TOOLS FOR SIMULATING AEOLIAN TRANSPORT NEAR INLETS

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District PDT Members

Rod Moritz (NWP), Gabriel Todaro/Kelly Legault (SAJ)

COASTAL INLETS RESEARCH PROGRAM

FY22 IN PROGRESS REVIEW

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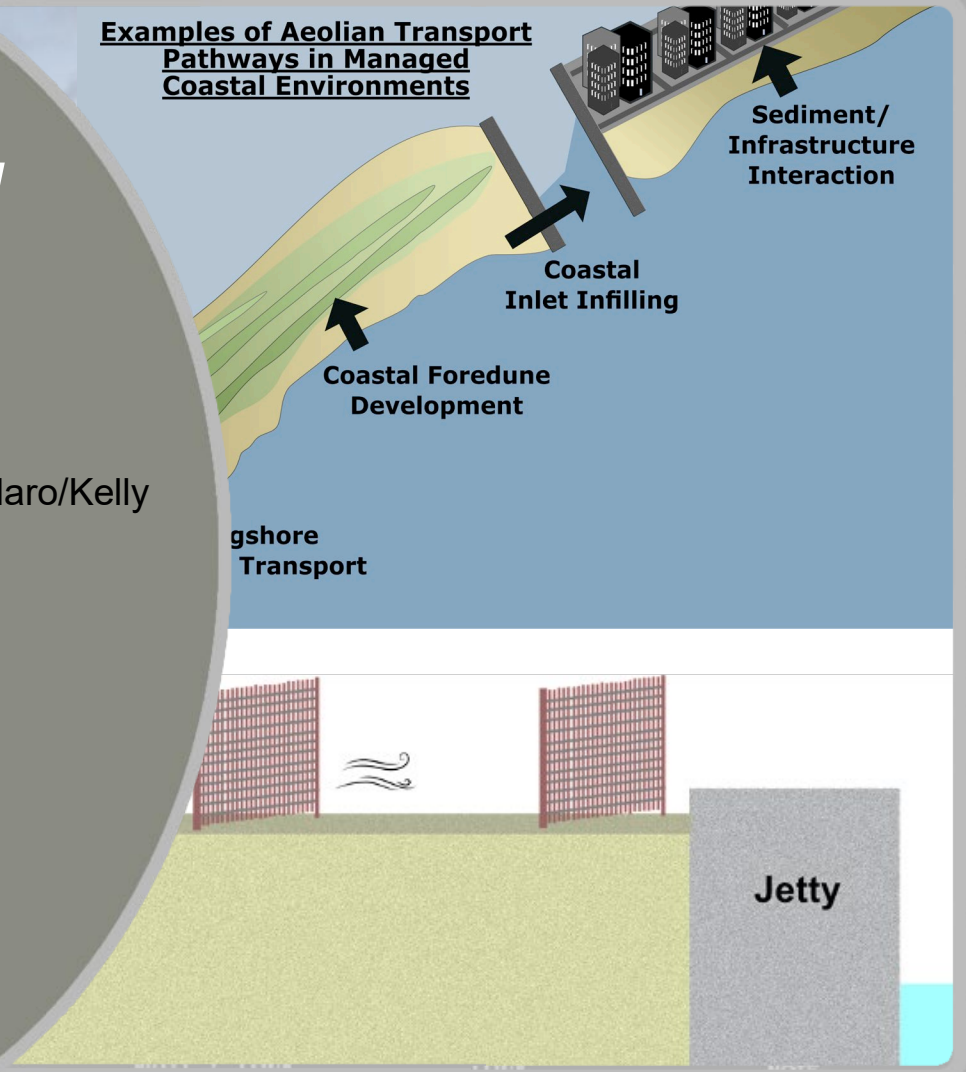
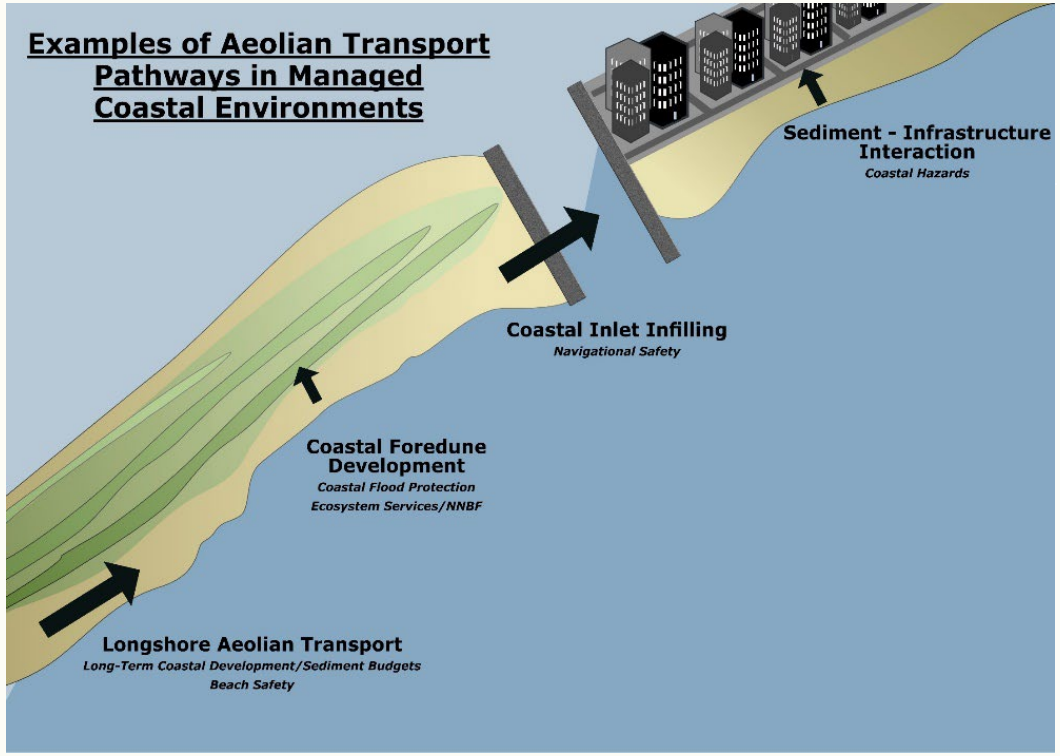
Acting Associate Technical Director, Navigation



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**



Relevant Statements of Need:

2014-N-10 Update of Engineering Guidance for the Development and Maintenance of Coastal Dune Systems

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

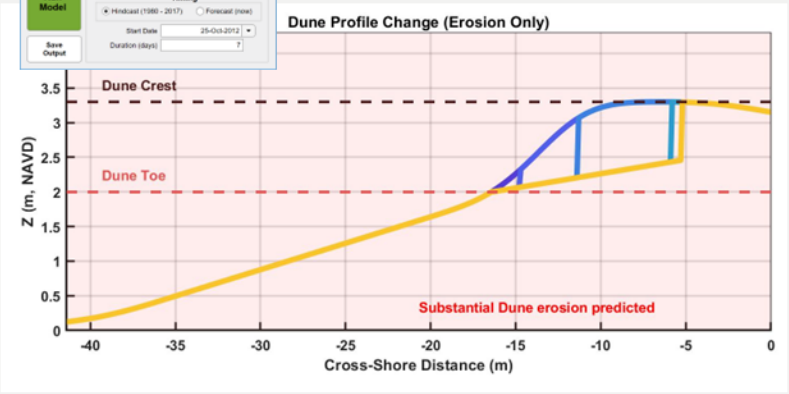
Capability and Strategic Impact Statement

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

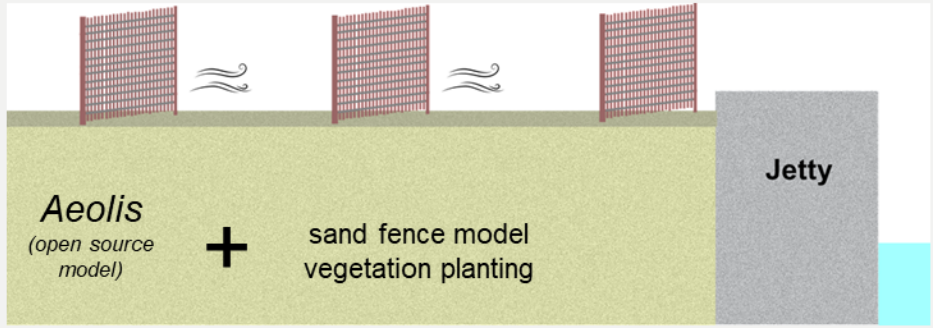
Work Unit Tool Development

Dune Response Tool (*DRT*)

