North Carolina Commission on Climate Change

12 January 2007

Coastal vulnerability to erosion, storm hazards and potential future sea-level rise....

Science for adaptation to future climate variability

S. Jeffress Williams
Coastal Marine Geologist
USGS, Woods Hole Science Center, Woods Hole, MA

USGS

Climate Change- A Growing Consensus.....

- "Changes consistent with global warming are already underway across the Northeast"
  (Union of Concerned Scientists, Oct 2006)

- "The scientific evidence is now overwhelming: climate change presents very serious global risks and it demands an urgent global response" (Stern Review: The Economics of Climate Change, 2006)

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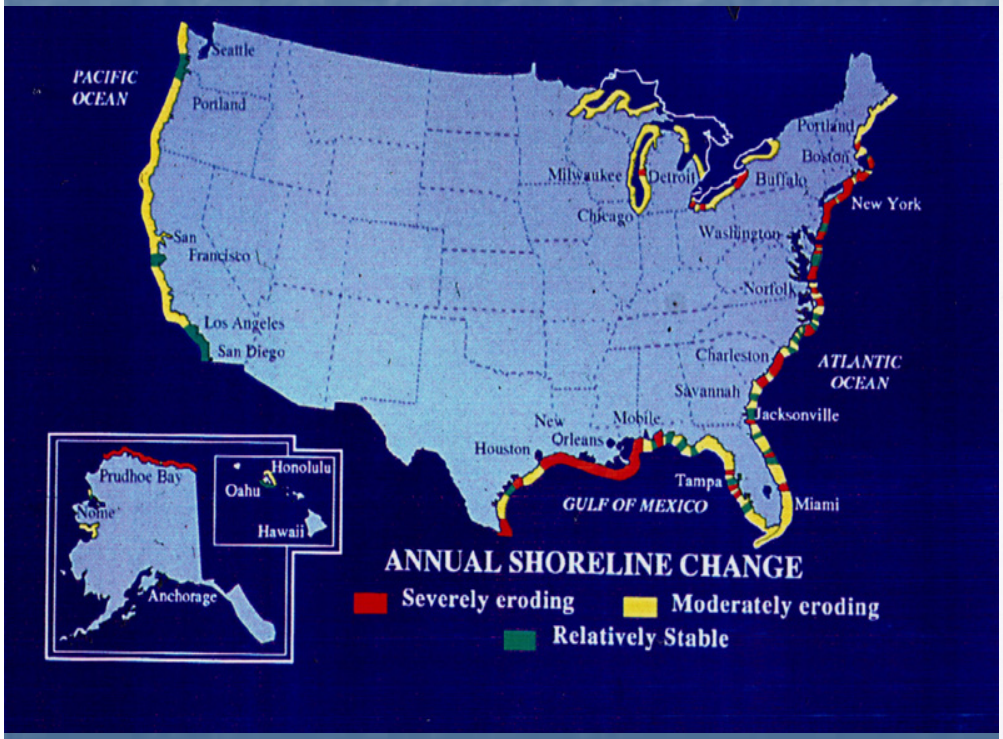
Natural Coastal Hazards

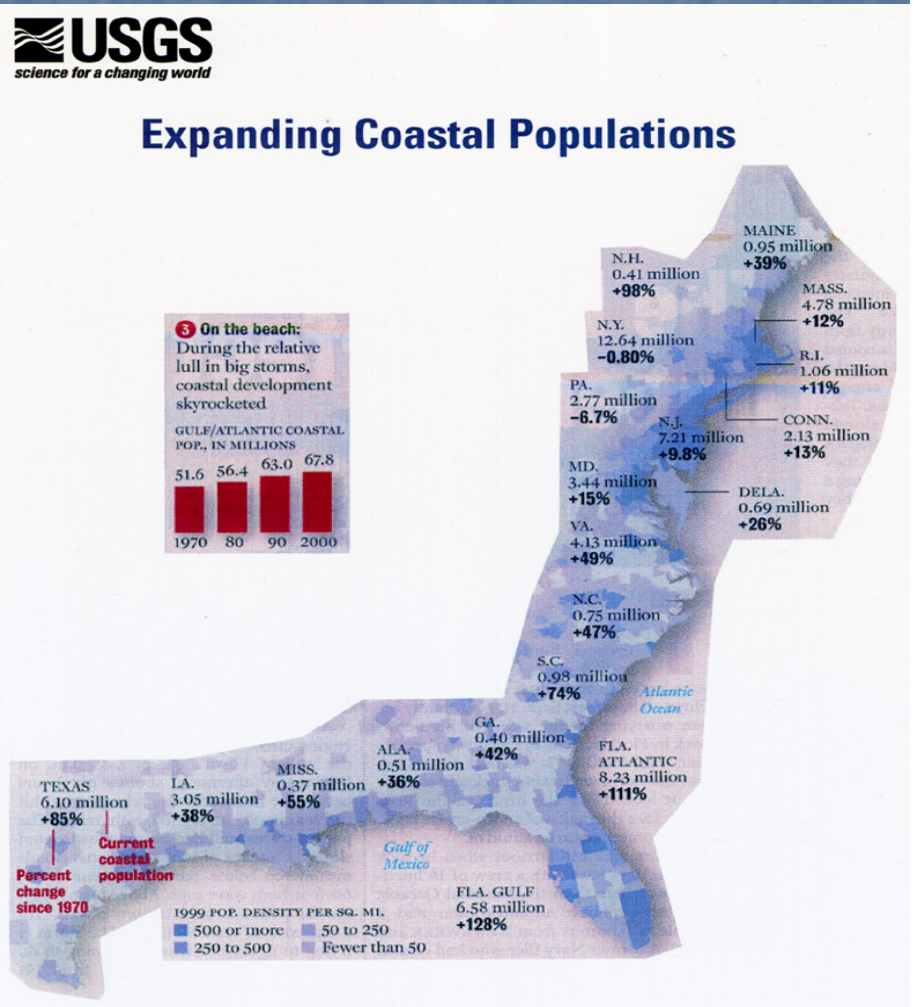
- Catastrophic storms (hurricanes, Nor'easters)
  - storm-surge flooding
  - shoreline erosion
  - high winds
- Coastal erosion
- Global sea-level rise
- Land subsidence
- Global and regional climate change
- Earthquakes
- Tsunamis
- Landslides
- Volcanic activity

Primary Processes Driving Coastal Change

- Geologic framework and character
- Coastal plain geomorphology and slope
- Relative sea-level change
  - global change
  - land subsidence/uplift
- Major storm events
  - tropical storms/ hurricanes
  - extratropical storms nor'easters
- Routine coastal processes
  - waves, tidal currents and winds
  - cold fronts and local storms
- Sediment budgets
  - sediment sources (headlands, bluffs)
  - sediment sinks (washover, inlets)
- Human activities
  - coastal engineering structures
  - dredging channels, inlets, canals
  - river modification (dams, levees)
  - fluid (oil-gas-water) extraction
  - climate change (SLR, storms)

America's Coastal Crisis – Coastal population and development are increasingly vulnerable to coastal hazards





2005: A Record Hurricane Season

N.A. Hurricane season: 1 June to 30 November

27 names storms

15 hurricanes

three Category 5 storms

- 29 Aug, Hurricane Katrina (150 mph winds, 27-35 ft storm surge, 200 mi dia, 55 ft waves, 920 mb central pressure, 1336 fatalities/4000 missing, most costly)

- 21 Sept, Hurricane Rita (155 mph winds, 15 ft surge)

- 19 Oct, Hurricane Wilma (160 mph winds, 882 mb winds, most intense)

