Gulf Coast Study

Impacts of Climate Change and Variability on Transportation Systems & Infrastructure

APTA Annual Meeting
October 5, 2011

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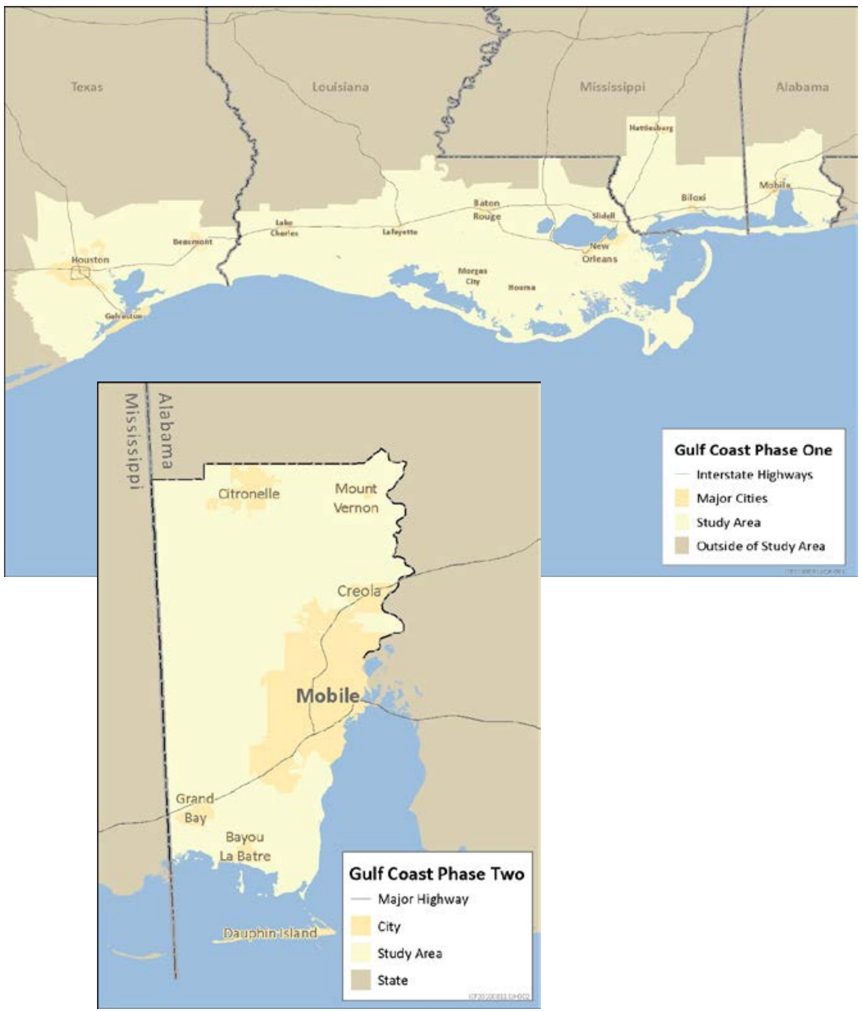
FHWA, Office of Natural Environment

Gulf Coast Study Goals

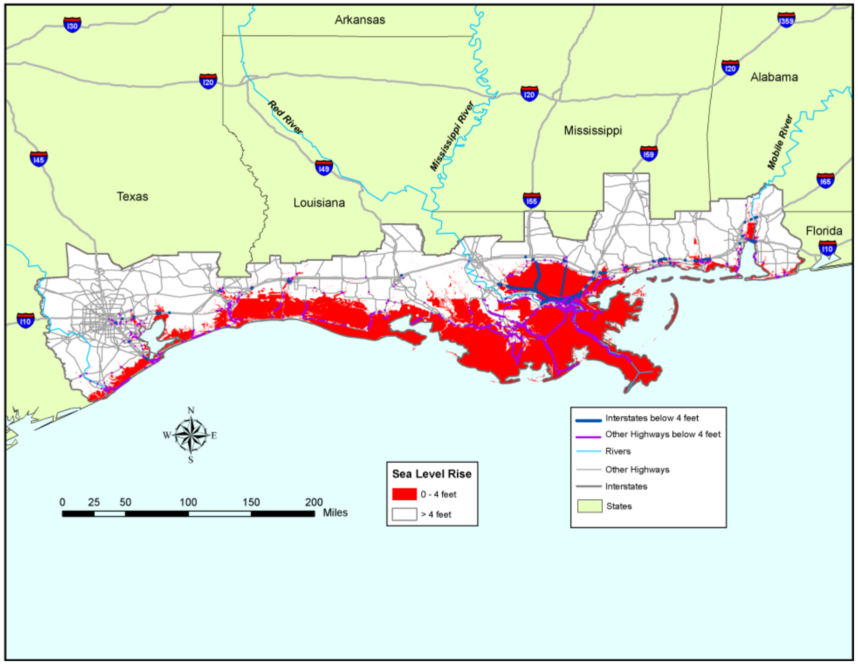


- **Phase 1**
  - Overview of climate change impacts on transportation infrastructure in central Gulf Coast (completed 2008)
- **Phase 2**
  - Focus on one metropolitan area – Mobile, AL
  - Development of adaptation tools and strategies that will be transferable to other areas
  - Timeframe: 2010-2013

Phase I Findings: Infrastructure Vulnerable to 4 Feet of Relative Sea Level Rise Includes…

- **24% of interstate miles, 28% of arterial miles, New Orleans Transit**
- **72% of freight port facilities**
- **9% of rail miles operated, 20% of rail freight facilities**
- **3 airports**

Highway Infrastructure Vulnerable to 4 Feet of Sea Level Rise

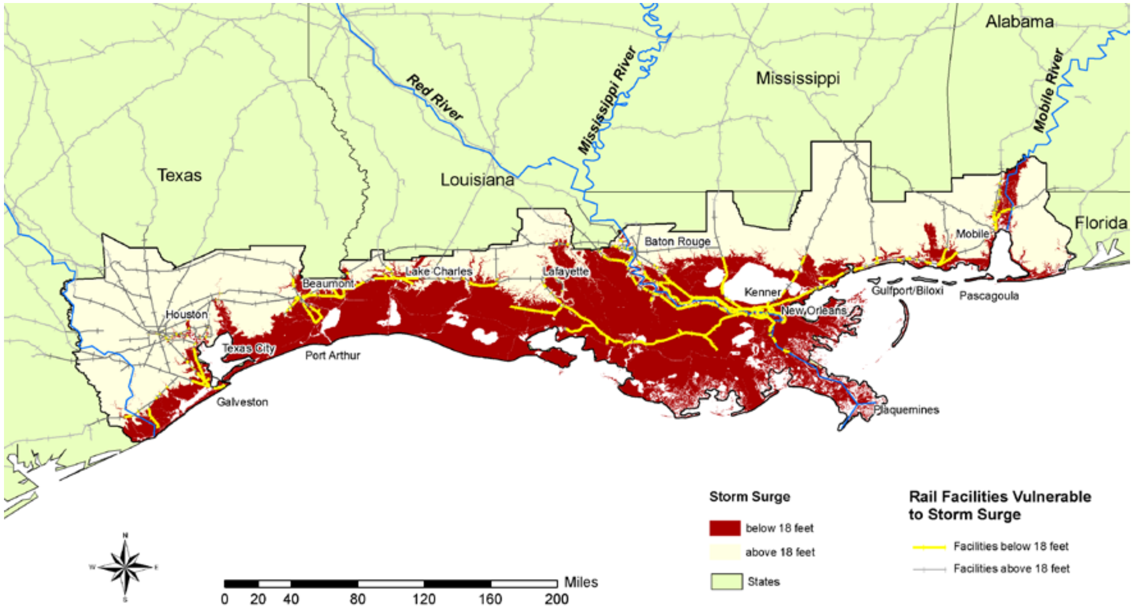


Source: Cambridge Systematics analysis of U.S. DOT Data.

Phase I Findings: Infrastructure Vulnerable to 18 Feet of Storm Surge Includes…

- 51% of interstate miles, 56% of arterial miles, and most transit authorities
- 98% of port facilities
- 33% of rail miles operated, 43% of freight facilities
- 22 airports

