Author comments: Generating synthetic fjord bathymetry for coastal Greenland

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Review by: J. Goff

We thank the reviewer for their supportive comments and have made corrections in line with the provided suggestions, much improving the original manuscript.

1) Page 2, line 16: the term "physically based" is too vague

> 'Physically based' had been used to differentiate between purely statistically calculated geometry as opposed to a geometry specifically implemented to be representative of "real" geomorphology or bathymetry. We agree that the term used is non-specific and therefore to reduce vagueness, we have replaced it with "geomorphologically realistic" at lines 16 (pg 2), 4 (pg 6), 30 (pg 14). The reference at line 31 (pg 4) has been removed.

2) Page 3, Line 19: Goff et al. (2014) should be referenced with regard to statistical modeling and interpolation.

> The reference has now been added.

3) Page 5, line 30: It is stated that "to the best of our knowledge, there are no studies that have considered spectral analysis of fjord bathymetry." That is technically true, but Goff et al. (2014) certainly investigated the statistical characteristics of subglacial channel geometry in great detail, and that has to be considered highly relevant to this study.

> We have now deleted line 30 and replaced it with:
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> "Whilst the spectral properties of mid-ocean bathymetry (Bell 1975, Goff and Jordan 1988) and subglacial channels (Goff et al. 2014) have been assessed, to the best of our knowledge this has not been done for fjord bathymetry."

4) Page 7: This description of the methodology for centerline picking includes a number of seemingly arbitrary values: an unknown "predefined distance interval", parent edge < pi/6, angle between any pair of new edges no less than pi/24, |x-xi|, |y-yi| < 16 km, |a-ak| < pi/8. The authors should endeavour to provide rationales for these values.

> The referee is correct to note that these parameters are somewhat arbitrary. Ultimately, they are chosen so that at least one path is found for each fjord, but not many more. We plan to formalise this process for the final DEM product
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> Essentially, what we are doing here is solving a optimization problem many times to find the optimal paths between a large set of start- and end-points, then choosing a subset of the them such that there is only one path between each pair of close start and end points. We have complicated the process somewhat by attempting to carry out the path generation and selection at the same time, in order to avoid the large number of paths that we would otherwise need to consider.
>
> The predefined distance interval is a simple finite difference parameter, and is picked so that there are enough nodes on a path to resolve it – this would be the same however we implemented the above. The ideal (but unattainable) value would be zero.

The relationship between child and parent edges is chosen to be small enough allow the path to turn quickly enough to follow the channel, and large enough so that the minimum radius of curvature is of the order of one channel width. The ideal value would be 2*pi, and restricting it simply anticipates the expectation that paths containing many loops will ultimately be rejected. In other words, this keeps paths close to the locally optimal direction, but allows some latitude so that branches can form.

The angle between new paths (pi/24) is another finite difference parameter – we cannot consider the continuum of angles spanning (-pi/6,pi/6). Again the ideal value would be zero and we reduce it progressively until the same (or similar enough) set of paths are generated.

The values |x-xi|, |y-yi| < 16 km are chosen to identify similar paths. The first two are chosen such that one of a set of seeds is identified within a small number of generations, if the paths that start from from them appear to be converging.

The condition |a-ak| < pi/8 is also chosen to identify similar paths. The angle must be greater than zero to allow branches to form from paths which are identical up to the point of the branch, and persist provided they arrive at distinct end point. A smaller angle reduces the number of branches in play at any one generation.

We have added additional text to section 3.1 to add further clarity.

5) Pages 7,8: I think that the demonstration of centerline picking would greatly benefit from using a path that was not a perfect straight line. This part is a bit hard to follow, and I think a curved path would give the reader a more intuitive sense about how it really works. I would suggest in particular that the geometry used for Figure 6 be the same as used for Figure 5. I also wonder: in looking at Figure 4b, wouldn't it be a lot simpler to just follow the path of maximum distance?

In line with the suggestions of both reviewers 1 and 2, to make the methodology as clear as possible, we have amended figure 5 so that it uses the same geometry as presented in figure 6. The algorithm is based on following the path of maximum distance, and all the additional complexity comes about because there are many possible start and end points. A simple approach might be to compute every optimal path between every possible start and end, and then choose among them somehow. For example, imagine two possible start points (seeds) and one possible end point. There are two optimal paths, and we need some way to decide whether to keep both, or just one (e.g if they are at the start of the same fjord). Our method is really just attempting to do this choosing 'on the fly', by discarding paths that start at nearby points to a 'better' path if they appear similar otherwise (have the same centroid and direction). By 'better' we mean that a path is closer to the centre of the channel (as measured by the maximum distance) on average along its length.

We have added additional text to section 3.1 to add further clarity.

6) Page 14, line 26: It is inaccurate to say that this is the first time such a methodology has been applied to fjords since subglacial channels are geometrically identical to fjords.

We agree with the reviewer and have amended the top of the discussion. The discussion now begins **"**Channel elevation point meshes have been implemented in different research fields including hydrology (Merwade et al., 2005, 2008), and glaciology (Goff et al., 2014). This study provides a key addition, which addresses sparse data availability with…**"**