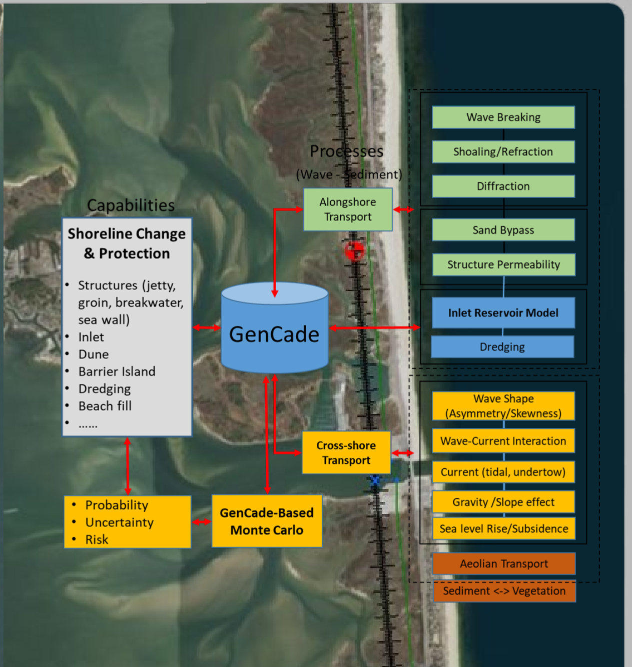
U.S.ARMY

GENCADE PREDICTION CAPABILITY AND UNCERTAINTY ESTIMATION OF LONG-TERM SHORELINE EVOLUTION



INLET ENGINEERING TOOLBOX

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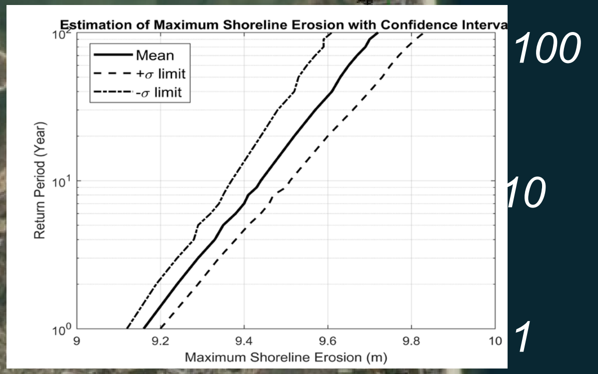

COASTAL INLETS RESEARCH PROGRAM

FY20 IN PROGRESS REVIEW

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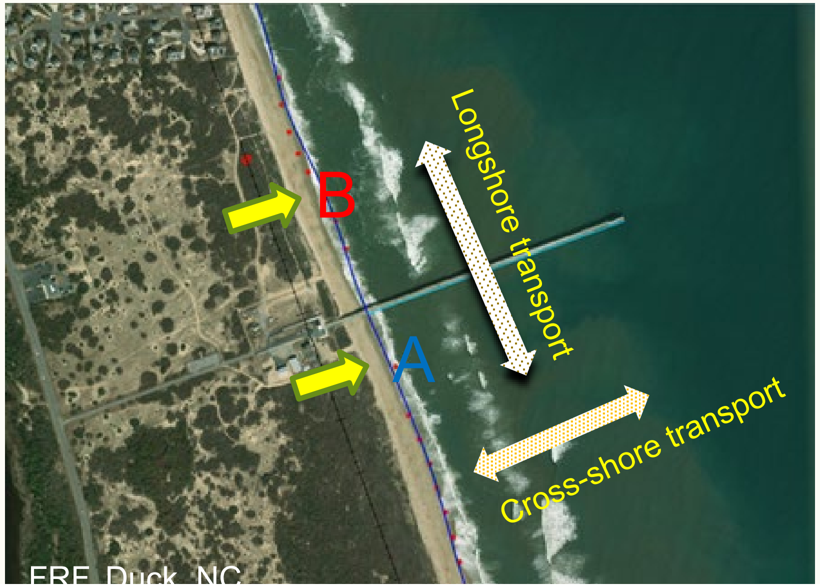
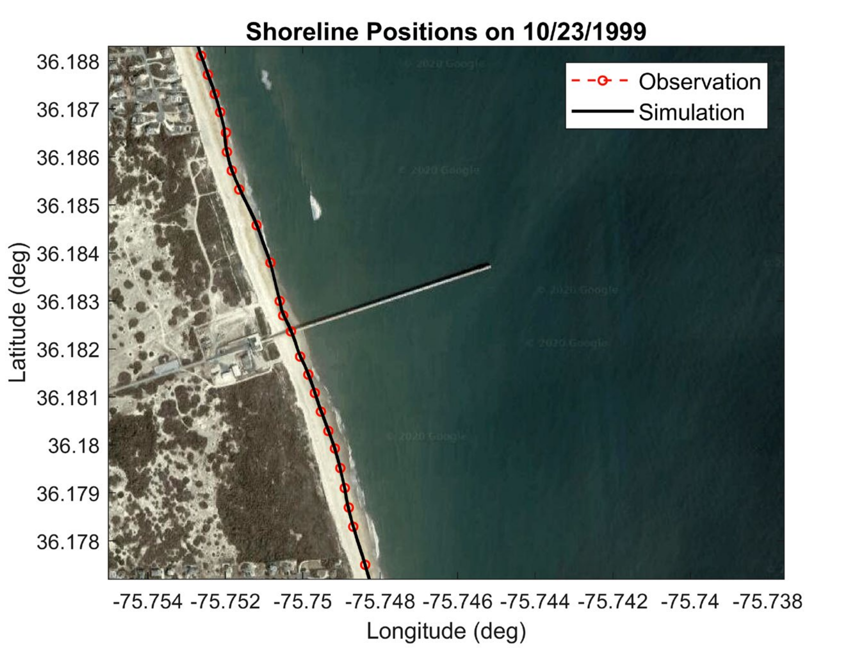
ERDC ENGINEER RESEARCH & DEVELOPMENT CENTER

Problem Statement

- **Quantifying erosion risk and uncertainty in simulating long-term shoreline changes is an important task in risk-based coastal management practice.**
- **Uncertainty and randomness exist physical processes: wave, wind, tide, storm, current, sea level change, subsidence, sediment properties and transport, etc.**
- **Uncertainties due to human errors also exist in protection practices such as volumes, locations, and schedules of sand nourishment, beach fills, and bypass.**
- **System errors (numerical models generated) can change from coast to coast.**





Strategic R&D: Innovation in Sediment Management (Shoreline Erosion)

SoN-2018-FRM-1333 (Understanding and Characterizing Uncertainty in Geotechnical Simulation Models to Support Risk-Informed Decision Making)
SoN-NFE-1538 (Nearshore Processes Research and Development),

Capability and Strategic Impact Statement

- Quantify model errors by long-term simulation.
- Provide probabilistic shoreline changes solutions driven by physical processes (wave, currents, sediment transport)
- Estimate uncertainty and risk in shoreline changes (sediment transport) by waves and human errors (beach fills) using maximum likelihood analysis
- Has a potential to provide risk-based erosion prediction for planning and management.

