ANALYSIS OF NEARSHORE NOURISHMENT EVOLUTION USING CMS

INLET GEOMORPHOLOGY WORK UNIT

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COASTAL INLETS RESEARCH PROGRAM

FY20 IN PROGRESS REVIEW

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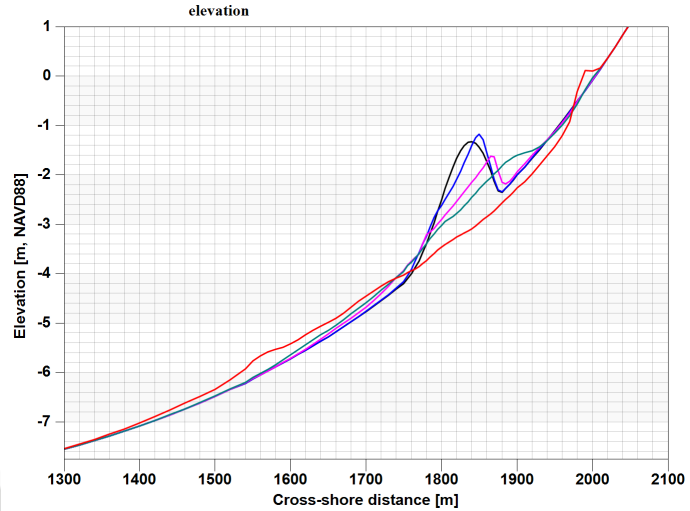

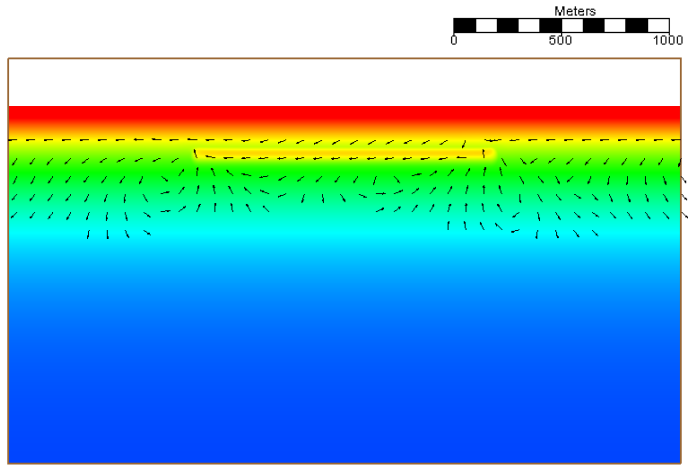

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Problem Statement

- Nearshore berms are constructed in a variety of configurations, but it is poorly understood how differing shapes/depths influence sediment transport and wave fields.
- Beneficial use of dredge material involves trade-offs between placement cost and its performance, both functions of water depth. Quantitative evaluation of placement performance at varying depths informs guidance for the beneficial use of dredge material.
- Nearshore placements introduce disequilibria into the littoral zone which may directly impact shoreline position. Modeling the wave, current, and sediment transport fields improves the understanding of their influence on the nearshore and the fate of placed sediment.
- A broad evaluation of nearshore nourishment methods in a representative range of environments provides a scoping level estimate of the nourishments' benefits.
- SON's
  - 2020-N-1564: Increasing Beach Nourishment Lifespan with Nearshore Nourishments
  - 2020-N-1481: Improving scoping level estimates of the lifespans and deflation rates of nearshore nourishments
  - 2019-N-1386: Strategic Nearshore Placement of Dredged Material to Sustain Coastal Beach & Dune Resilience
  - 2017-N-70: Analysis of Shoreline Response to Nearshore Placement Geometry
  - 2016-N-04: Quantifying wave and current driven sediment transport at nearshore dredge disposal sites

