Friedrich-Alexander-Universität Erlangen-Nürnberg

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Mapping supra-glacial lakes in NE-Greenland from Sentinel-2 time series using deep learning

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Background

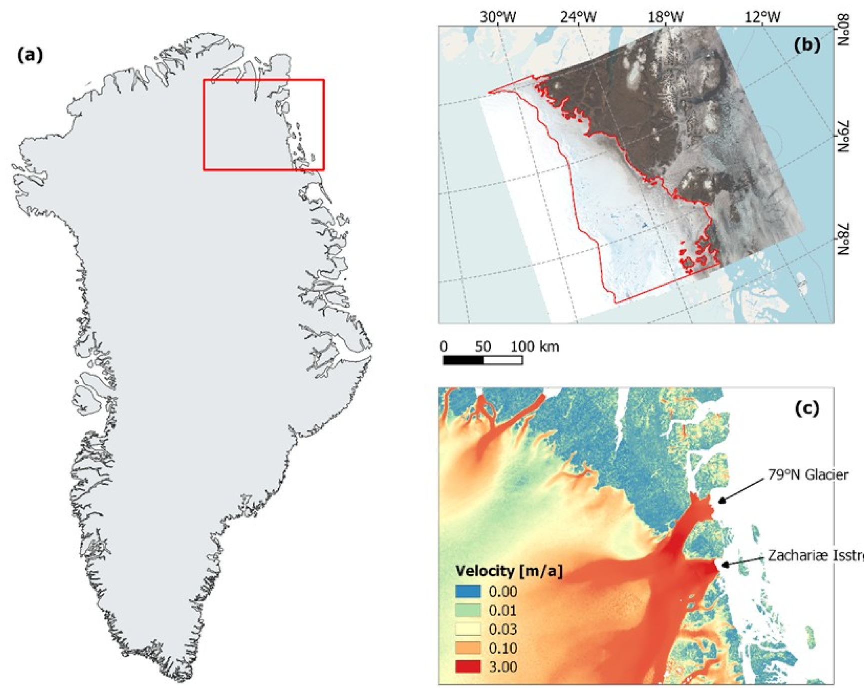
- Surface melt extent is increasing in Greenland
- Supraglacial melt water decreases albedo => positive feedback
- Lakes have an important role in the hydrological system of the ice sheet that is not yet well understood & quantified
- Impact on ice dynamics by (rapid) drainage events
- Lakes form each year at roughly same position, up to several km in size
- Lakes show strong seasonal and interannual variability in size and timing of formation

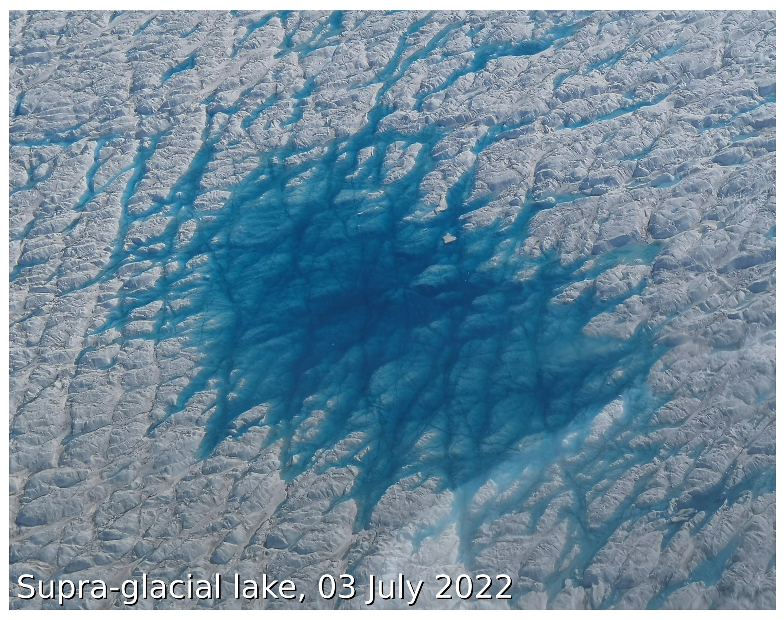
Objectives & Approach

- Determine large-sale seasonal and interannual variability of lake size and volume
- Sentinel-2 time series analysis
- Deep learning (DL) for lake area determination and improved cloud, cloud shadow and sink detection using U-Net architecture
- 3 approaches for lake depth estimates: radiative transfer modelling, ICESat-2 regression, regression model based on field observations

