Feature extraction of ArcticDEM and its application on mapping permafrost disturbance

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Abstract

We processed more than 200 TB multi-temporal elevation data (i.e. ArcticDEM) and used them to locate permafrost disturbance in the Arctic. ArcticDEM is a high resolution (2 m) digital surface model derived from optical stereo imagery that covers all land areas north of 60°N. We used both the strip and mosaic version of ArcticDEM for feature extraction including (1) calculating elevation difference by comparing the most recent digital surface model (DSM) and the oldest ones, (2) segmenting subsidence regions from elevation difference using the quick shift algorithm, and (3) extracting headwall lines that represent the sudden slope changes using thresholding and medial axis. We built an automated pipeline which utilized both workstations in our lab and a supercomputer (i.e. RMACC Summit) to download and process ArcticDEM grid by grid. We composed images using a hillshade calculated from the most recent DSM and the headwall lines for locating retrogressive thaw slumps, which is a type of permafrost disturbance resulting from the thawing of ice-rich permafrost. We used an object detection algorithm called YOLOv4 (You only look once) to identify thaw slumps. We combined YOLOv4's output and polygons of the subsidence regions to remove false positives. In this presentation, we will present the technical details of the automated pipeline for data processing and preliminary mapping results in Alaska.

Motivation and *Objective*

- ArcticDEM is a collection of 2-m resolution, multi-temporal digital surface models and covers all land areas north of 60°N.
- Permafrost disturbance such as a retrogressive thaw slump (RTS) can be observed from ArcticDEM.
- RTS distribution is essential for understanding the degradation of ice-rich permafrost and the corresponding impacts.

- *to automatically process ArcticDEM and apply feature extraction*
- *to identify RTS from ArcticDEM.*

