Response to Reviewer 1

Wytiahlowsky et al. present an extensive analysis of supraglacial channel characteristics for 285 glaciers within the Calais Canton, Switzerland. They manually delineated channels from high-resolution (0.15 m) orthophotos and use these delineations to perform their analysis which included investigating channel characteristics and its relationship to glacier properties. I found the manuscript to be well written and in general easy to follow, with clear and appropriate methodology to support the results and conclusions presented in the manuscript. While supraglacial channel analysis is not necessarily new, the number of channels and individual glaciers characterized in this study is impressive and allows for the understanding of supraglacial hydrology on a regional scale, which is very exciting for the field of glacial hydrology. The results of this work contribute to furthering the scientific understanding of supraglacial hydrology on alpine glaciers while also acting as a point of comparison for future studies of supraglacial channel formation in other alpine environments. My opinion is that this manuscript is suitable for publication in The Cryosphere. Below I have included some general and specific comments for the authors to review. We thank the reviewer for their constructive and encouraging comments and are delighted that they deem our manuscript suitable for publication. We address each point in turn below, with our responses indicated in blue text.

General Comments

-Figure 1: The manuscript would benefit from a overview of the glaciers within the Valais Canton. Currently, a lot of space is used to show the region that is not the study area. I would suggest to highlight the values area (as in panel a) but within a smaller area, then use a majority of the space to delineate and show all of the glaciers in the region (currently indicated by blue). A full view of all the glaciers in the area would allow the authors to then color-code them as (1) glaciers too small to be considered in this study <1km^2 (maybe white or gray to denote they are being excluded or alternatively leave them out due to the small size if they are not visible at the scale chosen), (2) glaciers without channels, and (3) glaciers with channels. Panel B does a good job in showing the large Alestsch glacier, however the debris cover is hard to see in panel C. This may be an artifact of the low-resolution of background imagery for figure 1 in the version of the manuscript submitted for review (I understand .png are often submitted early whereas .pdfs are instead used in the final version, if this is the case this last point can be ignored and I will assume the debris cover will be more apparent in the final version). Finally, if possible under the space limitations, it would be nice if some of the glaciers referenced in subsequent figures could be indicated in some way within Figure 1. This would make it easier to put specific glaciers into context when they are directly named later on in the manuscript. Amended – We have zoomed into Valais Canton on panel A and have colour coded the glaciers to show those with streams (>0.5 m), those without visible streams, those that are snow covered (omitted), and glaciers <0.1 km^2 (omitted). The imagery source has been updated for panels B and C which has increased the quality of the imagery.

-Figure 4. This is a great figure of the delineated channels, however, it would benefit from the inclusion of insets (or sub panels) that include the entire glacier overlaid elevation contours and annotated with the region with channels shown. By including both a glacier-wide view would help top put the streams into the glacier-wide context which is the focus of this work. Amended – We have added sub panels for each panel that show the location of the main panel on the glacier.

I am curious if glacier aspect has a relationship with channel formation. We have added in a sentence in section 4.3 to note that no relationship exists between aspect and drainage density (Kruskal-Wallis test: p = 0.61).

In referring to the two types of crevasses you see (ones that transport meltwater englacially vs. ones that redirect stream flow). The authors state that the crevasse fills with meltwater and overspills along the crevasse trace. This may be true as is seen in Greenland (e.g., Chudley et al., XXXX) but alternatively, the crevasses may have already advected shut, these old crevasses may then act as a preferential flow path as observed in Fig 8 (I see this frequently in Greenland). I would suggest elaborating on this process in the discussion, as a natural question that would arise would be why is the crevasse not hydrofracturing if it completely full of meltwater. While the answer would be the stress regime in such a case (it would suggest the crevasse is old, having advected into a compressional region). Altogether I feel this process deserves some added clarity within the discussion. Amended – We split the paragraph beginning on line 399 in the original version of the manuscript to enable us to expand on the influence of crevasses on meltwater routing.

Specific Comments

Comments regarding figures:

Fig 1: expand the description of the yellow start to include that it is a weather station. Amended – The legend has been relabelled to 'Weather station' and the station name is given in the methods.

Fig 2: Do the arrows indicate ice flow or water flow or both? Stating this in the caption would help clarify. Amended.

Fig 3: The x-axis labels are hard to see, I think all the font sizes in this figure need to be enlarged. The inclusion of the greater than/less than symbols in the x tick marks clutters the text making it even harder to read. I suggest instead including this information in the legend or using bracket notation. Amended – The font size has been increased, and we have changed the location of the x axis ticks to represent the range shown by each bar. We have clarified where we use equal to/greater than in the figure caption.

Figs 3 and 5: I am confused as to what the different colors represent, are they supposed to correspond to something? All of the different colors when one variable is being plotted is confusing. Particularly because different colors are being used in different figures. Note that this comment is only referring to Fig 3c-f, and Fig 5a,b,e-g. Amended – Plots that only show a single variable are now all the same colour.

Fig 5. Including an annotation to each of the subplots with the results from the spearman's rank analysis would be helpful here. Currently the reader has to go back and forth between figures 5 and 6 to interpret the data presented. The x-axis labels in 5d are very hard to read, I would suggest making these larger. Also, the outliers in panels c and d makes it difficult to see the differences between the box and whisker plots. Maybe consider excluding the outliers or a ρ djusting your subplot size/spacing so that the distribution is more clear, particularly in 4c and 5d. Amended – Spearman's correlation values have been added to Figure 5, and the y axis limit has been modified for the box plots.

Fi 7. This is a great figure, however, most of the the text in this figure is too small to read. Also, consider either making the ela dashed line bold or a different color (or both so it is easier to see). Amended – The text size has been increased, and the ELA line thickness has been doubled.

Fig 8: I would suggest adding arrows to indicate meltwater flow direction. Amended – Arrows have been added that indicate the meltwater flow direction, and this has been added into the caption.

Fig A2: all labels are too small to see. Amended.

Manuscript comments:

L63: Here you site WorldView-3 with a ~3.7m resolution, however, this is the short-wave infrared resolution, WorldView-3 has a 31cm panchromatic and a 1.24 m multispectral. Amended.

L127-137: There is a lot of information and numbers in this paragraph that becomes hard to follow, consider removing unnecessary information or making a figure or a table to accompany this information. Amended – We have edited this paragraph to remove some of the unnecessary detail.

L141-142: Explicitly state the channel width the method was successful on and then the channel size in this study area. Amended – we have added additional clarification.

L143: define the abbreviation NDWI_ice before use. Amended.

144: state that you are referring to multispectral here, WV-2 has a 46cm panchromatic resolution. Amended.

Paragraph starting on L332: Reference specific tables and figures within the appendix rather than the appendix as a whole. Amended.

L354: change "…crevassed area of a glacier, restricting the area" to "…crevassed area of a glacier which restricts the area…". As phrased it is unclear if your last clause is referencing the preceding clause or entirety of the sentence (which would not make sense), so I suggest removing the final clause for clarity. Amended.

L356: the end of this sentence is confusing as written. I suggest rephrasing the sentence to read something like "When crevasses are open they can intercept meltwater and…, crevasses that have closed modify small-scale surface topography and meltwater can be routed along the crevasse trace…" or something like that. Amended.

