The Relationship of Climate Change to Coastal Hazard Risk

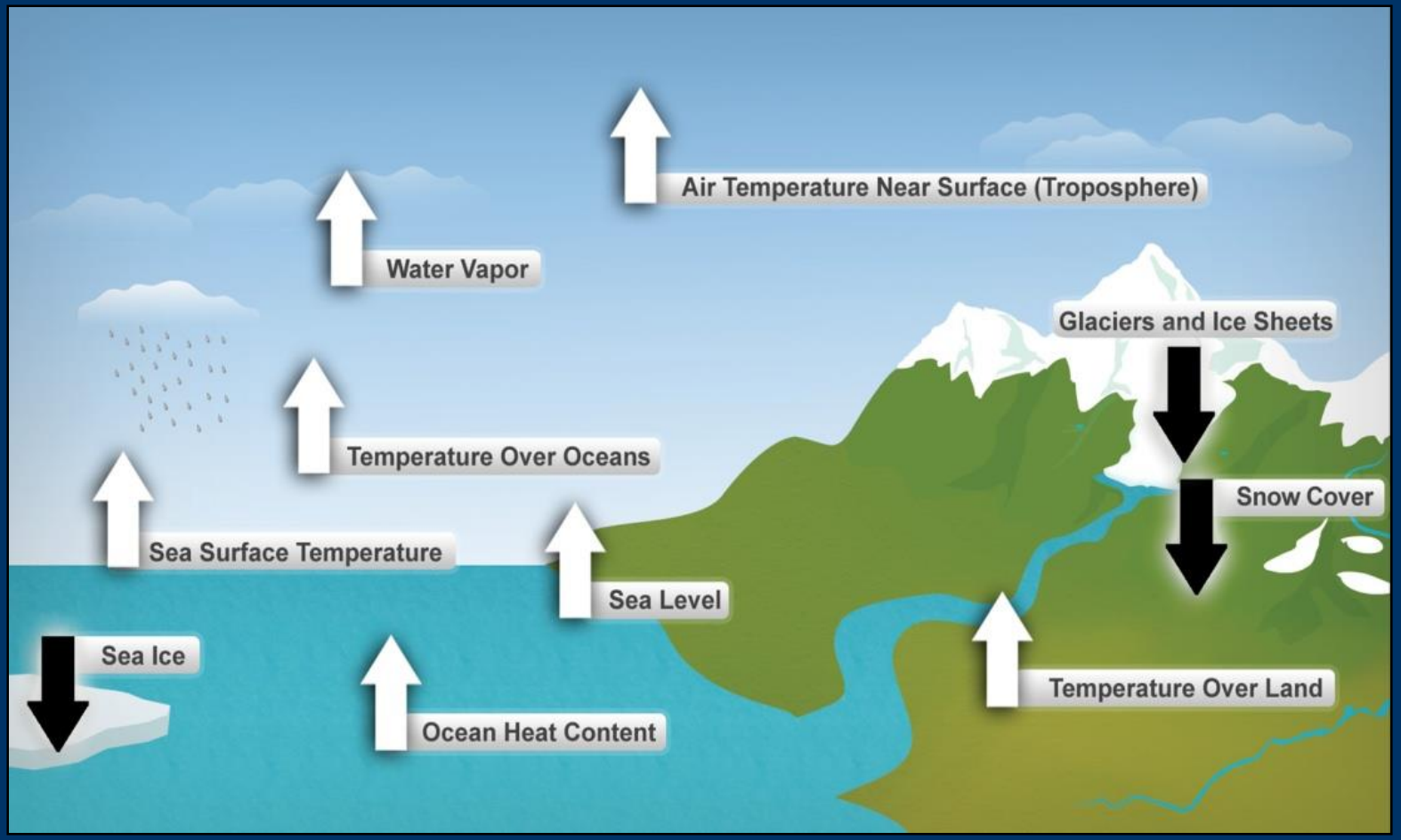
Doug Marcy
National Oceanic and Atmospheric Administration

Doug Marcy is a Coastal Hazards Specialist at the National Oceanic and Atmospheric Administration's Office for Coastal Management in Charleston, SC. He has been with NOAA for 16 years, creating more disaster resilient communities through his work on storm surge assessments, flooding and sea level rise geospatial mapping, and coastal hazard assessment projects. From 1999 to 2002, Doug worked as a Hydraulic Engineer with the U.S. Army Corps of Engineers, Charleston District. Before that, Doug worked at the South Carolina Office of Ocean and Coastal Resource Management. Doug has a Master's of Science in marine geology from the University of North Carolina at Wilmington and a Bachelor's degree in geology from the College of Charleston.

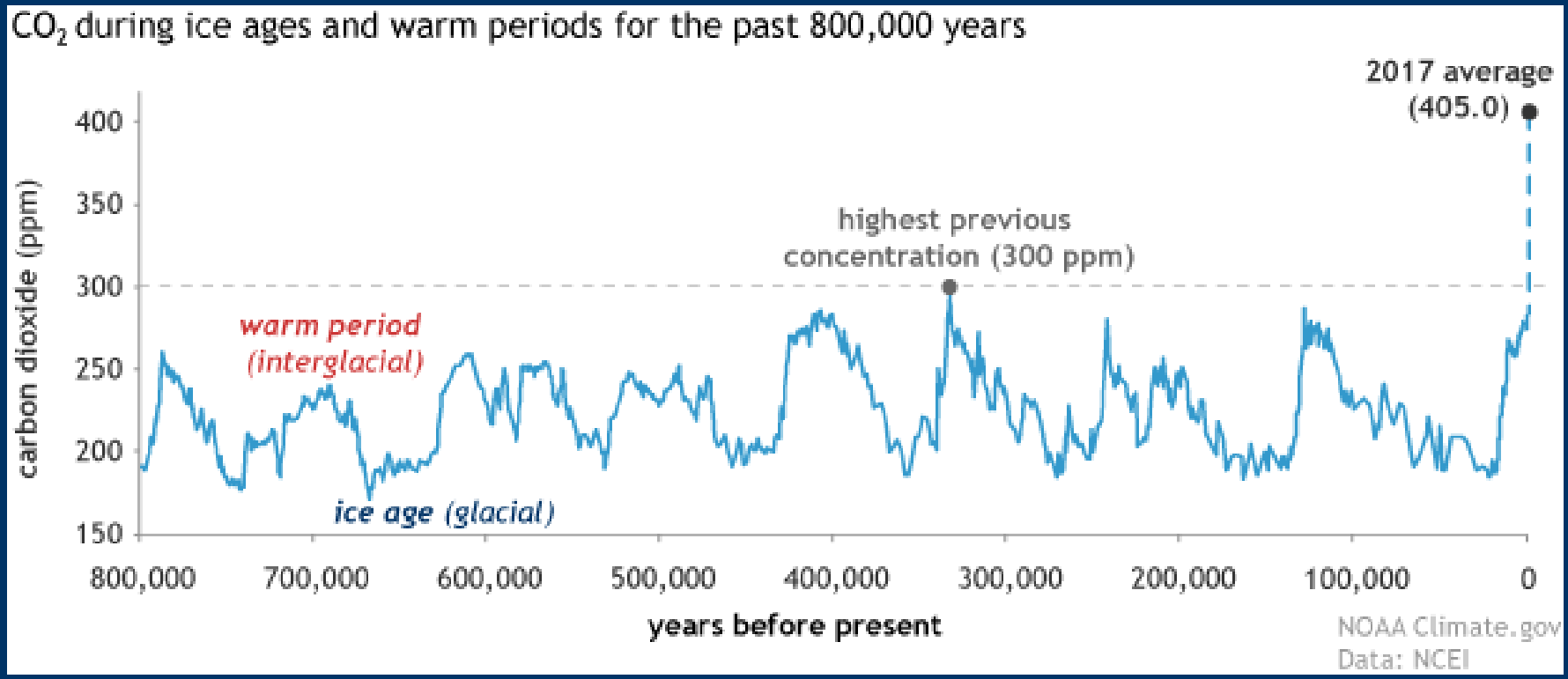
Coastal Effects of Climate Change with a Focus on Local Impacts of Sea Level Rise

Doug Marcy
NOAA Office for Coastal Management

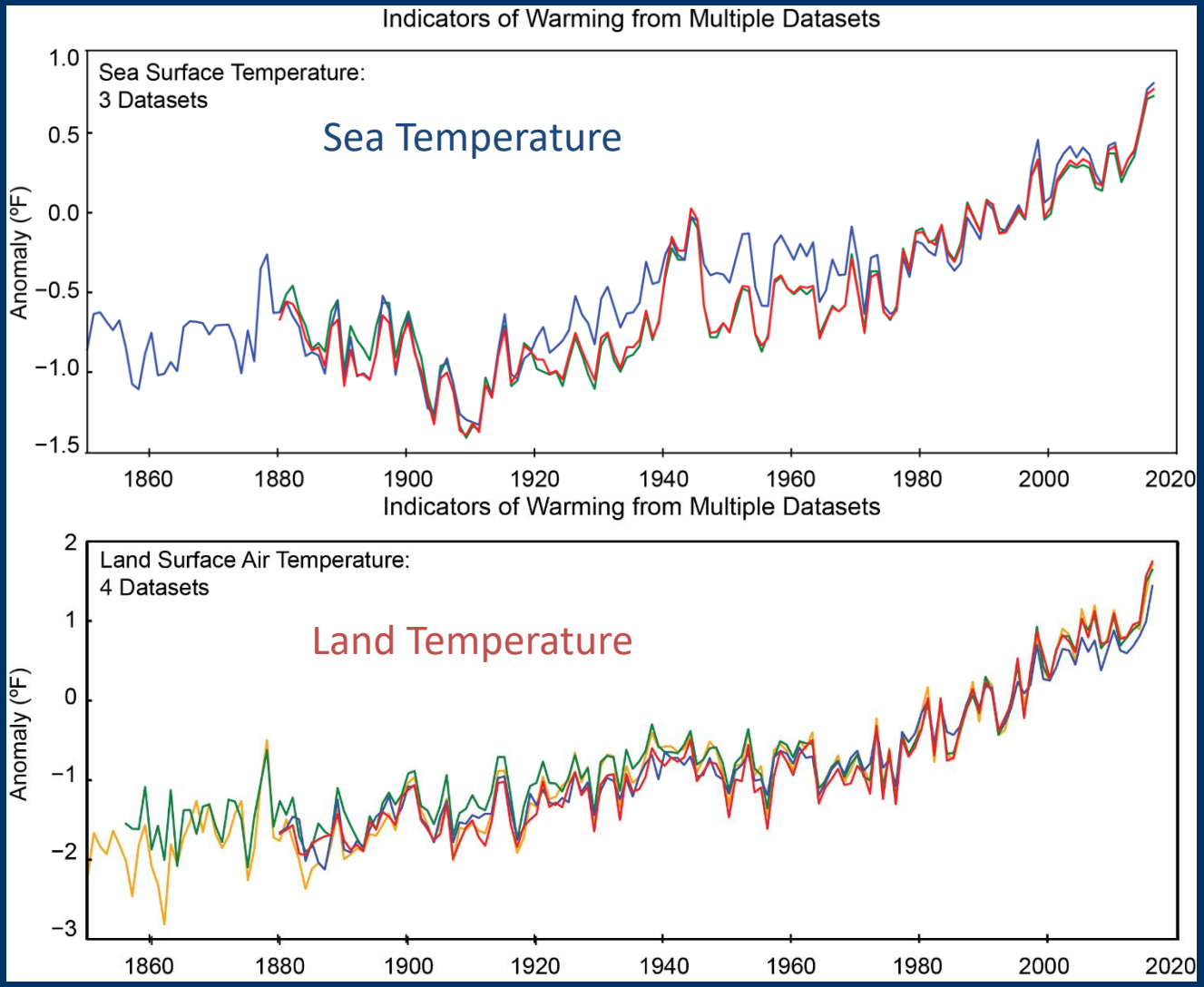
10 Indicators of a Warming World



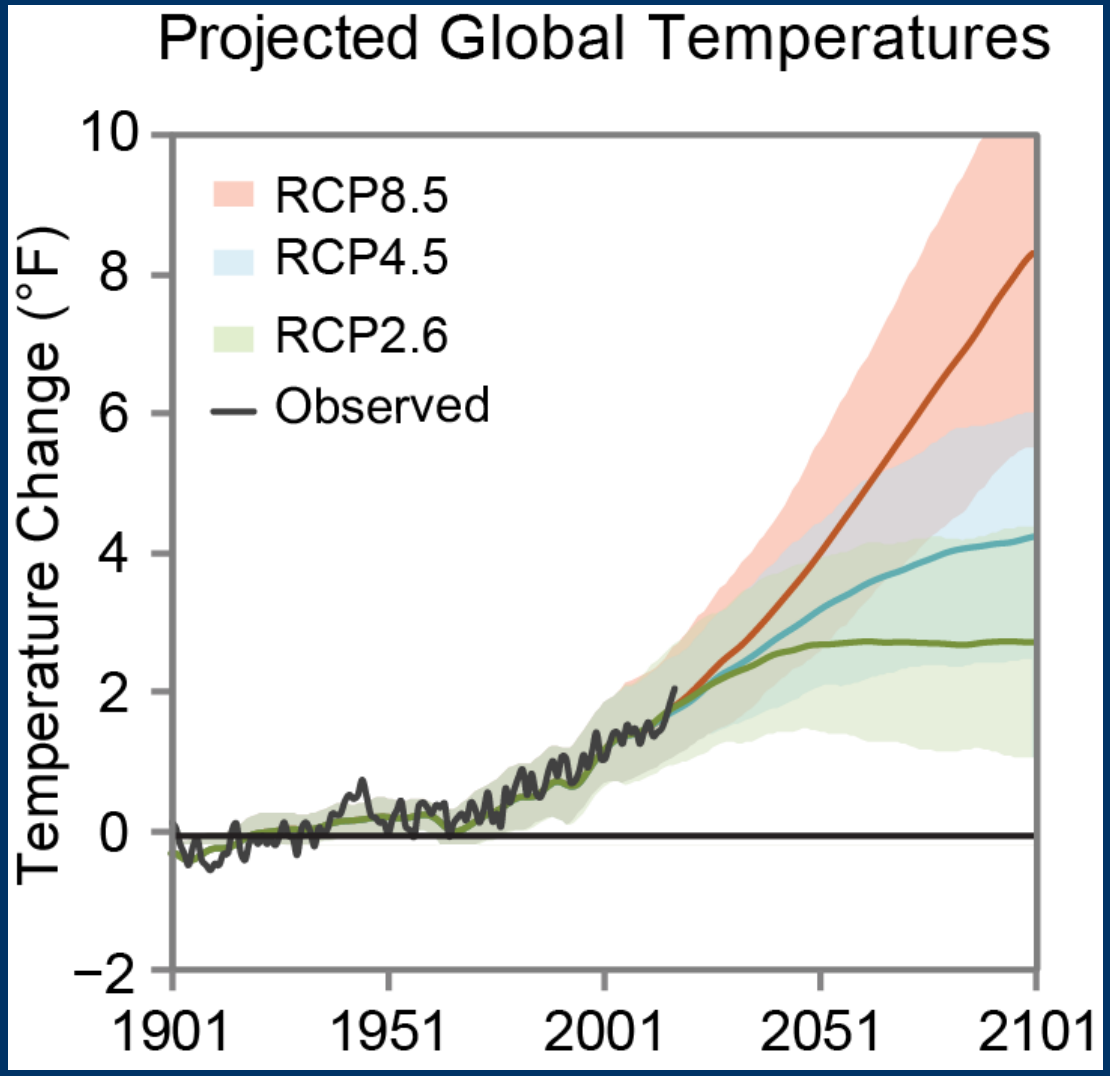
Carbon Dioxide (ppm)