Rail Infrastructure Vulnerable to 18 Feet of Storm Surge

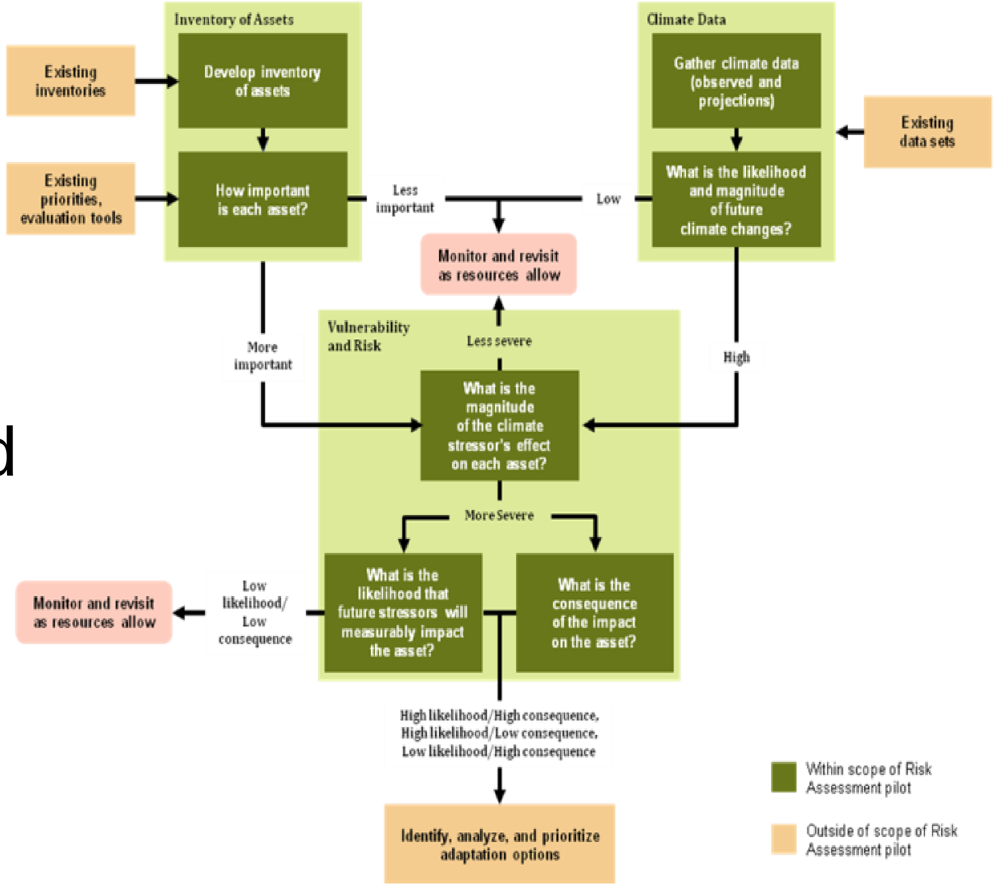


Phase I Provided Broad Overview of Impacts, With Limitations

- **Analysis of impacts based on land elevation rather than the height of facilities**
- **Analysis does not consider the presence of possible protective structures (levees, sea walls, etc.)**
- **A small flooded segment may render a larger portion of the infrastructure inoperable, due to the connectivity of the intermodal system**
  - Many transportation facilities depend on local roads (not elevated)
- **Phase II analysis can be much more detailed – more focused study area**

Vulnerability/Risk Assessment Conceptual Model

- Develop inventory of infrastructure assets
- Gather climate data
- Assess vulnerability and risk of assets to projected climate change
- Analyze, prioritize adaptation options
- Monitor and revisit

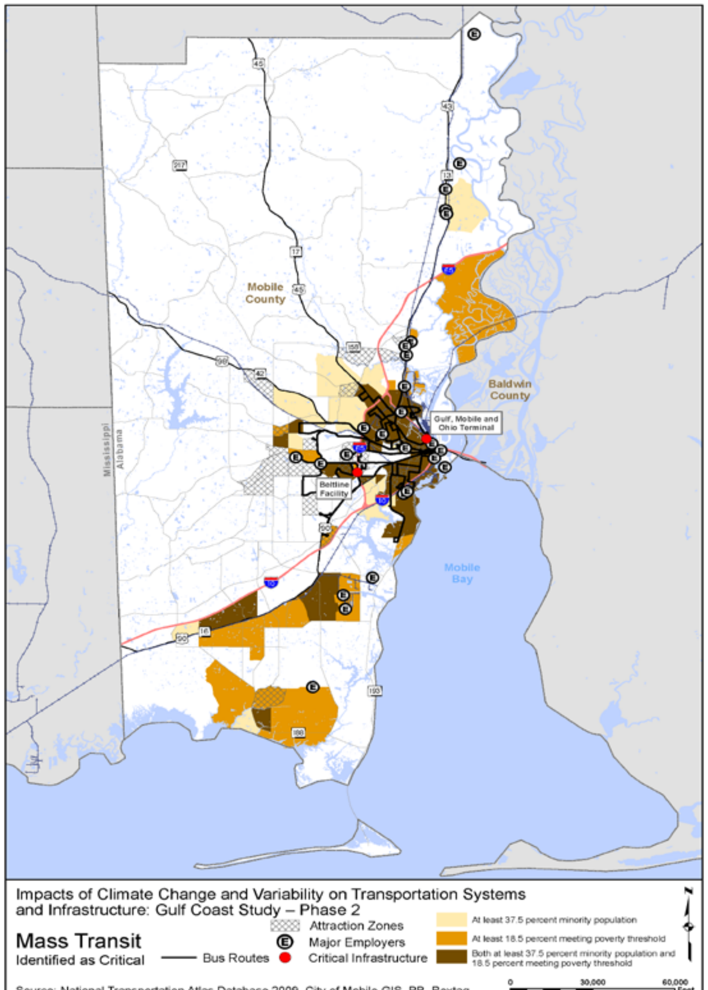


Inventory Assets and Identify Critical Transportation Systems

- **Delineate important assets**
- **Develop scoring summary based on available data**
- **Apply engineering judgment to fill data gaps**
- **Consider redundancy**

	HIGHWAYS											
	SocioEconomic					Ops.		Health and Safety				
	Component of National/International Commerce System	Important Multi-Modal Linkage	Functions as Community Connection	No System Redundancy	Serves Regional Economic Centers	Functional Classification (Interstate, etc.)	Usage	Identified Evacuation Route	Component of Disaster Relief and Recovery Plan	Identified Hazardous Materials Route	Component of National Defense System	Provides Access to Health Facilities
Facility List												
Facility A												

Inventory Assets and Identify Critical Transportation Systems (continued)



- **What is "critical" will vary by community**
- **Important to consider community priorities as well as traditional measures**
- **Professional judgment is important:**
  - Cannot always find data for the "boxes"
  - Not all critical criteria are quantifiable

Identifying Relative Sensitivity of Each Asset to Climate Effects

Modes	Sub-modes	Climate Stressors			
		Storm Surge and SLR	Wind	Precip.	Temp.
Bridges	Superstructure				
	Substructure				
	Operator houses				
Highways and roads	Paved roads				
	...				

Storm surge height greater or equal to...	Bridges close at 56 mph wind speeds...	Designed to 100-year flood...	See road pavement
Designed to 100-year storm surge...		Designed to 100-year flood...	
	Closure at wind speeds of 40 mph...		
Damage when surge overtops road		Designed to 50- to 100-year flood...	Pavement may soften above 108°F...
...	...	...	...

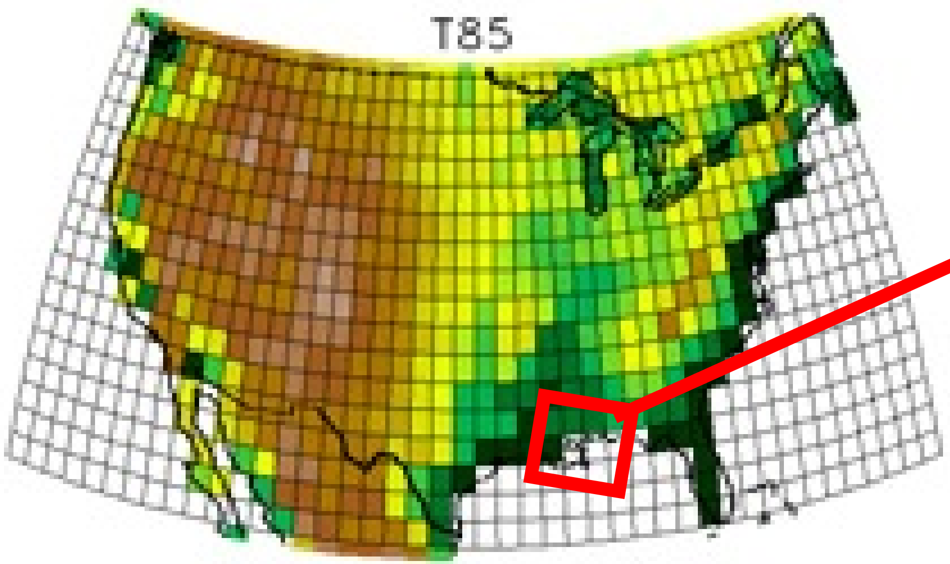
Sensitivity Screen Components

Background: Sensitivity Matrix Grid

Layer 1: Mapping of Sensitive Sub-modes

Layer 2: Climate stressor thresholds

Statistically Downscaled Projections Developed by USGS for Temperature and Precipitation

