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The Cryosphere Discussions
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Interactive comment on "Calving Front Machine (CALFIN): Glacial Termini Dataset and Automated Deep Learning Extraction Method for Greenland, 1972–2019" *by* Daniel Cheng et al.

Anonymous Referee #2

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General Comment Cheng et al. present an automated method for delineating glacier calving fronts – named Calving Front Machine (CALFIN) - based on a deep learning approach, accompanied by a new dataset of Greenland glacier termini. The principal input data are Landsat optical images acquired since 1972. The methodology builds on previous work by Mohajerani et al., Zhang et al., and Baumhoer et al. and uses computing systems, named neural networks, that learn patterns in training data, in order to identify similar patterns (such as glacier termini) in new data. The authors detail the various steps of the processing chain and produce a set of shapefiles, which are evaluated and intercompared with both internal and external (manually) retrieved calving front datasets using different quality metrics. The main outcome is an extensive

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dataset covering 66 outlet glaciers around Greenland with in total 22,679 individual calving fronts encompassing the period 1972-2019. The method and new data set reportedly exceeds the accuracy of previous work and approaches human levels of accuracy in delineating glacier termini, the key takeaway being the maturation of neural networks for automated calving front detection.

Automated calving front extraction is a long sought after goal, that recently gained new attention thanks to advances in modern computing technology and increasing availability of satellite EO data. The use of deep learning/neural networks – the subject of this paper - to achieve this is very promising indeed. This paper by Cheng et al. is a welcome addition to existing literature on this topic as is the associated dataset for the community, expanding on previous efforts. In particular, the extension to the early days of Landsat acquisitions, enabling the retrieval of a dense Greenland dataset covering nearly 50 years, is of great relevance for exploring factors that are controlling the varying response to climate change for the outlet glaciers in this region and for quantifying their contribution to future sea level rise.

That said, I do think there is some room for improvement of the manuscript, both in terms of presentation as well as substance. What is missing is a clear description of the objectives in the introduction, based on a literature review on the current standing, issues and knowledge gaps in calving front extraction based on machine learning. This gives the reader, not so familiar with the topic, as well as the presented methodological decisions and improvements a better context. Another weak point is that the 'data analysis' does not go any further than a figure showing a rather simple comparison with existing data sets along a flowline of one single glacier. Even though this is clearly written as a methodology paper this is a missed opportunity to showcase a nice data product in my opinion. Perhaps something can be said about general trends in advance/retreat in different regions. Also, I think some sections and descriptions are too brief and need further expansion. Further comments and suggestions for improvement are provided below:

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Specific Comments:

Pg 1 – Ln 2: The results uses -> the method uses

Pg 1 – Ln 6: CALFIN provides improvements: briefly describe these improvements

Pg 1 – Ln 7: CALFIN's ability to generalize to SAR imagery is also evaluated: briefly describe the outcome.

Pg 1 – Ln 8: ..deviating by 2.25 px -> deviating by on average 2.25 px

Pg 2 – Ln 4: Previous techniques -> Previous automated techniques

Pg 2 – Ln 3: . . .is a a strong. . . -> is a strong

Pg 2 – Ln 7: Something seems to be missing after this sentence, what has been done already on this topic and what are you going to do/improve in this study? See also above issue raised above.

Pg 2 – Ln 9: Sect 4.1 -> Sect 4

Pg 2 – Ln 9/10: Sect. 5 and Sect. 6 shows as well as discusses the results -> Sect. 5 and Sect. 6 show and discuss the results.

Pg 2 – Ln 12: Sentinel: Sentinel-1 or 2? Not clear from table or text.

Pg 2 – Section 2: This section is too brief and there is no need to add the table if only Landsat data is used in the current work as stated. Aside, it is not clear which Sentinel is meant, e.g. the Sentinel-1 SAR satellite has a repeat cycle of 6/12, not 10/12, Sentinel-2 has 10 days but is optical. Why not use higher resolution 15 m panchromatic band Landsat data?

Pg 2 – Ln 15: The basin selection is based on high drainage volume, based on what source? Also, for robust methodological development it is better to base the selection of study sites on different (fjord/glacier) morphology, scale or front type (e.g. with melange, no melange).

Pg 2 – Ln 20: remove space at beginning.

