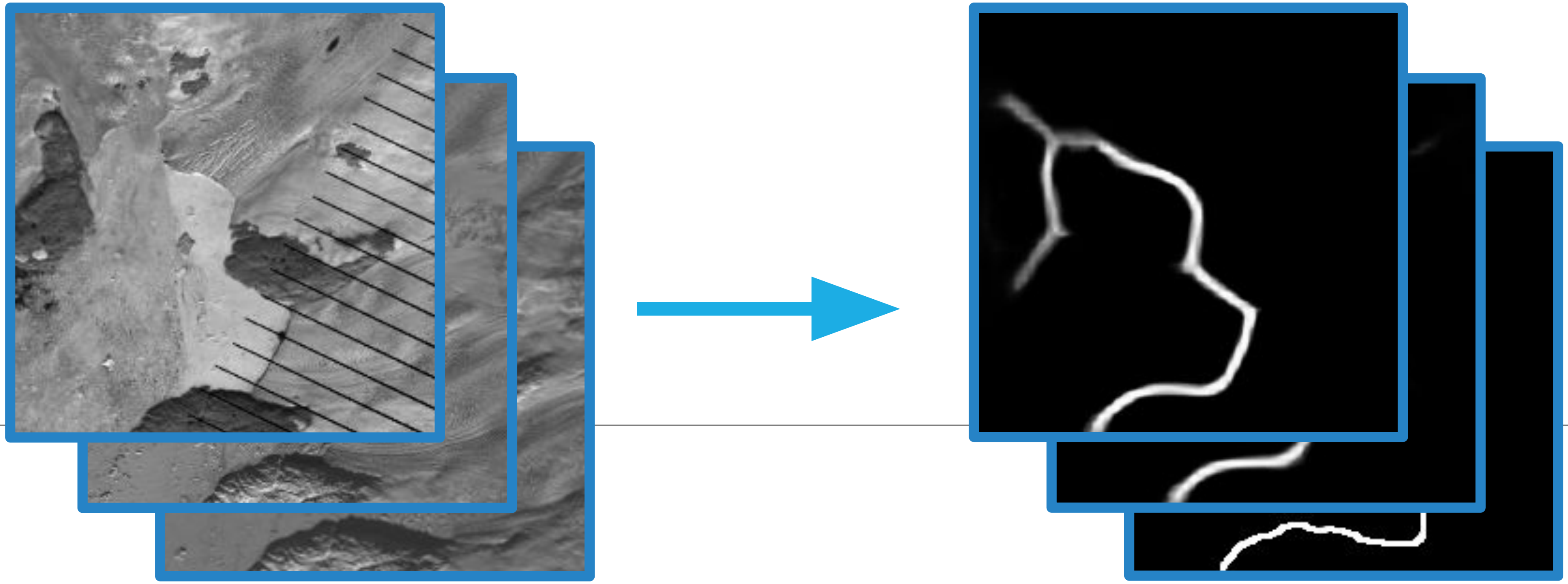
CALFIN: A Calving Front Mask Dataset for West Greenland, 1972-2018



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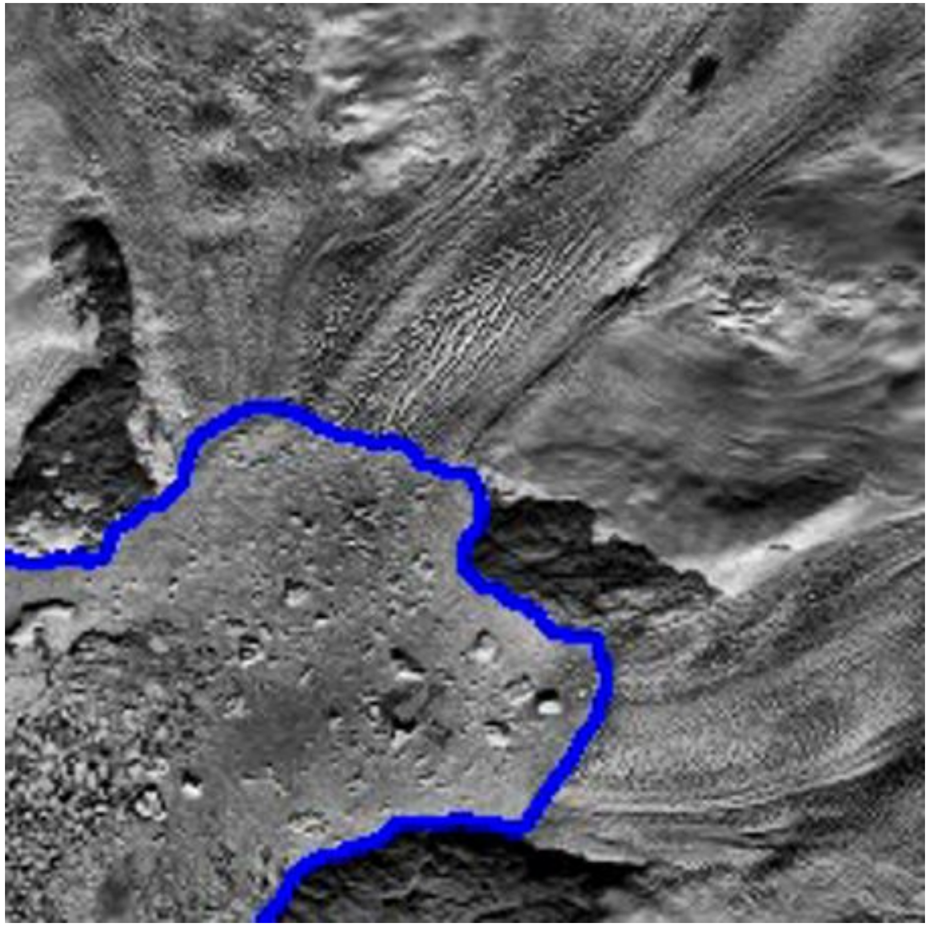
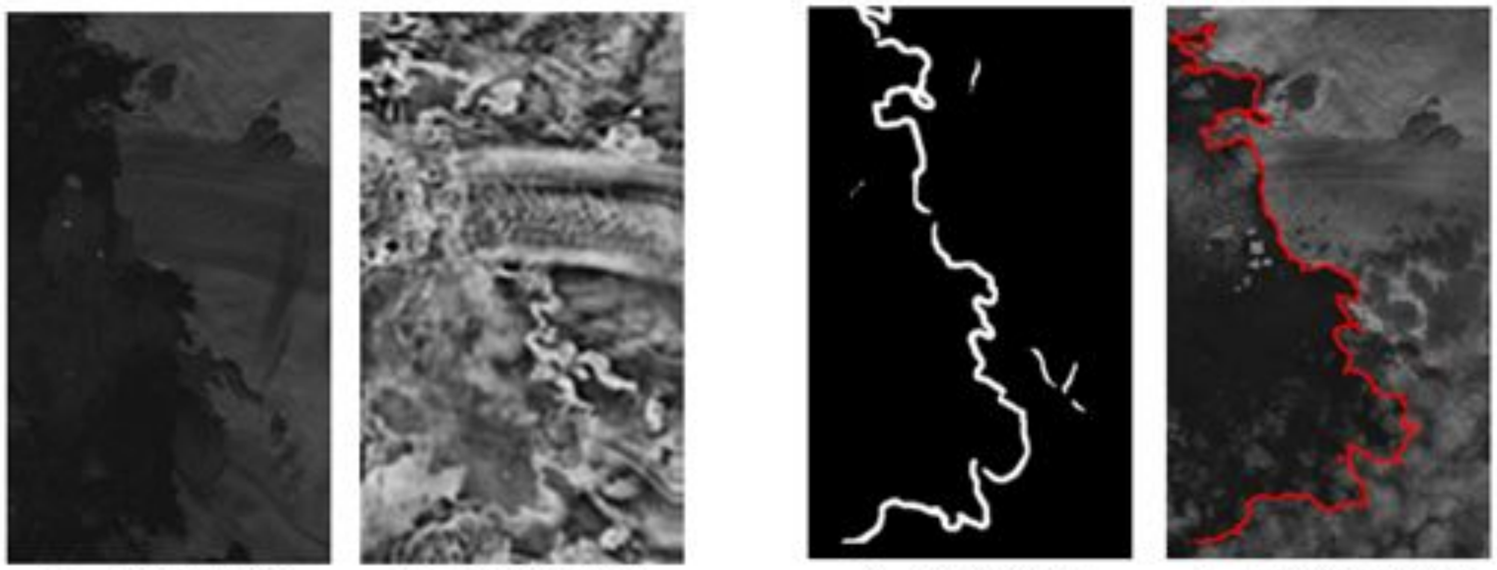
Motivation

