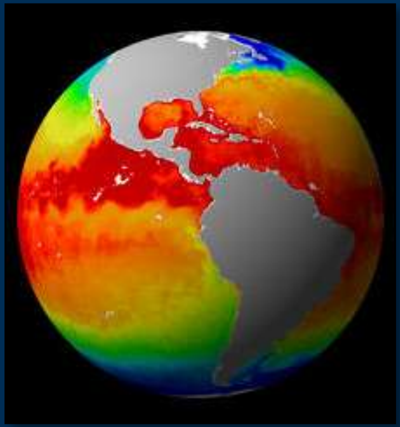
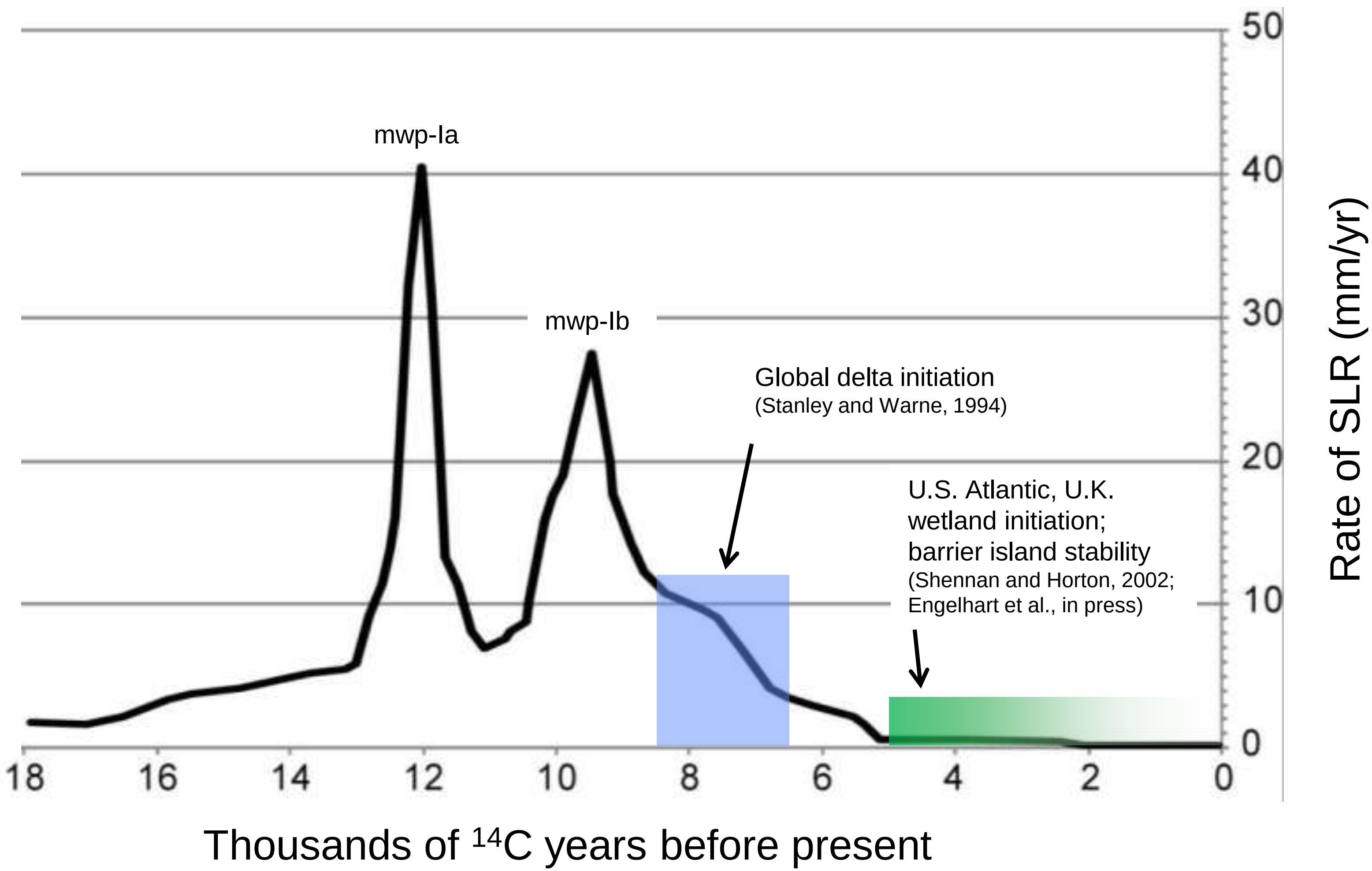
Sea-level Rise Science and Decision Making in an Uncertain Future

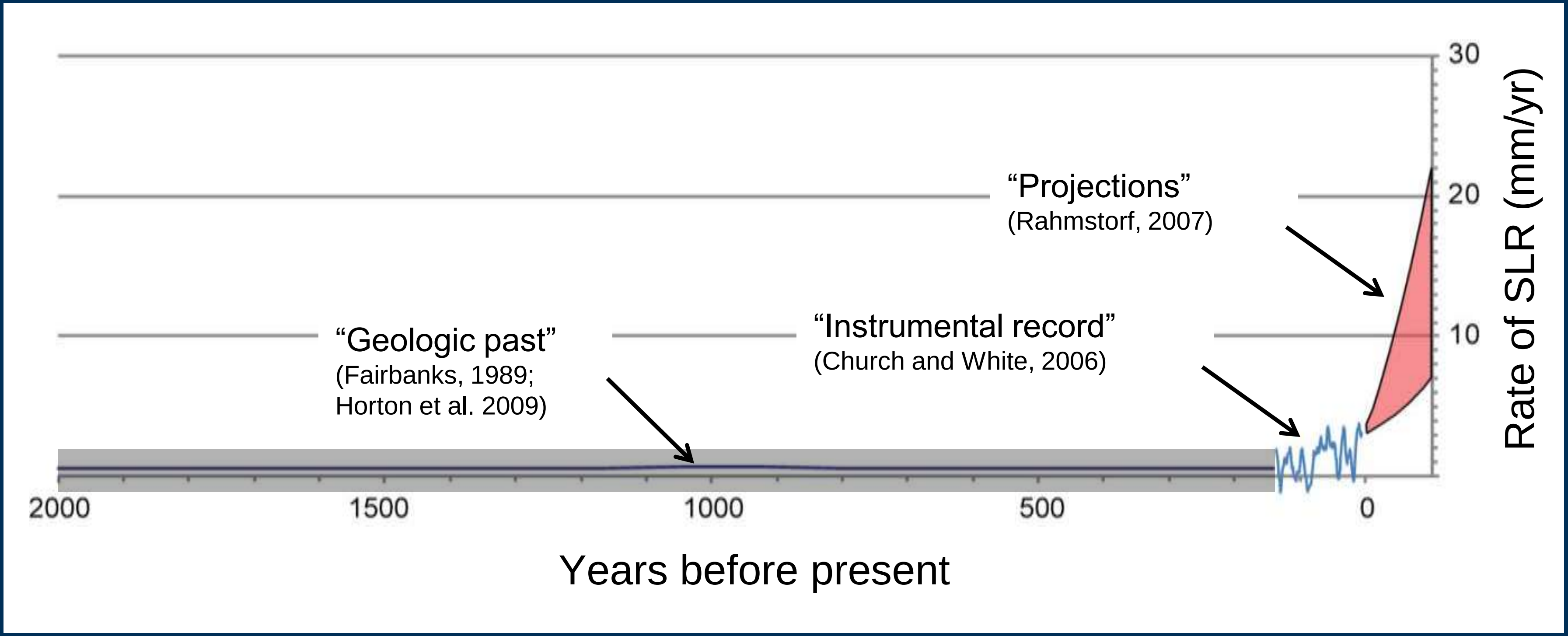


Rob Thieler
U.S. Geological Survey
Woods Hole, MA

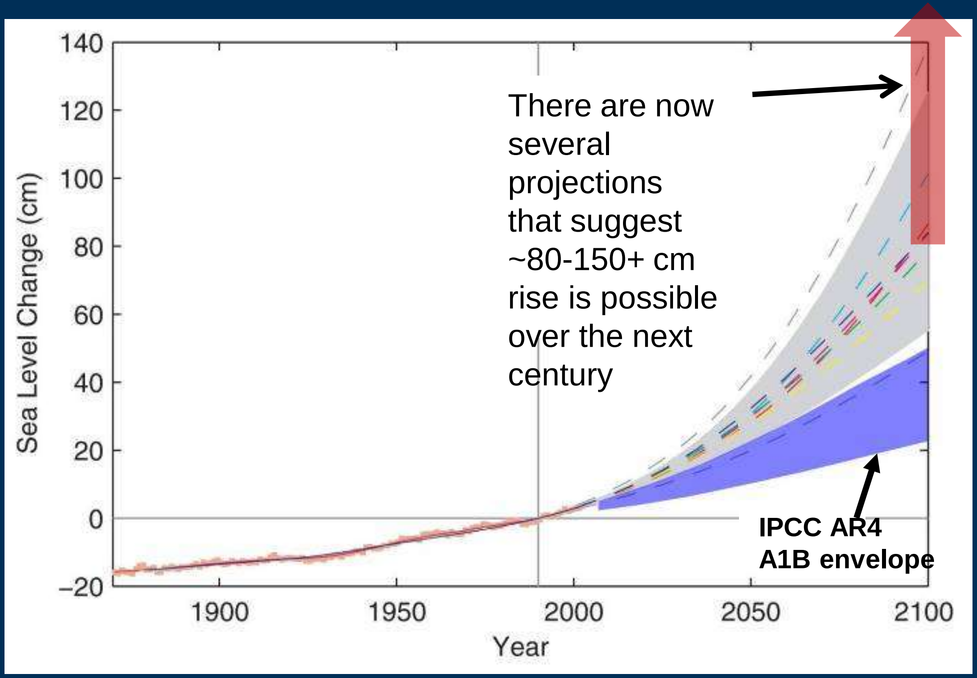
Sea-level rise rates since the Last Glacial Maximum

