TOWARDS A NATIONWIDE EROSION FORECAST USING XBEACH
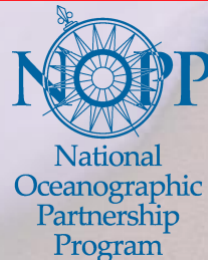
Nahruma Mehzabeen Pieu & Dr. Casey Dietrich
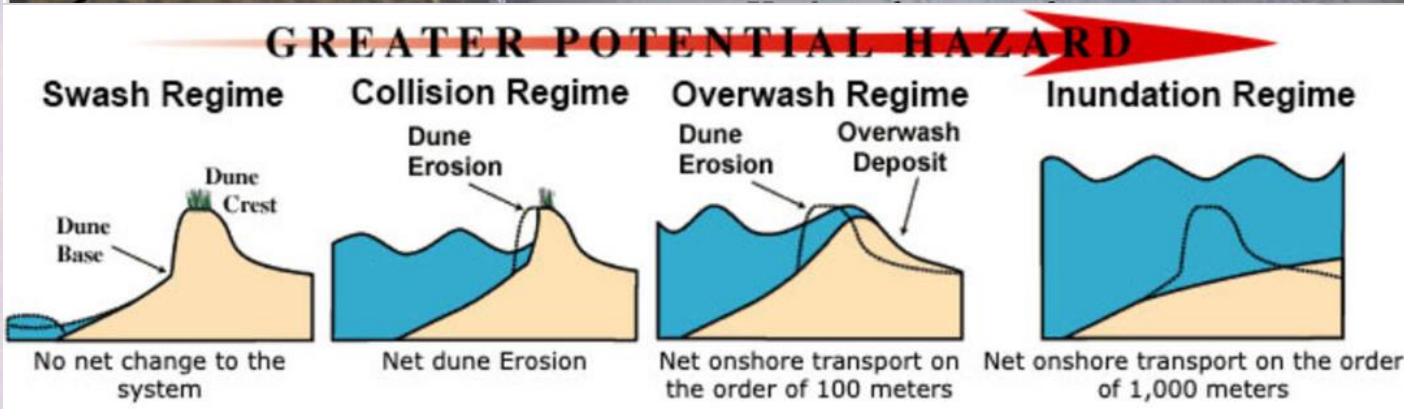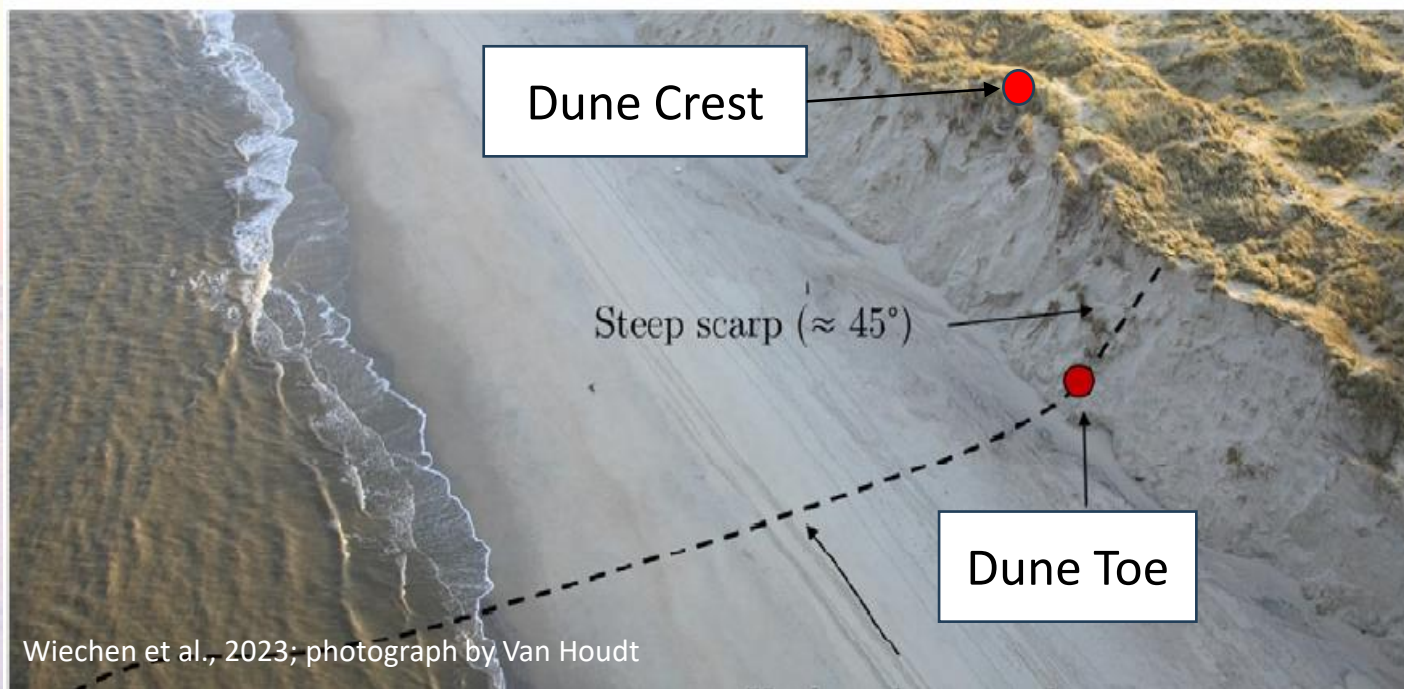
North Carolina State University

06/04/2024

Dunes Protect us During Storms
But Are Also Threatened by Them

Dune Crest

Steep scarp ($\approx 45°$)

Dune Toe

Wiechen et al., 2023; photograph by Van Houdt

GREATER POTENTIAL HAZARD

Swash Regime
Dune Crest
Dune Base
No net change to the system

Collision Regime
Dune Erosion
Net dune Erosion

Overwash Regime
Dune Erosion
Overwash Deposit
Net onshore transport on the order of 100 meters

Inundation Regime
Net onshore transport on the order of 1,000 meters

Dune Failure Cause Severe Damage
Can a Forecast System Prevent Loss?

Before

Source: weather.gov

After

Hurricane Fran (1996)

Dune Failure Cause Severe Damage
Can a Forecast System Prevent Loss?

