



Task 2: Climate Information

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Three main areas of work:

- Collect historical and projected weather and climate data
- Conduct storm surge and wave modeling, sea-level rise (SLR) analysis, and estimate potential inundation of transportation assets (i.e., exposure)
- Assess the extent to which particular transportation systems are affected by climate variations (i.e., sensitivity)



Setting the Stage for Task 3



Task 2: Climate Information

Historic and Observed Climate and Weather Data

Historic and Observed Climate and Weather Data—Approach



Approach for Collecting Observational Data:

Step 1. Identifying the Variables

Has the variable demonstrated impacts on the transportation system in Mobile? And/or is the variable anticipated to impact in the future?

Are observations available for this variable (preferably from a national site for replicability)?

Are projections for this variable available?

Resulting Variables

Temperature

Precipitation

Runoff

Sea Level Rise






Storm Events

Historic and Observed Climate and Weather Data—Approach



Step 2: Determining Best Data Available

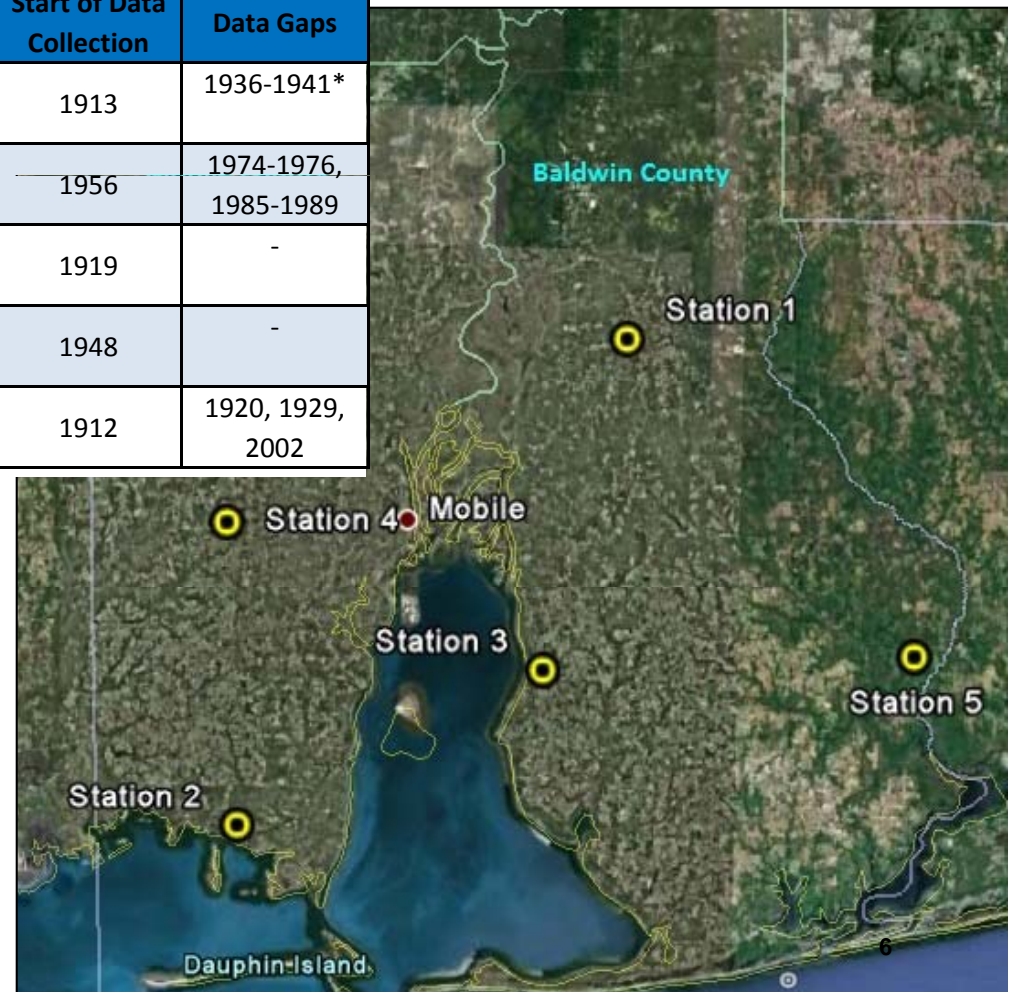
- Criteria: Availability, Replicability, Temporal/Spatial Resolution, Record-length

