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Reconstruction and back-calculation of the 2017 Piz Cengalo-Bondo landslide cascade (Switzerland)

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In the morning of 23 August 2017, a maximum of 3.5 million m^3 of granitoid rock broke off from the east face of Piz Cengalo, SE Switzerland. The resulting landslide entrained a maximum of 0.8 million m^3 of a glacier and continued as a rock avalanche, before evolving into a channelized debris flow which arrived at the village of Bondo at a distance of 6.5 km after a couple of minutes. The event resulted in eight fatalities in the upper part of the valley and led to severe damage in Bondo. The most likely candidate for the origin of the water causing the transformation of the rock avalanche into the initial debris flow surge is the entrained glacier ice. The amounts of water or ice stored in cracks in the failed rock mass and in the deposit of an older rock avalanche beneath are probably much less relevant. Subsequent debris flows can be attributed to stream flow having accumulated behind or leaked into the rock avalanche deposit, and melting of ice in the rock avalanche deposit.

We present a set of back-calculations of the process chain of the initial debris flow surge, employing the two-phase and three-phase mass flow models implemented with the r.avaflow computational framework. Thereby, we investigate inhowfar the documentation of the event can be reproduced by the model in a plausible way.

Entrainment and melting of the glacier ice as the sole water source can explain the observations. However, due to the relatively low overall ratio between melt water and rock the formation of a debris flow requires some further assumptions. We consider two possible scenarios: (i) a spatio-temporally differentiated water content in the landslide directly after entrainment of the glacier ice can be generated with r.avaflow by assuming entrainment of most of the ice by the frontal part of the initial landslide, leading to a debris flow at the front, with the rear part remaining mostly dry and depositing mid-valley. (ii) Another possible transformation mechanism relies on the assumption that the entrained glacier first remains beneath and then moves behind the rock avalanche as an avalanching flow of water and ice, and partly overtops and entrains the stopping rock avalanche immediately afterwards, generating the first debris flow surge.

In summary, our simulations confirm the plausibility of the assumed mechanisms of process transformation. However we note that these results are still preliminary. More research is necessary to better understand the initial conditions and mechanisms of this extreme landslide event.