



U.S. ARMY

CMS/C2SHORE MODEL DEVELOPMENT

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COASTAL INLETS RESEARCH PROGRAM

FY21 IN PROGRESS REVIEW

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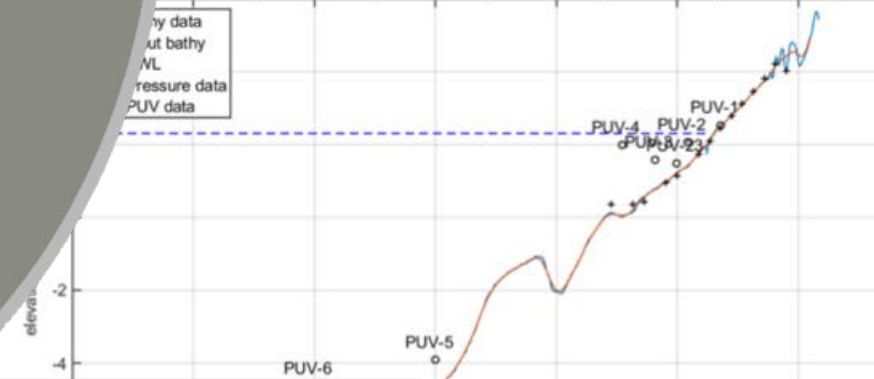
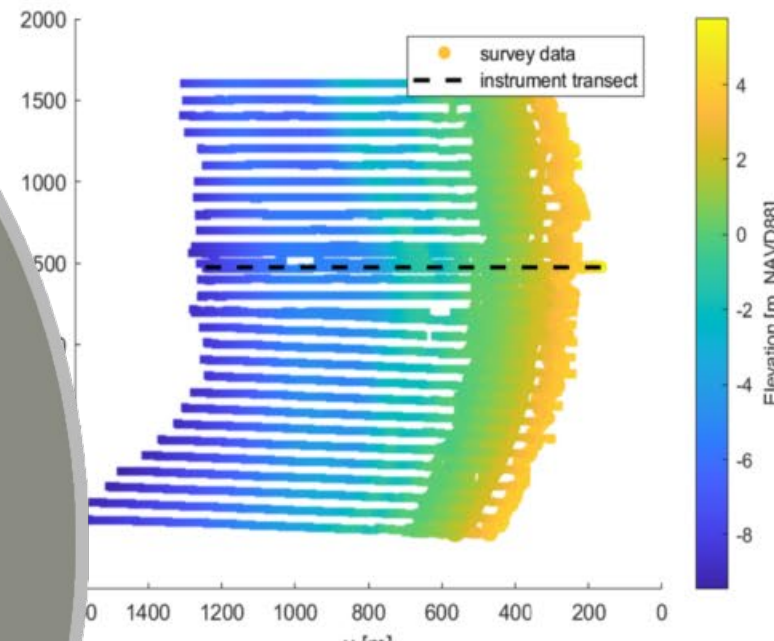
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Problem Statement:

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
-
- CERB and CWG initiative
 - 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: An improved CMS general transport model that predicts coastal morphology on storm scale and longer-term evolution including dunes.

- **C2SHORE:** The 2DH generalization of CSHORE is implemented and affords the capability to predict coastal morphology in CMS. Practical application includes evaluation of nearshore placement design and dredged material placement.
- **Swash:** Swash hydrodynamics are predicted as an extension of the proper CMS domain. Despite simplified physics, comparison with runup data are more accurate than the more complex formulation within CSHORE.



CMS/C2SHORE Advancements

- Extend formulation to include non-current advection transport
- Fix bed conservation issue
- Repair of lateral boundary conditions
- Wave dissipation error
- FRF Morphology modeling (previously presented)
- Swash code structure change
- Agate data, CMS results of wave evolution and swash
- FRF data, CMS preliminary swash results completed

CMS/C2SHORE Advancements Example

- Original Formulation:
Appropriate for suspended load only, with advection by currents only

$$\rho_s(1 - n) \frac{\partial z_b}{\partial t} = \alpha_t w_f (C_{t*} - C_t)$$

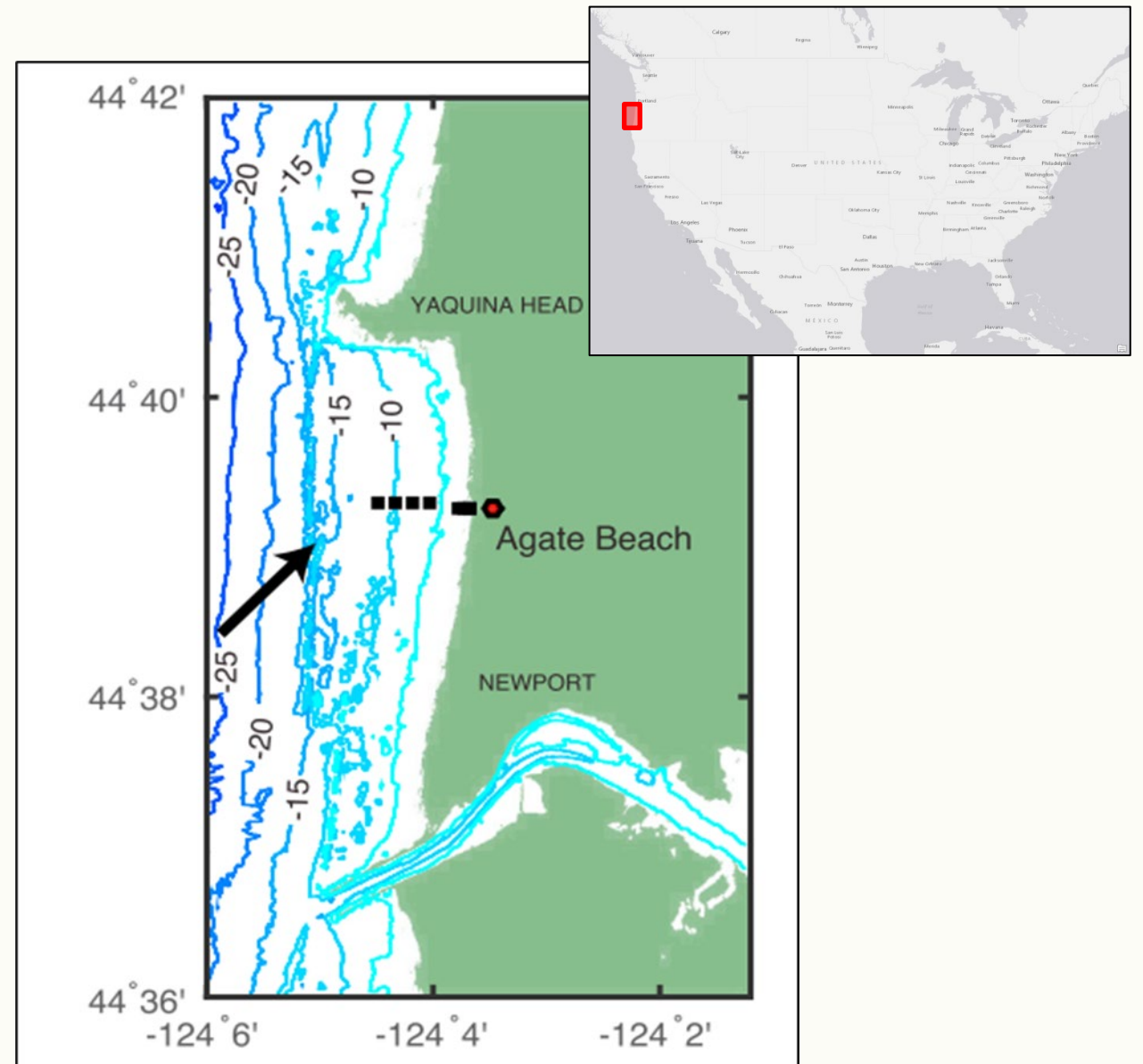
- New Formulation:
- Bedload
- Wave-related transport

