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U.S. Department of Transportation
Federal Highway Administration

U.S. DOT Gulf Coast Study, Phase 2

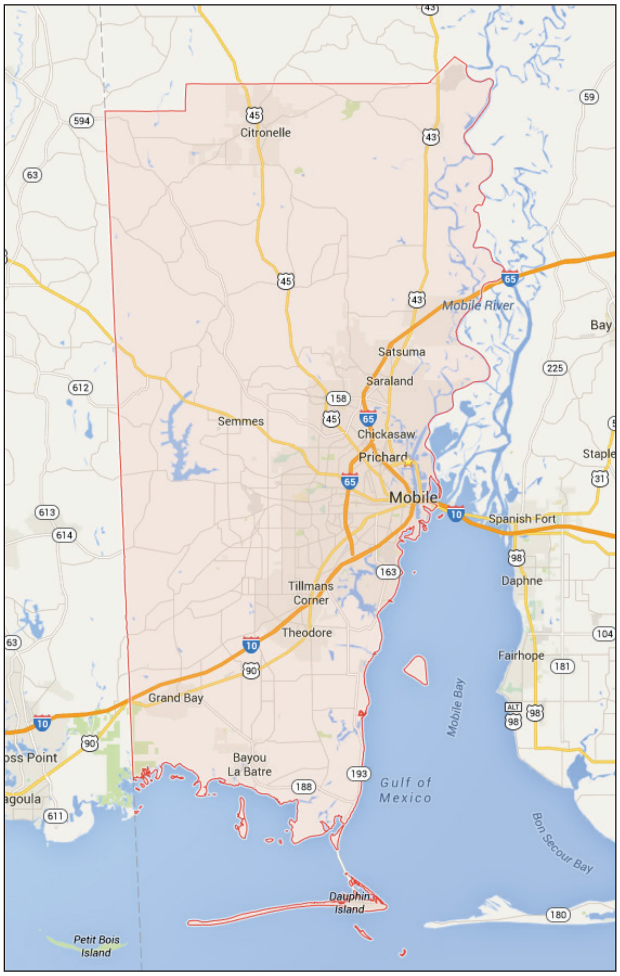
Task 2: Gather and Process Climate Information

Support for Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study Phase 2 developed methodologies for evaluating vulnerability and adaptation measures for local transportation systems. These transferrable methodologies were pilot tested in Mobile, Alabama. The project team evaluated the impacts on six transportation modes (highways, ports, airports, rail, transit, and pipelines) from projected changes in temperature and precipitation, sea level rise, and the surges and winds associated with more intense storms.

The second task of this project involved collecting and analyzing projected climate changes in the Mobile area. This information laid the foundation for a transportation vulnerability assessment conducted later in the project.

Objectives

- Quantify how key climate stressors—temperature, precipitation, sea level rise, storm surge, and wind—may change in Mobile under a range of time periods and greenhouse gas emissions scenarios
- Identify specific climate variables/thresholds most relevant to transportation decision making



Map of Study Area

Approach

The Gulf Coast Study took a comprehensive approach to climate projections for Mobile, developing projections covering 5 climate stressors, 3 emissions scenarios, 3 time periods, 3 sea level rise scenarios, and 11 coastal storm scenarios. Table 1 summarizes the approach used to gather and process climate change projections for Mobile.

Key Results & Findings

The analyses showed that Mobile is projected to experience a future that is hotter, with more extreme rainfall events and tropical storms augmented by sea level rise. A snapshot of temperature and precipitation projections is shown in Table 2. Both average and extreme temperatures are projected to increase over time. Precipitation projections are less clear-cut. Some precipitation variables are projected to increase, decrease, or stay the same depending on the emission scenario. However, heavy rain events will become more intense under all emission scenarios.

Table 1: Summary of Projected Climate Information Developed Under Phase 2 of the Gulf Coast Study

