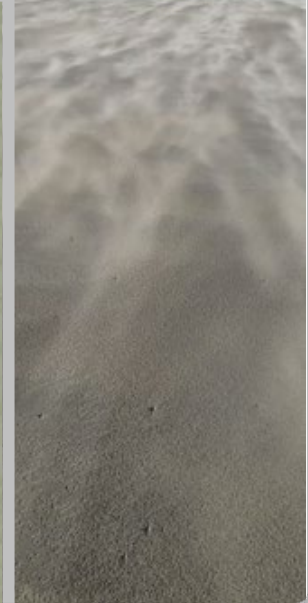


**U.S. ARMY**

CIRP TECHNICAL DISCUSSION
(21 JULY 2020):
TOOLS FOR SIMULATING AEOLIAN SEDIMENT
TRANSPORT NEAR INLETS
INLET ENGINEERING TOOLBOX

NICHOLAS COHN, KATE BRODIE

ERDC CHL, Coastal Observations and Analysis Branch



**US Army Corps
of Engineers®**



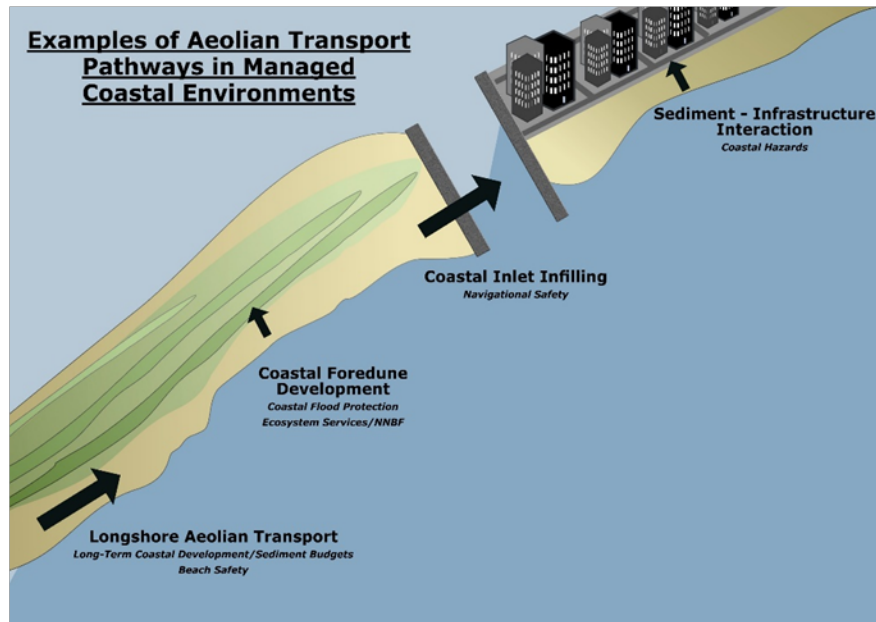
CHL

**COASTAL &
HYDRAULICS
LABORATORY**



ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

DISCOVER | DEVELOP | DELIVER



Tools for Simulating Aeolian Sediment Transport Near Inlets

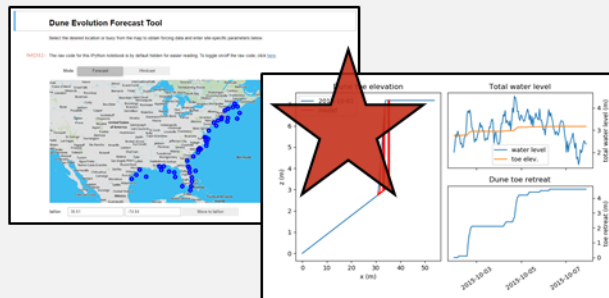


Inlet Engineering Toolbox

Nick Cohn, Kate Brodie

Primary Work Unit Goal: Development of process-based numerical modeling tools for simulating aeolian transport and dune evolution in managed coastal environments

Rapid Dune Erosion Forecasting Tool (*DEFT*)

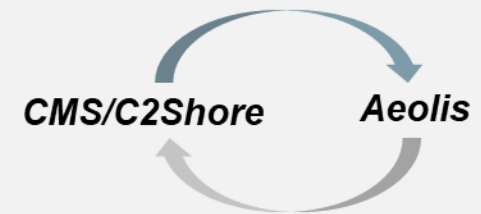


Modeling Aeolian Transport and Coastal Management Alternatives Near Inlets

Aeolis + sand fence model
(open source model) vegetation planting



Co-Evolution of Coastal Morphology from Wind and Waves



High

Tool Level of Maturity

Low

Short (hours to days)

Time Scale of Interest

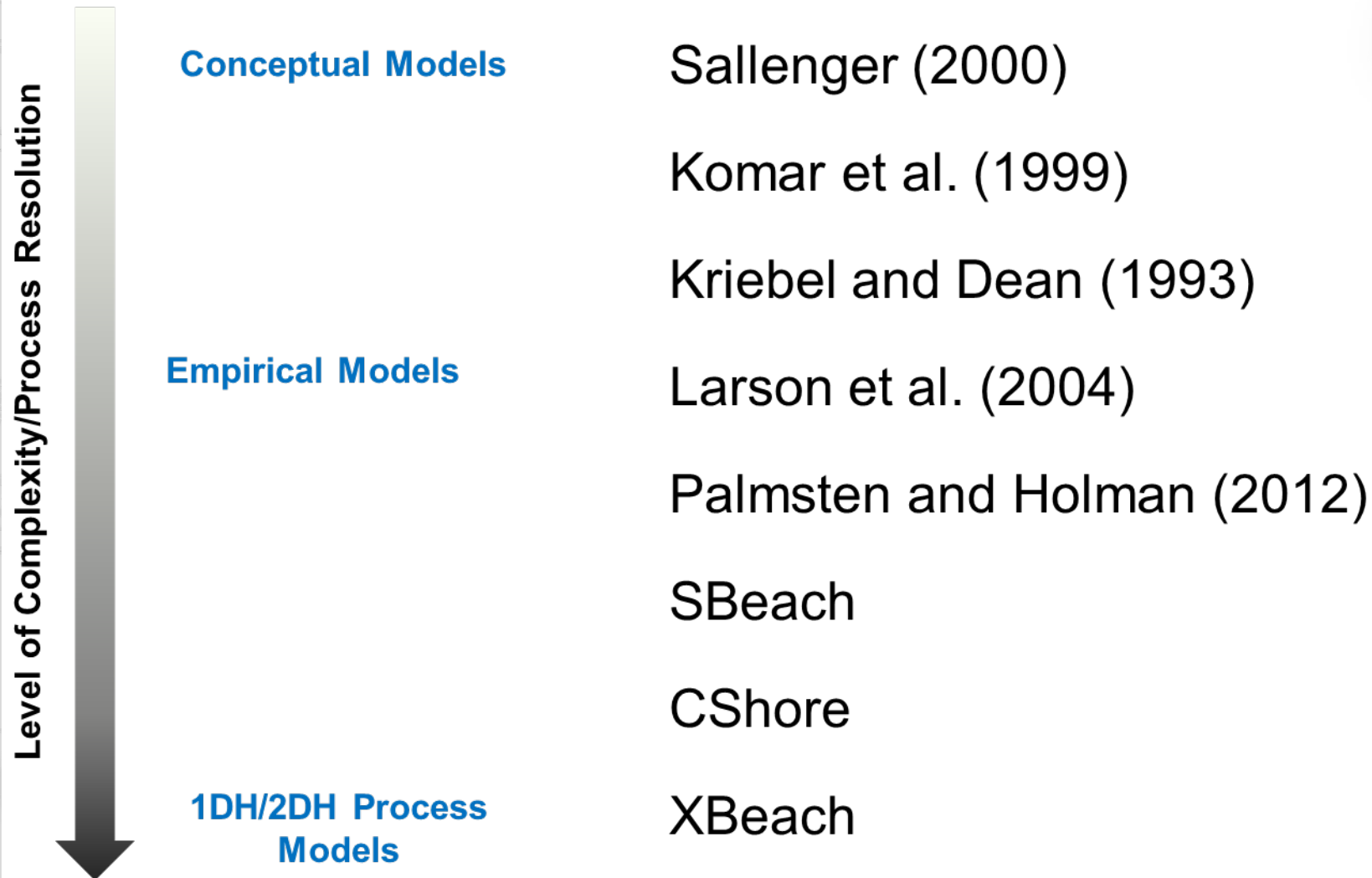
Long (months to years)

Why do we care about modeling dune erosion?





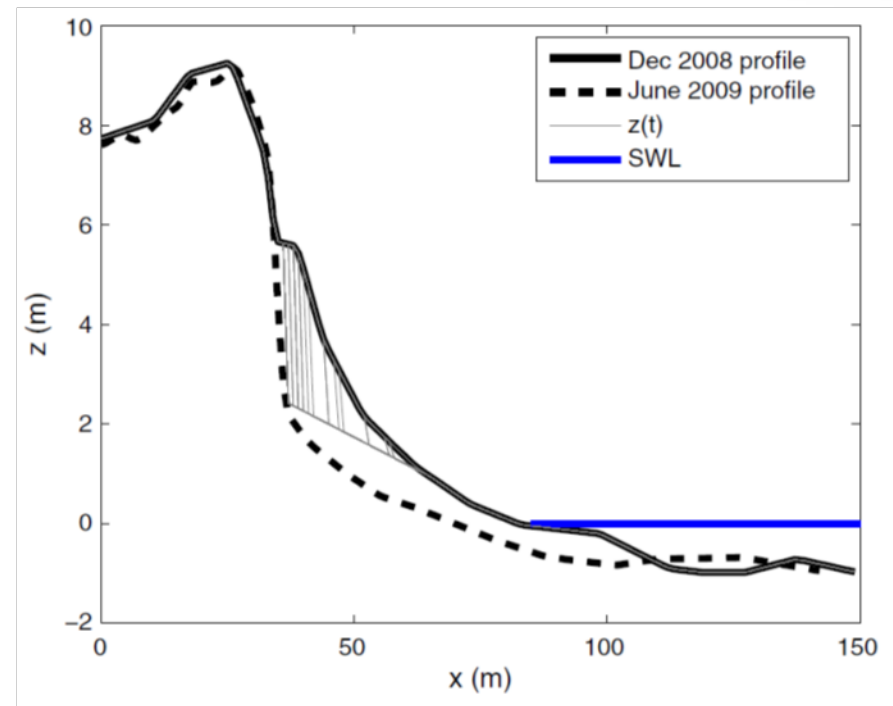
Numerical Tools for Simulating Dune Impacts





