INTEGRATED SUBAERIAL-SUBAQUEOUS COASTAL MORPHOLOGY MODELING
TOOLS FOR SIMULATING AEOLIAN TRANSPORT NEAR INLETS

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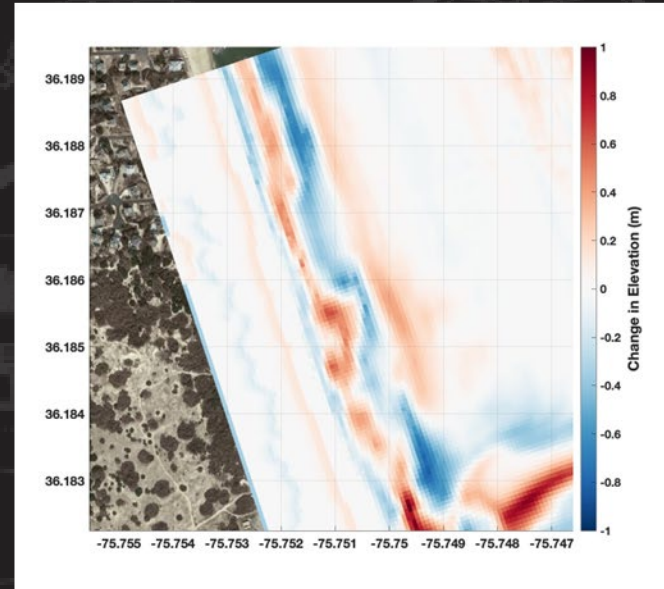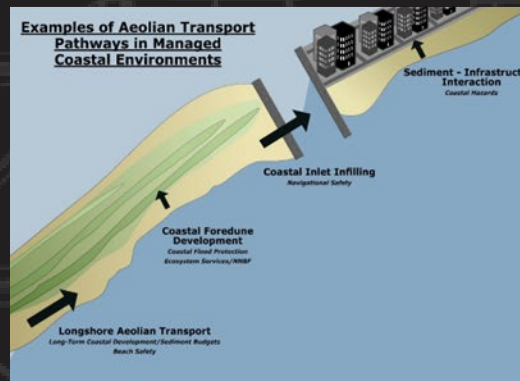## COASTAL INLETS RESEARCH PROGRAM
FY24 IN PROGRESS REVIEW

AEOLIS

CMS

Examples of Aeolian Transport Pathways in Managed Coastal Environments

Sediment – Infrastructure Interaction
Coastal Hazards

Coastal Inlet Infilling
Navigational Safety

Coastal Foredune Development
Coastal Flood Protection
Ecosystem Services/NNBF

Longshore Aeolian Transport
Long-Term Coastal Development/Sediment Budgets
Beach Safety

Change in Elevation (m)

US Army Corps of Engineers

ERDC

CIRP

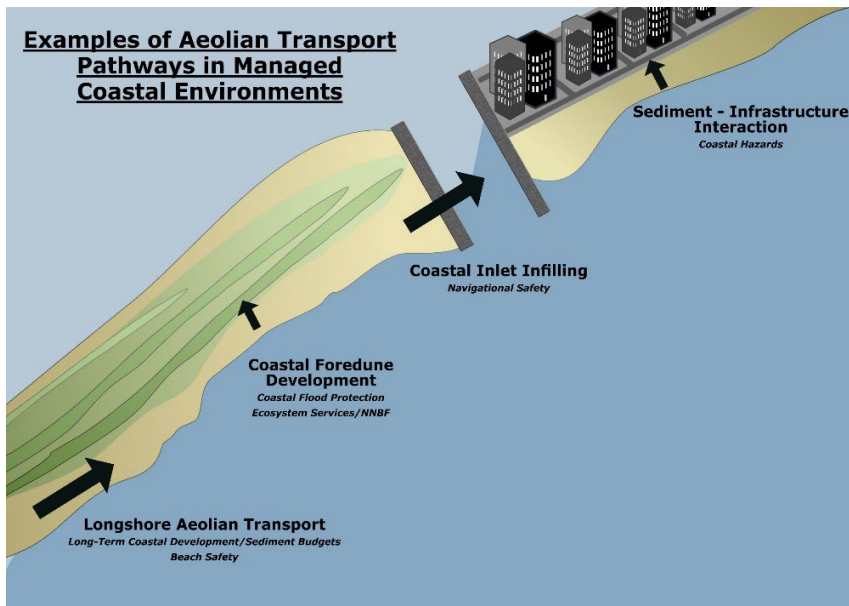U.S. ARMY

PROBLEM STATEMENT

Wind can transport sand and modify landscapes in managed coastal systems, resulting in sediment deposition that may adversely (inlet infilling) or positively (dune growth) impact project performance