- Determining where glaciers end is useful data
- Manual labeling is time intensive
- Many glaciers not labeled, new data needs to be added



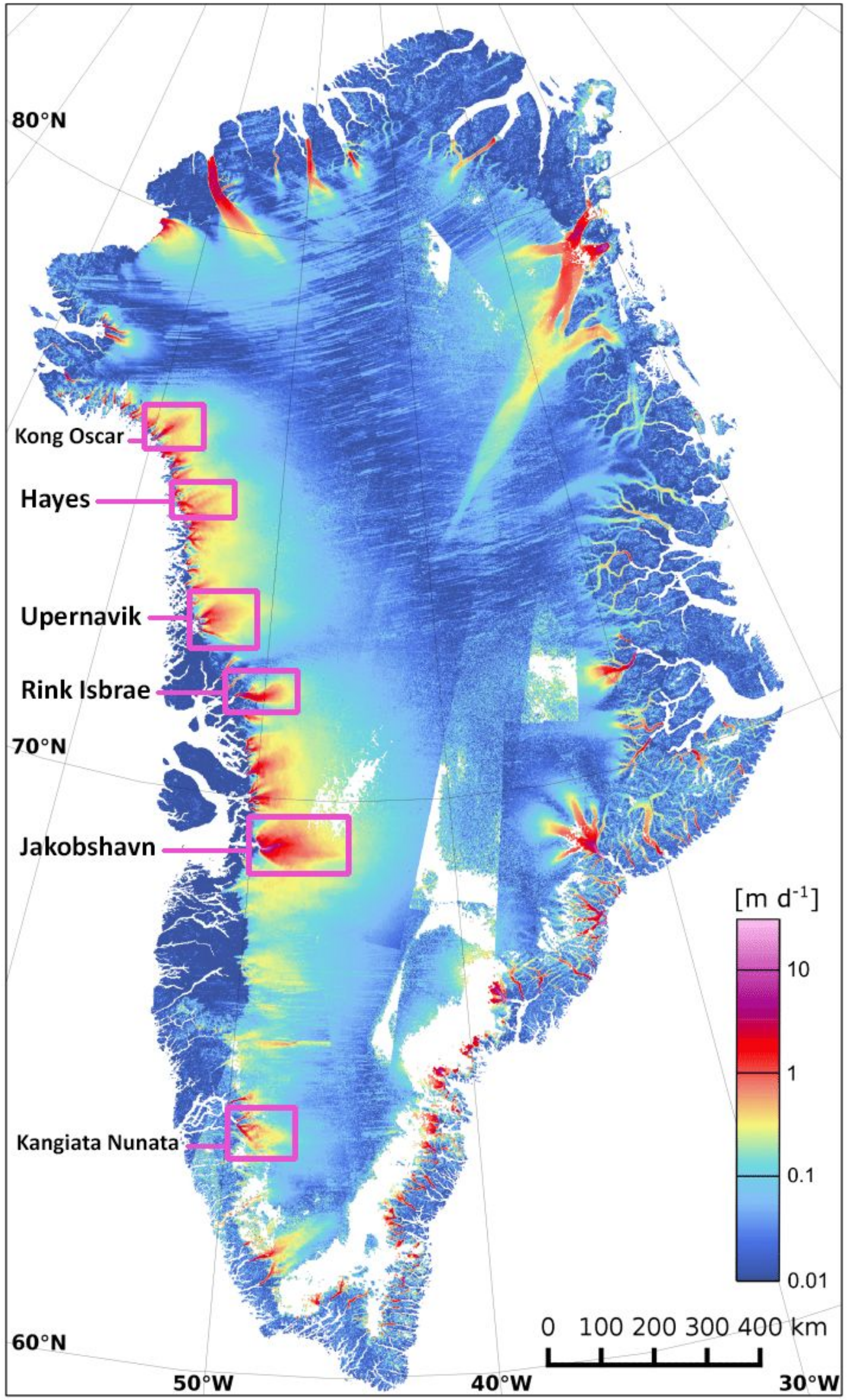
What is CALFIN?

- Dataset of calving front masks for West Greenland
- Data source: Landsat, 1972-2018.
- Automated with convolutional neural network tool, CALFIT



