

Dear Dr. Chang-Qing Ke, Dr. David Burgess, and Editors:

Thank you for reviewing our manuscript and providing constructive feedback. We have now revised the manuscript in accordance with the proposed changes. Our final responses to the reviews are below, with the reviewer's text in **gray**, the initial responses in **green**, and the updated responses in **red**. There are also additional changes throughout the manuscript to improve the clarity without changing the meaning or results. We again appreciate your time and insights, which have improved the quality of our manuscript.

Whyjay Zheng (on behalf of the coauthors)

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Reviewer 1 (Chang-Qing Ke)

This manuscript presents the first systematic inventory of active subglacial lakes in the Canadian Arctic based on ArcticDEM data from 2011–2021. The authors identify 37 lakes (35 of which are newly reported) and classify them into three categories, including two new types (terminal and partial subglacial lakes). The study provides quantitative estimates of lake area and volume changes, discusses recharge–drainage cycles, and reveals a significant negative correlation between lake activity and regional glacier mass balance. Overall, the paper delivers novel and valuable contributions to our understanding of subglacial hydrology in a rapidly changing region. Therefore, I recommend a minor revision of the paper.

Thank you very much for your positive and insightful review!

Major Comments

1. The correlation analysis currently compares the annual number of subglacial lake events with the regional total glacier mass balance. While this yields a significant correlation, the choice of metrics may not be the most physically meaningful. Event counts do not capture the volume of water exchanged, and the regional mass balance may not reflect the local conditions of specific lake basins. A more convincing approach would be to compare the cumulative volume change of events ( $\Delta V$ ) with the mass balance or runoff around the lakes?

As stated in the manuscript, the intended goal of this comparison is to understand “whether subglacial lake activities have been influenced by recent ice loss in the Canadian Arctic.” All the existing mass balance estimates for this area have not excluded the mass loss due to subglacial lake activities; it is likely that the volume change due to subglacial events will be highly correlated with the mass balance around the lakes (or the mass balance of the hosting glaciers), making this correlation unconvincing. In addition, Lake #14 has a  $\Delta V$  much larger than that of any other lakes in the inventory. Therefore, a comparison using  $\Delta V$  would be highly skewed by this single lake. We believe that the correlation between two less dependent variables, the number of lake events and the regional mass balance, is a more valid argument to link mass balance and lake activities. (The total volume change during the short-term events every year is typically  $\sim 1\%$  of the mass balance.)

We have added the statements above in Section 4.4:

*“When comparing with the mass balance, we use the number of short-term subglacial events instead of the volume changes associated with these events because of two reasons: (1) All the existing mass balance estimates for this area have not excluded the mass loss due to subglacial lake activities, so the volume change due to subglacial events can already be highly correlated with the mass balance of the hosting glaciers. (2) A comparison using volume change would be highly skewed by Lake #14, which accounts for 63% of the total volume change (Table 1).”*

2. While different regression models and error estimates are applied, potential underdetection of events and biases in water-volume estimates are not sufficiently discussed. I suggest the authors add a brief note in the Discussion or Conclusion to explicitly acknowledge these methodological constraints. In particular, it would be useful to clarify whether the number of DEM acquisitions varies between years, and if so, how this might influence the detection of short-term events and the apparent interannual variability in event counts. A short discussion of this potential bias would strengthen the robustness of the study.

We have added a section (Section 4.5) in the discussion section covering the following aspects:

1. Limits associated with our methodology for identifying the subglacial lakes and assessing the water volumes.
2. Interannual variability in DEM acquisitions and how it impacts the search for the lake events.
3. Potential bias associated with the water volume estimates of the lake events.