Suitable tools do not currently exist for USACE to simulate wind-blown sediment transport and related hazards

Examples of Aeolian Transport Pathways in Managed Coastal Environments

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Coastal Flood Protection Ecosystem Services/NNBF

Longshore Aeolian Transport
Long-Term Coastal Development/Sediment Budgets Beach Safety

Relevant Statements of Need:

2017-N-72 Improved Simulation of Dune Morphological Response at Short & Long Time-scales

2020-F-1539 Improved Capabilities for Quantifying Coastal Dune Evolution and Resilience

2023-F-1859 Adaptive Modeling for Coastal NNBF Applications

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CAPABILITY AND STRATEGIC IMPACT

This work unit aims to develop, extend, and validate state-of-the-art tools for simulating wind-driven sediment transport processes in proximity to navigational channels and in other USACE-managed coastal settings.

Lower Detail/Fidelity → *Higher Detail/Fidelity*

Dune Response Tool

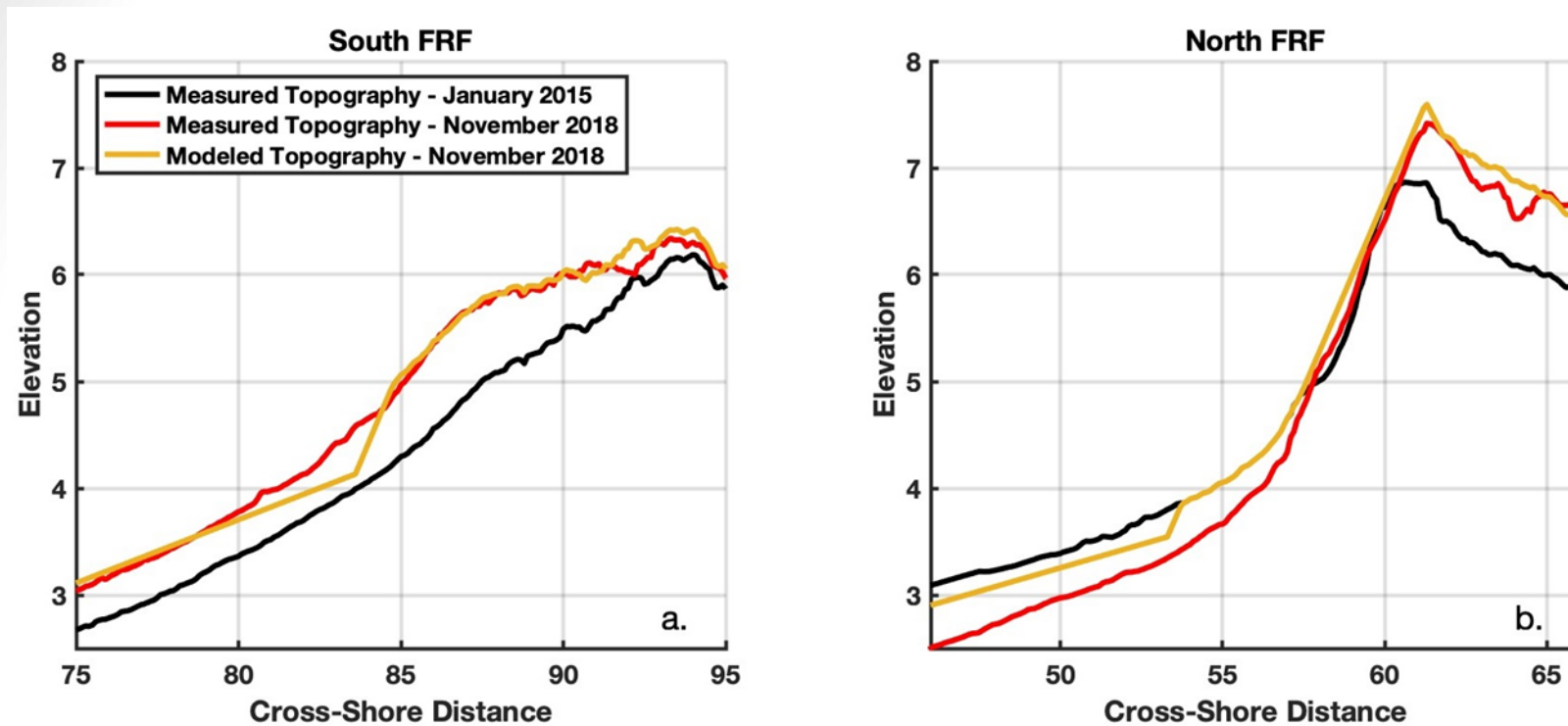https://github.com/erdc/dune-response-tool