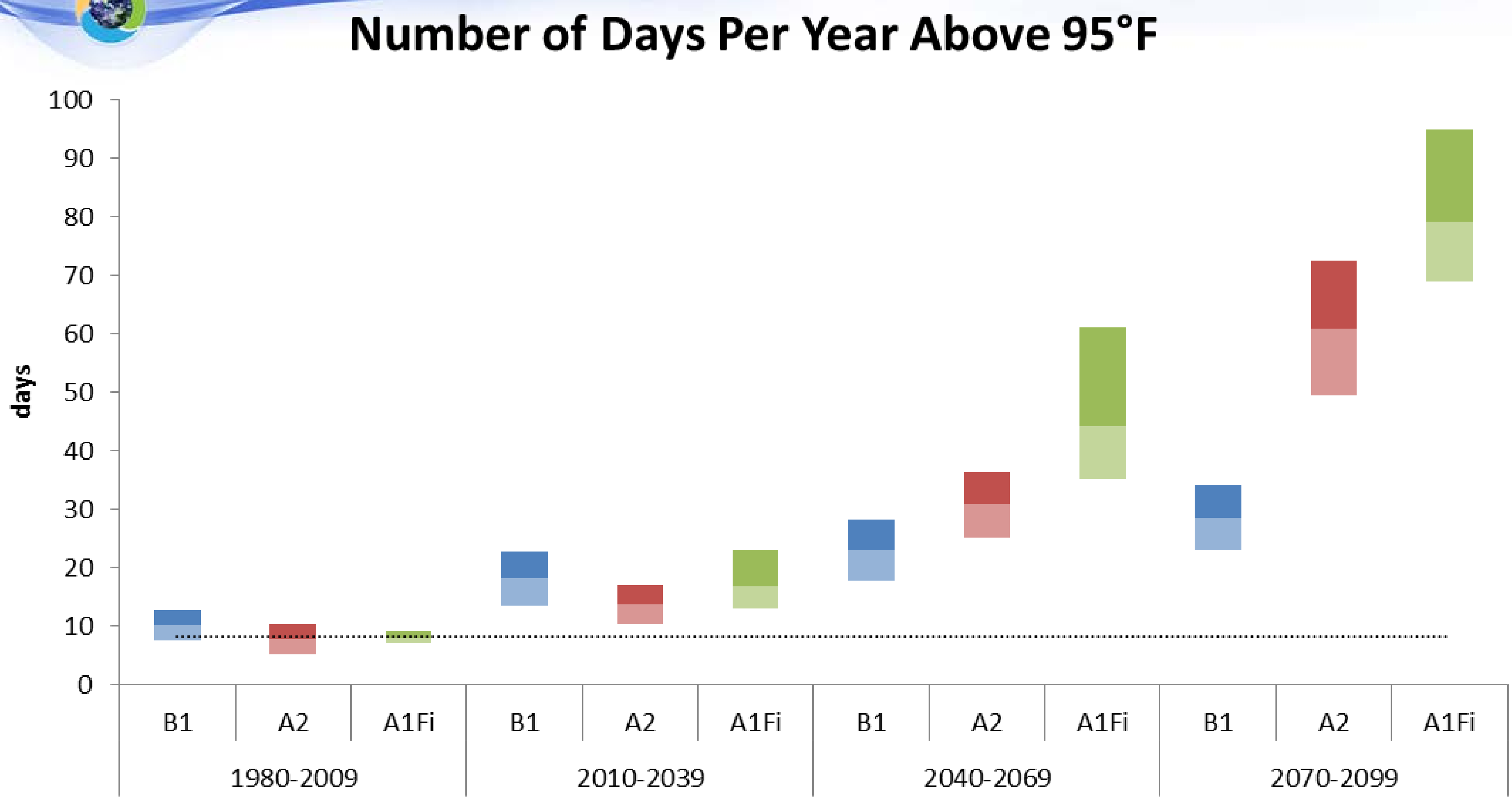


- 4 to 7 global climate models
- 3 emission scenarios (A1F1, A2, B1)
- 3 future time horizons (2010-2039, 2040-2069, 2070-2099)

"Secondary" variables chosen to provide data for specific climate impact analyses

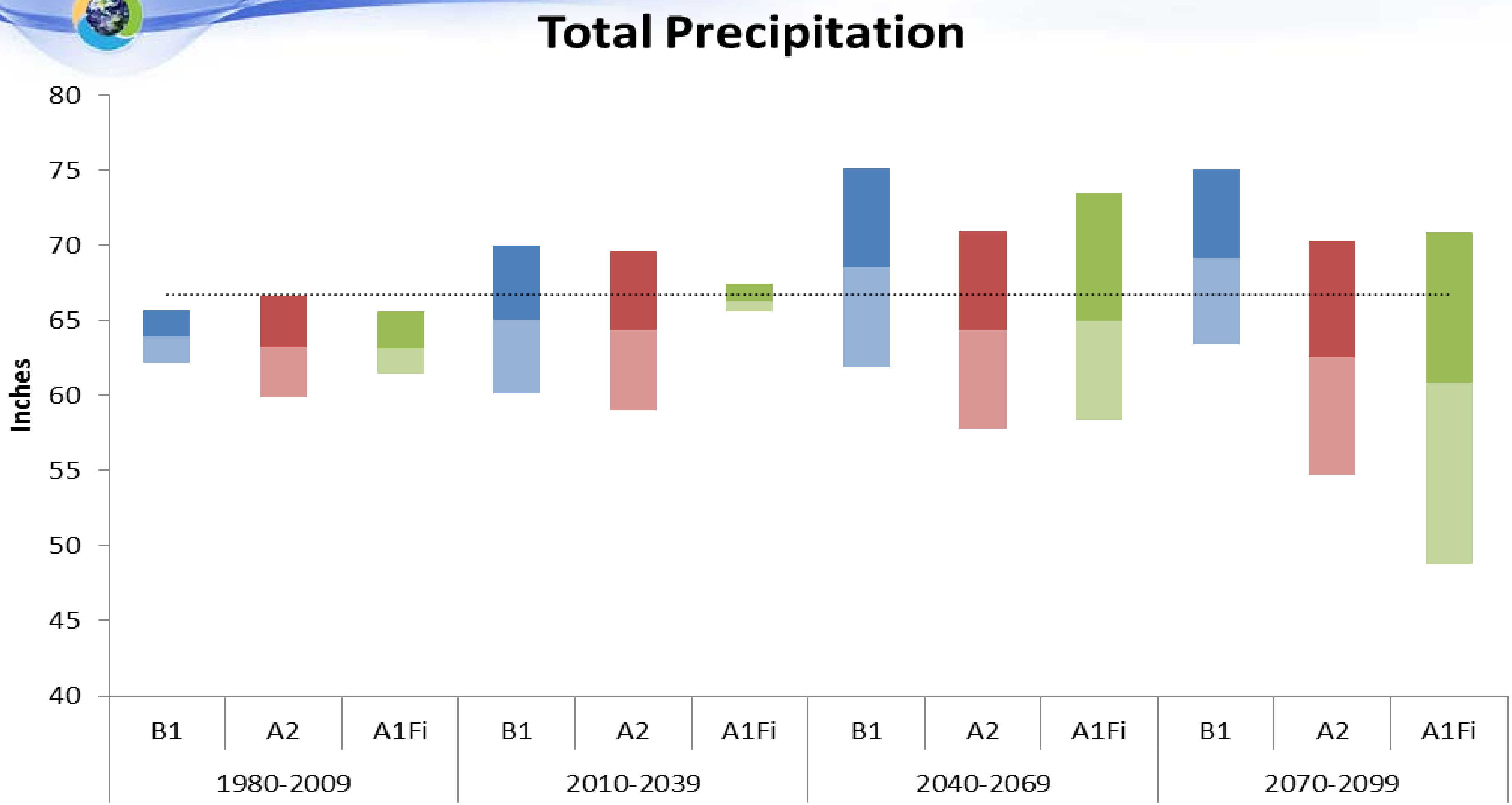
1.	Annual, seasonal and monthly total precipitation; Annual, seasonal, and monthly average minimum, maximum, and mean temperature	6.	Maximum 7-day average air temperature per year with the % probability of occurrence during each 30-yr period (mean, 50%, 90%, 95%, 99% occurrence)
2.	Daily high temperature: mean, 50 %ile, 95 %ile, and warmest day in the year during each 30-yr period	7.	Exceedance probability precipitation for 24-hour period with a 0.2%, 1%, 2%, 5%, 10%, 20%, and 50% exceedance precipitation events (e.g., 500-yr,…)
3.	Seasonal and annual number of days and maximum consecutive days of high temperatures at or above 90 ^{o}F, 95^{o}F, 100^{o}F, and 105^{o}F	8.	24-hour exceedence probabilities based on today's 0.2%, 1%, 2%, 5%, 10%, 20%, and 50% exceedance precipitation events
4.	Mean, 5%, 25%, 50%, 75%, 95%, and largest occurrences for the average minimum and maximum air temperature over 4 consecutive days	9.	Exceedance probability precipitation across 2 and 4 consecutive days: 0.2%, 1%, 2%, 5%, 10%, 20%, 50%, mean;
5.	Mean, 50%, 90%, 95%, and 99% occurrence of the coldest day of the year during each 30-yr period	10.	Largest 3-day total of precipitation each year

Temperature



Methodology: In the 30-year period, the number of days where the maximum temperature is at or above 95°F for each year was counted, and then averaged across the 30 data points.

