GRAIN SIZE INPUT NEEDS FOR SIMULATING AEOLIAN TRANSPORT ON SANDY BEACHES

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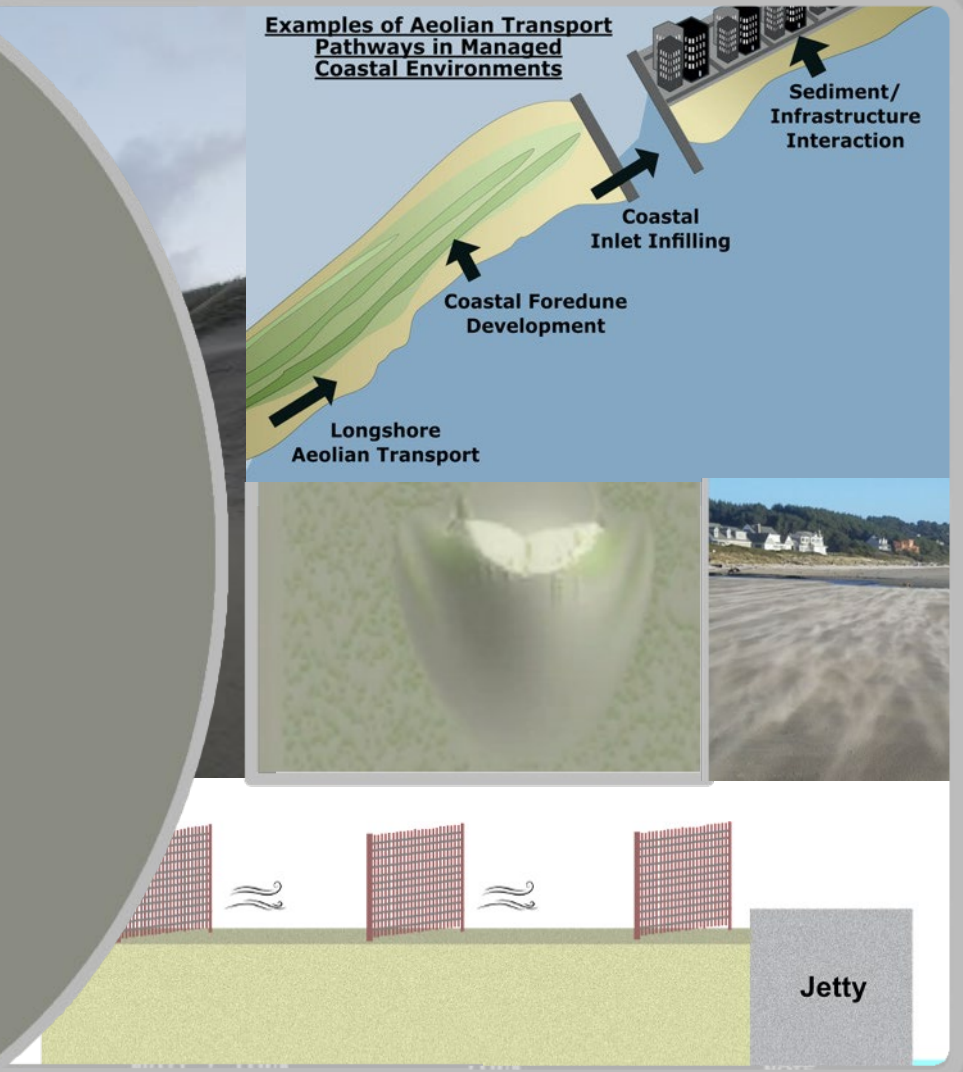
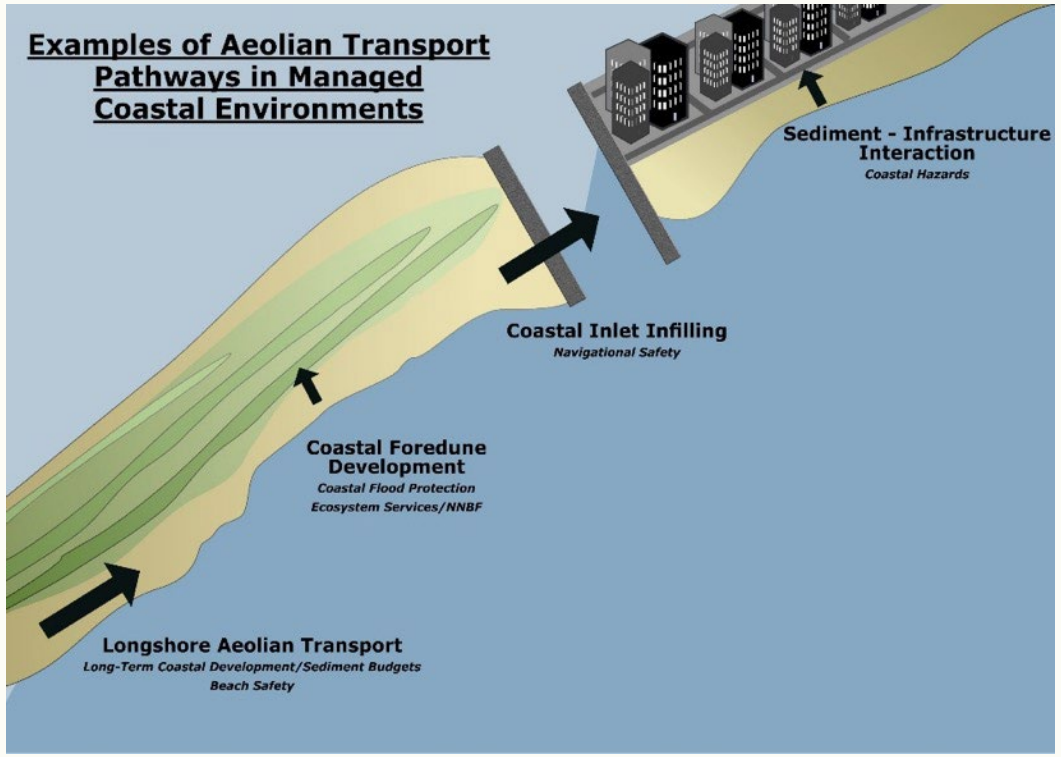
ERDC CHL, Coastal Observations and Analysis Branch

CIRP Technical Discussion
14 Dec 2021



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**

Outline

Primary Research Question for Today's Technical Discussion:

Does having more field data for input to model result in a better answer? Is a D50 value sufficient for aeolian transport modeling?

1. Theory/Approach Used by Aeolis to Simulate Multifraction Transport

2. Simulations Applied to Data Rich + Complicated Field Site (FRF)

3. Scale to ~Nationwide Using Sandsnap database

Model Processes

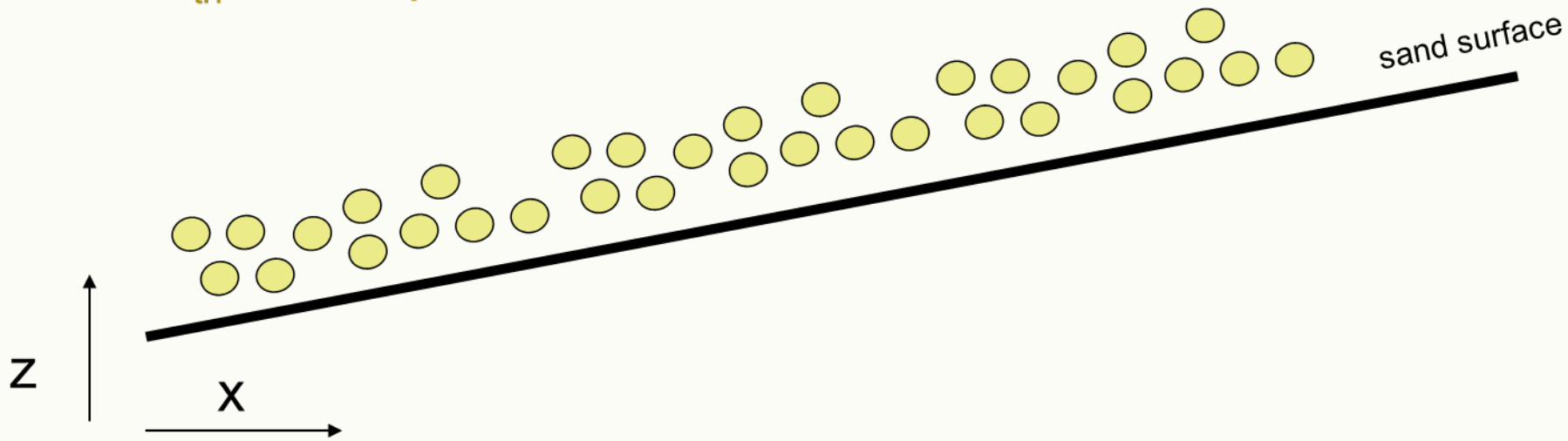
wind
(u)

$u < u_{th}$ - no transport

$u \geq u_{th}$ - transport

Factors that Effect Threshold Velocity:

- Grain Size
- Moisture
  - Precipitation
  - Wave Runup
  - Groundwater
  - Humidity
- Bedslope Effects
- Salt Crusting