L357: The term "bottom-heavy hypsometries". Amended – Reworded to "a larger portion of their mass at lower elevations".

L316: I think this should be referencing Figure 5e. Amended.

L317: This figure reference may also be incorrect. Amended – this should read Fig. 4a.

L371: change to "in order for channels to form". Amended.

L381: change "/" to "and", also remove "on" in the phrase "on the runoff hydrograph". Amended.

L390: specify lag time here, a lag between what and what? Melt and peak proglacial discharge? If so, state that here. Amended – this has been changed to reflect that it refers to the lag time between melt and peak proglacial discharge.

L393: comma between large and low. Amended.

L394: Break into two sentences, ending the first at the word “melt”. Amended.

L400: Define lag times here as well. Amended.

L400: Here you refer to “main stem segments”, but earlier in the text you referred to stream order. I suggest being consistent with terminology. Amended.

L451: change “/“ to “or”. Amended.

L465: change “additionally” to “The”. Amended.

L467: do you mean on instead of “and” here? Amended.

L470-1: I am not sure if this is true, most debris-covered research has been done in the Himalaya with some in Alaska (e.g., all work by Doug Benn and many others). Amended – The wording has been edited to emphasise that whilst research on debris-covered glaicers has documented and discussed supraglacial channels, little work has looked at the role of sediment within supraglacial channels.

L496: add “on” before meltwater routing. Amended.

L509: mountain glacier environments have glacier lake outburst floods which could cause abrupt acceleration, I would mention this here even though you do not see them in your area. Alternatively, refer to your specific area rather than “mountain glacier environments” more broadly. Amended.

Response to Reviewer 2

This is an interesting and well put-together study. It presents some interesting insights into supraglacial drainage networks on a large number of Swiss glaciers, which must be one of the first such studies that takes advantage of modern remote sensing/photogrammetric approaches. Supraglacial drainage networks on the Greenland Ice Sheet are a popular focus of research, but such networks on valley glaciers are understudied. I thus welcome the efforts of this paper. I would also like to congratulate the authors on their attention to detail. I think I came across just one typo throughout, and the formatting, presentation, writing style and all other such aspects are top class. I very much appreciate the care taken to ensure this. It makes the job of reviewers much easier, and indeed makes the work far more accessible to a readership. We thank the reviewer for highlighting the value of our manuscript, and we are grateful for their positive comments on its presentation. We appreciate the feedback and address each point in turn below, with our responses indicated in blue text.

Whilst I see value in the paper and welcome the efforts of the authors, I do have some concerns as follows:

1) One of the key issues I have is that I am not 100% certain of the broader aims of the work. The authors very clearly state on lines 91-92 that our 'aim is to characterise the morphometry of supraglacial channels on mountain glaciers, providing insight into where and why they form'. Whilst this is clear, I would like the authors to go further, and say why this matters – why, glaciologically speaking, should we be doing this? Why is it important for us to gain these new insights? I suspect the authors can address this relatively easily, but I would like to see clear statement as to the value of this work. It's worth saying that I think a lot of text that could contribute to such a statement already exists in the Introduction, so it's just a matter of coalescing the key points. Amended – We have added an additional statement of the importance of supraglacial channels, after the aims. In the first paragraph of the introduction we have added in information about the importance of supraglacial channels that route meltwater to the bed, and the implications that has for ice motion.

2) Perhaps my main concerns are about the subjectivity of the mapping of channels, and the assumption that not seeing channels of a certain size means there are no channels. I don't believe this is correct. I believe that the approach is more about resolution rather than presence. I go into some detail in my line-by-line comments below, and indeed the authors themselves actually raise this in the very last sentence of the paper! However, I believe this deserves more attention. Please see my comments below.

Mapping accuracy:

We acknowledge that there is a subjective element to channel delineation and have now tested the accuracy of the mapping by repeat mapping of the Rhone Glacier (Fig. 2a) which contains >100 streams (>0.5 m). We find a difference in drainage density of 2.6% and a 0.21% decrease in total channel length which we deem acceptable for providing a good representation of glacier drainage density, and have added this into section 3.1 in the methods. In addition, we have added an additional figure to the appendix that shows a comparison of our repeat mapping. The primary source of error was found to be determining where to stop mapping up-channel, which we explain in the methods. However, we aimed to take a conservative approach in when to stop making to reduce our chances of overinterpreting channel pathways.

Mapping resolution:

It is outlined throughout the manuscript that we only delineate channels that are around >0.5 m wide as we cannot clearly delineate channels below this resolution. We have amended the manuscript to clearly state 'no visible channels' when referring to glaciers where channels are not identifiable below

our resolution. We have also added our justification for not mapping or quantifying small channel networks, which is simply that we cannot do this reliably enough for each glacier. We could perhaps denote the presence of channels below our mapping resolution for our study area, however it is likely that these dense networks are only visible on large glaciers where there is more surface melt. Hence, we do not do this because it raises the same issue identified by the reviewer about our mapping threshold. Unfortunately, there is no consistent way for us to map the accurate distribution of all channels on every glacier in Valais, but we believe that the most consistent way for us to do this is to choose a clear threshold that we can confidently map above, whilst acknowledging that this may create a bias towards larger glaciers (section 5.1). We too agree that these smaller channels may be important, but they are simply outside of the scope of and data products available for this current paper. Hence, we our focus is on larger channels that carry the bulk of the meltwater.

3) Another key concern is about the timing of the analysis. The imagery for the analysis was gathered in the early part of the summer. Lower altitude glaciers in early summer will have more melt and thus more channels than those at higher altitude. This could be the main or even sole driver of the differences observed in channel density. I believe it is dangerous to use a single snapshot in time, particularly when it is this early in the melt season, to assess overall drainage density. I appreciate that the authors are constrained by data availability, but this is an important point that needs careful consideration.

We agree with the reviewer that imagery obtained at the end of the melt season would be preferable, but we are limited by the fact that the orthophotos were only available in mid-July. We have since quantified snow-cover at different elevations to reinforce the point that there are still sufficiently large snow-free areas in mid-July at all elevations. We find on average that 39.6% of each glacier was snow-free, which is slightly higher (45.0%) where a glacier has a lower mean elevation (2500 – 2800 m.a.s.l), although this is not a particularly large difference compared to the snow free area (39.5%) of the highest mean elevation band (>3700). We agree that glacier mean elevation is one of the main drivers of glacier drainage density (ρ = -0.66, Fig. 6). However, this relationship would be anticipated to be a strong control on drainage density regardless of when the imagery was acquired in July or late August, and our imagery does contain snow-free glacier areas at all elevations. We have now added information into the methods to provide better context on the year of imagery acquisition, and have acknowledged the impact of our imagery acquisition timings in the discussion.

I have a significant number of other comments which I relate to specific locations in the text. These are detailed below.