Before
Source: weather.gov

After

Hurricane Fran (1996)

Hurricane Dorian (2019)
Source:wavy

Before

After

Hurricane Florence (2018)
Source: wusa9 article
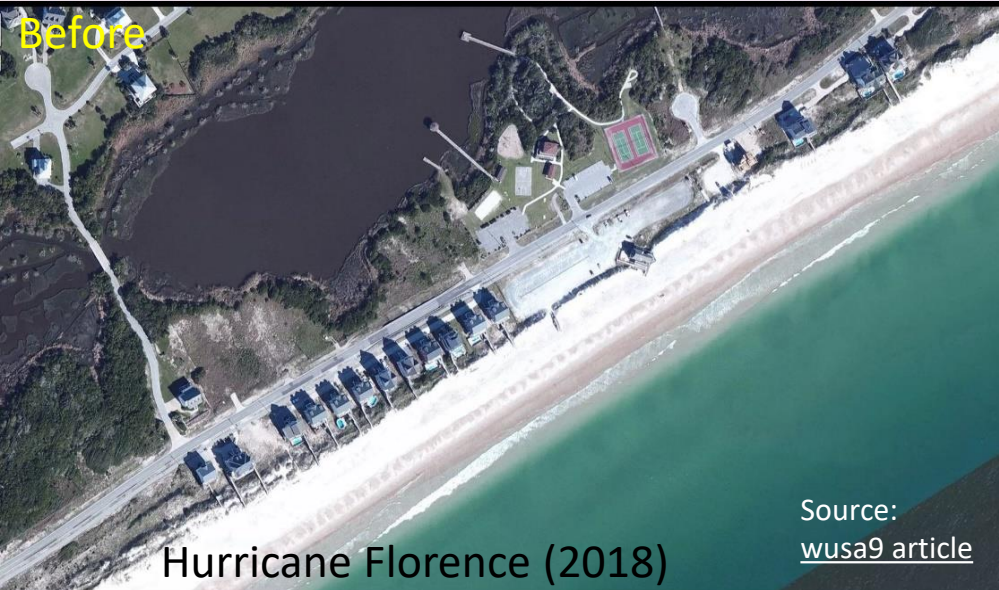
The Types of Model Predicting Erosion
Understanding The Balance Between Speed And Accuracy

Erosion Models :

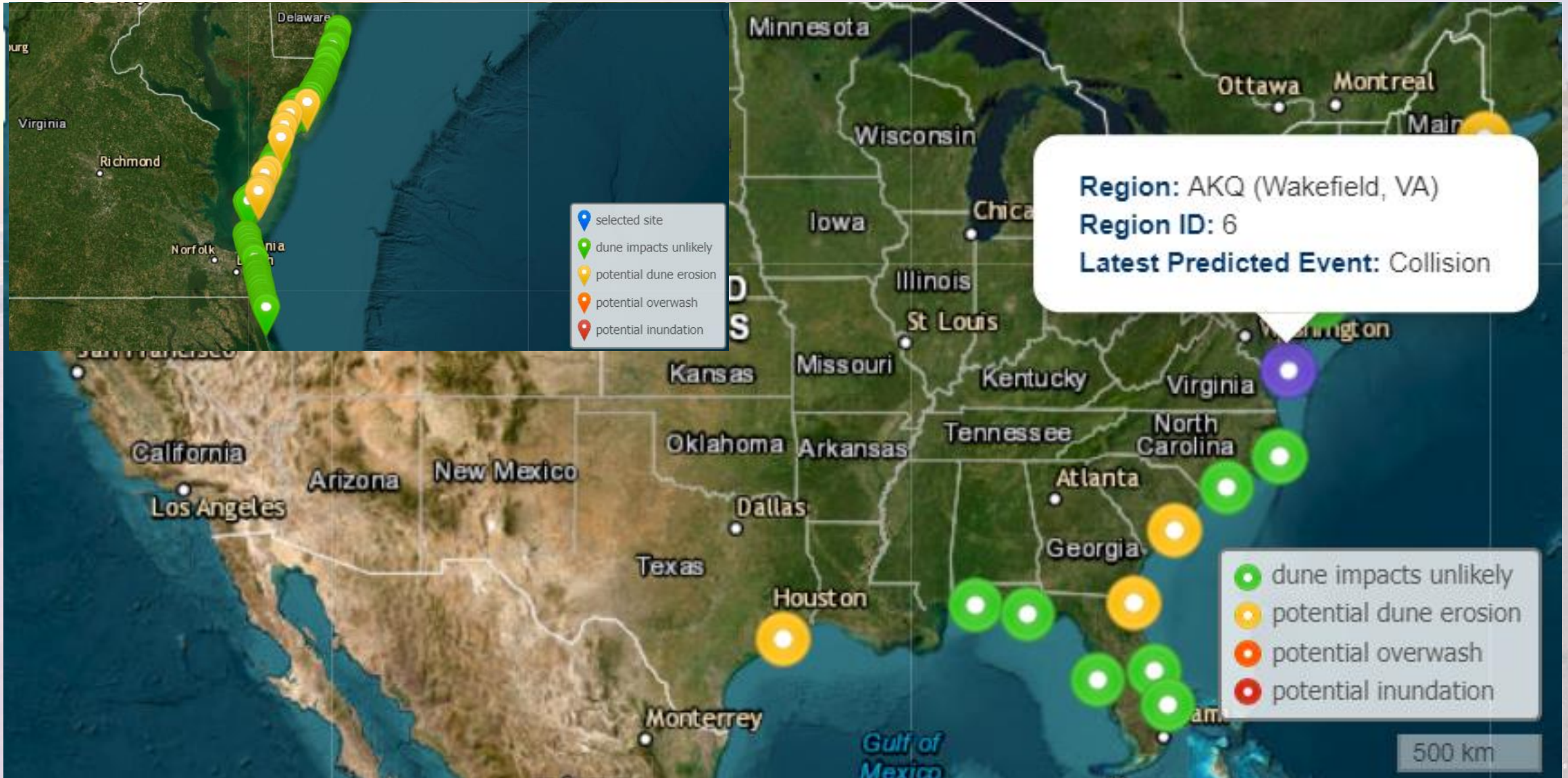|		
• Parametric model : Example-USGS TWL CCFS	Fast, Wide Coverage	Non-dynamic coastline
• Equilibrium model : Example-SBEACH	Fast	Assumes profile reaches equilibrium state
• Process-based models: Example- CSHORE, XBeach, etc.	Includes all physics	Time expensive

The Existing Forecast System ➝ Parametric
USGS TWL CCFS: They Overlook The Dynamic Nature Of The Coast