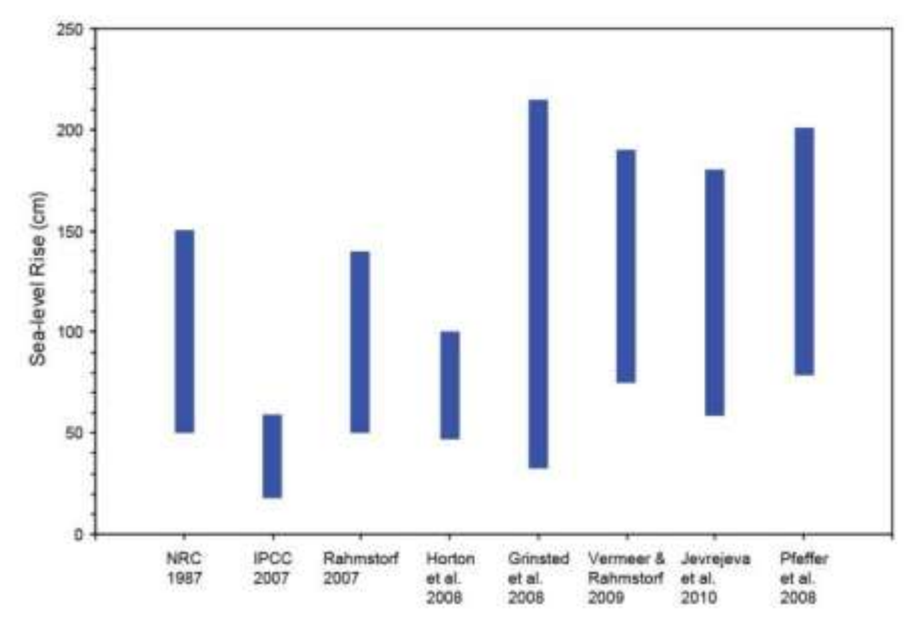


Past, present, and potential future rates of sea-level rise

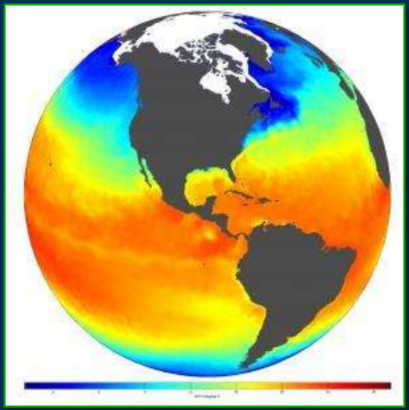


Historic and Projected Sea-level Rise

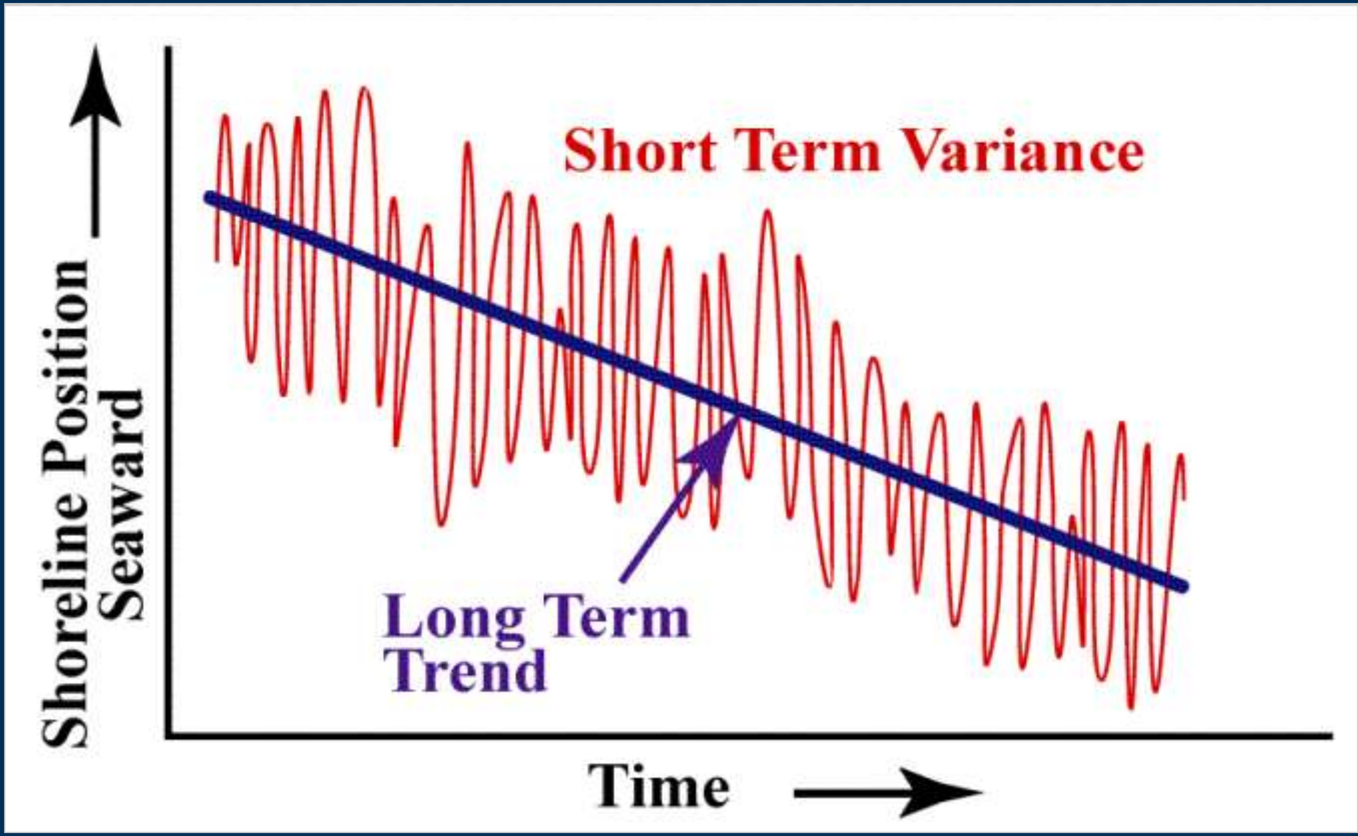




Importance of Spatial Scale



Importance of Temporal Scale



Short-term Variance

(hours to decade)

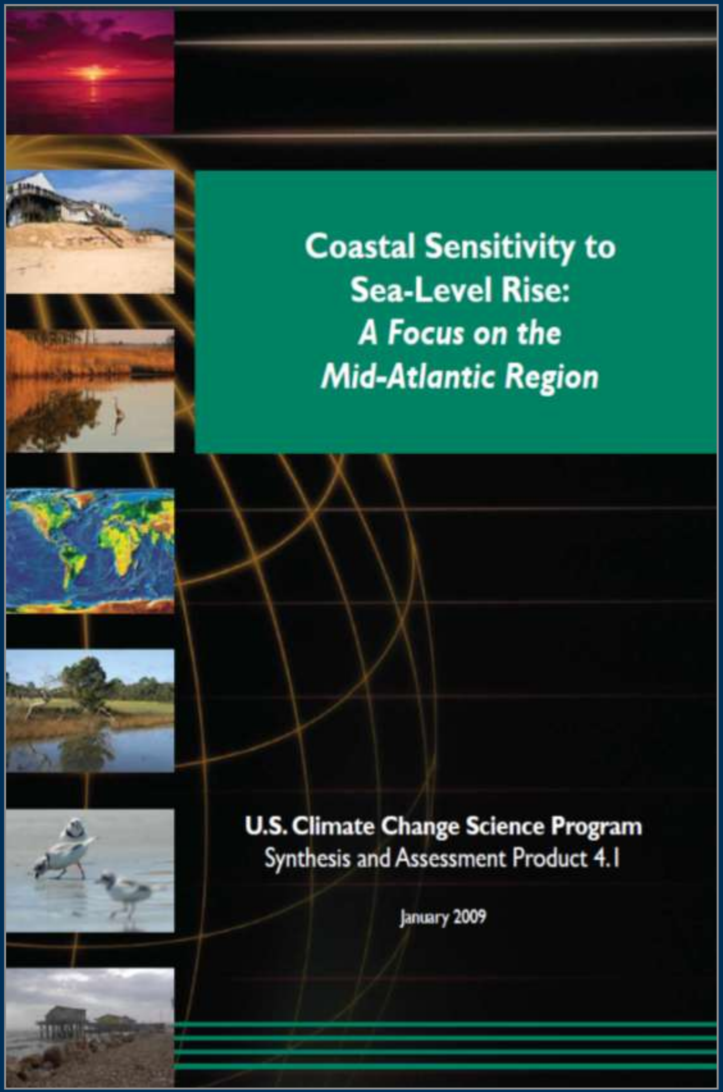
Storm impact/recovery
Annual cycles
El Niño