Line	Issue
13	It seems odd to state that your investigations explore '<2000 supraglacial channels'. This seems rather vague to me. '<2000 could mean anything from 1 to 1999. Can you be a bit more precise? Are you looking at a few tens, a few hundreds or nearly 2000? Amended – We have altered the abstract to reflect the exact number of channels (n = 1890).
13	I must confess to being quite surprised that only 85 of your studied 285 glaciers have supraglacial channels. What time of year did you carry out your investigations, since I think this would be significant. The orthophoto images are from mid-July 2020 which is mentioned in the methods. The 85 glaciers contain channels above our threshold of 0.5 m at this specific time. However,

	we acknowledge that channel networks become more developed at the end of the melt season, but no orthophotos are available at the end of August or early September.
34	You state here that glaciers and ice caps 'are anticipated to contribute to sea level rise throughout the 21st century and beyond'. It would be worth stating that they have indeed already been contributing too. Amended.
90	With reference to my point above, here you mention that you create an inventory of 'almost 2000 supraglacial channels'. This is a much clearer indication of the numbers involved than the <2000 referred to previously. We have modified this to be the exact number, in line with the abstract.
162	I'm pretty astonished by the manual effort that must have gone into mapping these channels. This is an impressive feat, so very well done! However, I have a couple of concerns. Firstly, how did you assess and quantify the accuracy of your manual approach? The channels you indicate as being mapped in Figure 2 are quite clear and relatively straightforward to delineate and map I would imagine. However, I would guess that some of the images you were using were less clear and the channels less well-defined. In such circumstances I suspect there's a degree of uncertainty and error in your mapping. How do you quantify this, and can you put some numbers on this? We have quantified the repeatability of our mapping by repeating the mapping (using the same mapper) for the Rhone Glacier (shown in Figure 2a) which contains >100 channels (>0.5 m), some of which are more complex to delineate. We find a 2.6% difference in the drainage density for the glacier and a 0.21% decrease in total channel length, when comparing our original to our repeat mapping, which is now detailed in section 3.1. We have added a figure in the appendix (Figure A3) that shows a comparison between the original mapping in this study, and the mapping completed as part of the accuracy assessment. This error acknowledges there is some subjectivity involved in mapping the channels, but it is low enough to ensure that the drainage density for each glacier is still a reliable reflection of the drainage network, and glaciers can clearly be grouped into low, medium and high drainage densities (for channels >0.5 m).
Figure 2	Following on from the point above, and particularly relating Figure 2, I am curious about how you determine what to include in your delineation. I can definitely identify several channels in part (a) that you do not choose to delineate in part (b). This causes me concern, since it suggests an (inevitable) degree of subjectivity is integral in this study, and there are clear consequences of this when it comes to considering metrics such as drainage density. Some of the channels not mapped by the authors are only just visible as they are quite fine and thus presumably smaller (in parts (c) and (d) for example, there are numerous very small channels, which would be very hard to map, but are worth being aware of). As a result, there is, I guess, a size- threshold element as to which channels are included. However, to me, there are some channels that I would consider to be of similar size (and clarity) to those which have been delineated but which the authors have chosen not to map. I think this issue is of considerable concern, and needs consideration

	and arguably, more channels need mapping. We agree that there is a degree of subjectivity and human error in the mapping (as quantified above). However, as mentioned in the methods we only map channels that can be clearly delineated at a 1:1000 scale, and whilst some small channels can be seen at this resolution, they cannot be clearly mapped and we focus on streams >0.5 m to prioritize accuracy and because they carry the bulk of the meltwater. We have now modified Figure 2 so that all images are shown at a 1:1000 scale so it is easier to see what is and is not visible at this resolution. We have modified panels a & b to an example that shows more small channels so it is more apparent where small channels exist but haven't been mapped.
218	This concept of the mapping resolution and the fact that you are mapping channels above this threshold, is important. However, in the imagery, it looks to me that there are hazy, grey areas which most likely indicate a dense network of small channels. Whilst you can't map these individually, they are areas of channels and so I wonder if this needs to be considered (particularly in your drainage density calculations). We agree with the reviewer that there are dense areas of very small channels that can be seen below the imagery on many glaciers but are too small to map clearly. Whilst we could identify the number of glaciers these occur on, this would not be a fair comparison between glaciers as it would be harder to define a cut-off resolution and as the reviewer notes, we are likely to only see these dense networks on larger glaciers. Thus, we take a conservative approach by only mapping channels we can clearly identify >0.5 m to avoid additional interpretation and to keep our focus on the larger channels that carry the bulk of the meltwater.
219	As a consequence of the threshold mapping resolution, I am uneasy about this differentiation between glaciers with and without channels. More accurately, those without are simply those without channels above the threshold mapping resolution. It seems likely to me that they do have supraglacial water flowing in channels, but these are in smaller networks that are not easily identifiable as discrete channels. We have added clearer language, i.e., 'glaciers without large channels (> 0.5 m)' when discussing glaciers without visible channels.
221	I am concerned about the observation that all glaciers above 5.6km^2 have channels, and the insights being drawn about bigger glaciers having channels. Could it not be simply that bigger glaciers have bigger channels while smaller glaciers have smaller channels. As a result, we don't see the smaller channels as easily (due to the image resolution), and so are swayed into seeing these as lacking channels? We agree that glacier area likely controls the size of the channels, which may affect drainage density because we only map large channels above our threshold (0.5 m). However, our research reveals that glacier area is not the primary control on drainage density, which is evident by the fairly weak but still significant Spearman's rank correlation (ρ = -0.10) between glacier drainage density and glacier area. This means

	that whilst the size of the glacier probably does affect the amount of channels we detect, there are other factors such as slope and glacier mean elevation that are more important for determining the density of channels.
231	I've said it previously, but I am very concerned about the distinction that is being made between glaciers where channels are/aren't present. It's about resolution and not presence to my mind. If glaciers experience melt, unless all surface water immediately enters the englacial region of a glacier, there must be some surface water and to my mind, this must (at least in part) be in the form of channels. I think the distinction is between the size of the channels and not their presence. I would also argue that given your imagery was gathered in mid-July, it is highly likely that the amount of generated melt is not at its maximum, particularly on glaciers at higher elevation. The impact of altitude could be fundamental, since at this point in the melt season, glaciers at lower elevation may well have much more melt occurring than those at higher elevations. This may thus be the driver of there being more, larger, and denser channels on these lower elevation glaciers. We have strengthened the language surrounding where glaciers do not have large (0.5 m) channels and mentioned why we use the resolution that we do in the methodology but acknowledge that the channels below our mapping resolution are present and may also be important. The imagery acquisition date will affect channel development, and we find that glacier mean elevation affects drainage density (ρ = -0.66) (Figure 6). However, we also find that other factors, e.g., slope, clearly affect drainage density. Hence elevation is not the sole driver of drainage density. It would be expected that elevation is an important control on channel distribution regardless of the date of imagery acquisition, as less melt will occur at higher elevations, resulting in smaller and fewer channels.
255	It is a little odd that some channels disappear 'below the mapping resolution'. I am assuming you mean that they disappear as they head downglacier, since the phraseology of the various ways channels terminate in this passage implies this. However, I would have imagined that as channels flow downslope, they get bigger (as they carry more water) rather than disappearing under the threshold resolution for mapping. Amended - The reviewer is right in that this terminology refers to channels that disappear downglacier, which seems counterintuitive as channels widen downglacier. However, there are many instances where a channel may have terminated in a crevasse or moulin, but the channel terminus location is obscured by debris/snow, or the imagery resolution is not sufficient for identifying the terminus. There are also instances where the channel disappears below the resolution down-channel, which may be because a crevasse has captured some meltwater up-channel, which we cannot pinpoint. In response to this comment, we have added a new sentence in paragraph 2 of section 3.1