$$\rho_s(1 - n) \frac{\partial z_b}{\partial t} = \alpha_t w_f (C_{t*} - C_t) - \frac{\partial \tilde{Q}_{x_i}}{\partial x_i}$$

Agate Beach Data set

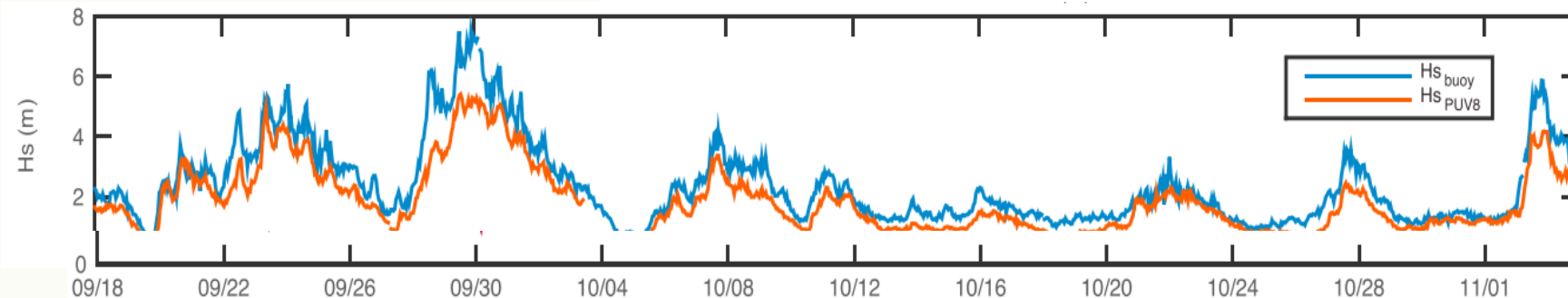
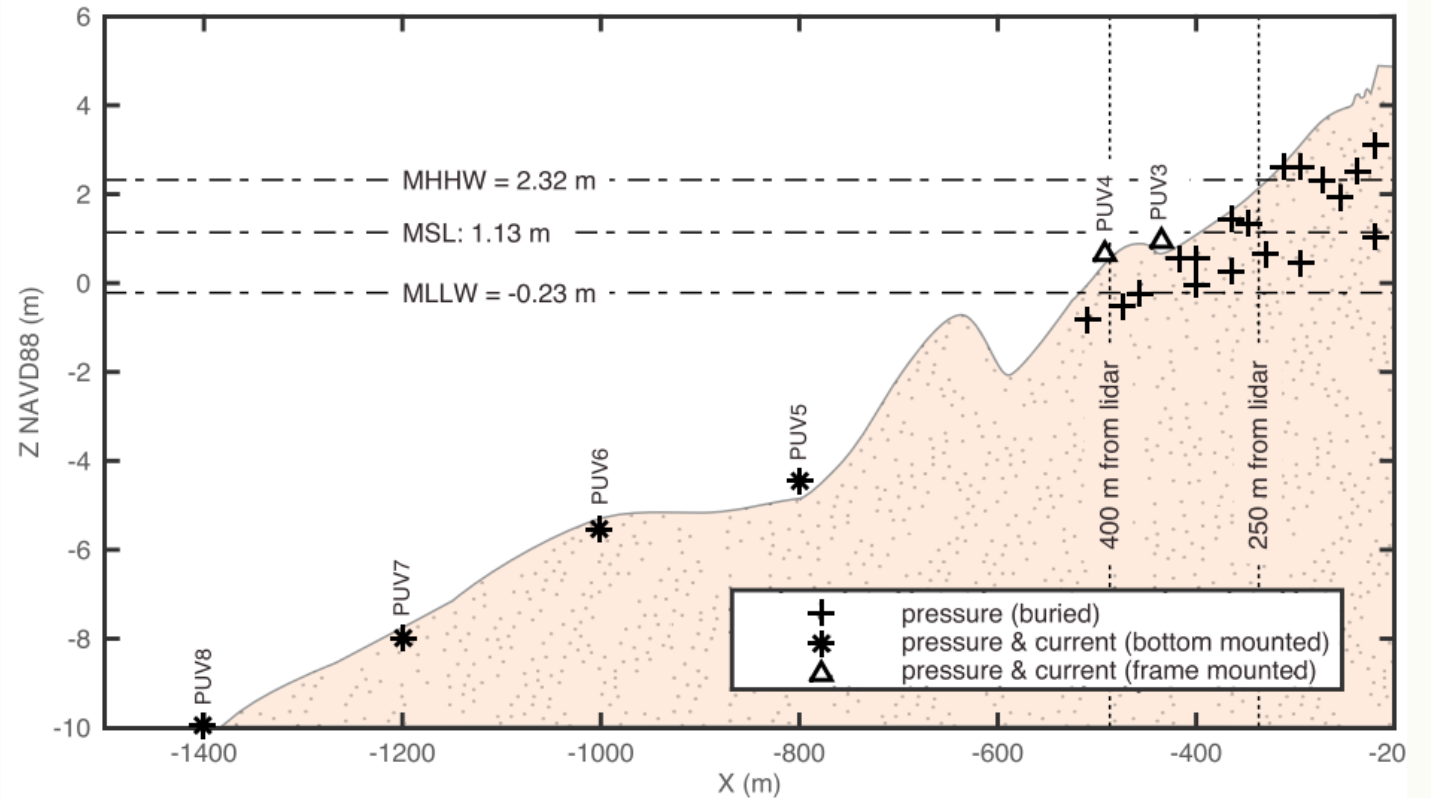
- Observations collected between 9/19 and 11/2, 2013
- Tidal range ~ 2 m
- Offshore wave heights ranged from 1.2 m – 4.7 m and peak period from 10 s -- 16.6 s
- Topobathymetry measured in cross-shore transects w/ GPS-equipped ATV, dolly, and jetski
- Mild slope (1/50 – 1/70)

Fiedler, J. W., Brodie, K. L., McNinch, J. E., & Guza, R. T. (2015). **Observations of runup and energy flux on a low-slope beach with high-energy, long-period ocean swell.** *Geophysical Research Letters*, 42(22), 9933–9941.