Rapid prototyping tool for storm-driven dune erosion and volumetric dune accretion



Aeolis *Process-based aeolian transport model with USACE management alternatives being added*



Aeolis+C2Shore: *Fully coupled subaqueous-subaerial model for simulating the co-cvolution of coastal morphology from wind and waves*

Short (hours to days) — **Time Scale of Interest** — *Long (months to years)*

Low (Limited Number of Processes Resolved) — **Model Fidelity** — *High*

High — **Tool Level of Maturity (at Start of Work Unit)** — *Low*

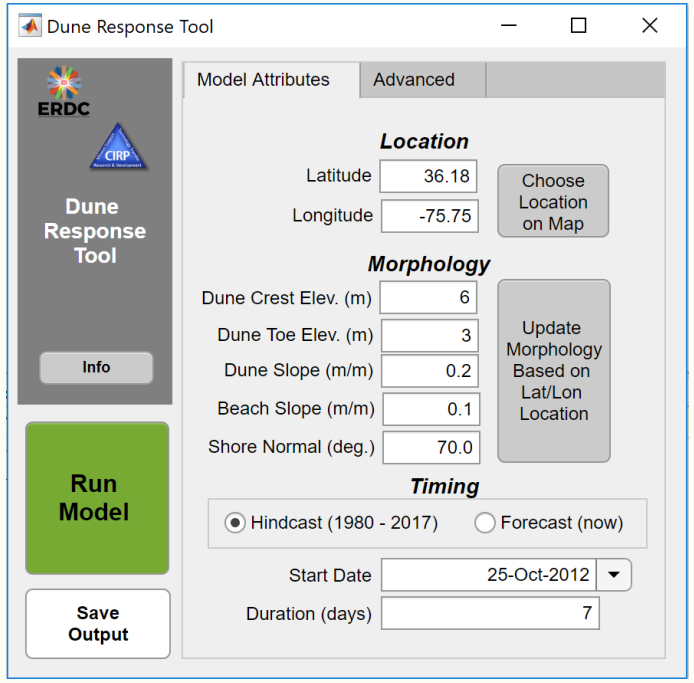
Faster (Seconds to Minutes) — **Computational Speed** — *Slower (Minutes to Days)*

Dune Response Tool

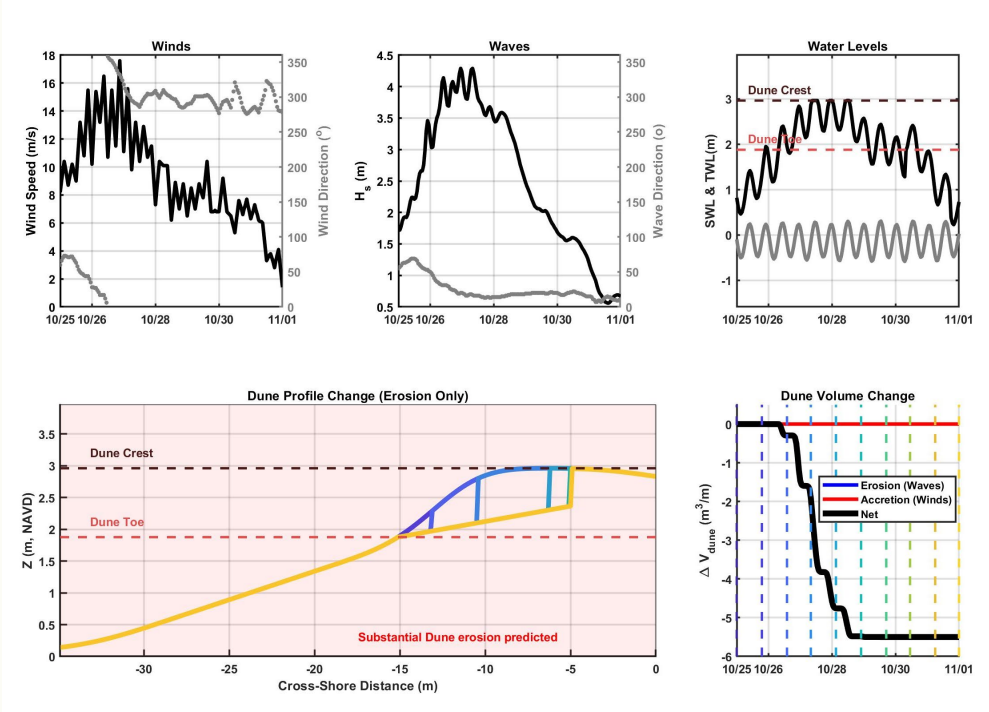
Why Develop DRT

- Reduced Physics Model
- Very fast (seconds to minutes)
- Suitable for planning efforts
- Webtool Capable

Graphical User Interface



Example Model Outputs



Dune Response Tool

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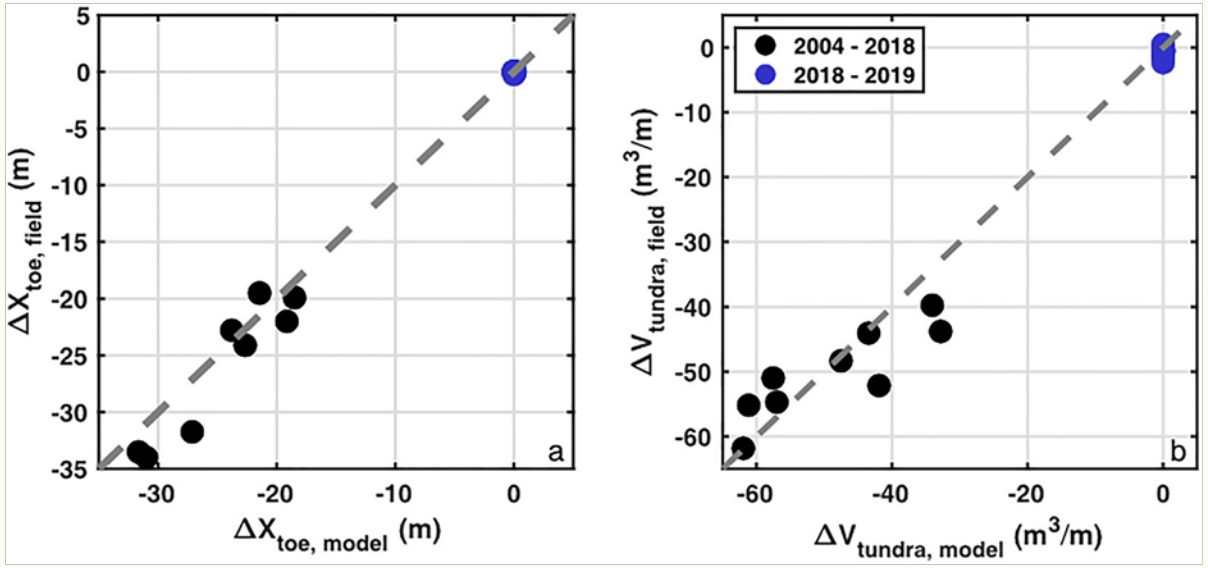
Validation of Erosion Module at Interannual Time Scale:
Point Hope, AK, USA