The Existing Forecast System ⟶ Parametric
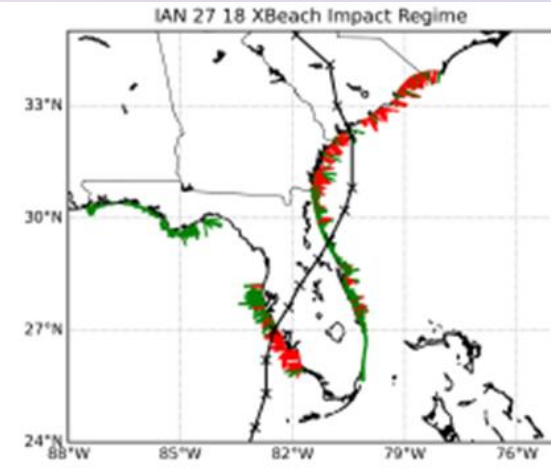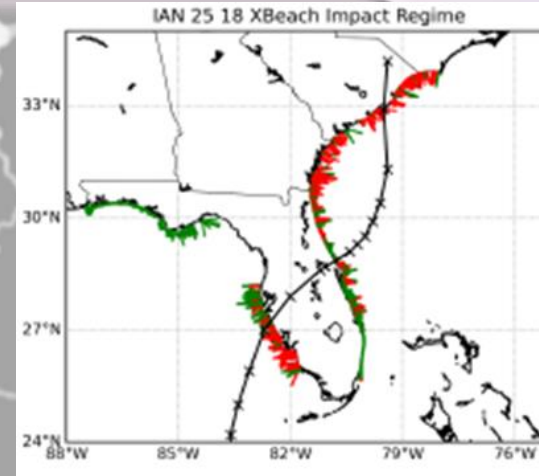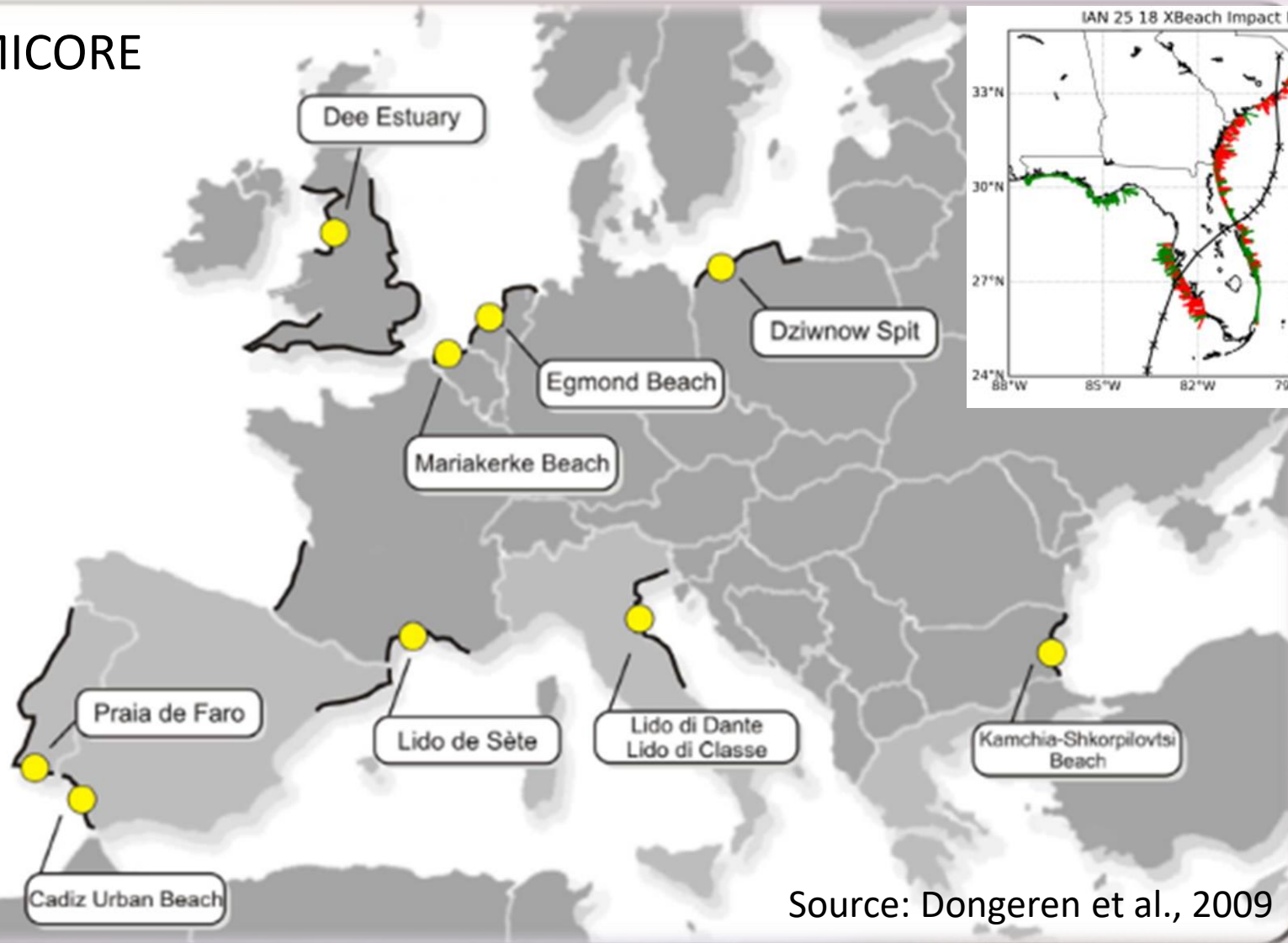## USGS TWL CCFS: They Overlook The Dynamic Nature Of The Coast

The Existing Forecast System ⟶ Parametric
USGS TWL CCFS: They Overlook The Dynamic Nature Of The Coast