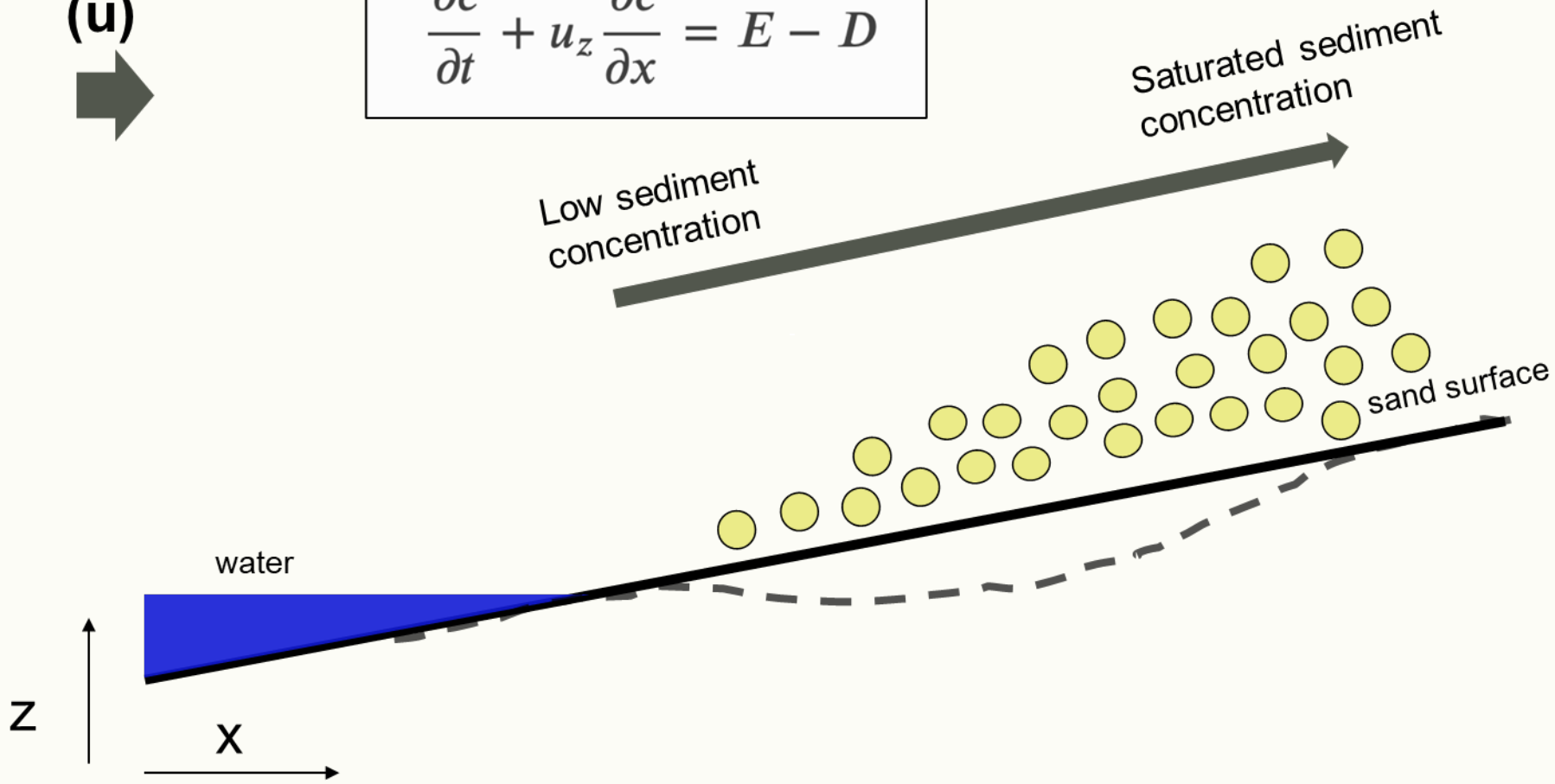


Model Processes

wind (u)

Advection Equation

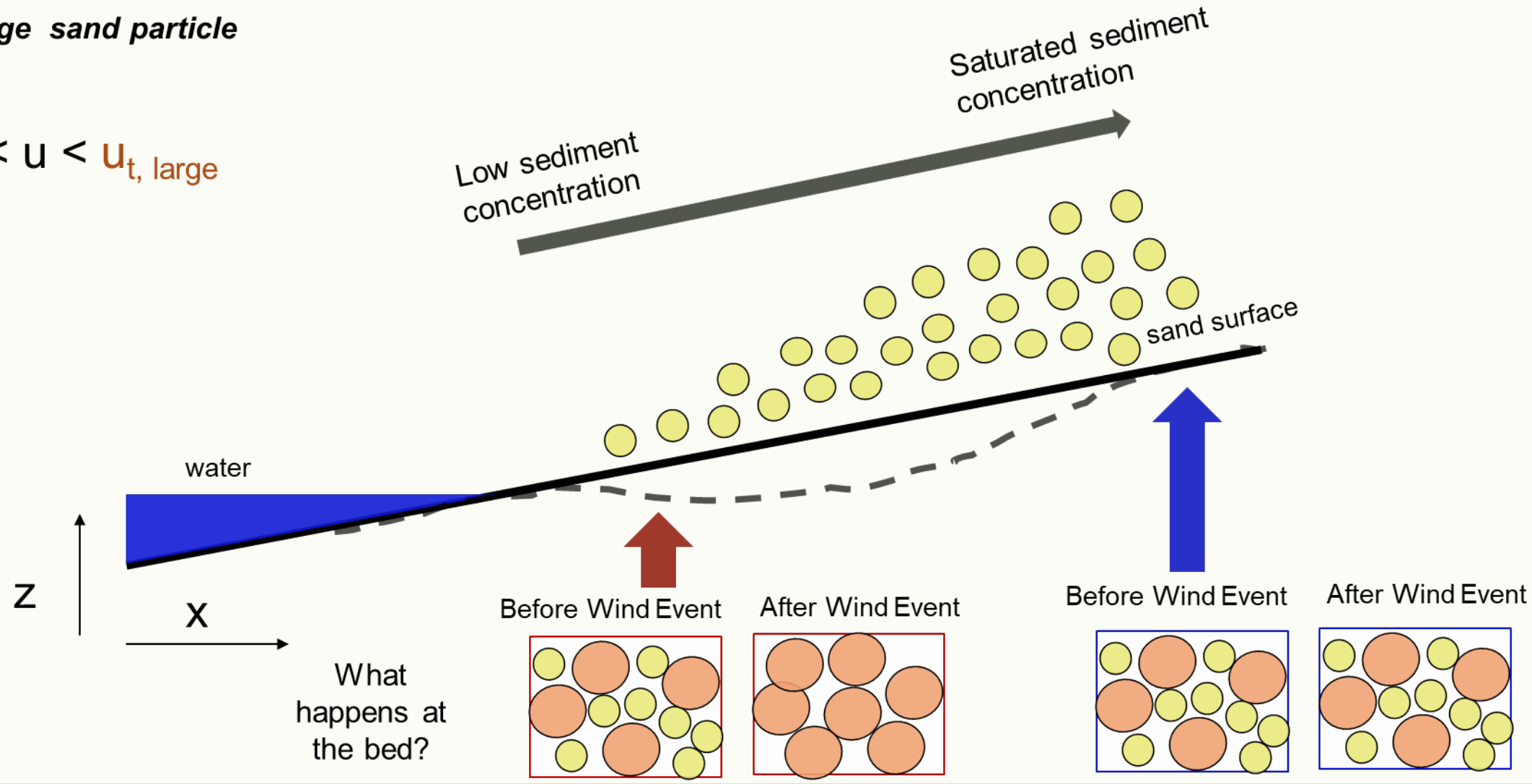
$$\frac{\partial c}{\partial t} + u_z \frac{\partial c}{\partial x} = E - D$$