Dune Response Tool

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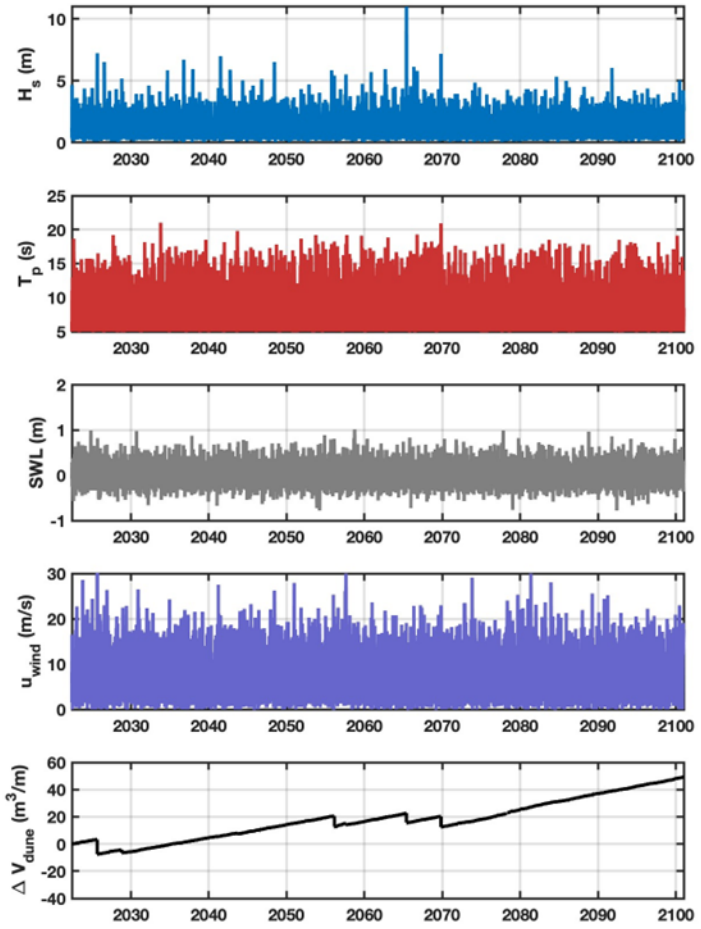
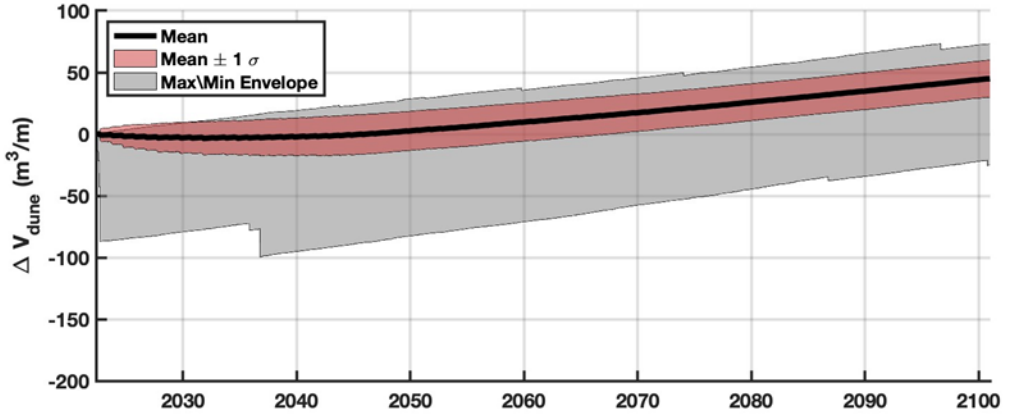
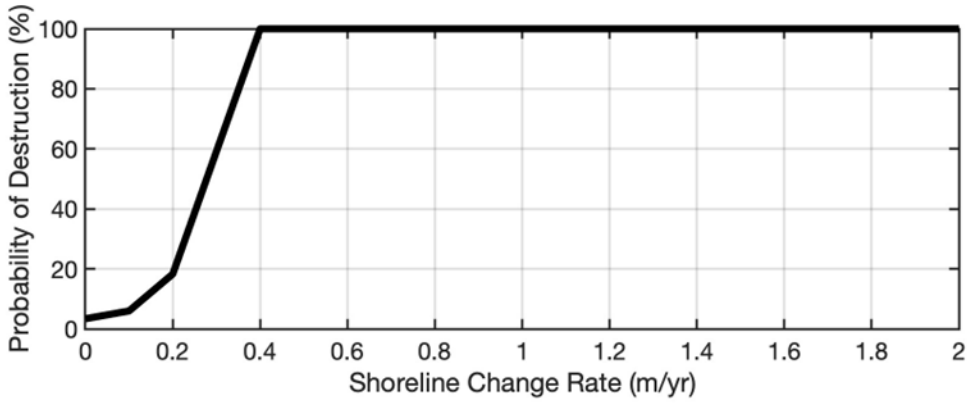
Probabilistic Modeling of Dune Growth/Erosion







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Dune Response Tool

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FY22 PMP Tasks:

- **Github – Open Source Code**

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

- **ERDC Tech Note Published**
- **Journal Paper**

  Journal of Geophysical Research: Earth Surface using DRT Erosion engine

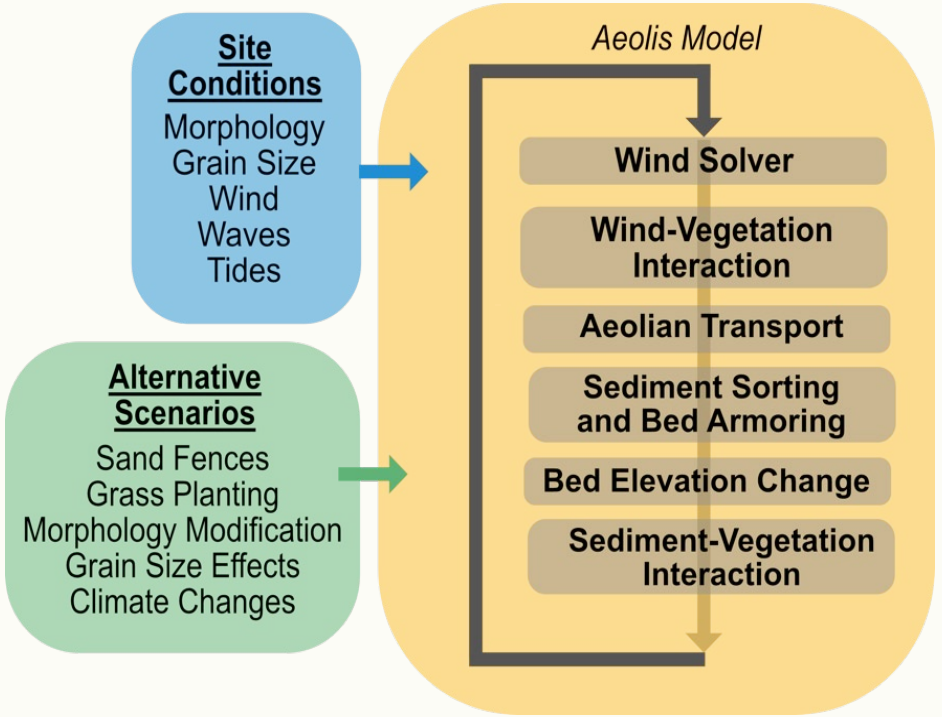
Future Steps:

- JP with both erosional and accretional capabilities
- Collaboration with Oregon State University for dune applications
- Adaptation of erosion engine for Arctic environments (EWN, Congressional Add, ESTCP funds)

AEOLIS

Why Develop Aeolis

- 1D and 2D Applications
- Modular code for adding in new USACE-relevant capabilities
- Suitable for planning and design efforts
- Growing user base for aeolian and NNBF applications



FY22 Tasks

- Code Development
- Training Courses
- Applications

Why Develop Aeolis

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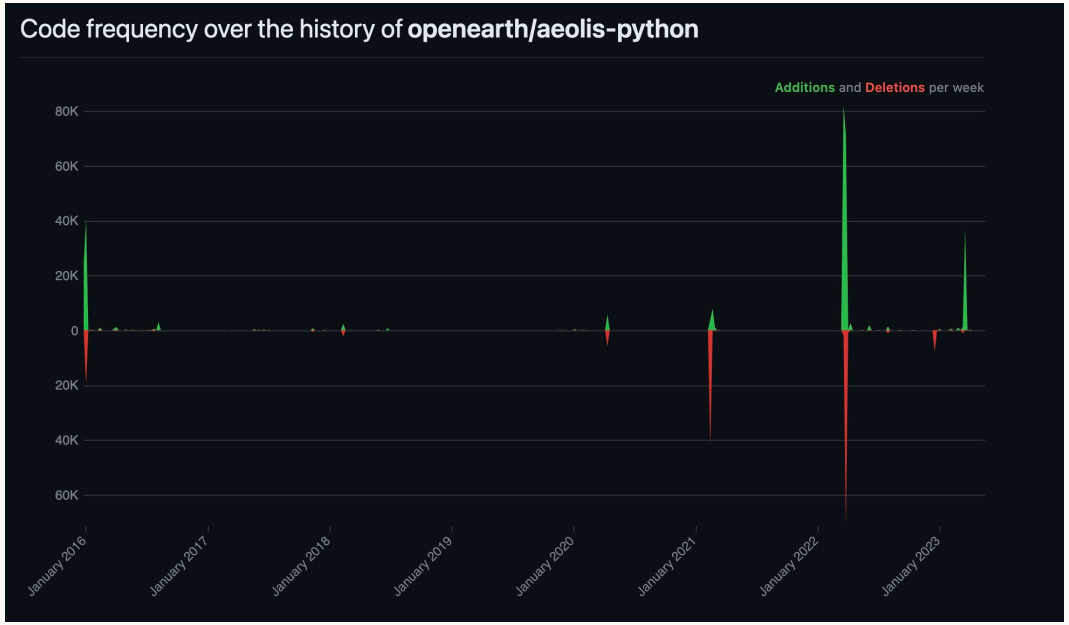
Code Development:

