Responses to Reviewer #1 to manuscript TC-2020-294

Thanks for your helpful comments to improve this manuscript.

Please Notes: Text in BLACK is the reviewer' comments and our responses are in BLUE.

Specific Comments:

Title: I think the title should point out that the author's approach is different from other studies, for example "base on …".

Response: We changed the title to "A new automatic approach for extracting glacier centerlines based on Euclidean allocation", which can reflect that our approach is different from other studies.

*(P1L20) "the largest length" -> "the longest length" or "the maximum length".

Response: We revised it to "the longest length".

*(P2L30) "Alternatively" might be "Therefore".

Response: It has been modified.

*(P2L31) Please add a sentence to explain the role of the two concepts of glacier axis and glacier centerline and their relationship with glacier flowline.

Response: We have further explained the related concepts involved in the question:

Glacier centerline is a central line close to the main flowline of glacier, which can be acquired base on glacier axis and be used to simulate the glacier flowline.

In addition, explanations of the relationship of some related concepts are shown in Figure A1.

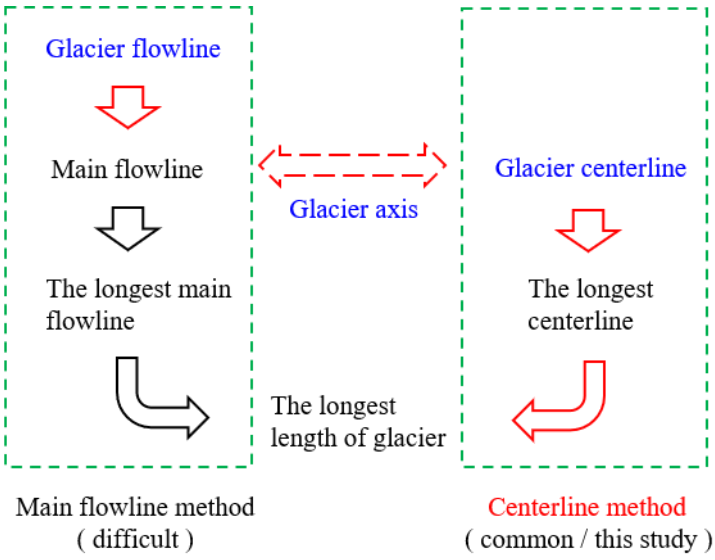

Figure A1: The schematic of the relationship of some related concepts.

*(P2L45) Delete “automatic”. It is too early to mention the importance of automatic extraction algorithm because it cannot be illustrated above.

Response: This word was deleted.

*(P2L46- P3L60) This section seems not make clear the challenge of current glacier centerlines extraction.

Response: So far, the biggest challenge for glacier centerline extraction is still automation. In the past, glacier length was determined manually in a laborious way. In recent years, several authors mentioned in the section have tried to extract the centerlines in batches, however, the results are not satisfactory. In this regard, we added the following summary:

So, the current biggest challenge is still the implementation of automation extraction of glacier centerline and the acquirement of more information about glacier length.

*(P4L80) The provincial boundary is not obvious to see in Figure 1, and the number of map’s scale is best such as 100, 200, 500, 1000 km.

Response: The Figure 1 was remapped.

*(P5L85) “arcpy” -> “ArcPy”

Response: It has been modified.

*(P5L95) Make some parameters clear, for example, P_G, A, P, A_G.

Response: We rewrote acronym of each parameter to clarify their meanings, listed in the Appendix A. The relevant parameters are explained as follows:

Table A1 The list of main acronyms in this study.

Acronyms	Description
A_t	The given area of an equilateral triangle
A_g	The polygon's area of the glacier's outer boundary
A_l	The final auxiliary line
A_r	The ridgelines of the glacier surface
G_{br}	The bare rock in glacier
G_{fcl}	The final glacier centerline
G_{fl}	The feature lines of glacier surface
G_{cl}	The original glacier centerline
G_{Labl}	The length in the ablation region of the glacier
G_{Lacc}	The length in the accumulation region of the glacier
G_{Lmax}	The longest length of the glacier
G_{Lmean}	The average length of the glacier
G_{pl}	The polyline of the outer boundary of the glacier
G_{po}	The polygon of the outer boundary of the glacier
L_{max}	The longest glacier length of RGI v6.0
D_L	The difference between G_{Lmax} and L_{max}
P_t	The given perimeter of an equilateral triangle
P_g	The perimeter of the glacier's outer boundary
P_{max}	The local highest point of glacier outline
P_{min}	The lowest point of glacier outline
RGI	The Randolph Glacier Inventory
SCGI	The Second Chinese Glacier Inventory
Z_{med}	The median elevation of the glacier

Please note that in Table A1, the parameters A_t, P_t, A_g and P_g correspond to A, P, A_G and P_G in the manuscript, respectively. The four parameters involved in the comment are explained as follows:

A_t *(A)*: The given area of an equilateral triangle;

P_t *(P)*: The given perimeter of an equilateral triangle;

A_g (A_G): The polygon's area of the glacier's outer boundary;

P_g (P_G): The perimeter of the glacier's outer boundary.

*(P5L101) Author should explain where the formula 1-3 comes from?

Response: Formula 1-3 are proposed in this study. Formula 1 expresses the relationship between the perimeter and the area of an equilateral triangle. Formula 2 represents the method for determining the glacier grade in this study. Formula 3 expresses the proportional coefficients for determining the relevant parameters of different levels based on the aspect ratio of the equilateral triangle corresponding to the area of glacier's outer outline.

