AdH (Adaptive Hydraulics) and Sediment Transport: SEDLIB Recent Developments

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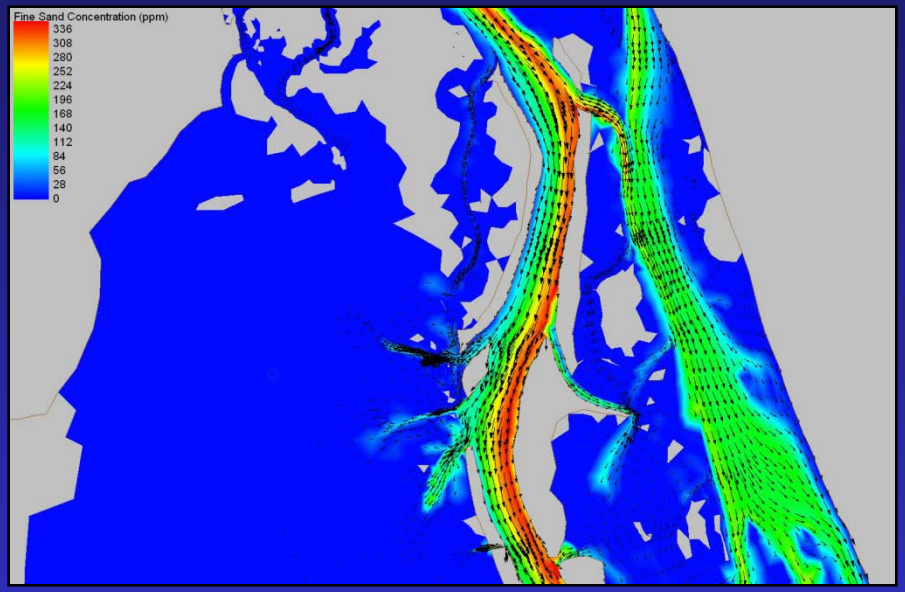
Sediment Transport Library (SEDLIB)

A generalized, robust sediment transport module:

- Riverine transport and morphologic change
- Coastal and estuarine transport and morphologic change
- Fate of contaminated sediments
- Fate of dredge material disposal

