How to reconstruct geometrical characteristics and failure conditions of an historic atypical complex flow-like landslide: example of the Deboule of La Ravine de l'Eglise (La Reunion Island, France)

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How to reconstruct geometrical characteristics and failure conditions of an historic atypical complex flow-like landslide: example of the Déboulé of La Ravine de l'Eglise (La Réunion Island, France).

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The reconstruction of scenarios of historical hazardous landslide and erosion processes is a milestone to understand their formation, and perform an appropriate hazard assessment. Here, we focus on the possible conditions that lead to a dramatic cyclone-induced gullying event on La Reunion volcanic island in the Indian Ocean.

In Cirque de Salazie, the Ravine de l'Eglise is a gully of 720 m long and 40 m wide. It formed in just the few days the cyclone Hyacinthe lasted from 15th of January to 27th of January 1980. Hyacinthe drenched Grand-Ilet with world-record-type rainfalls: 5254 mm in 12 days on Grand-Ilet, with a maximum of 1044 mm in one day. This sudden gullying phenomenon, locally called "Déboulé", poses a substantial threat to local dwellings and inhabitants. Grasping the conditions that lead to such dramatic process is a pre-requisite to mitigating the risks.

The heterogeneous properties of coarse volcanic materials, the complexity of the structural characteristics of the terrain and its hydrogeology make Déboulé a phenomenon that is difficult to understand and anticipate. As this rare, fast and hazardous cyclonic circumstances process cannot be observed in-situ, scenarios combining physically based hydrogeological and slope stability models are explored to describe conditions to form and propagate a Déboulé. The development of such integrated models requires the description of initial conditions that led to the event (rainfall amount, morphology of the terrain and its mechanical and hydrological characteristics) and also a detailed geometry of the gully to validate the simulation output.

In this communication, we present the methods used (1) to document the geometry of the Déboulé of La Ravine de l'Eglise (2) the morphological and hydrological triggering conditions of this event.

The original and final topography where the Déboulé of la Ravine de l'Eglise occurred was reconstructed with ca. 1/27 000 archive aerial photographs taken before (1978) and after (1984) the cyclone above Grand-Ilet. Using Structure-from-Motion processing on these two sets of archived images, we build historical digital surface models and ortho-photographs to retrieve quantitative metrics of the landscape evolution caused by the cyclone. The mass wasted during

the Déboulé is ca. 0.6 Mm^3 ± 0.1 Mm^3.We also access to the morphology of the area before the event allowing to identify conditions favorable to the initiation of such phenomenon such as closed depressions, lineaments and regressive erosion lining up the future gully and steep slope breaks.

The hydrogeological conditions of Grand-Ilet during Hyacinthe that caused the Déboulé, are simulated using GARDENIA, a BRGM application for lumped hydrologic modelling. The historic water table levels, especially that under Hyacinthe rainfall, are hindcast considering the rainfalls since 1978 and water table measured in a piezometer since 2010. The hindcast water reported on the reconstructed topography of 1978, crosses the bottom of the embankment that collapsed during Hyacinthe.

The reconstructed topographies and the hindcast water level are consistent with field evidences. Our results document and propose for the first time a quantification the geometry of a Déboulé and bring insight for the initiation of such process.