NEARSHORE PROCESSES

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COASTAL INLETS RESEARCH PROGRAM

FY20 IN PROGRESS REVIEW

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Problem Statement:

Coastal sediment transport remains poorly understood. No comprehensive and general predictive technology exists for rational design and planning of coastal planform evolution of time scales of relevance for USACE project design and implementation.

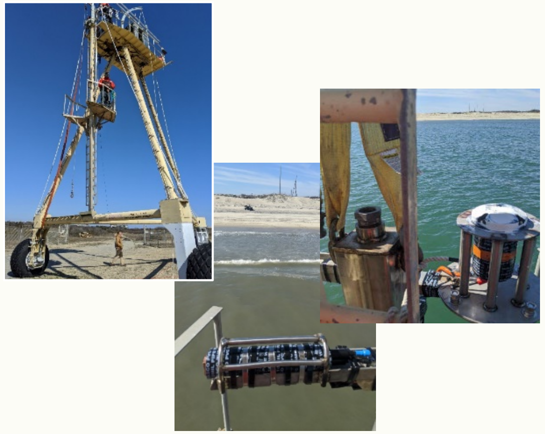
USACE missions this work benefits:

- Beach Nourishment and Nearshore Placement
- Navigation and Safety
- Flood Risk Management & Coastal Hazards

- 2020-1536/1538 Optical Current Measurements; Nearshore Processes Research and Development (N,F,E)
- 2018-N-05 Strategic Nearshore Placement of Dredged Material to Sustain Coastal Beach Dune Resilience

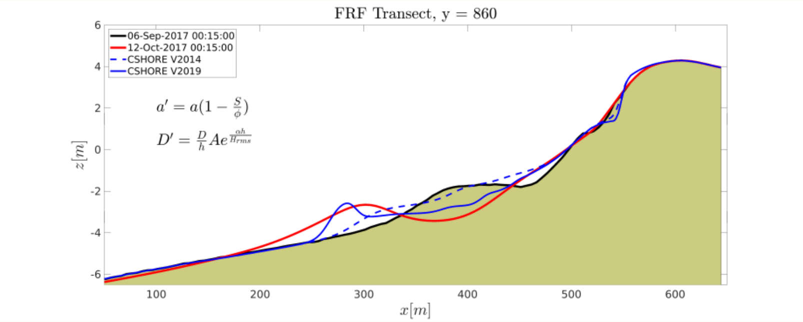
Capability and Strategic Impact Statement

GOAL: A general transport model that predicts from storm scale to longer term evolution, appropriate from DOC to dunes.



- **Nearshore placement:** Sound practice leaves high quality dredged material in the littoral zone, nearshore placement may be more economical, no model adequately predicts morphology change of placement

- **Storm protection:** Dunes are routinely built for storm protection. Design is based on inertia or on models that are inappropriate