Source:usgs.gov
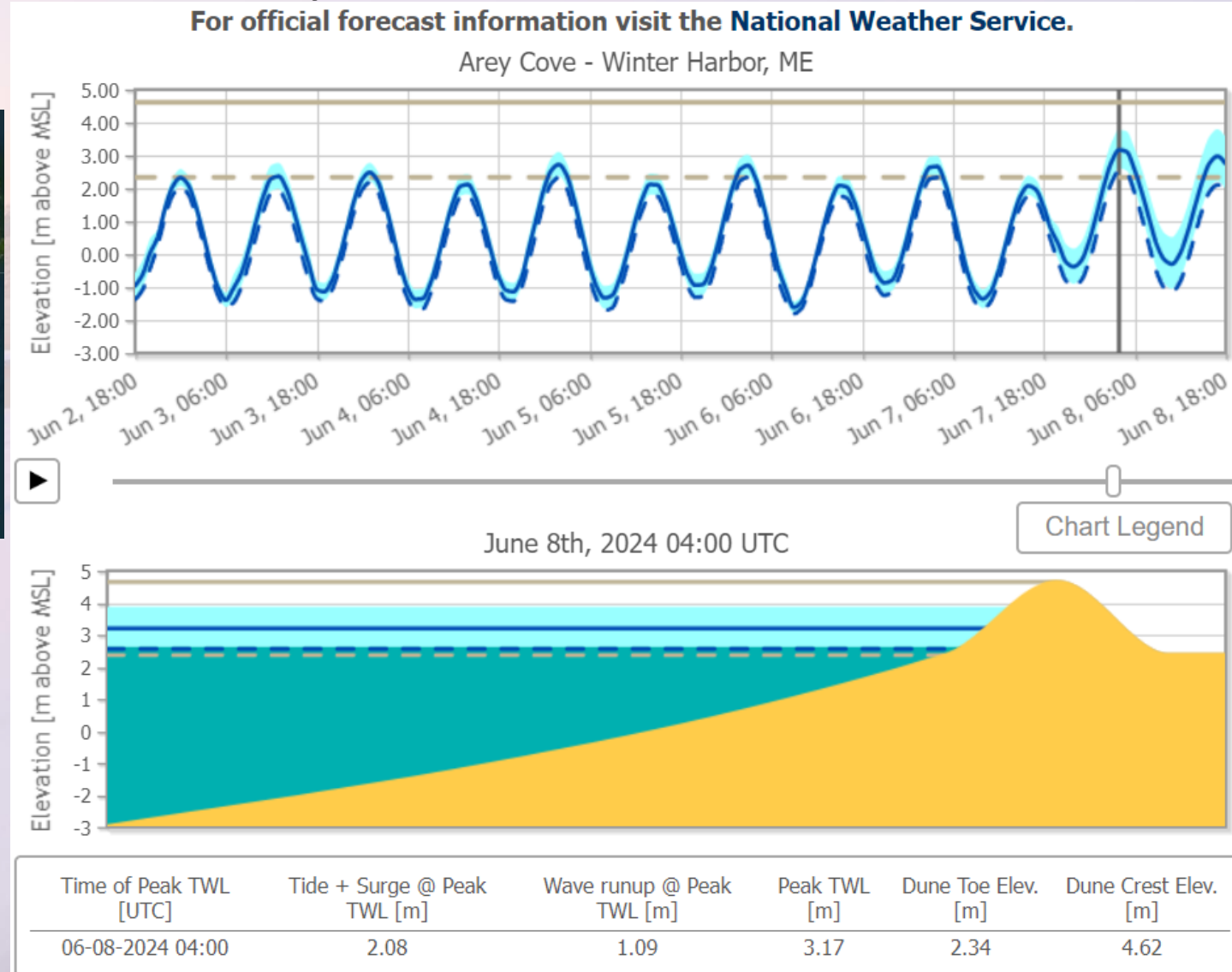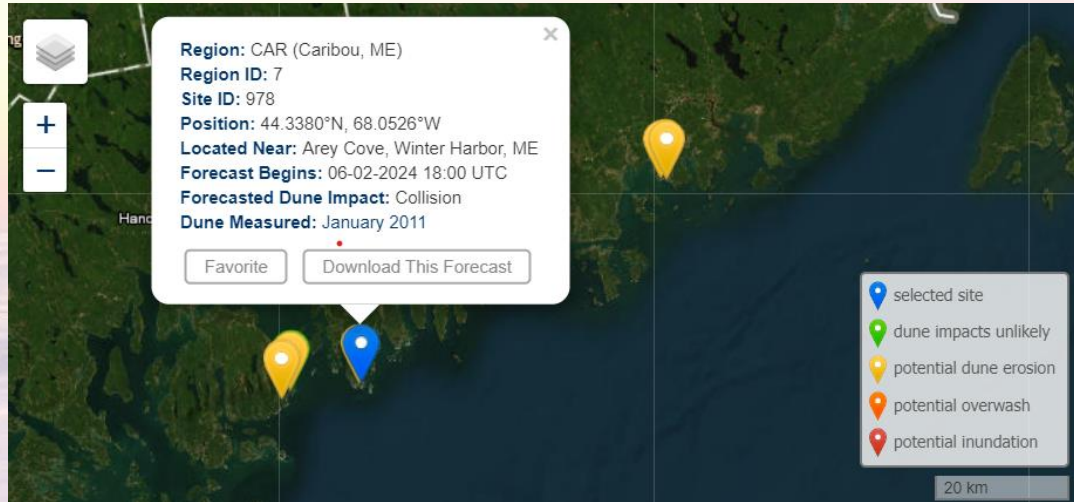
The Existing Forecast System → Process Based
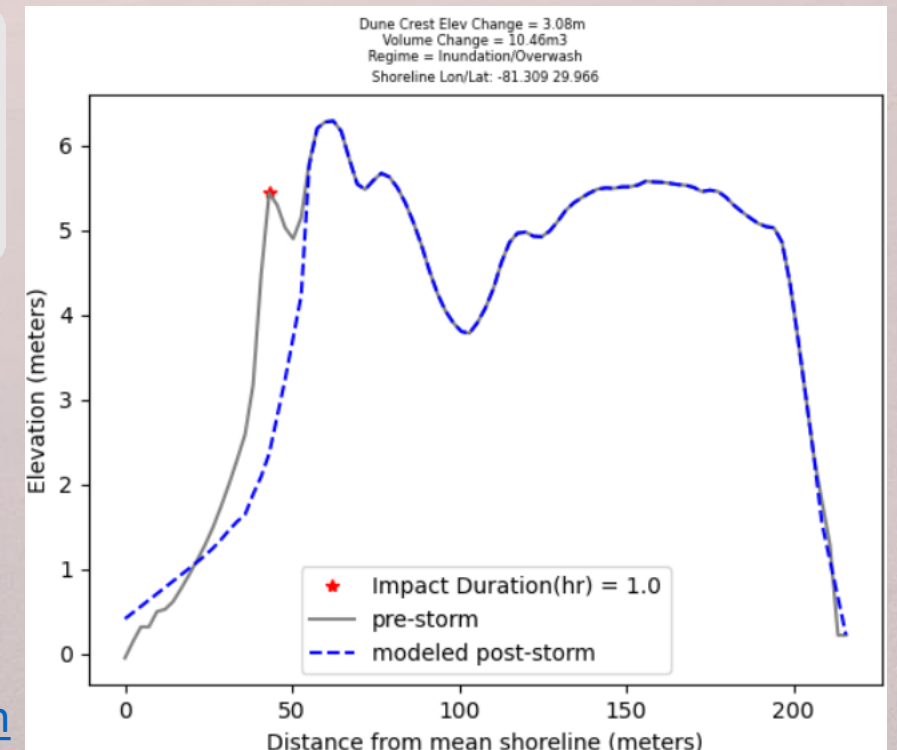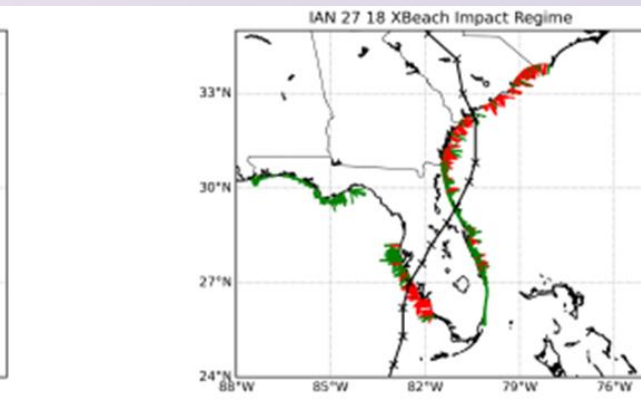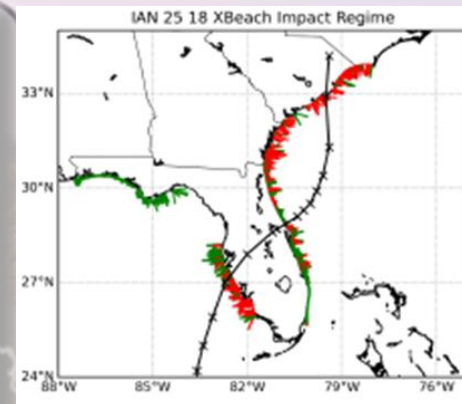## 1D Models That Ignore Lateral Sediment Flow