Capability and Strategic Impact Statement

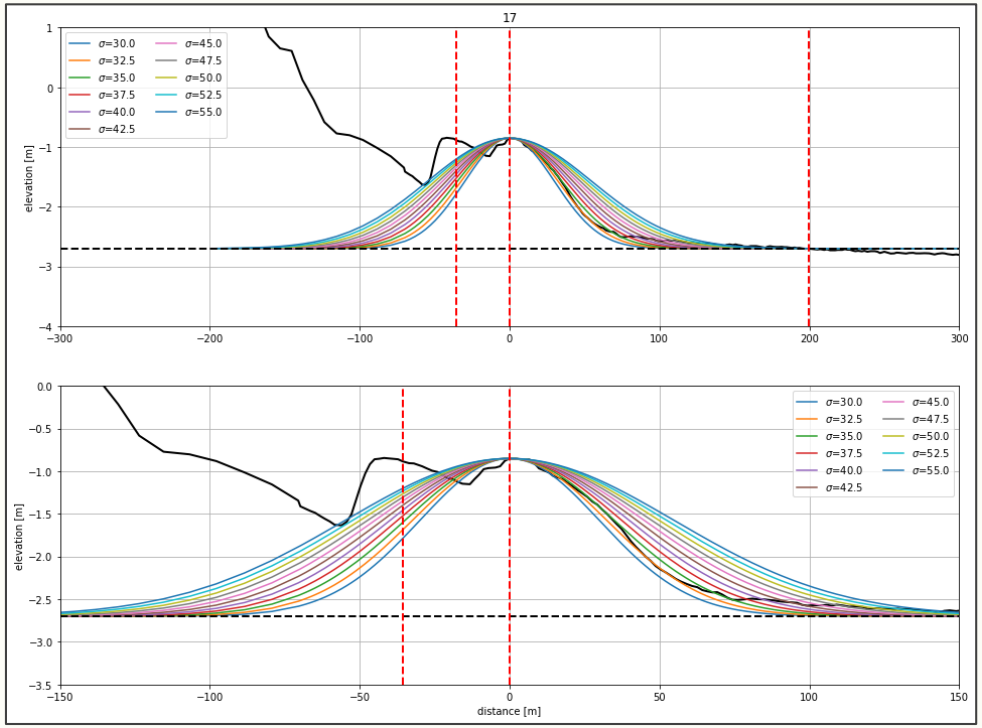
The modeling of idealized nearshore berm evolution provides a lucid representation of complex processes to inform design, management, and further research directions.

The modeling scenarios represent a range of conditions, analogous to real world cases, from which district engineers may draw conceptual guidance for their design and management projects.

Methods and Materials

- **Simulate nearshore berm evolution under idealized conditions**
  - **Equilibrium profiles derived from real bathymetry**
  - **Placement geometry related to actual placements**
    - **Berm crest height and width**
    - **Placement depth and shape**
  - **Sea-state derived from WIS statistics**
    - **Markov chain models**
- **Coastal Modeling System (CMS)**
  - **Loosely-coupled flow/waves for 6 months**
  - **Nearshore circulation driven by waves**
  - **Tidal influence and wind stress neglected**
- **Performance analysis in terms of wave attenuation and net profile change**
  - **Comparisons between placement depths and shapes**
  - **Longevity of nourishment's benefits**

