Geophysical Research Abstracts
Vol. 20, EGU2018-11371, 2018
EGU General Assembly 2018

Doing more with less or less with more: river channels adjust to convey their imposed loads of sediment and water

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Gravel bedded river channels adjust to transport the imposed flows and sediment loads, both of which vary enormously between regions. Previous work has shown that alluvial, gravel bedded rivers in high erosion rate landscapes tend to have a high ratio of bankfull Shields stress to critical Shields stress. This suggests that riverbeds in high sediment supply landscapes begin to mobilize at lower-than-bankfull flows, but it does not shed light on the role of climatic controls. To explore the combined effects of sediment supply and hydroclimate, we calculate a multi-decadal time series of predicted sediment transport for 29 rivers across the US, spanning a range of sediment supply and hydroclimatic regimes. In partial support of previous work, we find that there are rivers in both snowmelt and rainfall dominated climates that have adjusted to a 'threshold' state, in which the bed reaches threshold mobility near bankfull flow; however, we find that river channels in high sediment supply landscapes reach threshold bed mobility well below bankfull stage. We show that riverbeds subject to high sediment supply are generally mobile a larger portion of the time and that peak mobility is higher. This should be expected given that, regardless of hydroclimate, total sediment transport should roughly equal total sediment supply in an equilibrium system. Summing the total sediment transport and total water discharge across the multi-decadal time series, we find that the ratio of sediment to water (Qs/Qw) is higher in high sediment supply landscapes. Thus, it seems that high sediment supply river channels have adjusted to accomplish more sediment transport given the supply of water. Future work is needed to incorporate the combined effects of sediment supply and climatic variability into a unified quantitative theoretical framework to describe equilibrium channel morphology.