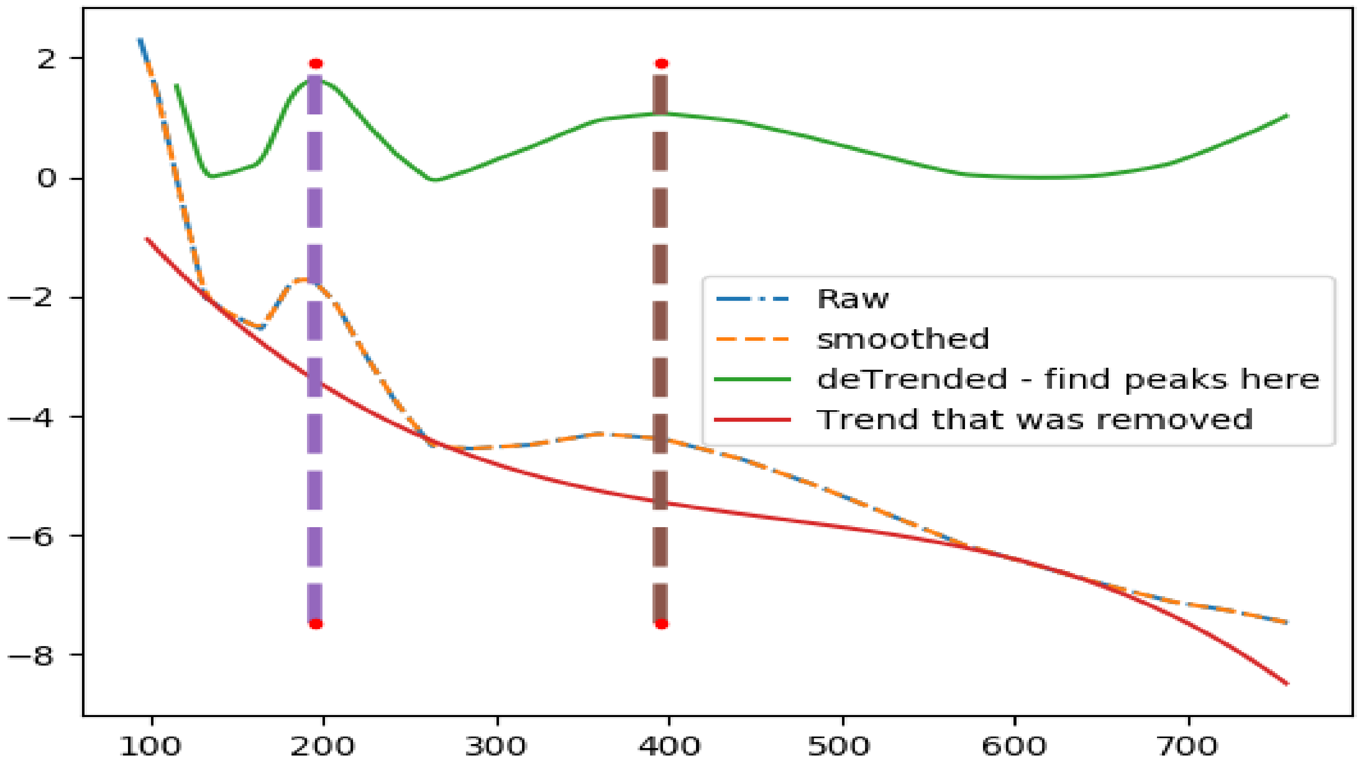


Measured Data to Advance Predictive Technology

- To develop reliable predictive numerical modeling technology with skill and generality.
- A coherent view of the relevant physics must first emerge from observations. First principles model is not realistic.
- A practical numerical model is dependent on high-quality data for comparison and justification of empirical devices.
- FRF data provides new model/data comparisons for waves, currents, morpho change
- Still dependent on laboratory for detailed sediment data

