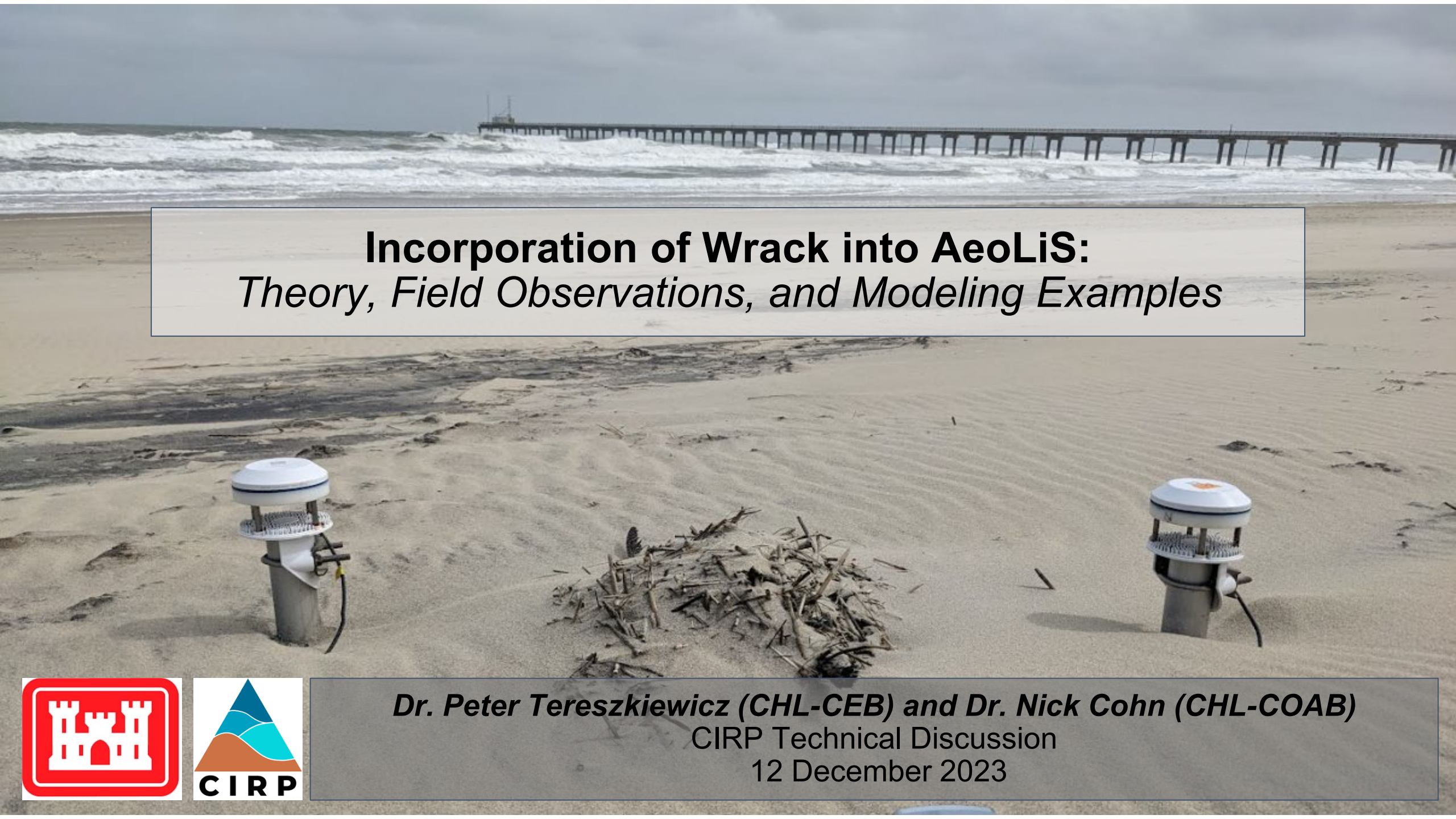


Incorporation of Wrack into AeoLiS:
Theory, Field Observations, and Modeling Examples

Dr. Peter Tereszkiewicz (CHL-CEB) and Dr. Nick Cohn (CHL-COAB)

CIRP Technical Discussion

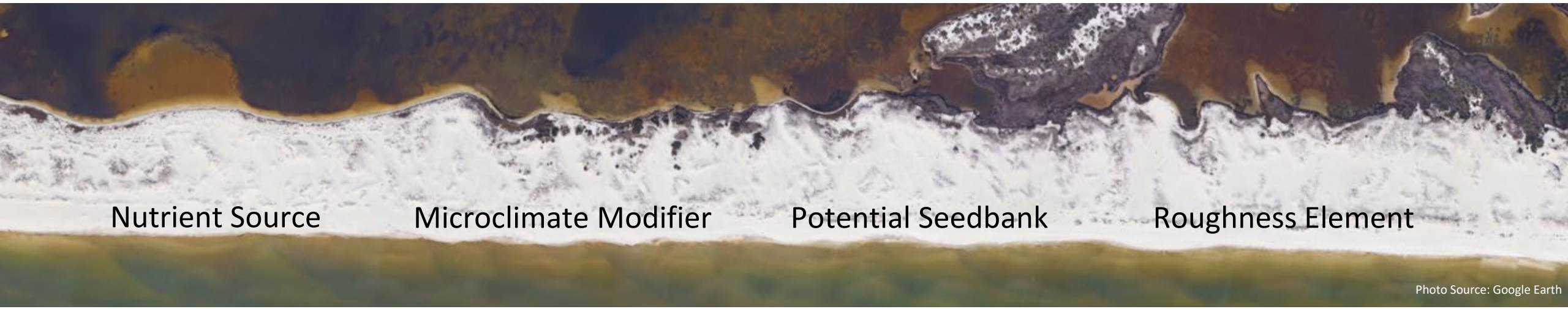
12 December 2023

Outline

1. Wrack Theory and Background
2. Field Experiment 1 – *Weeks to months*
3. Field Experiment 2 – *Seconds to hours*
4. Wrack Implementation into AeoLiS
    - -Application for Field Experiment 1 for 1D and 2D
    - -Exploration of Model for Regional Scale Studies
5. Conclusions

Beach Wrack

Vegetative, algal, or woody matter from seaside coastal formations or seagrass beds that is initially deposited at the high-water line



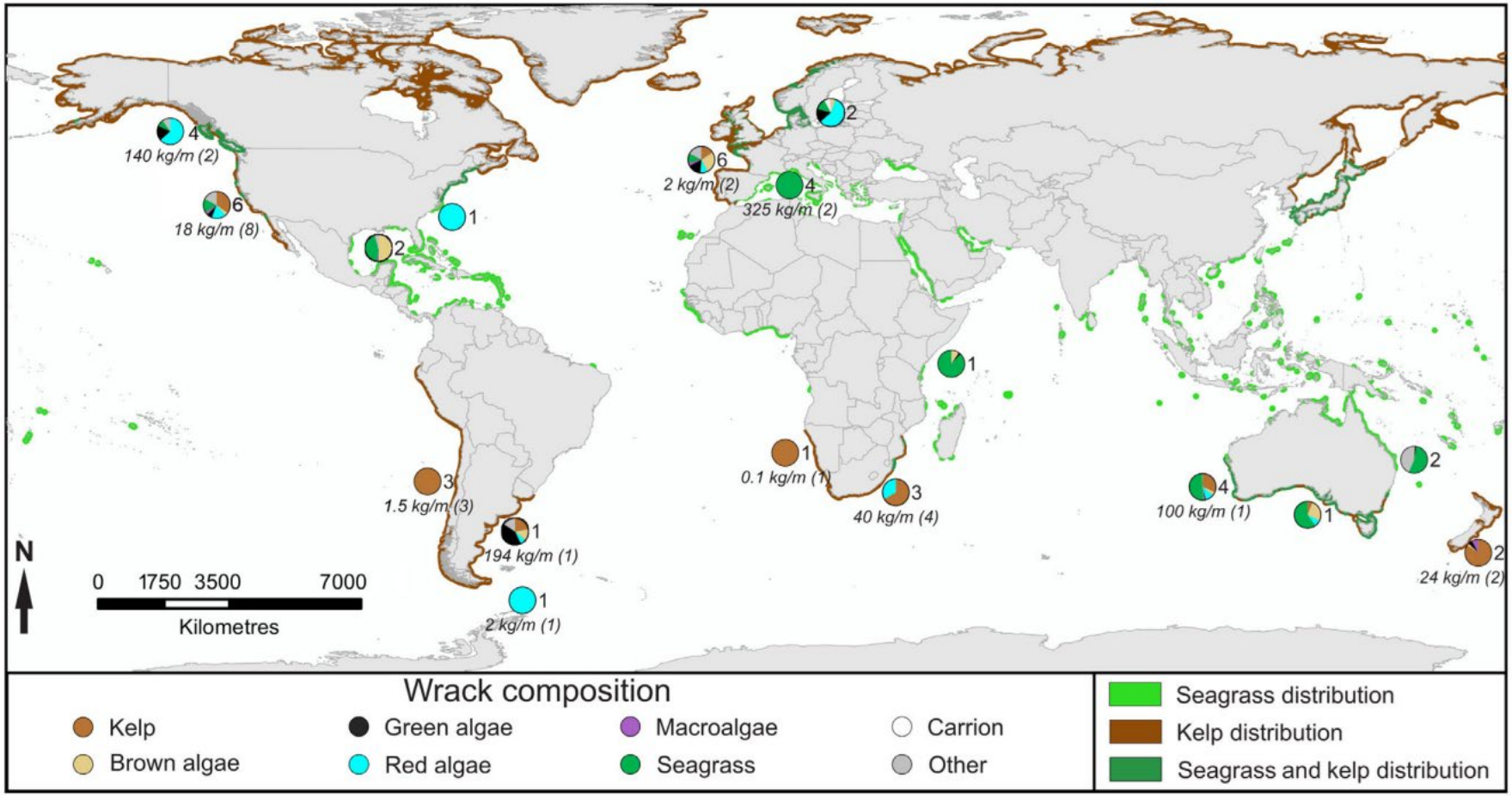
(Koop et al., 1981; Koop and Lucas, 1983; Inglis, 1989; Rossi and Underwood, 2002)

(Cowles, 1899; Rossi and Underwood, 2002; Barreiro et al., 2011)

(Cowles, 1899; Hesp, 1989; Pakeman and Lee, 1991)

(Hemminga and Nieuwenhuize, 1990; Balestri, Vallerini, and Lardicci, 2006; Nordstrom, Jackson, and Korotky, 2011; Egmond et al., 2019)

Spatial Distribution



Hyndes, G.A., Berdan, E.L., Duarte, C., Dugan, J.E., Emery K.A., Hambak, P.A., Henderson, C.J., Hubbard,D.M., Lastra, M., Mateo, M.A., Schlacher, T.A., 2022. The role of inputs of marine wrack and carrion in sandy-beach ecosystems: a global review. Biol. Rev. *preprint.* doi: 10.1111/brv.12886

Huge Mass of Sargassum Seaweed Is Targeting Florida's Coast, With Hazards to Health

By HealthDay | May 26, 2023, at 11:00 a.m.