Long-term Trend

(decades to centuries)

Sediment deficit or surplus
Sea-level rise

Coastal Sensitivity to Sea-Level Rise:
A Focus on the Mid-Atlantic Region

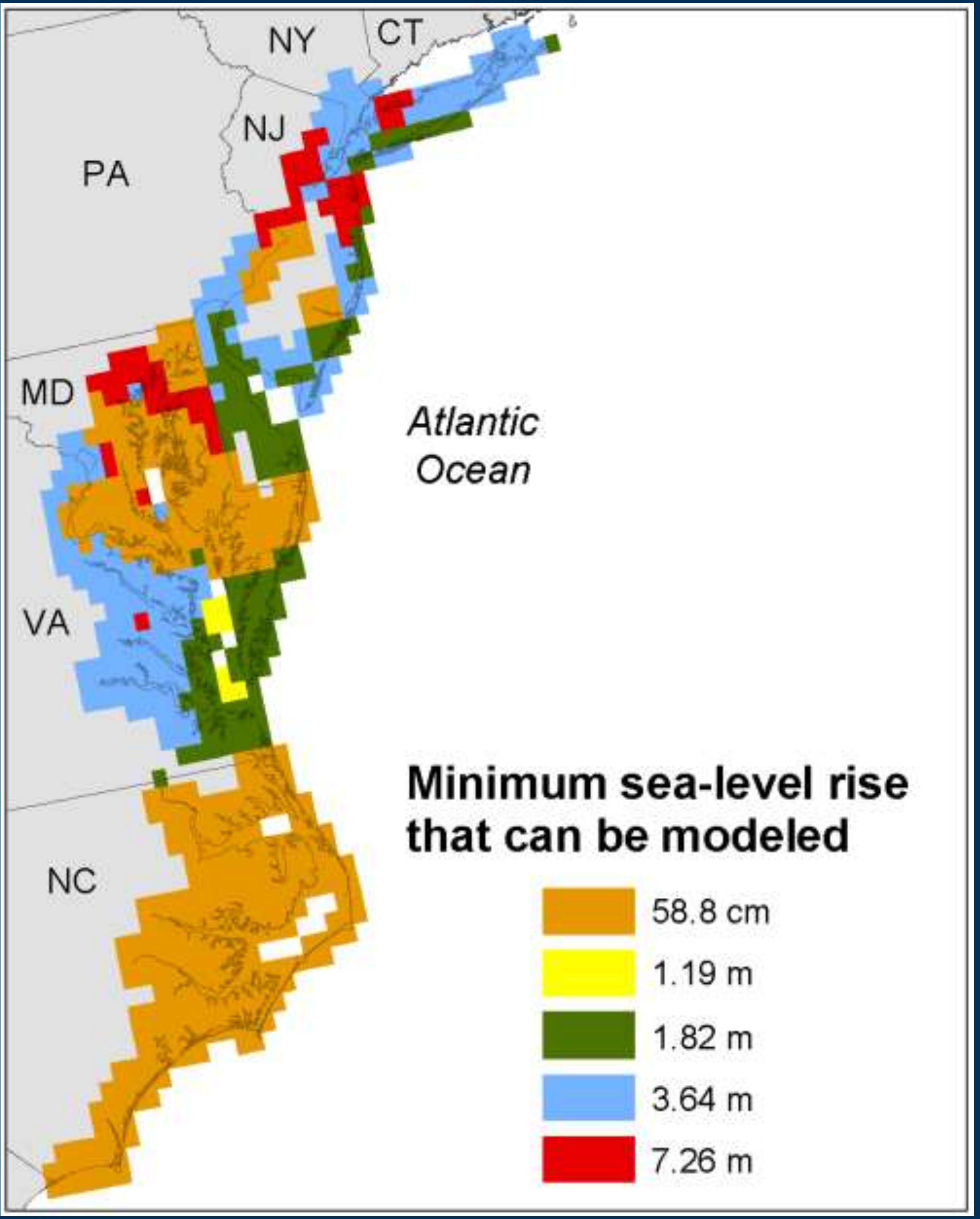


U.S. Climate Change Science Program

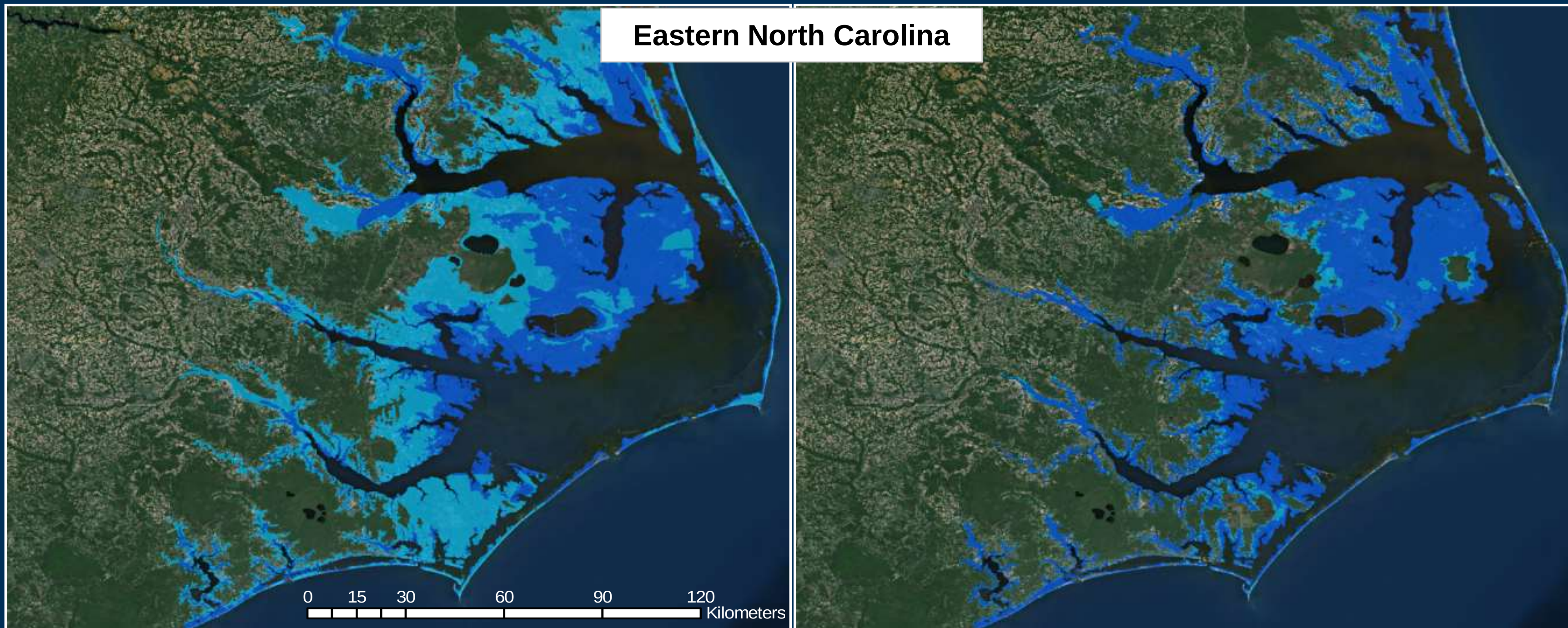
Synthesis and Assessment Product 4.1

Coastal Elevation Data

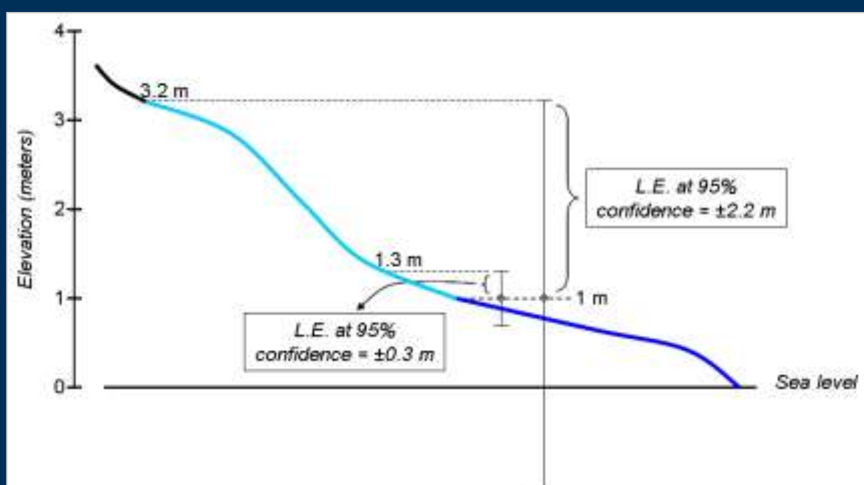
- Elevation is a critical factor in assessing potential impacts (specifically, inundation)
- Current elevation data do not provide the degree of confidence needed for quantitative assessments for local decision making
- Collection of high-quality elevation data (lidar) would be valuable