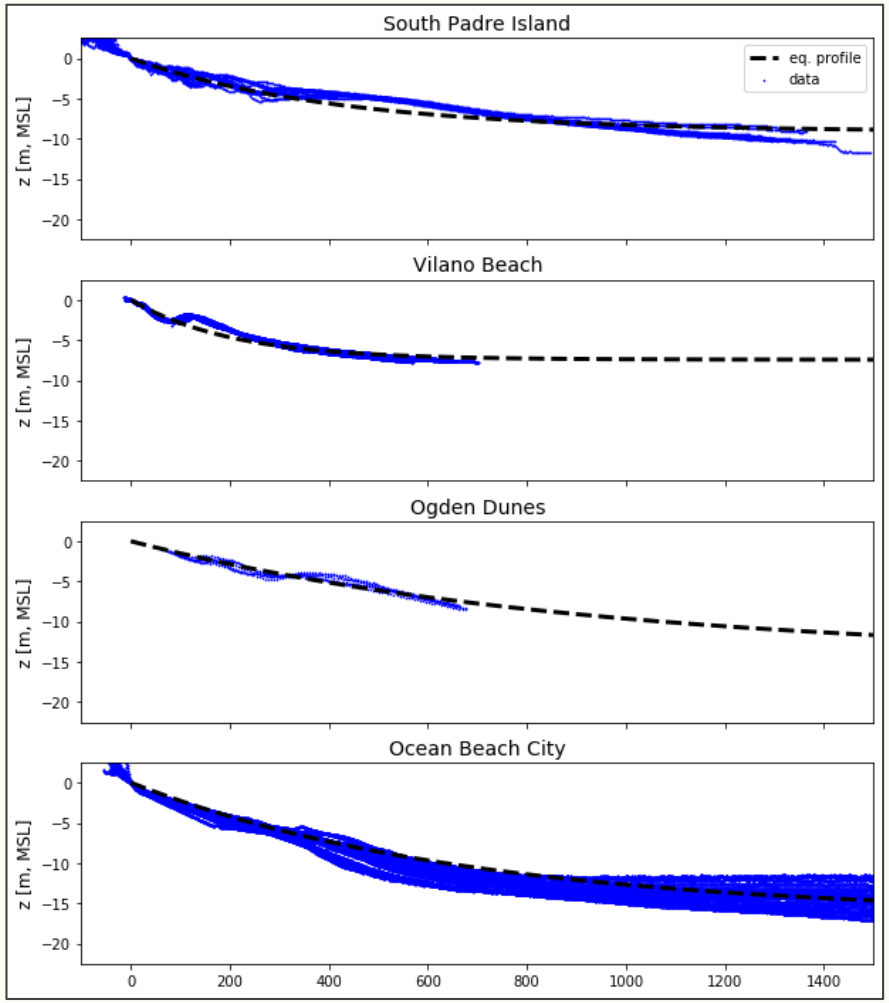
Ft. Myers Beach, FL data



Case studies

Name	Year	Volume [m^3]	Depth [m]	Shape
Ogden Dunes, IN	2016	1.07e+05	5.5	Mounds
Vilano Beach, FL	2015	1.15e+05	3	Linear
Ocean Beach City, CA	2005	2.3e+05	10	Mounds
South Padre Island, TX	2014	2.33e+05		