NATIONAL

Giant blobs of seaweed are hitting Florida. That's when the real problem begins

MAY 5, 2023 · 5:04 AM ET

Wrack Type and Deposition Geometry

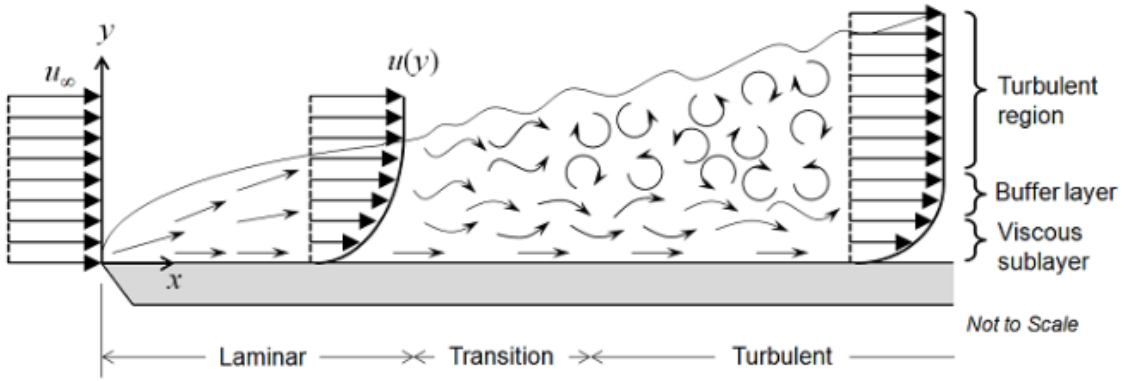
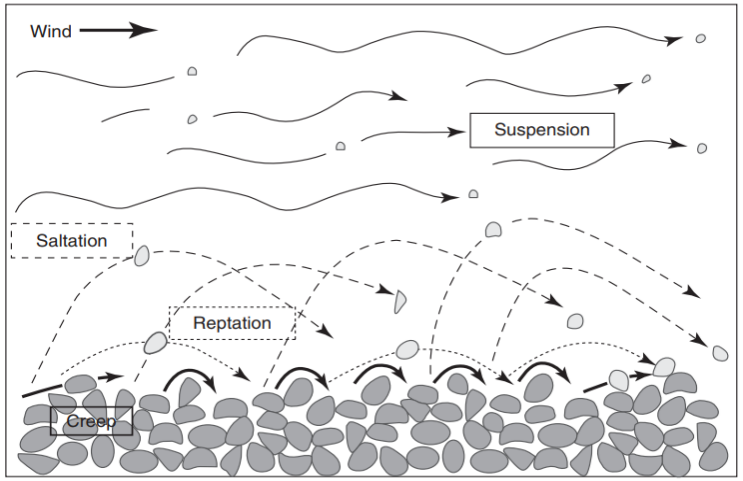


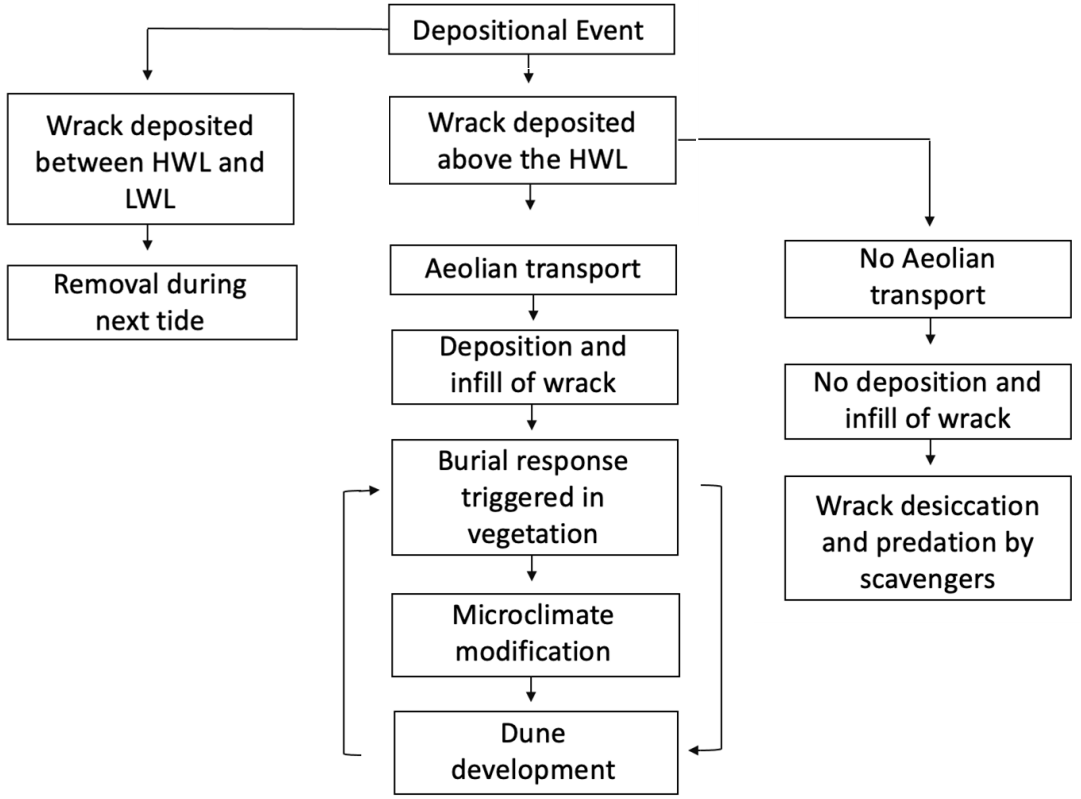
Photo Source: Schlichting and Gersten, 2000



Transport

Deposition

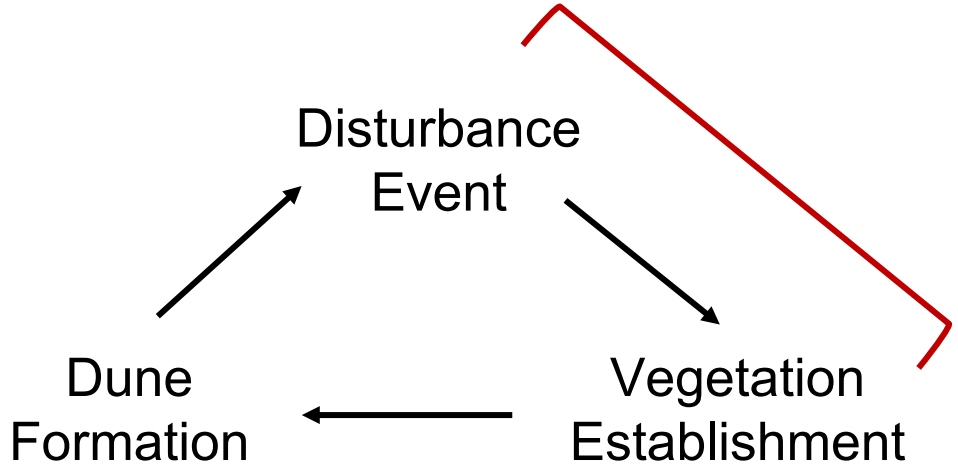
A Theoretical Synthesis



1). Vegetation Plantings (fast and expensive)

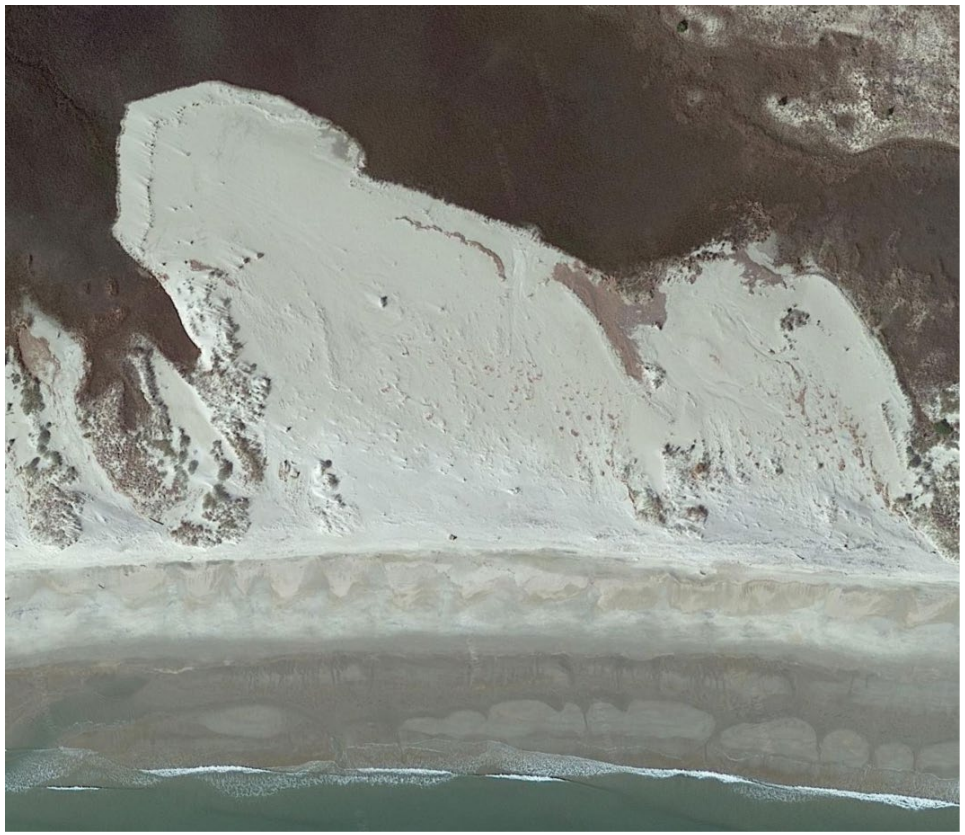
2). Allow natural propagation of vegetation (slow and cheap)

3). Wrack (fast and cheap)



Wrack Field Experiment #1:
Debordieu Island, SC

An overwash plain developed associated with high waves and water levels during a mid-latitude cyclone coinciding with an abnormally high tide (king tide) on 7 November 2021



Measured still water level of 2.6 m NAVD88, which was the 5th highest water level in 34-year record (Ellis 2022)

Deposited 1,440 m^2 of wrack on the washover plain

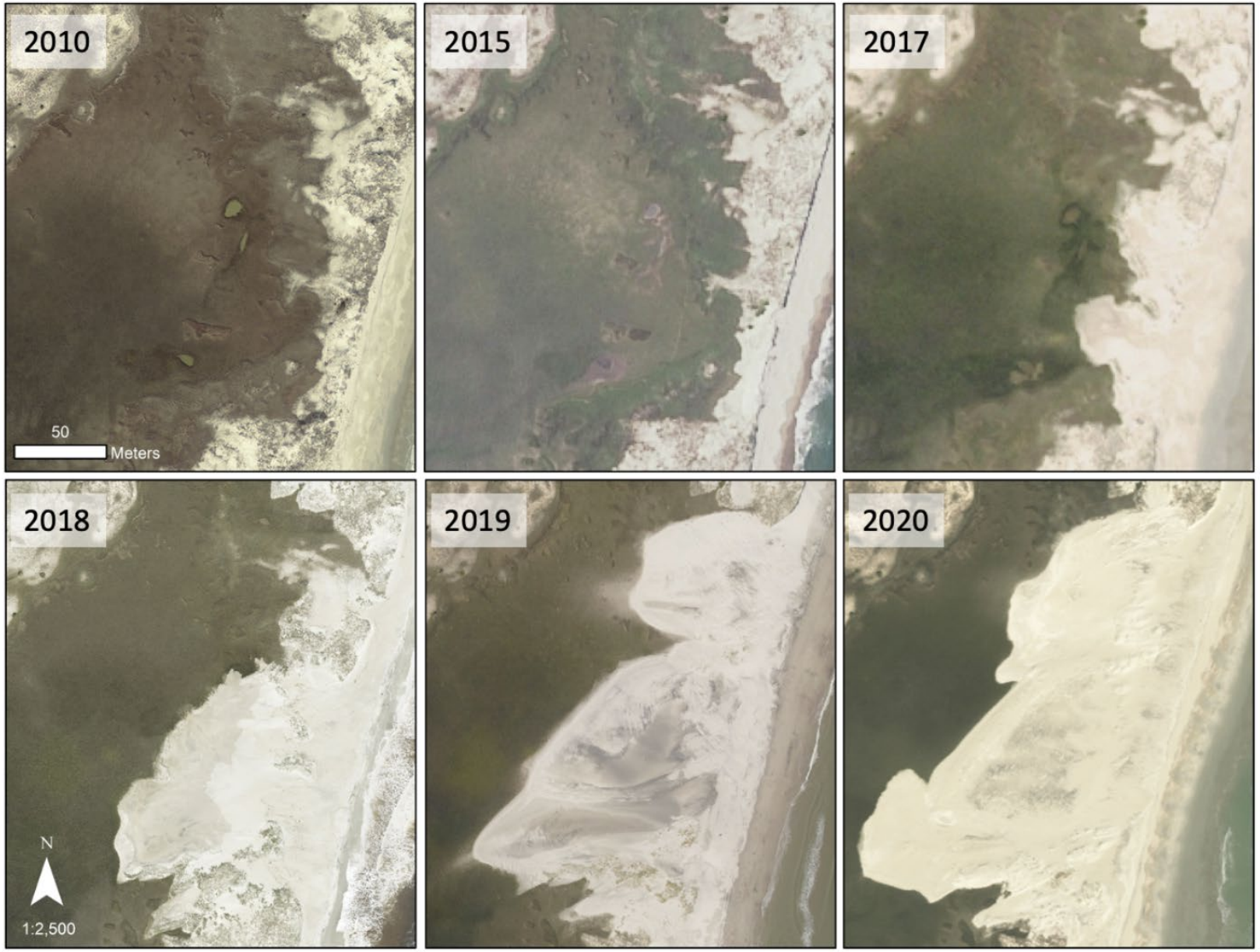
Washover Plain Evolution

Washover plays an active role in translating barrier islands landward (Dolan, 1972)

Aeolian processes can enhance or dampen the effect of landward translation

In the absence of surface roughness, washover plains can act as huge sediment sinks in a system.

