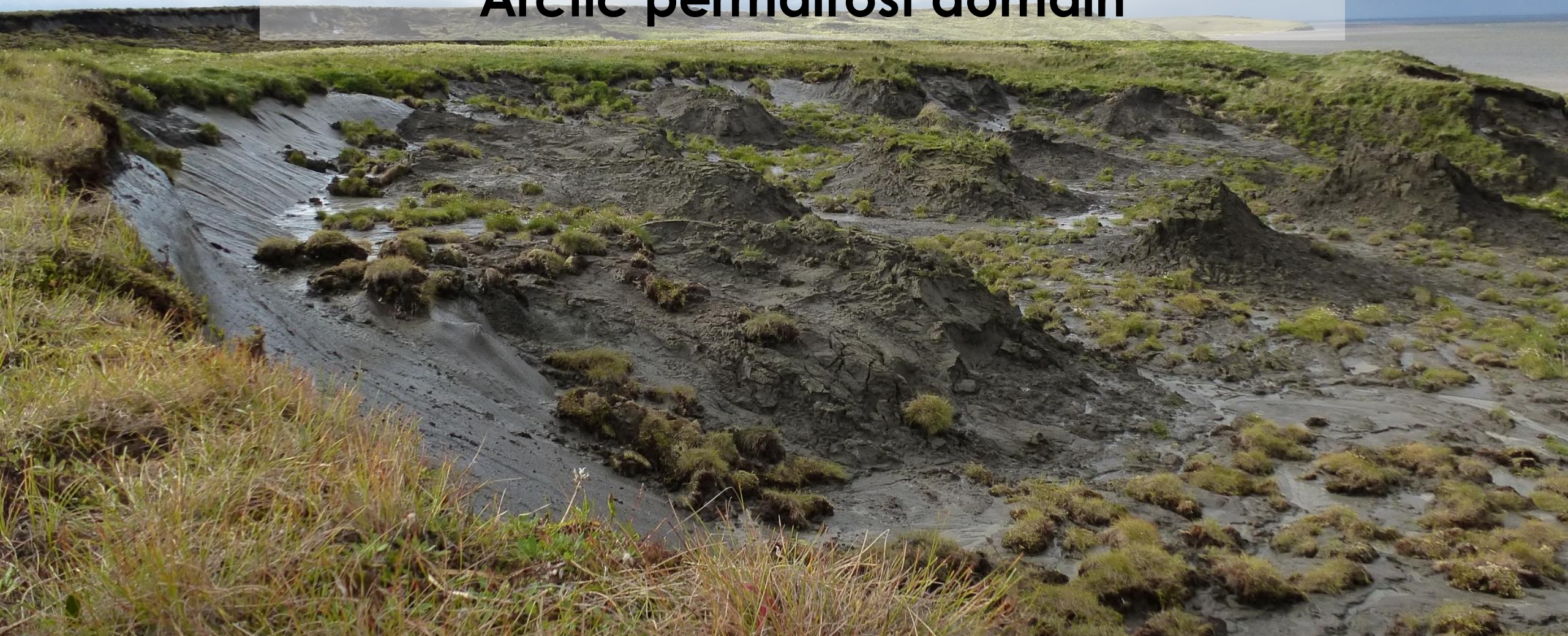




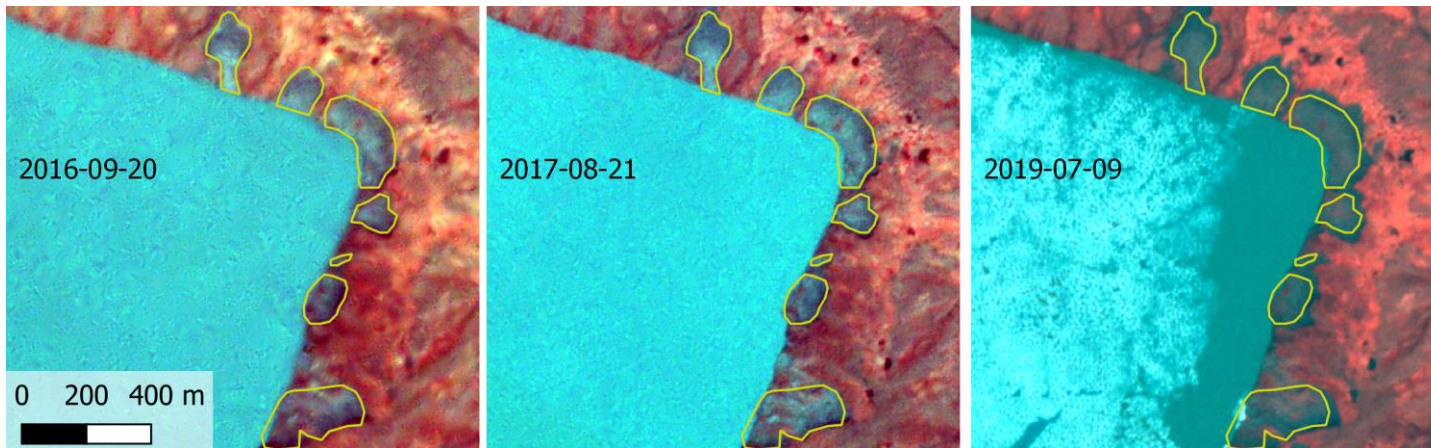
Deep learning for mapping retrogressive thaw slumps and landslides across the Arctic permafrost domain



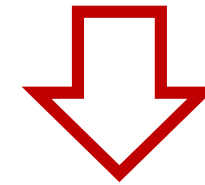
2022-05-12- NSF NNA CryoSlideRisk Workshop @ PennState
I.Nitze, K.Heidler, S.Barth, G.Grosse