AEOLIS

https://github.com/openearth/aeolis-python

CMS + AEOLIS

Long-Term Planning, Rapid Assessment

Design and Optimization

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(1) Dune Response Tool – *FY25 Development and Validation*

South FRF

Legend:
- Measured Topography - January 2015 (black)
- Measured Topography - November 2018 (red)
- Modeled Topography - November 2018 (gold)

a.

North FRF

b.

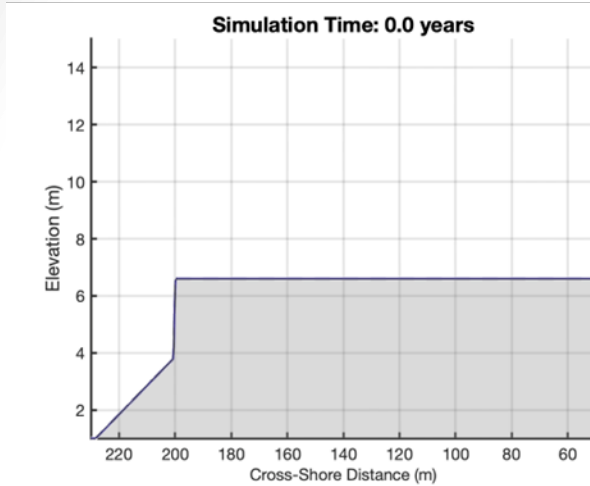| Parameter	Calibrated Value
Veg Deposition Length Scale (L)	21.2 m
Dune Erodibility Coefficient (C_s)	0.0015
Runup Coefficient (K)	1
Angle of Repose ($\tan\alpha$)	35.2°

- *Multi-site validation along the Outer Banks with single parameter sets*
- *Model simulations ~minutes to run*

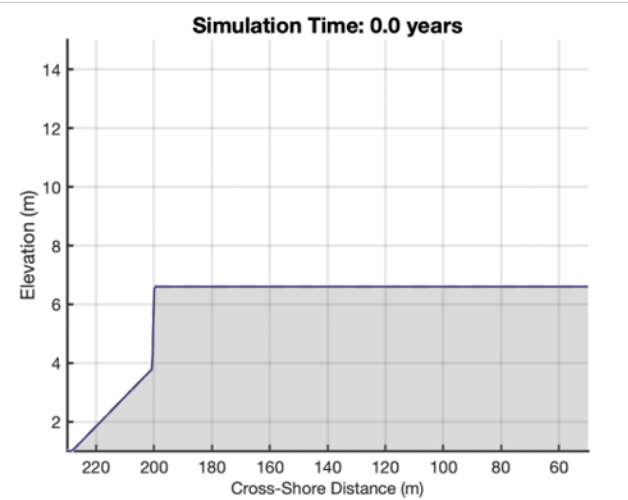US Army Corps of Engineers • Engineer Research and Development Center • Coastal and Hydraulics Laboratory