	to expand upon our terminus categories.
266	I'm a little uneasy about the statement: 'large channels often occur at the interface between debris-covered and bare ice'. Firstly, what do you mean by 'large'? Do you mean in terms of diameter or length, and what criteria do you use to designate a channel as large? Furthermore, this seems to be quite a significant statement. Like your other metrics, you should quantify this – what proportion occur at such a boundary? Does the statement really hold true, when the channels in Figures 4a, c, d and e do not seem to be controlled by debris presence, and nor do those in Figure 2. We have removed the size descriptive element from this sentence. The statement still holds true, however, as topographic depressions between medial and lateral moraines often capture this meltwater due to streams logically flowing into lower elevation areas. The reviewer notes that this isn't visible in much of Figure 4, but this is simply because not all of these show the described environment. Figure 4b does show a channel on the interface between clean ice and debris cover, and whilst panel 4e doesn't show a channel along this interface, it does show meltwater running off into the depressions between the lateral moraine and the glacier surface, which would likely be channelized if not for the thick debris and undulating topography.
278	In drawing conclusions about the relationship between, for example, sinuosity and slope, I think you need to express some measure of statistical significance so that we know whether these relationships are real. Spearman's rank values have been added to Figure 5, and the caption now specifies that each value displayed on the plots has a significance value of at least $p = <0.05$.
300-306	I am very uneasy about the statements made here. To simply state, for example, that 'a relationship between drainage density and glacier slope exists' needs statistical support. Looking at the graphs is Figure 5 (particularly e, f and g), I do not see a strong relationship, and so to back up your statements, you need to use some statistics to prove your point. Following suggestions from Reviewer 1, we have added in the spearman's rank values to Figure 5. Hence, when citing relationships in Figure 5, there are now statistics to support these relationships which resolves this comment.
308	I am not a statistician at all, so can't offer a lot of insight here. However, you make several statements prior to this point regarding relationships in your data, yet it is only here, towards the end of your results, that you directly address statistical relationships. I wonder if things need reordering slightly. We have now addressed this issue by adding Spearman's rank values (all statistically significant) onto Figure 5 so there is a quantitative measure of the relationships we refer to in section 4.3.

313-314	I come back to my concern raised above, that the relationship between drainage density and glacier altitude. I don't think this is surprising, particularly given the timing of the imagery used to explore drainage density. I feel that this is likely to be the most significant control. There is a relationship between glacier altitude and drainage density as noted by the reviewer (Fig. 6), but this relationship would likely exist regardless of imagery acquisition date because channels would be expected to be more prevalent at elevations characterised by higher surface melt. We are less concerned by the potential over-exaggeration of the impact of glacier elevation because Figure 6 shows that many relationships exist between our metrics and drainage density, and this is not solely dominated by elevation metrics. Hence, despite the date of imagery acquisition it was still possible to establish a range of controls on drainage density. We now acknowledge in the methods that our date of imagery acquisition means that we are unlikely to capture the peak extent of channel distribution and provide further detail on the climatic conditions that precede imagery acquisition. We also acknowledge the impact that our imagery acquisition date has on how extensive channel distribution is in section 5.1.
359-360	Whilst I rather like the schematics you provide in Figure 7, there is a degree of conjecture here, particularly in relation to the proposed hydrographs. I'd like it to be made clearer that these are not measured or calculated at all, but rather assumed. Even then, I am wary of them, since in reality, these hydrographs and their shape are strongly influenced by time of year, air temperatures, ease and speed with which channels are formed, diurnal temperature range etc. Amended – We have added a sentence to the figure caption to clarify that these hydrographs are conceptual and do not reflect measured proglacial stream discharge. In response to the concern about the time of year/air temperatures, we now note that these will change throughout the melt season due to increased subglacial drainage network efficiency.
369-371	Interesting point, but I'd also point out that higher temperatures will mean more melt is generated and thus there's more water available to incise deeply. We discuss this in lines 517 to 519 (in the pre-print version) and we deem this to be a valid point. However, we have now added an additional sentence that follows on from lines 369-371 (pre-print version) to ensure that this point is also included here.
391-393	Need a reference here to support the statement about lake drainage. Amended – an example from Gornergletscher has been included (Huss et al., 2007).
399-400	I am very wary of the statement: 'Our dataset provides new insight into meltwater transport across a large range of glaciers, allowing simple inferences to be made about connectivity and lag times'. Your data is all about channel mapping. Water transport and lag times are assumed based on this knowledge, so I would prefer that this is toned down a little. Amended – this has been toned down.
411	One thing we can't tell is whether the channels you are mapping are currently active. So, it is possible that the crevasse identified in Figure 8 has appeared relatively recently, thus intersecting the channel shown, and halting the flow of water in this

	channel further downglacier. I don't know how likely this is, but it should at least be considered, alongside the proposed idea that the crevasse is water-filled and thus flowing water overtops it. Without fieldwork observation, we are both speculating, so due caution in the interpretation needs to be exercised. The role of crevasses in intercepting and transporting meltwater has been expanded upon in the last paragraph of page 18 in the revised version.
416-417	Similar to the previous comments, I am wary of the statement: 'the delay between surface melt and proglacial discharge will be larger due to longer pathways and the potential for supraglacial and subglacial storage'. This is true, IF storage takes place. However, you don't know if this is the case. There could be highly efficient englacial/subglacial channels. Again, I think that it needs to be made clearer that these are suggestions rather than based on direct observations. We have modified the language in line 416 (pre-print version) to change 'will be' to 'may be', and we believe that the other text already reflects that we do not have in situ measurements, so these statements are speculative.
448	Throughout, you make reference to 'larger' channels, but this is never quantified. What do you mean by larger? Here, for the first time (I think) you indicate that by 'larger' you mean higher discharge. Is this what you have meant throughout? This needs making clear since to me, I had assumed you meant the physical dimensions of the channels. Regardless of what 'larger' means, I do think you need to quantify the criteria somewhat. We mean physical dimensions and we have now stated this more clearly, i.e. >0.5 m wide. We had mentioned discharge to indicate that channels with larger physical dimensions are typically accompanied by higher discharge, but this is a qualitative assumption as we did not systematically measure width because our channels were manually mapped as a centerline, and this would be too data collection intensive.
480-512	I'm not convinced of the need for this section comparing supraglacial drainage on glaciers and ice-sheets. I feel that the paper is drifting away from its focus a little by including this passage. I'm not suggesting that this section MUST be removed, but rather simply suggesting that its value to the wider paper is not terribly clear, and thus this could be considered. We think this section has value because most of the research on supraglacial channels has been conducted in an ice sheet setting. Hence it is useful to know how comparable channels on mountain glaciers and on ice sheets are, especially if there are some important differences that advance understanding beyond the body of knowledge gleaned only from ice sheet settings. We have added an extra sentence to state this at the beginning of section 5.3.
518-519	Presumably you mean an increase in the SIZE of the ablation area, but when referring to a 'reduction in area for smaller glaciers' you are referring to the entire glacier rather than the ablation area? A bit of clarity needed here. Amended – we have reworded line 518 (pre-print version) to instead say 'rising equilibrium lines' to avoid confusion regarding the mention of both ablation area and overall glacier

	area.
545	‘off the glacier’ rather than ‘of the glacier’. Amended.
557-560	This last statement is the first such mention of the existence of other channels beneath the mapping resolution. I believe this is important (see my earlier comments) and so for it to only appear as the final sentence in the conclusions is rather late. I would prefer to see this discussed earlier, and the importance considered more. We agree that it is important to acknowledge the presence of channels below our mapping resolution and have now mentioned this in the methods section. Please see our response to the second general comment on this topic for a more detailed response.