ArcticDEM

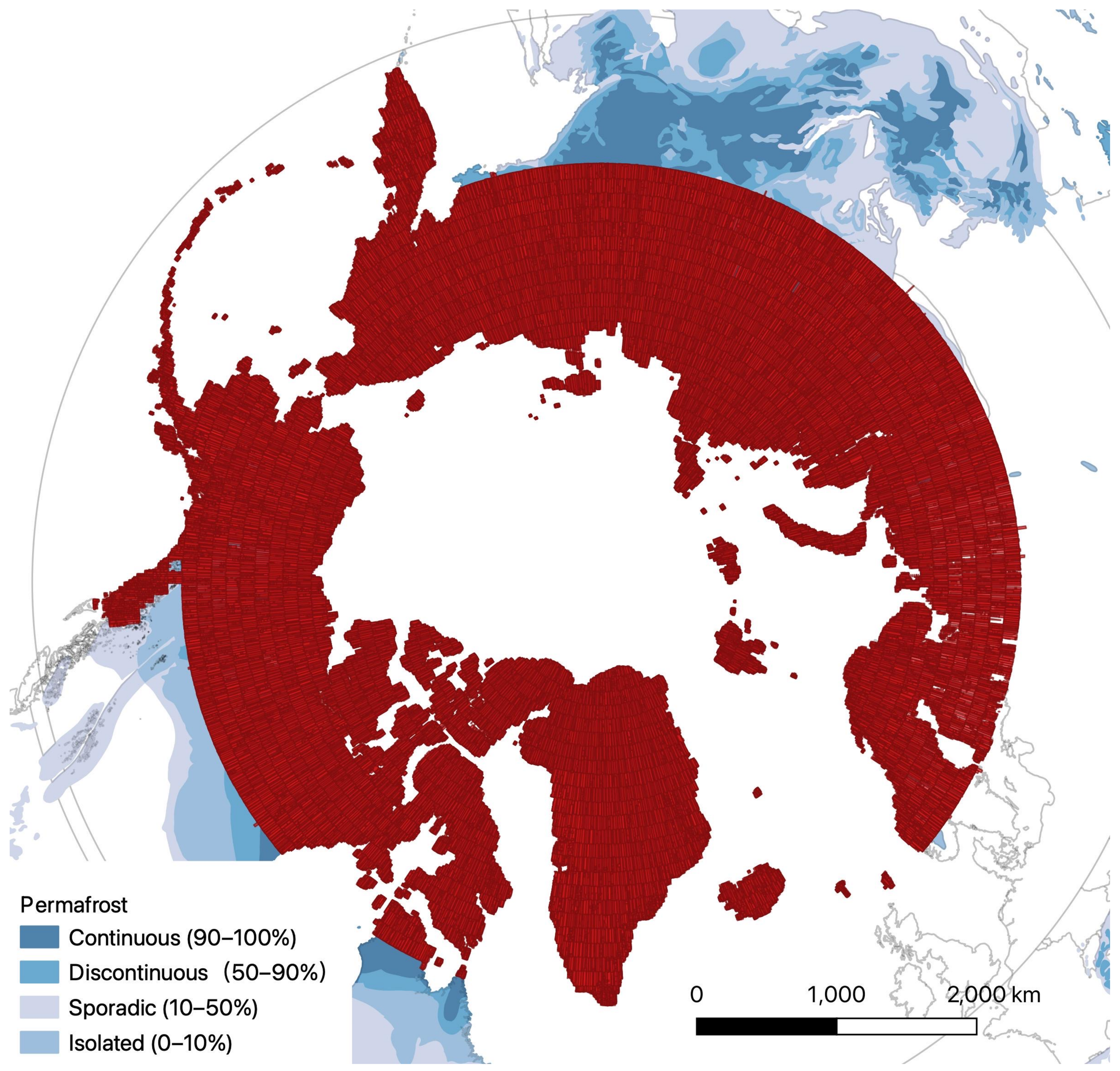


Figure 1. The coverage of ArcticDEM and permafrost distribution in the background. The density of ArcticDEM Strip for each point ranges from 1 to 10+.

Automated pipeline and feature extraction

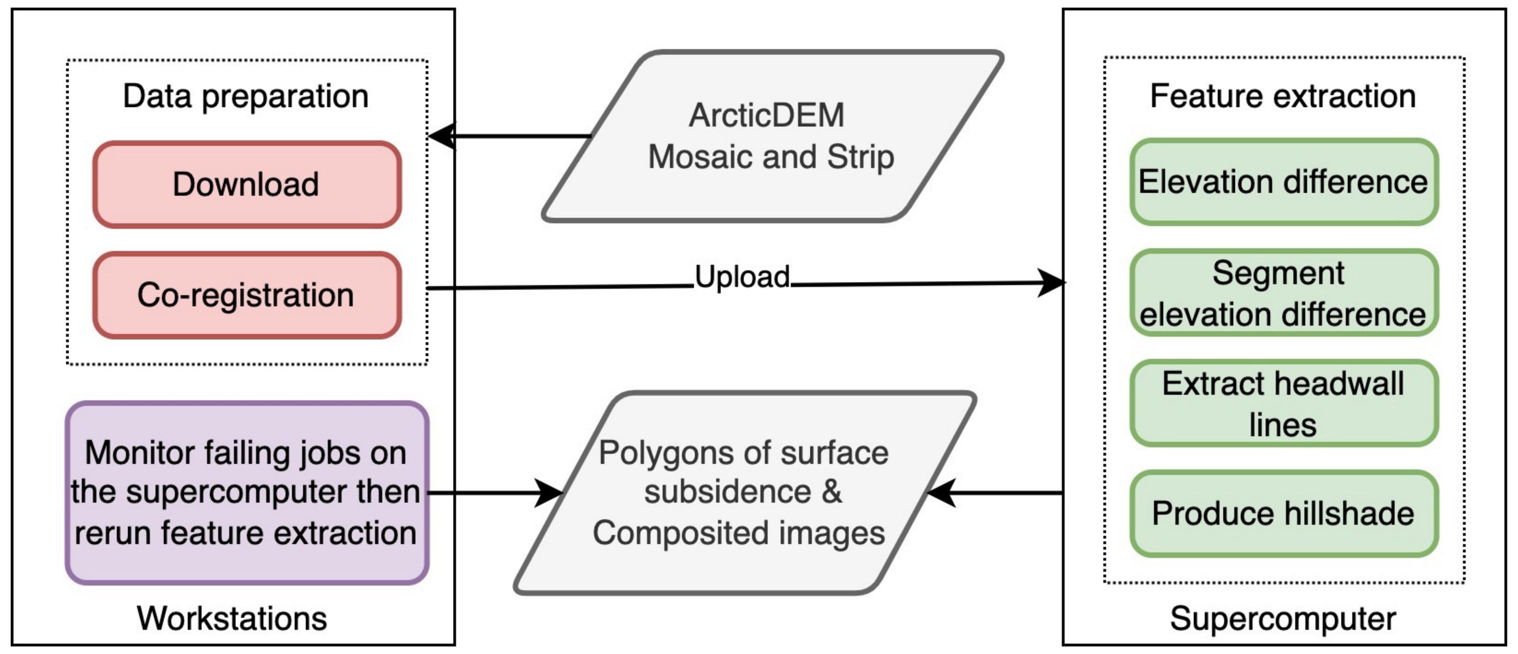


Figure 2. The diagram of the automated pipeline for processing ArcticDEM and feature extraction.

