Analysis of Idealized Nearshore Berm Evolution using CMS

Brian McFall, Douglas Krafft, Mitchell Brown, Cody Johnson

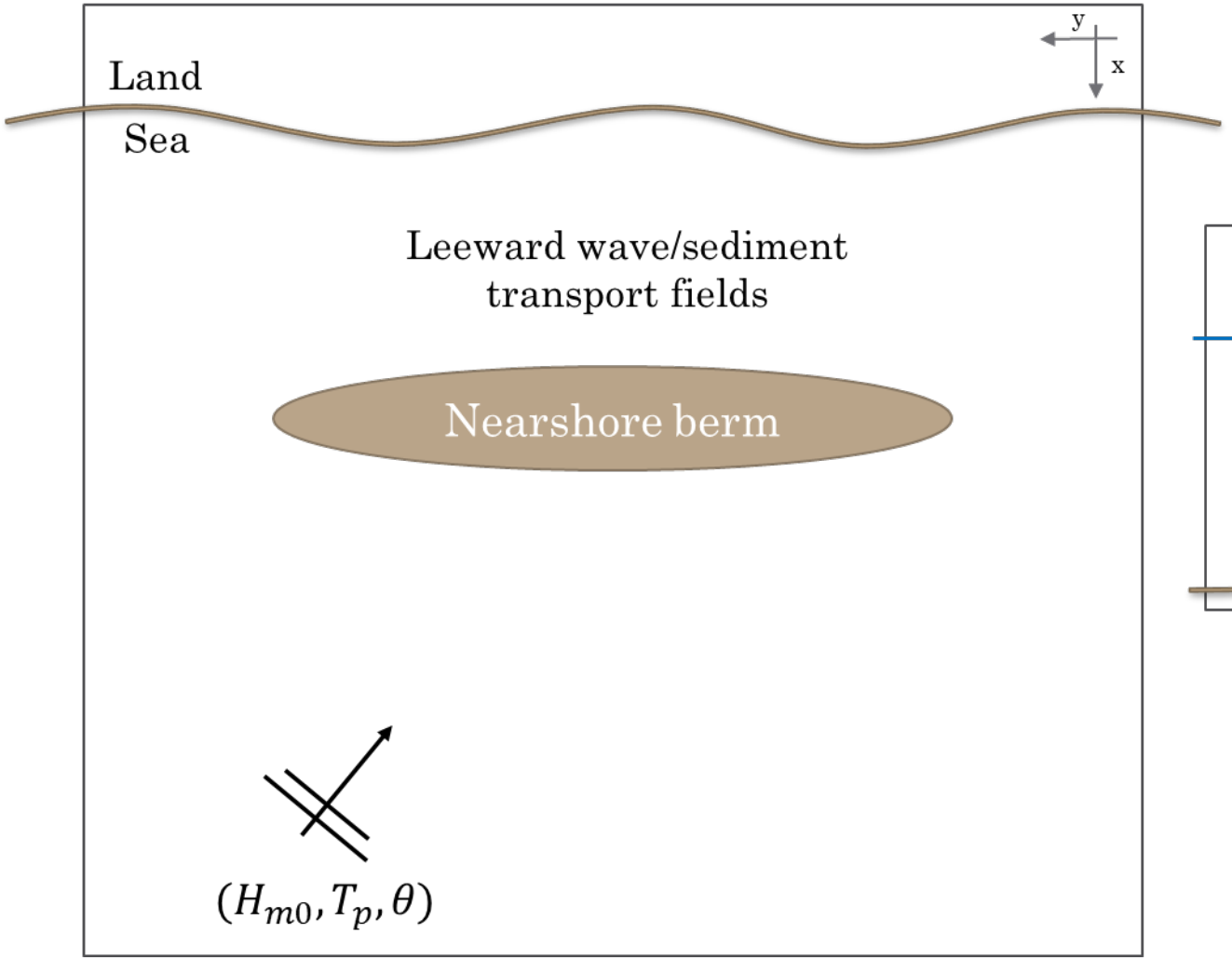
September 29th, 2020

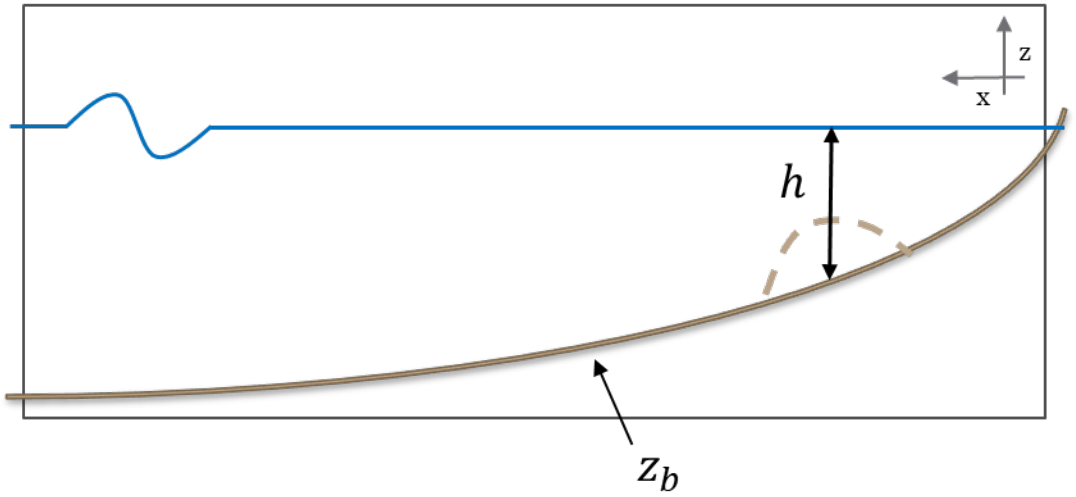
Background

- The strategic placement of dredged sediment with in the nearshore is an increasing utilized practice to beneficially use dredge material.
- Placement geometry and depth affect shoreline response and sediment transport in the vicinity of the disposal site.
- Complex nearshore processes defy easy conceptualization, therefore model simplifications are made to highlight presumed 1st-order controls/effects.
- **Project Goal**: Quantify wave attenuation and sediment transport/morphodynamics under idealized conditions to provide a high-level understanding of placement geometry/depth.

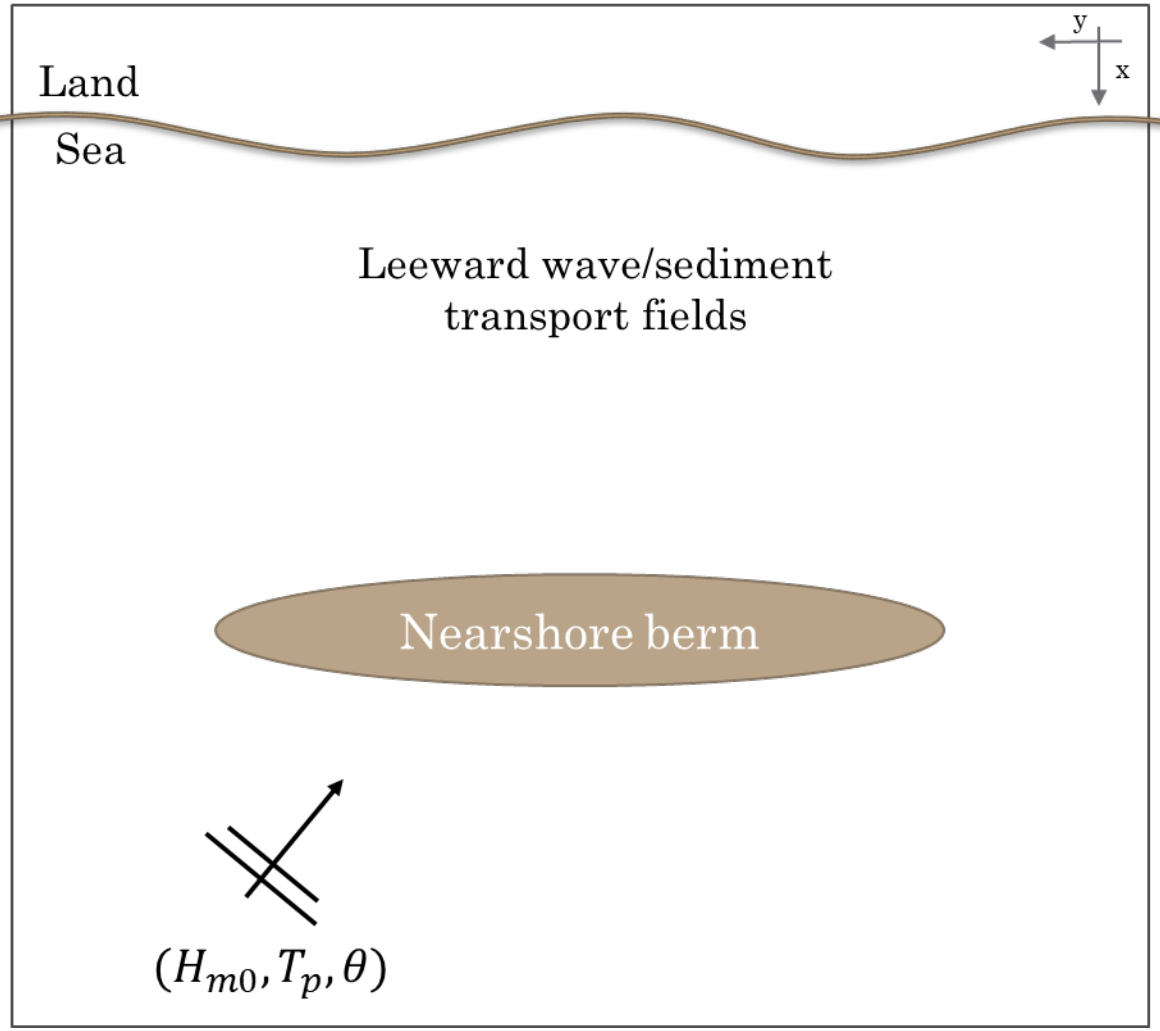
Ultimately, provide guidance for the beneficial use of dredge material to O&M in the field.