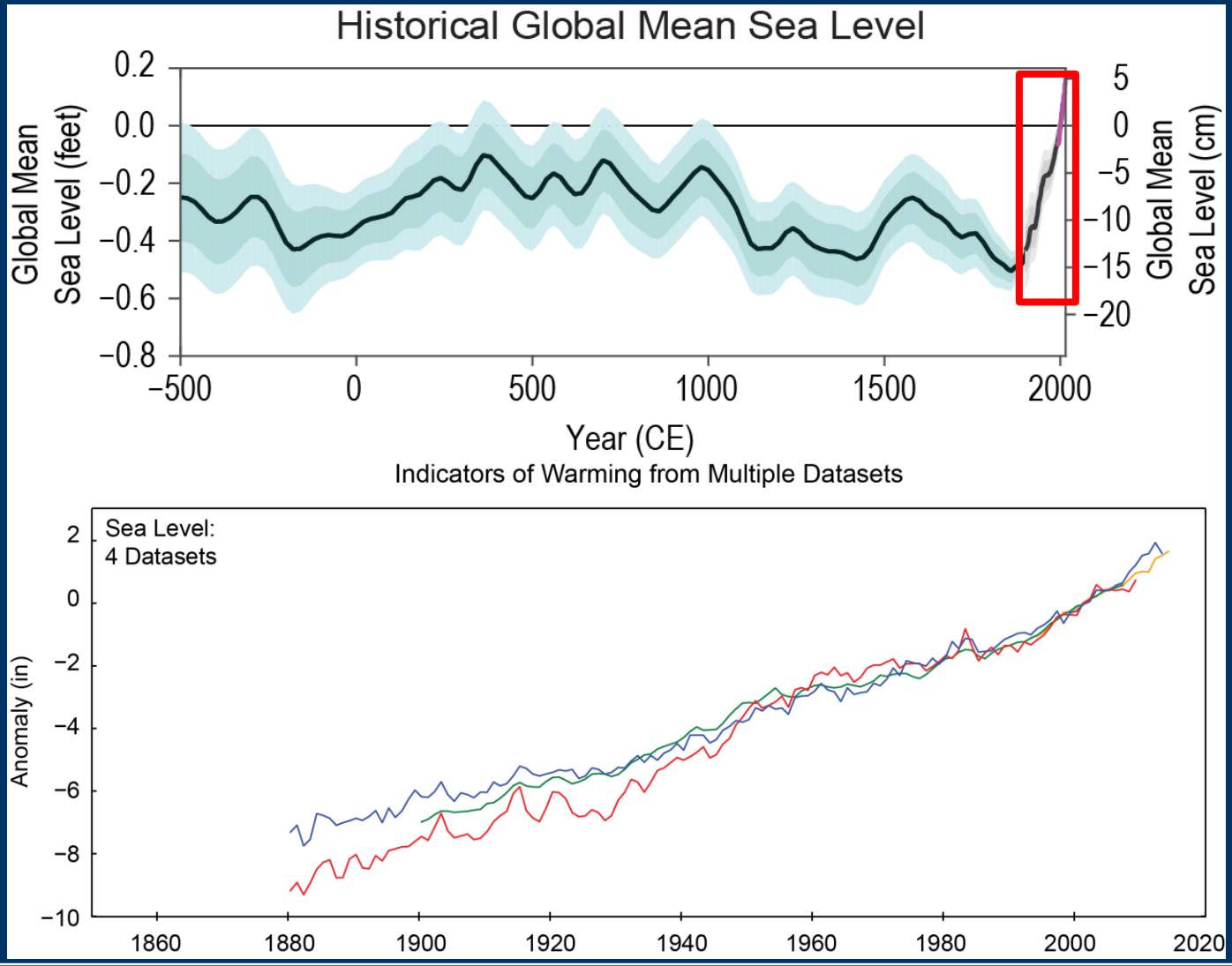
Historical Land and Sea Temperature



Future Temperature



Historical Sea Level Rise



Future Sea Level Rise

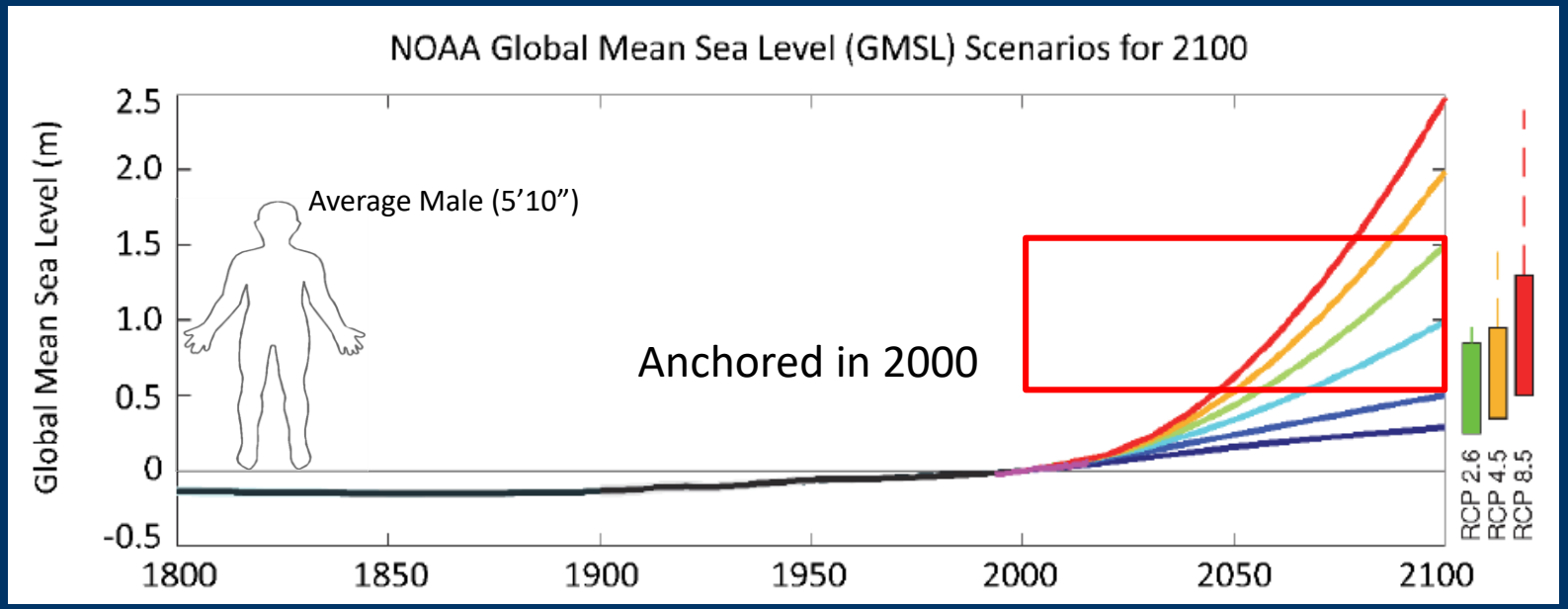


Table 4. Probability of exceeding GMSL (median value) scenarios in 2100 based upon Kopp et al. (2014).

GMSL rise Scenario	RCP2.6	RCP4.5	RCP8.5
Low (0.3 m)	94%	98%	100%
Intermediate-Low (0.5 m)	49%	73%	96%
Intermediate (1.0 m)	2%	3%	17%
Intermediate-High (1.5 m)	0.4%	0.5%	1.3%
High (2.0 m)	0.1%	0.1%	0.3%
Extreme (2.5 m)	0.05%	0.05%	0.1%

NOS Tech Report 83, (Sweet et al, 2017)

#393356

Fourth National Climate Assessment: Coastal Effects

Jeffrey Payne[1], William Sweet[2], Elizabeth Fleming[3], Michael Craghan, John Haines, Juliette Finzi Hart, Heidi Stiller, Ariana Sutton-Grier

[1] Jeff.Payne@noaa.gov, [2] William.Sweet@noaa.gov, [3] Elizabeth.C.Fleming@erdc.usace.army.mil

U.S. Global Change Research Program

Key Message 1: Coastal Economies and Property Are Already at Risk

America's trillion-dollar coastal property market and public infrastructure are threatened by the ongoing increase in the frequency, depth, and extent of tidal flooding due to sea level rise (SLR), with cascading impacts to the larger economy. Higher storm surges due to sea level rise and the increased probability of heavy precipitation events exacerbate the risk. Under a higher scenario (RCP8.5), many coastal communities will be transformed by the latter part of this century, and even under lower scenarios (RCP4.5 or RCP2.6), many individuals and communities will suffer financial impacts as chronic high tide flooding leads to higher costs and lower property values. Actions to plan for, and adapt to, more frequent, widespread, and severe coastal flooding would decrease direct losses and cascading economic impacts.

Figure 1. Flooding Impacts. Miami Beach raised the seawall and pumped out tidewater during a king tide (2016). Source: New York Times.

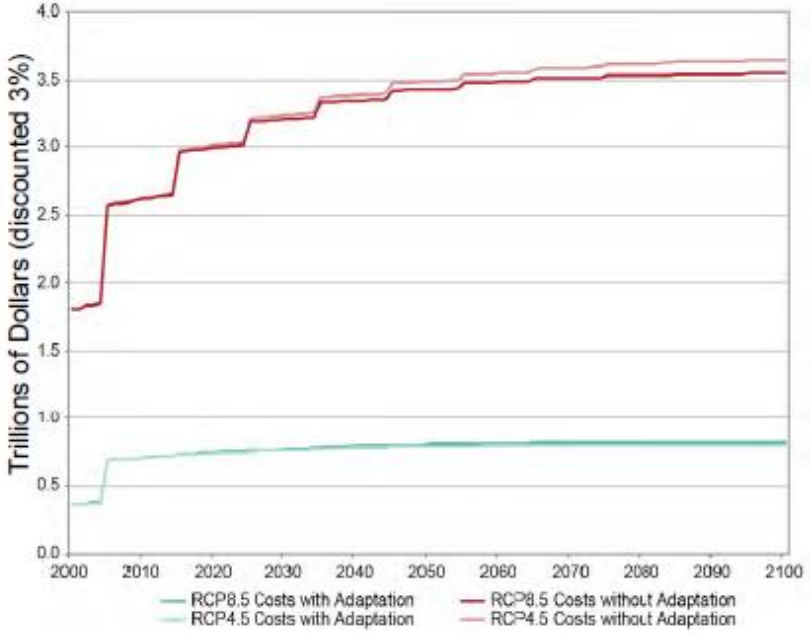


Figure 2. Cumulative Costs of Sea Level Rise to Coastal Property. Significant savings may occur if cost-effective adaptation measures are implemented. Source: US EPA CIRA.

#393356

Fourth National Climate Assessment: Coastal Effects

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U.S. Global Change Research Program

Key Message 2: Coastal Environments Are Already at Risk

Fisheries, tourism, human health, and public safety depend on healthy coastal ecosystems that are being transformed, degraded, or lost due in part to climate change impacts, particularly sea level rise and higher numbers of extreme weather events. Restoring and conserving coastal ecosystems and adopting natural and nature-based infrastructure solutions can enhance community and ecosystem resilience to climate change; help to ensure their continued health and vitality; and decrease both direct and indirect impacts of climate change.

Figure 3. Examples of Natural and Nature-Based Infrastructure Habitats. These habitats provide risk reduction by causing waves to slow, thus decreasing wave height, energy, and impact. Sources: NOAA, USGS, NSF.

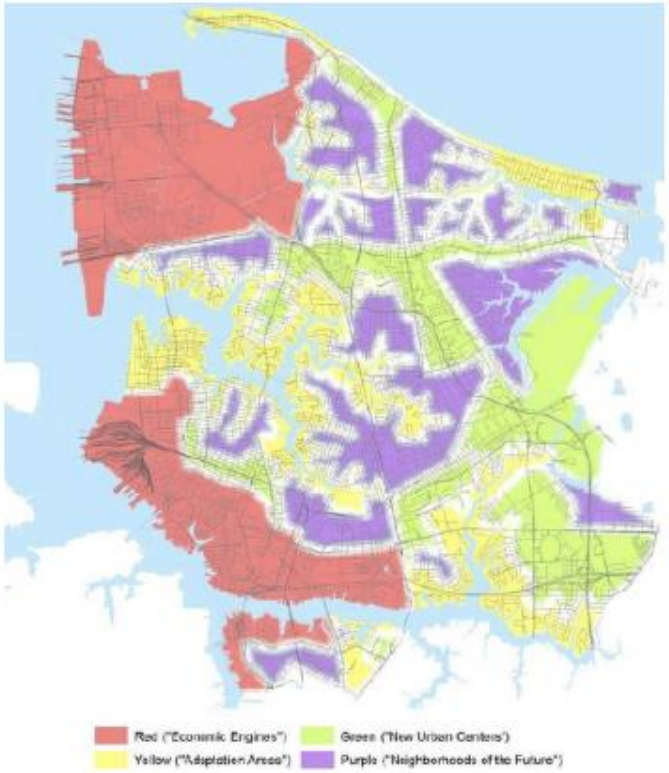

Figure 4. SLR Threatens National Security at the Norfolk, VA Naval Base. Norfolk is investing in traditional and NNBI strategies to mitigate SLR; the navy is studying effects of SLR on national security. Source: City of Norfolk.

#393356

Fourth National Climate Assessment: Coastal Effects

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U.S. Global Change Research Program

Key Message 3: Social Challenges Intensified

As the pace and extent of coastal flooding and erosion accelerate, climate change impacts along our coasts are exacerbating preexisting social inequities, as communities face difficult questions about determining who will pay for current impacts and future adaptation and mitigation strategies and if, how, or when to relocate. In response to actual or projected climate change losses and damages, coastal communities will be among the first in the nation to test existing climate-relevant legal frameworks and policies against these impacts and, thus, will establish precedents that will affect both coastal and non-coastal regions.

