Hazard mapping and an early warning system for lake outburst floods in the Cordillera Blanca, Peru

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Introduction

The Peruvian Cordillera Blanca is strongly affected by climate change impacts, like many other high mountain regions around the world. The combination of a high population density in close vicinity to strongly affected mountainous regions, treating glaciers has led to some of the most devastating glacier- and permafrost related mass movement disasters where thousands of people were killed during various events over the past decades. The main hazards include rock/ice avalanches, debris flows and glacier lake outburst floods (GLOFs), which are often parts of complex process chains. There are strong concerns that climate change favors such mass movements by destabilizing perennialsly frozen bedrock and steep glaciers, and that the frequency and magnitude of these events might increase in future. This poster focuses on the case of Nevado Huílca mountain with its proglacial lake ‘Laguna 513’ above the city of Carhuaz. In a first step, the hazards have been analyzed and the hazard map was updated. As a second step, a technical early warning system is currently being implemented in the field. These two core elements of an integrated hazard assessment are presented here.

Hazard mapping

A) Process understanding & field mapping

- Analysis of the complex process chain of the April event of 2011 and former events
- Magnitude/frequency relation (critical here)
- Scenario-building
- Hazard mapping in the field

B) Numerical modelling with RAMMS model

Scenario:

Return period:

Rock-ice avalanche volume (above Laguna 513): 350,000 m³
Total debris-flow/runout volume along the channel:

Hazard map with stations of the monitoring and early warning system. The stations are numbered and shown in the fotos below.

Hazard mapping and an early warning system (EWS) with the following functions:

- Real-time monitoring and early warning (geophones, cameras, pressure sensor)
- Long-term monitoring of hanging glaciers at Huáscar (cameras), water discharge (pressure sensor) and climate (station)

The EWS is mainly based on the geophones which automatically give an alert by text messages to selected persons. The cameras and the pressure sensor can be used to confirm/refine the events. During the test and calibration phase (~1–2 years), geophone signals of smaller avalanches are evaluated and thresholds for alerting are successively augmented.

The monitoring and early warning system started from Laguna 513 to the alluvial area of Carhuaz and Acopampa is roughly 90/60 minutes for the small/medium/large events, respectively. In case of a critical situation, local authorities need to make rapid decisions and can make use of a local radio network to inform residents in time. Responsibilities and unambiguous efficient alarm chains are currently elaborated.

Monitoring & early warning system (EWS)

- In combination with field work, model-based hazard mapping can be very helpful
- Uncertainties of such complex process chains are high
- Scenario-building is critical due to lack of information and distinct magnitude/frequency-relations
- A change of former magnitude/frequency-relations must be considered due to strong glacial retreat (debulking, unstable glaciers): ‘The past is the key to the future’ might not be valid anymore!
- Monitoring will improve knowledge on frequency of (smaller) avalanches
- EWS should be able to warn residents in time due to the long travelling distances of the floods and debris flows

The next steps comprise the complementation of the EWS, the initial test and calibration phase, as well as informing the population about the hazards and behavior in critical situations (use of marked evacuation routes). Finally, the implementation of acoustic alarms at some sites within the flood path and on the alluvial fan is planned to reach the entire population more efficiently.