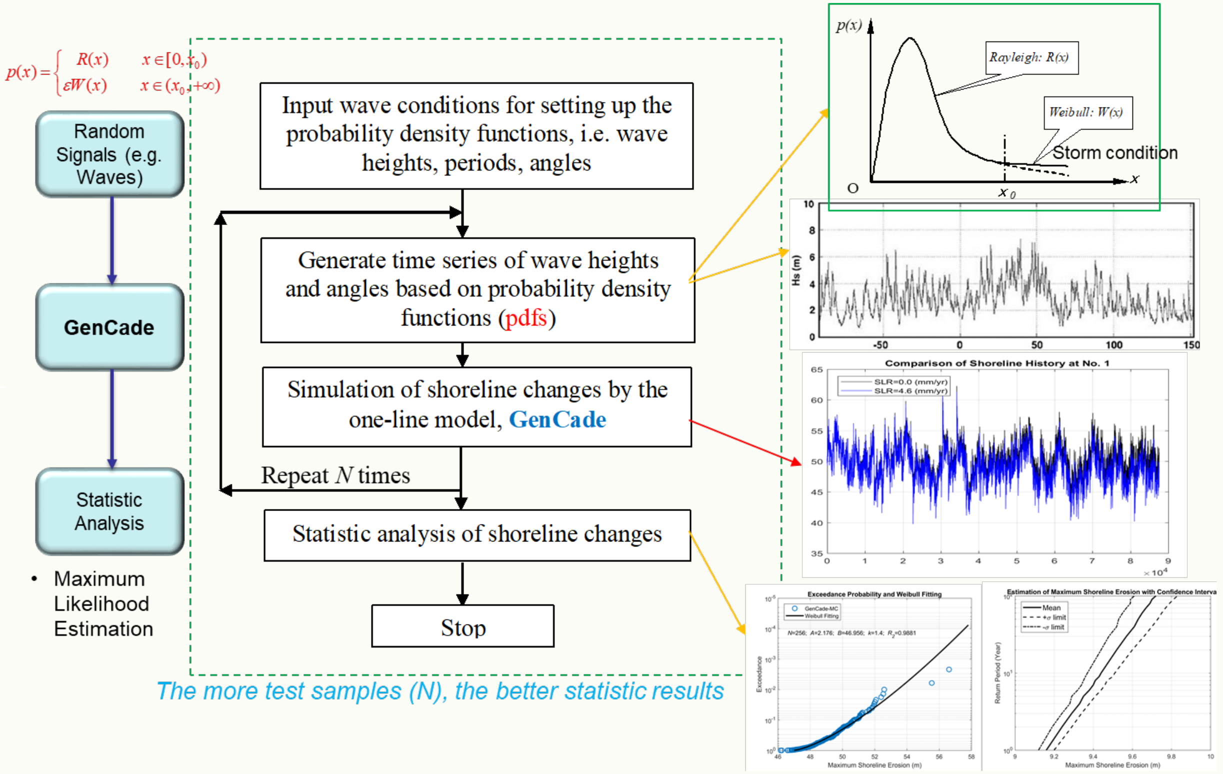
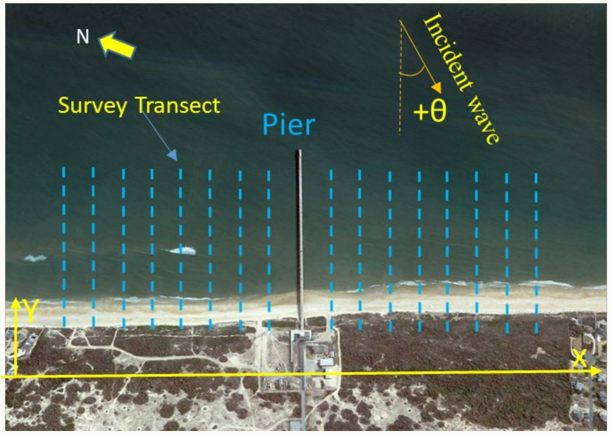
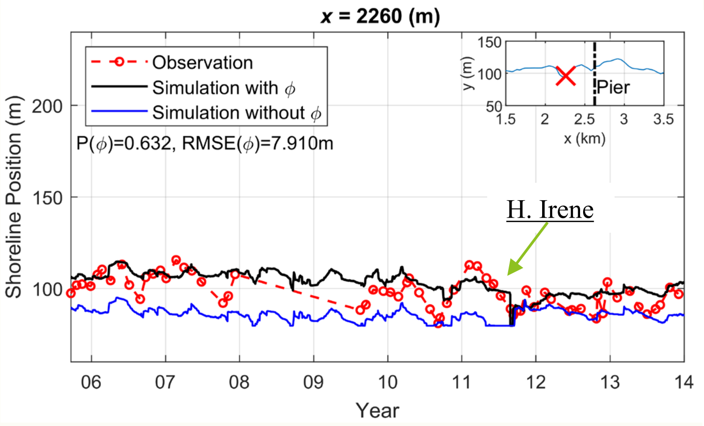