2006: Warmest year in recorded history

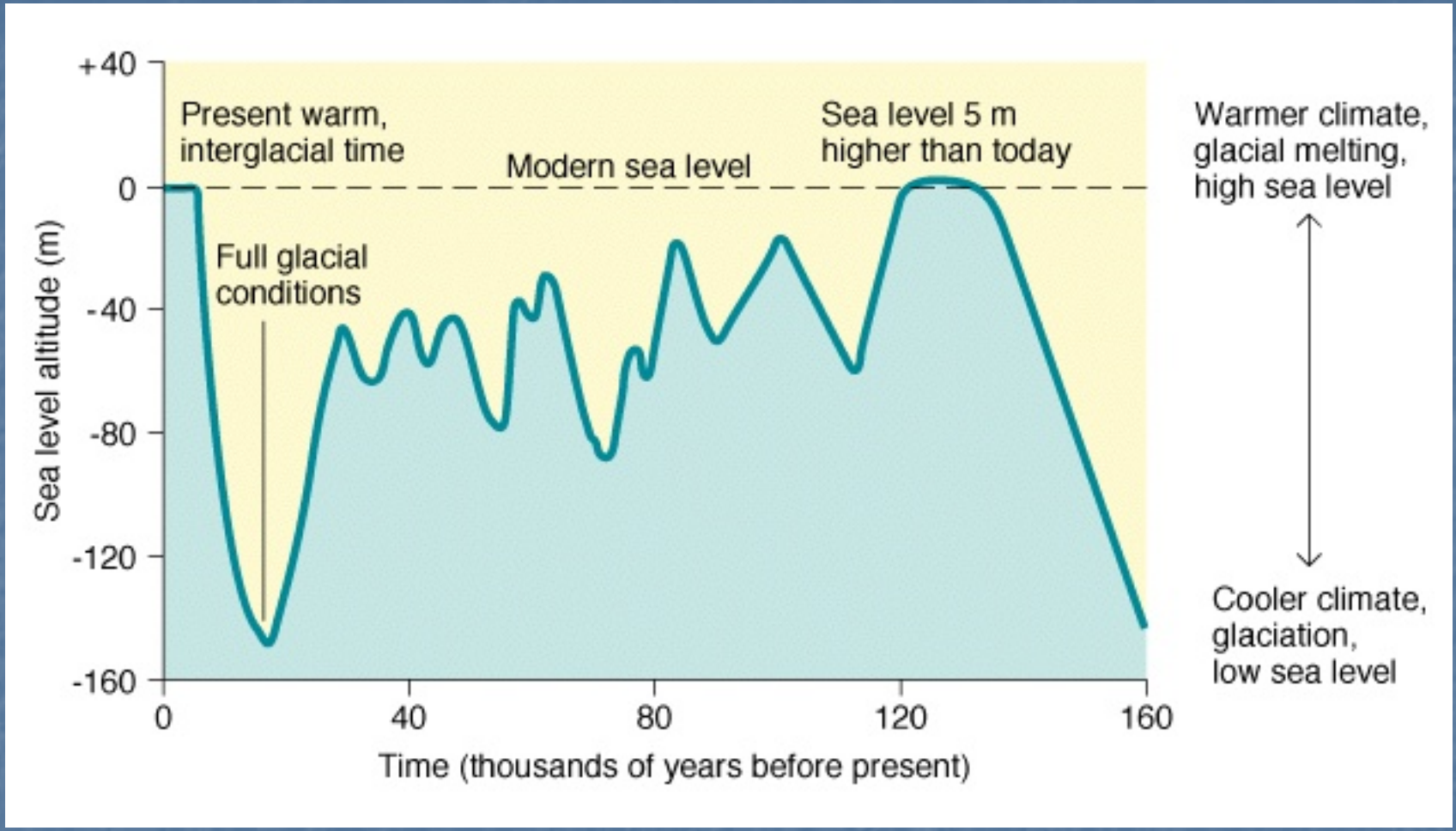
2007: ????

