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Characterisation and probabilistic modelling of small scale lahars on a basaltic shield: Karthala volcano, Grande Comore Island

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The Karthala volcano, on Grande Comore Island, is a basaltic shield volcano with sporadic occurrences of ash-forming phreatic eruptions. The two most recent, mildly explosive, eruptive phases in 2005 emplaced loose volcanic material on Karthala summit area, and caused the recurrent formation of small-scale secondary lahars up to 2012. Triggered by heavy precipitation, these flows impacted the settlements situated at the foot of Karthala, damaging roads and hundreds of houses and affecting thousands of inhabitants.

Aiming to get insights into the main characteristics of the flows, we mapped the debris deposits in the field and surveyed the morphology of the ravines used by the flows. We investigate the ability to model lahars numerically using Q-LavHA, a probabilistic model initially designed for lava flow modelling, and compare results to the widely used LAHARZ using a fitness index based on the outlined lahar deposit extent. We assess accuracy improvement of lahar simulations using an updated virtual topography (Digital Elevation Model) which considers the measurements of the ravine geometry acquired in the field.

The mapped extents of the lahars deposits ($\sim$5 km^2 over the western flank of Karthala) and characterization of the nature of the lahars, allow to define them as small-scale (volume of the order of 2-5.105 m3 with peak discharge of the order of a few 10 m3/s), rain triggered and low sediment concentration lahars. The comparison of the outputs produced by the two mass flow simulation models shows that Q-LavHA can be a potential candidate for lahar simulations, with accuracy values similar or higher to the ones obtained from simulations performed by LAHARZ. Its strengths lie principally in its accurate simulation of the lateral spread of the flow following a break in slope and its ability to model a bifurcation of the flow. Our results also indicate an increase of the accuracy (principally an improvement of the simulated flow trajectory) of the modelled outputs of LAHARZ and Q-LavHA when field measurements of channel topography are used to update the virtual topography on a small spatial scale. The numerical simulation results highlight the added value of such simulations as part of a hazard assessment, and can form the base for the future production of a lahar inundation hazard map for this highly populated volcanic island.