



Trigger Analysis and Modelling of Very Large Debris Flows in Santa Teresa, Cusco, Southern Peru

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Abstract. The Peruvian Andes have repeatedly been affected by large mass movements such as landslides, avalanches and debris flows. In 1998, two very large debris flows in the region of Machu Picchu (Sacsara and Ahobamba), southern Peru, destroyed the town of Santa Teresa, an important hydropower scheme and further infrastructure. The debris flows on the order of 5 to 25 million m³ volume rank among the largest recently observed events of this type worldwide. Despite their extreme dimensions, these events have not been studied in detail. An important limitation for more insight studies is the remote location of the mass flows and the very sparse information and data available for the study region. Neither triggering processes nor mass flow process characteristics have been understood to date. This study tries to fill some of these gaps in understanding that are critical to improved assessment of hazards and eventual risk reduction measures.

For the trigger analysis we used data and information from field work, a limited number of ground based meteorological data, and complementary satellite derived data. Results indicate that in the case of the Sacsara event, heavy rainfall likely was a main trigger. For Ahobamba, antecedent rainfall as well as snow and ice melt leading to saturation of glacial sediments must have played an important role.

Simulations with a dynamic debris flow model (RAMMS) allowed us to constrain a number of flow parameters such as flow height and velocity, runout distance and flow and deposition volumes. Strong surging flow behavior was detected, resulting in very large runout distance (exceeding 20 km); which rather depends on the largest single surge volume, not the total event volume. Based on the identification of potential mass flow sources we modeled a number of scenarios. The assessment of related hazards, including a preliminary hazard map, showed that several communities in catchments draining towards Santa Teresa are endangered by mass movements. Monitoring of the hazard situation is strongly recommended. Design and implementation of tailored risk reduction strategies are currently undertaken within an international Peruvian-Swiss project in close collaboration with local communities and the municipality of Santa Teresa.