Step 1. Identify variables	Step 2. Data specifications	Source
Temperature	Daily averages of minimum, maximum, mean temperature 5 station locations (2 in Mobile, 3 in Baldwin)	 USGS <i>science for a changing world</i>
Precipitation	Daily total precipitation 5 station locations	 USGS <i>science for a changing world</i>
Runoff	Monthly data for the 4 hydrologic units in Mobile from 1900-present	 USGS <i>science for a changing world</i>
Sea Level Rise	Dauphin Island, AL : 1967 to 2009 Pensacola, FL : 1924 to 2008	 NOAA
Storm Events	Varies, described in part, by precip and runoff	 NOAA 5

Historic and Observed Climate and Weather Data—Temperature and Precipitation



Station	Station ID # Name	County	Temperature		Precipitation	
			Start of Data Collection	Data Gaps	Start of Data Collection	Data Gaps
Station 1	USC00010583 Bay-Minette	Baldwin	1915	1936-1941*	1913	1936-1941*
Station 2	USC00011803 Codan	Mobile	1956	1974-1976, 1985-1989	1956	1974-1976, 1985-1989
Station 3	USC00012813 Fairhope	Baldwin	1918	1929, 1963- 2010**	1919	-
Station 4	USC00015478 Mobile	Mobile	1948	-	1948	-
Station 5	USC00016988 Robertsdale	Baldwin	1935	2002-2003	1912	1920, 1929, 2002



Historic and Observed Climate and Weather Data—Temperature and Precipitation



Historic/Observed Average Annual Mean Temperature

Average Annual Mean Temperature				
Station	1980-2009		1926-2009	
	Mean °F (°C)	Standard deviation	Mean °F (°C)	Standard deviation
<u>Bay-Minette</u>	66.9 (19.4)	31.2 (0.4)	67.2 (19.6)	31.0 (0.6)
<u>Coden</u>	66.0 (18.9)	31.2 (0.4)	66.5 (19.2)	31.0 (0.6)
Fairhope			68.0 (20.0)	30.9 (0.6)
Mobile	67.3 (19.6)	31.2 (0.5)	67.5 (19.7)	31.1 (0.5)
Robertsdale	66.4 (19.1)	30.9 (0.6)	66.8 (19.3)	30.8 (0.7)

Historic and Observed Climate and Weather Data—Temperature and Precipitation



Historic/Observed Total Annual Precipitation (Inches)

	1980-2009		1926-2009	
	Mean	Std Dev	Mean	Std Dev
Bay-Minette	69.1	(16.1)	64.7	(14.0)
Coden	67.1	(13.4)	64.2	(13.8)
Fairhope	68.0	(12.3)	65.1	(13.1)
Mobile	66.7	(11.3)	66.1	(11.2)
Robertsdale	66.6	(13.0)	66.7	(14.0)

