

## ***Interactive comment on “Automatically delineating the calving front of Jakobshavn Isbræ from multi-temporal TerraSAR-X images: a deep learning approach” by Enze Zhang et al.***

### **Anonymous Referee #1**

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#### General comments:

This paper presents the application and study of emerging machine learning techniques towards automatic calving front detection. Specifically, it utilizes a deep neural network architecture, U-Net, to automatically segment raw SAR imagery along calving fronts into digitized vectors. This study focuses on Jakobshavn from 2009-2015, and performs analysis using additional data products to cross-validate the results. The analysis correlates and validates data from the Greenland Ice Sheet CCI project, Bed-Machine v3 bedrock data, and the automatically determined calving fronts from this paper. Images to describe the study, and accompanying data tables, help communi-

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cate the work done.

The paper is well written and covers a novel emerging technique (deep learning in the cryosphere). Therefore, I would like to recommend it for publication. However, I do have two concerns, though it may not be within the scope of this paper. These concerns regard the paper's wider implications/context, and may impact the rigor/novelty/impact of this study.

The first concern relates to existing similar work conducted by Mohajerani, Y., et. al., in Remote Sensing. Please refer to their paper here: <https://www.mdpi.com/2072-4292/11/1/74/htm>. While the methods are no doubt similar (deep-learning UNet), the one covered in this paper seems to be more accurate and more comprehensively analysed, though by virtue of being more focused in scope. For comparison, this paper covers Jakobshavn, TerraSAR-X, while Mohajerani covers Jakobshavn, Sverdrup, Kangerlussuaq, Helheim, Landsat 8 in Mohajerani's paper. I think it is helpful to have corroborating evidence of the validity of this methodology - especially published in The Cryosphere. Regardless, while I can still make my recommendation, I will leave others to discuss this matter.

The second concern I have relates to the generalizability of the network. While I acknowledge this is not the focus of the case study, the following are some questions I, and perhaps others, would express interest in knowing.

#### Specific Comments

Page 7 Line 1 - It was mentioned that summer imagery has higher performance than winter imagery. Though the ice melange has similar texture to glacial ice, should it not be possible for further training to be performed to close this gap? Perhaps the network needs additional capacity to handle this differentiation?

Page 15 Line 6-8 - It is mentioned that this methodology can be applied to other domains. Do you have any analyses on how the network performs on other glacial do-

mains, such as Sverdrup, or Helheim?

Page 2 Line 29 - Does this network rely on features only visible at 3.3-3.5m? i.e., does lowering the pixel resolution adversely affect accuracy/performance? -Similarly, can the network handle lower resolution 30/60m datasets like Landsat?

Page 2 Line 34 - It is mentioned that the cloud cover issue is avoided. However, some light cloud cover does not always obscure calving front edges. Would it be feasible to train the network to handle these issues, to allow greater temporal resolution/constraints by not eliminating minor cloud covered images from the study? By extension, could the network handle Landsat 7 scan line errors, given additional training?

If this application/methodology is to be impactful beyond the scope of this study, it must be able to perform well on other not just on other conditions, but on other glacial domains, or even other datasets, without too much additional effort in retraining. Again however, it is not necessary to cover this, as I understand the above is not within the scope of the paper.

Nevertheless, this paper still represents a good case study on the application of these emerging machine learning techniques as applied to the cryosphere.

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2019-14>, 2019.

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