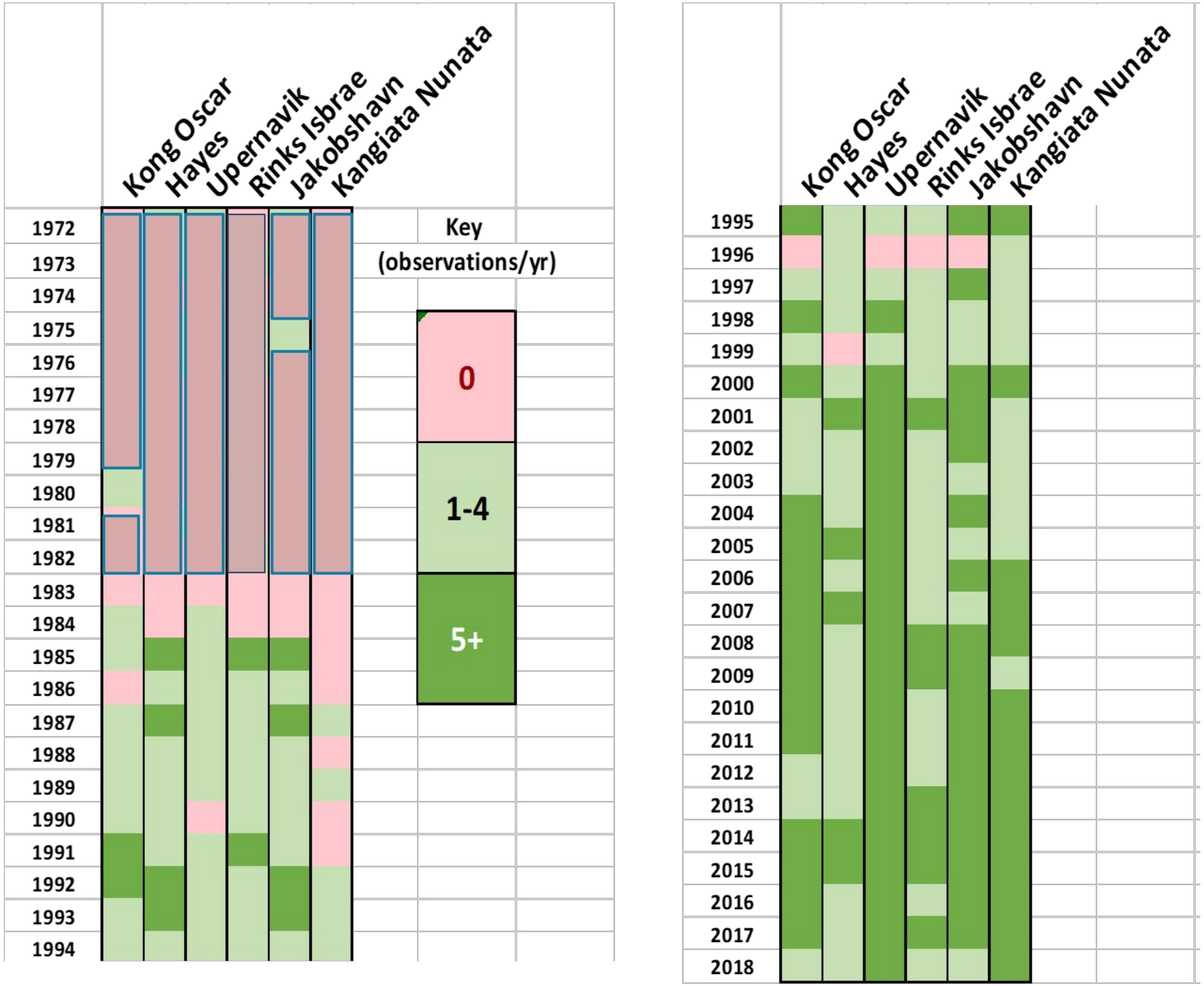
Spatial Coverage

- Data availability along West Greenland, for the 6 highlighted basins
  - Plotted over velocity map (Naglar, 2015)
- Basins selected for equal sampling of coastline
- Basins selected for study potential/high velocities



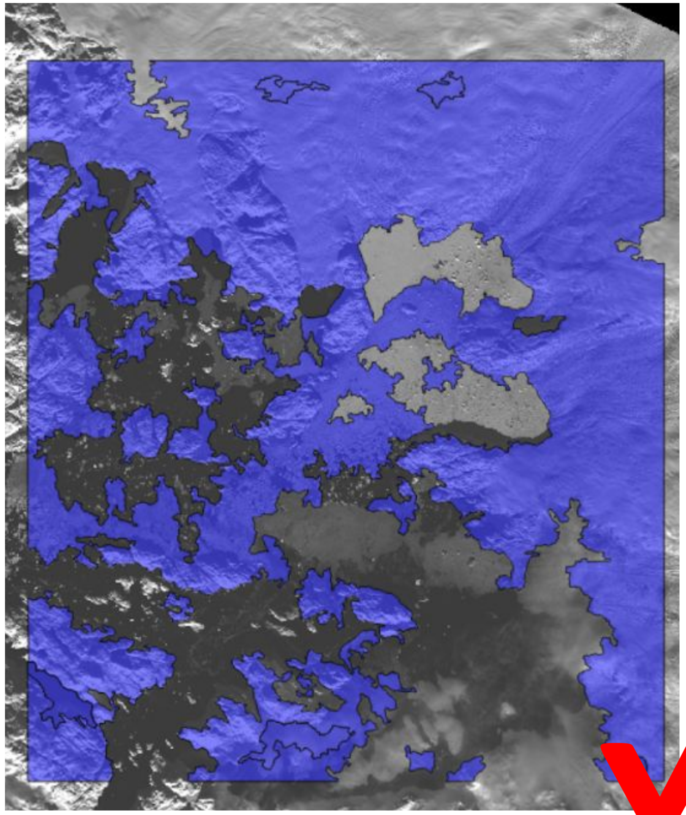
Temporal Coverage

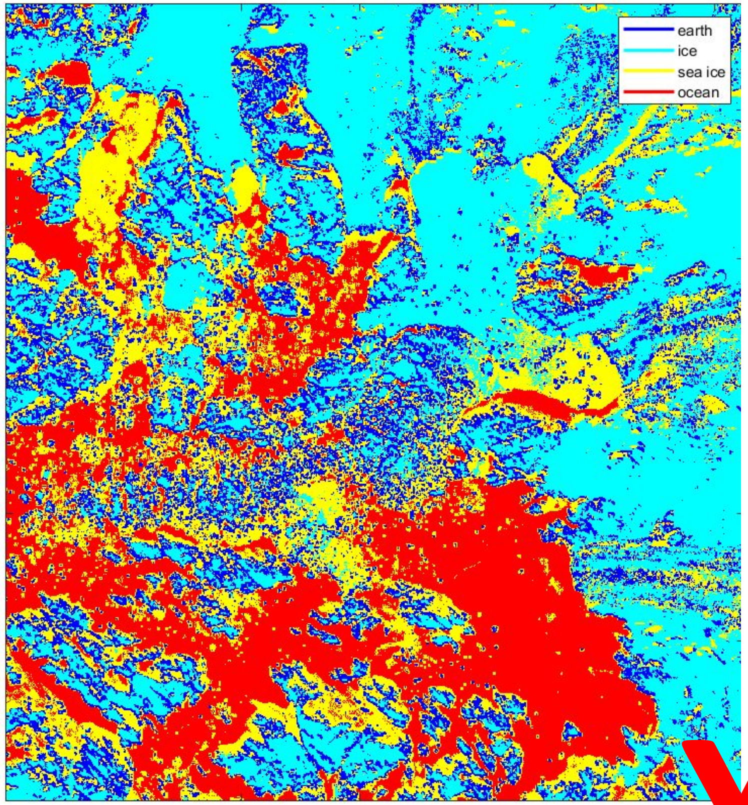
- Landsat availability per year, for all 6 basins.
- Gaps due to clouds or lack of classifier confidence
- Color key shows rough number of observations per year.



Approach

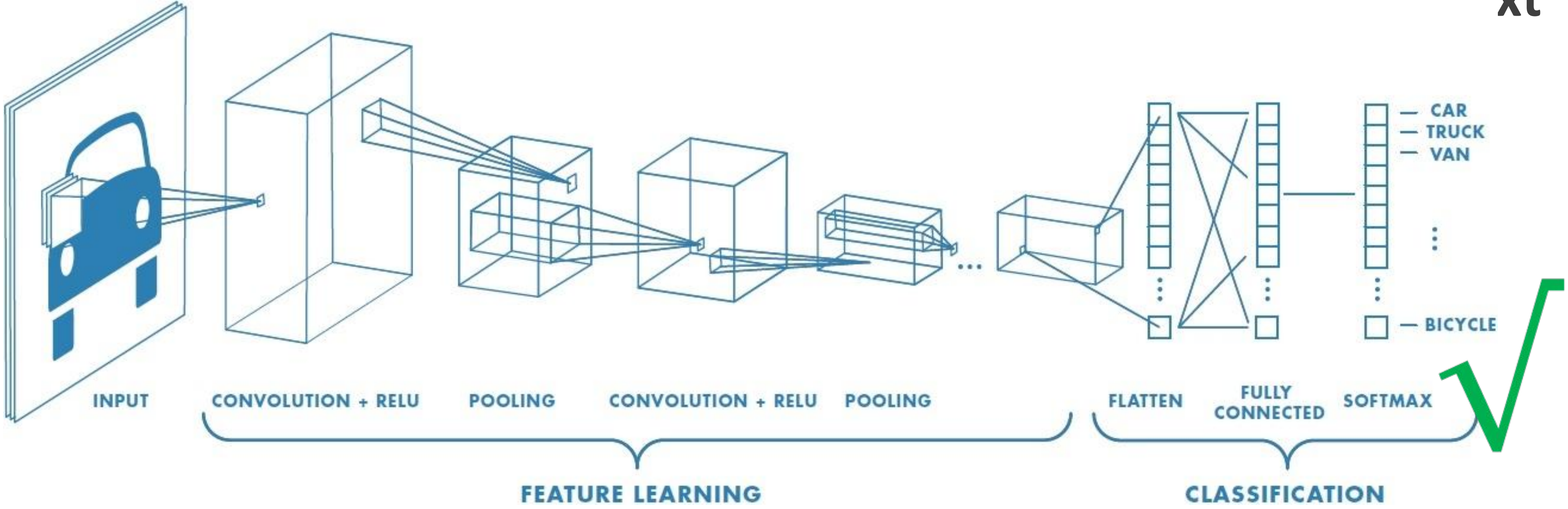
- Edge detection not enough
- Texture analysis not robust
- Neural networks provide solution