Effects of sea-level rise

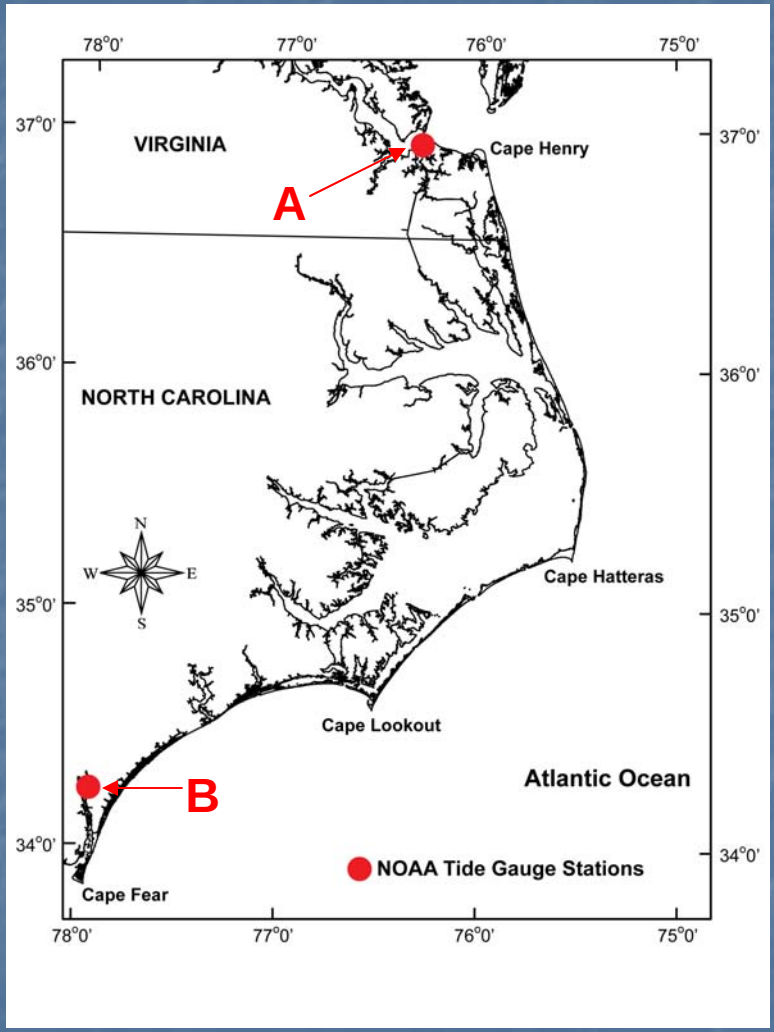
Greater potential impact

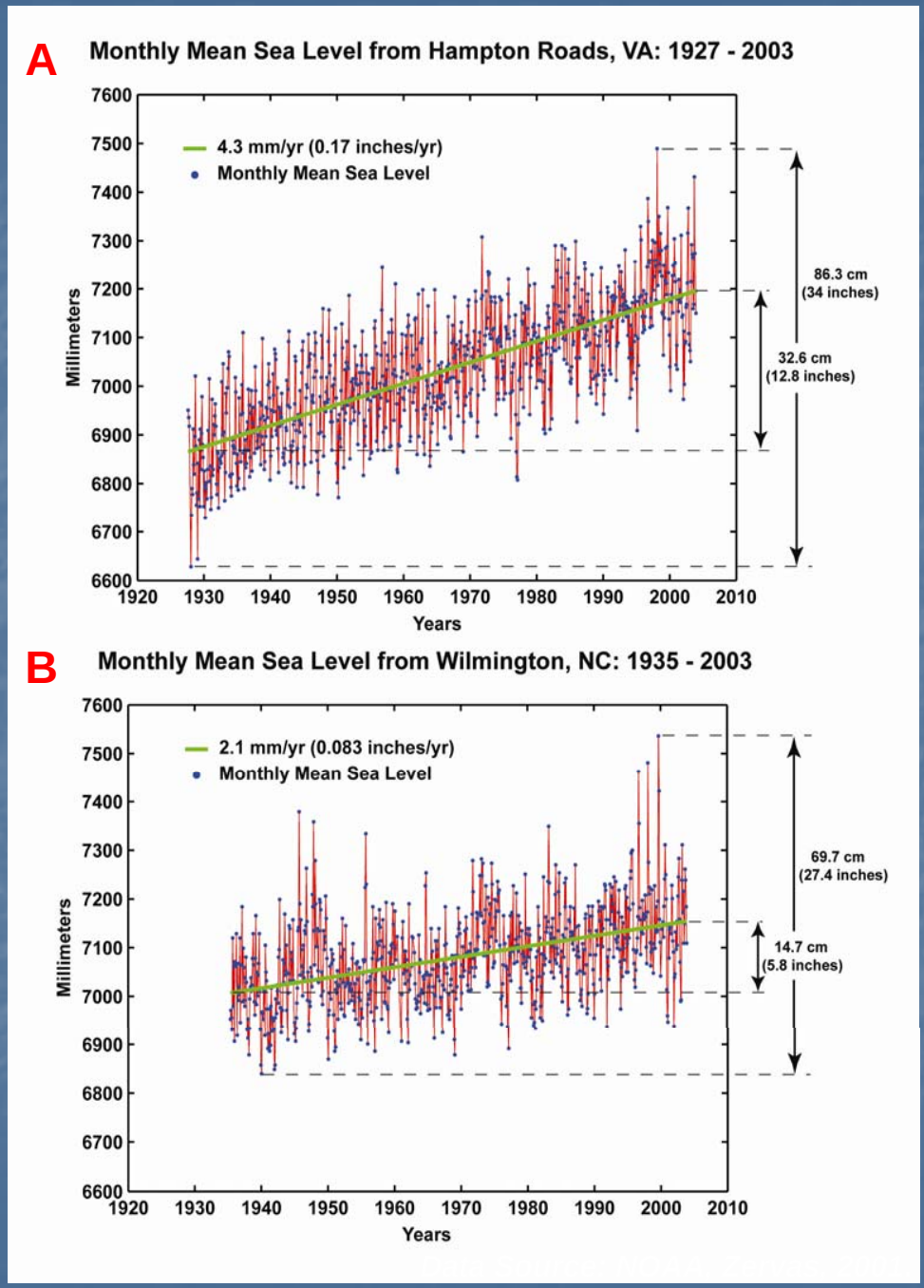
- Loss of coastal habitats and resources
- Increased beach-bluff-dune-marsh erosion
- Loss of recreation resources (beaches, marshes)
- Salt–water intrusion to water wells, septic systems
- Elevated storm-surge flooding levels
- Greater, more frequent coastal inundation
- Increased risk to urban infrastructure
- Greater risk to human safety & development

Global sea-level change over the past 160,000 years



(From Merrits et al.)


78°0'
77°0'
76°0'
75°0'
37°0'
36°0'
35°0'
34°0'
VIRGINIA
NORTH CAROLINA
Cape Henry
Cape Hatteras
Cape Lookout
Cape Fear
Atlantic Ocean
NOAA Tide Gauge Stations
A
B
N
S
E
W


A
Monthly Mean Sea Level from Hampton Roads, VA: 1927 - 2003
4.3 mm/yr (0.17 inches/yr)
Monthly Mean Sea Level
Millimeters
Years
86.3 cm
(34 inches)
32.6 cm
(12.8 inches)
B
Monthly Mean Sea Level from Wilmington, NC: 1935 - 2003
2.1 mm/yr (0.083 inches/yr)
Monthly Mean Sea Level
Millimeters
Years
69.7 cm
(27.4 inches)
14.7 cm
(5.8 inches)

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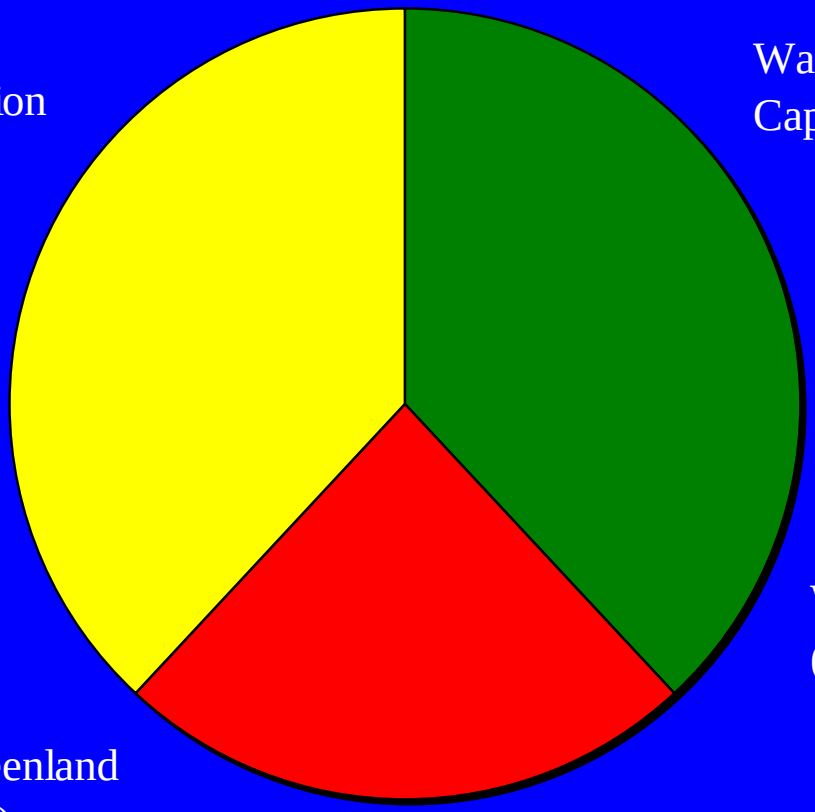
Best Estimates of Climate-Related Contributions to Eustatic Sea-level Rise (12 to 15 cm) Over the Last 100 Years