Fig. GenCade-Based Monte Carlo Simulation

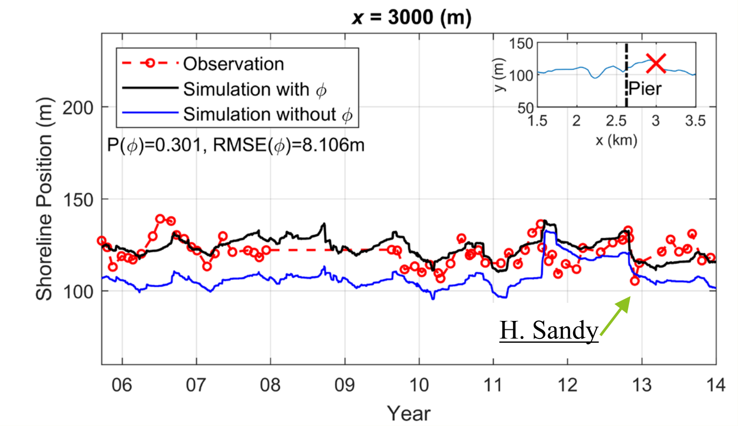
Case 1: Shoreline Evolution Simulation at Duck, NC: System Error by Model Validation



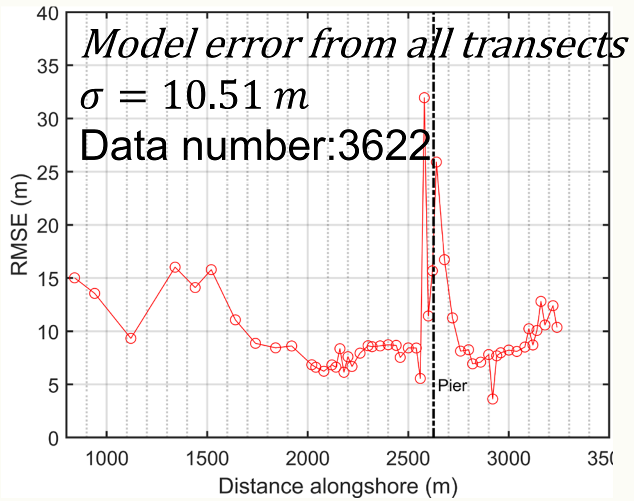
(a) Study site at FRF, Duck, NC

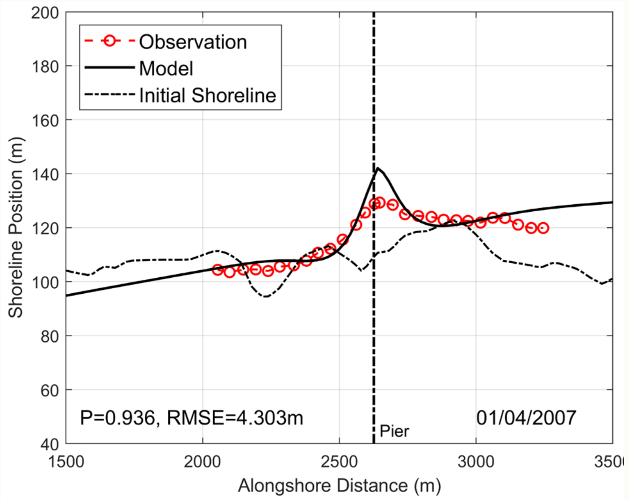


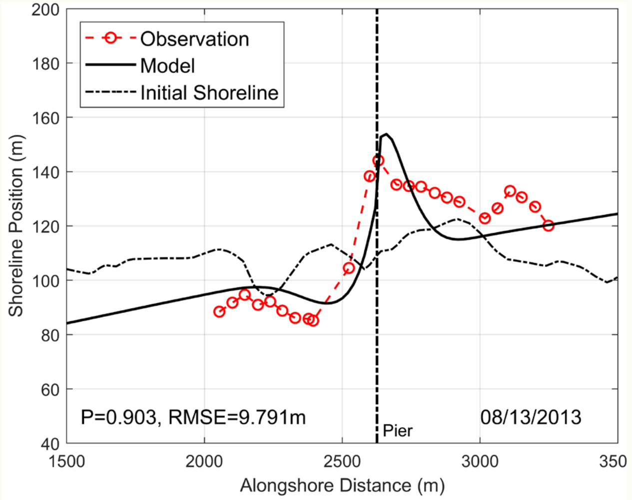
(a) Shoreline Evolution (north shore)