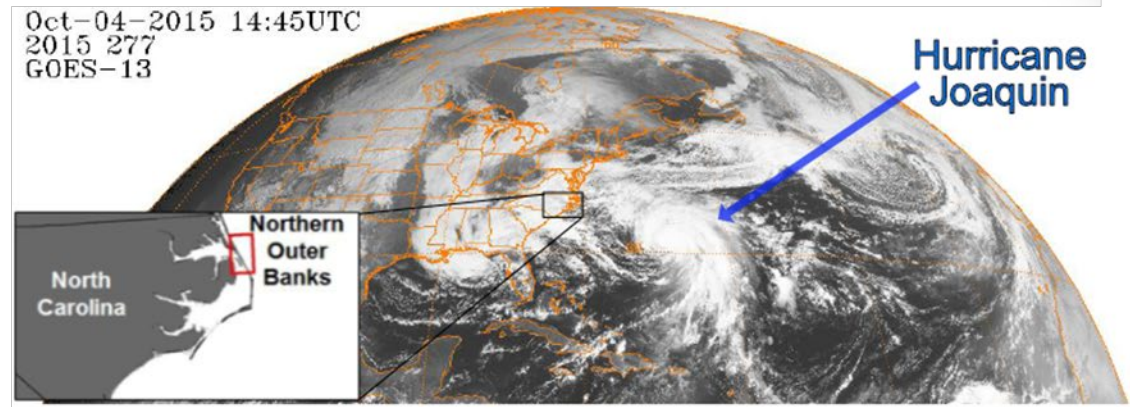
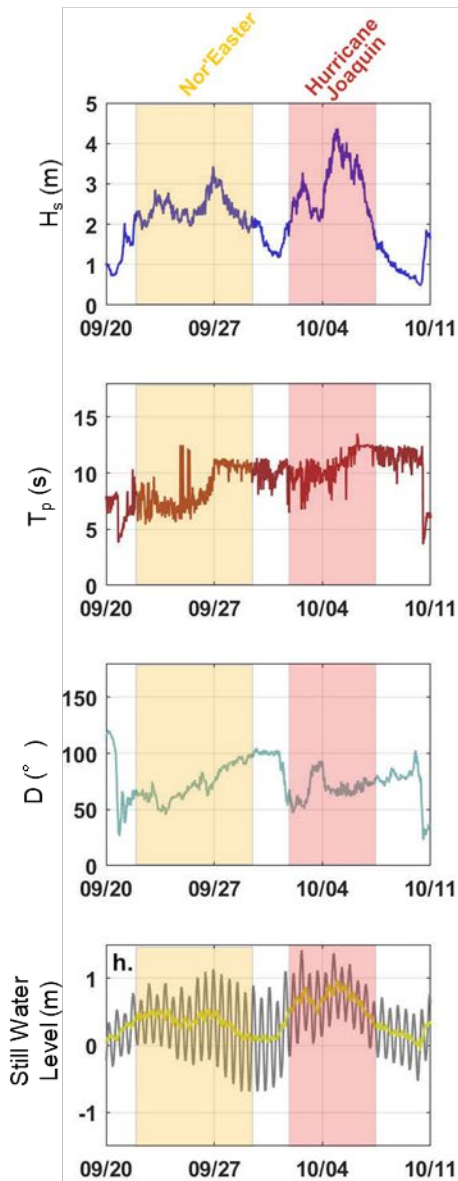
Palmsten and Holman (PH12) Dune Erosion Model

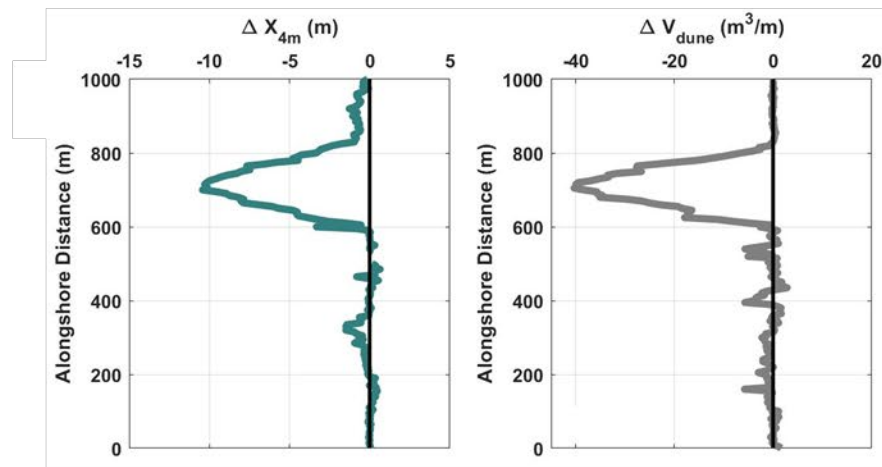
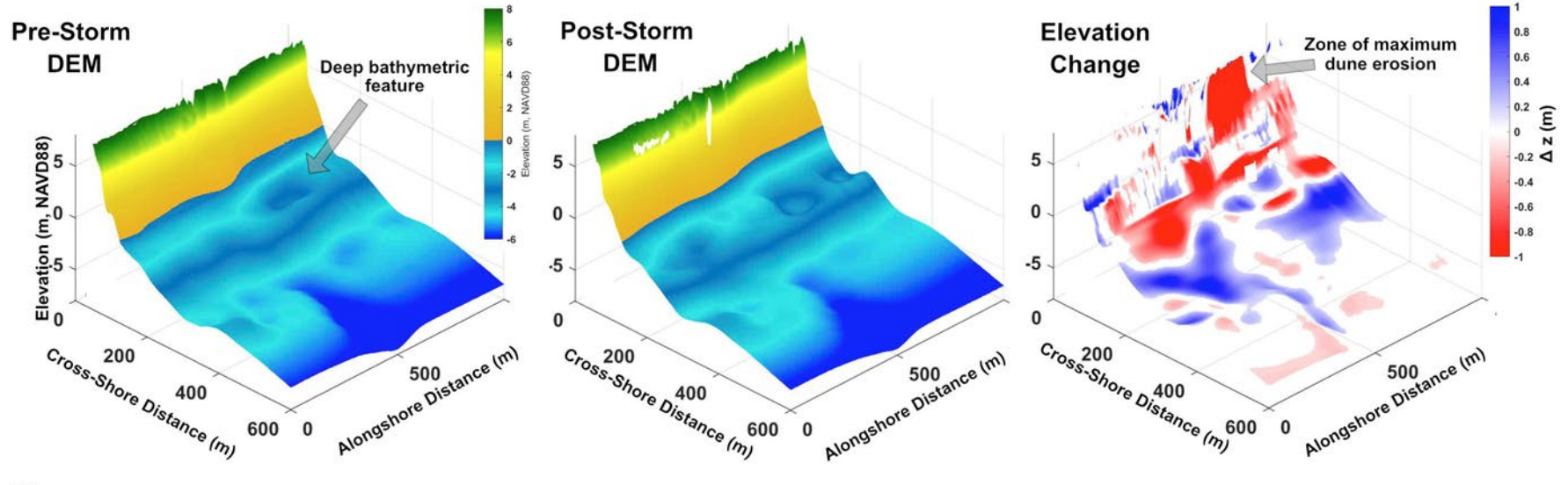
- Extension of the LEH04 model based on wave impact theory
- Assumes a dune trajectory slope and that a vertical dune face forms
- Successful application for lab and field cases

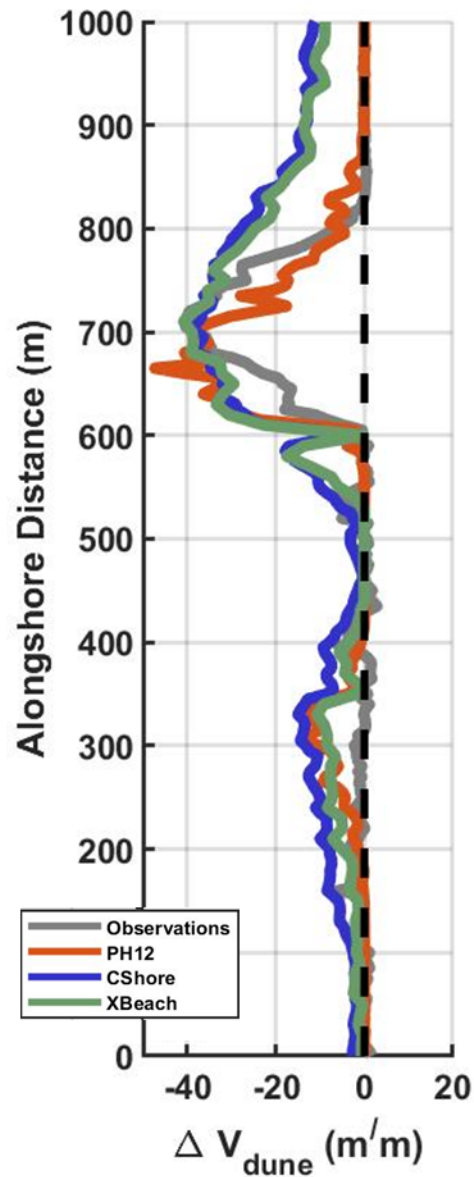


**Example application to the
Australian coast**

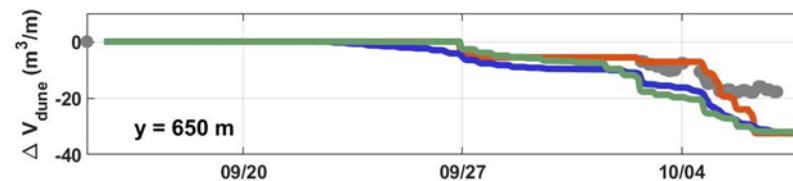
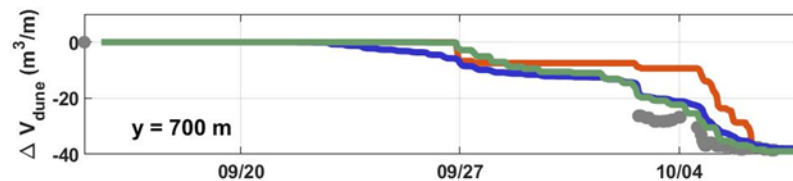
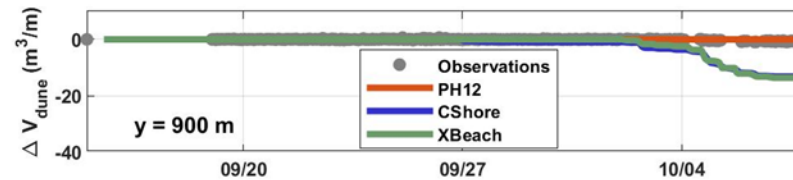
Joaq'Easter – US East Coast, 2015







Time Series of Volume Changes at Select Locations





PH12 Model Benefits

- **Fast Simulations**
 - run times = seconds to minutes
- **Easy to obtain inputs**
 - Dune topography
 - Beach slope
 - Wave runup
- **Limited Tuneable Parameters**
 - Easy to run
- **Successful application to a variety of coastlines**

Downsides/ Assumptions

- **Only evolves dune**
 - No beach evolution
- **Assumes vertical dune face when eroded**
- **Does not include subaqueous processes/feedbacks**



Appropriate for rapid
forecasting/planning
tool

Note: Higher fidelity models
may be appropriate for specific
USACE applications/timescales

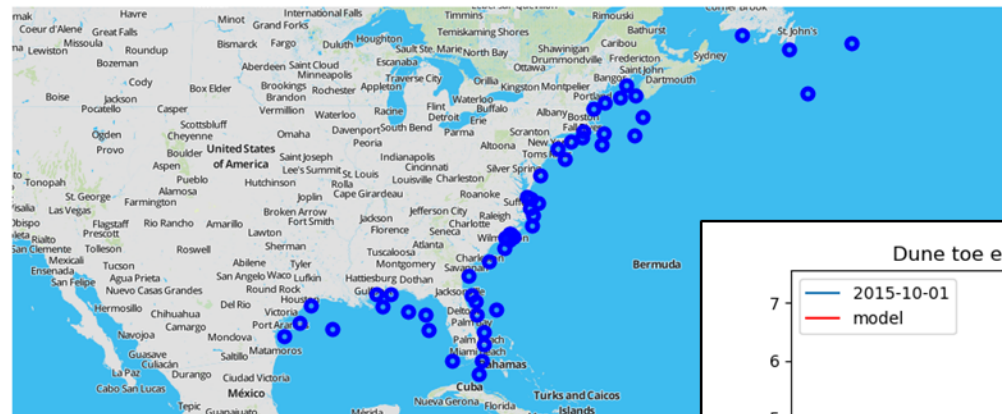
TOOL DEVELOPMENT

Dune Evolution Forecast Tool

Select the desired location or buoy from the map to obtain forcing data and enter site-specific parameters below.