(Gesch et al., 2009)



Elevation source: 30-m DEM — **Elevation source: 3-m lidar data**



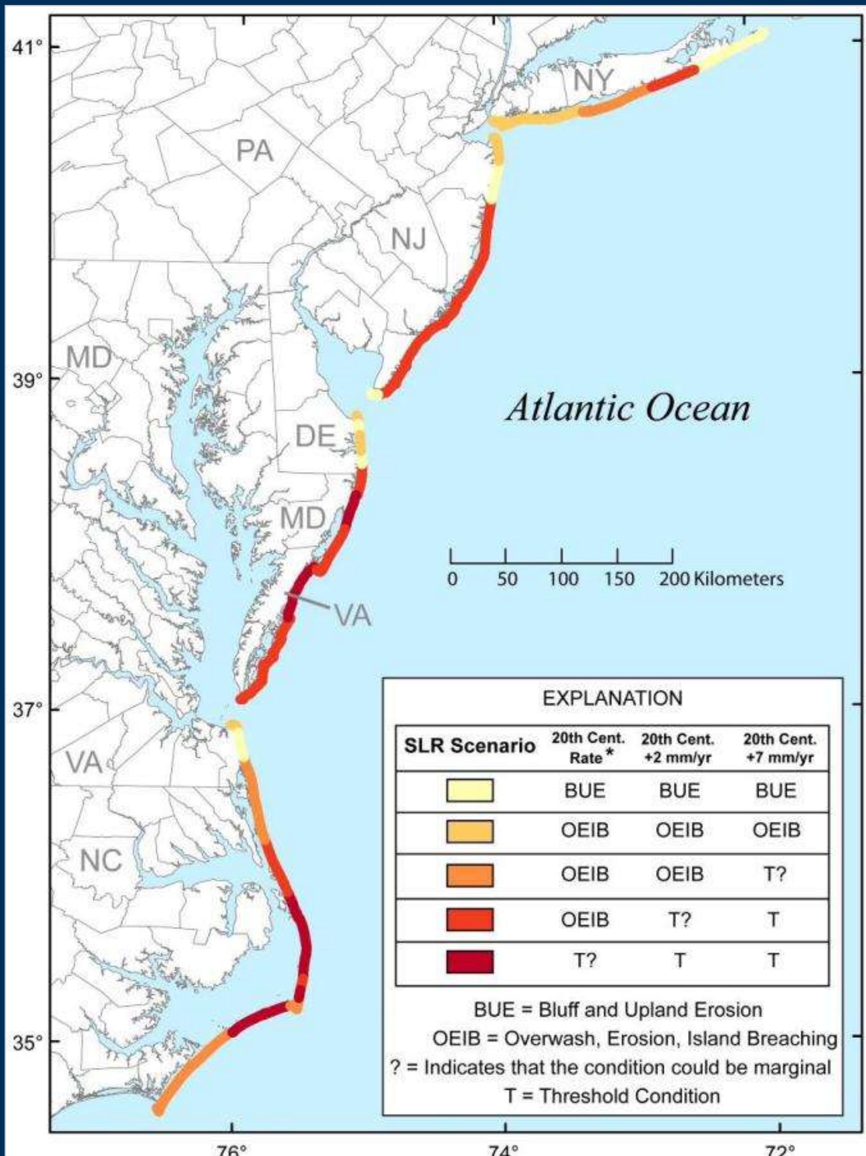
Dark blue **Land ≤ 1 meter elevation**

Light blue **Area of uncertainty associated with 1 meter elevation**

- High quality elevation data reduce uncertainty of potentially inundated areas

(Gesch et al., 2009)

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



(Gutierrez et al., 2009)

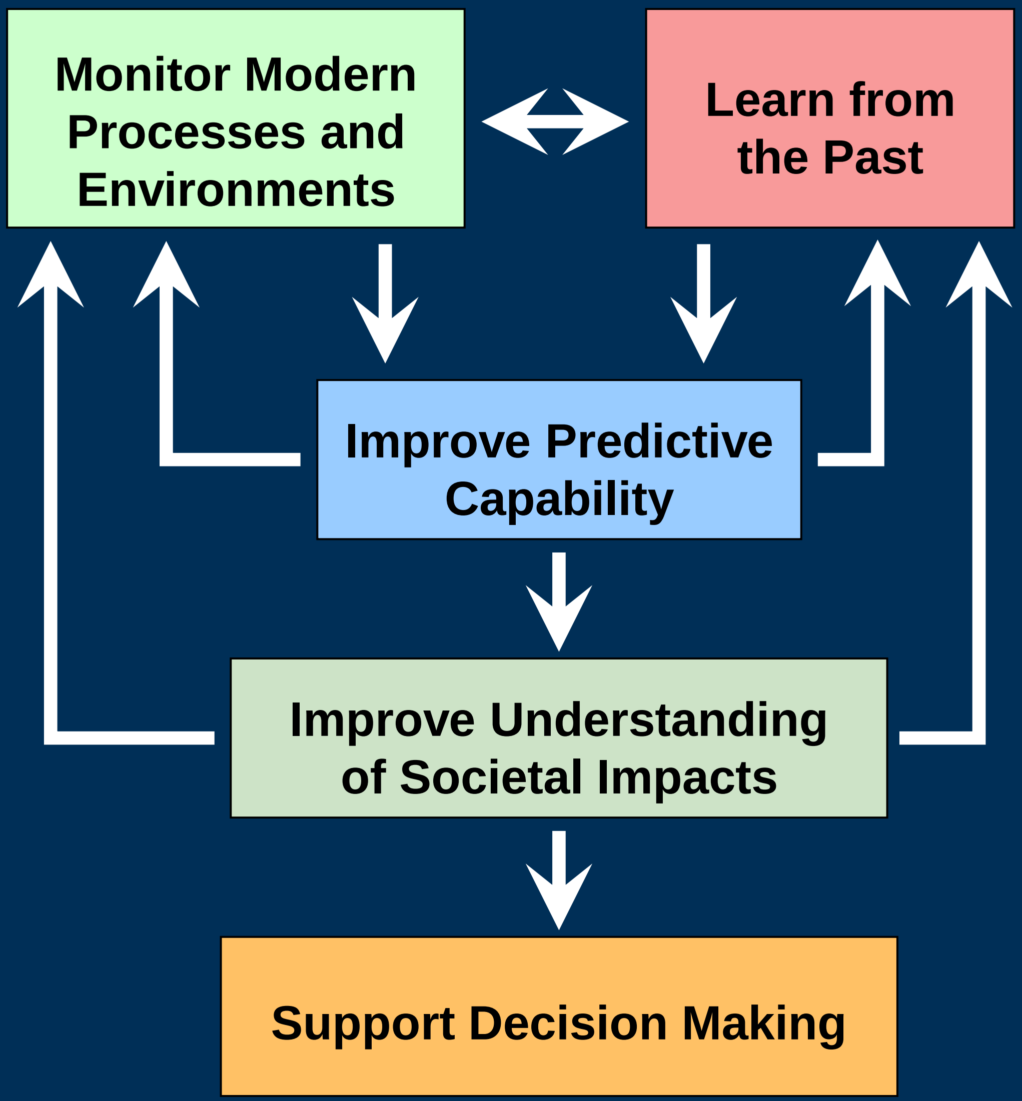
Bluff erosion

Overwash

Island Breaching

Threshold Crossing

Science strategy to address the challenge of climate change and sea-level rise

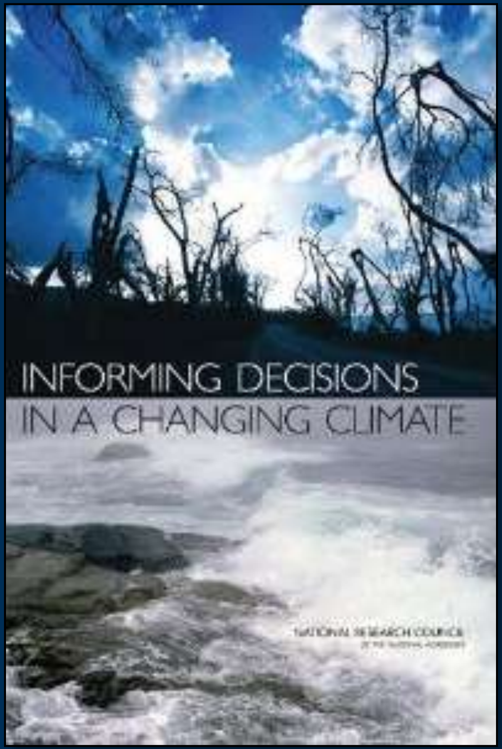


(Thieler et al., 2009)