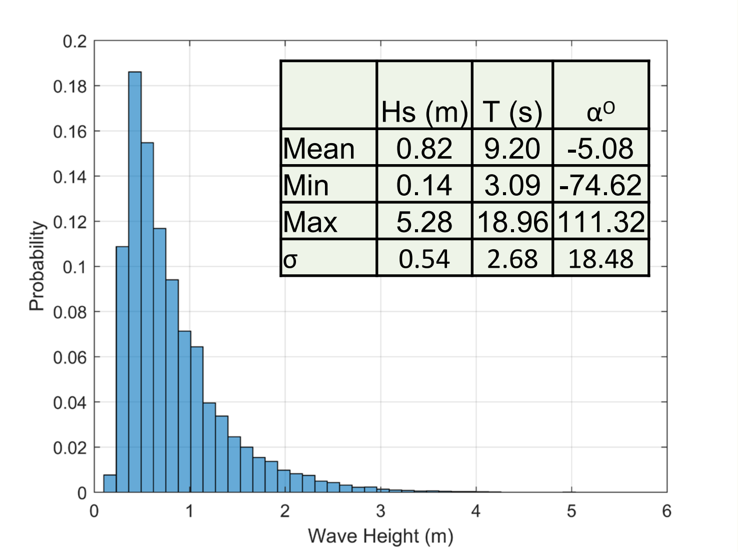
(b) South shore



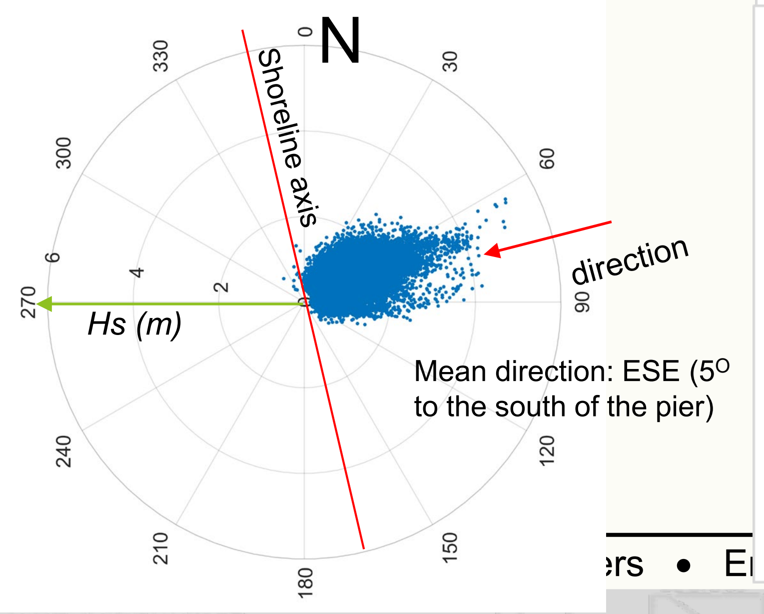


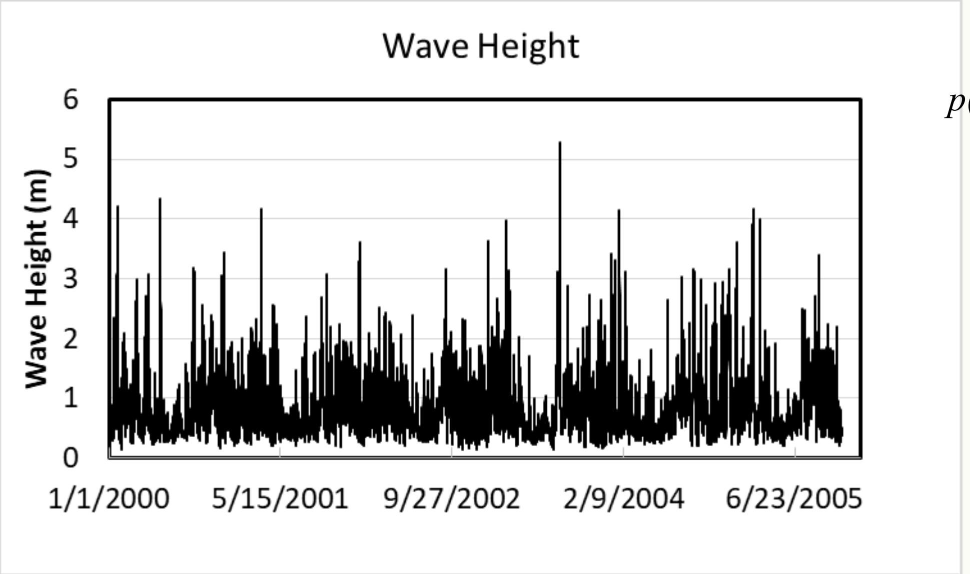


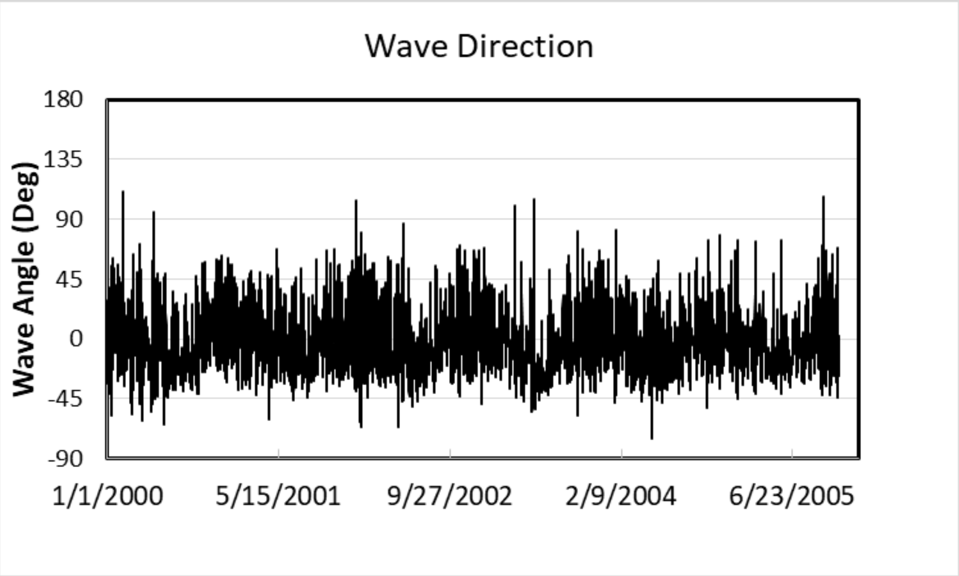
Creating Waves using PDF: Spectrum Approach



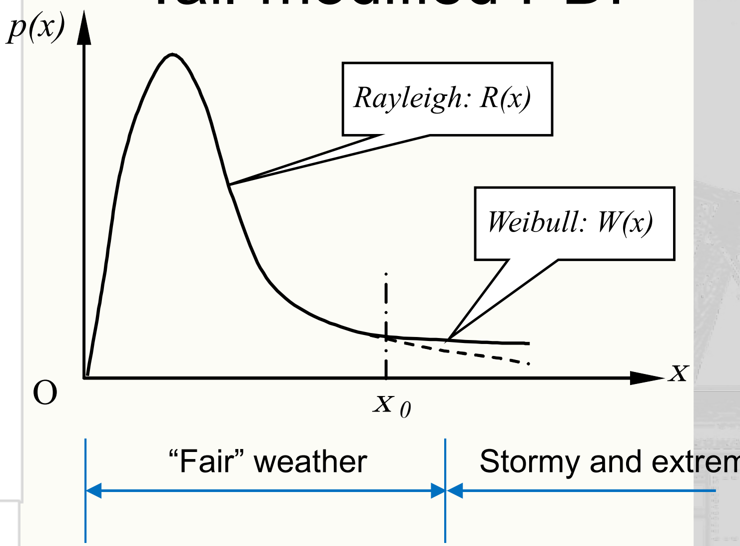
	Hs (m)	T (s)	α°
Mean	0.82	9.20	-5.08
Min	0.14	3.09	-74.62
Max	5.28	18.96	111.32
σ	0.54	2.68	18.48