The addition of wrack can have a positive roll in preventing volume loss.



Wrack Field Experiment #1:
Debordieu Island, SC

Time Scale Focus: Weeks to Months

30 wrack piles installed with erosion pins and studied for 8 months.

Hourly meteorological data collected from an *in situ* station.

Wrack: *Beach Aggradation via Trapping of Wind-Blown Sands*

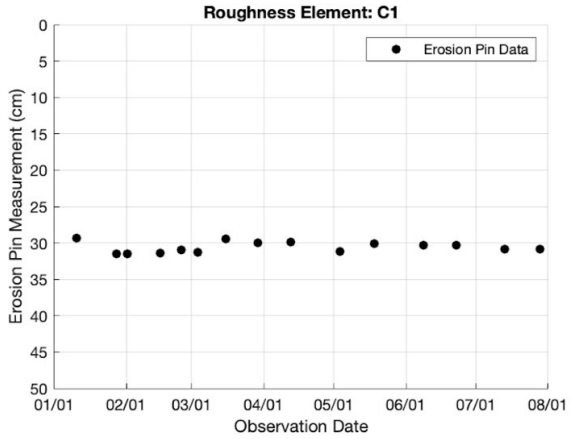
N 1:350

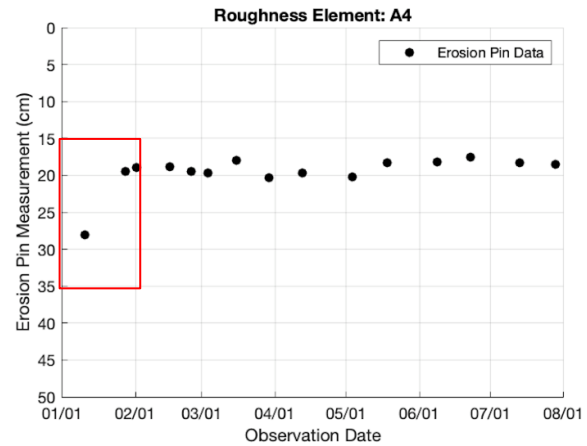
Wrack: *Modifier of Marine-Redistribution of Sediments*

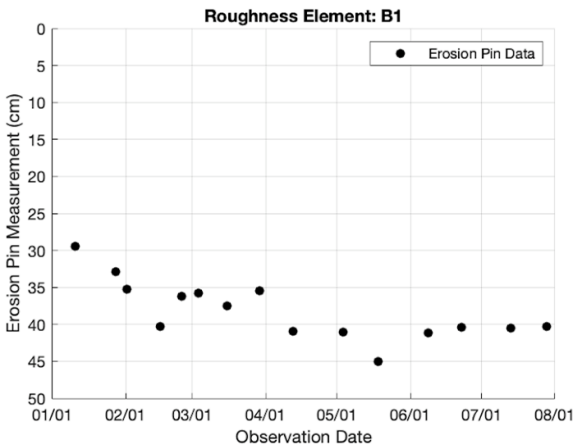
Pre-Event

Post-Event

N 1:350


Roughness Element: C1
Erosion Pin Data
Erosion Pin Measurement (cm)
0
5
10
15
20
25
30
35
40
45
50
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
Observation Date


Roughness Element: A4
Erosion Pin Data
Erosion Pin Measurement (cm)
0
5
10
15
20
25
30
35
40
45
50
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
Observation Date


Roughness Element: B1
Erosion Pin Data
Erosion Pin Measurement (cm)
0
5
10
15
20
25
30
35
40
45
50
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
Observation Date


10 Jan 2022
27 Jan 2022

Wrack Field Experiment #2:
ERDC Field Research Facility

Time Scale Focus: Minutes to Hours

27 September 2023

2 Small Field Experiments:

- to measure the rate of wrack pile infilling
- to measure flow reduction in the lee of the wrack pile

Wrack piles and instrumentation deployed during a falling tide.

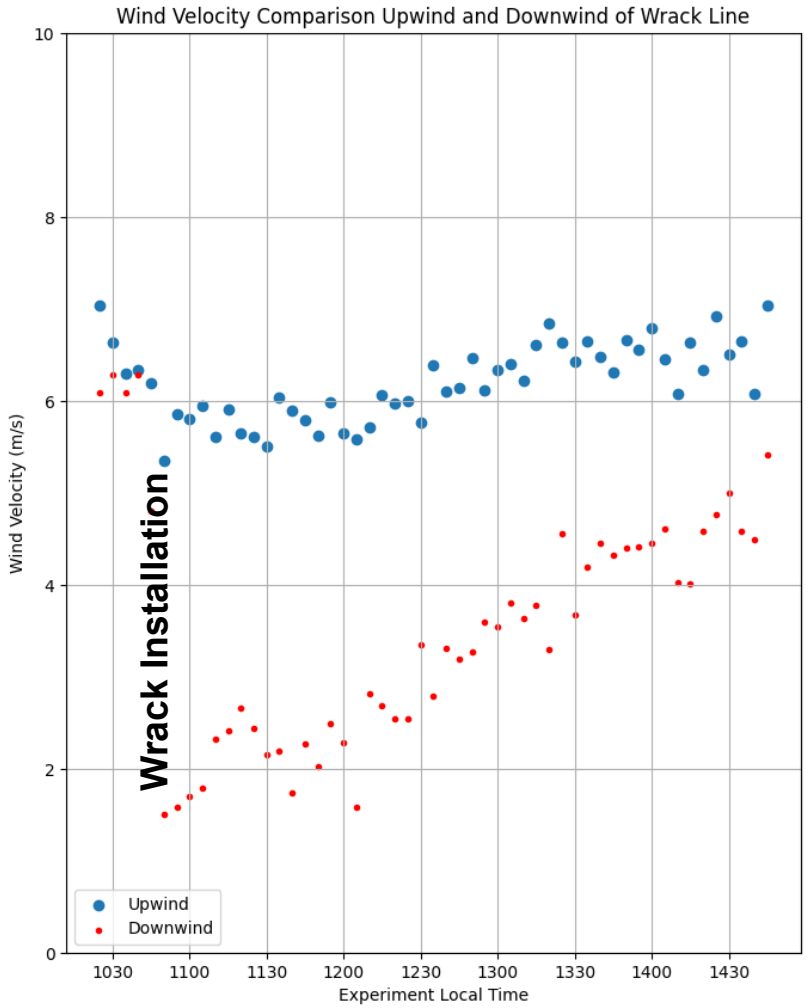
Wrack Field
Experiment #2: ERDC
Field Research Facility

Wrack Field Experiment #2: ERDC Field Research Facility

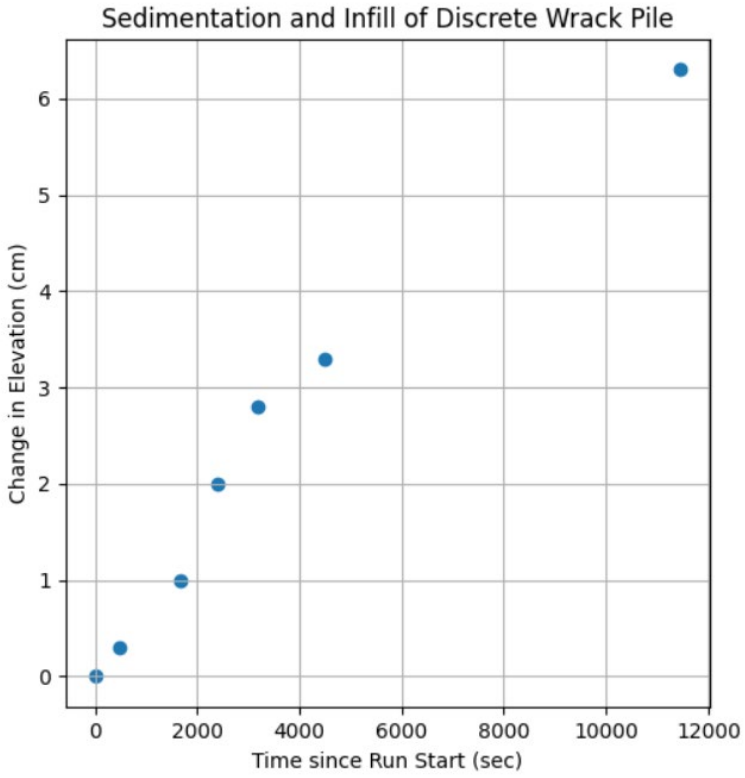
2 ATMOS 22 Sonic Anemometers deployed 0.5 m in advance of the wrack pile crest and 0.5 m in the lee of the wrack pile crest.

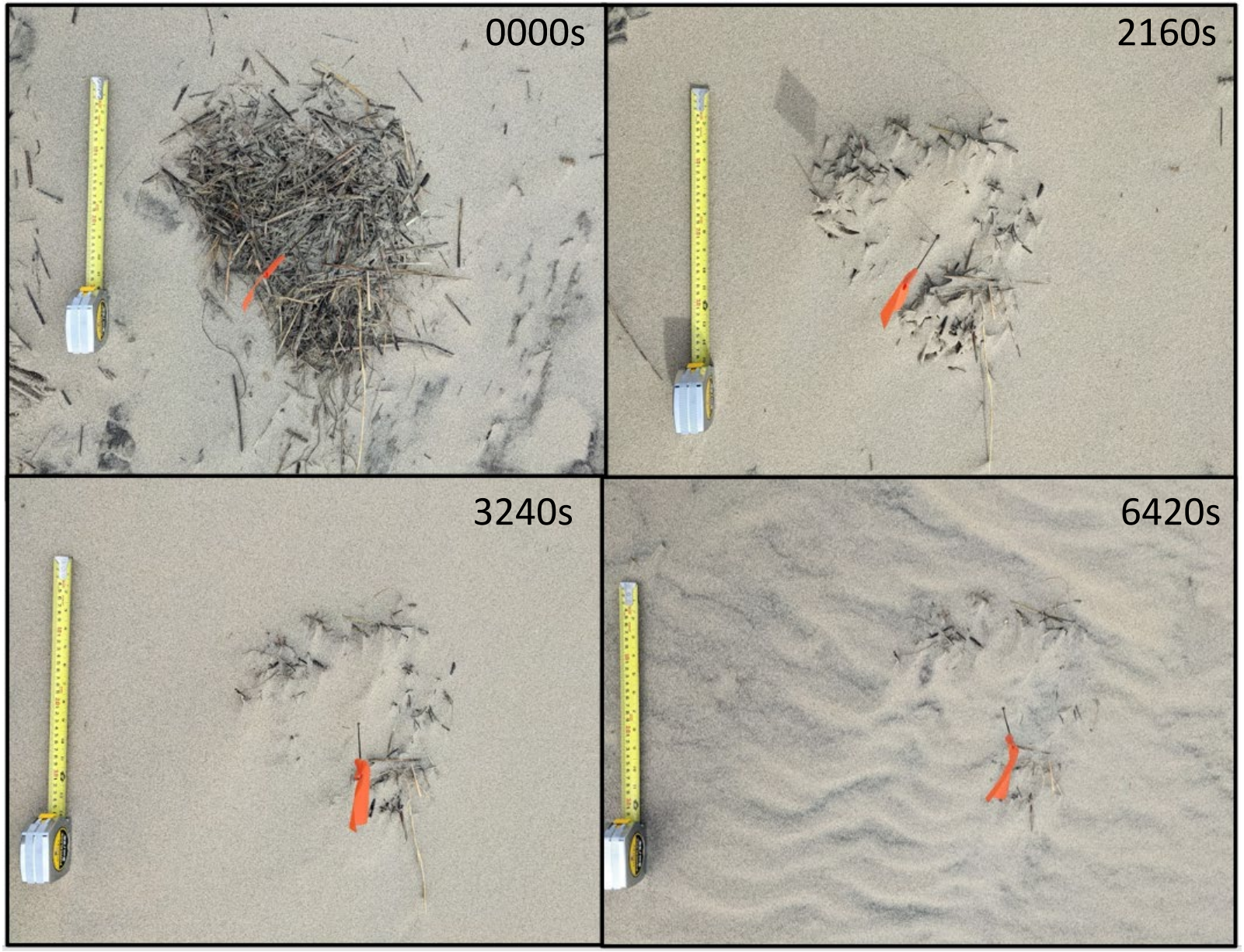
Measurements collected for ~3 hours at 5 min sampling interval

Wrack Field Experiment #2: Measurements



Wrack Field Experiment #2: Measurements (cont.)