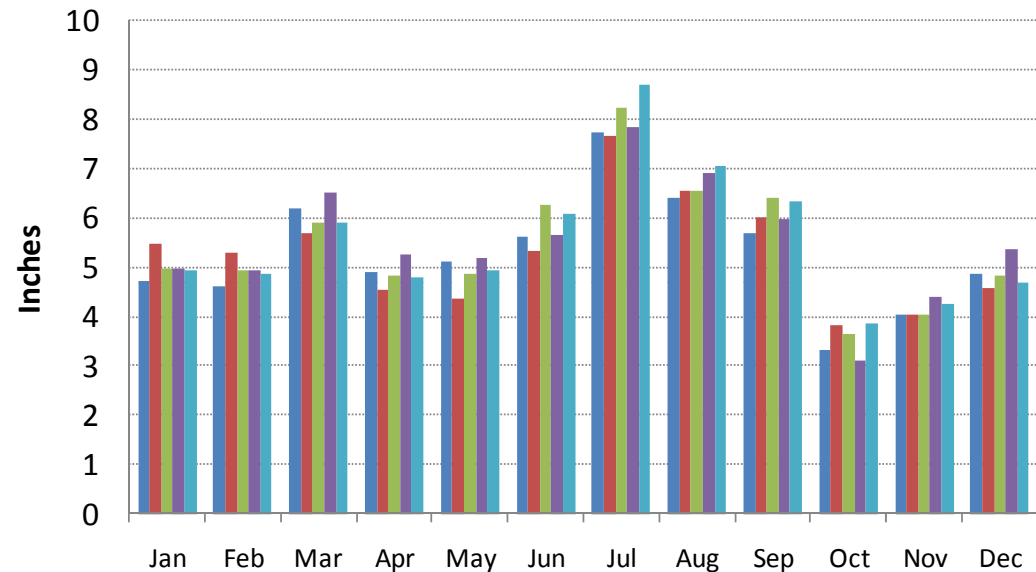
Historic and Observed Climate and Weather Data—Storm Events



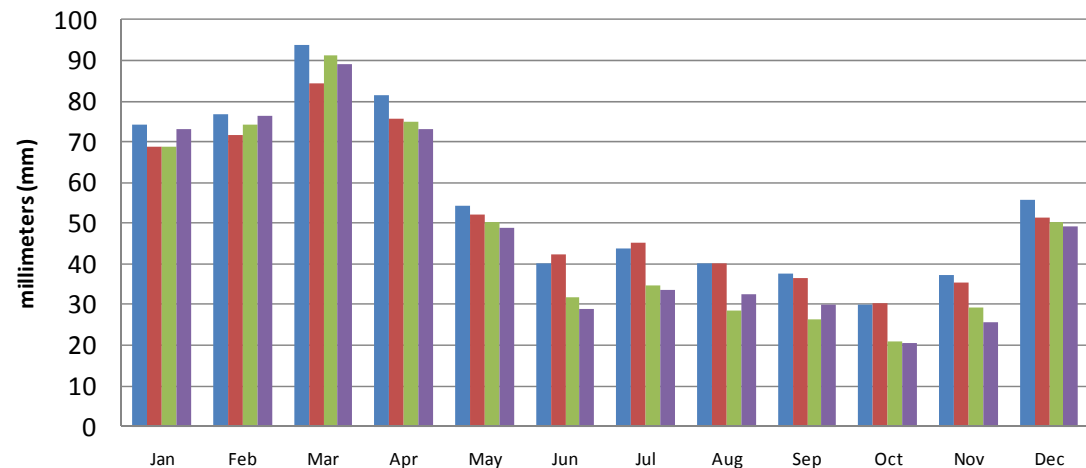
Storm Events

- Severe tornado-producing thunderstorms in March, April, May and October, November, December
- Flash flood season in late winter/early spring
- Tropical cyclones/hurricanes from June through November

