Geophysical Research Abstracts
Vol. 19, EGU2017-15075, 2017
EGU General Assembly 2017

Streamwise decrease of the 'unsteady' virtual velocity of gravel tracers

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Gravel tracers are usually inserted and transported on top of the riverbed, before they disperse vertically and laterally due to periods of intense bedload, the passage of bed forms, lateral channel migration and storage on bars. Buried grains have a lower probability of entrainment, resulting in a reduction of overall mobility, and, on average, in a deceleration of the particles with distance downstream. As a consequence, the results derived from tracer experiments and their significance for gravel transport may depend on the time scale of the investigation period, complicating the comparison of results from different experiments.

We developed a regression method, which establishes a direct link between the transport velocity and the unsteady flow variables to yield an 'unsteady' virtual velocity, while considering the tracer slowdown with distance downstream in the regression. For that purpose, the two parameters of a linear excess shear velocity formula (the critical shear velocity $u*_c$ and coefficient a) were defined as functions of the travelled distance since the tracer's insertion.

Application to published RFID tracer data from the Mameyes River, Puerto Rico, showed that during the investigation period the critical shear velocity $u*_c$ of tracers representing the median bed particle diameter (0.11 m) increased from 0.36 m s^{-1} to 0.44 m s^{-1}, while the coefficient a decreased from the dimensionless value of 4.22 to 3.53, suggesting a reduction of the unsteady virtual velocity at the highest shear velocity in the investigation period from 0.40 m s^{-1} to 0.08 m s^{-1}. Consideration of the tracer slowdown improved the root mean square error of the calculated mean displacements of the median bed particle diameter from 8.82 m to 0.34 m. As in previous work these results suggest the need of considering the history of transport when deriving travel distances and travel velocities, depending on the aim of the tracer study. The introduced method now allows estimating the travel velocities directly after seeding (representing the velocity of sediment at the bed surface subject to actual transport), or the longer term transport of sediment, helping to understand the velocity of sediment transfer in river networks as a basis for catchment-wide river restoration plans in the course of the project 'HyMoCARES', which is co-financed by the European Regional Development Fund within the Alpine Space programme.