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Exhaustion law for post debris-flow sediment redistribution inferred from terrestrial laser scanning and photogrammetry (Roßbichelgraben, Germany)

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Debris flows in settled areas often cause huge economic losses and threaten human lives. Recent studies provide quantitative evidence for increasing frequencies of debris flows in the last decades due to increased rainstorm frequencies, e.g. in the Northern Calcareous Alps (Dietrich & Krautblatter, 2017). In June 2015 an extraordinary rainfall event (approx. 90-120 mm/45 min) triggered several debris flows in southern Germany resulting in damages of about 5 million euros and > 200 evacuated people.
Terrestrial laser scanning (TLS) campaigns in 06/2015, 06/2016, 09/2016, 05/2017, 06/2017, 07/2017, 08/2017 and 10/2017 have been carried out in the Roßbichelgraben torrent, consisting of more than 500 single laser scans. Additionally, a rainfall station was installed in the catchment to investigate rainstorm-induced controls on post debris-flow volume changes in the torrent.
The results provide insights into the mobilised volume and the post debris-flow sediment redistribution in the channel. It shows that more than 11,150 $\pm$ 1,200 m^3 of sediment have been mobilised during the debris-flow event. Erosion depths reach up to 6.5 m in Main Dolomite lithology. The following multi-temporal laser scans reveal that sediment exhaustion effects continue for one and a half years, predominantly in summer months (up to -120 m^3/month). Subsequently, the torrent starts to fill up slowly with sediments (up to 30 m^3/month). Rainfall data suggests that a higher frequency of intense rainfall events leads to higher corresponding erosion and deposition volumes in the studied area.
Besides, we used a DJI Phantom 4 Pro to compare the TLS-derived results with a Structure-from-Motion analysis. Ground control points (n > 20) were taken from the temporally synchronised TLS surveys. The computed volumes are in a similar range.
The results contribute to better understand the erosivity of debris flows (Dietrich & Krautblatter, submitted to JGR-ES). We show that the time-dependent sediment redistribution after a debris-flow event can be related to heavy rainstorm events. A further monitoring of the torrent may give both researches and practitioners more than just a sophisticated guess for channel exhaustion effects and refill rates. Future UAV surveys clearly reduce the investigation and processing time of the gathered data.

Dietrich, A. & Krautblatter, M. (2017). Evidence for enhanced debris-flow activity in the Northern Calcareous Alps since the 1980s (Plansee, Austria). Geomorphology, 287, 144-158.
Dietrich, A. & Krautblatter M. Deciphering controls and developing an erosivity model for highly erosive debris flows. Submitted to Journal of Geophysical Research-Earth Surface.