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Numerical Dispersion of Bed Load in a 1D Model Mimics Physical Flume Results

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Motivation

Bed-load dispersion describes how sediment particles spread out relative to each other during transport (Lewis, et al., 2016). The longitudinal dispersion of bed load particles as they move downstream in a river is relevant both to cases of polluted sediment and pulses of sediment released during reservoir flushing events or dam removals.

Physical Experiments (1, 2)

To quantify the rate of bed-load dispersion, we conducted a series of flume experiments using successive additions of different-colored sediment in a 22m x 0.9m, upstream-fed, tilting flume at the U.S. Engineer Research and Development Center's (ERDC) Coastal and Hydraulics Laboratory (Gibson, et al., In Prep.).

- Red, Purple, Yellow, Green, and Blue particles introduced for varying durations
- Samples of final surface (1) collected at 0.3m intervals to determine fraction of each color present (2)
- Dispersion coefficients (*K*) calculated using the method of moments (Ramos, et al., 2015)

1D Numerical Modeling (3, 4)

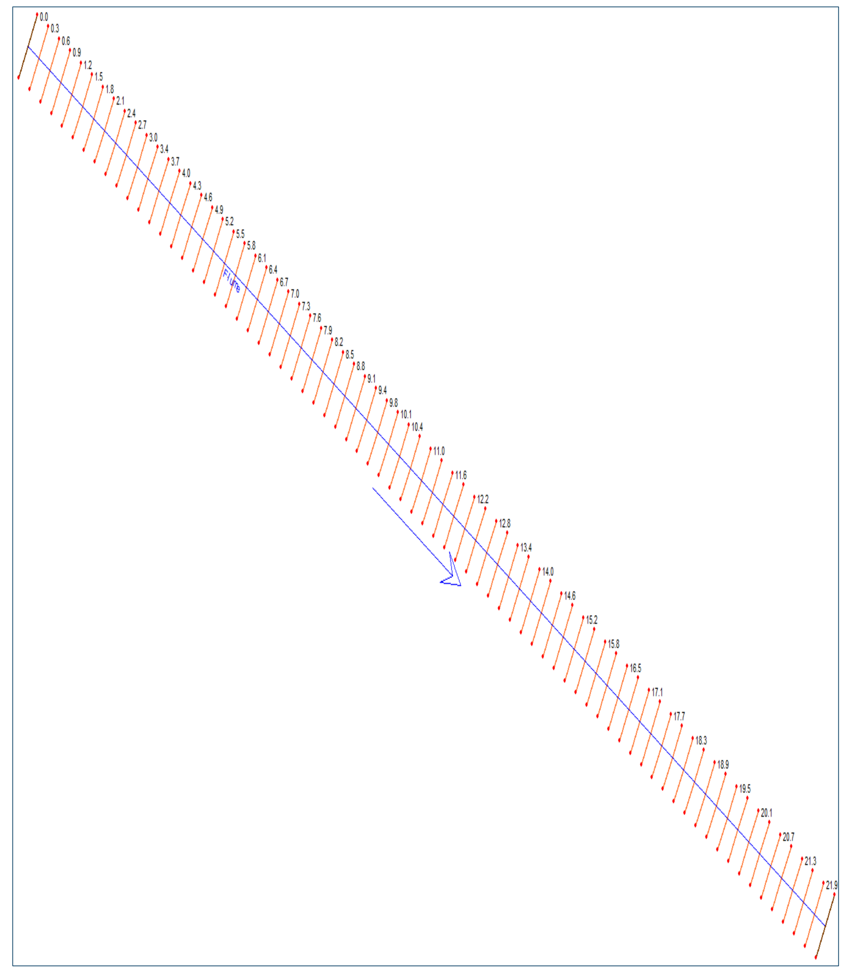
We modeled the flume runs using the quasi-unsteady state, one-dimensional sediment modeling capability of HEC-RAS. We adjusted the active layer thickness and the bed-load depositional exchange increment to match the active layer distribution of colors. The bed-load depositional exchange increment sets the ratio of active layer vs. bed-load material that are mixed into the bed during deposition.

