

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

INLET ENGINEERING TOOLBOX

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CIRP

esearch & Developmer

COASTAL & HYDRAULICS LABORATORY

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COASTAL INLETS RESEARCH PROGRAM

FY20 IN PROGRESS REVIEW

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Shoaling/Refra Sand Bypa Shoreline Change & Protection tructure Perr Structures (jetty groin, breakwat sea wall) GenCade Barrier Island Dredging GenCade-Based Uncertainty Monte Carlo 100 Mean $- - - +\sigma$ limit ---- -σ limi 10 9.4 Maximum Shoreline Frosion (m

Wave Breaking





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Problem Statement

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





Longitude (deg)

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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.

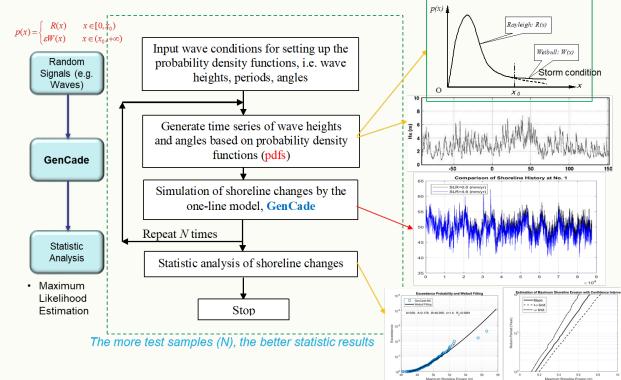
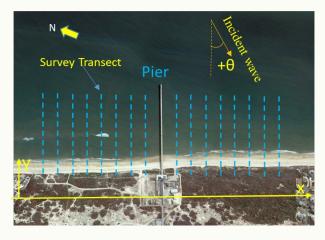


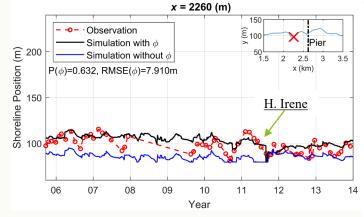
Fig. GenCade-Based Monte Carlo Simulation

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

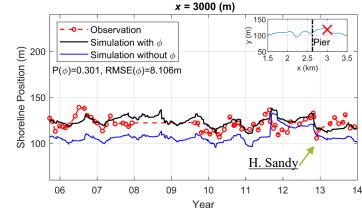


(a) Study site at FRF, Duck, NC

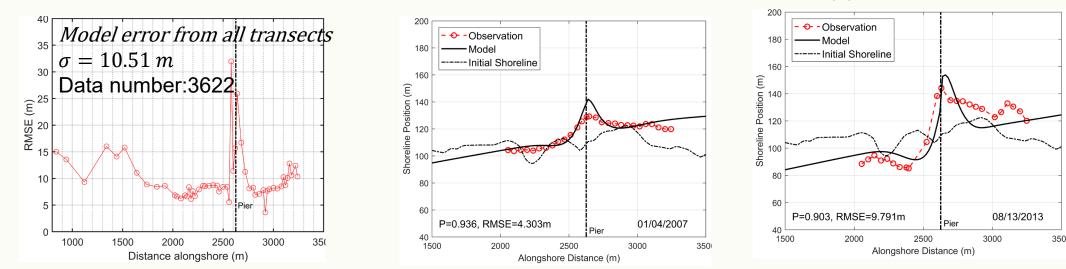


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(a) Shoreline Evolution (north shore)