Average Total Monthly Precipitation



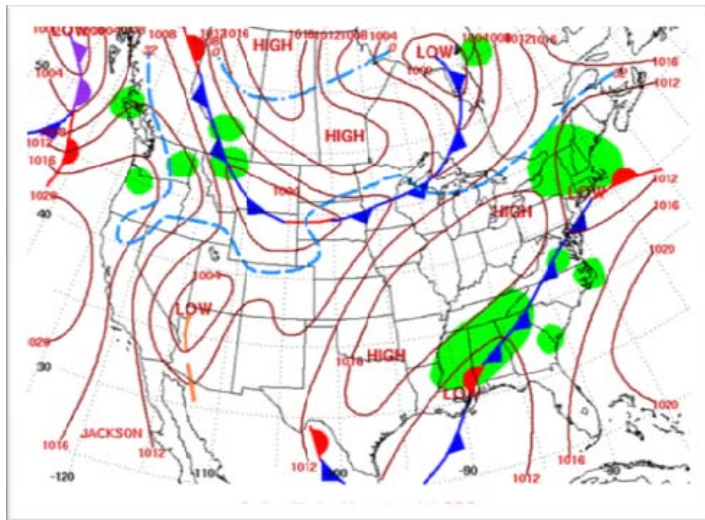
Average Monthly Runoff



Historic and Observed Climate and Weather Data—Storm Events



Investigated 5 Case Studies



Description of storm damage to transportation infrastructure

Example: April 4-5, 2008	Value at Peak Storm Intensity	Value averaged across surrounding days
Surface Temperature – Max.	82 °F	77 °F
Surface Temperature – Min.	60 °F	61 °F
Precipitation Totals	8.32 in over 15 hr	-
Precipitation Rate	1.71 in/hr	-
Runoff/Discharge		
- Crooked Creek	300 ft ³ /s	12 ft ³ /s
- Chickasaw Creek	3000 ft ³ /s	275 ft ³ /s
- Fowl River	500 ft ³ /s	40 ft ³ /s
Wind Gusts	31 mph	-
Sustained Winds	23 mph	-
Surface Pressure	1003-1004 mb	1009 mb
Highest observed water level		
- Dauphin Island	1.58 ft	0.71 ft
- Mobile Docks	2.04 ft	0.97 ft
- Pensacola	1.58 ft	0.95 ft

Historic and Observed Climate and Weather Data—Storm Events



NEW: A request to Mobile Stakeholders, please send any information (anecdotal or literature) of impacts on Mobile for the following 5 storm event case studies to Kevin Harrison by August 29, 2011:

- Severe Thunderstorm and Tornado Outbreak, November 15, 2006
- Severe Hailstorm, March 5, 1998
- Heavy Rain Event, April 4-5, 2008
- Hurricane Georges, September 28, 1998
- Hurricane Katrina, August 29, 2005



Task 2: Climate Information

Projected Temperature, Precipitation, & Runoff Information


Projected Climate Data—Temperature and Precipitation



- **Projecting Variables:**

- Through an interagency agreement, USGS provided statistically downscaled projections for **temperature** and **precipitation**:
 - Temperature: Daily minimum, maximum, average
 - Precipitation: Daily totals
 - Three time horizons (2010-2039, 2040-2069, 2070-2099)
 - 4 to 10 Climate models (PCM, Hadley, ...)
 - 3 emission scenarios (A1fi, A2, B1)
 - Projected at the 5 observed station locations
- Secondary variables were calculated from daily temperature and precipitation (*ex., total number of days and maximum consecutive days of high temperatures at or above 95°F, 100°F*)