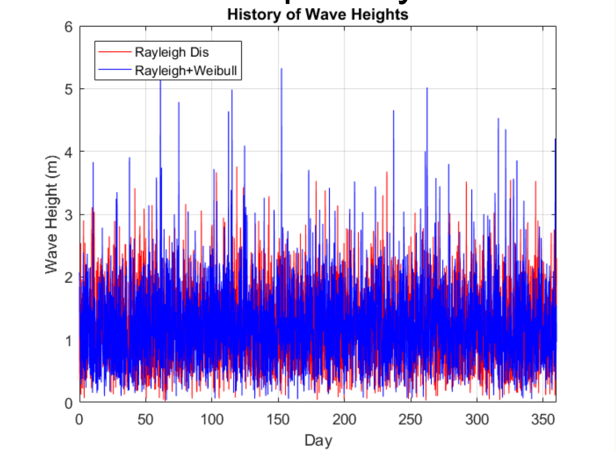




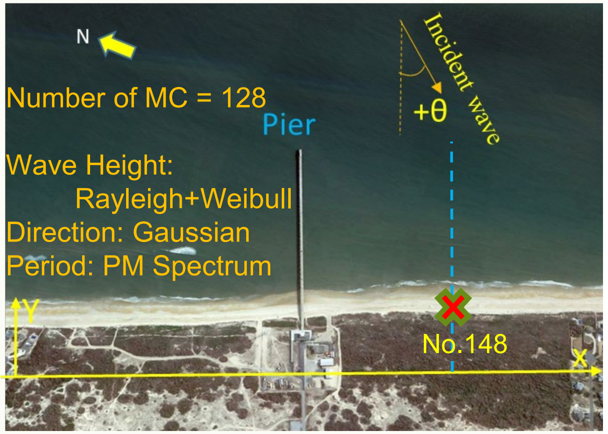
Tail-modified PDF



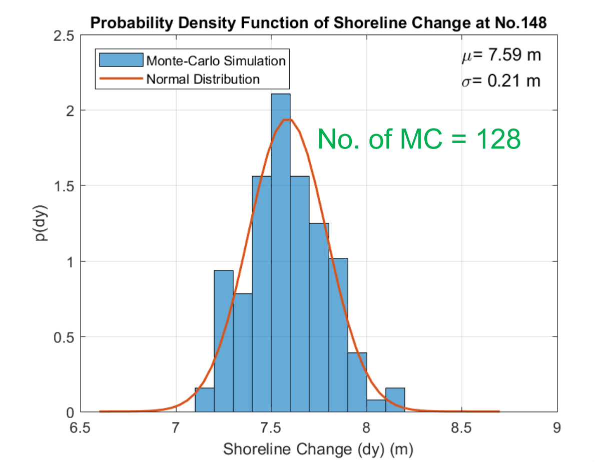
Wave samples by PDF



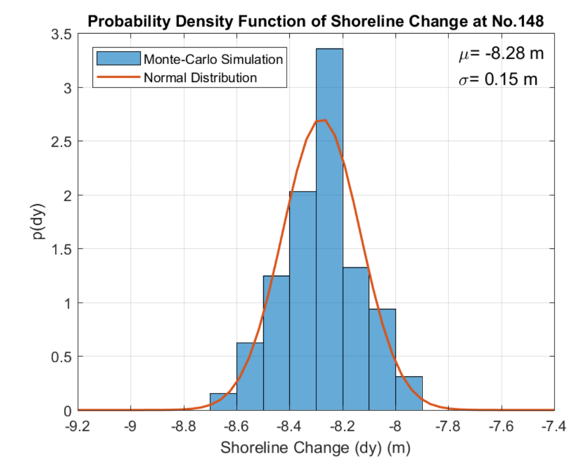
Monte-Carlo Simulation and Uncertainty of Shoreline Changes in Duck, NC