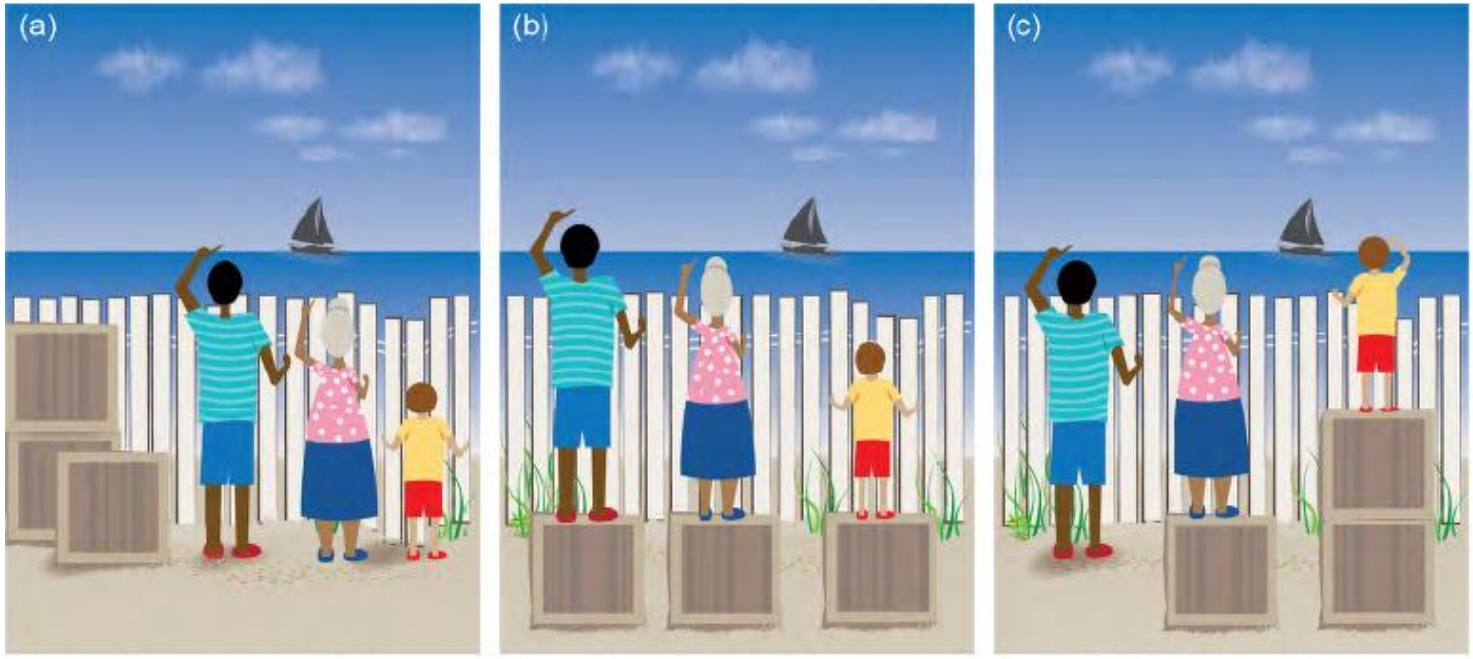


Figure 5. Resource Allocation Options. Society has limited resources to help individuals and communities adapt to climate change. Key: (a) Finite resources available. (b) Equal allocation of resources. (c) Equitable distribution of resources. Source: Adapted from Craig Froehle.

U.S. Global Change Research Program

Fourth National Climate Assessment, Vol II — Impacts, Risks, and Adaptation in the United States

Chapter 19 | Southeast

Key messages address:

- Urban Infrastructure and Health Risks
- Increasing Flood Risks in Coastal and Low-Lying Regions
- Natural Ecosystems Will Be Transformed
- Economic and Health Risks for Rural Communities

Federal Coordinating Lead Author: Adam Terando

Chapter Lead: Lynne Carter, Louisiana State University

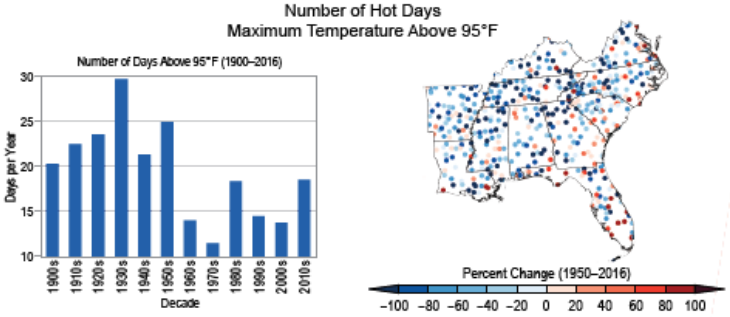
Chapter Authors: Kirstin Dow, Kevin Hiers, Kenneth E. Kunkel, Aranzazu Lascurain, Doug Marcy, Michael Osland, Paul Schramm

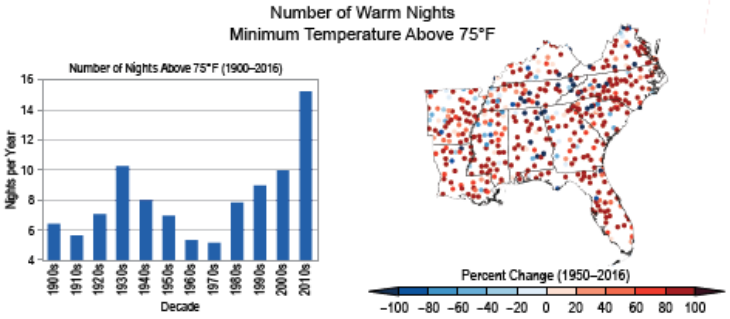
Review Editor: Alessandra Jerolleman, Jacksonville State University

Key Message 1

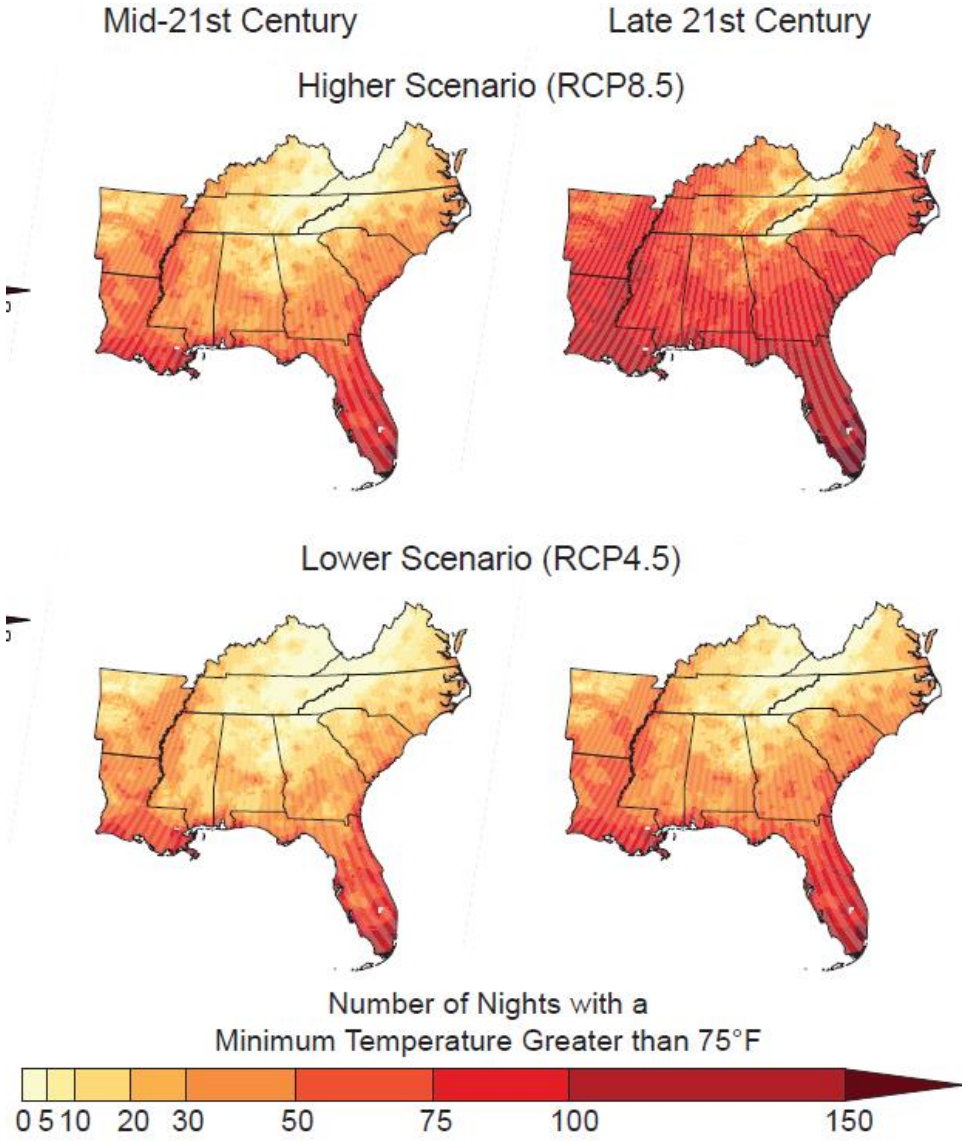
Urban Infrastructure and Health Risks

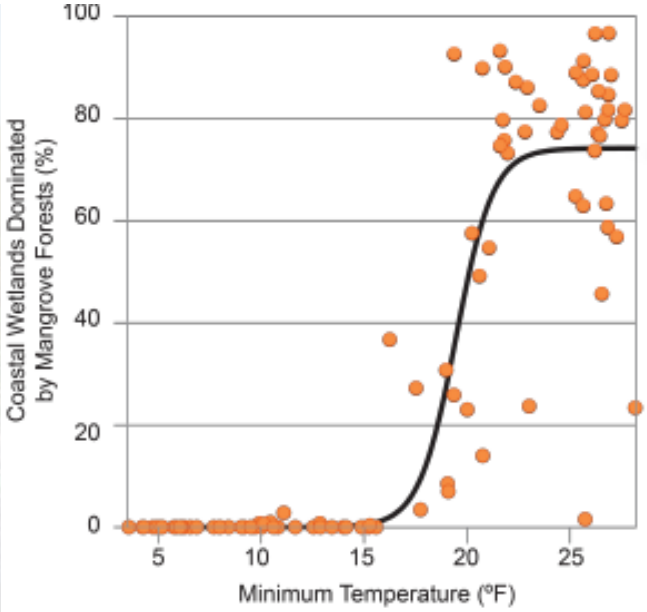
Many southeastern cities are particularly vulnerable to climate change compared to cities in other regions, with expected impacts to infrastructure and human health. The vibrancy and viability of these metropolitan areas, including the people and critical regional resources located in them, are increasingly at risk due to heat, flooding, and vector-borne disease brought about by a changing climate. Many of these urban areas are rapidly growing and offer opportunities to adopt effective adaptation efforts to prevent future negative impacts of climate change.





Hotter Nights for Growing Cities





Salt Marshes Transitions to Mangroves

In Louisiana and parts of northern Florida, coastal wetlands (top left) are expected to look and function more like the mangrove-dominated systems (bottom left) currently present in South Florida and the Caribbean. Mangrove forests are sensitive to freezing temperatures (right) but with warmer winter temperatures these are expected to expand northward at the expense of salt marshes. This shift has implications for wildlife dependent on these two habitats, but also could societal benefits in the form of coastal protection against wind and waves. Figure adapted from Osland et al. 2013.

Key Message 3

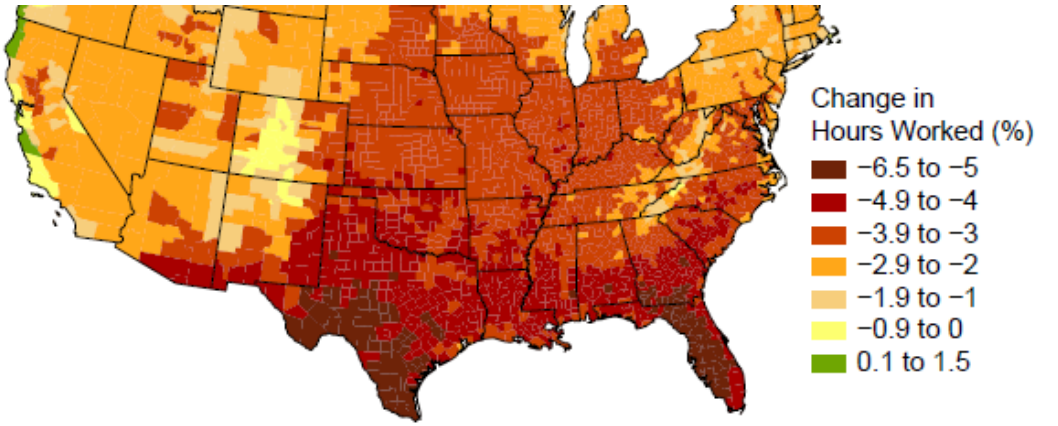
Natural Ecosystems Will be Transformed

The Southeast's diverse natural systems, which provide many benefits to society, will be transformed by climate change. Changing winter temperature extremes, wildfire patterns, sea levels, hurricanes, floods, droughts, and warming ocean temperatures are expected to redistribute species and greatly modify ecosystems. As a result, the ecological resources that people depend on for livelihood, protection, and well-being are increasingly at risk, and future generations can expect to experience and interact with natural systems that are much different than those that we see today.

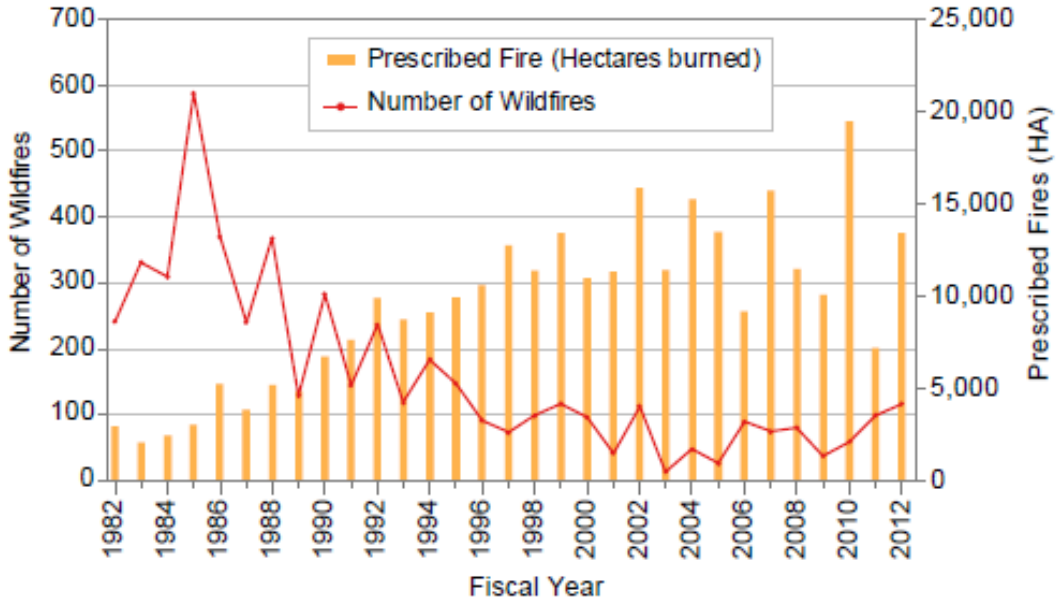
Key Message 4

Economic and Health Risks for Rural Communities

Rural communities are integral to the Southeast's cultural heritage and to the strong agricultural and forest products industries across the region. More frequent extreme heat episodes and changing seasonal climates are projected to increase exposure-linked health impacts and economic vulnerabilities in the agricultural, timber, and manufacturing sectors. By the end of the century, over one-half billion labor hours could be lost from extreme heat-related impacts. Such changes would negatively impact the region's labor-intensive agricultural industry and compound existing social stresses in rural areas related to limited local community capabilities and associated with rural demography, occupations, earnings, literacy, and poverty incidence. Reduction of existing stresses can increase resilience.