Targets

Retrogressive Thaw Slumps



- Erosion
- Dynamic
- Progressive/Polycyclic
- Small (m^2 - $<1\text{km}^2$)
- Often undetected
- Clustered Distribution

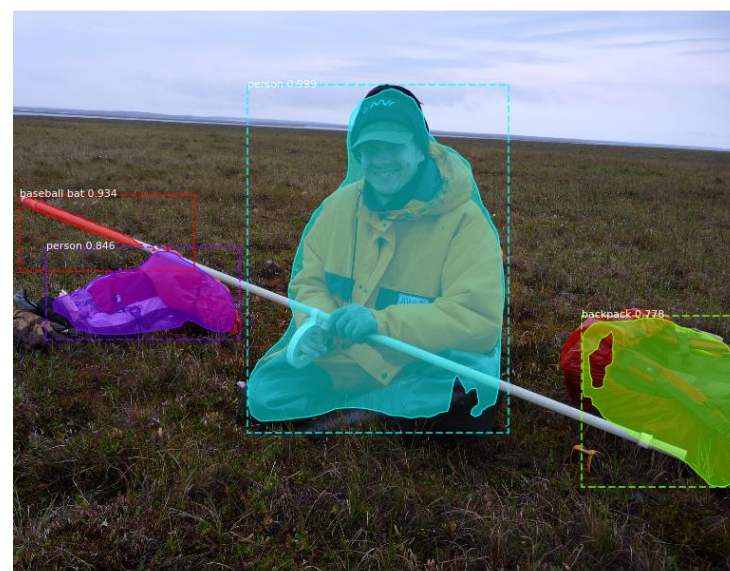


Segmentation Problem

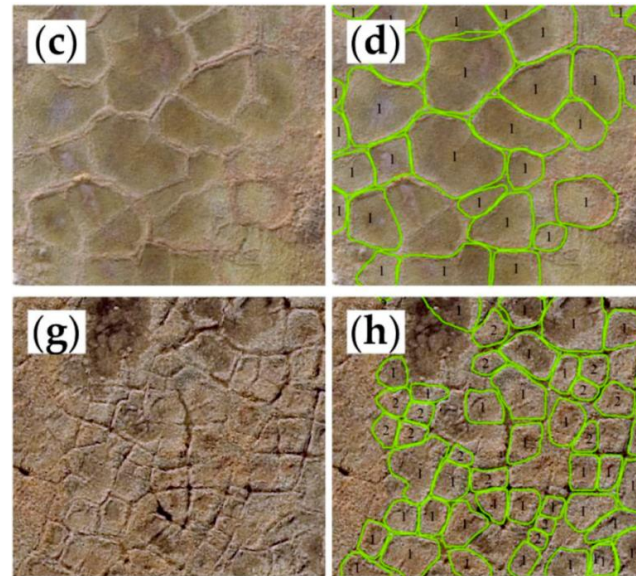
Deep Learning for Object Segmentation

New Data + Techniques available !

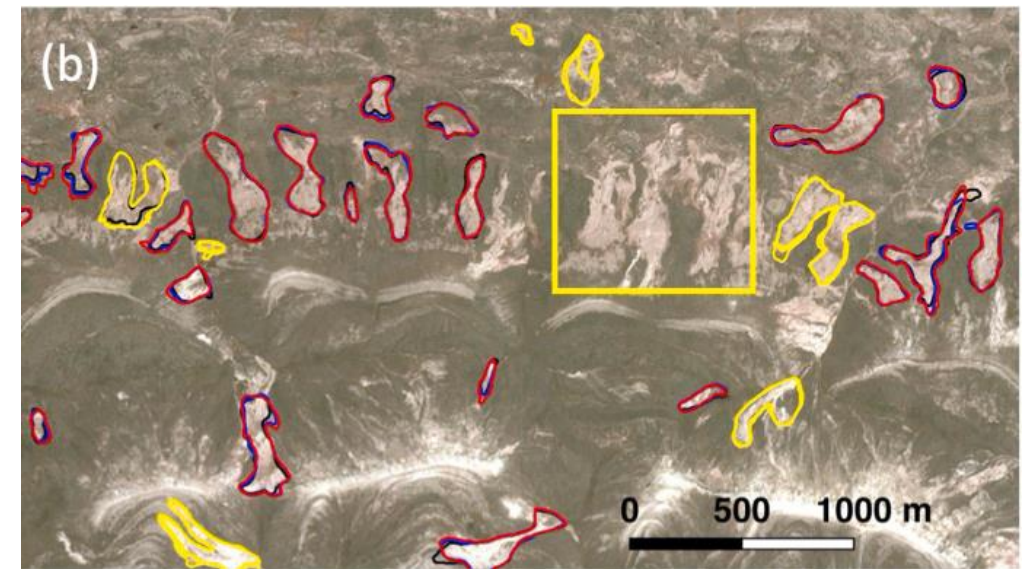
Only few permafrost DL studies -> even fewer for Thaw Slumps



Mask R-CNN on a photo



Zhang et al., 2020 (+ other from Chandhi's group)