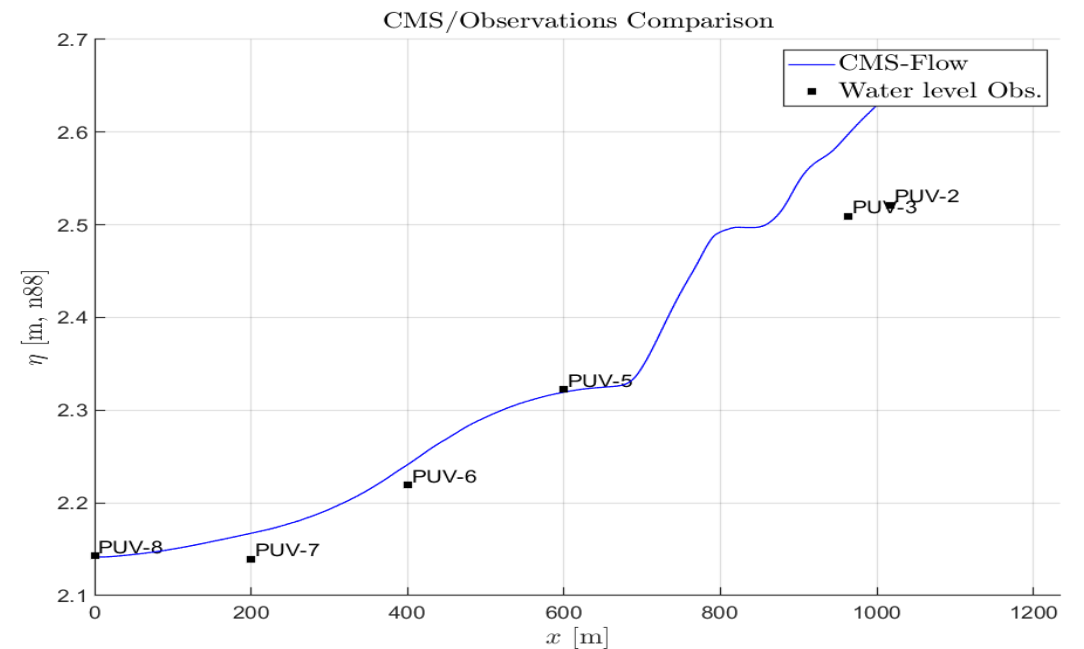
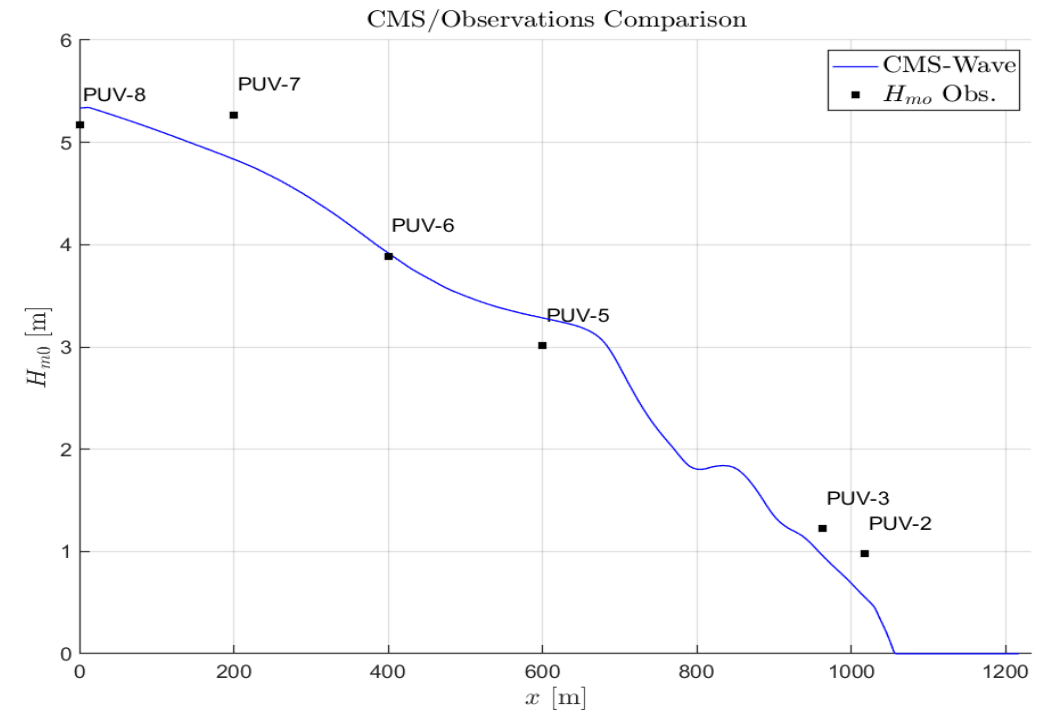
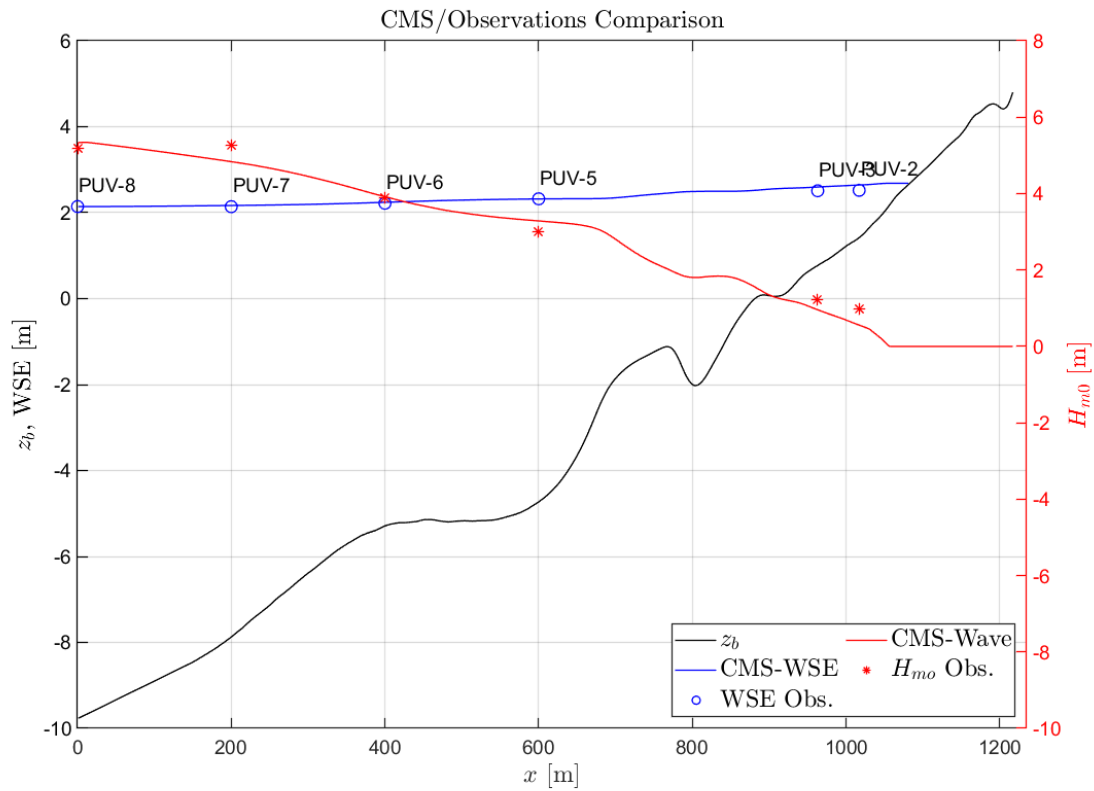