Heat-related Health Threats to Outdoor Rural Workers Estimated percent change in hours worked in 2090 under a higher scenario (RCP8.5). Projections indicate an annual average of 570 million labor hours lost per ye in the Southeast by 2090 (with models ranging from 340 million to 820 million labor hours). Estimates represent a change in hours worked as compared to a 2003–2007 average baseline for high-risk industries only. These industries are defined as agriculture, forestry, and fishing; hunting, mining, and construction; manufacturing, transportation, a utilities. Source: adapted from EPA 2017.

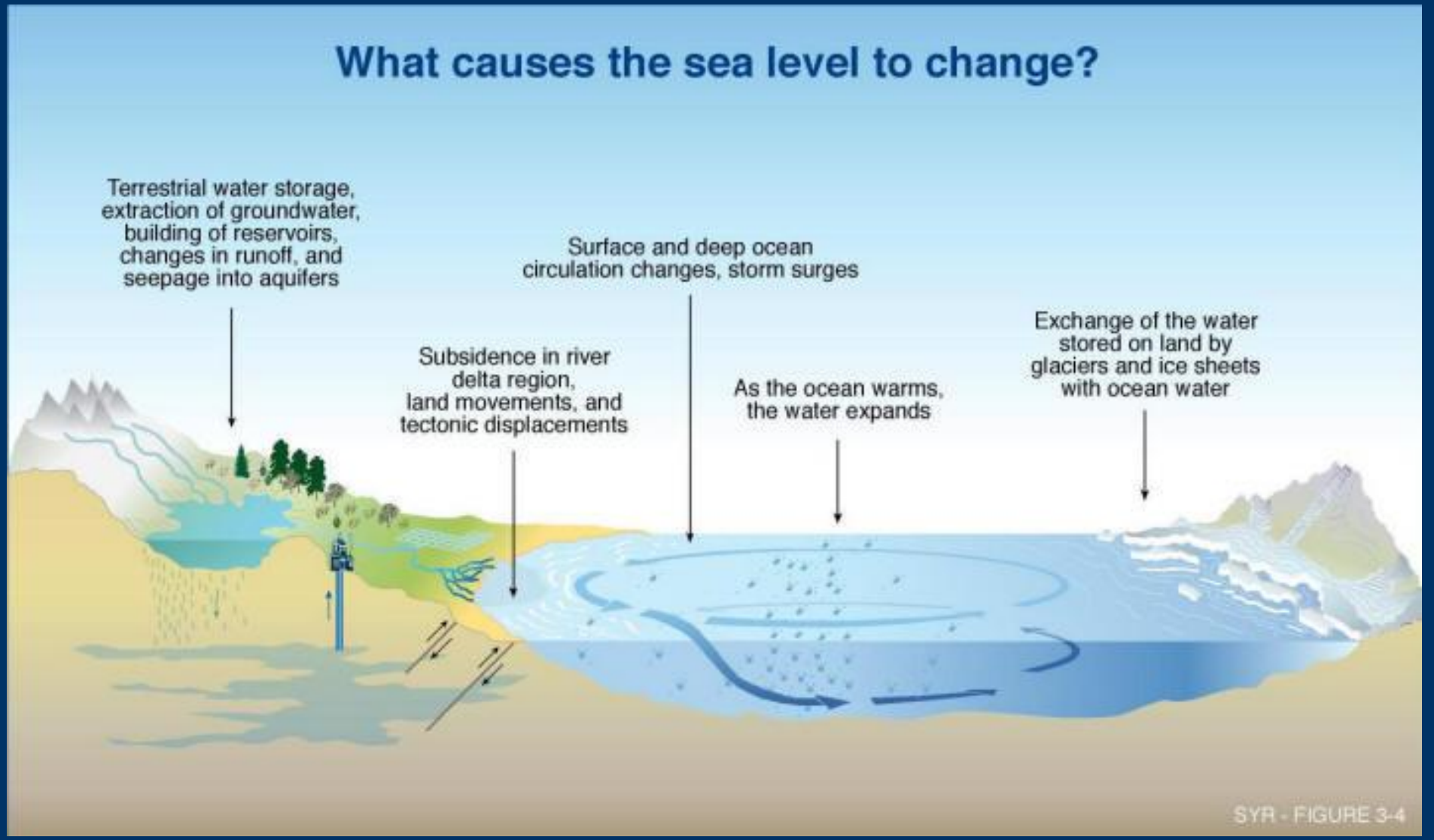


19 Key Message #2

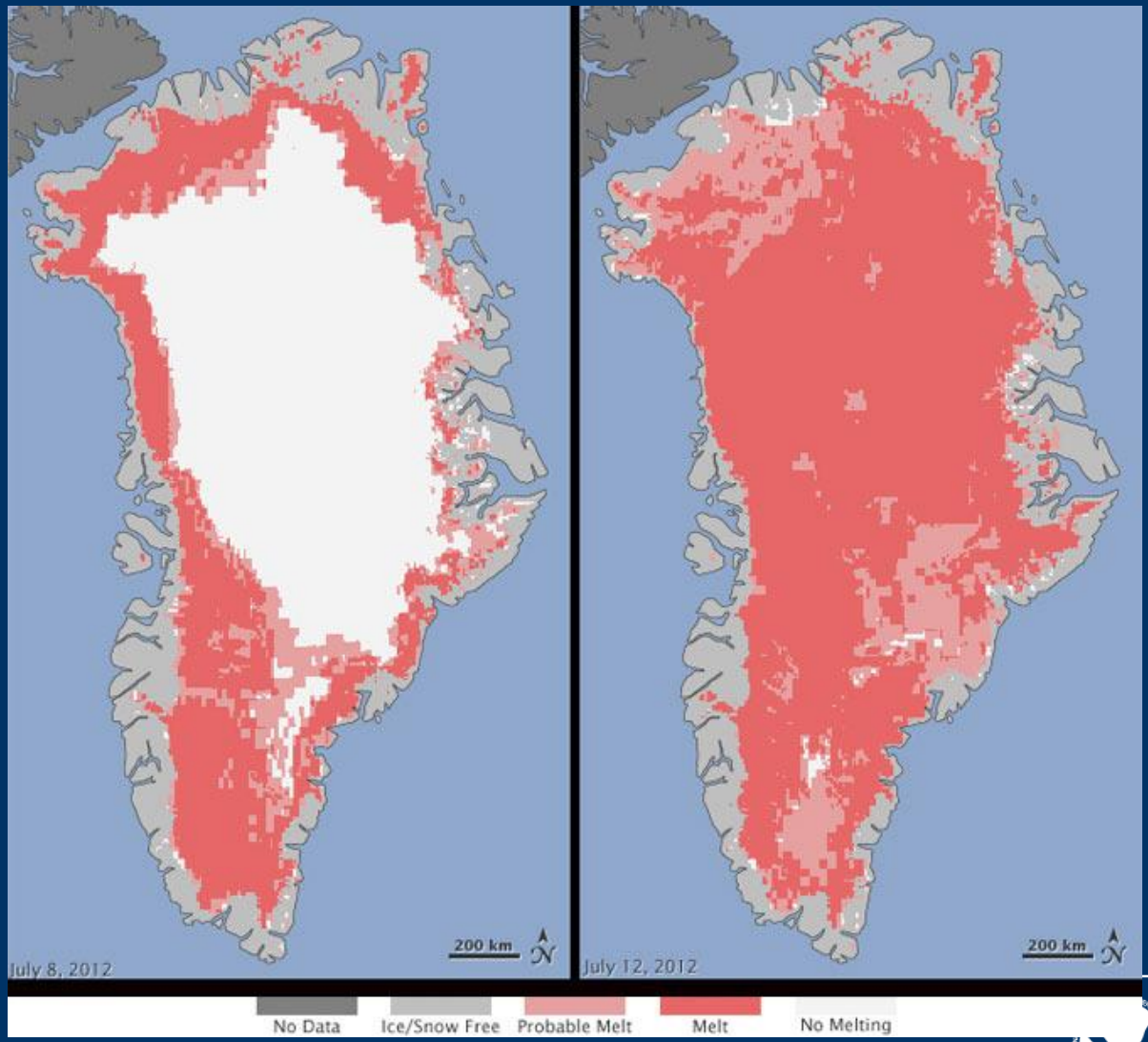
Increasing Flood Risks in Coastal and Low-Lying Regions

The Southeast's coastal plain and inland low-lying regions support a rapidly growing population, a tourism economy, critical industries, and important cultural resources that are highly vulnerable to climate change impacts. The combined effects of changing extreme rainfall events and sea level rise are already increasing flood frequencies, which impacts property values and infrastructure viability, particularly in coastal cities. Without significant adaptation measures, these regions are projected to experience daily high tide flooding by the end of the century.

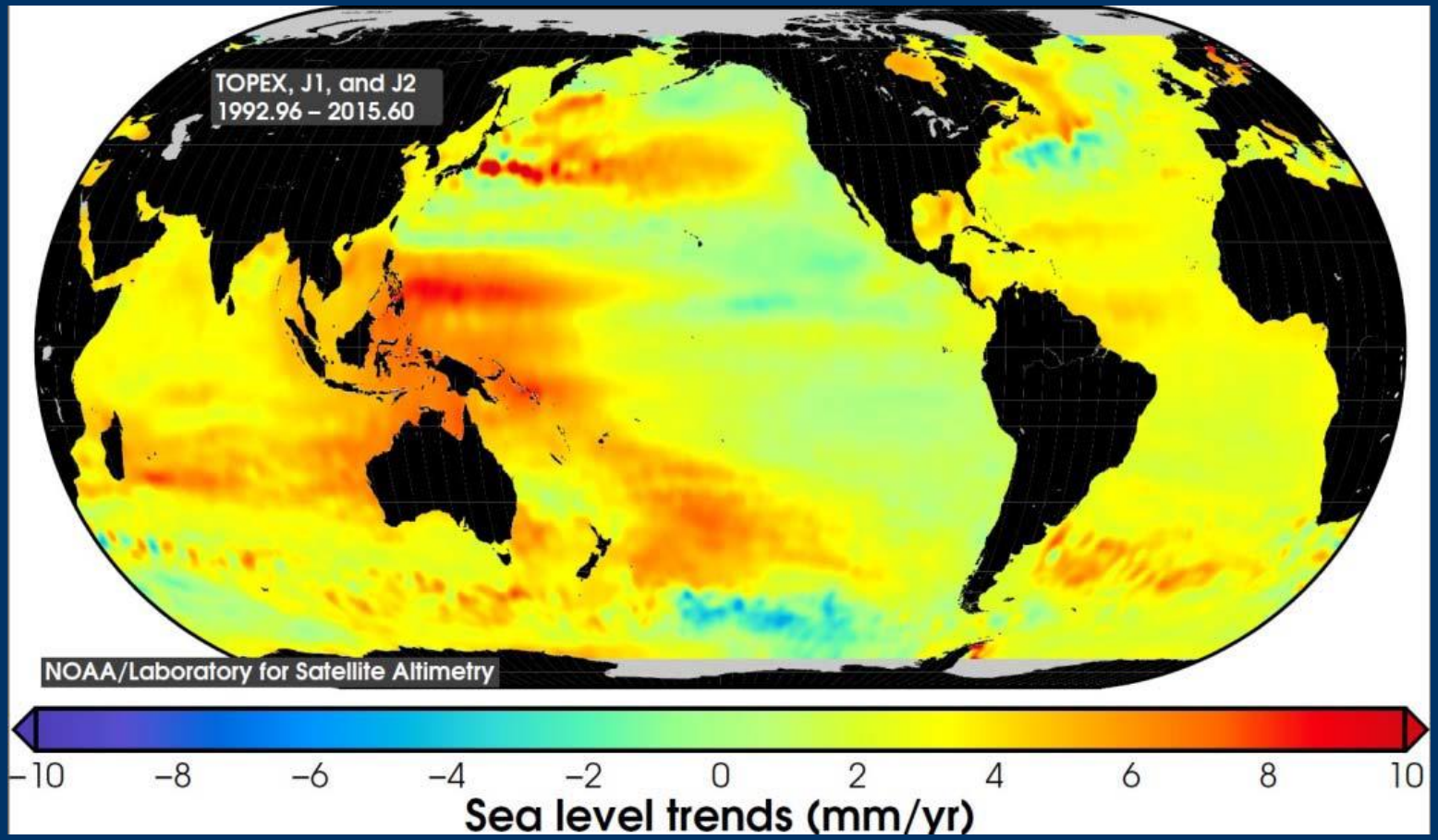
Sea Level Change



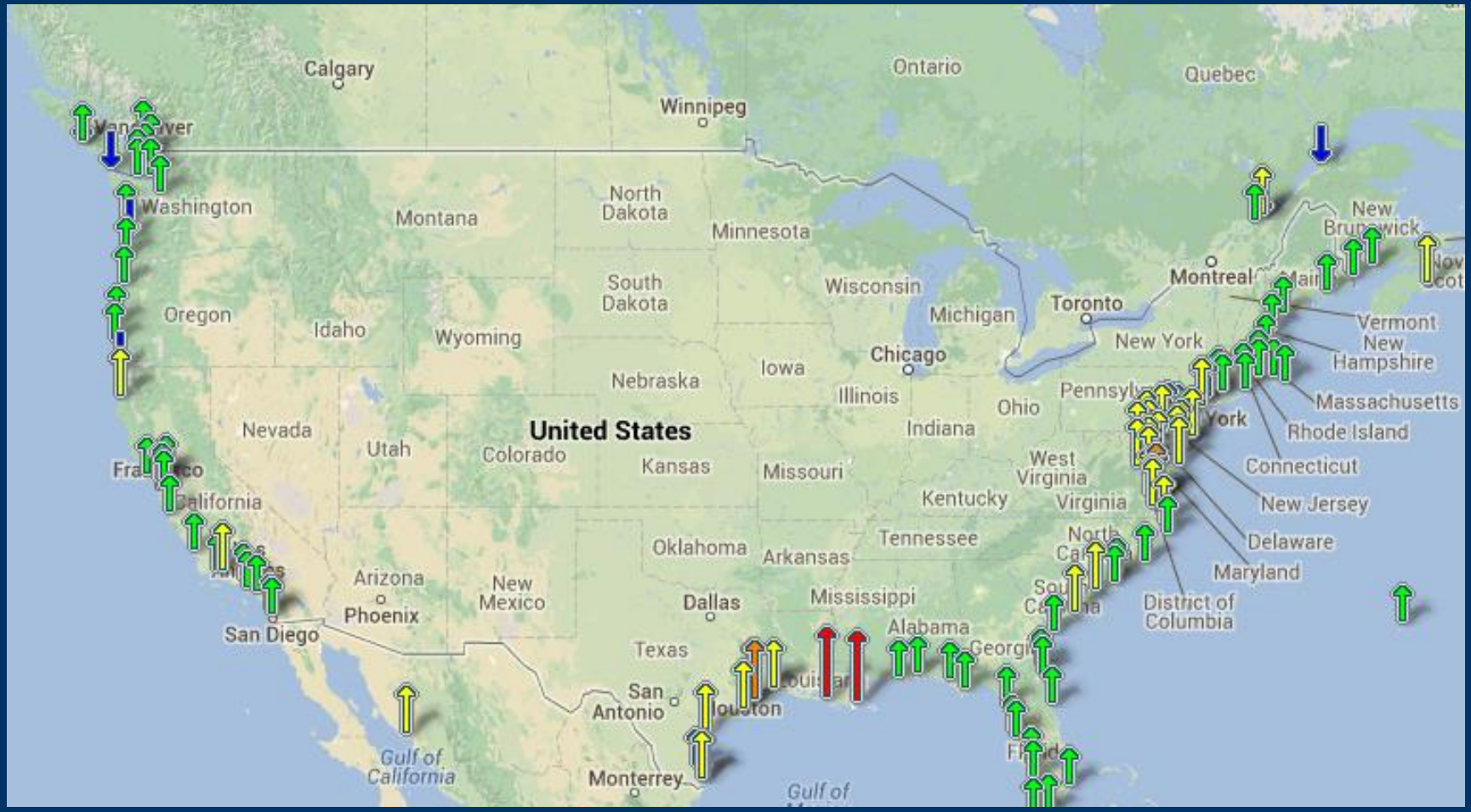
Greatest source of uncertainty?