Climate Stressor	Scenarios	Timeframes	Approach
Temperature	B1, A2, and A1Fi emission scenarios	2010-2039 (near-term) 2040-2069 (mid-term) 2070-2099 (end-of-century)	Projections were statistically downscaled from a variety of global climate model outputs, and compared to the current baseline to estimate change. Projections were developed for numerous variables, tailored to transportation needs to the extent possible. Results focused on shorter-term extremes, such as number of days above 95 degrees.
Precipitation	B1, A2, and A1Fi emission scenarios	2010-2039 (near-term) 2040-2069 (mid-term) 2070-2099 (end-of-century)	Precipitation projections were calculated for several variables using the same approach for temperature. Variables were tailored to the needs of transportation practitioners and included changes in 24-hour rainfall associated with the 2, 5, 10, 20, 50, 100, and 500-year storms.
Sea Level Rise	30 cm (1 ft) of global sea level rise by 2050, and 75 cm (2.5 ft) and 200 cm (6.6 ft) by 2100		A range of possible global sea level rise values were selected based on a literature review. Then, global sea level rise values were adjusted based on local data on subsidence and uplift of land and modeled for Mobile to determine what locations would be inundated under each scenario.
Storm Surge and Wind	11 storm scenarios based on historical storms modeled with different trajectories, intensities, and sea levels	Not applicable	11 storm scenarios were developed using Hurricane Georges and Hurricane Katrina as base storms, and then adjusting certain characteristics of the storms (such as track, wind speeds, and central pressure) to simulate what could happen under alternate conditions. Storm surge depth and extent were modeled using the ADvanced CIRculation model (ADCIRC). ADCIRC also provided estimates of wind speeds. Wave characteristics were simulated using the STeady State spectral WAVE (STWAVE) model.

Table 2: Projected Changes in a Subset of Temperature and Precipitation Variables in Mobile, Alabama

	Near-term (2010-2039)	Mid-term (2040-2069)	End-of-century (2070-2099)
Temperature			
Average annual temperature	+1.4-1.6°F	+2.4-4.6°F	+3.2-7.7°F
Number of days above 95°F	+8-9 days	+15-37 days	+22-76 days
Precipitation			
Total annual precipitation	+4-4 inches	+3-7 inches	+0-9 inches
24-hour precipitation from the 100-year storm	+4-5 inches	+3-5 inches	+4-6 inches

Figure 1: Modeled Sea Level Rise Inundation with 6.6 feet (2.0 meters) of Global SLR

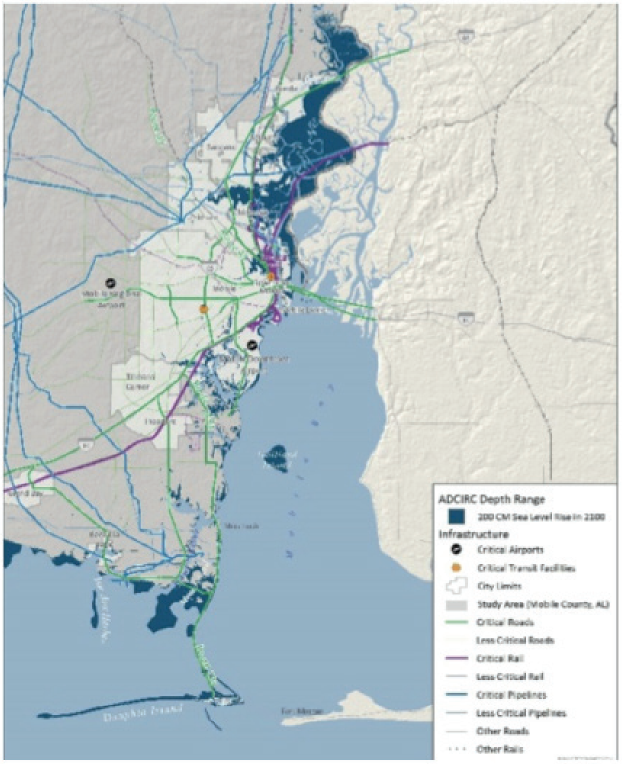
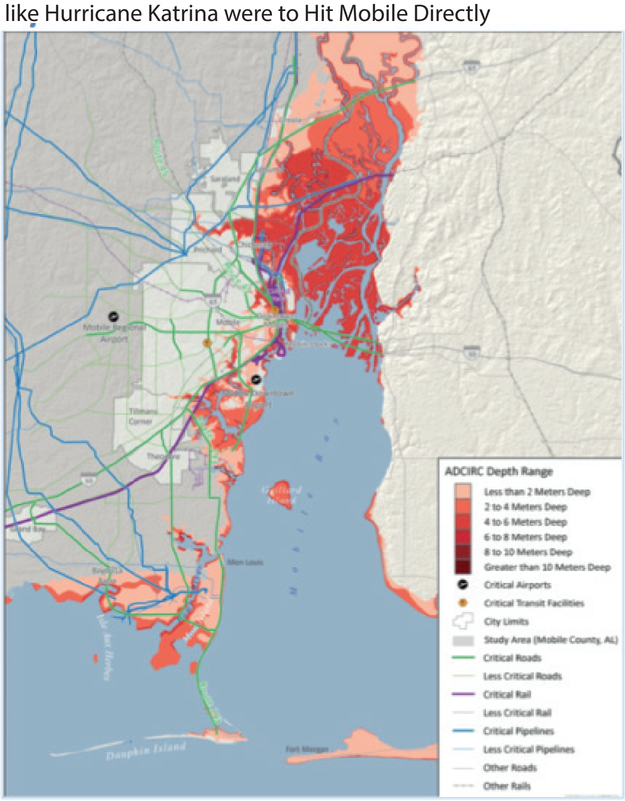