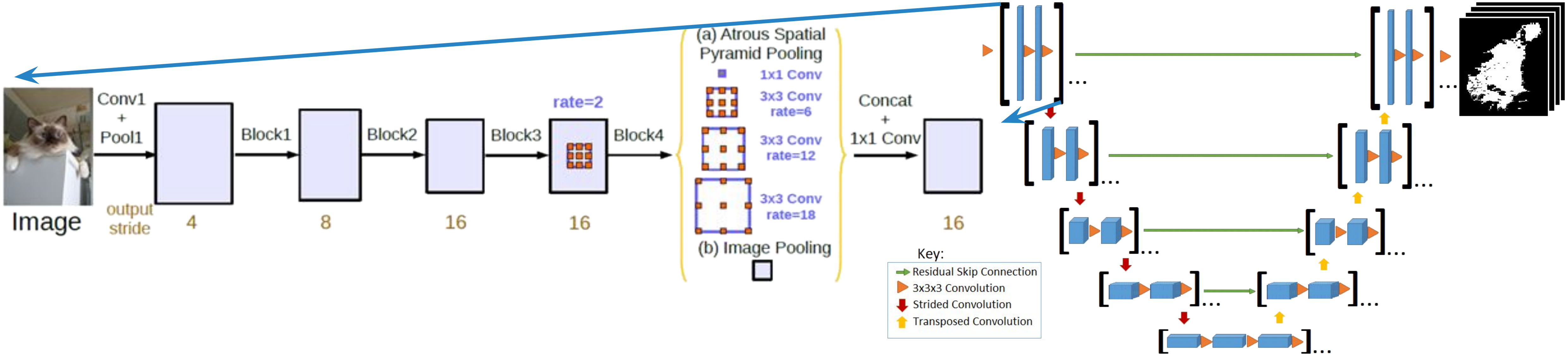
Approach – Neural Networks

- NNs automatically learn features and relations between features
- Convolutional NNs allow for shared filters, shared local context



CALFIT - Architecture

- UNet CNNs allow for shared near-global context, pixel-level segmentation, and efficient computation (O Ronneberger, 2015)
- DeeplabV3+ with Xception based UNet offers state of the art results (LC Chen, 2018)



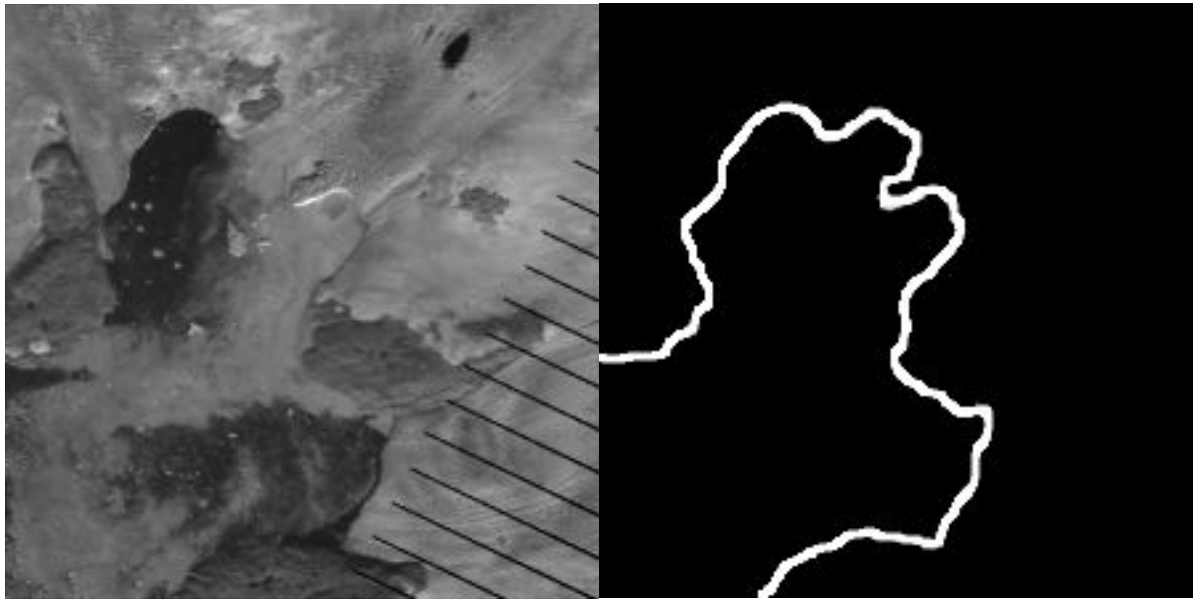
CALFIT Insights

- Global context is needed
  - Local context not as important
  - Strong dependence on having full front + glacial ice
- Train on problematic images
- Augment data, but be careful with scale/distort

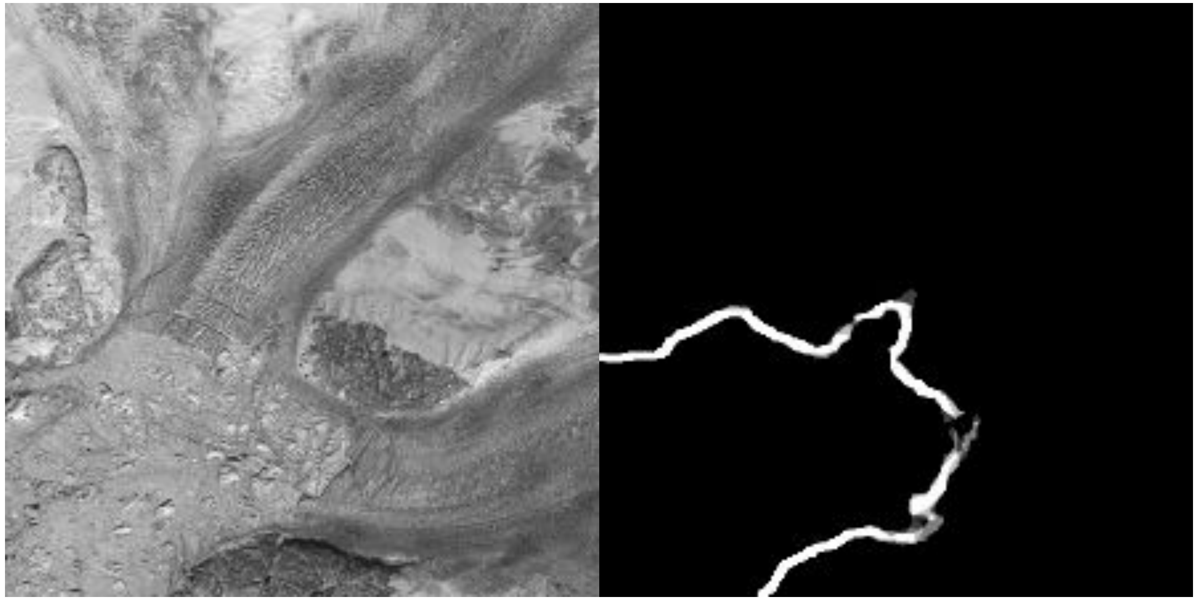
Architecture	Best IoU
UNet 256 32-4-2	0.3802
Deeplabv3+ MobileNetV2 224	0.6956
Deeplabv3+ MobileNetV2 256	0.6026
Deeplabv3+ Xception 224	**0.8794**
Deeplabv3+ Xception 256	0.8986
Deeplabv3+ Xception 384	0.8257
Deeplabv3+ Xception 512	0.6956

