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Rocks and Rivers that Remember: Using Smartrocks To Constrain Bedload Transport Statistics and Evolving Thresholds of Motion in Natural Mountain Rivers

Joel Johnson[1], Kealie Pretzlav[2], Lindsay Olinde[3], D. Nathan Bradley[4], and Claire Masteller[5]
[1]Department of Geological Sciences, University of Texas at Austin, Austin, Texas, USA (joelj@jsg.utexas.edu)
[2]Balance Hydrologics, Berkeley, California, USA (kpretzlav@balancehydro.com)
[3]Watershed Protection Department, City of Austin, Texas, USA (lindsay.olinde@austintexas.gov)
[4]U.S. Bureau of Reclamation, Boulder, Colorado, USA (dnbradley@usbr.gov)
[5]Department of Earth and Planetary Sciences, Washington University, St. Louis, Missouri, USA (cmasteller@wustl.edu)

Instrumented “smartrock” tracer clasts hold the potential to quantify unique and useful sediment transport statistics from the point of view of each grain--a Lagrangian reference frame. In this presentation we synthesize lessons learned based on two successful smartrock field deployments in natural mountain rivers during snowmelt floods. Our sensors contain accelerometers, data loggers and batteries. We have primarily used smartrock data to simply measure the exact timing of grain rests and motions, although future analyses and additional sensors could be used to measure many more aspects of transport. In addition to methodological suggestions and challenges, we show how smartrock data can be used to measure (a) rest and hop time scaling over a range of timescales, and (b) changes in thresholds of motion through time as a function of discharge. In data from Halfmoon Creek, Colorado, USA, and Reynolds Creek, Idaho, USA, rest duration scaling is heavy-tailed and varies systematically with both timescale and shear stress. The shear stress dependence suggests that bedload clast dispersal becomes less superdiffusive as flood size becomes larger. We identify several likely diffusion regimes, and hypothesize how timescales of flow variability from turbulence to daily discharge cyclicity may cause scaling breaks over minutes to hours. In addition, thresholds of motion tend to increase with cumulative flow (reducing transport rates over time), but also decrease with increases in discharge (increasing transport rates until grains restabilize at the higher flow). The threshold data are used to calibrate and partially validate a new model for discharge-dependent threshold evolution. Finally, we brainstorm ways in which smartrocks could be used to explore sediment transport questions in other Earth surface environments.