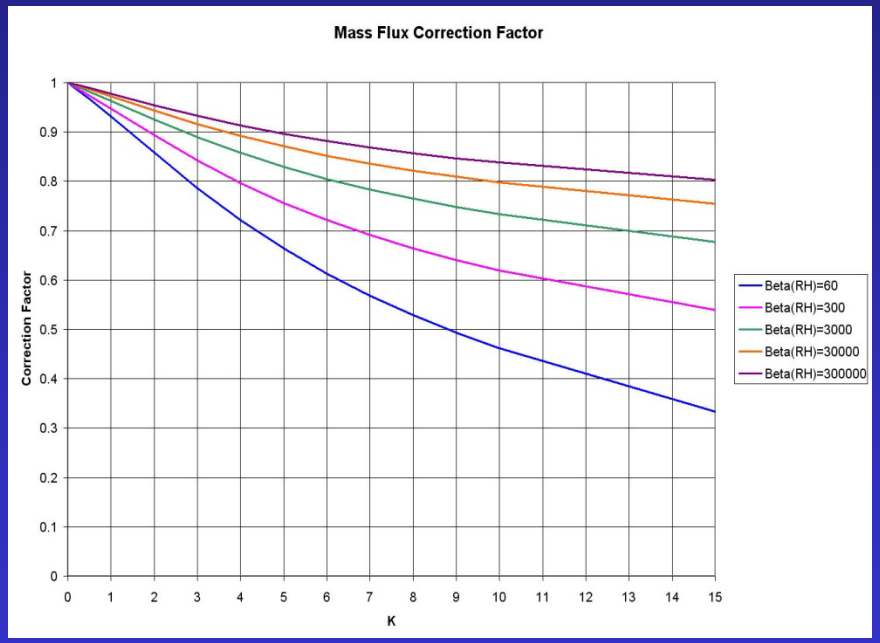


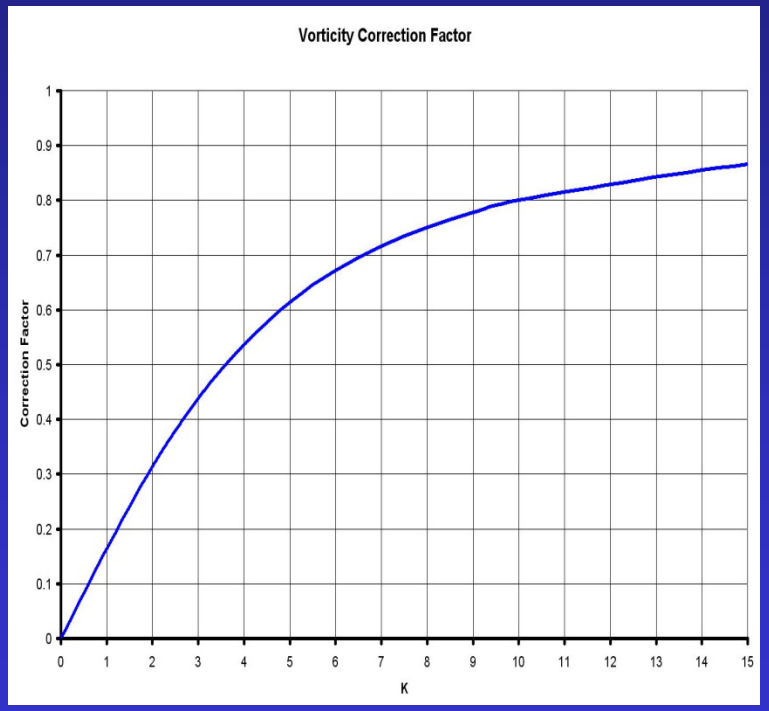
Velocity vectors and color contours of suspended concentration of fine sand in Pool 5 of the Mississippi River

Sediment Transport Library (SEDLIB)

$$\frac{\partial(dC)}{\partial t}+\frac{\partial(u_{vc.x}dC_{FC})}{\partial x}+\frac{\partial(v_{vc.y}dC_{FC})}{\partial y}+$$
$$\frac{\partial}{\partial x}\left(dD_X\frac{\partial C}{\partial x}\right)+\frac{\partial}{\partial y}\left(dD_Y\frac{\partial C}{\partial y}\right)+S_{ss}(C,R_{CP})=0$$

Suspended and Bedload Nonequilibrium Transport are both dependent on standard advection diffusion equation solution schemes, with factors passed to the parent code from the library to account for sediment properties





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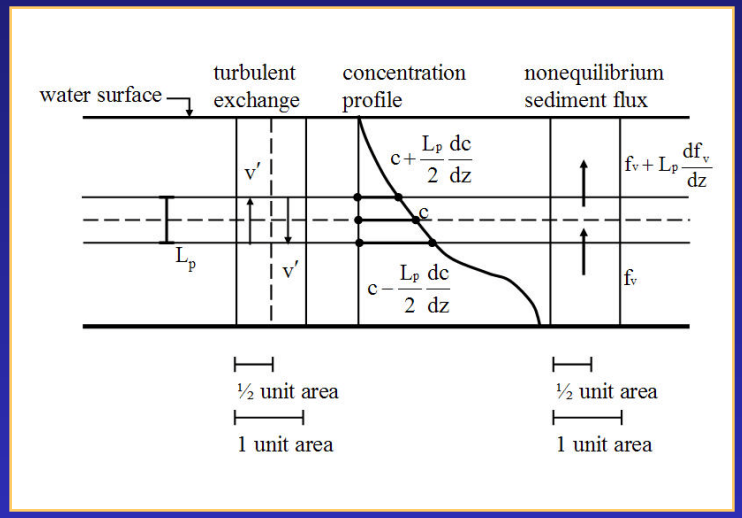
Nonequilibrium Suspended Sediment Profile

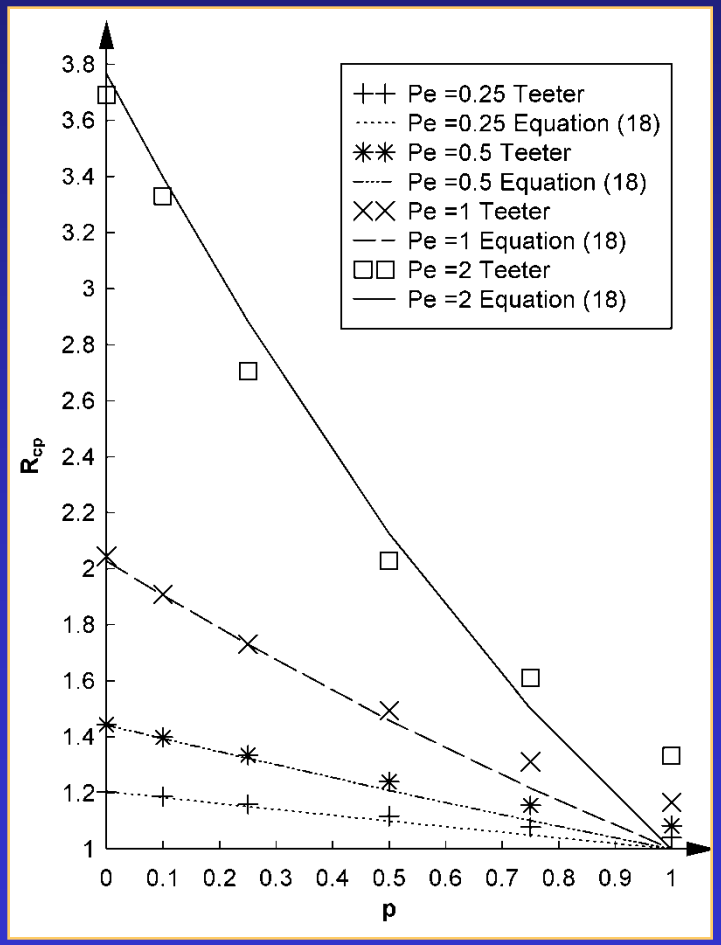
Brown, G.L. (2008) “An Approximate Profile for Nonequilibrium Suspended Sediment” J. Hydr. Engrg. Volume 134, Issue 7 pp 1010-1014.