Out[51]: The raw code for this IPython notebook is by default hidden for easier reading. To toggle on/off the raw code, click [here](#).

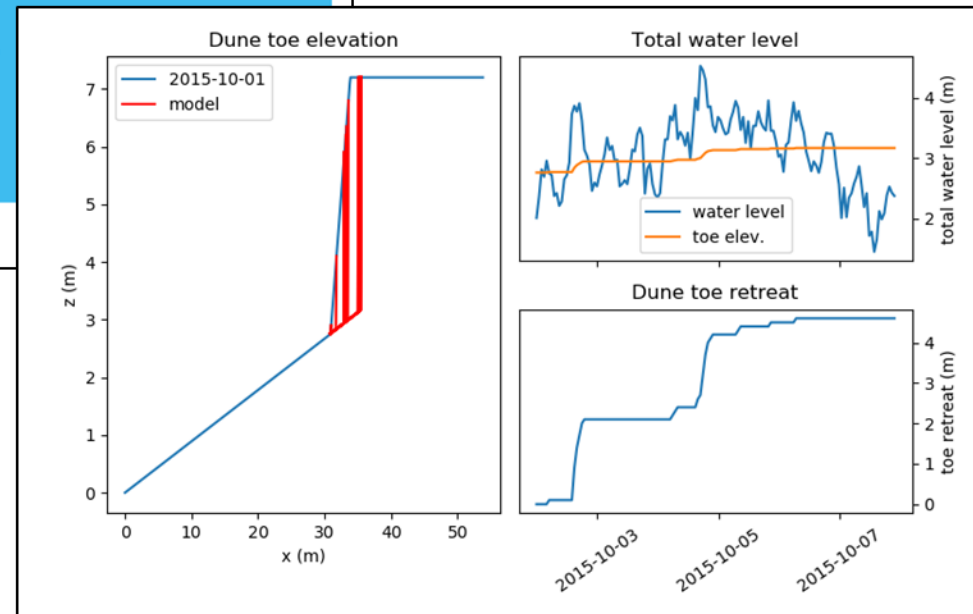
Mode: ☒ Forecast ☐ Hindcast



lat/lon:

FY18/19 – Python Jupyter Notebook Development

Hurdles: GUI stability,
Dependency issues,
Deployment complications





TOOL DEVELOPMENT

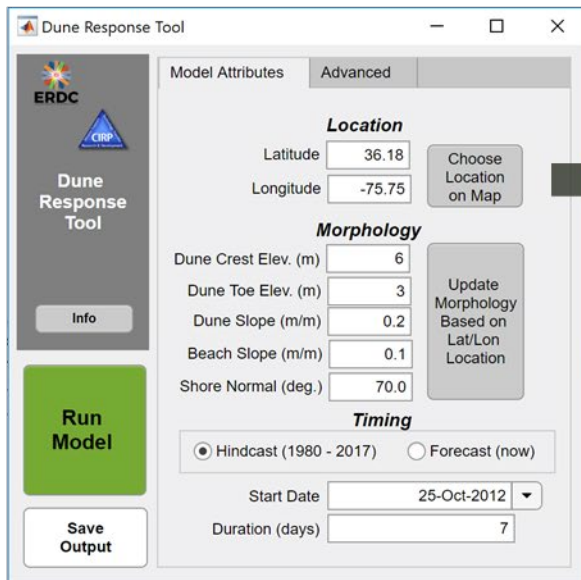
**Mid year FY20
changeup – started
over with Matlab GUI
development**

Advantages:

- Stable and expandable interface
- Deployable on individual computers w/ or w/o Matlab
- Platform independent
- Deployable on Webserver (e.g., Azure)

The screenshot shows the 'Dune Response Tool' window. On the left is a sidebar with the ERDC and CIRP logos, the text 'Dune Response Tool', an 'Info' button, a large green 'Run Model' button, and a 'Save Output' button. The main panel has tabs for 'Model Attributes' and 'Advanced'. The 'Advanced' tab is active, showing input fields for 'Location' (Latitude: 36.18, Longitude: -75.75) and 'Morphology' (Dune Crest Elev. (m): 6, Dune Toe Elev. (m): 3, Dune Slope (m/m): 0.2, Beach Slope (m/m): 0.1, Shore Normal (deg.): 70.0). There are buttons for 'Choose Location on Map' and 'Update Morphology Based on Lat/Lon Location'. The 'Timing' section has radio buttons for 'Hindcast (1980 - 2017)' (selected) and 'Forecast (now)', a 'Start Date' dropdown set to '25-Oct-2012', and a 'Duration (days)' field set to '7'.

TOOL DEVELOPMENT



Dune Response Tool

Model Attributes **Advanced**

Location

Latitude: 36.18
Longitude: -75.75

Morphology

Dune Crest Elev. (m): 6
Dune Toe Elev. (m): 3
Dune Slope (m/m): 0.2
Beach Slope (m/m): 0.1
Shore Normal (deg.): 70.0

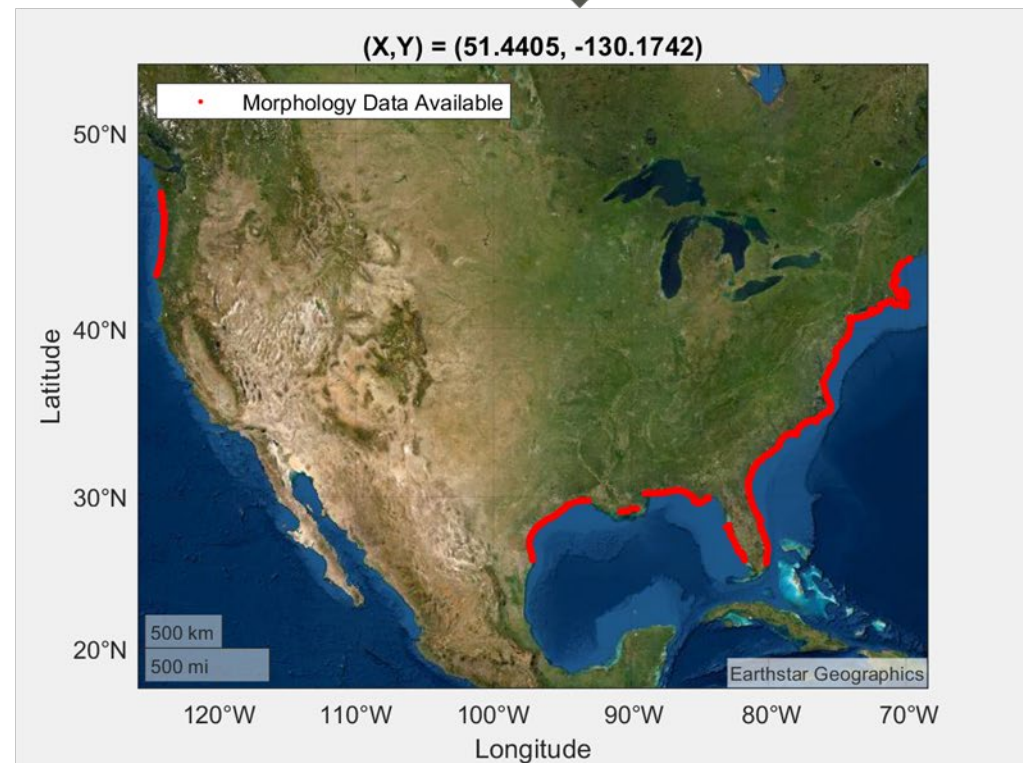
Timing

☒ Hindcast (1980 - 2017) ☐ Forecast (now)

Start Date: 25-Oct-2012
Duration (days): 7

Buttons: Info, Run Model, Save Output, Choose Location on Map, Update Morphology Based on Lat/Lon Location

Step 1. Type in location coordinates manually or choose on map



TOOL DEVELOPMENT



Dune Response Tool

Model Attributes: **Advanced**

Location

Latitude: Longitude:

Morphology

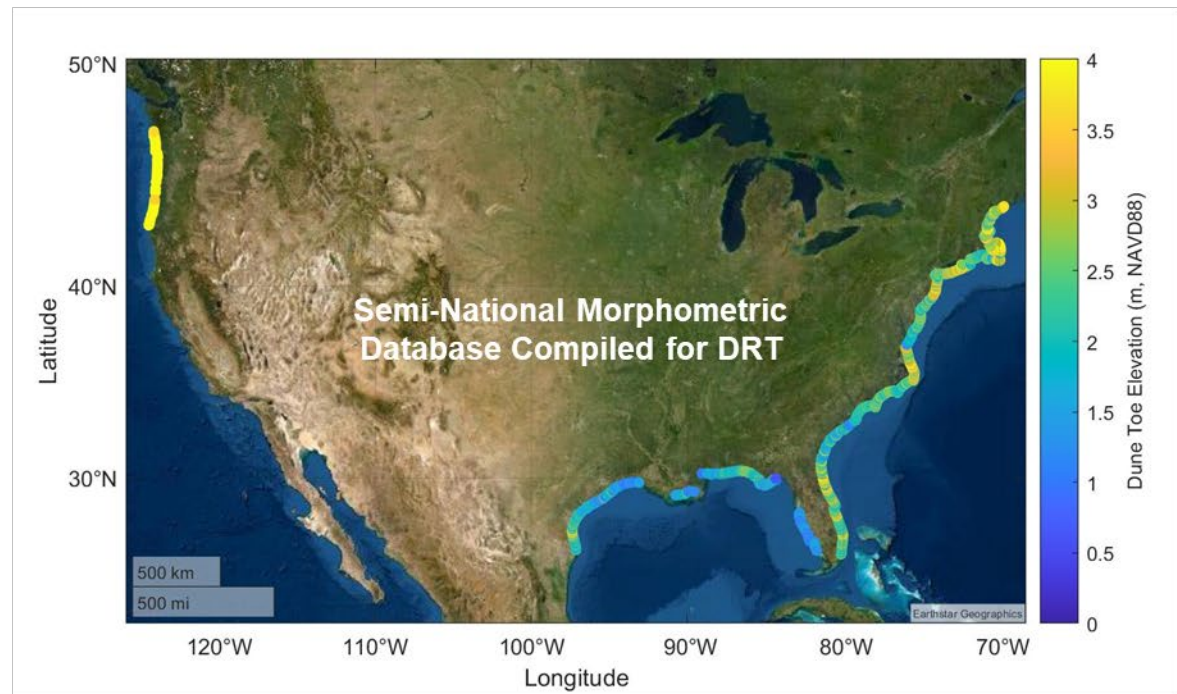
Dune Crest Elev. (m): Dune Toe Elev. (m): Dune Slope (m/m): Beach Slope (m/m): Shore Normal (deg.):

Timing

☒ Hindcast (1980 - 2017) ☐ Forecast (now)

Start Date: Duration (days):

Step 2. Beach and dune morphology selection



Data Sources

East Coast US:
Doran et al., 2020

Gulf Coast US:
Doran et al., 2020

Pacific Northwest US:
Mull and Ruggiero, 2016

****Can easily utilize CA, Great Lakes, Alaska, Puerto Rico, and/or Hawaii data if available**

TOOL DEVELOPMENT



Step 3. Timing (required)
and advanced features
(optional)

Dune Response Tool

ERDC
CIRP
Dune Response Tool
Info

Run Model

Save Output

Model Attributes | **Advanced**

Model Parameters

Median Grain Size (mm)	0.35
Wave Runup Factor	1.26
Dune Slope Trajectory	0.54
Dune Erodibility Coefficient	0.0025
Aeolian Transport Coefficient	2.78

