Ice-avalanche scenario elaboration and uncertainty propagation in numerical simulation of rock-/ice-avalanche-induced impact waves at Mount Hualcán and Lake 513, Peru

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- Yvonne Schaub (1) Email author (yvonne.schaub@geo.uzh.ch)
- Christian Huggel (1)
- Alejo Cochachin (2)

1. Department of Geography, University of Zurich, , Zurich, Switzerland
2. Unidad de Glaciología y Recursos Hídricos, Autoridad Nacional del Agua, , Huaraz, Peru

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Abstract

The interest in numerical simulation of cascading processes involving mass movements and lakes has recently risen strongly, especially as the formation of new lakes in high-mountain areas as a consequence of glacier recession can be observed all over the world. These lakes are often located close to potentially unstable slopes and therewith prone to impacts from mass movements, which may cause the lake to burst out and endanger settlements further downvalley. The need for hazard assessment of such cascading processes is continuously rising, which demands methodological development of coupled numerical simulations. Our study takes up on the need for systematic analysis of the effect of assumptions taken in the simulation of the process chain and the propagation of the corresponding uncertainties on the simulation results. We complemented the research of Adv Geosci 35:145-155, 2014 carried out at Lake 513 in the Cordillera Blanca, Peru, by focusing on the aspects of (a) ice-avalanche scenario development and of (b) analysis of uncertainty propagation in the coupled numerical simulation of the process chain of an impact wave triggered by a rock/ice avalanche. The analysis of variance of the dimension of the overtopping wave was based on 54 coupled simulation runs, applying RAMMS and IBER for simulation of the ice avalanche and the impact wave, respectively. The results indicate (a) location and magnitude of potential ice-avalanche events, and further showed (b) that the momentum transfer between an avalanche and the impact wave seems to be reliably representable in coupled numerical simulations. The assessed parameters—initial avalanche volume, friction calibration, mass entrainment and transformation of the data between the models—was decisive of whether the wave overtopped or not. The overtopping time and height directly characterize the overtopping wave, while the overtopping volume and the discharge describe the overtopping hydrograph as a consequence of the run-up rather than the wave. The largest uncertainties inherent in the simulation of the impact wave emerge from avalanche-scenario definition rather than from coupling of the models. These findings are of relevance also to subsequent outburst flow simulation and contribute to advance numerical simulation of the entire process chain, which might also be applied to mass movements other than rock/ice avalanches.