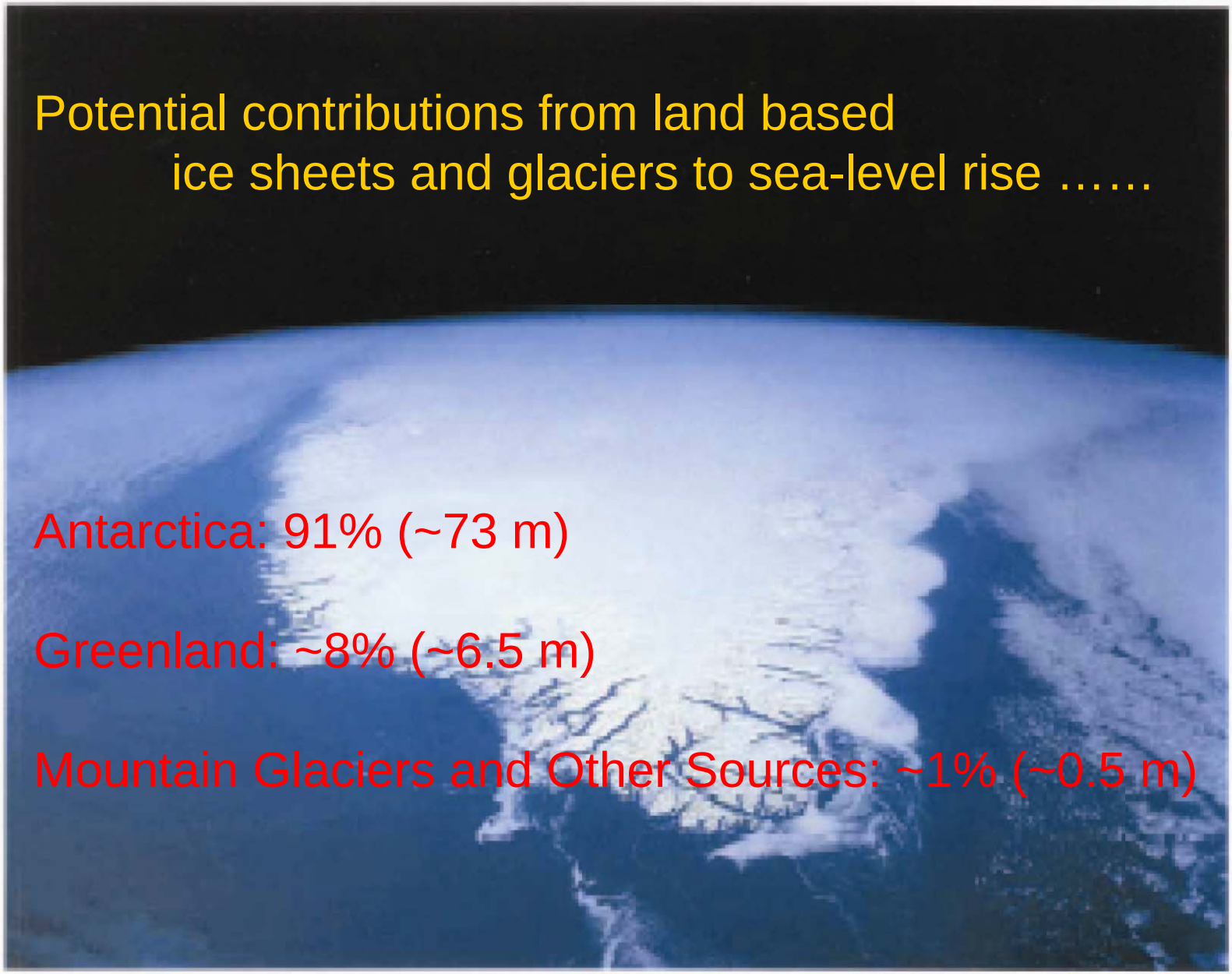
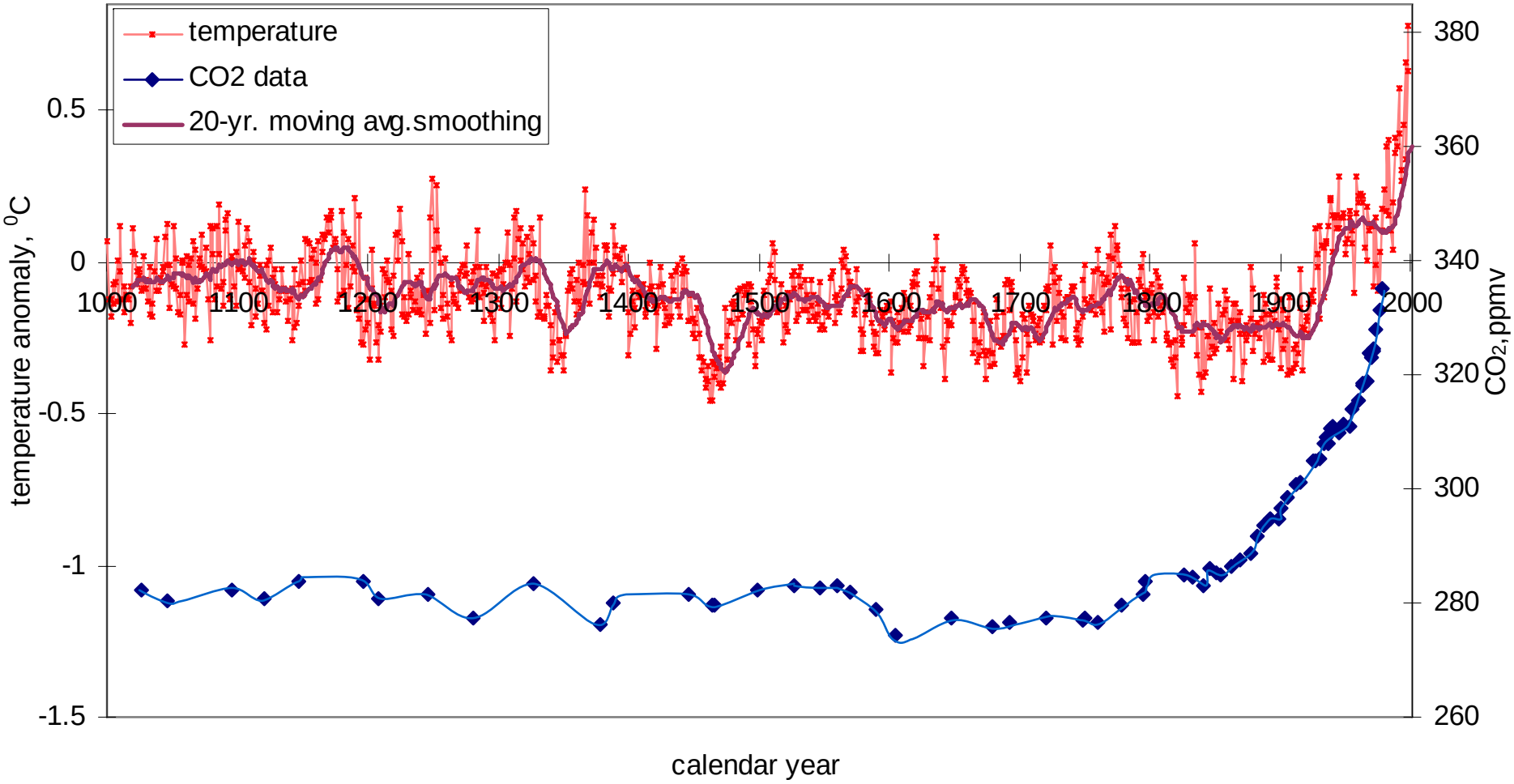
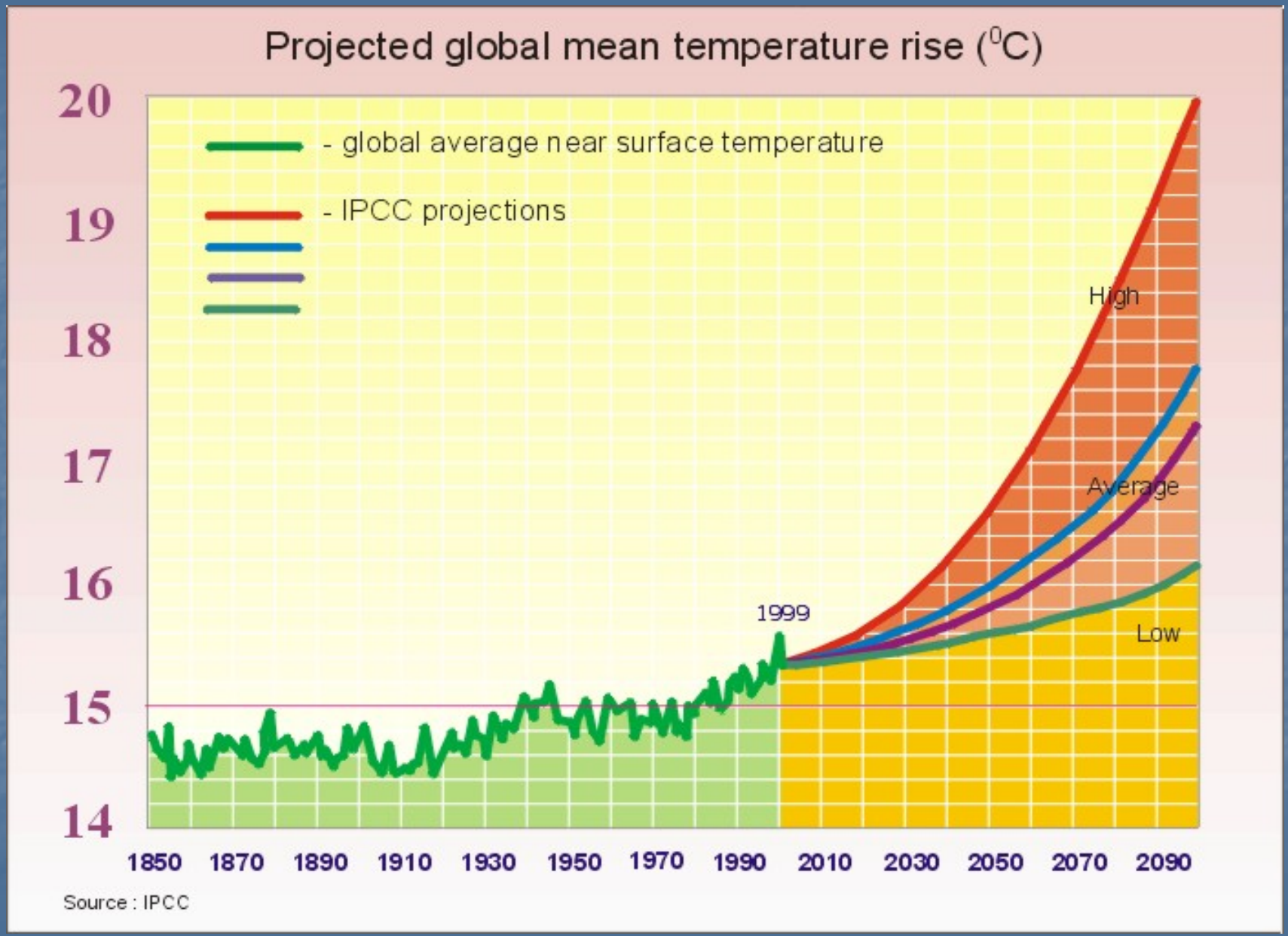