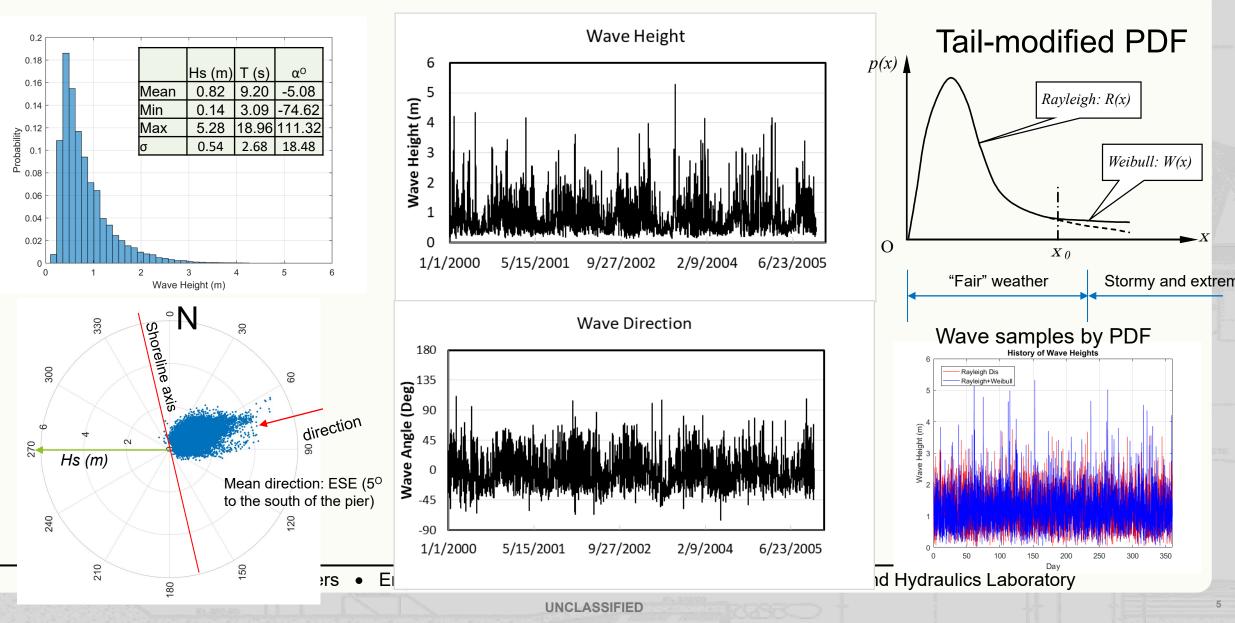


(b) South shore



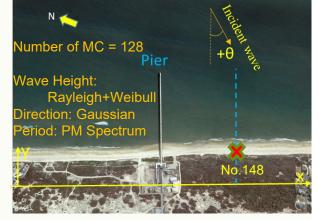
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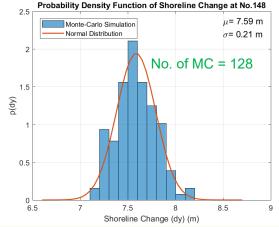
Creating Waves using PDF: Spectrum Approach



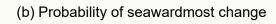
Monte-Carlo Simulation and Uncertainty of Shoreline Changes in Duck, NC

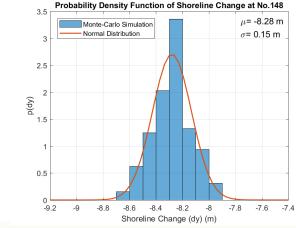
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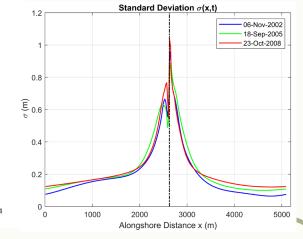




(a) Study site at FRF, Duck, NC

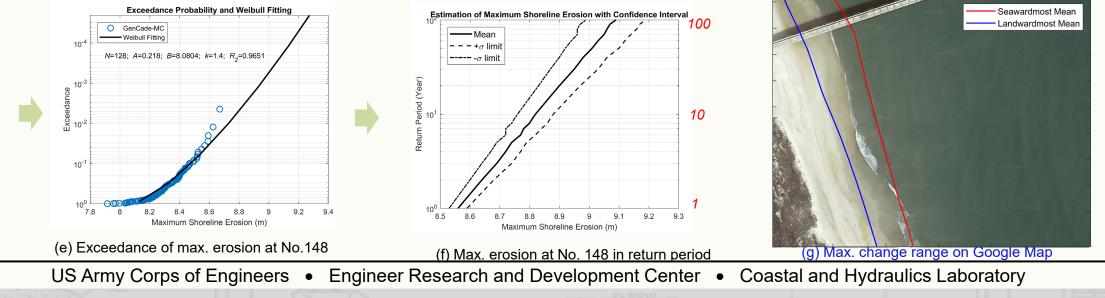






(c) Probability of landwardmost change

(d) Standard deviation alonghshore



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

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

 $\Delta y(t) = \overline{\Delta y}(t) + N(0, \sigma^2)$ 370m Fenwick Island, DE RERM WIDTH VARIES (BASE CONTRACT + OPTION WIDTH VARIES (BASE CONTRACT) LANDWARD CREST OF DUNE (SEE NOTE 1 (Oct-Nov 200) First Fill 5H-19 (TYP)