- Improved moisture and groundwater capabilities
- Seperation bubble dynamics
- Dune erosion module
- Improved aerodynamic roughness parameterization
- Vegetation shear couplers
- Bug fixes
- Improved documentation

AEOLIS

Sprint Sessions:
Sweden,
Netherlands,
USA, Belgium

Code Development



Code Development

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

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

Training Courses

Self guided python-based course for running Aeolis

https://github.com/erdc/aeolis-python/tutorials

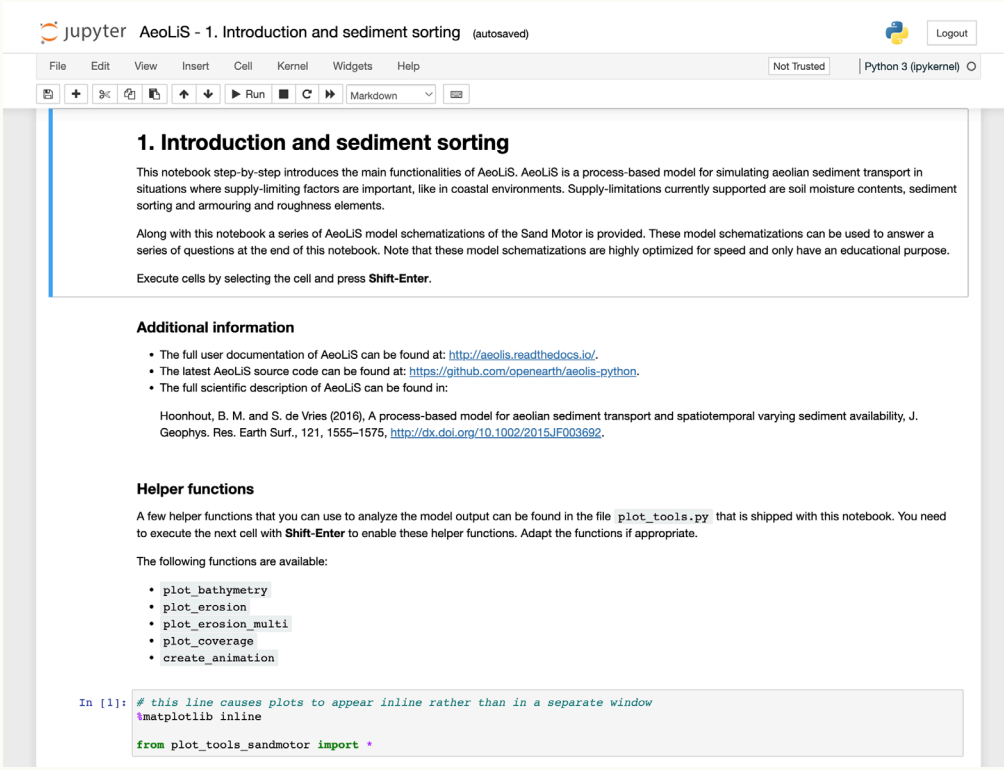
CHAPTER 0	Model Introduction, Installation & Set Up, Overview of Model Inputs & Outputs
CHAPTER 1	First Model Run, Introduction to Vegetation, Constant Wind & Tide
CHAPTER 2	Introduce Constant Waves & Runup
CHAPTER 3	Introduce Variable Wind Magnitude & Direction (WIS), Introduction to Selecting Dates to update boundary conditions from WIS & NOAA
CHAPTER 4	Inclusion of Variable Waves & Tides, Introduce Dune Erosion module in model
CHAPTER 5	Introduction to Multifraction Sediment Transport, Utilizes SandSnap Data, Comparison of Multifraction and Single D50 Transport rates
CHAPTER 6	Introduce Changing Locations, Utilizes datasets from the DRT & Sandsnap to update morphology, boundary conditions, and grain size