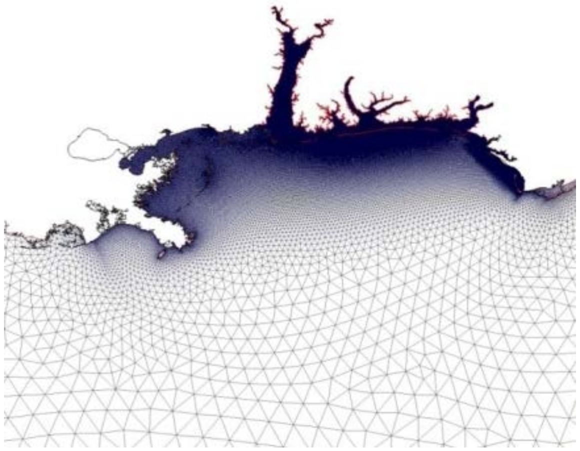
Precipitation

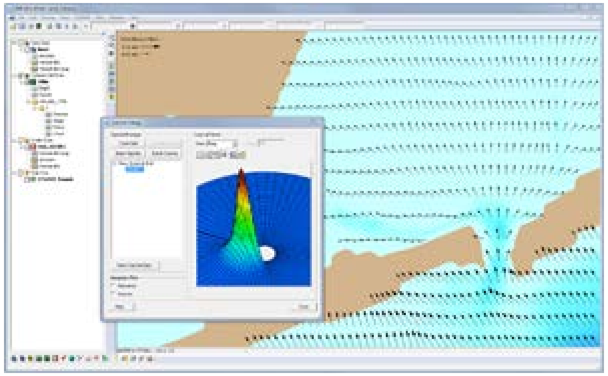


Methodology: In each 30-year period, the daily values for annual precipitation was summed for each year, and then an average was done across all 30 data points.

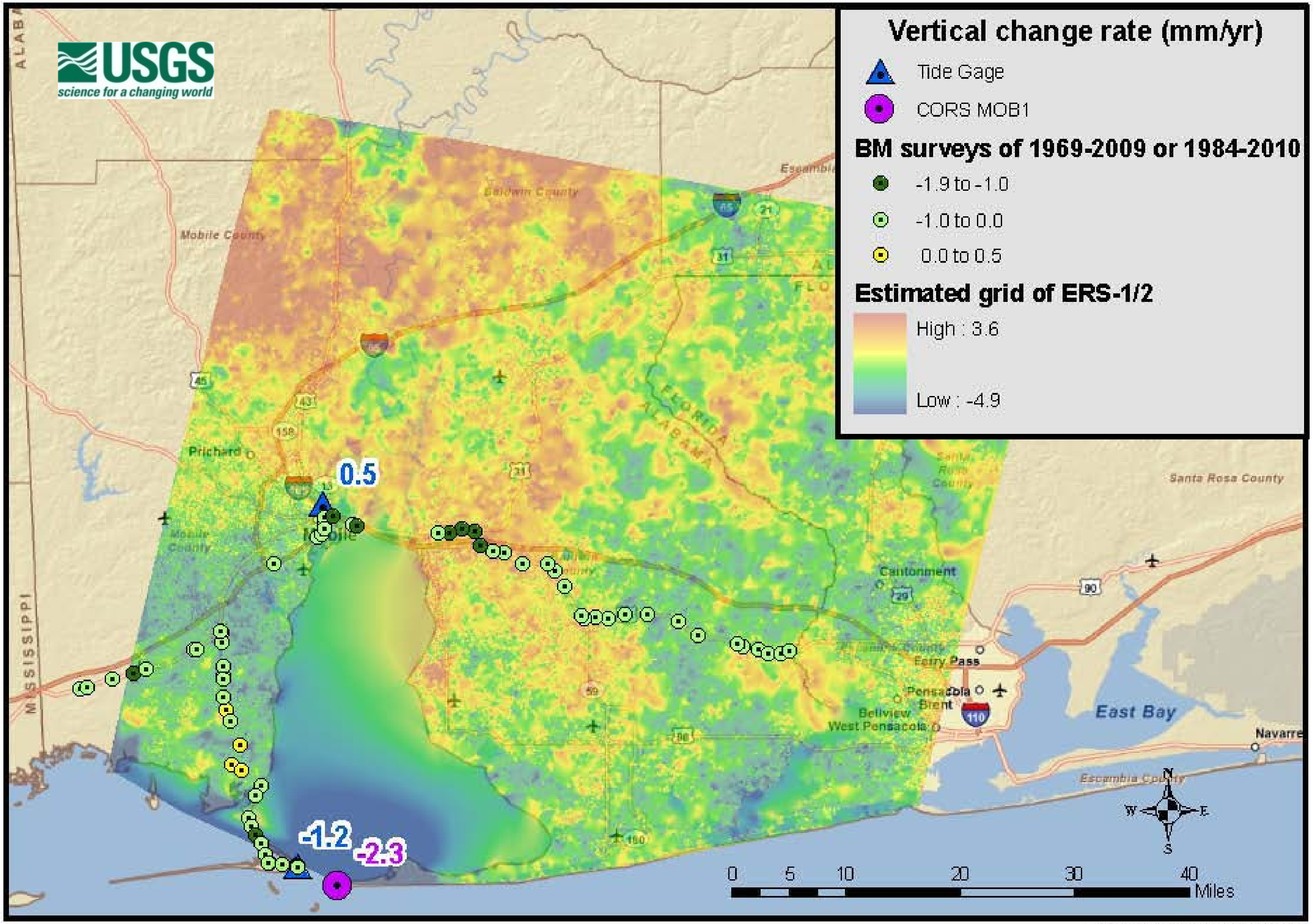
Scenario-Based Approach Used for Sea Level Rise and Storm Surge

- **Sea level rise analysis**
  - Range of recent global SLR scenarios used (30, 75, 200cm)
  - Accounts for local subsidence
- **Storm Surge Modeling – ADCIRC**
  - Range of storm intensities
  - Output includes surge distribution and dynamics
- **Wave Modeling – STWAVE**
  - Inputs from ADCIRC output and boundary conditions
  - Outputs include key aspects of wave energy
- **Exposure of transportation systems will be assessed using a GIS analysis**