Projected Climate Data—Temperature and Precipitation

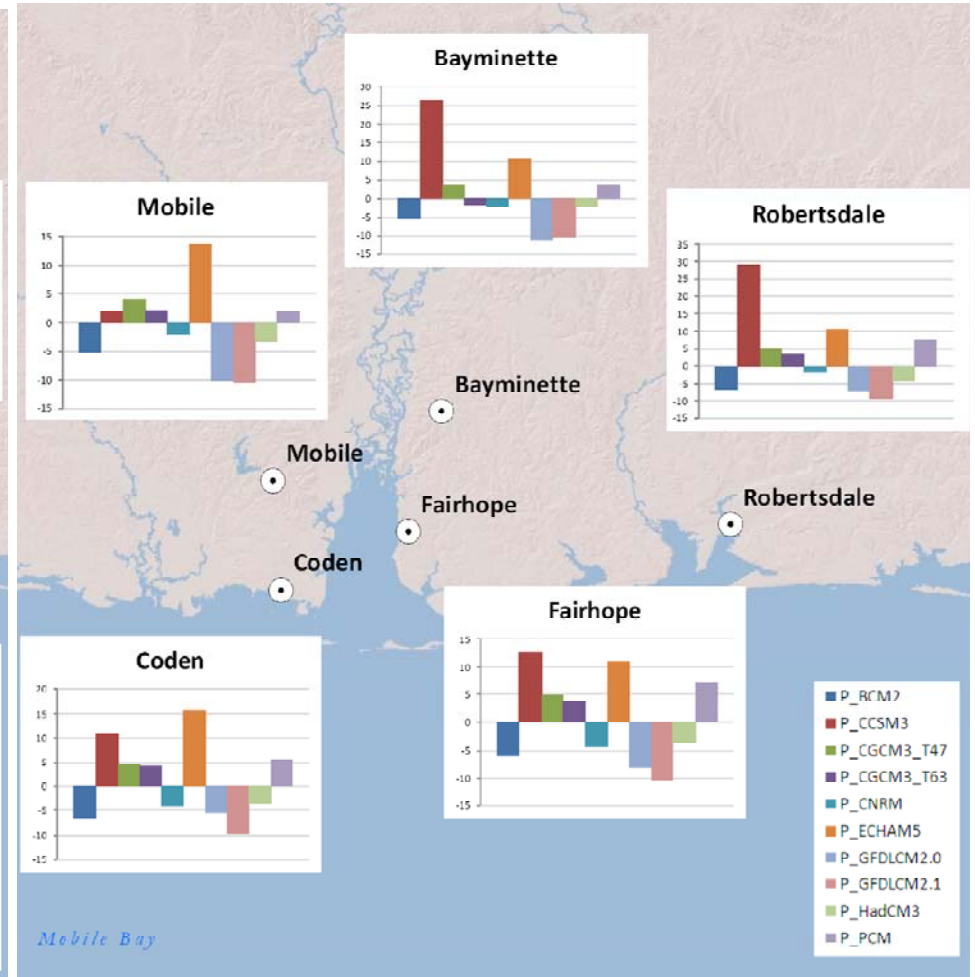
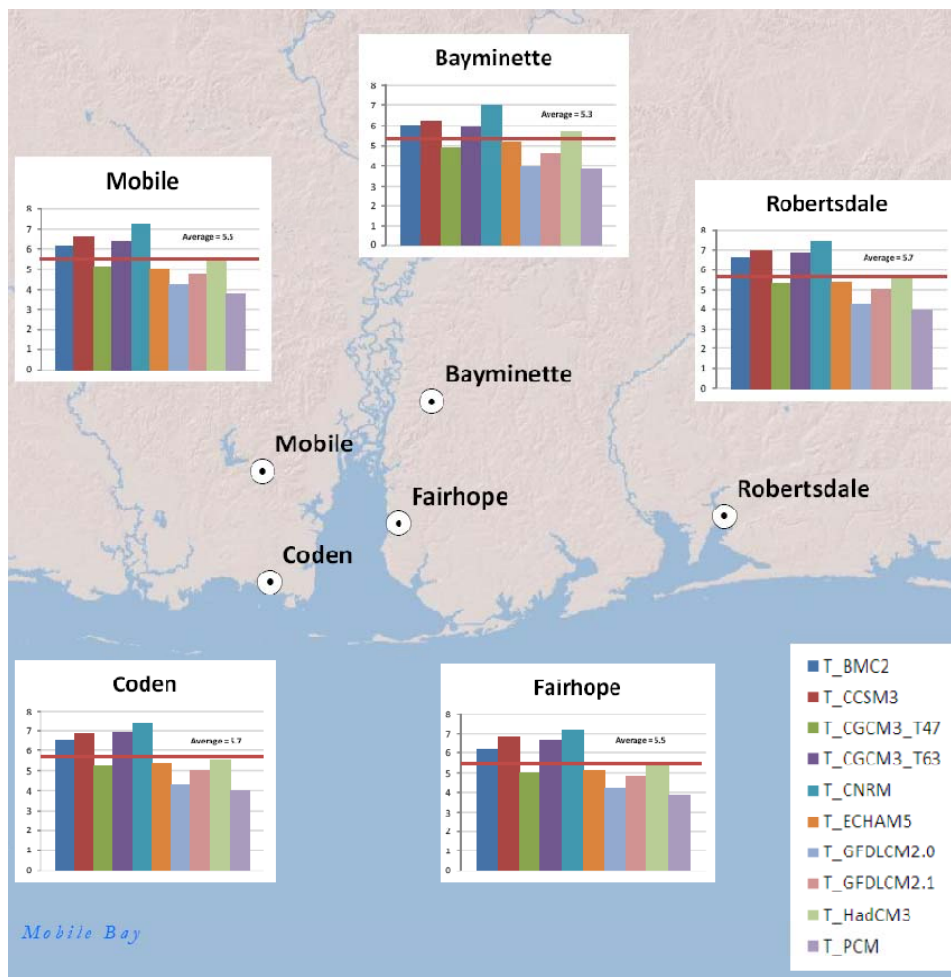
	<p>1. Annual, seasonal and monthly total precipitation; Annual, seasonal, and monthly average minimum, maximum, and mean temperature</p>	<p>6.</p>	<p>Maximum 7-day average air temperature per year with the % probability of occurrence during each 30-yr period (mean, 50%, 90%, 95%, 99% occurrence)</p>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