Below is the relevant text added to the manuscript:

1. *Our methodology is not capable of detecting subglacial lakes without distinct elevation change signals. Stable lakes are absent from the inventory because they do not affect ice surface elevations through hydrological events. Active lakes with a frequent drainage-recharge cycle might also be overlooked because the resulting elevation changes resemble noise in a linear model.*
2. *The interannual availability of ArcticDEM acquisitions varies. Observations are typically in the spring and summer, and the winter elevations are missing because the DEMs were extracted from optical images, which cannot be captured during the polar night. Thus, the actual timing of the short-term events within a year is uncertain. This can underestimate the associated water volume if the immediate maximum or the minimum elevations before or after the event are missing.*
3. *Our method assumes that at the subglacial lake area, the elevation change observed at the ice surface directly translates to the change of subglacial water volume based on the conservation of glacier ice. This neglects that ice can flow into a surface depression after subglacial water is drained, and vice versa. Therefore, our water volume measurements are again likely to underestimate the true volume of the water movement (Smith et al., 2017).*

4. *The elevation change model is selected manually and does not necessarily represent the true physical progress resulting from the subglacial drainage or recharge. This imposes an additional uncertainty for detecting short-term events and water volume estimates due to model selection. For example, Lake #7 likely started a short-term drainage event in 2021 (Figure 5b), but we are not able to report it with a linear model. It is needed to extend the elevation time series for this case to better fit the potential drainage event with the sigmoid or the Gaussian Process regression model.*

#### Minor Comments

1. A clearer hierarchical structure would improve readability. In particular, separating the Methods, Data, and Results/Discussion sections more explicitly would help the reader follow the workflow and findings more easily.

We have separated the Materials and Methods section into the Data section and the Methods section for clarity. For the Results and Discussion section, we prefer to keep the current structure as it can help us better cross-link the results and our interpretations.

2. The conclusion section restates results but could benefit from one or two sentences highlighting broader scientific implications or future directions, e.g., how satellite missions (ICESat-2, SWOT) might improve detection of similar events.

We added a new section (Section 4.5) which includes a brief discussion on how current and future satellite missions will improve our ability to monitor subglacial lake activities. Below is the relevant text added in the manuscript:

*“Some current and future satellite missions may be used to improve the detection of subglacial lake activities. ICESat-2 will continue to provide precise elevation data every three months along its ground tracks, extending the elevation time series for better modeling. The CryoSat-2 and Surface Water and Ocean Topography (SWOT) satellites can also measure ice surface topography over time at hundred-meter-scale spatial resolution, thus potential data sets to detect active subglacial lakes. The SWOT satellite could also be used to trace other relevant signals, such as increased water outflow at nearby proglacial lakes and streams, as long as they are located within the orbital limit south of 78°N.”*

3. In Figure 2, it would be helpful to indicate the locations corresponding to panels b and d. Currently, only one subglacial lake is shown in the figure; if these panels correspond to a different lake, please clarify this in the caption or text.

Panels B and D are from the same lake shown in Panels A/C, but are sampled from different pixels. Thank you for pointing this out; the data used in Panels B and D should have been identical for better clarity. We have synchronized the data used in both panels and placed a marker in Panel C indicating the sampling point. We have also updated the figure caption for better clarity:

Figure 2. Schematic of the analysis workflow. (a) A map of linear elevation change rate for subglacial lake 18 (Table 1), highlighting signals such as glacier surge and subglacial lake. Dark areas are unglacierized, defined by the RGI 7.0 glacier outlines (RGI 7.0 Consortium, 2023). (b) Example time series of the surface elevation at the subglacial lake site, fitted with a linear model. (c) The elevation data near the lake region are reprocessed using a sigmoid regression model. This map now shows the elevation change during a short-term event ( $dh$ , Equation 4). The green star indicates the location of the example time series used in panels b and d. (d) Same time series as panel b but fitted with a sigmoid model, with the indicated elevation change ( $dh$ ) mapped in panel c. See Sections 3.1-3.2 for more details.

4. In Figure 5, the ICESat-2-aligned ArcticDEM elevations are classified as “good” (purple squares) and “suboptimal” (yellow circles). Could the authors clarify how these categories are defined? Are they based on intrinsic DEM quality, on ICESat2-to-DEM alignment performance, or some other criterion?

