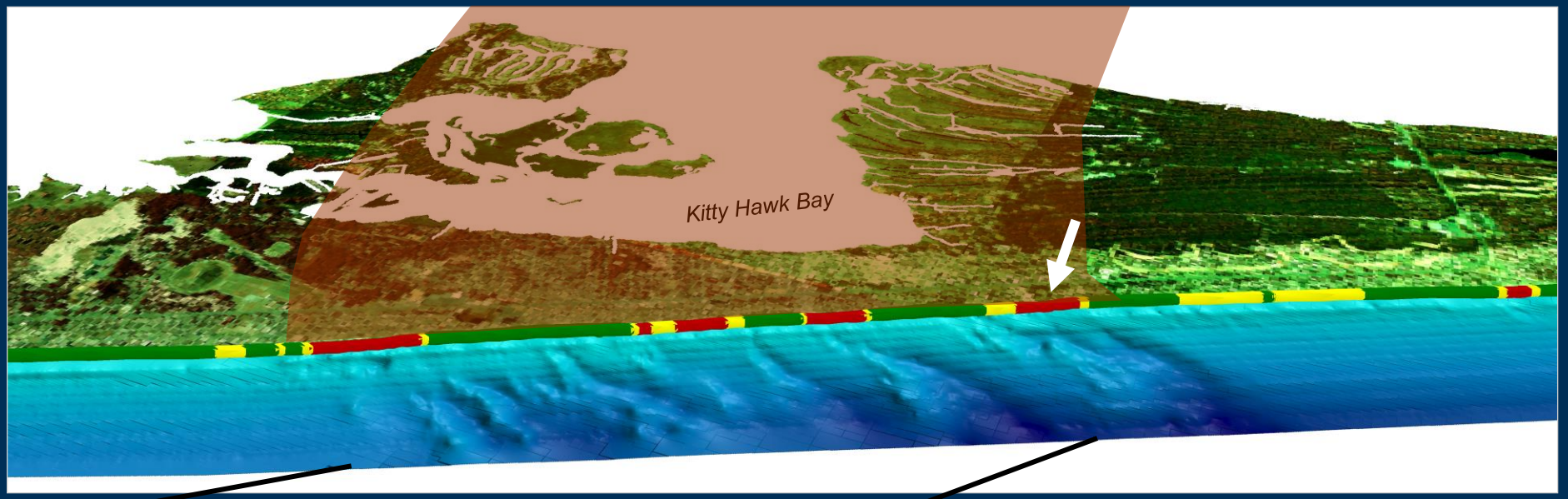
Beach Response Models

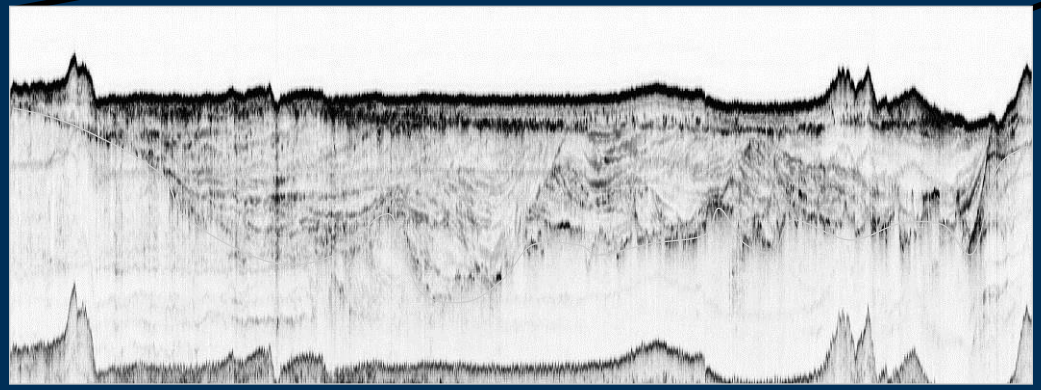



Rob Thieler*
U.S. Geological Survey
Woods Hole, MA

*representing a large network of collaborators, including Nathaniel Plant, Ben Gutierrez, Erika Lentz, Hilary Stockdon, Joe Long, Cheryl Hapke, Mike Fienen, John Masterson, Dean Gesch (USGS); Radley Horton (Columbia); Kevin McGarigal et al. (UMass)