Sea Level is Not Rising at the Same Rate Everywhere



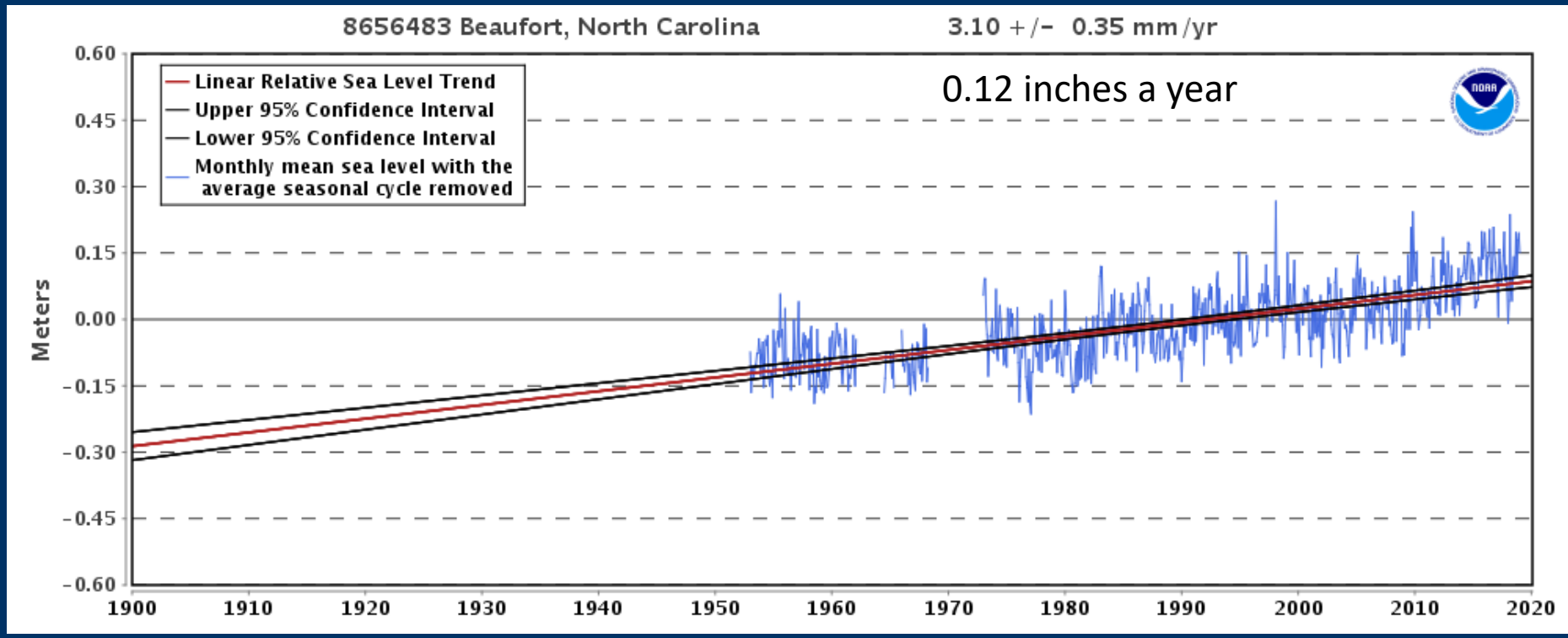
Land Motion Plays a Big Part Too



Sea Level Trends
mm/yr (feet/century)

15 to 21 (5 to 7)	6 to 9 (2 to 3)	-3 to 0 (-1 to 0)	-12 to -9 (-4 to -3)
12 to 15 (4 to 5)	3 to 6 (1 to 2)	-6 to -3 (-2 to -1)	-15 to -12 (-5 to -4)
9 to 12 (3 to 4)	0 to 3 (0 to 1)	-9 to -6 (-3 to -2)	-18 to -15 (-6 to -5)

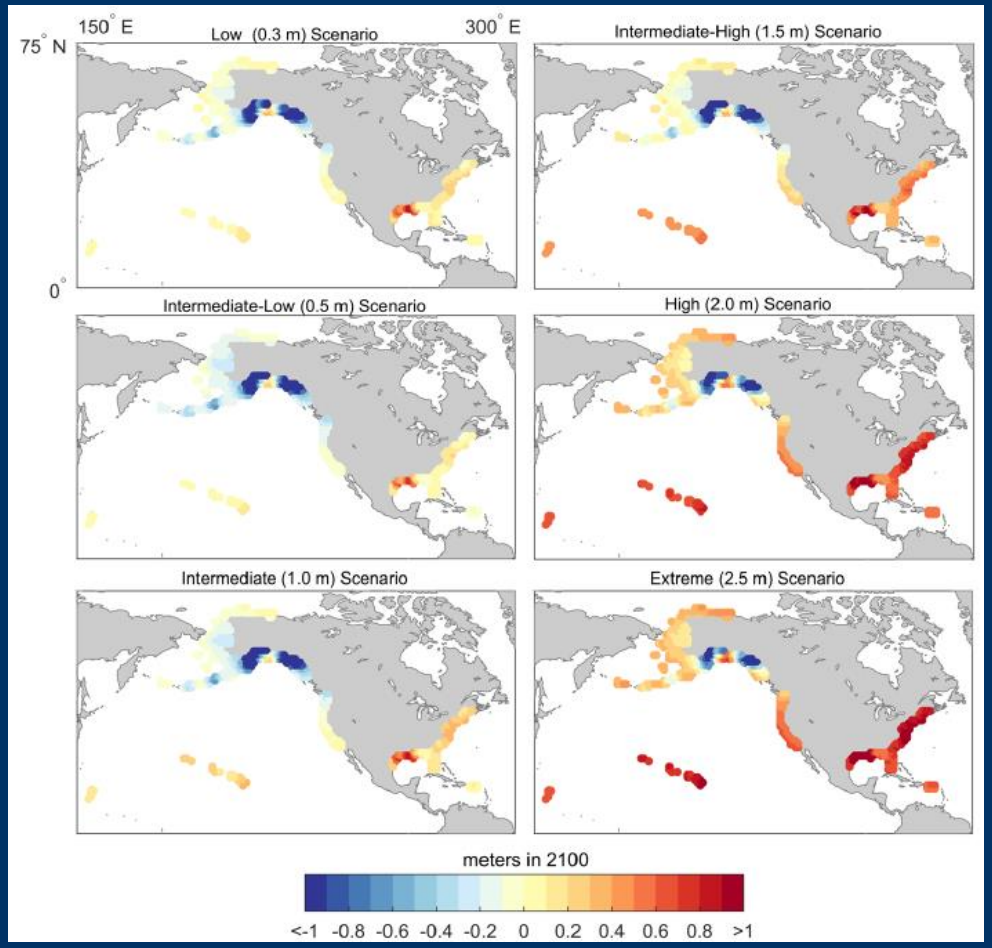
Local Sea Level Rise

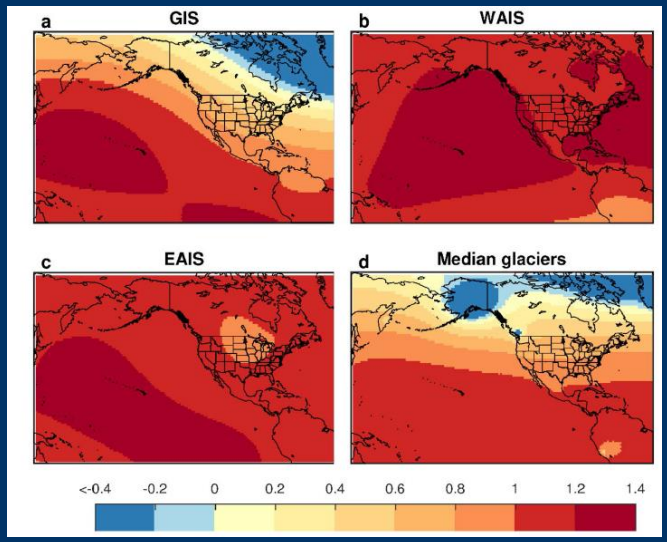


1.02 feet in 100 years

~41% is due to Vertical Land Motion (based on rate of .00420FT/year)

Relative Sea Level Rise





Globals SLR adjusted for

1.) Oceanographic Factors

2.) Gravity Changes due to Melting Land Based Ice

3.) Vertical Land Movement

NOS Tech Report 83, (Sweet et al, 2017)

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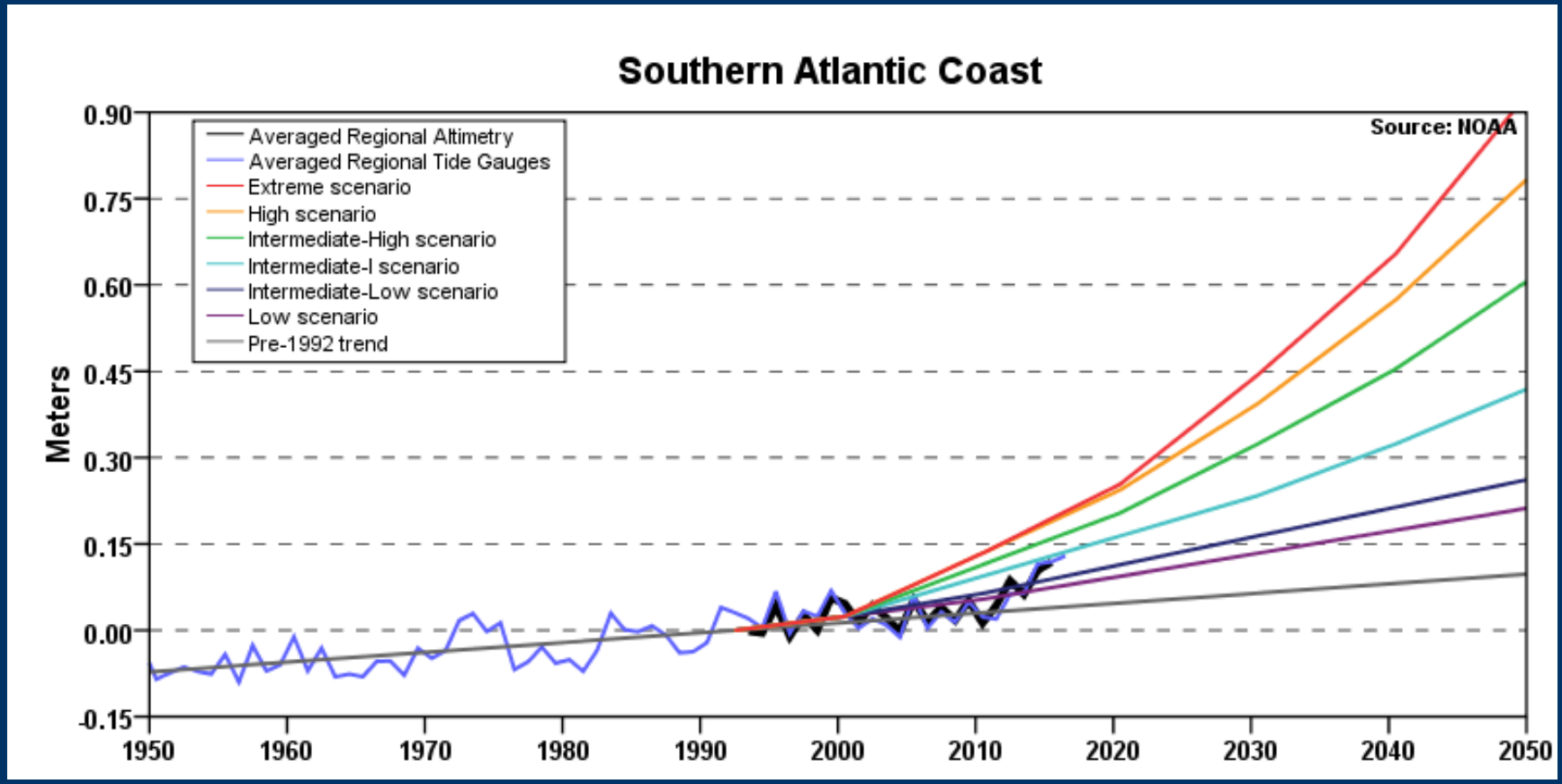
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

How Are We Tracking?



What Scenario To Use?

Higher risk tolerance:

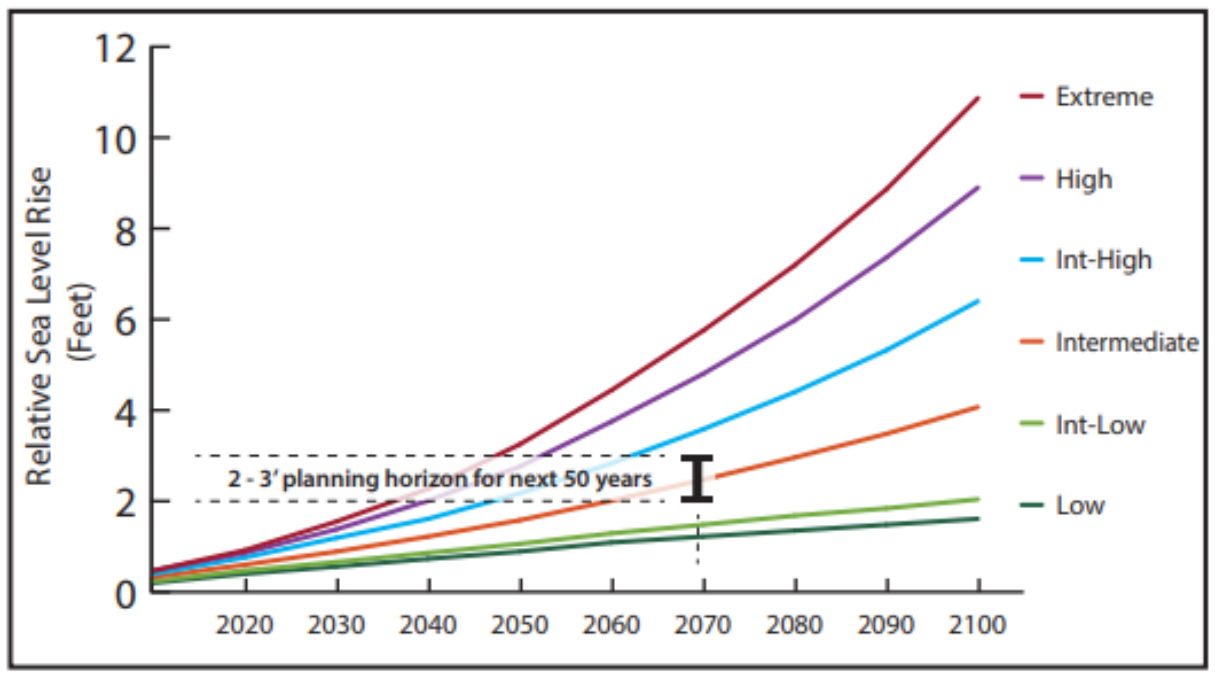
- Greater flexibility to accommodate flooding
- Lower consequence
- Ability to change in near term

