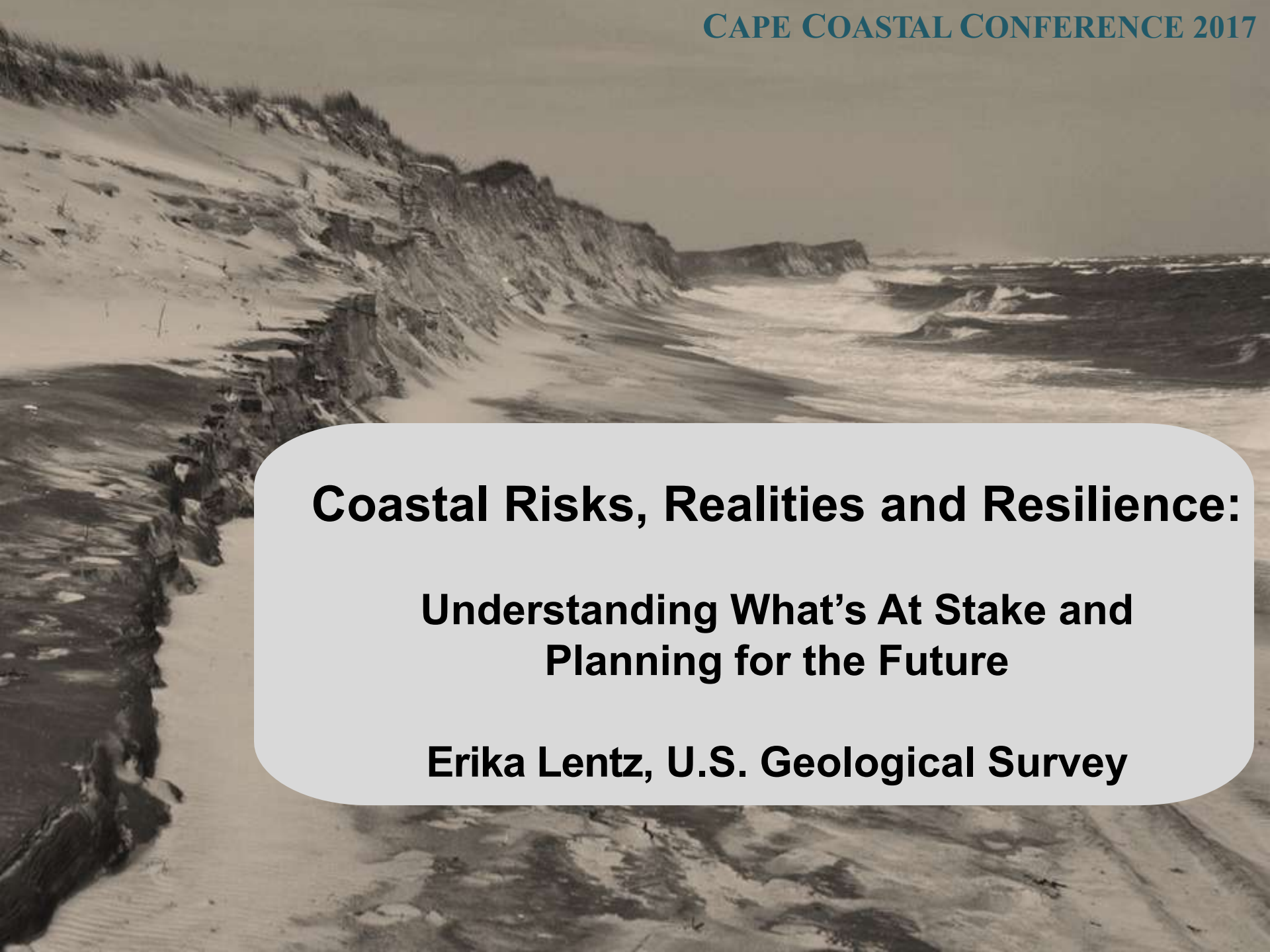


Coastal Risks, Realities and Resilience:

Understanding What's At Stake and Planning for the Future

Erika Lentz, U.S. Geological Survey

Key Points

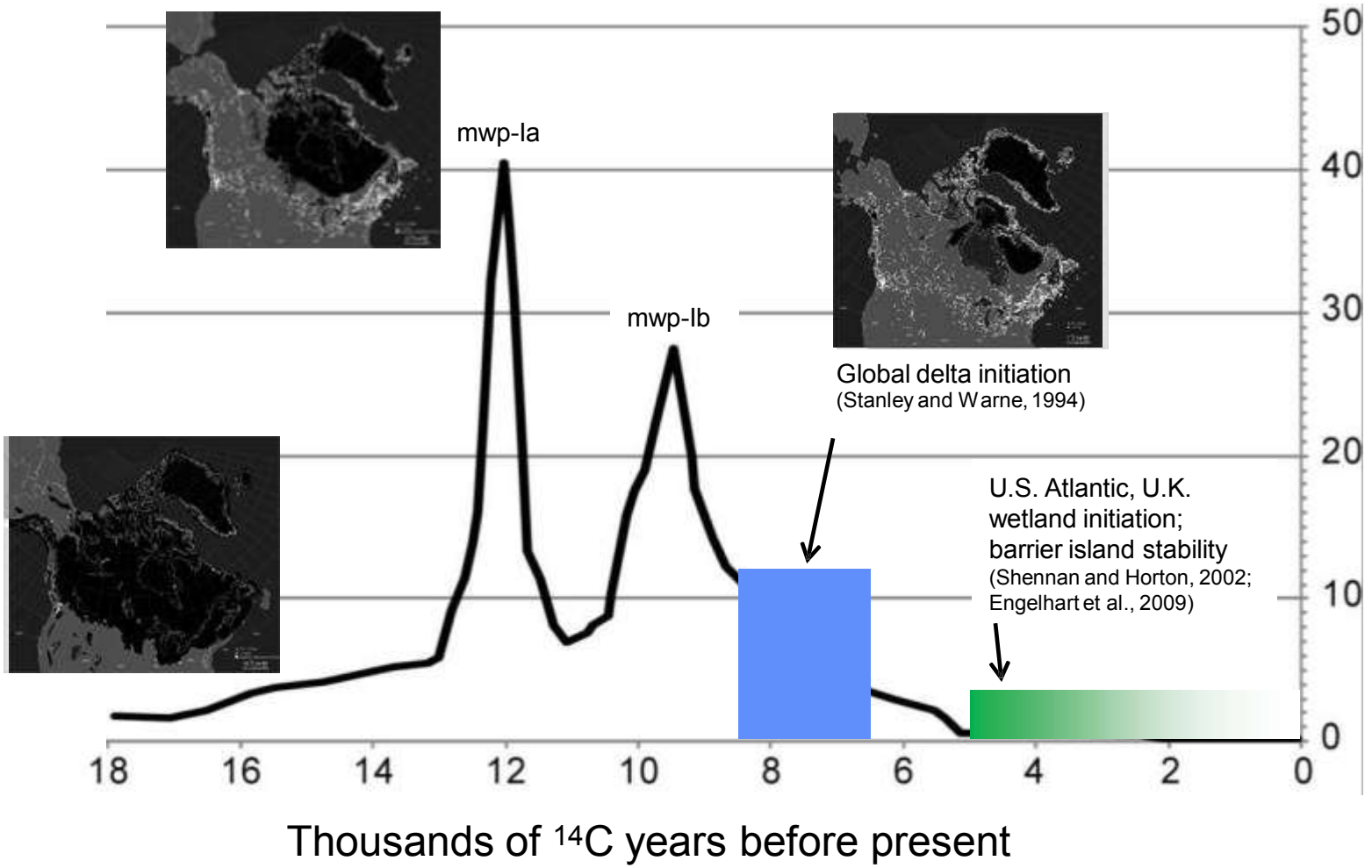
- By 2100, the Northeastern U.S. is most likely to see sea levels rise between **2 to 4.5 feet**. Worst case scenarios are much higher (**11 feet**). All projections mean sea-level rise rates will be higher and faster than the past 2000 years.

- The coastal landscape varies, and so does the response to climate drivers.

- Effective adaptation to future coastal change will require a variety of approaches to coastal management.

- Uncertainty doesn't mean we can't act.

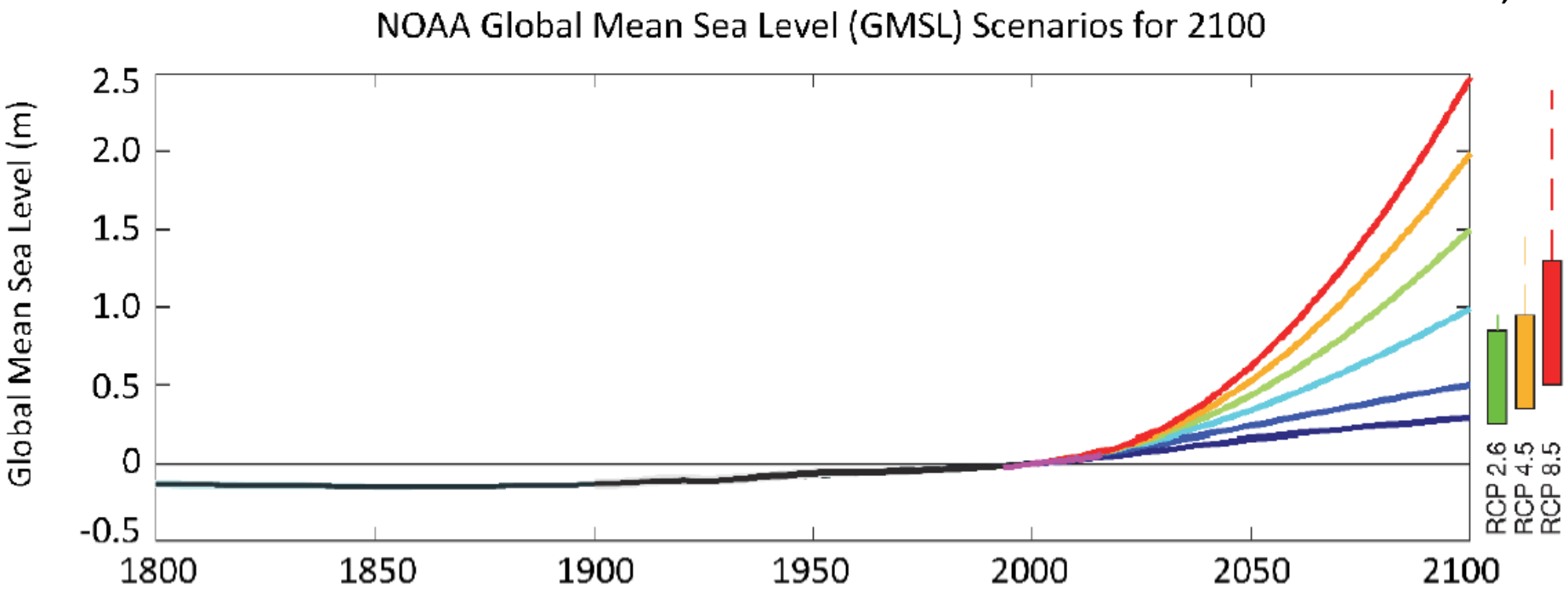
Sea-level rise rates have varied since the Last Glacial Maximum



