Erosion and bed-load transport processes on time-scales from minutes to thousands of years – Alp Valley, Switzerland

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Sedimentary basins surrounding the Alps provide an archive to derive information about their erosional history. A wide range of methods with varying temporal resolution and uncertainties, e.g. thermochronology or the sediment budget, had been used to quantify erosion on different time scales. Thus, a linkage between time scales remains problematic depending on several factors, e.g. defining the appropriate parameter to be quantified in terms of erosion, or a sufficient sampling interval. Sampling frequency decreases whereas sampling-interval length increases with time. Currently, it is not possible to resolve the temporal evolution with a resolution compatible with methods used to determine recent erosion and sediment transport.

To obtain insights into time-scale linkage and to facilitate future linkage to longer scales (thousands to millions of years), we focus our analysis on shorter scales ranging from minutes to hundred years. Our study area, the Alp Valley, is located in the northern Swiss Prealps comprising the Alp trunk river (drainage area ~ 30 km²) and two tributaries, the Erlenbach (0.74 km²) located on a large landslide complex and the Vogelbach (1.56 km²) incising into bedrock. This choice is particularly due to the availability of continuous time series on bed-load and water discharge as well as precipitation from the tributary basins – period 2007 to 1983; data from Swiss Federal Institute for Forest, Snow and Landscape Research – and the Alp Valley – period 2007 to 1900; data from Swiss Federal Office for the Environment, Federal Office of Meteorology and Climatology MeteoSwiss. The continuity of these data sets coincides with a very high sampling frequency and very short sampling-interval length (1 minute – 10 minutes – daily), which allowed us to infer bed-load transport back to 1900 using the relationships between bed-load discharge, water discharge and precipitation derived for the period 2007 to 1986.

The bed-load discharge values are a lower bound of erosion based on our preliminary data. Here, the bed-load discharge does not account for suspended and dissolved load, and therefore it represents a minimum net-removal of material from the considered drainage basin. So far, we suspect that the short-term measurements of bed-load and water discharge as well as precipitation reflect climate (e.g. precipitation) including climate variability depending on e.g. seasons. This is also supported by the rapid response of the Erlenbach and Vogelbach streams to increased precipitation by increased water discharge promoting bed-load transport. To finally incorporate the thousand year time-scale to our analysis, we will perform cosmic ray-exposure dating on channel-bed material from the Erlenbach, Vogelbach and Alp basins to determine their average denudation rates. This should also allow us to place constraints on the processes which control sediment transport on longer time scales: climatic versus tectonically controlled bedrock incision (Vogelbach) or landsliding (Erlenbach).