(1) Dune Response Tool – *Demonstration of Capabilities*
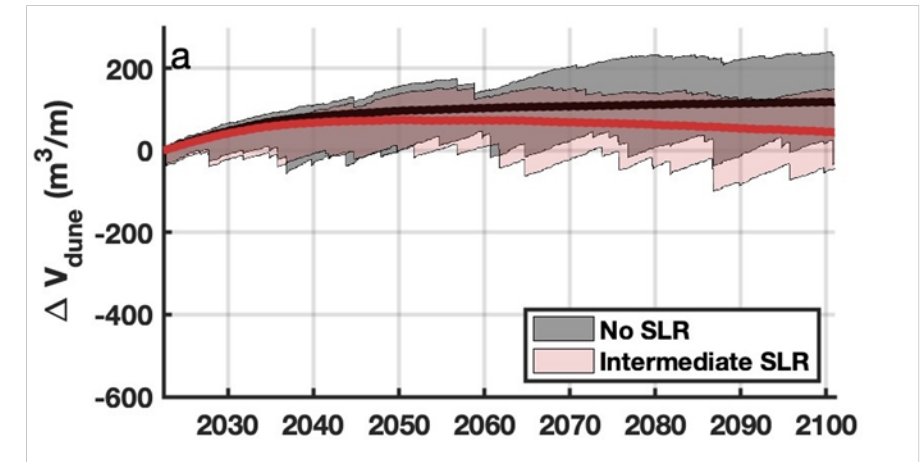
Stable Shoreline, Intermediate SLR Curve

Mean SCR, Intermediate SLR Curve

Example Probabilistic Predictions

- *Fast model simulations enable long-term predictions, including effects of climate change*

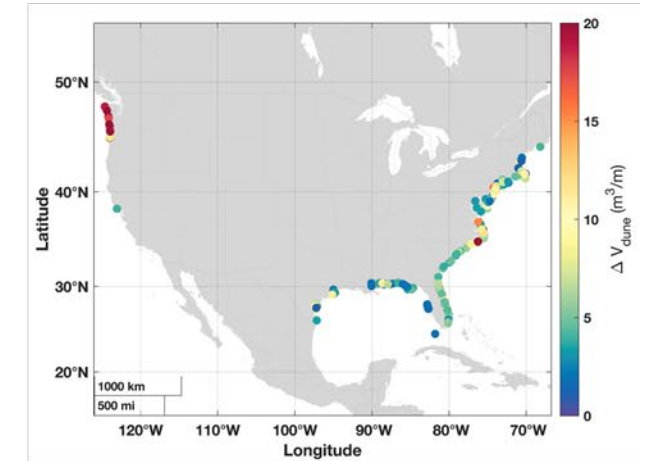**DRT Deliverable:** Journal Publication submitted to *Earths Future*

DRT Deliverable: Source code updated on GitHub
https://github.com/erdc/dune-response-tool

DRT Deliverable: CIRP Technical Discussion

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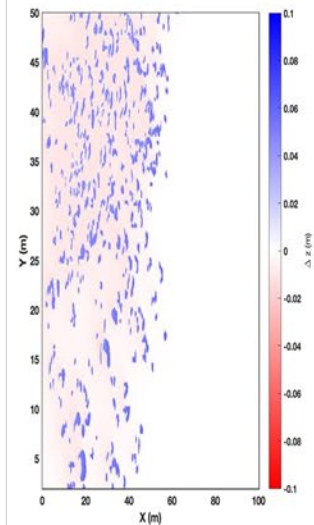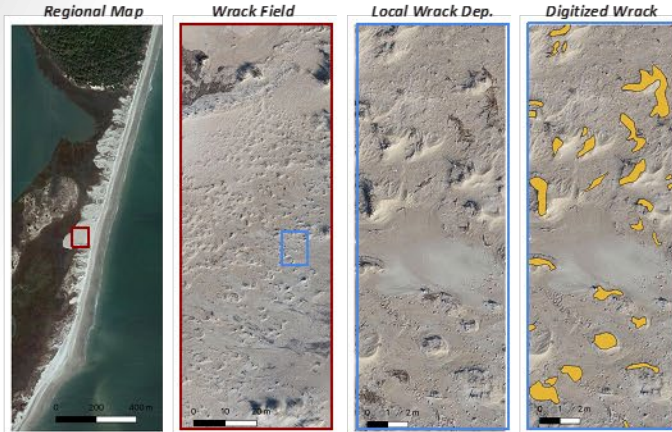# (2) AeoLiS – *Validation and Demonstration of Capabilities*