AEOLIS

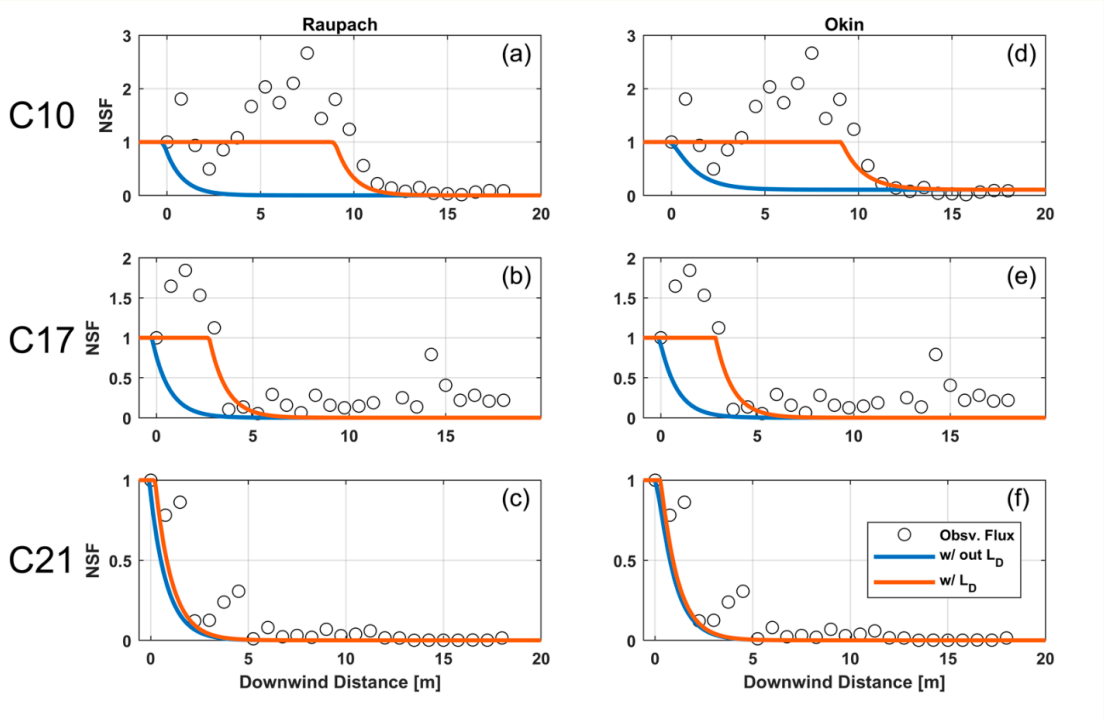
Training Courses

In person course development

FY23 Deliverable



AEOLIS



Model Applications

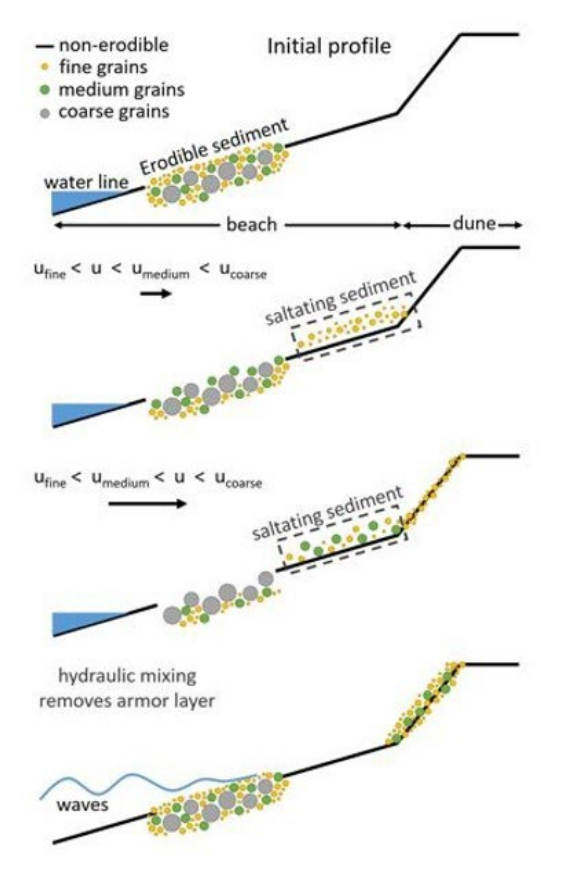
RESEARCH ARTICLE

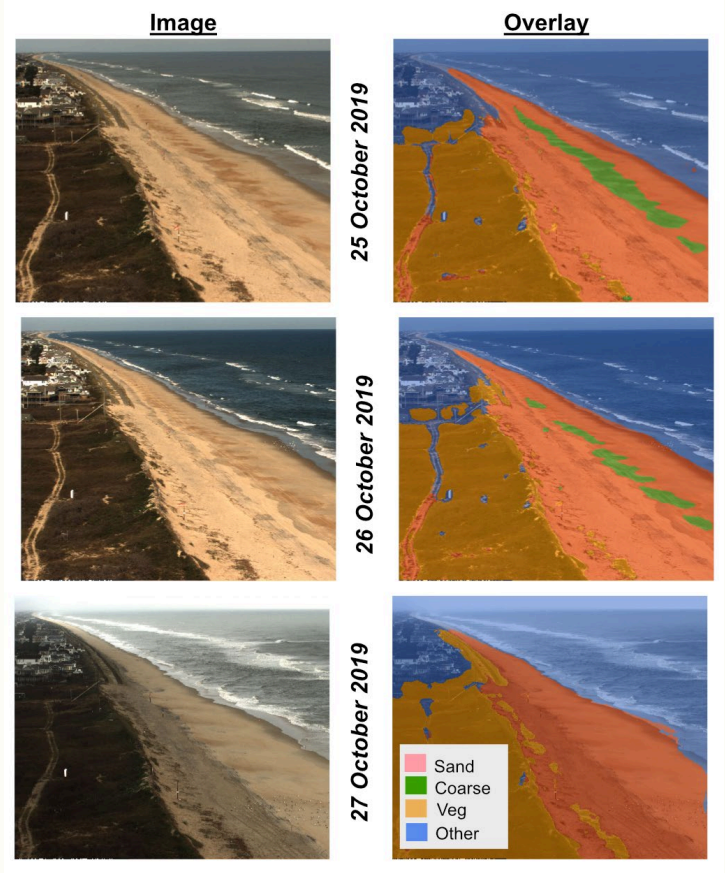
ESPL WILEY

Observations and modeling of shear stress reduction and sediment flux within sparse dune grass canopies on managed coastal dunes

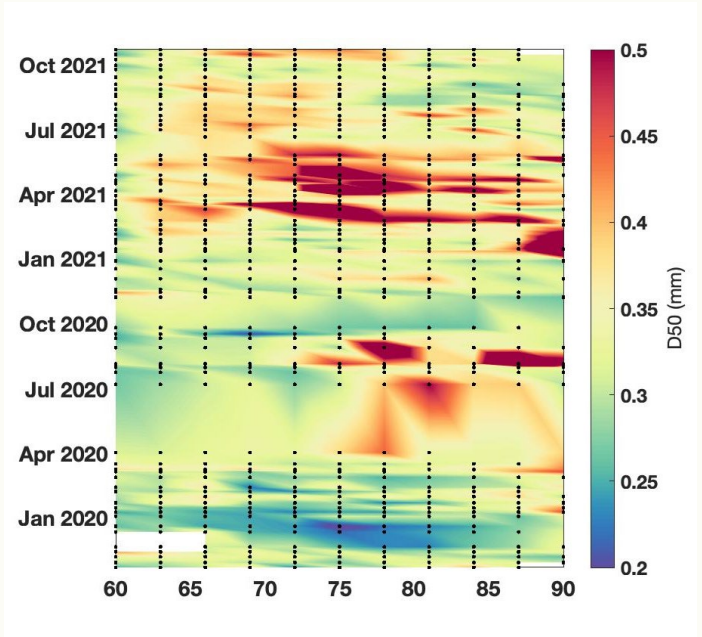
John Dickey[1,2] | Meagan Wengrove[1] | Nicholas Cohn[3] | Peter Ruggiero[4] | Sally D. Hacker[5]

AEOLIS





Does spatio-temporal variability in grain size on the beach influence long-term wind-blown transport rates?



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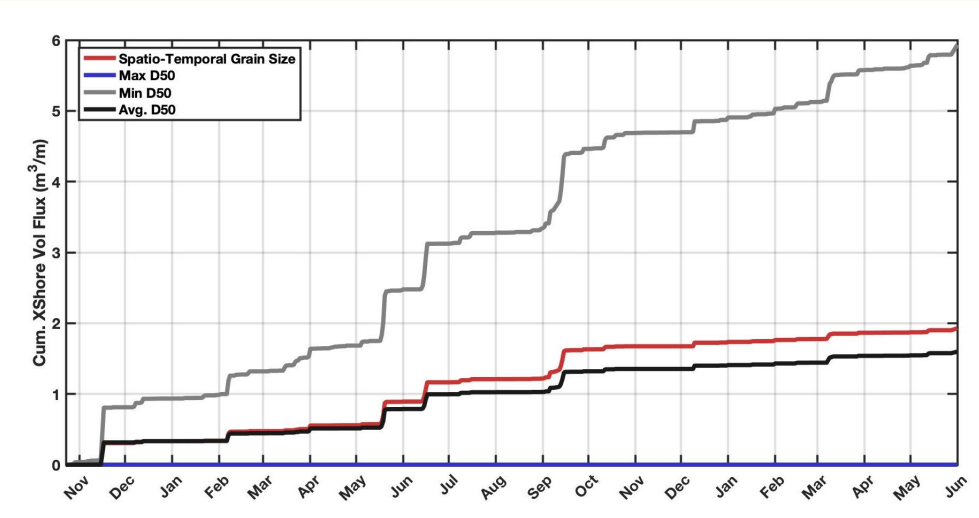
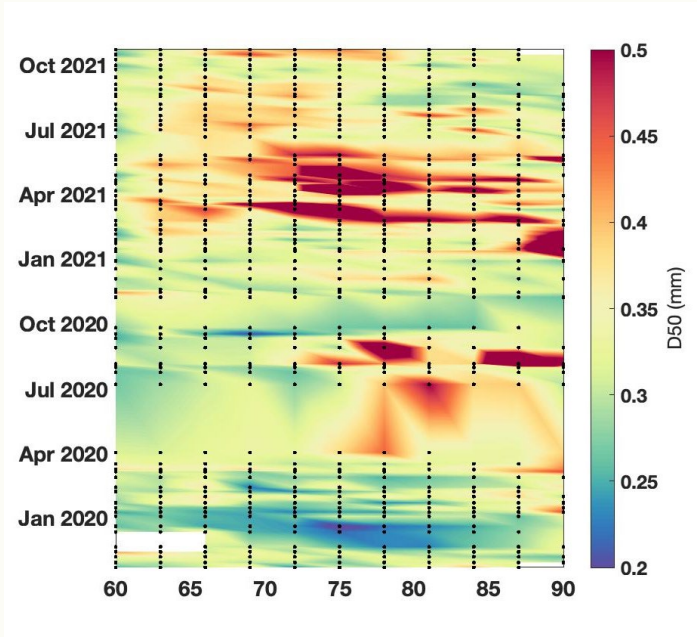
AEOLIS



