Modeling of major cliff collapse and subsequent lahars in the Prêcheur catchment, Martinique.

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The Prêcheur river is located to the West of Montagne Pelée, in the Northern part of Martinique island. For several decades it has produced numerous lahars that directly threaten the Prêcheur village, at the mouth of the river. In recent years, the most important lahars have been correlated to massive collapses of the Samperre cliff, 9 km upstream from the sea, that create a reservoir of loose material at the bottom of the cliff. In 2010, a lahar started from this reservoir, destroyed a bridge and inundated part of the Prêcheur village. A new major period of collapses of the Samperre cliff started on 2 January 2018, involving more than 4×10^6 m^3 of material. In the following days, intense rainfalls triggered several lahars that reached the Prêcheur village but remained confined in the river bed. Since then, lahars and collapses have continued to occur, even though their frequency has decreased with time and their intensity is smaller compared to the onset of the crisis. One single lahar overflowed the river bed on 22 February 2018 without significant impact on infrastructures.

In this study, we test different possible scenarios to model the first and most important phase of the collapse of the Samperre cliff, that occurred in early January 2018, with the shallow-water model SHALTOP. We constrain the collapse geometry with photogrammetric 3D models and LIDAR topographic surveys, acquired in 2010 and in late January 2018. We also consider an intermediate volume to take into account a possible retreat of the cliff face between 2010 and 2018. The modeled traveled distances are compared to field observations. Finally, we use geomorphological and geological observations to identify potentially unstable structures within the cliff, and model the associated collapses.

These simulations provide insights on the possible geometry (extent and depth) of the debris reservoir at the bottom of the cliff, after a major collapse episode. This is of prior importance in order to estimate the location and volume of future lahars. In order to investigate their dynamics, we model the major 2010 lahar, for which the initial debris reservoir volume is known (about 2 Mm^3). We first simulate the progressive remobilization of the reservoir by water with the r.avaflow numerical code. In a second test, we impose instead a constant flow discharge upstream until the same volume has been released. We test different parameters to identify which ones have the most significant influence on the lahar travel time, from its initiation until it reaches the Prêcheur village.