Informing Decisions in a Changing Climate

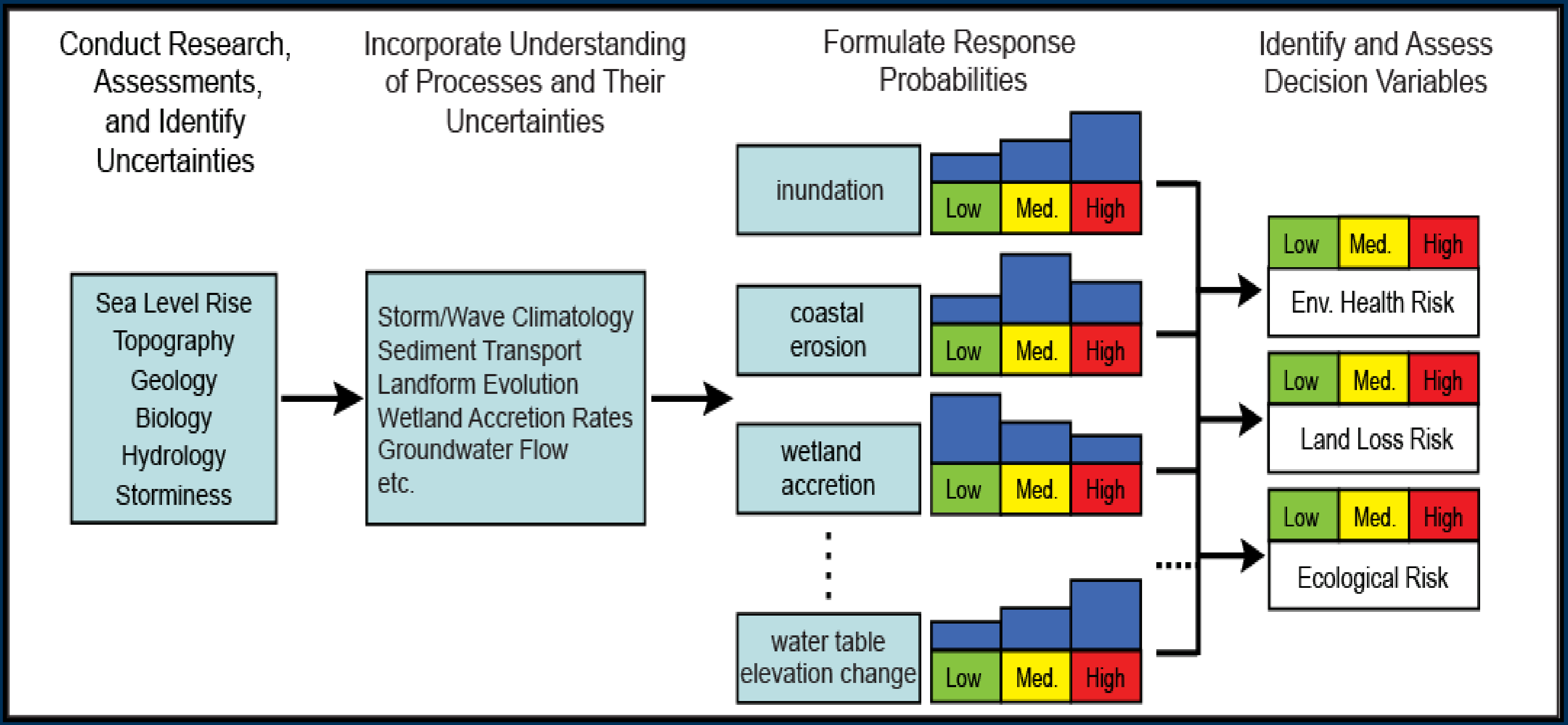
National Research Council (2009)

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.



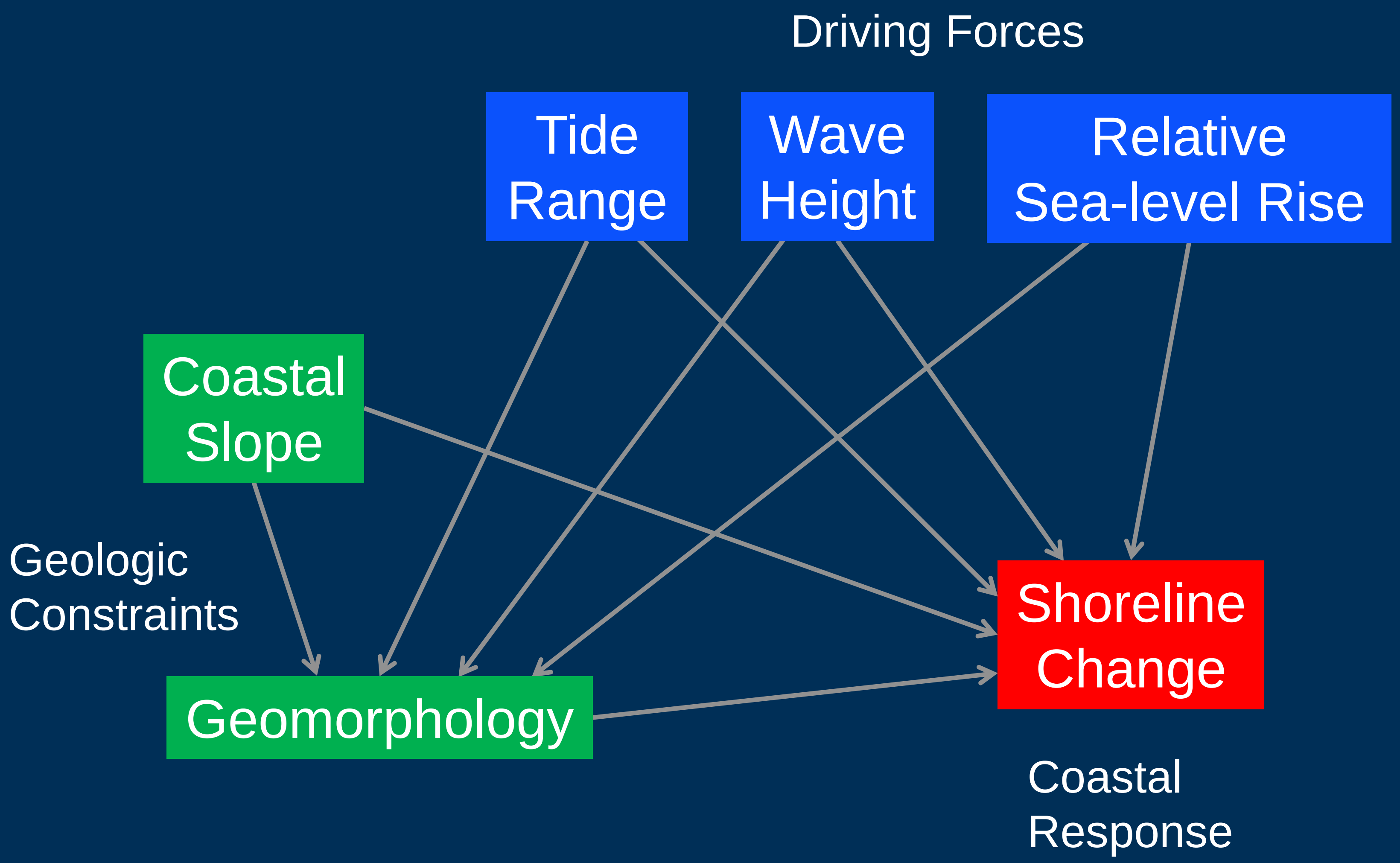
- Decision makers must expect to be surprised because of the nature of climate change and the incompleteness of scientific understanding of its consequences.
- An uncertainty management framework should be used because of the inadequacies of predictive capability.