AeoLiS Deliverables: Journal Publications accepted at *Coastal Engineering*, *Environmental Modeling and Software*, and *Sustainability*
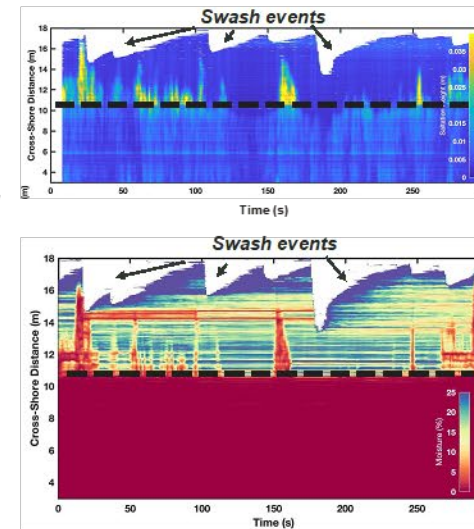
(2) AeoLiS – *FY 25 Development*

Wrack

Regional Map | Wrack Field | Local Wrack Dep. | Digitized Wrack

- *Continued FY24 work adding in wrack-sediment interactions into AeoLiS by Pete Tereszkiewicz*
- *Documentation still needed*

Moisture

Coastal Engineering 185 (2023) 104376

Contents lists available at ScienceDirect

Coastal Engineering

journal homepage: www.elsevier.com/locate/coastaleng

Simulating surface soil moisture on sandy beaches

Caroline Hallin [a,b,*], Christa van IJzendoorn [a], Jan-Markus Homberger [c], Sierd de Vries [a]

- *Work started by ORISE Post-Doc Savannah DeVoe to test recently added (but largely untested) moisture and groundwater capabilities in AeoLiS*

FRF Field Data of Moisture and Aeolian Transport

Optimization and Code Debugging

- *Continual model updates for bug fixes and improvements*
- *Current developmental code released in July on PyPI; stable version expected in coming months*
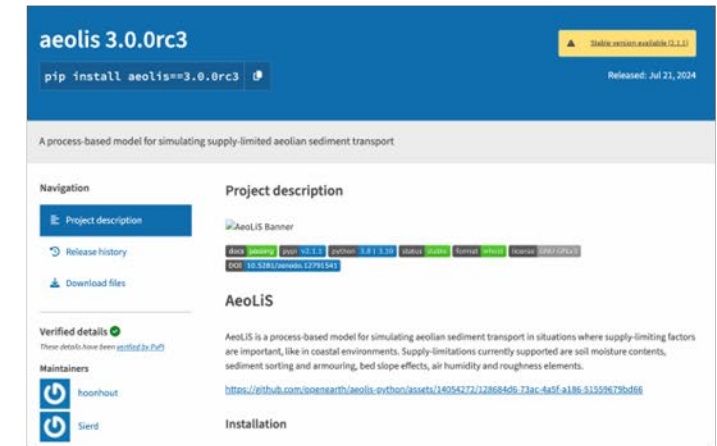
(3) AeoLiS + CMS – *FY 25 Development*

- All open-source models

- Extended capability for standard USACE models

- Fast computations

CMS
Flow
Waves
Sediment
Transport
Morphology

Topography
Water Depth
Winds

aeolian.f
aeolian.py

AeoLiS

Updated Topography

.struct file

non-erodible layer

- *Incorporation of hard structures files into coupled framework, including both CMS and AeoLiS, to enable long-term simulations at engineered coasts*
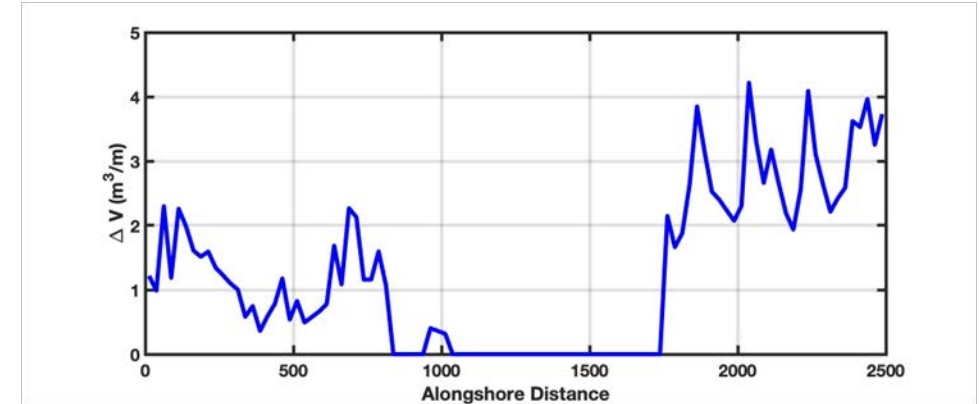
Source: PlumIslandErosion.com