Model Type

☒ Deterministic Case

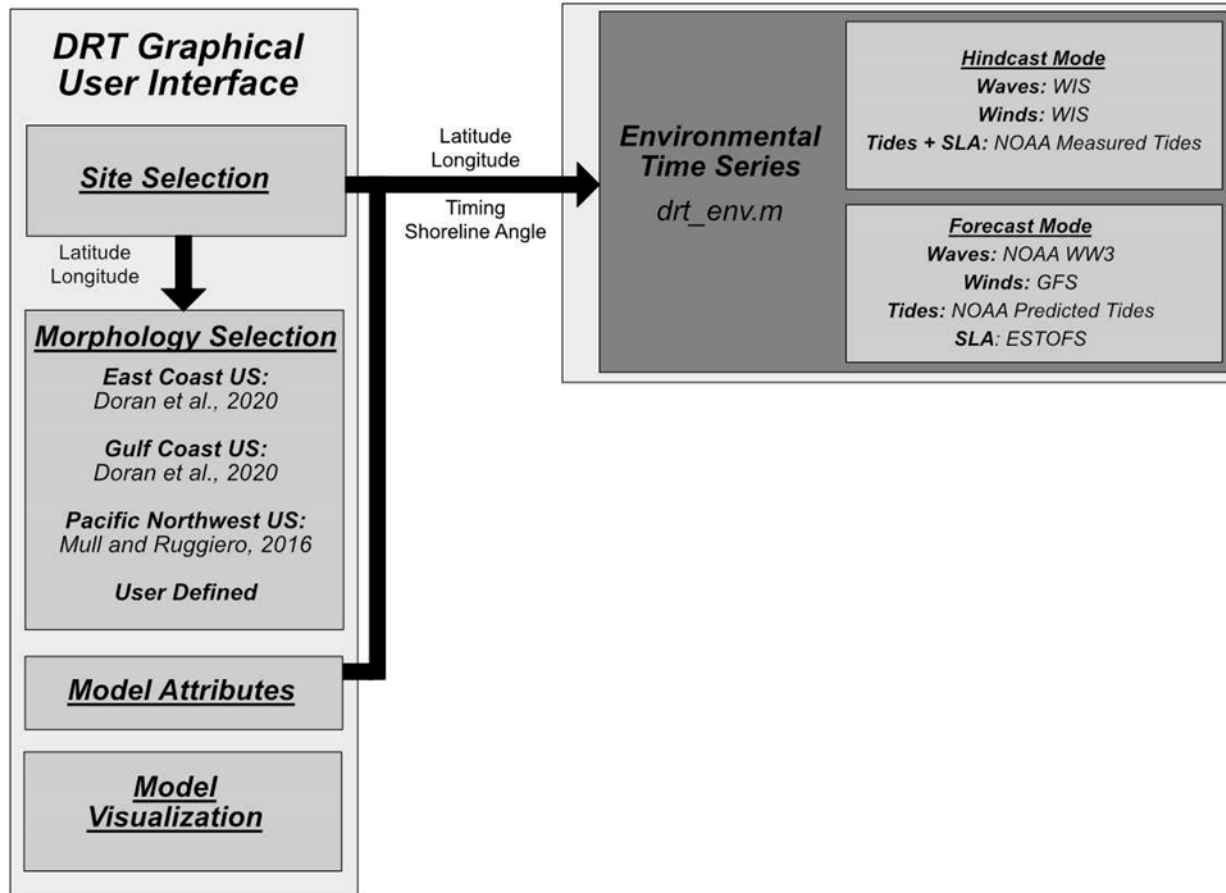
☐ Ensemble Run

Variable: Beach Slope ▼

Min. Value	0.05
Max. Value	0.2



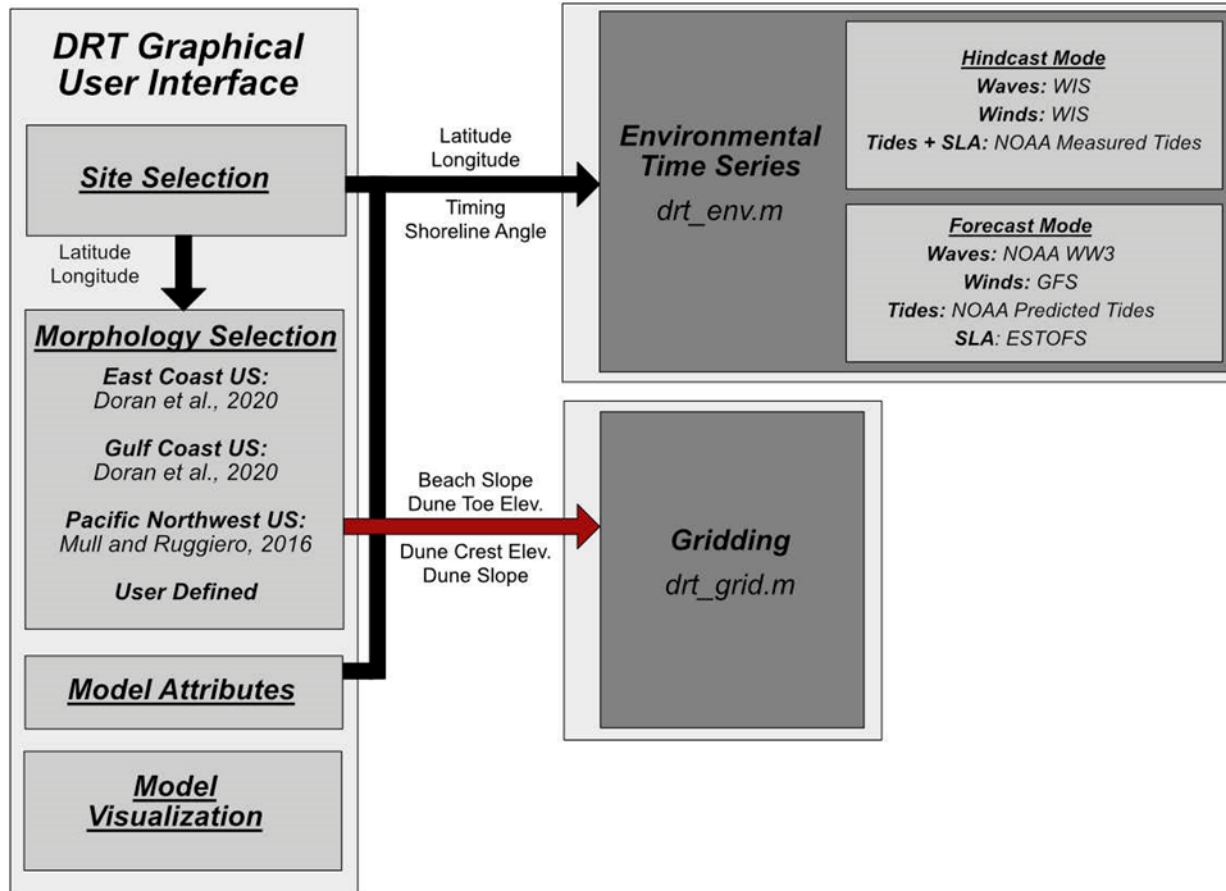
TOOL DEVELOPMENT



** Redundancy built in to pull different data servers in case of server outages

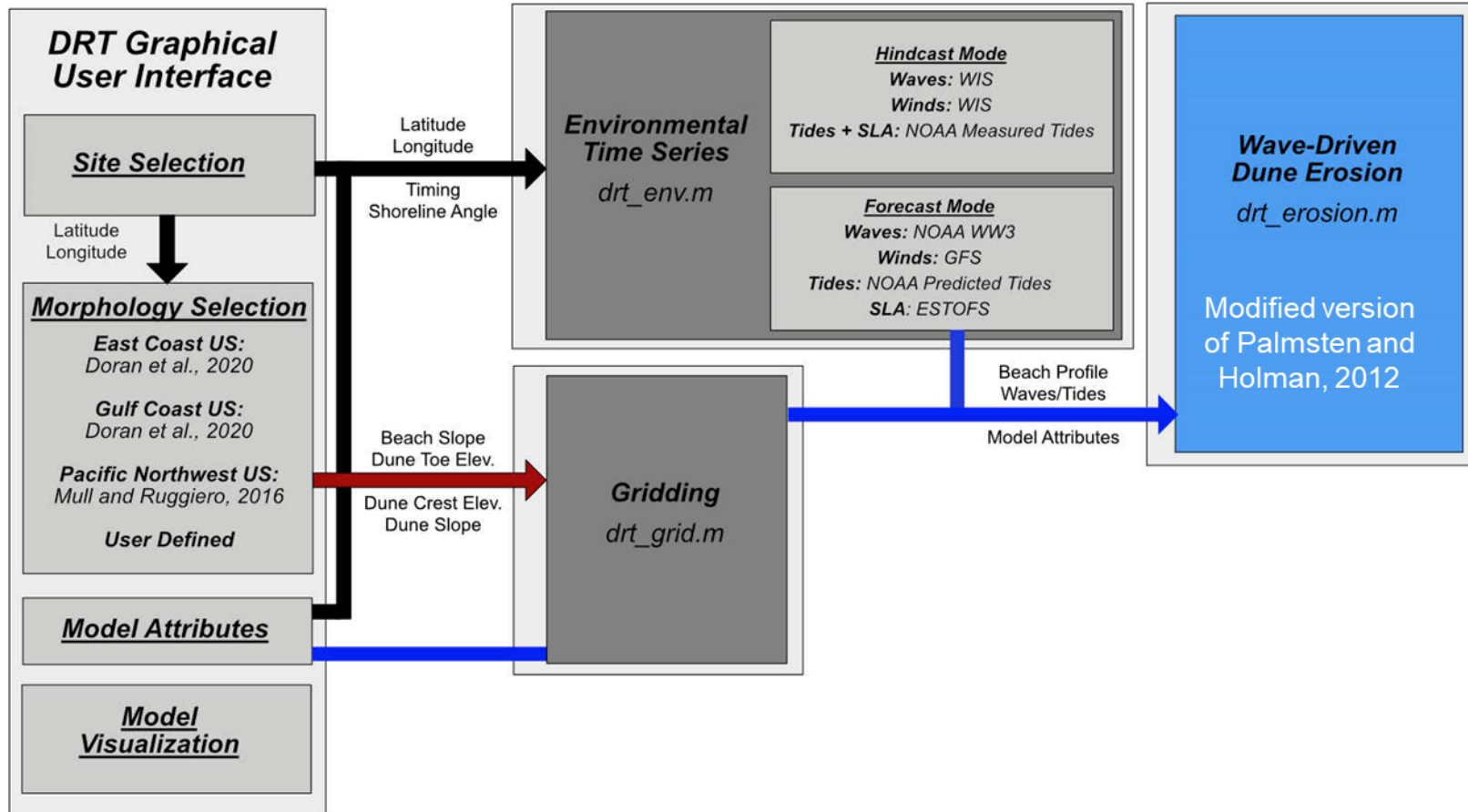


TOOL DEVELOPMENT



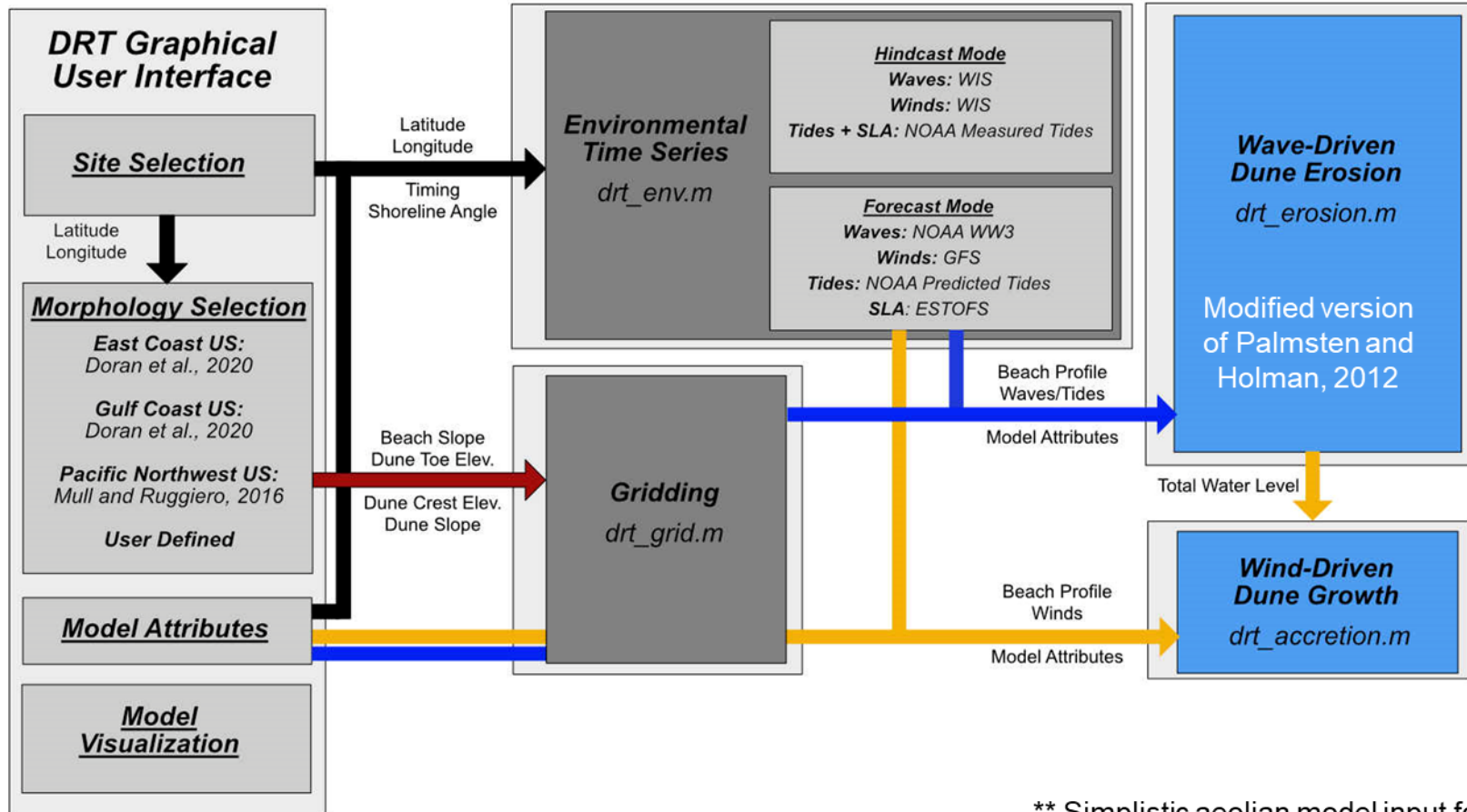


TOOL DEVELOPMENT





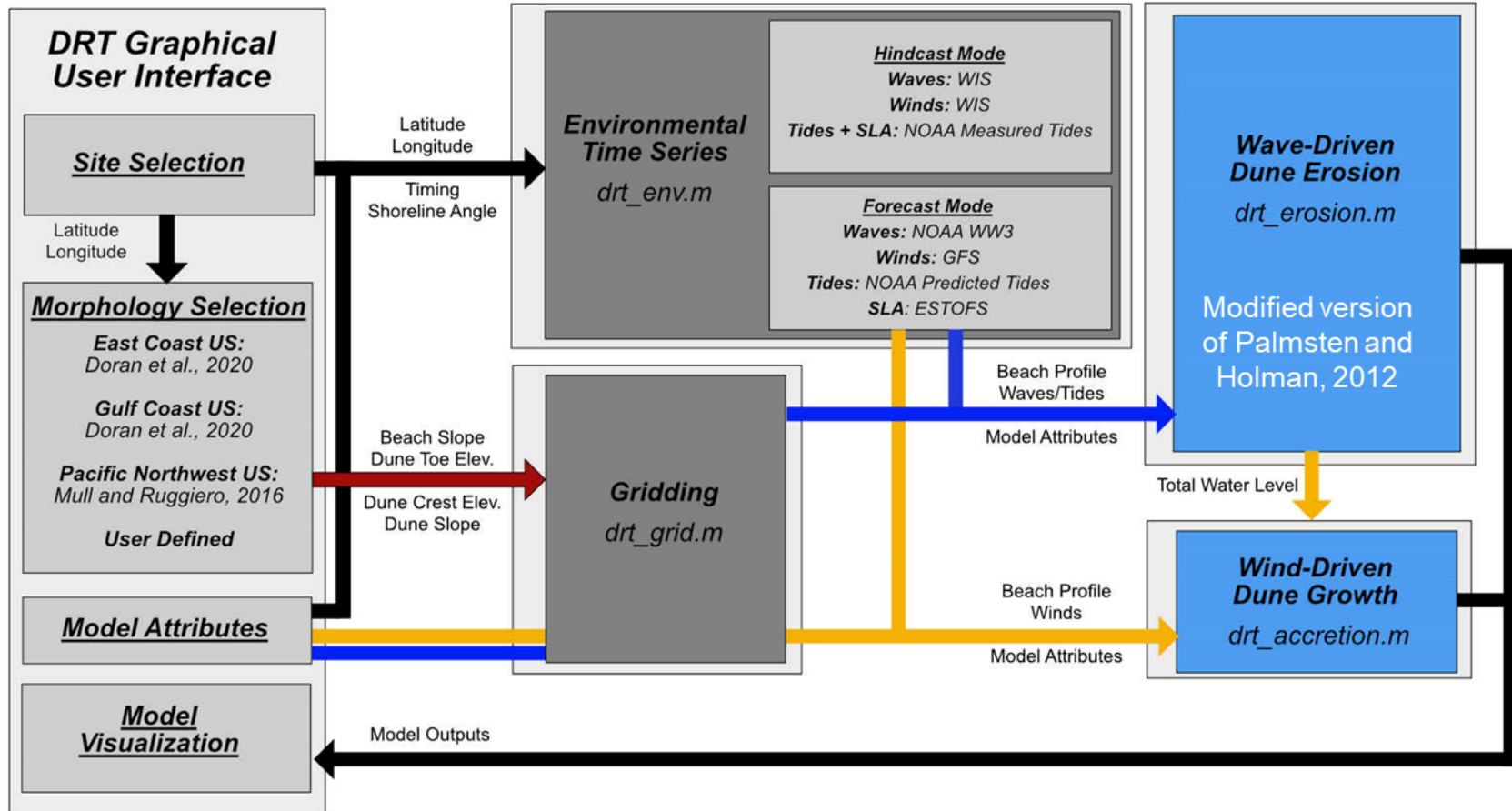
TOOL DEVELOPMENT



