Analysis and reconstructed modeling of the debris flow events 2012, 2013 in Austria with RAMMS and FLO-2D

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INTRODUCTION

An extreme accumulation of heavy rainfall events, most of which were of a small spatial extent, led to flooding across the entire province of Styria from June to August 2012 and the entire province of Salzburg from May to June 2013. High intensity debris flows and landslides occurred in the geologically unstable Greywacke zone, whereas sediment- and flood processes dominated in those areas of the Limestone Alps that received very intensive precipitation.

Numerous immediate response measures were already undertaken on the day of the event's occurrence. The aim of the very detailed event documentation and -analysis was to understand the extreme process sequence and to reconstruct and simulate the debris flow itself two-dimensionally with FLO-2D and RAMMS.

STUDY SITES

The catchment Lorenzerbach (event 2012) with a catchment area of 5.84 km² and the catchment Sattelbach (event 2013) with 1.40 km² are situated in the greywacke zone. Both catchments are prone to debris flows.

METEOROLOGY AND PRECIPITATION

Lorenzerbach (Event 2012)

The precipitation event that ultimately triggered this debris flow began at 13:00 UTC on the 19th of July 2012 and ended at 05:30 UTC on the 21st of July 2012. The average for the entire catchment area amounts to slightly more than 141 mm. The catastrophic impact of the event is however not only due to the rainfall intensity of this precipitation event itself, but also in combination with the precipitation of the weeks preceding it.

Sattelbach (Event 2013)

After a 3 days lasting pre-event precipitation period a once more aggravation of precipitation occurred between the night-time of 1st of June until the early hours of 2nd of June. The analysis of the precipitation intensities with the help of weather radar data revealed an overall precipitation of approximately 80 mm until the event date in the respective catchment area.

EVENT DESCRIPTION

Lorenzerbach (Event 2012)

The dominant process type of the mass movement event may be described as a fine-grained debris flow. The damage in the residential area of St. Lorenzen was caused by a debris flow pulse in the lower reach of the Lorenz torrent. This debris flow pulse was in turn caused by numerous landslides along the middle reaches of the torrent, some of which caused blockages, ultimately leading to an outburst event in the main torrent. The back-calculated debris flow pulse indicated a peak discharge of approximately 500 m³/s. This debris flow event „only" lasted about 1½ minutes, but deposited a volume of about 35.000 m³ of material in the village.

Sattelbach (Event 2013)

As the trigger event for the debris flow a 2000 m² large landslide in the upper part of the catchment area can be specified. Because of the steepness of the ravine a debris flow comprising a volume of about 12.000 m³ of material. Due to the steep, very profoundly carved ravine the debris flow had to follow the middle reach of the ravine, at the apex of the debris cone the debris flow first heavily swung against the orographic left side and initially loaded the objects on the left bank. Subsequently the debris flow swung to the orographic right side of the valley and destroyed the personnel house of a hotel.

ANALYSES OF THE EVENT

Lorenzerbach (Event 2012)

Attempts at reconstructing the event processes as well simulating the debris flow in 2D were undertaken in the course of the event documentation and analysis. The thus obtained discharge heights and flow velocities corresponded with the well documented event. The 2D simulations were carried out with the programs FLO-2D and RAMMS, which are capable of simulating debris flows. The rheological parameters of the debris flow material were determined with the aid of a rotational viscometer, conveyor-channel and inclined ramp (BOKU-IAN). The debris flow hydrograph, bedload and bedload ratio were reconstructed using data from the event documentation, such as difference models, geological mapping, wetted perimeters, witness's statements, etc.

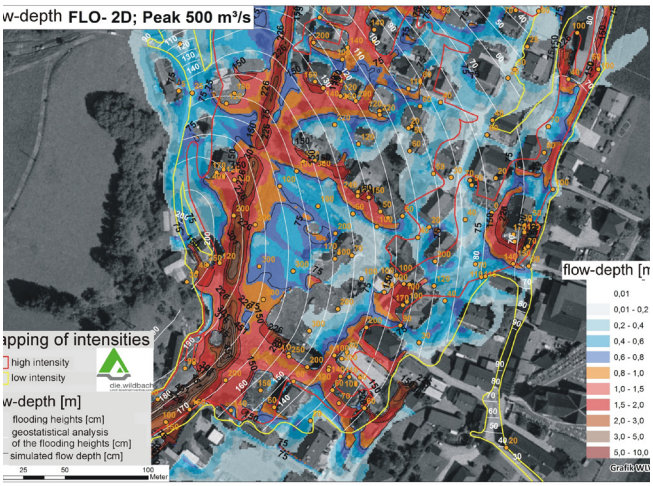

Figure 1. Comparison of simulated flow depths with mapping results and geostatistics

Sattelbach (Event 2013)

A digital laser model, the results of the event documentation, an assessment of the debris flow load and an analysis of the debris flow material in the washout zone served as a basis for the simulation. Due to the course of the event the documented landslide area in the upper catchment basin on the one hand and several other slips in the middle reach on the other hand were set as input values to the model.

DISCUSSION OF THE RESULTS

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 event documentation were collated and input parameters defined for the calculations. Thus, it is only through the back calculation of such mass movement events that the applicability (possibilities and limits) of simulation models can be inferred. Reliable input parameters are generally considered to include the fracture- or release area in the upper catchment, the estimated debris volume as well as the analysis of debris samples and reconstructed impact demarcations and deposition areas. The sediment inputs from the headwaters to the apex of the debris cone were accounted as material inputs estimated section-wise along the torrent length. The simulated flow depths at the debris cone apex are in relatively good agreement with reconstructed flow depths. Larger deviations were found for the lateral expansion of the transported material in the residential area. Both models generally have great difficulties simulating the previously mentioned extreme super-elevation and the resulting change of flow direction. This clearly shows the limits of what can currently be done with model calculations and -simulations.

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KEYWORDS

Event analysis, debris flow simulation, FLO-2D, RAMMS

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