Lower risk tolerance:

- Little flexibility to accommodate flooding
- Higher consequence
- Inability to change in near term

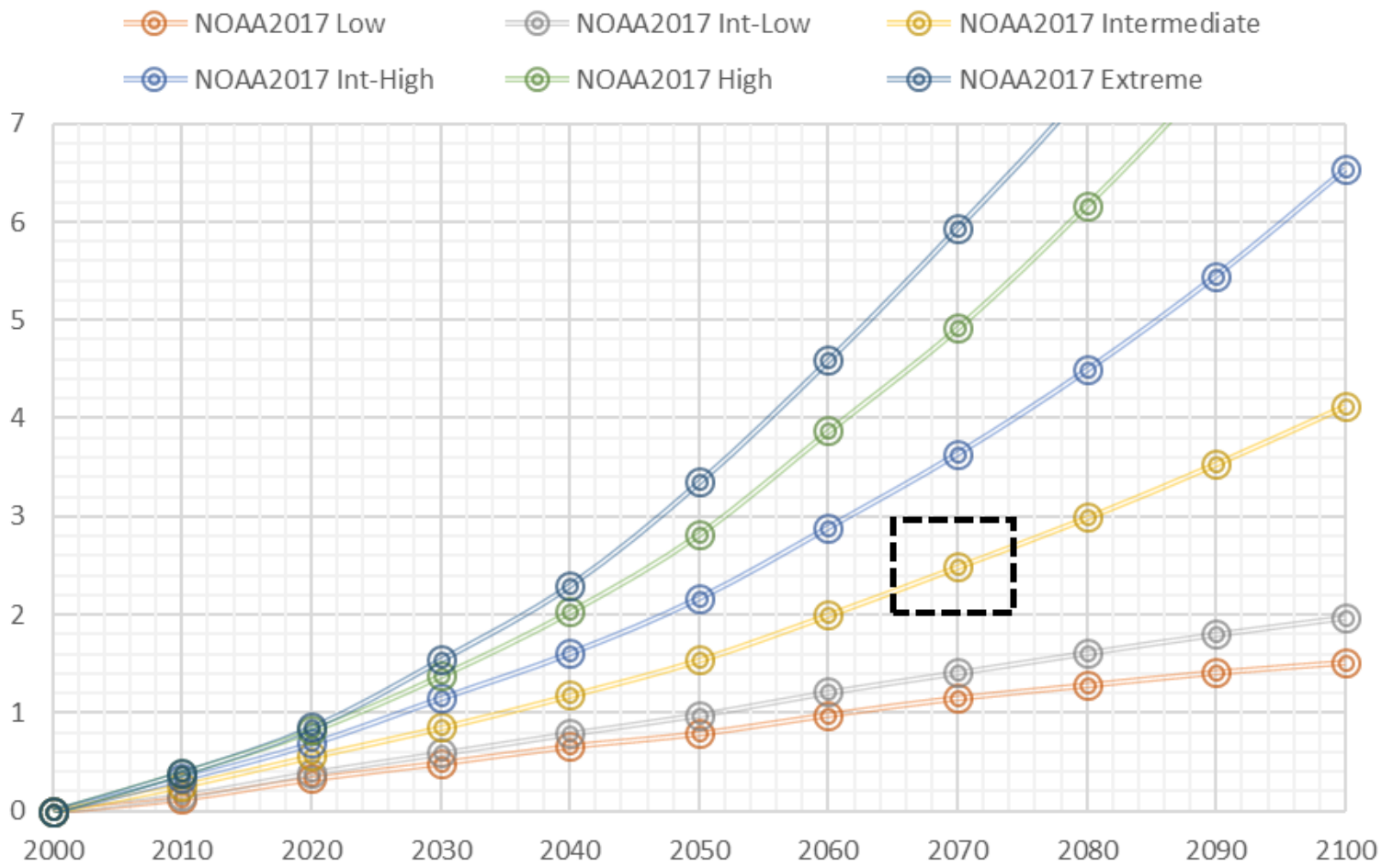
Selecting a SLR Scenario (example)

- A 2.0 foot increase will be used for short-term, less vulnerable investment, such as a parking lot.
- A 3.0 foot increase will be used for more critical longer term investments, such as emergency routes and public buildings.