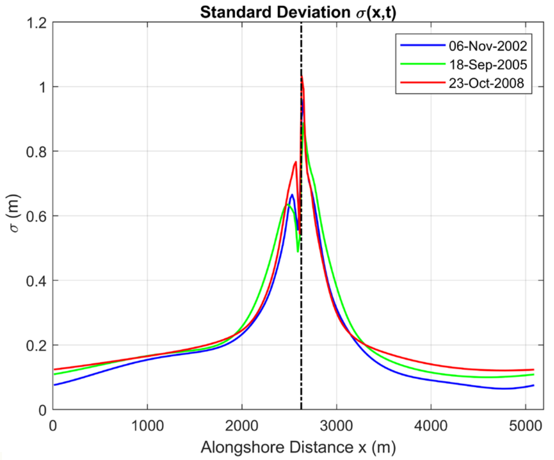
(a) Study site at FRF, Duck, NC



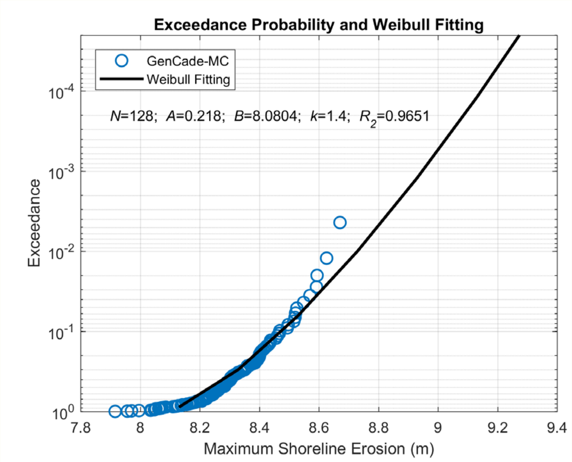
(b) Probability of seawardmost change



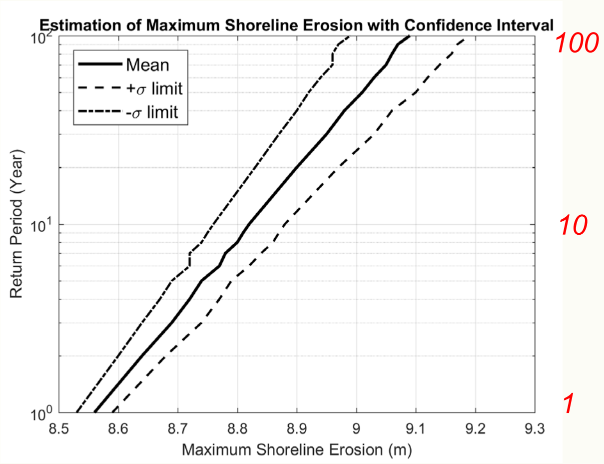
(c) Probability of landwardmost change



(d) Standard deviation alongshore



(e) Exceedance of max. erosion at No.148



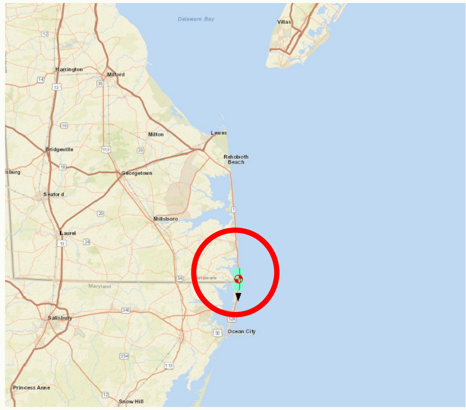
(f) Max. erosion at No. 148 in return period

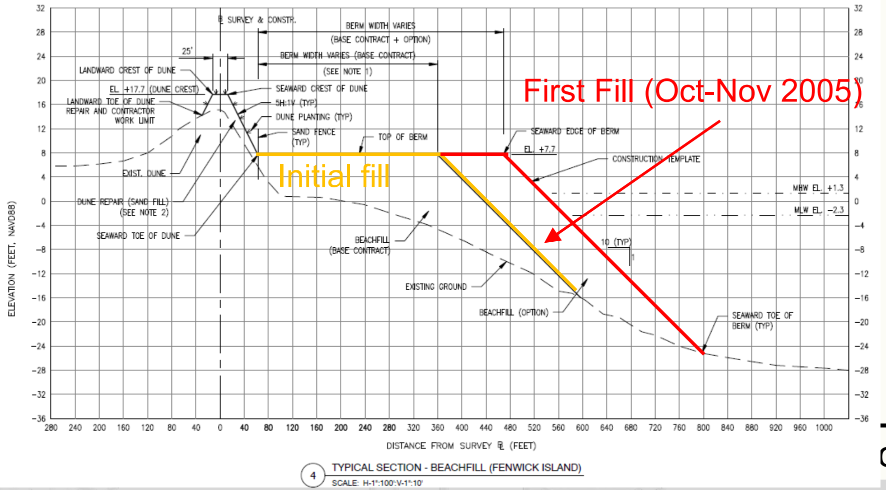
(g) Max. change range on Google Map

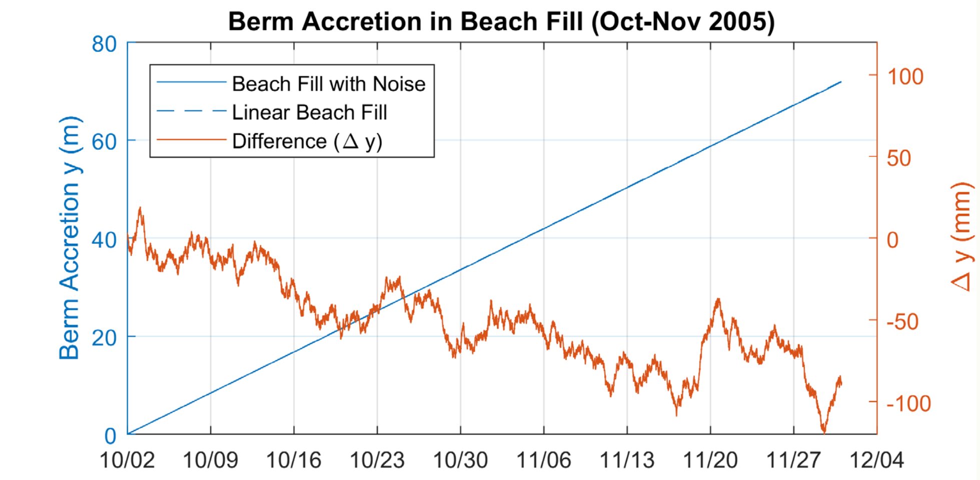
Case 2: Assessment of Uncertainty due to Beach Fill ($\Delta y(t)$)

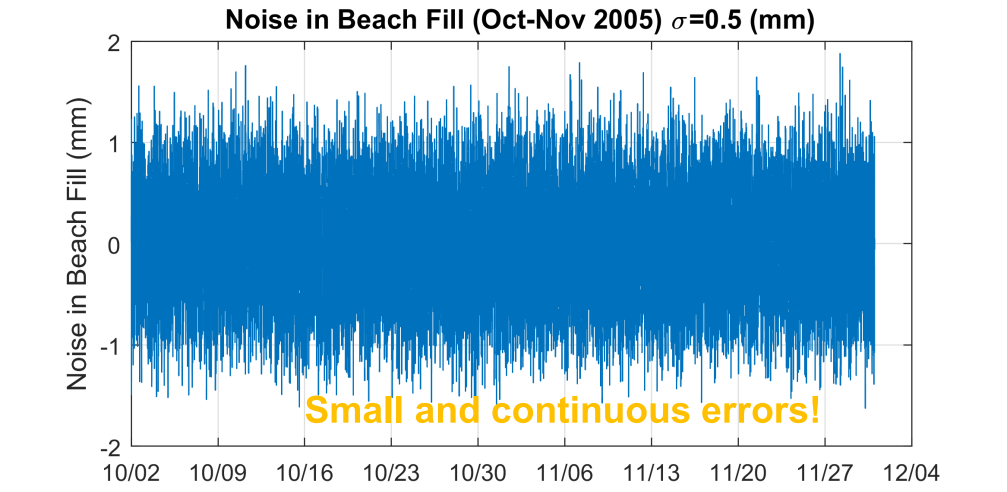
Beach fill (Δy) = Planned Beach Fill ($\overline{\Delta y}(t)$)+ White Noise