Huang et al., 2021

DL Model Framework

Input data → DL model → RTS footprints



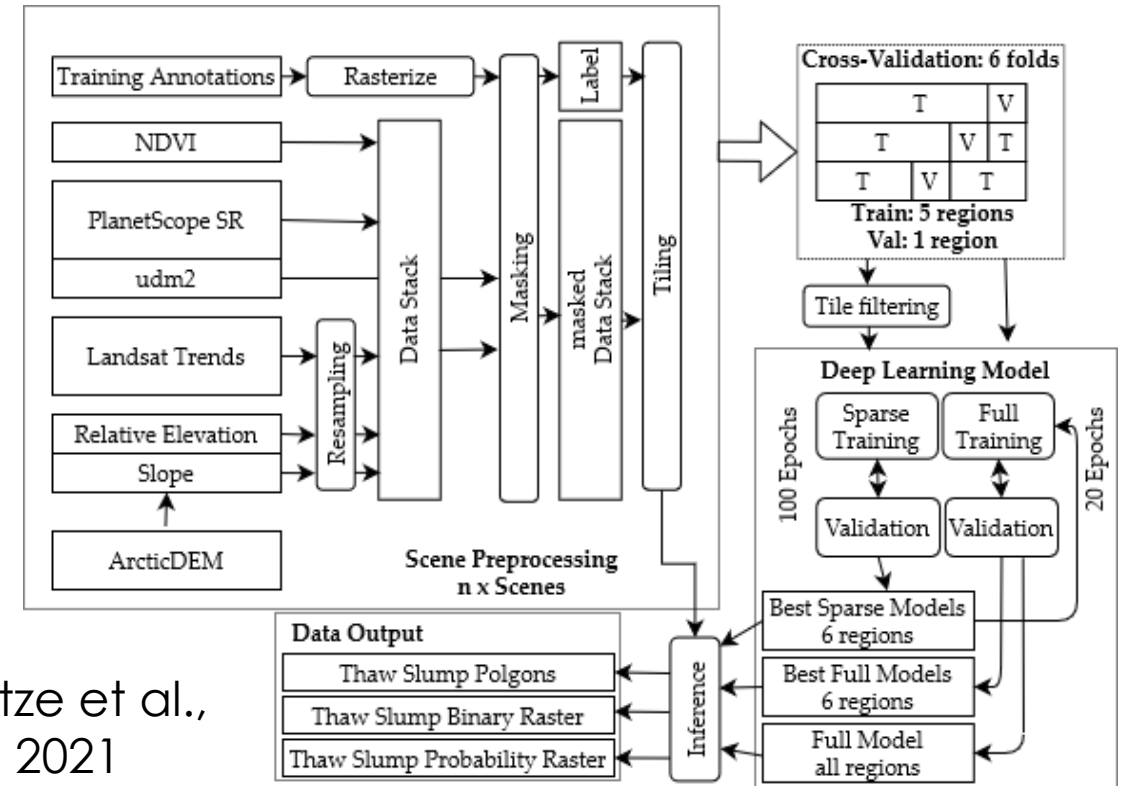
Automated Processing

- Flexible configuration with yaml files
- Target can be any object

Flexible Model Architecture

- Segmentation architecture
- Encoder/backbone network
- Loss functions

Data Augmentation Pipeline



Data

1. Planet SR Scenes (2018-2021) – 3m SR

- Multispectral (B-G-R-Nir) (A)
- NDVI (B)

2. Landsat Trends*

- TCB, TCG, TCW (C)

3. ArcticDEM

- Relative (detrended) elevation (D)
- Slope (E)

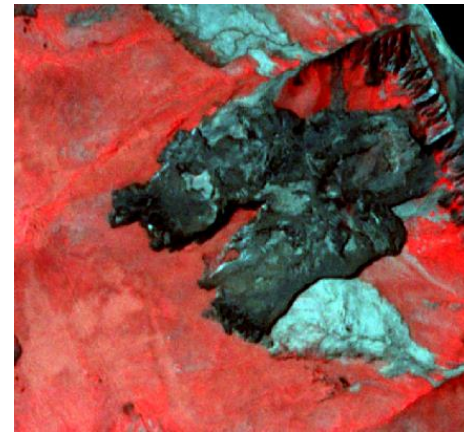
4. Training Data (polygons) $n=2182$

- How to delineate RTS?

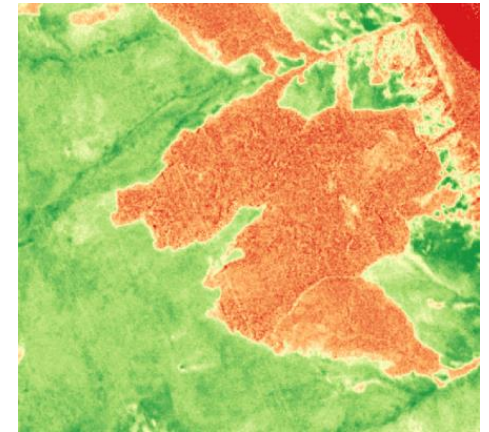
Output

- Raster (binary + probability)
- Vector (footprint)

