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Kinetic sieving sorting experiments at the grain scale in bedload transport on steep slopes

Philippe Frey (1), Hugo Lafaye de Micheaux (1,2), and Coraline Bel (1)

(1) Irstea, University of Grenoble Alpes, Erosion torrentielle, neige et avalanches research unit, St. Martin d'Heres, France (philippe.frey@irstea.fr), (2) Université de Lyon, UJM-Saint-Etienne, CNRS, UMR5516, Laboratoire Hubert Curien, Saint-Etienne, France

Bedload, the coarser material transported by the turbulent flow in river channels, in contact with the bed, has major consequences for public safety, water resources, and environmental sustainability. In mountains, steep slopes drive intense transport of a wide range of grain sizes. Resulting size sorting or segregation is largely responsible for our limited ability to predict sediment flux and river morphology.
Most studies have concerned the spontaneous percolation of fine grains into immobile beds. However when the bed is moving, the segregation process is different as statistically dynamic void openings permit downward percolation of larger particles. This process also named 'kinetic sieving' has been studied in industrial contexts, rarely in fluvial sediment transport.
We present an experimental study of two-size mixtures of coarse spherical glass beads entrained by a shallow turbulent and supercritical water flow down a steep channel with a mobile bed. The particle diameters were 4 and 6mm, the channel width 6.5mm and the channel inclination 10%. The water flow rate and the particle rate were kept constant at the upstream entrance. First only the coarser particle rate was input and adjusted to obtain bed load equilibrium, that is, equality of sediment influx and outflux with neither bed degradation nor aggradation over sufficiently long time intervals. Then a low rate of smaller particles (about 1% of the total sediment rate) was introduced to study the spatial and temporal evolution of segregating smaller particles. Flows were filmed from the side by a high-speed camera. Using image processing algorithms made it possible to determine the position, velocity and trajectory of both smaller and coarser particles. After a certain time, a quasi-continuous region of smaller beads developed under moving and above quasi-immobile coarser beads. Results include the time evolution of segregating smaller beads, assessment of segregation velocity and streamwise and vertical particle velocity depth profiles.