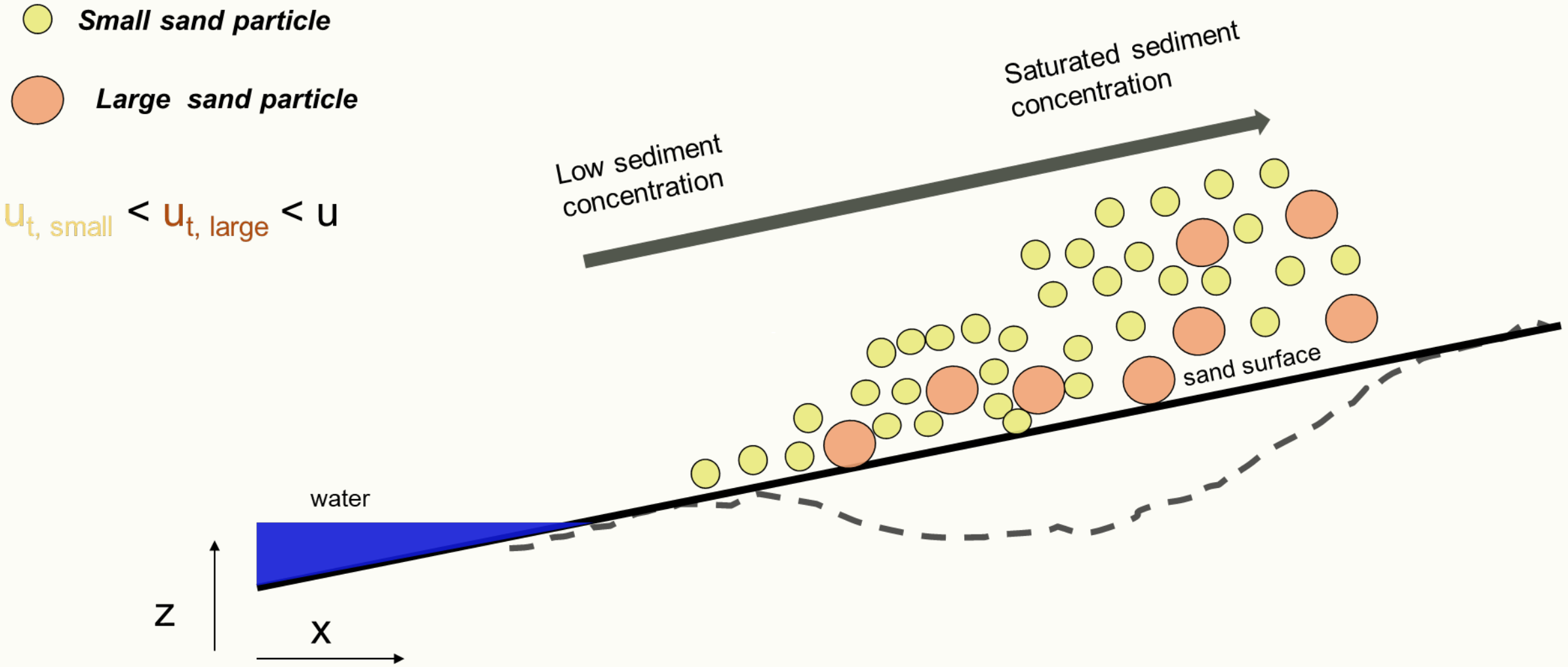


Small sand particle

Large sand particle

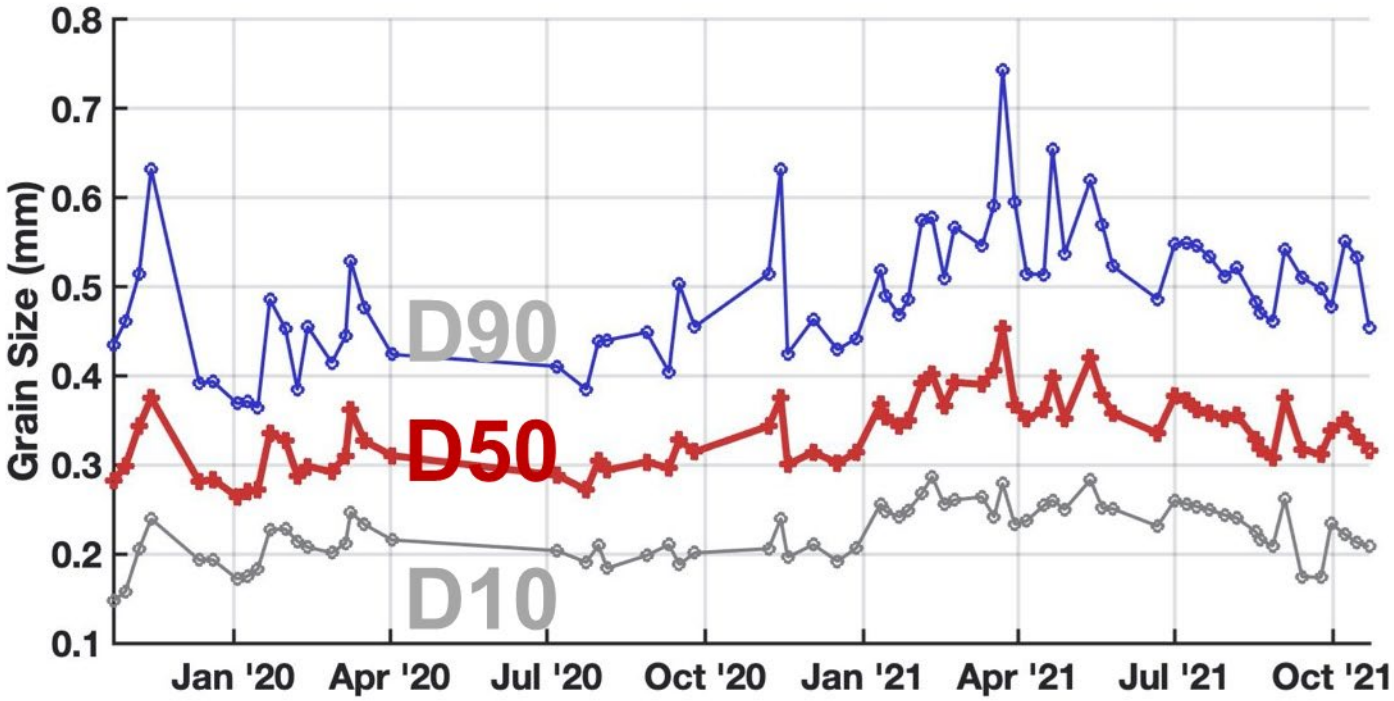
$u_{t,\,small} < u < u_{t,\,large}$

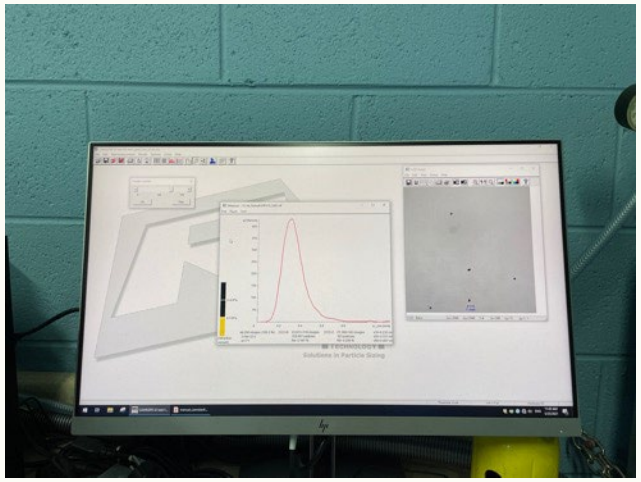


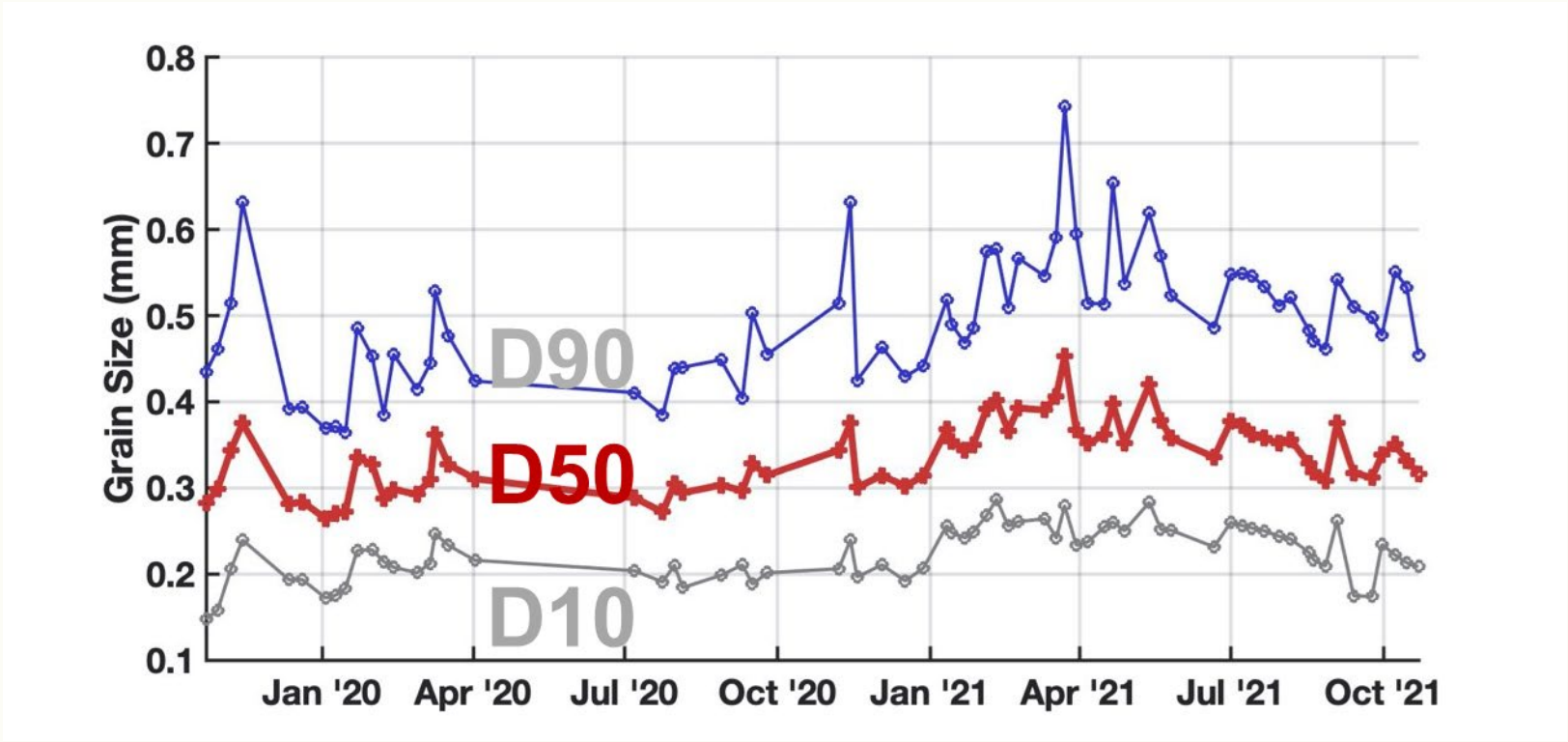

Small sand particle
Large sand particle
$u_{t,\,small} < u_{t,\,large} < u$
Saturated sediment concentration
Low sediment concentration
sand surface
water
z
x

Model Application 1: *Field Research Facility (Duck, NC)*


0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Grain Size (mm)
D50
Jan '20
Apr '20
Jul '20
Oct '20
Jan '21
Apr '21
Jul '21
Oct '21


0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Grain Size (mm)
D90
D50
D10
Jan '20
Apr '20
Jul '20
Oct '20
Jan '21
Apr '21
Jul '21
Oct '21

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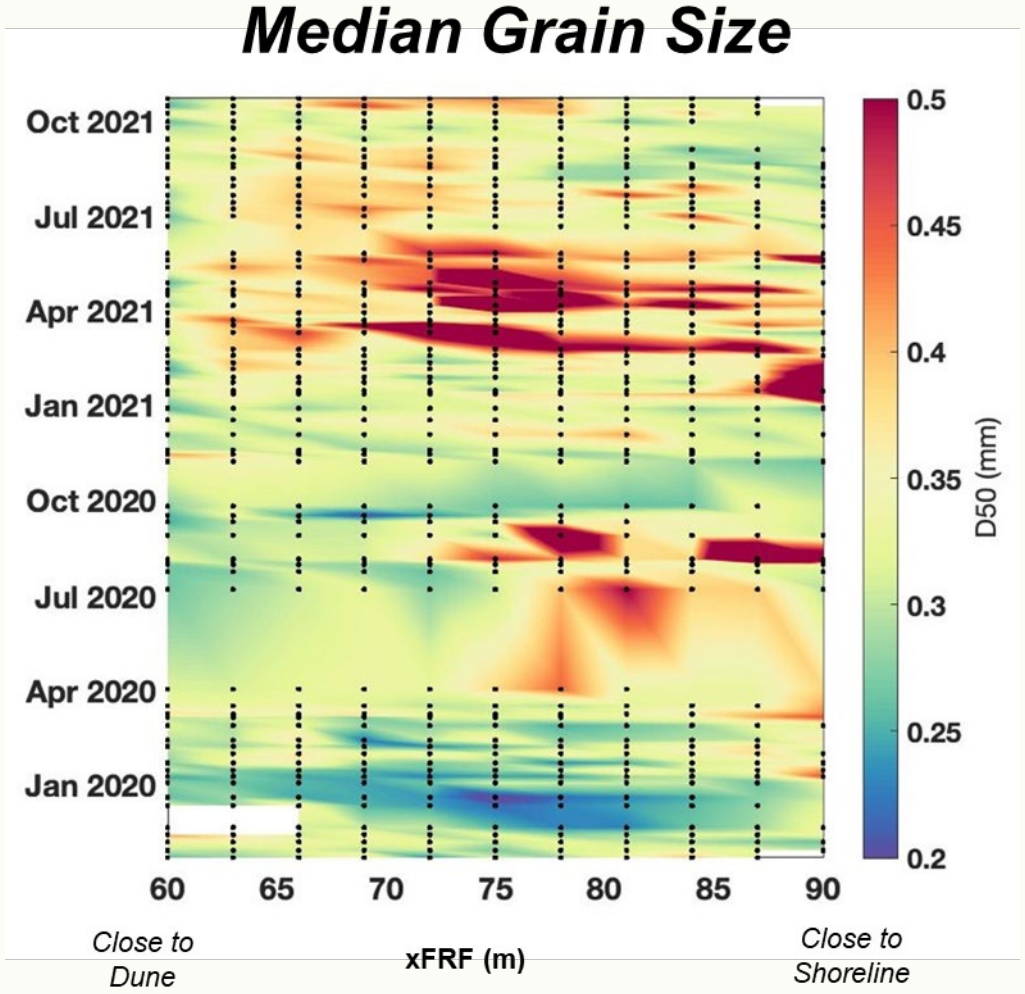

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Morphology
(Daily topography from dune lidar)

