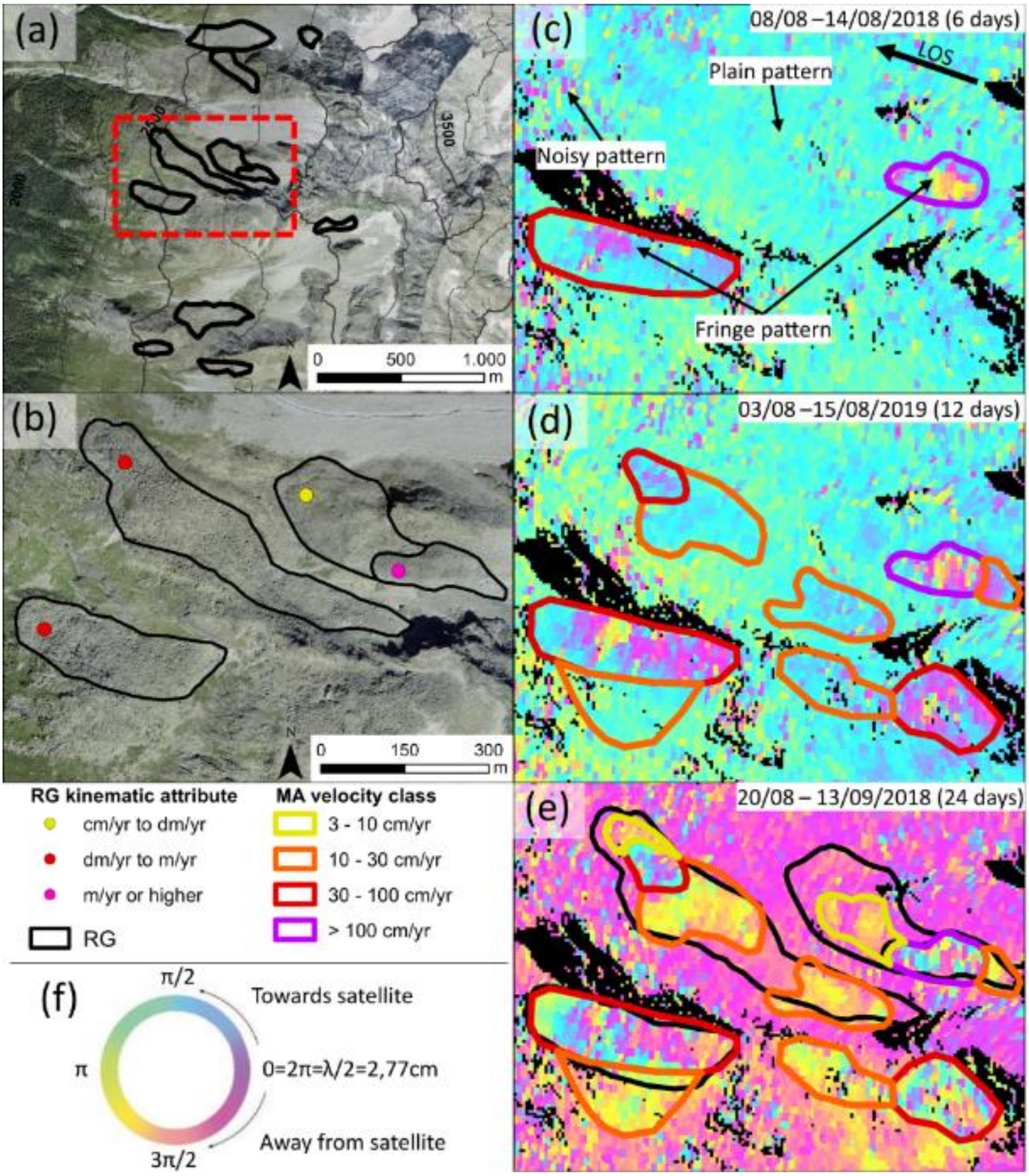
We have strived to address this point. According to Barsch (1996) an area close to the front of the rock glacier can be considered more representative. We have included this clarification in the rewritten text, please see the new sentences in our reply to point 2 of this document (lines 273-275).

L300-301: If there is a specific reason to use a qualitative estimation of the percentage of moving area(s) instead of calculating this precisely, this should be explained here.

We have strived to address this point. A qualitative estimation is conduced when the rock glacier outline is not available from the existing inventory. We have rewritten this sentence: *"Information of the moving area(s) used to assign kinematic attributes is also documented, such as the time characteristics (e.g., observation time window and temporal frame) and the spatial representativeness, i.e., the percentage of moving area(s) surface inside the rock glacier unit compared to the total area of the rock glacier unit (e.g., < 50 %, 50-75 % and > 75 %, also qualitatively estimated if the rock glacier outline is not available from the existing inventory)*."

Figure 4: for consistency, outline the mapped rock glaciers here as well, as has been done in Figure 3?

Comment accepted. We have modified figure 3 as suggested (please see below).