Wrack Field Experiment #2: Conclusions

Shear velocity reduction in the lee of wrack piles is dynamic and is modified by sediment infilling.

Sediment infilling takes place on an order of hours under steady transport conditions.

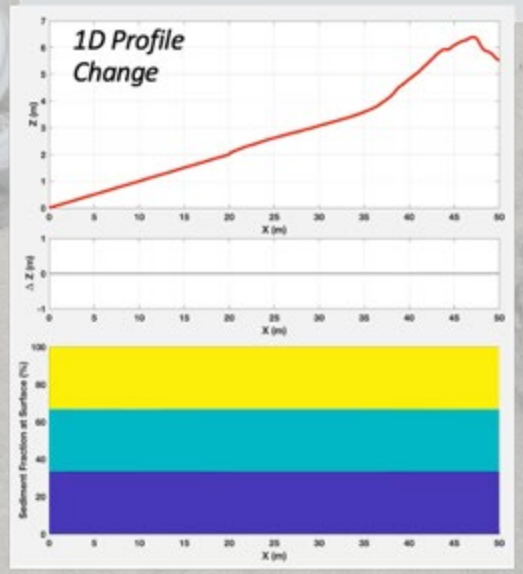
Further field work should more rigorously measure on the second to sub second scale while measuring infilling mass

AEOLIS

Multi-fraction aeolian sediment transport and morphology change model for coastal systems

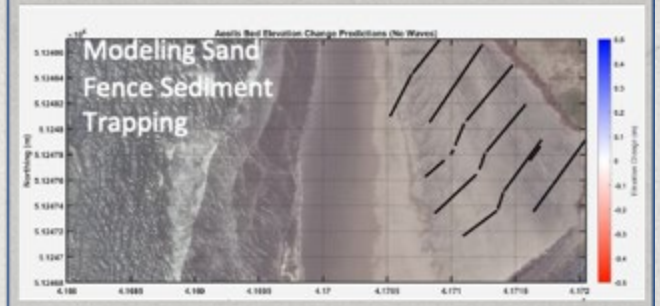
Local Coastal Foredune Growth Patterns and Mechanisms

2D Profile Change

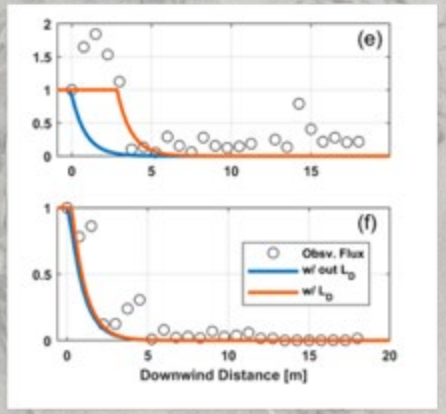


Regional+ Scale Assessments of Aeolian Transport Rates

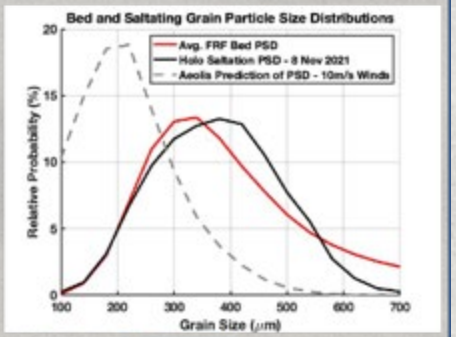
NNBF and Coastal Management



Scientific Exploration

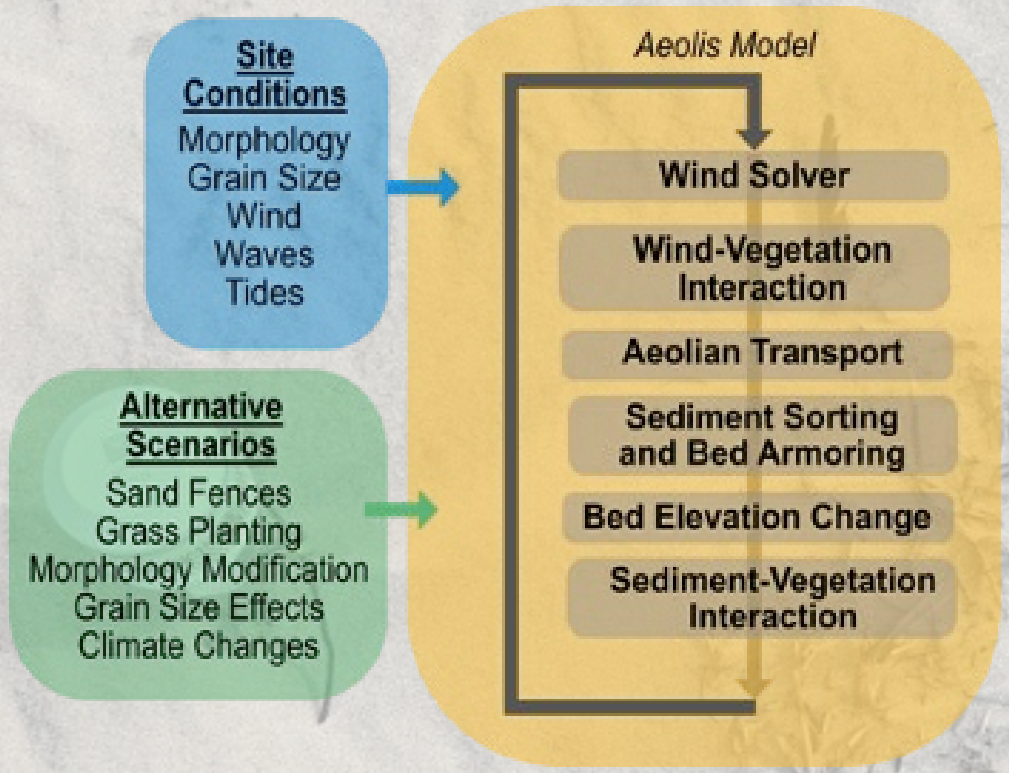


Multifraction sediment pickup



Vegetation shear coupling

AEOLIS



Wrack Parameterization in AeoLis

Renken (2015) compared the flow reduction in the lee of short grass, tall grass, and shrubs.

AeoLis uses the shrub field data collected from Renken (2015) to reduce the shear velocity values in the lee of the wrack pile by 85%.

AEOLIS

Modeling Approach:

1. 1D Proof on Concept Simulations applied to SC/Field Site 1

2. 2D Hindcast Simulations applied to SC/Field Site 1

3. Exploratory regional scale simulations

Wrack Parameterization in AeoLis

Renken (2015) compared the flow reduction in the lee of short grass, tall grass, and shrubs.

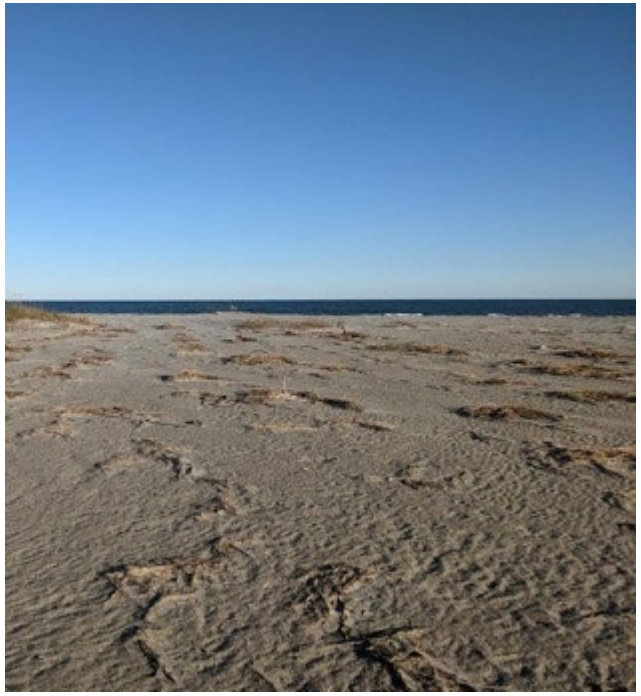
AeoLis uses the shrub field data collected from Renken (2015) to reduce the shear velocity values in the lee of the wrack pile by 85%.

Initial 1D Run

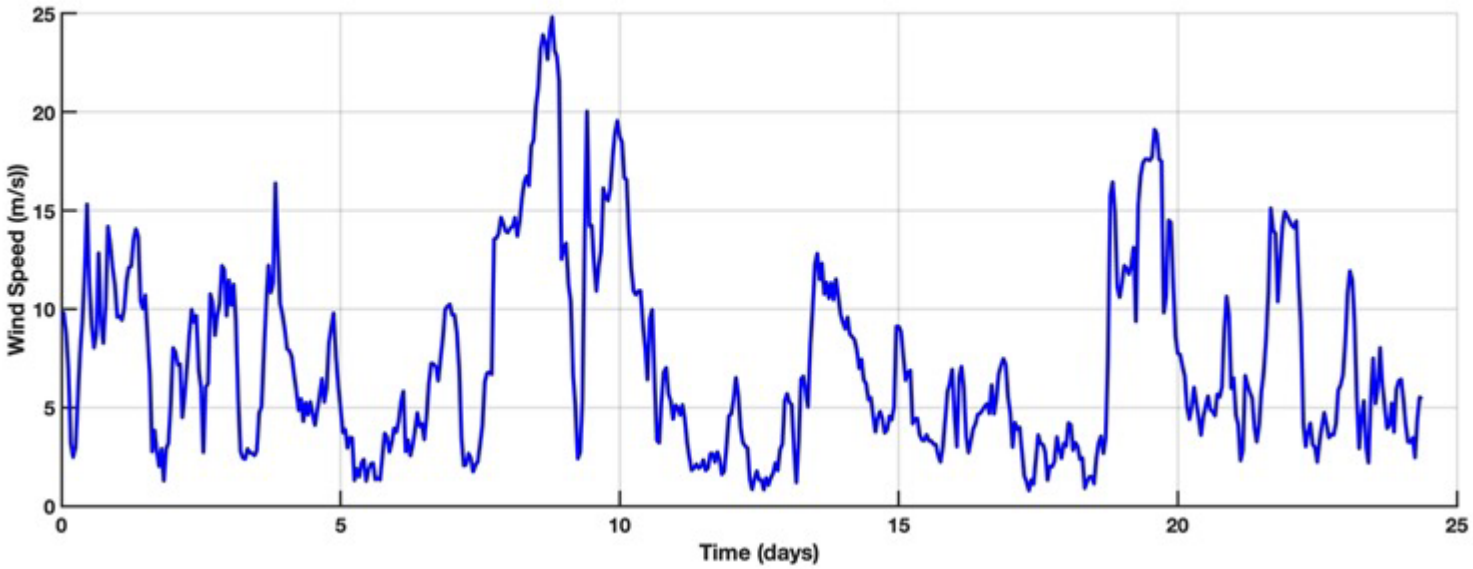
15 cm wrack pile used with wind speeds from Jan 2022