Database & Fieldwork

- Study site: Zachariæ Isstrøm and Nioghalvfjerdsbræ
- Sentinel-2 time series since 2016
- Almost daily coverage
- Lowrance sonar on lightweight, remote controlled experimental boat
- ICESat-2 lake depth profiles

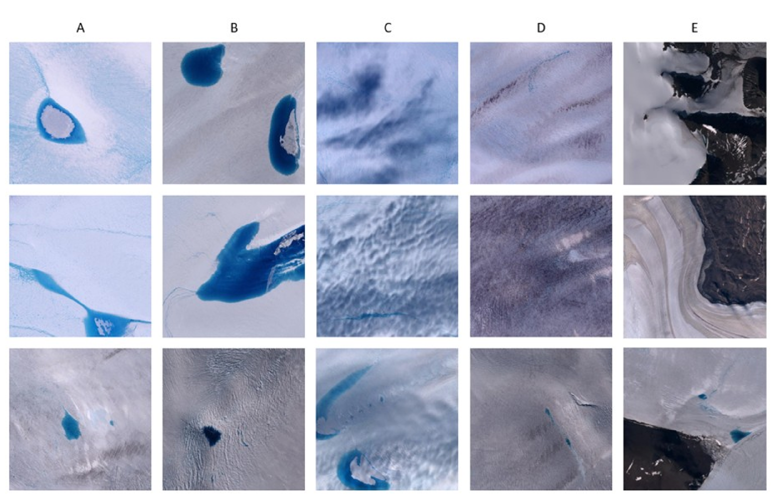




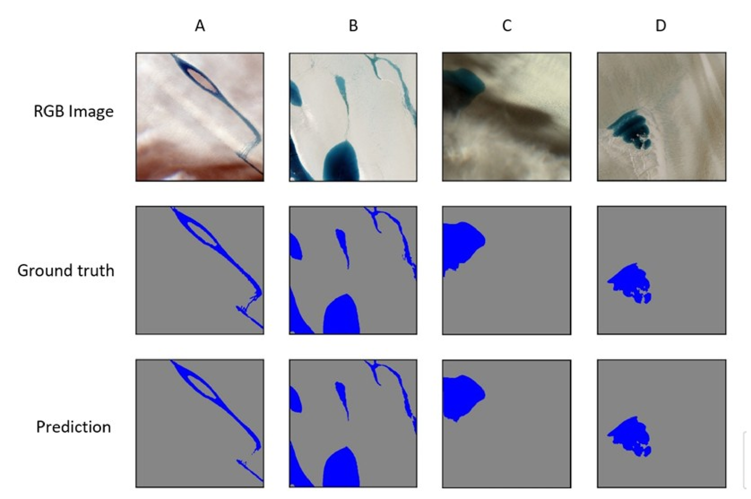
Supra-glacial lake, 03 July 2022

Remote controlled depth sounder, 03 July 2022

Lake area mapping using DL

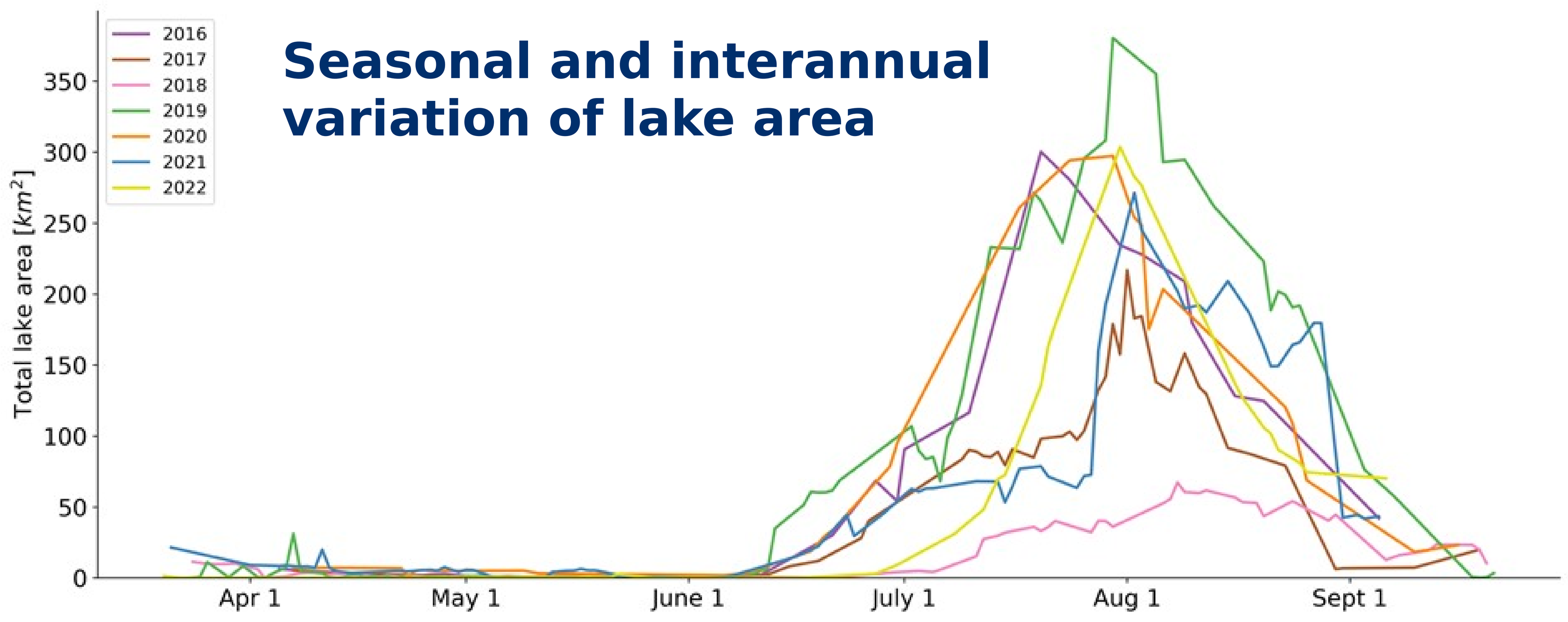


