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TLS-recorded massive bedrock erosion of a hyperconcentrated flow in an Alpine Gorge: approaches to modelling the event (Höllentalklamm, Germany)

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High-intensity precipitation events and the resulting extreme discharges in mountain torrents are immensely dangerous and destructive hazards that can put lives in danger and cause expensive damages to infrastructure. There is a high probability that further changes in climate will favour the genesis and therefore increase the frequency of such extreme events. Nevertheless, there is a pronounced desire to experience breathtaking mountainous landscapes, especially when easy accessible. An example is the Höllental gorge (between 1032 and 1062 m a.s.l., Wetterstein mountains, Germany), a key touristic attraction in the region with up to 100k visitors per year. Especially for such highly frequented places, the knowledge and comprehension of possible risks from hydrological and geomorphic hazards is crucial. With this in mind, we are reconstructing and discussing possible modelling approaches of a recent event of a hyperconcentrated flow through the gorge.

In June 2020 a local extreme precipitation event between 50 and 60 mm/h caused a rapid accumulation of the surface runoff due to the steep slopes of the Höllental (inclination of $\approx 110\%$). Secondary sediment storages were mobilized and transported to the main channel where a hyperconcentrated flow developed at the beginning of the gorge. Depending on the percentage of transported sediment in the flow, temporary transitions to a debris flow were possible. Throughout the ravine, massive forces reshaped the rock walls and the channel bed by particle erosion, shearing and relocation of boulders up to 20 m³.

In this study we present a comparison of two terrestrial laser scan campaigns, the first two weeks prior to the event and the second just five days after. We were able to accurately calculate the morphological changes along the sides of the channel and obtained a unique data set for bedrock erosion rates due to the impact of a hyperconcentrated flow. We mapped the flow height throughout the whole gorge by identifying the visible transition of undisturbed to roughened rock surfaces. DEM difference calculation upstream allows to determine the erosion and deposition heights as well as the corresponding volumes. Additionally, electrical resistivity tomographies reveal the thickness of (still) available sediment upstream.

Here we discuss possible numerical and analytical modelling approaches and analyse preliminary

results. We aim at coupling the observed erosion rates to calculated velocities of a model that integrates the complex topography as well as the rheological parameters of the flow. A calibration of the model will be achieved with the mapped flow height in the gorge. Due to the complexity of the gorge, a frequently used numerical simulation as well as a analytical open-channel flow model will be analyzed and compared.

This study presents a unique dataset of effective erosion rates with records collected pre- and post-event. The results contribute to strongly improve the understanding of the flow dynamics in hyperconcentrated flows and give unparalleled information about erosion processes in narrow bedrock channels.