** Simplistic aeolian model input for deployability reasons, more complex model could be added



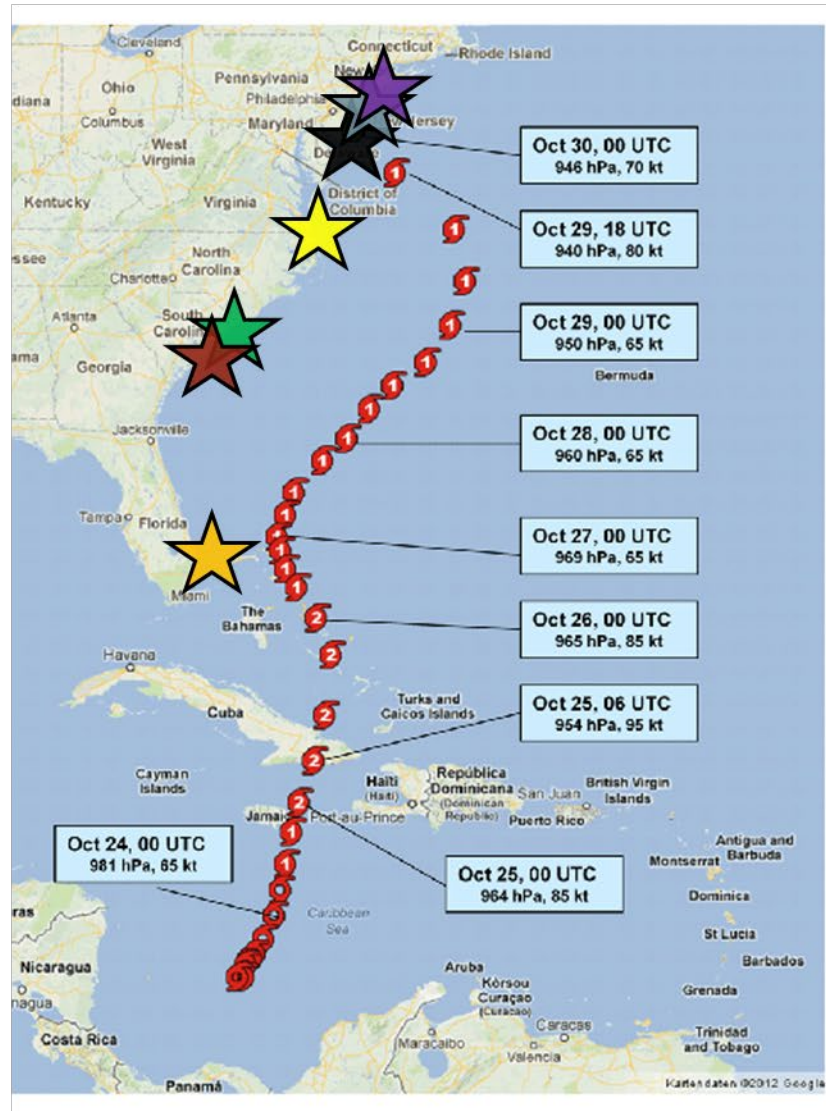
TOOL DEVELOPMENT



Example Case – Hurricane Sandy



Mantoloking, NJ
 Long Beach Island, NJ
 Dewey Beach, DE
 Virginia Beach, VA
 Myrtle Beach, SC
 Folly Beach, SC
 Ft. Lauderdale, FL



Example Case – Hurricane Sandy

Ft. Lauderdale, FL

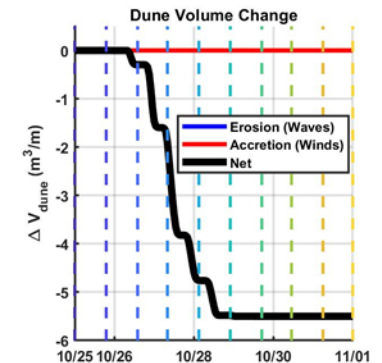
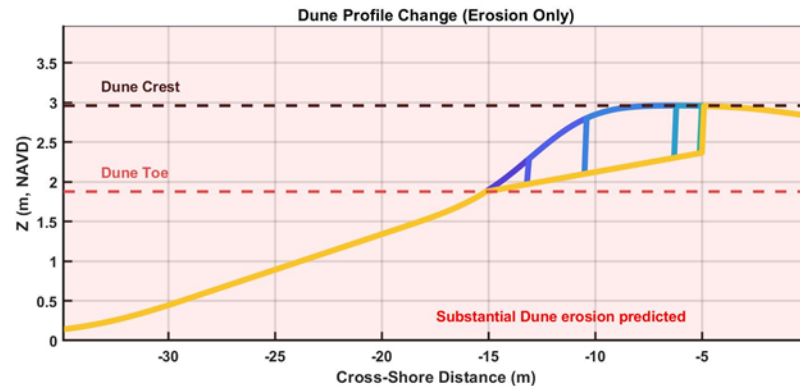
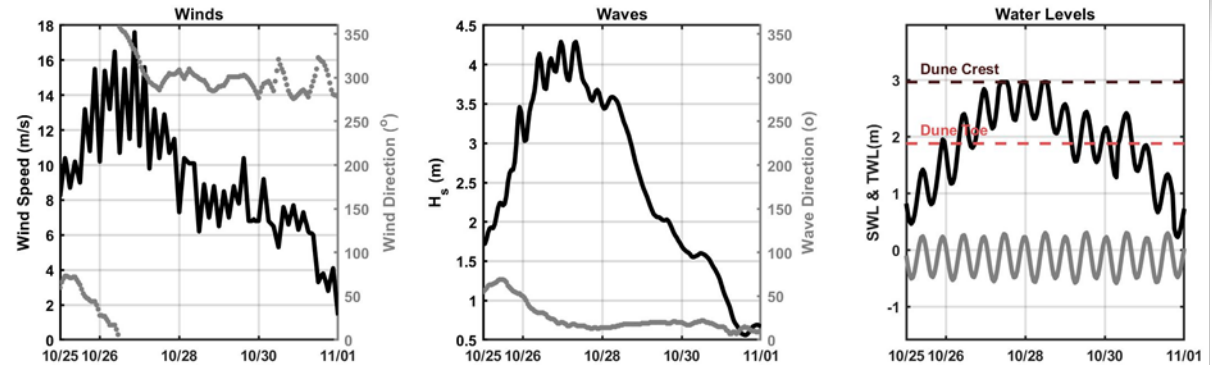