Winds assumed to be shore normal

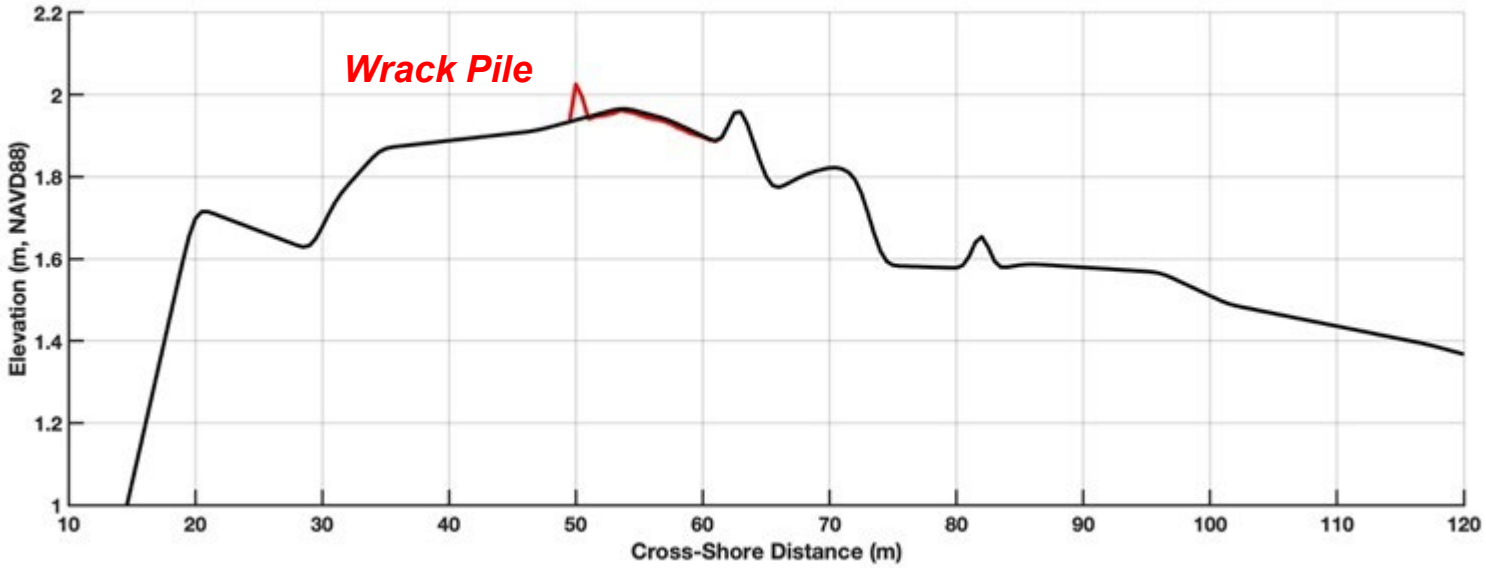
No Tides



Wind Time Series



Topography Grid

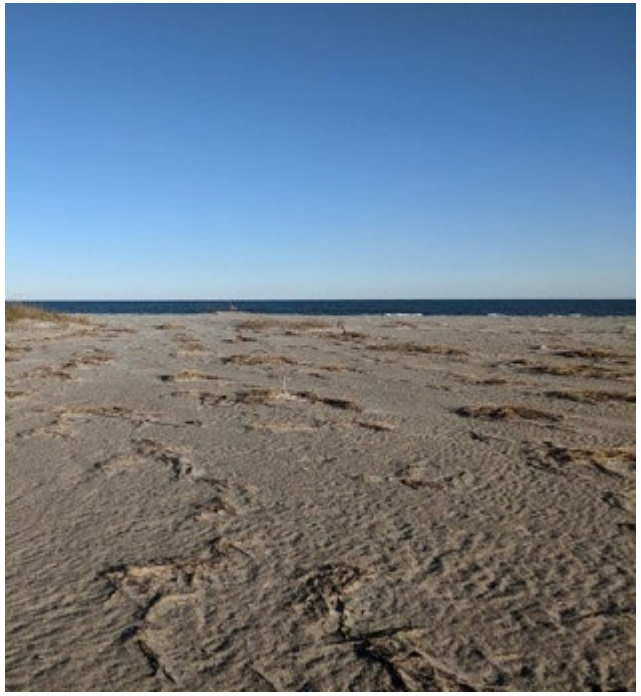


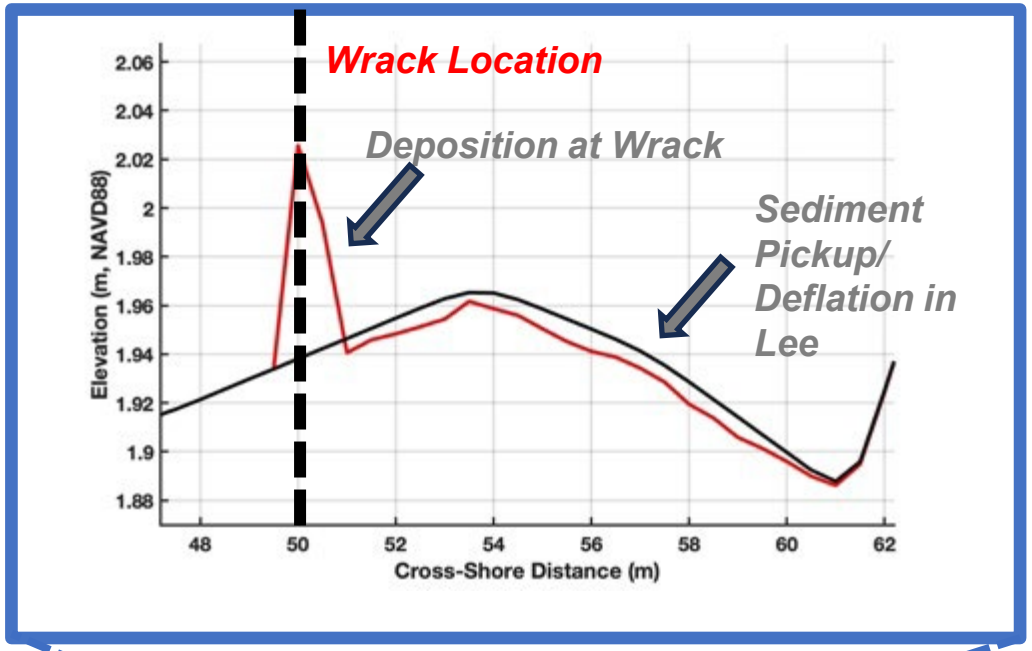
Initial 1D Run

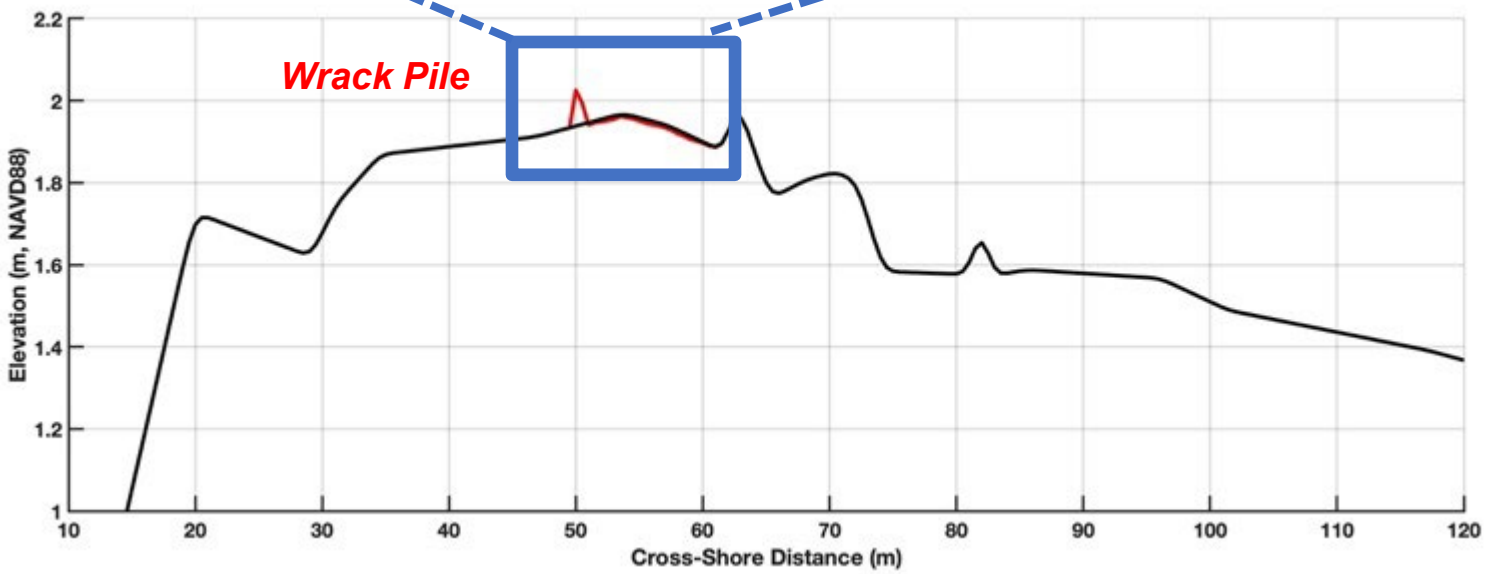
15 cm wrack pile used with wind speeds from Jan 2022

Winds assumed to be shore normal

No Tides







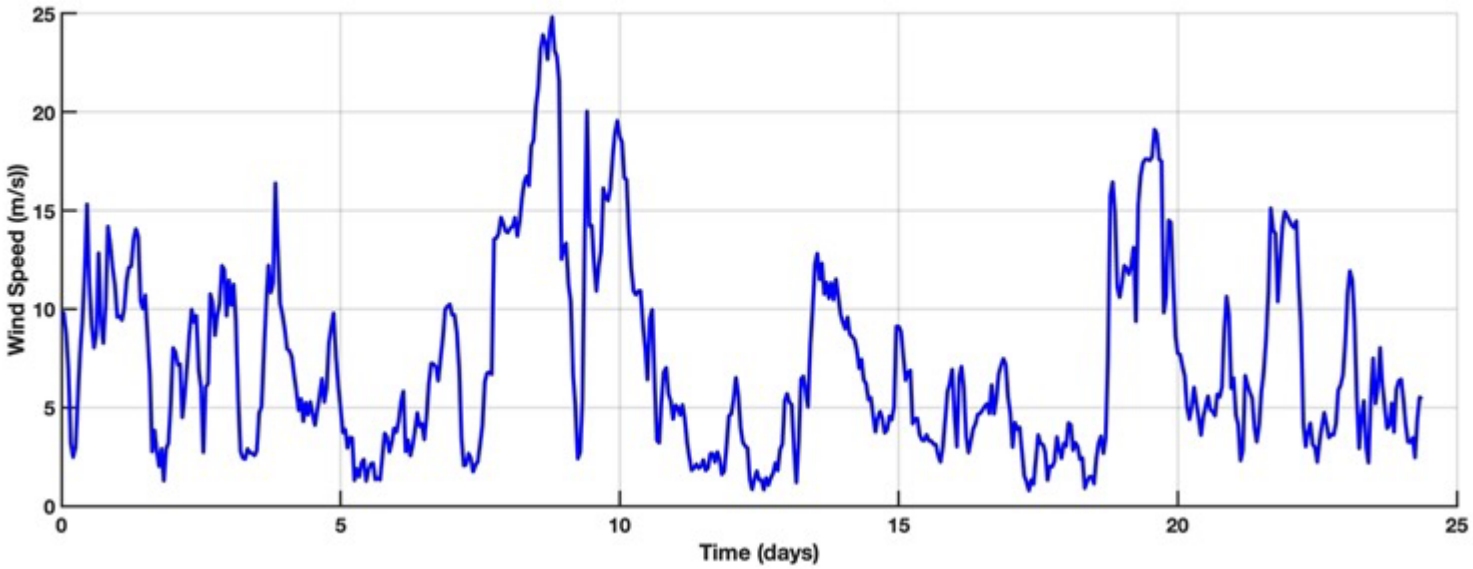
Additional 1D Runs – ***Adding Capabilities***