$$\Delta y(t) = \overline{\Delta y}(t) \ + N(0, \sigma^2)$$



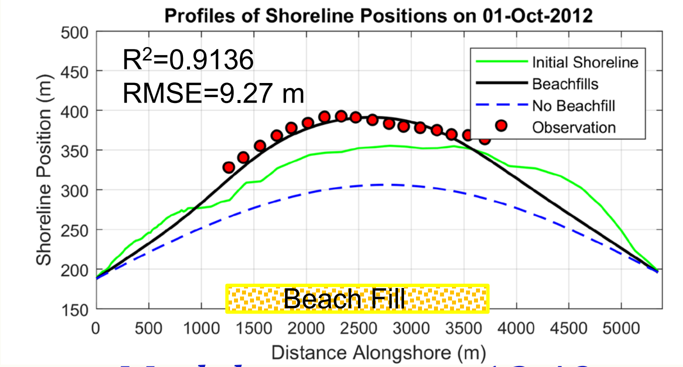






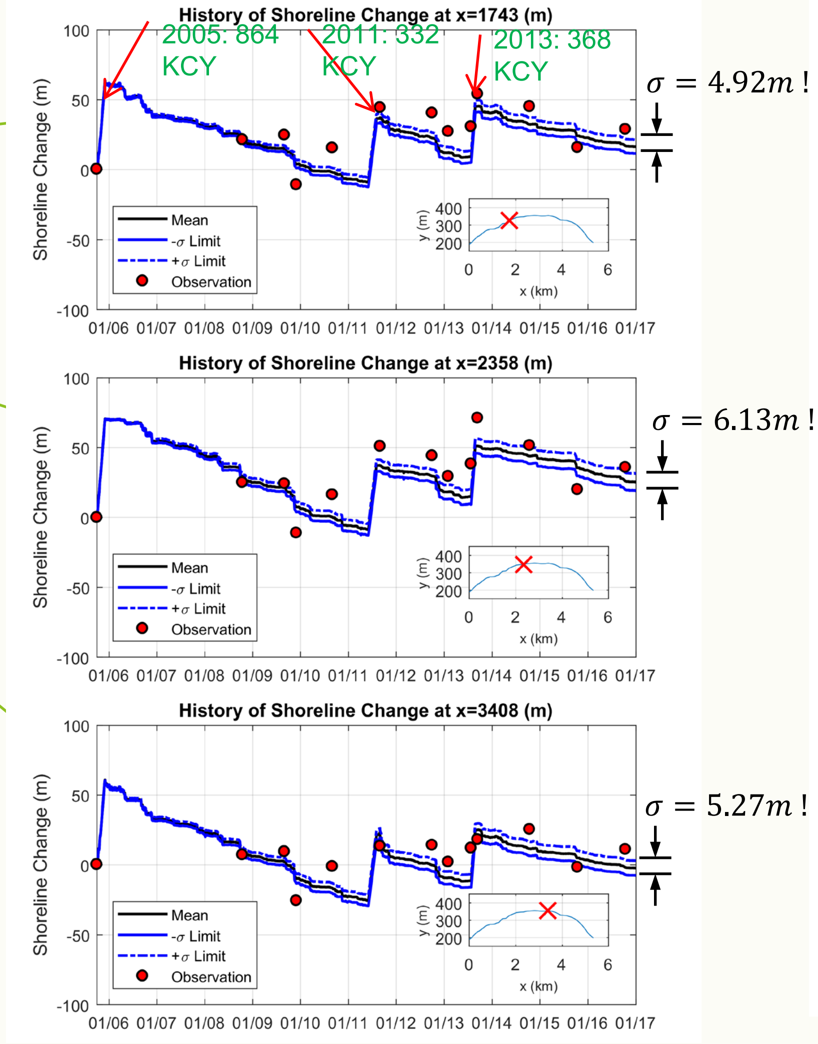
Shoreline Changes with Uncertainty in Beach Fill

- 12-year Shoreline Changes (2005-2017)
- Periodical beach fills : 2005, 2011, & 2013
- MC runs = 128

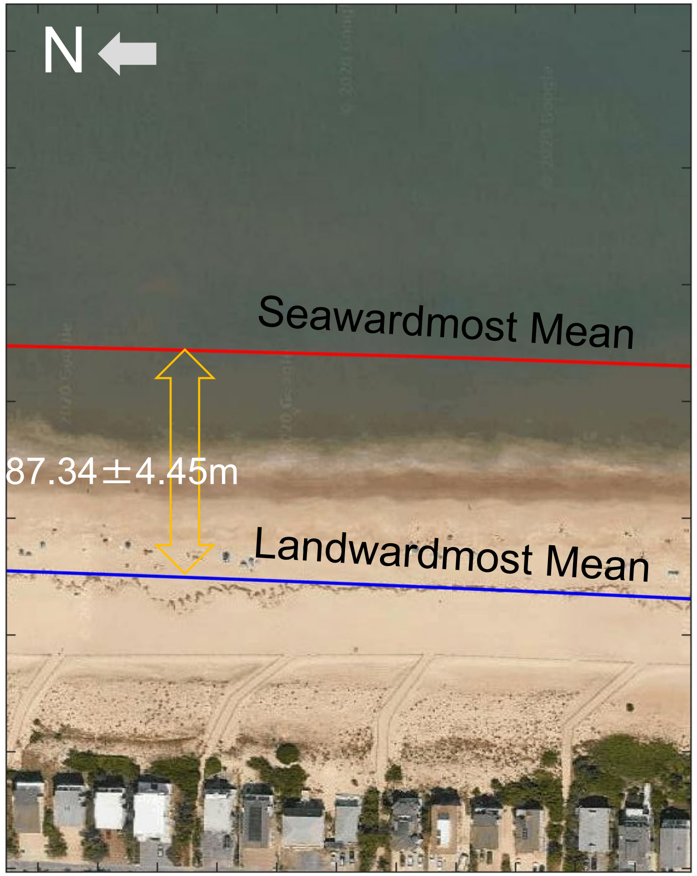


Model error: $\sigma = 12.49m$ (216 data)