- Different colors were modeled by changing the grain size by 0.01mm
- Fraction of each color in active layer calculated at same sample cross sections

(1)

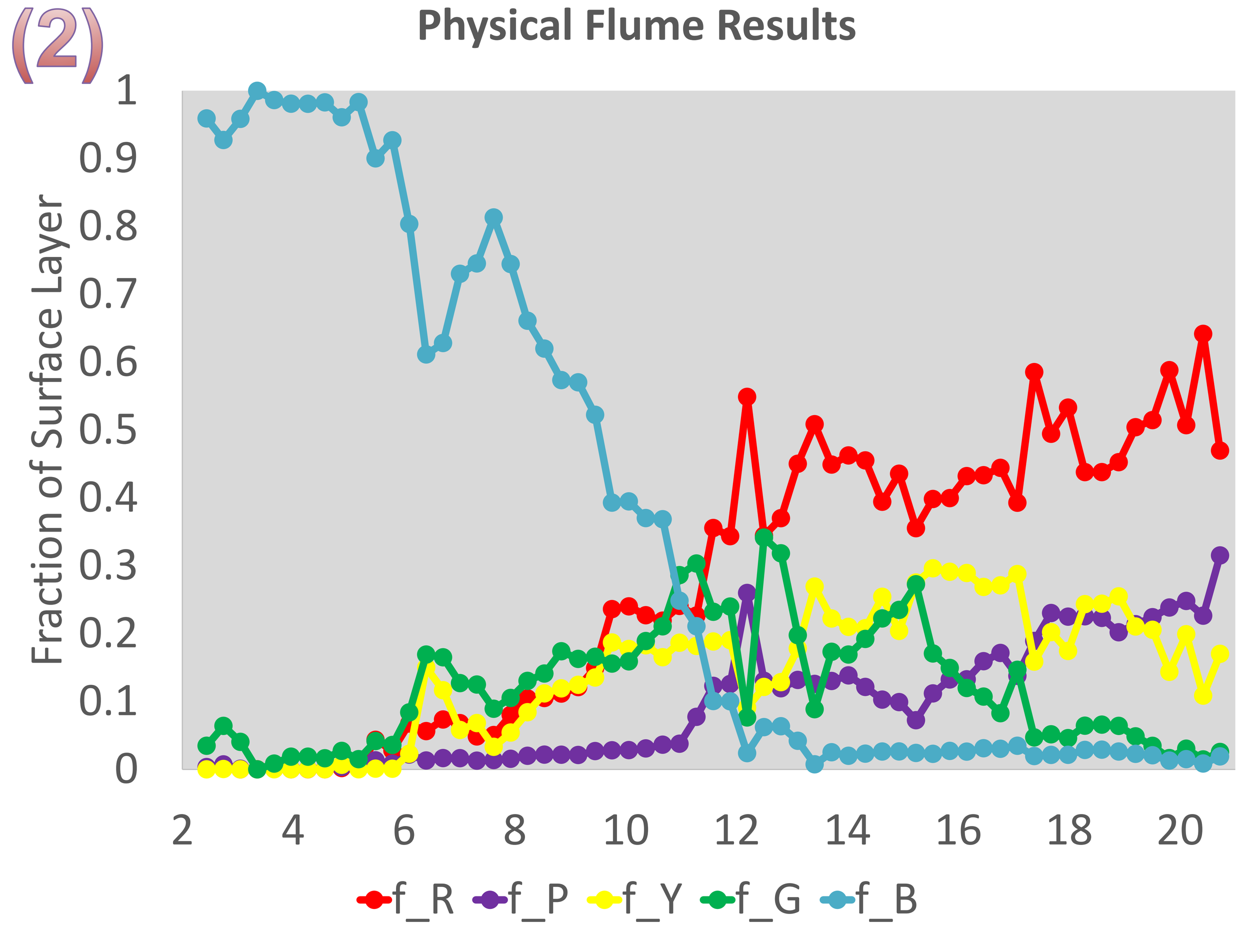
Flume experiment with different-colored sand particles. Flow was from top to bottom of photo.

(3)



1D sediment model layout with 0.3m cross-section spacing. Flow is from top to bottom.

(2)



Fraction of different colored sediment collected from the surface layer at the conclusion of flume experiment. Flow was from left to right.