- Divide the coverage of entire ArcticDEM to 58667 grids and group grids into many subsets, with each contains 100–200 grids.
- Due to storage limitation, we download ArcticDEM files for a subset, then remove the files after going through the pipeline.
- All the steps including dividing subsets, uploading and downloading files are automated.

Identify retrogressive thaw slumps

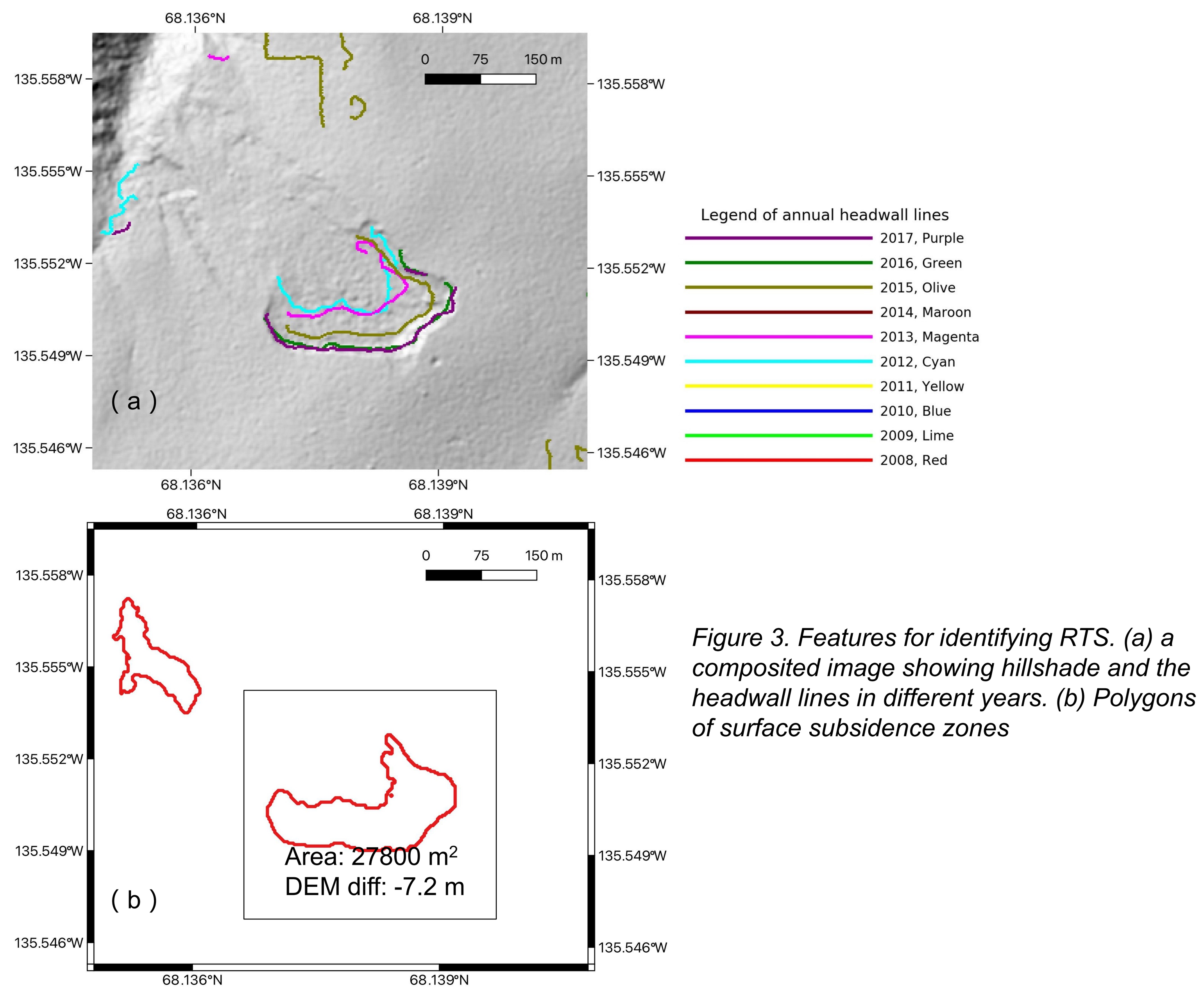


Figure 3. Features for identifying RTS. (a) a composited image showing hillshade and the headwall lines in different years. (b) Polygons of surface subsidence zones

1. Use the automated pipeline to produce features as shown in Figure 3.
2. Use an object detection algorithm (YOLOv4) to identify RTS locations from a composited image (e.g. Figure 3a).
3. Combine YOLOv4's output and polygons of the subsidence regions to remove false positives.