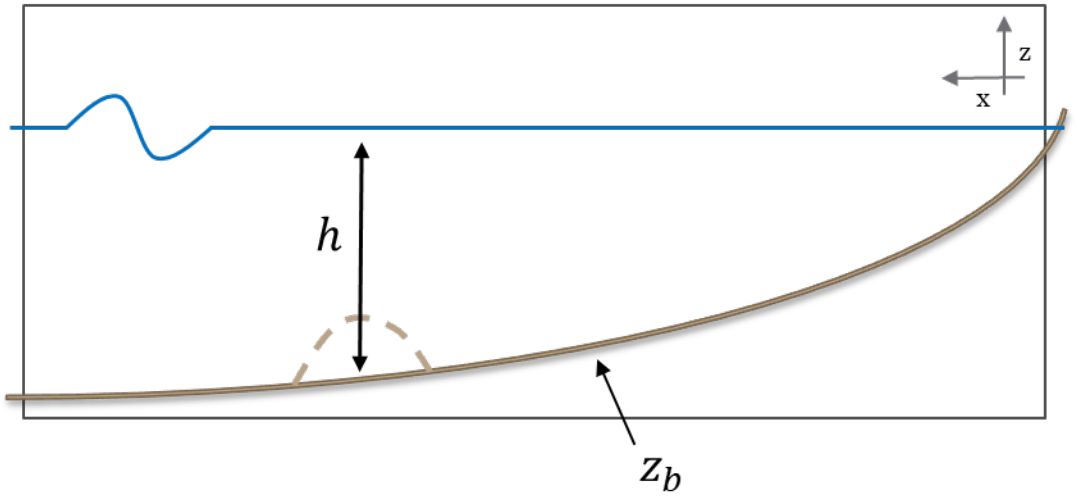
Idealized problem



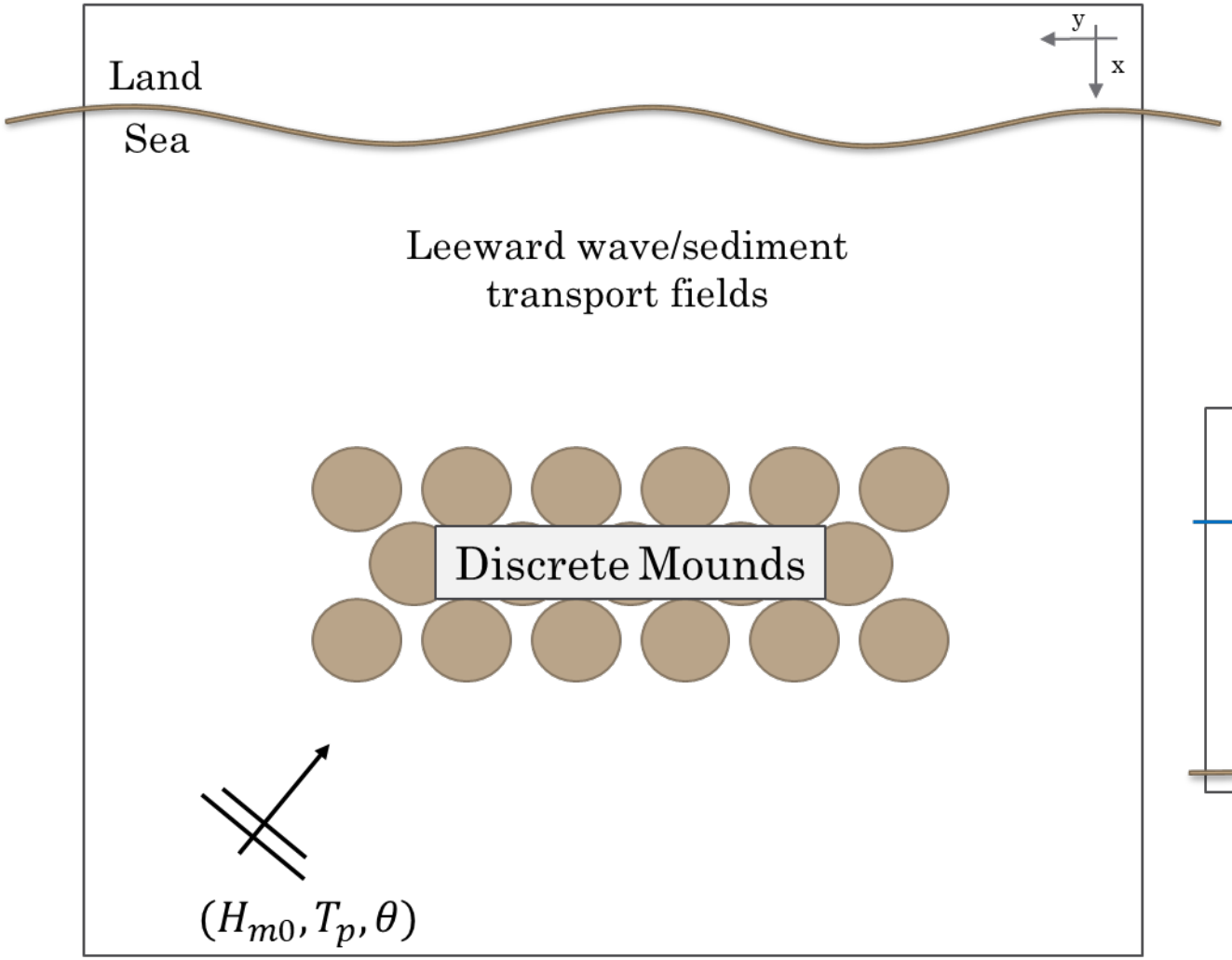


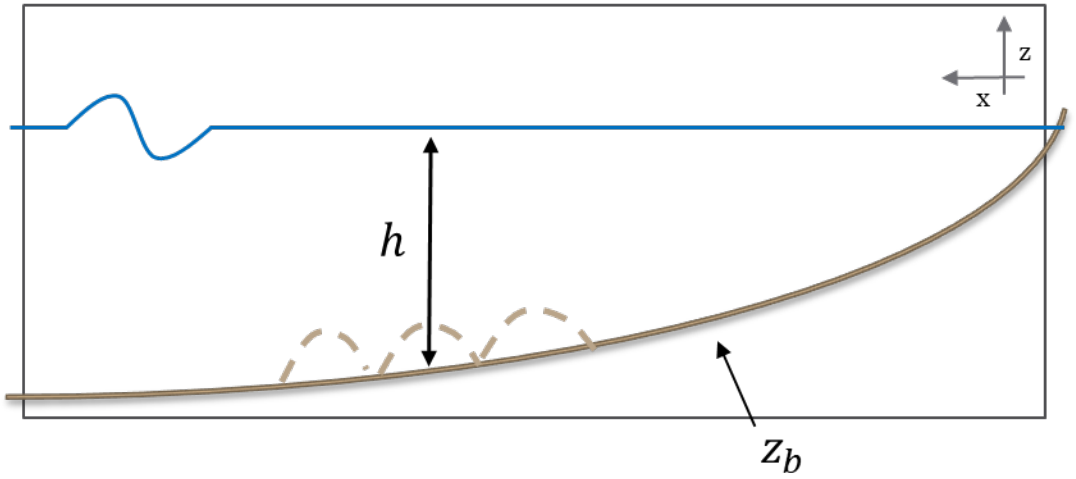
Idealized problem

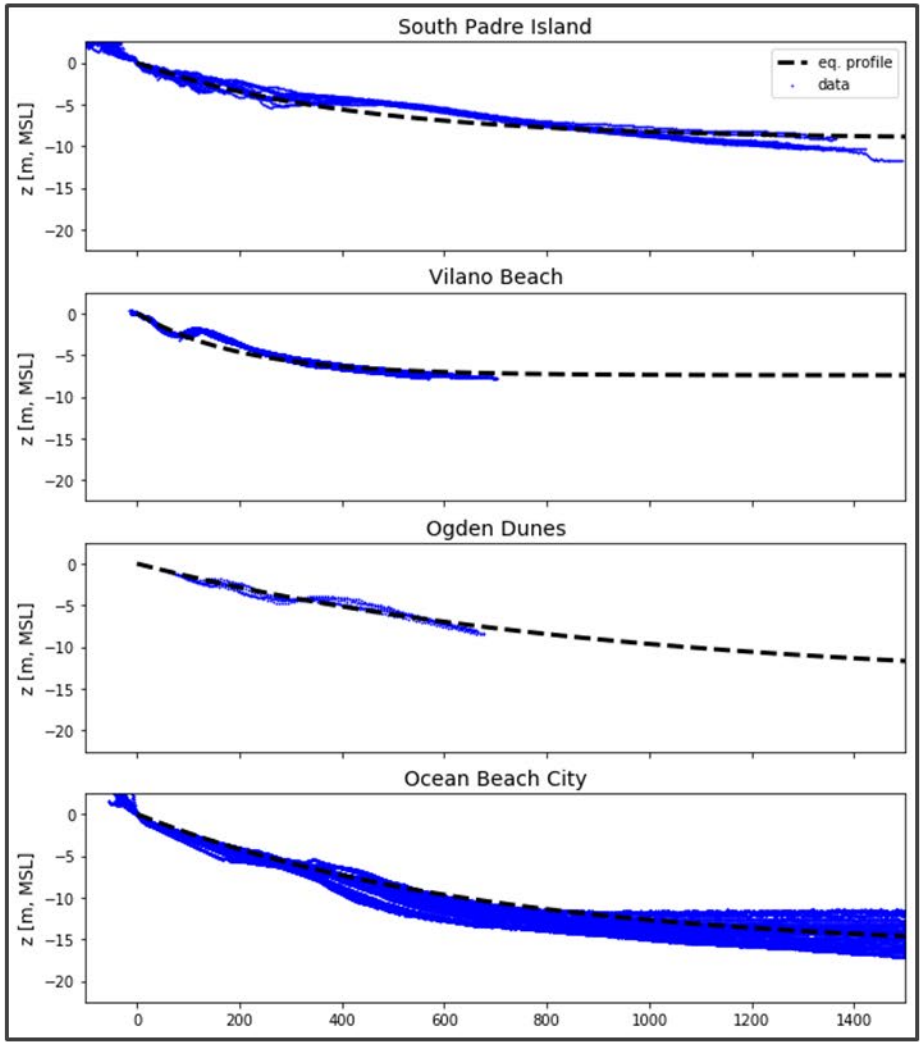




Idealized problem







$$z_b = -h = \frac{-S_0}{k}(1 - e^{-kx})$$

$S_0 =$ Shoreline slope

$k =$ Profile decay coefficient

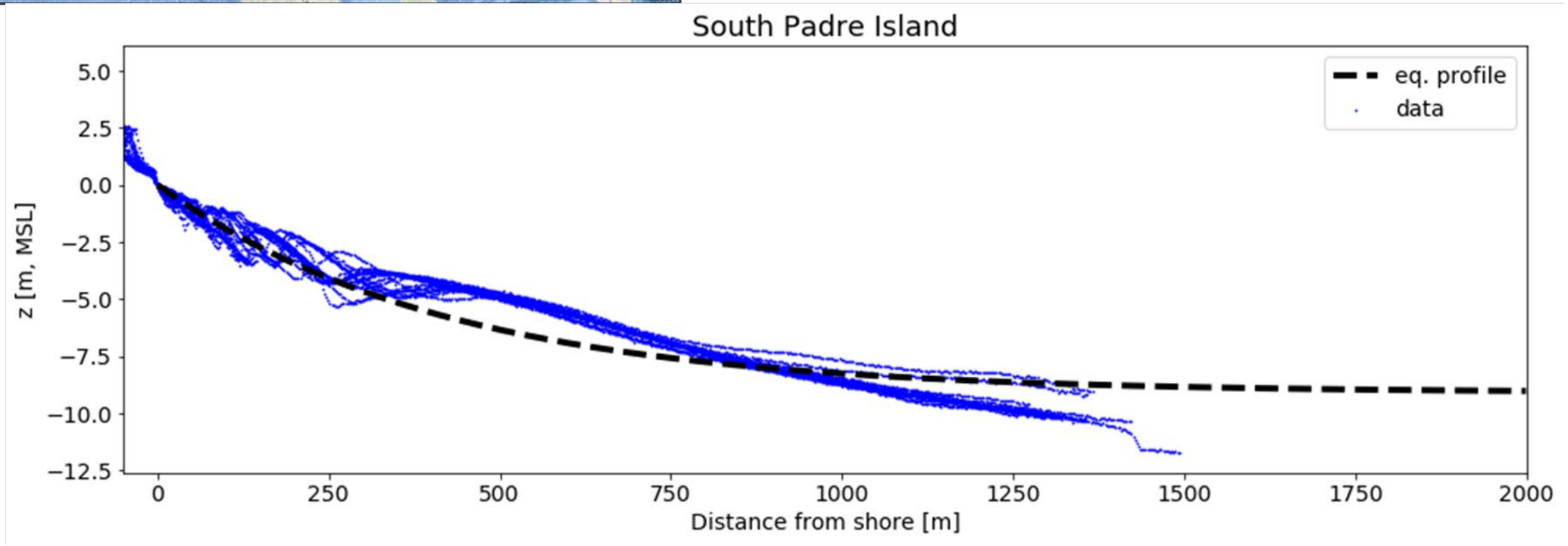
McFall, B. C. (2019). The Relationship between Beach Grain Size and Intertidal Beach Face Slope. *Journal of Coastal Research*, *35*(5), 1080–1086.