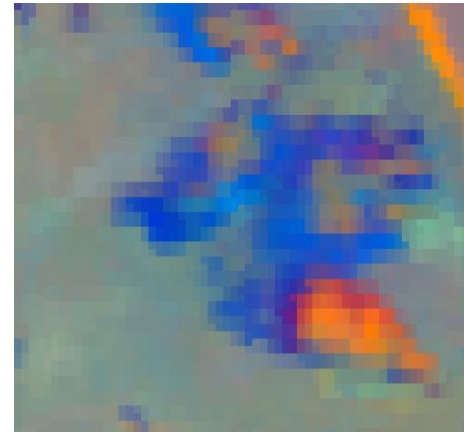
A



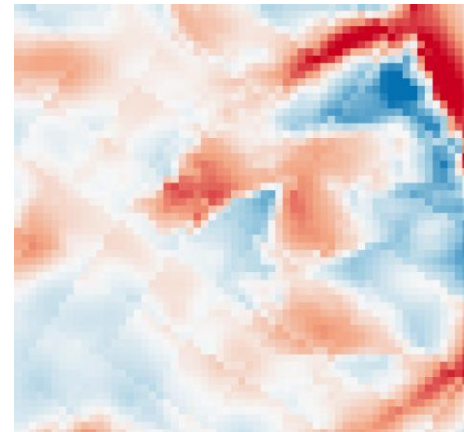
B



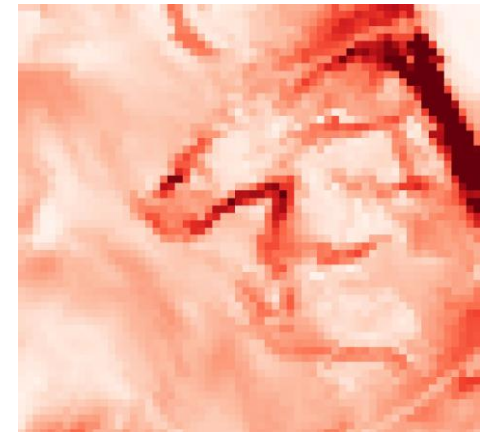
C

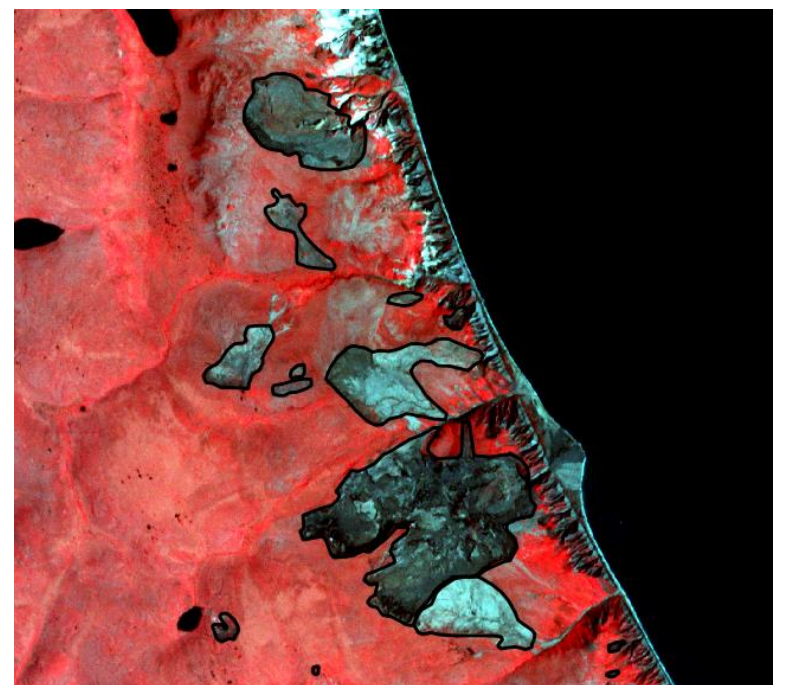