(SLR rate based on Fairbanks, 1989; ice extent from Dyke, 2004)

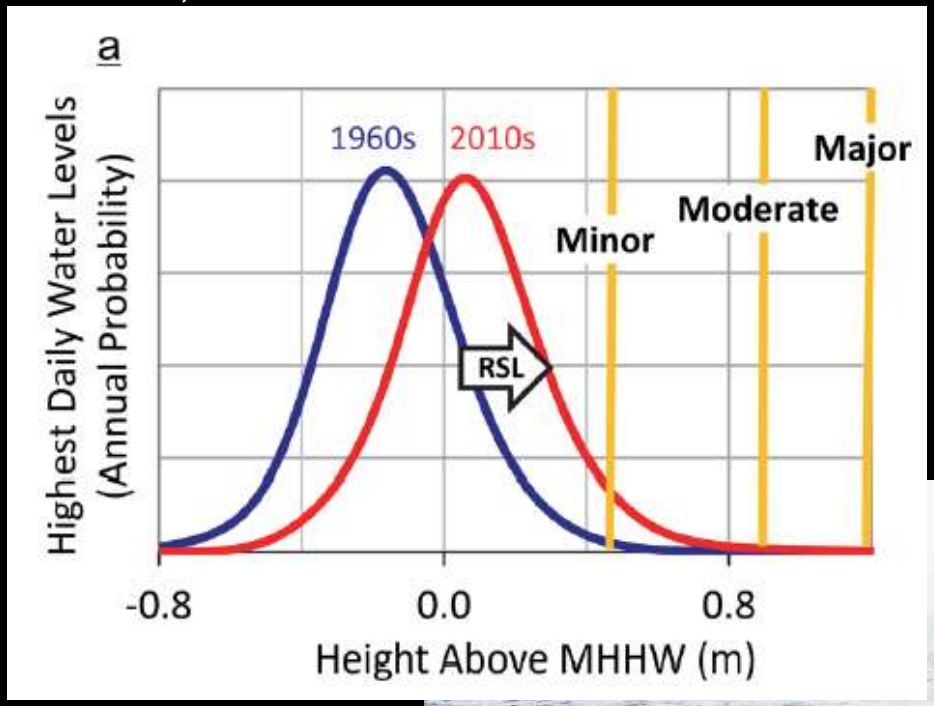
The future will not look like our recent past

Sweet et al., 2017

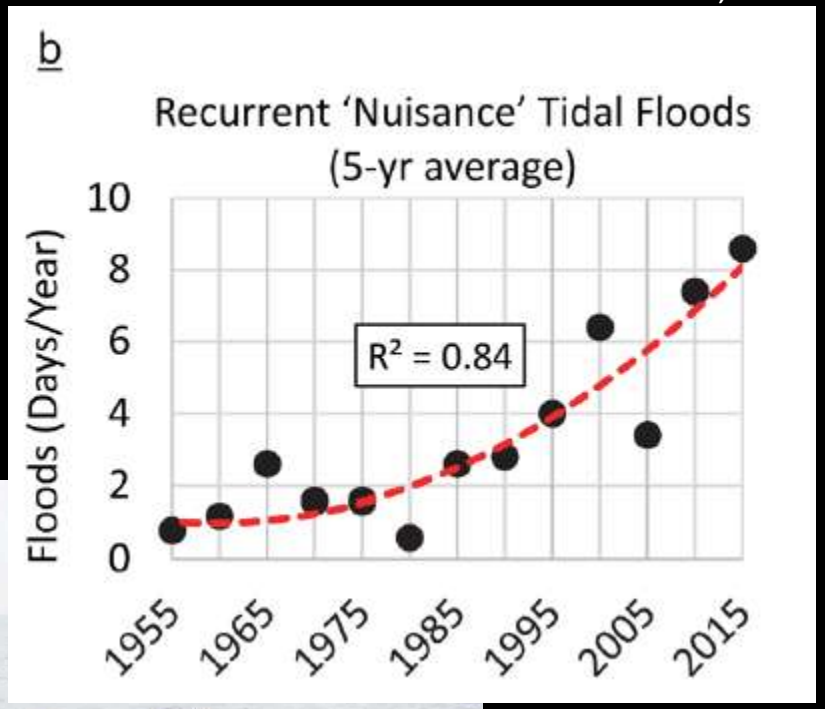


Sea-level rise is already affecting us

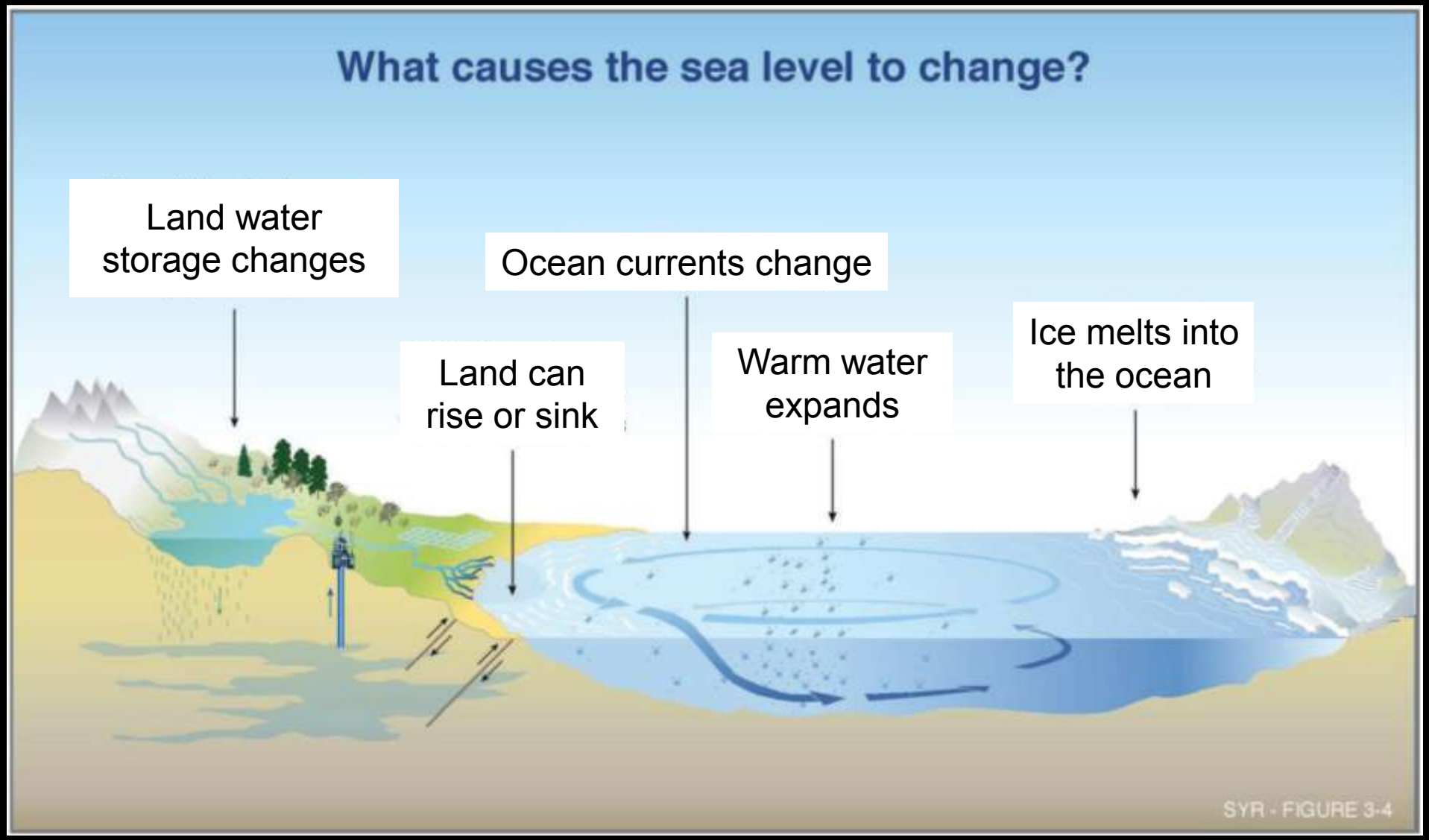
Sweet et al., 2017



Sweet et al., 2017



King Tide in Boston, October 2016

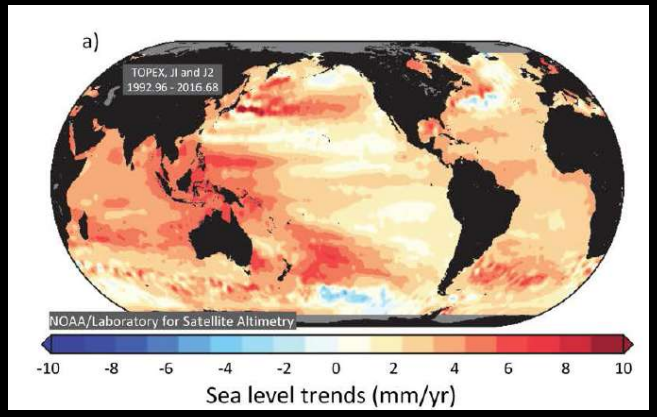

What causes the sea level to change?
Land water storage changes
Land can rise or sink
Ocean currents change
Warm water expands
Ice melts into the ocean
SYR - FIGURE 3-4

(IPCC, 2001)

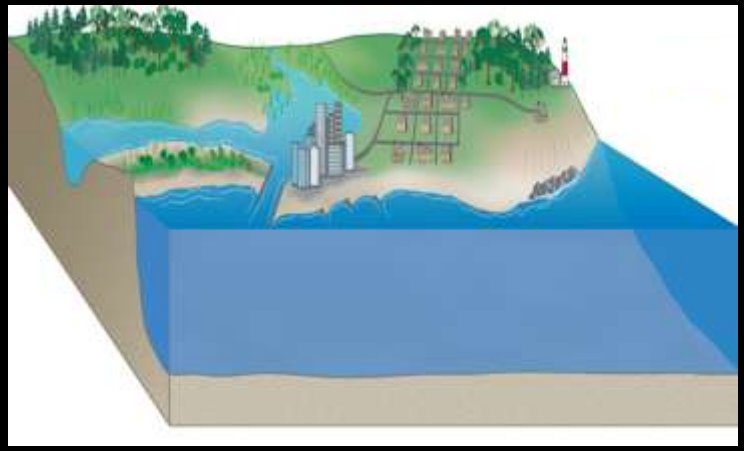
Predicting future sea level requires considering:

global

regional



and local factors.

