EGU25-19362, updated on 24 Mar 2025
https://doi.org/10.5194/egusphere-egu25-19362
EGU General Assembly 2025

National Inventory of Glacial Lakes in Kyrgyzstan: Integrating Remote Sensing for Hazard Assessment and Local-scale Monitoring

Valentine Piroton and **Hans-Balder Havenith**
Department of Geology, University of Liège, Liège, Belgium (v.piroton@uliege.be)

This study presents the most comprehensive and recent inventory of glacial lakes in Kyrgyzstan, offering one of the first digitized polygon-based datasets covering the entire country. It examines the dynamics of glacial lakes and glacial lake outburst floods (GLOFs) within the context of rapid glacier retreat and permafrost degradation due to climate change. Using Sentinel-2 imagery acquired during the summer months (July to October) of 2022–2024, this research employs a Python-based workflow in ArcGIS Pro to identify and delineate glacial lakes. A total of 41 atmospherically corrected images with <5% cloud cover were analyzed, ensuring optimal coverage and resolution (10 m), capable of detecting lakes larger than 0.003 km². A threshold of 0.07 from the Normalized Difference Water Index (NDWI) was used to generate an initial water mask. Polygons were refined based on morphological filtering, proximity to glaciers identified in the Randolph Glacier Inventory (within 30 km), and elevation criteria derived from the ALOS Global Digital Surface Model (AW3D30) (>3,000 m a.s.l.). All polygons were manually reviewed for accuracy.
The inventory identifies more than 2000 glacial lakes across Kyrgyzstan. The highest density is found in the Terskey (1,137 lakes) and Kyrgyz (323 lakes) mountain ranges, as well as in the southwestern regions of Osh and Batken, where higher altitudes favor lake formation. Glacial lakes are mainly located between 3,250 and 3,850 meters, with larger lakes typically dammed by bedrock or a combination of damming types. Ice-dammed lakes are more common at higher latitudes, whereas those dammed by landslides are found at lower latitudes. Analysis of optical images from 2023 and 2024 revealed lakes newly formed or enlarged, underscoring the rapid evolution of these features due to glacier retreat and the crucial need for regular inventory updates.
This inventory outlines the spatial distribution and physical characteristics of glacial lakes, as well as those most at risk of GLOFs. As highlighted in previous studies, most endangered lakes fall into three genetic categories: moraine-glacier lakes, supraglacial lakes, and those dammed by landslides and debris flows. Adygine and Kol-Ukok lakes were selected as case studies to illustrate these hazardous types. Fieldwork conducted in August 2023 and 2024, including drone and geophysical surveys, validated the dataset and provided insights into the geomorphological and geological factors influencing lake stability, including the role of permafrost in slope dynamics. Drone imagery revealed key surface features, enhancing understanding of the local context and informing future assessments of potential instability. Semi-automated mapping is a valuable tool for hazard assessments, but limitations persist. Shadows, cloud cover, seasonal water-filled

depressions, and residual snow can cause false positives, while terrain complexity and variations in water turbidity or sediment loads affect accuracy. Manual verification remains essential to ensure reliability.

This national glacial lake inventory provides the basis for future studies, highlighting the roles of climate change and geology in shaping vulnerable mountain systems. By integrating regional-scale remote sensing data with fieldwork, this approach strengthens hazard assessments by providing crucial local context in high-risk areas, ensuring more reliable analyses.