A conceptual approach to the multivariate, uncertainty problem



Explicitly include uncertainties, as well as management application

Step 1. design a network

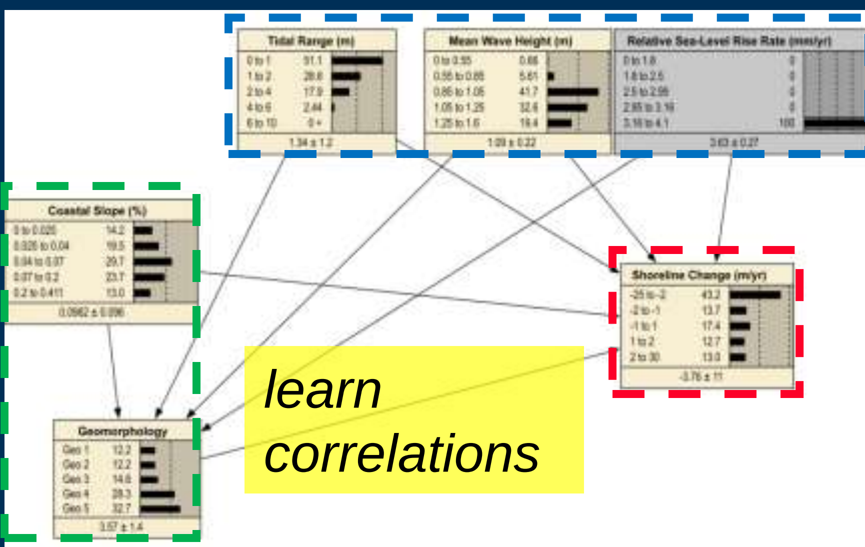


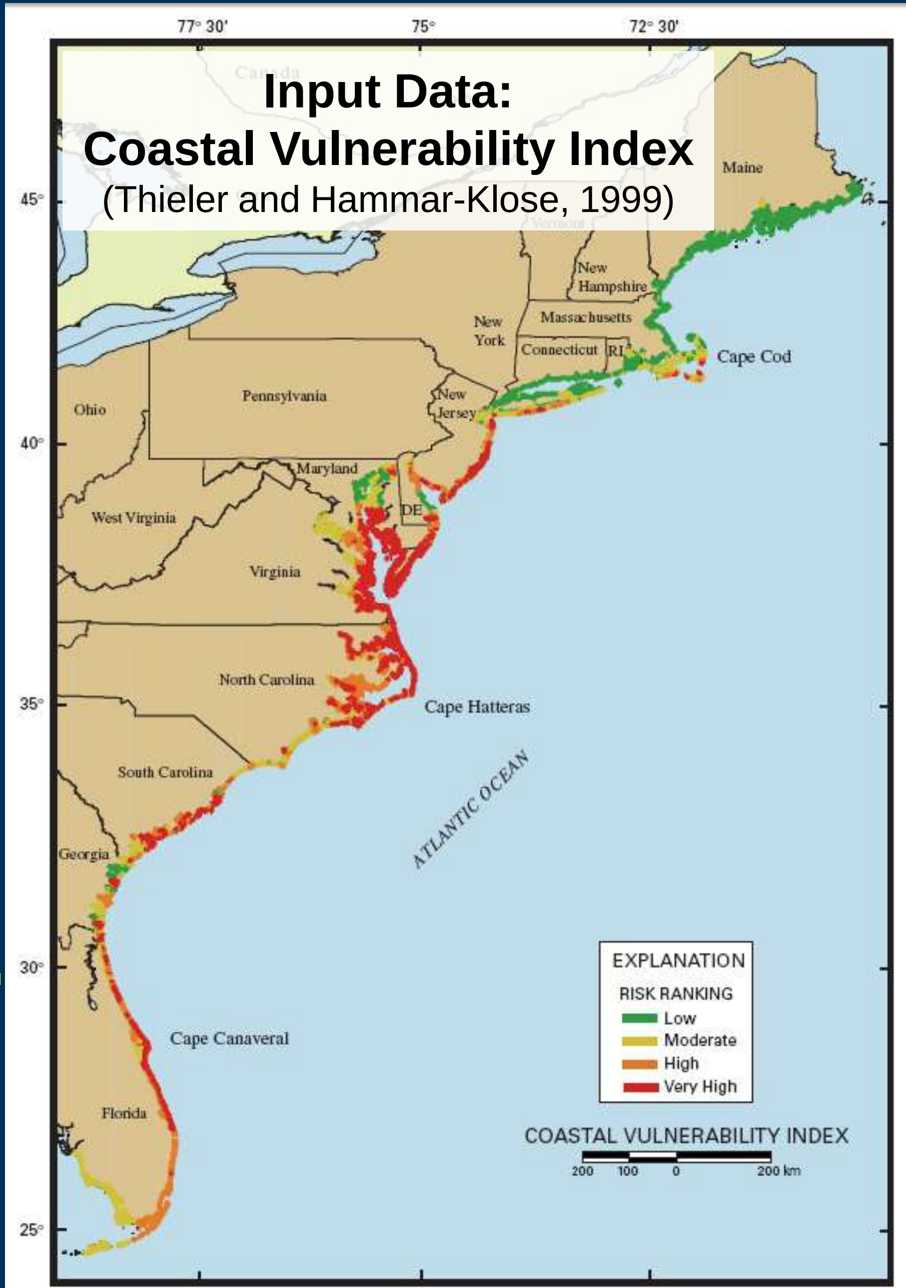
(Gutierrez et al., 2011)

Step 2. train a network

Utilized existing data for six geological and physical process variables

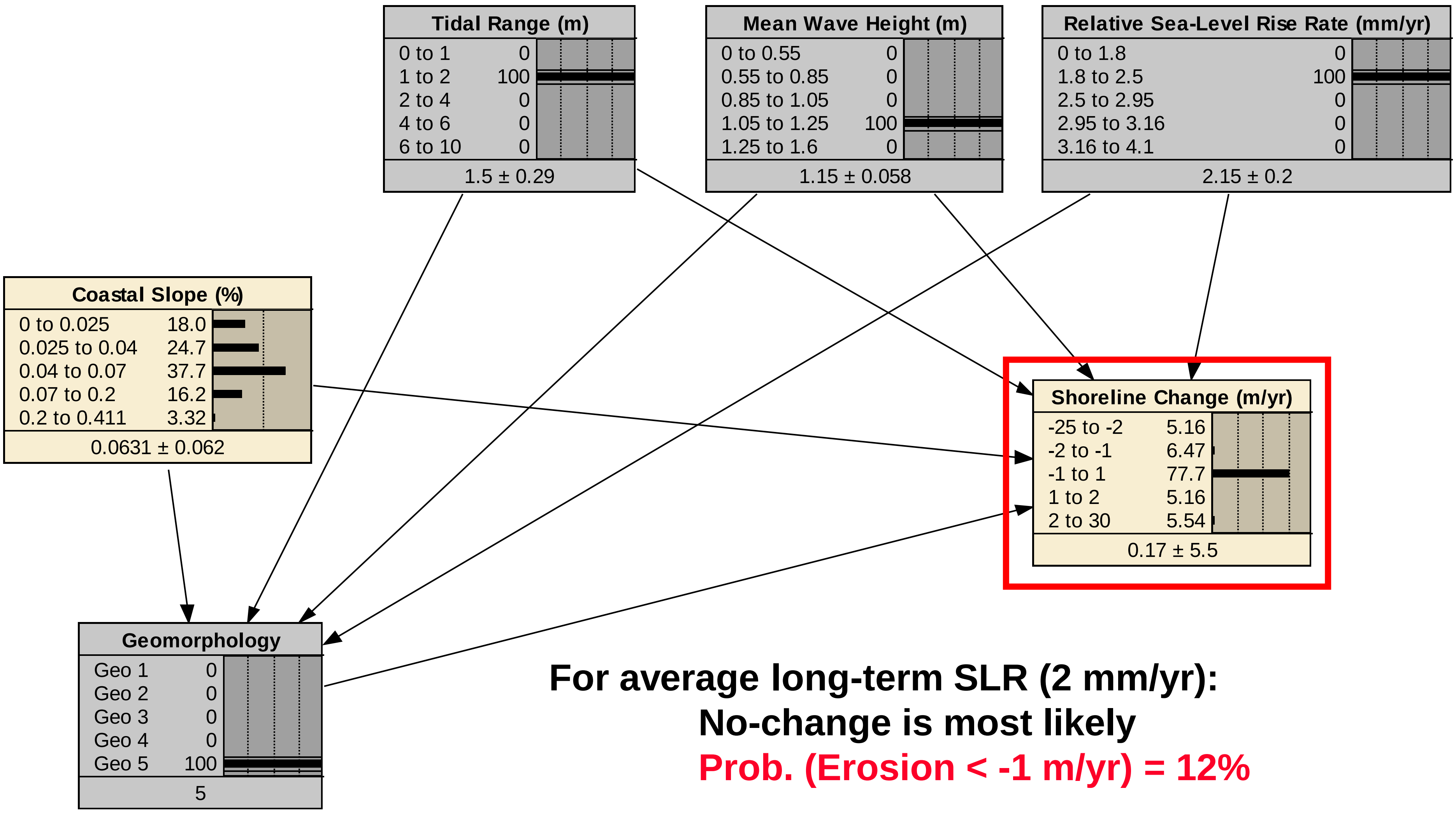
- Geomorphology
- Coastal slope
- Relative sea-level rise rate
- Mean sig. wave height
- Mean tidal range
- Historic shoreline change rate





(Gutierrez et al., 2011)