Preliminary results

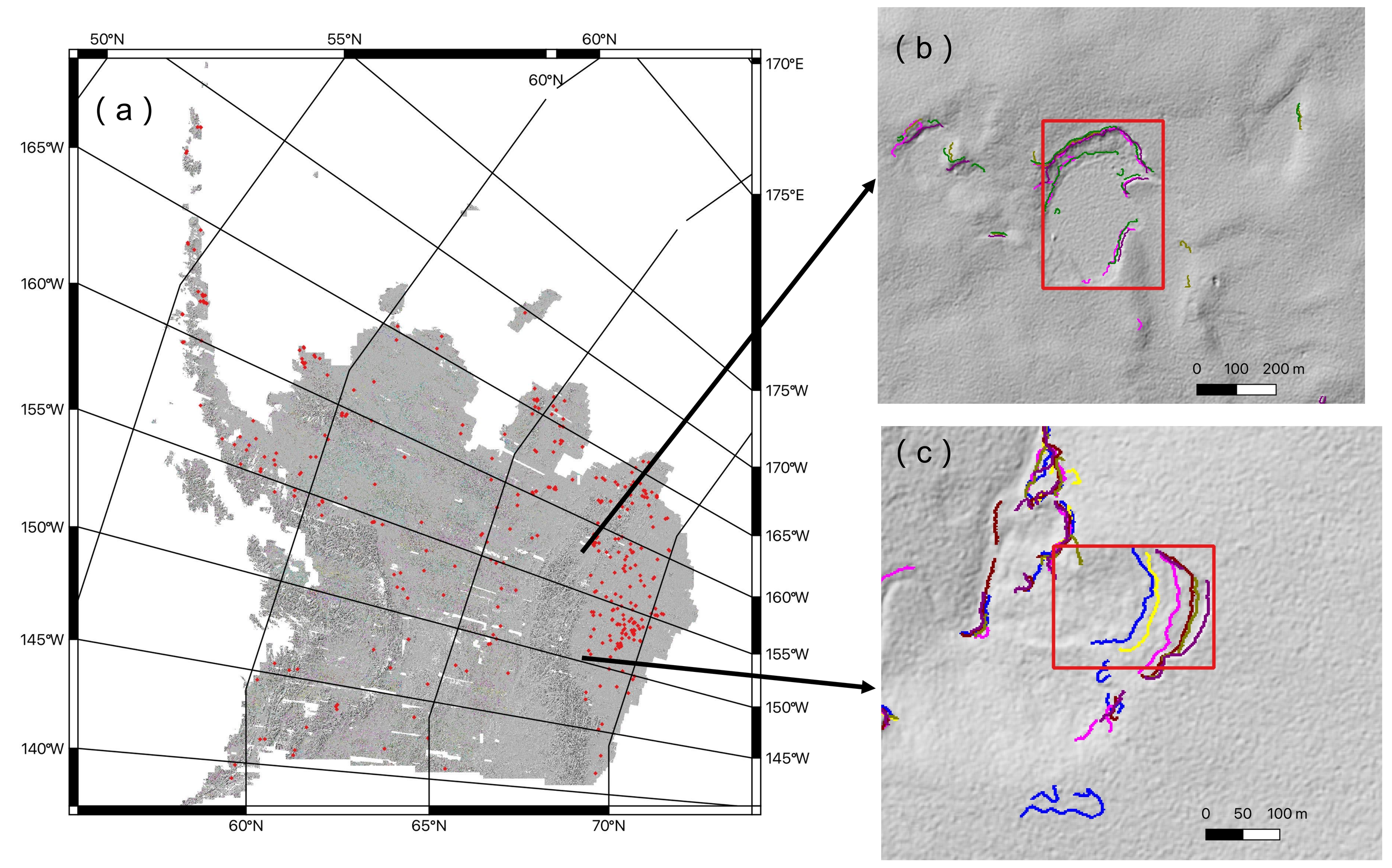
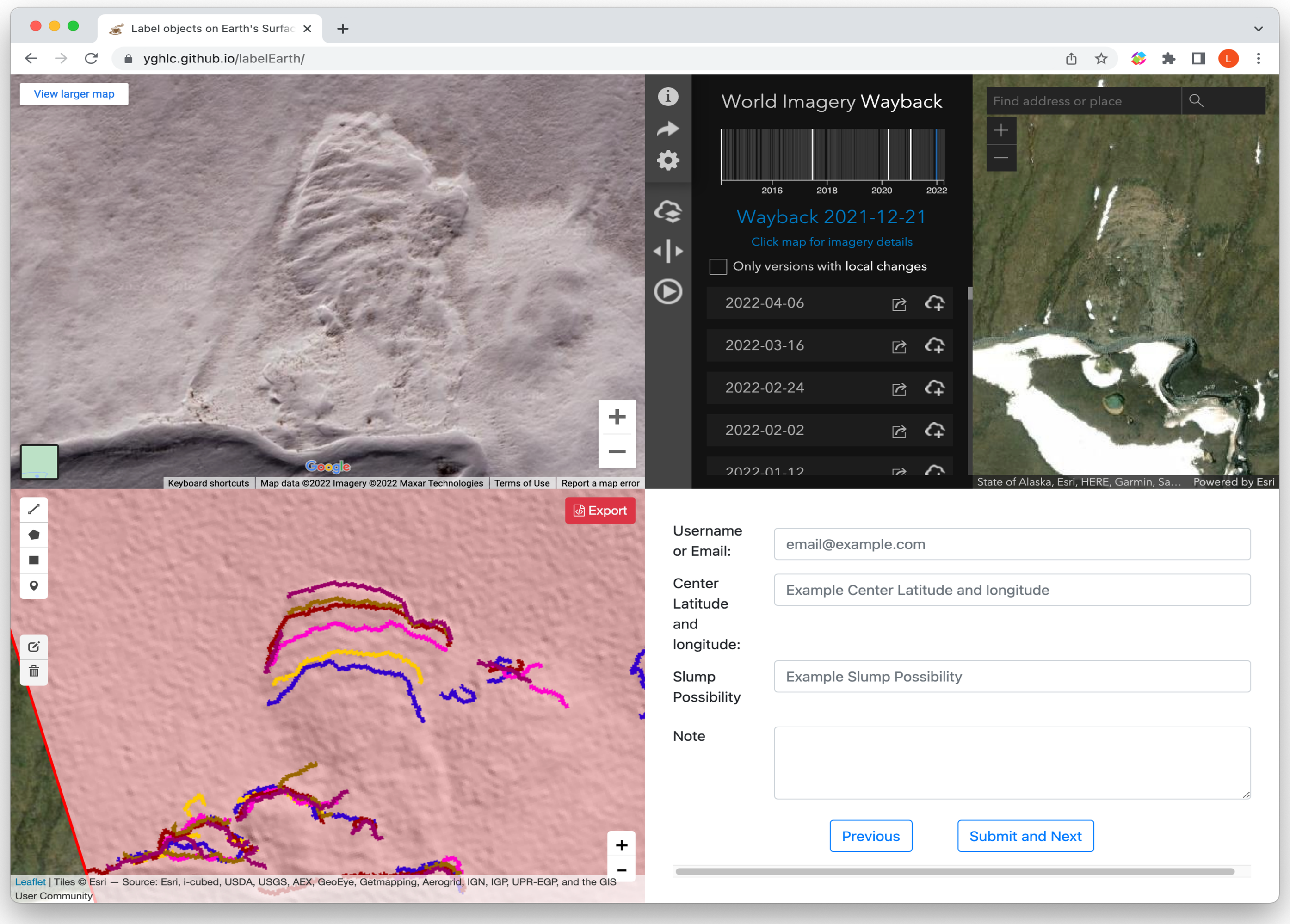


Figure 4. The overview (a) of 366 RTSs identified from ArcticDEM and two examples (b & c), These 366 ones has been manually validated but need further validation using multi-source imagery or field investigation.

Future work

- Crowd-sourcing system (web) for validation:



References

- Huang, L., Luo, J., Lin, Z., Niu, F., & Liu, L. (2020). Using deep learning to map retrogressive thaw slumps in the Beiluhe region (Tibetan Plateau) from CubeSat images. Remote Sensing of Environment, 237, 111534.
- Bochkovskiy, A., Wang, C. Y., & Liao, H. Y. M. (2020). Yolov4: Optimal speed and accuracy of object detection. arXiv preprint arXiv:2004.10934.

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