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Simplified simulation of rock avalanches and subsequent debris flows with a single thin-layer model. Application to the Prêcheur river (Martinique, Lesser Antilles)

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This work focuses on the use of thin-layer models for simulating fast gravitational flows for hazard assessment. Such simulations are sometimes difficult to carry out because of the uncertainty on initial conditions and on simulation parameters. In this study, we aggregate various field data to constrain realistic initial conditions and to calibrate the model parameters. By using the SHALTOP numerical code, we choose a simple and empirical rheology to model the flow (no more than two parameters), but we model more finely the geometrical interactions between the flow and the topography. We can thus model both a rock avalanche, and the subsequent remobilization of the deposits as a high discharge debris flow.

Using the Prêcheur river catchment (Martinique, Lesser Antilles) as a case study, we focus on extreme events with a high potential to impact populations and infrastructures. We use geological and geomorphological data, topographic surveys, seismic recordings and granulometric analysis to define realistic simulation scenarios and determine the main characteristics of documented events. The latter are then reproduced to calibrate rheological parameters. With a single rheological parameter and the Coulomb rheology, we thus model the emplacement and main dynamic characteristics of a recent rock avalanche, as well as the travel duration and flooded area of a documented high discharge debris flow. Then, in a forward prediction simulation, we model a possible $1.9 \times 10^6 \, m^3$ rock avalanche, and the instantaneous remobilization of the resulting deposits as a high-discharge debris flow. We show that successive collapses allow to better reproduce the dynamics of the rock avalanche, but do not change the geometry of the final deposits, and thus do

not influence the initial conditions of the subsequent debris flow simulation. A progressive remobilization of the materials slows down the debris flow and limits overflow, in comparison to instantaneous release. However, we show that high discharge debris flows, such as the one considered for model calibration, are better reproduced with an instantaneous initiation. The range of travel times measured for other significant debris flows in the Pr\^echeur river is consistent with our simulation results, with various rheological parameters and the Coulomb or Voellmy rheology.