Step 3. Make predictions

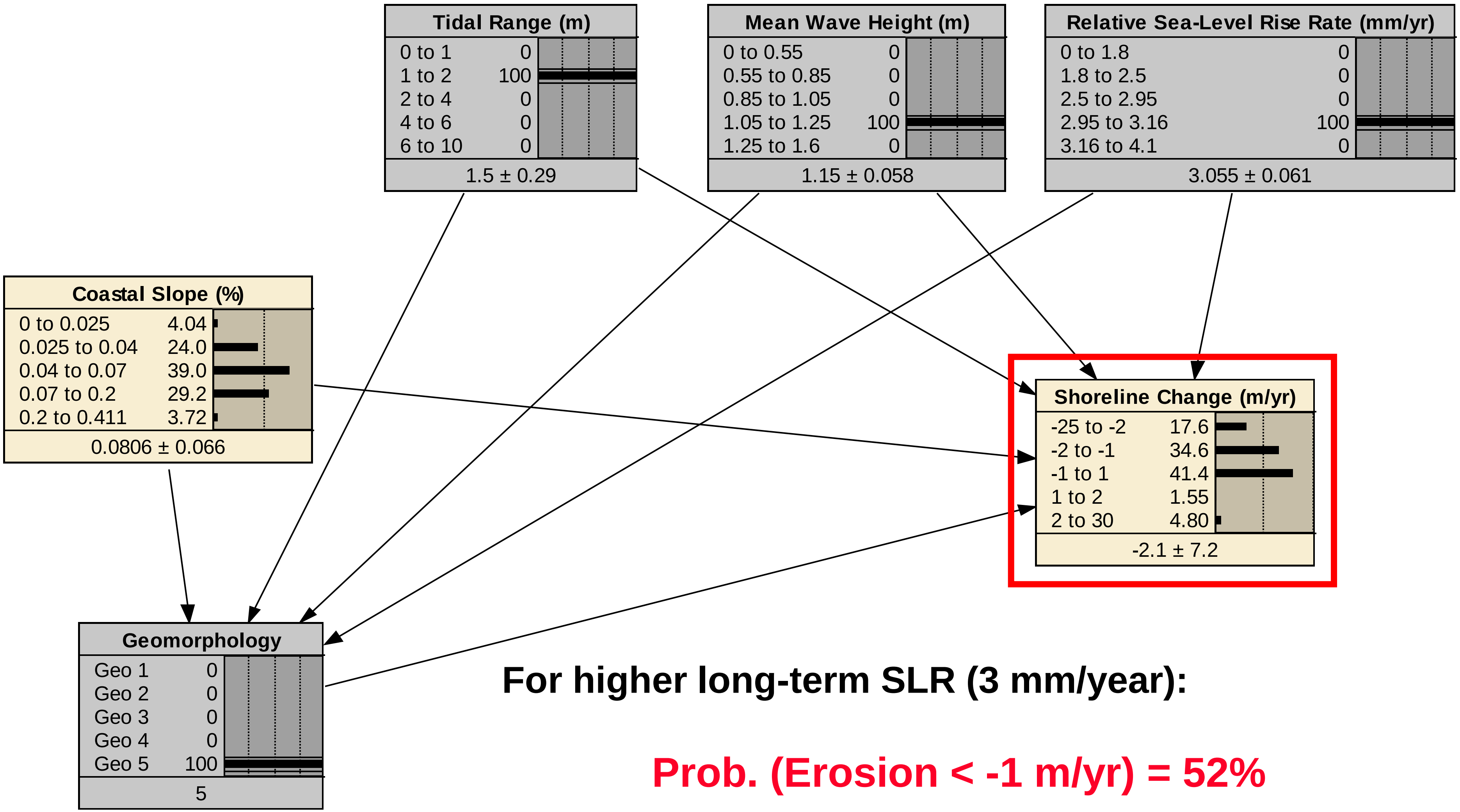


For average long-term SLR (2 mm/yr):

No-change is most likely

Prob. (Erosion < -1 m/yr) = 12%

Step 4. Make projections

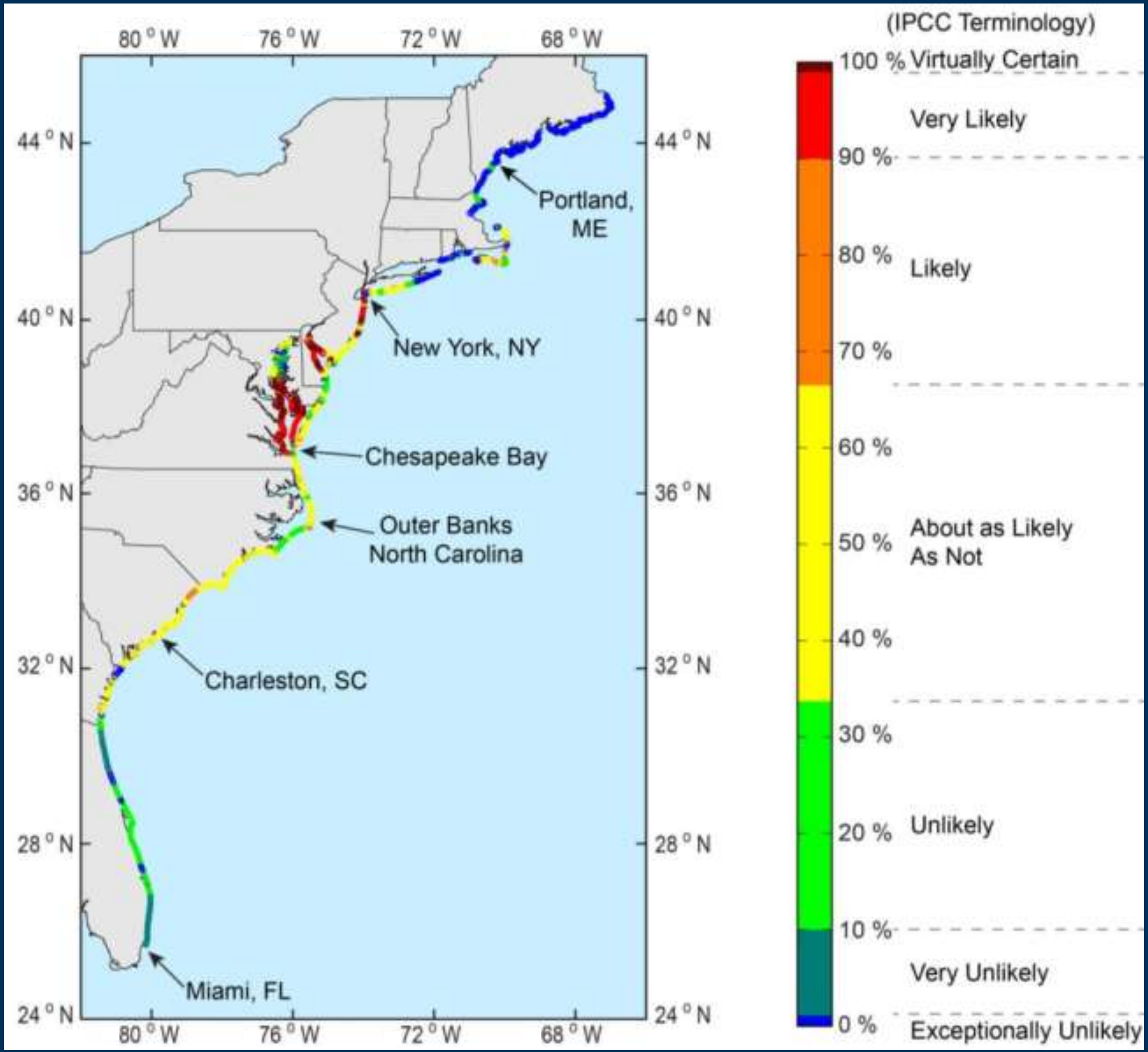


For higher long-term SLR (3 mm/year):

Prob. (Erosion < -1 m/yr) = 52%

Mapping Erosion Risk Using Bayesian Networks

Probability of shoreline erosion >2 m/yr

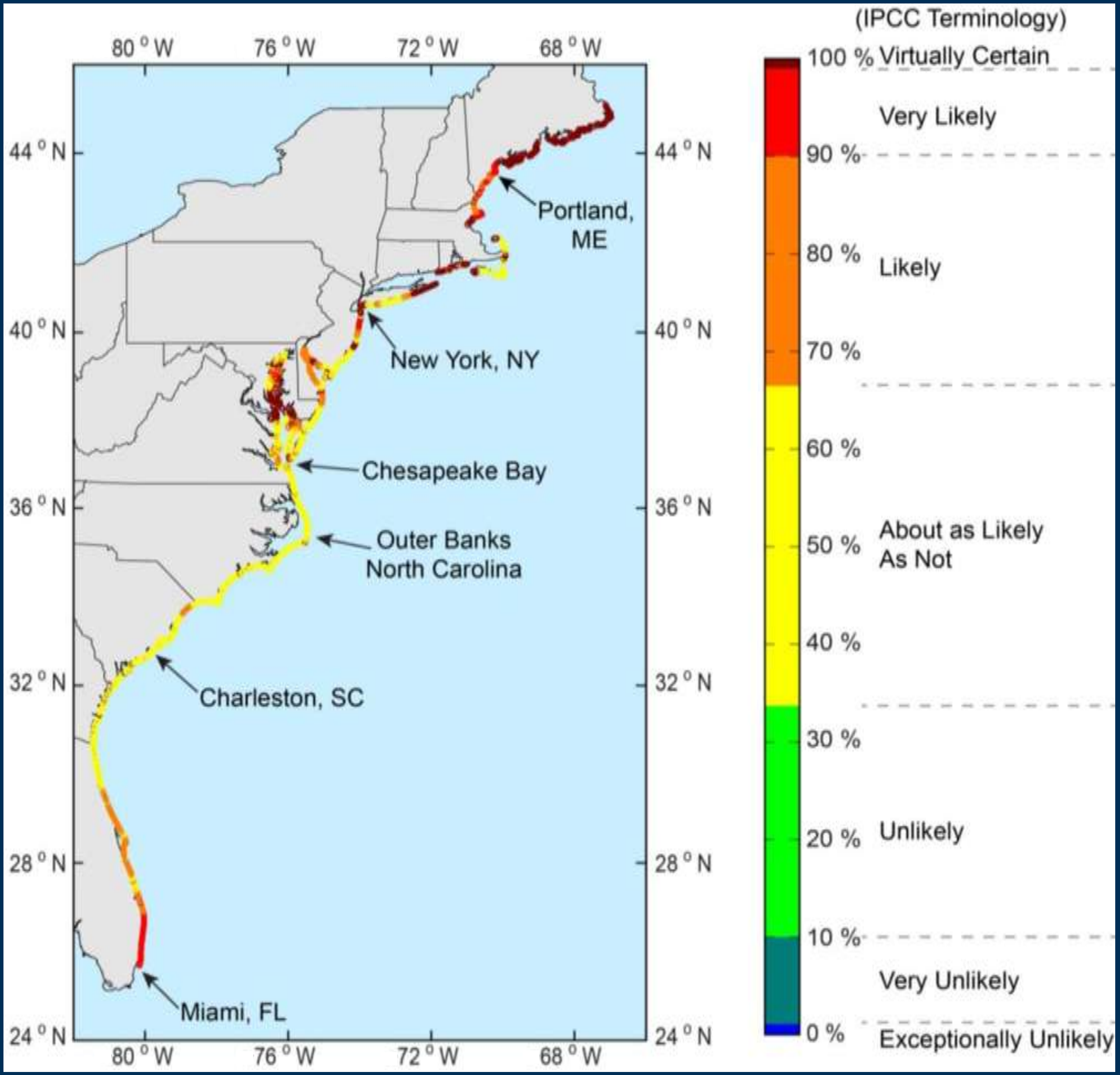


(Gutierrez et al., 2011)

