

Dear Mr Schlögl,

Thank you for the positive re-assessment of our manuscript and for the two additional comments. We have addressed both points and reply to each in detail below. In the following, the comments are reproduced and addressed. Our comments and edits are given in orange. An updated version of the manuscript accompanies this response, with all changes marked. We hope the revisions meet your expectations.

With best regards,

Alexander Maschler & Co-Authors

(1) Title: I suggest a slight further modification to avoid the term "alpine" in the title, which could overstate the geographical scope ("Alpine" as in the Alps) or create ambiguity ("alpine" as an altitudinal zone). Maybe consider "mountainous terrain" or "high-mountain environments" instead?

Thank you for the suggestion! We agree that alpine can overstate the geographical scope and have changed it to "...mountainous terrain"

(2) Limitations: Please expand the limitations section slightly to reflect 2.1 weather and illumination constraints (as noted in section 5.1) and their impacts on data acquisition and processing

Thank you for the comment. We moved a part of the discussion from 5.1 to 5.2 and created the new subsection 5.2.1 Weather and illumination challenges

2.2 the dependence on proprietary tools (Skylens) during crisis response and the implications this has for scalability and reproducibility. You may also wish to briefly note the context-dependence of regulatory approvals and the associated transferability limits.

Thank you for the suggestions. We clarified the dependence on proprietary tools such as Skylens in section 5.4, lines 549-551 and 555-565. We also clarified context dependence of regulatory approvals in lines 520-525 and specifically for the Blatten case in lines 565-570.

Author's response to Ref.1

We sincerely thank Alexander Raphael Groos for the careful re-assessment of our manuscript and for the constructive feedback provided. The comments have allowed us to clarify and improve the manuscript considerably. We address each point in turn below; our comments and edits are given in orange.

With best regards,

Alexander Maschler & Co-Authors

Report 1

Terminology

I appreciate that the introduction now includes a paragraph clarifying the terminology and that the choice of the term “automated dock-based UAV systems” is convincingly justified. However, I noticed that the adjective “manual” (e.g., “manual UAV missions/surveys”), which is used several times for comparison with dock-based UAV operations, may be ambiguous. Campaign-based UAV surveys can also be highly automated after mission initiation by a remote pilot and are therefore not necessarily “manual” in the sense of manually piloting the UAV. In most cases, I assume the authors refer to VLOS missions requiring the on-site presence of a remote pilot. Terms such as “UAV missions/surveys with on-site pilot presence” (or a similar formulation) would therefore provide a more precise comparison.

Thank you for the comment. We followed your suggestion and replaced the term “manual UAV survey” with “survey with on-site pilot presence”

Dock-based UAV system in operation

An overview figure showing the UAV dock in operation at the three different study sites could help readers better understand the environmental settings under which the missions were conducted. It may also be useful to indicate the dock locations in Figs. 1-3.

Thank you for the suggestion. We now include an overview figure of the dock in operation in figure 4. We reorganized the figure to improve the readability. The location of the dock was changed throughout the test campaigns; we have therefore decided not to add the different dock locations in Figs. 1-3.

Geohazard context of Supphellebreen

From my perspective, the observations of the Supphellebreen icefall are still not sufficiently embedded within a natural hazard context. The manuscript mentions a GLOF at Supphellebreen in 2004, but it remains unclear whether this event was triggered by a large calving event (e.g., serac collapse), assuming the triggering mechanism is known. In Fig. 1a, a lake is indicated. Is this the lake associated with the 2004 GLOF? If not, is it considered a potential natural hazard? Otherwise, the motivation for selecting this study site could perhaps be framed differently. For example, it could be presented as a testbed

for detecting velocity changes in steep or hanging glaciers that may precede failure events or partial glacier collapse.

Thank you for the suggestion. The lake in Fig. 1a is associated with the GLOF. Unusually warm temperatures and rainfall during spring caused the lake level to significantly increase, until the terminal moraine, which dams the lake, breached, causing the GLOF (see Breien et al., 2008 for a detailed analysis of the event chain). The typical subglacial drainage system was not established yet at that time of the year. Calving or serac collapses did not contribute to the GLOF 2004. We improved the motivation for the study site selection. (line 144-158).