15 cm wrack pile used with wind speeds from Jan 2022

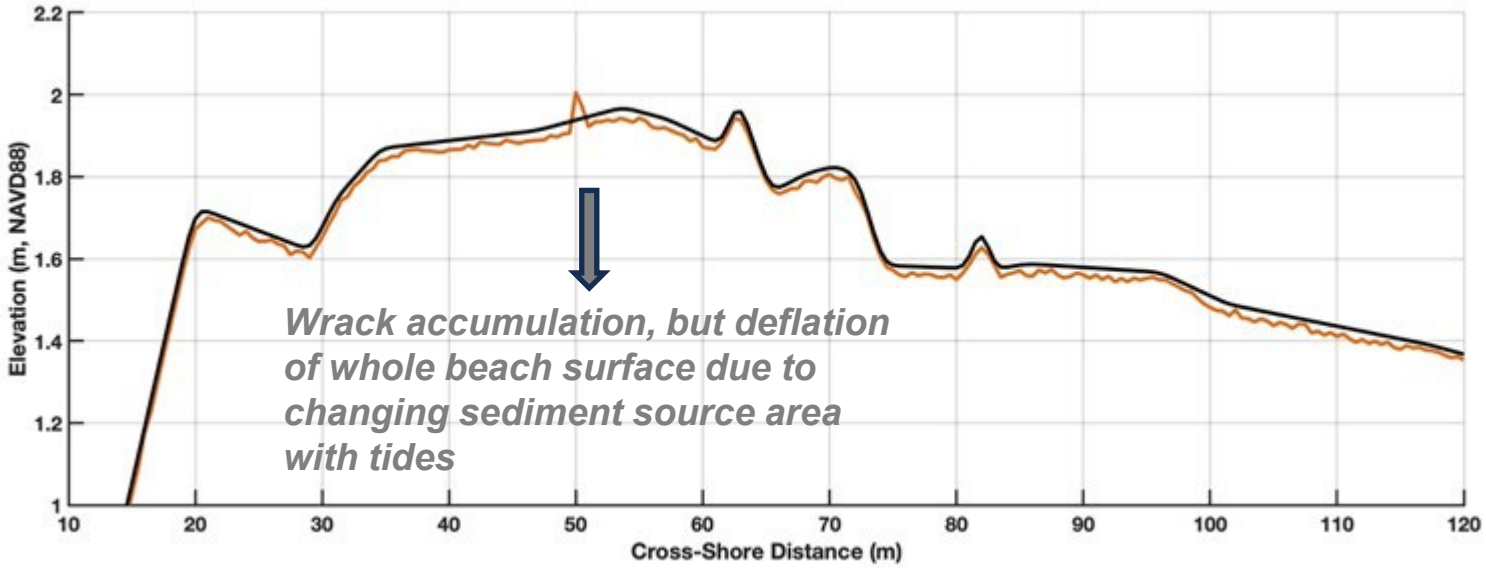
Winds assumed to be shore normal

Add Tides

Wind Time Series



Topography Grid

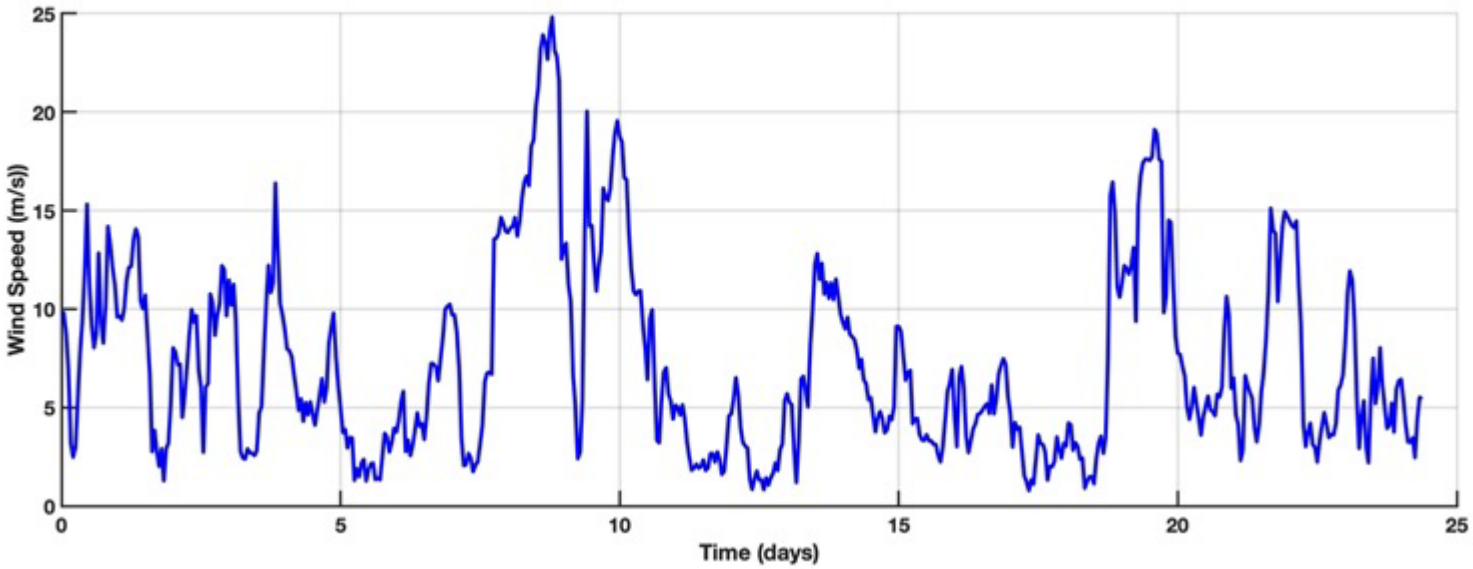


Additional 1D Runs – ***Adding Capabilities***

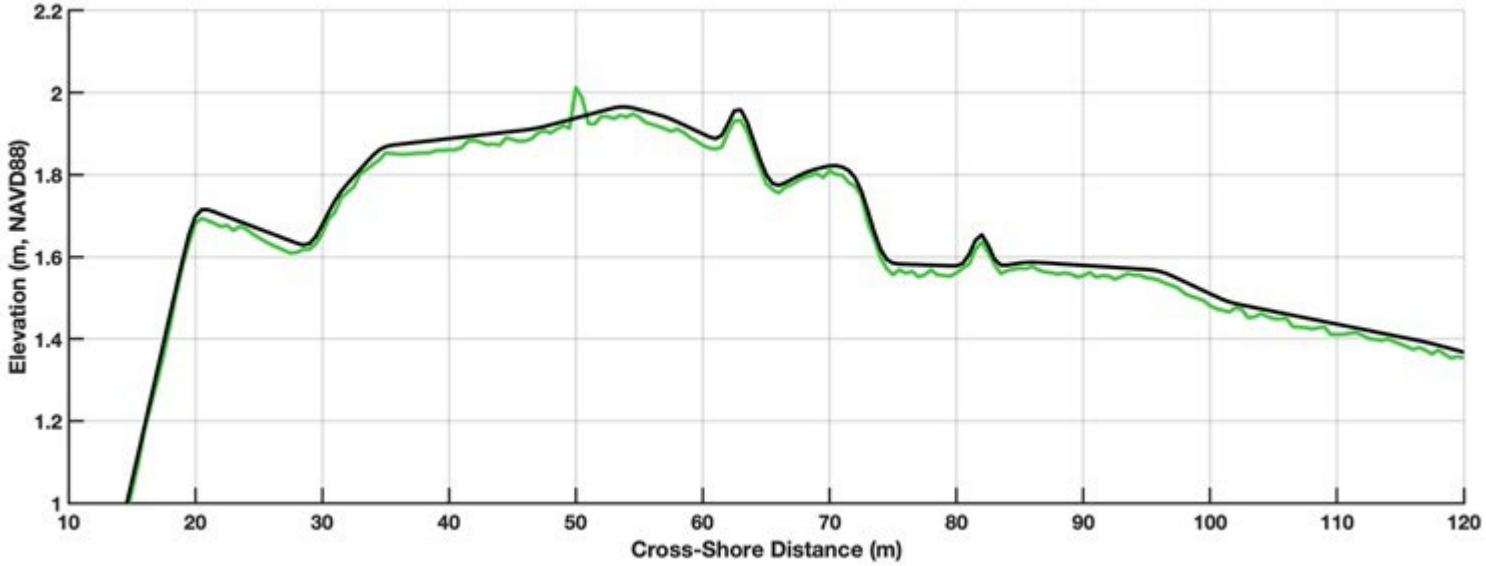
15 cm wrack pile used with wind speeds from Jan 2022