Komar, P. D., & McDougal, W. G. (1994). The analysis of exponential beach profiles. *Journal of Coastal Research*, *10*(1), 59–69.

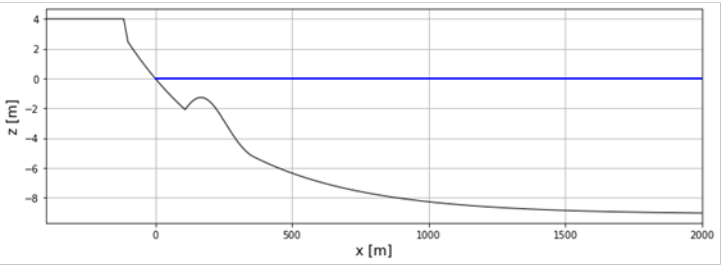
$$z_b = -h = \frac{-S_0}{k}(1 - e^{-kx})$$

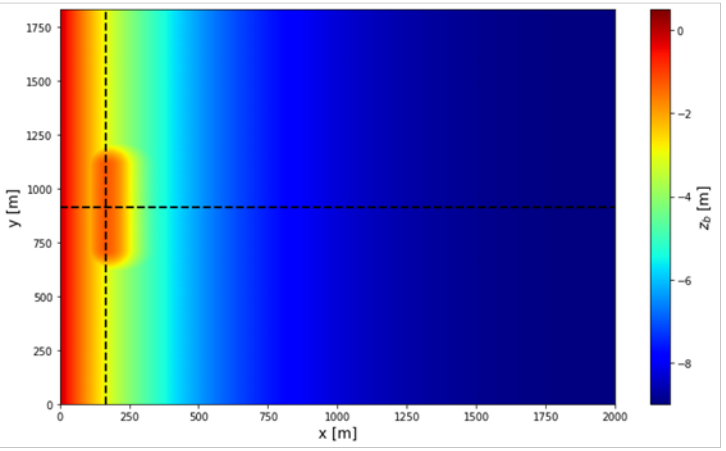
$$S_0 = 0.022$$

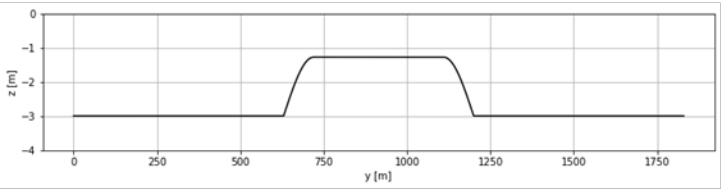
$$k = 0.002$$



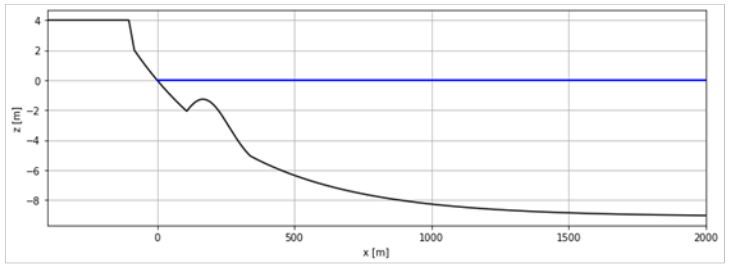
Linear Berm

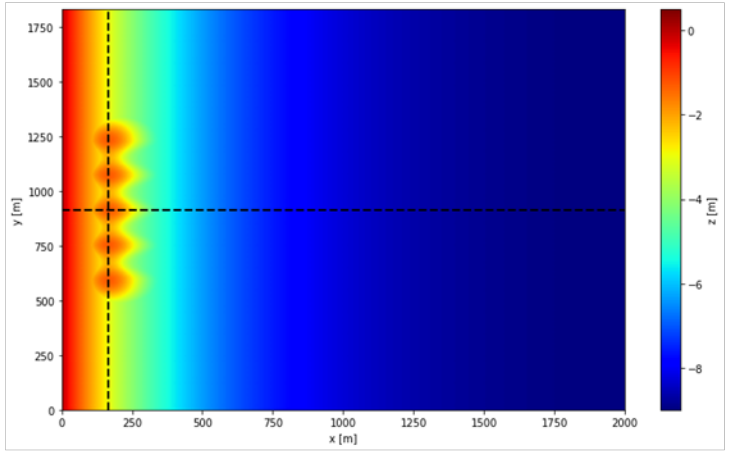


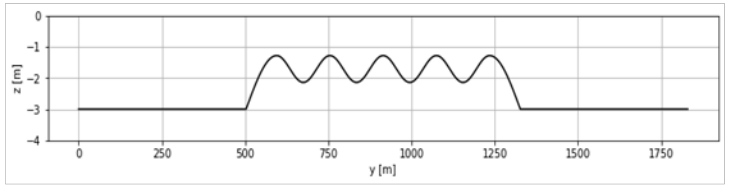




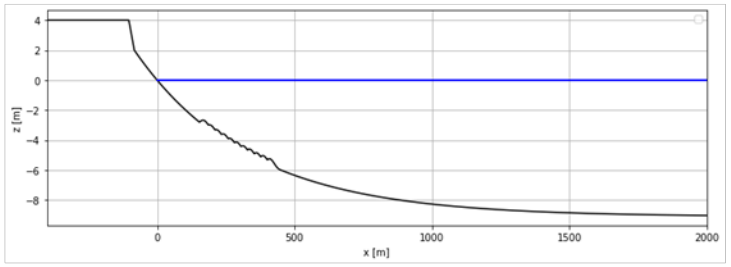
Undulated Berm

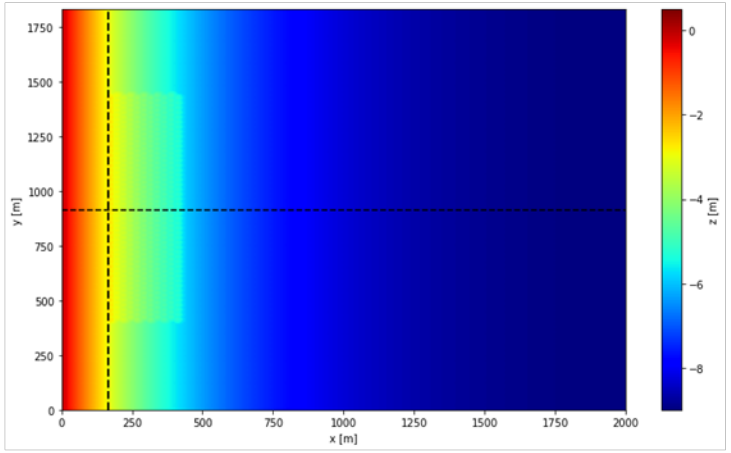