Projected Climate Data—Temperature and Precipitation



Annual Mean Temperature, End of Century (A2)

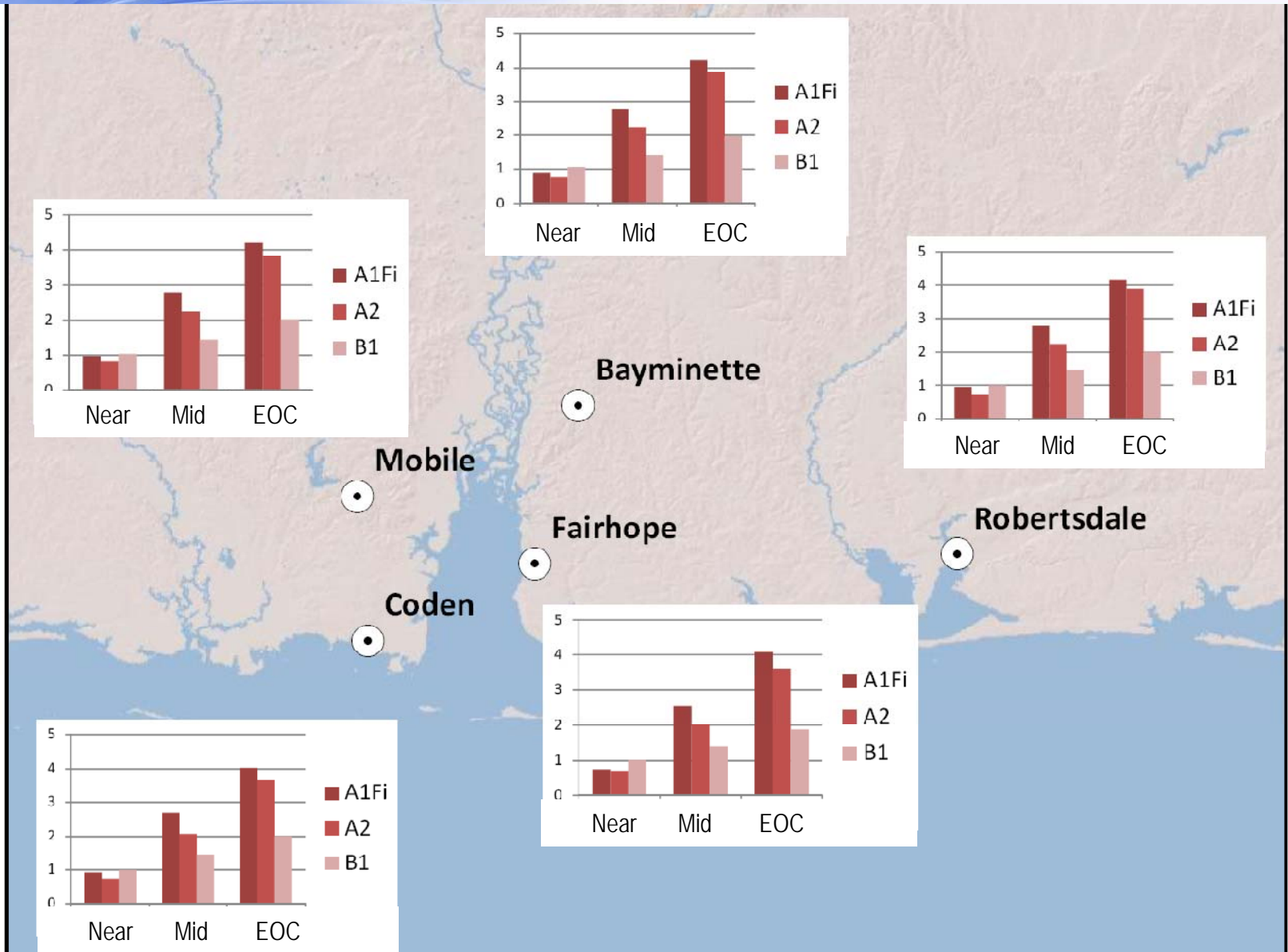
Annual Total Precipitation, End of Century (A2)