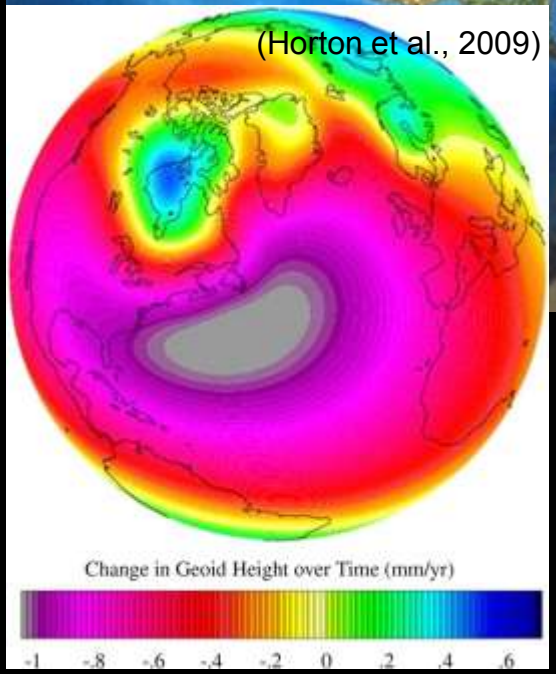


GLOBAL

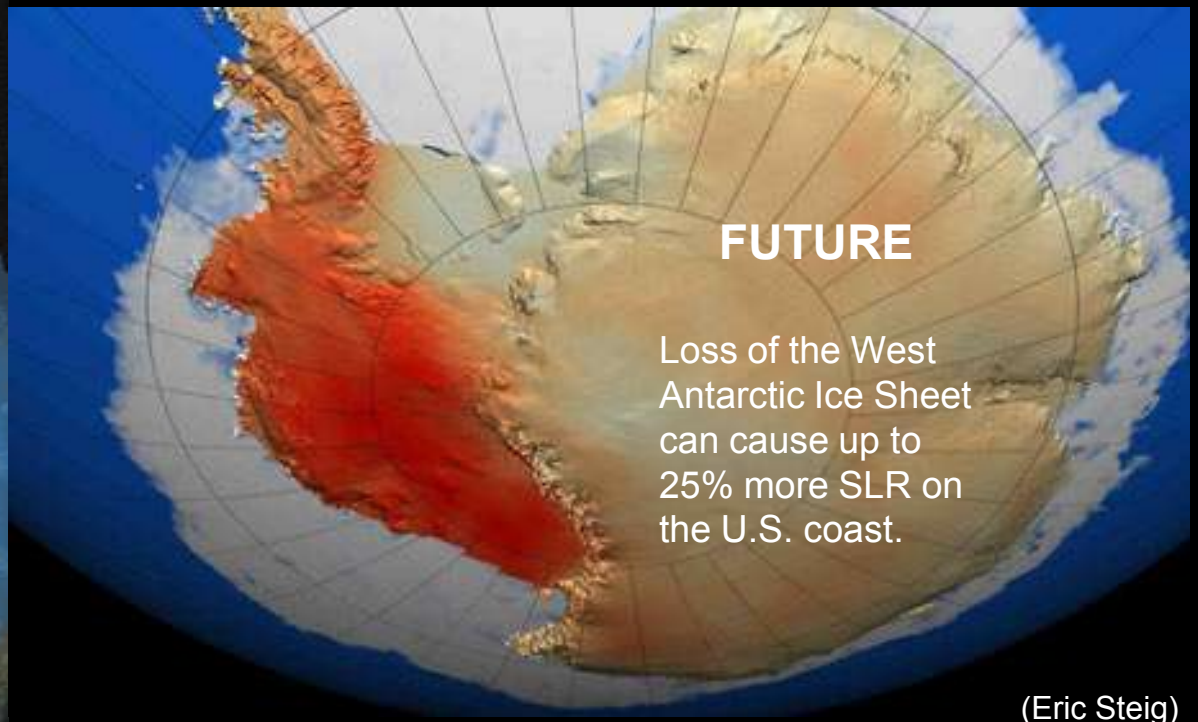
PAST

Earth is still undergoing isostatic adjustment from deglaciation

(Illinois Geological Survey)



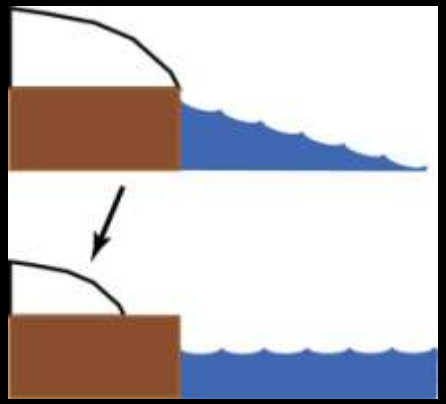
(Horton et al., 2009)

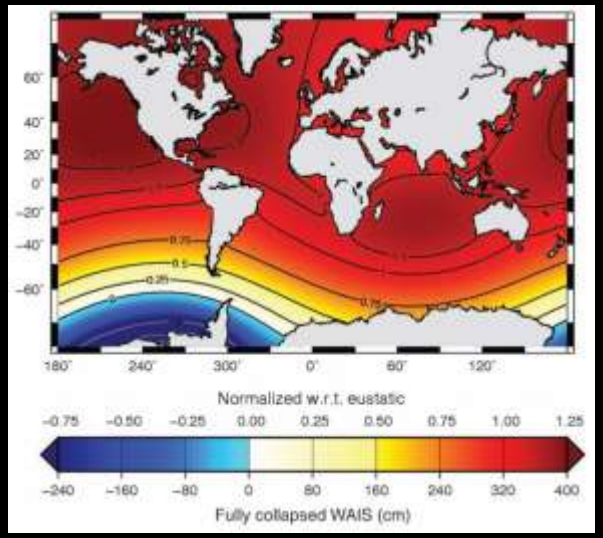


FUTURE

Loss of the West Antarctic Ice Sheet can cause up to 25% more SLR on the U.S. coast.

(Eric Steig)

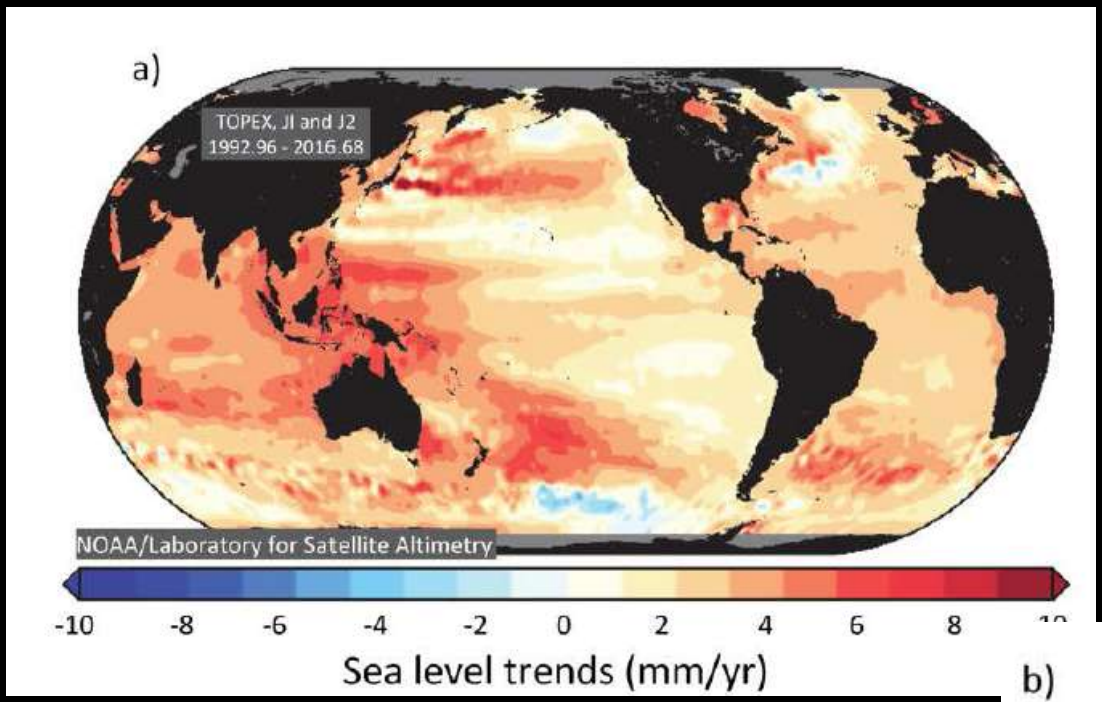




(Bamber et al., 2009)

Changes in sea level rise rates from 1992-2016

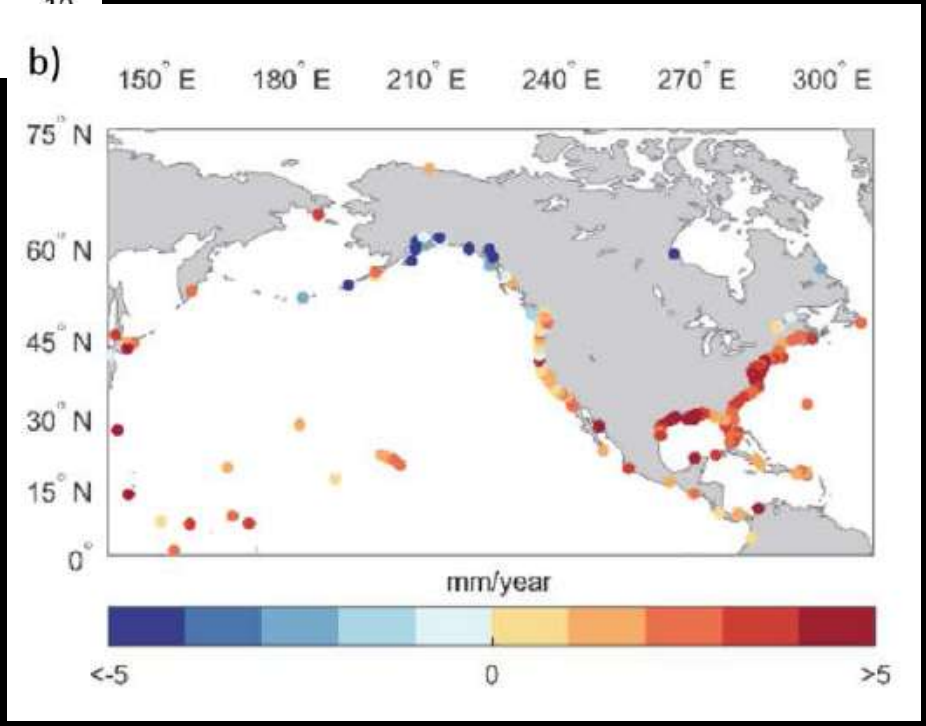
REGIONAL



Changes in circulation and ocean warming can increase sea level by tens of centimeters, for example in the northeastern U.S.