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(3) AeoLiS + CMS – *Demonstration of Capabilities*

Merrimack Inlet/
Newburyport, MA

Source: PlumIslandErosion.com

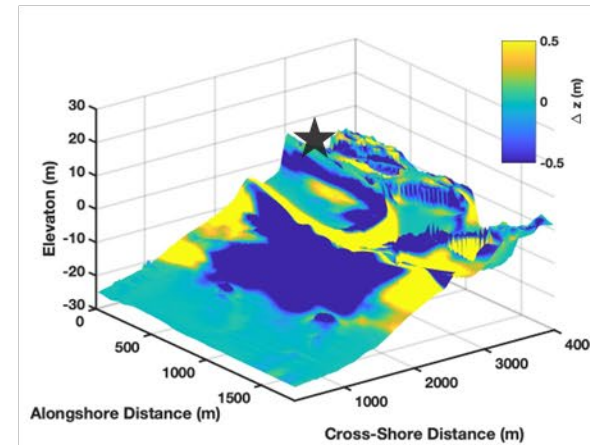Source: Boston Globe

Assessment of Alongshore Variable Impacts
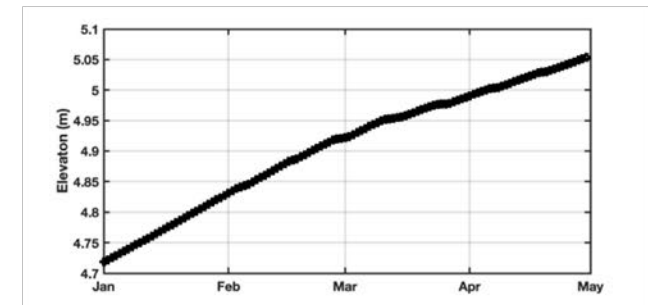

Case Study/Debugging Site for Structure Testing

- *Models no longer erode hard structures in coupled framework, enabling better representation of relal world sysems*

Benchmarking for Long Term Simulations

- *Dune crest elevation grows in model, despite erosional beach system*

SUMMARY

FY24 Major Advancements in Capability

Dune Response Tool	AEOLIS	CMS + AEOLIS
https://github.com/erdc/dune-response-tool	https://github.com/openearth/aeolis-python	
Open-Source Product (Moderately Tested)	Open-Source Product (Most Tested)	Open-Source Product (R&D Tool)

Planned FY25 Products & Advancements

- Support Aquaveo on Aeolis SMS Integration
- Ongoing CMS-AeoLiS rollout in CMS work unit
- ORISE Post-Doc continuing with AeoLiS and CMS-AeoLiS testing
- Probabilistic version of DRT next step development funded under Open Coast Physical Processes SFA/CODS
- DRT reimburseable funding through Navy and Air Force
- Proposal for AeoLiS validation for ecosystem restoration purposes in final stage of consideration for EMRRP funding

FY24 Major Products & Collaborations

- **CIRP Technical Discussions**
  - Dun Response Tool
  - CMS-Aeolis Coupling

- **Publications**
  - **Cohn, N.** and **Anderson, D.** (in review). Projecting the longevity of coastal foredunes under stochastic meteorological and oceanographic forcing. Submitted to *Earths Future*
  - McFall, B. C., Young, D. L., Whitmeyer, S. J., Buscombe, D., **Cohn, N.**, Stasiewicz, J., et al. (2024). SandSnap: Measuring and Mapping Beach Grain Size Using Crowd-Sourced Smartphone Images. *Coastal Engineering*
  - van Westen, B., de Vries, S., **Cohn, N**, et al. (2024). AeoLiS: Numerical Modelling of Coastal Dunes and Aeolian Landform Development for Real-World Applications. *Environmental Modeling and Software*
  - Heminway, S., **Cohn, N.**, et al. (2024). Exploring ecological, morphological, and environmental controls on coastal foredune evolution at annual scales using a process-based model. *Sustainability*

- **Global & Growing Network of AeoLiS Collaborators & Users**
  - Core Development Team: ERDC, TU Delft, Deltares, Lund University
  - Growing code base, online documentation, and validation

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