Agate Beach data set

- 18 pressure sensors
 - Between -1 m and +3 m NAVD88
 - $f_s = 2$ Hz
- 9 frame mounted PUV sensors
 - Between MSL and $h=11$ m
 - Controlled for shore normality
 - Deviated less than 30% from linear waves
 - Removed energetic nearshore eddy motions



Results: Case A1



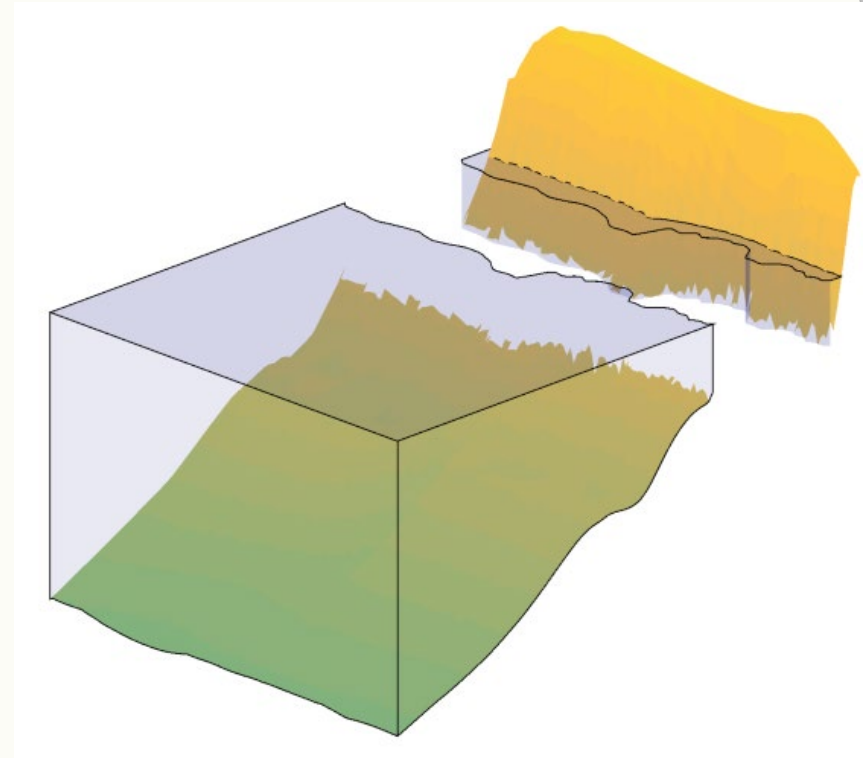
Swash Modeling

CMS SWASH Extension:

- Instantaneous
- Wave and currents are combined
- Demarcation is a minimum depth (under revision at present)
- Hydrodynamics are one-way coupled, appropriate for simulations with low current at interface.
- Transport is two-way coupled
- Bed conservation is rigid
- Simplified propagation model:

$$\frac{M_{i+i} - M_i}{\Delta x} = -g\bar{h}_i \frac{\partial z_b}{\partial x} - c'_f g\bar{h}$$