Results & Error Analysis

- Upernavik
  - Able to capture glacial tongues
  - Uses texture gradient to detect ice mélange boundary



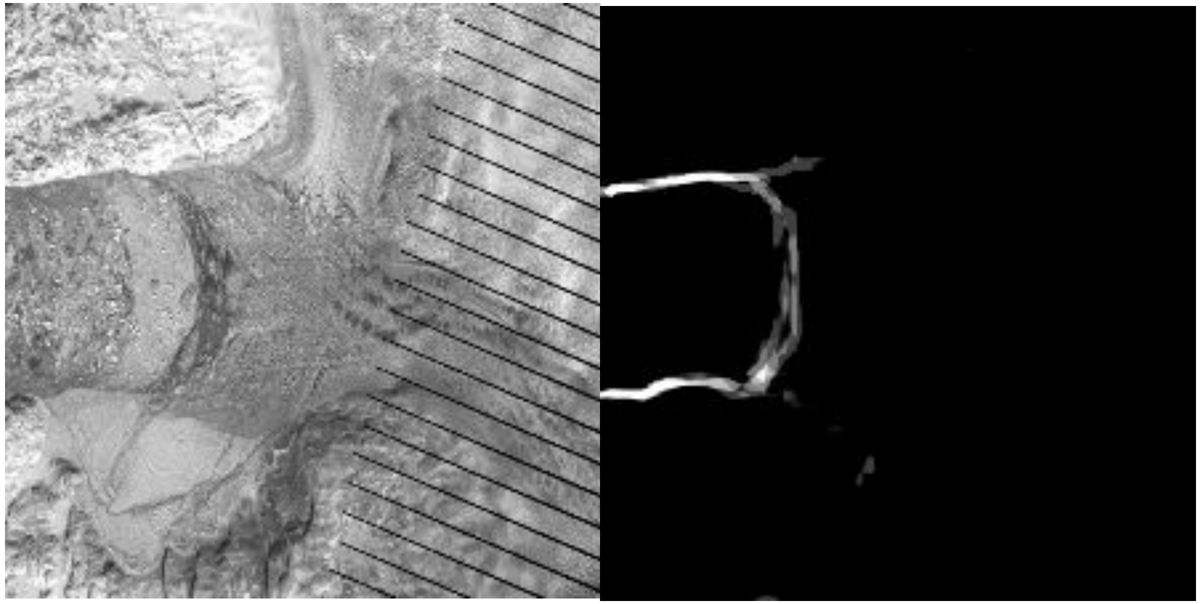
Upernavik-NE 2007-08-10



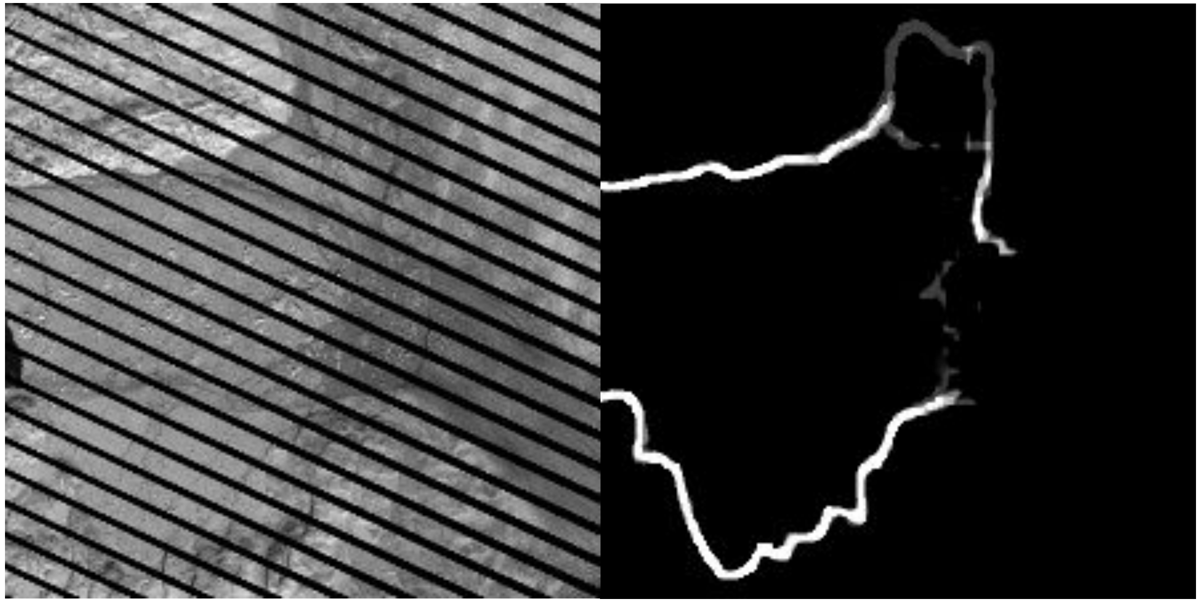
Upernavik-NE 1988-05-16

Results & Error Analysis

- Jakobshavn
  - Ice mélange causes uncertainty
    - Manageable with postprocessing
  - Compression/scaling may decrease accuracy