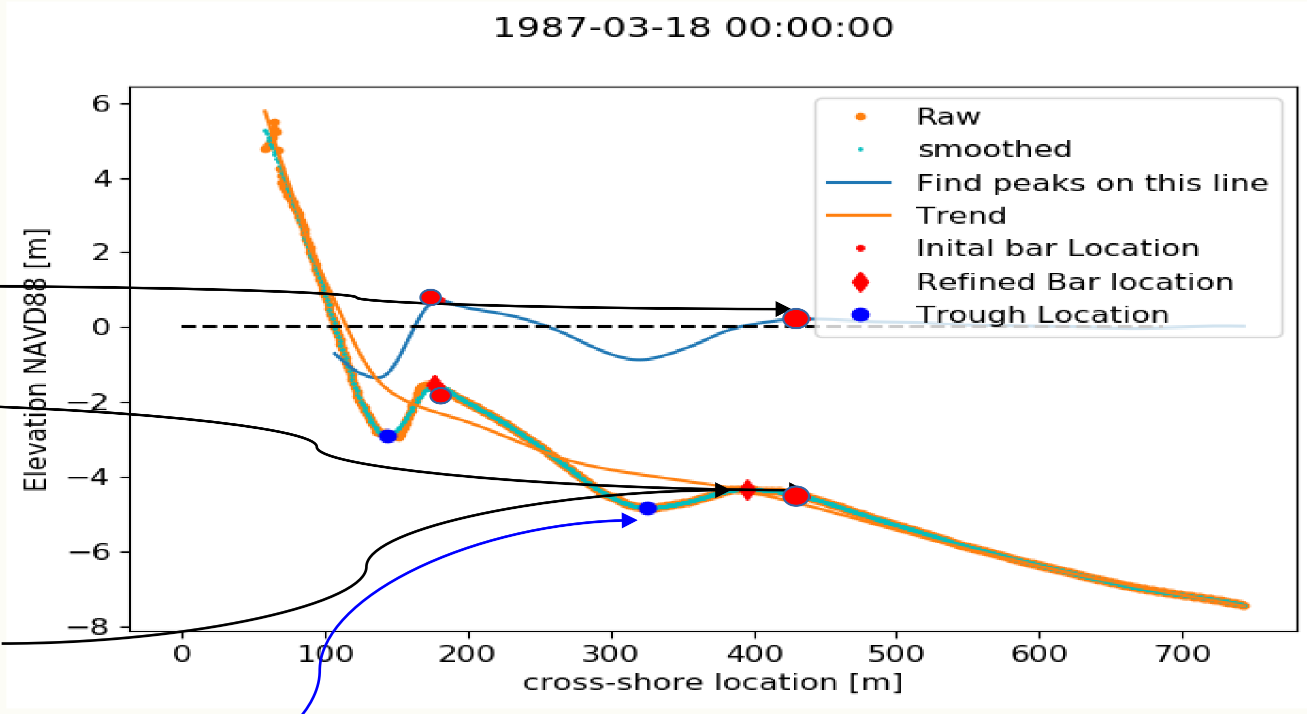
Sandbar evaluation tool

- Status:
  - Developed 1D profile tool
    - Applied it in 2D
      - Worked OK
  - Explored 2D method from GIS world
    - Geomorphons
    - Comes with GRASS
      - GIS world comes with its own complications
        - rigid API's



1D - How's it work?

- Smooth measured data (dots) to produce smoothed profile
- Remove cross-shore trend
  - Mean profile from 1987-2019 (this case)
- Produce detrended signal and find peaks (small dots)
- Place locations (dots) on measured profile
- Find dx/dz = zero onshore of intial bar location to create refined bar location (diamonds)
- For each bar location find deepest location shoreward of point to identify trough locations (circles)



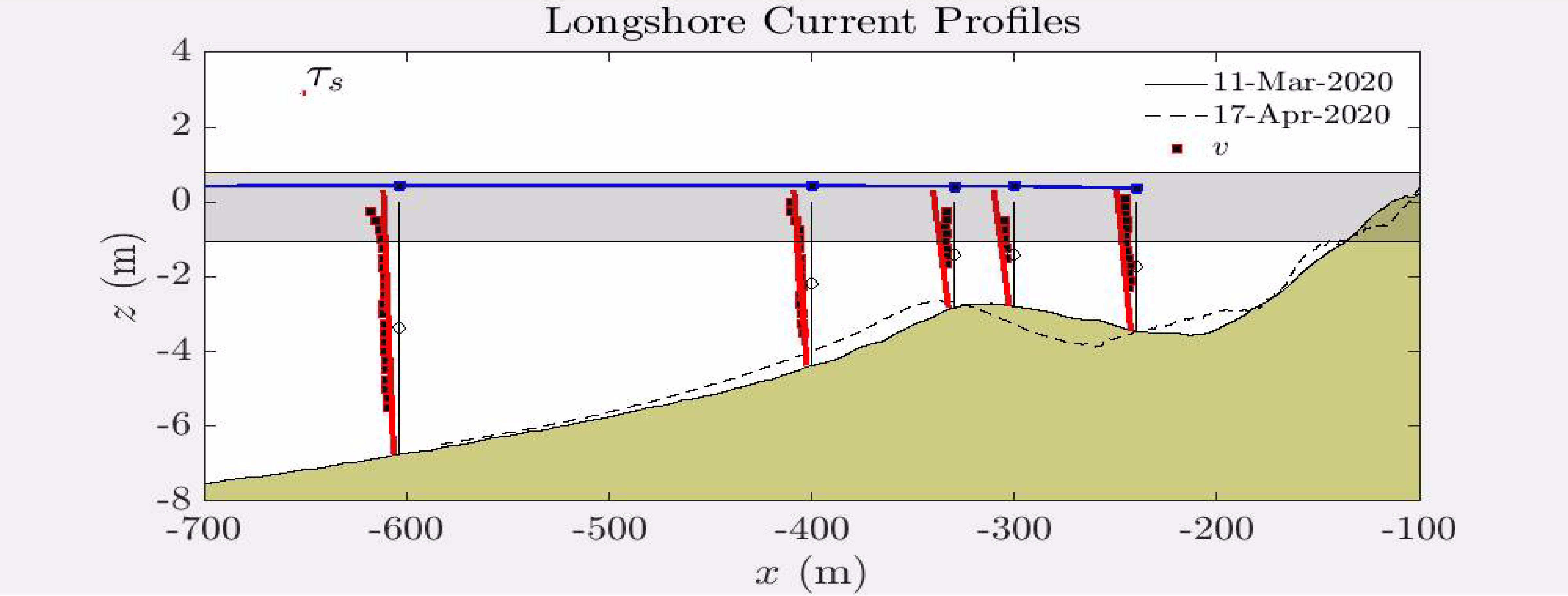
Sometimes it works really well!