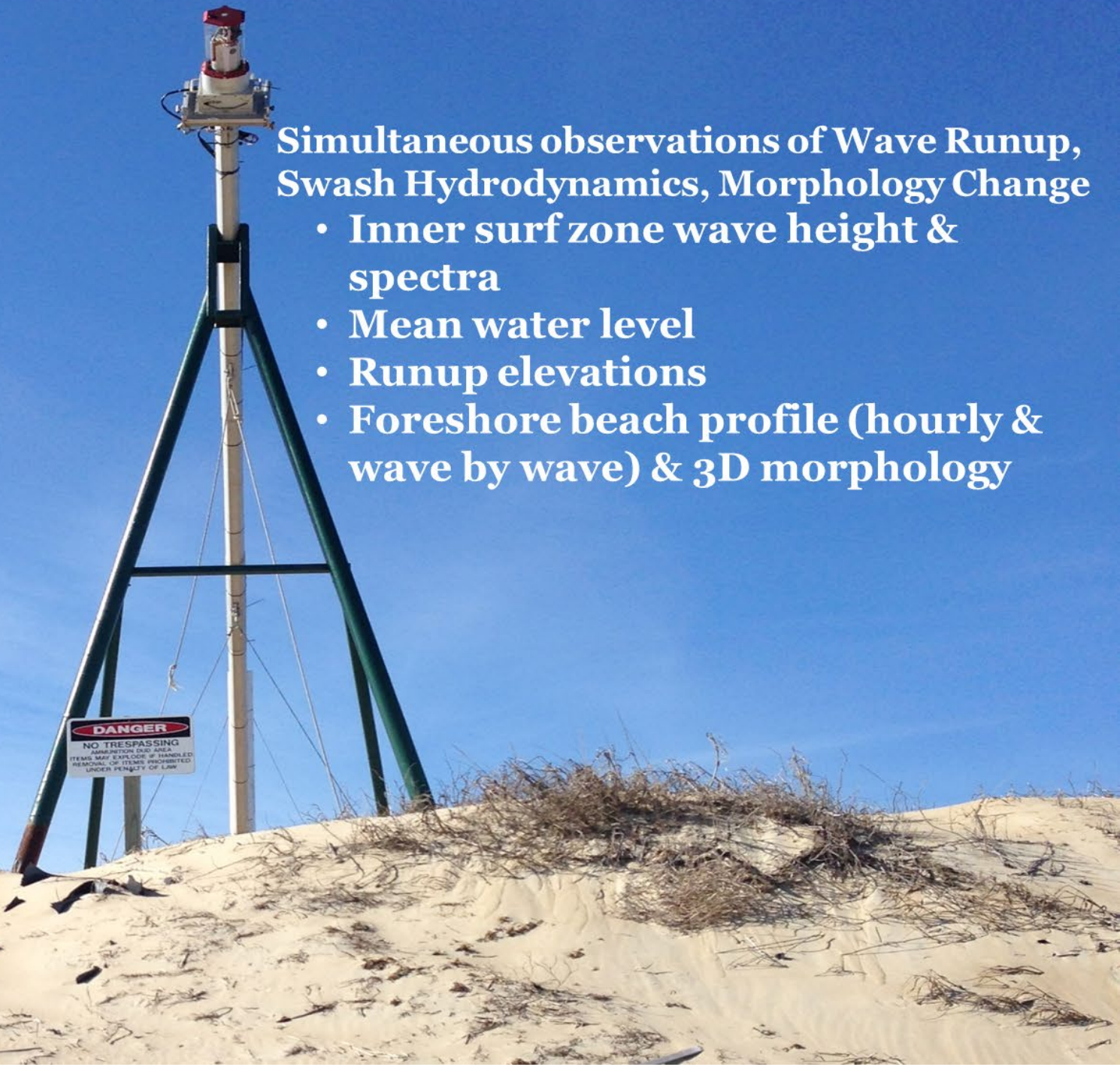
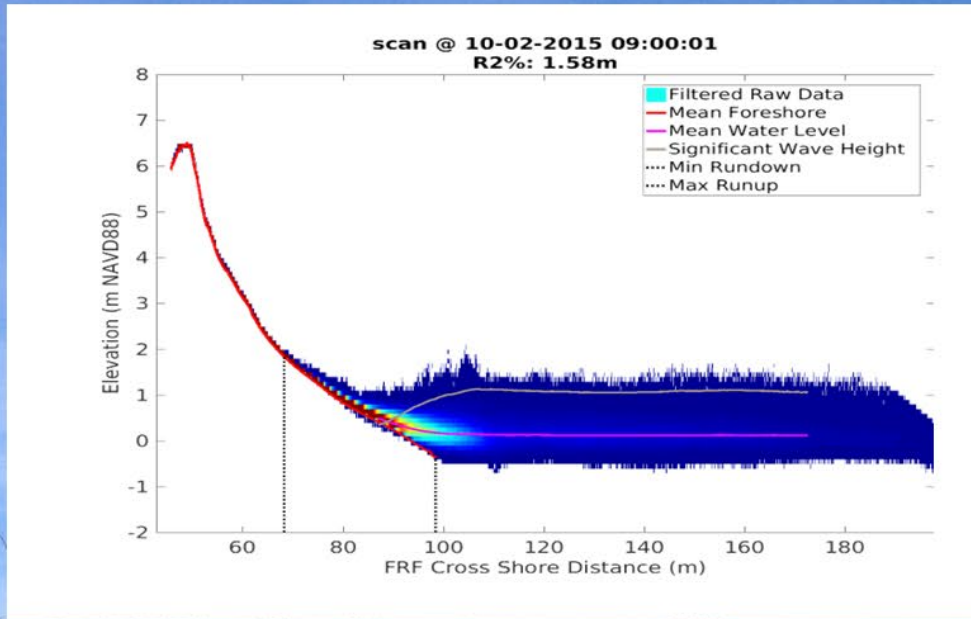
- Necessarily dependent on empirical data



Continuous Dune Lidar Tower, used at Agate and FRF

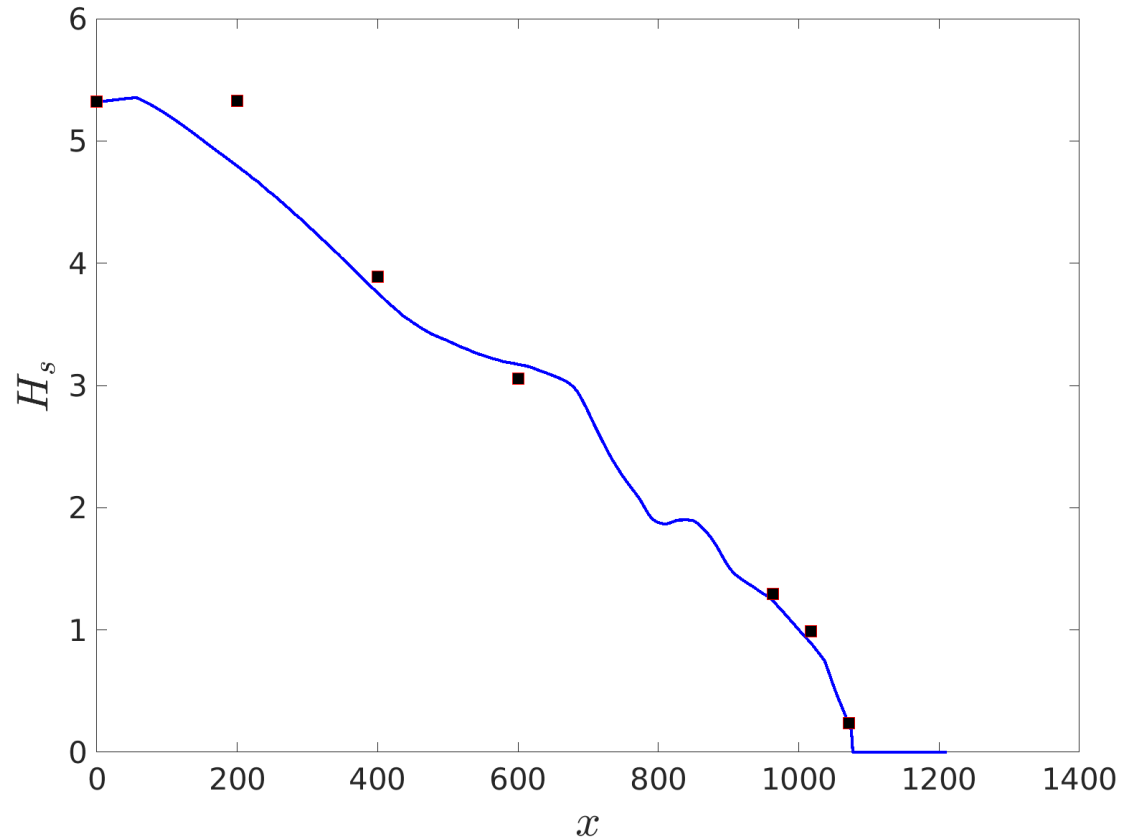
Simultaneous observations of Wave Runup, Swash Hydrodynamics, Morphology Change