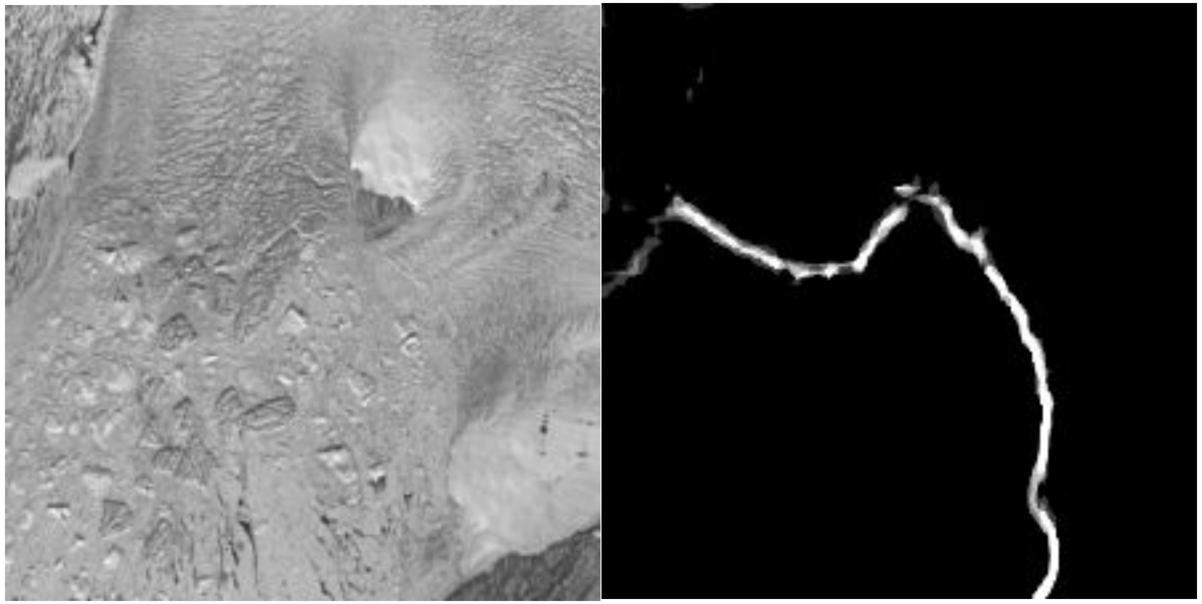
Jakobshavn 2004-04-10



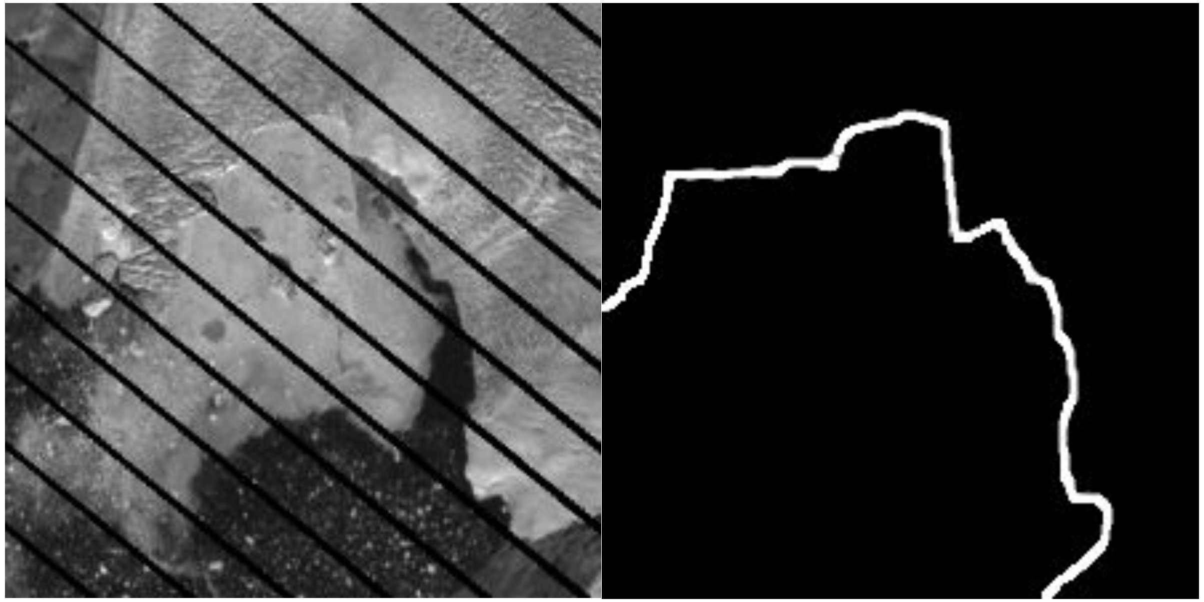
Jakobshavn 2011-04-21

Results & Error Analysis

- Hayes
  - Extra training allows ice mélange to be more clearly separated
  - Not as consistent due to complexity of fronts