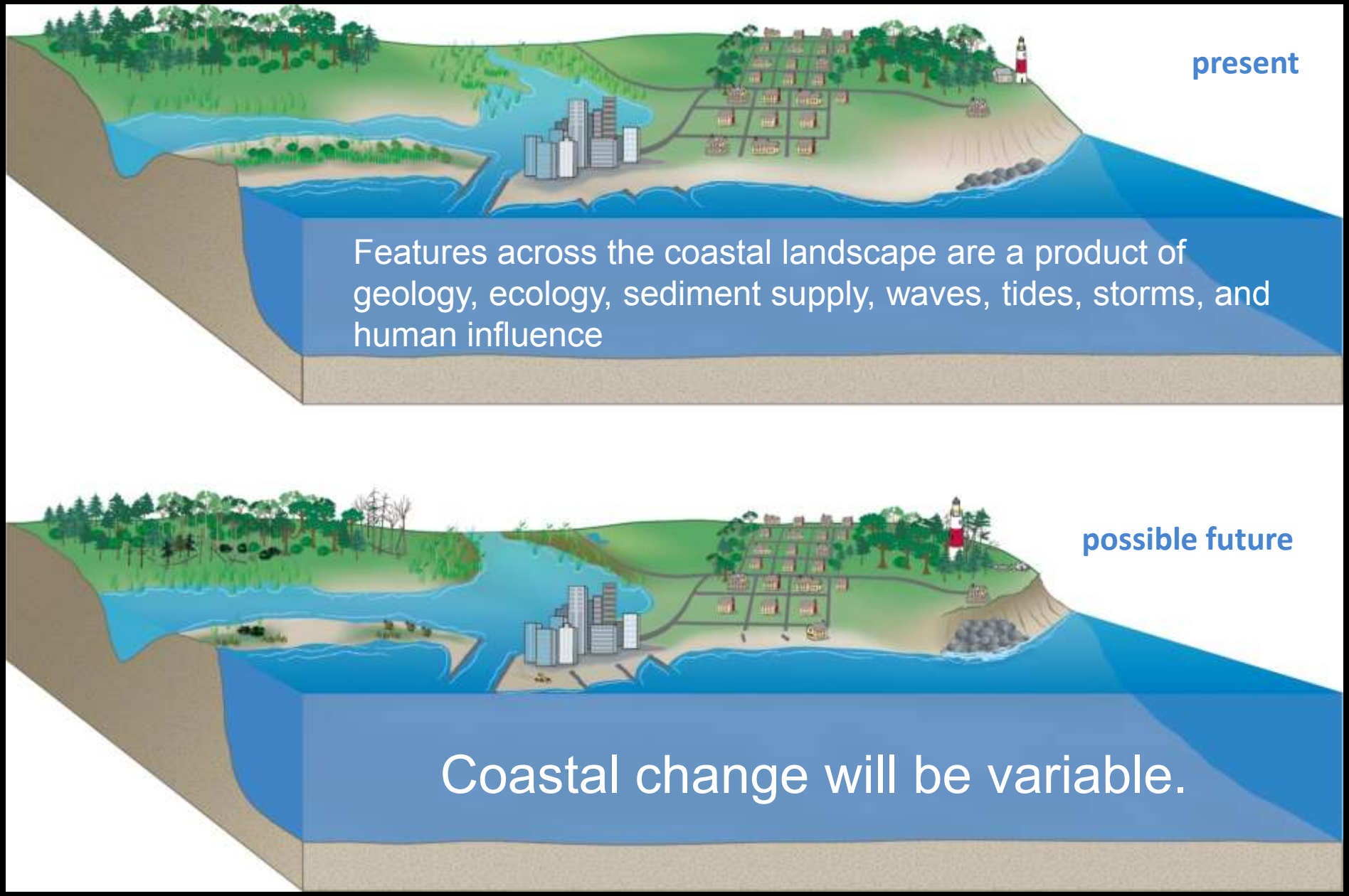
www.star.nesdis.noaa.gov/sod/lsa/SeaLevelRise

Relative sea-level rise over last 30 years

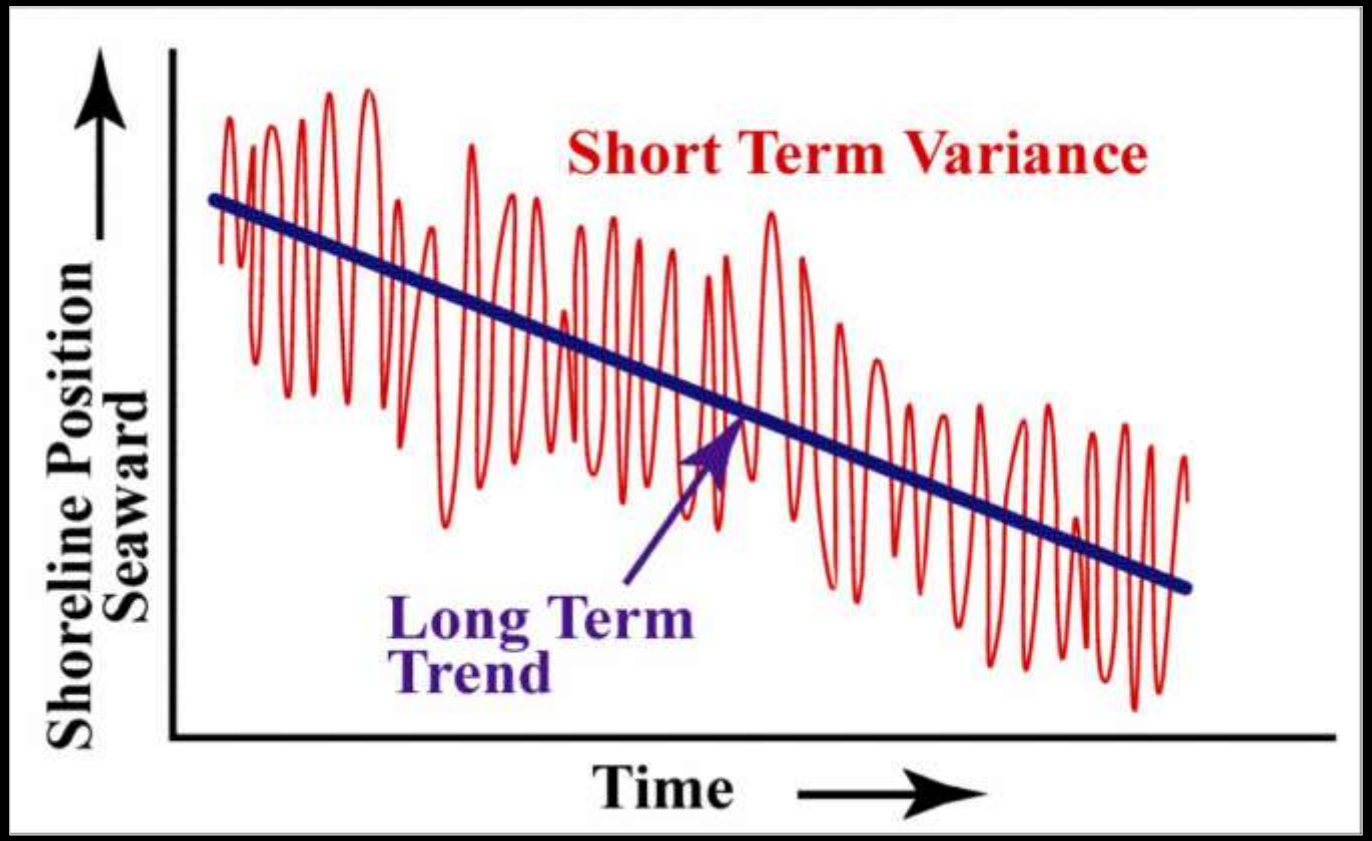


NOAA, 2017

LOCAL


present
Features across the coastal landscape are a product of geology, ecology, sediment supply, waves, tides, storms, and human influence
possible future
Coastal change will be variable.

Timescales matter



Short-term Variance

(hours to decade)

