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Climate-based analysis of spatial and temporal distribution of fine sediment sources in an Alpine environment

Anna Costa (1), Peter Molnar (1), Laura Stutenbecker (2), Fritz Schlunegger (2), Maarten Bakker (3), and Stuart N. Lane (3)

(1) Institute of Environmental Engineering, ETH Zurich, Zurich, Switzerland (costa@ifu.baug.ethz.ch), (2) Institute of Geological Sciences, University of Bern, Bern, Switzerland, (3) Institute of Earth Surface Dynamics, University of Lausanne, Lausanne, Switzerland

Four main sediment sources can be identified in an Alpine environment: glacier erosion, hillslope erosion, channel erosion and mass wasting events (e.g. rockfalls and landslides). The spatial distibution of fine sediment sources varies throughout the hydrological year according to climatic conditions. While during spring, temperature-driven snow melting largely contributes to discharge and transport capacity of the catchment, autumn intense rainfalls can trigger debris flow events and landslides with a large pulse of sediment mobilized and released to the channel network. At the end of the summer, when the catchment is snow free up to high elevations, glacier melting discloses a large amount of fine sediments to be mobilized.

In this work, precipitation and temperature are considered as control factors for activating different sediment sources and different sediment transport processes. The aim of this work is to analyse and understand basin-scale sediment dynamics of the Upper Rhône basin, a 5200 km2 cathcment located in the south-western part of Switzerland. The correlation between fine sediment loads and climatic variables is used to infer information on the spatial and temporal variability of active sediment sources. Turbidity data measured continuously at the outlet of the Upper Rhône River are considered as a proxy for suspended sediment concentration. Gridded climatic datasets are used to compute total daily precipitation and mean daily air temperature over the entire basin and over different tributary catchments. The relation between fine sediment loads and climatic conditions is analysed by estimating the Spearman's rank correlation coefficient between turbidity, precipitation and temperature time series, assuming different time lags. The indirect effects of temperature are better evaluated by analysing the temporal evolution of snow covered areas simulated by a simple temperature index model.

The correlation of fine sediment loads is much greater with temperature than with precipitation: the continuous and slower snow and glacier melting process, uniformly distributed at basin scale, shapes discharge and turbidity signals, while the effect of more localized precipitation events is superimposed. However, peaks of suspended sediment load are caused by heavy rainfall events. The lag of maximum correlation gives information on the concentration time in the basin, while its variability over time indicates the evolution of the spatial distribution of water and sediment sources.