ACRP 11th call - Project DEUCALION III

The importance of geomorphology for debris-flow activity in Alpine catchments

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Project structure

WP1 – Local sediment dynamics

WP2 – Critical channel runoff

WP3 – Regional sediment availability

WP4 – Susceptibility model and future developments

WP5 – Project management

SUSTAINABLE DEVELOPMENT GOALS

Introduction

This is a follow up project of DEUCALION II, where Prenner et. al. (2018 & 2019) developed a hydro-meteorological model to calculate the regional trigger probabilities for debris flows over a 50 year period (1963-2013). This improved forecasting of debris-flow events compared to simple intensity-duration thresholds. However, a significant number of false positive predictions promts the need to also consider geomorphology!

Hypothesis:

Quantification of the spatial and temporal variation of geomorphological susceptibility improves our ability to predict debris-flow initiation in mountain catchments.

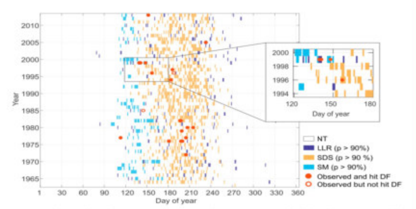


Fig. 1: Daily predicted trigger classes marking a temporal debris flow susceptibility exemplarily for the precipitation zone Gallenkirchen from 1963 to 2013 based on model Mhmeß. A day is colored according to its trigger class cl-(NT = no trigger; LLR = long-lasting rain; SDS = short›duration storm; SM = snowmelt) limited to a probability P(cI-| x1, ...xₙ)of more than 90%. Filled red circles indicate observed debris flows that were correctly predicted (true positives), and open red circles indicate obsen/ed debris flows that were not predicted (false negative). (Prenner et. al. 2019)

Methods

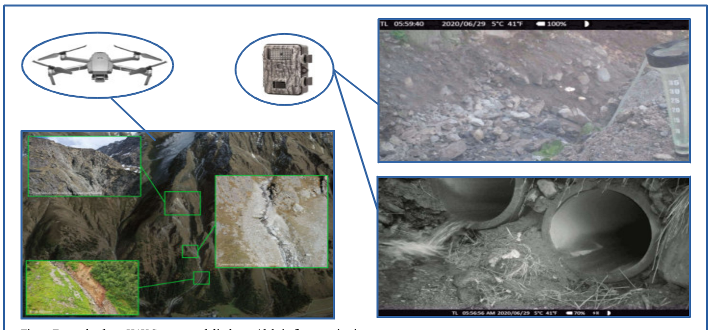


Fig. 3: Examples from UAV Surveys and discharge/debris-flow monitoring

Study regions

In this study we aim to quantify the importance of geomorphology for debris-flow formation in the initiation zone as well as in the transit channel of small mountain catchments in Austria. We focus on two regions (Pitzvalley and Defreggen valley) and selected catchments in Austria where detailed information on hydro-meteorological trigger conditions is available (Prenner et al., 2018 & 2019, Mostbauer et al., 2018).

Fig. 2: Study regions overview

WP 1: Local sediment dynamics

A set of six sub-catchments has been selected from the two regions for continuous monitoring of local sediment dynamics.The geomorphic changes are systematically documented over a period of three years with repeated UAV surveys.

WP 2: Critical channel runoff

At the same time discharge and flow type (flood, debris flow) is monitored at the downstream reach of each creek. The data will be used to calibrate a rainfall-runoff model to evaluate critical runoff conditions for debris-flow initiation.

WP 3: Regional sediment availability

At regional scale, existing digital elevation models (DEM) of high spatial resolution, geologic maps, historic land use and event data are used to identify geomorphological features which increase debris-flow susceptibility.

Project progress

WP 1: Local sediment dynamics

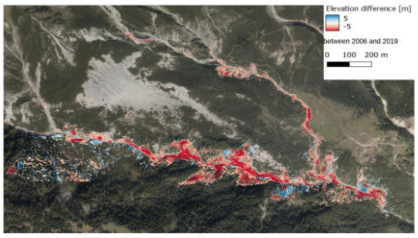


Fig. 4: DEM of difference in the Lattenbach catchment

Several field trips have been carried out in the first monitoring season. The most active catchment was the Lattenbach (3 DF-events). Here we processed:

- 5 UAV surveys between May and October 2020
- 3 ALS datasets from 2006,2016,2019

We find that most of the exported sediment originates from earthflows and glacial deposits. Sediment budgeting is within the order of magnitude of observed DF volumes.

