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The Cryosphere Discussions

Interactive comment on "Subglacial permafrost dynamics and erosion inside subglacial channels driven by surface events in Svalbard" *by* Andreas Alexander et al.

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First of all we would like to thank Doug Benn for reviewing our manuscript and provide helpful and constructive feedback, which will certainly help to improve the paper. In the following we present our responses to the referee comments and how we will address these in the revision of the manuscript.

The referee comments are presented in ***bold and italic***, our replies follow immediately thereafter.

General comments

This is a worthwhile paper, that presents novel and useful data on air and ground temperatures within subglacial conduits under a cold-based glacier tongue in Svalbard. The data include good cave maps and very useful temperature series from a number of sites, spanning both warm and cold parts of the year. The paper is very clearly written and structured, and most is ready for publication without revision.

We thank the reviewer for this overall positive judgment of our manuscript.

The only shortcomings with the paper concern how it is placed in the context of previous work, and the significance of the some of the conclusions, which is rather over-stated in the closing paragraph of the Discussion.

We thank the reviewer for pointing out the shortcomings of our manuscript in regards to the literature and will improve the manuscript with the suggestions from Doug Benn, as well as the second anonymous reviewer (see response to RC2). We will further on remove the scrutinized closing paragraph of the discussion part from the manuscript (P19 lines 21-34).

Detailed comments

Page 2, Line 26: high sedimentation rates in polythermal and cold-based glacier catchments. The authors have missed the most important factor concerning the sediment budget of these glaciers: most of the examples cited are either surge-type or were more dynamically active during the Little Ice Age.

We thank the reviewer for pointing out this factor. We have indeed missed it.

The Hodgkins study focused on Finsterwalder-breen (surge-type); in Hallet's global compilation the Svalbard examples are surge-type; Etzelmüller looked at Larsbreen and Longyearbreen, both of which were more dynamically active in

the past (see Sevestre et al., 2015 regarding former dynamics of Longyearbreen).

While we see the reviewers point regarding the Hodgkins and Hallet studies, we still consider Etzelmüllers' study of Larsbreen and Longyearbreen as relevant literature, as Larsbreen is one of the two study sites of this manuscript.

Sollid and Sørbel conducted a palaeo-study and inferred the glacier thermal regime, so this does not provide independent evidence of the link between thermal regime and sediment dynamics. My point is that the high sediment load on Svalbard glaciers mostly relates to past surges, in which sediment can be elevated to high levels by thrusting and other processes. This sediment is then released and reworked by fluvial and gravitational processes during quiescence. Papers by Lovell should be cited in this respect. (e.g. 1: Lovell, H., Fleming, E.J., Benn, D.I., Hubbard,B., Lukas, S. and Naegeli, K., 2015. Former dynamic behaviour of a cold-based valley glacier on Svalbard revealed by basal ice and structural glaciology investigations. Journal of Glaciology, 61(226), pp.309-328. 2: Lovell, H., Benn, D.I., Lukas, S., Otte-sen, D., Luckman, A., Hardiman, M., Barr, I.D., Boston, C.M. and Sevestre, H., 2018.Multiple Late Holocene surges of a High-Arctic tidewater glacier system in Svalbard. Quaternary Science Reviews, 201, pp.162-185. 3: Lovell, H., Fleming, E.J., Benn, D.I.,Hubbard, B., Lukas, S., Rea, B.R., Noormets, R. and Flink, A.E., 2015. Debris entrainment and landform genesis during tidewater glacier surges. Journal of Geophysical Research: Earth Surface, 120(8), pp.1574-1595.).

Lines 28-9: This statement implies that there is a 'missing' process of sediment erosion. This is not the case. Boulton (1972) is a very old source with regard to erosion mechanisms; much more recent and comprehensive sources can be cited, which give more attention to fluvial processes. Additionally, the erosional capability of sub-glacial channels under cold glaciers (and Tellbreen in particular) was flagged up by Naegeli et al. 2014. Dendritic subglacial drainage systems in cold glaciers formed bycutâ ĺĘAËĞRandâ ĺĘAËĞRclosure processes.

Geografiska Annaler: Series A, Physical Geogra-phy, 96(4), pp.591-608.

We will rework the paragraph in discussion (P2, L25-29), remove the reference to Boulton (1972) and instead refer to the literature and the processes nicely explained by Doug Benn in this helpful comment.

Page 4, line 9: Recent work on Tellbreen should be cited here, to provide proper context for the study. Key facts from the following papers should be summarised in a sentence or two at this point in the paper: Origin of the subglacial channels in Tellbreen: Naegeli et al. 2014 (cited above), and in other Svalbard glaciers: Gulley, J.D., Benn, D.I., Müller, D. and Luckman, A., 2009.A cut-and-closure origin for englacial conduits in uncrevassed regions of polythermalglaciers. Journal of Glaciology, 55(189), pp.66-80.Dynamical history of Tellbreen: Lovell, H., Fleming, E.J., Benn, D.I., Hubbard, B.,Lukas, S. and Naegeli, K., 2015. Former dynamic behaviour of a cold-based val-ley glacier on Svalbard revealed by basal ice and structural glaciology investigations. Journal of Glaciology, 61(226), pp.309-328.

We will add a few sentences in the paragraph, describing the study site at Tellbreen, to include information from the two papers mentioned by the referee.

Most of the Discussion is well written, building a set of sound conclusions and inferences from the data. The sections on subglacial channel erosion are especially welcome. This process has been previously inferred from the existence of subglacial channels at Tellbreen (Naegeli et al.), but the present paper adds valuable insights about processes and rates.

We thank the reviewer for this positive feedback.

However, two points in the Discussion need attention: Page 19, line 3-6. It is difficult to see how refreezing of the sediment should cause such a catastrophic drop in sensor temperature. A phase change from liquid to solid in surrounding saturated sediment should result in a temperature increase, not a drop, because

freezing gives up latent heat. This feature of the record almost certainly reflects sensor malfunction.

We thank the reviewer for pointing this out and will remove the sentence regarding refreezing of the sediment as a potential explanation of the temperature drop (P19, L4-5).

Page 19, lines 21-34. From this point on, the Discussion loses its grip on reality and wanders off into wild speculation. Beneath thinning Svalbard glaciers, the thermal trend is from warm to cold-based conditions, as diminishing ice thickness allows conductive losses to the surface to increase during winter. The authors have convincingly shown that this trend can be reversed locally by the presence of channels which advect additional heat to the bed from the surface during the summer months. There is nothing in the data that indicate that these highly localised and seasonal changes could impact the broader hydrological system or dynamics. Indeed, Tellbreen, like the majority of small glaciers in Svalbard, has strongly negative surface mass balance and is in terminal decline. The trends of thinning ice and permafrost aggradation will continue regardless of local seasonal heating around surface-fed conduits. The paper does not need vague speculation about wider 'impact' in order to be relevant - indeed, the paper is weakened by it. Just end the Discussion at line 21.

We will remove the scrutinized discussion section from the manuscript (P19, L21-34) and end the discussion at line 21, as nicely suggested by the referee.

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