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How bed-load discharge relationships can shift in response to climate change

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At its simplest level, an increase in water discharge (Qw) will usually lead to an increase in sediment discharge (Qs) from a drainage basin. Though expressed in many different ways (e.g. stream power, flow depth or velocity), this relationship forms the basis of most sediment transport relationships (e.g. Einstein, Parker, Meyer-Peter Muller etc..). There are significant differences between the predictions of bedload yield from different formulae, but all assume their relationship to be stable through time. For example, a flood of 50 m3s-1 will produce similar bedload yields (accounting for some scatter) at different times.

Results from a cellular river basin evolution model (CAESAR) that contains a detailed multi grainsize sediment transport model, indicate that over longer time scales the relationship between Qs and Qw is not stable. By modelling how the daily bedload yield from a medium sized river basin (400km2) responds to changes in climate over the last 10 000 years, high resolution - long term, basin scale sediment discharge relationships can be simulated. These show that quasi linear relationships can be established between Qs and Qw during stable climatic periods, but an increase in flood magnitude and frequency over a sustained period ($>$10 years) can lead to a massive increase in the amount of sediment delivered for identical sized floods. Thus different ‘climatic periods’ can produce a massively different relationship between Qs and Qw (differences of up to 3 orders of magnitude). Furthermore, over the 10 000 years simulated there is considerable variation in response, with sediment discharges for a medium sized flood (30 m3s-1) varying over 8 orders of magnitude. The change in Qs/Qw relationship is heavily influenced by sediment supply and the ‘context’ of the climate period. For example a wet period may exhaust the supply of sediment for following

wet periods - resulting in a lower Qs to Qw relationship. These results may have important implications for sediment transport formulae, engineering calculations based on these (e.g. reservoir siltation), and predictions of how river systems will respond to climate change.