Pg 3 – Ln 1: This produces -> This results in

Pg 4 – Ln 2: resized: Do you mean crop or actually resize, as the latter would involve changing the resolution?

Pg 4 – Ln 1: ..cloud pixel.. -> how are the cloud pixels identified? Did you include a cloud detection?

Pg 4 – ln 14/16: encoder/decoder: it would be nice to show this in the figure for clarity

Pg 4 – Ln 22: 224 px: wasn't it 256, can you clarify?

Pg 4 – Ln 22: What is the effect of the reduction in input resolution?

Pg 6 – Ln 4: This section is too brief and needs more details on the confidence measure and applied filter criteria.

Pg 6 – Ln 12: Fjord boundary masks: how are these created and based on what source data? Can you expand on this? Also, are they static for the whole time series? I can imagine that ice thinning over several decades affects the ice/ocean/fjord boundary.

Pg 6 – Ln 18: . . .verification each. . . -> verification of each

Pg 7 – Ln 2: error -> the error

Pg 7 – Ln 7: data that is -> data that are

Pg 8 – Ln 2: list tables that print -> show tables with

Pg 8 – Ln 8: CALFIN-VS-L7-only/none: explain what this means

Pg 8 – Ln 11: Antarctic basins: this contradicts Pg 2 - Ln 14 stating that the area of interest is restricted to Greenland

Pg 8 – section 4.3.1: The varying conversion of pixels to distance in this paragraph is confusing, can you clarify this, what is the pixel resolution, how is this calculated, why

does it vary?

Pg 9 – Ln 2: generalization capability: please briefly explain what this means.

Pg 9 – section 4.3.3 & 4.3.4: For both intercomparisons the mean pixel distance comparisons is skewed, in the caption of figure 11 it is also mentioned 'undeservedly'. How then can we use this metric to decide which one is better?

Pg 11 – Ln 14: make sure to make this an active link.

Pg 12 – Ln 3-5: Too brief, more discussion needed to explain the loss function.

Pg 12 – Ln 5: Explain what is meant by "over-fitting"

Pg 12 – Ln 12-13: Once. . .processing: sentence incomplete.

Pg 12 – Ln 25: While the methodology is restricted by its preprocessing requirements and inability to handle branching/nonlinear calving fronts: How are the preprocessing requirements different?

Pg 12 – Section 6.2: Some of this existing work description should go to the introduction to show where gaps/shortcomings are and as motivation for the improvements introduced in the current implementation.

Pg 13 – Section 6.3: As mentioned in the general comment, this section is hardly a data analysis and very brief, even the description of the figure. A clear improvement, obvious from the figure, is the much denser and longer temporal coverage, this should be mentioned somewhere.

Pg 13 – Ln 2: validate -> compare

Pg 13 – Ln 7: length change -> I would rather call it "advance and retreat"

Pg 13 – Ln 18/19: To perform . . . the results: this sentence seems incomplete.

Pg 14 – Ln 18: ground truth fronts: None of these fronts are actual ground truth fronts, even when manually delineated (also elsewhere in manuscript).

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Pg 15 – Ln 2: Overall, the goal of . . .: this goal was nowhere clearly stated

Figures/Tables

Most figures lack a proper scale bar, this would be very helpful to evaluate the different results. Also, individual lines are sometimes very difficult to distinguish (for example in fig 10). Not sure if this can be improved.

Table 1: As no data other than Landsat is used in the study, I don't see much need for this table. See issue raised previously.

Figure 1: For a nicer figure, updated maps, without gaps, are available at the Greenland Ice Sheet CCI website (see: http://esa-icesheets-greenland-cci.org/)

Figure 2: The legend should provide a range

Figure 3 & 5: No need to add c) in my opinion

Figure 6: It appears that several 'difficult' sections/gaps are connected with a straight line, how does this work (e.g. what gap tresholds are used)?

Figure 6a: I don't see a red coastline mask

Figure 8-12: There seem to be no references in the text to these figures, please add.

Figure 12: caption "Sample" -> Examples

Figure 13: caption "1995-2016 (ESA-CCI), 2005-2017 (MEaSUREs)": check years vs line in image, ESA CCI starts in 1990, MEaSUREs in 2000

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