Photo: Williams and Ferrigno, 1995

Millenial temperature reconstruction (Mann, 1999) compared to the CO_2 data from Taylor and Law domes




Projected global mean temperature rise (⁰C)
20
19
18
17
16
15
14
- global average near surface temperature
- IPCC projections
High
Average
Low
1999
1850
1870
1890
1910
1930
1950
1970
1990
2010
2030
2050
2070
2090
Source : IPCC

Current and Projected Sea-level Rise……

1. The observed rate of sea level rise averaged over the 20th century is 0.10 to 0.24 m.

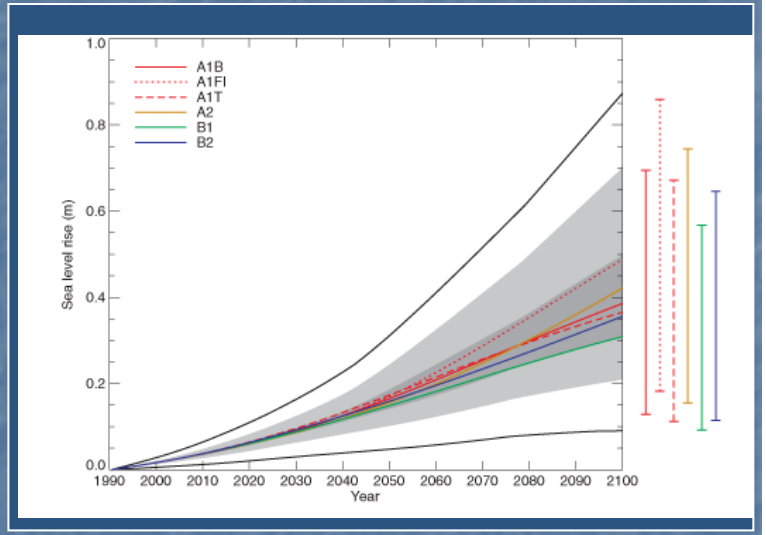
2. Rise is the result of contributions from:

   a) Thermal expansion of the oceans

   b) Meltwater from glaciers and ice caps

3. Models project a rise of 0.09 to 0.88 m with a central estimate of 0.48 m by 2100.

Note: Sea level is likely to double for NC.



IPCC sea-level rise scenarios as determined from seven global climate models (Church et al., 2001).

USGS Coastal Change Hazards Research

Goal: Provide the science and information required to predict coastal change and the vulnerability of coasts to coastal change hazards at national and regional scales so that the human and economic costs of coastal change hazards are reduced or eliminated.