They are based on (1) the intrinsic DEM quality, provided as a bitmask raster for each ArcticDEM strip; (2) whether the elevations are flagged by the Elevation Verification from Multiple DEMs (EVMD) algorithm or not. Relevant description can be found in L69-77. We have added the following sentence in the Figure 5 caption: “*Suboptimal elevations are flagged using the EVMD algorithm and the intrinsic ArcticDEM bitmask labels (see Section 2.1).*”

5. Table 1 could be enhanced by indicating which lakes are newly reported to highlight the contribution, or the previous reported lakes can be labelled in Figure 1.

This is a good idea. We have created an additional column named “previous identification” in Table 1 to indicate which lakes are newly found in our study, and which have been reported previously, with corresponding references.

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## Reviewer 2 (David Burgess)

Review of ‘Active subglacial lakes in the Canadian Arctic identified by multi-annual ice elevation changes’. Whyjay et al.

This paper contributes new and valuable information on the existence, location, and multiannual dynamic activity of subglacial lakes across Arctic Canada. To achieve this, the authors have optimized the use of available satellite imagery digital elevation models (DEMS) and lidar data to produce important metrics (area, timing of fill/drain events, magnitude of vertical displacements, and cyclical changes in subglacial lake water volumes) characteristic of the subglacial lakes identified. Results from this work have potential to guide future research towards understanding the response of subglacial lakes to future climate scenarios.

Scientific rigor of throughout this paper however is lacking. This paper exhibits poor writing style, inconsistent formatting, and very poor sentence structure; all of which obfuscate the intended meaning throughout. Many statements are left unsupported by

proper referencing, inconsistencies amongst the figures exist in terms of style and background graphics exist, and figure captions are poorly written – see comments below.

This paper cannot be accepted in its current form.

Thank you for your thorough and honest review. We will improve the overall clarity and paper structure in the revised manuscript to fully address the raised concerns. Please find our response below.

## INTRODUCTION

L4 & 5: provide uncertainties on the measurements of lake area and water volumes

The maximum and minimum values are reported for these quantities in the abstract, which we believe are clearer and easier for readers to quickly get a broad overview of these lakes. Instead, we have added a new section in discussion (Section 4.5) which covers the the limits and uncertainties of the lake area and volumes.

L 6: need reference after "... yearly."

We prefer to avoid adding a reference citation in the abstract by adhering to the suggested abstract guidelines listed on the The Cryosphere website: "*reference citations should not be included in this section, unless urgently required*". After a careful assessment, we decided to remove the statement regarding the mass balance in the Canadian Arctic to address this issue. This will not alter the storyline and the flow of the abstract.

L7: " to the Canadian Arctic".

We have addressed this comment together with the comment below.

L7: The characterization 'nearly exclusive' is an oxymoron needs to be changed.

We have addressed this comment together with the comment below.

L7: Given the numerous subglacial lakes globally identified in Livingstone et al.,(2022), ie. 755, and the fact that a recent study by Gray et al. (2022) examined subglacial lakes that would meet the definitions of 'Type 1 and 2' as defined in this study, confirms that these type of subglacial lakes are not 'exclusive' to the Canadian Arctic.

We agree. We have modified the text to: "We propose a classification system for subglacial lake type ... Types 2 and 3 are newly introduced in this study, there are 11 and 15 lakes classified as these two types, respectively."

L8: indicate coefficient of correlation here.

We have added the correlation coefficient and the associated p-value here.

L8: is glacier loss ‘accelerating’ or just entered a step-wise shift to enhanced mass loss? If accelerating, this should be explained and referenced in the text.

The glacier loss pattern is close to a step-wise shift to enhanced mass loss during the study period (2012-2022), see Figure 7. We have changed the word “accelerated” to “increased” in the abstract.