$$\frac{c}{c_a}=\left(\frac{Z}{A}\frac{(1-A)}{(1-Z)}\right)^{-K}$$

$$K=\frac{1}{\beta_{ss}\kappa}\frac{(1+F_{v.a})}{\left(\frac{u_*}{v_s}+F_{v.a}\right)}$$

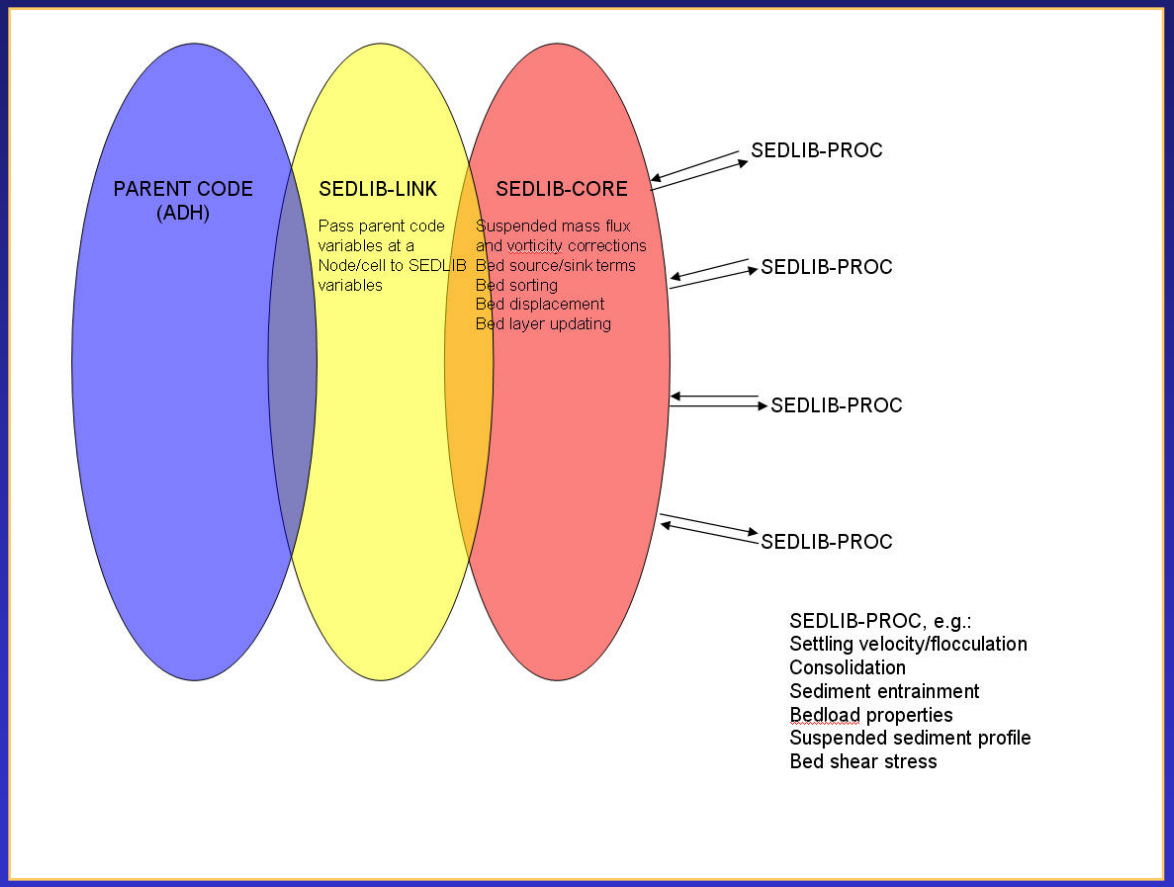
$$F_{v.a}=\frac{f_{v.a}}{v_a c_a}$$



Sediment Transport Library (SEDLIB)

Objective: design the library such that fundamental algorithms are integrated (SEDLIB-CORE) whereas process descriptions are peripheral (SEDLIB-PROC).