Hayes 1992-07-03

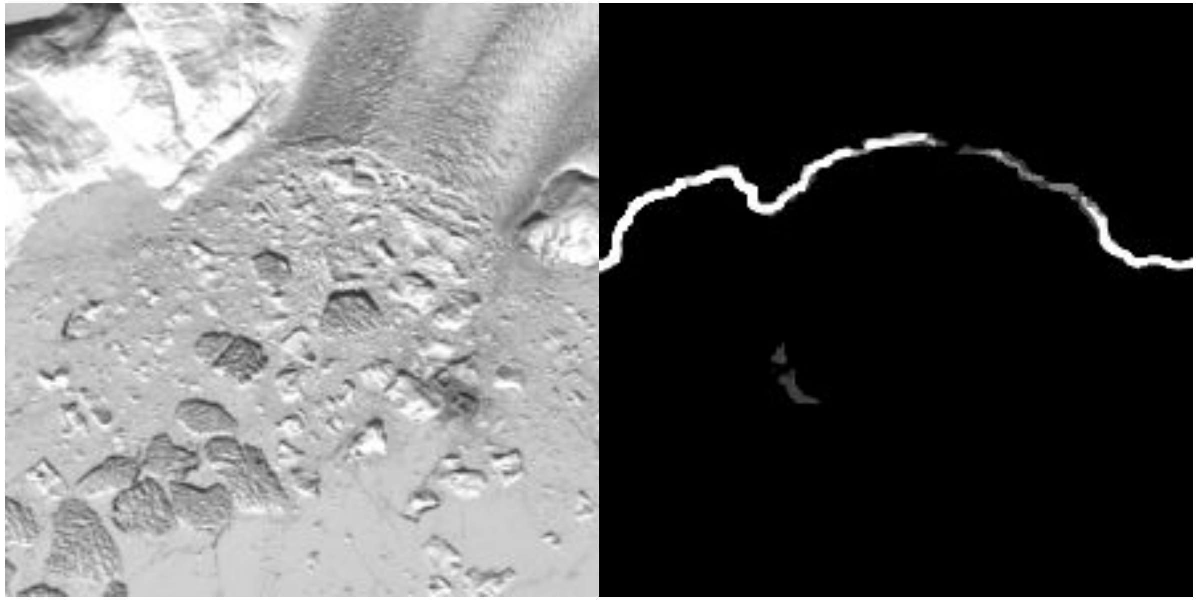


Hayes 2008-07-30

Results & Error Analysis

- Kong-Oscar
  - Worst accuracy all around
  - Requires additional training

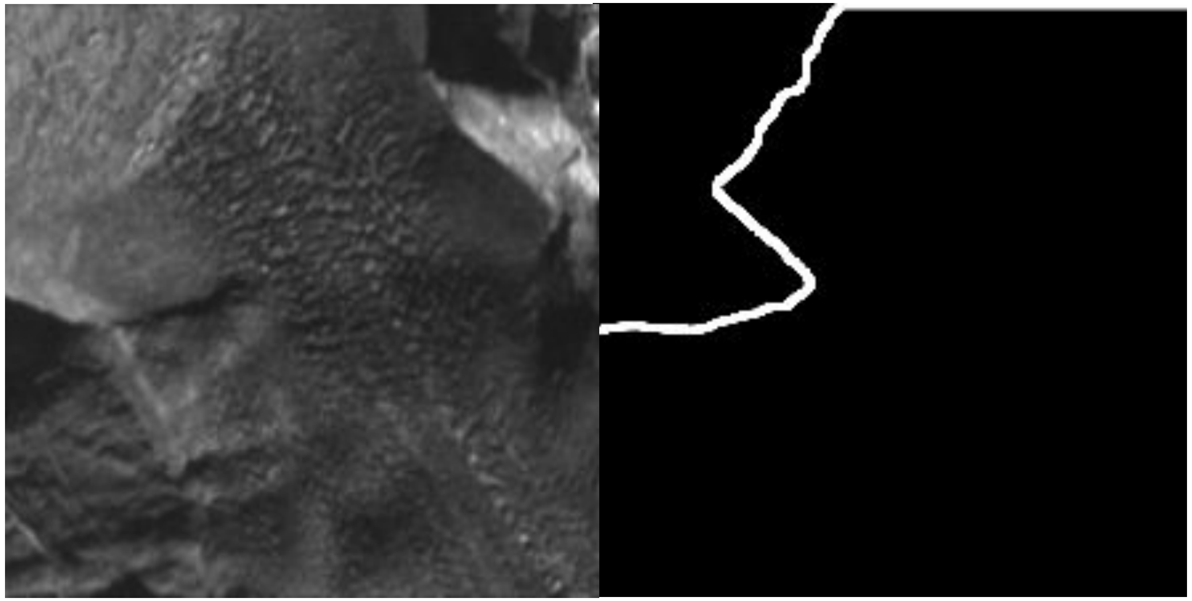
Kong-Oscar 2000-08-07



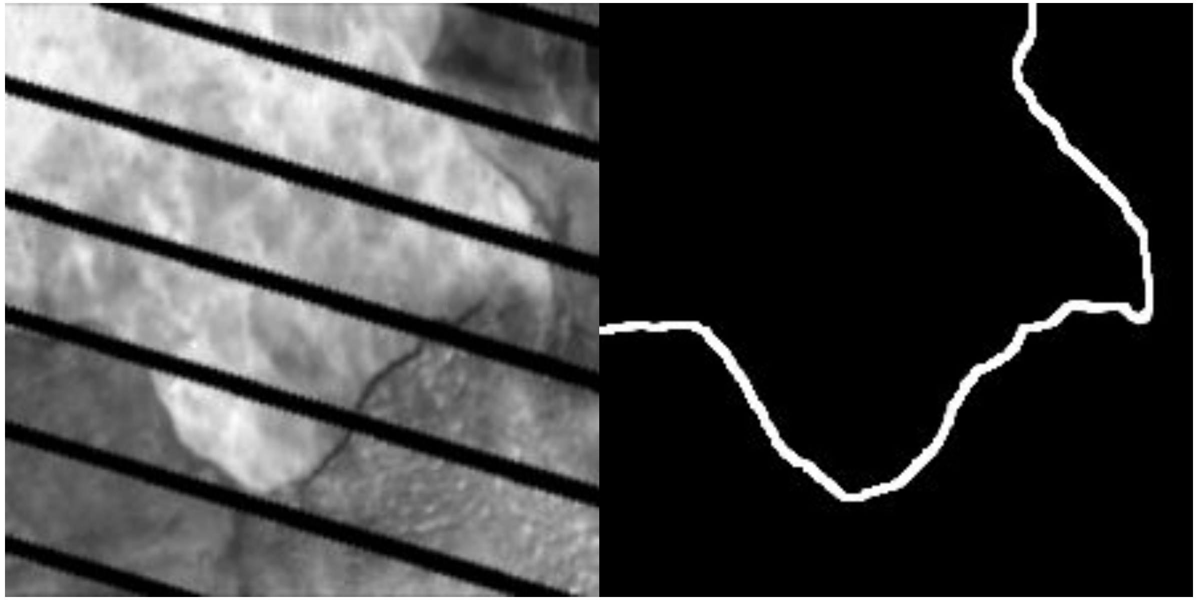
Kong-Oscar 2003-05-03

Results & Error Analysis

- Kangiata-Nunata
  - Handles light cloud cover/Landsat 7 scanline errors
  - Shows signs of overfitting/memory effects



