Candidate CHARTS Model Summary

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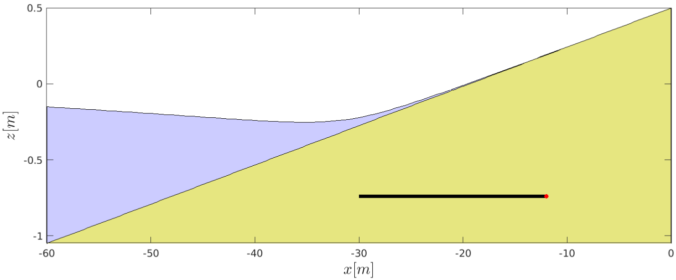


Model Objectives

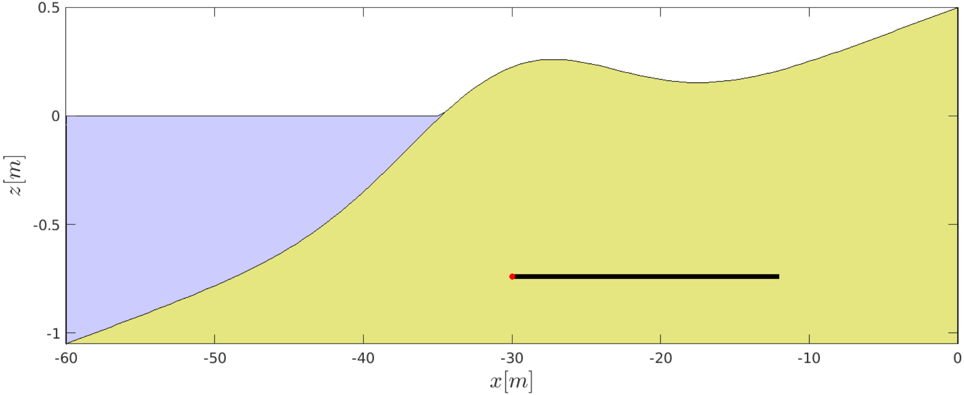
The CHART effort requires simple, stable, and computationally efficient hydrodynamics framework that can be customized to meet USACE needs.

First incarnation hydro model:

- One-dimensional
- Phase-averaged but low-frequency resolving
- Based on NLSW
- includes forcing through boundaries, waves, winds (but no wind generation)
- Heuristic wet/dry
- Emphasis on simple and efficient
- Somewhat numerically diffusive (Fischer's) num soln, but steep slopes (or more accurately, large slope breaks) cause issues
- Includes numerical apparatus for two-scale closure approximations, including skewed wave-forms

Ponding

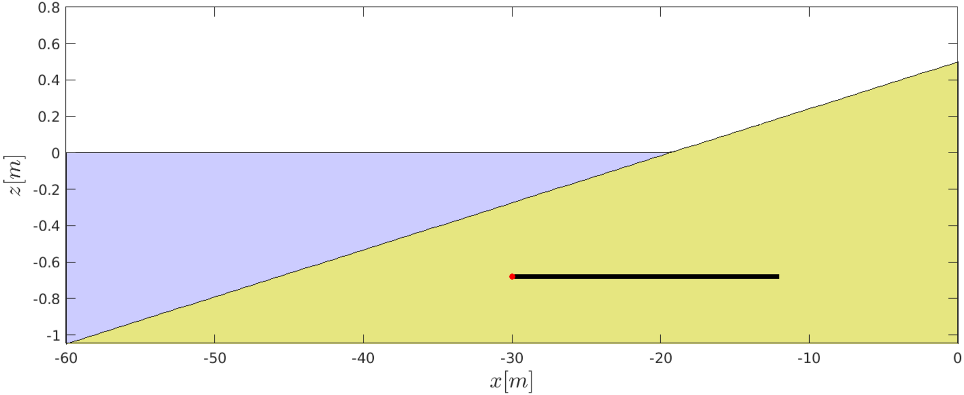
Overtopping capture, but no infiltration



