The influence of hillslope-channel coupling conditions in transport-limited debris-flow catchments

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INTRODUCTION

Nowadays hazard maps, delineating endangered areas of examined natural processes, are a common tool for spatial planning in Alpine regions. Various countries published guidelines or recommendations for the required hazard assessment (Besson, 1996; Stötter et al., 1999; Petrascheck and Kienholz, 2003; Steinmann et al., 2008, e.g.). Most of these guidelines are based on a local scale approach and are defined by the spatial identification related to the magnitude and frequency of, for instance, a debris-flow event. Debris flow hazard assessment consists therefore primarily in the determination of the probability of occurrence and its magnitude. Probability is the likelihood of debris flows to occur in the future, which is a function of the availability of erodible sediments, the occurrence probability of debris slides, and the frequency at which certain intrinsic (location-based) or extrinsic (climatic) thresholds are exceeded (Jakob et al., 2005). Bovis and Jakob (1999) established a differentiation between transport-limited basins in which an almost unlimited amount of sediment is available to feed debris flows (supply-unlimited) and weathering-limited basins in which sediment supply and channel recharge rates are lower, and a substantial time period must elapse before the next debris flow is possible (supply-limited). They proposed a constant threshold over time for supply-limited and transport-limited watersheds with respect to debris-flow initiation and report nearly 7 times higher debris flow activities in transport-limited basins (~ 8000 m^3 a-1).

BACKGROUND

In Alpine regions the amount of water, necessary to trigger a debris-flow event, is mainly correlated to a critical rainfall event. While the study of debris-flow triggering rainfalls has raised a great number of publications (Badoux et al., 2009; Caine, 1980; Guzzetti et al., 2008; Suwa et al., 2009, e.g.), not many systematic studies have been made investigations of hillslope-channel coupling conditions as sediment supply agents in transport-limited catchments. Unsorted solid material can either originate from active hillslope-channel processes or directly mobilized within the main channel. In this proposal, hillslope-channel processes refer to those processes that involve a transfer of slope-forming materials from higher to lower ground, under the influence of gravity, without the primary assistance of a fluid transporting agent. Such hillslope-channel processes can be slow or rapid, shallow or deep and include one or more of the mechanisms of creep, flow, slide or fall (Brunsden, 1979).

HYPOTHESES

The proposed research aims to improve the understanding of the dynamic system which determines sediment transfer within transport-limited catchments. Contrary to the conventional approaches of a static threshold for initiation of debris-flow events over time, this proposal hypothesizes a dynamic extrinsic threshold based on hillslope-channel coupling conditions (active/inactive). Figure 1 illustrates dynamic transport-limited watersheds with respect to debris-flow initiation— considering hillslope-channel coupling. The lower abscissa indicates the sediment contribution over time by active/inactive channel coupled hillslope events. The arrows mark single events of high volumetric impacts as for instance caused by large landslides. The sediment contribution of continuous active/inactive hillslope events as well as single impacts causes a dynamic change of the level of the sediment supply rate. The later directly influences the extrinsic threshold envelope for debris-flow initation. A debris-flow event occurs if the precipitation index of a rainfall event will reach the extrinsic threshold. Beside the geological-geophysical approach, the proposed project will further identify subsystems and their interdependencies like the

function of soil on stability and rheological characteristics of triggered mass movements, the relevant hydrological conditions and the influence of mitigation measurements.

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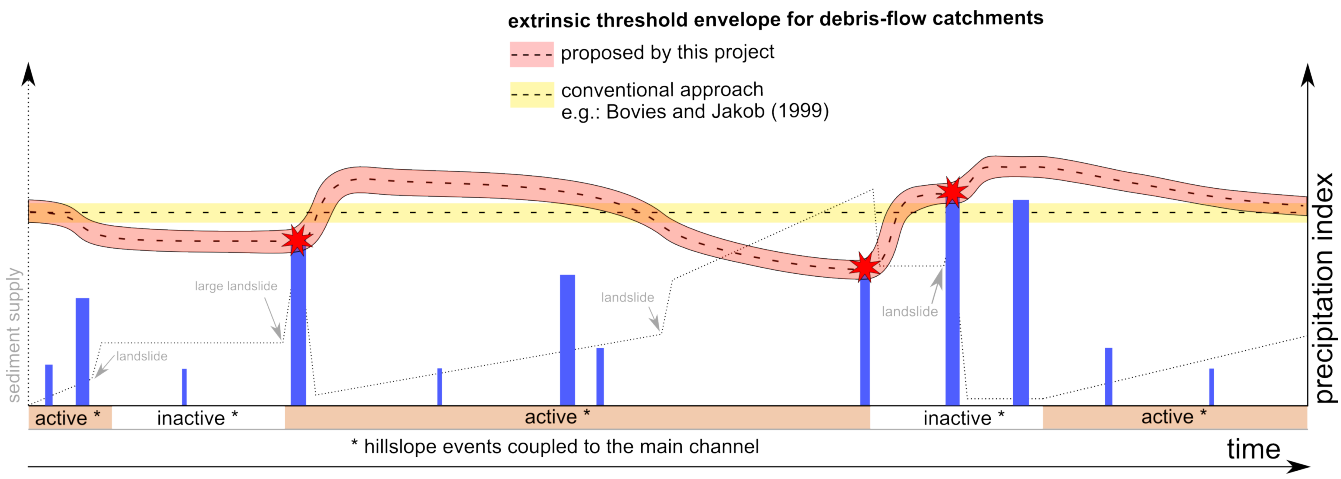

Figure 1. Concept of a dynamic extrinsic threshold in transport-limited catchments with respect to debris-flow initiation.

KEYWORDS

debris-flow; hillslope-channel coupling; sediment supply; transport-limited catchments

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