L13: subglacial hydrological networks can be on the order of hundreds of kilometres long (Ehenfucht et al., 2024)

We have removed the words “*a few kilometers long*” and have added Ehenfucht et al. (2024) as one of the references for this statement.

L 15-16: subglacial lake drainage events have been reported to increase glacier flow by hundredfold in Alaska (Kamb, et al., 1988), and higher for glaciers on Iceland.

Glacier surges indeed involve changes in subglacial hydrological conditions, but none of the past studies have clear evidence that water is released from a persistent subglacial lake during an active phase of a surge. We are conservative about this suggested argument. (No changes are made to the manuscript.)

L 19-20: Stearns, et al., (2008) is one of dozens of papers reporting on the influence of subglacial lake drainage events on glacier dynamics. This alone is not adequate evidence for suggesting subglacial lake drainage as a key mechanism for controlling glacier mass balance.

The statement about the relationship between the lake drainage and the glacier speed change begins at the previous sentence, where three references are cited for the quantitative effects. The sentence labeled here focuses on a further calculation about the quantitative contribution to the glacier mass balance. After a careful examination, we added Bell (2008) as another reference. There are also studies that show unclear relationship (e.g., Smith et al., 2017, which is cited elsewhere in the manuscript), and we decided not to include them for this statement. We are open to any specific suggestions which may be unfortunately missed.

These two relevant sentences have been updated as follows:

*“During subglacial lake drainage events, glacier speed can increase by 5–10%, bringing more ice to the downstream area where surface and frontal ablations are strong (e.g., Stearns et al., 2008; Siegfried et al., 2016; Andersen et al., 2023). This acceleration can translate into a few additional gigatonnes of ice discharge, suggesting that subglacial floodscan act as a controlling factor of glacier mass balance (Bell, 2008; Stearns et al., 2008).”*

L 29: the word ‘however’ is not necessary here.

The statement has been modified as: *“The first global inventory was released in 2022 and contains 773 subglacial lakes (Livingstone et al., 2022), most of which are located in*

*Antarctica (87%) and Greenland (8%).”*

L33. The word ‘partially’ is not adequate. This region is heavily glacierized, particularly across the high Arctic (Arctic Canada North) where glaciers and ice caps cover ~50% of Ellesmere Island, the 10th largest island globally.

We can see there is a disagreement about to what extent is adequate to be called “partially.” To avoid this ambiguity, we have removed the word “partially.”

L 34: Please use the adopted terminology for identifying glaciers and ice caps in the Canadian Arctic, which is ‘Arctic Canada North’ and ‘Arctic Canada South’ (eg. RGI V7.0, Rounce et al., 2023).

We have made 5 changes throughout the manuscript accordingly: “northern Canadian Arctic” to “Arctic Canada North” or “ACN”, and “southern Canadian Arctic” to “Arctic Canada South” or “ACS”.

L 34-36: when referring to the Canadian Arctic as whole, total mass change for this region is to be reported as a whole, ie. ACN + ACS, as it is displayed in Fig 7.

We have modified this sentence as per suggested: *“This region is one of the major contributors to global glacier mass loss at a rate of  $-53.6 \text{ Gt yr}^{-1}$  (2000–2023), which is only preceded by Alaska among all of the global glacier (excluding ice sheets) regions.”*

L 34-36: For which period (s) of time do these reported numbers of mass change apply? This value changes annually.

The data represent the glacier mass change from 2000 to 2023 (Zemp et al., 2025). We have added this information to this sentence; see the response above.

L 37: WRT the sentence ‘The first discovery was a hypersaline lake..’. This sentence needs to be removed as there never was a hypersaline lake discovered on Devon, so it is incorrect to refer to it as such.

We recognize this issue and have modified the sentence to ensure (1) the word “discovery” is not used (since the earlier work inferred the potential existence of the lake instead of discovering it), and (2) emphasize that the claimed subglacial lake was a misidentification according to Killingbeck et al. (2024).