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



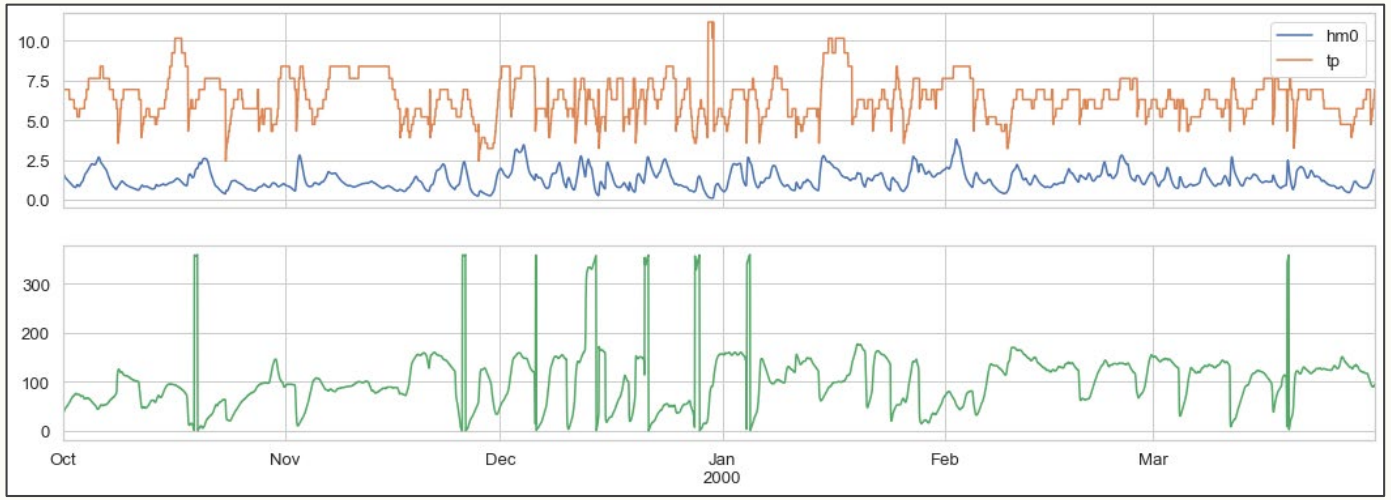
Markov chain model

$$S^{ijk} = (H_s^i, T_p^j, \theta^k)$$

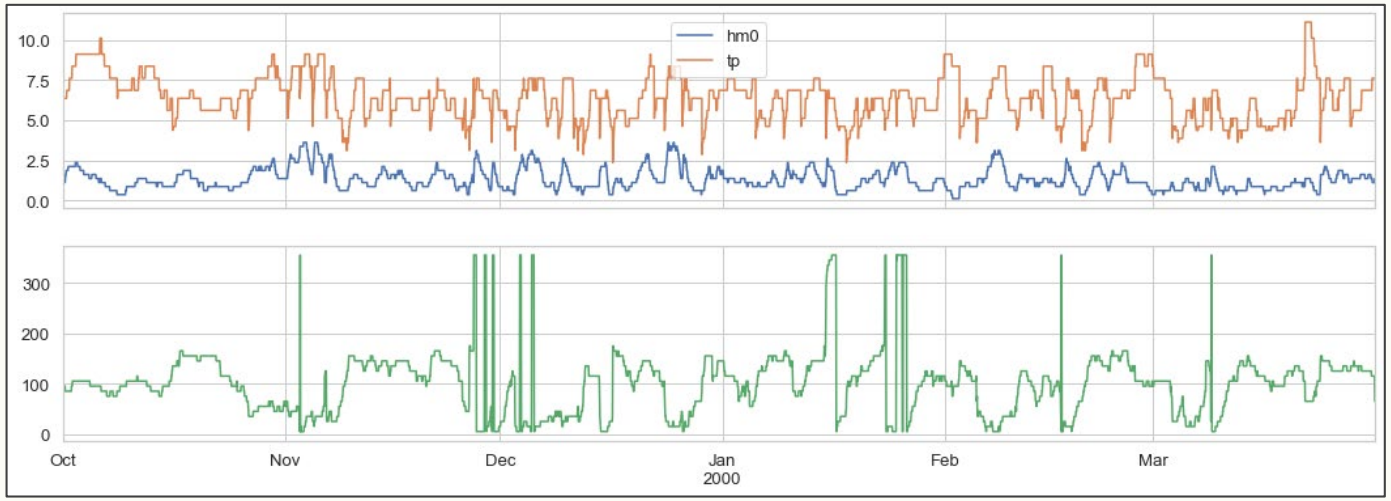
$$P\left(S_{t+1} = S^{i'j'k'} \mid S_t = S^{ijk}\right) = p_{ii'jj'kk'}$$

