

# Landslides in moraines as triggers of glacial lake outburst floods: example from Palcacocha Lake (Cordillera Blanca, Peru)

Landslides

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## Abstract

Studies focusing on moraine deposits which slide into glacial lakes are scarce, even though they can trigger impact waves responsible for generating glacial lake outburst floods. We focused on landslides in lateral moraines as possible triggers. Detailed geomorphological, geophysical, and satellite radar interferometric investigations of the Palcacocha Lake moraine (Cordillera Blanca, Peru) together with laboratory tests on samples from the site provided data for slope stability calculations using GeoSlope software and hydrodynamic impact wave modeling using the Iber code. We identified landslides that could affect Palcacocha Lake and calculated their stability (factor of safety) under specified conditions, including variable water saturation and earthquake effects. Calculations showed that the moraine slopes are close to the threshold value ( $F_s = 1$ ) for stability and are especially sensitive to water saturation. The height of impact waves triggered by a landslide in 2003 and the potential wave heights from newly identified, possibly active landslides were calculated, based on landslide volume estimates, detailed lake bathymetry, and basin topography. Results show that potential future landslide-triggered waves could have similar properties to the 2003 impact wave. Evidence gathered in this study suggests that glacial lake outburst floods triggered by landslides from moraines, however, would be probably smaller than floods resulting from other types of slope processes (e.g., ice/rock avalanches) if dam breach is not taken into account. This assumption has to be critically evaluated against site-specific conditions at a given lake and any possible environmental factors, such as climate change or earthquake that may mobilize larger volumes of moraine material.