Coastal erosion is influenced by geologic setting



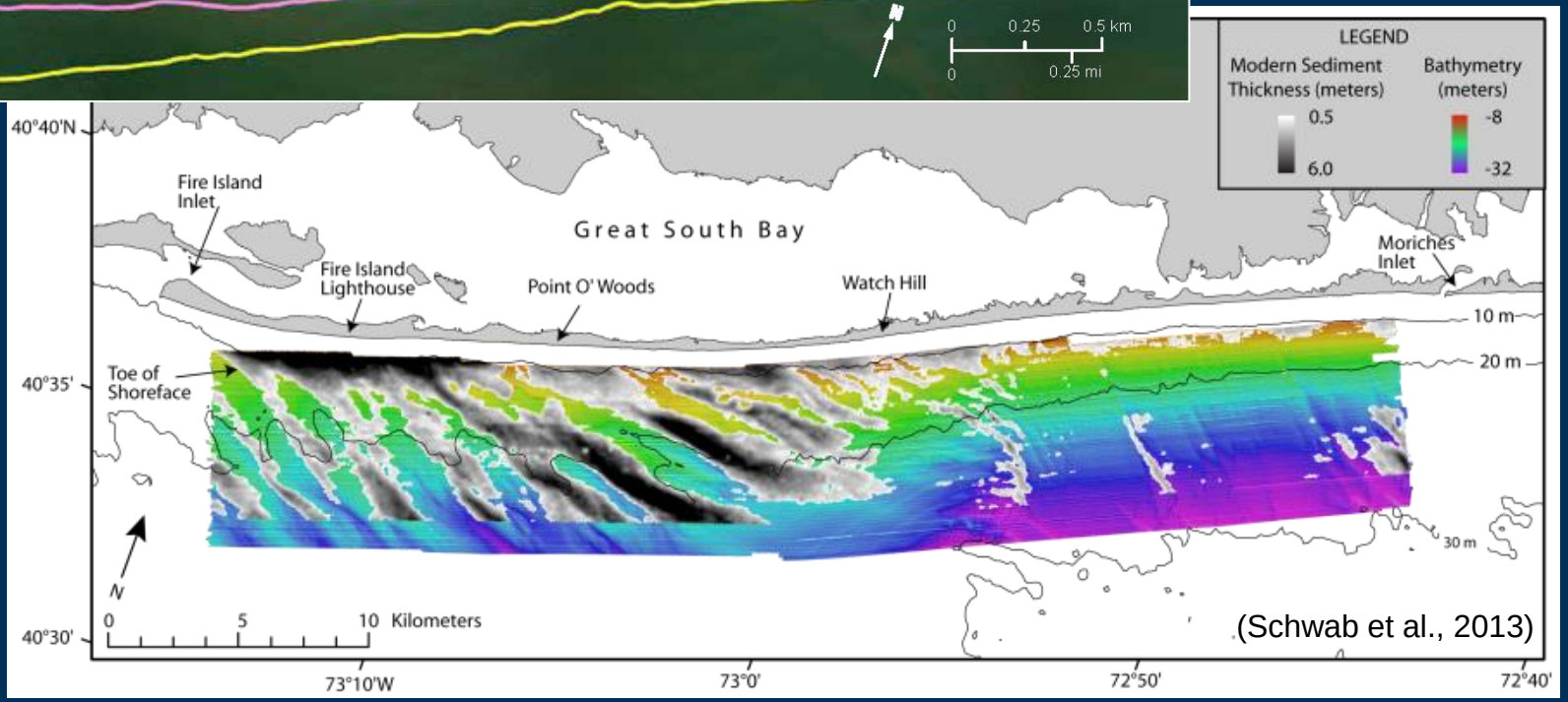


paleo-Roanoke River channel passes under Kitty Hawk, North Carolina

(McNinch, 2004; Thieler et al., 2013; 2014)

Coastal erosion is influenced by geologic processes

- Data
- Knowledge
- Tools
  - DSAS
  - ROMS



(Schwab et al., 2013)

Objective is to understand and predict interactions between coastal morphology and oceanographic driving forces

Requirements are

Testable models that demonstrate some predictive skill

- sea-level rise, shoreline change, morphology, groundwater, plover nesting

Ability to link the different models and predict integrated response

Observable input data to initialize and drive the models

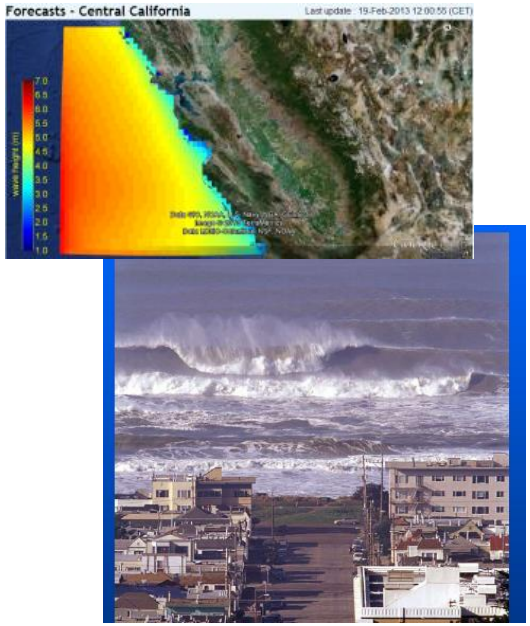
Updatability

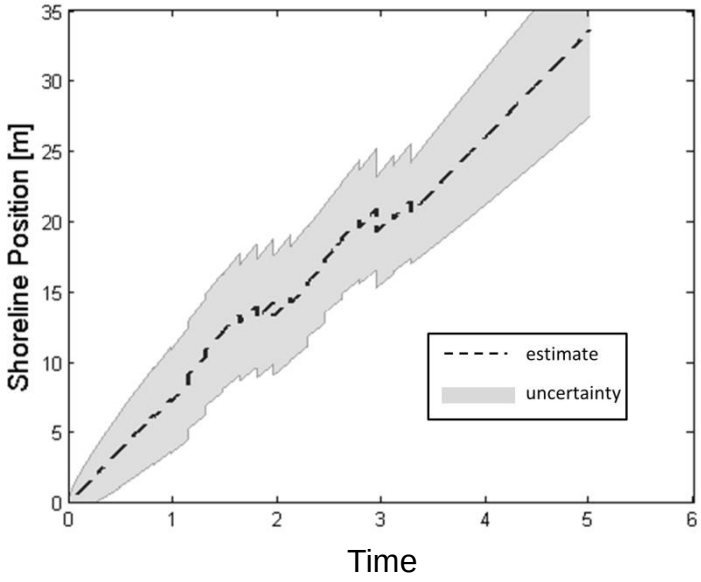
- new observations to test integrated predictions
- analysis to identify knowledge gaps in data or understanding
- new prediction scenarios aimed at research and applied questions