Response to Reviewer 3

This is a novel paper involving the generation of a unique and valuable data set on surface stream characteristics for 85 glaciers in Valais, Switzerland from open access 0.15 m resolution SwissTopo orthophotos and DEM. The lead author is to be congratulated for manually digitising the 1890 streams, although it is a shame this couldn't have been automated. Automation was attempted, based on previous methods applied to the Greenland Ice Sheet, but these were found not to work here. Having created the data set, the paper investigates statistical relationships (correlation, PCA) between channel variables (segment length, channel slope, sinuosity, minimum elevation, maximum elevation and elevation range) and several glacier variables (drainage density, glacier area, mean slope of the snow-free area, aspect, glacier minimum elevation, glacier mean elevation and glacier maximum elevation). DiUerences in certain channel characteristics between clean and debris covered glaciers are investigated, as are diUerences between the way the channels terminate (moulins, crevasses, running oU the terminus or edge of the glacier, etc). The results are shown in a set of nicely produced figures and tables, and examples of diUerent types of streams are shown in Fig 4 (although I'd like to have seen an example of a stream which terminates in a lake, although this type of termination only makes up 1% of the total). We thank the reviewer for their positive assessment of our paper and respond to each comment in turn below in blue text. Firstly, in response to the final sentence above, we have expanded the spatial coverage of Fig. 4e so a small supraglacial lake is visible on Gornergletscher.

I think the justification for the work is adequately provided in the Intro, although I'd add the importance of the supraglacial stream network, and particularly for whether the water enters moulins or crevasses or not, for understanding subglacial drainage evolution, water pressures, and basal motion to this. Amended – we have now added additional information and references.

The data sets and methods are described well, although I'd like to hear more about precisely what automated methods were attempted and why they failed.

The first paragraph of the methods has been reworded because it suggested that we attempted more than one method of automation. We did not attempt other methods such as flow routing because the DEM was > 3 times coarser than the orthophoto and would reduce the number of channels we could detect. The methods text now clearly conveys that we tested the $NDWI_{ice}$ method (following Yang and Smith, 2013) and describes the imagery we tested it on, prior to opting to map channels manually. The $NDWI_{ice}$ method is likely best suited to coarser imagery where the output is not complicated by water filled crevasses, ponded surface melt and surface debris.

I also note that the orthophotos were collected in mid-July 2020. Can this melt season be put into some perspective? Was it a high accumulation winter previously? What was the weather doing in the spring and early summer? So what were the snow / ice conditions in mid-July this year compared to other years? What are the implications of using orthophotos from this time? I imagine results would be very diUerent if they'd been collected later in the summer during very high melt conditions? Does the timing of the orthophotos explain why you only found 85 (out of 285) glaciers with streams on them? This seems quite a low number to me.

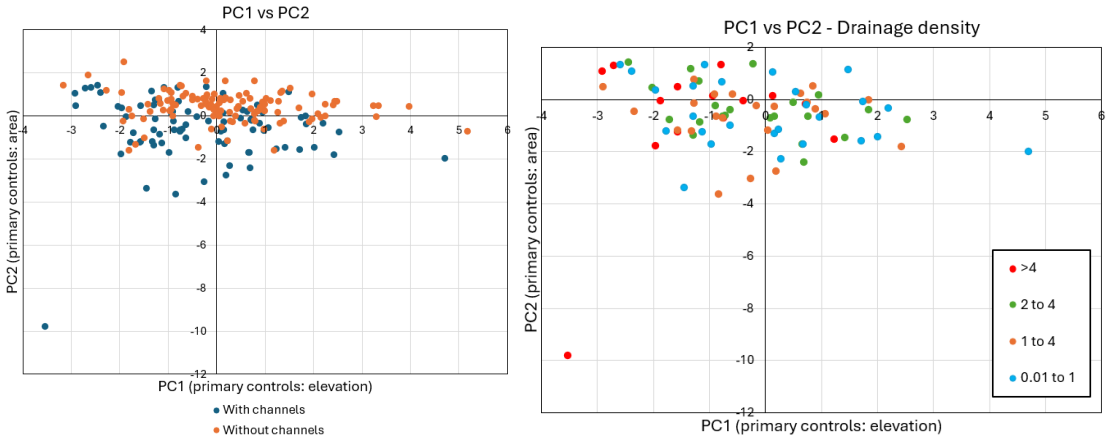
We have now added into the methods that the conditions that preceded the acquisition of the orthophotos in mid-July 2020 were not highly abnormal. The previous winter (DJF) precipitation total was 570 mm which is lower than the 2009/10 to 2019/20 average of 704 mm, meaning there was less winter accumulation than normal. Temperatures began to rise above freezing in May time, and May in

2020 was warmer (3.4˚C) than the 2010-2020 mean temperature of 1.7˚C. However, July was colder than average (4.8˚C) compared to the 2010-2020 mean of 6.3˚C. Hence, it is possible that the snow-cover at the time of imagery acquisition was slightly below average (2010-20).

In response to our detection of channels >0.5 m on 85 out of 285 glaciers, this more than likely represents the size distribution of glaciers in the study area, as 200 out of our 285 glaciers are smaller than 1 km^2 meaning that channels (if present) are likely to be harder to detect from our imagery resolution (15 cm). It may seem logical to simply omit these smaller glaciers from our dataset, but we do still find clearly mappable channels on some (33) of the glaciers <1 km^2. We now acknowledge in the methods that these glaciers likely have some smaller channels that are not sufficiently clear enough to map, but likely still form a key hydrological component of these glaciers.

The results are clearly presented overall, and the statistical analysis seems generally robust, and the results sensibly interpreted. The PCA doesn't add very much, and I wonder whether the authors had considered collapsing potential independent glacier variables (glacier area, mean slope of the snow-free area, aspect, glacier minimum elevation, glacier mean elevation and glacier maximum elevation) using PCA and then investigating the correlations between the PCAs and potentially dependent channel variables (segment length, sinuosity, drainage density)? This would appear justified given the significant correlations between all the variables (Fig 6), and the desire to try to explain the variability in channel characteristics.

We have explored how to reduce the dimensionality of the independent variable space following the reviewer's suggestions. We collapsed the glacier independent variables into a new PCA and explored correlations between the PCAs. This reinforced the importance of glacier area and elevation as a control on where channels exist, particularly when looking at the difference in clustering between glaciers that do and do not have channels (clustering differences are only apparent for glacier area) (see below). We also grouped points by drainage density to see if there is any clustering with the PCA that would provide insight into where the highest drainage densities occur. However, this has not provided any new insight and the original PCA already highlights the importance of area and elevation, as their presence in PC1 and PC2 explains 50% of the total variability. Instead, we strengthen the language around our PCA to state that it is evident that glacier area and elevation are the primary controls on variability within the dataset.