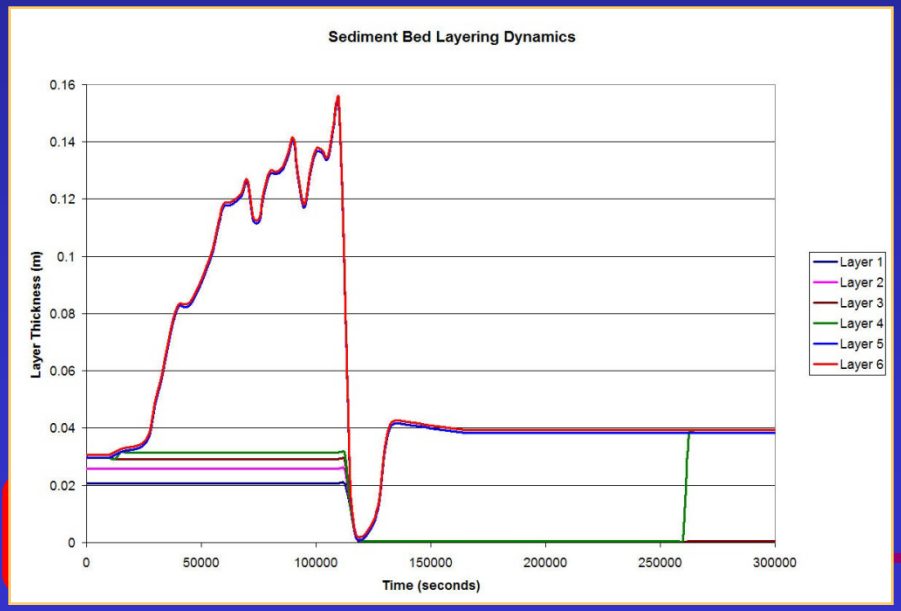
Allows for rapid and easy expansion of the libraries to include new research and development products.



Sediment Transport Library (SEDLIB)

$$\frac{\partial\left(\left(1-p_{AL}\right)\varepsilon_{AL.i}\,\theta_m\right)}{\partial t}+\frac{\beta_{AL.i}S_{E.i}+\beta_{AL.i}S_{BLE.i}-S_{D.i}-S_{BLD.i}}{\rho_w s_i}+\left(1-p_{AS}\right)\varepsilon_{AS.i}\frac{\partial\left(\eta-\varepsilon_m\right)}{\partial t}\theta_m=$$

$$\left(1-p_{AS}\right)\frac{\partial\left(\eta-\varepsilon_m\right)}{\partial t}+\frac{\partial\left(\left(1-p_{AL}\right)\varepsilon_{AL}\,\theta_m\right)}{\partial t}+\sum_{i=1}^{i=ngc}\frac{\left(\beta_{AL.i}S_{E.i}+\beta_{AL.i}S_{BLE.i}-S_{D.i}-S_{BLD.i}\right)}{\rho_w s_i}=0$$



- Suspended and Bedload Nonequilibrium Transport
- Bedload with Bendway and Bed Slope Corrections
- Implicit Bed Sediment Sorting Calculations
- Multiple bed layer erosion within a single time step
- Mixed sediment modeling capability
- Optimized Bed Layer Bookkeeping Algorithm
- Multiple bed layer bulk density and sediment specific gravity capability
- Bed shear stress under ice
- Bed shear stress induced by wave-current interaction
- Bed consolidation
- SEDFLUME bed properties input capability

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SEDLIB - Some Changes

No need to include sediment in any size order
Or type order (sand, then clay)

NO EXTRA BEDLAYER OR EXTRA GRAIN

Multiple specific gravity values, bed porosity, ect

Automatic Eddy Viscosity Changed

SEDLIB - Some Changes

Standard technique for new process implementation

SP NSE 1 0

Sediment process	Process type	Process number	Any needed coefficients (1-20)

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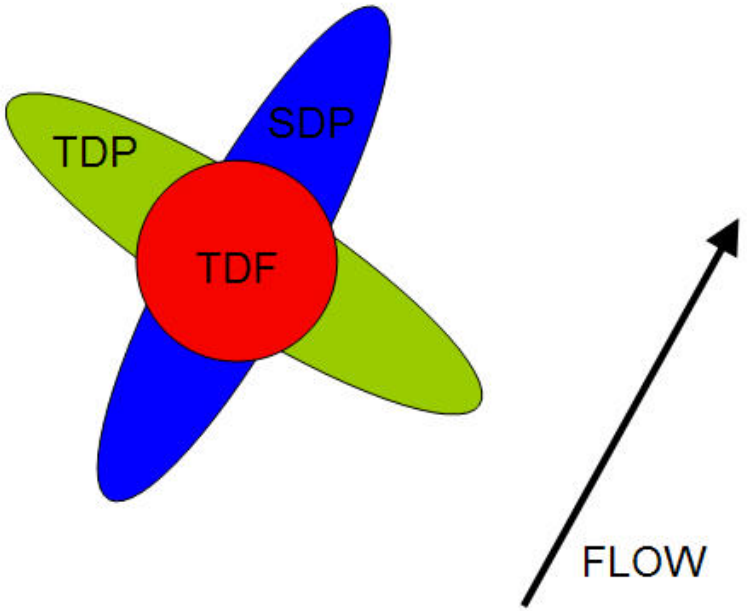
ADH - Automatic Eddy Viscosity



