Onset of gravel motion in mountain gravel-bed streams: Computations based on bedload measurements

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Abstract. Studies concerned with channel change in mountain gravel-bed streams often need to know the flow that initiates motion of gravel and cobble particles. Two basic methods are available to quantify the onset of motion: (1) determinations based on measured bedload transport rates and (2) computations based on flow, stream gradient, and bed-material size (e.g., critical dimensionless shear stress; empirical critical shear stress equations and methods that account for particle mixtures). Methods listed under (2) assume that a specified flow, stream gradient, and bed-material size produce a specific bedload transport rate. However, gravel transport rates for a specified flow and bed-material size vary widely between streams and are difficult to predict. Thus, direct bedload measurements are a more suitable approach for quantifying the onset of gravel motion in mountain gravel-bed streams.

The onset of gravel motion may be at some low gravel transport rate, or be indicated by some visible rating curve property. When analyzed on a double logarithmic scale, a bedload rating curve is a straight line with no visually or mathematically distinctive features. In this case, the onset of gravel motion is defined as an arbitrary, low transport rate (total or fractional transport). Fractional transport rates can be computed in terms of weight-based transport rates or as particle-number transport rates. The flow competence approach computes onset of gravel motion from the largest or median particle size in a sample. An alternative approach is to plot bedload data in linear scales and visually identify the flow at which either total or fractional transport rates increase significantly above the marginal rates at low flow (Onset of Phase II Transport).

A bedload trap with an opening of 0.3 by 0.2 m and a trailing net 1.8 m long was developed at Colorado State University. Mounted temporarily on ground plates, several samplers can be deployed simultaneously, each sampling for about 1 hour. The large dimensions of the trap combined with a high sampling intensity facilitates representative measurements of gravel transport rates and particle sizes during low and high transport. Gravel transport rates were measured over a wide range of flow and provide a suitable data set to compare the onset of gravel motion as computed from several direct measurement approaches.

Analysis indicate that critical flow was not identical between the methods, and the ranking order of critical flow derived from these methods from lowest to highest critical flow varied between streams. Critical dimensionless shear stress for the D_{50} surface particle size typically exceeded the value of 0.06 in most of the computations. This suggests that the values commonly used to compute initiation of motion for gravel-bed stream may be too low.