- Inner surf zone wave height & spectra
- Mean water level
- Runup elevations
- Foreshore beach profile (hourly & wave by wave) & 3D morphology

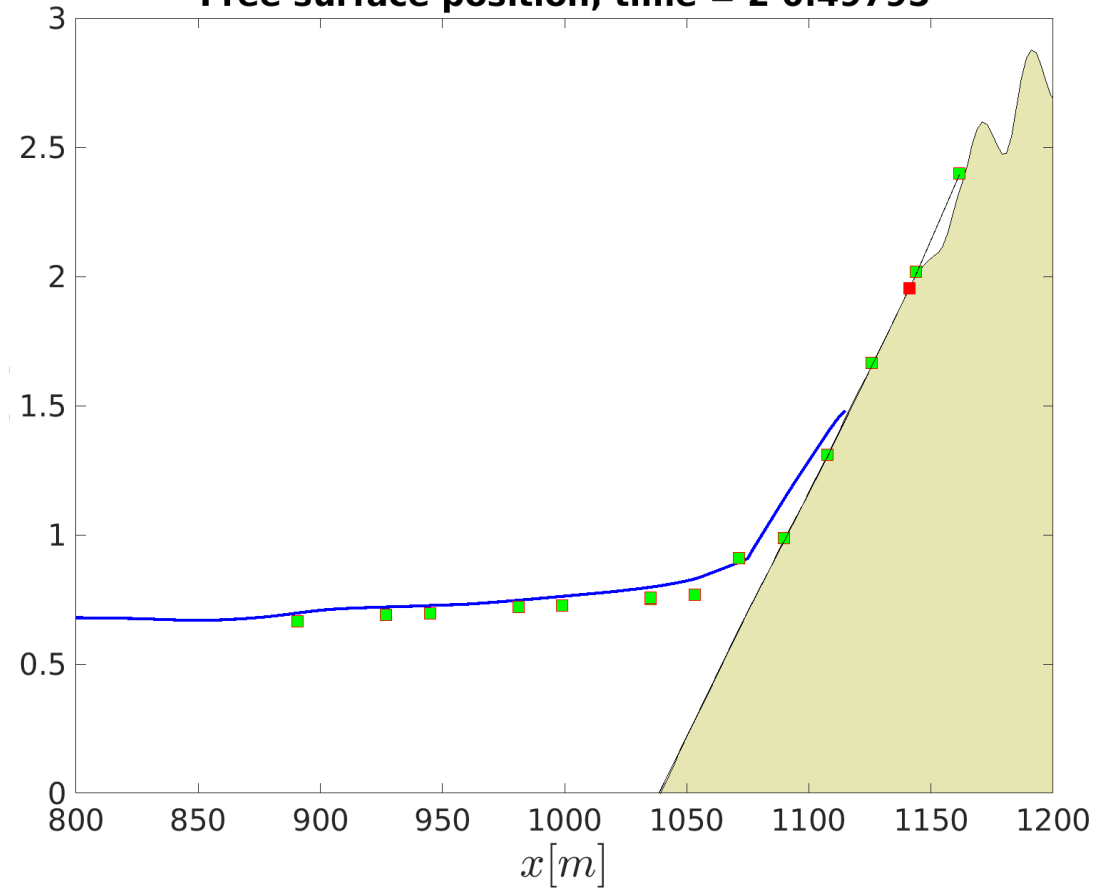


Agate Modeling

Wave Height
 $dx = 2$

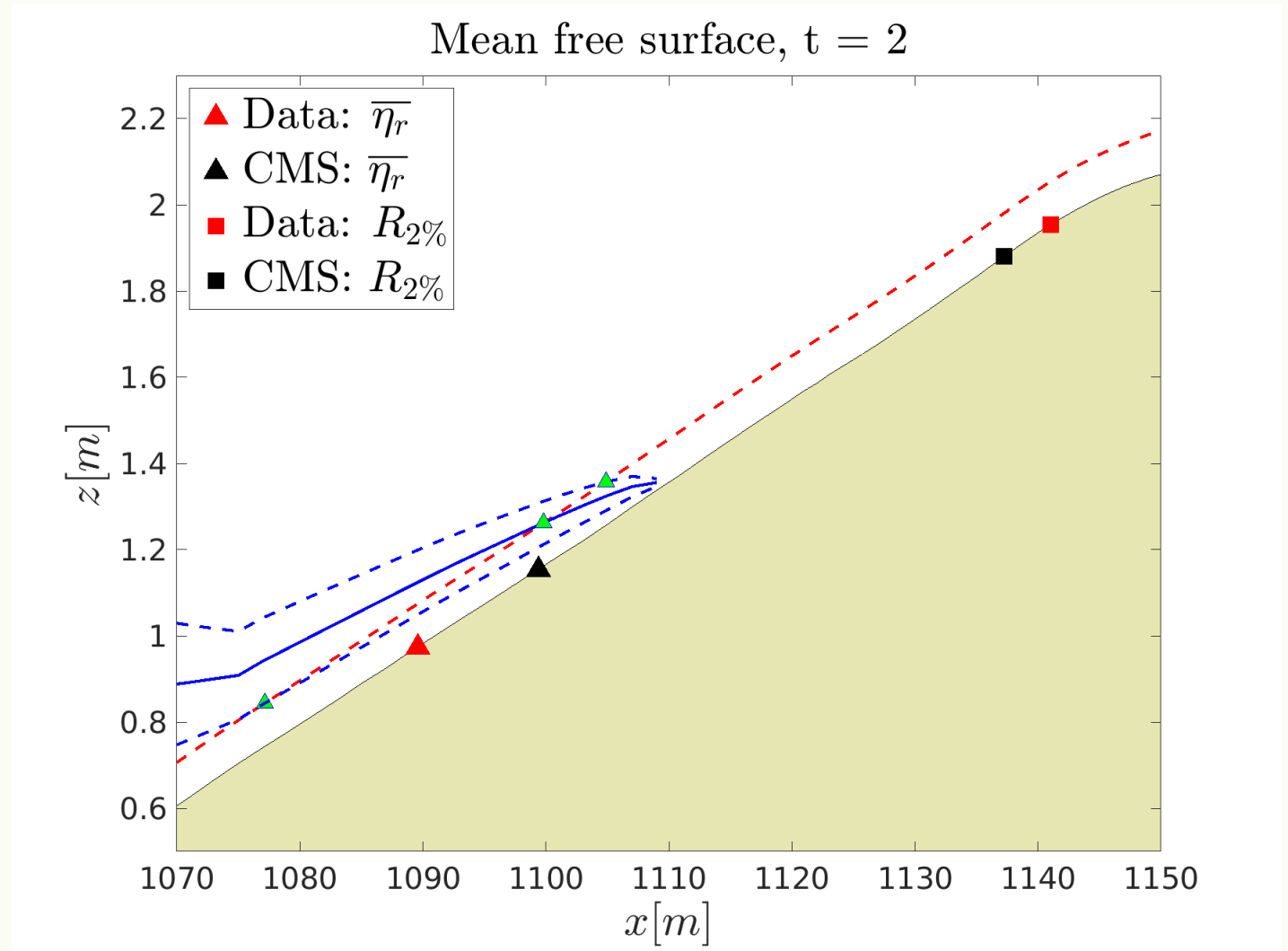