Storm impact/recovery
Annual cycles
El Niño

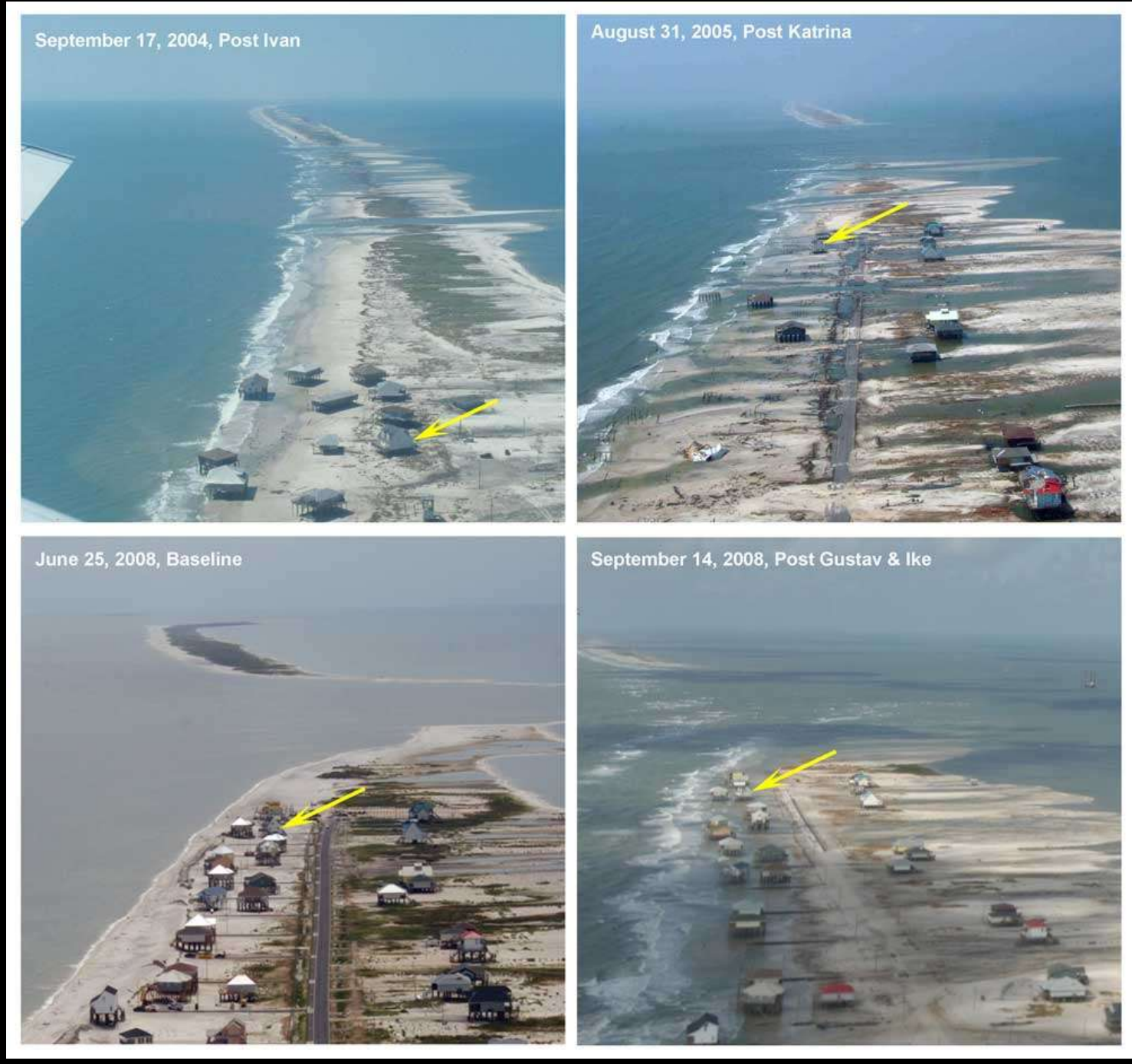
Long-term Trend

(decades to centuries)

Sediment deficit or surplus
Sea-level rise

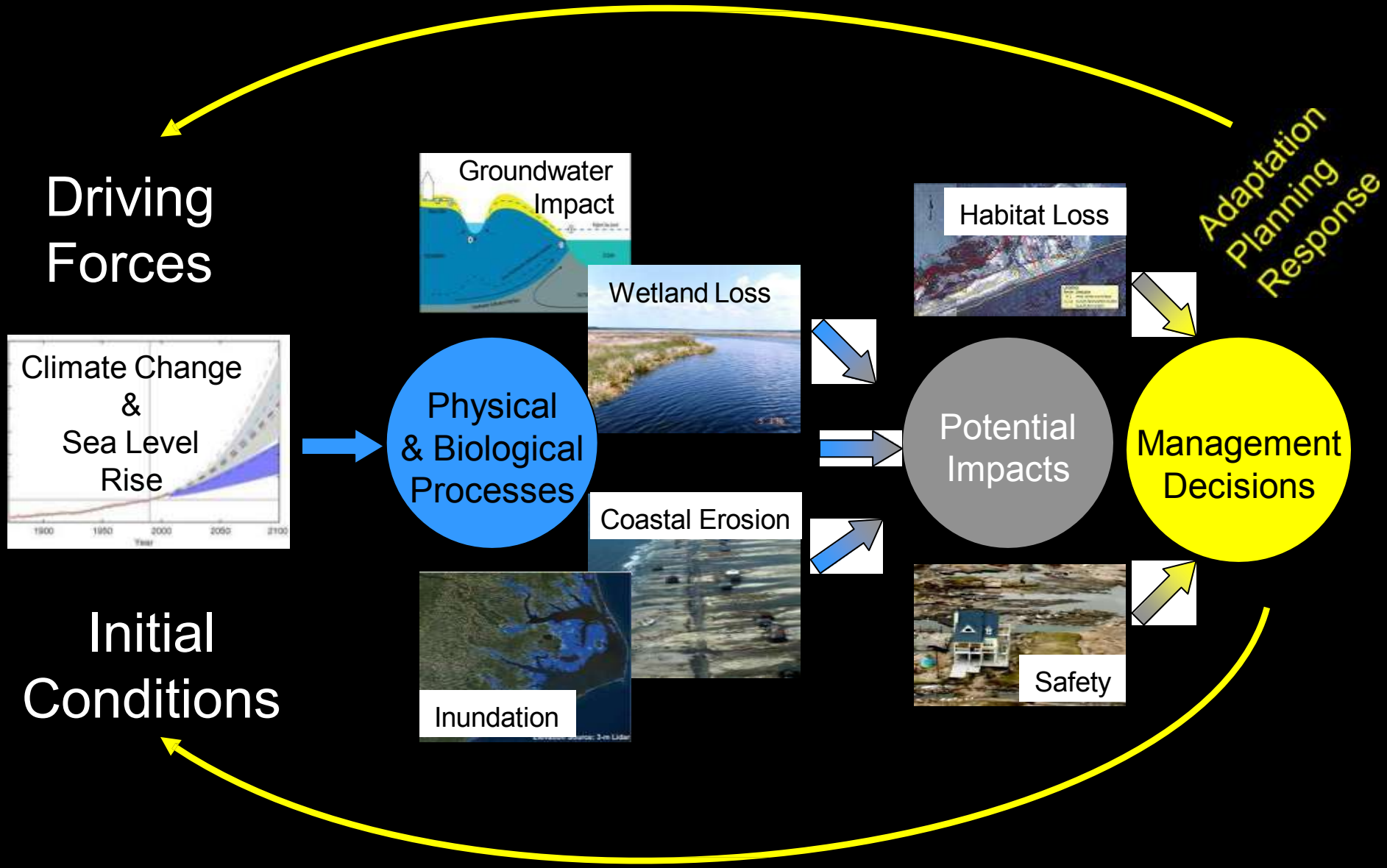
The strongest hurricanes are anticipated to become both more frequent and more intense in the future, with more precipitation.

Photo: Steven Senne



Successive hurricane impacts on Dauphin Island, AL

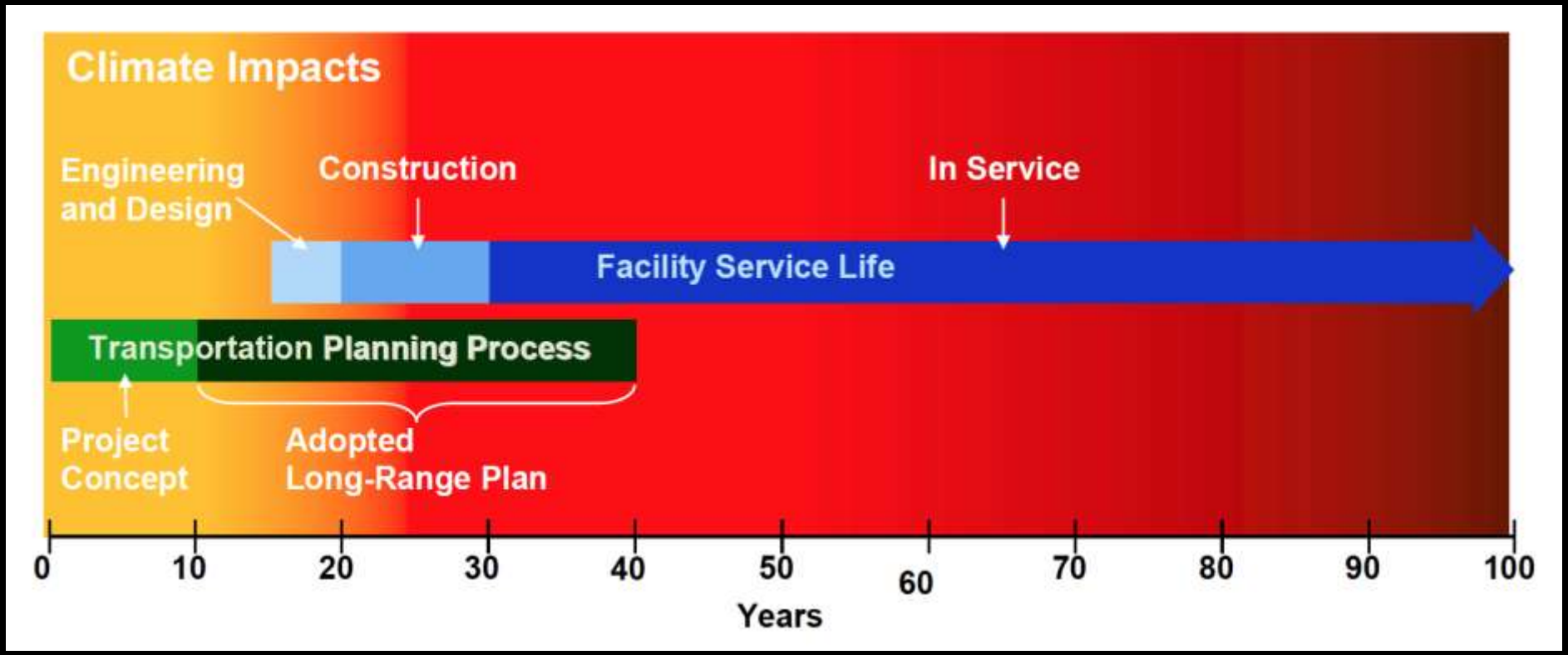
Coastal change impacts:
A multivariate problem with uncertainties everywhere



