Analysis and Reconstructed Modeling of the Debris Flow Events on the 29th of August and the 4th of September 2016 of Afritz (Carinthia, Austria)

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INTRODUCTION

Afritz, a small village on the debris cone of the Tronitzer torrent, was hit two times by subsequent debris flows on the 29th of August and on the 4th of September 2016. These events caused damages to residential buildings and other infrastructural facilities. A detailed event documentation and analysis was carried out to understand the extreme process sequence and to reconstruct and simulate two-dimensionally the debris flows itself with FLO-2D and RAMMS. The purpose of the simulations was to calibrate input parameters for further simulations in similar torrents.

STUDY SITE

The catchment area of the Tronitzer torrent, with a size of 1.99 km², is located in Carinthia in the South of Austria. Paragneiss and mica schist dominate in the upper and middle catchment and the bedrock is covered by moraines in the middle part of the catchment. 75 % of the total catchment area is covered by forest, mainly by spruce (*Picea abies*).

METHODS

After both events, comprehensive documentation works were performed to collect data about *e.g.* deposition area, grain-size distribution, damages on buildings and the triggering precipitation. To determine the discharge, profiles were measured along the channel in accessible areas. After the second event, an ALS-flight was carried out over the entire catchment area in order to determine how much debris was eroded.

In addition to the data collection, an attempt was performed to reconstruct the first debris flow with FLO-2D and RAMMS::DEBRIS FLOW. The models, especially the rheological parameters, were calibrated on the bases of the collected data in the field. The ALS-Data (1x1 m), the surface areas of the buildings on the debris cone, the bed roughness and a reconstructed sedigraph were used as input data. As a basis for the estimation of the sedigraph, the documented outcomes from the event analysis (reconstructed impact boundaries based on silent witness, debris flow peak discharge, analyzed event time for event-duration, debris flow mass) were used.

METEOROLOGY AND PRECIPITATION

In order to analyze the triggering event Inca Data, based on satellite and radar data calibrated by observation stations, were used. Due to frequent convective rainfall during summertime, the soil was almost saturated. Heavy precipitation on 29th of August started at 15:00 UTC, leading to the first debris flow. The highest measured intensity inside the catchment was about 11 mm/15 min, increasing to the western border of the

catchment to 19 mm/15 min. This has led to a precipitation from 27-35 mm in the middle and in the western part up to 55 mm. The precipitation for the second event was slightly higher, with 13-33 mm, and again for the middle and the western part of the catchment up to 58 mm.

Additional, hail was reported in the upper part of the catchment during the second event.

EVENT DESCRIPTION

In the upper catchment, signs of extreme surface runoff were observed. This led to an enormous water concentration below the drainage of a forest road, which triggered a superficial landslide that initiated bed erosion. This area can be defined as the starting area of the debris flow.

Due to the lateral and vertical erosion, the debris flow was found in the middle reach of the Tronitzer Torrent and spread out at the fan. One reason might be the wood in the torrent, which probably formed blockages, ultimately leading to an outburst from the torrent bed. Several smaller debris flows were observed until midnight. The DEM of Difference (DoD) shows erosion of approximately 56,000 m³ of sediment in total.

Figure 1 deposition area of the second debris flow on the 4th of September 2016 (©WLV)

Within one week, precisely on the 4th of September, the second debris flow occurred at about 14:00 UTC. Due to the open banks caused by the first debris flow, around the same amount of debris was mobilized and transported down to the debris cone. The dominant process type of the second mass movement event was a more fine-grained flow than the first one. However, because of early warning, the settlement was already evacuated. In total, 45 buildings were damaged along the Tronitzer torrent.

CONCLUSION

The two debris flows at the Tronitzer torrent were a result of several circumstances, *e.g.*, intensive precipitation with hail in short time, the extreme surface runoff or the water concentration at the drainage of the forest road. The back-calculation of such debris flow events is seriously hampered by the extent and quality of the data basis. Phenomena registered in the course of the event were collected and the input parameters defined for the calculations. Due to the great complexity of the underlying processes, for nearly all of the necessary input parameters only ranges of values could reliably be given. The rheological parameters might be used for other similar torrents as well.

Out of the several parameter combinations, the BEST-FIT variation was defined. In summery the results with FLO-2D showed good agreement with the documented flow paths. The flow depth and the heights of the debris flow depositions instead were overestimated. The "Best-Fit" result with RAMMS showed a strong overestimation in comparison to the documented event on the right site and an underestimation on the left site of the Tronitzer torrent.

Based on the event analysis, protection measures were planned and are currently under construction. These measures comprise a debris flow breaker and a bedload sorting dam with a capacity of 43,000 m³ in total at the debris cone head, a water retention basin in the upper catchment and bedded rockfill and concrete sills to stabilize the bed in the middle reach.

Keywords: debris flows, event documentation, event analysis, FLO-2D, RAMMS, DEM of Difference (DoD)