BEACHFI

EXISTING GROUND

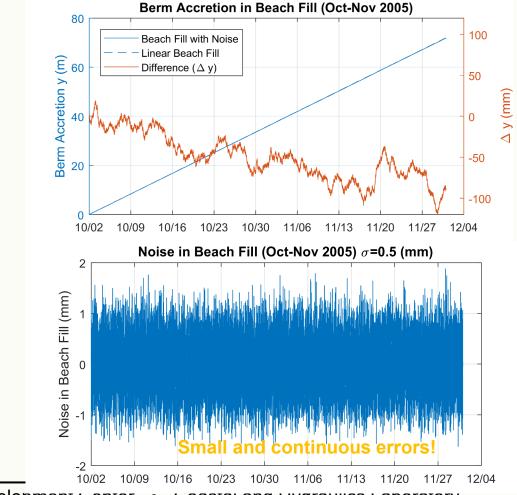
DISTANCE FROM SURVEY & (FEET

4 TYPICAL SECTION - BEACHFILL (FENWICK ISLAND

BEACHFILL (OPTION)

SEAWARD TOE OF

(SEE NOTE 2) SEAWARD TOE OF DUNE



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Shoreline Changes with Uncertainty in Beach Fill

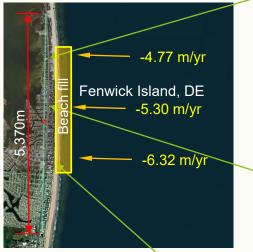
(a) Shoreline change with errors • 12-year Shoreline Changes (2005-2017) • Periodical beach fills : 2005, 2011, & 2013 History of Shoreline Change at x=1743 (m) 100 N 🖛 • MC runs = 128 2013: 368 KCY $\sigma = 4.92m!$ Change (m) Ð Shorelir € 400 € 300 Fenwick Island, DE -50 σ Limit Observation 370m Seawardmost Mean 01/06 01/07 01/08 01/09 01/10 01/11 01/12 01/13 01/14 01/15 01/16 01/17 History of Shoreline Change at x=2358 (m) 100 $\sigma = 6.13m!$ Shoreline Change (m) 87.34±4.<mark>45</mark>m Landwardmost Mean € 400 € 300 -50 Limit Profiles of Shoreline Positions on 01-Oct-2012 $+\sigma$ Limit 500 Observation R²=0.9136 E 450 -100 RMSE=9.27 m Beachfills 01/06 01/07 01/08 01/09 01/10 01/11 01/12 01/13 01/14 01/15 01/16 01/17 400 (400 (No Beachfil History of Shoreline Change at x=3408 (m) Observation 100 eline 300 Change (m) $\sigma = 5.27m!$ Shore 200 Beach Fill Shoreline 150 400 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 0 E 300 Distance Alongshore (m) $+ \sigma \mid imit$ Model error: $\sigma = 12.49m$ Observation x (km) -100(216 data) 01/06 01/07 01/08 01/09 01/10 01/11 01/12 01/13 01/14 01/15 01/16 01/17

(b) Max. change range on Google Map

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Uncertainty-Based Assessment of Beachfill Effect

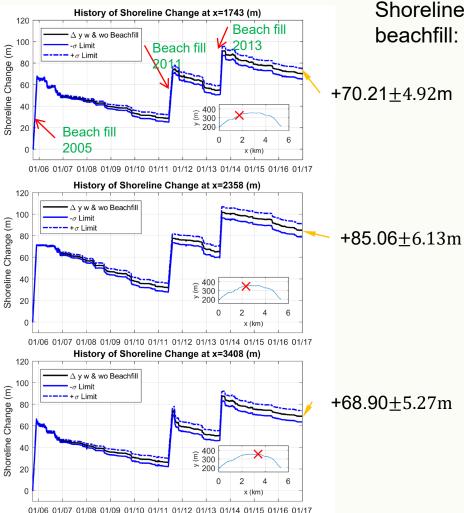
- 12-year Shoreline Changes (2005-2017)
- Periodical beach fills : 2005, 2011, & 2013



 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:



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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 timeconsuming 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)

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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