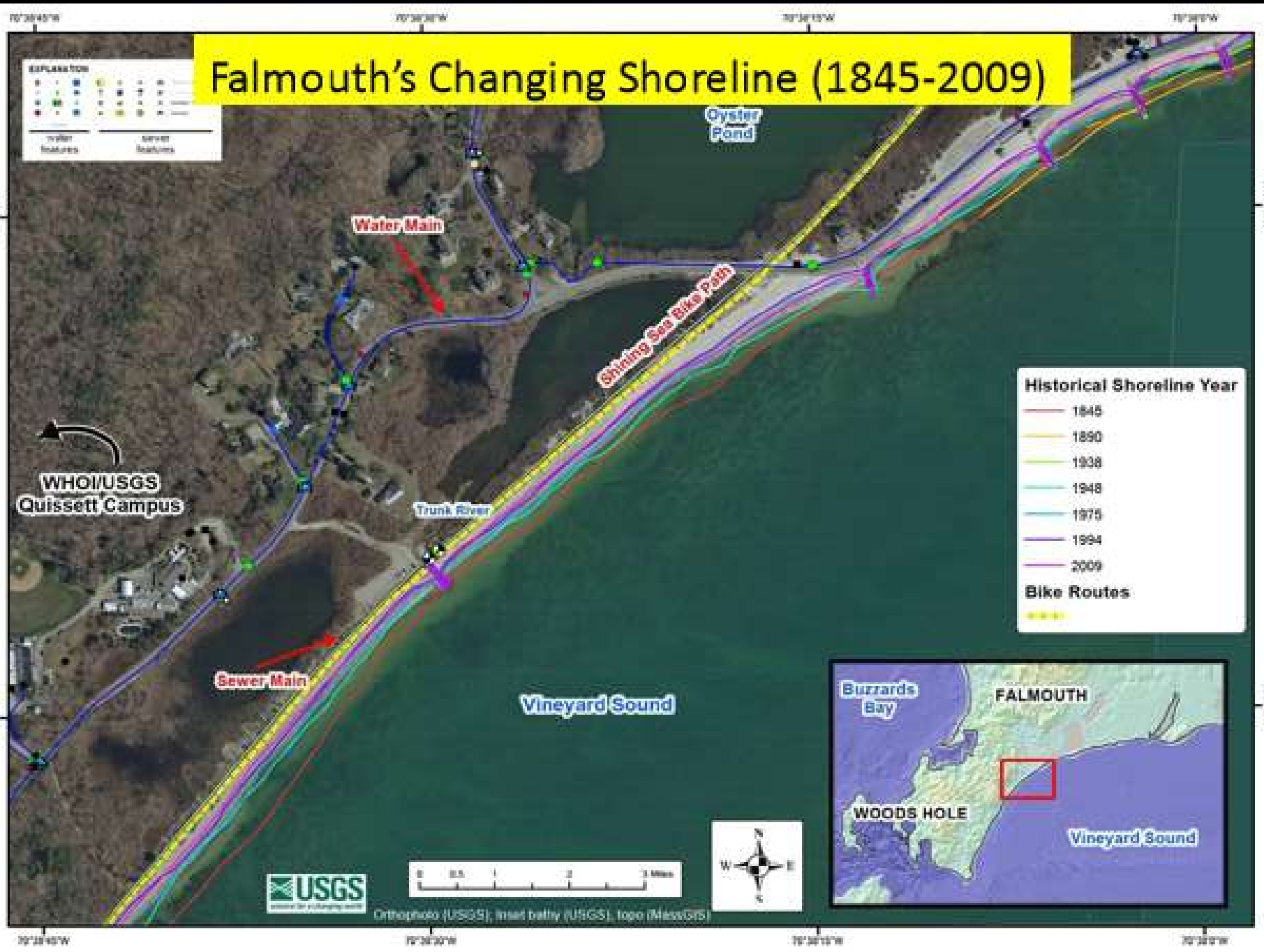
Timing matters

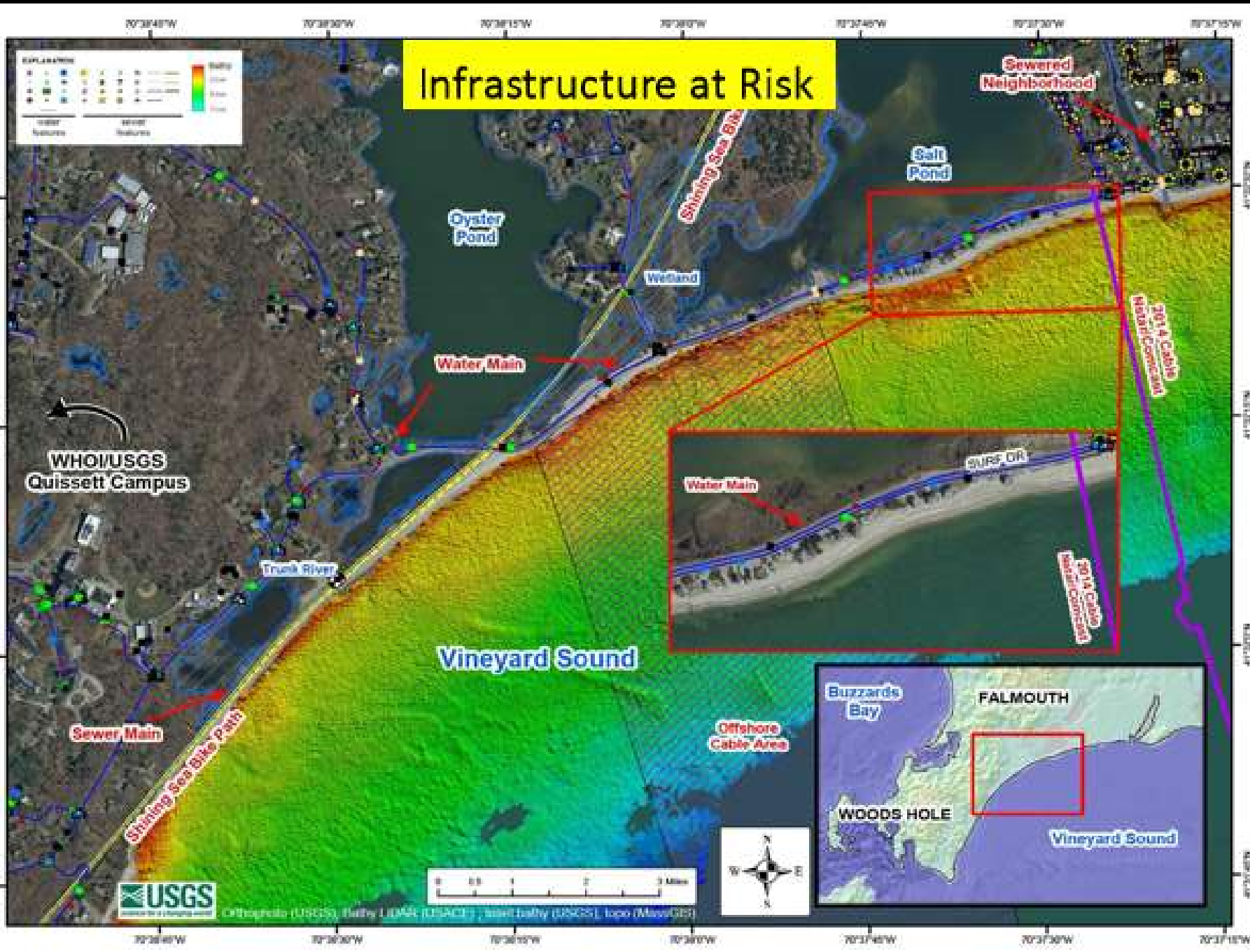
Decisions are being made…

- Now (both short- and long-term)
- Regardless of whether information and understanding is adequate



(Savonis, 2011)

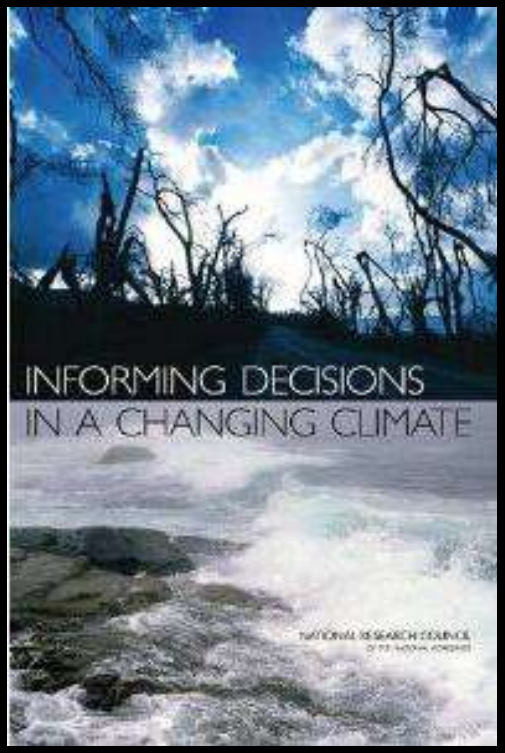

Falmouth's Changing Shoreline (1845-2009)
EXPLANATION
Oyster Pond
Water Main
Shining Sea Bike Path
WHOI/USGS
Quissett Campus
Trunk River
Sewer Main
Vineyard Sound
Historical Shoreline Year
1845
1890
1938
1948
1975
1994
2009
Bike Routes
Buzzards Bay
FALMOUTH
WOODS HOLE
Vineyard Sound
USGS
Orthophoto (USGS); Inset bathy (USGS), topo (MassGIS)


Infrastructure at Risk
Sewered Neighborhood
Salt Pond
Shining Sea Bike Path
Oyster Pond
Wetland
Water Main
2014 Cable Relocation
WHOI/USGS Quissett Campus
Trunk River
Vineyard Sound
Sewer Main
Shining Sea Bike Path
Offshore Cable Area
SURF DR
Water Main
2014 Cable Relocation
Buzzards Bay
FALMOUTH
WOODS HOLE
Vineyard Sound
USGS

