

Heavy rainstorm triggered floodings in central Switzerland in summer 2014 - event analysis and planning of protection measures with the help of numerical models

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INTRODUCTION

On July 24, 2014, a heavy rainstorm occurred in the community of Schangnau (Canton Berne, Switzerland). Within an hour up to 96 mm of precipitation have been measured. Due to wet weather conditions during the entire month of July, the soils were oversaturated, causing rapid surface runoff into the streams and thus floods and debris flows.

The aim of the on-going project is to restore or increase the level of protection against flood and debris-flow hazards. To achieve this, an event analysis was performed, in which both, natural hazard processes and hydrometeorology were studied in detail. On these findings the hydraulic engineering measures were planned and will serve as well for future prevention measures (e.g. emergency planning, hazard maps).

EVENTS

As a consequence of the rare hydrometeorological event, overbank flooding of the Emme River and numerous tributary torrents occurred, causing severe damage in settlement areas, on infrastructure and agricultural land. Large amounts of sediment and driftwood were deposited in and outside watercourses. In many places, existing protection structures were damaged or completely destroyed, mainly due to intense bed and lateral erosion processes.

The closest discharge measuring station at the Emme River is located in the municipality of Eggiwil, some kilometres downstream of Schangnau, at which a maximum discharge of 310 m³/s was recorded. According to the existing hazard maps, this corresponds approximately to a 300-year flood event.

A comparison of affected areas with the existing hazard of Schangnau from 2003 showed some larger discrepancies (e.g. flooding in zones where no hazard was delineated).

MEASURES

During intervention, numerous emergency measures have been implemented by firefighters, military and federal protection and support services (e.g. removal of stream obstructions by debris and/or driftwood). The goal was to reduce immediate danger, which, given the relatively low damage occurred by the subsequent rainstorm events by end of July and in early August 2014, succeeded. In the subsequent phase of repair and reconstruction, 35 individual measures were defined in order to repair the damages or maintain existing protection measures where needed. In doing so, protection of people and property should be at least restored to the same level as before the events of July and August 2014. The range of planned protection measures include slope stabilisation measures by means of log cribs or array of blocks, bed stabilisation with check dams, bed load excavation, dikes and driftwood screens or even channel displacements (GEOTEST AG & Ruefer Ingenieure AG, 2015). The findings from the event analysis could be considered as a basis for the development of emergency and recovery measures (e.g. design discharge).

Due to the complexity of process interactions and for effective planning of measures, numerical modelling was carried out at the two most problematic tributary mountain torrents Sädclgraben and Gärtelbach. For debris flows we chose RAMMS::Debrisflow (Christen et al., 2012), whereby in particular the suitability of so-called NoFlux-

cells (Hohermuth, 2014), a new feature that allows to implement mitigation structures, was applied. As shown in figure 1 NoFlux-cells were implemented where the event will be deflected and should not flow through, e.g. dams or houses (Wernli, 2015). Implementation is possible with small effort in contrast to modification of the terrain model itself and quality of modelling results increases significantly (e.g. more realistic deposition area and heights, deposition behind buildings, etc.).

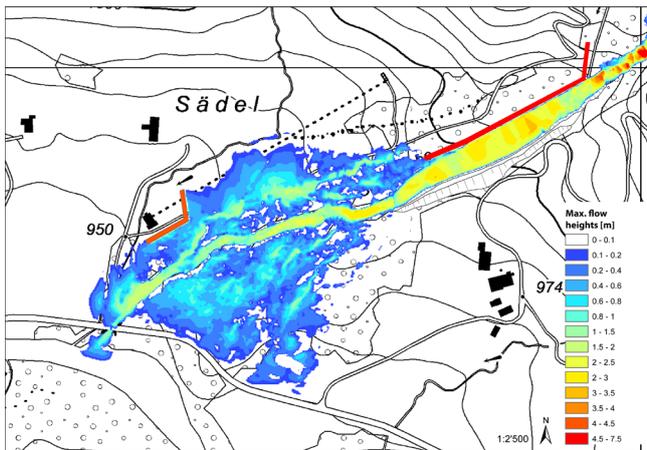


Figure 1. Debris flow modelling at Sädelgraben in Schangnau with RAMMS using NoFlux-cells for protection dams (red and orange lines).

As a basis for numerical modelling we used a high-resolution terrain model (LDTM50cm; KAWA 2012). Areas with lower accuracy caused by dense vegetation were corrected with differential GPS measurements. In a following step we calibrated the friction parameters needed for the debris-flow modelling on the basis of a well-documented event occurred in 2012 at Sädelgraben. Validation of the detected best-fit parameters was performed on the basis of the event in July 2014. Best results were achieved with a turbulent friction term of $\xi = 300$ m/s² and a Coulomb friction term of $\mu = 0.13$. Additionally, a two-dimensional flood model (Hydro_AS-2D; Hydrotec 2015) was used where process combinations of debris flow and floods

KEYWORDS

rainstorm; flooding; debrisflow; protection measures; numerical models

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were assumed, such as at Gärtelbach, or dimensioning of protection measures was crucial, such as the design of a dike at Emme river near Bumbach. Thus, modelling results considerably helped to improve the design of the protection measures.

CONCLUSIONS

The event analysis has shown that sediment deposits (aggradation), erosion processes, blockage with driftwood and process chains (e.g. blockage of the receiving stream by bed load deposition of a tributary torrent) were critical to the flood event in Schangnau. Thus, the reasons for the discrepancies between the existing hazard map and the extreme event of July 24, 2014 are mainly twofold: (a) local fuzziness of the hazard map due to limited methods at the time of its elaboration and (b) more general deviations in the hazard map because intensities and return period of the event were higher than expected in any hazard scenario. While aspect (a) can be improved by new methods such as delivered by numerical modeling and experiences from past events, aspect (b) might be enhanced by analyzing the event characteristics and detecting possible changes in magnitude and frequency, at which an essential requirement for the latter is the disposal of reliable data. Therefore, we strongly recommend a regular review of hazard maps.

It has been shown that numerical models represent a valuable contribution in reviewing and designing of protection measures, as already observed in other studies (e.g. Scheuner et al., 2011). It enables as well complex scenario building and testing the effects of different individual processes. Nevertheless, expert's opinion remains crucial to reduce uncertainties in hazard assessment, especially regarding aggradation or blockage processes, which can only be incorporated in numerical models with great effort.