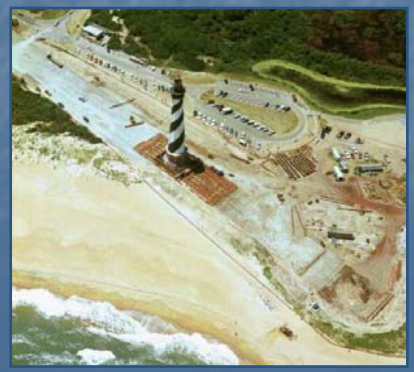
Sandy coasts

Federal lands

Infrastructure planning

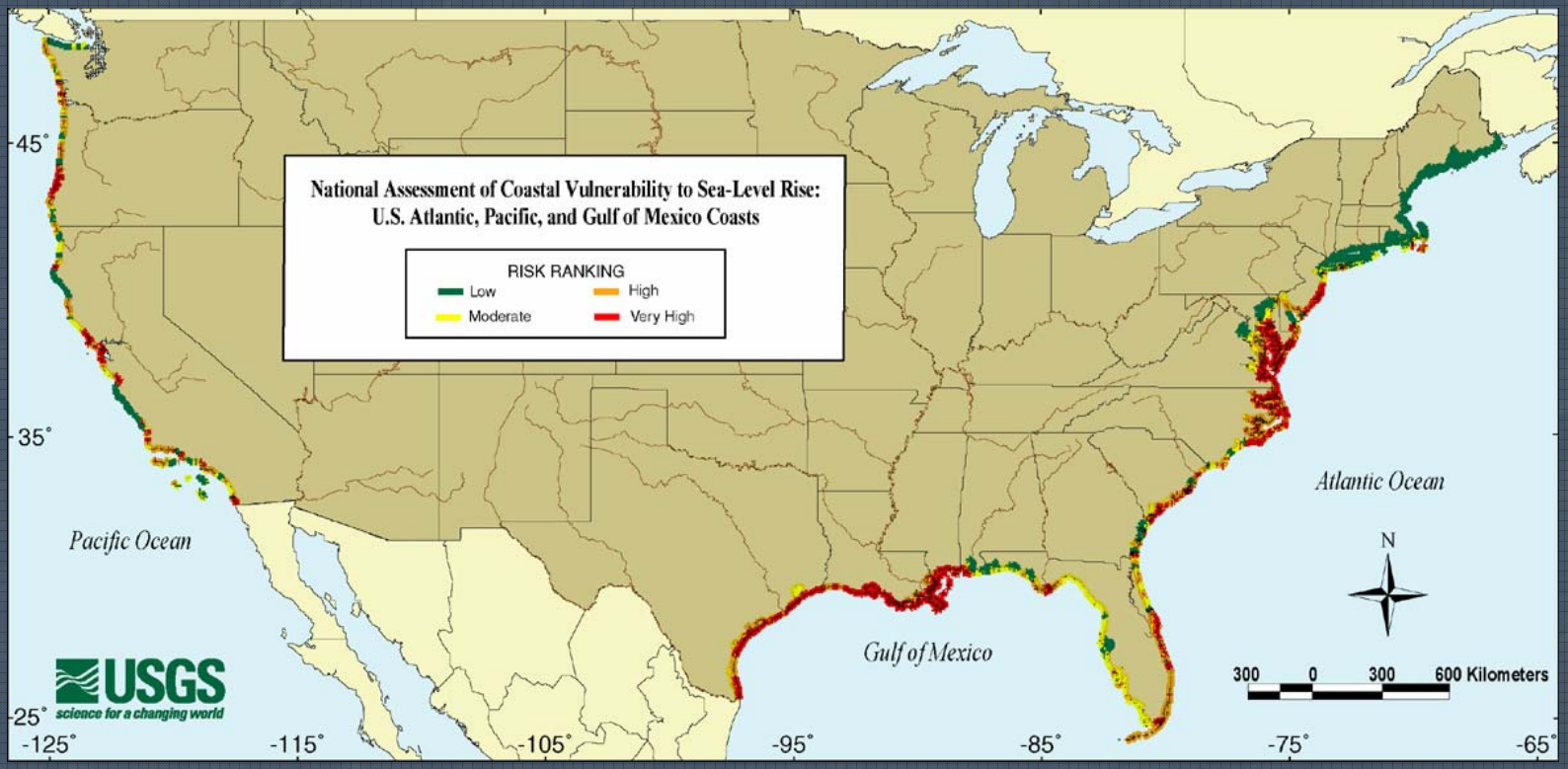
Cliff coasts

Fed, State, Local mitigation



Hazard mitigation

Coastal Vulnerability Index

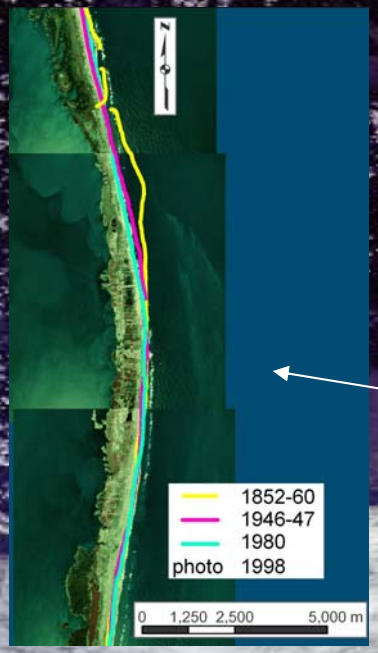


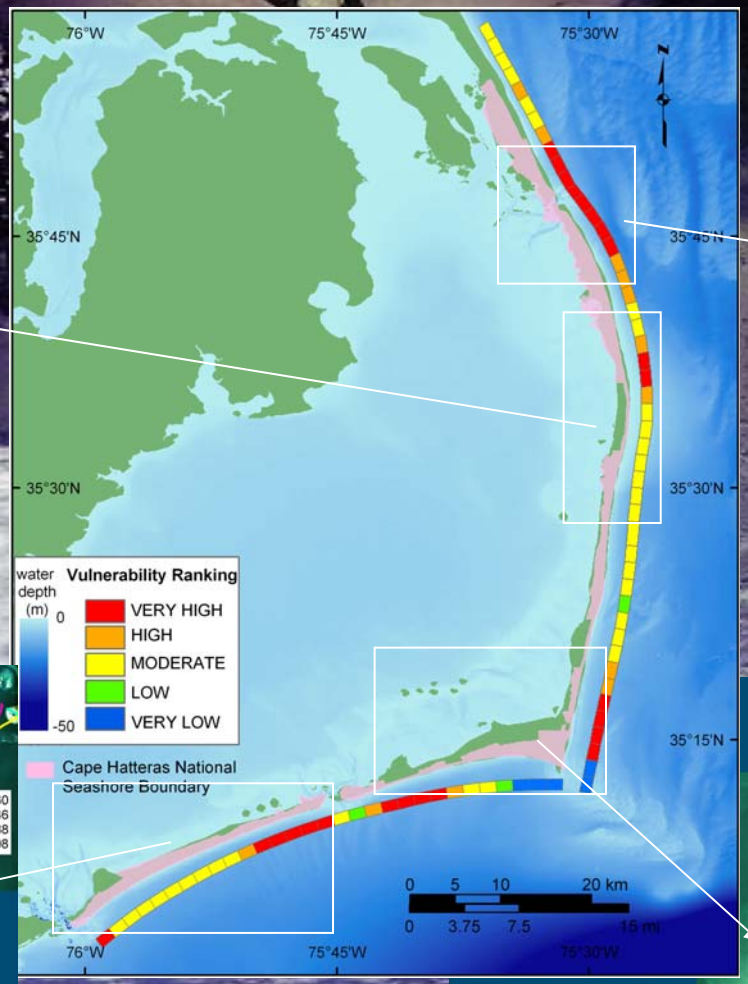
National Assessment of Coastal Vulnerability to Sea-Level Rise

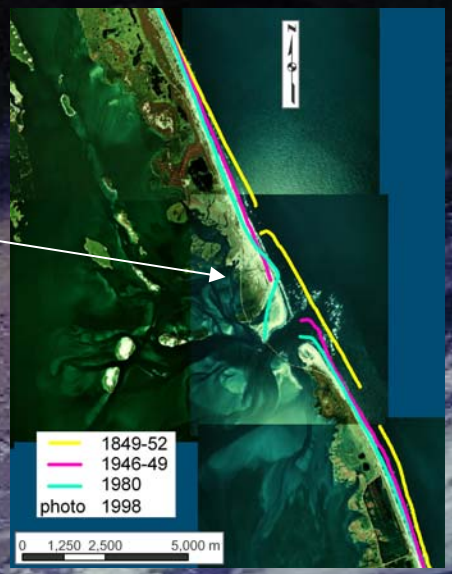
E. Robert Thieler, S. Jeffress Williams, Erika Hammar-Klose

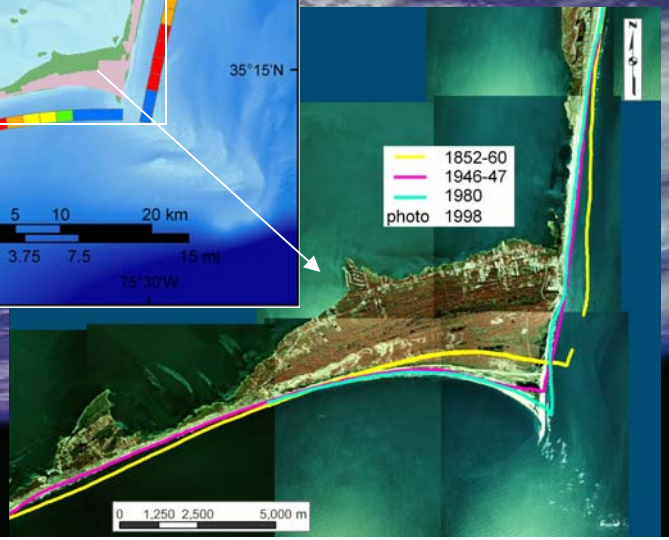
http://woodshole.er.usgs.gov/project-pages/nps-cvi/
http://pubs.er.usgs.gov/