Left plot: PC1 compared against PC2. Glaciers with channels (>0.5 m) are in blue and glaciers without large channels are in orange. PC1 is primarily controlled by minimum, and mean glacier elevation but closely followed by max elevation. PC2 is primarily controlled by glacier

area. Right plot: PC1 vs PC2 with the points colored based on their drainage density.

I think the weakest part of the paper is the Discussion, which is not suUiciently focussed on the results presented, occasionally confuses results vs previous work, and appears a little long-winded and speculative in places. I think there are some interesting points to come out of the results and some legitimate comparisons that could be made with previous similar work on the Greenland Ice Sheet and other glaciers in the Arctic or which are debris covered. It's just that these need to be more streamlined and succinctly articulated. The Conclusions would then be stronger, and the paper would have more impact.

Following the suggestions in the detailed comments, we have rewritten the paragraphs highlighted by the reviewer as being weak in structure and focused on outlining our results first, before bringing in previous research. During this process we have also condensed parts of the discussion, specifically the sections on comparing our study area to ice sheets and debris cover, which has helped to streamline the discussion. We have tried to reduce speculation in places, and we have done this by toning down sections on our hypothesized hydrographs and where we discuss predicting glacier meltwater pathways based on hypsometry.

I provide more comments on all these points in the details below, together with recommendations for where grammar could be improved, clarity could be enhanced, or where I have queries.

I have one more general query which is why did the authors decide to use the English names for all the glaciers? Would it not be more appropriate to use the local Swiss names (which are in German or French)? Amended - We have modified the manuscript to use the local language for each glacier.

I think the work should be published if the authors are able to address my comments and suggestions.

Detailed line by line comments

13. I'd say '~ 2000' [as <2000 could be anything between 0 and 1999]. Amended.

12-14. Seems odd as worded. Would this be better: "Here we use high-resolution (0.15 m) orthophotos across a sample of 285 glaciers in Valais Canton, Switzerland, to identify 85 that contain supraglacial channels. For these 85 glaciers, we delineate ~ 2000 supraglacial channels (> 0.5 m wide) and investigate their distribution and characteristics." Amended – We have reworded the sentence but have shortened the suggested version to keep within the 250-word limit.

15-16. What are 'lower relief slopes'? Should this be 'lower angle slopes'? This phrase is used several times throughout the paper. Amended – we have changed this to 'lower angle' throughout the manuscript.

21. Should be "…where all channels terminate englacially…". Amended.

23-24. You could delete "the majority of channels reach the terminus supraglacially and" as you already said that on lines 18-19. Amended – We have reworded this sentence to make it less repetitive but kept the mention of where channels terminate to save the reader having to revisit information earlier in the paragraph.

43. Suggest “channels has implications…” Amended.

44-45 Suggest ‘…through and under glaciers, with potential to impact suspended sediment…’ Amended.

48-50. The distinction between channels vs channel absence is a bit artificial here as the former is typical on an ice surface in the ablation area whereas the latter will be confined to higher elevations. Can you distinguish between importance of channels vs absence in ablation areas as this controls delivery of water to bed which influences subglacial water pressures and basal motion (e.g., Banwell, A., Hewitt, I., Willis, I. and Arnold, N., 2016. Moulin density controls drainage development beneath the Greenland ice sheet. Journal of Geophysical Research: Earth Surface, 121(12), pp.2248-2269). Channels vs absence on firn at higher elevations reflects melt rates vs infiltration capacity, and I agree this has implications for portioning of refreezing vs runoU. Amended – We have replaced these sentences with the implications of surface-to-bed routing of meltwater.

52-53. ‘…glacier systems…’ is vague. If you elucidate importance for proglacial water quality, glacier dynamics, and mass balance above, you could refer to these things again here. But are you going to address the impacts in this paper? If not, I suggest delete this last clause. Amended – we have removed the last clause.

64-65. Suggest “…larger ice sheets also apply…” Amended.

67-8. Suggest “…about supraglacial channel distribution in mountainous environments, but previous research has helped to establish some fundaments (e.g., Knighton…” Amended.

75 ‘present’ => ‘presence’ Amended.

76 ‘influences’ [i.e. singular as refers to ‘presence’] Amended.

76-80. These two sentences are repetitive. Suggest combine to make the point about the controls of discharge and slope just once. ‘increased slope’ should say ‘high slope’. Amended.

80. ‘discharge rates’ is wrong as discharge is a rate [discharge is the volumetric flow rate of a stream]. Amended – this has been removed.

86. Suggest changing ‘systems’ => ‘glaciers’. Amended.

132 ‘records an historical’ Amended – this section has been removed.

122-137. To what extent is all this info on climate and glacier area change relevant? Can you delete it all (or much of it)? Amended – we have removed the sentences that follow on from “the mass balance of Swiss glaciers in recent decades (Fischer et al., 2015; Davaze et al., 2020)…”

146 Need a comma here “small amounts of water, or incised channels where…” Amended.

141-147. You say you applied automated methods [i.e. plural] and refer to Yang et al 2019. Does this reference detail all the diUerent automated methods you applied? But then you only mention the first method you used and refer to Yang and Smith. This sems odd. Why did you single out just this one method to talk about if you applied others? Clarify here how many methods you applied, what they were, and what the problems with all of them were. Amended

– We acknowledge that the wording may have been confusing and have reworded this information to clarify that we only tested the $NDWI_{ice}$ method of channel detection. Other methods such as flow routing would not have been viable with the resolution of the available DEM.

148. when you say 'multispectral methods' do you mean 'automated methods' [as referred to on line 141]? Amended – Yes, this is now clarified that in the text.

149. You mention your data set here "high resolution cloud-free orthophoto imagery" but was this the data you first attempted to detect channels on automatically as mentioned above? State above what data you were working with. We have now added information about the imagery used to test the NDWI approach. This was the same orthophoto imagery (0.15 m) referenced throughout.

150-52. Suggest "hence 6% of glaciers were still snow-covered down to their termini and were omitted from further analyses as the presence or absence of channels could not be detected." Amended.

I assume by this statement that you included glaciers that were still largely snow-covered, as long as they had some exposed ice on them? Yes, we did. However, the mean percentage of snow-free glacier area was 38.9% in mid-July when we acquired our imagery. A very small number of high-elevation glaciers only had a small area of ice exposed, with a minimum snow-free area of 5%. This snow-free glacier area increases to 45.0% when glaciers have a mean elevation between 2500 and 2800 m.a.s.l. The lowest mean for an elevation band is 36.6% between 3100 and 2400 m.a.s.l, demonstrating that there is not a large difference between the elevation bands. This information has now been added into the manuscript.

150-7. You need to reorder this material. First state how many glaciers you start with, then how many you remove because they are too small, then how many of those you remove because they are still completed snow covered. Amended – this paragraph has been restructured.

167-8. How easy was it to distinguish how the streams terminated? We find that it is typically easy to identify where the streams terminate due to the imagery resolution, whereas the largest source of error is when the mapper stops mapping up-channel to avoid over interpreting. We expand upon our mapping accuracy in new sentences that have been added to the first paragraph of section 3.1.