Observed:

Major dune erosion, overwashing

Predicted:

Major dune erosion



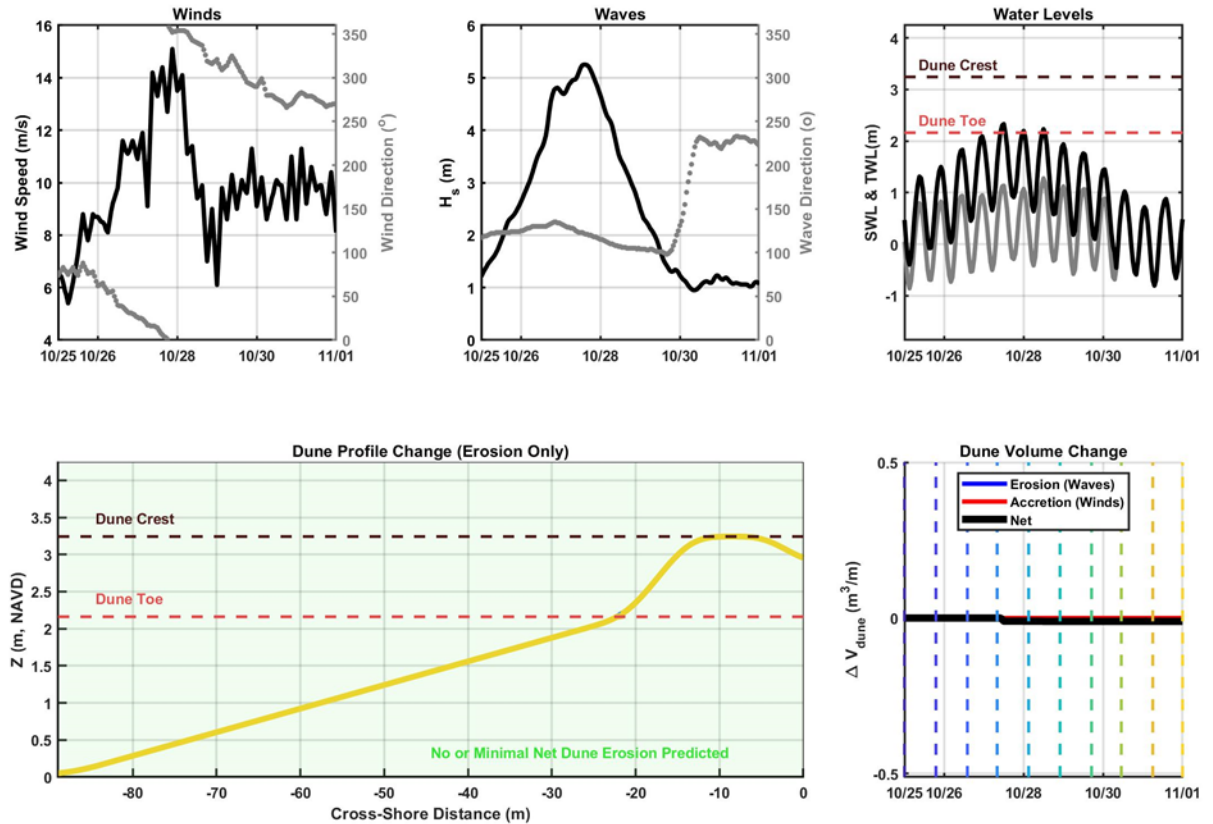
Example Case – Hurricane Sandy

Folly Beach, SC



Observed:
Beach erosion,
limited dune impacts

Predicted:
Limited dune
impacts



Example Case – Hurricane Sandy

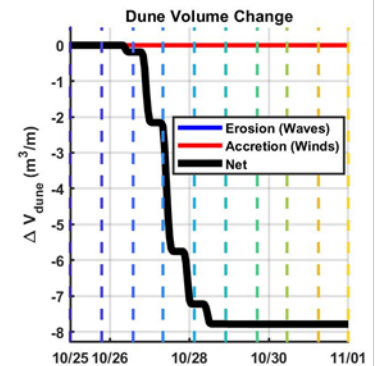
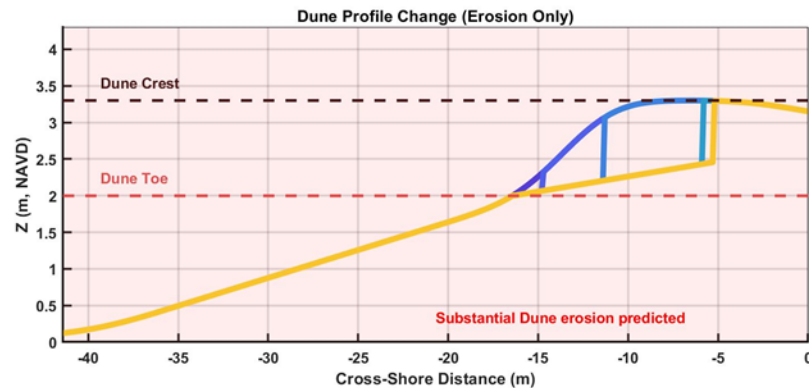
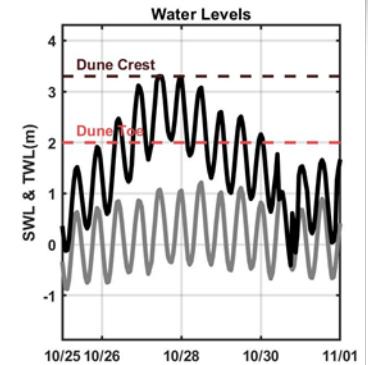
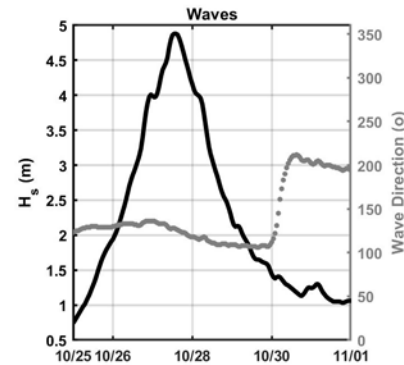
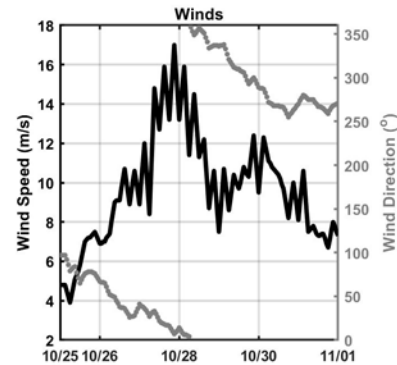