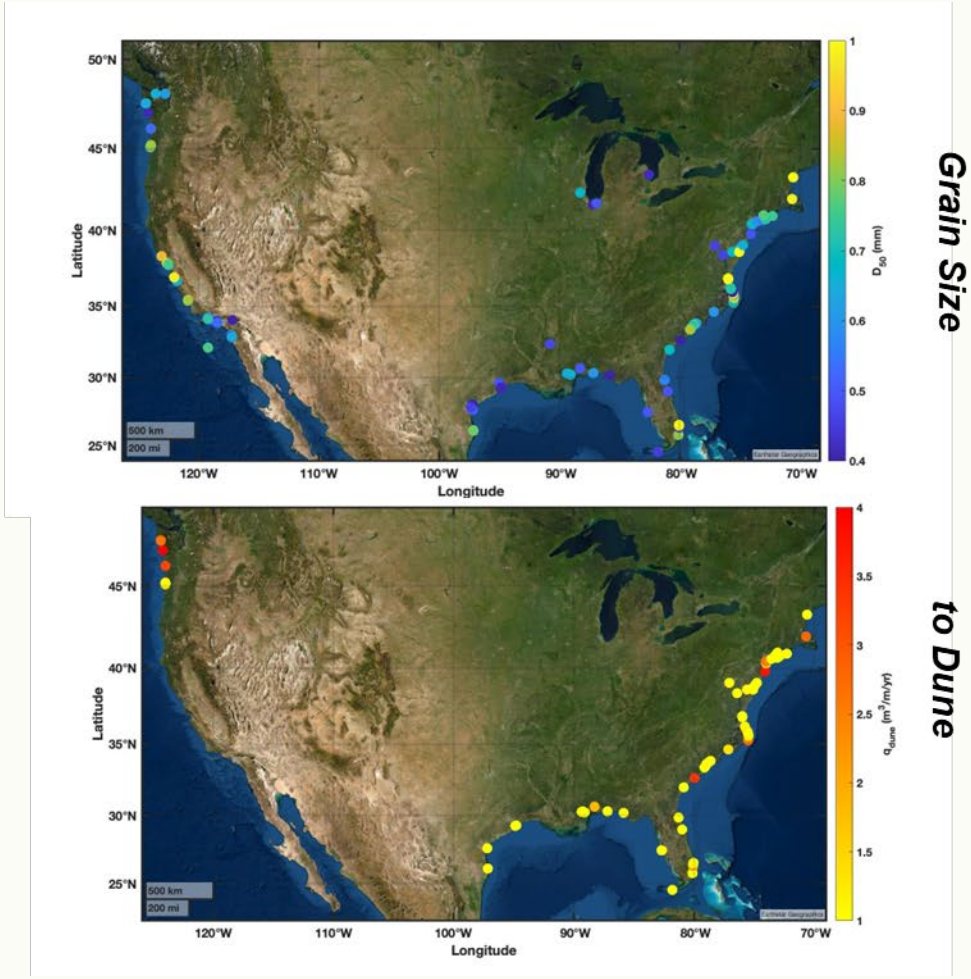
- **Average D50** across all samples results in ~20% less transport than more frequent data availability. Need to pick grain size data carefully
- 2D simulations suggest that persistence of coarse deposits on the beach can have alongshore dune growth rates

Does spatio-temporal variability in grain size on the beach influence long-term wind-blown transport rates?



Product: *CIRP TD, Future JP?*

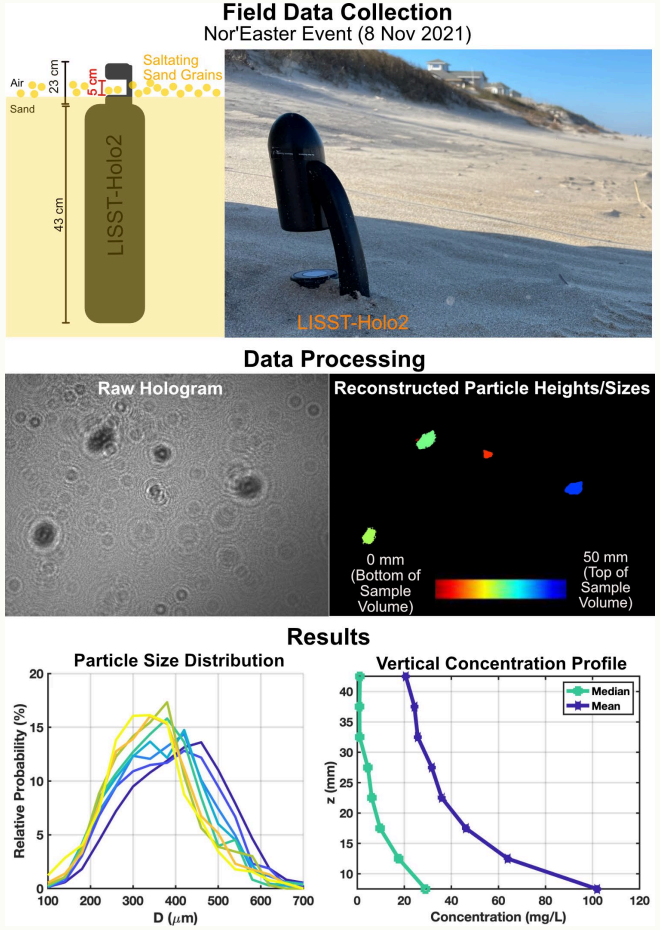
AEOLIS

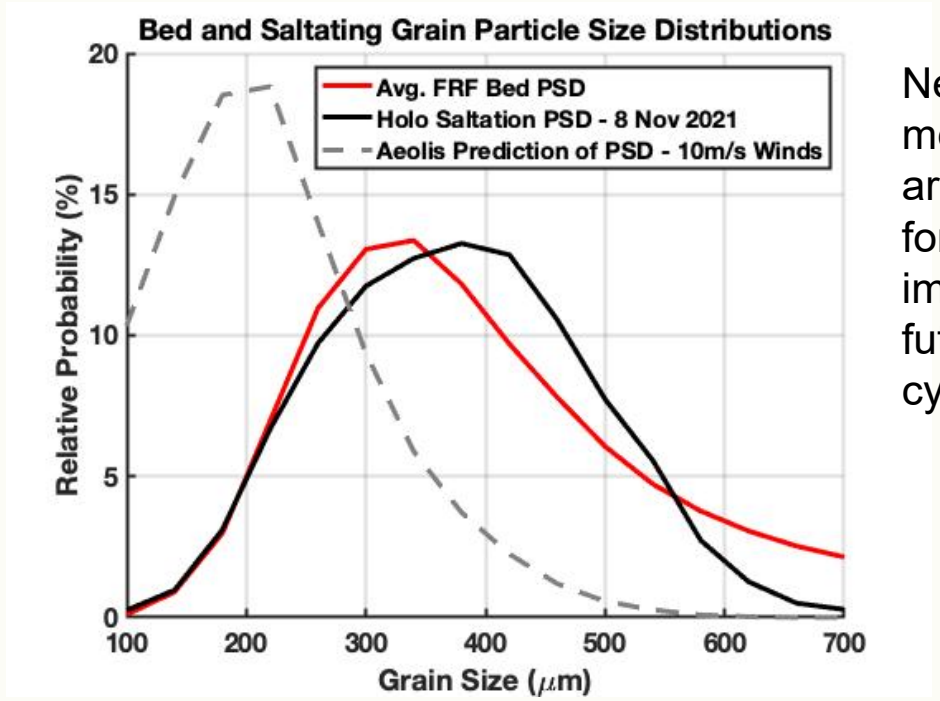


Automated codes to estimate wind-blown sediment fluxes around the country using SandSnap grain size and public data sources for winds, waves, tides, and morphology

Product: *CIRP TD*

AEOLIS





New field measurements are guiding need for model improvement for future R&D cycles

Product: *RD22 Presentation*

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Why Develop Aeolis

- 1D and 2D Applications
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- Suitable for planning and design efforts
- Growing user base for aeolian and NNBF applications

FY22 PMP Tasks:

- **Model Development, Sprints, and Maintenence** ✓
- **Course Development**
- **Model Applications** ✓
- **Journal Paper**

  ESPL using Aeolis ✓

Future Steps:

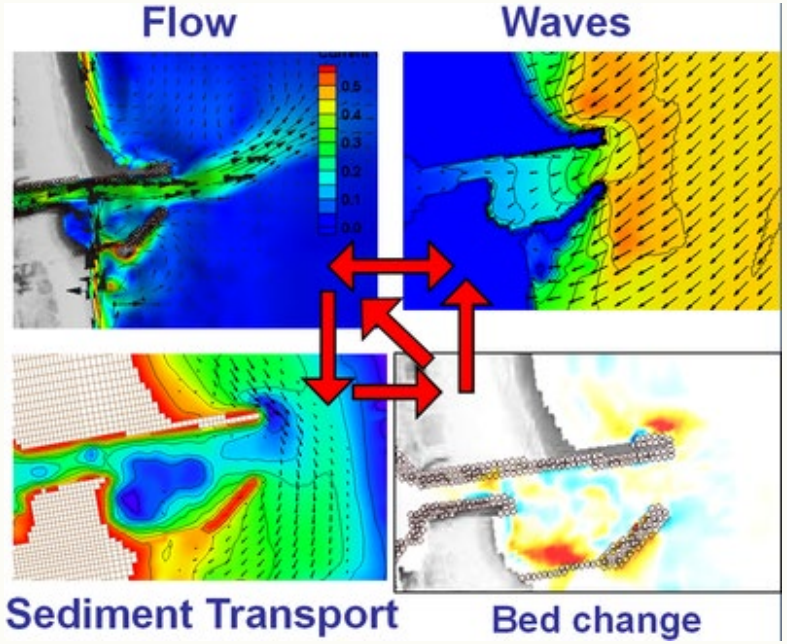
- JP on Aeolis
- Ongoing collaboration with TU Delft, Lund University, Oregon State University, and others
- Model coupling efforts to integrate Aeolis to USACE models
  - GenVeg/Doonies → EWN, OSU Add
  - CSHORE --.> USCRP, OSU Add
  - CMS → CIRP

2D CMS-Aeolis Coupling

Why Develop 2D Coupling Capabilities

- Both subaerial and subaqueous processes important for driving the evolution of coastal systems
- Quantifying aeolian transport effects on inlet fluxes requires 2D coupled solutions
- Leverages existing USACE models and GUI tools

Traditional CMS Workflow –
Aeolian Transport Not Considered



Goal:

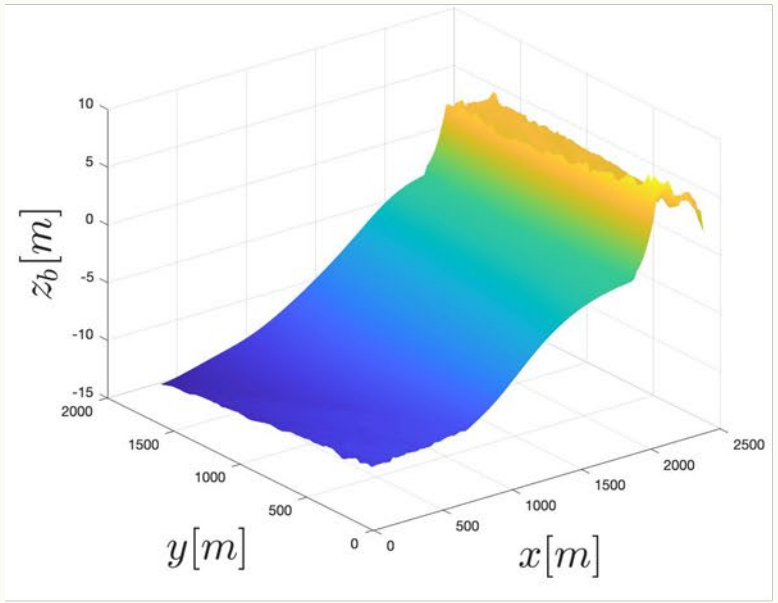
Add in capability to directly couple Aeolis with CMS for 2D applications

Approach:

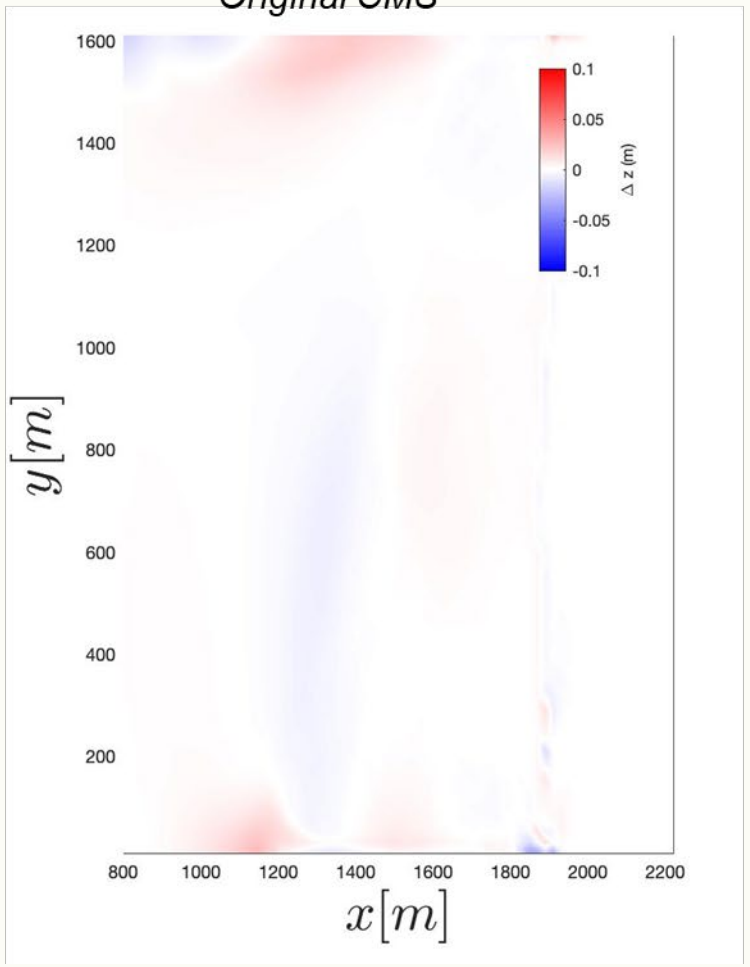
- **cms_flow.f90 (modification)** – modify main code to call aeolian steering file and handle topographic updates (Brad Johnson)
- **aeolian.f90 (new)** – steering file to update topography from wind Includes system call to **aeolian.py** which generates all Aeolis input files, runs Aeolis, and returns data to CMS
- **scenario.cmcards** (modification) – new options for coupling interval and subaerial grain size