$$p_{ii'jj'kk'} = \frac{N_{ii'jj'kk'}}{N_{ijk}}$$

WIS data

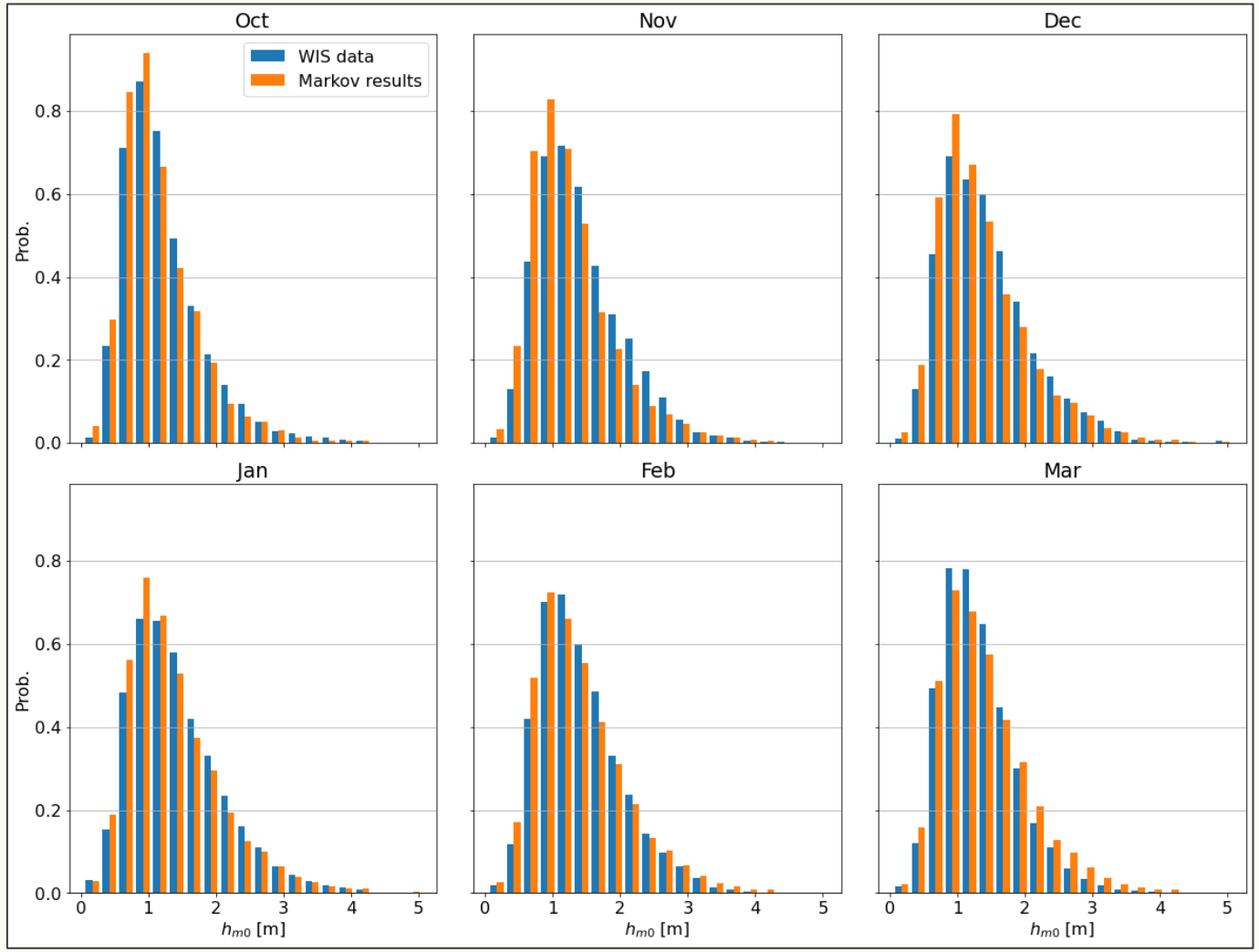


Synthetic time series

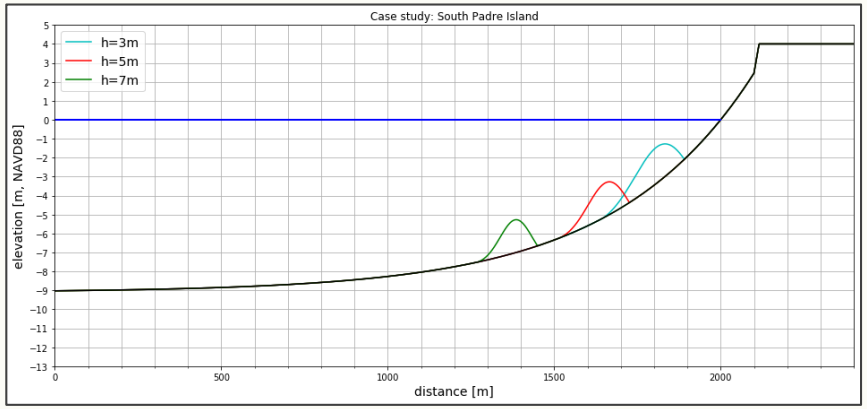


Markov chain model

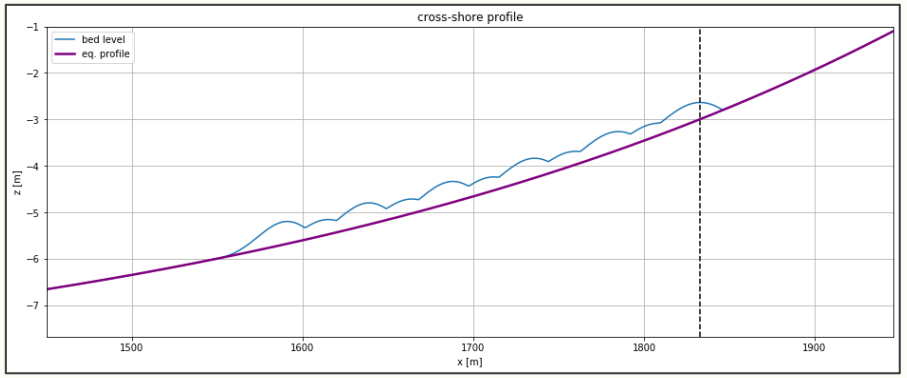
month	WIS H_{m0}	Markov H_{m0}	H_{m0} Percent Error	WIS T_p	Markov T_p	T_p Percent error
Oct	1.18	1.09	-7.0	6.32	6.13	-3.1
Nov	1.37	1.20	-12.1	6.51	6.32	-3.0
Dec	1.40	1.30	-6.8	6.38	6.37	-0.2
Jan	1.38	1.32	-4.0	6.36	6.35	-0.2
Feb	1.36	1.35	-1.0	6.38	6.37	-0.2
Mar	1.27	1.34	5.5	6.32	6.35	0.5