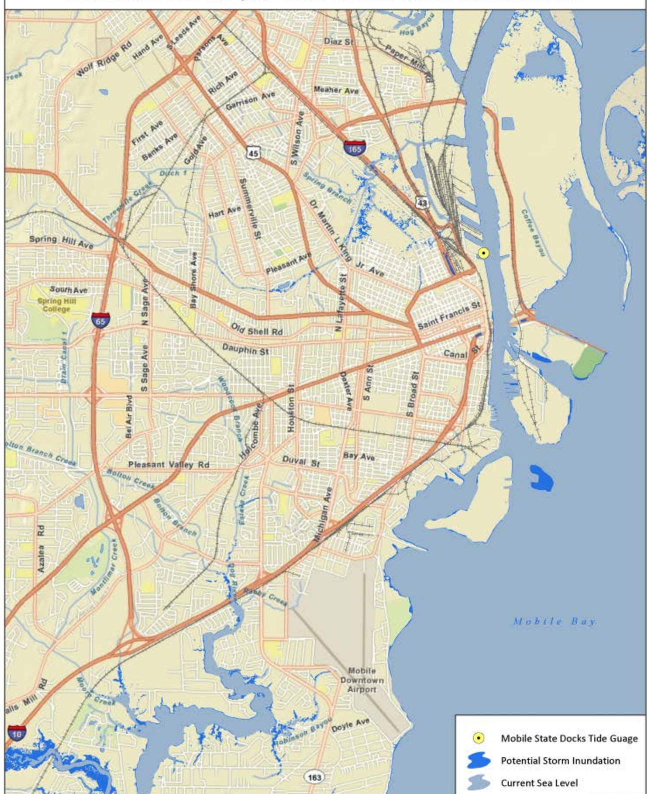
Projected Climate Data—Subsidence



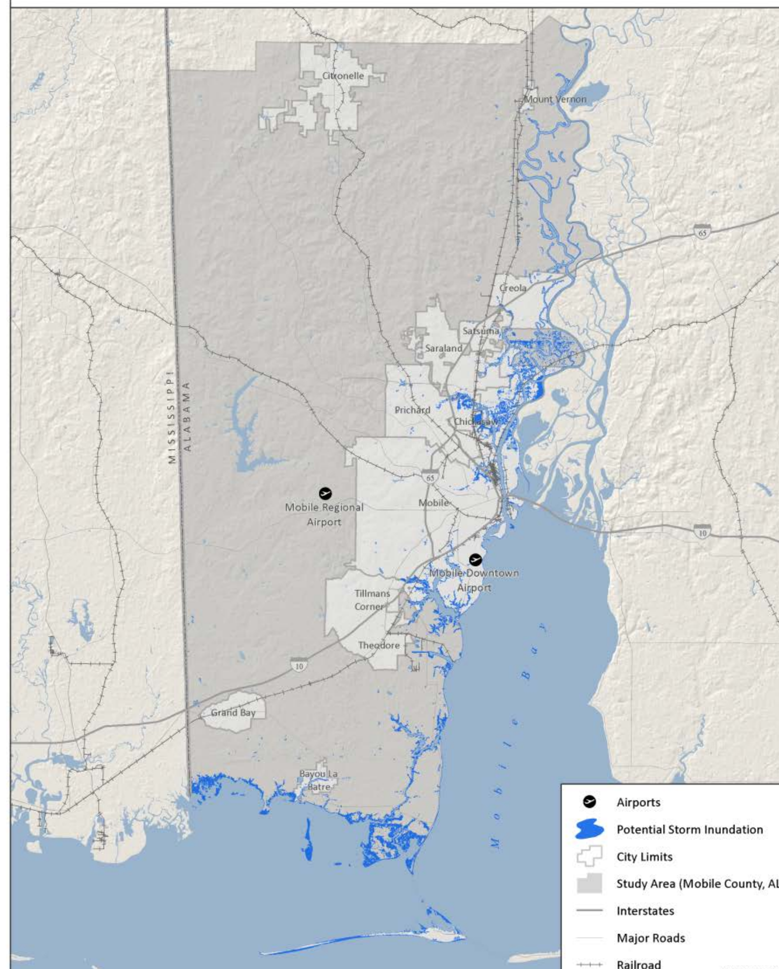
K. Van Wilson, USGS, 02-11-11

Projected Climate Data—Sea Level Rise

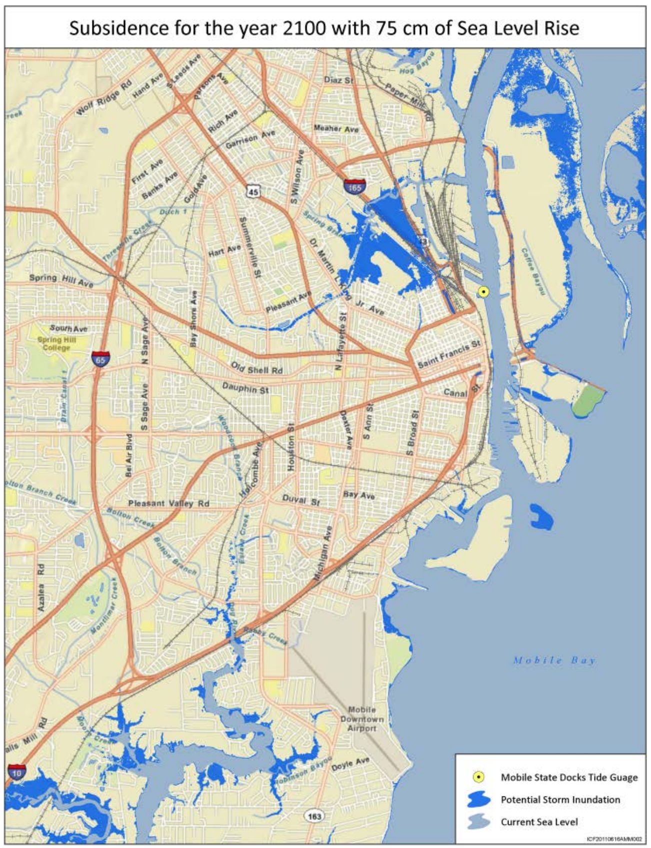
Subsidence for the year 2050 with 30 cm of Sea Level Rise