Fig 2. The stream in C looks like it used to terminate in the moulin identified but that a new moulin on a crevasse has opened up above it. Upon further inspection of the feature that is visible upstream, it is not a moulin and the channel runs directly through it, without appearing to capture any meltwater. There are many moulins in that area, but they appear much darker in the imagery, and this feature looks to be a darker depression that contains debris. Hence, the channel terminus has been correctly identified.

256-7. You say 'When only considering terminal segments…' but you used the term 'channels terminate in a range of settings' on line 254. So what do you mean by 'terminal segments'? You mean ignoring those that join another channel or disappear below map resolution? Amended – We have clarified that we do indeed mean channels that do not join another channel or disappear below the mapping resolution.

Are there segments that disappear below map resolution but then look as though they reappear again down glacier? How common is this? What are the implications for your results?

If there are channels that disappear and reappear, we cannot confidently assume that they are part of the same channel, hence they will have been mapped separately. As we have now more clearly described in the methods, we take a conservative approach to mapping to avoid over-interpreting channels. A gap in channel mapping should not significantly affect the drainage density of the glacier, but it will affect the assigned terminus of the channel (i.e., assigned "disappears below the mapping resolution"). We do not include channels that disappear below the mapping resolution in the calculations for meltwater routing. Hence, if a channel disappears below the mapping resolution, and subsequently reappears and terminates in a crevasse, we would still be capturing the final channel terminus location, without affecting our values for where meltwater is routed. However, it is likely that we underestimate the number of englacially terminating channels where the terminus cannot be clearly identified, as we don't detect the true location where it re-emerges, but this would not be possible to identify without further information (e.g. from dye tracing).

261 'singular' => 'single' Amended.

261-2. I don't understand what you mean by 'Thus, when the percentage of channels terminating in each position are extracted as an average value from each glacier…' 'are' should read 'is' as its singular as it refers to 'the percentage'. But even with this grammatical change I don't think the statement makes sense, does it? Amended – we have reworded this sentence to clarify the meaning of the text. We are trying to convey that we calculate channel termini locations for each glacier (e.g., 30% of channels terminate englacially and 70% terminate supraglacially) and when you average these values for all glaciers you get X% terminating at a certain location. We display this value because it is likely more useful than using the raw data for all channels because a few large glaciers contain a disproportionately large portion of the channels.

274-5. You could cut words (and improve style) here and just say "Here, we investigate links between diUerent supraglacial channel characteristics. Previous studies…" [You refer to Fig 5 at the end of the relevant sentence below so no need to refer to it up front]. Amended.

279-80. Is this accurate? I think I'd remove the word 'clear' [as the boundary looks a bit fuzzy to me] and I'd say a sinuosity of 1.3 [eyeballing the figure suggests you have 8 values > 1.2 but only 4 > 1.3 for slopes > 20 degrees]. Amended.

280-281. Do you need the word 'segment' here? You just said channel length on line 277. Amended - For the purpose of clarity and consistency we have kept 'segment' here and added 'segment' into line 277 and into the figure captions that use channel segment length as a metric.

281. You say 'which often have a lower density of crevasses' but there's no evidence for this in Fig 5b that is referred to. Is this interpretation – in which case this could be moved to the Discussion section. Or do you have evidence for this, in which case refer to it here. Amended – we have removed this.

282-283. You don't need to refer to the slope-sinuosity relationship in Fig 5a again here as you've just dealt with that. Just stick to telling us what the upper boundary for the slope-length relationship is. For example, you could say that except for one outlier, channels >500 m long are confined to slope < 20 degrees. Amended.

290 Consider "…along with…' => "…as do…" Amended.

300. What do you mean by this sentence? '…less evident' than what? '…lower number of data points' than what? Haven't you just been referring to the influence of a glacier characteristic (slope) on channel characteristics (length & sinuosity)? Amended – we have rephased the sentence to make it clear that we are referring to the number of data points in Fig. 5a-b compared to Fig. 5e-h. The reference to slope in the paragraph above refers to slope of individual channels, hence it is grouped with the paragraph on the controls on channel characteristics. This differs to the mention of slope on line 300, which refers to the overall slope of the glacier, rather than at a specific channel. This was likely confused by the mention of 'glacier slopes' when Fig. 5a was mentioned, hence we have now edited this to improve the clarity.

302-305. I think these statements about drainage density vs minimum or maximum glacier elevation and ref to Fig 5f and g are spurious. What you say is based on just 4 data points, which is not an adequate sample. I'd just point out no obvious relationships between drainage densities and either min or max elevation. Amended – we now note that there is less evidence of a relationship in Fig. 5g (p = -0.39), and tone down discussion of Fig. 5f, but suggest that a larger dataset would be needed to validate whether a relationship might exist between glacier drainage density and minimum glacier elevation.

306. Do you mean 'interception' not 'inception' here? Amended.

316. Should say 'Fig 5e' here. Amended.

340. What do you mean by 'variables such as drainage density'? This is not clear. What is drainage density an example of? Should you not just list all the variables that are not closely related to just one other variable? Note you're saying that drainage density is not obviously related to a single causal variable, which was my interpretation of the bivariate plots 5f and g above. Amended.

341. The word 'singular' is used incorrectly here. You could say "… not closely related to just one other variable. Overall, our PCA analysis reveals no single main driver of variance.." Amended.

354. I think 'restricting' should be changed to 'determining' or 'aUecting' or 'controlling' as the first part of your sentence is just establishing a general relationship not the direction of that relationship. Amended.

354-6. This sentence is not quite grammatically correct as it should be '…can either intercept…or route…". I'm not quite sure what you're saying here. Are you saying that shallow crevasses may simply route the surface water along them, contributing to the supraglacial drainage system and maintaining channel length? Whereas deep crevasses may intercept surface water and deliver it to the englacial drainage system, thereby reducing surface channel length? Amended – this has been rewritten to more clearly convey what the reviewer has suggested.

358. I think 'surface' is redundant here. Amended – this has been removed.

358. I think you should introduce Fig 7 at the start of the next paragraph and introduce it fully. Is it depicting the influence of slope more than elevation? Or at least as well as elevation? Amended – we now introduce figure 7 in the second paragraph and that paragraph now discusses both slope and elevation.

361-371. You refer to 'valley glaciers' and 'Upper Theodul Glacier' in this paragraph but you don't systematically take us through the increasing drainage densities going from left to right in your Fig 7. I think it'd be helpful to describe the drainage density component to Fig 7 more systematically and thoroughly, perhaps with more ref to your case study e.gs shown in Fig 4. Amended – we have rewritten this paragraph to go through Figure 7 in an orderly manner with reference to case studies.

360. Can you say 'Alpine settings' rather than just 'the study area' to make your conceptual model more generic? Amended.

362 'higher' => high. [you say 'small' not 'smaller so should say 'high' not 'higher']. I'd not use comparative adjectives through this paragraph unless it's obvious what your comparison is with. Amended.

370. It will not just be glaciers extending to lower elevations that will require channel incision rates to increase. It'll be the likes of Upper Theodul Glacier too won't it? Amended – this is indeed true, but what we meant to convey was that whilst warming will be universal, glaciers with larger portions of their mass at lower elevations will likely be more vulnerable to temperature increases. We have modified the text to reflect this.