Variable Wind Directions

Wind Time Series

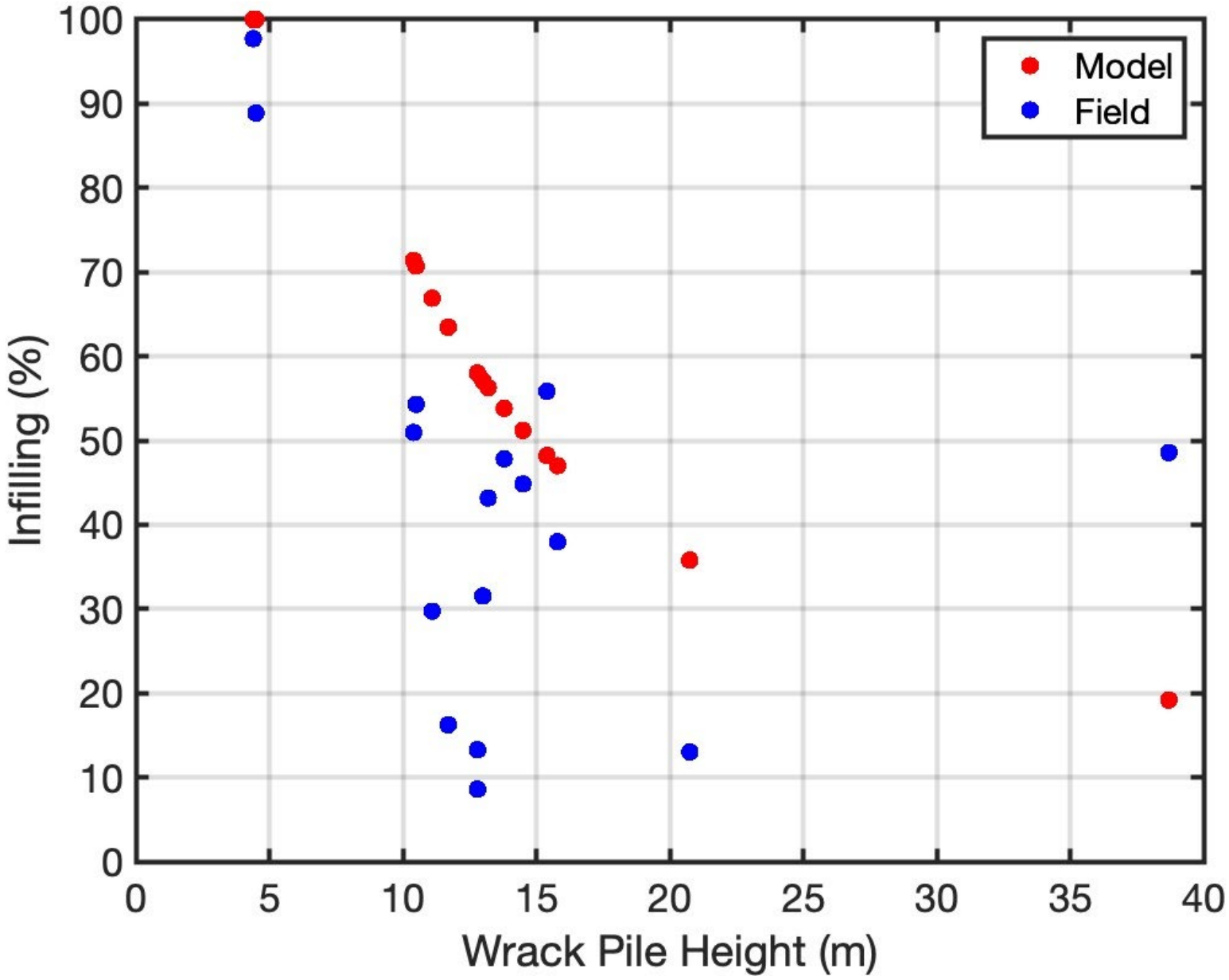


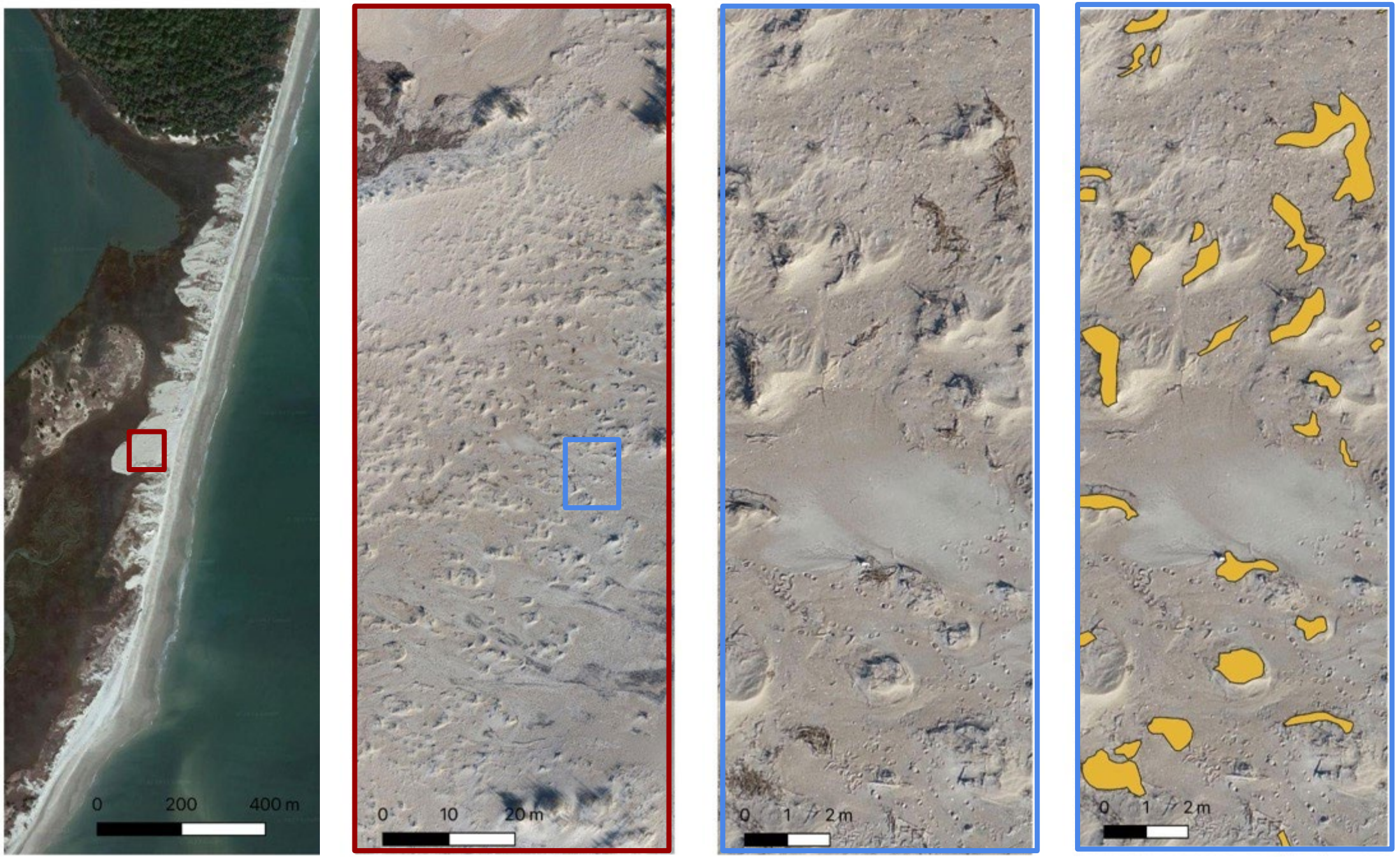
Topography Grid



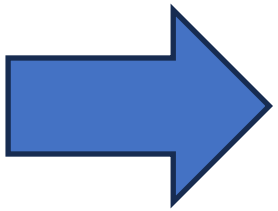
In 1D case studies, model runs are overpredicting wrack pile infilling in all cases.

Disconnection could be driven by complex interactions of adjacent wrack piles or other complex changes in surface roughness.

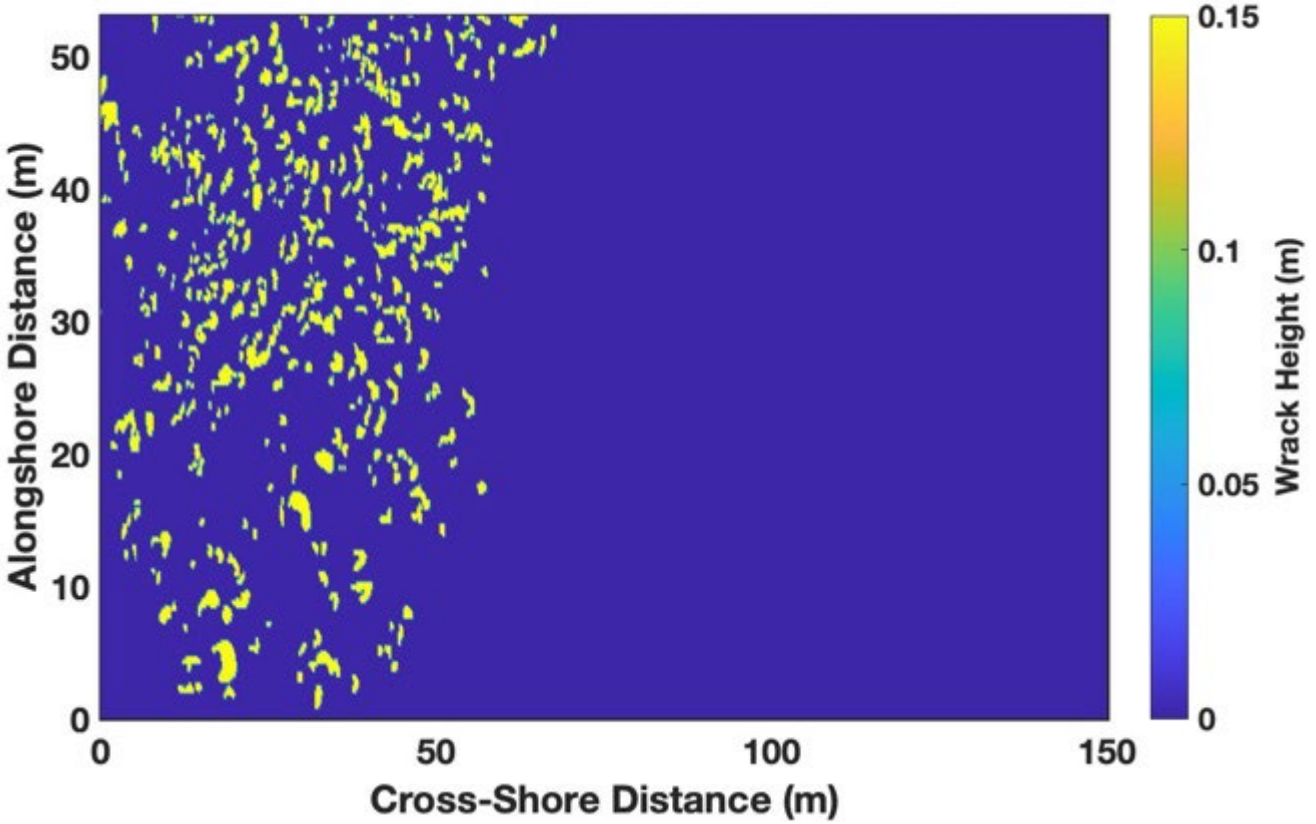



Regional Map
Wrack Field
Local Wrack Dep.
Digitized Wrack
0 200 400 m
0 10 20 m
0 1 2 m
0 1 2 m

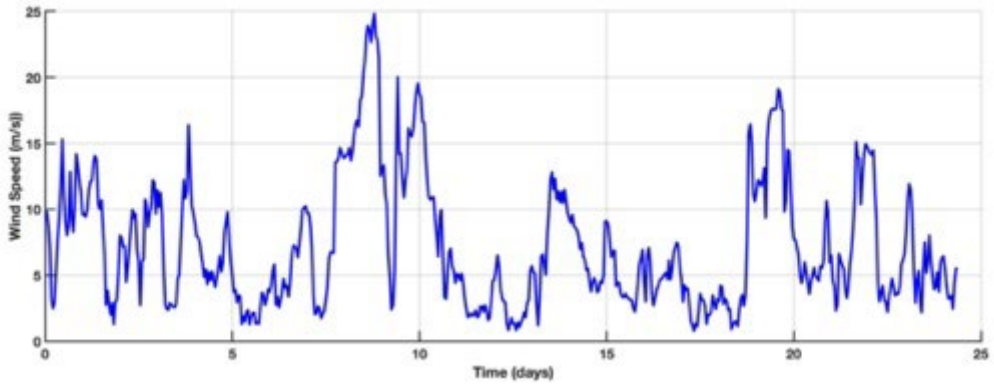
Wrack Field



Beach *Ocean*

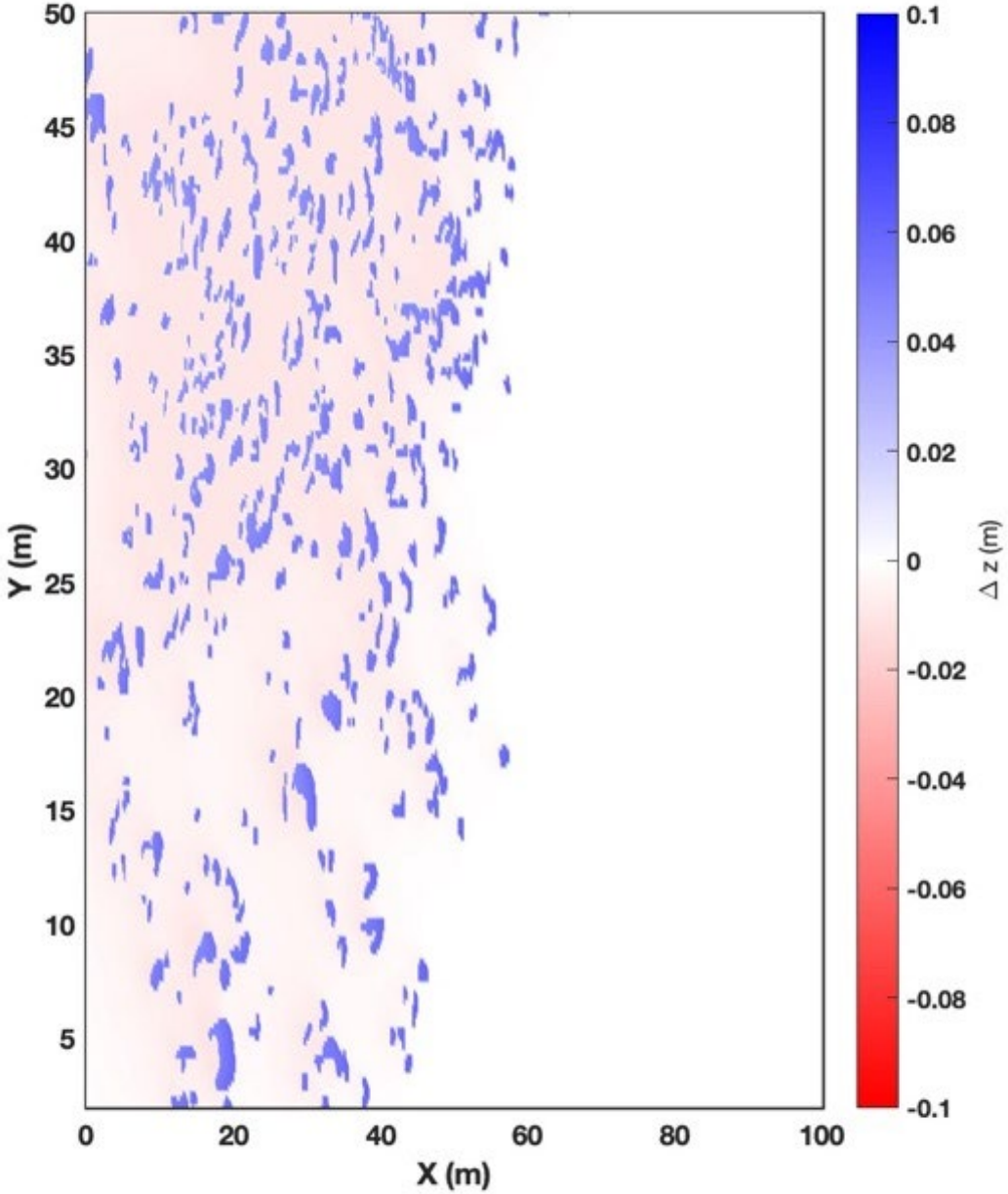


Wind Time Series



Digitized Wrack

2D Grids with 20cm resolution used to simulate accretion and erosion patterns on beach at field site



