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Modelling cascading and erosional processes for glacial lake outburst floods in the Quillcay catchment, Huaraz, Cordillera Blanca, Peru

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Huaraz as the largest city in Cordillera Blanca has faced a major disaster in 1941, when an outburst flood from Lake Palcacocha killed several thousand people and caused widespread destruction. Recent studies on glacial lake outburst flood (GLOF) modelling and early warning systems focussed on Lake Palcacocha which has regrown after the 1941 event, from a volume of half a million m3 in 1974 to a total volume of more than 17 million m3 today. However, little research has been conducted so far concerning the situation of other lakes in the Quillcay catchment, namely Lake Tullparaju (12 mill. m3) and Cuchillacocha (2.5 mill. m3), which both also pose a threat to the city of Huaraz.

In this study, we modelled the cascading processes at Lake Tullparaju and Lake Cuchillacocha including rock/ice avalanches, flood wave propagation in the lake and the resulting outburst flood and debris flows. We used the 2D model RAMMS to simulate ice avalanches. Model output was used as input for analytical 2D and 3D calculations of impact waves in the lakes that allowed us to estimate dam overtopping wave height. Since the dimension of the hanging glaciers above all three lakes is comparable, the scenarios in this study have been defined similar to the previous study at Lake Palcacocha. The flow propagation model included sediment entrainment in the steeper parts of the catchment, adding up to 50% to the initial flow volume.

The results for total travel time as well as for inundated areas and flow depth and velocity in the city of Huaraz are comparable to the previous studies at Lake Palcacocha. This underlines the importance of considering also these lakes within an integral hazard analysis for the city of Huaraz.

A main challenge for modelling GLOFs in the Quillcay catchment using RAMMS is the long runout distance of over 22 km combined with the very low slope gradient of the river. Further studies could improve the process understanding and could focus on more detailed investigations of the stability of the steep glaciers and rock faces, or on incorporation of bathymetric and geotechnical dam information with the application of 3D wave generation simulation. First applications of the beta version of the RAMMS erosion model for GLOF sediment entrainment are promising and could be refined with additional field studies.