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Analysing the impacts of extreme precipitation events on geomorphic systems in torrential catchments – a comparative study from Upper Styria, Austria

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Introduction

Sediment-laden torrential flooding events are among the most frequent geo-hazards in Austria and lead to costs of several millions of Euros (€) every year (Oberndorfer et al., 2007). Short and intense summer precipitation events in alpine regions know to trigger torrent hazards such as flash floods, hyper-concentrated flows and debris flows. Empirical observations and climate model simulations show that the intensity and frequency of precipitation extremes increased in the last 100 years (Scherrer et al., 2016). This trend is predicted to continue in the future, likely resulting in an increase to the number of hazardous torrential processes is also likely to increase.

The effective design of protection measures is highly dependent on the analysis of past extreme events. Studies are needed to ensure that these measures are adequate to protect lives and infrastructure. The occurrence of hazardous hydro-geomorphic processes is controlled by rainfall and also by the availability of sediment and the connectivity of sediment deposits (hillslope-channel-coupling) among other factors (Hungr et al., 2005). Repeated topographic surveys are used to assess hillslope-channel relationships and quantify geomorphic work of different geomorphic processes in torrent systems. During low-frequency high-impact events geomorphic process rates can increase by orders of magnitude (Korup, 2012). The analysis of pre- and post-event high-resolution topographic data is crucial for the understanding of sediment dynamics and changes in channel morphology in torrential catchments. The aim of this study is to investigate the response of three different torrent catchments to extreme precipitation and runoff events.

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Study sites

The three study areas are located in the Niedere Tauern, which are part of the Central Alps in Austria, Province of Styria. The Schoettlbach catchment is dominated by mica-schist and the proportion of quaternary sediment is around 20 %. The Lorenzerbach and Schwarzenbach catchments are characterized by different gneiss, phyllite as well as schists and a quaternary sediment share of approximately 50%. In the last decade all three catchment were struck by heavy rainfall that triggered torrential events causing considerable damage to human settlements and infrastructure, even though the catchments have different geographical properties (see Table 1).

Table 1

	Schoettlbach	Lorenzerbach	Schwarzenbach
Catchment area [km²]	70.5	5.5	11.3
Sea level of the estuary [m a.s.l.]	815.0	688.2	693.5
Sea level of the spring [m a.s.l.]	1801.0	1864.1	1948.2
Main channel length [km]	16.8	6.4	8.4
Average channel bed inclination [%]	5.9	18.3	14.9
Mean aspect	SW	NE	NE
Mean annual precipitation [mm/d]	737	1172	1172
Discharge 150 year event [m³/s] (Wundt)	165.0	34.1	40.4
Sediment load 150 year event [m³] (Zedlacher)	52,000	18,000	29,000
Buildings in red and yellow hazard zones	156	49	120
Date of event	08/04/2017	07/21/2012	07/21/2012
Point cloud – acquisition date	11/2018	08/2012	08/2012

Methods

High-resolution topographic data of the pre- and post-event data situation are available. The point clouds of the Lorenzerbach and Schwarzenbach as well as the pre-event dataset of the Schöttlbach catchment were collected with a Riegl – LMS-Q560 airborne laser scanning system mounted on a helicopter. For the post-event point cloud, a lightweight Riegl VUX-1LR mobile laser scanner mounted on a RiCopter (drone) was used in the Schöttlbach catchment. All datasets differ in accuracy due to flight altitude, scan angle, point density and footprint diameter. The same interpolation algorithm was applied for all point clouds to guarantee their comparability. Geomorphic change detection (GCD) analysis are performed to investigate sediment dynamics and estimate erosion and deposition volumes.

Preliminary results and future work

The outcomes of the GCD analysis are compared with results of event documentations done by the Austrian Service for Torrent and Avalanche Control. The calculated sediment load for a 150-year flood event is based on the approach of Zedlacher (1986). The

preliminary results indicate that this approach highly underestimates sediment output during extreme events for all three catchments. Based on the analysis of surface models, we aim to clarify the amount and origin of mobilized sediments, with the overarching question whether intensified precipitation events under climate change conditions will cause a shift of the torrential system towards higher sediment yields.

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