Myrtle Beach, SC



Observed:
Limited dune impacts

Predicted:
Major dune impacts



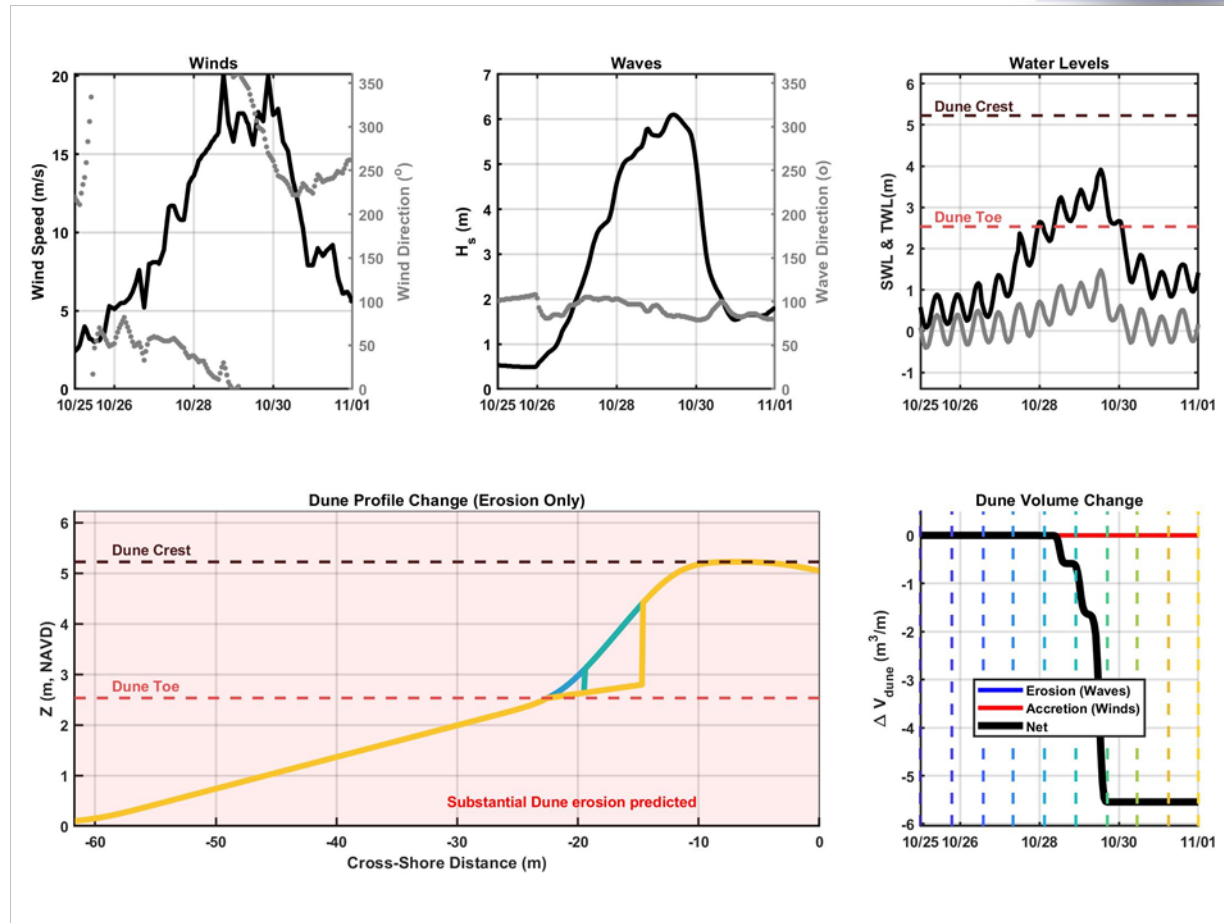
Example Case – Hurricane Sandy

Virginia Beach, VA



Observed:
Dune scarping/retreat

Predicted:
Dune scarping/retreat



Example Case – Hurricane Sandy



Dewey Beach, DE

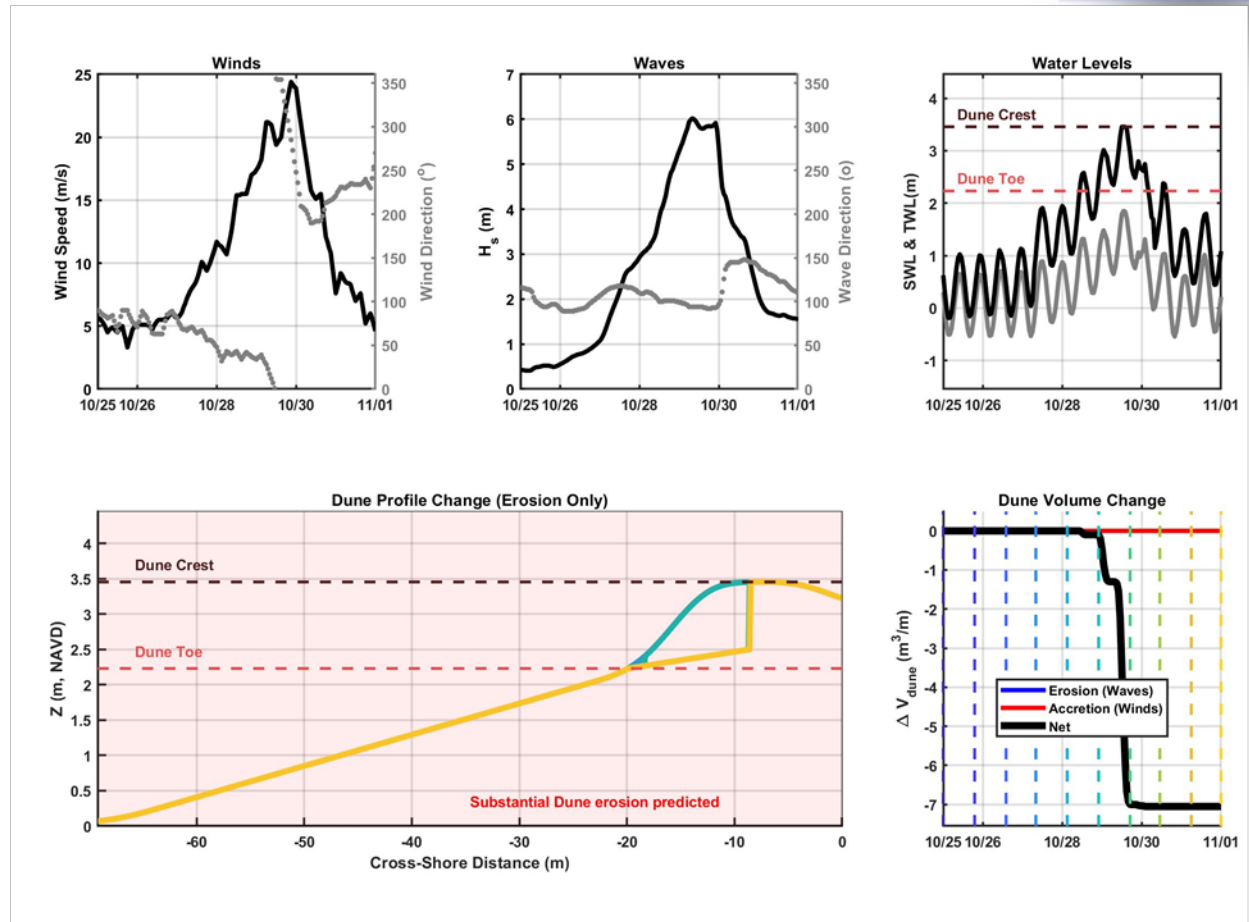


Observed:

Major dune impacts

Predicted:

Major dune impacts



Example Case – Hurricane Sandy



Long Beach Island, NJ

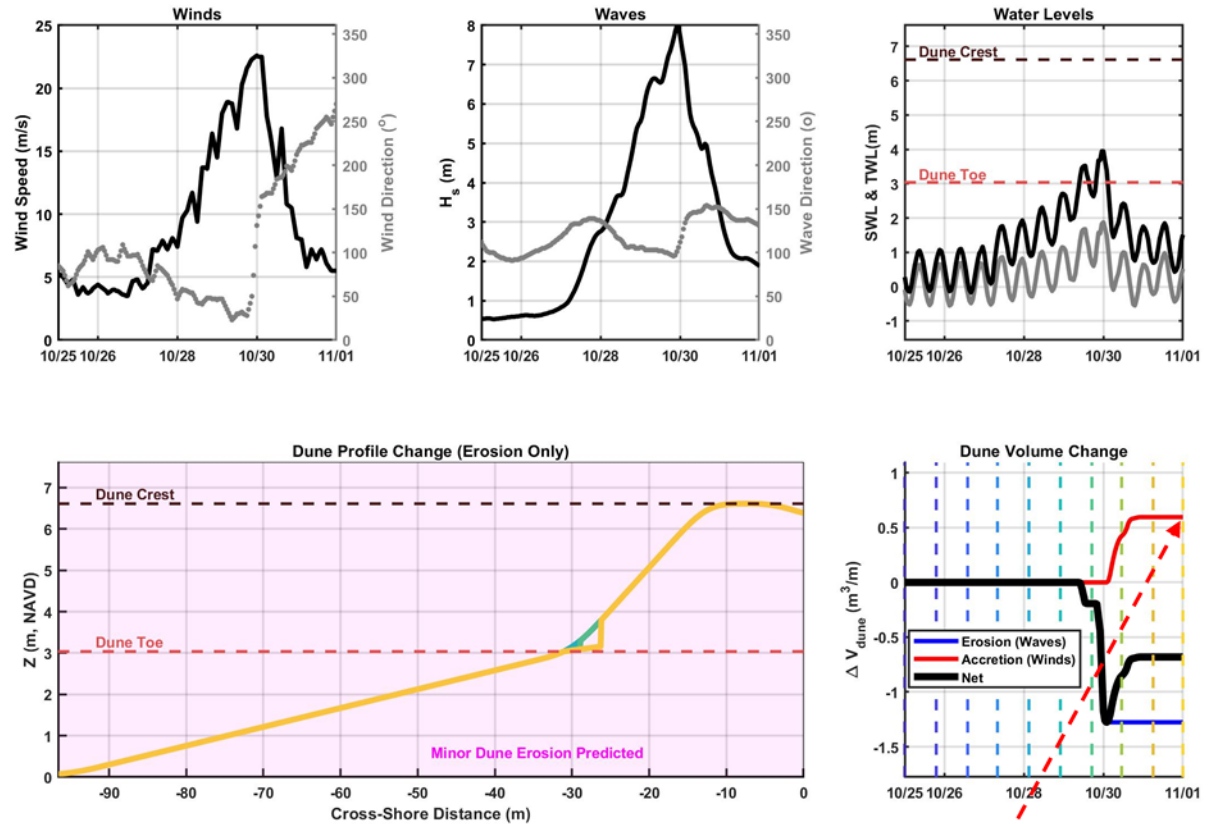


Observed:

Major dune impacts

Predicted:

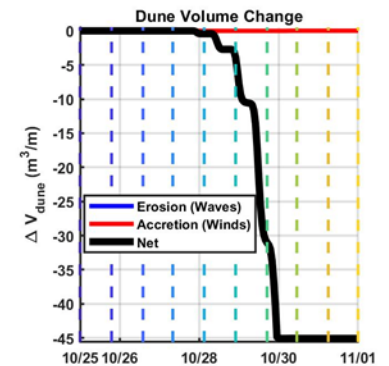
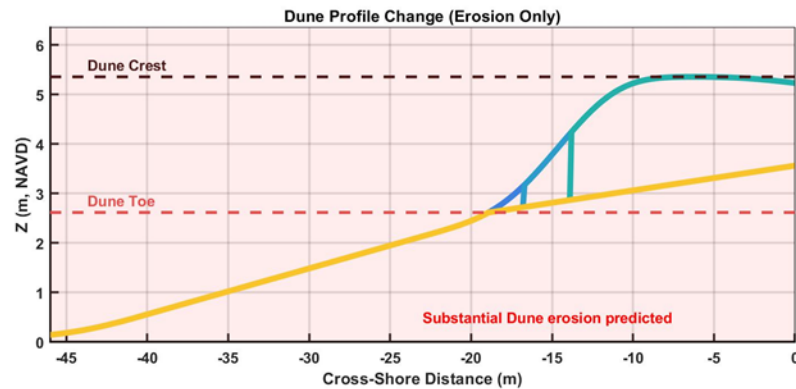
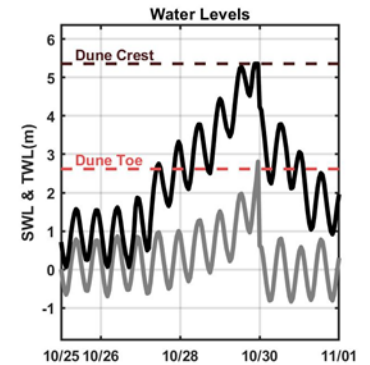
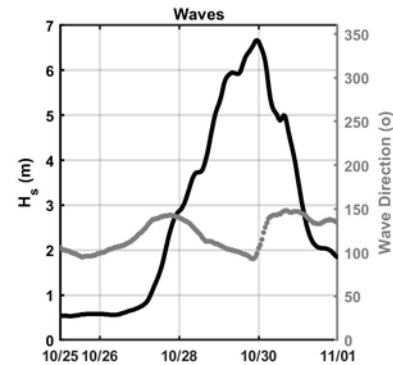
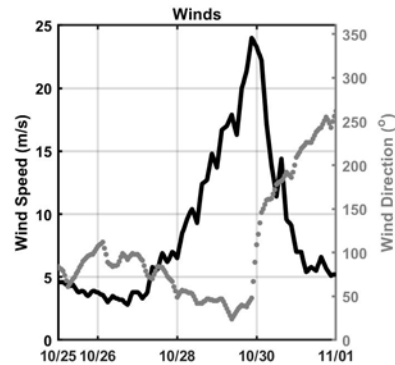
Minor dune impacts
(Note: morphology represents nourished profile after Sandy)



Numbers are small, but wind blown transport expected to occur during this event

Example Case – Hurricane Sandy

Mantoloking, NJ



Observed:
Dune
breaching/destruction

Predicted:
Dune destruction

Example Case – Hurricane Sandy

Myrtle Beach, SC

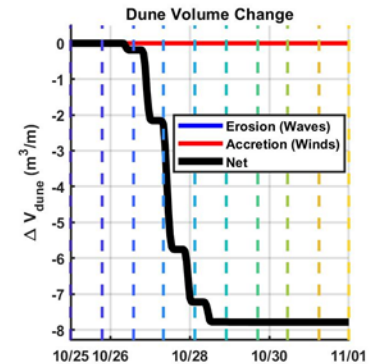
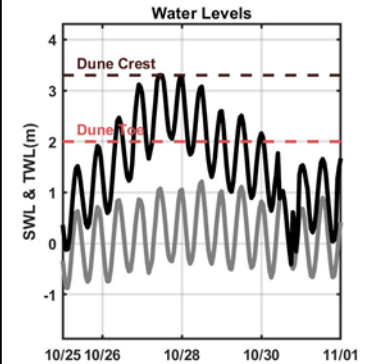
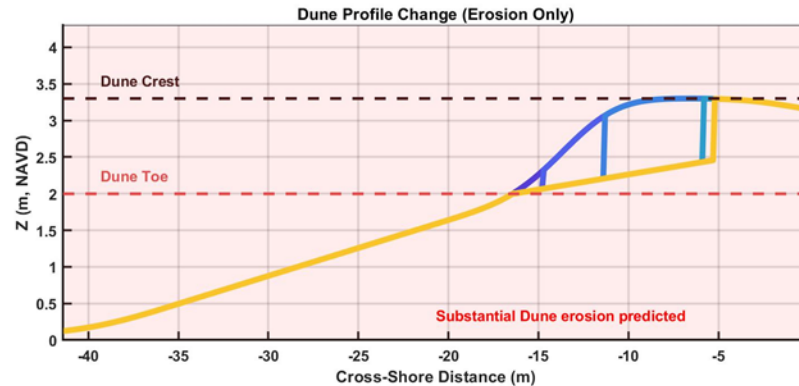


Overall hindcast simulations match reality well except at Myrtle Beach (and Long Beach Island).