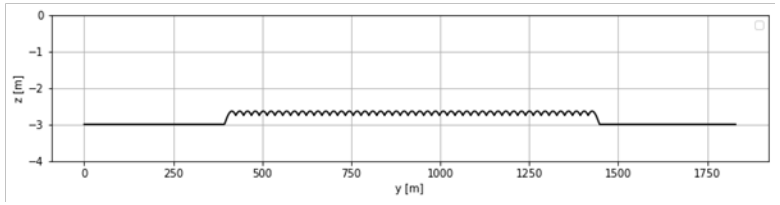




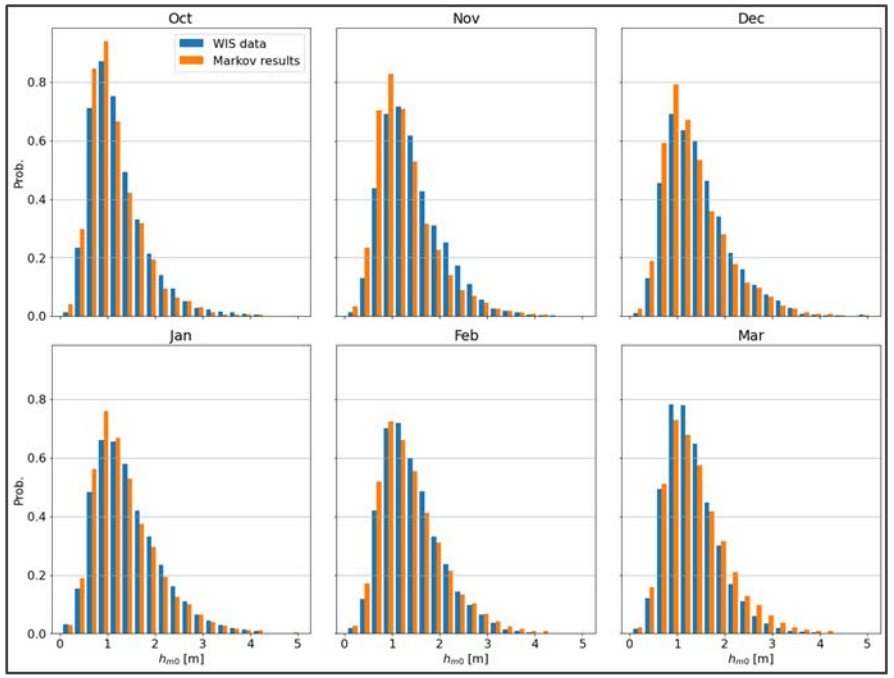
Discrete Mounds



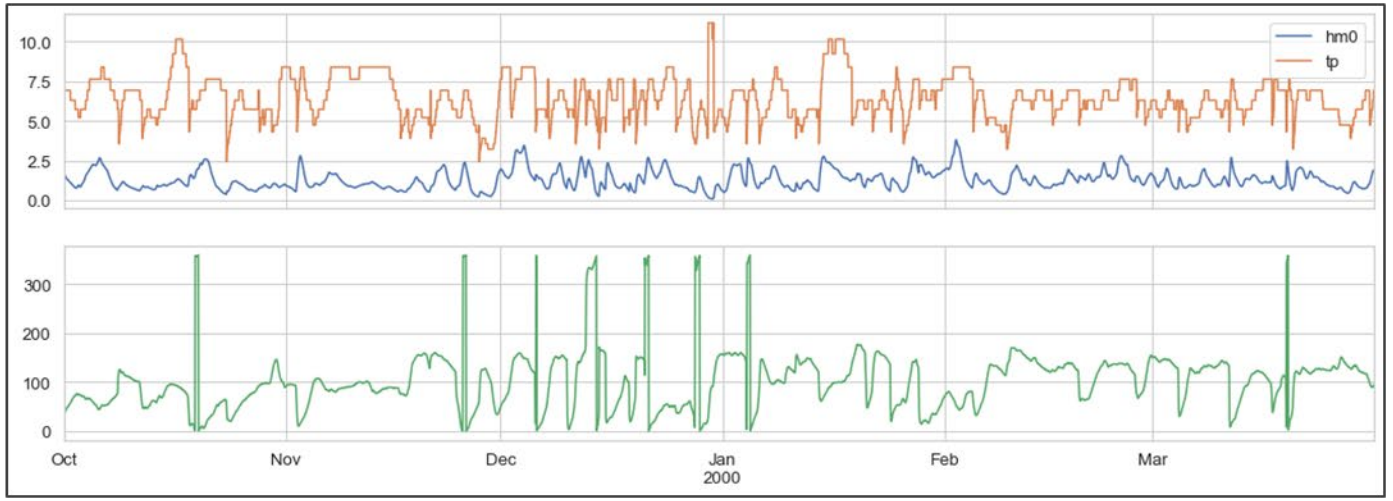




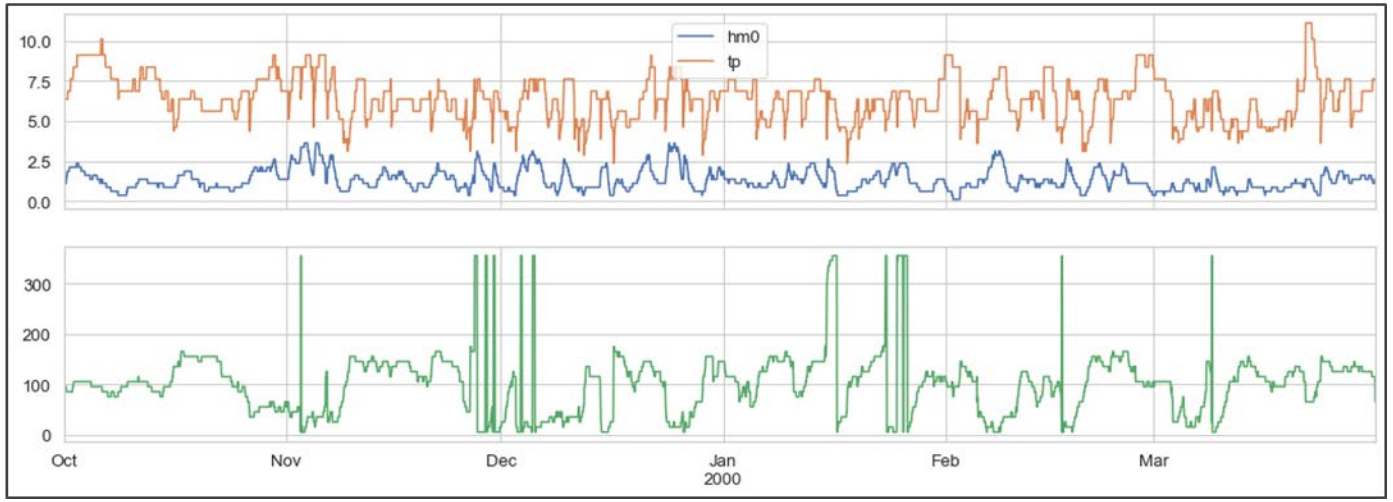
Markov Chain model



WIS data



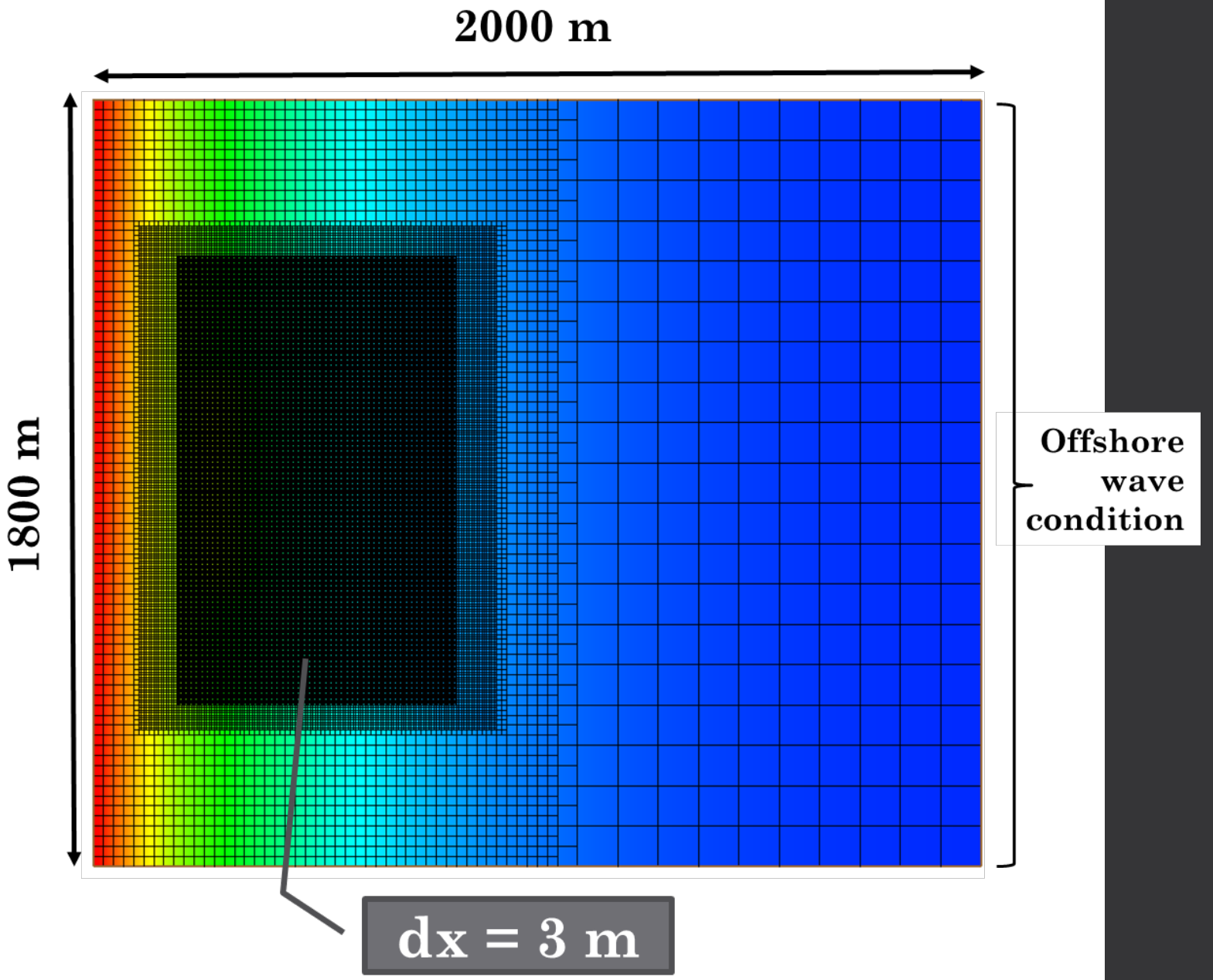
Synthetic time series



De Masi, G., Bruschi, R., & Drago, M. (2015). Synthetic metocean time series generation for offshore operability and design based on multivariate Markov model. *MTS/IEEE OCEANS 2015*

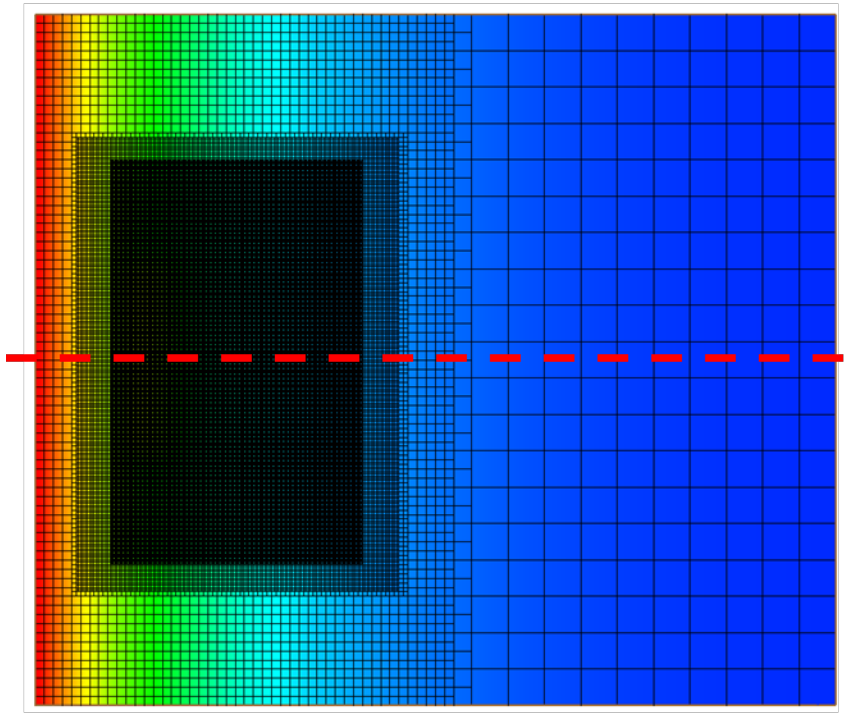
Coastal Modeling System (CMS)