Implemented according to experimental/theoretical arguments

TDF – Turbulent Diffusion (Webel and Schatzmann, 1984)

SDP – Streamwise Dispersion

TDP – Transverse Dispersion

EEV = 1.0 WILL BE NEW DEFAULT

$$\varepsilon_{SDP} = 2\int_{\frac{1}{e}h}^{h} \left(u(z) - \bar{u}\right) dz$$

$$\bar{u} = \frac{1}{h}\int_{0}^{h} u(z)\,dz$$

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Ice Friction

Brown, G. L., G. Savant, C.; Berger, and D. S. Smith. 2009. Considerations for stationary ice covered flows in ADaptive Hydraulics (ADH) ERDC TN-SWWRP- 09-4. Vicksburg , MS : U.S. Army Engineer Research and Development Center . https://swwrp.usace.army.mil/

Theoretical description of the frictional effects of stationary ice have been developed.

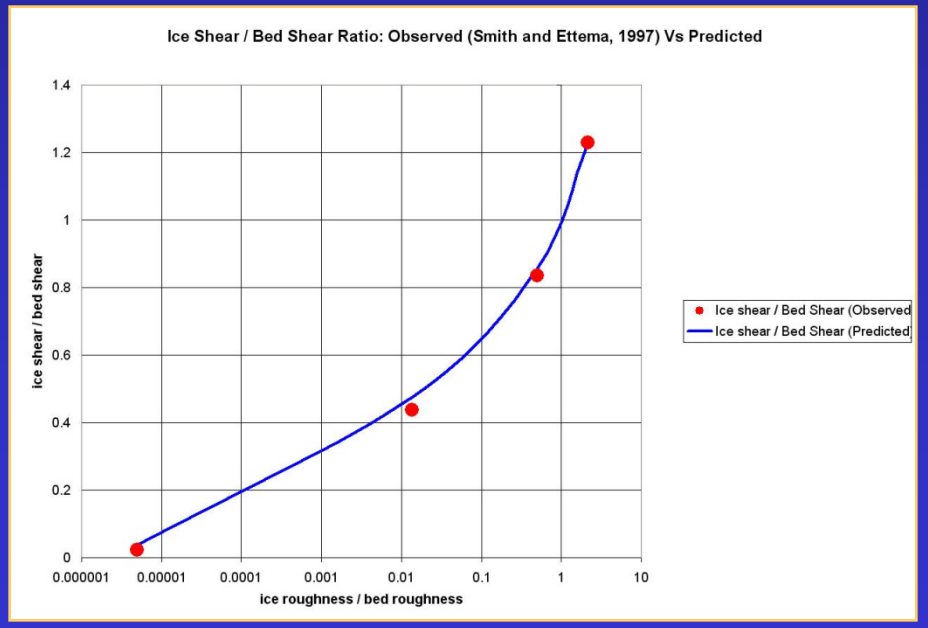
Theory partitions friction between bed and ice frictional components.

Theory has been compared to observed data.

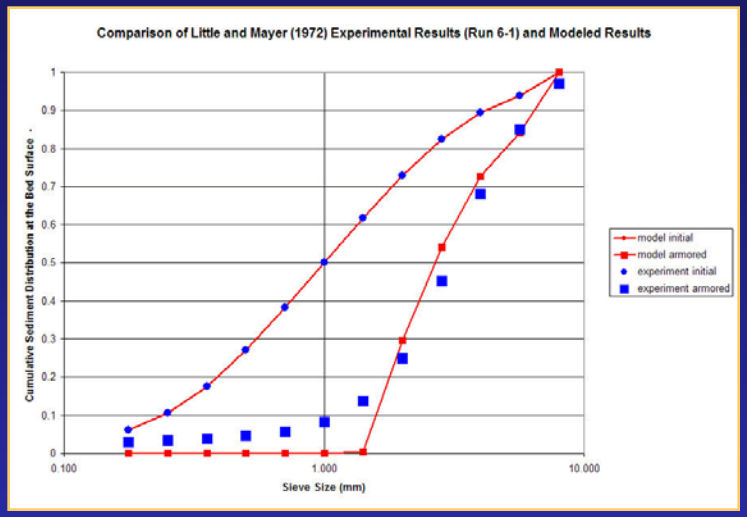
Method has been implemented into ADH.

