Earth Surface Dynamics Discussions

Earth Surf. Dynam. Discuss., referee comment RC1
https://doi.org/10.5194/esurf-2021-8-RC1, 2021

Comment on esurf-2021-8

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Referee comment on "Kinematics and geomorphological changes of a destabilising rock glacier captured from close-range sensing techniques (Tsarmine rock glacier, Western Swiss Alps)" by Sebastián Vivero et al., Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-8-RC1, 2021

Dear authors,

Your manuscript entitled 'Validation and application of sequential unmanned aerial vehicle surveys to monitor the kinematics of a rapid rock glacier' intends to show the added value of using UAVs and Structure-from-Motion-based photogrammetry for the quantification of rock glacier dynamics. The study is based on the comparison and analyses of photogrammetrically processed images acquired in the period 2016 to 2019. The manuscript aims at proposing technology-immanent benefits of using UAVs for rock glacier monitoring. As the main outcome, kinematic and volumetric changes and its variations and characteristics are presented.

Due to the general arguments and some detailed comments, I think that the manuscript needs amendment, please see my remarks as follows. In addition, even though I am not a native English speaker, I think the text is basically well-prepared and requires minor proof-reading only.

According to the manuscript's title and presentation, the main aim of your contribution is to introduce UAVs in rock glacier monitoring and to propose SfM-photogrammetric UAV surveys as favorable approach compared to established techniques. This assumption is a

central issue because even though UAVs are not as long in use as other methods and devices, today, UAVs are already established in geosciences. Therefore, research based on UAVs should either focus on methodological questions, which is not case in your study, or otherwise should in detail discuss and explain geomorphological changes, which rather should be the aim of your manuscript. Therefore, I think it is necessary to revise the title and presentation of the manuscript. In addition, as there are other previous studies, please expand the relating literature discussing UAV-based surveys on rock glaciers. Also, the discussion on relating studies as in the present form needs revisions, please see my detailed comments concerning P12L362-376.

In terms of validation of the UAV-based results, geodetic measurements are shown in order to independently assess the quality. However, the way of how the UAV survey-related design and the relating provided information are presented does not allow to completely comprehend the methodological benefits. Several details concerning the survey design, such as the planned and actual flight paths and coverages, the estimated theoretical precision compared to actual achieved precision, the details of processing including, e.g., the quality of tie points on the image plain, as well as a dimensionless theoretical assessment of the achieved quality are just some but relevant information that would help to promote UAV-based surveys, which is not the case in the current form of the manuscript. I think that such a methodological discussion and information is the prerequisite for a technology-featuring presentation of the manuscript. In contrast, the manuscript appears as a well designed and presented case study of a rock glacier's kinematics but does not introduce new methodological approaches and therefore, should focus on the characteristics and specifics of the landform investigated. In this sense, it appears rather inappropriate to contend that UAVs are a new method for rock glacier monitoring as this is not the case.

Concerning the survey design it would be necessary to first define what is required in terms of survey quality and the landform investigated in order to then conclude whether it was appropriate or not. Instead, the manuscript is characterized by a rather vague survey concept in order to subsequently conclude that the results are quite appropriate. In other words, at first it should be declared what survey quality is strived and estimated, which would then allow for assessing whether or whether not the results are appropriate.

The description of the processing needs revision. Without presenting and discussing photogrammetrically relevant parameters, such as exterior and interior orientation parameters, the quality of tie points and residuals of GCPs, photogrammetric studies are not comprehensible and meaningful. Therefore, the robust and detailed workflow that is

stressed by the authors lacks these important components, which I think needs to be amended and the formulation revised. In addition, today, numerous articles are based on SfM-MVS photogrammetry. I suggest to expand and discuss the relevant literature in more detail, as there is no ample discussion and interrelationship with existing subject-specific literature yet.

Other methodological questions could deal with potential issues using the RTK-based survey configuration, e.g., are UAV-based surveys solely using direct georeferencing really capable of achieving the required quality? This could be worth discussing.

