Modifying Bagnold's bedload transport equation for use in watershed-scale channel incision models

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Abstract. Stream channels may respond to disturbance via incision, or bed erosion, which then propagates through the channel network. This watershed-scale incision response can be modeled using a sediment mass balance, but this requires applicable sediment transport equations. Unfortunately, many sediment transport relationships rely on variables that are difficult to quantify throughout river networks (e.g. shear stress, velocity, and flow depth). Bagnold's empirical bedload transport relationship is attractive because it is based on specific stream power, a relatively straightforward parameter to estimate at large spatial scales using channel slope, discharge, channel width, and bed grain size. However, Bagnold's equation is also dependent on flow depth, so we developed new bedload and total load equations replacing flow depth with specific discharge. Our new equations are parsimonious yet have similar accuracy to other, more established, alternatives. We also explore the applicability of various approaches to quantifying specific critical stream power, and support previous conclusions that these critical values for incipient particle motion can be estimated based solely on sediment grain size. Finally, we test our new sediment transport equations by applying them in a simple channel incision model. Our model results are in relatively close agreement to flume observations and can predict incision rates better than a more complicated morphodynamic model. These new sediment transport equations are well suited to application at stream network scales, allowing for quantification of this important process with major implications for river management.