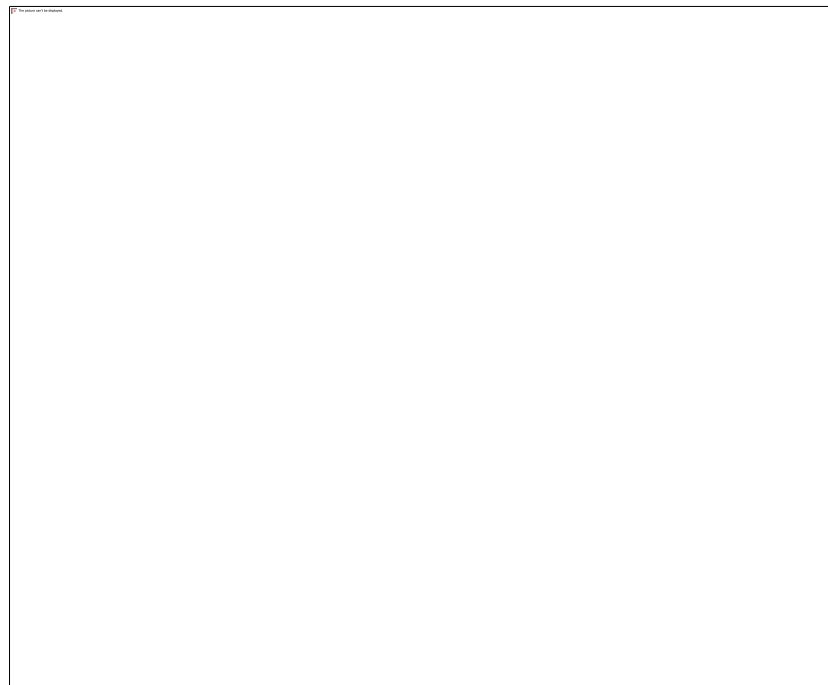
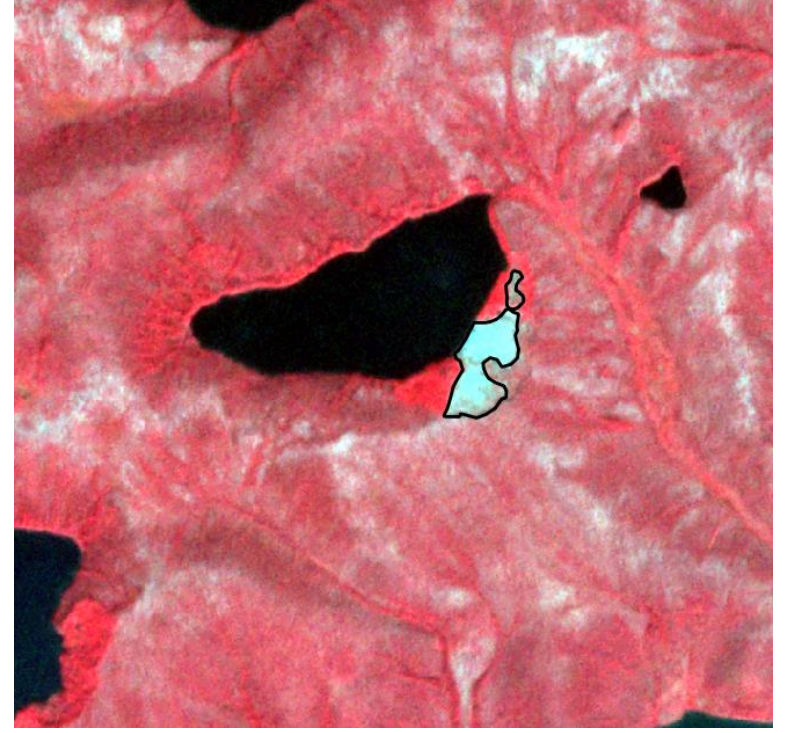
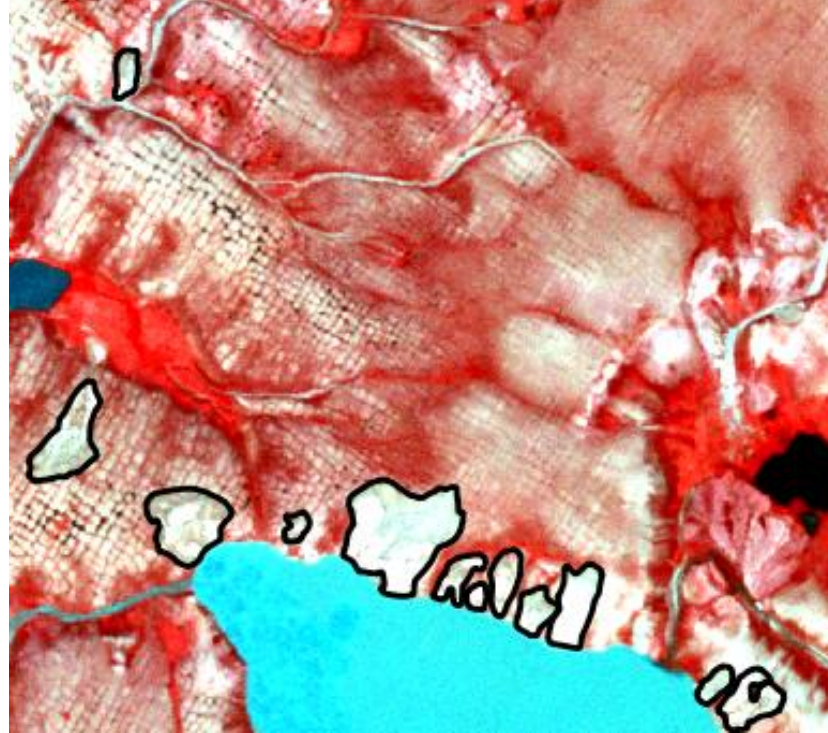
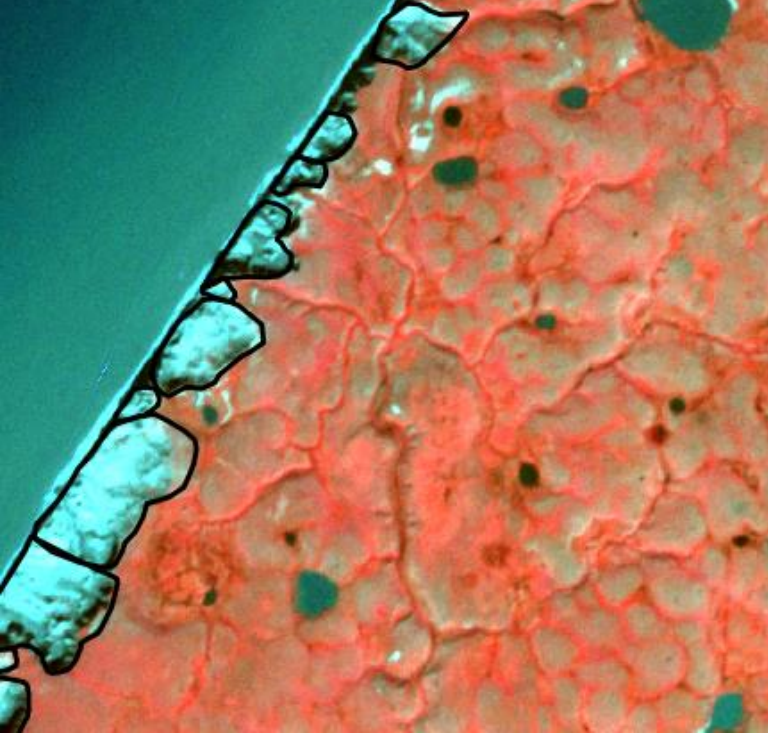