Integration and prediction of coastal change

- Short- and long-term coastal hazard processes (i.e., storms, sea-level rise)
- Uses data and models

storm/wave models + shoreline data = coastal change prediction and prediction uncertainty





Shoreline change near San Francisco using Kalman filter (data assimilation)

(Long and Plant, 2012)

National Assessment of Coastal Change Hazards

Extreme erosion during Hurricane Irene
Rodanthe, NC

Long-term cliff erosion
Pacifica, CA

Goal: Identify, quantify, and model the vulnerability of the U.S. shorelines to coastal change hazards

Ongoing Tasks

- Impacts of severe storms & hurricanes
- Long-term shoreline change
- Coastal vulnerability to sea level rise

USGS

Probabilities of coastal change

What is the likelihood that hurricane induced water levels will exceed the elevation of the base and crest of protective sand dunes?

Collision

Waves/surge higher than base of dune lead to erosion

Overwash

Waves/surge overtop dune crest, moving sand landward

Inundation

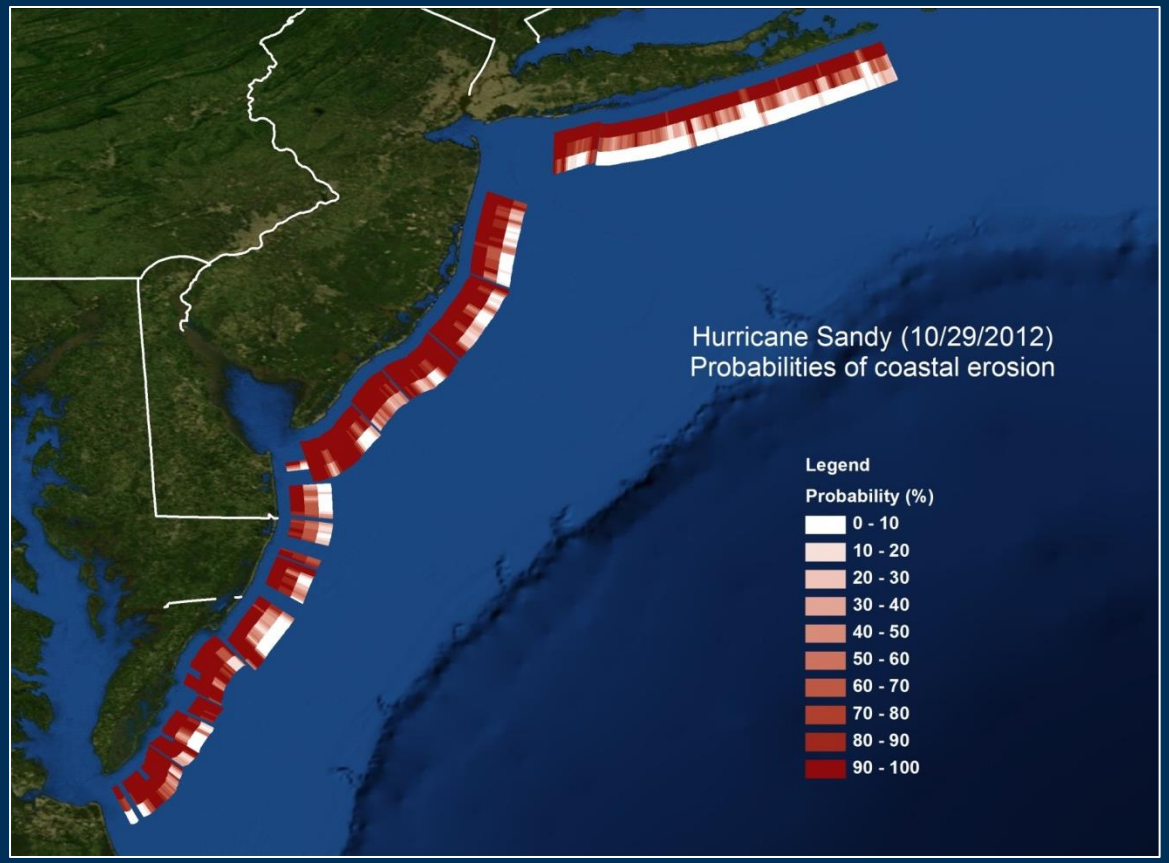
Mean water levels are higher than dune crest, submerging beach system

1) Scenario-based approach for generalized storms
2) Real-time mode for approaching storms