The relevant statements have been updated as follows:

*“... a potential subglacial lake site was identified beneath the Devon Ice Cap in 2018 (Rutishauser et al., 2018), but later work showed that the hypothetical lake did not exist, and it is more likely to be a layer of frozen bedrock beneath the summit of the Ice Cap (Killingbeck et al., 2024, 2025).”*

L 40: The fact that there are 2 subglacial lakes in close proximity of each other is not on its own a justification to suggest that more subglacial lakes across the Canadian arctic **must** exist.

Yes, you are correct. We have removed this statement: “*Considering the proximity of these two lakes, it is very likely that other active subglacial lakes exist in the vast Canadian Arctic.*”

L 45-46. Change ‘...helped identify numerous...’ to ‘...has been used to identify...’

Changed.

L 47: ...*limiting the potential discovery...* ‘It would be worth noting here that the density of satellite coverage increases with latitude for polar orbiting satellites such as cryosat and icesat.

Thank you for the suggestion. We have extended the sentence as “*However, this method requires a satellite swath to pass over the lake area, limiting the potential discovery for kilometer-scaled lakes outside satellite swaths, despite the fact that the track density of satellite coverage increases with latitude for the polar regions.*”

L46L: ‘... *identify numerous subglacial lakes....*’. Where were these lakes ‘discovered?’

We have expanded this sentence by providing specific locations; i.e., “*beneath the Greenland and Antarctica Ice Sheets.*”

#### MATERIALS AND METHODS

L61: Add the remote sensing and RGI data to this intro.

We have splitted the materials and methods section to Data (Section 2) and Methods (Section 3). This update should address this comment.

L71: spell out DBSCAN acronym

We have added the full name of the DBSCAN method.

L81: is visible crevassing not evident over active subglacial lakes? And is crevassing not an ‘obvious change’?

Crevassing is not exclusively linked to a subglacial lake origin. Compared to altimetry data, crevassing as seen in optical images can also be inconsistent over time if heavy snow cover is present.

To further clarify that we do not solely rely on surface crevassing to identify subglacial lakes, this sentence has been changed to “*Surface crevassing may be present at the edge of the area with distinct  $dh/dt$  signals, which are checked using optical satellite image data.*”

L84: ‘... conditions of land cover...’, do you mean glacier ice surfaces?

We mean the land cover at places where we observe the unusual elevation changes. There are three possibilities: glacier surface (glacier surge / subglacial lake), water (ice marginal lakes / calving front / Type 3 subglacial lakes), and unglacierized terrain (new bedrock exposure).

We have modified the relevant text in the manuscript as follows to improve clarity: “*Based on the spatial characteristics of the elevation change signals and the land cover at places where we observe unusual elevation changes,...*”

L 87 : do these features not exhibit crevassing around the grounded margin of the subglacial lake?

Crevassing is present at most (though not always) of the subglacial lake margins. The changes in these crevasse fields before and after an active event, however, are less obvious than the changes in glacierized area, which we use to distinguish the other three categories. We have modified the text to better reflect this idea. (See the response to L81.)

L 88: ‘Satellite images..’ should be written as ‘Optical satellite image data’

This has been modified as per suggested.

L89: are these zones always close together? Or can they also be separated, if so by how far?

We have added the emphasis in the text: “*Two zones must be adjacent to each other to be classified as a glacier surge signal.*”

L94: why is the criteria for new bedrock exposure specifically state to be from ‘2020 onward’?

Choosing this specific year is for convenience in reviewing the optical images. To clarify our strategy, we have changed the sentence to “*dh/dt is more neutral (closer to zero) than the surrounding area, and the new unglacierized surface can be recognized from optical images. We compare the images acquired after 2020 and during 2013-2015 to identify new unglacierized surfaces.*”

L 159: state basic specs for ALOS-2, PALSAR-2, ie. wavelength, perpendicular baseline.

