Grain size distributions of fluvial sediment mixtures: Indicators for sequential dependent hydraulic control of bedload transport

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A recent trend in fluvial sand and gravel sediment mixtures studies has been an attempt to relate hydraulic control to some statistical parameters of grain size distributions. A common method is to compare grain size parameters to flow parameters in a general way. Another common idea is that in a fluvial system, two 'end member' theoretical grain-size distributions exist and any best-fit relation to them can explain the dynamical fate of the sampled empirical distributions.

A fluvial sedimentary system is composed of three elements, which are forces, morphology, and sediment grains and it builds together a process-response system evolving in time. However, many monitoring programs do not deal adequately with the problem of an appropriate time scale that is sufficient to integrate all processes responsible for the net erosion, transport and deposition of sediments.

The studied data set from Oak Creek consist of grain size distributions taken over 56 days from January to March 1971. The data set is very popular among scientists and was studied and reanalyzed often over the last three decades. In our approach, we divide the sampled period to seven dynamical phases beginning each time with a peak flow followed by flow decay. The paper looks at the time dependency of the sediment grain-size evolution, reflected in the parameters of the log-hyperbolic Probability Density Function (PDF), under specific flow regime pattern from peak flow to decay and examines how it changes with time. The results show that under the same flow regime, but with different bed source material, the resulting pattern of particle size distributions will evolve in a different way. Such a sequential analysis, together with the descriptive statistical power of the log-hyperbolic process related model, will expose the true relationship between the flow and the sediment in any time phase. The paper will show that the most suitable statistical tools to study the above-mentioned processes are the log-hyperbolic PDF and the hyperbolic shape triangle. These tools posses the highest descriptive power to represent a wide variety of grain size distributional forms and the ability to connect it to process-oriented approach.

The morphology of the investigated Oak Creek has been chosen to be very simple and ‘flume like’ and is easy to quantify and the same goes for the flow measurements taken by Milhouse. The sediment’s grain-size distributions are the element of the system that remembers best the dynamic processes and their directions and conserves the integrated information in their hydrodynamical acquired attributes. Any attempt to relate hydraulic forces to sediment grain-size distributions should consider few fundamental aspects:
a. What is the available grain-size distribution in the active layer as reflected by the entire sampled field population? The scientific respond is the ‘super sample’ approach.
b. What should be the approach, knowing the fact that although momentary hydraulic forces posses an accurately measurable potential energy, the bed sediment is, in most cases, not in equilibrium with that energy? A common characteristic of fluvial dynamics is the fact that the

erosive and transport capacity of such hydraulic systems is not saturated. The scientific respond is a sequential analysis approach in the relation between grain size characteristics and hydraulic measurements.
c. What is the relation between the grain size distributions of a sequence of samples and the relation between source material and its sorting products? The scientific respond is a use the best available PDF for the characterization of grain size distributions. The PDF’s parameters should posses a proven process relationship.