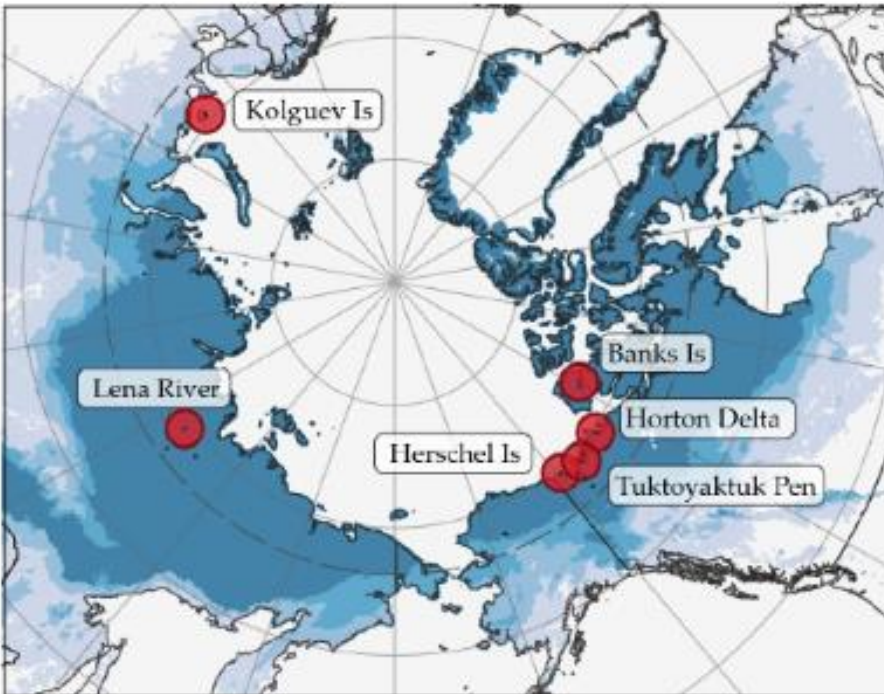
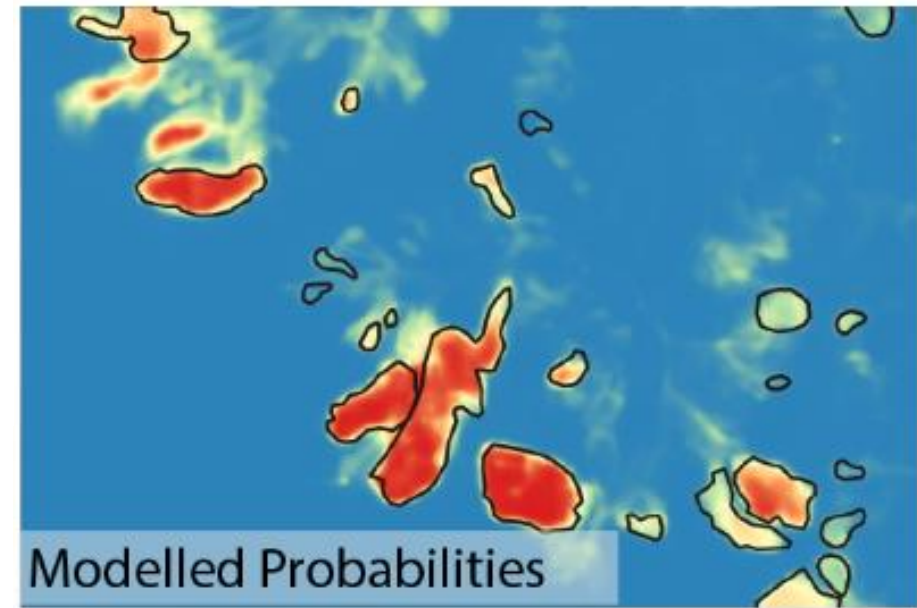
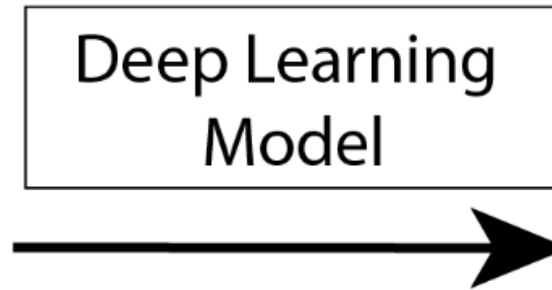
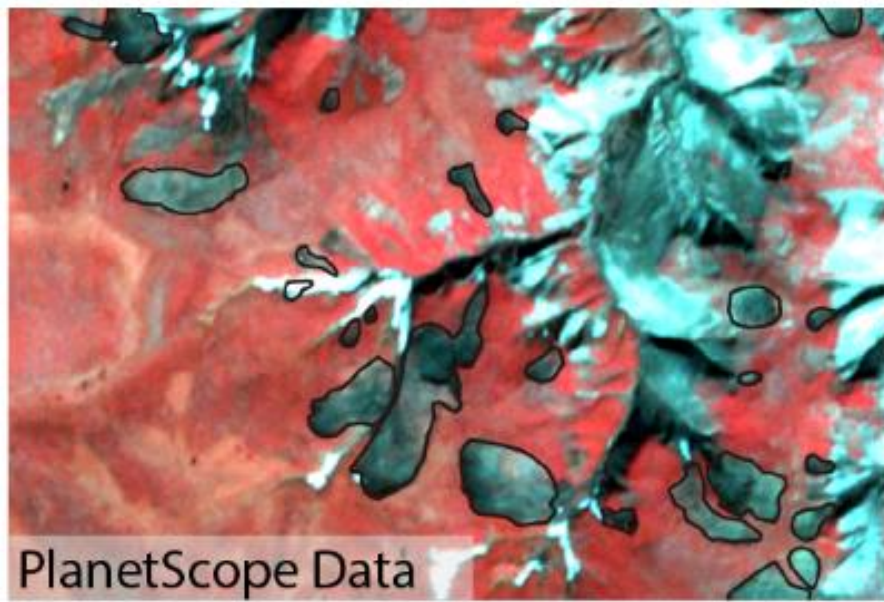
D