Modeling Longshore Currents

- Data provides a justification for the simplifications
- Bottom shear stress is comprised of surface shear and wave stress
- Wave stress a cosh squared profile
- Depth-invariant eddy viscosity
- Expression is 'nearly' quadratic

$$V = V_b + \frac{\tau_b}{\rho \nu_t} z' - \frac{D_B \sin \alpha}{\rho \nu_t c \left(\sinh 2kh + 2kh\right)} \left(k z'^2 + \frac{\cosh 2kz' - 1}{2k} \right)$$

Modeling Longshore Currents

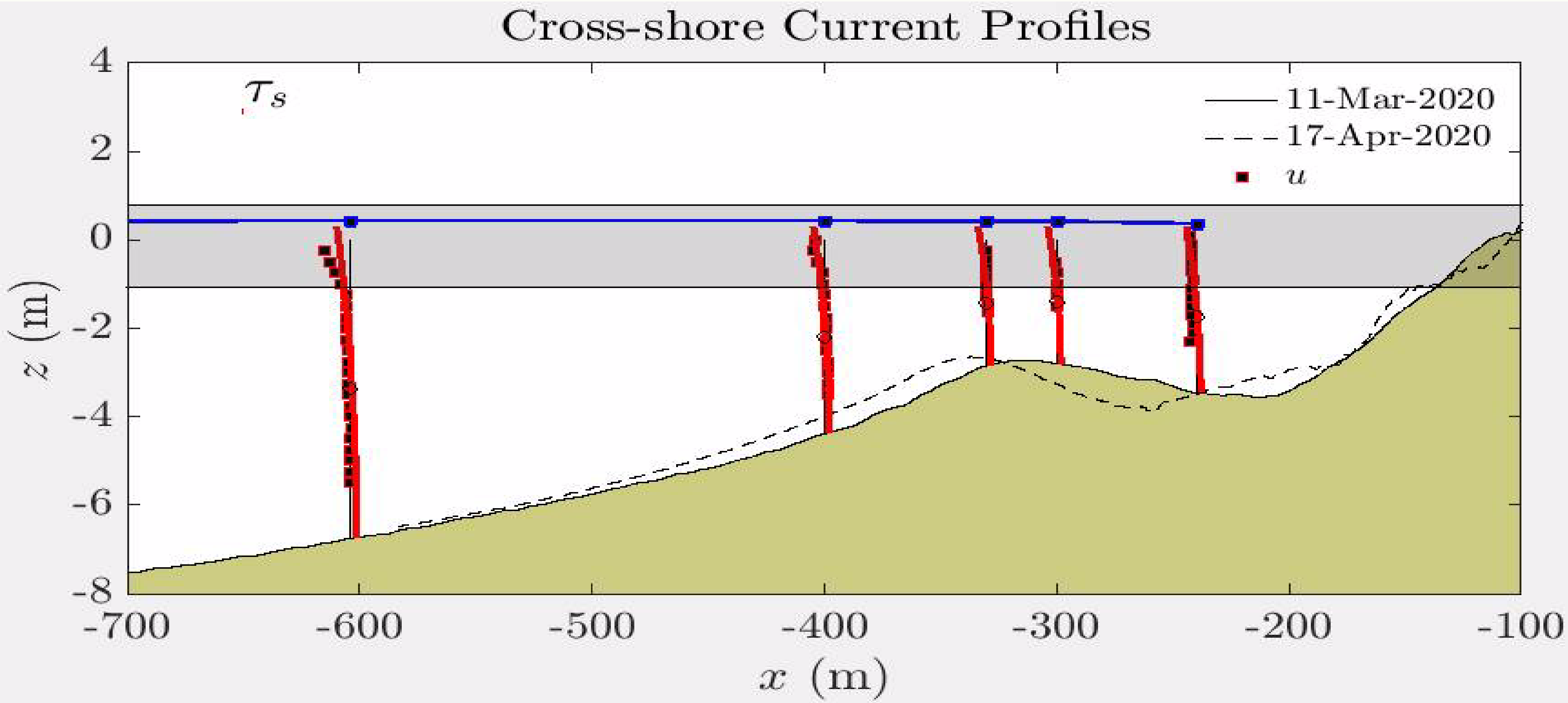


Modeling Cross Shore Currents

- The exact same approach used in LS is not possible in cross-shore (owing to the pressure part of the wave stress)
- If we assume that wave stresses(?) and eddy viscosity(ok) are depth-invariant, then appropriately described by quadratic in the vertical
- 3 conditions, stress on bottom, stress on top, Mass flux:

$$U = \left(\frac{Q_x}{h} - \frac{\tau_{bx} h}{2\rho\nu_t} - \frac{\tau_{sx} - \tau_{bx} h}{6\rho\nu_t} \right) + \left(\frac{\tau_{bx}}{\rho\nu_t} \right) z' + \left(\frac{\tau_{sx} - \tau_{bx}}{2h\rho\nu_t} \right) z'^2$$

Modeling Cross Shore Currents



Modeling Suspended Sediment

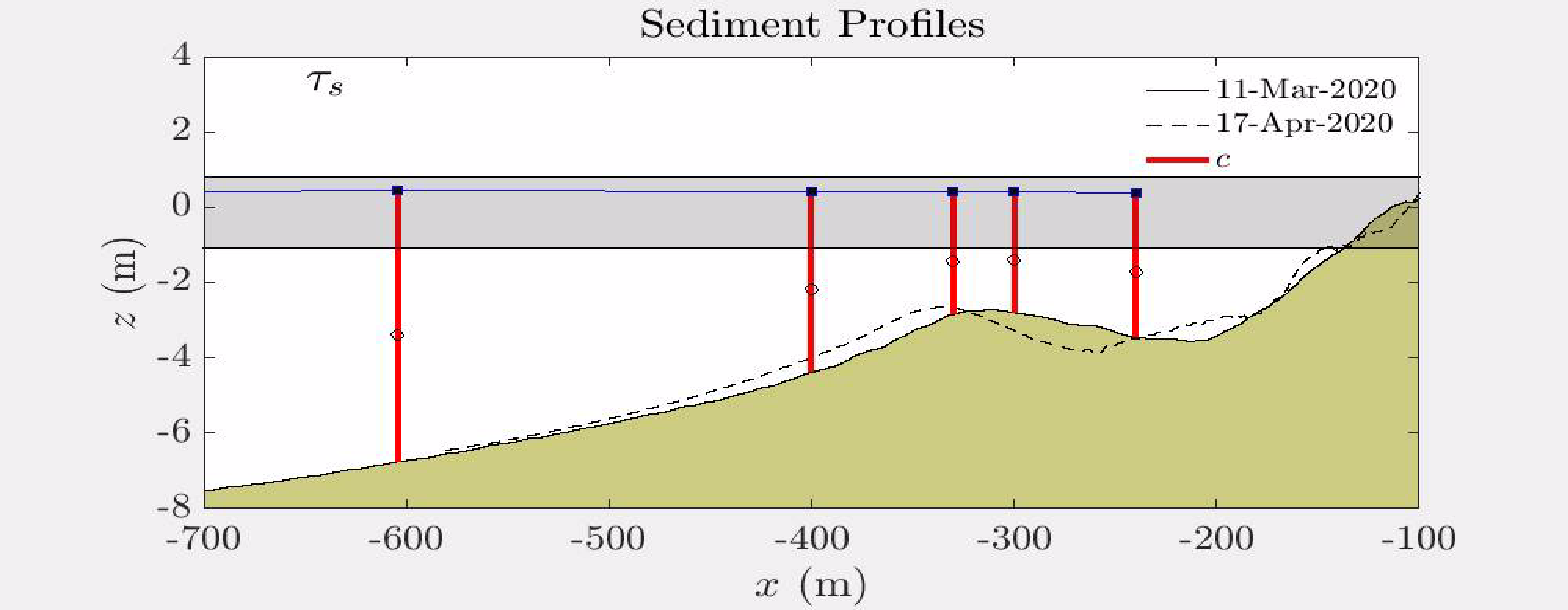
- Depth-dependent currents provides the opportunity to move towards process-based models
- Requires depth-dependent sediment profiles.