USGS

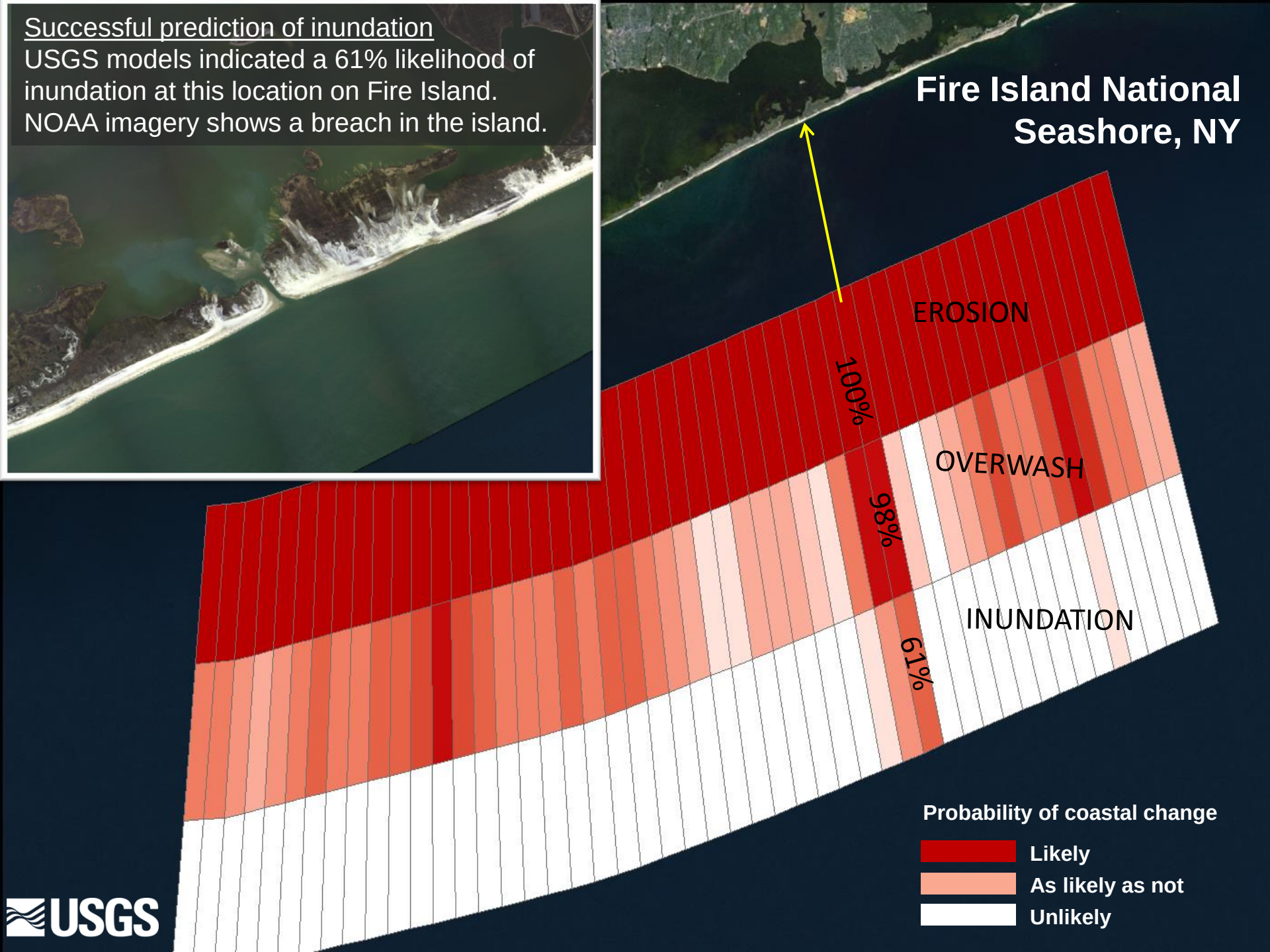
Real-time forecast of coastal erosion – Hurricane Sandy

- Inputs:
  - Lidar-based shorelines, dunes (USGS, USACE)
  - Storm surge (NOAA)
  - Wave conditions (NOAA)
  - Wave runup (USGS)
- Output: Probabilities of
  - Dune erosion
  - Overwash
  - Inundation
- Assessments are posted online and updated with current NHC meteorology as the storm approaches landfall.