What are we getting wrong?

Observed:
Limited dune impacts

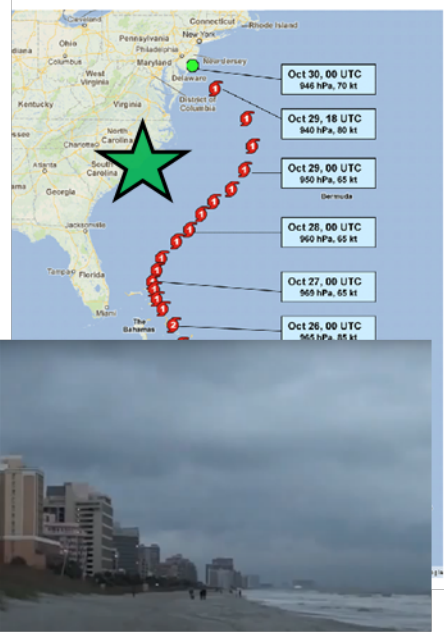
Predicted:
Substantial dune impacts



Example Case – Hurricane Sandy



Myrtle Beach, SC



Observed:
Limited dune impacts

Predicted:
Substantial dune impacts

Dune Response Tool

Model Attributes Advanced

Model Parameters

Median Grain Size (mm)	0.35
Wave Runup Factor	1.26
Dune Slope Trajectory	0.54
Dune Erodibility Coefficient	0.0025
Aeolian Transport Coefficient	2.78

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☐ Deterministic Case

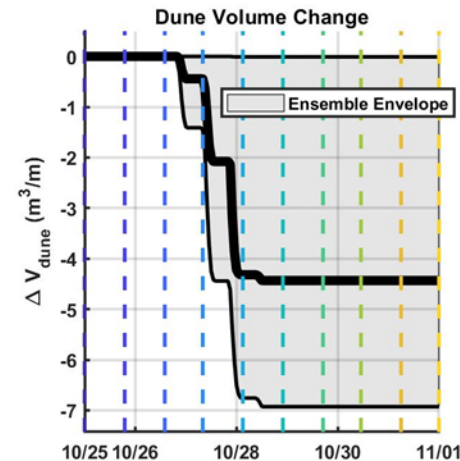
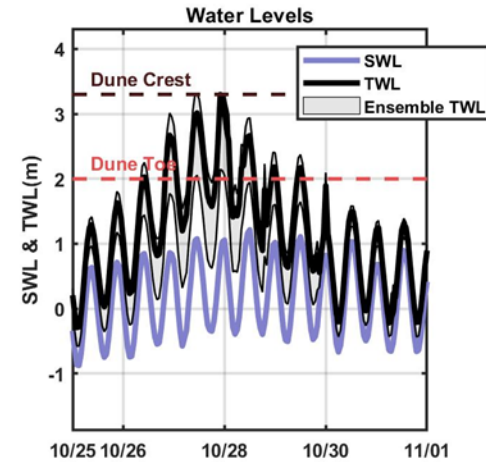
☒ Ensemble Run

Variable: Beach Slope

Min. Value	0.035
Max. Value	0.0916

Run Model

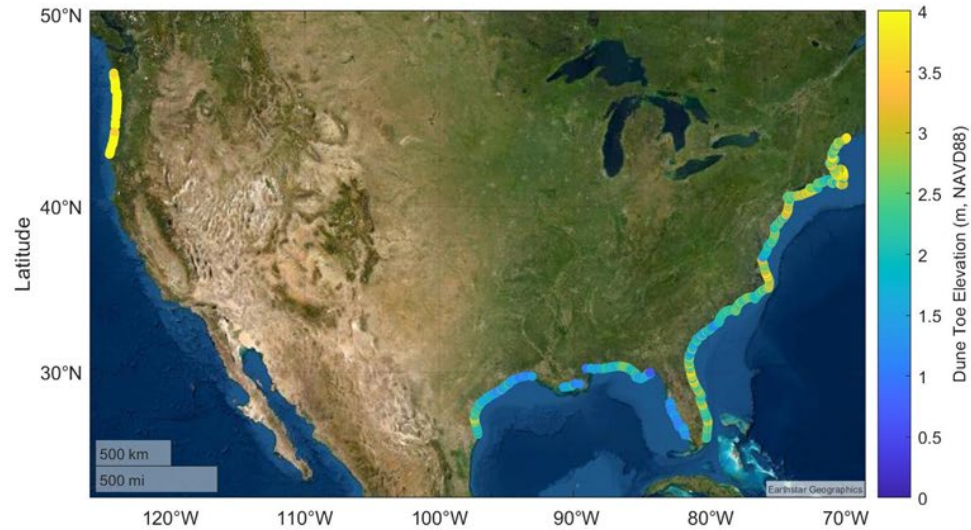
Save Output



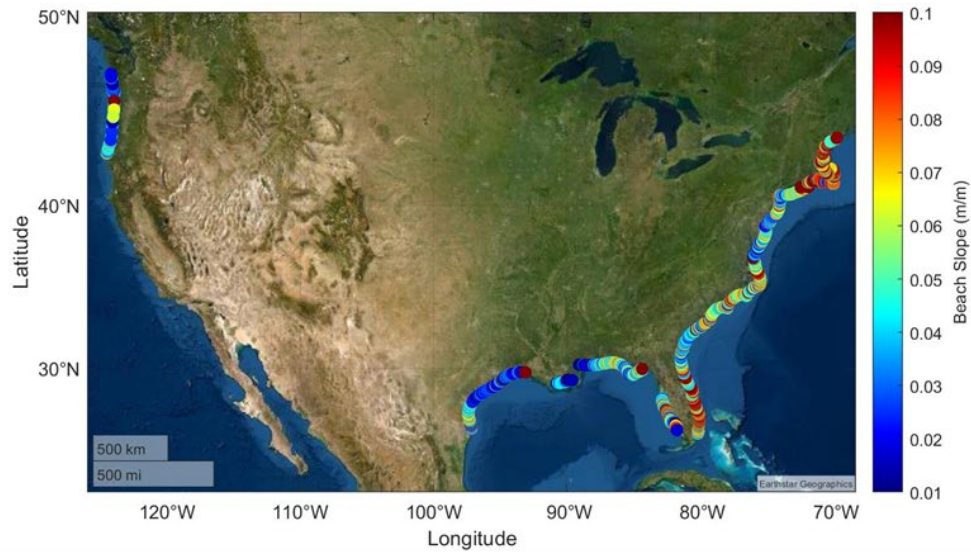
Ensemble runs can inform envelope of potential erosion



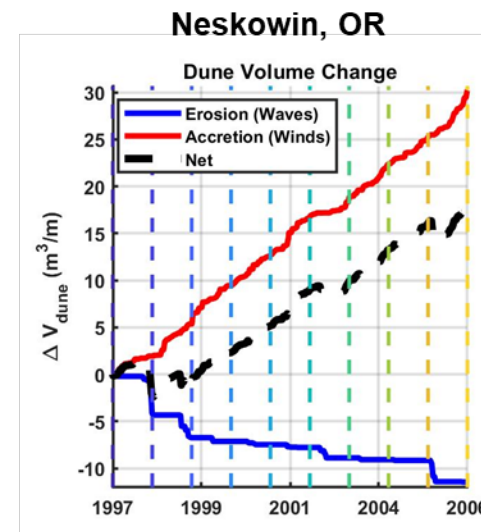
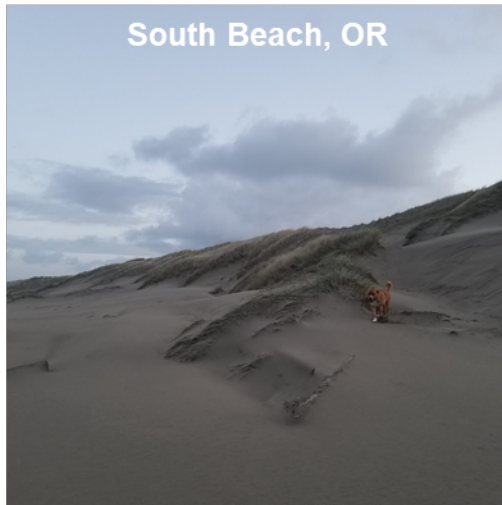
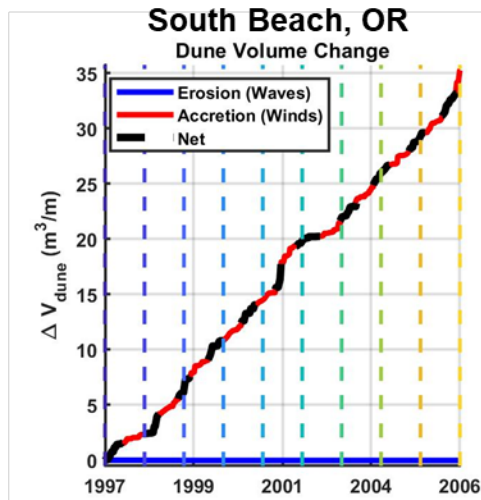
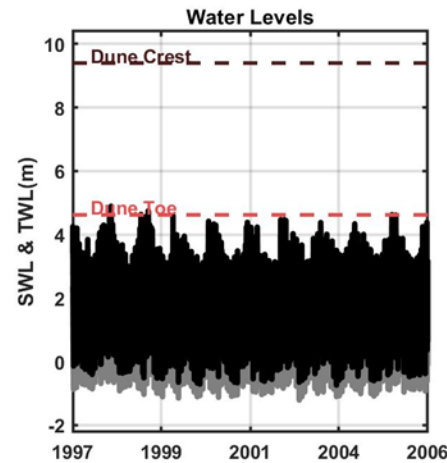
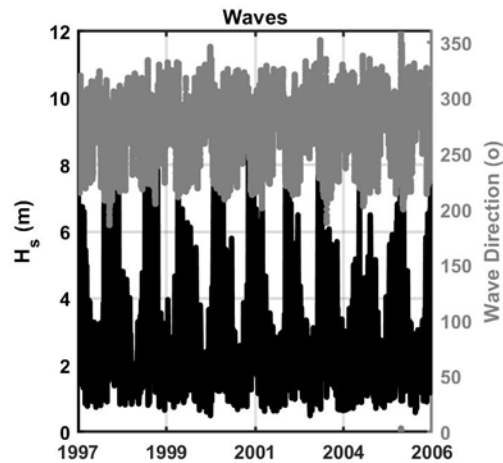
Dune Toe Elevation



Beach Slope



Example Case – Long Term Dune Evolution, Oregon





Next Steps:

- Testing and Feedback from District partners

Useability

Ease of deployment

Additional features?

- Add morphometrics for missing areas if suitable data can be found (JALBTCX, USGS, academics, ect...)
- Publicly release code





Questions/Comments?