

Authors' Response to Reviews of

Multi-scale variations of hydro-mechanical conditions at the base of the surge-type glacier Kongsvegen, Svalbard

Coline Bouchayer et al.
The Cryosphere,

AR: Author's Response

Dear Coline Bouchayer and co-authors,

Thank you for submitting a revised version of your manuscript. While I find that the referees' comments and concerns have been addressed overall satisfactorily, I have some minor comments that I ask you to address. Therefore, I would like to see a revised version of the manuscript before proceeding with the publication process.

Line numbers below refer to the tracked change version of the manuscript.

Best,

Nanna B. Karlsson

AR: We thank you for the thorough reviews that have helped improve the manuscript. We have revised the manuscript to account for your comments. We have documented our revisions in an attached document that highlights all changes with additions marked in blue and removals crossed out in red. Below, we provide a detailed response to all comments, where our detailed Author Responses are labeled AR and shown in blue font.

Main comments:

Throughout the manuscript, there are some typos, grammatical errors, and spelling mistakes. I have flagged most of them below, but I would encourage the use of either a spell-checker or an AI-assisted grammar checker such as Grammarly.

AR: Dear Nanna B. Karlsson we thank you for taking over the editing of the manuscript and for your careful reading and associated comments, which helped improving the manuscript. We have checked carefully the manuscript and have removed these types of mistakes.

I find the use of "low intensity melt season" and "high intensity melt season" ambiguous. Please clarify in the beginning of the manuscript what is meant by the term "intensity". E.g., is it spatial melt extent, duration of melt season, or melt rates?

AR: We thank the editor to have pointed that out. We have therefore replaced the term intensity by high or low melt rate melt season as this is precisely what we are referring to.

There are several references to Fig. 7c but there is no Fig. 7c.

AR: We have corrected and refer now to Fig. 7b.

Sections 5.1 and 5.2

These sections nicely summaries the theory behind the observed subglacial parameters and the opening paragraphs are easy to follow. However, later in the sections the readability is reduced due to the extensive use of Q,p,S etc. rather than naming the physical process. I suggest rewriting parts of these two sections so that the processes behind the variable names are mentioned much more frequently (if not every time). For example:

'At the same time, the larger R during the decline of Q requires a lower p to drive the flow, resulting in a clockwise hysteresis in the pQ relationship (Preceding class, Fig. 2).'

Could be changed to:

'At the same time, the larger hydraulic radius during the decline of runoff (Q) requires a lower water pressure (p) to drive the flow, resulting in a clockwise hysteresis in the pQ relationship (Preceding class, Fig. 2).'

AR: We have followed the suggestions and we have modified these sections as suggested.

Also, do you mean "decrease in Q"? rather than decline?

AR: We used them as synonyms but we have now replaced all 'decline' by 'decrease' for consistency.

Minor comments:

Lines 5-6: "Additionally, we derive subglacial hydraulic gradient and radius of channelized subglacial drainage system from seismic power, recorded at the glacier surface."

I assume that you are deriving not one radius but the radii of multiple channels in the system?

AR: We have changed the sentences for more precision to : ' Additionally, we derive the median values of subglacial hydraulic gradient and radius of channelized subglacial drainage system from seismic power, recorded at the glacier surface.'

line 83: It would be appropriate to also cite Schoof, C.: The evolution of isolated cavities and hydraulic connection at the glacier bed – Part 1: Steady states and friction laws, *The Cryosphere*, 17, 4797–4815, <https://doi.org/10.5194/tc-17-4797-2023>, 2023.

AR: We have added the suggested citation.

Line 90: Here a reference to more recent drillings into subglacial till could be added. For ample,

M. Lüthi, M. Funk, A. Iken, S. Gogineni, M. Truffer, Mechanisms of fast flow in Jakobshavn Isbræ, West Greenland: Part III. Measurements of ice deformation, temperature and cross-borehole conductivity in boreholes to the bedrock. *J. Glaciol.* 48, 369–385 (2002).

Or

S. H. Doyle, B. Hubbard, P. Christoffersen, T. J. Young, C. Hofstede, M. Bougamont, J. E. Box, A. Hubbard, Physical conditions of fast glacier flow: 1. Measurements from boreholes drilled to the bed of Store Glacier, West Greenland. *Case Rep. Med.* 123, 324–348 (2018).

AR: Doyle et al. 2018 was already cited so we added Luthi et al., 2002.

line 117: Double fjord: ""into Kongsfjorden fjord". Please correct.