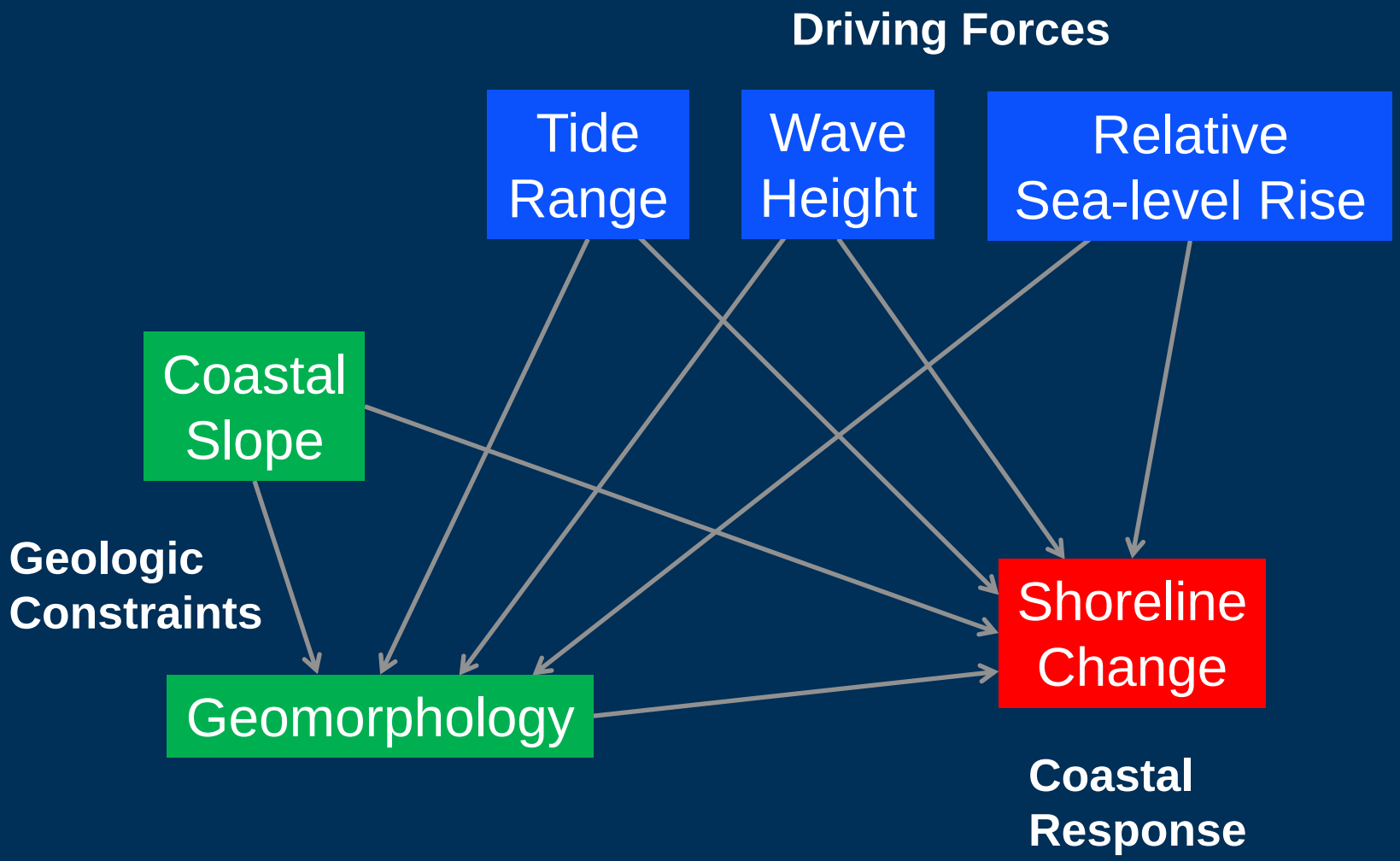


% of coast very likely to experience coastal change :			
	Dune erosion (inner)	**Overwash (middle)**	**Inundation (outer)**
Long Island, NY	93	12	4
New Jersey	98	54	21
Delmarva	91	55	22

USGS


Successful prediction of inundation
USGS models indicated a 61% likelihood of inundation at this location on Fire Island.
NOAA imagery shows a breach in the island.
Fire Island National Seashore, NY
EROSION
100%
OVERWASH
98%
INUNDATION
61%
Probability of coastal change
Likely
As likely as not
Unlikely
USGS

