Geophysical Research Abstracts
Vol. 14, EGU2012-1816, 2012
EGU General Assembly 2012

Integrating field measurements with flume experiments for analysing fluvial bedload transport in steep mountain streams

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Fluvial bedload transport has high importance within sediment budgets of steep catchments and steep mountain streams. It is also of crucial importance as headwater catchments and steep mountain streams can be relevant sediment sources for lowland river systems. Measured under comparable conditions of discharge, rates of fluvial bedload transport can differ by up to one order of magnitude, which is due to the irregular nature of sediment movement. Bedload transport at a defined site depends on factors such as local flow conditions, bed material composition and amount of sediment supply from upstream sources.

Irregular deviations from mean rates of bedload transport can be caused by sporadic inputs of material from hillslopes. Permafrost degradation and shifts in ground frost regimes as caused by climate change can lead to increased frequencies and intensities of mass movements on slopes including the increased frequency of rock fall events. By the destabilisation of slope systems higher amounts of sediment are available from a larger number of activated sediment sources. At the same time, a higher frequency of extreme rainfall events and thermally determined runoff-peaks from glacier-fed systems is leading to an increased number of peak runoff events showing a high transport competence with significant fluvial bedload transport.

A better general understanding of the exact mechanisms and the dynamics of fluvial bedload transport is essential for the further improvement of river engineering management and hazard mitigation projects.

Since 2004, extended and interdisciplinary field investigations on fluvial bedload transport using a novel combination of methods and techniques have been performed in a number of selected stream segments in supply-limited fluvial systems in the inner Nordfjord (Erdalen and Bødalen drainage basins) in western Norway. Field studies include (i) continuous channel discharge monitoring, (ii) frequently repeated surveys of channel morphometry and granulometric analyses, (iii) different tracer techniques (painted stones, magnetic tracers), (iv) Helley-Smith and other basket measurements, (v) horizontally installed impact sensors, (vi) underwater video filming, and (vii) extended biofilm analyses, including also controlled biofilm growing experiments with fixed baskets in selected channels.
In addition, field studies with horizontally installed impact sensors were also carried out in selected transport-limited fluvial systems in the Coast Mountains of British Columbia (Canada) in 2010 and 2011.

The extended field studies are integrated with advanced flume experiments which were carried out in 2010 and 2011 at the Department of Geography at the University of British Columbia (UBC), Canada for calibration of field measurements.

As a key achievement, the entire range of different bedload component grain sizes can be covered by the applied combination of techniques, and the presented integration of interdisciplinary field measurements with flume experiments appears to be a useful approach to study mechanisms, controlling factors and rates of fluvial bedload transport in steep mountain streams.