Towards Predicting Sheet Flow Sediment Transport as a Diffusive Process

Alexandru Sheremet¹, Joseph Calantoni², and Christopher S. Thaxton³

¹Department of Civil and Coastal Engineering, University of Florida, Gainesville, FL 32611, USA
²Marine Geosciences Division, Naval Research Laboratory, Code 7440.3, Stennis Space Center, MS 39525, USA
³Department of Physics and Astronomy, Appalachian State University, Boone, NC 28608, USA

Numerical investigations are performed of sheet flow transport using a discrete element model (DEM) to simulate the motions of every sediment particle in a small, but physically relevant domain. The transport rates and time series for particle concentration as a function of depth agree well with existing laboratory measurements. Using the detailed output from the DEM simulations we investigate the self-diffusion of particles along and transverse to the direction of instantaneous net transport across the entire sheet flow from the immobile packed bed up through the top of the saltation layer. As one might expect, self-diffusivities are proportional to the local shear rate. As well, the diffusion along the flow direction is much larger than in the transverse direction throughout the bed. Our model is consistent with classic sediment transport formulae that equate the instantaneous sediment transport rate with the instantaneous bed shear stress. However, using the same instantaneous bed shear stress, we have attempted to correlate the sediment transport rate directly to the characteristic advection and diffusion exhibited by the particles in the simulation. Our investigation is aimed at elucidating the role of particle diffusion in sheet flow sediment transport.