We have added the specs in Table A1 and the baseline information for each pair in Section 2.3.

- L183: Why is it necessary to ‘argue’ that the sub-glacial lakes in the Canadian high Arctic are located in the ablation zone? Shouldn’t this be clear by comparing published elevations of the ELA with elevation of the subglacial lake?

We have updated this paragraph with the comparison between the ELA values from the past literature and the lake elevations.

Actions taken in the manuscript:

1. Table 1 has been updated with an additional column showing the ice surface elevation in 2016 at the lake sites. These elevations are used to compare with the ELA measurements.
2. The relevant text in this paragraph has been updated to: “The WGS84 ellipsoid height of the ice surface above the subglacial lake in 2016 varies from 59 m (Lake 1) to 1239 m (Lake 5; Table 1). We compare these numbers to the equilibrium line altitude (ELA) of the Meighen Ice Cap (~500 m above sea level; Burgess and Danielson, 2022), the ELA of the Agassiz Ice Cap (~1100 m above sea level; Gray et al., 2015), the optical images in the summer (Figures S1–S37, panels b), and a map of the average surface mass balance between 1958 and 2015 (Noël et al., 2018). The comparison shows that all lakes reported in this study are either within the ablation zone or close to the boundary of the accumulation-ablation zone.”

- What is the relevance of the subglacial lakes residing in the ablation zone? Would it be possible for the subglacial lakes to exist above the ELA. Please expand on this.

Our methods can only detect active subglacial lakes. In Greenland Ice Sheet, stable subglacial lakes tend to be located above the ELA (Bowling et al., 2019; Fan et al; 2023). Hence, it would be worthwhile to describe the spatial distributions of the subglacial lakes reported in this study in terms of glacier zones. We have added this statement in the end of the original paragraph in the manuscript: “*Note that our method is unable to detect stable subglacial lakes; in the Greenland Ice Sheet, these lakes tend to be located above the ELA (Bowling et al., 2019; Fan et al., 2023).*”

- Are you referring to the elevation of the ice surface over the subglacial lake, or the elevation of the subglacial lake below the ice?

For L181, we refer to the ice surface elevation. We have modified this to “*ice surface elevation change*”.

- It is recommended that the authors also explore the freely available NASA Operation IceBridge swath thickness data for these analyses. Where overlap exists the OIB data may provide important information on the ice geometry, basal conditions may help explain subglacial lake dynamics and surrounding hydrology.

This is a good idea, and we will explore the OIB data in our follow-up research for these subglacial lakes. (No changes are made to the manuscript.)

L184:

- Using the post-2000 decadal ELA averages from insitu monitoring (Burgess and Danielson, 2022) to identify which glaciological zone the lakes reside in is more realistic than using the 1958-2015 ELA by Noel et al., 2018.

Reference: Burgess DO and Danielson BD (2022) Meighen ice cap: changes in geometry, mass, and climatic response since 1959. Canadian Journal of Earth Sciences, 59, 884–896, ISSN 14803313 (doi: 10.1139/cjes-2021-0126)

We have integrated the ELA values from Burgess and Danielson (2022) to guide our inferences of where the ablation/accumulation zones begin/end. See the response to L183.

L209: change ‘barely show...’ to ‘show minimal surface change..’

We have changed it accordingly.

L219: the subglacial pathway for Lake 14 was clearly revealed by Gray et al., 2024 and should be acknowledged as such.

We have modified the sentence as follows to acknowledge the successful detection by Gray et al.:

*“Nevertheless, Gray et al. (2024b) identified an outflow channel connected to the eastern end of Lake 14 during its quick drainage in 2020–2021. Additionally, our analysis reveals two interconnected lake systems...”*

#### CONCLUSIONS AND OUTLOOK

L 287: ‘account for complete subglacial lakes...’ change to ‘account for complete subglacial lake alone ‘.

Changed.