MICORE

Source: Dongeren et al., 2009

Source: NCSU XBeach

The Existing Forecast System → Process Based
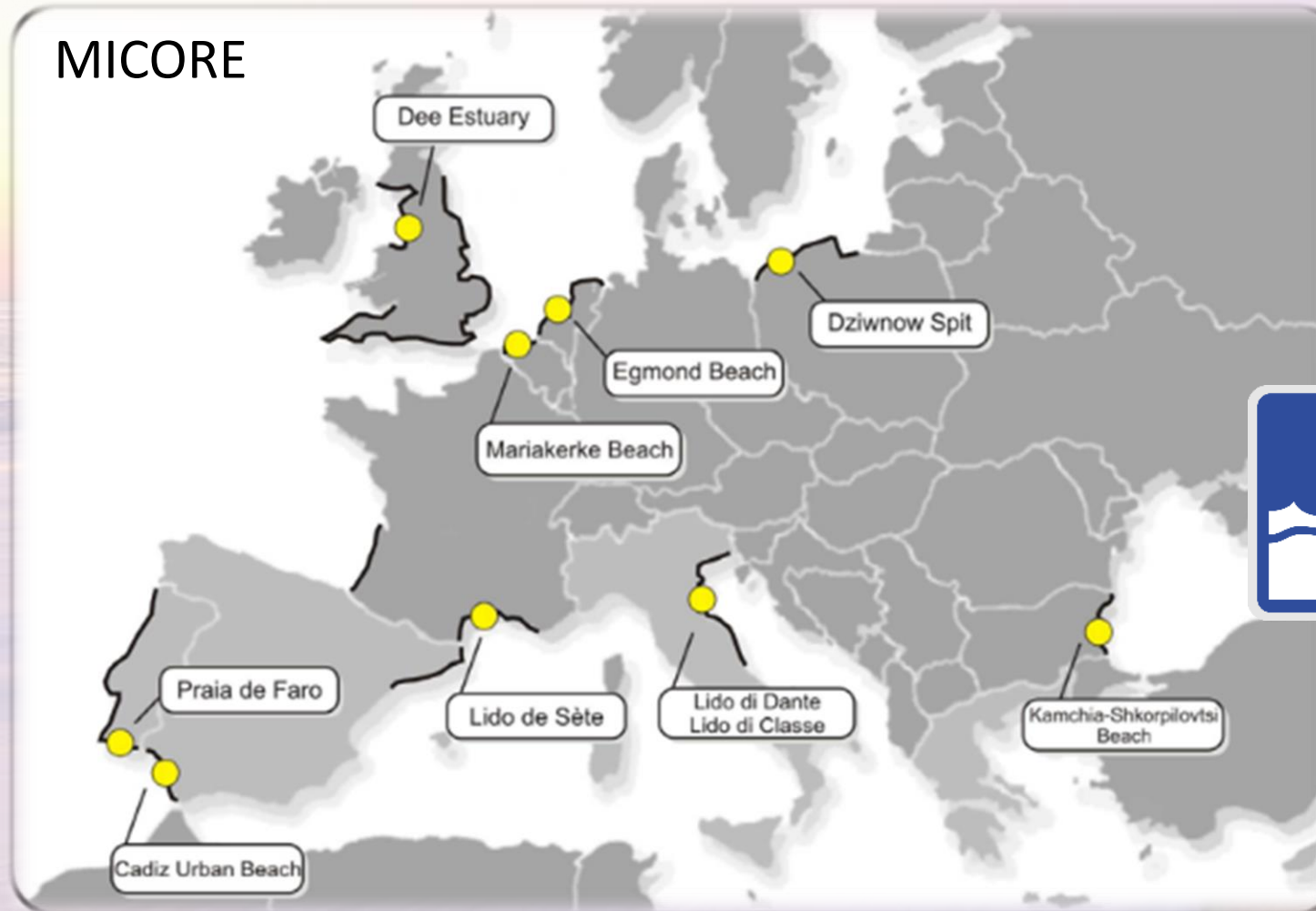## 1D Models That Ignore Lateral Sediment Flow
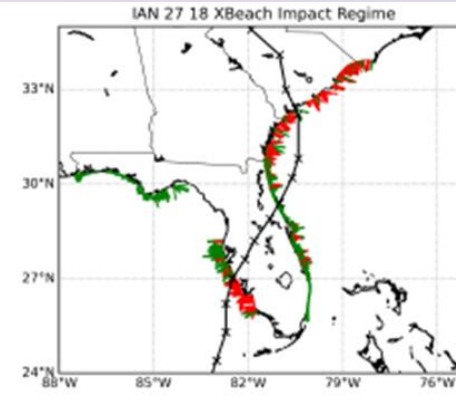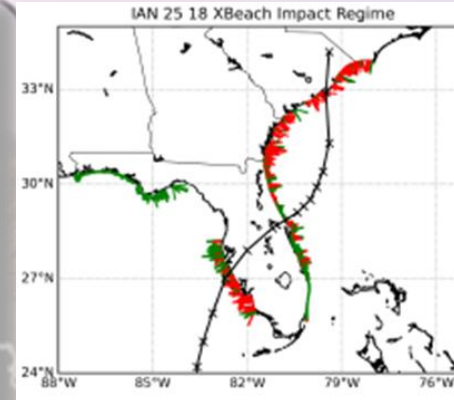
MICORE

Source: Dongeren et al., 2009

Source: NCSU XBeach

The Go- to Morphological Model For Forecast Studies
XBeach: Adapting Improved Physics And Versatility But Always 1D

MICORE

Source: Dongeren et al., 2009

Source: NCSU XBeach

- Open source
- Incorporates many types of coast
- Over prediction

Parameters Associated With Xbeach
Case by Case Basis or One Size Fits All?

Parameter	Range	Default	Combined Parameters	McCall et al., 2010	Lindemer et al., 2010	Harter & Figlus 2017	Nederhoff 2014	Schambach et al., 2018	Roelvink et al., 2010
Morfac	10	10	10		10	10			
Smax ,Өmax	0.8-1.2	-1	0.8	varies		0.8			
γua, facua	0.1-0.3	0.175	0.3				0.25	0.3	
Wetslp	0.1-1.0	0.15	0.2	0.15					
hmin	0.001-1.0		0.05	0.08					0.05
dtheta_s	0.1-20	10	20						

Research Questions

- Can we identify a set of parameters that is good enough for general application?