The presentation of the rock glacier's velocities based on an area-based matching algorithm needs revisions. The validation of the velocity values should be expanded and the description revised, as the matching settings (grid size, correlation window size) are necessarily adjusted to the specific case and pair of images, e.g., the approx. 13 m large windows should be able to track 13 m long displacements (cf. P8L227). As a consequence, this results in high correlation values (R^2 values presented in Section 4.1) and therefore, such a comparison of geodetically and NCC-derived velocities inherently cannot be completely independent. And this at least should be mentioned. Similarly, the presentation of the movement's directional quality (Section 4.2) could be more comprehensible by explicitly mentioning that the directions were smoothed, as a directional filter was applied (Section 3.3).

The surface velocity fields should be revised, as thus far, categories of different velocities are presented and instead, vectors that show the exact displacement value should be presented, which also would allow for including and presenting the displacement vector-specific LoD value. As mentioned in Section 3.3 (P9L251), it would be a real benefit for the reader if these vector-specific LoDs would be shown in maps.

Detailed comments:

P1L10-11: As the survey configuration details are not completely outlined, it is not tenable to contend that a rigorous procedure is introduced.

P1L20-21: As the comparison with GNSS-based measurements is mentioned here and the description of the rock glacier dynamics, the main research contribution is the investigation of the specific rock glacier's dynamics and behavior rather than methodological questions.

P2L36-48: What about rock glacier kinematic surveys beyond the European Alps?

P2L52-53: Style – "[…], evidence of […] identified as evident signs […]".

P2L61: Style – "The quantification […] has been measured […]".

P3L72: "[…] Unmanned Aerial Vehicles (UAV) systems […]". Plural ending not correct, please check throughout the manuscript.

P3L79-80: Expand the list of published studies dealing with UAV-based rock glacier surveys. As there are already studies demonstrating the benefits and challenges of UAV-based rock glacier surveys and as generally, the landform rock glacier does not entail a specific methodological treatment compared to other landforms and as SfM photogrammetric UAV-based surveys are today already established, this cannot be the research question.

P3L81: Yes, but both a protocol and relevant details of the UAV-related configuration and processing are not discussed in this manuscript and therefore, this should not be mentioned and understood as the research question.

P3L82: It is meant "[…] high altitude […]", please clarify.

P3L84-85: General statement that I do not support. One could also argue, as the surface velocities are in a hardly observable cm-range, a thorough validation is necessary. Therefore, no, different rock glacier velocities are not an argument.

P3L86: So far it was not mentioned in the manuscript that the quality of kinematic data is an issue, so, maybe it should be clarified at first that kinematic measurements are of

diverse quality, which is why a thorough validation is necessary.

P3L92-93: This is the formulation of the study's aims, which are a better understanding of the rock glacier behavior and dynamics. Therefore, your study contributes to rock glacier monitoring rather than the technique or methodological questions and therefore, the presentation should not focus on UAVs for the simple reason that these are maybe not that commonly used on rock glaciers yet, which is, if indeed, possibly coherent with the number of rock glacier studies.

P4L111: "[…] 2016. the []".

P4L114: Please clarify, that this specific landform "Tsarmine" was meant.

P5L427: As it is a specific number of points (58), it cannot be "around".

P5L132: I would say that 2 cm are also in the cm range, please clarify.

P5L141: Table 2 is mentioned before Table 1, modify.

P5L152: Add the focal length's unit.

P5L154: Do you really mean "accuracy" of the RTK-based camera positions, as I cannot see the relationship to other, independent measurements, please clarify.

P5L155: Explicitly mention that the low accuracy is too low in terms of the study-relating aims, because low accuracy per se could still suffice.

P5L155-156: Please expand with a few words the tests mentioned in order to make the statement more comprehensible. In addition, with "mainly" you mean "mostly"?

P6L160-161: As you describe the planned image overlap of your survey, a citation does not make sense; delete the reference or clarify.

P7L198: It should be "[…] GCPs next to the […]" or similar.

P7L203: In order to discuss the quality of the bundle adjustment it is necessary to present and discuss the data of exterior and interior orientation parameters and the quality of the tie points.

P7L210: Check plural ending and indefinite article. Also, mention for clarity that the orthomosaics were resampled to 0.01 m, as the GSDs differed (cf. Table 1).

P7L213: Mention the subsections number instead of "previous step", as this would be clearer.

P7L21-216: As you describe the principle, it does not make sense to relate to rock glaciers; the principle is valid for every surface surveyed.

P7L217: With "extensive" it is meant "larger", which is more applicable, I think.