Free surface position, time = 2 0.49795



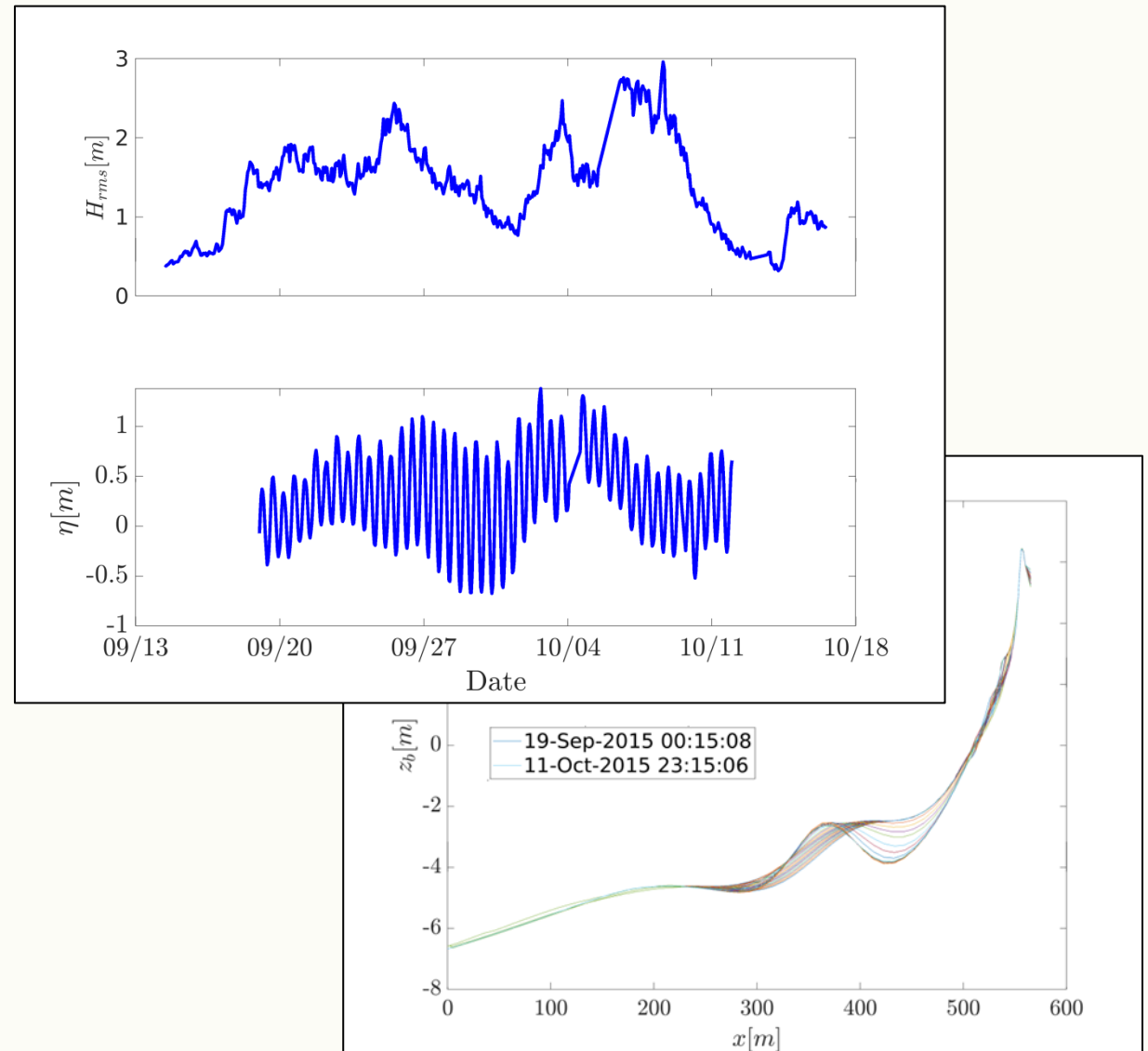
Agate Runup Predictions

- Using $A_0 = 6$, developed on the basis of CSHORE results
- $R_{2\%}$ well-predicted
- Swash excursion is under-predicted by 30%



