Reply to reviewer 1

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

Major comments

1) The study describes most steps suggested for compiling rock glacier kinematic inventories, but the scientific (or applied) purpose for such inventories is little discussed. As described now, the inventoring appears more for the sake of inventoring rather than with clear scientific or applied purposes. I strongly suggest to add to the paper scenarios of how rock glacier inventories with kinematic attributes as presented in the study can be used, scientific and applied, and to discuss which applications are feasible in terms of characteristics of such inventories, and which not. For instance, it seems that the use of kinematic classes does not really enable monitoring of rockglacier activity from repeat inventories at the scale of decades. Rock glacier activity will in most cases likely not change so much within decades that a rock glacier shifts its kinematic class. On the same topic: how do the differences between the individual study inventories (e.g. slow movements included in some, not in others) impact on application scenarios. It seems these differences complicate use for geomorphological purposes. Problems seem to exits in particular for the smallest and largest movement rates (> 1m/yr). What impact does it have on application scenarios that it is difficult to quantify the largest movement rates? So, in sum, which application scenarios exist for the suggested kinematic inventories, which are feasible with the current characteristics, which require further refinements of the inventories, which application scenarios seem not possible in the foreseeable future? You summarize "The achieved results open up new possibilities for the understanding and numerical modelling of permafrost, mountain landscape dynamics,... ". But which application exactly become feasible now? An own section in the discussion part of the paper on application potentials and limitations could be dedicated to this topic.

We agree with the reviewer. We have rewritten the last paragraph of the introduction (lines 81-91) to better introduce the purpose of this work. Our changes address reviewer 2's comment too. 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.

Then, as suggested by the reviewer, we have added an additional section to the discussion (call "*Further application scenarios*", line 541) to better explain how rock glacier inventories with kinematic attributes can be used for other applications. This new section, now hosts old text taken from lines 478-484 of the original manuscript. The text of this new section now reads as follows:

"*This method holds potential for gaining new insight on rock glacier dynamics at a global scale. The spatial distribution of rock glaciers is frequently used as proxy for the past or present occurrence of permafrost (Haeberli, 1985; Boeckli et al., 2012; Schmid et al., 2015; Marcer et al., 2017), and the kinematic of these landforms can be used to derive indirect information about permafrost. The methodology proposed in this work promotes the assignment of standardized kinematic attributes to rock glaciers, and therefore fosters the compilation of consistent information on permafrost at a global scale. Possible applications that will benefit from the proposed approach include the calibration of permafrost numerical models (Cremonese et al., 2011; Boeckli et al., 2012; Lilleøren et al., 2013; Schmid et al., 2015; Sattler et al., 2016; Marcer et.al., 2017; Westermann et al., 2017) and artificial intelligence algorithms for assessing rock glacier activity over large areas (Frauenfelder et al., 2008; Boeckli et al., 2012; Kofler et al., 2020; Robson et al., 2020). Furthermore, indirect information on ice content within rock glaciers (Schmid et al., 2015; Marcer et al., 2017) may be used for water storage estimation (Bolch et al., 2009; Jones et al., 2018a).*

The kinematic attributes assigned in this work are not intended for any monitoring purpose. The proposed standardized classes allow reducing subjectivity at the expense of more precise velocities. In most cases, the kinematics of the rock glacier do not change much over the decades and a change in the kinematic class is not likely. Monitoring activities on rock glaciers are conducted using specific and more precise techniques (Delaloye et al., 2013; Fey and Krainer, 2020; Strozzi et al., 2020; Kääb et al., 2021). The approach here described can only support (i) the identification of sites to start monitoring activities and (ii) the large-scale geohazard assessment in order to identify rock glaciers that may be a source of natural hazard (Delaloye et al., 2013; Kummert et al., 2018)."

2) The interpretation of interferograms by an operator to derive kinematic classes seems to be a critical but (as the authors confirm) a partially subjective decision. It would thus be important to show several typical interferogram examples for each velocity class in order to demonstrate that and how velocity classes can be derived. Some expamples could be included in a figure in the main text, but a larger representative collection in the appendix or supplement. This would help others that want to produce similar inventories substantially.

The reviewer asked for more details on how to map and classify moving areas from interferograms. To address the reviewer's concern, we have added two examples (i.e., Figure S1) to the Supplementary material.

