Master theses: Detecting glacier lakes using deep learning

Thousands of glacier lakes have been growing in high mountains because of ongoing atmospheric warming and glacier retreat in past decades. Glacier lakes could become an important resource for drinking water, irrigation, and hydropower generation. However, many of these lakes are unstable and some have drained in sudden glacier lake outbursts (GLOFs) with catastrophic consequences for mountain communities. Reliable identification of where glacier lakes form and grow therefore plays an important role in ensuring sustainable development in high mountain regions. Time series of satellite images have helped to generate a growing number of glacier lake inventories in recent years. However, mapping lake outlines has largely relied on labor-intensive manual digitization with limited transferability between individual catchments, let alone between mountain regions.

Deep learning (DL) has become a popular technique for semantic segmentation of satellite imagery, particularly because these algorithms can learn adaptively to extract features at both spatial and temporal scales (Figure 1). However, the potential of DL for automatic detection of glacial lakes on satellite imagery remains largely untapped[1–4], despite the large number of manually labeled lake outlines.

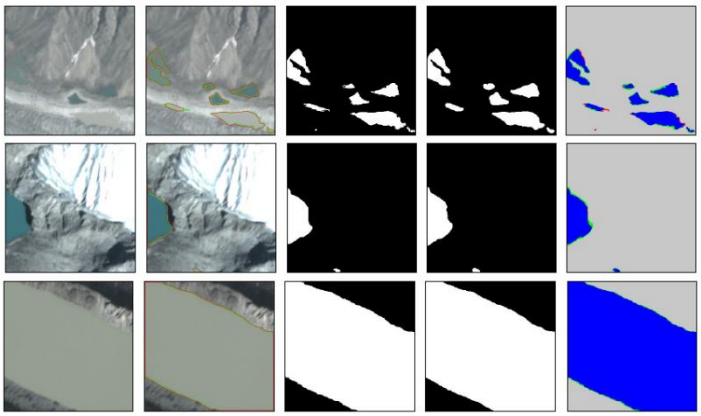

Figure 1: Example of automatically identified glacier lakes in the Himalayas using a U-Net architecture. Previous studies using DL for glacial lake extraction have largely focused on the Himalayas, while little attention has been paid to other regions. From Qayyum et al. (2020).

The research groups on Machine Learning and Natural hazards jointly offer supervised

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to explore the requirements for Deep Learning to systematically identify glacial lakes in the world's glaciated mountain regions.

The goal of the work is to (1) **propose a Deep Learning framework capable of robustly quantifying the current distribution of lakes in diverse environments**, from rugged, heavily glaciated mountains in the Himalayas to plateau landscapes in Scandinavia to largely deglaciated regions in the European Alps. Another goal is to (2) **learn a single model to track lakes in a selected mountain range simultaneously over time**, based on multitemporal stacks of Landsat imagery and digitized lake outlines.

The ideal candidate will have advanced knowledge of machine learning and mathematics, supported by a strong background in scientific programming language (R, Python, Matlab, or equivalent). Expertise in remote sensing and skills in a GIS environment (ArcGIS, QGIS, SAGA-GIS, or equivalent) are a plus. We offer a large collection of manually labeled training data and workflows to acquire and pre-process Landsat imagery.

Interested? Then please contact the two members of the research group Machine Learning (Prof. Tobias Scheffer: scheffer@cs.uni-potsdam.de) and Natural Hazards (Dr. Georg Veh; georg.veh@uni-potsdam). Work on the theses can begin immediately.

Further reading: 1. Wu, R. *et al.* A Deep Learning Method for Mapping Glacial Lakes from the Combined Use of Synthetic-Aperture Radar and Optical Satellite Images. *Remote Sens.* 12, 4020 (2020). | **2. Qayyum, N., Ghuffar, S., Ahmad, H., Yousaf, A. & Shahid, I.** Glacial Lakes Mapping Using Multi Satellite PlanetScope Imagery and Deep Learning. *ISPRS Int. J. Geo-Inf.* 9, 560 (2020). | **3. Wang, J., Chen, F., Zhang, M. & Yu, B. NAU-Net:** A New Deep Learning Framework in Glacial Lake Detection. *IEEE Geosci. Remote Sens. Lett.* 19, 1–5 (2022). | **4. Thati, J. & Ari, S.** A systematic extraction of glacial lakes for satellite imagery using deep learning based technique. *Measurement* 192, 110858 (2022).