Little if any observed data for moving ice is known to exist.

If observed data becomes available, the theoretical development for moving ice can be tested as well.

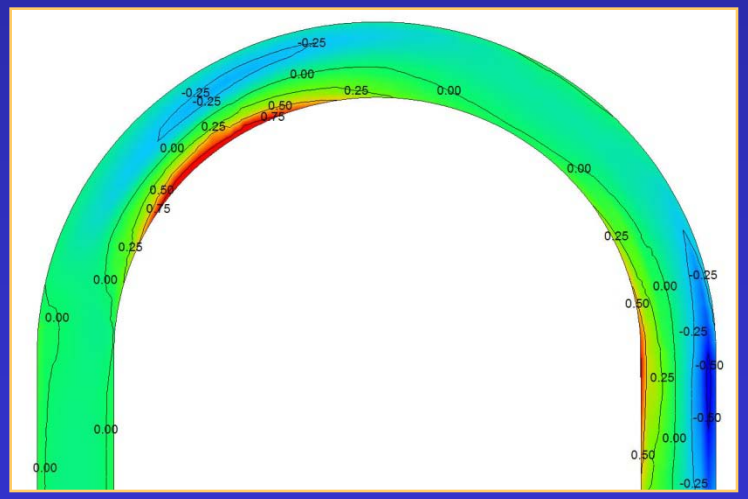


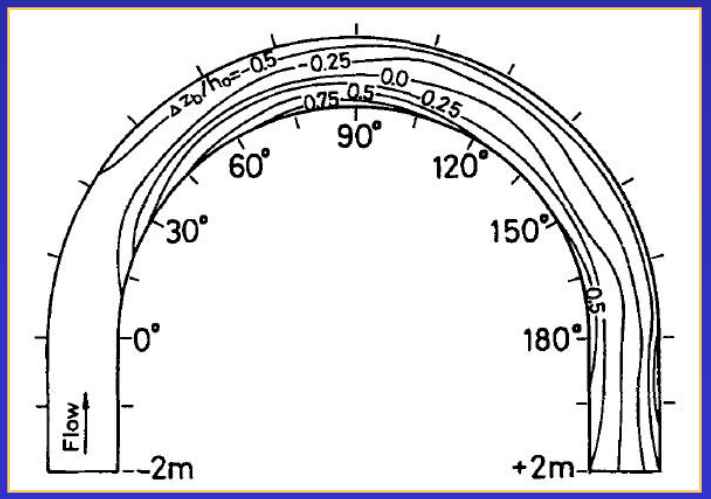
Laboratory Test Cases



Little and Mayer armoring experiment

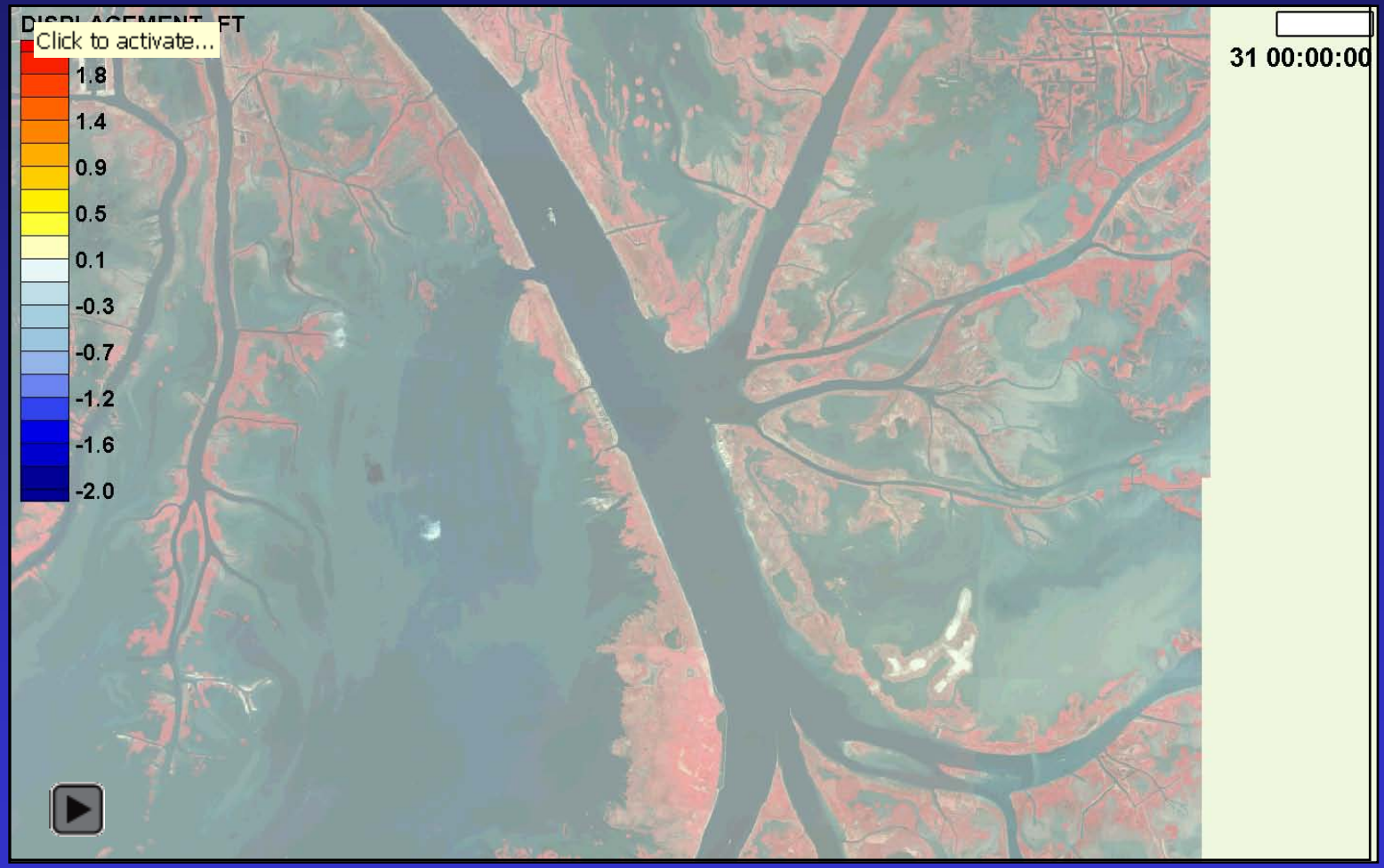
These show good agreement with laboratory data, demonstrating the ability to model bed sorting and bendway morphological evolution