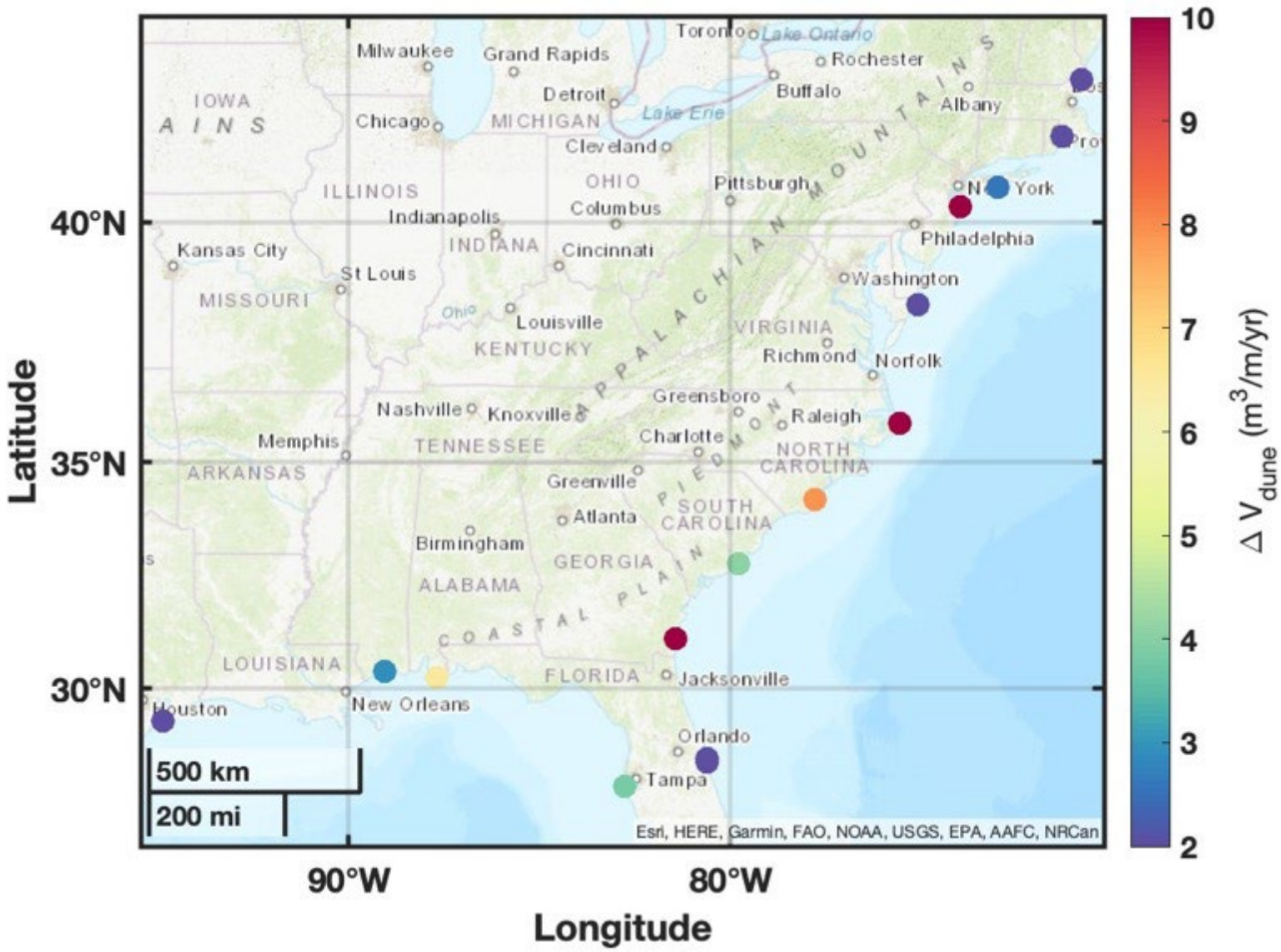
Exploratory Regional Scale 1D Simulations

1 Year of winds, waves and tides used to force AeoLiS at select locations across US East and Gulf Coasts

Synthetic profile based on measured morphometrics

Sandsnap grain size

Net Dune Growth – No Wrack

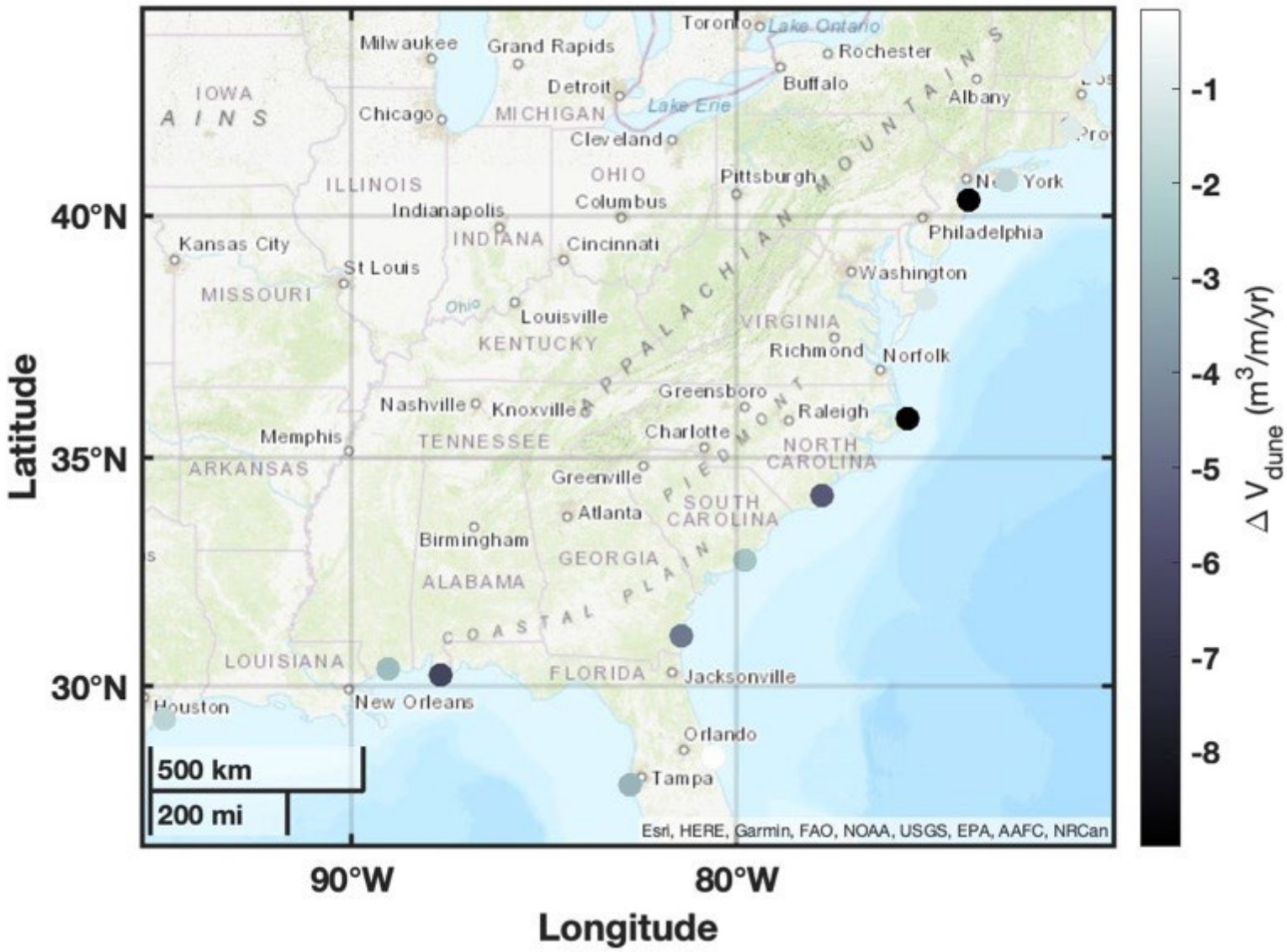


Exploratory Regional Scale 1D Simulations

Adding wrack on the upper beach can modify transport gradients, including trapping wind-blown sand on the upper beach and re-allocating sediment that would be deposited in the vegetated dune lower on the beach profile

Trends are highly dependent on local site properties

Difference in Result Including Wrack



AEOLIS

CMS

Wrack: *Modifier of Marine-Redistribution of Sediments*

Pre-Event

Post-Event

N 1:350


AEOLIS
CMS
Photo credit: Patrick Hesp

Drivers in Vegetation Emergence

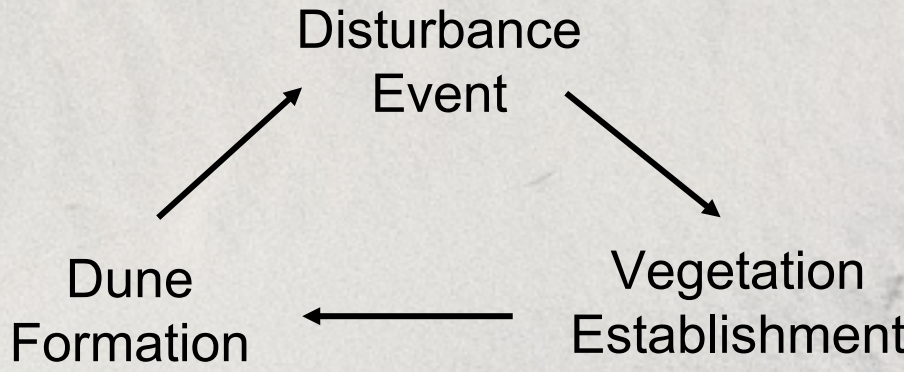
Max Veg Emerge to Erosion Pin Change
R^2 = 0.011
P value = 0.669

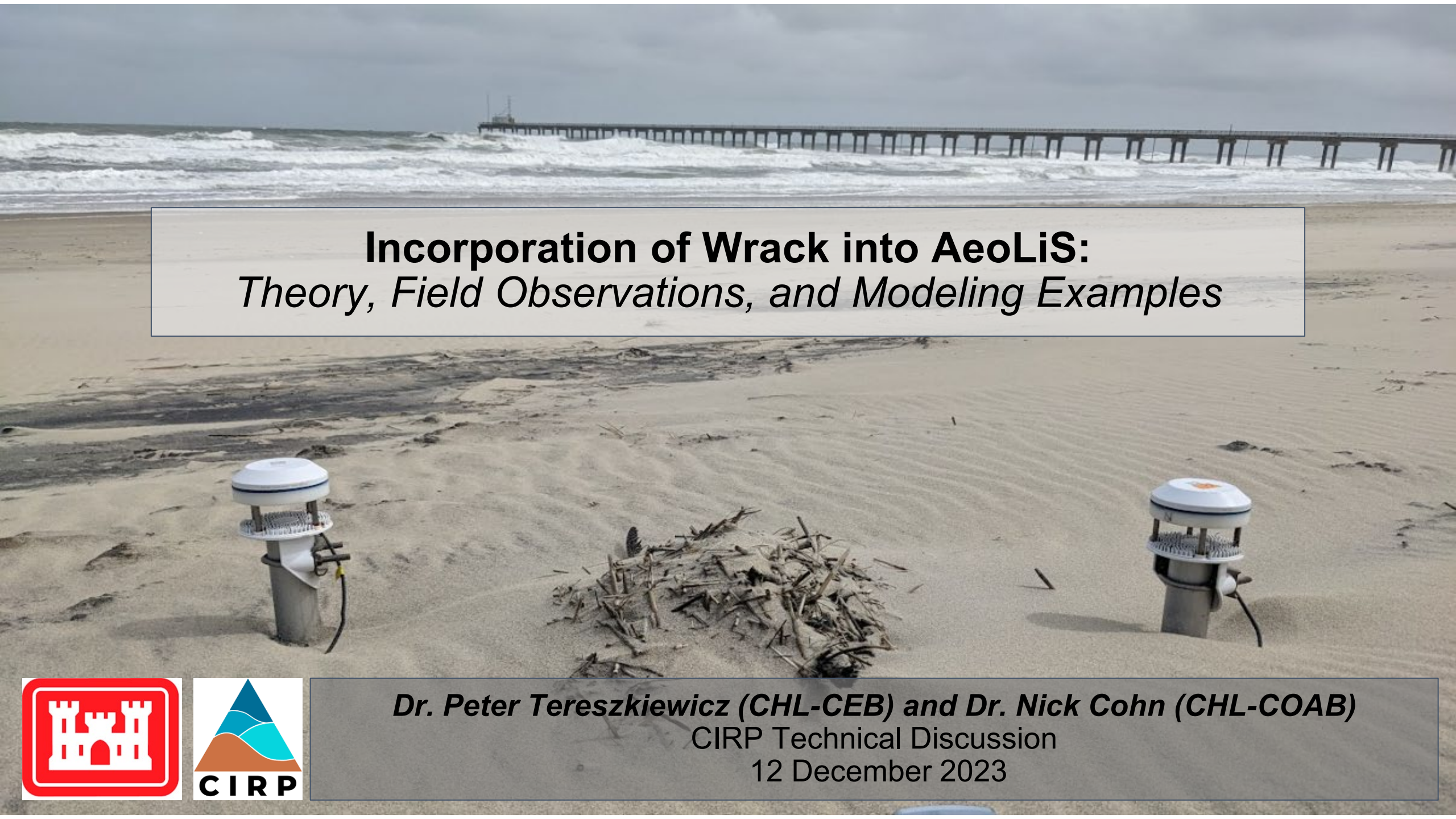
Max Veg Emerge from High Tide Line
R^2 = 0.00147
P value = 0.876

Max Veg Emerge to Wrack Pile Size
R^2 = 0.00386
P value = 0.744

Conclusions

- Beach wrack is an effective surface roughness element that plays critical roles in dune formation and vegetation establishment.
- Initial incorporation into the AeoLis captures sediment infilling capability; however, further work to refine the magnitude of infilling and explore the height dependence on the flow reduction.
- While this presentation focused on the incorporation of wrack into AeoLis, there is the capability to expand this work incorporate wrack into CMS and GenVeg models moving forward.
- This modeling work is being further supplemented with field work from other EWN projects.





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CIRP Technical Discussion

12 December 2023