(a) Shoreline change with errors

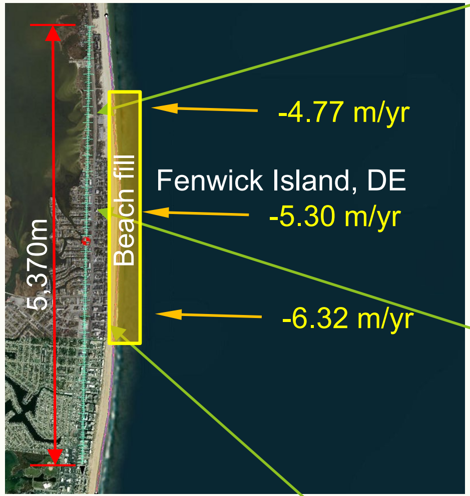


(b) Max. change range on Google Map



Uncertainty-Based Assessment of Beachfill Effect

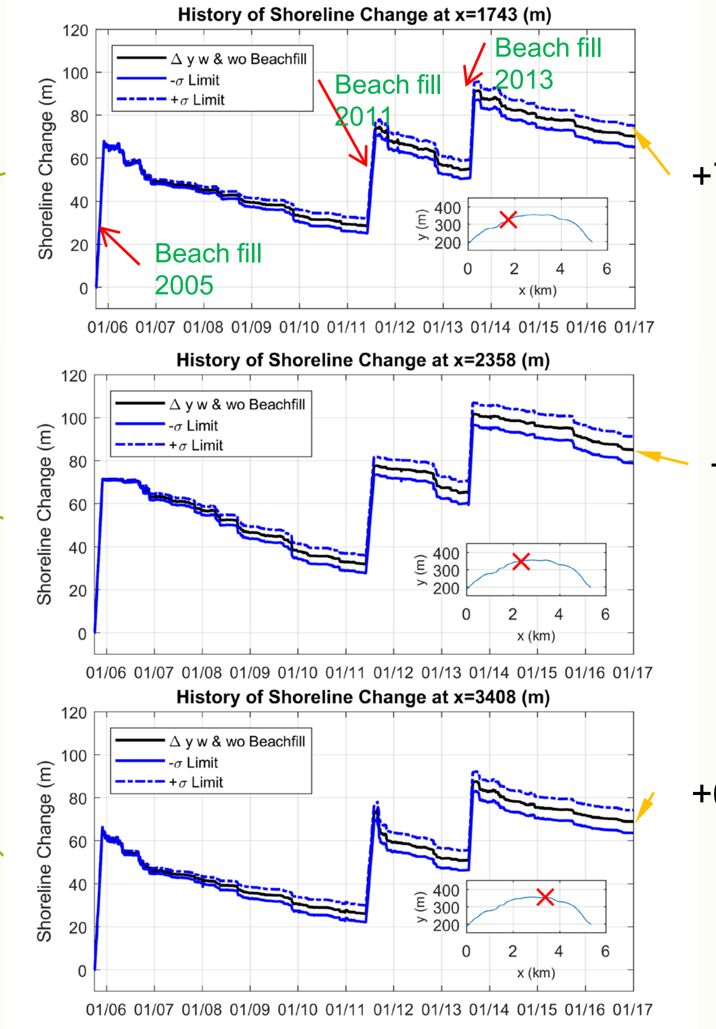
- 12-year Shoreline Changes (2005-2017)
- Periodical beach fills : 2005, 2011, & 2013



- Shoreline retreat rate without beachfill:

  4.77~6.32 m/yr or

  15.65~20.73 ft/yr

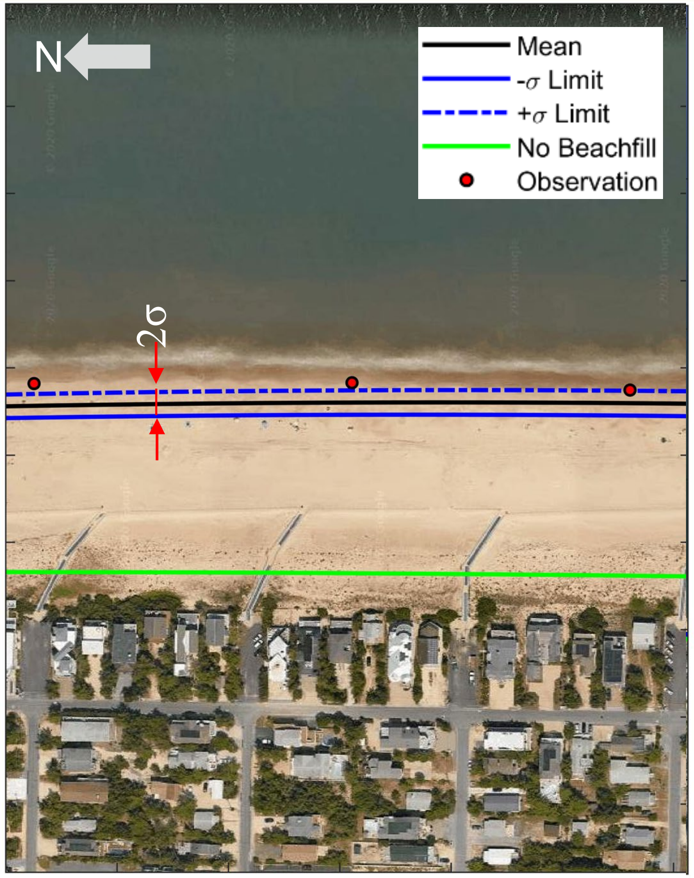


After 11 years Shoreline advanced by beachfill:

+70.21±4.92m

+85.06±6.13m

+68.90±5.27m



Summary

FY20 Major Advances in Capability

- Update GenCade-MC using the release version of GenCade (validated in long-term simulations)
- Develop user interface based on SMS (ongoing)
- Develop capability to assess parameter uncertainty (e.g. beach fills)
- Test the code in HPC (GenCade-MC is time-consuming if the number of samples becomes large)

FY20 Major Products & Collaborations

- JA (1), under revision
- TR (1), CHETN (1), CP (1)
- 1 Webinar (LRD)
- 1 CIRP TD
- Conference Presentation (ASBPA 2019)
- Collaboration with RSM-SBAS project, USACE-NAN (Long Island), Texas A&M (Mega beach nourishment in the Netherlands)

FY21 Products/Advances

- Complete dynamic user interface (SMS)
- Technical Transfer (webinar, TD, etc.)
- Publish results (TR, JA, CP)
- Develop non-stationary wave PDFs to represent seasonal variations of waves
- Study the uncertainty of sediment volume changes in long-term shoreline evolution
- Probabilistic Description of Multi-Variates (Joint Probability) in shoreline model
- Data collection and analysis