Geophysical Research Abstracts
Vol. 18, EGU2016-7588, 2016
EGU General Assembly 2016

Surface change modelling of small-scale debris flow dynamics (Mühlsturzgraben National Park Berchtesgaden, Germany)

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Frequency and magnitude of debris flow events in steep mountain torrents as well as their triggering and controlling factors and thresholds are crucial parameters to better understand debris flow initiation, propagation and runout. Related knowledge is of particular interest if human settlements or infrastructure are potentially affected.

The small (ca. 0.5 km^2) but steep Mühlsturzgraben (MSG) catchment (Δh = 1250 m) drains into the Klausbach valley (National Park Berchtesgaden, Germany), a popular (tourist) destination easily accessible by public transport. The MSG experiences frequent high-runoff events with the activity of debris and hyperconcentrated flows due to both, lithologic preconditioning and location-specific high rainfall intensities at the northern fringe of the Eastern Alps. Additionally, the study area shows an intense glacial imprint with steep slopes and over-deepened valleys causing an ongoing (paraglacial) adjustment of this dynamic and transient landscape to non-glacial conditions. The steep catchment is composed of two major lithologic units (separated from each other by the Raibl Formation): Since the lower Ramsau dolomite is highly susceptible to frost weathering, largest amounts of coarse and fine debris in the MSG are provided from this unit predominantly via small-scale primary and secondary rockfall. However, intense rainstorms and/or snowmelt are finally responsible for the initiation of frequent debris flows flushing out the sediments (across the road) into the main valley. In contrast, the overlaying massive Dachstein limestone tends to release larger scale rock- and blockfall. If such events directly hit avalanche snow deposits (which often last for several months in the catchment), major debris flows can be spontaneously triggered through liquefaction (a similar event took place in September 1999).

To investigate recent surface dynamics in the MSG catchment various high resolution digital terrain data is generated and analysed complementary. Monitoring of present-day surface dynamics started in July 2015 using a terrestrial laser scanner (Riegl LMS Z620i). After capturing high density point clouds from several scan positions, the data were registered using re-flectors fixed in the bedrock and a semi-automatic iterative closest point (ICP-) algorithm called multi-station-adjustment. After filtering and triangulation of the data, short term surface change is calculated and – in a second step - compared to and verified by terrestrial and airborne photogrammetric approaches. Sub-recent surface change during the past 5 years will be assessed by comparing the TLS data with ALS data from 2010. Photogrammetric analysis of multiple aerial pictures from the mid-1940s onwards enables us finally to reconstruct and quantify surface change over the longest time period of 60-70 years.

The data will be interpreted with respect to external triggering rainfall events, which might change through time due to internal system dynamics (e.g. sediment availability). The installation of a climate station within the MSG catchment in summer 2015 and two nearby located climate stations operated by the National Park Berchtesgaden enables us to analyse local precipitation variabilities and debris flow triggering thresholds of rainfall intensity in detail.

This presentation is supported by the National Park Berchtesgaden.