385 'or a slightly delayed peak. [peak;singular] Amended.

400-1 suggest 'main stem channel segments' Amended.

407 Delete 'compared to 0 % at the Aletsch glacier' as you've just said that. Amended.

409-10. "…but rather may act as part of the channel network and are mapped as individual segments as they may not be continuous." The second part seems to contradict the first part. Surely a channel network must be continuous, doesn't it? Whether you can see it all or not is another matter. Can you clarify the point you're making here? This section has been rewritten in response to another reviewer's comment and hopefully helps to improve the clarity. What we are trying to convey is that there is uncertainty over whether crevasses capture or route meltwater, so we don't map meltwater along crevasses / crevasse traces unless meltwater can be clearly seen to reemerge.

411-12. What do you mean "We attribute the diUerence in drainage pathways…"? Is this the diUerence in drainage density between Aletsch and Upper Theodul Glacier'? Things are getting a bit hard to follow here. Amended – this section has been separated into a new paragraph and we have reworded this sentence to provide added clarity.

414-428. This is all rather speculative and rather long-winded. Also, it seems odd to be talking about specific glaciers again having introduced your conceptual model (Fig 7). Can't you continue to talk in the generic way wrt Fig 7, having given examples of the 3 types of glaciers depicted in the previous paragraph? Can you summarise much more succinctly and based on evidence where possible, the impacts of the diUerent surface stream densities, on hydrographs, basal motion, and proglacial hydrochemistry? Amended – this section has been rewritten more concisely within a new, smaller paragraph. It now focuses on how the glaciers described above fit into the conceptual model.

Fig 8. I'm not convinced Fig 8 adds to the paper as it's just one example of a particular

phenomena that's not especially groundbreakingly novel. Figure 8 is used to illustrate one of the uncertainties we have with identifying where meltwater is going, rather than being novel, hence we believe that keeping it is helpful.

435-453. This whole paragraph is very speculative. It contains 4 instances of the word 'likely' and 2 of the word 'may'. I don't think this deserves 18 lines of prose. Amended – we have rewritten this paragraph to more clearly convey our evidence first, followed by a more logical wording of the evidence to support our conclusions.

441. I find the term 'higher relief slopes' odd. Is this used widely in the fluvial geomorphology literature that I don't know about? Why not just say 'steeper slopes'? If you agree, can you check all instances of this term in the paper and change accordingly? Amended – we have changed the language throughout.

442. '…this figure'. What figure are you referring to here? The 20 degrees? I think this sentence needs writing more precisely. Does your PCA allow you to add evidence to the statement I think you're making here? We have amended the text to clarify that we are referring to Fig. 5a. The point is that flatter areas are more likely to contain larger channels, and larger channels are more likely to be sinuous. Given the argument set out we would be looking for a relationship between sinuosity and glacier slope (mean) in the PCA, which isn't particularly apparent. This is likely because mean, min or max slope are unlikely to provide a good enough measure of whether a large enough low angle slope is present.

454 -464. It's diUicult to work out from this paragraph, which statements are based on the new evidence presented in this paper, and which are based on previous research. Ideally these discussion paragraphs should clearly state the former and then bring in the latter to show the extent to which previous work supports or contradicts the findings from the new work presented.

For example, where is the evidence for the first sentence? The only thing I recall wrt debris-covered vs clean glacier is Fig 5c which shows no diUerence in the sinuosity between debris-covered and clean glaciers in Valais.

Amended – we have merged the paragraphs from lines 454 to 464 and lines 465 to 478 to make the paragraph more concise. We now clearly state the evidence from our research at the beginning of the paragraph and contextualize it amongst previous research later in the paragraph. The axis of Fig. 5c has been amended and the differences (even if small) between the three classes are now more obvious in the figure. The data from this figure was found to be statistically different based on an ANOVA test, which provides support for there being some difference between the classes.

465-478. As above. Potentially some interesting points in here but the discussion must be related to the results you show. Amended – we have reduced this paragraph and merged it with the previous paragraph which now more clearly follows on from results we show.

481-499. Again, I do not think enough in this paragraph stems from the work presented in the results. It's too speculative. Can you just compare your results with the results of similar work (a lot by Lawrence Smith, Kang Yang and coworkers) on the GrIS? By all means oUer a sensible reason for any diUerences, but avoid all the lengthy speculation. Amended – in response to this comment and the one below, we have merged this paragraph with the one below to provide a more concise comparison between our work and research on ice sheets.

500-512. OK This para is better and does what I suggested above. I don't think the last sentence follows on from the rest of the paragraph. Instead, I'd weave that info and the refs into a point in your introduction, justifying that the study of surface streams and where they terminate is important for subglacial water pressures, subglacial drainage evolution, and basal motion. Amended – this sentence has been removed and further information on the implications of where channels terminate has been added to the introduction.

514-529. I think this para is basically fine – it's speculative but then it must be as it's about the future.

532. Should say "…dataset on…" Amended.

536. Delete 'existing'. I'd say ''low slopes'. Amended.

537 suggest change 'mass' => 'area' as that is what you measure. Could delete 'We find that'

Amended.

539 'low ice surface slopes' YES!

543-5. This sentence is not quite grammatically correct. "…the percentage of channels…revealing that…80% of channels" do one thing and 20% do something else doesn't make sense. It is not the percentage of channels that reveals it. I think this whole sentence needs rewriting (also of =>oU). As I mentioned earlier wrt lines 261-2, I don't follow what you mean by 'averaged by glacier'. Whether you simply calculate the % of diUerent types of channel irrespective of glacier and quote those, or whether you calculate the % of diUerent types of channel for each glacier, and then average all the percentages for the diUerent channel types, and quote those doesn't matter. You get the same result. Unless I've misunderstood something. Amended – we have rewritten this paragraph and split it in two. When we refer to average by glacier, we mean that we have calculated the % of channel terminus locations per glacier and then averaged this amongst the dataset. This is to make sure that each glacier is weighted the same, because if we didn't calculate the average per glacier, the data would be over-represented by the Aletsch glacier (582/1890 channels) which contains entirely englacially terminating channels, which is not the case for most glaciers in Valais.

546-7. What exactly do you mean by "The variation in where channels are located'? Are you talking about elevation on the glacier, whether they're on clean ice or debris, close to or far from medial moraines, steep slopes or shallow slopes, or what? Amended – this was redundant, and we now just refer to where the channel terminates.

548-9. The phrase 'with diUerent glacier geometries likely predictive of glacier drainage density and channel pathways' is vague. You've not mentioned glacier geometry so far in the paper so what are you referring to? And 'pathways' has been mentioned 4 times but again not very clearly defined. You say glacier geometry is likely predictive of glacier drainage density and channel pathway and refer to Fig 7. But if I look at your evidence in Fig 5e-h it's not clear that anything shown really controls drainage density, is it? Your corelation matrix in Fig 6 shows highest correlations between glacier slope, glacier mean elevation and drainage density so glaciers with low slopes and low mean elevation have the biggest drainage densities. Anyway, I think the paper would be strengthened if you based your conclusions on the evidence that you present in the results section and avoid weak speculative statements. Amended – we have rewritten this

section to clarify what we mean by channel pathways. We have also provided an example of how drainage density and proglacial stream hydrographs can be predicted based on glacier characteristics.