Shoreline Change Vulnerability for Cape Hatteras National Seashore









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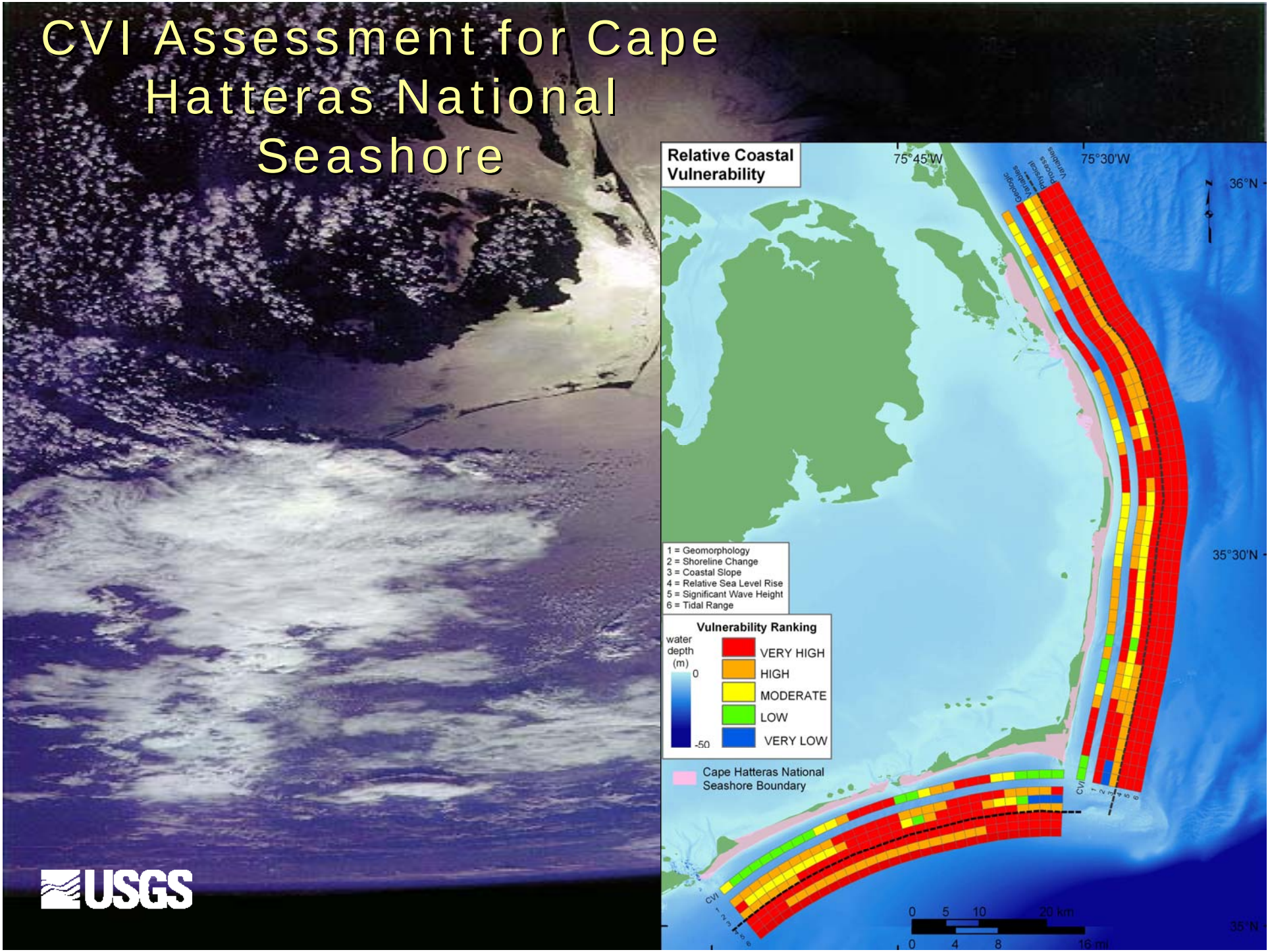
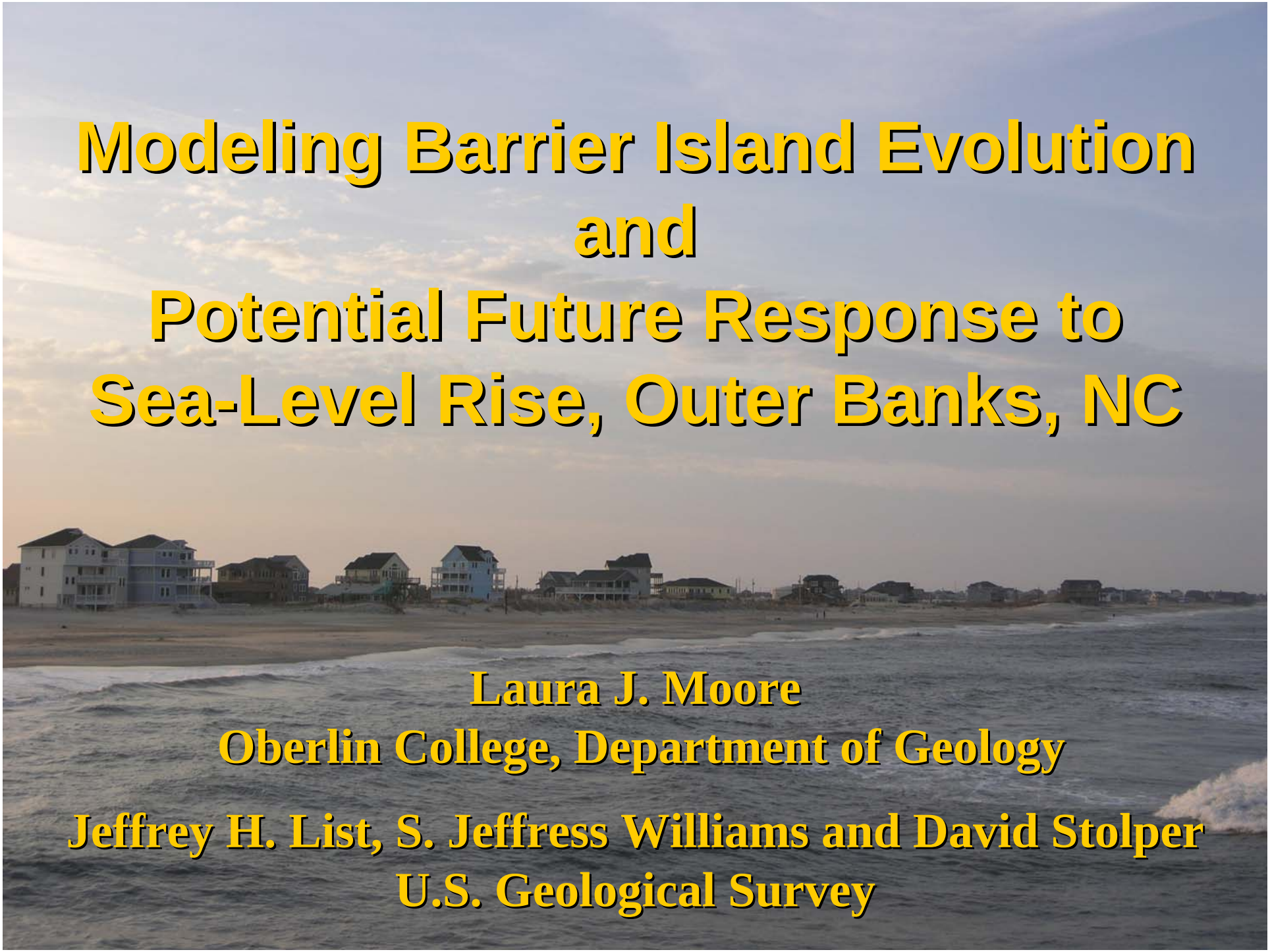
CVI Assessment for Cape Hatteras National Seashore



USGS



Modeling Barrier Island Evolution and Potential Future Response to Sea-Level Rise, Outer Banks, NC

Laura J. Moore
Oberlin College, Department of Geology

Jeffrey H. List, S. Jeffress Williams and David Stolper
U.S. Geological Survey

Summary of preliminary results

- For NC barriers, sea-level rise rate is most important in determining migration rates. Sediment supply modifies rates.

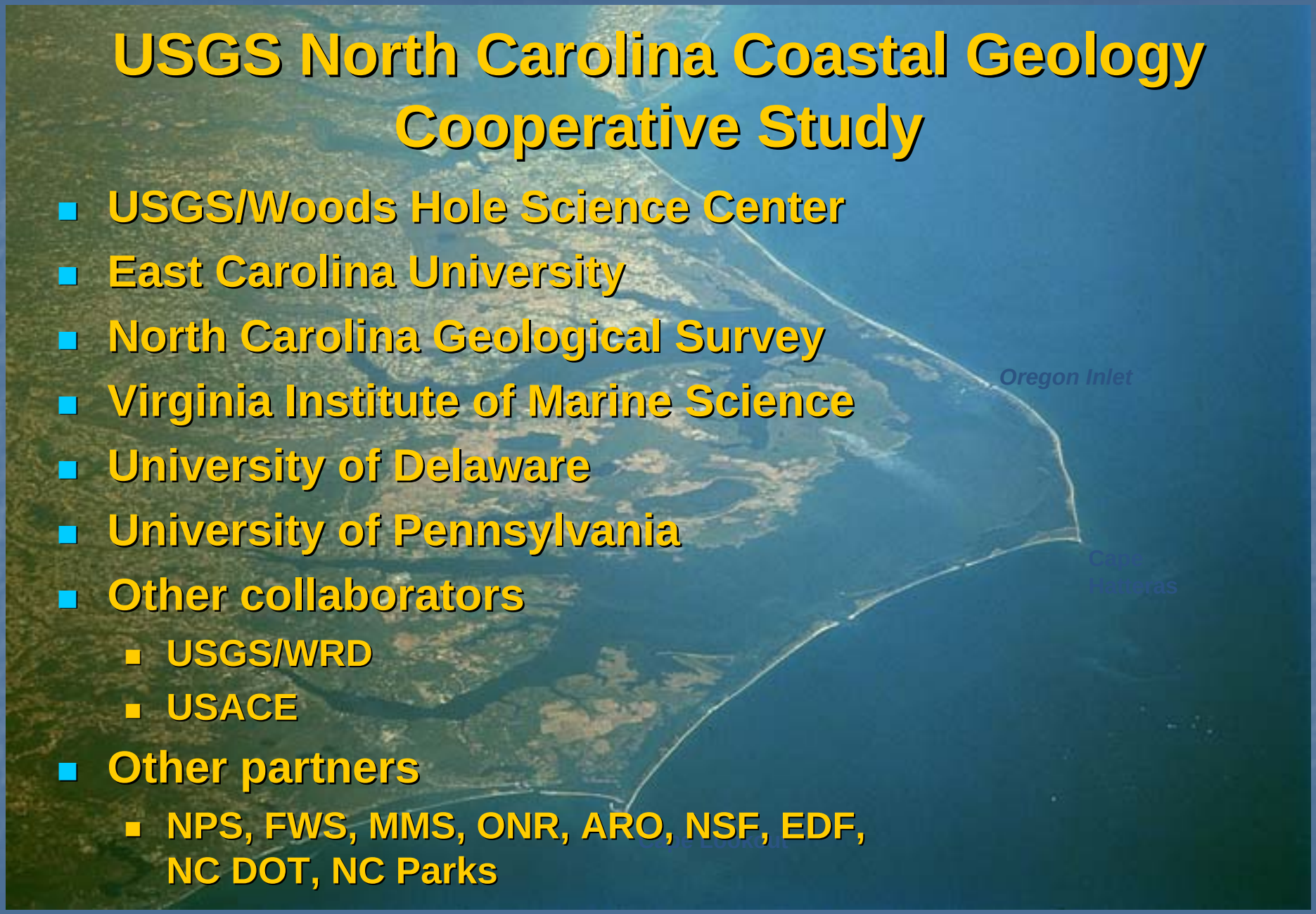
- 8500-yr Holocene model simulation with closure depth of -20 m and removal of 4.5 x 10^9 m^3 to shoals reproduces modern barrier/shelf morphology.