Examples of the subsets chosen for algorithm development

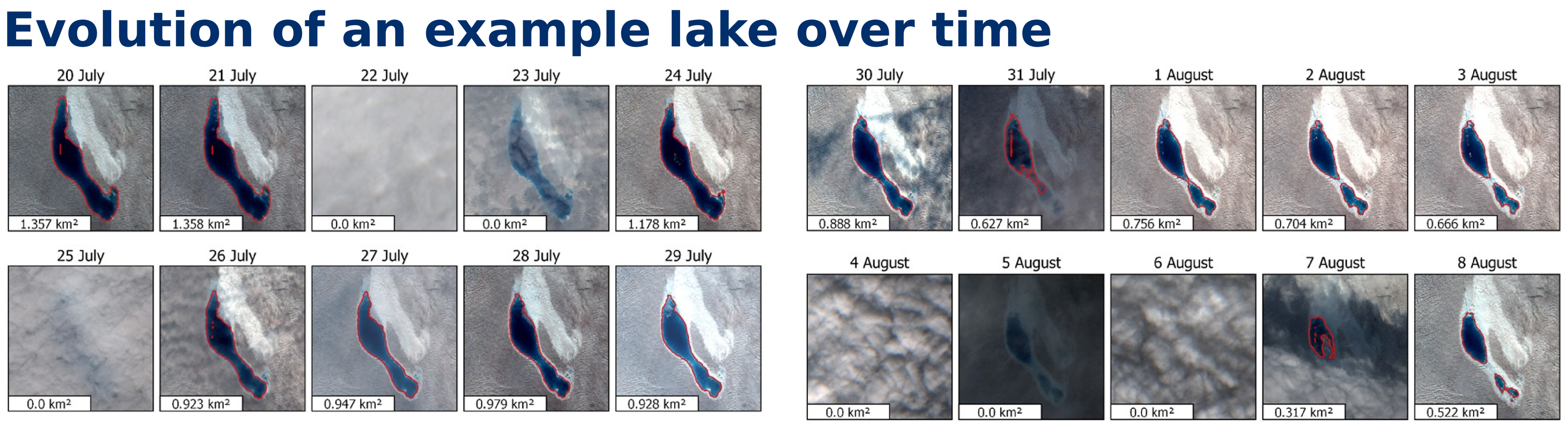


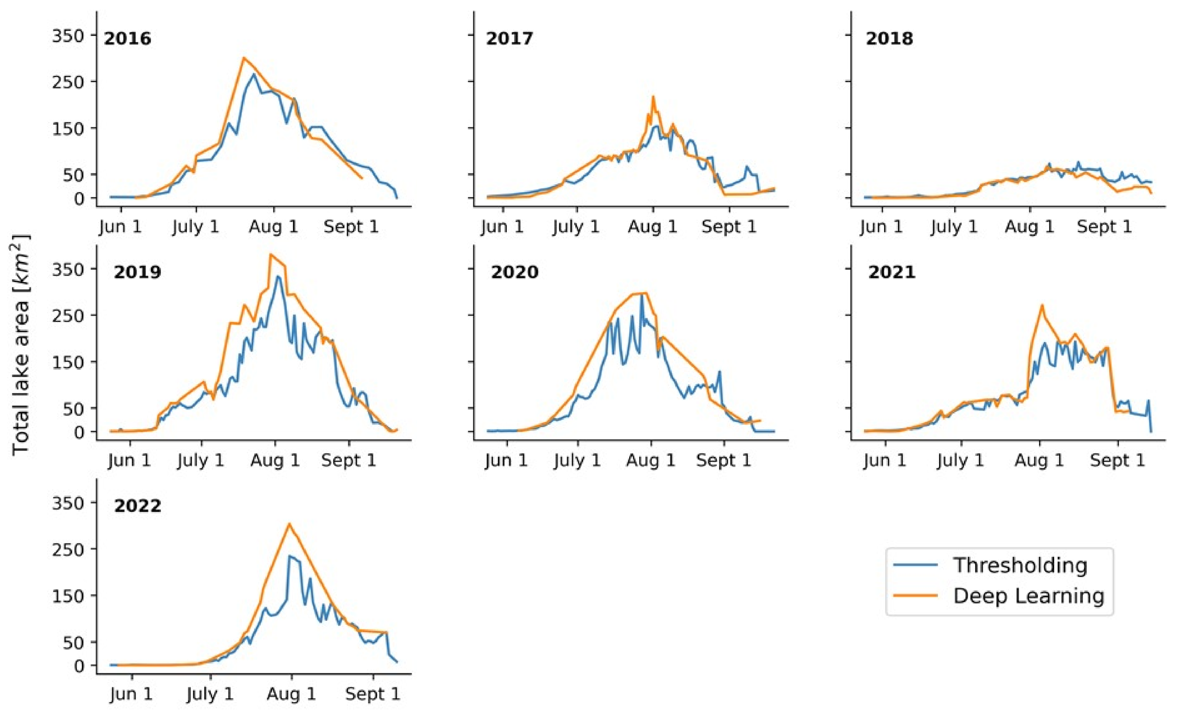
U-Net performance: Kappa 0.93; F1-Score: Lakes 0.9, Rocks: 0.95, IS: 1.0