AR: We changed 'Kongsfjorden fjord' to only Kongsfjorden.

Caption Fig. 1: Here it says "Kongsvegen glacier" but in the preceding section it is stated "Kongsvegen glacier (hereafter Kongsvegen)". Please be check for consistency.

AR: We have removed 'glacier' as suggested.

Line 152: Word missing: "in the range 10 to 40 cm"

AR: We have changed 'in the range' to 'in between'.

Line 258: "at a multi-day time scales into" -> "at a multi-day time scale into"

AR: We have made the suggested change.

Line 276: Shouldn't this be "Lagging class" and not "in-phase class"? Otherwise, "in-phase" is mentioned twice.

AR: Thank you for pointing out this mistake. We have made the change.

Fig. 3: To make this figure more colourblind-friendly, please reconsider changing the linewidth of one of the

lines in g-h so that lines are more distinct.

AR: We have changed the color of the force and we passed the figure into a colorblind tester to ensure the readability of it for every reader.

Fig 4 caption: "Color scales are scaled..." -> "Colors are scaled..."

AR: We have made the change.

Fig 5: To make this figure more colorblind-friendly, please consider removing the gray background so that the light green classification is easier to distinguish. Alternatively, the light green could be hashed. I would also suggest making the lines thicker. Especially the surface velocity is difficult to see.

AR: We have followed the suggested changes.

Line 365: "During Q important excursions of August 2021..." is there a word missing here? What is meant by "important excursions" - is it the same as "events"?

AR: We have changed the wording for event to avoid confusion.

Line 391: Word missing: "...and also at accounting for some fluctuations around this period."

AR: We did not see any word missing but we have therefore rephrased this sentence to clarify the point: 'In analyzing variations within this band, we aim primarily to capture the diurnal variation (around 24 hours) and to take account of certain fluctuations around this period.'

Line 441: Word missing (?): "As stated above, we expect S to vary in a similarly to p ."

AR: We have corrected to the sentence to: 'As stated above, we expect S to vary similarly to p '.

Line 478: "yielding to" -> "leading to"

AR: We have made the change.

Line 508: Please explain what "hydraulic roughness" is. Alternatively, use a different term since this is the only time that term is used.

AR: We have changed the sentence for a clearer wording: 'the picture is less clear likely due to changes in roughness (e.g., roughness of the ice-walls and/or of the underlying bed) in the subglacial drainage system.'

Lines 514-515: Word missing? "... when the melt begins leading the immediate increase in p "

AR: This sentence was indeed incorrect. We have changed it to: 'We suggest that at the beginning of the melt season, the drainage system is not yet developed leading the immediate increase in p '.

Lines 533-534: Word missing "...if we account for that the 2022 record does not cover..."

AR: We have changed the sentence to: ' $P - Q$ relationship in 2022 shows similar behavior to that in 2021, if we take into account that the 2022 record does not cover the descending branch of Q '.

Line 543: "view of geometric adjustment" What is a geometric adjustment? this term hasn't been used before so please clarify.

AR: We have change the wording for consistency to: 'The *Preceding class* behavior of $p - Q$ on multi-day scales further supports the transient evolution of the subglacial drainage system at this scale.'

Lines 638-641: I would suggest adding 2-5 sentences explaining in a bit more detail what you have measured and which subglacial parameters you derive from the measurements.

AR: We have now added: 'In this study, we adopt a multi-method, multi-scale analysis to examine the processes governing the responses of Kongsvegen, Svalbard to changes in runoff over the 2021 and 2022 melt seasons. Our approach involves measuring basal water pressure and the forces exerted on subglacial sediment at the base of a 350-meter borehole. These measurements are complemented by surface cryoseismology, which, when combined with runoff modeling, enables us to derive subglacial hydraulic pressure and radius. We

then analyze the relationships between these variables across seasonal, multi-day, and diurnal time scales to investigate the complex responses of the subglacial environment to changes in surface melt and precipitation. Here, we synthesize the broad spectrum of relationships between the observed data series in four classes and interpret them in terms of drainage system evolution and till rheology (Fig. 9).'

References: There are two entries for the same manuscript "Rada Giacaman, C. A. and Schoof, C.: Channelized, distributed, and disconnected: spatial structure and temporal evolution of the subglacial drainage under a valley glacier in the Yukon". One is published in TC Discussions the other in TC. Unless there is a reason for referencing the TC Discussions paper, that reference should be removed.

AR: Thank you for pointing that out. We have made the change.