Winds

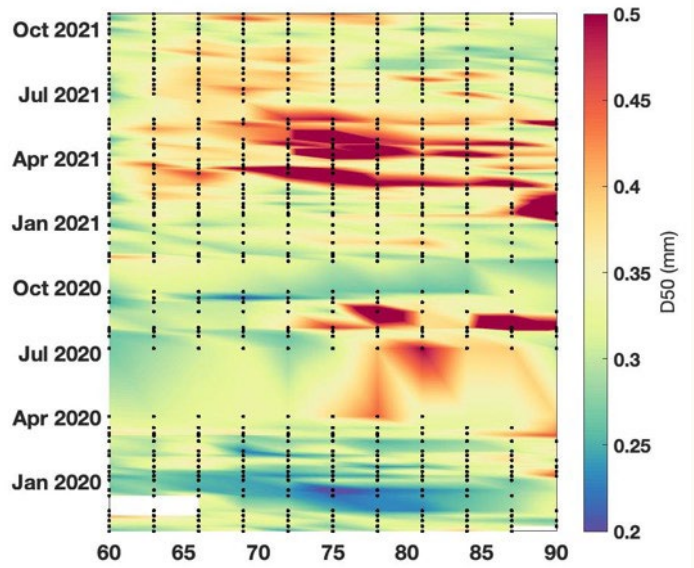
Waves

Tides

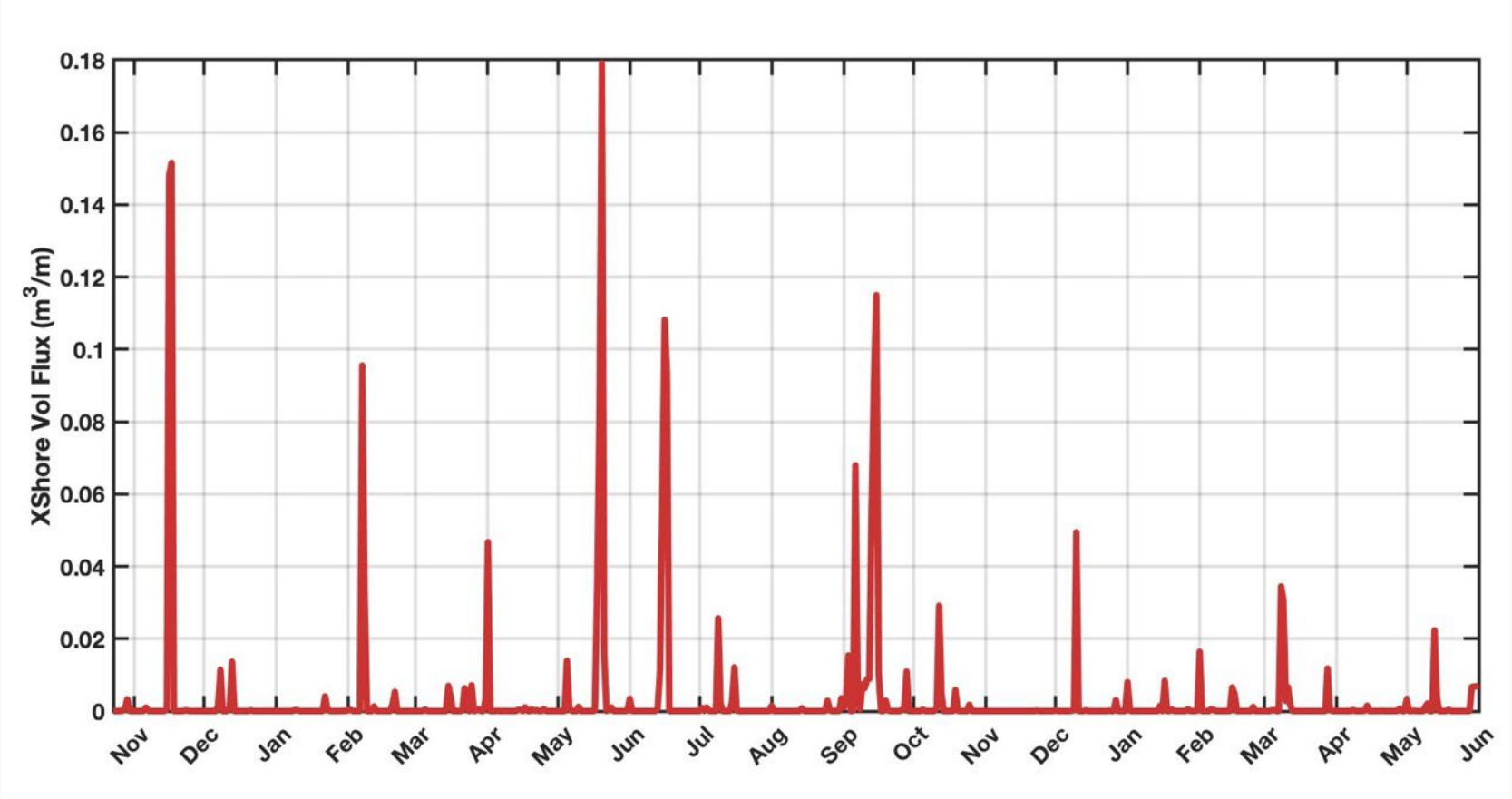
→ ***Aeolis*** → ↓

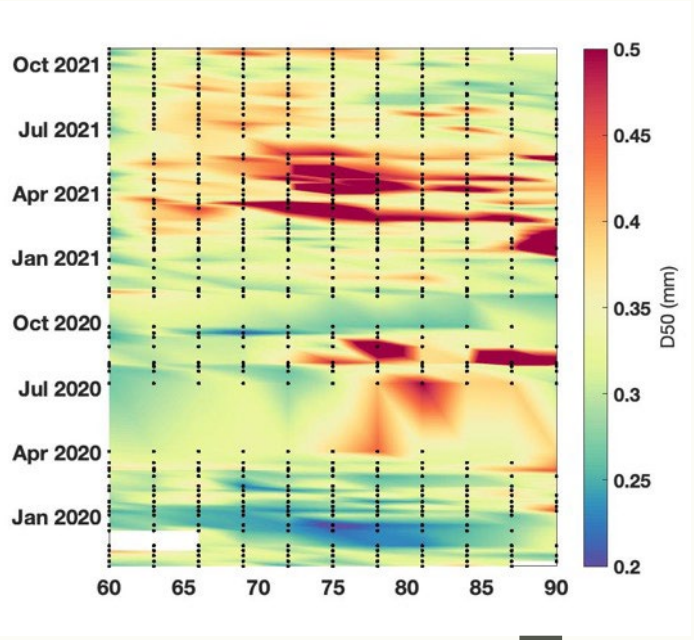
Cross-shore sediment flux

Data Collection/Analysis Funding: CODS Nearshore Processes/6.1 Aeolian



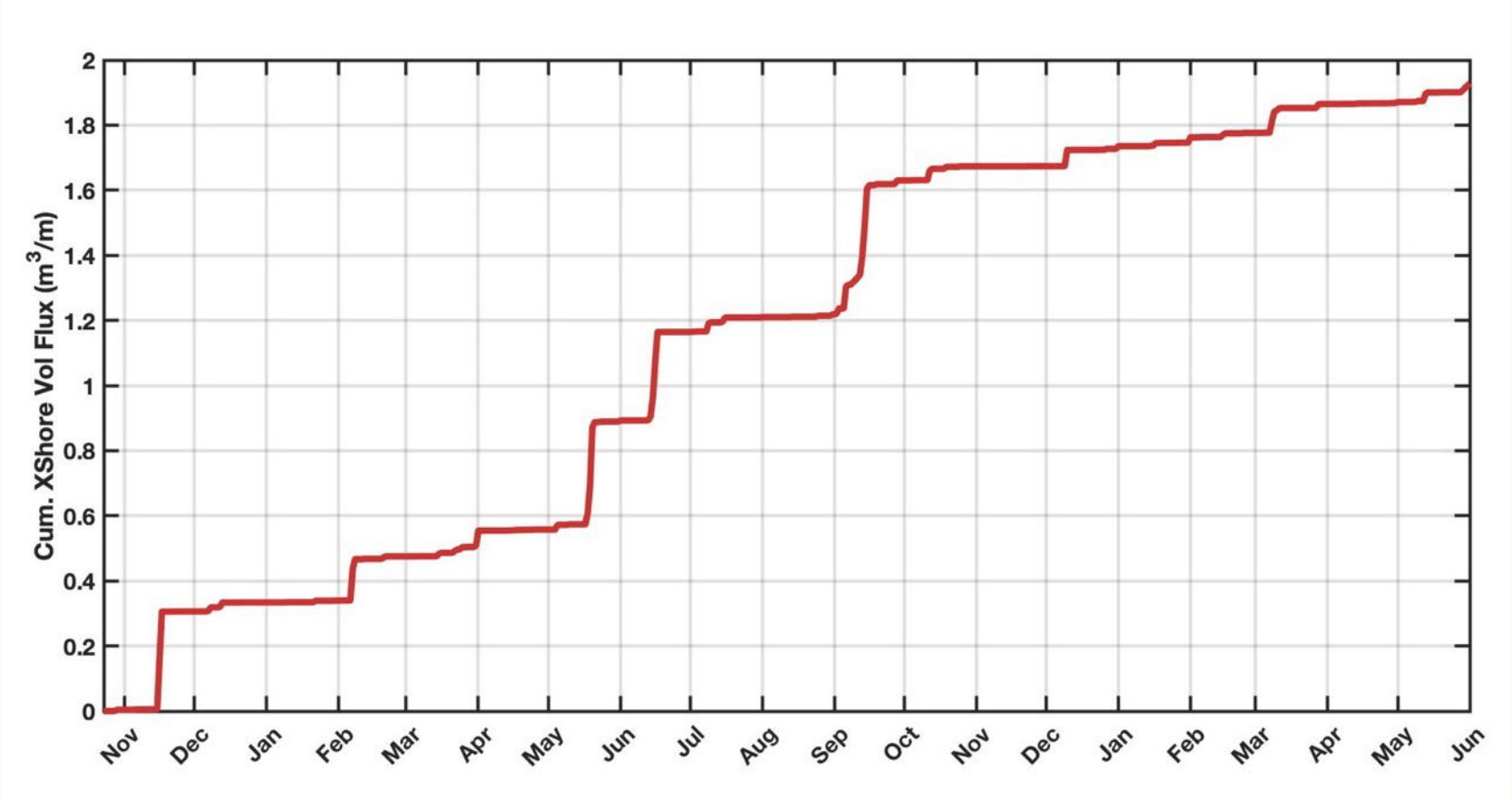
Aeolis case with daily interpolated variations in grain size



