Mapping and monitoring of landslide-dammed lakes using Sentinel-2 time series - a case study after the 2016 Kaikōura Earthquake in New Zealand

Lorena Abad¹, Daniel Hölbling¹, Raphael Spiekermann², Zahra Dabiri¹, Günther Prasicek³,⁴, and Anne-Laure Argentin³

¹Department of Geoinformatics - Z_GIS, University of Salzburg, 5020 Salzburg, Austria (lorenacristina.abadcrespo@sbg.ac.at; daniel.hoelbling@sbg.ac.at; zahra.dabiri@sbg.ac.at)
²Landcare Research, Private Bag 11052, Manawatu Mail Centre, Palmerston North 4442, New Zealand (SpiekermannR@landcareresearch.co.nz)
³Department of Geography and Geology, University of Salzburg, 5020 Salzburg, Austria (guenther.prasicek@sbg.ac.at; anne-lauremarine.argentin@sbg.ac.at)
⁴Center for Interdisciplinary Mountain Research, University of Lausanne, 1967 Bramois, Switzerland (gunther.prasicek@unil.ch)

On November 14, 2016, a 7.8 magnitude earthquake struck the Kaikōura region on the South Island of New Zealand. The event triggered numerous landslides, which dammed rivers in the area and led to the formation of hundreds of dammed lakes. Landslide-dammed lakes constitute a natural risk, given their propensity to breach, which can lead to flooding of downstream settlements and infrastructure. Hence, detecting and monitoring dammed lakes is a key step for risk management strategies. Aerial photographs and helicopter reconnaissance are frequently used for damage assessments following natural hazard events. However, repeated acquisitions of aerial photographs and on-site examinations are time-consuming and expensive. Moreover, such assessments commonly only take place immediately after an event, and long-term monitoring is rarely performed at larger scales.

Satellite imagery can support mapping and monitoring tasks by providing an overview of the affected area in multiple time steps following the main triggering event without deploying major resources. In this study, we present an automated approach to detect landslide-dammed lakes using Sentinel-2 optical data through the Google Earth Engine (GEE). Our approach consists of a water detection algorithm adapted from Donchyts et al., 2016 [1], where a dynamic threshold is applied to the Normalized Difference Water Index (NDWI). The water bodies are detected on pre- and post-event monthly mosaics, where the cloud coverage of the composed images is below 30%, resulting in one pre-event (December 2015) and 14 post-event monthly mosaics. Subsequently, a differencing change detection method is performed between pre- and post-event mosaics. This allows for continuous monitoring of the lake status, and for the detection of new lakes forming in the area at different points in time.

A random sample of lakes delineated from Google Earth high-resolution imagery, acquired right
after the Kaikōura earthquake, was used for validation. The pixels categorized as ‘dammed lakes’ were intersected with the validation data set, resulting in a detection rate of 70% of the delineated lakes. Ten key dams, identified by local authorities as a potential hazard, were further examined and monitored to identify lake area changes in multiple time steps, from December 2016 to March 2019. Taking advantage of the GEE cloud computing capabilities, the proposed automated approach allows fast time series analysis of large areas. It can be applied to other regions where landslide-dammed lakes need to be monitored over long time scales (months – years). Furthermore, the approach could be combined with outburst flood modeling and simulation to support initial rapid risk assessment.