L: 289:

L: 290: Improper reference. Goeller et al., 2016 deals with Antarctic lakes not Greenland, upon which your comparison with the Canadian Arctic subglacial lakes is based.

Thank you for pointing this out. We have removed this argument regarding Goeller et al. (2016).

L:291: in order to provide any substance to this claim, this statement must be backed up with evidence that the ice cap / ice sheet under discussion has morphological and glaciological characteristics that conform to conditions where subglacial lakes are known to exist.

This comment has been addressed as we plan to remove the associated argument (see response for L290).

L 294: What roles could subglacial lakes play towards ‘... influence the glacier mass balance’? Neither this study or Gray et al., 2024 noted any significant change in ice velocity during subglacial lake outflow events. Please be specific as to how the subglacial lake activity has affected mass balance, and support with references.

Our hypothesis is that these lakes can contribute to ice loss by melting even without a change in ice velocity. However, we agree that this is a new idea to test, and there are no prior studies examining it. Therefore, we addressed this comment by being conservative in the writing. We now state “*these lakes have the potential to influence the glacier mass balance as indicated by the correlation found in this study.*” [This paragraph has been moved to the second last paragraph of Section 4.4.]

L294: ‘..., lake melting...’, do you mean ablation of glacier ice due to contact with subglacial lake water? Please clarify

Yes, it is correct. We have changed “lake melting” to “the ablation of glacier ice due to contact with lake water” to better reflect this idea. [This paragraph has been moved to the second last paragraph of Section 4.4.]

L295: the statement ‘...more hidden ice loss.’ is highly speculative. We don’t know anything about the level of contact between the water and ice, water temperature, water turbulence, ice accretion...

We have removed this statement. [This paragraph has been moved to the second last paragraph of Section 4.4.]

L297-298: Wording of the statement ‘...allowing the retreat and mass loss of the calving front.’ needs to be changed. Calving of lake terminating ice fronts may however be facilitated by the presence of water at the margin.

We have changed the wording as suggested. The sentence has been updated to: “*In addition, calving of lake terminating ice fronts may be facilitated by the presence of water at the margin, resulting in glacier retreat.*” [This paragraph has been moved to the second last paragraph of Section 4.4.]

L293-391: this paragraph reads like an introduction. Generalizations are being made without specific reference to what was observed. Please replace with a concise summary of what was observed, implications and how this work can be improved, including future monitoring strategies.

Thank you for the general comment regarding this last paragraph. We have moved this paragraph to the second last paragraph of Section 4.4 and addressed the other associated comments. We wrote a new concluding paragraph summarizing what we have found regarding new lakes, the significance of this study, and the outlook. The new content is as follows:

*Although these subglacial lakes are small, with only two exceeding 10 km<sup>2</sup>, their hydrological activity has caused substantial changes in the ice surface elevation. Most lakes follow a slow recharge and rapid drainage cycle, with drainage events likely lasting for several months. The drainage of the lake leads to the glacier surface lowering, and in five*

lakes the ice elevation decrease exceeds 100 m. The subglacial lake dynamics do not show a clear influence on glacier flow speed, but a significant correlation between the frequency of short-term hydrological events and the regional glacier mass balance is identified. These findings suggest that enhanced glacier mass loss may trigger subglacial lake activities through increased meltwater supply and altered hydraulic conditions.

The observed total water movement from the short-term drainage events is at the scale of several cubic kilometers (i.e., several gigatonnes assuming water density =  $1000 \text{ kg m}^{-3}$ ), which accounts for ~1–2% of the observed regional mass change (-457 Gt in 2012–2021, Figure 7; Zemp et al., 2025). Nevertheless, with a warming climate, subglacial lakes in the Canadian Arctic may become more active, implying an increased significance for glacier mass balance. Continuous identification and monitoring of these lake activities through field and satellite observations will be essential for accurately understanding their contributions to glacier flow dynamics, frontal retreat, and mass balance.

