Geophysical Research Abstracts
Vol. 17, EGU2015-4452, 2015
EGU General Assembly 2015

Deriving debris-flow characteristics from vertical laser profile scanners

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Two well-known debris-flow channels in the Swiss Alps, the Dorfbach, in the community of Randa, canton of Valais and the Spreitgraben (community of Guttannen, BE) were fitted with a setup of two laser profile scanners each. Since 2011 (Randa site) and 2012 (Spreitgraben site), these devices have been scanning the passing debris flows at rates of 50 Hz or 75 Hz, recording several million across bed profiles with point densities of roughly 20 points per meter during debris-flow events. In order to comprehend the vast possibilities this extraordinary data set offers, a preliminary evaluation has been undertaken, writing code that allows for a semi-automatic extraction of the main debris-flow characteristics maximum flow height, peak discharge, total discharge as well as spatially distributed flow velocity.

The analysis of 13 events, of which 12 took place at the Dorfbach site, and one took place at the Spreitgraben site, revealed that a large-scale Particle Image Velocimetry (PIV) approach can be used to derive flow velocities, and these in turn can be used to compute discharge curves for all of the recorded events. Total automation has proven to be unrealistic, because the choice of the bed geometry greatly influences discharge results. Also, excluding outlying velocity values is necessary, in order to find reliable peak discharge values.

Nevertheless, we find that the laser scanners offer distinct advantages over the 'established' setup consisting of geophones and a radar gauge because the scanners catch the debris flow as it changes its flow path and offer much higher resolution in terms of distributed flow height measurements. Furthermore, the single profiles of the recorded debris flows were analyzed with regard to their surface geometry by fitting fourth order polynomials to find the points of inflection along the profiles. From this, we have been able to estimate the amount of flow height that debris flows gain by building their well-known convex fronts, and have found that this can add up to 10 % of their width in height and 100 % of the 'regular' flow height in the channel.

The possibilities these datasets offer have by no means been explored to their full extent. The scanners also offer reflectance values that have hardly been taken into account so far, as well as the possibilities to study bed changes and the building of lateral levées, which are clearly visible in some of the datasets. We hope that by providing this preliminary analysis, and a first version of a toolbox that allows working with these kinds of datasets, future studies will yield results that can benefit efforts to improve debris-flow monitoring, modeling and understanding.