Bayesian Network for Predicting Coastal Vulnerability to Sea-level Rise

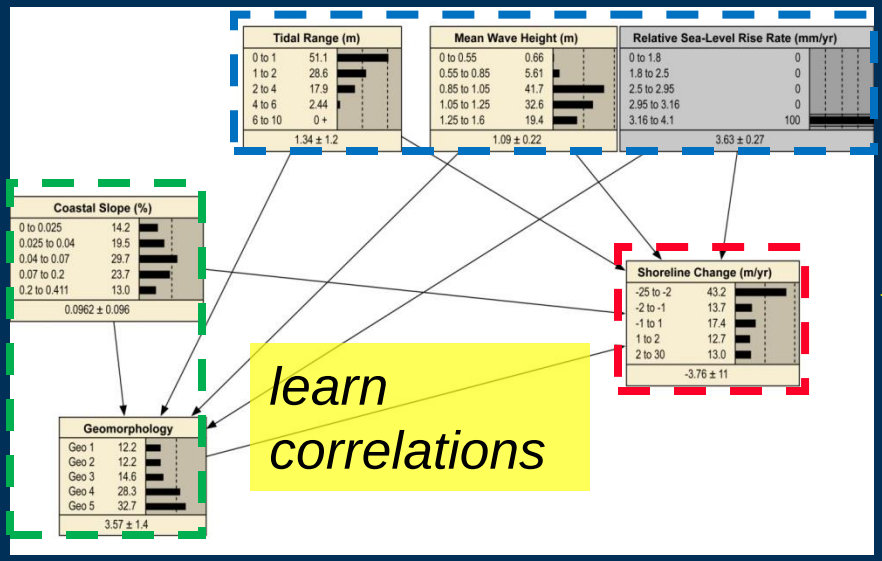


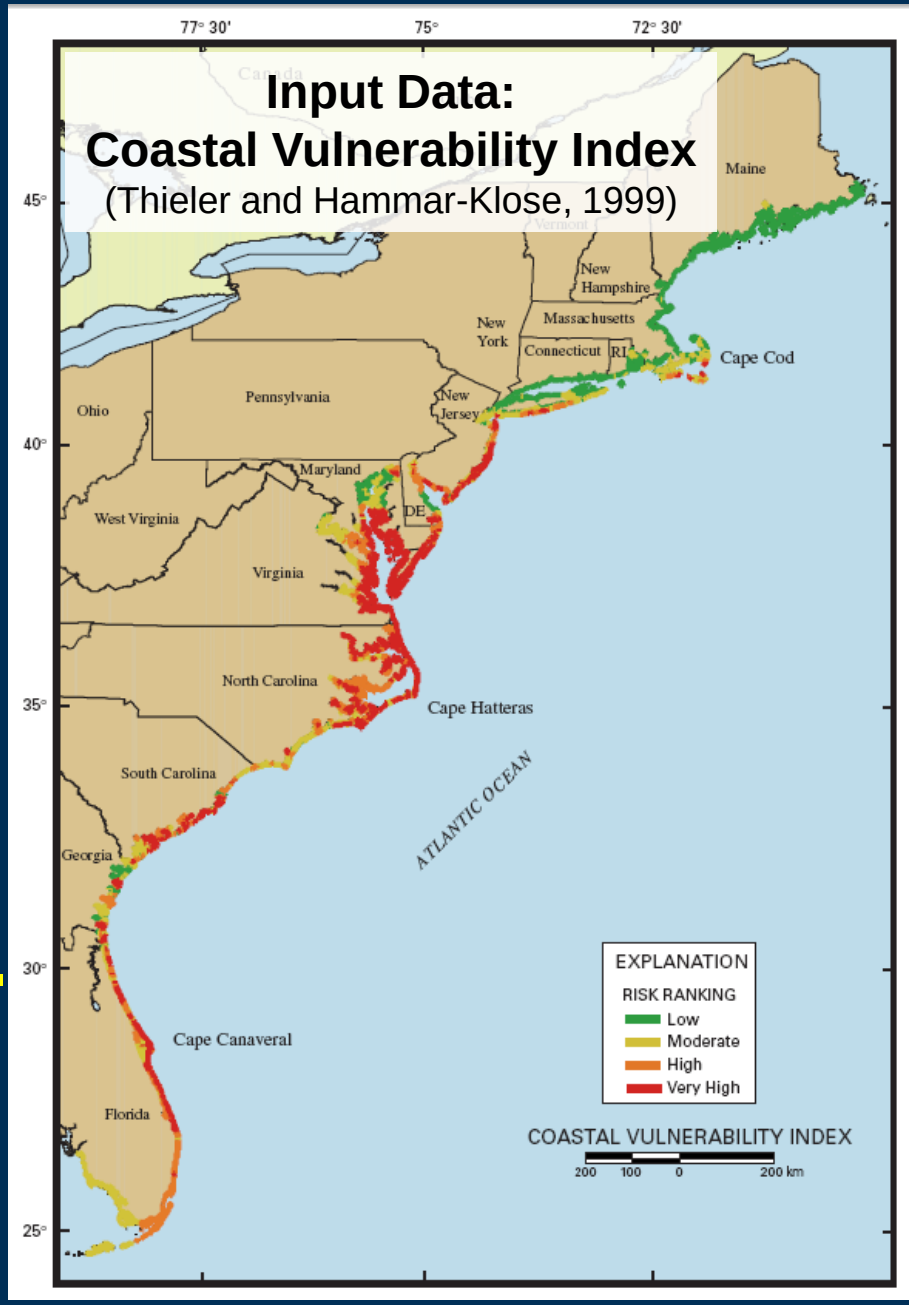
(Gutierrez et al., 2011)

Step 2. train a network

Existing data for six geological and physical process variables

- Geomorphology
- Coastal slope
- Relative sea-level rise rate
- Mean sig. wave height
- Mean tidal range
- Historic shoreline change rate