Figure 2: Modeled Storm Surge Depth and Extent if a Storm like Hurricane Katrina were to Hit Mobile Directly



The temperature and precipitation projections were used to develop climate narratives that were used in later tasks of the project. These narratives were defined as the mean of the results +/- 1.6 standard deviations (or, the 5th and 95th percentiles). The narratives were called "Warmer" and "Hotter" for temperature, and "Drier" and "Wetter" for precipitation. Development of climate narratives was necessary due to the large volume of data points arising from the initial climate projection analysis.

The study also found that sea level rise could inundate several areas in Mobile County. The lowest sea level rise scenario of 1 foot (0.3 meters) would inundate about four percent of critical roadway miles, for example, and also worsen storm surge from incoming storms. Under a scenario of 6.6 feet (2 meters) of sea level rise, about 13 percent of critical roadway miles, 20 percent of critical rail miles, and 24 of 26 critical ports would be inundated.

Finally, the study found that transportation infrastructure in Mobile is highly exposed to flooding from hurricanes and other tropical storms. If a storm like Hurricane Katrina were to directly hit Mobile, nearly half of the critical roadway miles would be inundated, along with 72% of critical rail lines, 92% of critical ports, and 65% of Mobile Downtown Airport (Figure 2). If an even more intense coastal storm were to hit Mobile, the vast majority of critical transportation infrastructure studied could be inundated.

Lessons Learned

Collecting, interpreting, and utilizing information about projected changes in climate can be complicated at best, and daunting at worst. However, careful scoping can dramatically reduce the resources needed to develop the information. Lessons learned include:

- It is essential to consider what types of data (e.g., climate stressors, time frames, and scenarios) will be most useful for the vulnerability assessment prior to data collection.
- Selected data thresholds should correspond to inputs to transportation design, operations, and maintenance decisions.
- It is important to engage transportation engineers when determining the data to develop.
- More is not necessarily better when it comes to climate projection data. Early climate data scoping exercises can help zero in on the data that will be most informative.

Tools and Resources for Gathering and Processing Climate Information

Several new resources have become available since climate information for the Gulf Coast study was developed. Statistically downscaled climate data for the entire country are now available, and sea level rise scenarios have been modeled for most of the United States coastline. A few of these resources are summarized in Table 3.

Table 3: New Tools and Resources for Gathering and Processing Climate Information

Climate Stressor	Resource
Temperature, Precipitation	**CMIP Climate Data Processing Tool – U.S. DOT** Developed under the Gulf Coast Study as a direct result of the lessons learned in Task 2, the CMIP Climate Data Processing Tool is an Excel-based tool that calculates transportation-specific temperature and precipitation variables at the local level from downscaled climate model data. The list of 59 specific output variables represents the variables identified as being relevant to transportation practitioners under this study. The tool relies on data from the U.S. Bureau of Reclamation's Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections database.
Temperature, Precipitation, Runoff, Snow, Soil Moisture	**National Climate Change Viewer – USGS** Web viewer providing projections at the county and state level based on statistically downscaled CMIP5 data. The viewer Includes projections of high temperatures, low temperatures, precipitation, runoff, snow, soil water storage, and evaporative deficit, and for each variable it provides annual and monthly averages, as well as the 10th, 25th, 50th, 75th, and 90th percentiles for near-term, mid-term, and end-of-century.
Sea Level Rise	**Sea Level Rise and Coastal Flooding Impacts Viewer – NOAA Coastal Services Center** Web viewer (with geospatial data available for download) showing the depth and extent of inundation for the entire United States coastline for sea level rise scenarios ranging from 1 foot to 6 feet.
Sea Level Rise	**Sea-Level Change Curve Calculator – U.S. Army Corps of Engineers (USACE)** Online calculator that estimates relative sea level rise at a given location for each year until 2100, given local subsidence/uplift and a range of global sea level rise scenarios.
Sea Level Rise	**Sea Level Rise Affecting Marshes Model (SLAMM)** Mathematical model that uses elevation data and other information to simulate potential impacts of long-term sea level rise on wetlands and shorelines.

For More Information

Resources:

Gulf Coast Study:
http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/

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