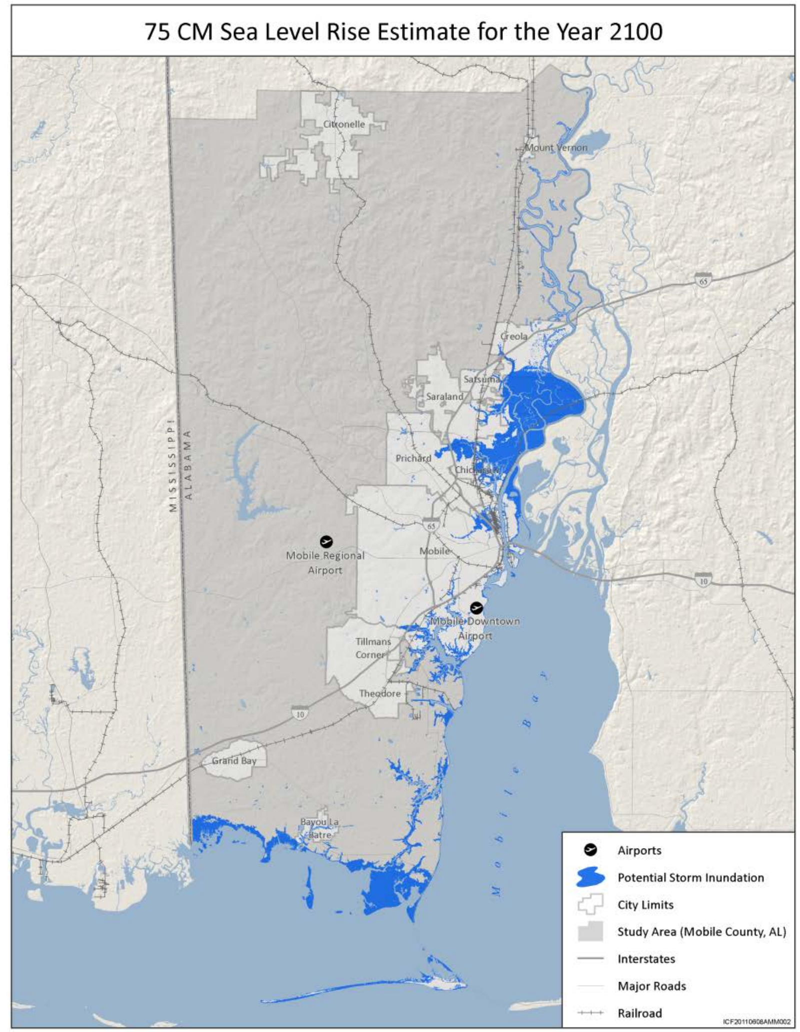


30 CM Sea Level Rise Estimate for the Year 2050

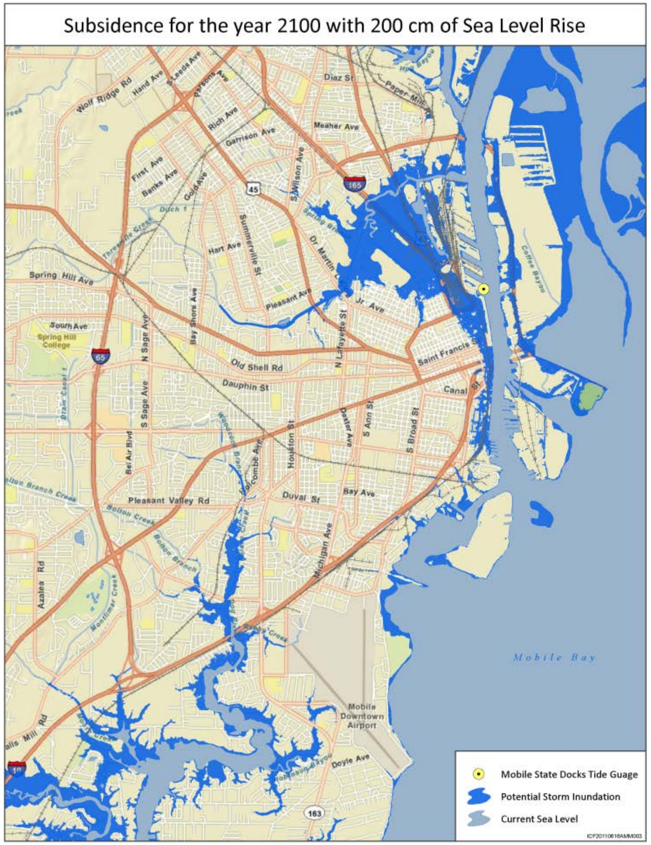


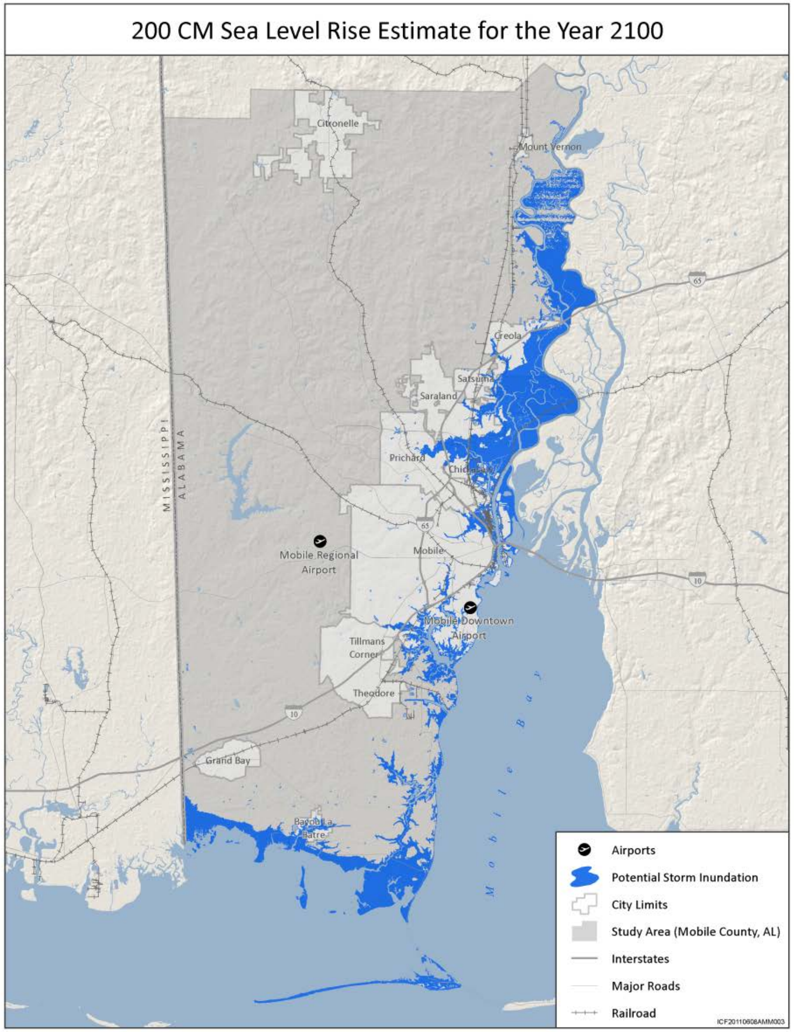
Projected Climate Data—Sea Level Rise





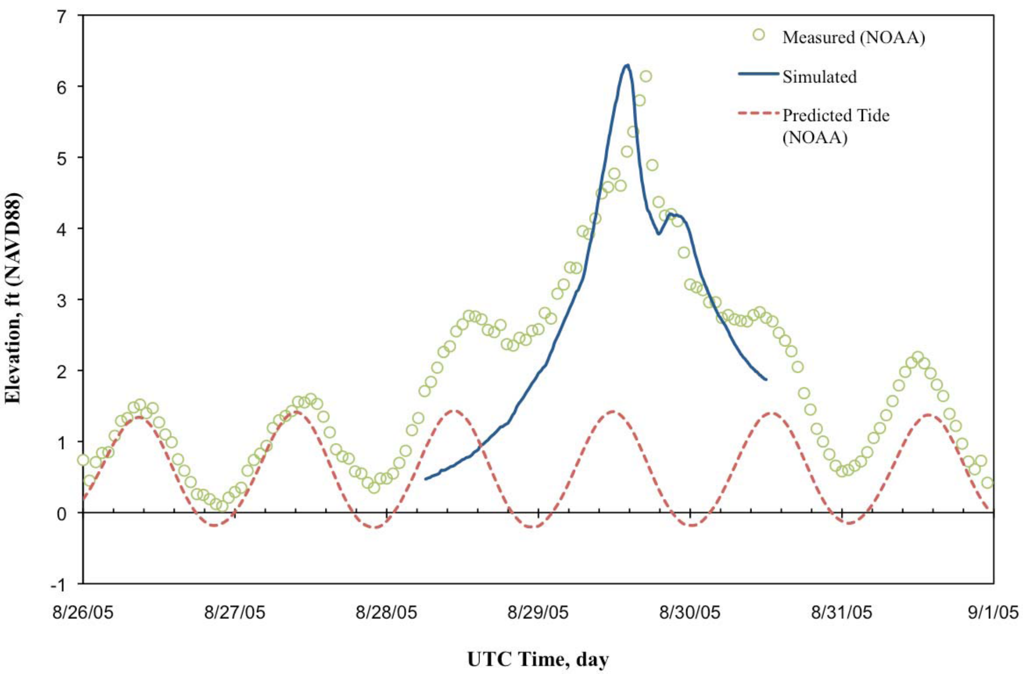
Projected Climate Data—Sea Level Rise





Storm Surge Modeling Simulations

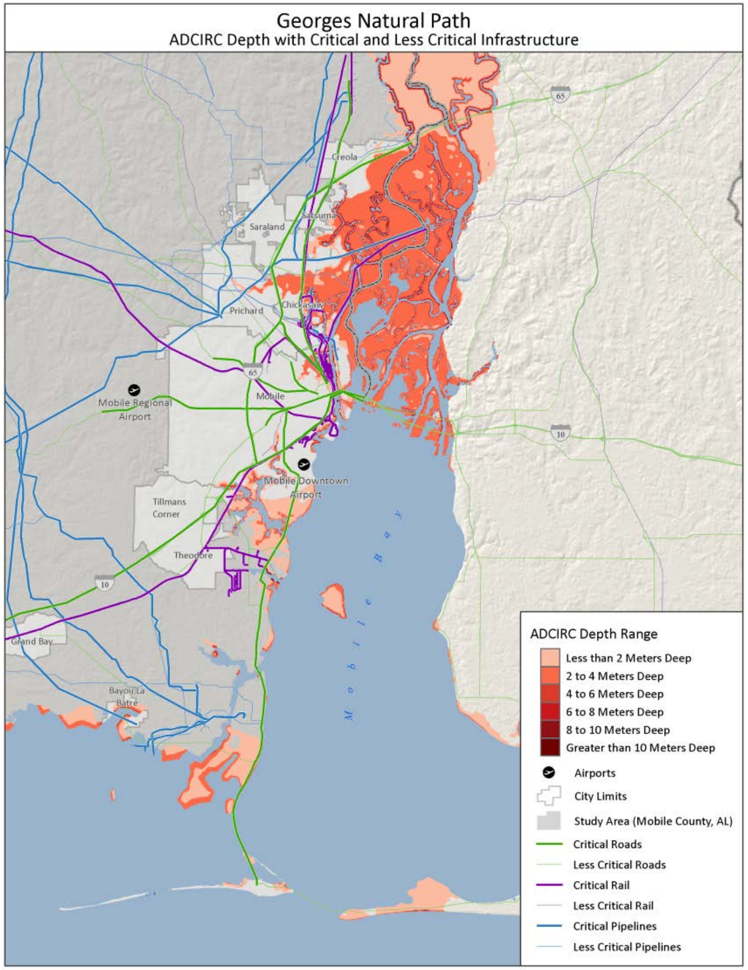
Katrina: Simulation vs. Observation

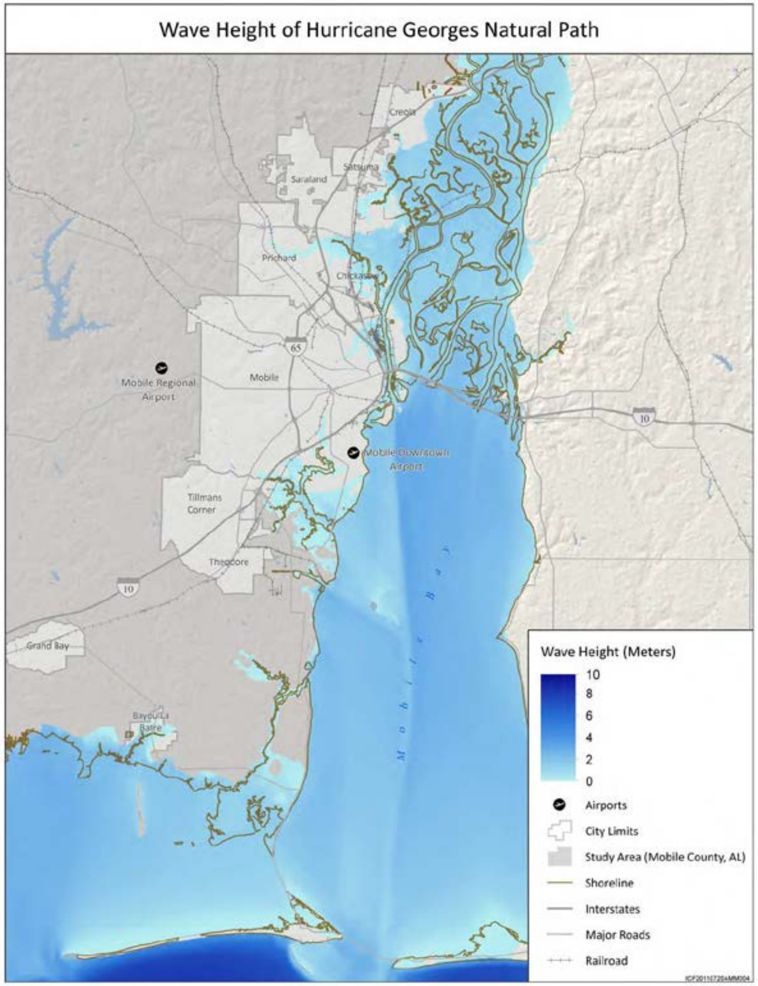


Hurricane Georges	Hurricane Katrina
Natural Path, No Sea Level Rise	Natural Path, No Sea Level Rise
Natural Path, 30 CM Sea Level Rise	Natural Path, 75 CM Sea Level Rise
Natural Path, 75 CM Sea Level Rise	Shifted, No Sea Level Rise
Natural Path, 200 CM Sea Level Rise	Shifted, 75 CM Sea Level Rise
	Shifted, Intensified, No Sea Level Rise
	Shifted, Intensified, 75 CM Sea Level Rise

