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Transient response in longitudinal grain size to reduced sediment supply in a large river

Michael Singer (1,2)

(1) University of St Andrews, School of Geography and Geosciences, School of Geography and Geosciences, St Andrews, United Kingdom (michael.singer@st-andrews.ac.uk), (2) Institute for Computational Earth System Science, University of California Santa Barbara, Santa Barbara, CA, USA

Bed material grain size is an important degree of freedom in fluvial systems as they adjust to system-wide perturbations such as sediment supply changes. However, little is known about processes and patterns of such adjustment in longitudinal grain size sorting in large rivers. This research uses unprecedented datasets collected in a large fluvial system to investigate transient response to recent supply changes associated with anthropogenic activities. Separate fining trends for gravel and fines, a protracted gravel-sand (G-S) transition, and bed patchiness identified in Singer (2008) were interrogated using output from a hydraulic model with grain size distributions (GSDs) extracted from ∼125 cross sections spanning ∼400 river kilometers of the Sacramento River, California. The analysis suggests that interactions between hydraulics, bed material sorting, and sediment flux explain these previously identified anomalies. Highest values of sorting occur in the G-S transition and represent the overlap of separate fining trends for gravel and fines, where the long profile is jagged with evidence of progressive incision. Much of the sediment in this poorly sorted zone is organized into patches, where transport apparently occurs as bedload sheets. Patchiness occurs over short length scales leading to strong differences in entrainment and flux, regardless of hydraulic conditions. A modified Shields stress is proposed that is scaled by GSD sorting to improve characterization of entrainment/disentrainment. Sediment flux calculations based on an equation sensitive bed material conditions (Singer and Dunne, 2004) reveal a strong relationship between fine sediment flux and d90, suggesting that the efficiency of fine patch flux controls bed material bed surface roughness. Results are in part consistent with Paola and Seal (1995) suggesting that patches are a result of overlapping pdfs of shear stress and sorting and with Ferguson (2003) in that the final end of the protracted G-S transition corresponds to the point at which shear stress and sorting decline concomitantly. However, the transition zone contains anomalously high sorting values characterized by fine bedload sheets that are probably associated with vertical river adjustment and fining due to decreases in gravel supply and therefore a relative increase in fine sediment supply from tributaries, bank erosion, and vertical winnowing and incision. This research gives new insight into transient river channel behavior in response to sediment supply. It demonstrates that the position of the G-S transition and the length scale of the transtion from gravel to sand is a function of feedbacks between sediment supply, transport capacity, and hydraulics.

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