Wave forcing

A one-line wave model:

$$H_{i+1} = \min\left(\left\{H_i^2 \frac{c_i n_i}{c_{i+1} n_{i+1}}\right\}^{1/2}, \gamma h_i\right)$$



Equilibrium Transport Model

A simple traction (or energetics) model that assumes transport is in equilib with forcing:

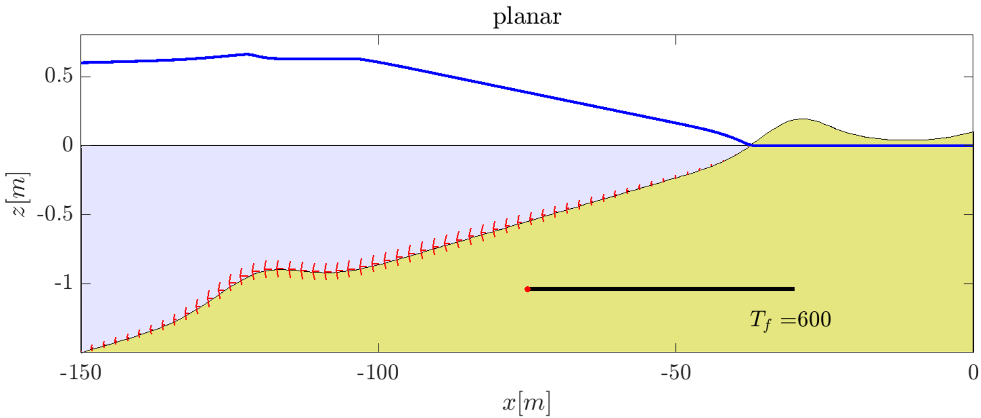
$$\overline{q_{eq}} = \frac{8B}{T}\sqrt{g(s-1)d_{50}^3}\int_0^T (\theta(t)-\theta_{cr})^{3/2}dt$$

Bottom evolution is dictated by conservation of sand

$$\frac{\partial\, z_b}{\partial t} = -\frac{1}{1-n}\frac{\partial\, \overline{q_{eq}}}{\partial x}$$

where n is the bed porosity, which is solved numerically for the bed evolution in time with an first-order time-explicit scheme with second-order central differences in space.

Equilibrium Transport Model With Waves



Non-Equilibrium Transport Model

Accounting for spatial gradients is achieved by equating gradients in transport q and bed-pickup P and fallout, F

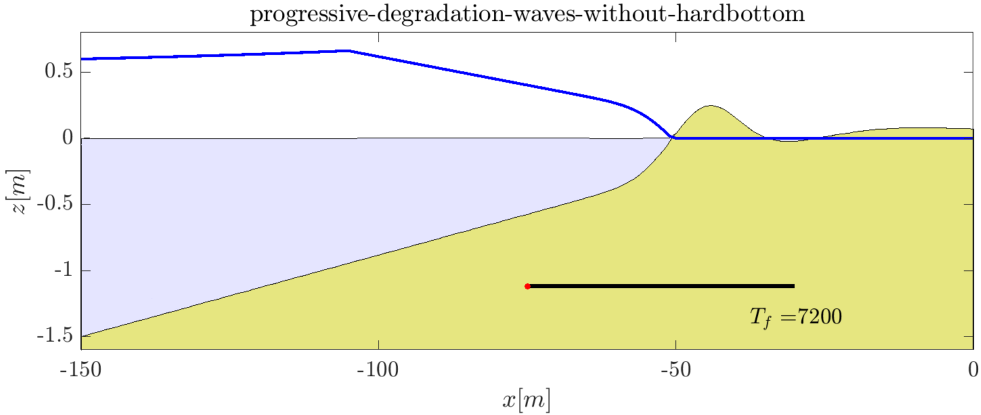
$$\frac{\partial \overline{q}}{\partial x} = P - F$$

Fallout F can be expressed in terms of near-bed concentration, c as $F = w_f c = \frac{w_f}{u\delta}\overline{q}$ which makes use of $q = u\delta c$ where δ is a bedload layer thickness $\sim 0.01m$. Similarly, the pickup, $P = A\frac{w_f}{u\delta}\overline{q_{eq}}$ where A is a modifier equal to 0 or 1 indicating the availability of sand in the bed to be suspended. Note that the formulation can also be represented with a disequilibrium model