The main basis is the classification of glacier scale and the scale of glaciers is divided into 12 levels in the SCGI. The values of classification intervals are 0.1, 0.5, 1, 2, 5, 10, 20, 50, 100, 200 and 300 km^2. Combined with the sensitivity of the algorithm to each grade of glaciers during the experiment, this research divides the glaciers into 5 grades (interval value: 1, 5, 20 and 50 km^2). In the experiment, we also found that when the outer perimeter of glaciers (P_g) of the same scale differs greatly, the extraction results of glacier centerlines differ greatly. In addition, the shape of alpine glacier resembles a triangle. Therefore, the P_g was considered in the glaciers' classification in this study, and the classification results were fine-tuned according to the above three formulas with reference to the values of the SCGI's grading intervals.

*(P7L124) Some word's fonts in Figure 2 are not uniform. Please check. In addition, I have a question, did DEM need preprocessing? Such as filling.

Response: It has been checked that Figure 2 includes two fonts. The main body of the flow chart uses the Times New Roman (nine pounds) and the module name uses the Microsoft Elegant Black (10 pounds).

Figure 2 briefly shows the processing for DEM. The actual processing includes a series of preprocessing such as clipping, filling, condition selection, focus statistics, and inverse terrain calculations.

*(P8L134) median elevation Z_{min} -> median elevation Z_{med}. Please check the full text.

Response: It has been modified.

*(P9L144) "the material flow" -> "the mass flow".

Response: It has been modified.

*(P9L147) As for post-processing, please introduce in more detail.

Response: Firstly, the ridgelines of the glacier surface (A_r) were obtained by clipping the ridge lines using G_{po}. The set of all possible starting points of auxiliary lines was gained by intersecting A_r with G_{pl}. Then, the ridgeline clusters connected to each starting point were achieved and marked by traversing the point set. The number of auxiliary lines was initially determined. Finally, the longest length of each auxiliary line was calculated by adopting the critical path algorithm. The final auxiliary lines (A_l) were obtained by screening all auxiliary lines using the three parameters of P_4, P_5 and P_{11}.

The related processing methods are explained in the P10L153- P11L159 of the manuscript. The

processing objects (the disconnected lines and the abnormal lines) of steps i and ii are shown in the discussion section (Figure 15). The post-processing of steps iii, iv and v are shown in Figure A2 in more detail.

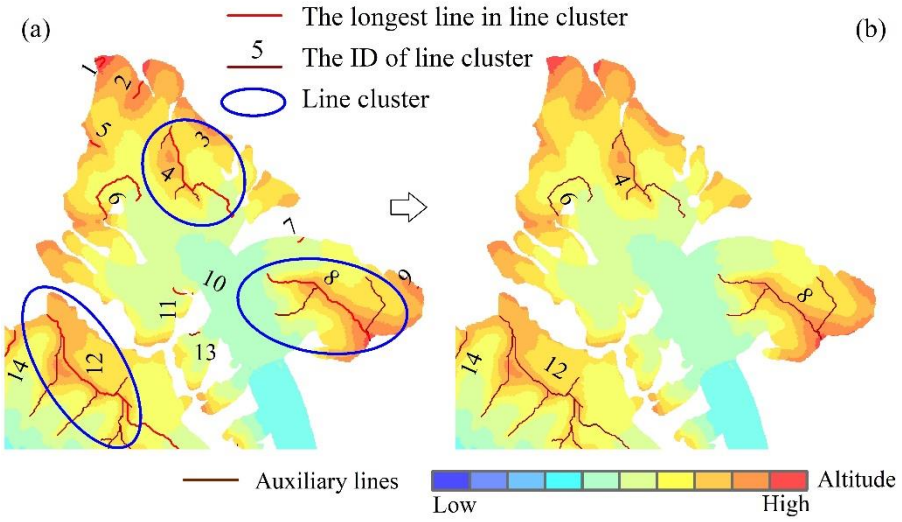

Figure A2: The schematic of post-processing. (a) Before pre-processing; (b) After pre-processing. A total of nine line-clusters are removed by screening.

*(P12L198) How exactly did the authors get the final glacier centerlines?

Response: Firstly, the feature polylines (G_{fl}) after automatically deriving by the program are input, and the function of Euclidean allocation in ArcPy is called to generate the division glacier surface. Then the common edges between regions on the dividing glacier surface are identified. Finally, the common edges are automatically checked and processed (including smoothing process) to obtain the corresponding vector data. This study regards them as the final glacier centerlines.

*(P14L234) How exactly did the authors visual inspection? Some glacier centerlines may be visually indistinguishable.

Response: The method of visual inspection is detailed in section 4.2 (Sample selection and assessment criteria). Indeed, we also found this problem, however, it is hard to avoid. This research is based on a 2D algorithm. Theoretically, the extraction result of the glacier centerline is correct as long as it meets its definition. Nevertheless, we still loaded it on Google Earth for inspection. In addition, we compared it with the glacier length in the RGI v6.0, and further evaluated the extraction results of glacier centerlines.

*(P19L280) Is the DEM used for maximum length calculation in RGI6.0 same with the author's?

Response: We all used SRTM DEM to calculate the longest length of the glaciers. The difference

is the spatial resolution of SRTM DEM (this study: 30 m; RGI v6.0: 90 m).

*(P24L364) Maybe I missed some details. How did the authors get ELA through Z_{min}? Maybe the author meant Z_{med}?

Response: We thank the reviewer for the comment. ELA is estimated by Z_{med}, and the relevant content has been corrected above.

*(P26L409) When the article was accepted, I requested the authors to consider making the source code or tool available on Github or some elsewhere.

Response: We agree to you. We will provide an executable file and test results if the paper can be published.