Projected Climate Data—Storm Surge

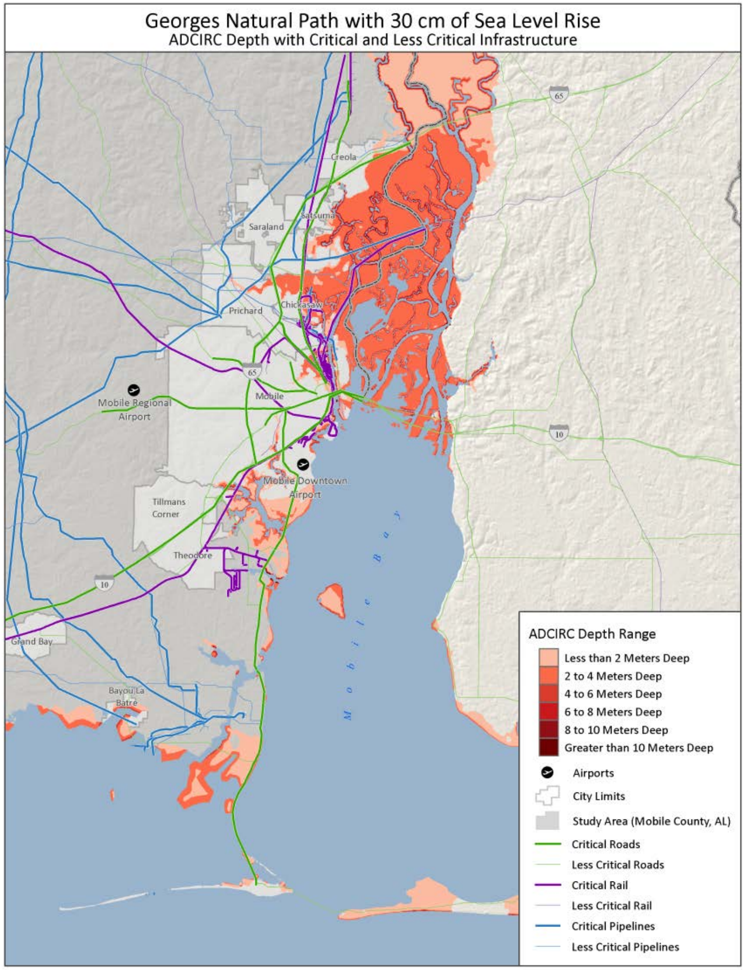
Georges Natural Path, No Sea Level Rise

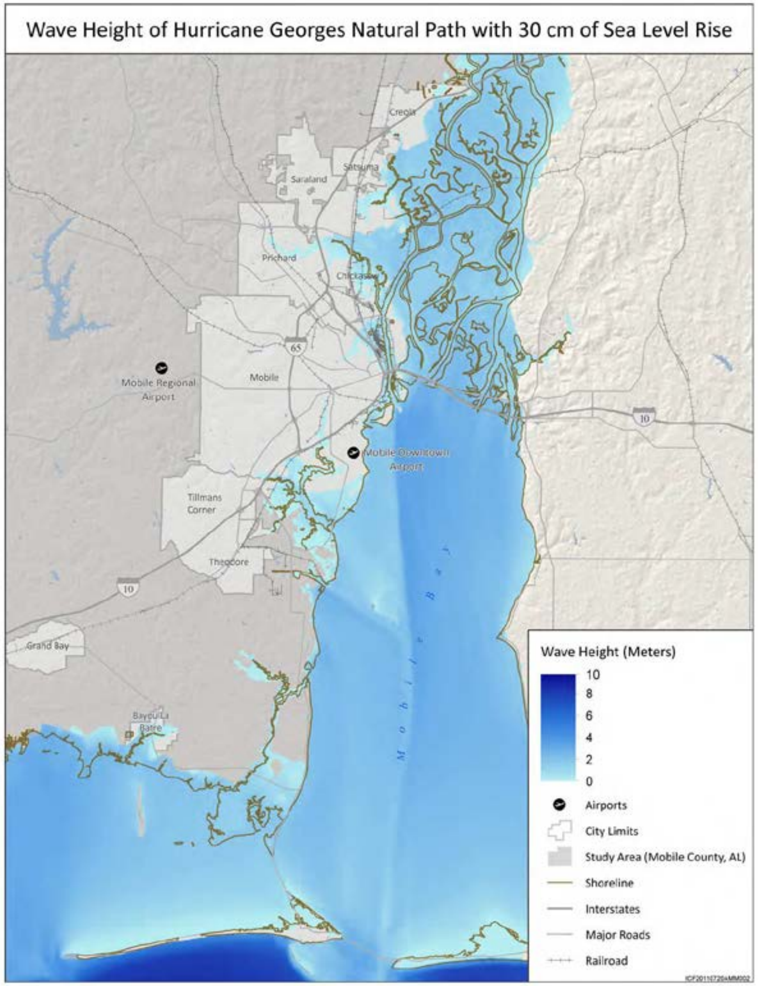




Projected Climate Data—Storm Surge

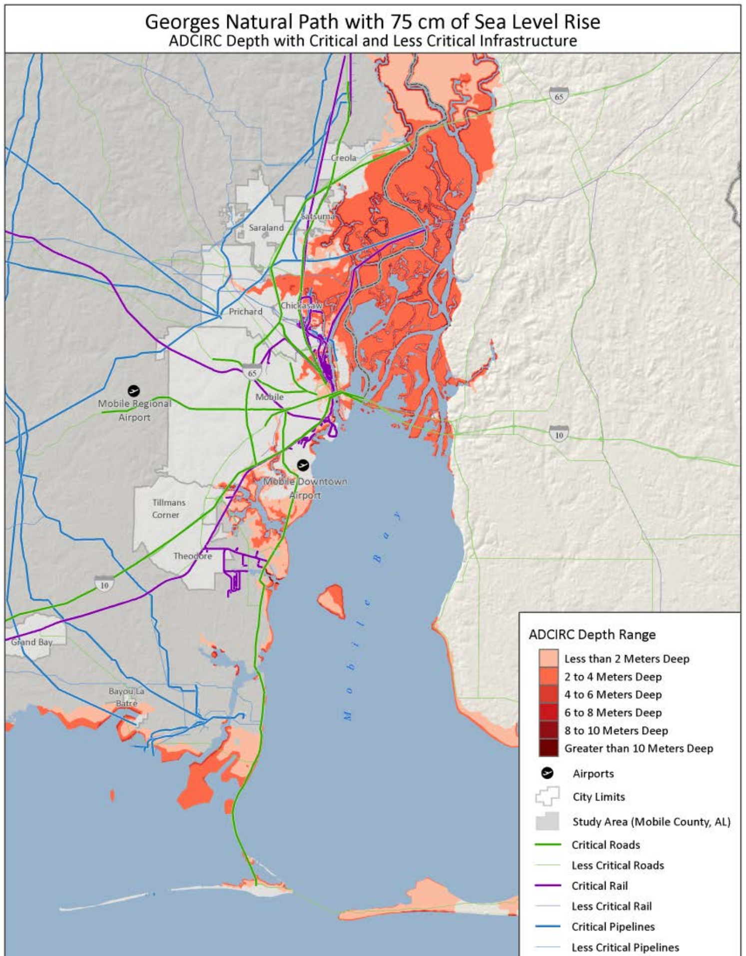
Georges Natural Path, 30 CM Sea Level Rise