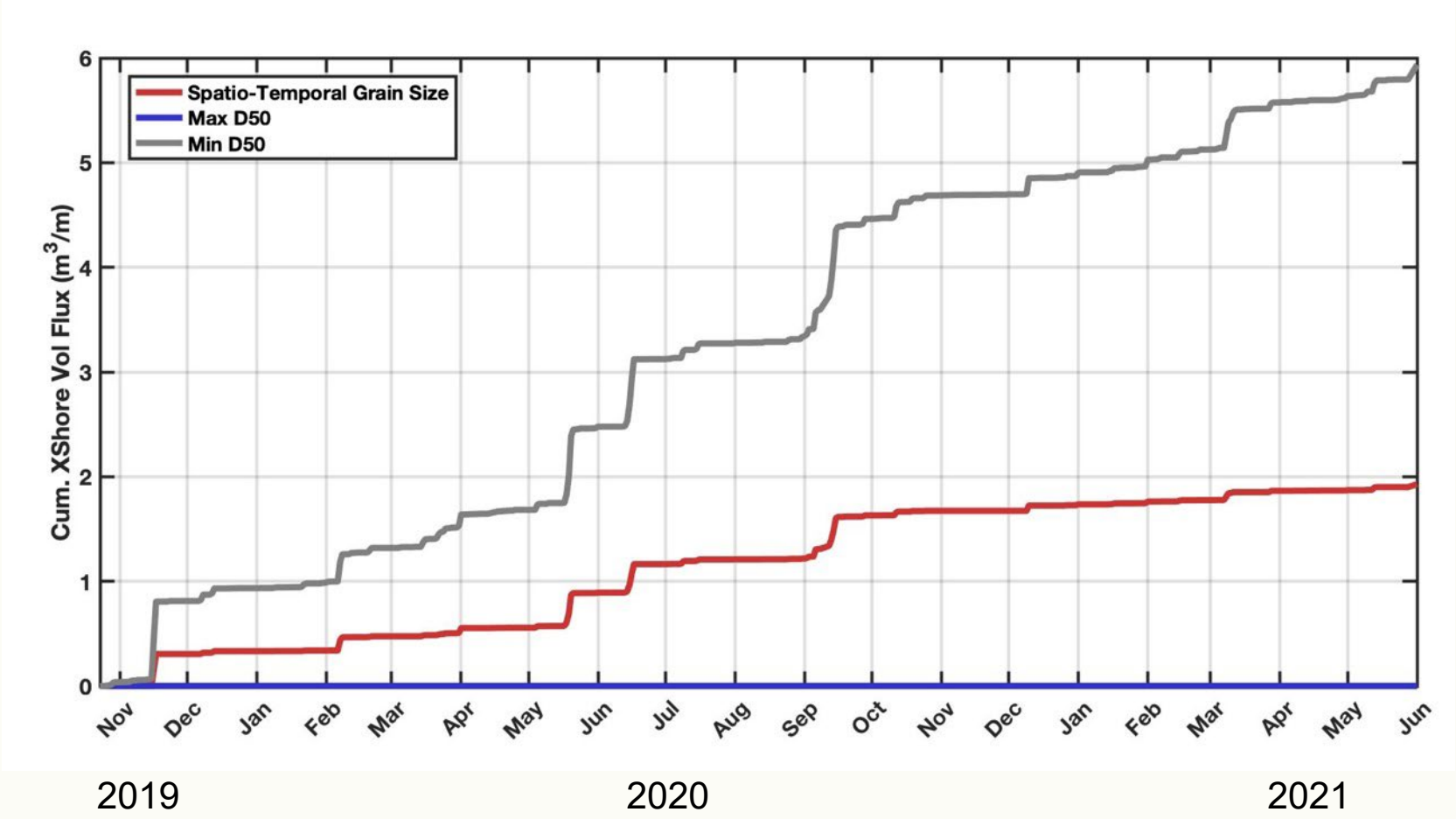


Aeolis case with daily interpolated variations in grain size

Fluxes consistent with dune growth rates of 1-3 $m^3/m/yr$ at Duck

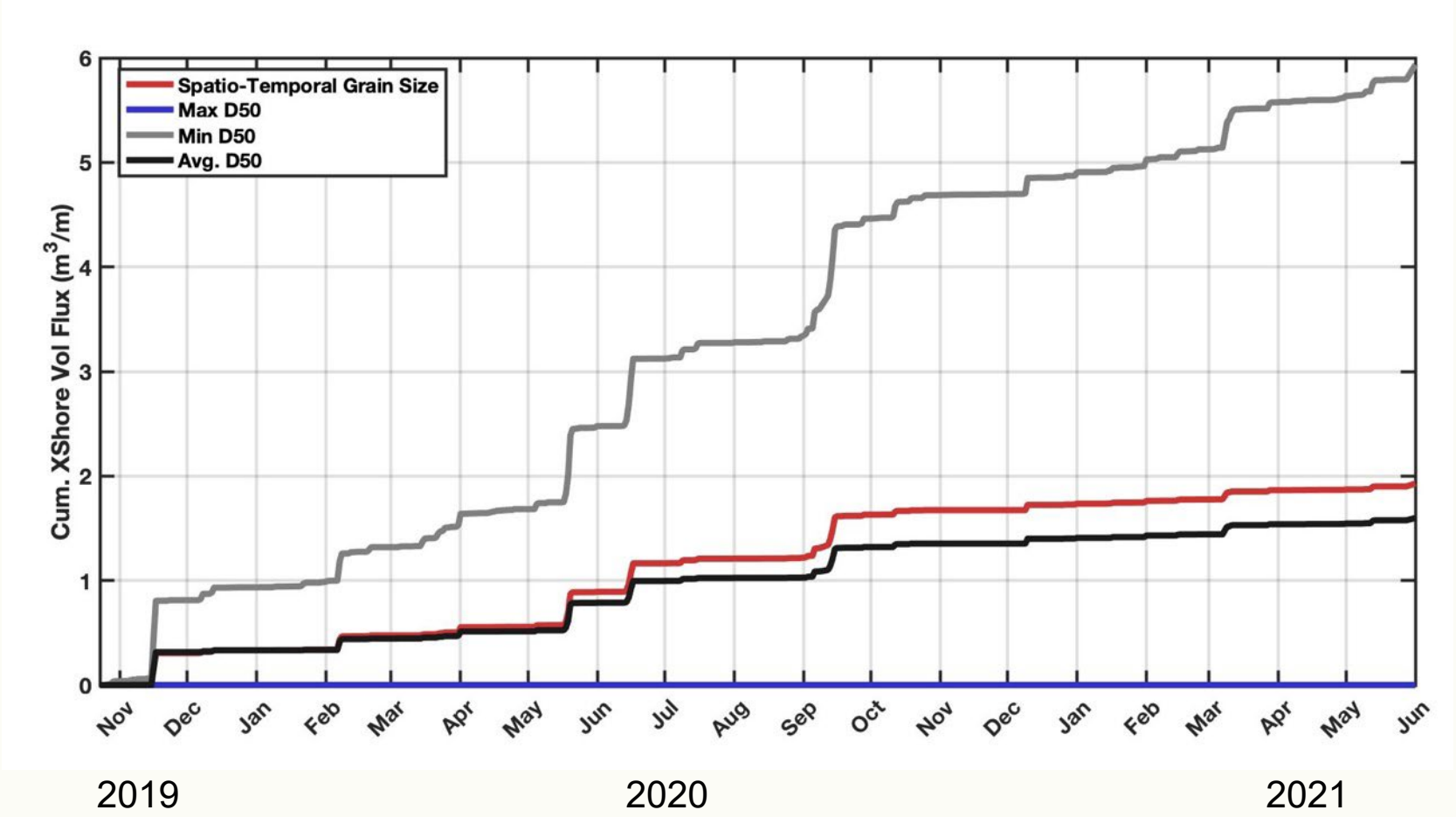


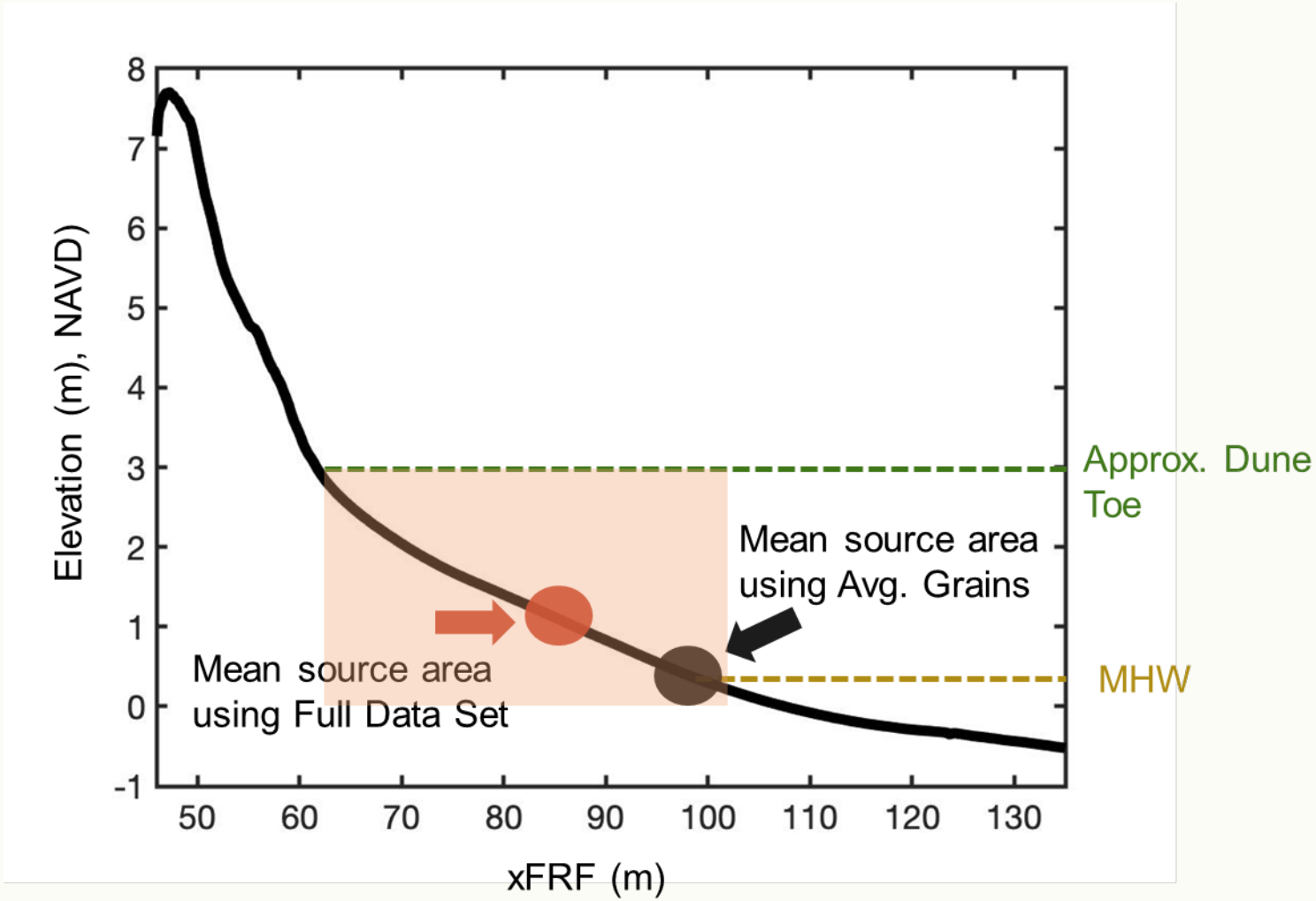
- **Finest grain size sample** in record results in 3X as much predicted transport
- **Coarsest sample** results in nearly no transport