Yen and Lee bendway experiment

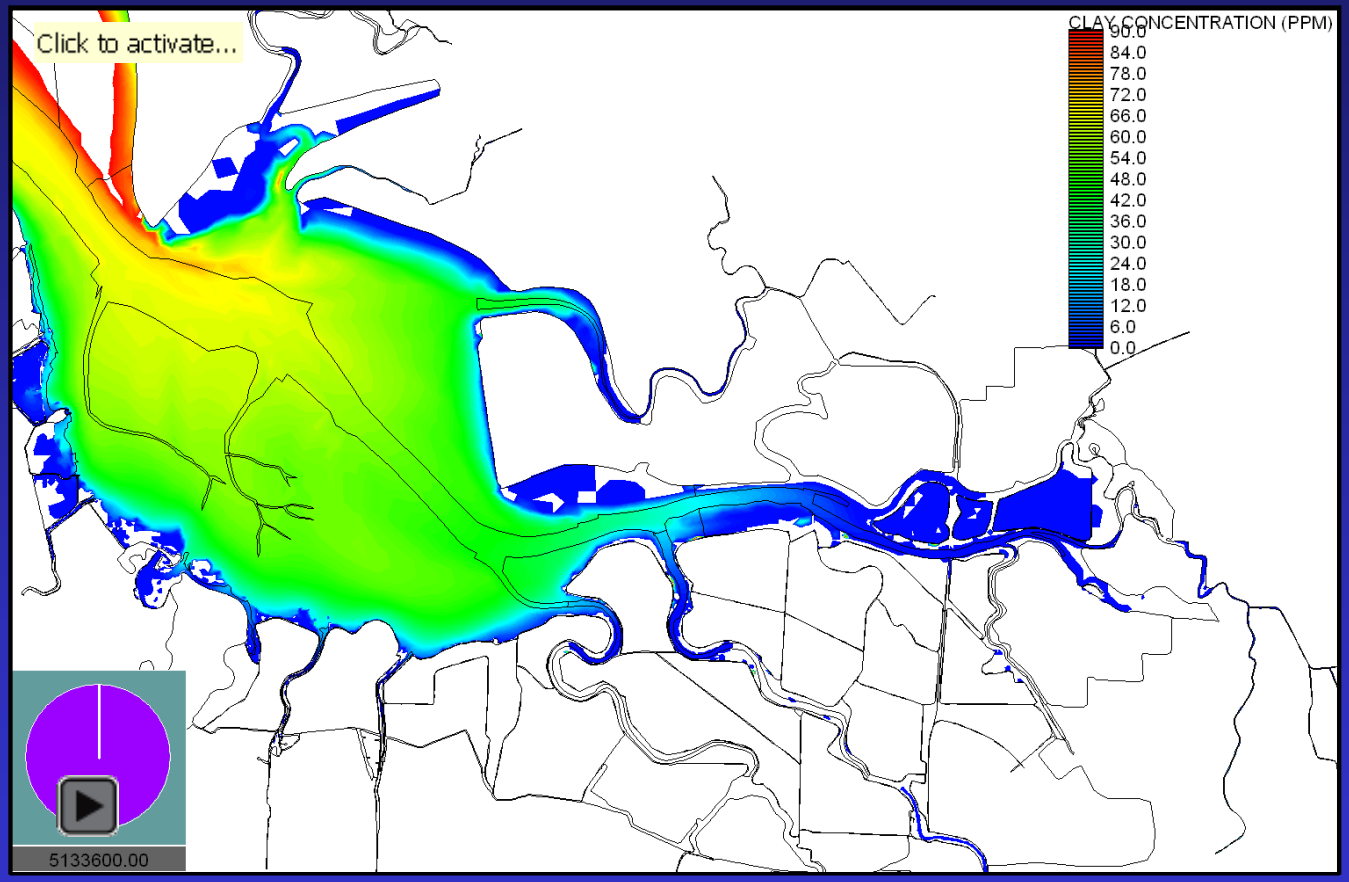
ADH/SEDLIB – Riverine Sediment transport