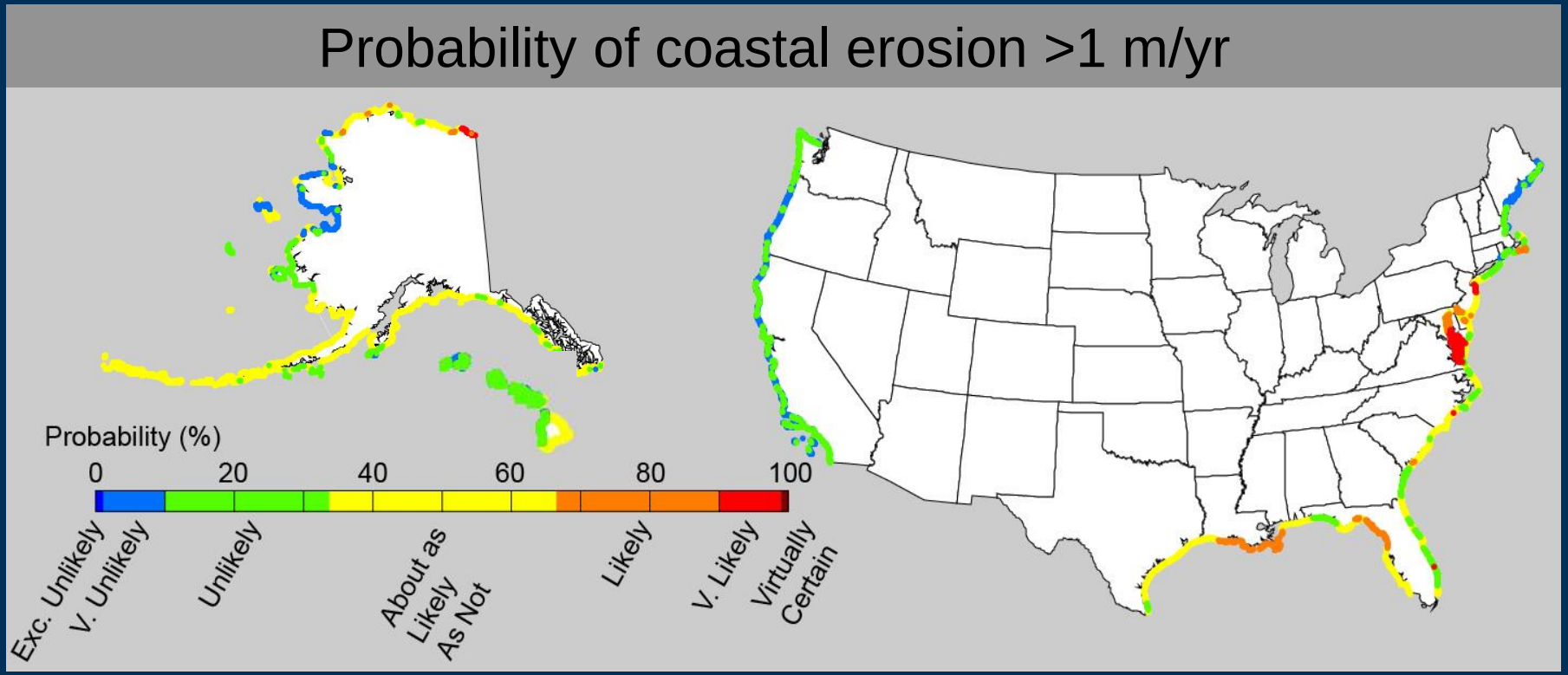




(Gutierrez et al., 2011)

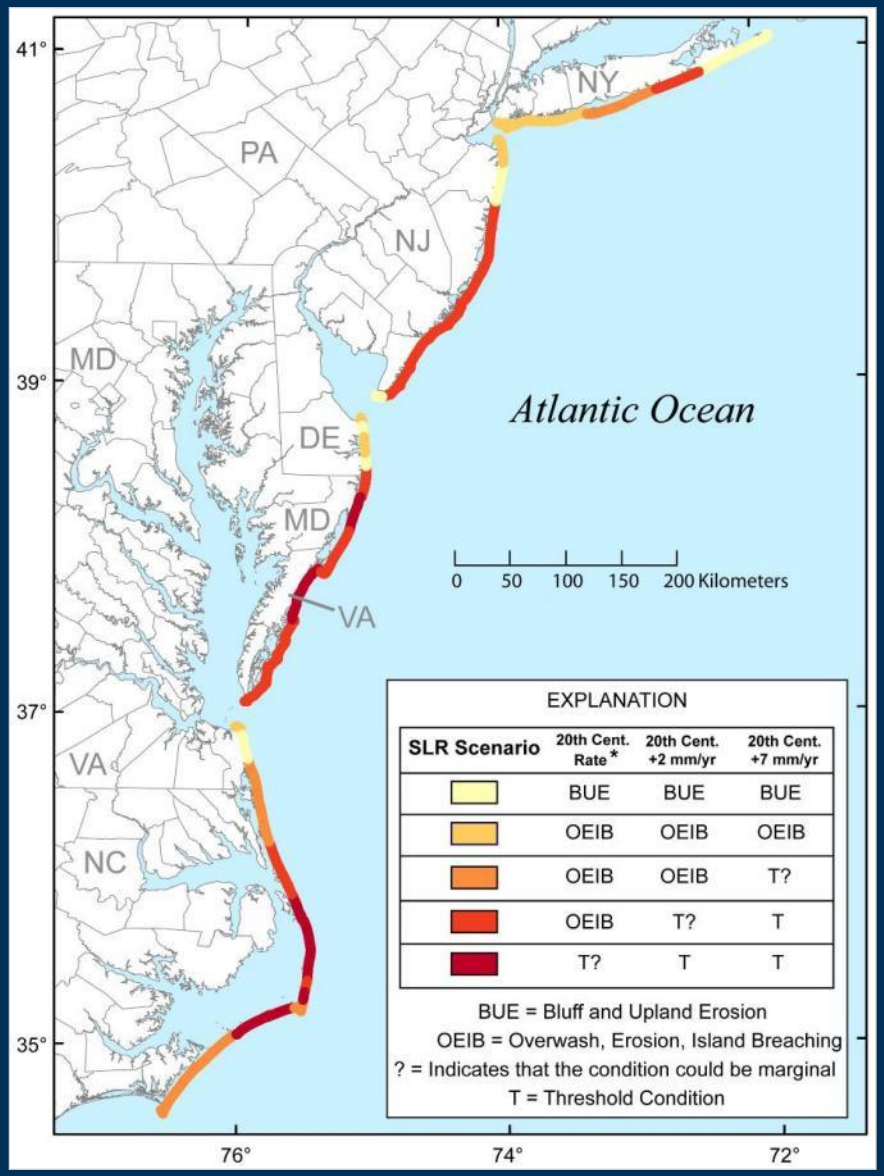
Predicting sea-level rise impacts

- Bayesian Network uses climate forcing and geologic constraints
- Prediction and uncertainty maps identify where better information is needed (input data, process understanding)
- Provides scientific knowledge context for decision makers
- Can use to focus research resources



