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Syneruptive and climatically induced lahars at Cotopaxi volcano, Ecuador

Theresa Raab and Michael Krautblatter
Technichal University of Munich, Chair of Landslide Research, Munich, Germany (theresa.raab@tum.de)

Cotopaxi volcano (5897 m asl) is considered one of the most dangerous active volcanos worldwide and is located in the densely inhabited Inter Andean valley of Ecuador. The presence of an extensive ice cap poses an actual danger of large-scale primary lahars during volcanic eruptions, and the rapid retreat of the glacier is hypothesized to generate recurrent small-scale secondary lahars. Up to now, important erosion- and confluence-effects of mass flows are not yet considered in previous lahar models of Cotopaxi. Here, we investigate the dynamics of syneruptive lahars as well as the impact of global warming and glacier retreat on climatically induced secondary lahars at Cotopaxi volcano.

First, we carefully designed eight primary lahar scenarios in the northern and southern drainage systems of Cotopaxi. The simulations are carried out using the 2D debris flow model 'RAMMS', and the frictional parameters are calibrated with a well-documented lahar event of 1877. The release volumes of future lahars are selected dependent on typical eruption scenarios expected at Cotopaxi volcano (Volcanic Explosivity Index 1 to 4), and range from 3 to 60 million m3. Since the model allows to compute sediment entrainment and deposition processes along the lahar trajectory, we can assess volume changes and downstream evolution of the lahar.

Considering the experienced and projected rapid rise of the equilibrium-line altitude of tropical Andean glaciers, which is likely accompanied by permafrost degradation, we aim to anticipate and model resulting slope instabilities possibly leading to the formation of secondary lahars. We therefore analyze a one-year thermal record gathered by temperature loggers placed near the glacier margin between 5050 and 5250 m asl, and combine it with recently conducted geoelectrical and geoseismical surveys in order to investigate structure, conditions and thermal response of the formerly glacier-covered pyroclastic subsurface.

Our results will contribute to the multi-hazard risk assessment in the RIESGOS project (2017-2020) funded by the German Ministery of Education and Research. In this study, we show very carefully calibrated lahar models capable of reproducing previously non-respected effects such as confluence, erosion reach and propagation speed which provide more accurate representation of key processes shaping lahar hazards.