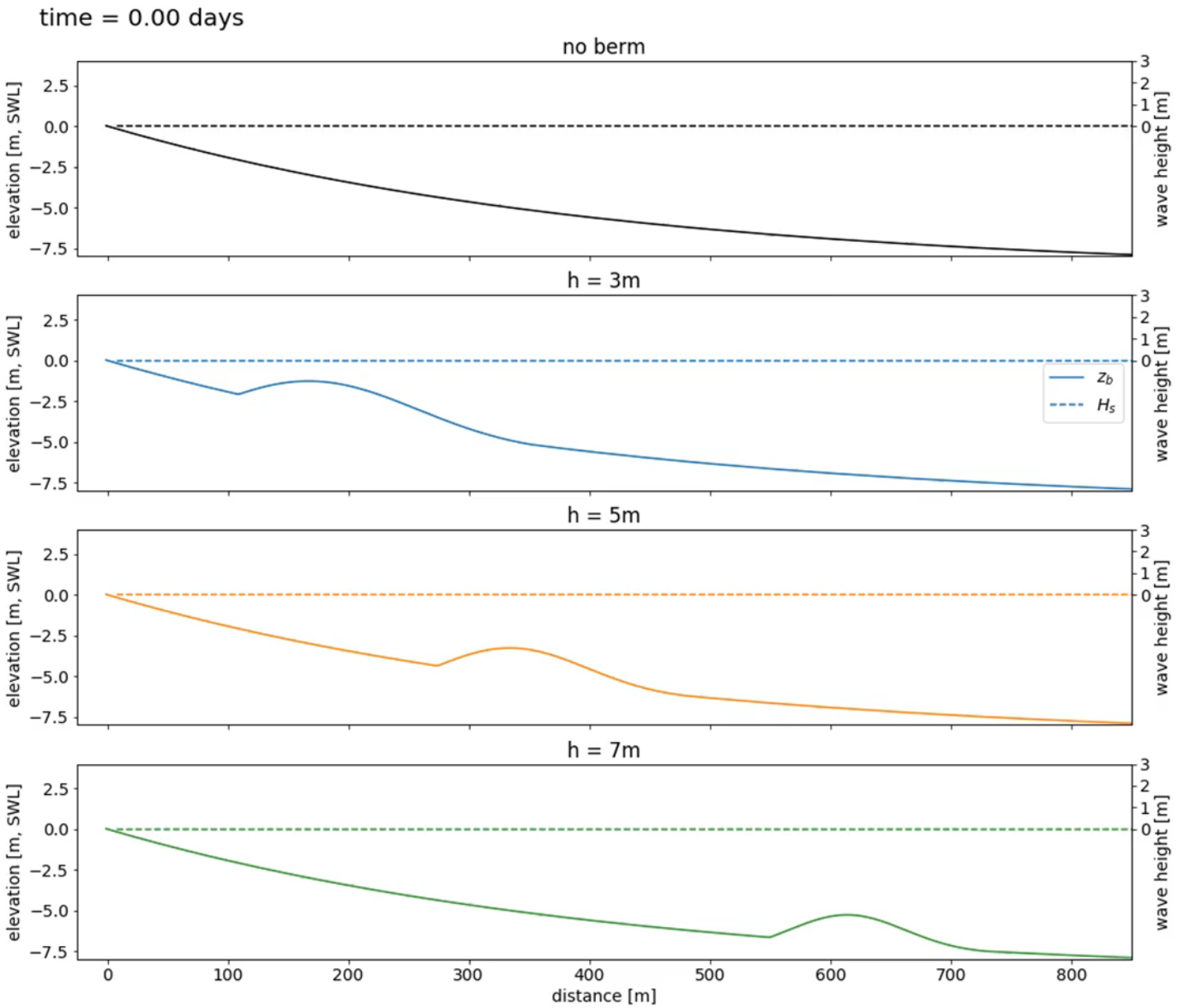
- Coupled waves/flow
- Phase-averaged wave model
- 6 month simulation time
- Open boundary water levels pinched at zero
- LundCIRP sediment transport formula
- Uniform grainsize depending on case study



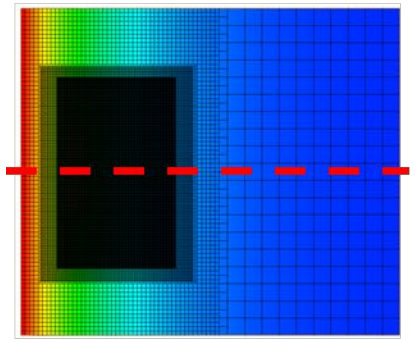
Linear Berm

Profile location





Profile location



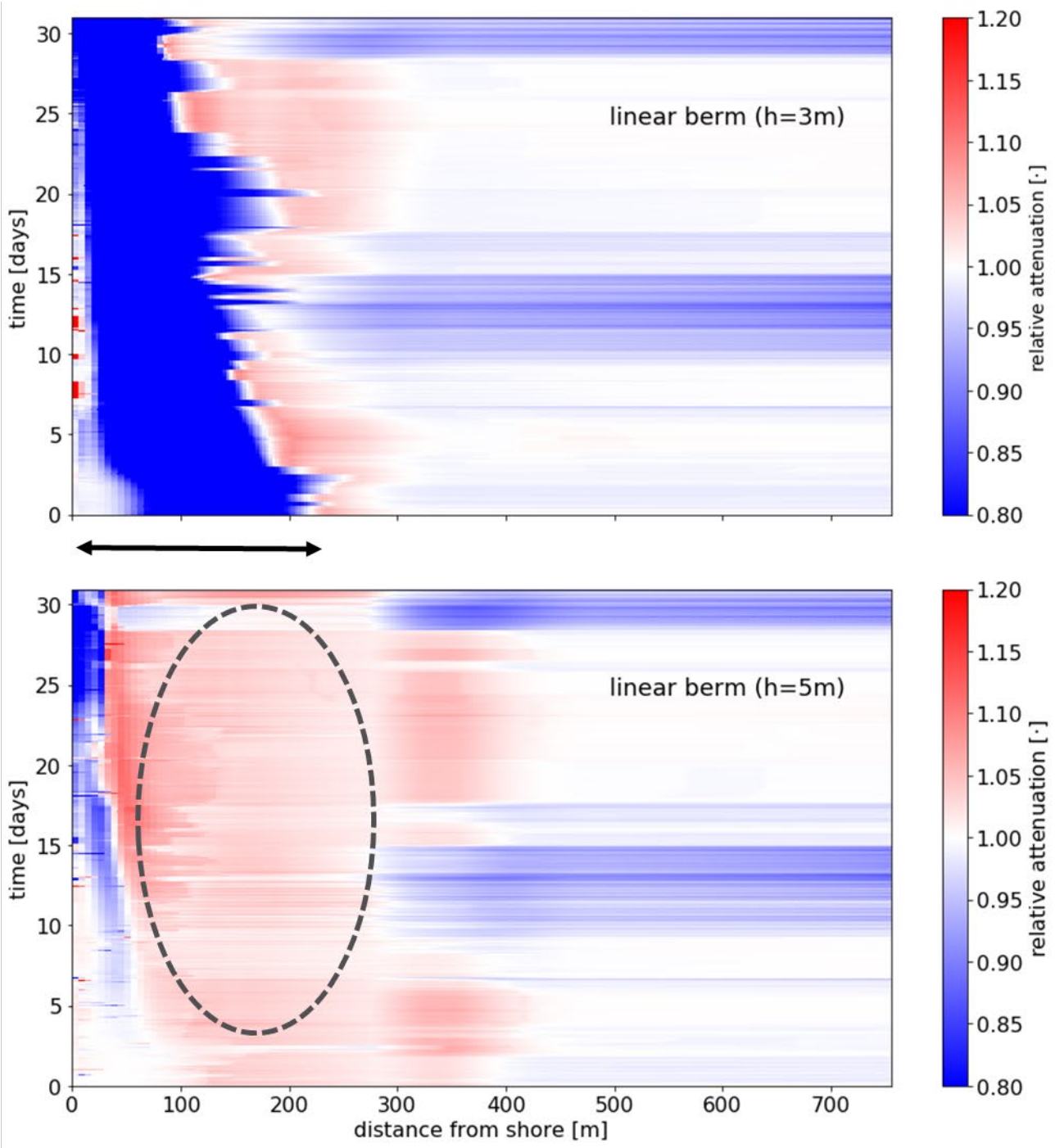
- Relative wave height

$$\alpha = \frac{H_s}{H_s^*}$$

H_s = Significant wave height

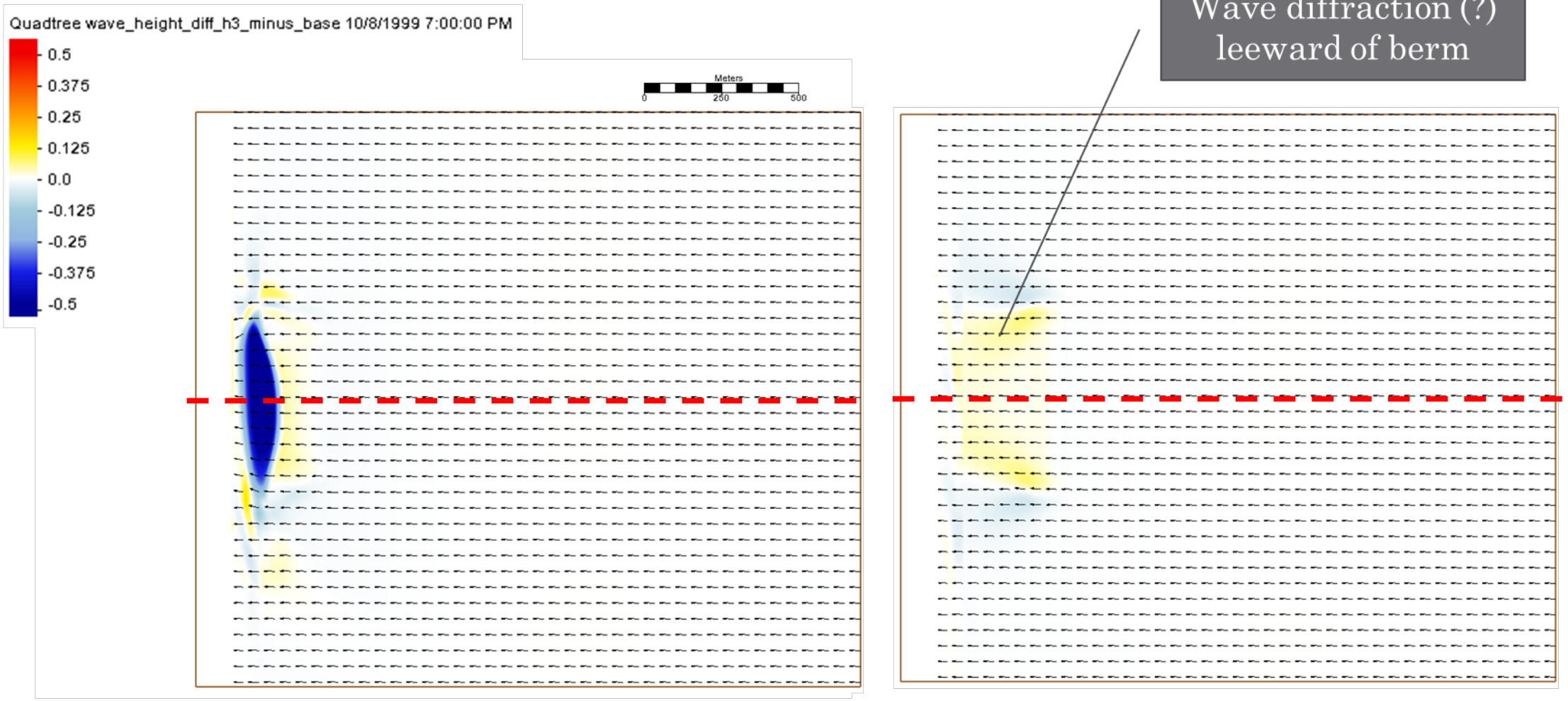
H_s^* = Wave height in control case

- Increased wave energy dissipation in surf zone for h=3m simulation
- Amplification of wave energy leeward of berm for h=5m