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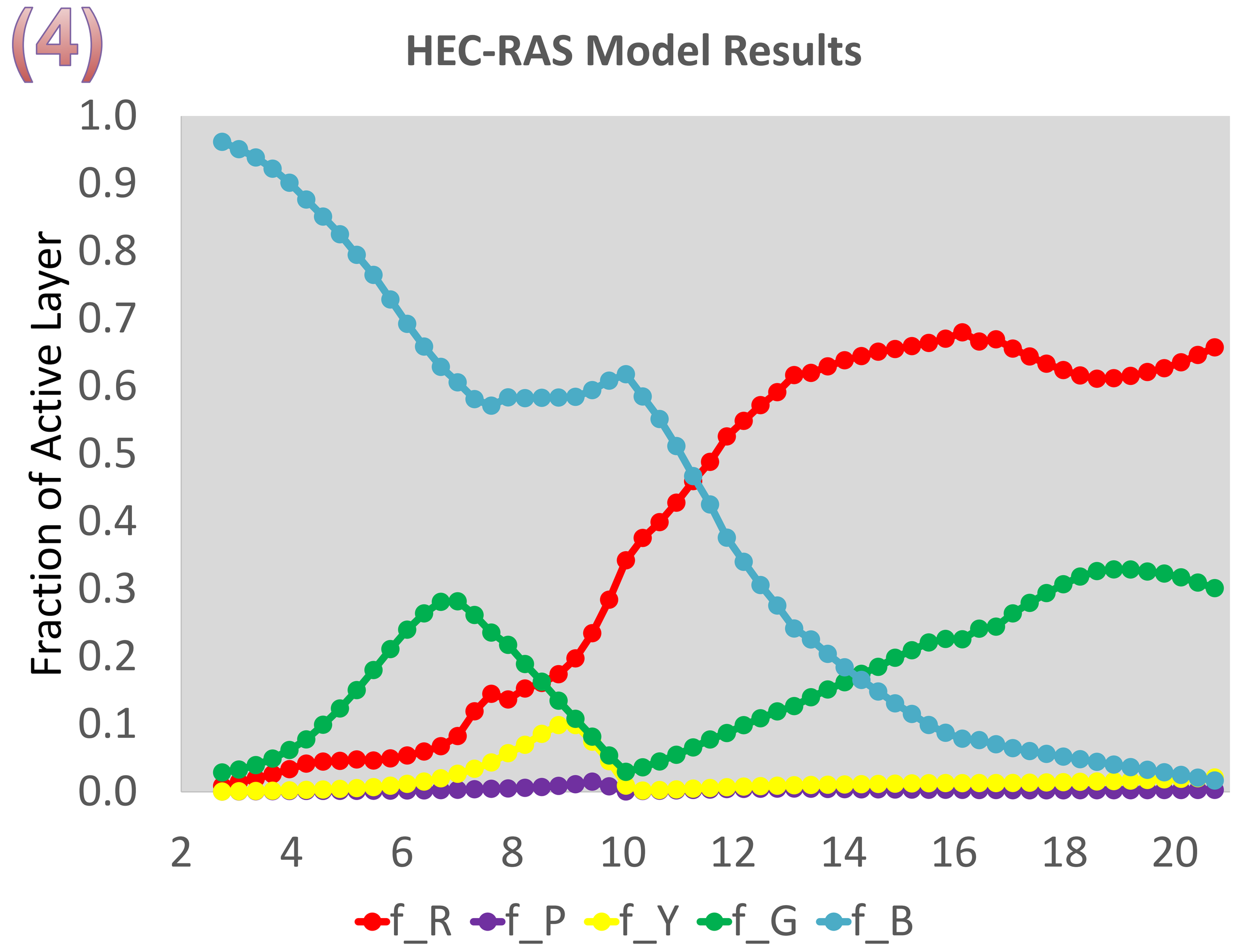
(4)



Fraction of different colored sediment in the model's active layer at the conclusion of the 1D model run. Flow was from left to right.

Conclusions

Longitudinal bed-load dispersion can appear in a one-dimensional sediment transport model that does not explicitly simulate dispersion. This is caused by the mixing and armoring algorithms of the numerical model.

- The optimal parameters varied between the flume experiments, but smaller active layer thicknesses generally performed better.
- Models may need to be modified to track multiple grain classes of the same particle size to improve accuracy.
- A portion of the dispersion in the flume experiments was due to mixing and burial of grains by bedforms, which were not explicitly modeled.

References

Gibson, S., K. Ramos, R. Heath, D. Abraham, T. Dahl, A. Sánchez. In preparation. Inverse Size Dependence of Sediment Velocity and Dispersion Near the Sand-Gravel Transition: Bed Form Influence on Bed-Load Sediment Flux, Advection, and Dispersion.

Lewis, J.W., A. Sánchez, T.A. Dahl, I. Floyd. *Bed-Load Dispersion: A Literature Review*. ERDC/CHL SR-16-5. Vicksburg, MS: U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory. http://acwc.sdp.sirsi.net/client/search/asset/1054488.

Ramos, K., S. Gibson, L. M. Kavvas, R. Heath, and J. Sharp. "Estimating Bed-Load Advection and Dispersion Coefficients with the Method of Moments." In World Environmental and Water Resources Congress 2015, 1736-41, 2015.

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