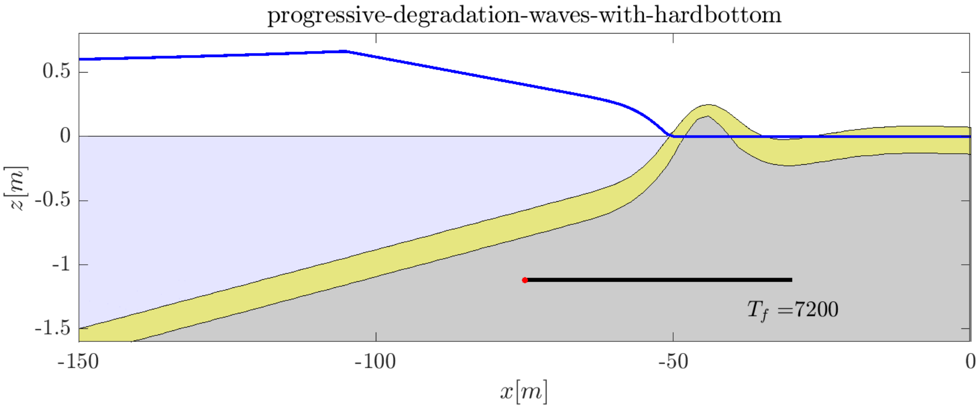
$$\frac{\partial \overline{q}}{\partial x} = \frac{A\overline{q_{eq}} - \overline{q}}{L} \quad \text{where} \quad L = \frac{u\delta}{w_f}$$

and L has the physical interpretation of a horizontal advection length that a particle travels while falling through the boundary layer.

Non-Equilibrium Transport Model

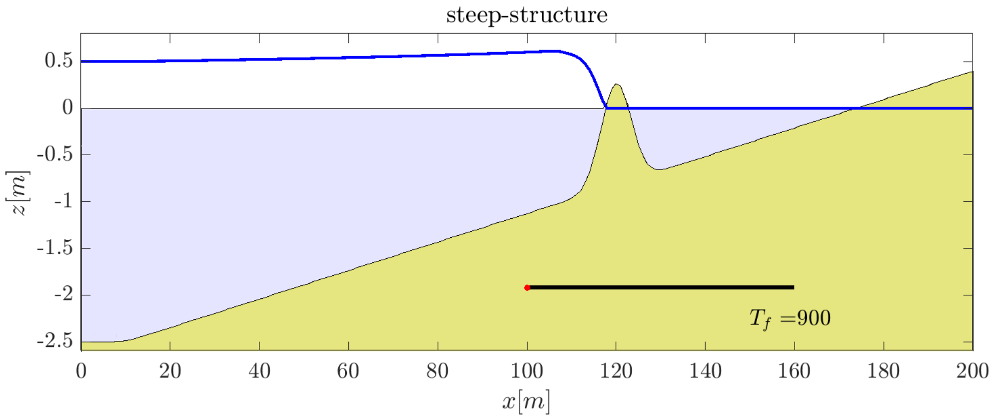


Non-Equilibrium Transport Model



Challenges

In cases of large slope (esp with large concavity), MBC can cause instability



Challenges

Clock time for simulating 24 hrs

H	$50s$
$H+W$	$200s$
$H+S_{eq}$	$60s$
$H+S_{neq}$	$440s$

So these runtimes are getting close to being prohibitively large if we run 100K runs: 500 days on singe thread for non-equilibrium transport.

Next Steps and Considerations

- Runtimes can be improved, but improved by 25%, not 75%
- Improved MSBC is needed but tricky – could add prohibitive numerical cost
- Ugly $2\Delta x$ in hydro is difficult to remove from current field, but it's straightforward to remove it before doing the sed computations
- Still have option to shelve this work return to the old CSHORE/SBEACH workflow development