## FIGURES

### Figure 2.

- This lake (18) should be identified and matched to the mosaic in Fig 3.
- Hatch lines should be more narrowly spaced – they do not clearly define the nonglacierized areas.
- Why are non-glacierized areas depicted differently between figs 2 and 3?
- This sentence ‘A map of the elevation change can be derived...’ does not seem very effective or meaningful...
- ‘ using a selected (?) regression model ...’ which model was used?

Thank you very much for the comments. We have incorporated all of the suggested improvements here for Figure 2. The nonglacierized areas now use the same legend (dark areas) as in Figure 3. The captions has been updated as follows:

*Figure 2. Schematic of the analysis workflow. (a) A map of linear elevation change rate for subglacial lake 18 (Table 1), highlighting signals such as glacier surge and subglacial lake. Dark areas are unglacierized, defined by the RGI 7.0 glacier outlines (RGI 7.0 Consortium, 2023). (b) Example time series of the surface elevation at the subglacial lake site, fitted with a linear model. (c) The elevation data near the lake region are reprocessed using a sigmoid regression model. This map now shows the elevation change during a short-term event ( $dh$ , Equation 4). The green star indicates the location of the example time series used in panels b and d. (d) Same time series as panel b but fitted with a sigmoid model, with the indicated elevation change ( $dh$ ) mapped in panel c. See Sections 3.1-3.2 for more details.*

### Figure 3.

- Usage of ‘ – ’ is inconsistent between legends.

Thank you for spotting this. We have changed the “-5” label in the bottommost legend with “-5”.

Figure 4: Many of the yellow (suboptimal) points appear to align with the valid points used in the analysis. Please explain how these suboptimal points differ from the 'good' points.

They are based on (1) the intrinsic DEM quality, provided as a bitmask raster for each ArcticDEM strip; (2) whether the elevations are flagged by the Elevation Verification from Multiple DEMs (EVM) algorithm or not. A relevant description can be found in L69-77. We have updated the caption with text as follows:

*Purple squares are observations used for the regression model (green curve), and yellow circles are the suboptimal elevations excluded from the regression model. Suboptimal elevations are flagged using the EVM algorithm and the intrinsic ArcticDEM bitmask labels (see Section 2.1).*

Fig. 4

- Polygons outlining Lakes 2 and 3a-c to be at such small scale that it is difficult to see any differences between the 2015 and 2016 Landsat images
- Why do many of the yellow (suboptimal) points that align with the 'good' points?
- Perhaps a different scale should be used for the point quality as the error bars are meaningless for most points.
- Supplementary material for all figs?
- Please state

These lakes did not change their surface appearance much during the event as seen from the optical images. For the first four panels, we have zoomed in on the lake regions so readers can fully explore the details at each lake's scale.

For the suboptimal points that align with the 'good' points, they are flagged by the intrinsic DEM quality, provided as a bitmask raster for each ArcticDEM strip. A relevant description can be found in L69-77. We have updated the caption with text; see the response to the previous comment. We have also removed the error bars from these plots, as they are not the main points here and can be confusing. (The error bars in Figure 5 are still kept.)

Fig. 7

- Spell out 7- axis titles in full.
- X axis titles are unclear due to location of 'year' labels. The labeling should definitely start at the first column. For fig 7 it should start at 2011, as it does in fig 5
- Why do the x-axes for graphs in fig 7 show 2011-2021 but 2011-2022 for fig 5. Should these not match?

We have updated the figure axes (including x-axis label positions and y-axis names) as suggested.

Due to the search strategy, the subglacial events are very likely incomplete between 2021 and 2022. As we use the period 2012-2021 for the correlation analysis, we decided to further exclude the period 2011-2012 from this graph so that the data presented here are consistent with the correlation analysis and the reported p-values. The corresponding text in the figure label has also been updated to: "The records of short-term events in 2011–2012 and

*2021–2022 are excluded for this graph because they may be incomplete due to searching constraints.”*

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