E







Automated Segmentation

Model Selection

UNet, UNet++, DeepLabV3

Quantitative Assessment

OA, Kappa, F1, IoU, Precision, Recall

Regional Cross-Validation in six Arctic Regions

5 regions training; 1 validation

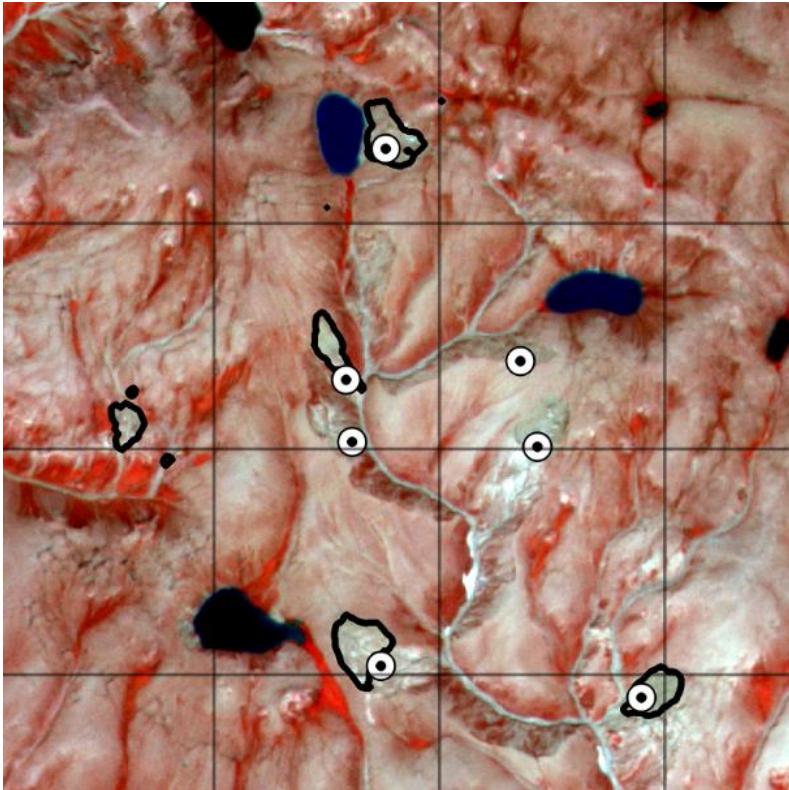
Results

- Good model performance in Horton, Lena, Kolguev
- Variable transferability
- Best model: UNet++
- Standardized pan-Arctic training data required for upscaling

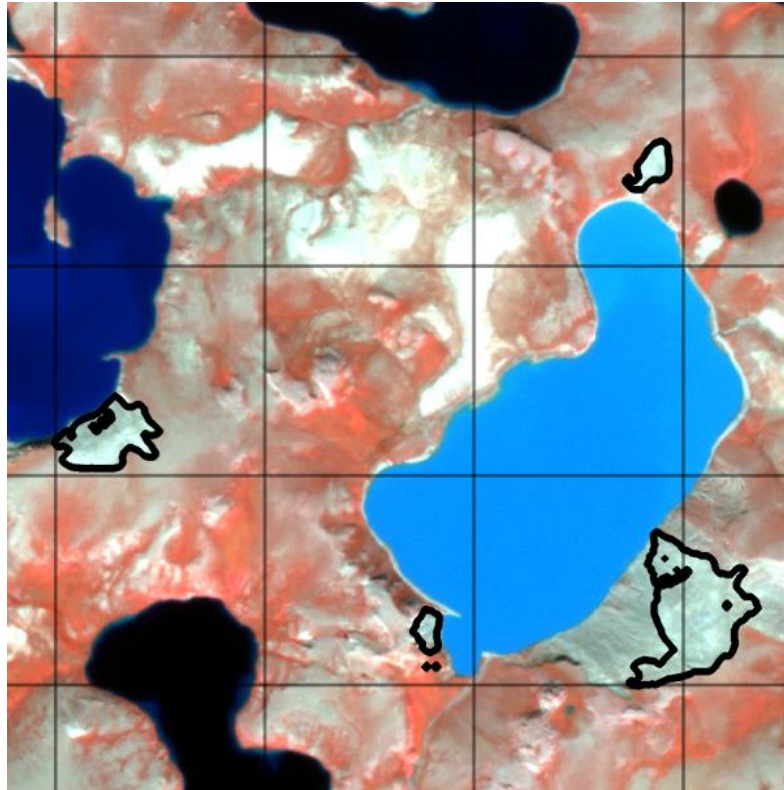
Inference + Scaling

The good ones !