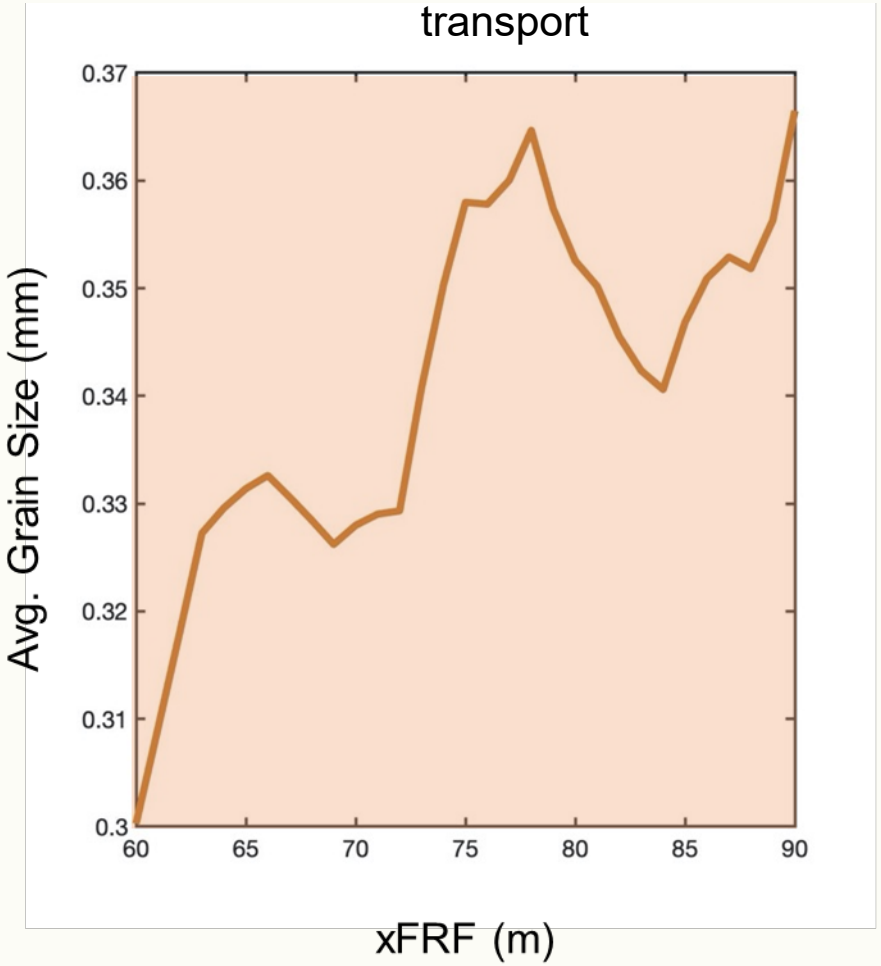
- **Average D50** across all samples results in ~20% less transport than more frequent data availability

- Collective data suggests single sample can result in lots of error. Need to pick grain size data carefully





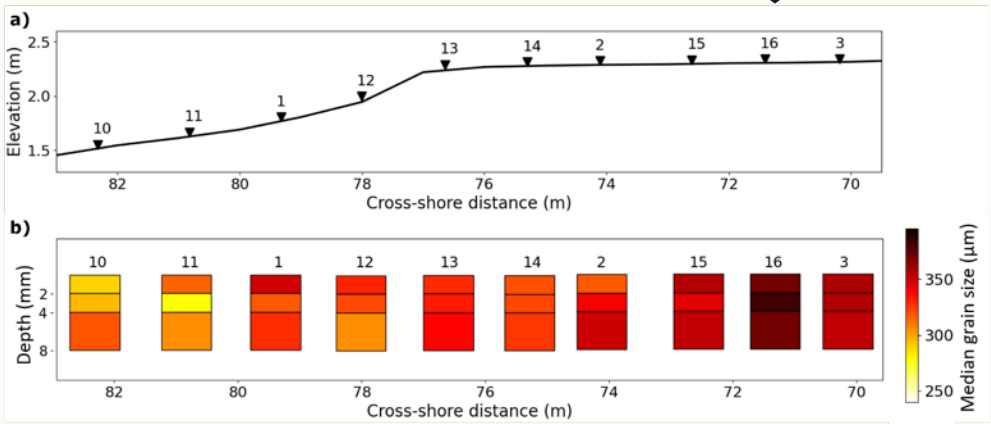
Field data shows cross-shore gradient in grain size, which affects source area of aeolian transport



Related Ongoing R&D on Aeolian Sediment Supply

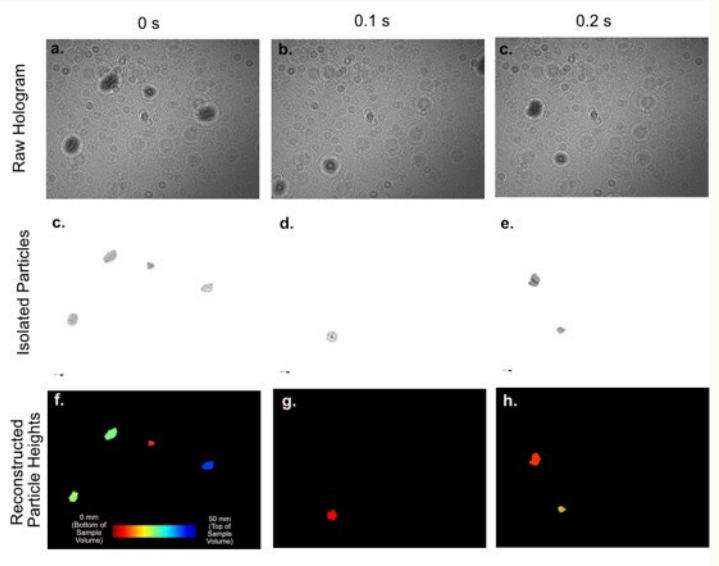
Collaboration with TU Delft: New approaches to micro-scale field sediment sampling

Cross-shore gradients in top 8 mm of Duck surface during DUNEX

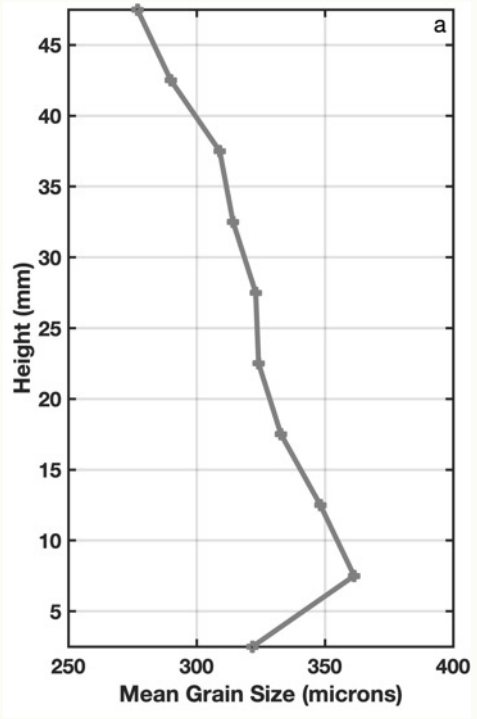


Work of Christa van IJzendoorn et al., submitted to ESPL

In-situ Measurement of Saltating Sand Grain Sizes Using Holography



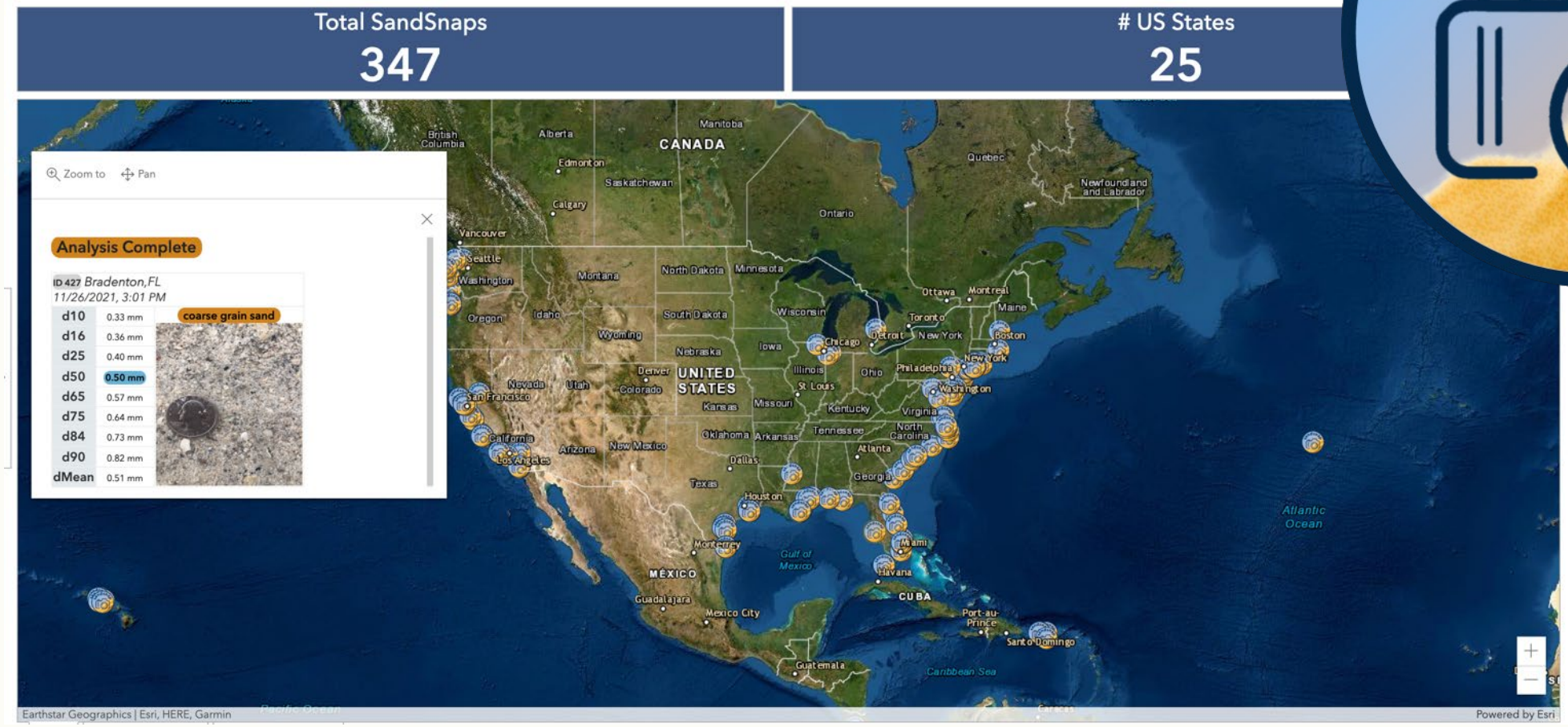
Underwater technology adapted to measure aeolian particle sizes at sub-second scale