- What is the sensitivity of XBeach to its inputs?
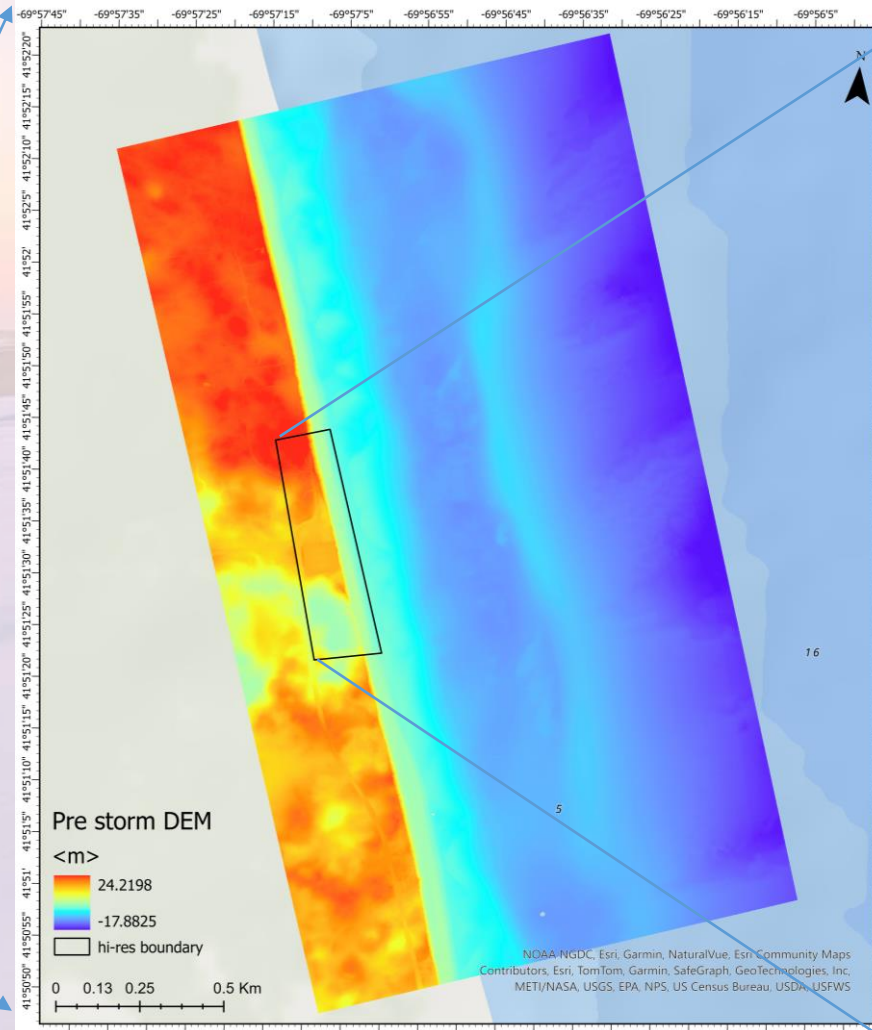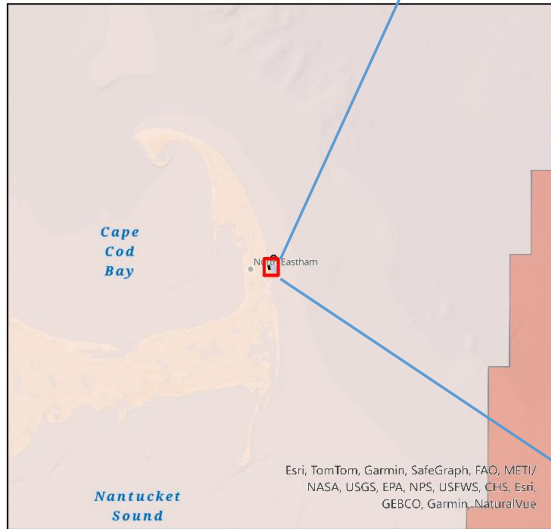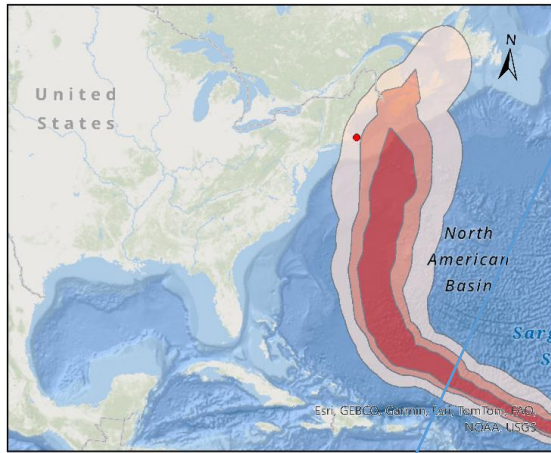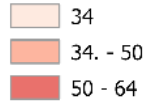 - Forecast and Hindcast?
  - Fine and Coarse Grid? (Future)

What I Want to Achieve

- to develop a XBeach 2D model for Nauset Light Beach, but using methods that can be translated easily to other U.S. coastal regions.

- develop a best-possible hindcast of the erosion and beach changes during Hurricane Lee, via comparisons with post-storm observations.

- examine the model sensitivity to resolution and input parameters, but with a goal to confirm the general applicability of parameters that have been used widely in the literature.

Focus Area at Nauset Light Beach, Massachusetts
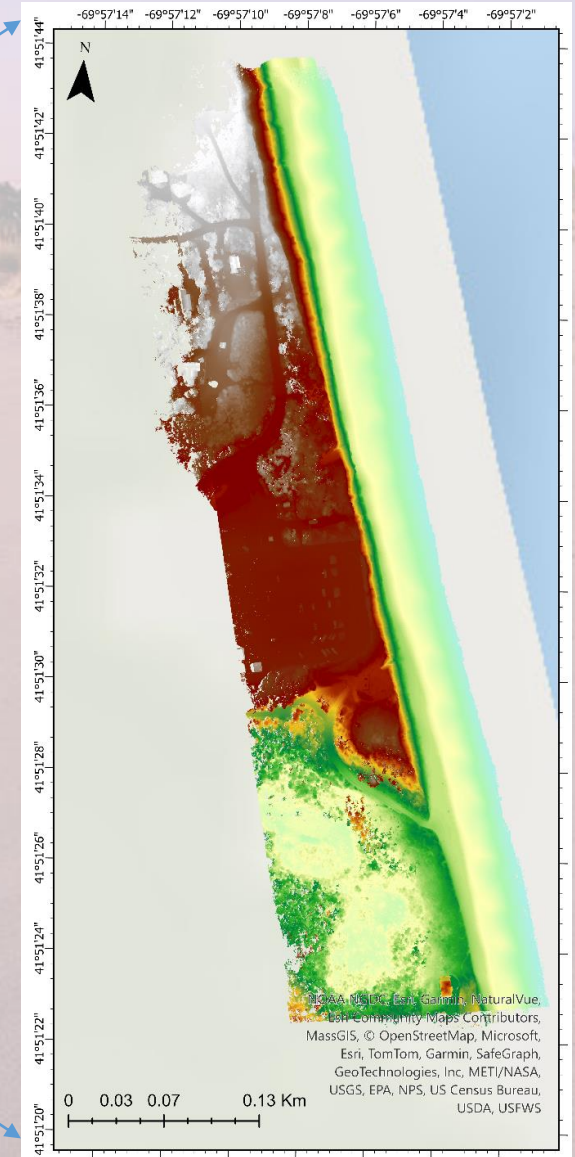
XBeach Model