Banks Island, Canada

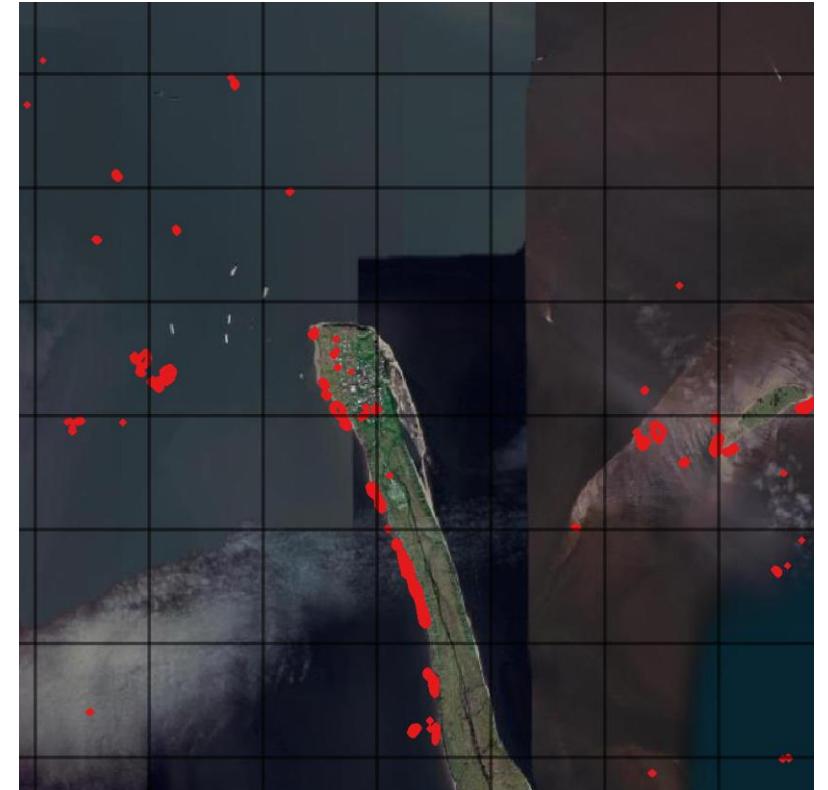


Bluenose Moraine, Canada

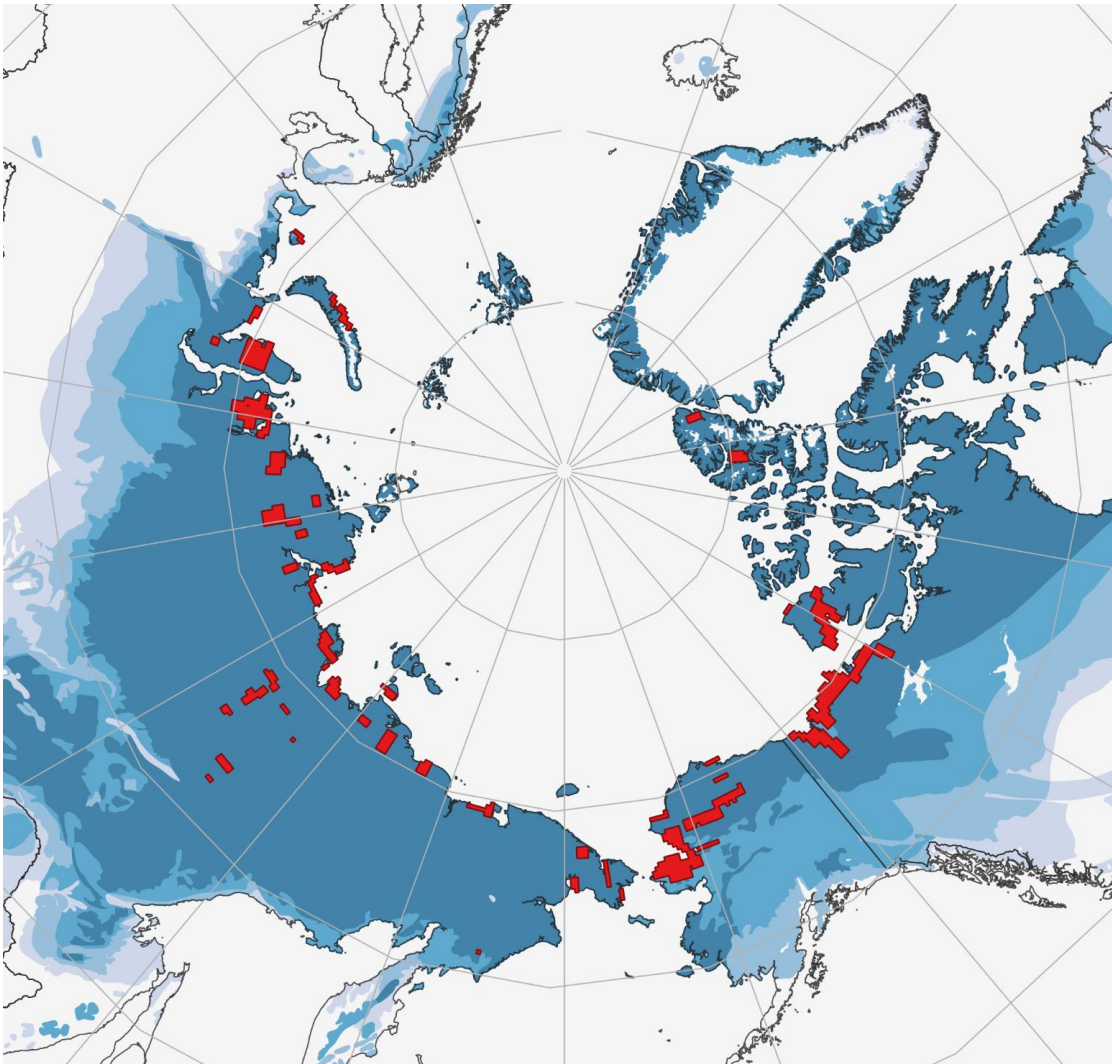


Not so good

Bykovsky Peninsula, Russia



Spatial Expansion + Operationalization



Requirements

- Improved (automated) data ordering
- More sophisticated (raster) data management
- Operationalization
- More training data
 - RTSInAction Group

Current data footprint

Summary

- Automated configurable DL workflow to map RTS
- Planet input data + other *free* data sources
- Good results but variable transferability



- More + standardized training data required
- Upscaling next step
- Continuous monitoring and model improvement

Thank You

Contact: ingmar.nitze@awi.de

Github repo code: <https://github.com/initze/thaw-slump-segmentation>

Github repo data: https://github.com/initze/DL_RTS_Paper

Twitter: @i_nitze

Landsat Trend App: <https://ingmarnitze.users.earthengine.app/view/hotspottcvisapp>

References

Nitze, I., Heidler, K., Barth, S., & Grosse, G. (2021). Developing and testing a deep learning approach for mapping retrogressive thaw slumps. Remote Sensing. <https://doi.org/10.3390/rs13214294>