Work of Cohn and Dickhudt, in prep

ERDC Data Collection/Analysis
Funding: 6.1 Aeolian, CFDC

Model Application 2: *Sandsnap*



SandSnap
POC: Brain McFall

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

Model Application 2: *Sandsnap*

SandSnap
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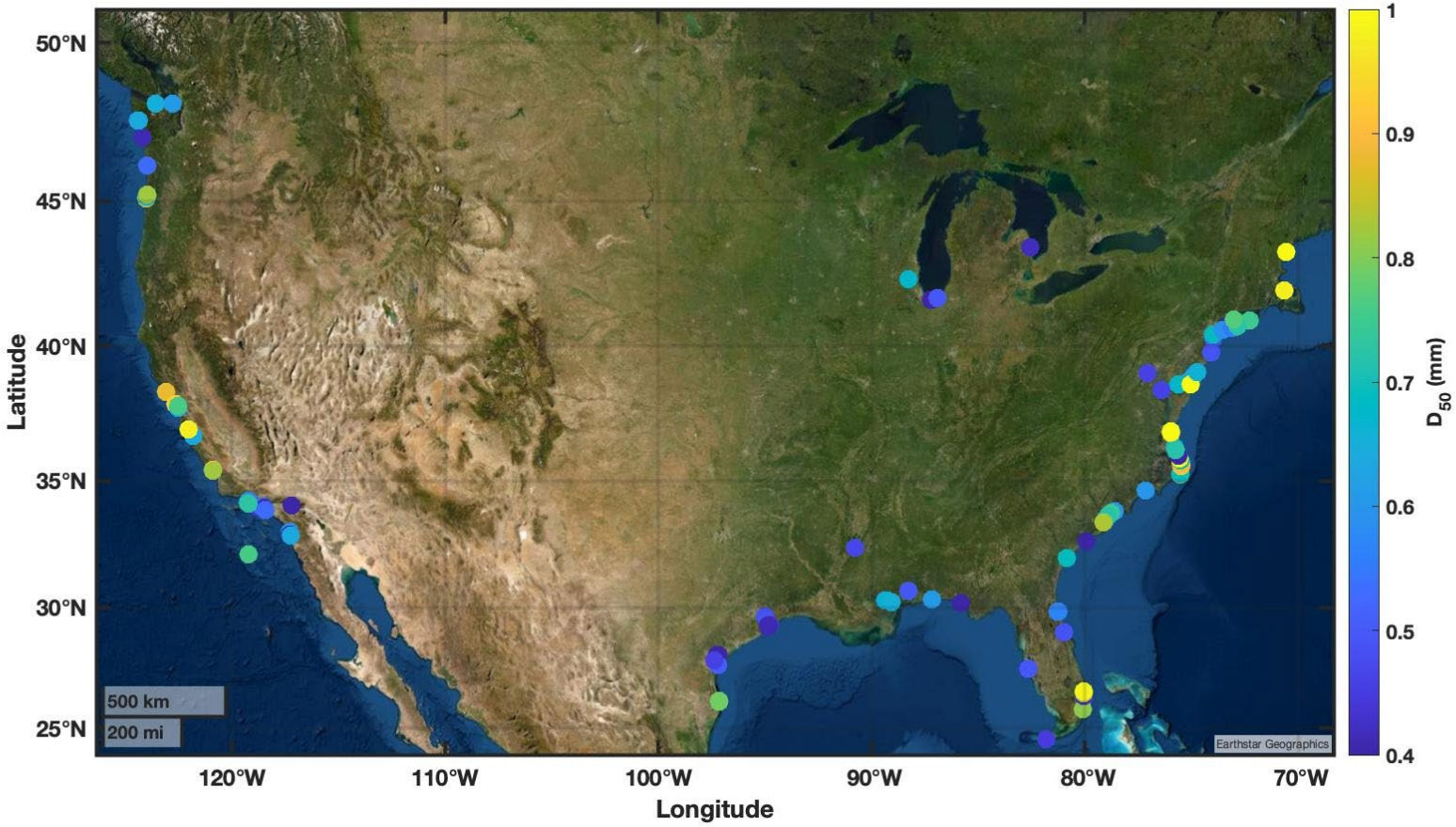
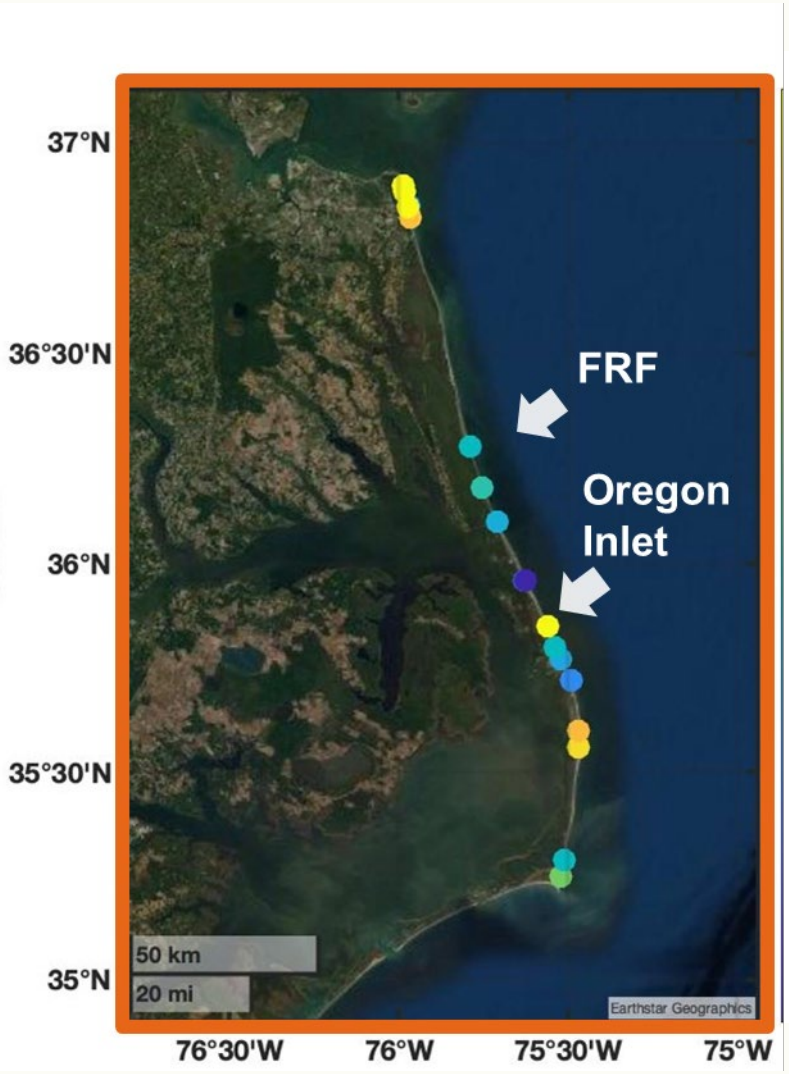
End to End Python Code developed to:

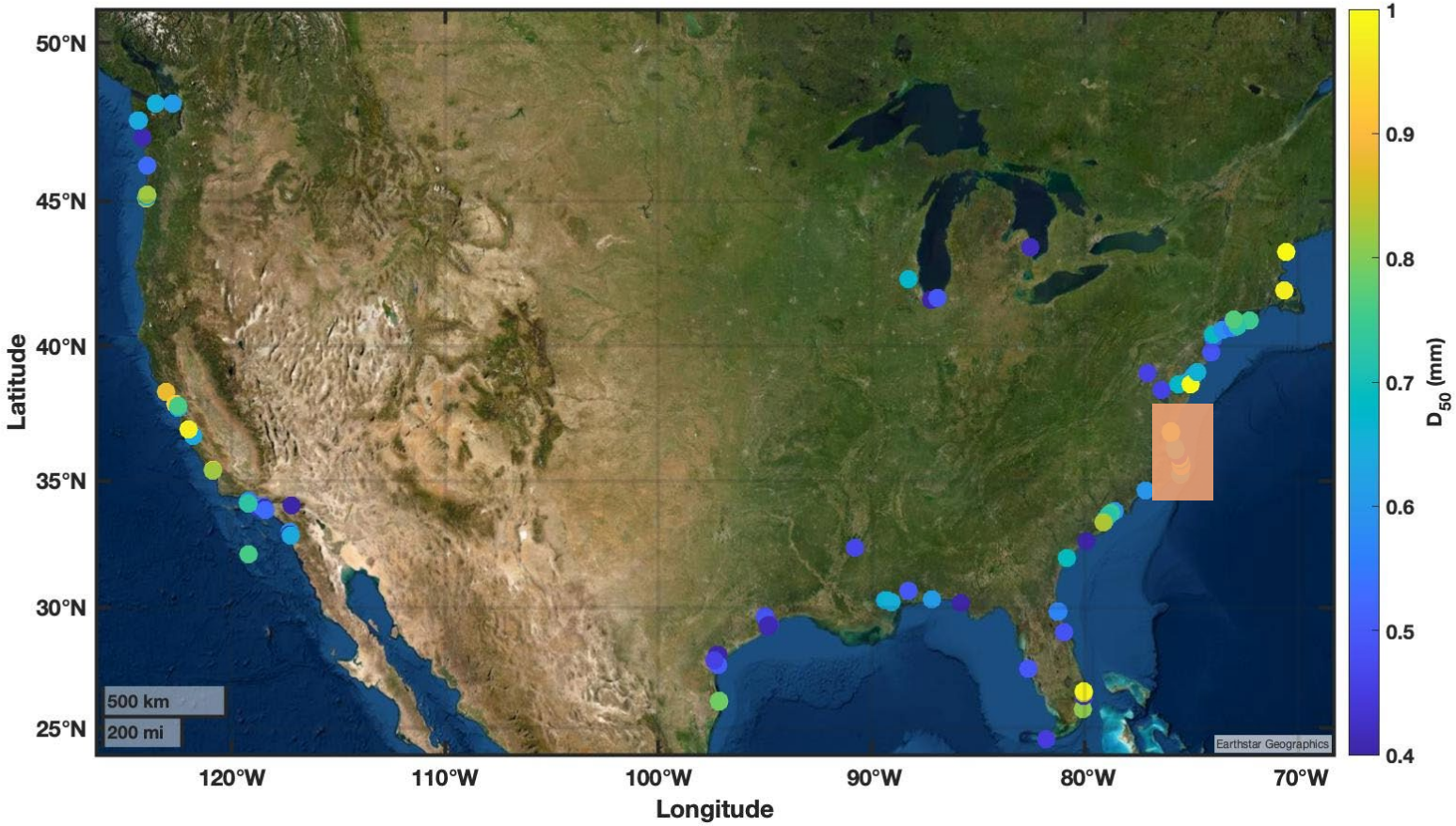
(1) Load in all Sandsnap data

(2) Develop automated input scripts and boundary conditions for Aeolis for any site in the country
- *Morphology* (from DRT database)
- *Waves*
- *Winds*
- *Tides*