Seasonal and interannual variation of lake area



Evolution of an example lake over time





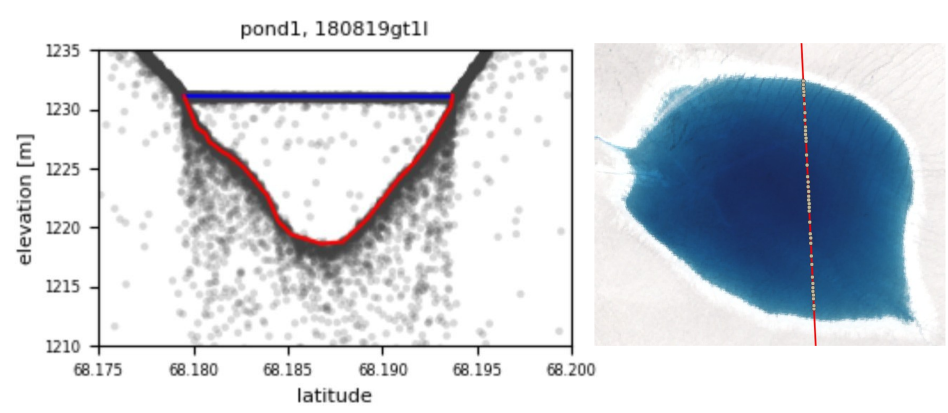
Intercomparison of lake area derived by deep learning and a threshold-based approach

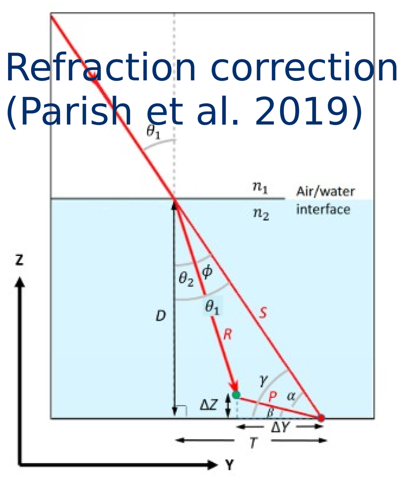
Lake depth estimation

Radiative transfer model:

$$z = \frac{\ln(A_d - R_\infty) - \ln(R_w - R_\infty)}{-g}$$

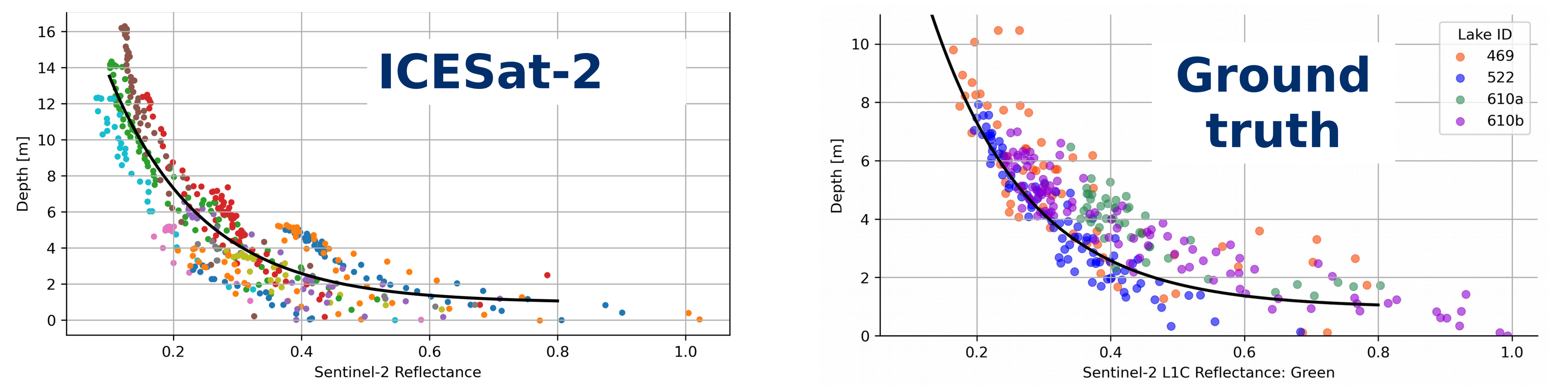
ICESat-2:





Refraction correction (Parish et al. 2019)

Regressions between green reflectance and lake depth:



Total lake volume over time from all three methods

Stars indicate drainage events of one or several large lakes