$$\Delta H_s = H_s - H_s^*$$

Simulation time = 8 days

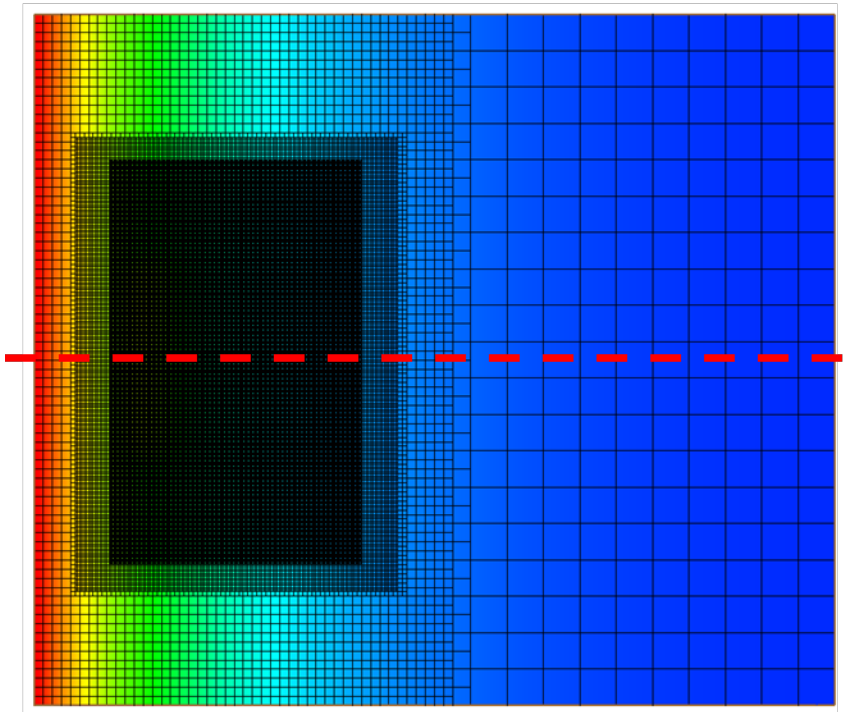


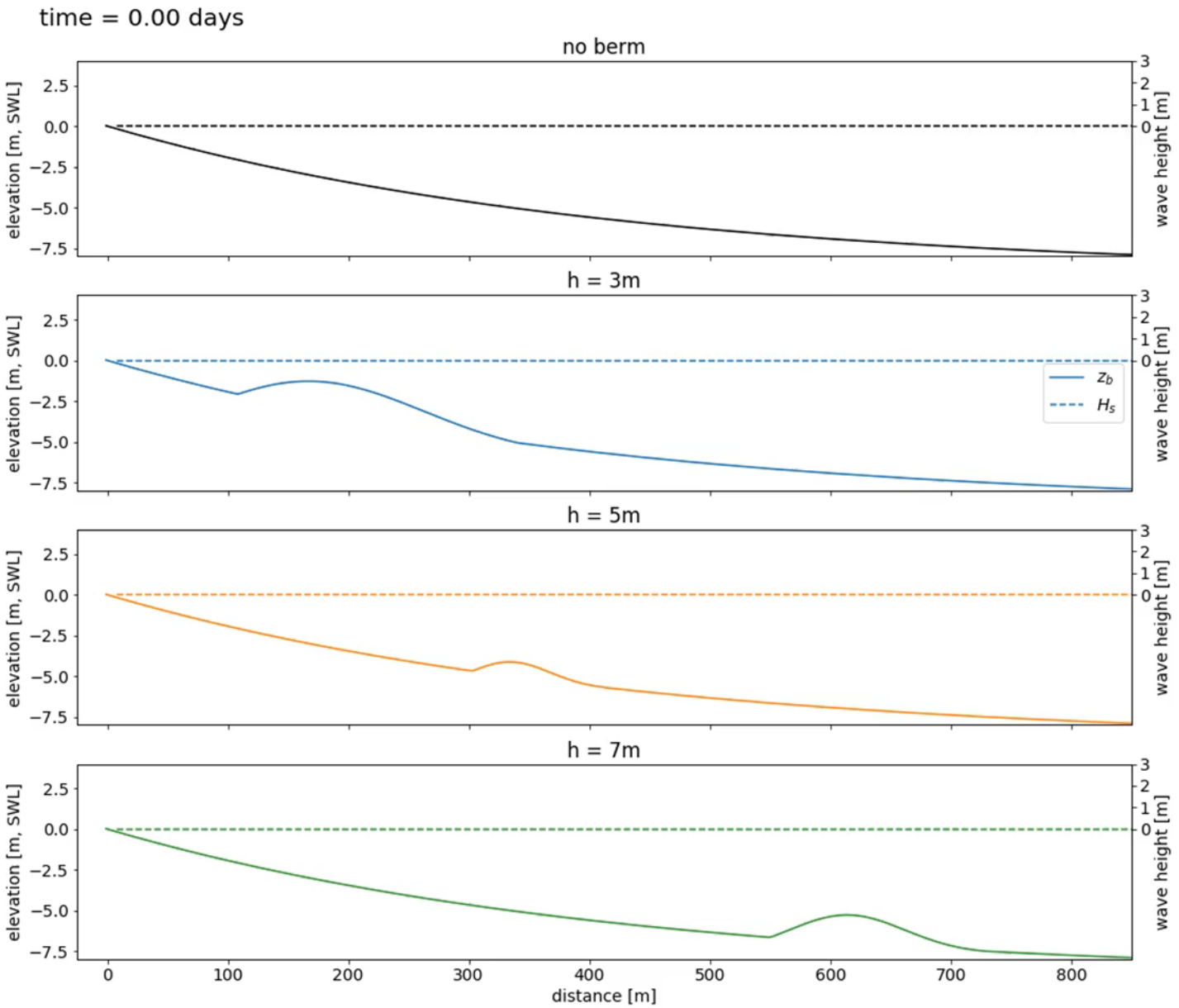
Linear berm h=3 m

Linear berm h=5 m

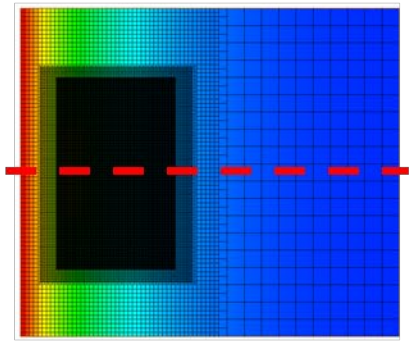
Undulated Berm

Profile location

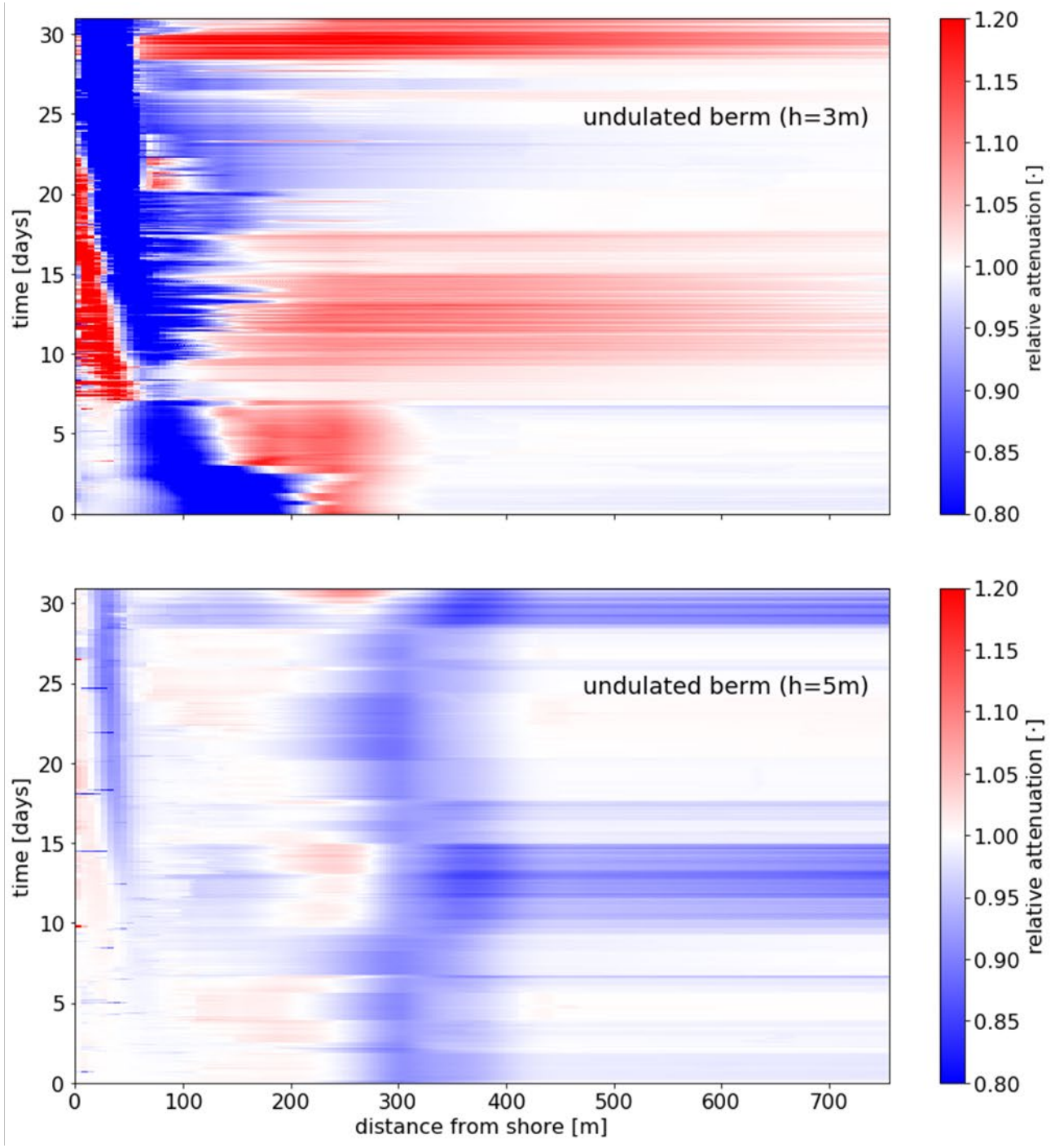




Profile location

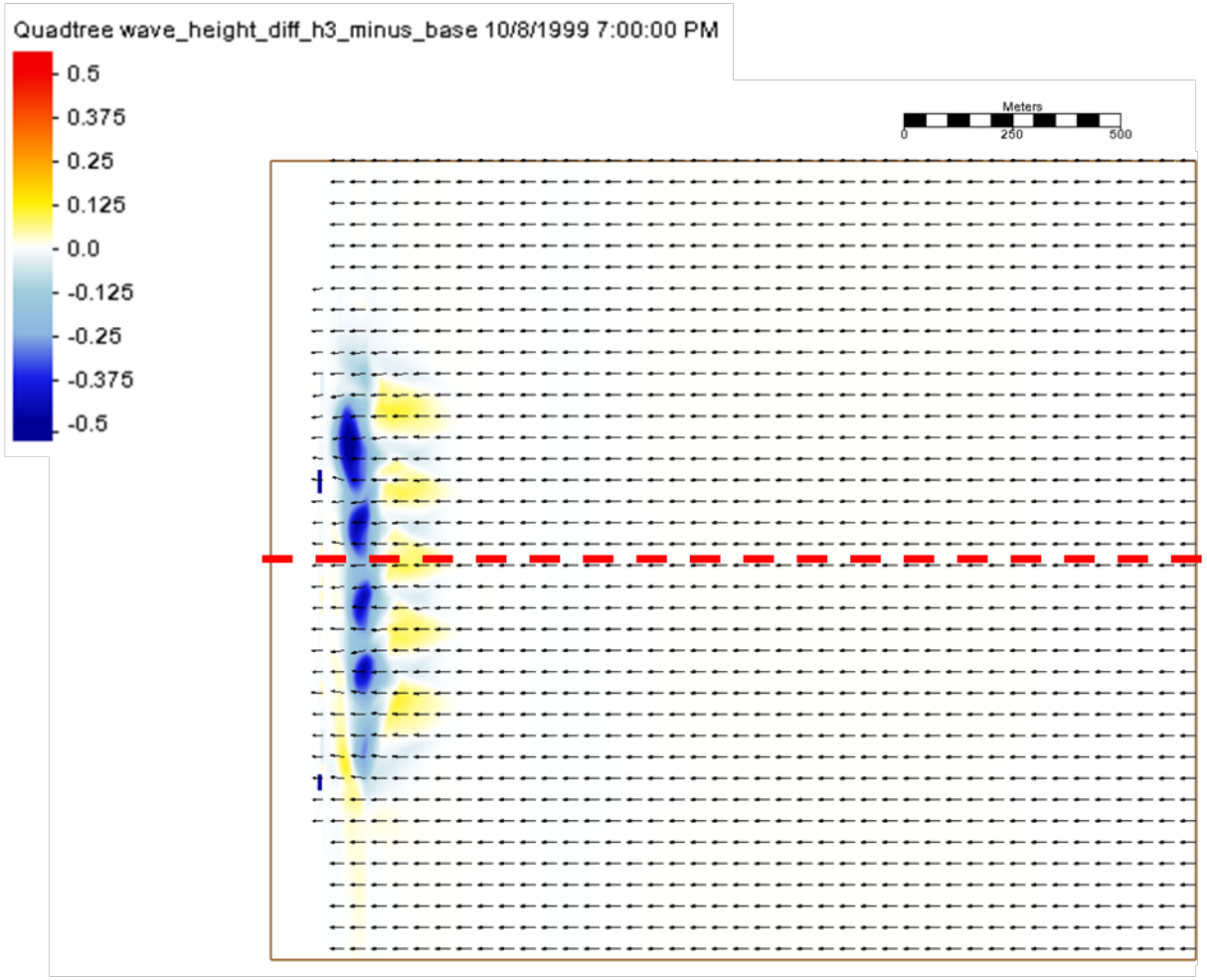


- Less energy dissipation in surfzone
- Also, less amplification of wave energy leeward of berm for h=5m