- If sea-level rises 0.9 m by 2100 AD, the NC barriers may migrate up to 3x more rapidly than at present.

- If sea-level rises above IPCC predictions by 2100, the Outer Banks may become vulnerable to system-wide "threshold collapse."

USGS North Carolina Coastal Geology Cooperative Study

- USGS/Woods Hole Science Center
- East Carolina University
- North Carolina Geological Survey
- Virginia Institute of Marine Science
- University of Delaware
- University of Pennsylvania
- Other collaborators
  - USGS/WRD
  - USACE
- Other partners
  - NPS, FWS, MMS, ONR, ARO, NSF, EDF, NC DOT, NC Parks

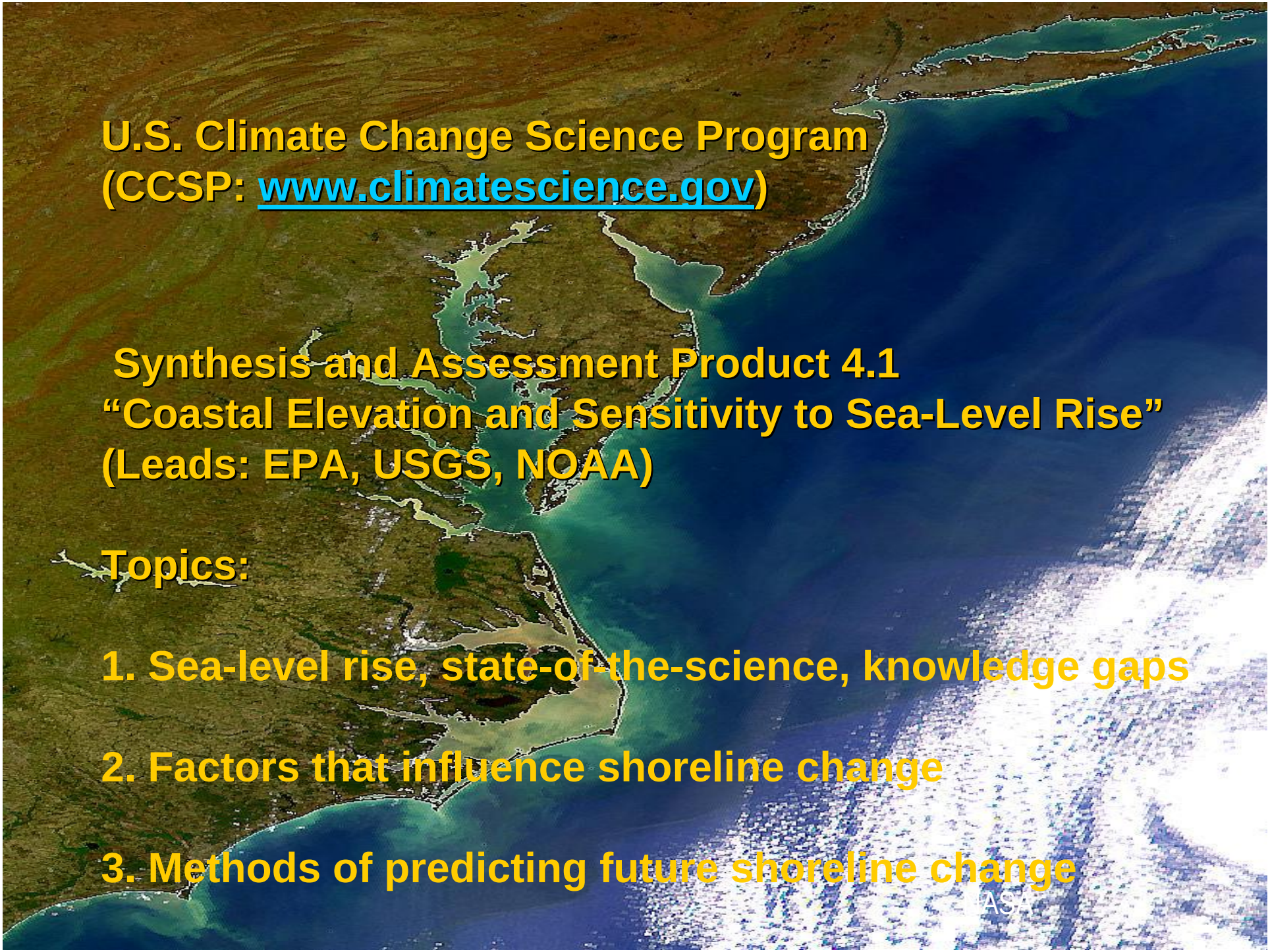


(NASA photo)

Study Objectives

- Delineate the geologic framework of northeastern North Carolina
- Take a holistic view of the coastal system -- estuaries, barrier islands, and continental shelf
- Understand the physical processes driving coastal evolution
- Predict the coastal system response to oceanographic and climatic forcing at time scales from storm events to centuries

(NASA photo)



U.S. Climate Change Science Program
(CCSP: www.climatescience.gov)

Synthesis and Assessment Product 4.1
"Coastal Elevation and Sensitivity to Sea-Level Rise"
(Leads: EPA, USGS, NOAA)

Topics:

1. Sea-level rise, state-of-the-science, knowledge gaps

2. Factors that influence shoreline change

3. Methods of predicting future shoreline change

Conclusions

- Sea-level rise is a primary driver of coastal change and is rising. Future rates of coastal erosion and inundation will increase.
- Climate change is warming the oceans, SLR is accelerating due to thermal expansion and increased melting of glaciers and ice caps. Future sea level is likely to be ~18 inches higher by 2100 . Melting on Greenland and Antarctic could further accelerate SLR.
- Warming ocean temps seem to be increasing hurricane intensity, in addition to a natural 25 yr cycle of storm activity. Links to hurricane frequency are still uncertain.
- Science should guide coastal management and policy adaptation to climate variability.

IPCC, 2001; NRC, 2002; Hansen, 2005; Alley, 2005; Church and White, 2006; Overpeck et al, 2006; Emanuel, 2006; Otto-Bliesner, 2006; Kolbert, 2006