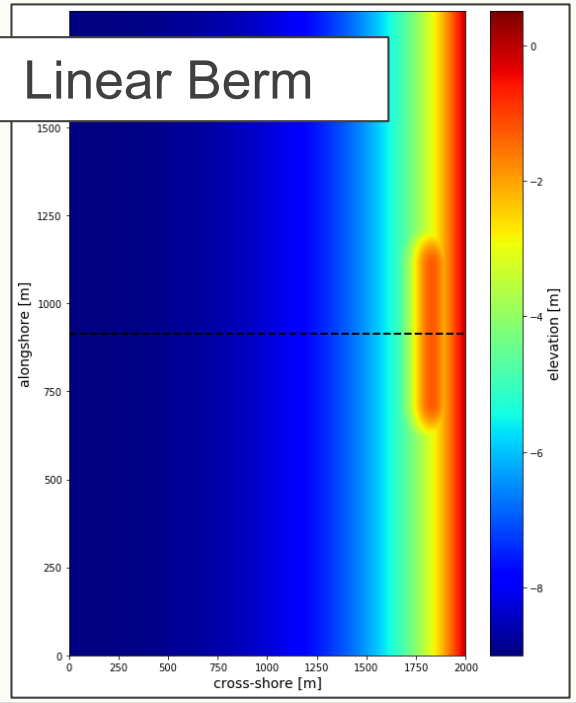
Nearshore berm shapes and depths



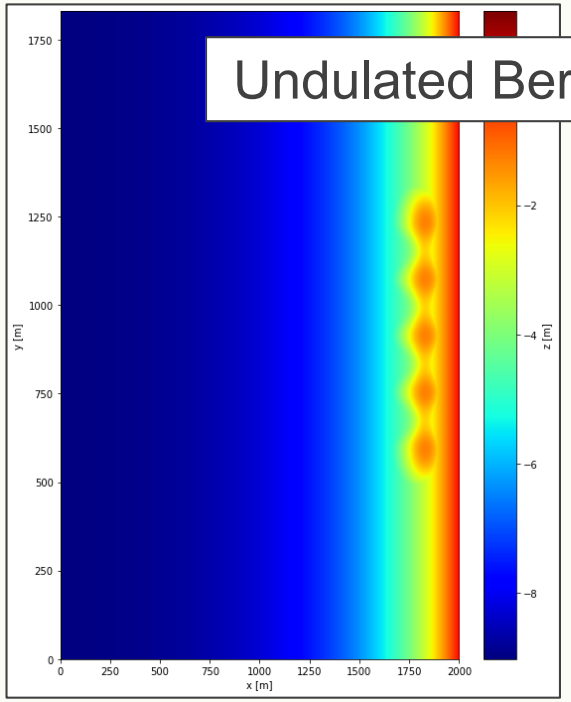
Discrete Mounds

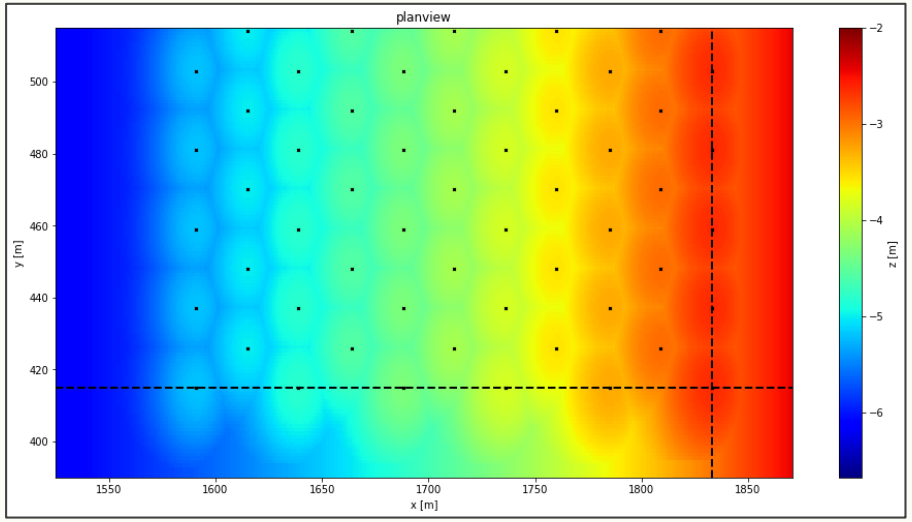


Linear Berm



Undulated Berm





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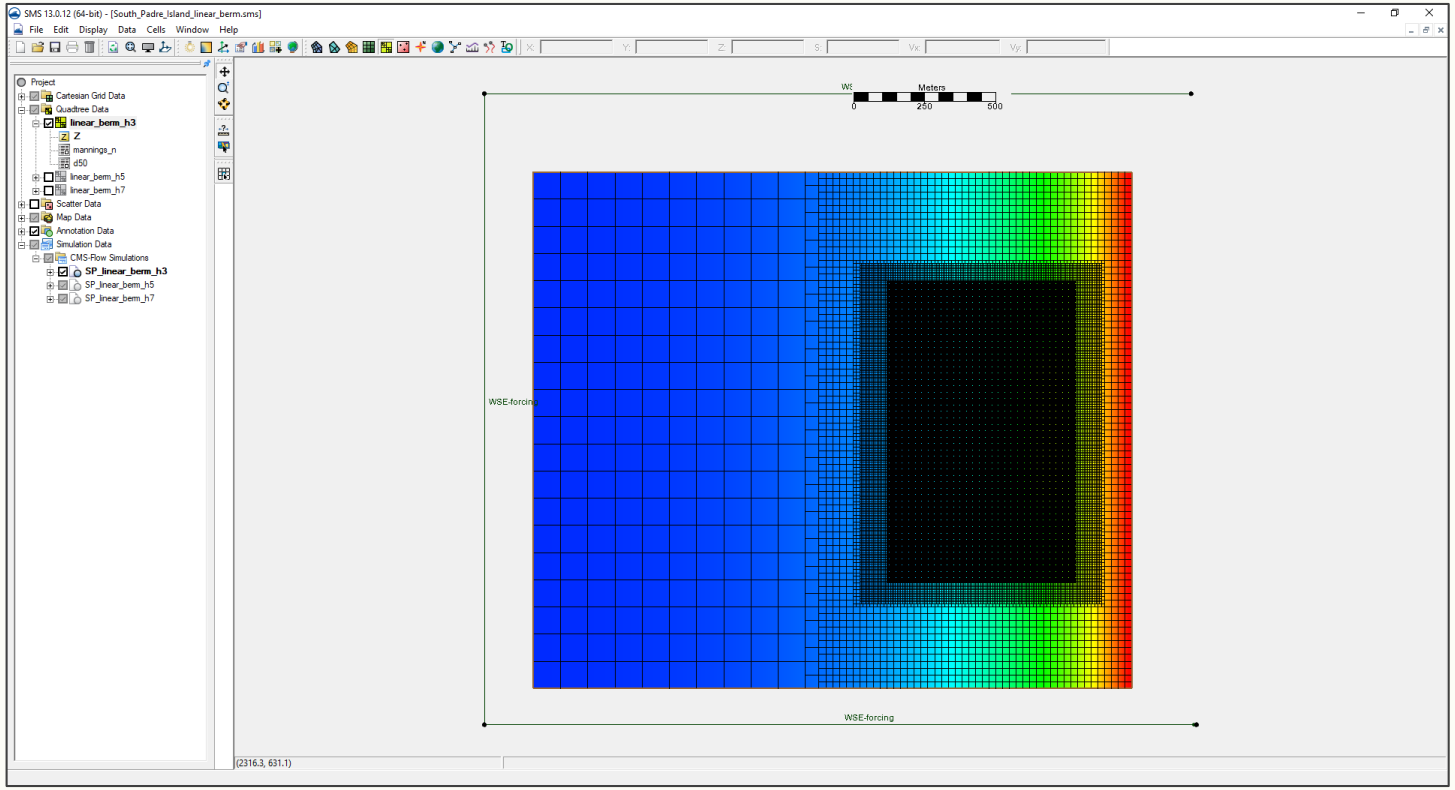
Cases

Coastal Modeling System (CMS)

4 profiles x 3 depths x 3 berms
+ 4 base cases = 40 cases

Shape	Depth [m]	South Padre Island	Ogden Dunes	Ocean Beach City	Vilano Beach
No berm	N/A	X	X		
Linear berm	3	X	X		
	5	X			
	7	X			
Undulated berm	3	X			
	5	X			
	7	X			
Discrete mounds	3	X			
	5	X			
	7	X			



