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Rapid assessment of debris flow erosion and deposition dynamics by means of terrestrial laser scanning at Illgraben, Switzerland

P. Schuerch (1,2), A.L. Densmore (1), N.J. Rosser (1), and B. McArdell (2)

(1) Durham University, Department of Geography, Durham, DH1 3LE UK, peter.schuerch@durham.ac.uk, (2) Swiss Federal Institute for Forest, Snow and Landscape Research, 8903 Birmensdorf, Switzerland

Debris flows are a primary geologic hazard in mountainous areas worldwide but we have a poor understanding of how flows interact with their channels as they progress downstream. This interaction is important because it affects the hazard of a single flow and makes subsequent flows harder to predict and control. We quantify the patterns of, and controls on, erosion and deposition in debris flows by comparing high-resolution topographic change with flow properties (discharge, composition, density). An understanding of how debris flows erode and deposit is crucial for hazard mitigation. Such interactions affect flow volume and thus maximum runout distance. Changes to the channel cross-section also influence the behaviour of future flows.

The Illgraben fan has experienced 36 debris flows since June 2000, generally in response to summer (May–October) convective storms. The local geology and high relief allow for a very high sediment yield of 150'000 m^3/yr.

A debris flow channel may be dominated by erosion, translation (no net volume change) or deposition. We show that at the Illgraben areas of erosion and deposition have a complex distribution along the channel, and that this distribution changes between events. These observations suggest that local channel geometry and slope play a major role. We present high resolution (0.2 m grid) change maps from successive sets of terrestrial laser scanning data along a 300 m study reach. We use change maps to derive lag rates of single debris flow events by projecting the volume change onto a flow axis down the channel Thalweg. We relate lag rate and pattern of deposition and erosion to the flow properties of these events including hydrograph, bulk density, volume, front velocity and composition. We test these results for correlation with measures of channel geometry including hydraulic radius, bed slope, and flow cross-section.