(3) Run and post-process outputs







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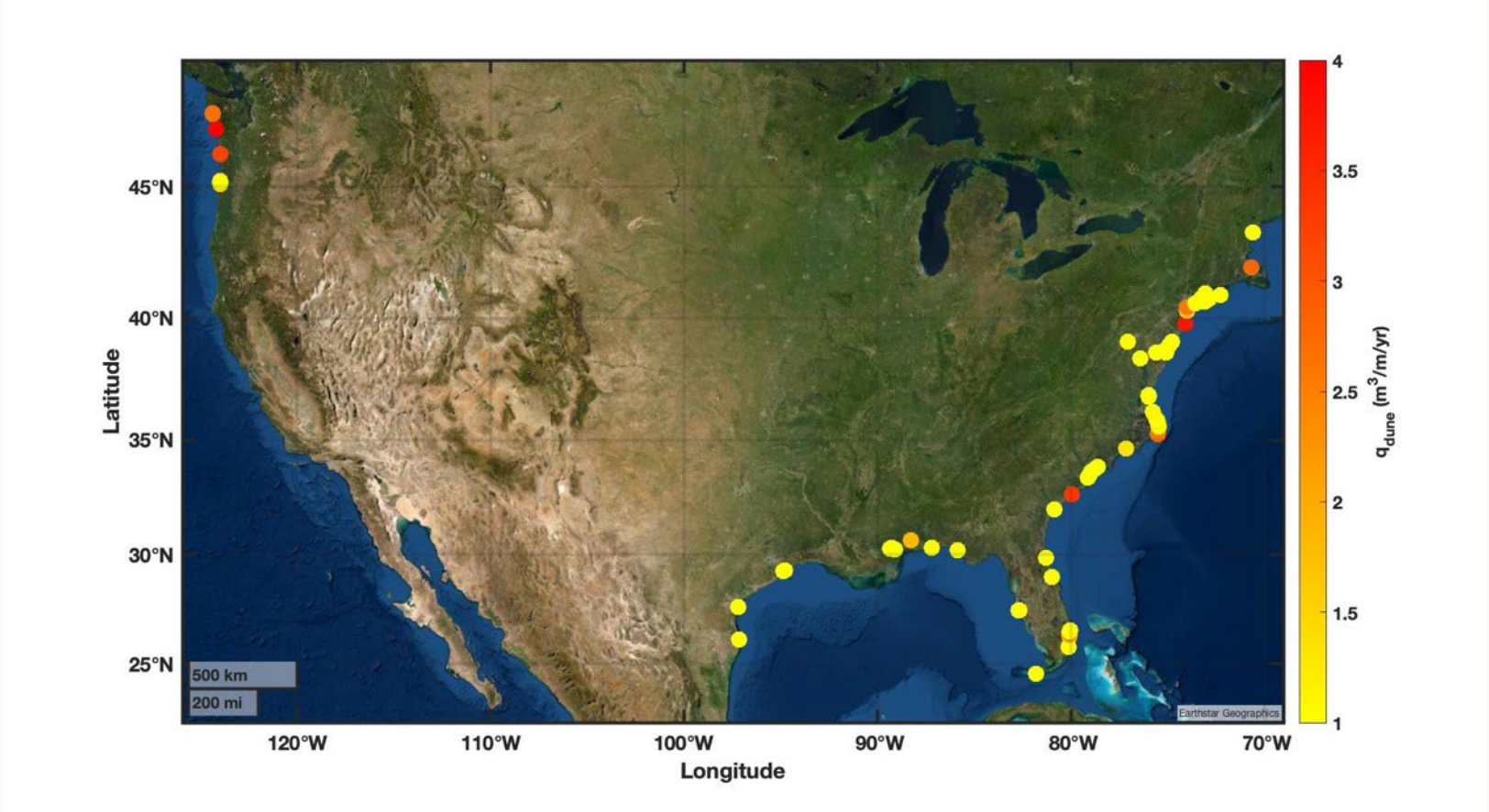
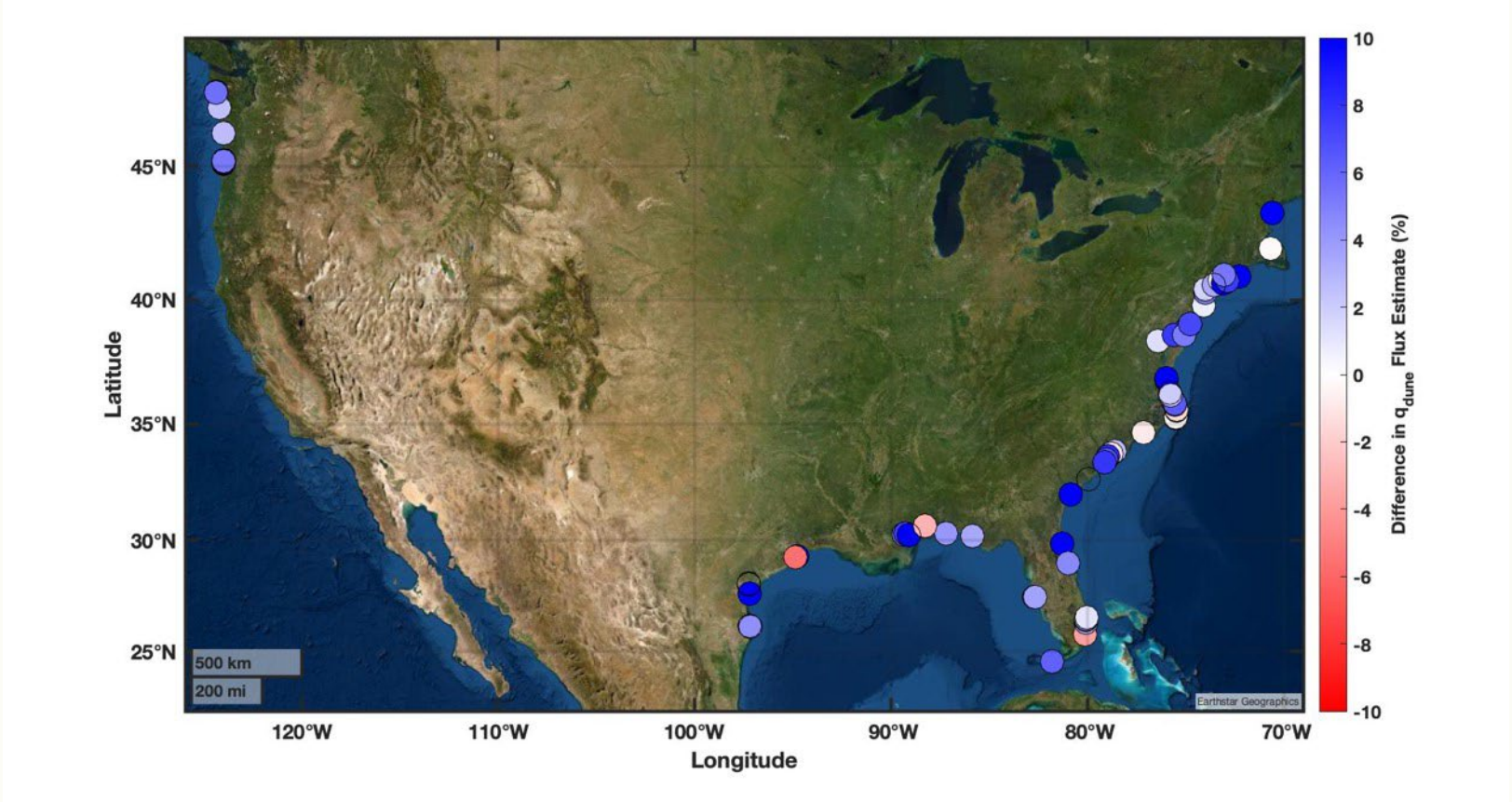
Multifraction Runs for 2018



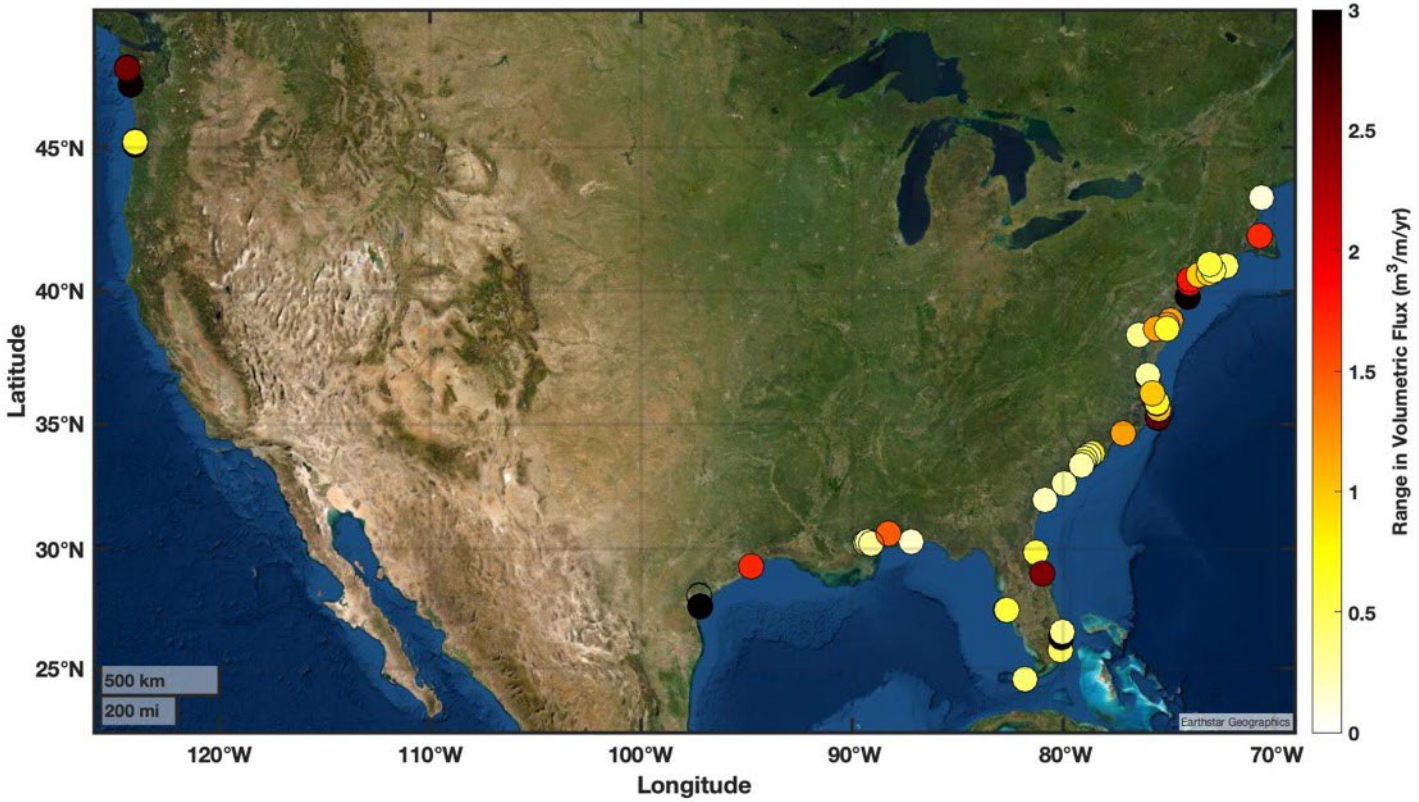
- Large spatial variability in expected dune growth rates, with largest magnitudes generally in the Pacific Northwest

Percentage Difference in Multifraction vs. Single Fraction Runs for 2018



- 81% of sites have an increase in predicted sediment flux to dune when including multifraction effects
- Sites with reduction likely due to armouring effects

Range in Predicted Annual Flux Rates (2015 – 2018)



- Large interannual variability that can be highly local due to hurricanes, storm tracks, and shoreline orientation

Summary

- **Input grain size can have a large influence on simulated fluxes**

- **Predicted sediment transport rates generally higher when accounting for multifraction transport effects**
    - Magnitude of increase is relatively small, particularly in sites with narrow grain size distribution
    - Reductions in expected transport due to armouring effects on some Gulf Coast and Florida sites

- **Large variability nationwide in expected dune growth rates**
    - Qualitatively trends here show agreement with field datasets

- **Many sites have strongly oblique winds. Small changes in shoreline angle has large effect on predicted cross-shore flux**