2D CMS-Aeolis Coupling

Example 2D case for Benson Beach, WA –
10 m/s onshore wind for 5 days



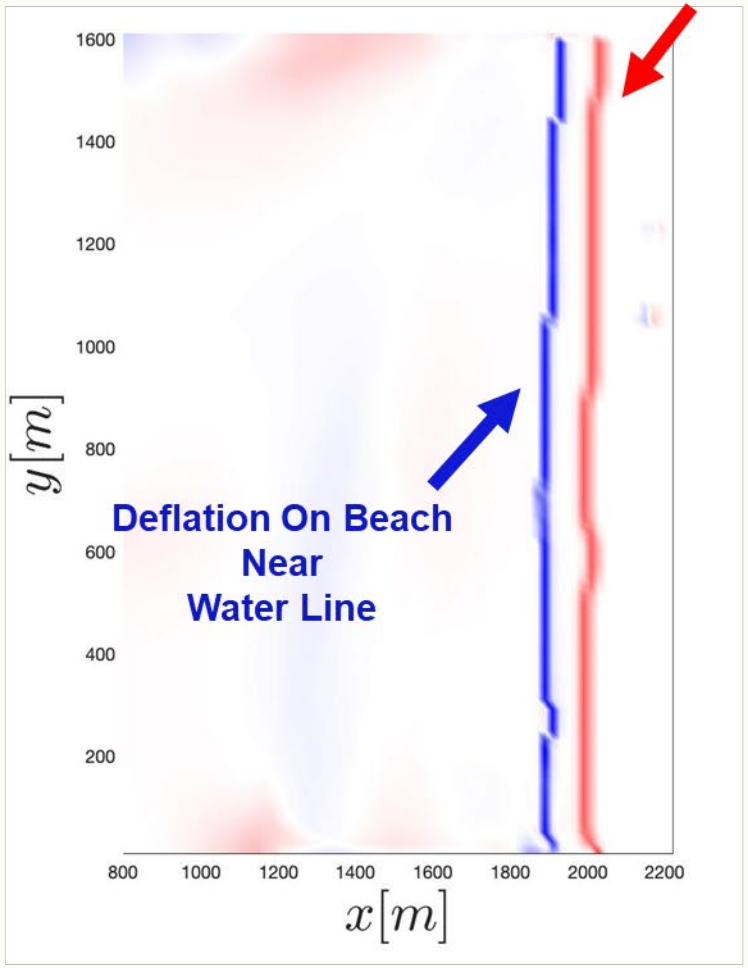
Original CMS



CMS + Aeolis

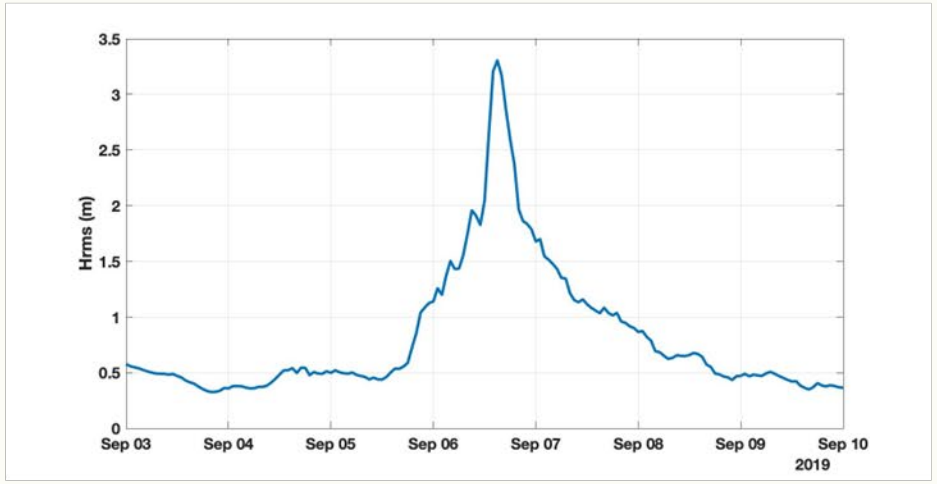
Deposition in Vegetated Dune

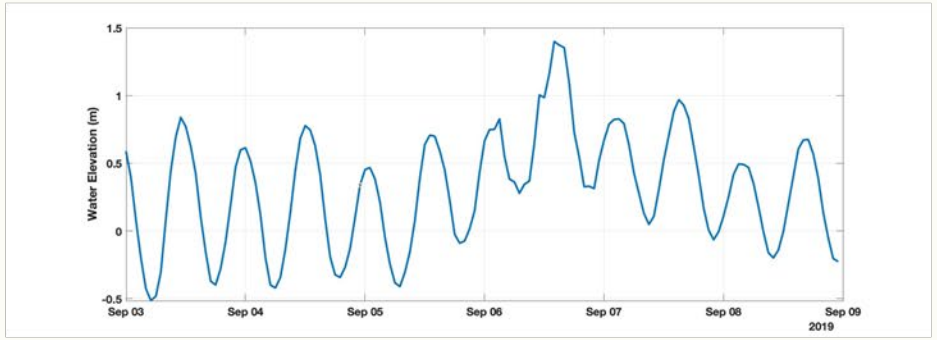
Deflation On Beach Near Water Line

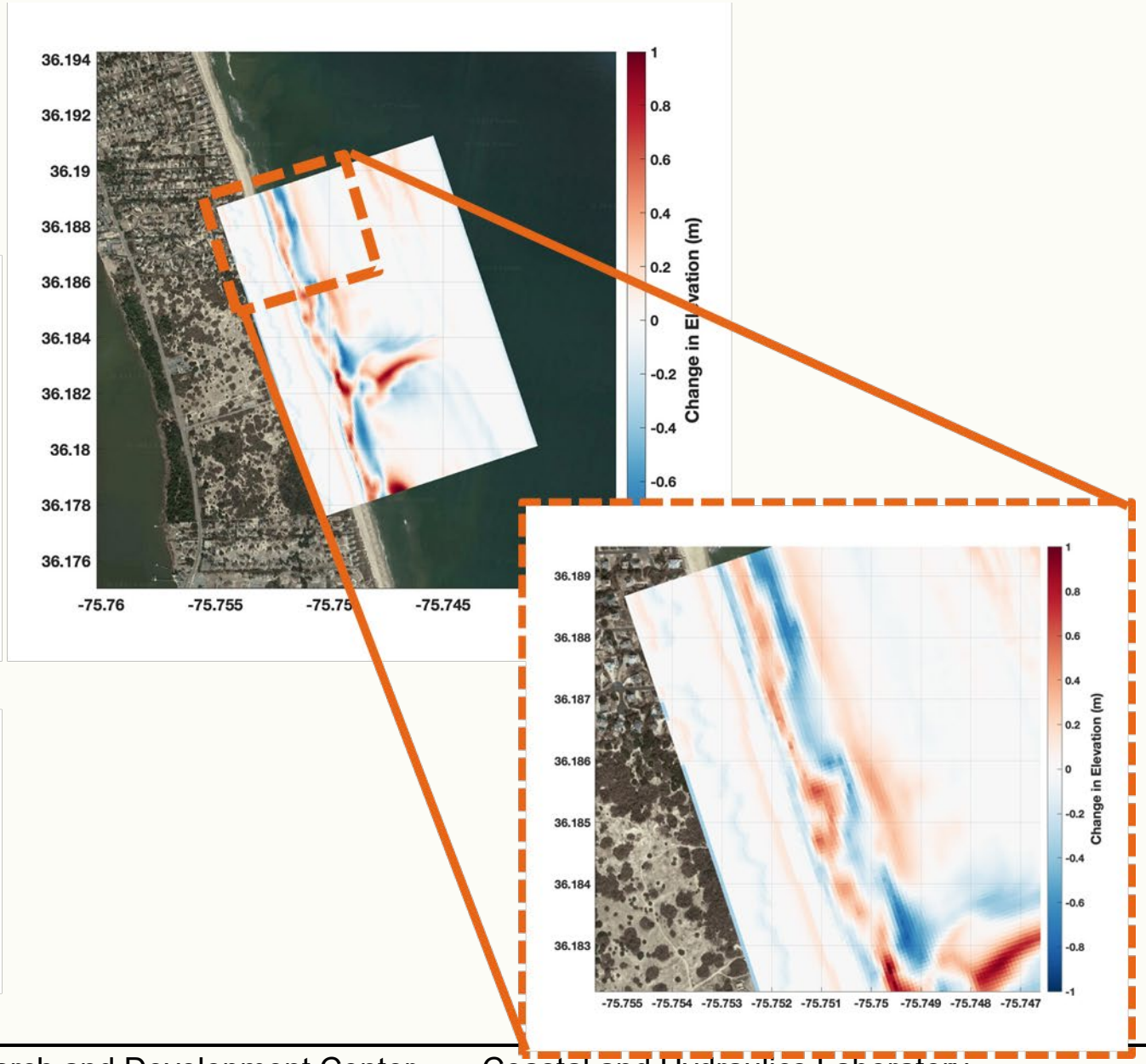


2D CMS-Aeolis Coupling

Example 2D case for USACE Field Research Facility







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Summary

FY22 Major Advances in Capability

- Aeolis
  - Major code updates for 1D and 2D applications
  - Bug tracking system
  - Self Guided Short Course Development
  - In Person Course Development
  - Journal Paper, Tech Note
- DRT + CMS/Aeolis

FY22 Major Products & Collaborations

- 2 TNs published
- 2 JPs published
- 1 Conference Presentation
- 1 CIRP TD and 1 PDT Meeting
- Collaboration with Oregon State University, Lund University, TUDelft, KU Leuven, and Deltares on Aeolis Development

Planned Outyear Products/Advances

- Aeolis
  - In-person model training (Coastal Sediments)
  - Conference presentations and papers
- 2D CMS-Aeolis Coupling
  - Major development push and application of tool to real world conditions
    - Atlantic, Pacific, and Gulf Coasts