Mississippi River Delta

Bed displacement

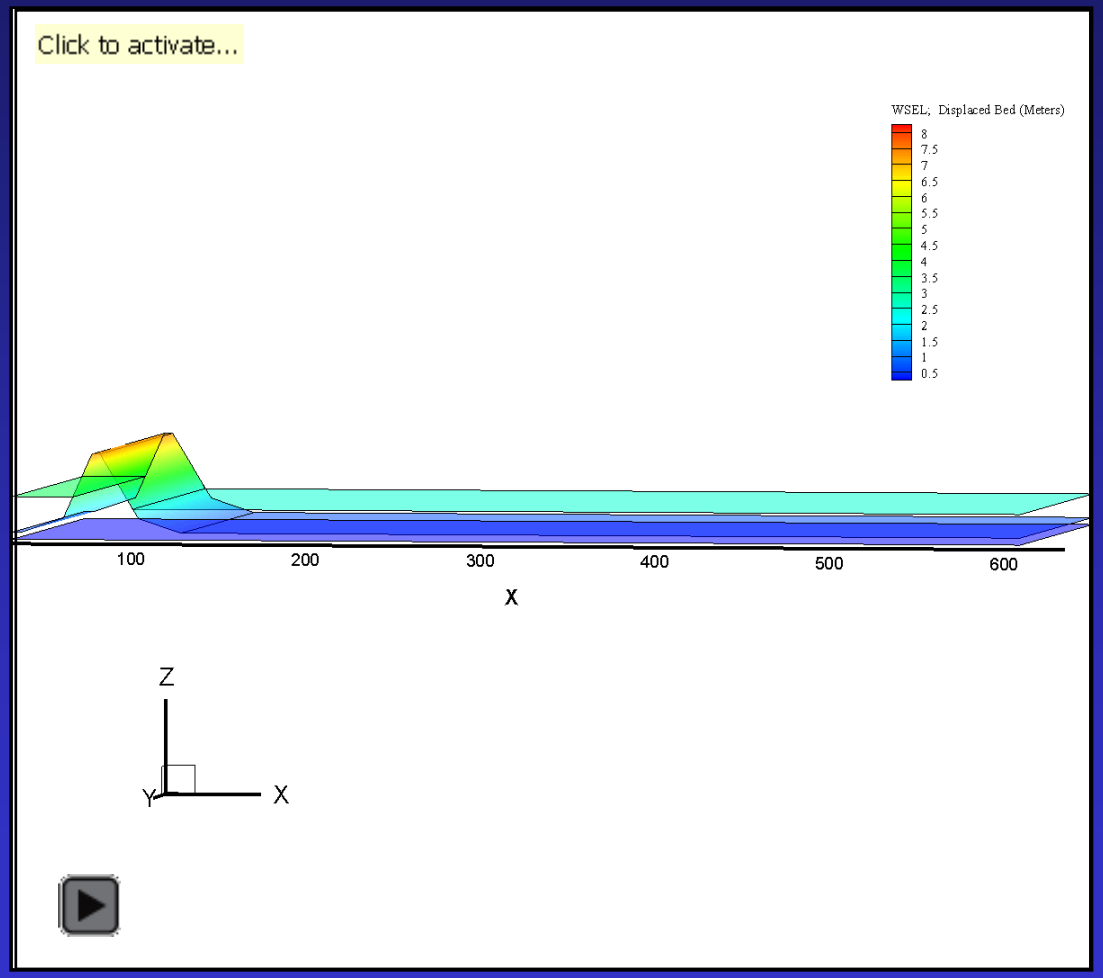
ADH/SEDLIB - Estuarine Sediment Transport



South San Francisco Bay

Fine sediment concentration

ADH/SEDLIB – levee overtopping



Idealized levee overtopping and erosion