$$c = c_0 e^{-k_s z} \quad ; \quad k_s = \frac{w_0}{\nu_s}$$

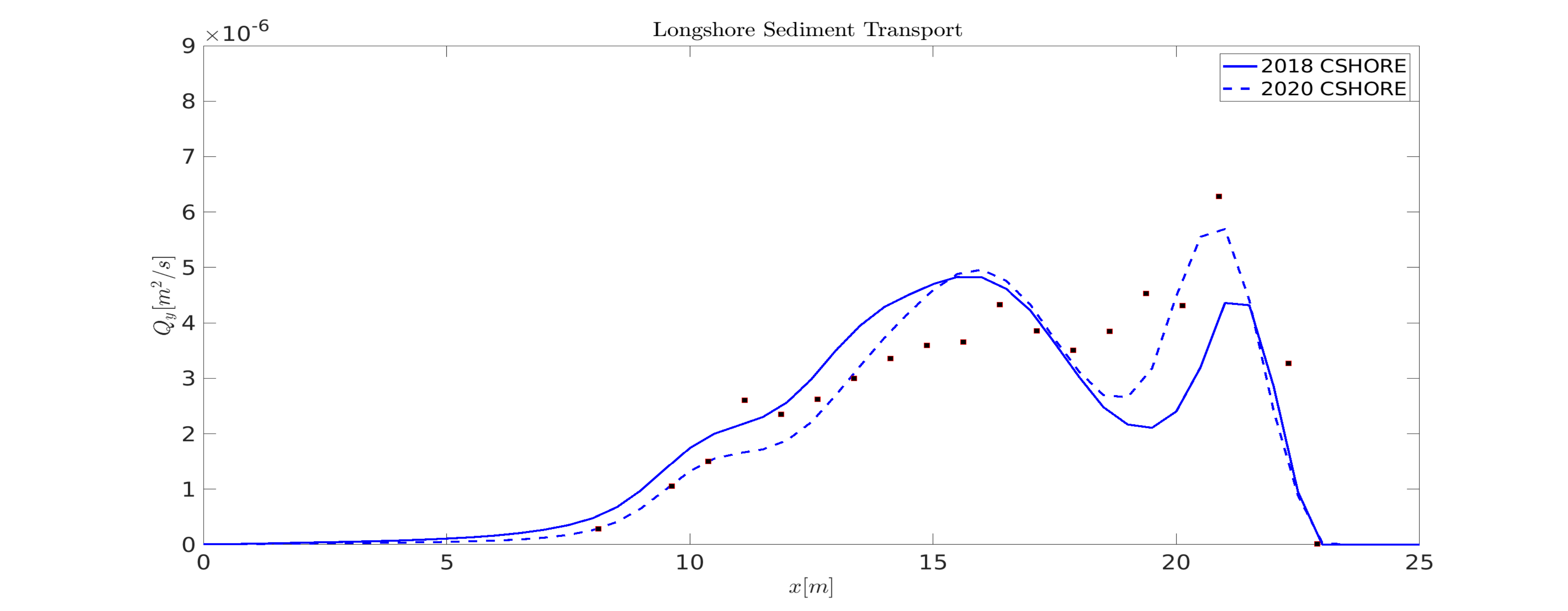
- Tantamount to fall velocity matched by upward gradient diffusion
- Near-bed concentrations are related to turbulent dissipation (a modified CSHORE method)
- Simple analytic expressions permit the corrected transport at no computational expense

$$\int_0^h cU\,dz = \frac{c_0 A_0}{k_s}\left(1 - e^{-k_s h}\right) + \frac{c_0 A_1}{k_s^2}\left(1 - e^{-k_s h}(k_s h + 1)\right) + \frac{c_0 A_2}{k_s^3}\left(e^{-k_s h}\left(-k_s h(k_s h + 2) - 2\right) + 2\right)$$

Modeling Suspended Sediment



Modeling Suspended Sediment



Summary

FY20 Major Advances in Capability

- New bar tracking tool-> elucidate the physics
- New depth-dependence is advance towards reality.

FY20 Major Products & Collaborations

- New CSHORE_DEPTH_DEP
- CIRP TD
- U Washington, WHOI
- Leveraging with CODS, F&C

FY21 Products/Advances

- Comprehensive comparison of FRF morphology change with models
- Further CSHORE Family model development.
- Framework established to run large scale model simulations hooked to FRF data and C/2Shore
  - Metrics hook into established work flows for batch scale skill assessment
  - Leverage Data Assimilated Now-Cast Bathy at FRF (v1 EOY – FY21)