(Gutierrez et al., 2011; USGCRP NCA, 2014)

Mid-Atlantic Assessment of Potential Dynamic Coastal Responses to Sea-level Rise



(Gutierrez et al., 2009)

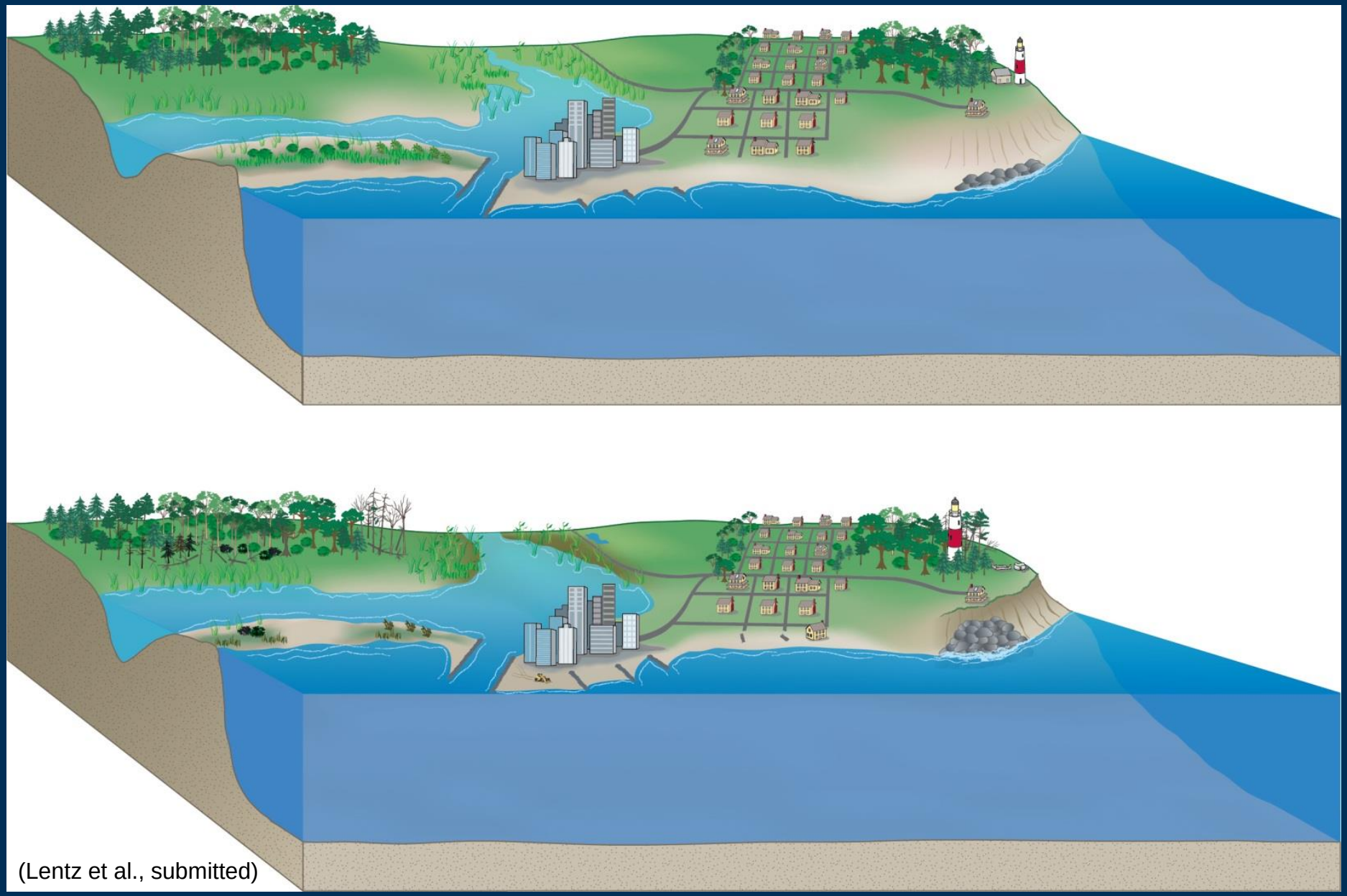
Bluff erosion

Overwash

Island Breaching

Threshold Crossing

Variable response to SLR across the landscape



(Lentz et al., submitted)

Model requirements

1. Assess probability of landscape change vs. land loss in response to SLR;
2. Produce at broad spatial scale (NE region); and
3. 30 m resolution

Use regional datasets and their uncertainties to generate predictions