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Temporal pattern and memory in sediment transport in an experimental step-pool channel

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In this work we study the complex dynamics of sediment transport and bed morphology in steep streams, using a dataset of experiments performed in a steep flume with natural sediment. High-resolution (1 sec) time series of sediment transport were measured for individual size classes at the outlet of the flume for different combinations of sediment input rates, discharges, and flume slopes.

The data show that the relation between instantaneous discharge and sediment transport exhibits large variability on different levels. After dividing the time series into segments of constant water discharge, we quantify the statistical properties of transport rates by fitting the data with a Generalized Extreme Value distribution, whose 3 parameters are related to the average sediment flux. We analyze separately extreme events of transport rate in terms of their fractional composition; if only events of high magnitude are considered, coarse grains become the predominant component of the total sediment yield.

We quantify the memory in grain size dependent sediment transport with variance scaling and autocorrelation analyses; more specifically, we study how the variance changes with different aggregation scales and how the autocorrelation coefficient changes with different time lags. Our results show that there is a tendency to an infinite memory regime in transport rate signals, which is limited by the intermittency of the largest fractions. Moreover, the structure of memory is both grain size-dependent and magnitude-dependent: temporal autocorrelation is stronger for small grain size fractions and when the average sediment transport rate is large. The short-term memory in coarse grain transport increases with temporal aggregation and this reveals the importance of the sampling frequency of bedload transport rates in natural streams, especially for large fractions.