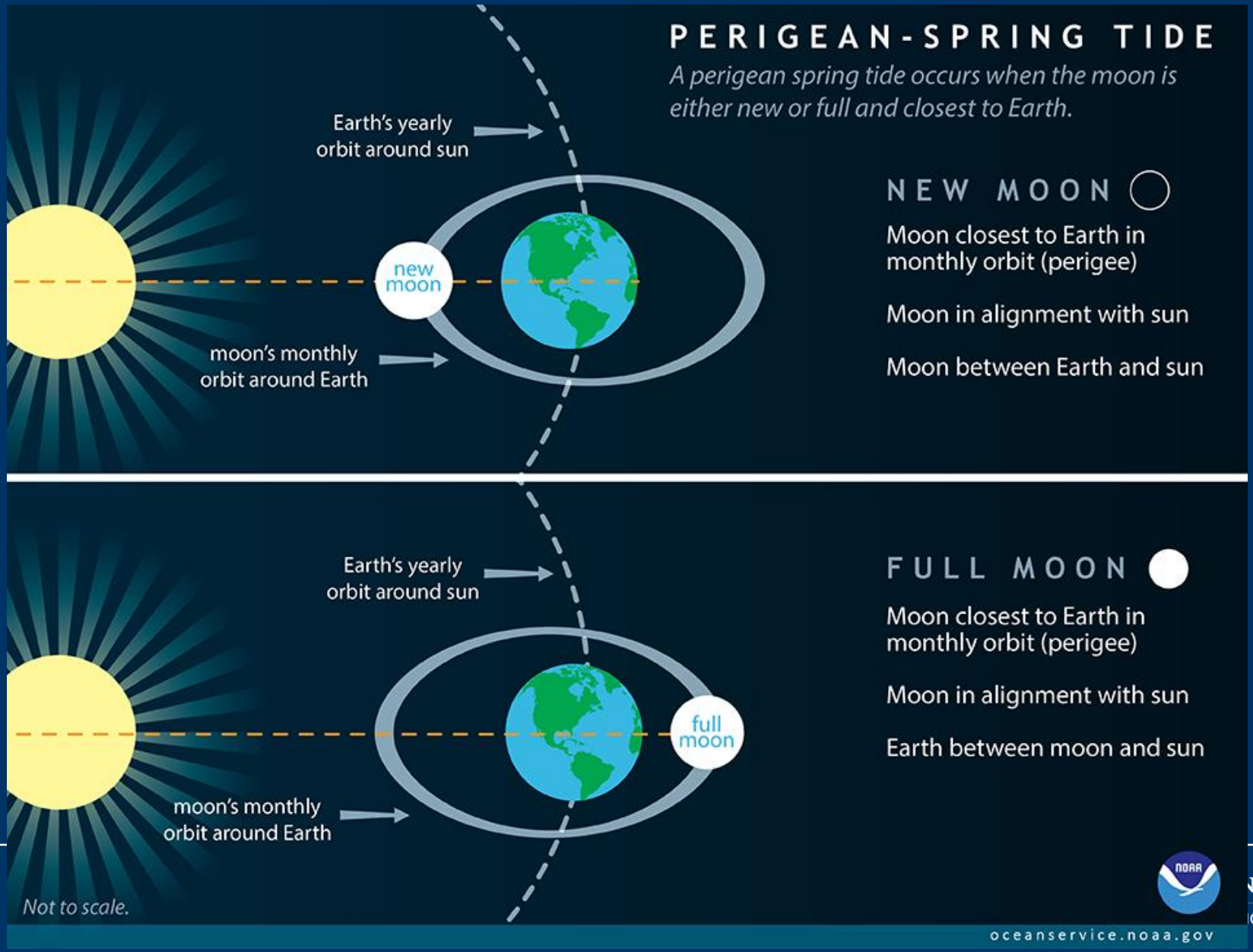


From City of Charleston Sea Level Rise Strategy Document Draft Revision

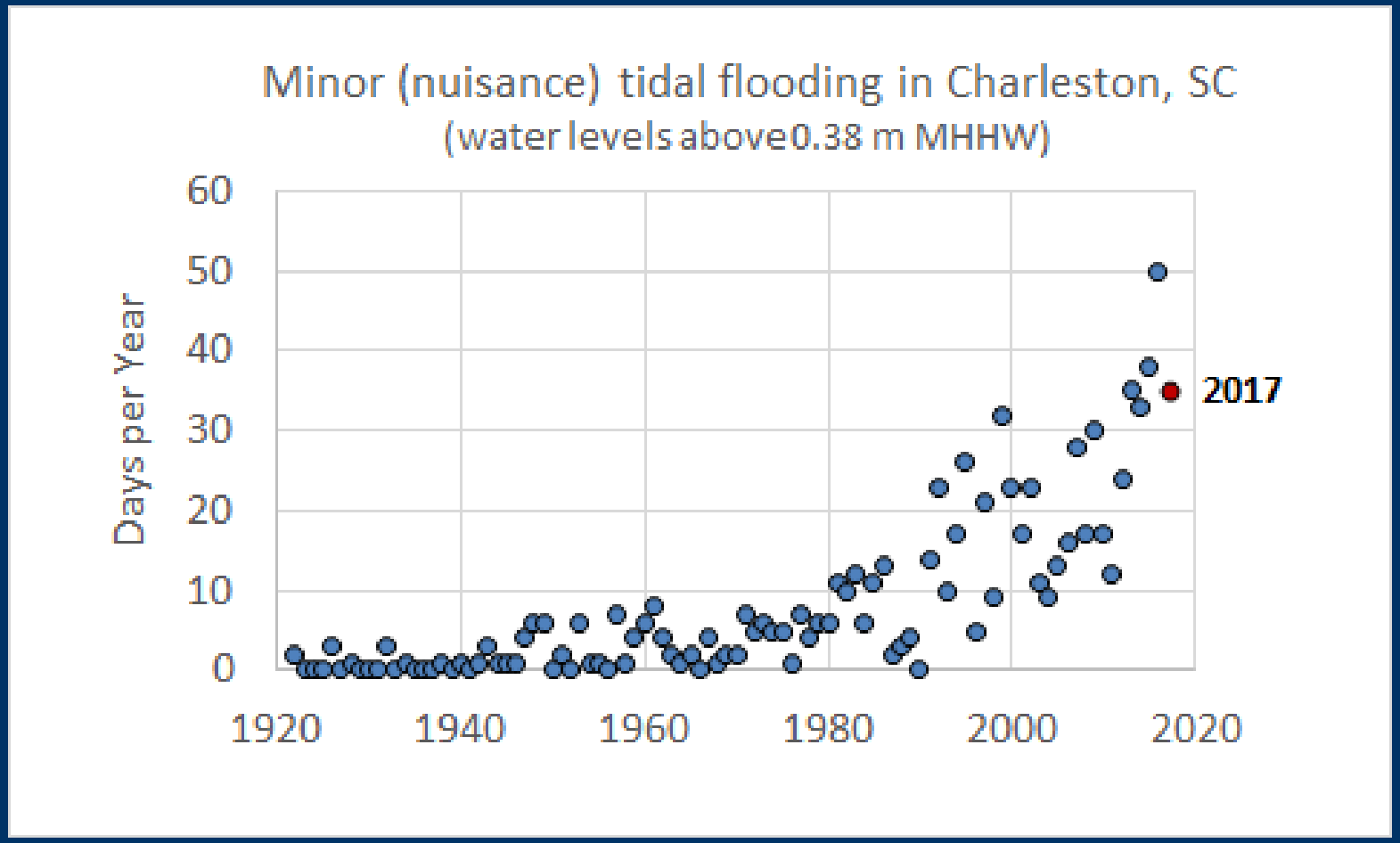
NCA4 Scenarios for Beaufort, NC



High Tide Events

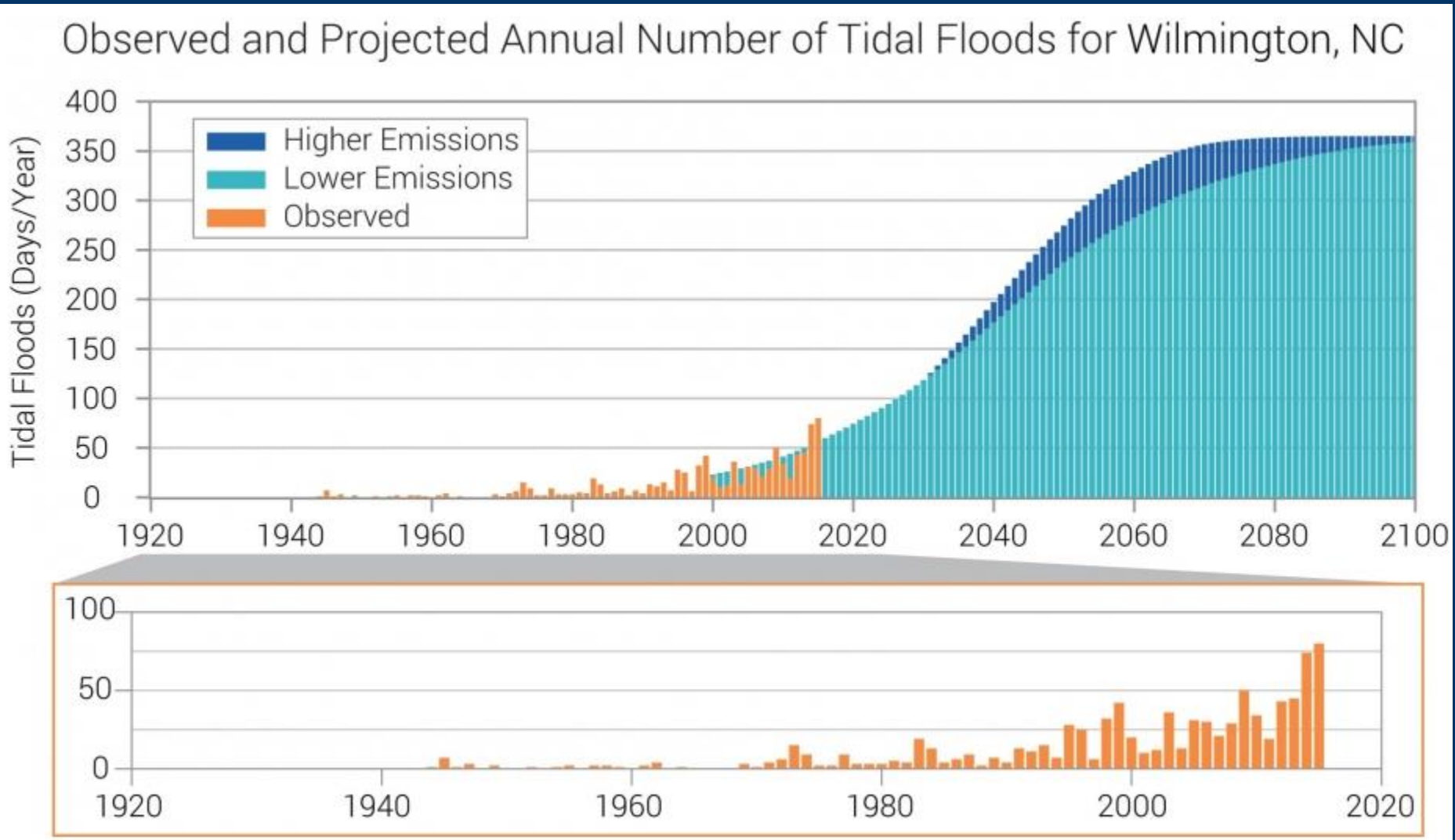


Increase in High Tide Flooding Events



From Sweet et al., 2014


STOP
ALL WAY



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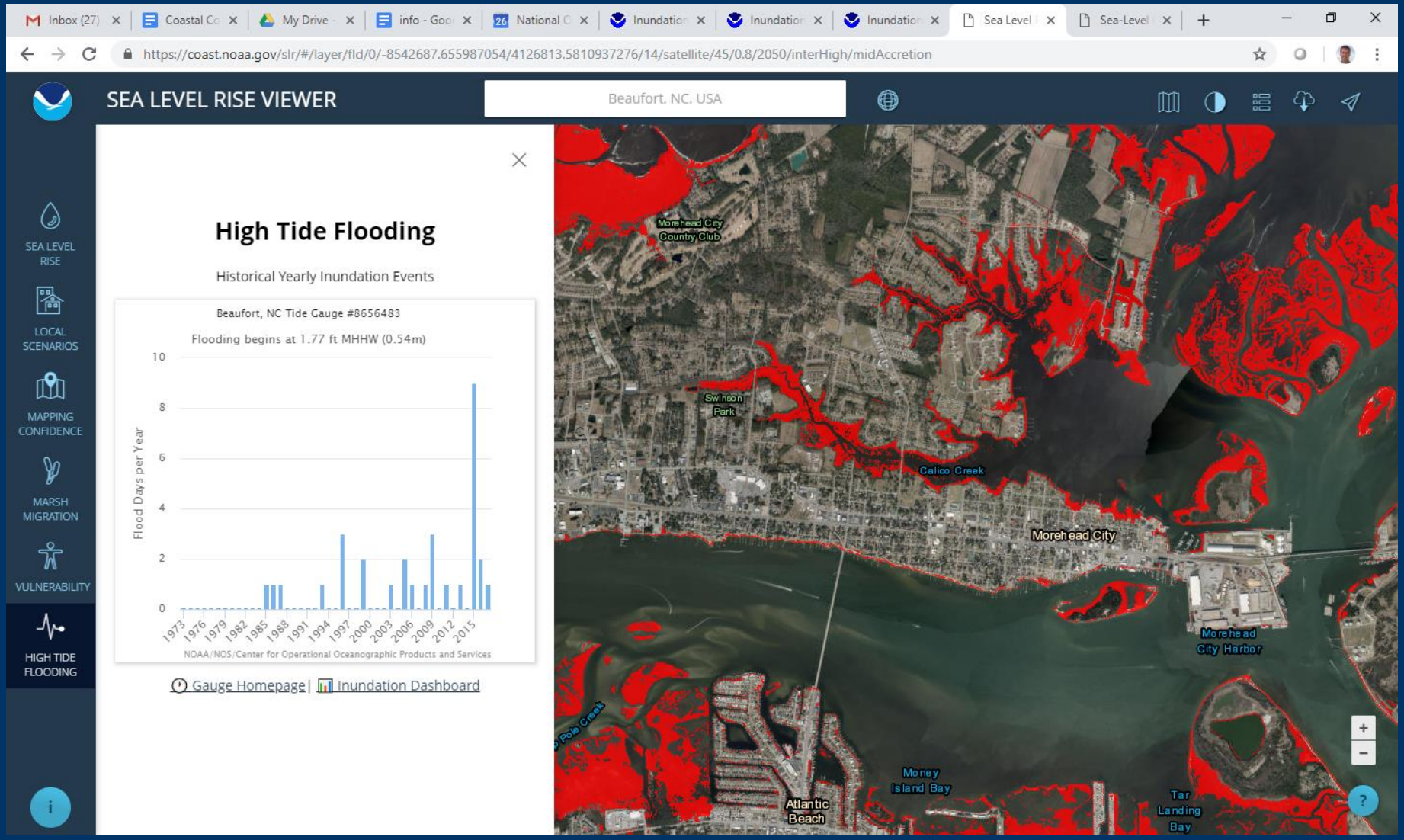
Increase in High Tide Flooding Events



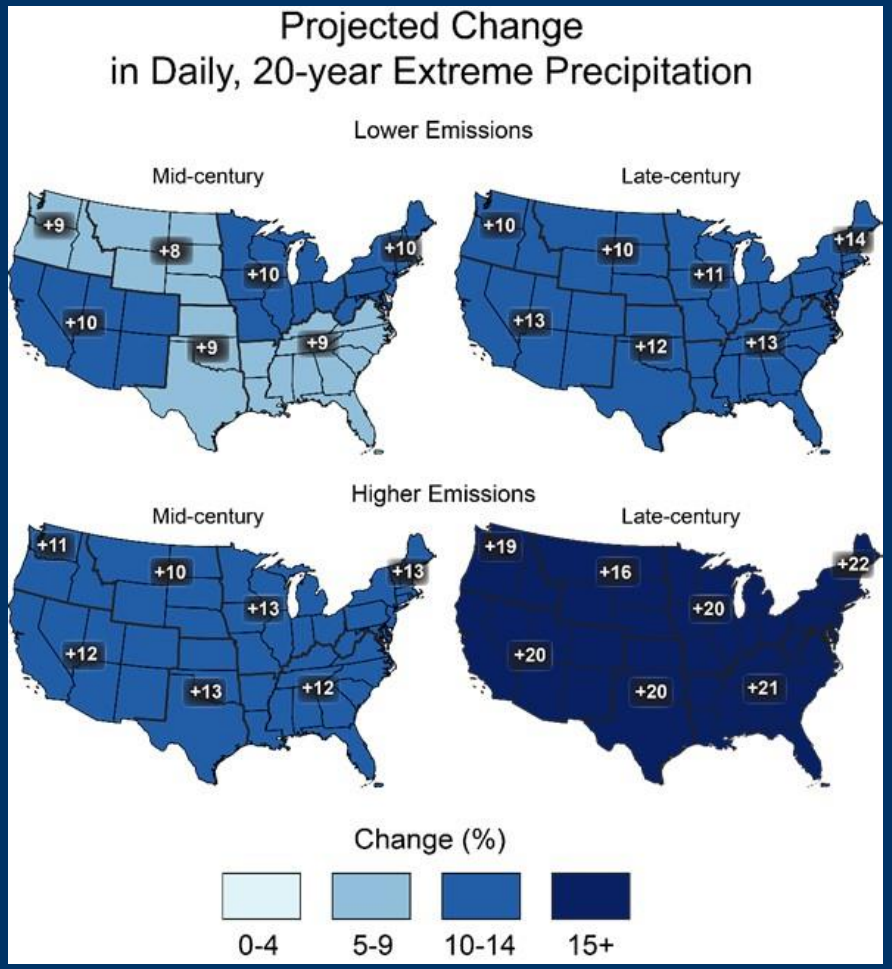
Event	Date	Damages	Casualties
Southeast tornadoes and flooding (FL, AL, AR)	April 27–28, 2014	$1.8 Billion	33
South Carolina record flooding	October 1–5, 2015	$2.1 Billion	25
Hurricane Matthew	October 7–9, 2016	$10.1 Billion	49
Louisiana flooding (Baton Rouge)	August 11–15, 2016	$10.1 Billion	13

Table 19.1: Billion-Dollar Flood Events in the Southeast (2014–2016)

Values are Consumer Price Index adjusted and are in 2017 dollars. *Source: NOAA NCEI 2017.*[84]

Future Precipitation Change in the United States

- The frequency and intensity of heavy precipitation events are projected to continue to increase over the 21st century (*high confidence*).



https://science2017.globalchange.gov

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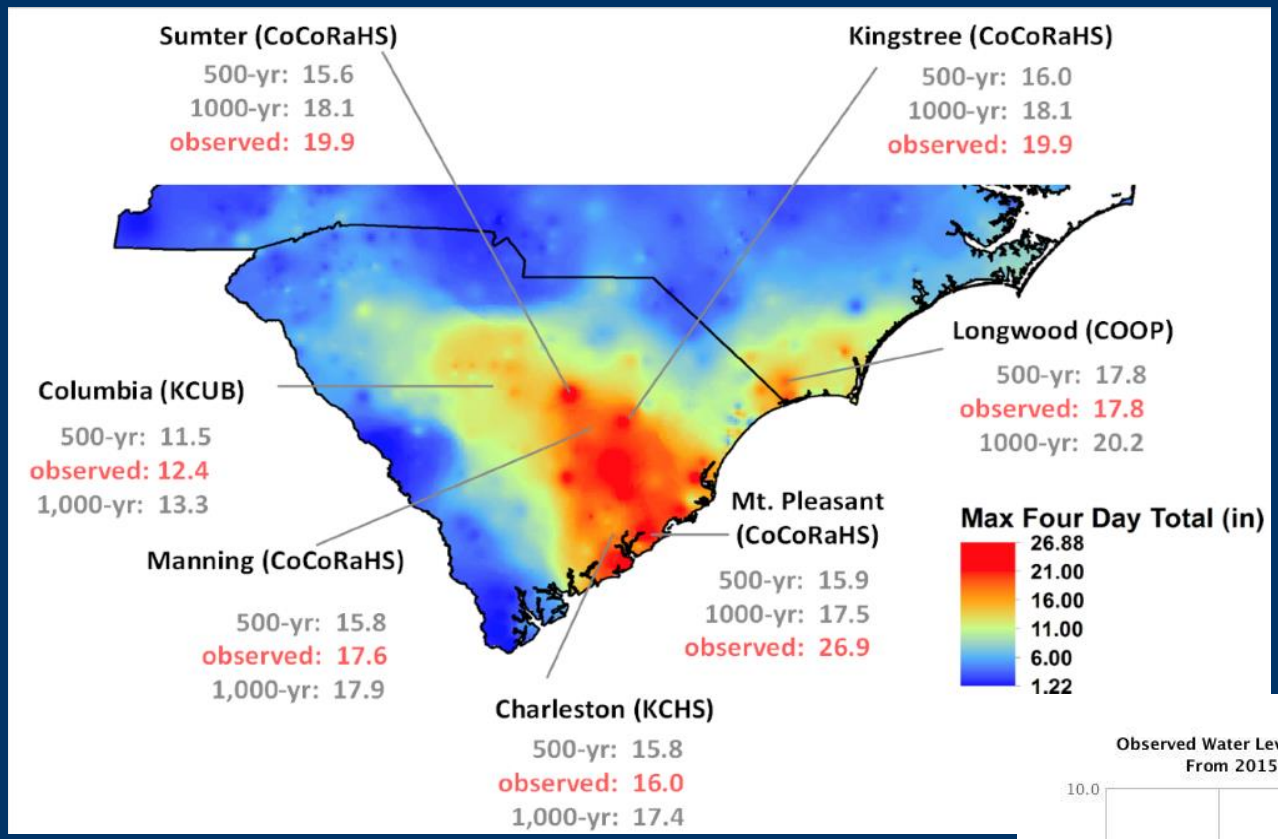
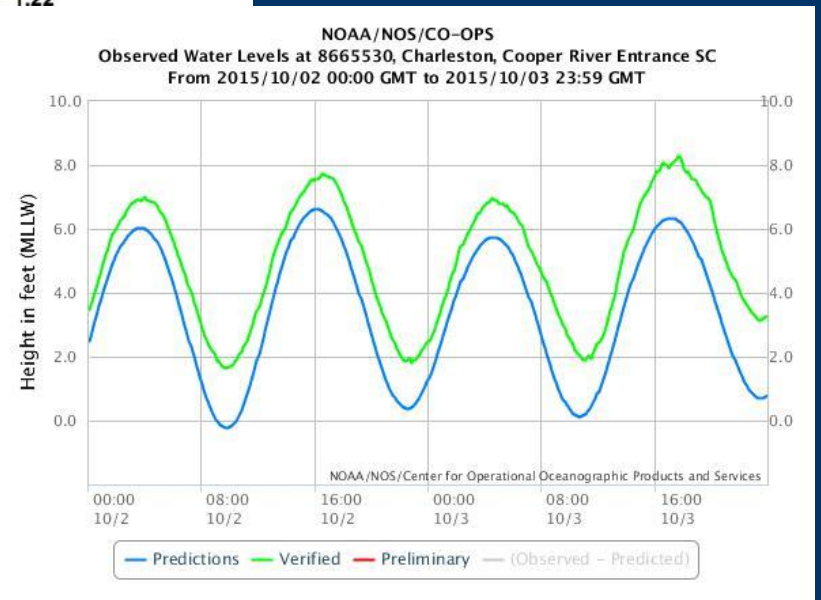
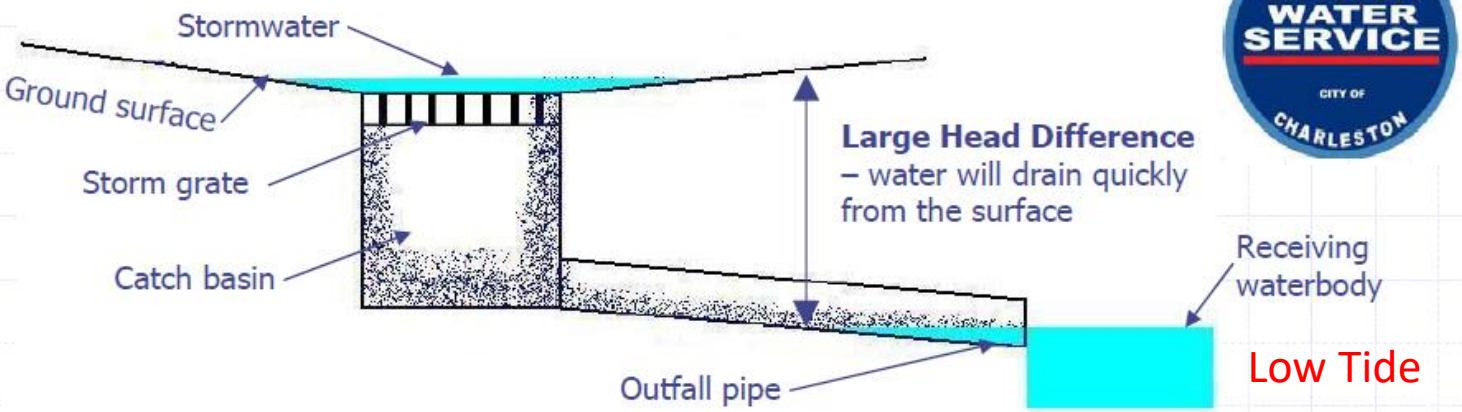
Combined Events – October 2015

