Geophysical Research Abstracts,
Vol. 11, EGU2009-7750, 2009
EGU General Assembly 2009
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Quantifying postglacial sediment storage at the mountain-belt scale

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Sediment storage is an important, though often neglected, term in the sediment budget, building a crucial link between rates of erosion and sediment flux. Mountain belts in particular host large valley fills that modulate fluxes of water and sediment, buffer the geomorphic coupling between hillslopes and river channels, reduce local valley relief, and protect bedrock from erosion by fluvial incision and mass wasting processes. Here we propose a slope gradient-based region growing algorithm to automatically extract areas of postglacial fluvial and lacustrine valley fills from a digital elevation model at the mountain-belt scale. Applying this method to the European Alps, we find that the non-cumulative magnitude-frequency relationship derived from over 17,000 individual sediment storage units, expressed by either area or volume, follows an inverse power law over five orders of magnitude with scaling exponents –1.77 and –1.65, respectively. We show that 90% of the area covered by sediment storage lies in the lower quartile of the mountain belt's elevation and below the median local relief. We estimate that on average 5.8($\pm$4.5)% of the studied catchments are occupied by fluvial valley fill. Minimum trapping efficiency increases with catchment size, possibly reflecting the larger accommodation space of trunk valleys generated by multiple glacial-interglacial cycles. Independently derived estimates of sediment storage for the Alps corroborate our first-order quantification. Furthermore, comparison with sediment storage mapped in tectonically more active mountain belts suggests that uplift, precipitation, and rock type may have minute effects on the extent and spatial distribution of sediment storage at the mountain-belt scale.