Estimating Supraglacial Lake Area for Greenland using Sentinel-2 Images and Deep Learning

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I. Motivation and Objectives

- Greenland's ice sheet is rapidly losing mass, contributing to sea level rise.
- The extent and volume of supraglacial lakes is a measure of the amount of melt occurring on the ice sheet.
- Supraglacial lakes can retain meltwater to a certain degree and may accelerate melt due to albedo reduction.
- The draining of supraglacial lakes can have local effects on ice dynamics.
- High-resolution Senttinel-2 imagery is used to estimate multi-annual maximum extent coverage of supraglacial lakes over the entire Greenland.
- Developing a novel methodology that includes improved cloud, cloud shadow, and terrain sink detection using deep learning techniques.
- The new methodology is expected to provide more accurate and frequent data on supraglacial lake extent coverage across large areas of the ice sheet.

II. Methodology

1. Obtained Sentinel-2 satellite images via Google Earth Engine for 2019-2022 maximum melt extent in Greenland.
2. Dataset: 1019 RGB images and corresponding annotations with 512x512 resolution, split randomly into 70% training, 15% validation, and 15% testing sets. Random flip augmentation applied to training set.
3. Trained U-Net deep learning model with MobileNetV2 encoder on training set. Validated on validation set, tested on separate test set.
4. Measured the maximum supraglacial lake areas in Greenland using binary masks generated by the model's output.

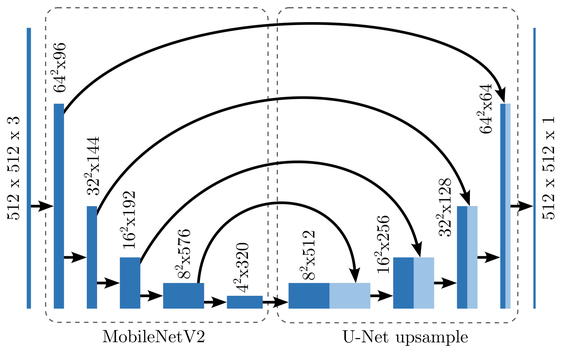
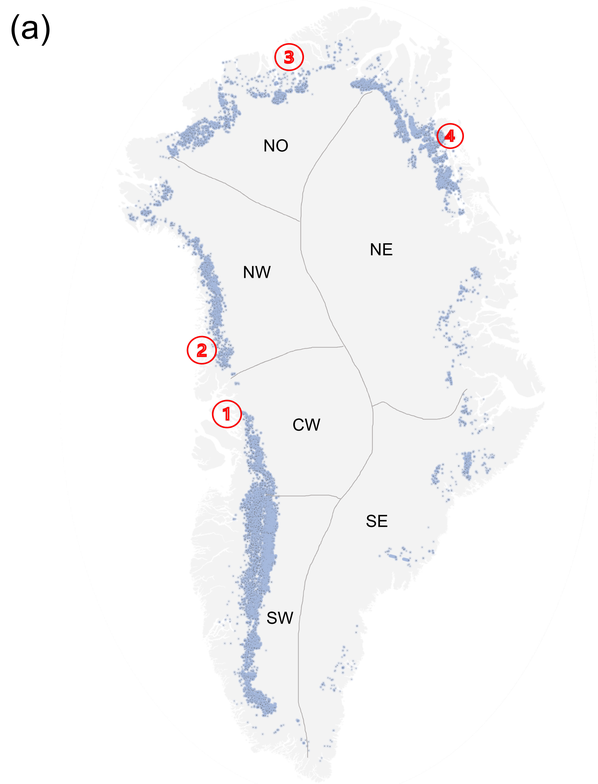
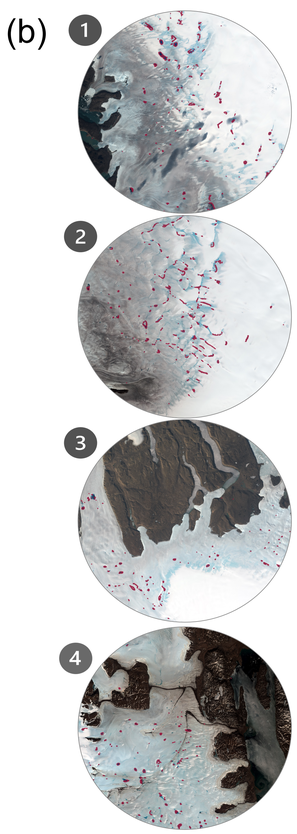


Figure 1. U-Net architecture with MobileNetV2 encoder for supraglacial lake mapping.





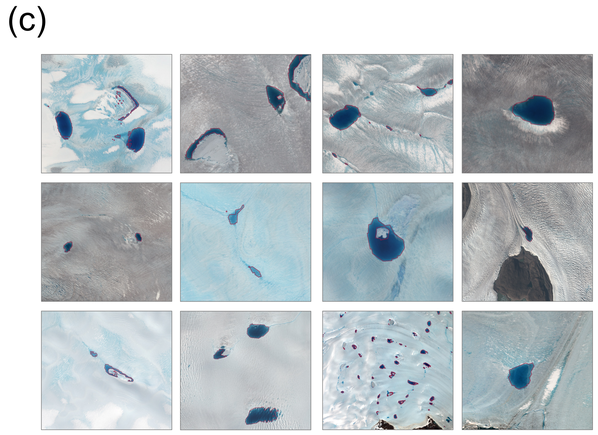


Figure 2. (a) Distribution of supraglacial lakes in Greenland in 2022. (b) Segmented supraglacial lakes at the locations indicated in (a). (c) A closer look at the segmented supraglacial lakes in different years and subregions of Greenland.

III. Results

The accuracy of the model was calculated to be 99.6% by comparing the predicted lake areas to the ground truth labels. The results of the study, including the maximum supraglacial lake areas for each subregion are presented in Figures 2 and 3.

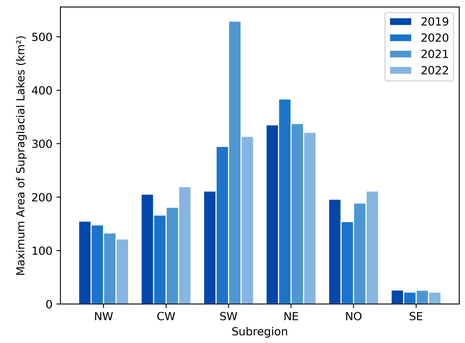


Figure 3. Maximum area of supraglacial lakes between 2019-2022 in Greenland subregions.

IV. Conclusion and Outlook

- We estimated the maximum area of supraglacial lakes in Greenland subregions by using deep learning and Sentinel-2 images.
- Demonstrated the effectiveness of deep learning as a powerful tool for monitoring and mapping supraglacial lakes on a large scale.
- Process Sentinel-2 archives for 2016-2018 to identify trends and compare with meteorological observations to understand supraglacial lake response to varying weather conditions.

V. Acknowledgment

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VI. Reference

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