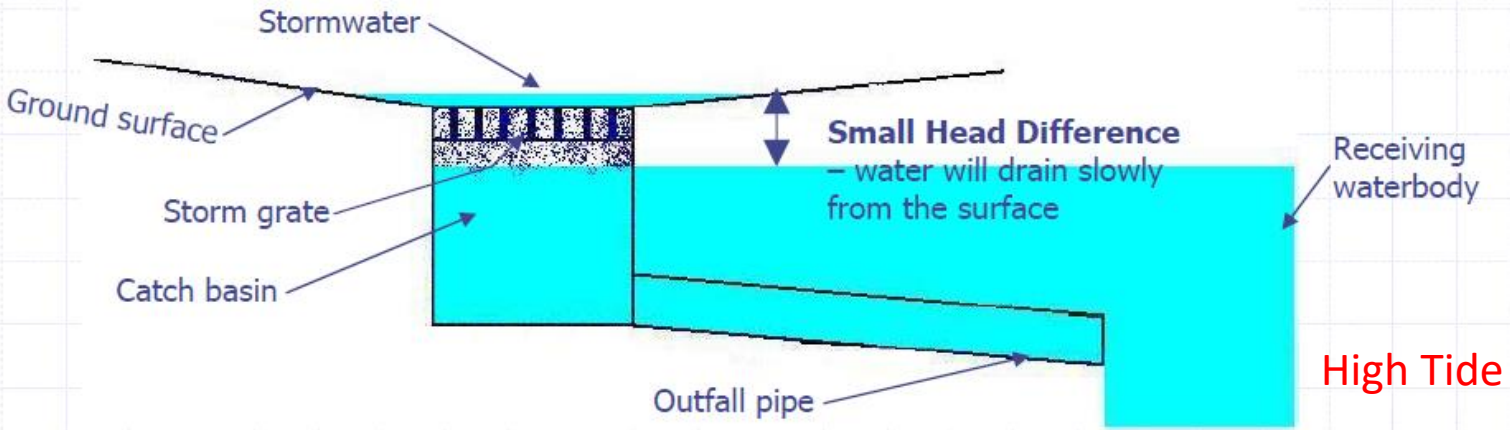




Stormwater 101

- Head – difference in elevation of two water surfaces





http://www.charleston-sc.gov/index.aspx?NID=588

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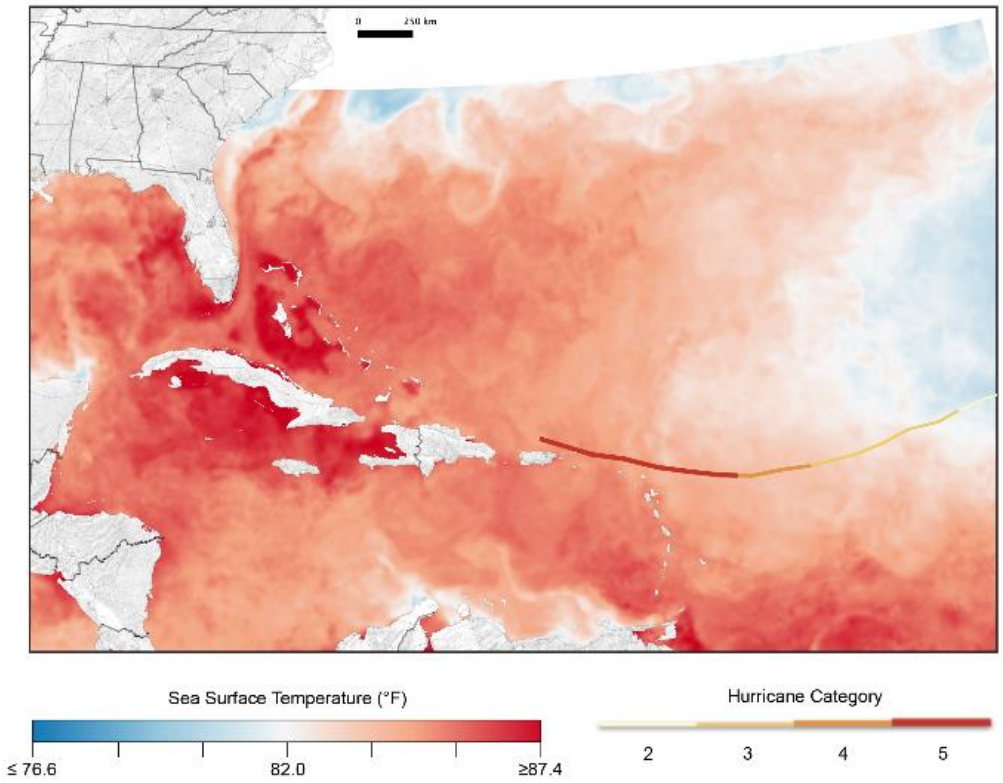
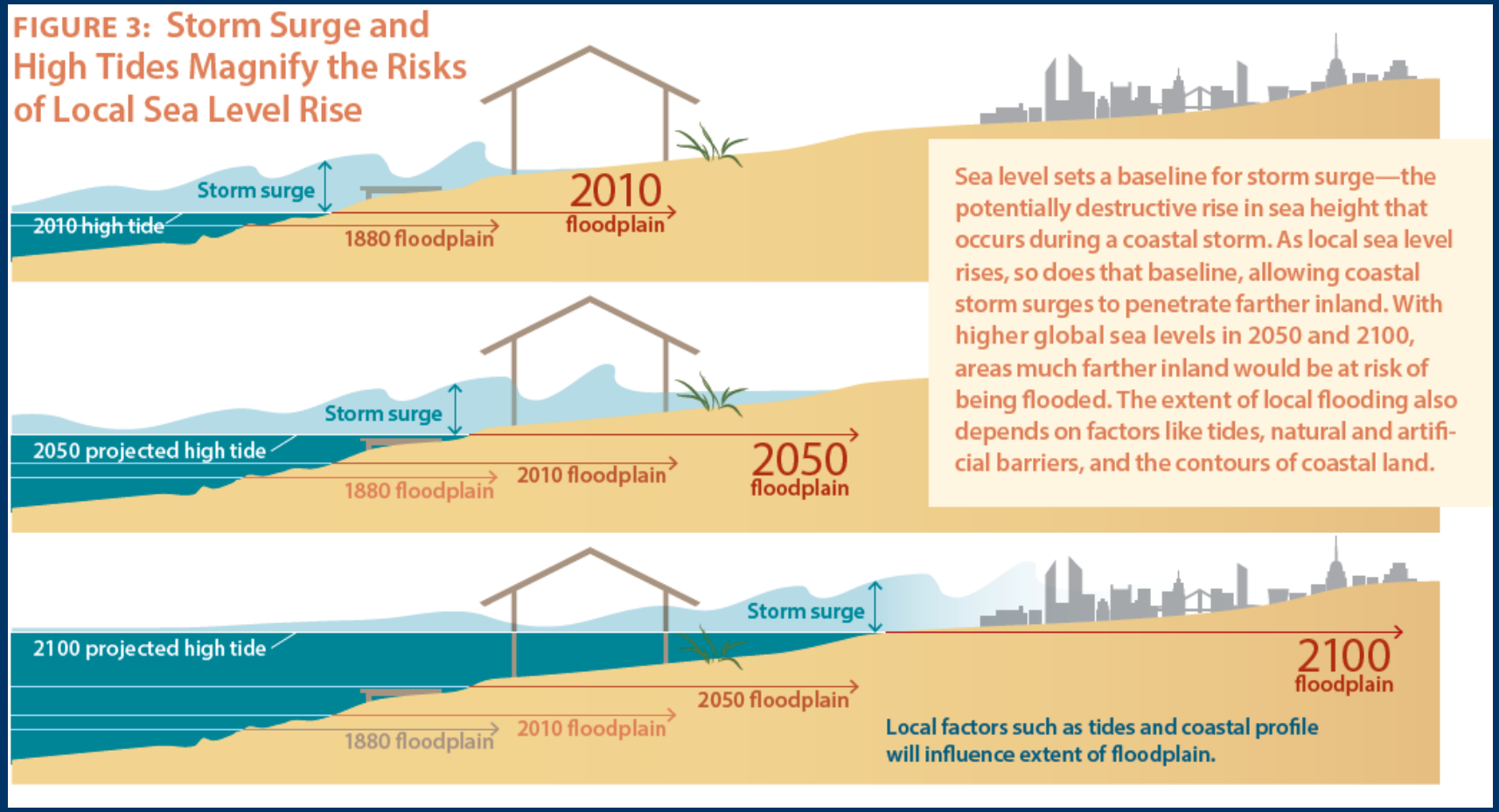
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Fig. 19.14: Warm Waters Contribute to the Formation of Hurricane Irma

Two factors supported Hurricane Irma's strength as it reached the Southeast region: the very warm waters it passed over, depicted in this figure, and the light winds Irma encountered in the upper atmosphere.[101] High-intensity hurricanes such as Irma are expected to become more common in the future due to climate change.[103] *Source: NASA 2017.*[102]



SLR Will Make Future Storms Worse



What Are We Going To Do?

RESILIENCE

"the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events"

National Academy of Sciences, 2012

Prepared communities have some things in common.

- *assess and communicate risk and vulnerability*
- *consider effectiveness and economics*
- *foster partnerships and market solutions*
- *practice ecosystem conservation and restoration*
- *make informed policies and recovery plans*
- *provide local governance and support*

Raising Roads, Armoring and Walls

City of Charleston: Laura Cabiness

$235,000,000 Capital Investment Between 1990 - 2020

- $81.1M Complete
- $27.2M Under construction
- $126.9M Funded

- $4.1 2016 Maintenance Budget

Tunnel Collection and Pumping

Calhoun Street Drainage improvements

Completed 2001

10 ft. and 6 ft. Tunnels

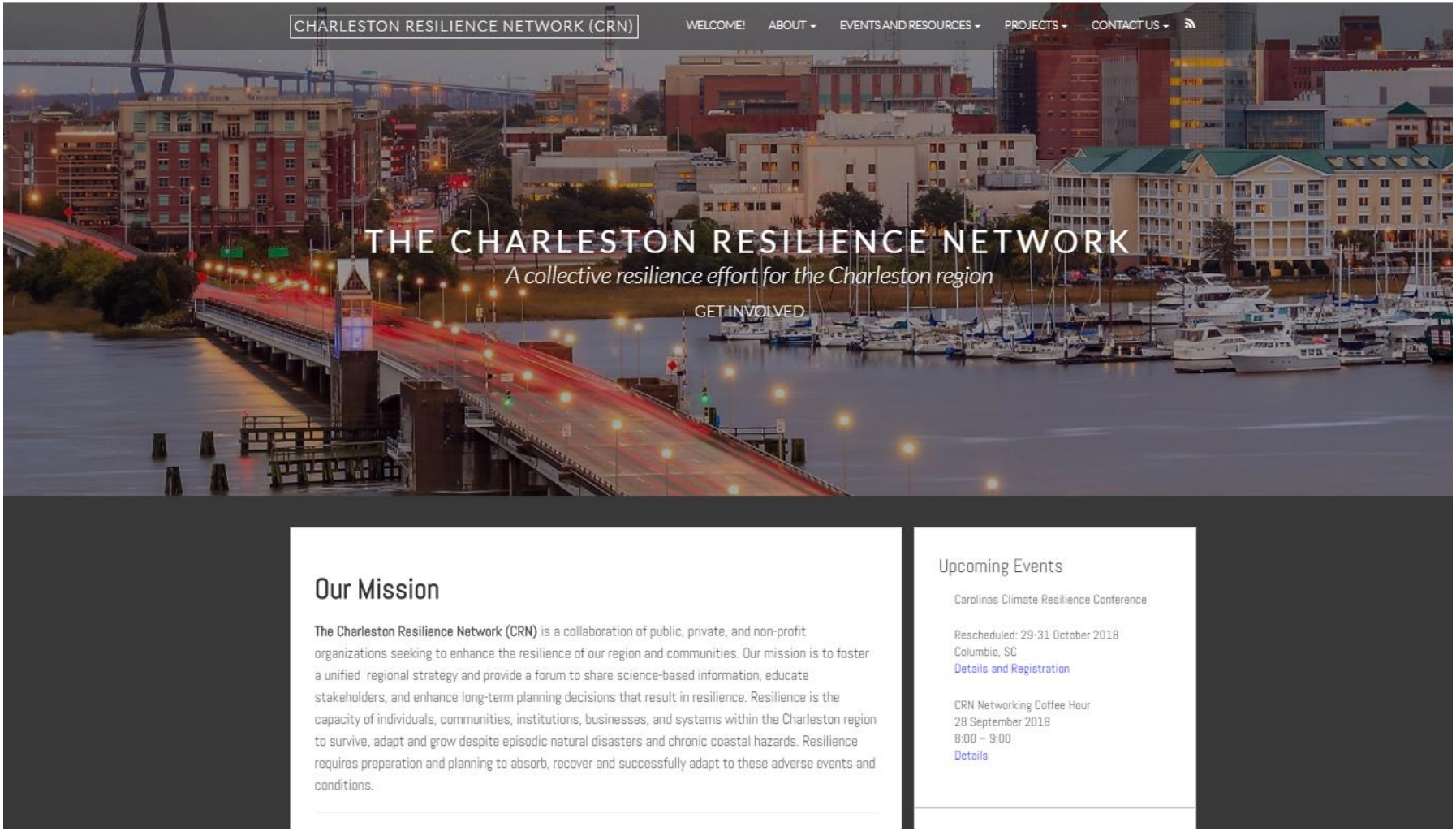
City of Charleston: Laura Cabiness

Tybee Island, GA SLR Adaptation Plan Calls for Modernizing Stretch of Vulnerable Causeway

https://www.researchgate.net/publication/289995
90_Tybee_Island_Sea-Level_Rise_Adaptation_Plan

Fig. 19.11: Isle de Jean Charles Planning Meeting

Chantel Comardelle, Isle de Jean Charles Tribe's Executive Secretary, leads a discussion at a community meeting for the Tribe's resettlement planning process in Pointe-aux-Chenes, Louisiana, on January 18, 2016. The meeting was supported by the Lowlander Center. *Photo credit: The Lowlander Center Team.*


CHARLESTON RESILIENCE NETWORK (CRN)
WELCOME!
ABOUT
EVENTS AND RESOURCES
PROJECTS
CONTACT US
THE CHARLESTON RESILIENCE NETWORK
A collective resilience effort for the Charleston region
GET INVOLVED
Our Mission
The Charleston Resilience Network (CRN) is a collaboration of public, private, and non-profit organizations seeking to enhance the resilience of our region and communities. Our mission is to foster a unified regional strategy and provide a forum to share science-based information, educate stakeholders, and enhance long-term planning decisions that result in resilience. Resilience is the capacity of individuals, communities, institutions, businesses, and systems within the Charleston region to survive, adapt and grow despite episodic natural disasters and chronic coastal hazards. Resilience requires preparation and planning to absorb, recover and successfully adapt to these adverse events and conditions.
Upcoming Events
Carolinas Climate Resilience Conference
Rescheduled: 29-31 October 2018
Columbia, SC
Details and Registration
CRN Networking Coffee Hour
28 September 2018
8:00 – 9:00
Details

Robustness vs. Resilience

- Robust systems, designs, and projects are sturdy **(Gray Infrastructure).**
  - They function and perform within specifications regardless of externals stressors.
  - External stressors are absorbed or deflected without internal change.

- Resilient systems, designs, and projects adapt, adjust, and change in response to internal and external stressors **(Green Infrastructure)**
  - They have response gradients and thresholds or tipping point.
  - Their performance may shift to alternate states or regimes

Questions?

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