L337: Interesting observation that would deserve to be discussed

This sentence has been discussed in paragraph L449-457. We have modified the sentence L453-456 to better resume this point following the reviewer's suggestion: "*For this reason, (i) the faster moving areas seem to prevail over their counterparts in some regions (Fig. 9a), and (ii) moving areas with velocity class "< 1 cm/yr" are probably not mapped in the Central Andes, Northern Tien Shan, Disko Island, Vanoise, Southern Venosta, and the Swiss Alps regions (Fig. 9a), where the focus is set on the more active landforms.*"

L338-340: While the observation that the number of moving areas exceeds the number of rock glaciers is little surprising, an analysis of the correlation between number of moving areas and rock glacier size would be interesting here.

We fully agree. However, some rock glacier inventories (four) only contain the rock glacier locations (indicated by a point shapefile) and the polygon outline, hence the relevant rock glacier area, is not available

Figure 9, Tables 3 and 4: Essentially, Figure 9 a and b are showing the data provided by the Tables 3 and 4, respectively. I would suggest to move the tables to the supplementary information. If necessary, the in information from the final two columns could be added to Figure 9.

Comment accepted. We have moved table 3 and 4 in supplementary material (Table S3 and S4). Information of "Total region extension" was already included in Table 1. We have included the information of "maximum number of MAs associated with one RG" in figure 8b (please see the new figure in our reply to point 4).

L394-395: State the resolution that would be necessary for the documentation here.

Comment accepted. Following the reviewer's suggestion, we have added "*(greater than 10 m)*"

L424-426: Okay, but using velocity classes instead of precise values is a loss of information on the other hand. I think the authors should discuss the downsides of using velocity classes here as well.

Comment accepted. Following the reviewer's suggestion, we have described the loss of information due to velocity classes in the method. Lines 219-224 have been rewritten, please see the new text in our reply to point 2.

L440: I think the manuscript would benefit from a more detailed appreciation of alternative techniques that would be suited to derive kinematic information that could be included in a rock glacier inventory.

Comment accepted. Following the reviewer's suggestion, we have added some sentences to line 465. Please see the new text in our reply to point 1.

Technical corrections:

L25: hydrology and climate changes reasons? Maybe "hydrological and climate change assessment"?

Comment accepted. We have rewritten with "hydrological and climate change assessment".

L33: These "slope movements" are termed "moving areas" in most of the remaining manuscript. To avoid confusion, I'd like to suggest to stick to either one of these terms

Comment accepted. We have replaced "slope movements" with "moving areas" where necessary to avoid confusion.

L34: This should be analysis (or analyses), also throughout the manuscript (e.g. Lines 59, 88, …)

Comment accepted. We have modified accordingly.

L34-36: Complicated sentence, rephrase.

We have followed the reviewer's suggestion. Accordingly, we have rewritten the sentence: "*The method and the results are analysed, and some drawbacks related to the intrinsic limitations of interferometry and to the lack of rock glaciers without detectable movements in some investigated regions are observed*".

L43: This should be: "can be important for…"

Comment accepted. We have added "*be*".

L57: Maybe: "were produced after the year 2000"

Comment accepted. The text was changed accordingly.

L73: Not clear: "were developed in literature"

To address the reviewer's concern, we have removed "*in literature*" from this sentence.

L81-83: Rephrase, maybe: "[…] and test the inclusion of kinematic information in rock glacier inventories (RoGI) in an international cooperation effort […].?

Comment accepted. This sentence was rewritten (lines 81-91), please see the new text in our reply to the first general comment at the beginning of this document.

L161 and 166: This should be: "consists of"

Comment accepted. We have modified accordingly.

L162: This should be: "moving areas are"

Comment accepted. We have modified accordingly.

L181-182: Maybe: "that includes kinematic information"?

Comment accepted. We have modified accordingly.

L178: This should be: "to a rock glacier unit", right?

Comment accepted. We have modified accordingly.

L221: This should be "In accordance with recent studies […]" or "Following recent studies […]

Comment accepted. We have rewritten "*Following recent studies (e.g., Barboux et al., 2014), the velocity classes, listed in order of increasing velocity, include: […]*".

L300-301: The use of the terms rock glacier unit and rock glacier is confusing here. Is the percentage estimated with respect to the area of the rock glacier unit or rock glacier system here?

To address the reviewer's concern and to avoid confusion, we have added "*unit*".

Tables 3 and 4: Total extent instead of extension?

Comment accepted. We have modified accordingly.

L359: This should be: "investigated in the study regions"

Comment accepted. We have modified accordingly.

L364: This should be: "were not mapped" The authors refer to published inventories here, right?

In this sentence we refer to relict rock glaciers classified in this work. To address the reviewer's concern and to avoid confusion, we have rewritten this sentence: *"Relict rock glaciers (i.e., without detected movements) are classified only in Troms (205; 49 %), Southern Venosta (60; 18 %), Finnmark (32; 56 %), and Western Swiss Alps (19; 3 %), while in the other regions they are not mapped in this work (Fig. 7) for specific motivations.".*

L408-409: I guess kinematics should be plural in this sentence

Comment accepted. We have modified accordingly.

L551: This should be: "numerical modelling of permafrost and mountain landscape dynamics"

Comment accepted. We have modified accordingly.

L552: delete “if at all”

Comment accepted. We have modified accordingly.

L553: “even if still preliminary for some of them”?

Comment accepted. We have removed “*for some of them*”