Copyright statement in Figures 1-3

The copyright symbol is probably unnecessary. I assume it is sufficient to simply state the data provider.

We removed the copyright symbols and state only the data provider

Specific comments

- Line 17: “hazard scenario” → still not entirely clear for Supphellebreen (a fast-moving glacier is not, per se, a natural hazard)

We have clarified the specific hazard scenario for Supphellebreen in Section 2.1 (lines 146–158).

- Line 31: “glacier hazards” → “glacier-related hazards”? -> we agree and have made the change accordingly

- Line 73: “geohazard environment” → “geohazard setting”? -> we agree and have made the change accordingly

- Line 83: “Across the three test sites” → “Across the three complementary study sites” -> we agree and have made the change as suggested

- Line 94: “Test sites” sounds rather technical; I would suggest “study sites” -> we agree and have changed the term to “Study sites”

- Line 116: The central research question and the site-specific research questions should appear at the end of the Introduction, rather than here

Thank you for the comment. We moved the research questions to the introduction (line 81-90).

- Line 128: “Its lower part” → this is imprecise. The regenerated glacier is a separate ice body and not part of Supphellebreen

We agree and clarified this issue in the text (line 132).

- Line 140: If known, please mention here what triggered the GLOF (see general comment above)

We have added a couple of sentences explaining the cause of the GLOF (line 144-150).

- Line 143: How does the 2022 flood and debris-flow event relate to your monitoring setup and observations? Is it intended as an example of the potential impact of a larger GLOF? Caption Fig. 1: The lake is mentioned here, but its relevance remains unclear. Is this the lake associated with the 2004 GLOF? Is it moraine- or ice-dammed? Is it stable, or has it formed recently? Does it pose a hazard?

We mention both the 2004 and 2022 event and shortly their impacts as requested in the previous revision round. The lake is associated with the 2004 GLOF, and we clarify that it is moraine-dammed. However, the lake is not the main focus of the study and we clarified that Supphellebreen is a good testbed due to steep terrain and highly dynamic glacier behavior.

- Line 154: rock “towers” → pillars or rock towers (quotation marks unnecessary)

We agree and have removed the quotation marks.

- Line 161: “currently under investigation” → in what sense, and by whom?

We clarified this (...under investigation for research purposes). By us and other researchers

- Fig. 4: Since the details in the photographs and figures on the right-hand side are difficult to discern, I would suggest removing them. In addition, “M3C2 distance change” is not explained in the text before this figure appears, so it should either be briefly explained in the caption or introduced earlier in the text.

We reorganised Fig. 4 and removed the photographs as suggested. We now include one larger image that shows the drone dock during the operation as suggested in the previous comment. We also clarified the use for M3C2 in the caption.

- Line 219: Please explain why the flights were conducted during twilight conditions. The rationale currently only appears in the Discussion section.

We added the following in the text (lines...): “... to achieve uniform, diffuse illumination conditions across the glacier surface.”

- Line 225: Flights up to 3000 m a.s.l. are mentioned, whereas Table 2 lists a mean altitude of 150 m a.g.l. What was the purpose of the flights up to 3000 m a.s.l.? I assume they were not related to the mapping of the area shown in Fig. 7.

Flights up to 3.000 m asl where conducted, at a mean altitude of 150 m above the ground level. However, the main area of interest for monitoring and also our analysis was the mapping area shown in Fig. 7 (deposits).

- Line 252: “openDroneMap” → “OpenDroneMap” ‘

We agree and have made the suggested change accordingly.

- Line 332: “conventional UAV surveys would not have been possible...” → “UAV surveys requiring an operator on site would not have been possible...”

We agree and have made the change as suggested.

- Line 540: “5.3” → should be “5.4”

This is correct. Thanks for pointing this out!