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Monitoring sediment migration in a pre-Alpine channel bed using a high-resolution laser scanner, Erlenbach drainage, Switzerland

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Gravel-bed dominated mountain streams are characterized by highly variable, short-term interaction between channel morphology and sediment transport. While a number of recently developed techniques, such as cosmogenic nuclide dating, thermochronology and geochronology of detrital minerals, are successfully utilized to quantify sediment transport and erosion in mountainous stream catchments on longer time scales (ka to Ma), these methods have no resolution power at time intervals shorter than a few ka. In contrast, recently developed terrestrial laser scanning has become an effective tool in geomorphology to monitor shortest-term fluctuations in sediment transport and storage. A typical laser-scanner survey can rapidly acquire large amounts of high-resolution (typically up to a few cm) topographic data, such that repeated measurement campaigns may be used for precise monitoring of transient sediment transport. However, defining the appropriate sampling interval and data density still is problematic: continuous monitoring of mountainous catchments is too expensive, whereas limited temporal coverage will not allow the measurement of parameters related to sediment transport. In order to optimize the sampling strategy, we started to conduct laser-scanner surveys in a well-monitored perennial mountainous drainage. Our study area is the lowermost reach of the Erlenbach stream with a drainage area of 0.74 km^2. It is located on a landslide complex composed of pre-Alpine flysch in the northern Prealps, Switzerland, at elevations of 1110 to 1655 m. Precipitation, sediment and water discharge are continuously monitored by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) yielding the boundary conditions required for a survey period. This is important for the evaluation of subsequent scanning-based observations. So far, we carried out two campaigns in June and October 2008 using a Leica ScanStation®.

The initial comparison of the June and October data yielded promising results. Elevation differences in the channel surface could be resolved at the cm-scale. The interpretation of these data in terms of degradation and aggradation is difficult because the laser beam did not penetrate through the actual water column resulting in apparent channel-bed morphology changes. Furthermore, individual clasts below approximately 20 cm in diameter could not be mapped due to the limited resolution of the point cloud in these two campaigns. Hence, channel patches composed of smaller clast size appear as rather smoothed areas in the digital surface model derived from these data. For example, we observed aggradation and degradation areas often in distinct smoothed zones (e.g. downstream of boulders) implying that they were characterized by grain sizes ranging from sand to conglomerate of several cm in diameter. Furthermore, the average grain-size distribution of the Erlenbach surface-bed material contains d90 = 35 cm, d50 = 7.5 cm, and d30 = 1.8 cm, revealing that up to 75% of the grain-size spectrum is still not covered by the applied scanning resolution. The monitoring carried out by the WSL provides therefore important information to fill this arising gap. However, to better evaluate the significance of our observations, our ongoing research approach requires continuous monitoring of the Erlenbach channel section at a higher frequency, an appropriate 3-D triangulation for an accurate data analysis, and quantitative data processing.