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Controls, mechanisms and limits of sediment transfer in of the most active debris flow catchments in the Alps, the Illgraben catchment

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The ca. 8.9 km^2-large Illgraben debris flow catchment that is located in the Rhône valley in the Central Alps of Switzerland represents one of the most active torrents in the Alps. In this paper we present data about sediment yields for segments where hillslopes and channels represent a fully coupled network, and contrast these with sediment yields measured for decoupled hillslopes. We further explore the dynamics of sediment transfer in the Illgraben and illustrate how sediment discharge in this catchment has influenced the morphology of the Rhône valley. The data are detailed sediment yields measured in 2006 in various areas of the Illgraben watershed, geomorphic maps based on field observations and orthophoto analyses, and sedimentological information collected in the field.

The results of the one-year survey clearly illustrate that sediment yields are between one and two orders of magnitude larger in segments where hillslopes are fully coupled with the channel network. Furthermore, the limits on sediment transfer apparently differ between the channel-hillslope coupled system and the decoupled hillslopes. In particular, temporary accumulation of material along the Illgraben channel (the coupled system) that was supplied from adjacent hillslopes during the last 40 years implies that production rates of sediment by hillslope mass failure has exceeded the export rate of material for this time span. This suggests a transport-limited sediment discharge in the

Illgraben catchment for the last 40 years. One implication of this is that initiation of debris flows in the Illgraben watershed is more limited by the availability of intense rainfall than the availability of sediment. In contrast, on the decoupled hillslopes, sediment flux appears not to be driven by the parameters that scale sediment transport (e.g., precipitation). We propose that vegetation cover stabilizes the decoupled hillslopes and thus controls and limits the transfer of sediment from them.

Petrographic composition observations of the Illgraben fan deposits indicate two distinct sediment sources where the mode of sediment production and transfer are different (rock fall, landslides and debris flows). The presence of clasts form both sources in the fan deposits implies multiple processes of erosion, deposition, mixing and reentrainment in the catchment before the material becomes exported to the Illgraben fan and to the Rhône River. Finally, the sedimentological analysis of the interface between the Illgraben and the Rhône River reveals that the massive supply of coarse grained material increases the sediment flux and the ratio between bedload and suspension load of the Rhône River, and thus modifies the flow pattern from meandering or anastomosing before the influx of the Illgraben, to braided thereafter. Hence, the effects of the direct coupling between hillslope and channelized processes in the Illgraben watershed are not only seen by high sediment yields and rapid topographic modifications of the Illgraben catchment, but also by the morphologic adjustment of the Rhône valley.