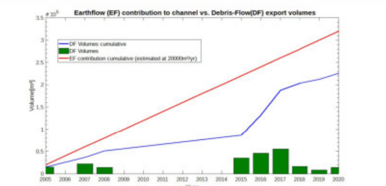
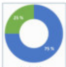


Fig. 5: Contributed/exported volumes in the Lattenbach catchment

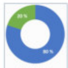
WP 2: Critical channel runoff



- installation of 10 cameras along the channel in the study catchments
- DF-initiation zone narrowed down
- solid picture of catchment response to heavy rainfall
- influence of snowmelt on the discharge in channels

Fig. 6: Catchment response at the Lattenbach

WP 3: Regional sediment availability



- comparison of several morphological parameters
- several correlations found , e.g. SCA vs. fan slope

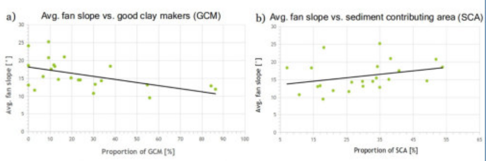


Fig. 7: a) Avg. fan slope vs. GCM b) Avg. Fan slope vs. SCA for catchments in the Pitztal, Tyrol

Challenges

COVID travel restrictions and weather dependencies required creative preparation and flexible adaptation of the field work during the first field season.

Outlook

- publication of results from the Lattenbach catchment in a SCI-journal in the first half of 2021
- field work will start as planned in the end of May
- ongoing collaboration with national and international partners

Dissemination

Articles (*SCI journal):

- Kaitna, R., Prenner, D., Hübl, J. (2020): Muren. In: Glade, T., Mergili, M., Sattler, K. (Hrsg.): ExtremA 2019. , p. 489-510
- Aigner, P., Kaitna, R.: Deucalion 3. Zeitschrift für Wildbach-, Lawinen-, Erosions- und Steinschlagschutz, 84/186, pp. 218-219.
- *Huebl, J., Kaitna, R.: Monitoring of debris flow surges and triggering rainfall at the Lattenbach creek, Austria. Environmental and Engineering Geoscience. doi: 10.2113/EEG-D-20-00010
- *Hanus, S., Hrachowitz, M., Zekollari, H., Schoups, G., Vizcaino, M., and Kaitna, R. (2021): Timing and magnitude of future annual runoff extremes in contrasting Alpine catchments in Austria. Hydrology and Earth System Sciences Discuss. [preprint], doi: 10.5194/hess-2021-92, in review

Conference contributions:

- Aigner, P., Sklar, L., Hrachowitz, M., Kaitna, R. (2020): The importance of geomorphology for debris-flow activity in alpine catchments. AGU Fall Meeting. NH001-0011 (vPICO).
- Aigner, P., Sklar, L., Hrachowitz, M., Kaitna, R. (2020): Why are some alpine catchments debris-flow active and others not? - the influence of geomorphology on debris-flow initiation. In: EGU General Assembly 2020,EGU2020-7805 (vPICO).

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References

Prenner, D., Kaitna, R., Mostbauer, K., &Hrachowitz, M. (2018). The value of using multiple hydrometeorological variables to predict temporal debris flow susceptibility in an Alpine environment. Water Resources Research, 54, 6822–6843. https://doi.org/10.1029/2018WR022985

Mostbauer, K., Kaitna, R., Prenner, D., and Hrachowitz, M.(2018) The temporally varying roles of rainfall, snowmelt and soil moisture for debris flow initiation in a snow-dominated system Hydrol. Earth Syst. Sci., 22, 3493–3513, https://doi.org/10.5194/hess-22-3493-2018

Prenner, D., Hrachowitz, M., Kaitna, R. (2019): Trigger characteristics of torrential flows from high to low alpine regions in Austria,Science of the Total Environment, 658, 958-972, https://doi.org/10.1016/j.scitotenv.2018.12.206