Informing Decisions in a Changing Climate

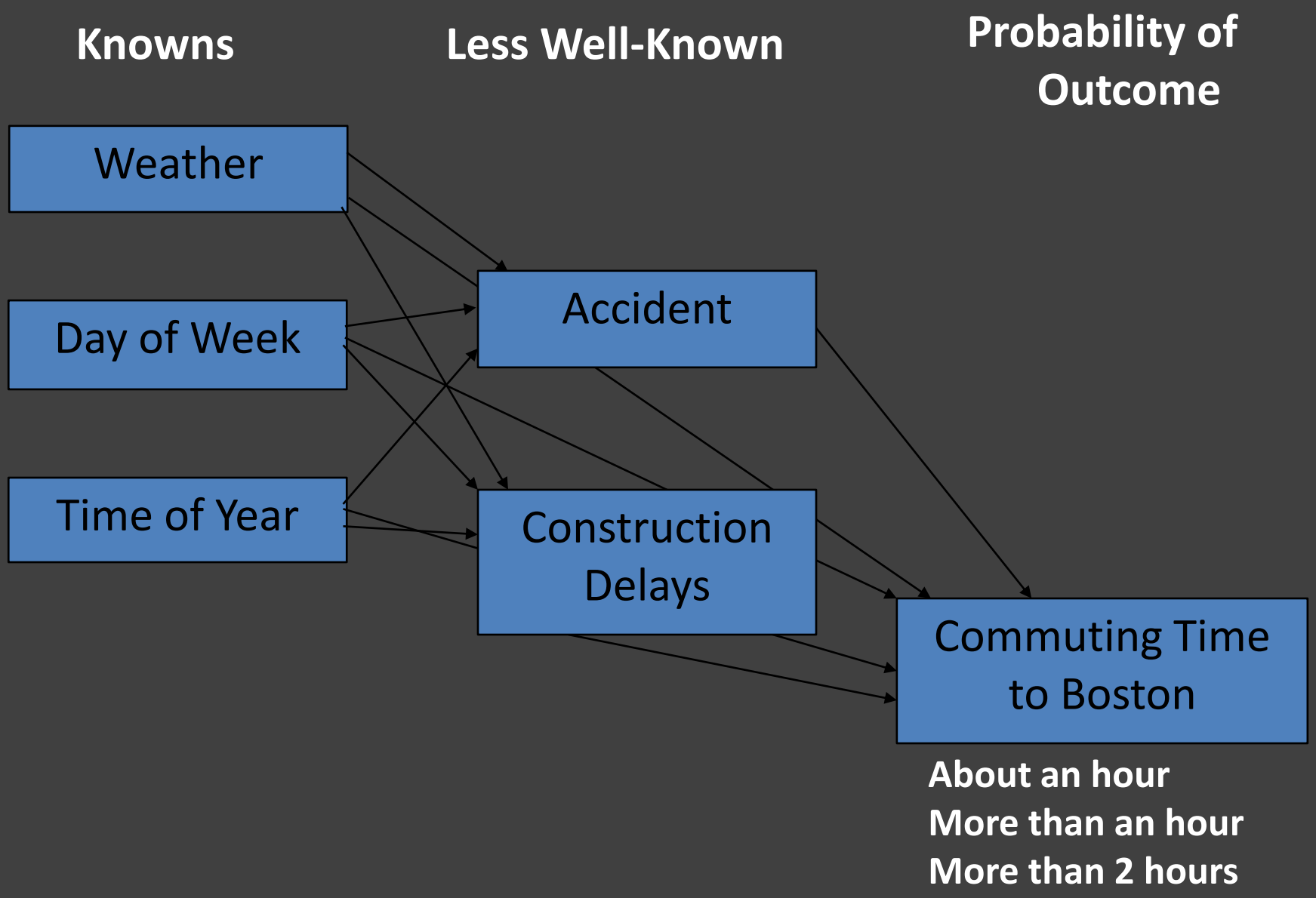
National Research Council (2009)

The end of "Climate Stationarity" requires that organizations and individuals alter their standard practices and decision routines to take climate change into account. Scientific priorities and practices need to change so that the scientific community can provide better support to decision makers in managing emerging climate risks.

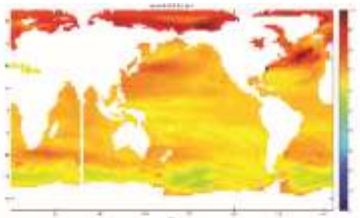


- Decision makers must expect to be surprised because of the nature of climate change and the incompleteness of scientific understanding of its consequences.
- An uncertainty management framework should be used because of the inadequacies of predictive capability.

Bayesian Networks: An Example

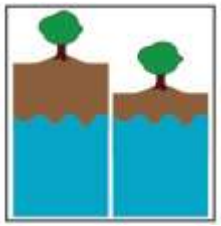


Modeling Coastal Response to Sea-Level Rise



Sea-Level Projections

Probability of Outcome



Adjusted Land Elevation

Knowns

+

Less Well Known

Vertical Land Movement

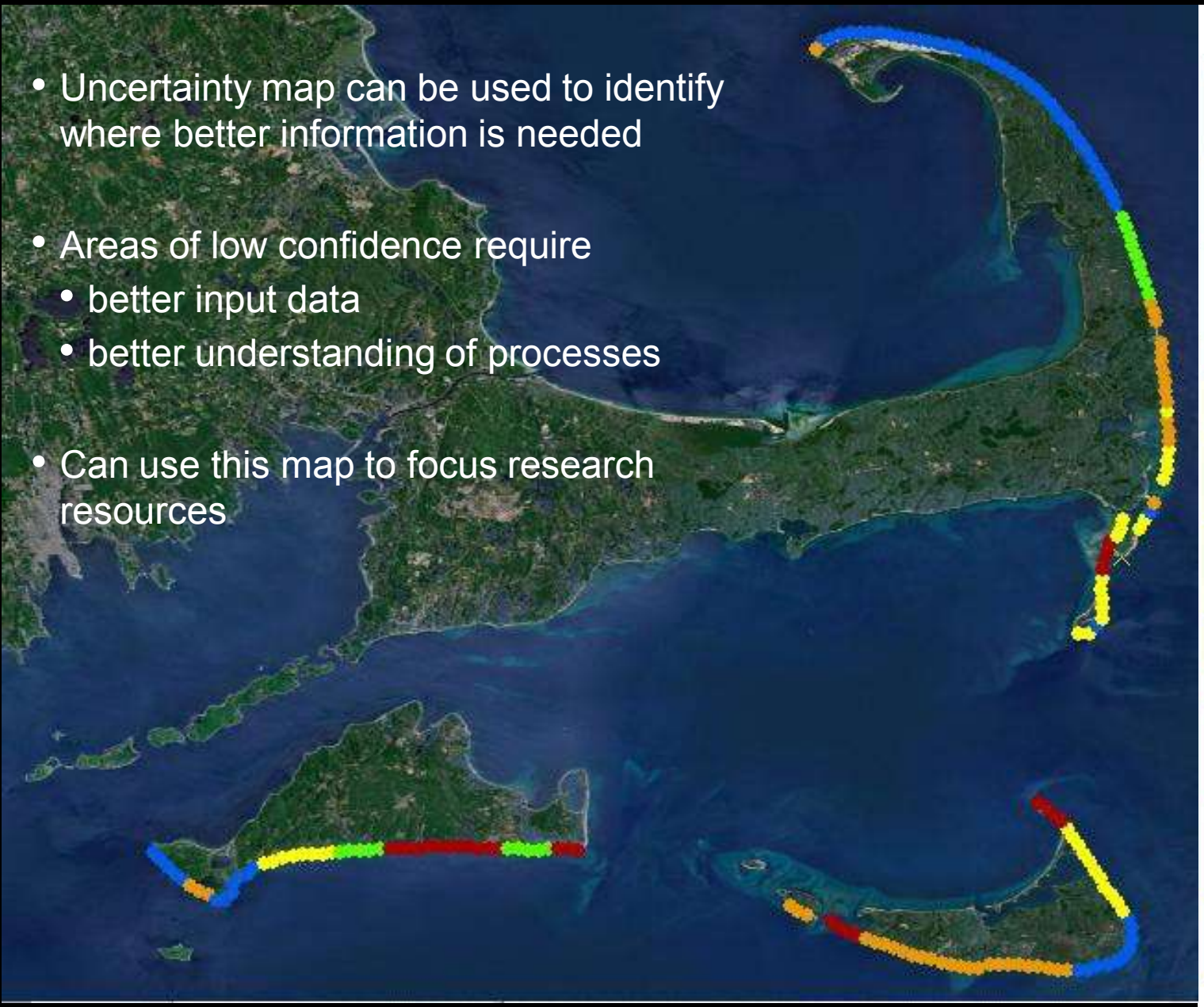
Elevation

Coastal Response Type:
Dynamic vs. Inundation

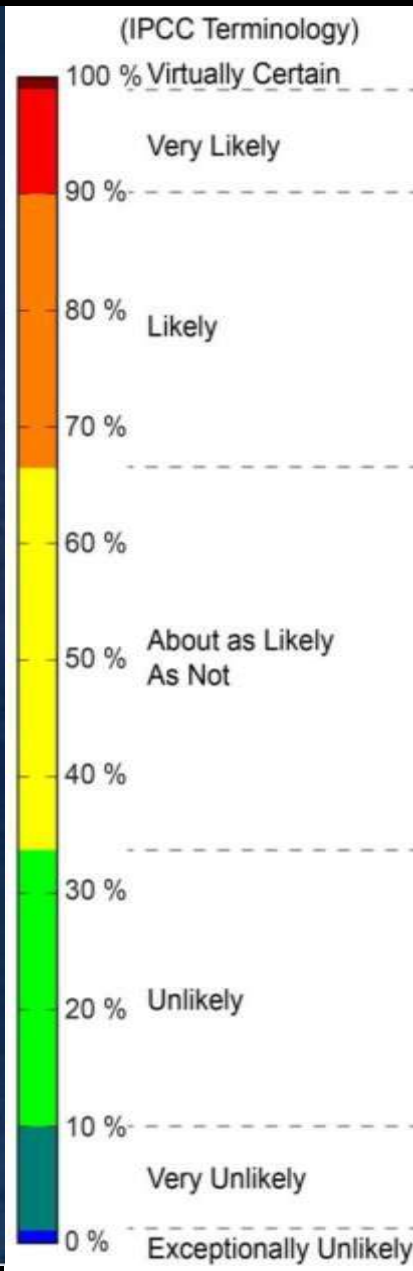
Land Cover

We can start to anticipate where change is most likely

Probability of coastal erosion >1 m/yr



- Uncertainty map can be used to identify where better information is needed
- Areas of low confidence require
  - better input data
  - better understanding of processes
- Can use this map to focus research resources



Likelihood of Storm Impacts

Collision	Overwash	Inundation
		
Waves/surge higher than base of dune lead to erosion	Waves/surge overtop dune crest, moving sand landward	Mean water levels are higher than dune crest, submerging beach system

Probability of Collision, Overwash, and Inundation (landward-seaward bands) during Nor'easter

https://marine.usgs.gov/coastalchangehazardsportal/

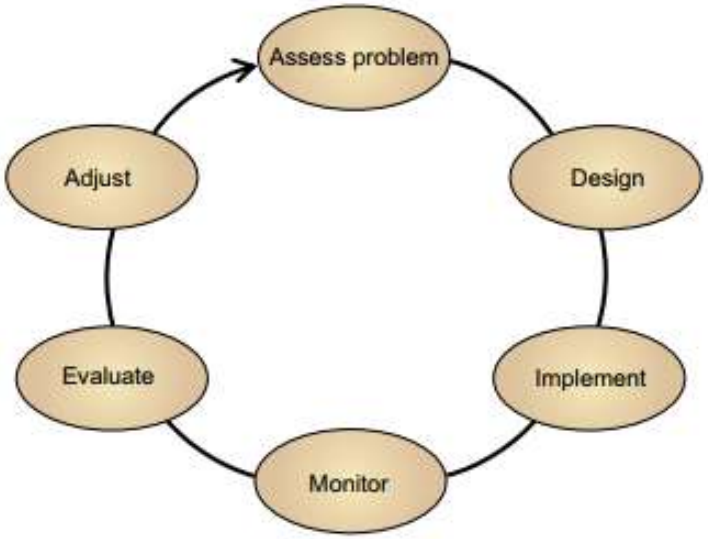
Risk-based framing for decision-making

"What is most likely to happen?" (e.g., with future climate)

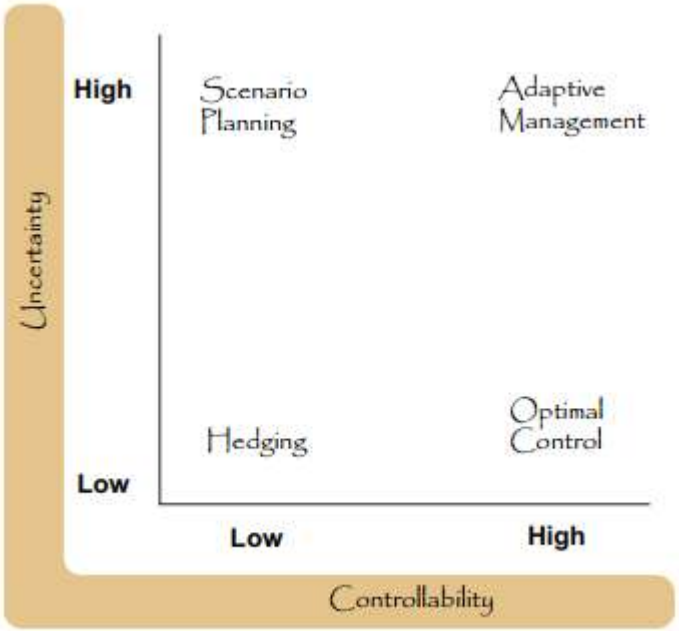
AND

"How bad could things get?" (e.g., as a result of uncertainty in climate sensitivity and the climate system response).