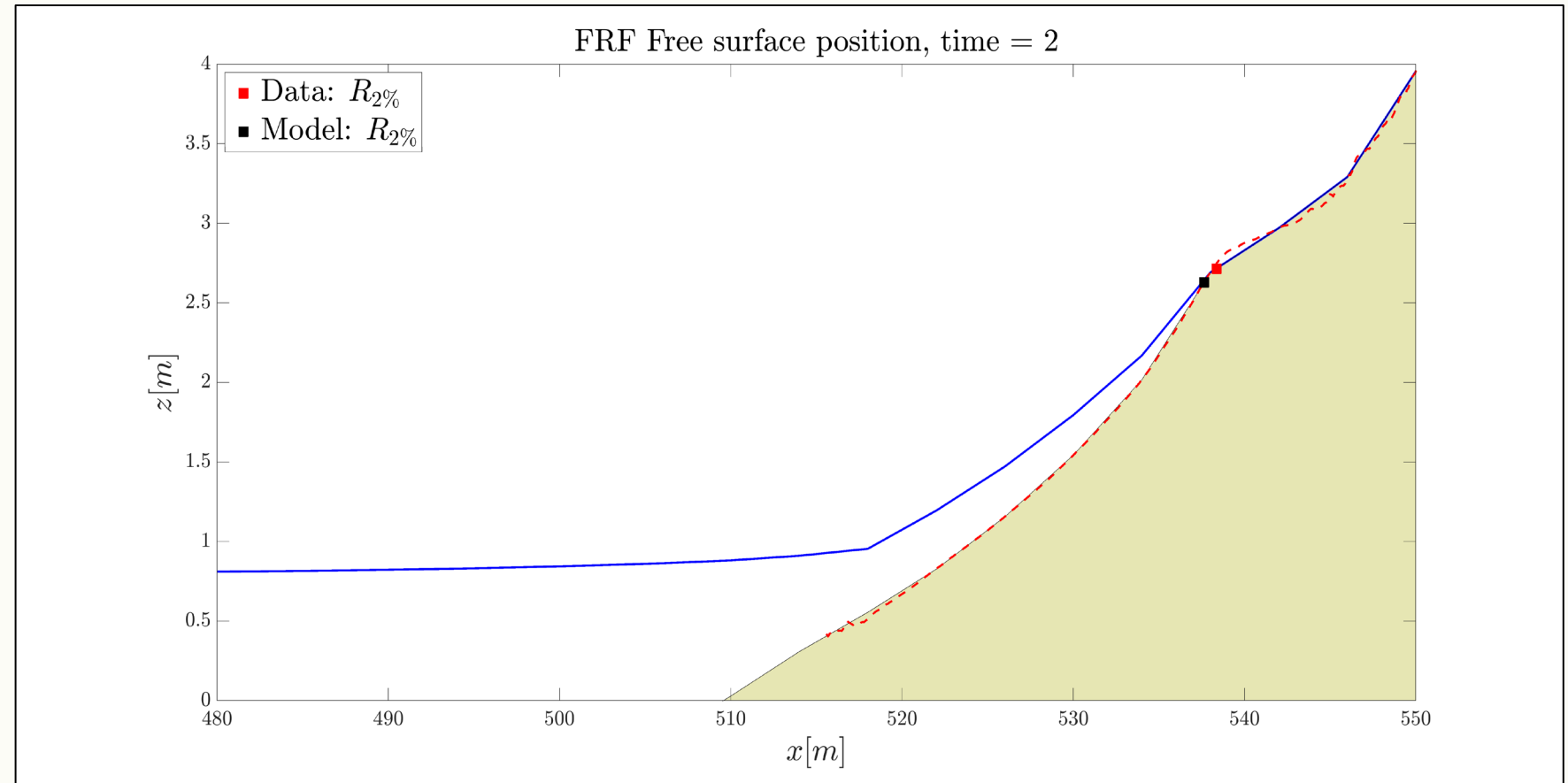
FRF Runup Predictions

- Using three weeks of well-curated data for BC, swash
- Decouple errors due to bottom position inaccuracy by running hourly cases (533 cases) in one dimension with interpolated bathy.
- 2DH swash data are not yet available



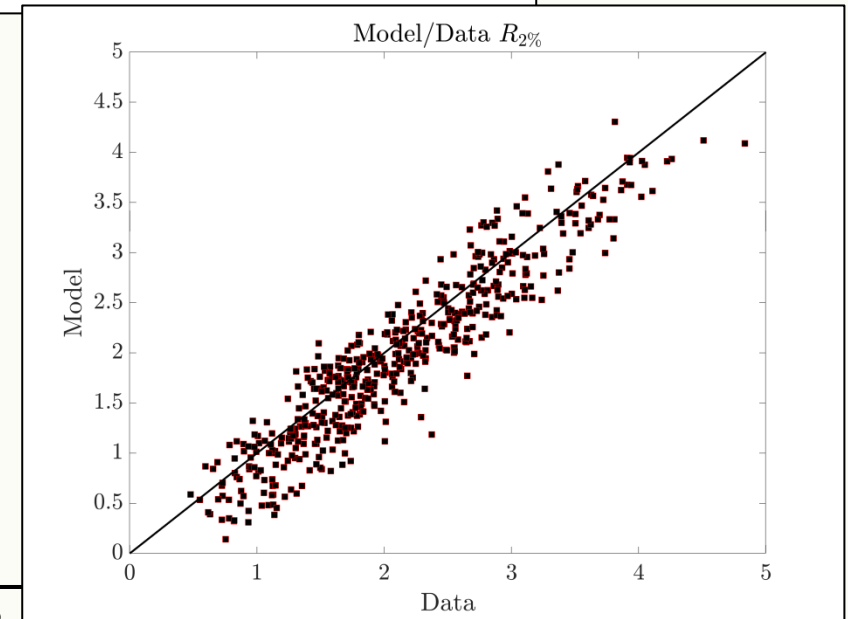
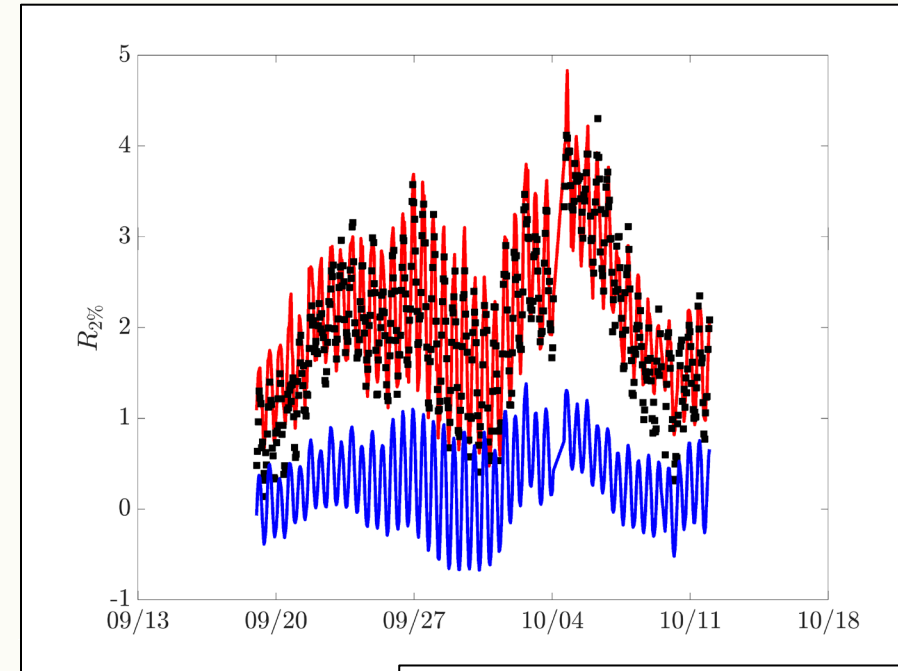
FRF Runup Predictions

- Using $A_0 = 5.2$
- 533 CMS runs is computationally expensive due to 2DH and transients
- $R_{2\%}$ well-predicted
- Some dependence on full/swash boundary



FRF Runup Predictions

- Runup has water level variation and wind-wave modulation
- Use is made of $A = 5.2$, minimizing error σ
- Simple swash propagation method is more efficient, stable, and accurate when compared with CSHORE computation.



Summary

FY21 Major Advances in Capability

- New CMS/C2SHORE transport
- Operational CMS swash computation
- Detailed mode/data comparisons on East/West

FY21 Major Products & Collaborations

- Draft TR of swash formulation
- CWG Webinar
- 2 CIRP TD (one pending)
- Collaboration with Scripps
- All data for model comparisons are leveraged from Nearshore Processes WU

Planned Outyear Products/Advances

- Alter swash domain demarcation
- DUNEX participation, new detailed 2DH swash data
- Trial swash formulation with longshore variation.