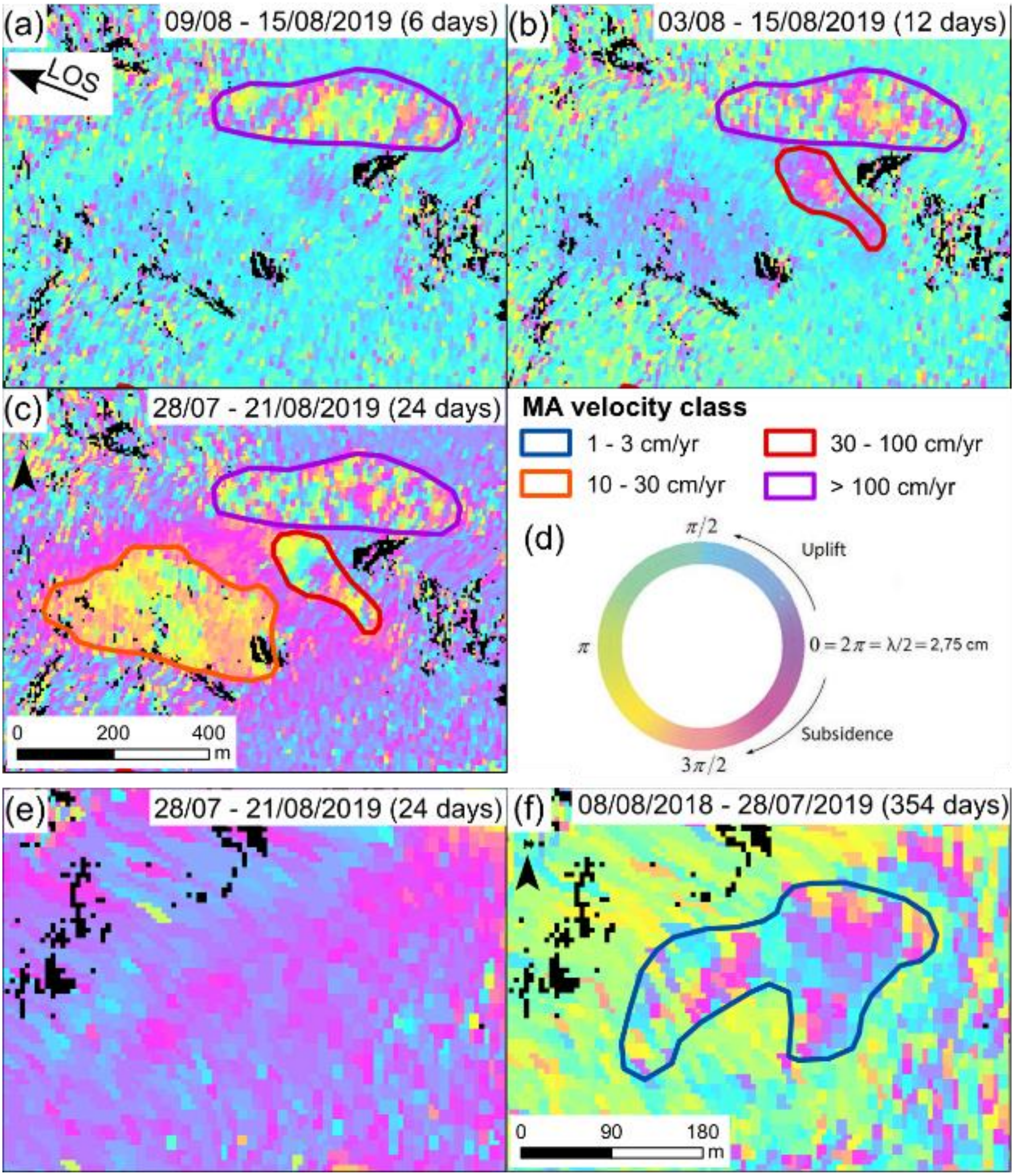

Figure S1. Sentinel-1 interferograms from descending orbit (a, b, c, e and f) and phase cycle (d). In the first example (from a to c) with a 6-day interferogram (a) a fringe pattern with a complete phase cycle (corresponding to 2.75 cm in 6 days, i.e., 167 cm/yr) is outlined and classified as > 100 cm/yr. With a 12-day interferogram (b) the previous fringe pattern become decorrelated, and a new fringe pattern with a half phase cycle (corresponding to 2.75/2 cm in 12 days, i.e., 42 cm/yr) is outlined and classified as 30-100 cm/yr. Observing a 24-day interferogram (c) a complete phase cycle within the previous mapped 30-100 cm/yr moving areas is visible, along with a new fringe pattern with a half phase cycle (corresponding to 2.75/2 cm in 24 days, i.e., 21 cm/yr, 10-30 cm/yr). In the second example (e and f), with a 24-day interferogram (e) a fringe pattern is not detectable, and a half phase cycle becomes visible with a 354-day interferogram (f, corresponding to 2.75/2 cm in 354 days, i.e., 1.5 cm/yr, 1-3 cm/yr).

Minor comments

3) Last sentence of abstract: this is much a repetition from a statement further up in the abstract, but here you say you demonstrate, further up you test. So, do you test or demonstrate? Reduce repetition.

Following the reviewer's suggestion, we have replaced "*test*" with "*demonstrate*" (line 30) and we have modified the last two sentences of the abstract (line 36-38): "*This is the first internationally coordinated work that incorporates kinematic attributes within rock glacier inventories at a global scale.*"

4) Line 121. Did you conduct the aerial photography work (they are not included in the paper!), or are they taken from the papers cited? Please clarify.

Comment accepted. We have replaced "*conducted*" with "*available*" in line 121.

5) Line 201. Villarroel et al. 2018 give also a nice overview what rock glacier movements can be measured using Sentinel-1 interferometry, which not.

Comment accepted. Villarroel et al. 2018 was added in line 201 of the revised manuscript.

6) Line 551. To me it seems that not the proposed inventorying itself opens new possibilities. It is rather radar interferometry that opens these possibilities. Your kinematic inventoring method is mainly an application of radar interferometry, right?

We do not fully agree with the reviewer. It is not InSAR per se that opens up new possibilities, considering that this technology has been around for some decades. Rather, we believe it is the standardized procedure applied in this paper, considering the promising preliminary results presented, which offers new opportunities. To address the reviewer's concern and clarify the meaning of this sentence, we have rewritten the text as follows: "*The promising results derived from the application of the InSAR-based standardized procedure open up new possibilities for understanding rock glacier dynamics and sensitivity potential of permafrost degradation to climate change. Currently, these tasks are mainly based on detailed measurements of a limited number of landforms*.".