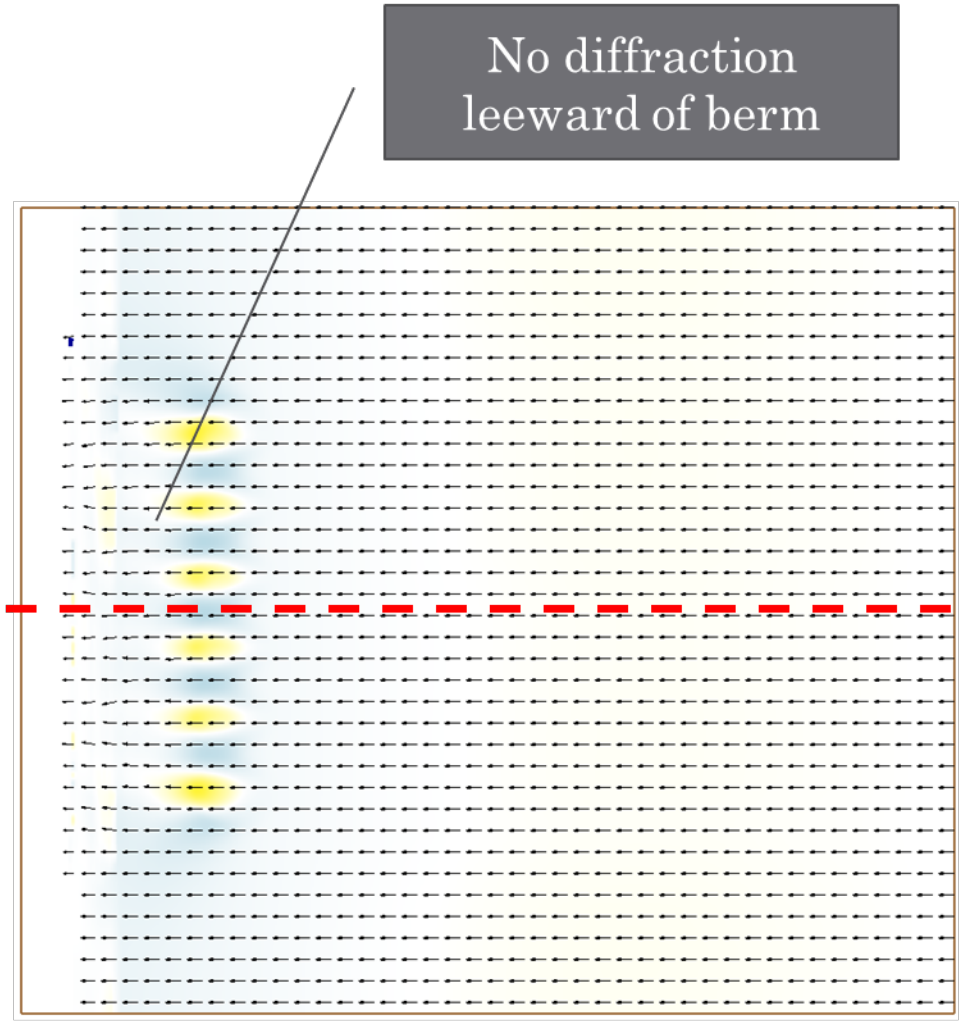


$$\Delta H_s = H_s - H_s^*$$

Simulation time = 8 days

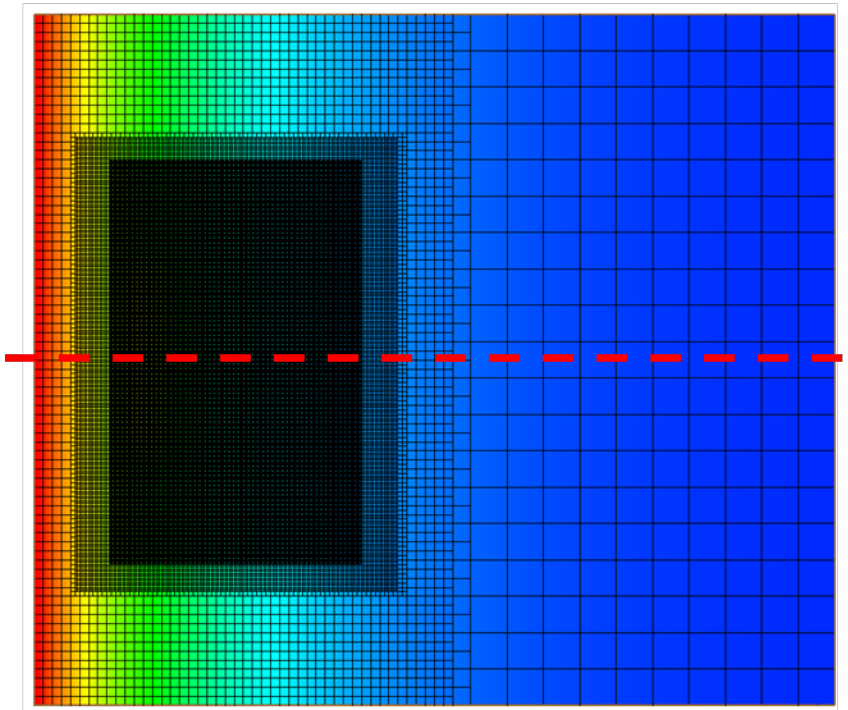


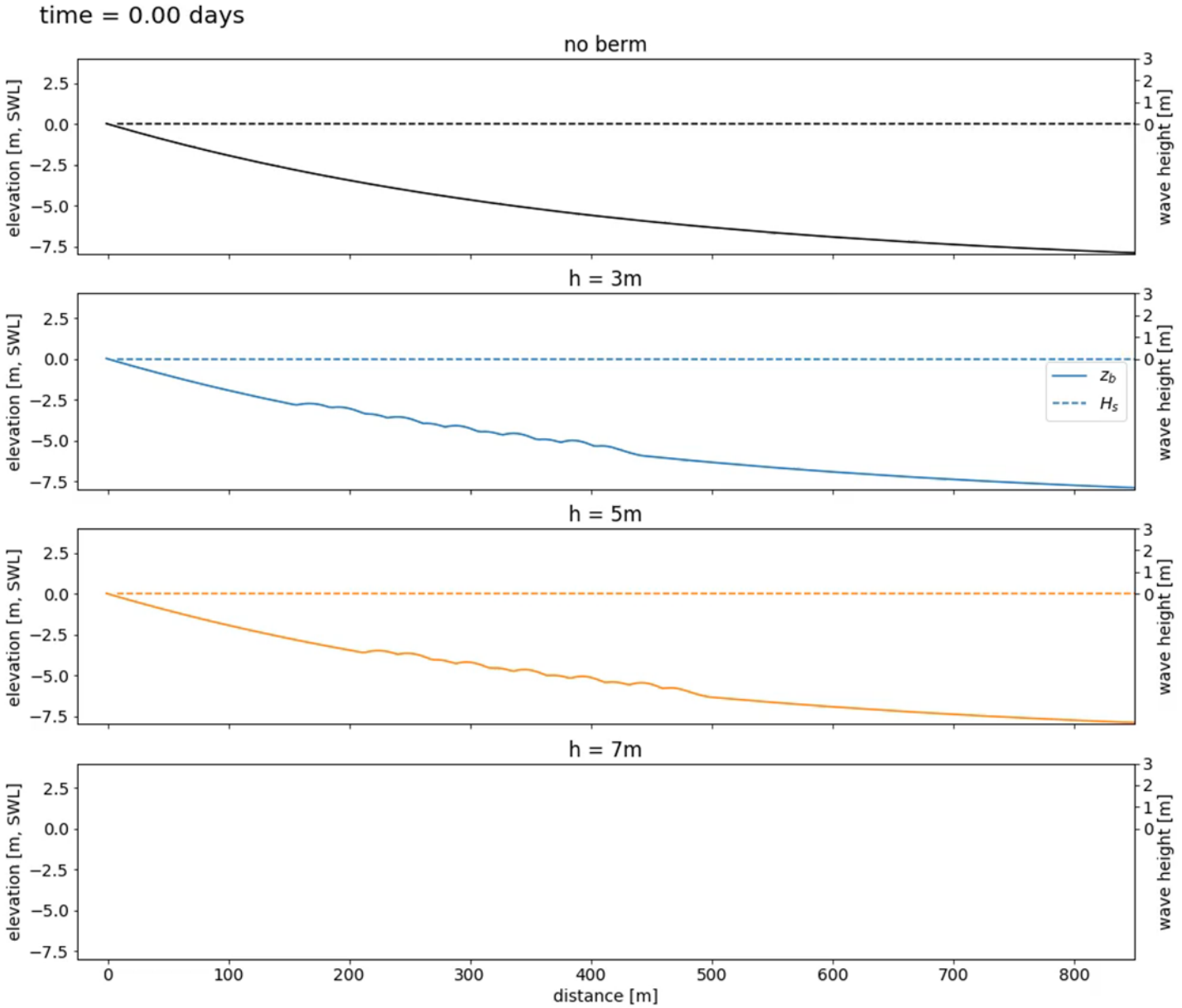
Undulated berm h=3 m



Undulated berm h=5 m

Profile location



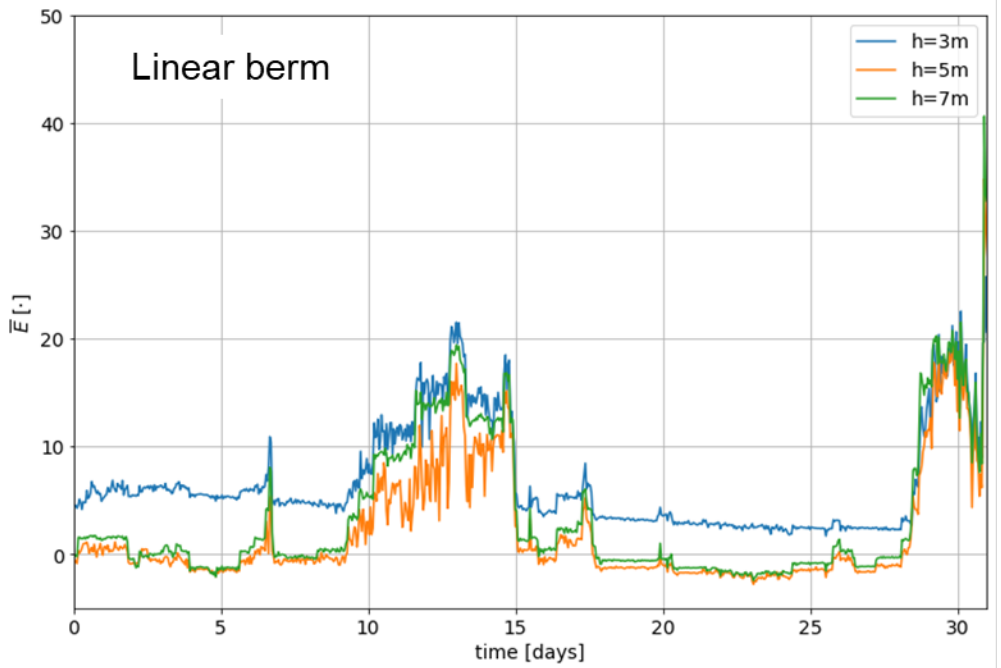


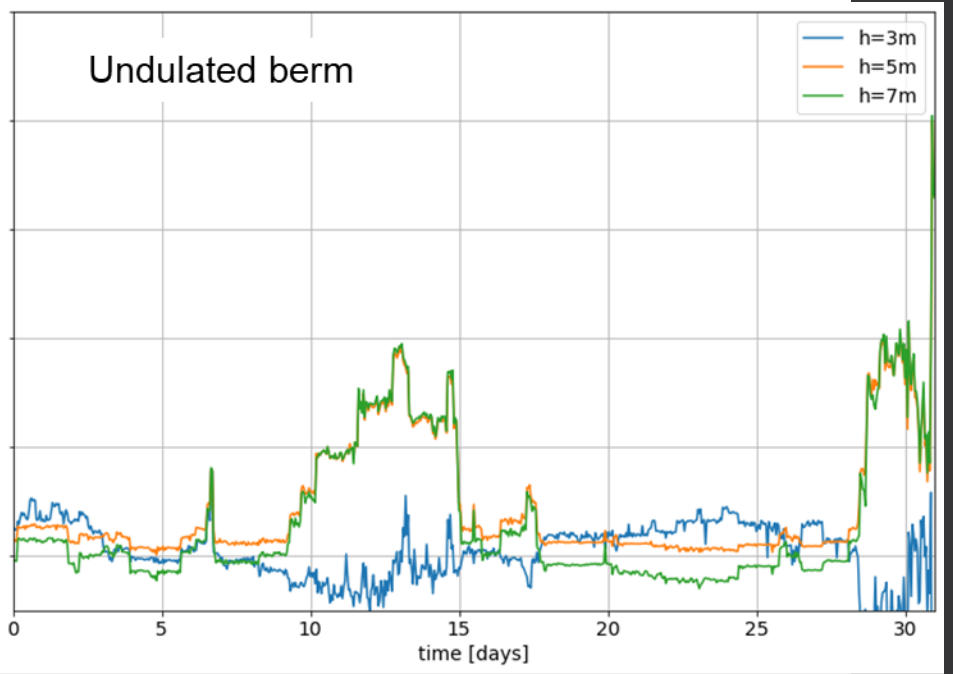
$$E = \frac{1}{8}\rho g H_s^2$$

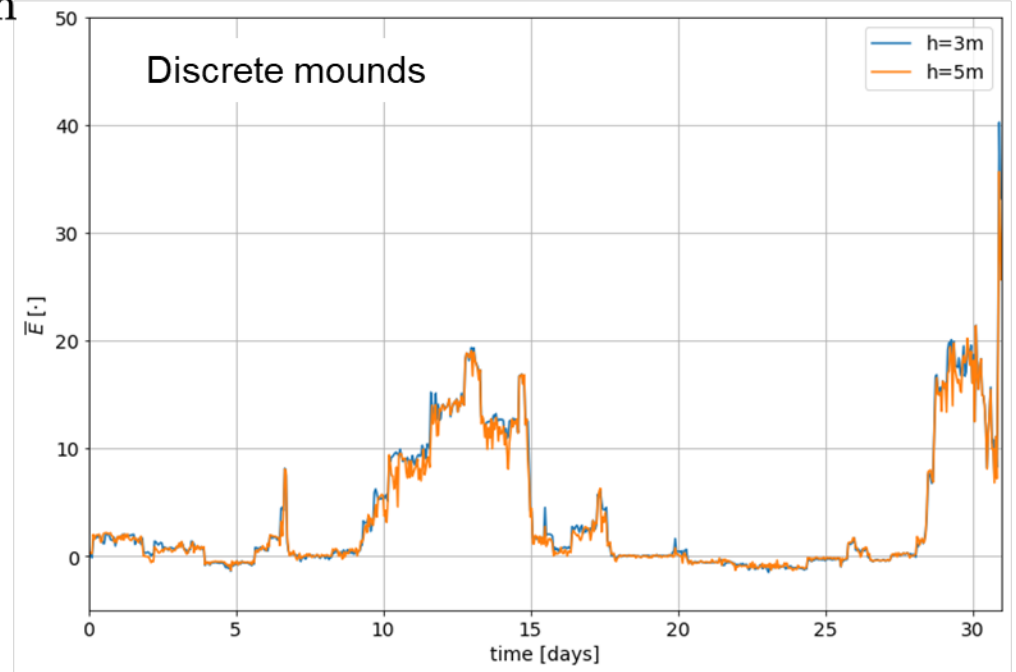
$$\Delta E = E^* - E$$