P8L237: Please check with the journal requirements whether or not the citation ("their Fig 2") is appropriate.

P8L240: As it is a specific number of points (69), it cannot be "around". Also, show the 69 subareas in the map.

P9L255: As it is a specific number of points (35), it cannot be "ca.". Moreover, I cannot find the relating results of the mentioned comparison. In addition, show the spatial distribution of these 35 points in a map, as this is not the case yet.

P9L272: For understanding: these are the same 35 points mentioned in Section 3.4 (here used as independent *z* check points)?

P9L274: Is the term 'significant' in the sense of statistically significant appropriate here?

P11L335-337: Agree, but why are then the relating details of acquisition, processing and analysis not presented yet?

P11L337-339: Disagree, the inability of potentially new UAV-users cannot be anticipated, which is also attenuated by the high degree of automatization and usability of modern UAVs. Also, the depreciation of commercial UAV flight providers is not comprehensible as the necessary information needs to be negotiated and should be part of the contract, which is why commercial UAV survey providers of course could deliver the required data and metadata.

P11L342: This discussion could be more controversial as 30 minutes could be the net flight time, but usually the setup and pre-flight checks also need time as well as accompanying geodetic measurements and moreover, UAV flights are more weather-dependent (so probably it is necessary to wait for optimum conditions), which is why usually a UAV survey takes remarkably more time than 30 minutes.

P12L344: The different LoD values resulting from NCC and GNSS are not completely shown yet, only partially in Table 3.

P12L352: Elaborate, what are the "[…] suitable environmental conditions […]"? In addition, what is the point of " […] that means about four months a year […]"? Usually, also geodetic surveys (except permanent measurements of a single point) are conducted in the snow-free season, so this is not specific for UAV surveys.

P12L350-356: This is a rather general discussion and the relating pros and cons were not investigated in the study.

P12L360-361: As it is obviously necessary to make SfM photogrammetric studies more comprehensible using protocols and standards, consequently, why don't you present and discuss the complete survey details including planning, theoretical and actual quality estimates, processing settings etc.?

P12L362-376: This is a repetition of how (only) some others (i.e. not all relating studies) performed UAV-based studies on rock glaciers and as the text passage stresses you performed something what others did not, the character of this text passage is rather contemptuous. Therefore, I suggest to revise or exclude this text passage.

P12L373: Disagree, it cannot be concluded that companies are not willing to deliver what is necessary, it is rather necessary to adequately negotiate a contract by those interested in processing the data.

P12L374: The term “intrinsic” is distracting, as interior orientation parameters could be meant with this but which are not presented in Table 2 or elsewhere in the manuscript.

P12L375: To perform all working steps by oneself is not a guarantee for high-quality results. I fail to see any argument and therefore suggest to revise or exclude this paragraph.

P13L395: Add “[…] Tsarmine rock glacier […]” for clarity.

P14L411-412: Not the kinematic points but their velocities are shown.

P14L432: Which proposed uncertainty analysis you are relating to here? I cannot find relating data.

P14L434: Disagree, there are no details presented concerning the customized data acquisition and robustness of processing.

P14L434-440: As UAV-based SfM-photogrammetric studies are already established and as the landform of rock glaciers does not entail any specific methodological adaptations, I fail to understand what is concluded in this text passage and therefore suggest revision.

P15L449: Disagree, the current form of the manuscript does not show all details relevant in SfM-photogrammetric studies.

P18L564: The list of references needs revision, e.g., the publication in P18L564, which is not mentioned in the text yet.

Figure 4: In the legend: shouldn’t the category be “1-LoD” instead of “LoD-1”? As already mentioned, I think it would be favorable to show real vectors instead of categories, which would then also allow to show the displacement-specific LoD values.

Figure 6: The hillshade could be more low-contrast or so, which would then probably

better allow to perceive the lines.

Figure 7: The categories of elevation differences are partially overlapping and therefore, seem to be wrong, e.g., categories "-4.50 to -3.70" m and "-3.80 to -3.00" m etc.

Table 1: This table could be expanded with values of theoretically achievable precision estimates, which are survey configuration-specific.

Table 2: Expand the table by showing both, the RMSEs of GCPs and CPs on the modelled surface as well as the image plane.

Table 3: Mention the relating confidence interval.

I hope you will find my comments appropriate,

Gernot Seier