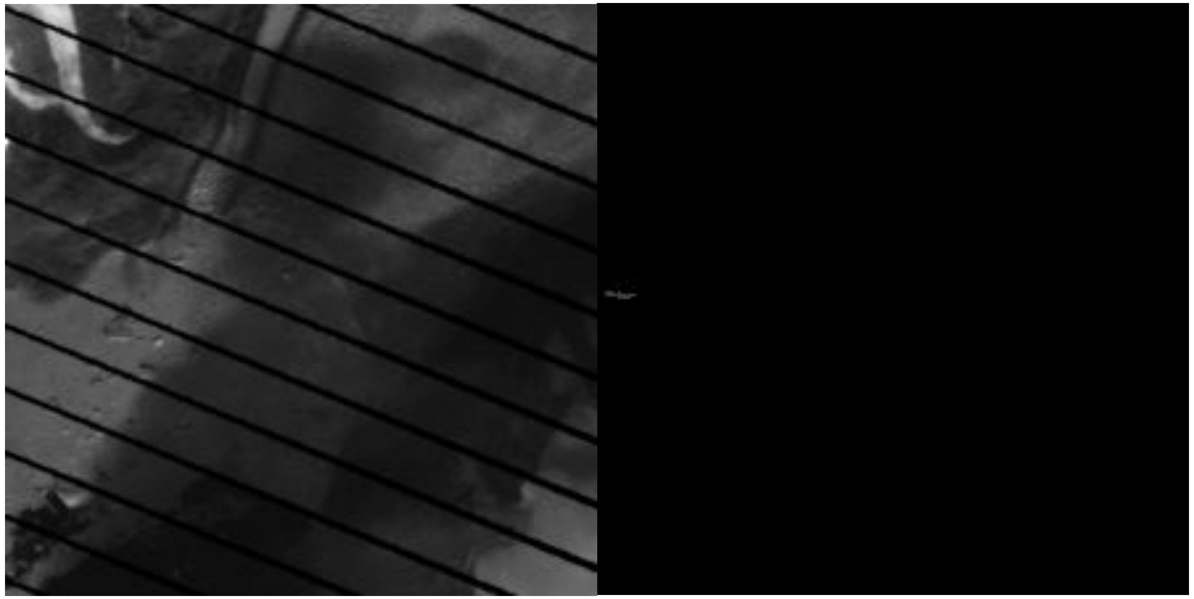
Kangiata-Nunata 2000-02-22



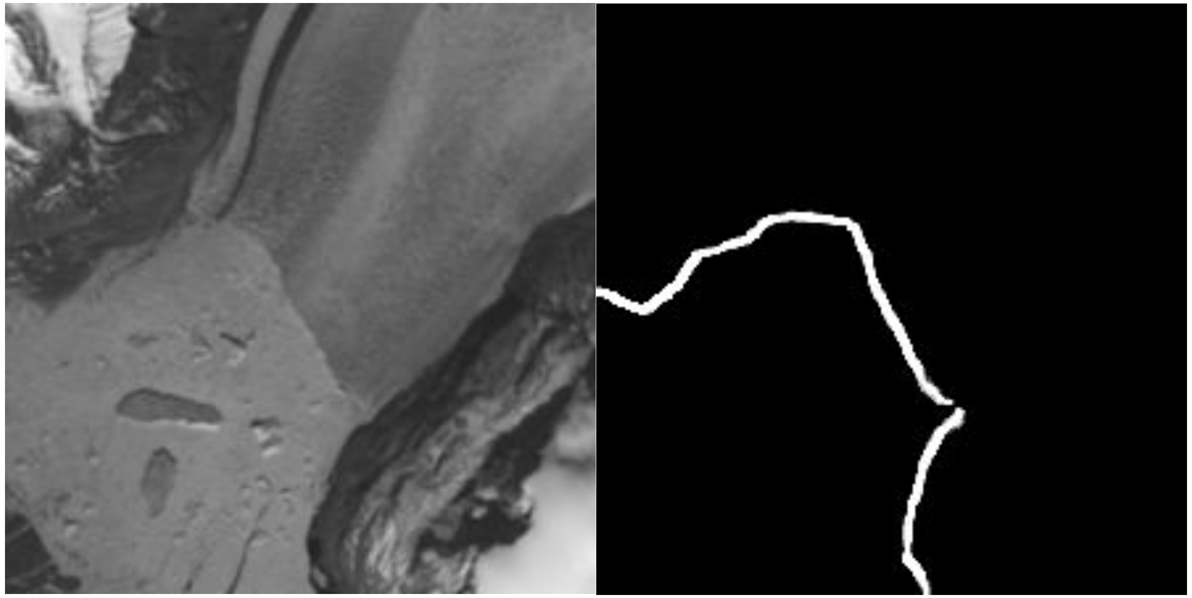
Kangiata-Nunata 2009-08-09

Results & Error Analysis

- Rink Isbrae
  - Some images need to be manually labeled and retrained on



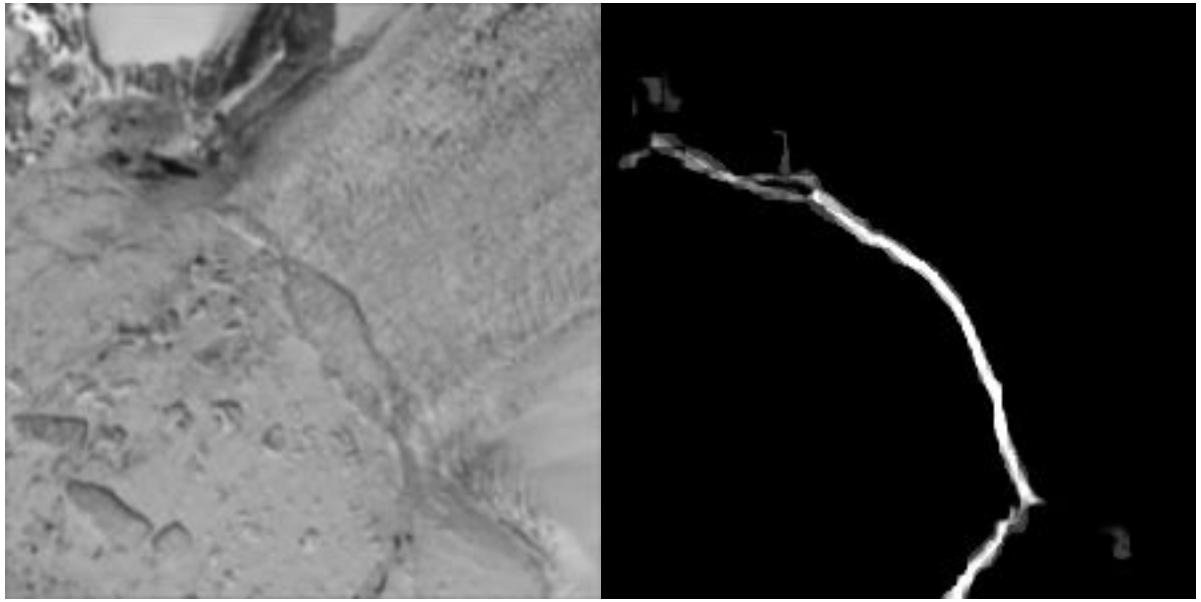
Rink-Isbrae 2004-09-13



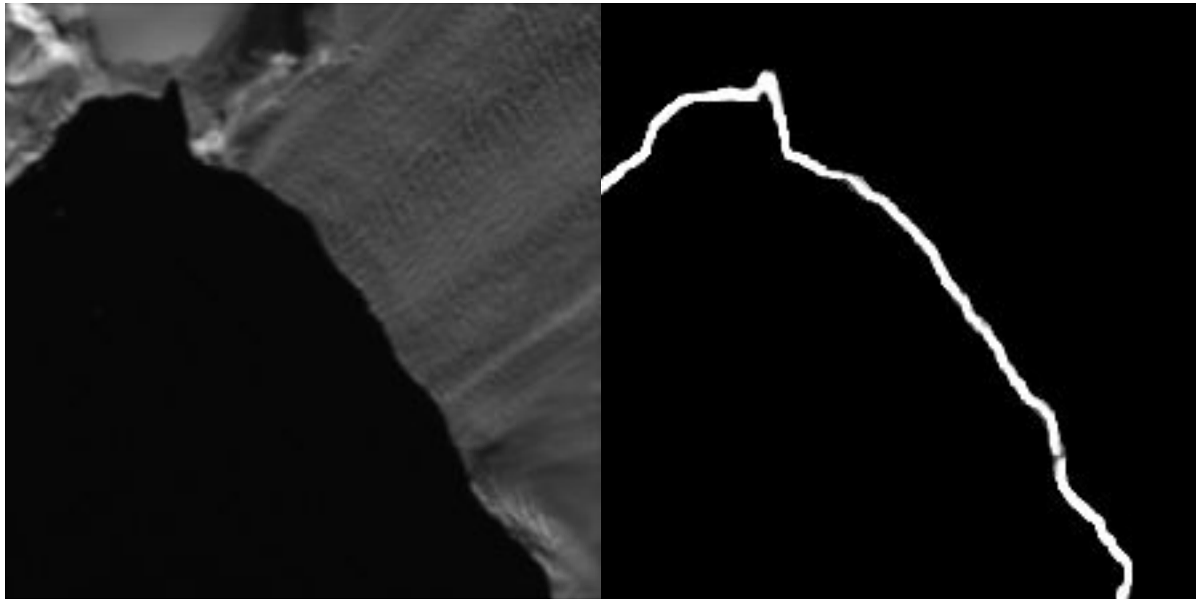
Rink-Isbrae 2018-05-23

Results & Error Analysis

- Docker-Smith North
  - Sparsely trained
  - Calving events handled well
  - Higher texture contrast, higher confidence
- Key goal: generalization



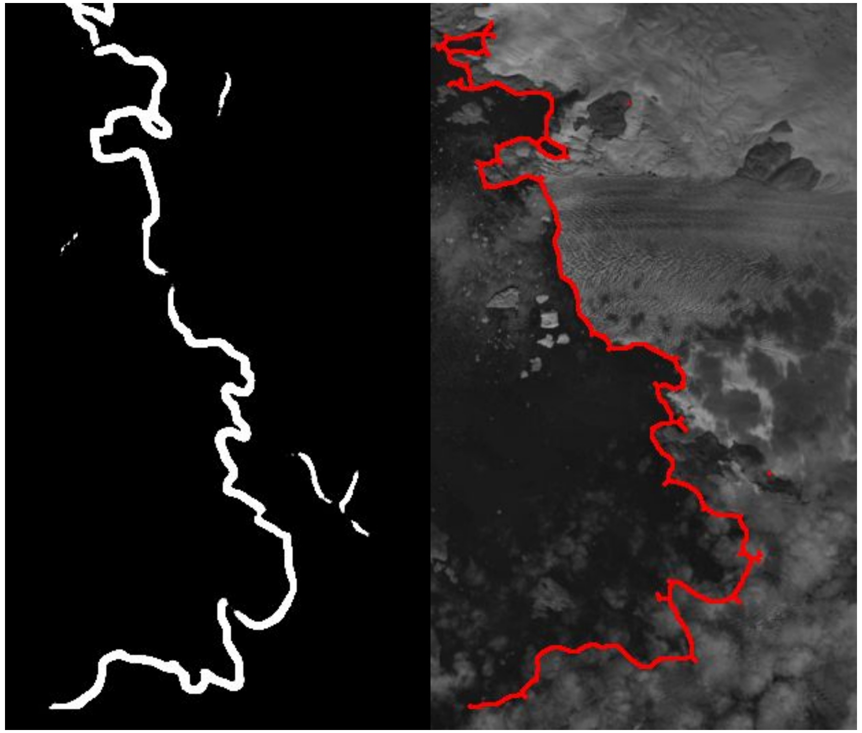
Docker-Smith-N 1997-06-18



Docker-Smith-N 1997-09-22

Future Work - Postprocessing

- Issues:
  - Pixel level mask not as useful as poly-line
  - Temporal information is not propagated
- Solution:
  - Use OpenCV to manually get 1st contour
  - Initialize line and evolve it over time
  - Use NN output to inform evolution



Future Work

- Spatial resolution – accuracy tradeoff
  - Larger input size offers theoretical improvements, practical drawbacks
- Additional data incorporation/evaluation
  - SAR
  - Non-marine terminating glaciers
  - Existing SHP extraction/comparison
- Preliminary results: https://www.ics.uci.edu/~dlcheng/
  - Level 0 Product – unprocessed masks
  - Level 1 Product – postprocessed Shapefiles

Acknowledgements

- CALFIN exists alongside/builds on existing work
- Similar work:
  - **Yara Mohajerani, Michael Wood, Isabella Velicogna, and Eric Rignot.** Detection of glacier calving margins with convolutional neural networks: A case study. Remote Sensing, 11(1), 2019
  - **Enze Zhang, et al.** Automatically delineating the calving front of Jakobshavn Isbrae from multi-temporal TerraSAR-X images: a deep learning approach. The Cryosphere Discussions, 2019:1–20, 2019.
  - **Celia A. Baumhoer, Andreas J. Dietz, and Claudia Kuenzer**

Thank you!