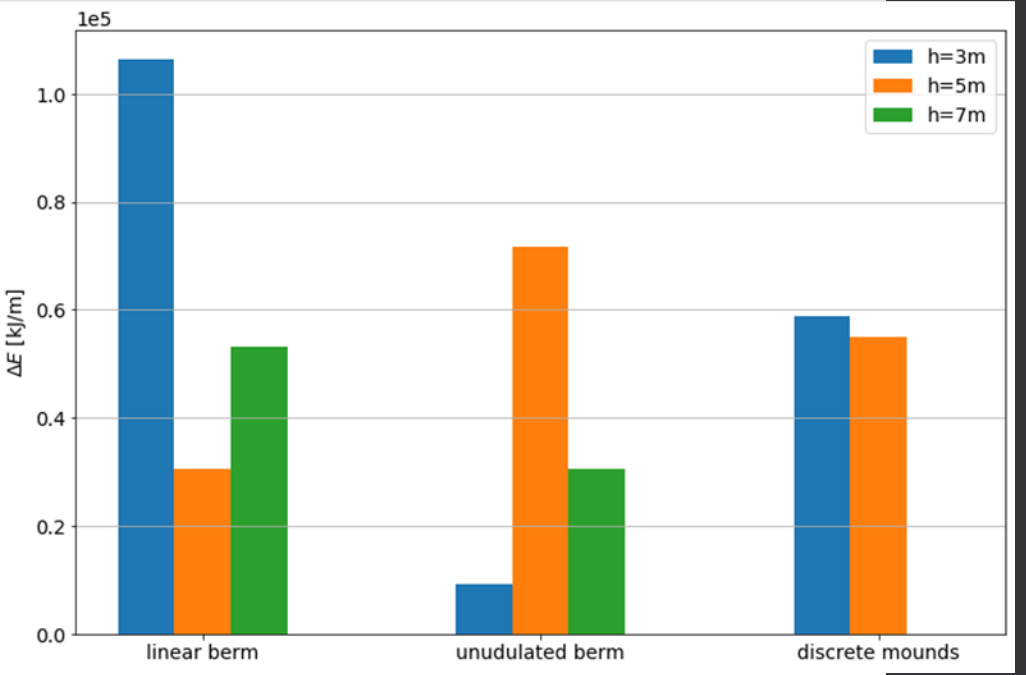
$$\bar{E} = \frac{\int \Delta E dx}{\int E^* dx}$$

$E^* =$ Energy from control case









Future work

- Concise method to quantify, summarize, and communicate the results
  - Consider effects in 2D
- Analyze shoreline and profile accretion
- Inter-site comparison that considers on-shore/off-shore sediment transport depending on dissipative/reflective nearshore profile.

Thank you!