Adaptive Management Process



Approaches to Decision Making



Willams et al., 2009

Structured decision making:
Defining shared goals and a common vision

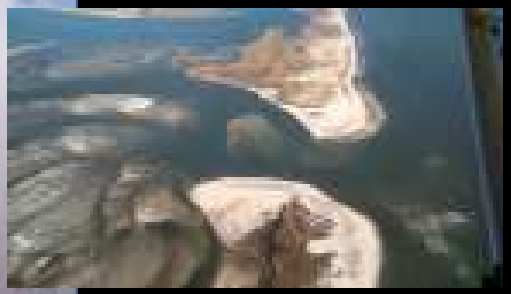
Sustain services and infrastructure

+

Ensure persistence of habitats and iconic landscapes

Ted Blanco

Coastal land availability vs. land loss



Charlie Flagg

Actions: Manage differently, adapt existing structures, acquire new or existing land

Summary

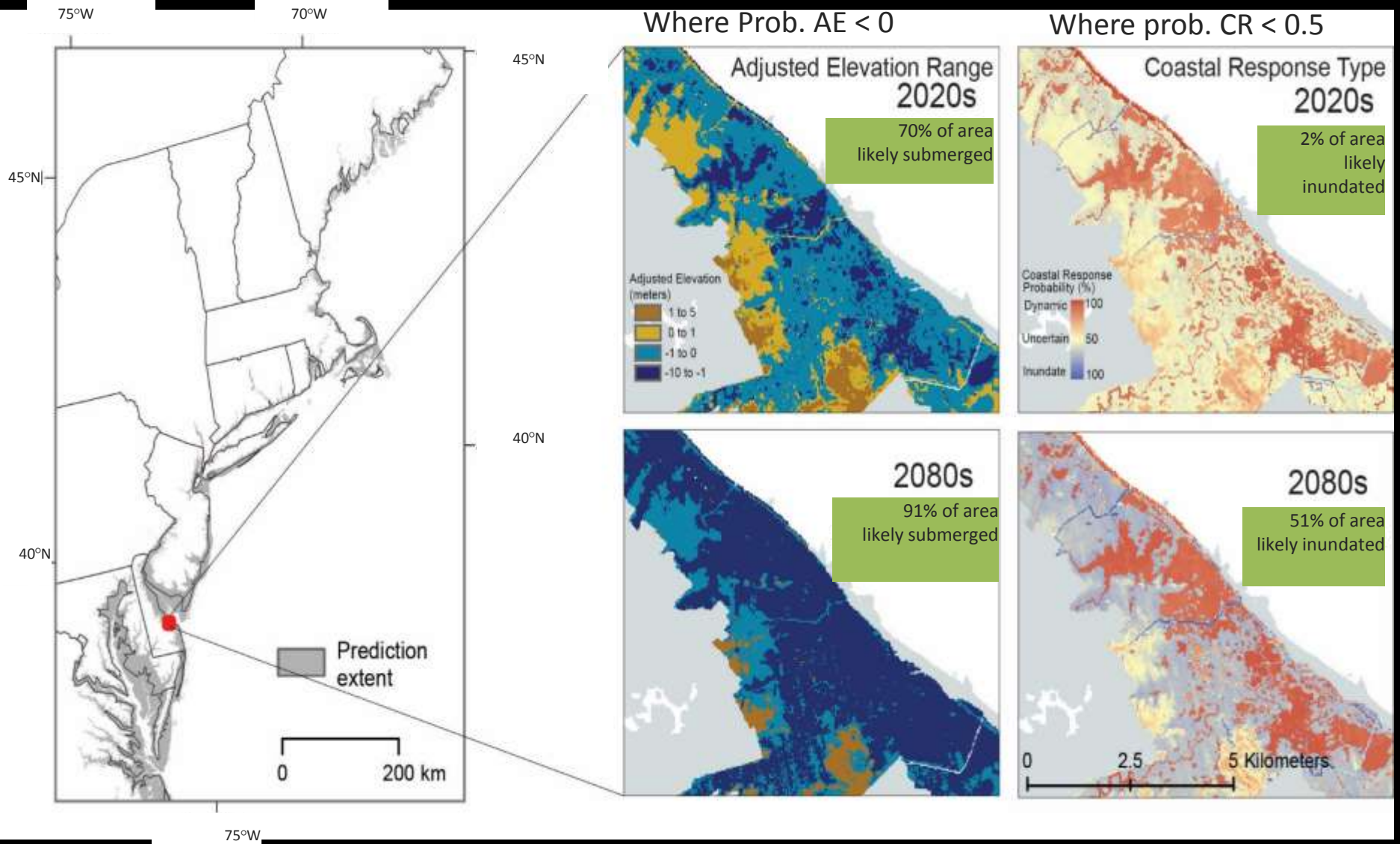
- The coastal landscape is variable in both configuration and response to change

- We know a lot about where and when the coast will change, and we need to know more
  - Rates of sea-level rise and magnitudes poorly constrained
  - Uncertain where and when storms will hit
  - Human action is difficult to predict
  - There will be major changes to the coast, ecosystems, and resources

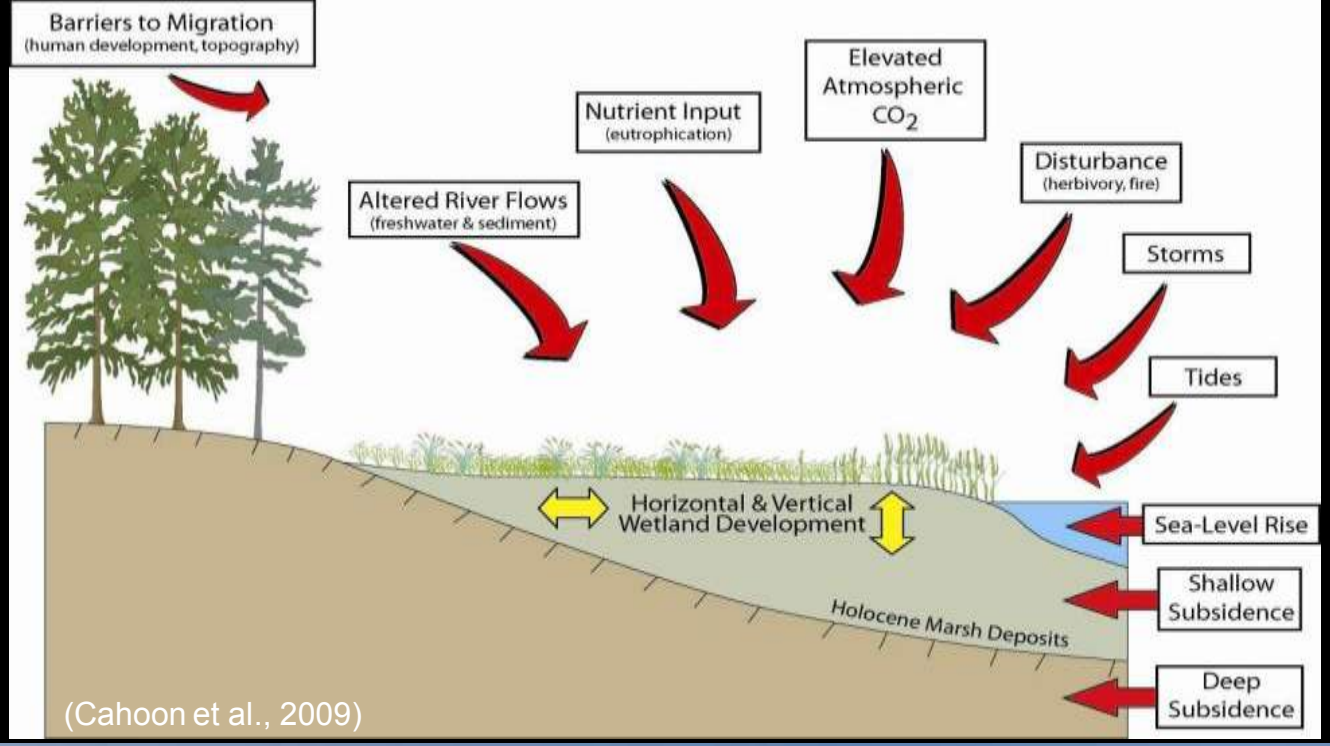
- We can prepare using both uncertainty and knowledge
  - Adaptive management and scenario planning will allow for planning flexibility and vision
  - Understanding your risk tolerance can help frame decision-making

Visualizing the coastal response to sea-level rise

(DRAFT not for citation; Lentz et al., in development)


75°W
70°W
45°N
45°N
40°N
40°N
75°W
Prediction extent
0
200 km
Where Prob. AE < 0
Where prob. CR < 0.5
Adjusted Elevation Range
2020s
70% of area likely submerged
Adjusted Elevation (meters)
1 to 5
0 to 1
-1 to 0
-10 to -1
Coastal Response Type
2020s
2% of area likely inundated
Coastal Response Probability (%)
Dynamic
100
Uncertain
50
Inundate
100
2080s
91% of area likely submerged
2080s
51% of area likely inundated
0
2.5
5 Kilometers

Dynamic equilibrium of marshes



and beaches