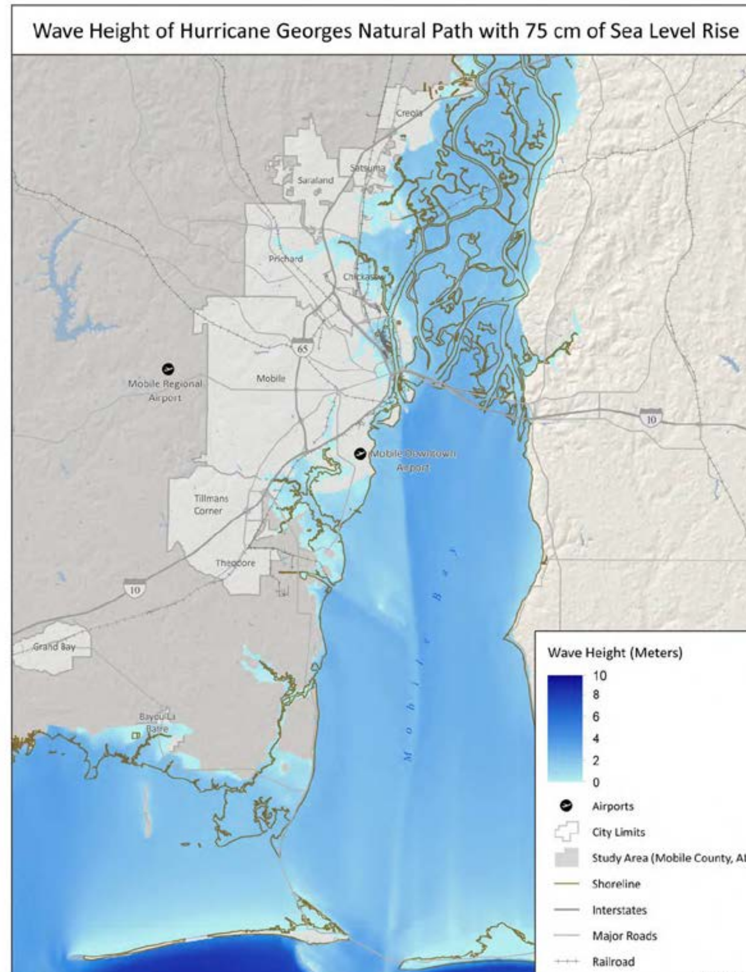




Projected Climate Data—Storm Surge

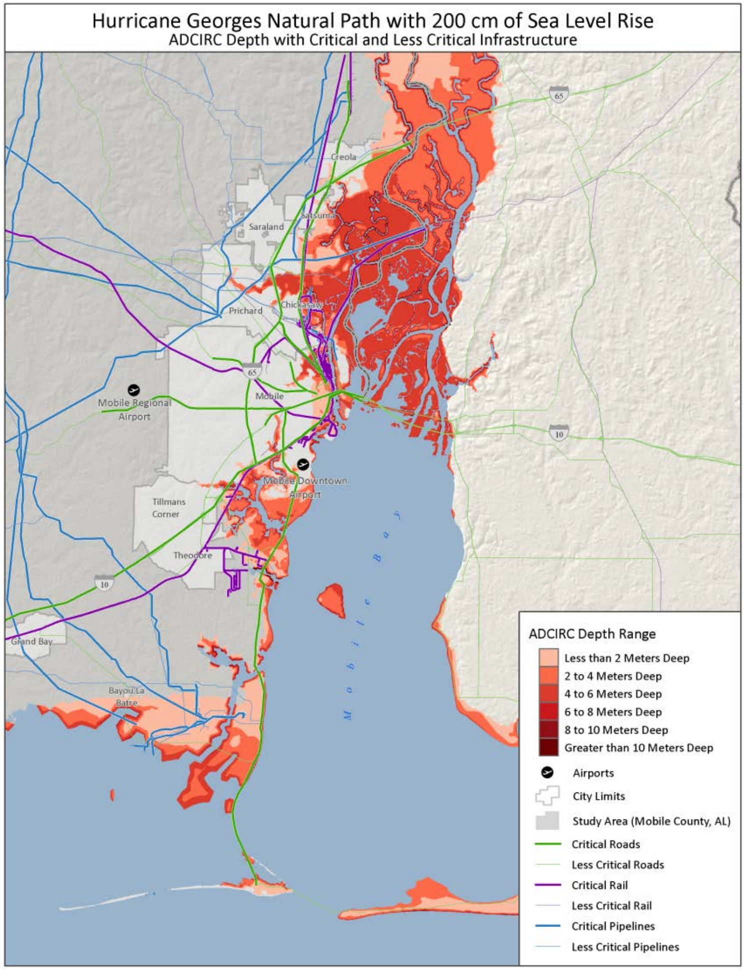
Georges Natural Path, 75 CM Sea Level Rise

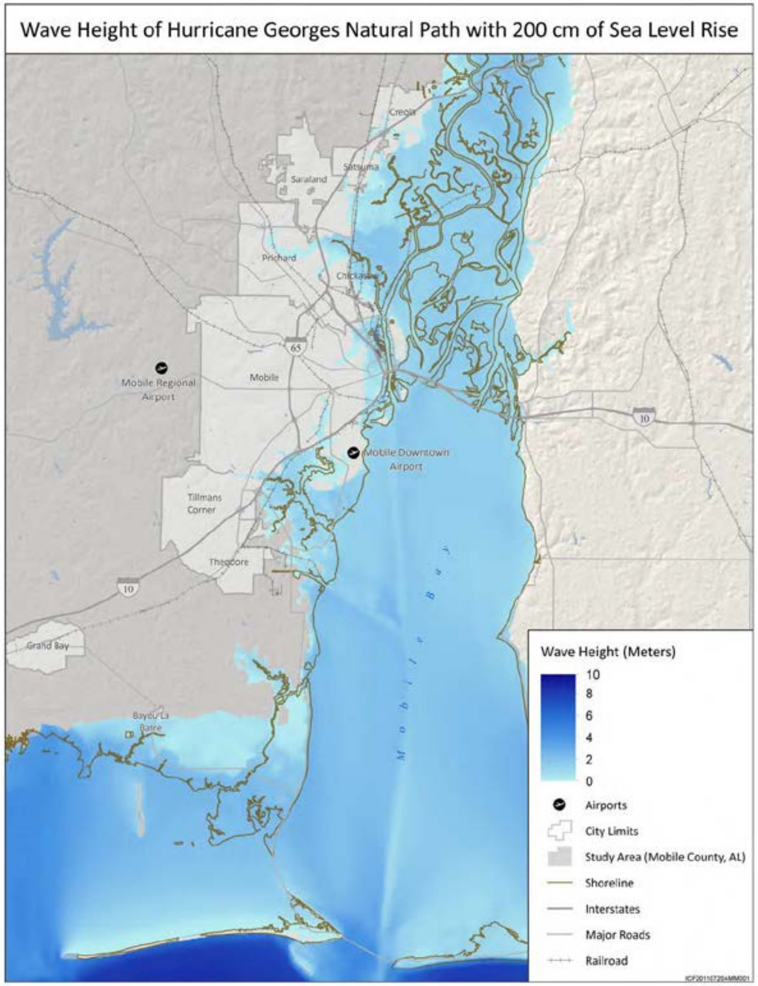




Projected Climate Data—Storm Surge

Georges Natural Path, 200 CM Sea Level Rise





Lessons Learned: Needed Data Can Be Difficult to Obtain

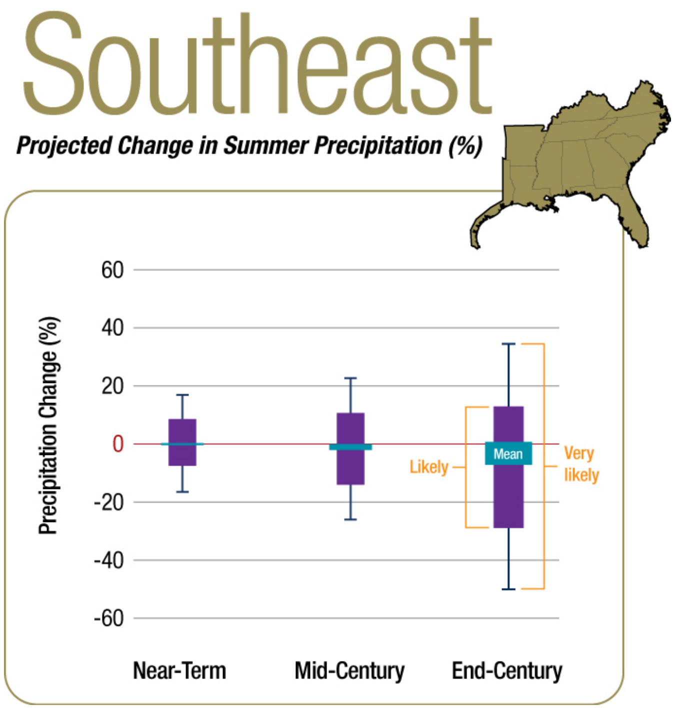
- **Site specific climate projections are difficult to find**
  - Downscaling global models is a complex activity
  - Universities are often important players in developing this data – have been partners in many assessments
  - Some national-level downscaled data available (climatewizard.org)
- **Transportation asset inventory data time consuming to assemble**
  - Many different sources even within one agency
  - Many different formats
  - LIDAR data does not capture all needed details

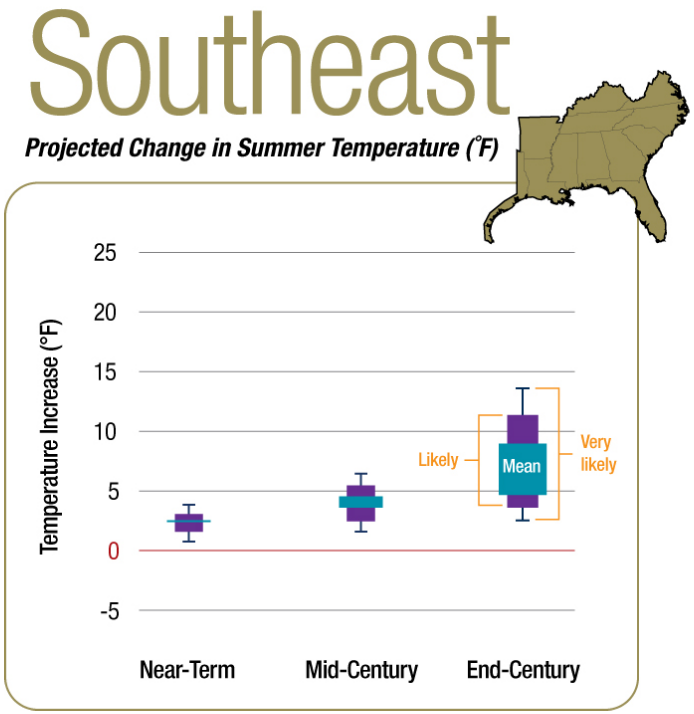
Lessons Learned (continued)

- **Interdisciplinary cooperation is key**
  - Need to include science information, engineering specifications, planning processes, etc.
  - Multi-disciplinary stakeholder communication is not easy
  - Understand existing decision-making processes and frameworks
- **Impacts and concerns will vary by region – no one-size-fits-all answers**

Lessons Learned: Embrace the Uncertainty

- **Must be comfortable with range of climate projections**
- **Not all climate trends are clear**





Thank you.

Sustainable Transport and Climate Change Team

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www.fhwa.dot.gov/hep/climate/gulf_coast_study

Gulf Coast Study: Task Objectives

- **Task 1: Identify critical transportation assets in Mobile**
- **Task 2: Climate impacts**
  - Develop climate information
  - Assess sensitivity of assets to climate stressors
- **Task 3: Determine vulnerability of critical assets**
  - Perform a qualitative assessment of vulnerability
  - Perform an engineering assessment of the most vulnerable assets
- **Task 4: Develop risk management tool(s)**
- **Task 5: Coordination with planning authorities and the public**
  - Ongoing task throughout project
- **Task 6: Information dissemination and publication**

Task 2.3: Analysis of Transportation Exposure to SLR, SS, and Wave Action

- **Overlay of transportation assets on:**
  - RSLR inundation
  - Storm surge inundation
  - Wave characteristics

- **Outputs to include:**
  - Number, type, area/length, criticality of assets exposed; single points of potential failure