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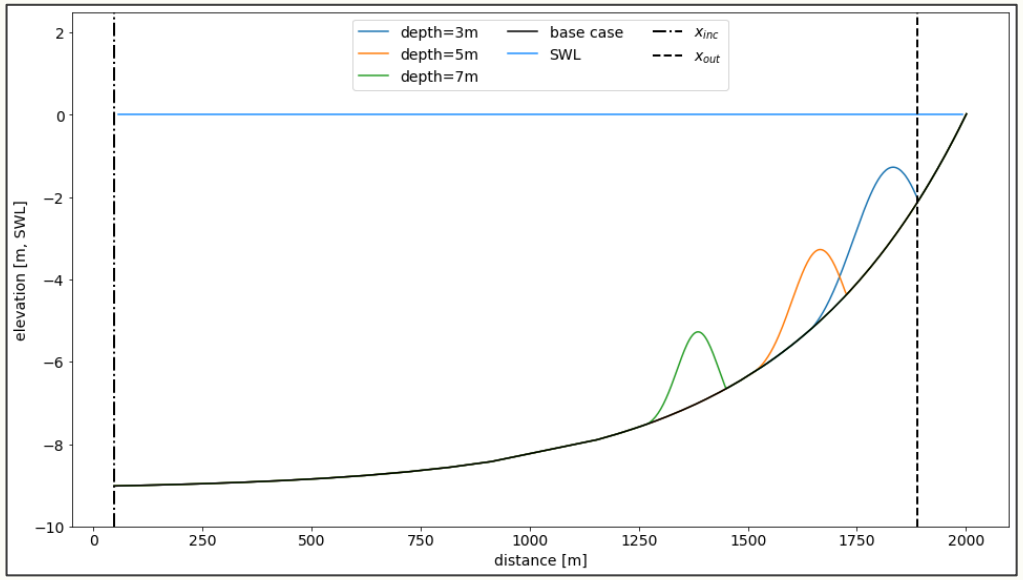
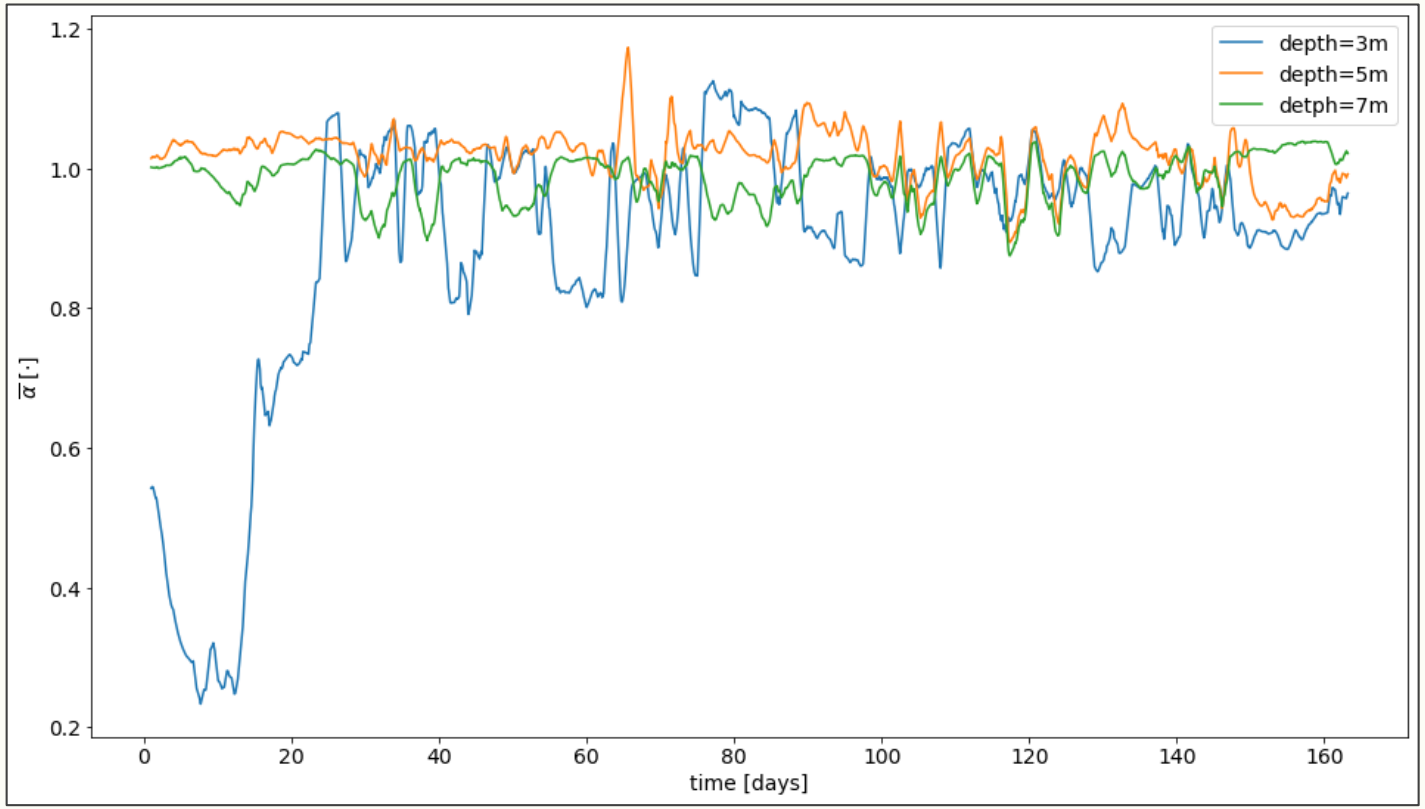
Results

$$\alpha = \frac{H_{out}}{H_{inc}} \qquad \bar{\alpha} = \frac{\alpha}{\alpha_{base}}$$





Summary

FY20 Major Advances in Capability

- Methodologies developed for generating representative synthetic wave forcing and depth profiles that include placements
- CMS simulations for a test matrix of placements to quantitatively estimate design impact (in progress)

FY20 Major Products & Collaborations

- Upcoming CIRP TD (09/29)
- Generalized codes for synthetic wave forcing and depth profiles with nearshore placements

FY21 Products/Advances

- Journal Article analyzing relative impacts of different placement designs from the idealized simulation test matrix
- Profile modeling of nearshore placements adjacent to beach nourishments and estimates of lifespan increases