Mapping Prediction Uncertainty

Higher probability = higher certainty of outcome

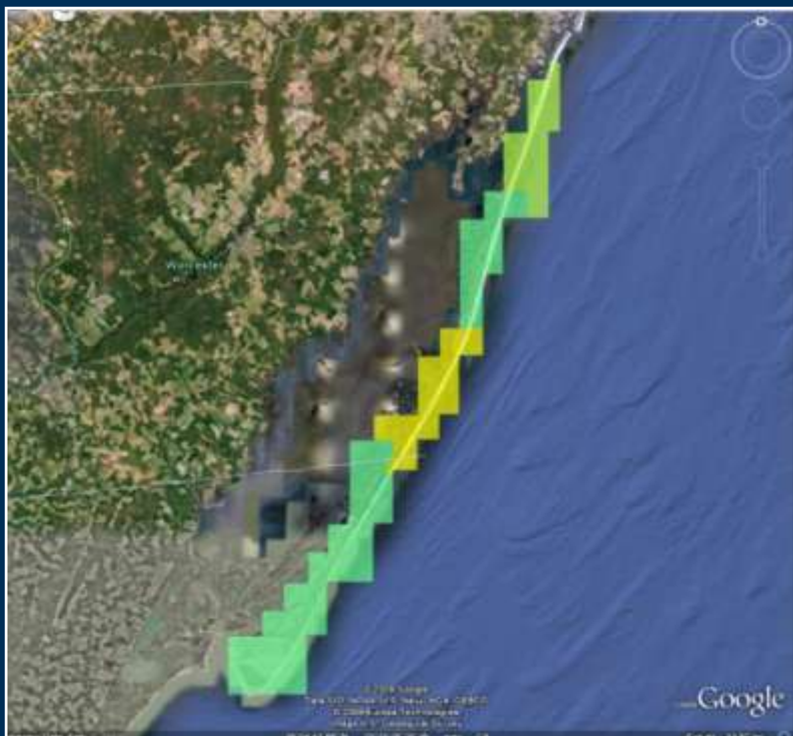
- Uncertainty map can be used to identify where better information is needed
- Areas of low confidence require
  - better input data
  - better understanding of processes
- Can use this map to focus research resources



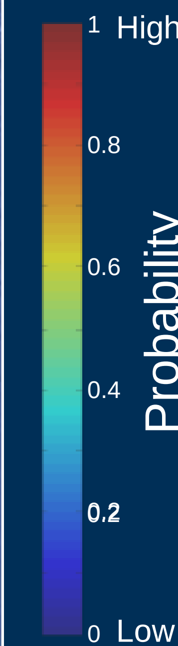
(Gutierrez et al., 2011)

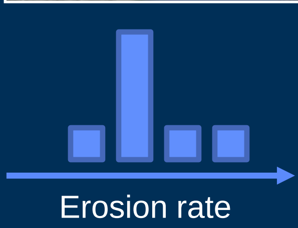
Application of a Bayesian network to an uncertain future: Probability of shoreline erosion >1 m/yr at Assateague Island National Seashore

Current conditions

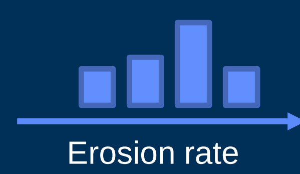


SLR +1 mm/yr, Wave ht. +10%





- Narrow probability distributions
- Relatively low uncertainty



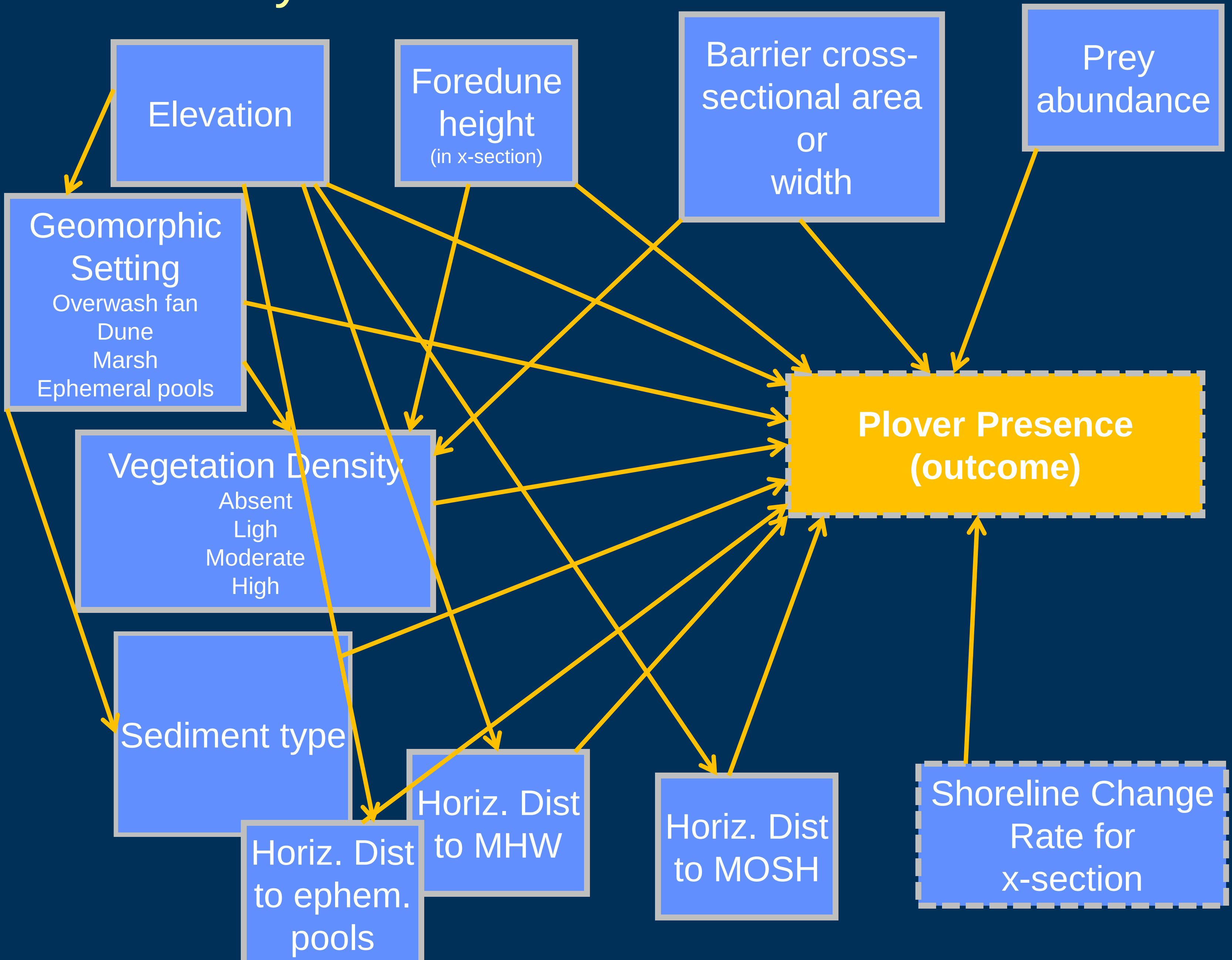
- Higher likelihood of erosion
- Broader distributions
- Increased uncertainty

Decision Support for DOI Agencies

Piping plover, *C. melodus*

- **Listed species**
- **DOI management responsibility**
- **Lifecycle includes substantial time on NPS lands for breeding, migrating, wintering**
- **Have interesting and specific habitat requirements that we can predict**
  - **Rangewide habitat availability**
  - **Attributes and distribution of breeding, foraging areas**
  - **Wave run-up and inundation sensitivity (morphologic and hydrodynamic detail)**
- **Can feed predictions back into population dynamics models**

Plovers in a Bayesian Network



Summary

- Future sea-level rise is problematic
  - It is a certain impact (we have already made a commitment to several centuries of SLR)
  - It is an uncertain impact (rates and magnitudes poorly constrained; human response unknown)

- Effective climate change decision support will require changes in how we do science and how decision makers assimilate and use scientific information

- Probabilistic approaches have many applications
  - Convey what we know and what we know we don't know
  - Synthesize data and models
  - Provide basis to focus research resources
  - Furnish information to support decision-making