ADCIRC + SWAN

1.47 km

coastline

2.7 km

1 m

10 m

10 m

1 m

xbGrid
coastline_collected

0   0.15   0.3   0.6 Km

More Sediment In Model And More Erosion Offshore

Observation   Default   Combined

WL + wave

accretion — 3.00, 1.00, 0.50, 0.10, 0.05, 0.00, −0.05, −0.10, −0.50, −1.00, −2.00, −7.00 — erosion

	Erosion (m3)	Accretion (m3)
obs	1323.06	6901.48
default	1769.22	20904.71
calibrated	3186.98	11577.44

More Sediment In Model And More Erosion Offshore

Observation · Forecast · Hindcast

accretion — 3.00, 1.00, 0.50, 0.10, 0.05, 0.00, -0.05, -0.10, -0.50, -1.00, -2.00, -7.00 — erosion
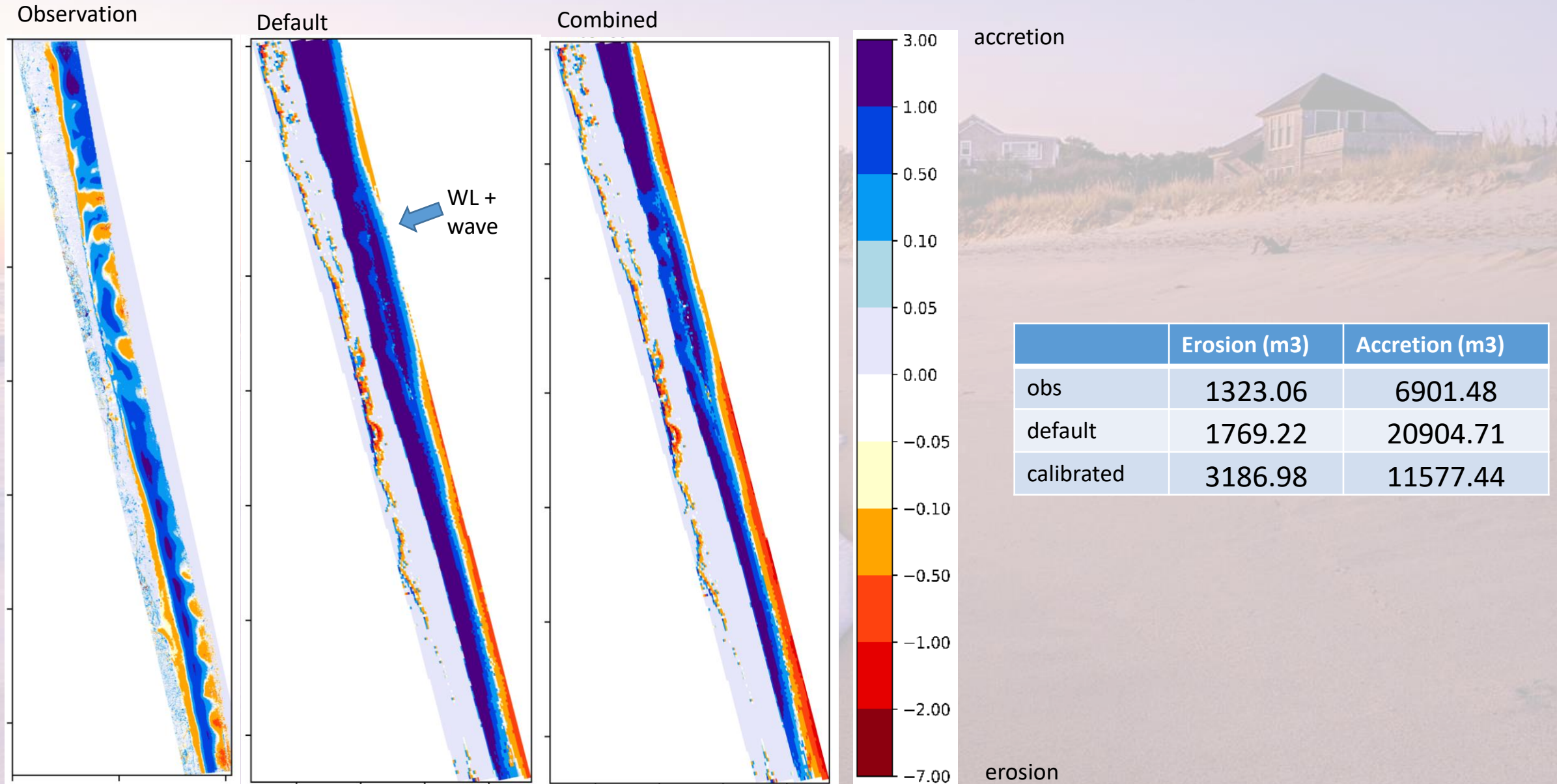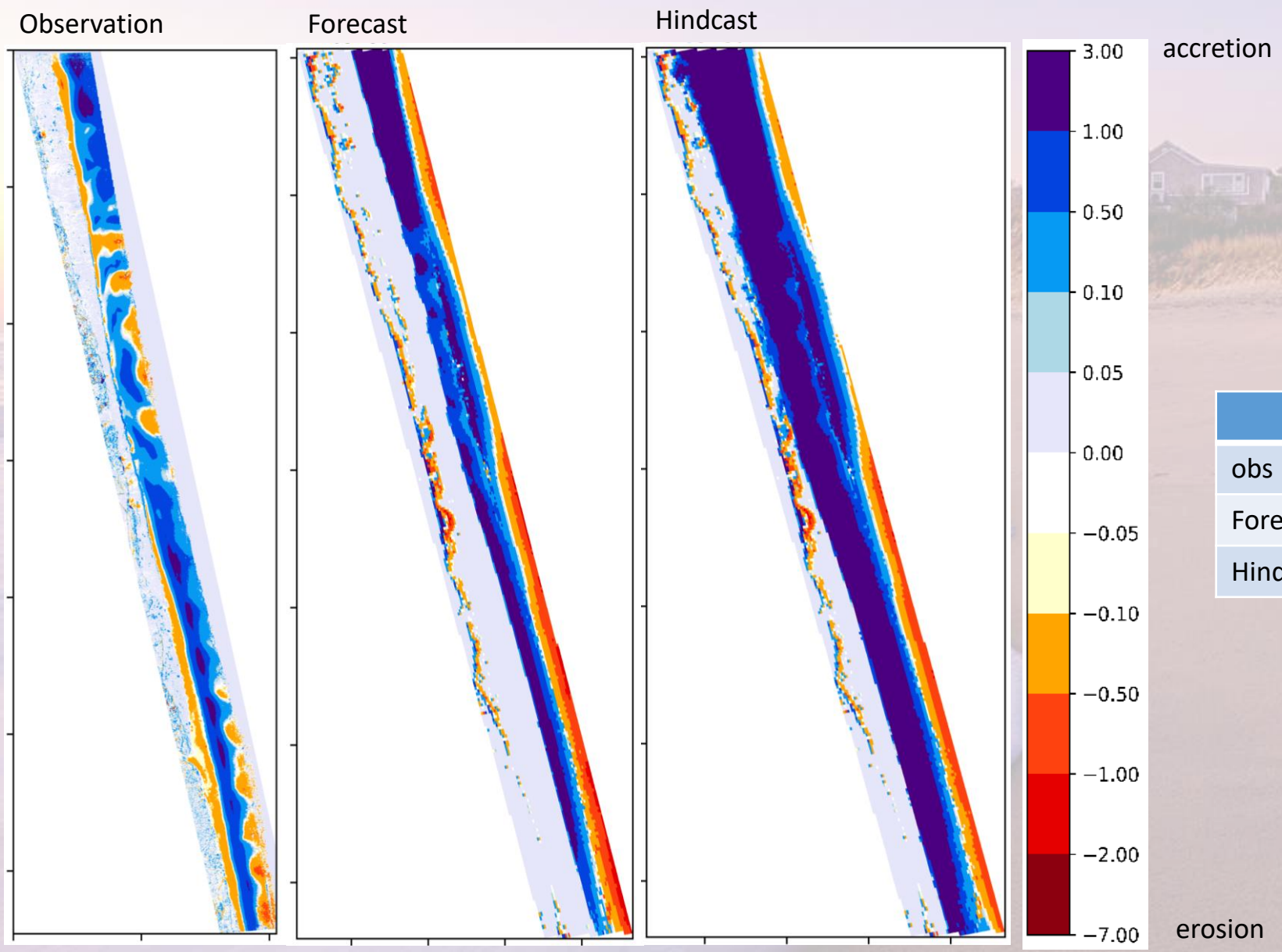
	Erosion (m3)	Accretion (m3)
obs	1323.06	6901.48
Forecast	3186.98	11577.44
Hindcast	2293.74	28514.45
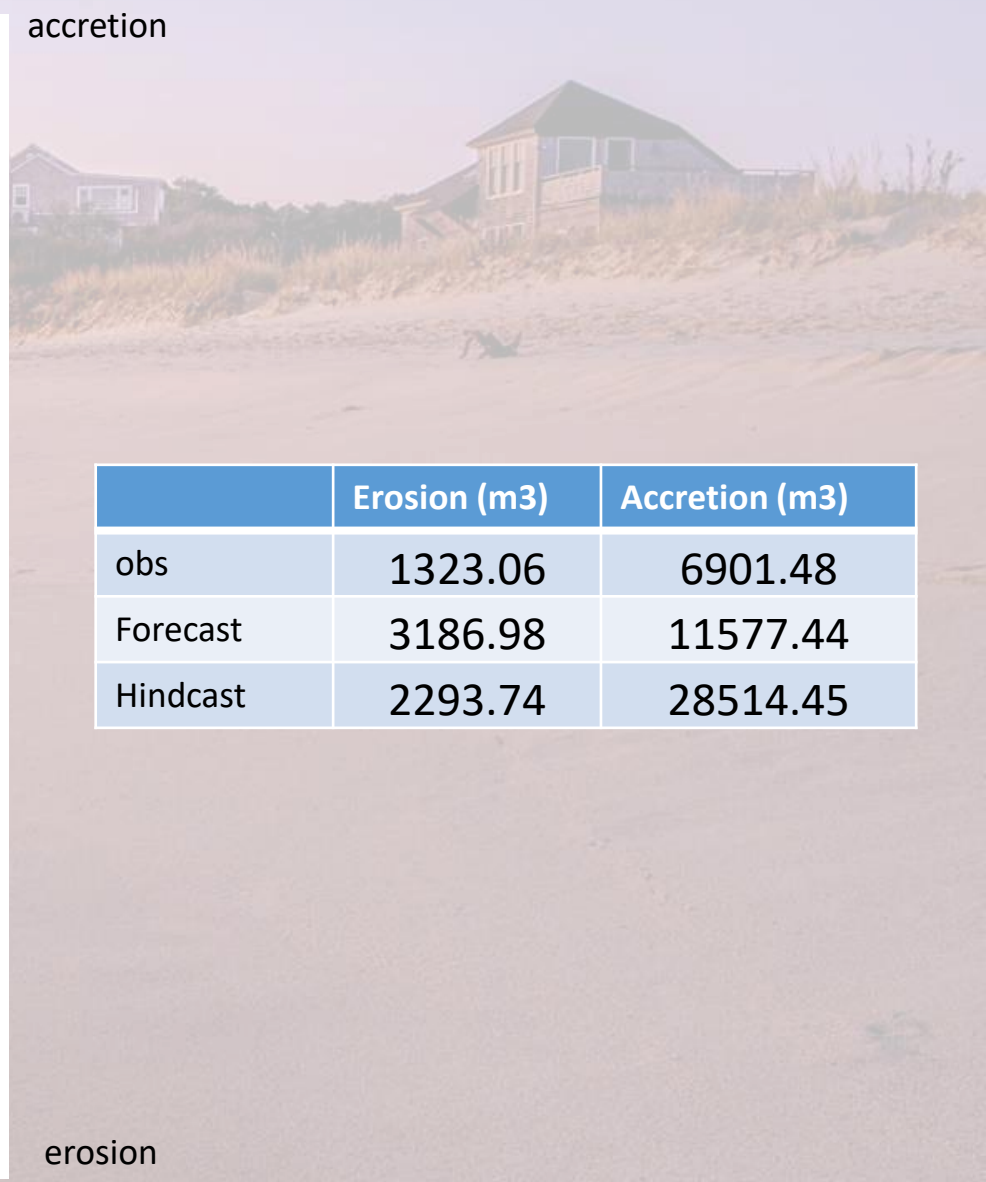
Conclusion

- Calibration is required to achieve meaningful erosion forecasts.

- There is no such "one-size fits all" parameterization for XBeach (yet).

- More study is required to understand the input parameter behavior with XBeach.