Projected Climate Data—Temperature and Precipitation

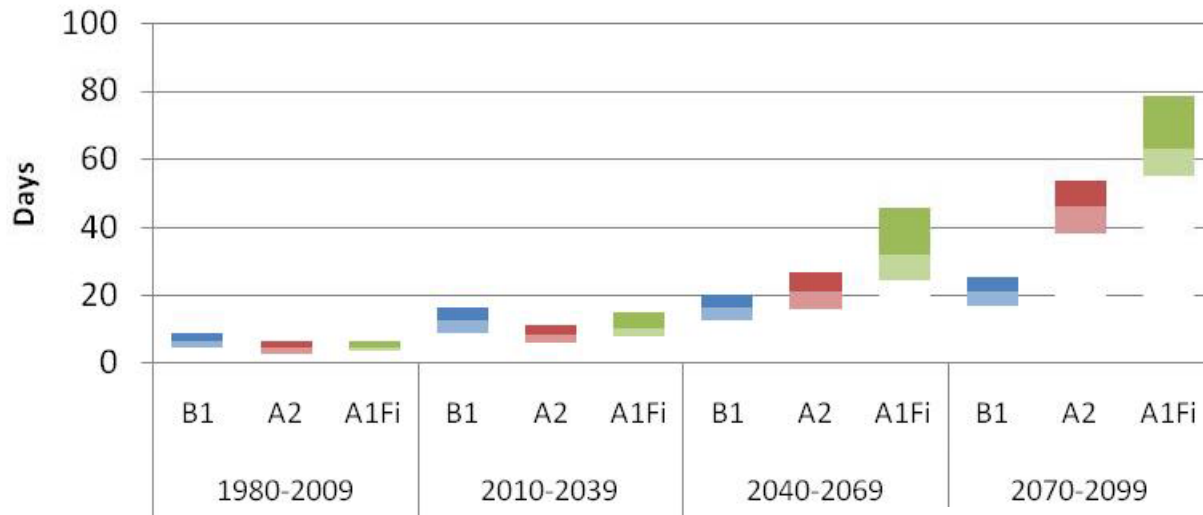


Increase in Maximum Projected Temperature (°F)



Projected Climate Data—Temperature and Precipitation

Number of Days Per Year Above 95°F



Maximum Number of Consecutive Days Above 95°F



Projected Climate Data—Temperature and Precipitation



Key Points

- Projected increases of temperature effects tend to grow with future time and increased emissions
- By end of century, Annual Average Mean Temperature is projected to increase between 3.1°F (B1) to 6.2°F (A1Fi)
- Projected changes in Average Annual Total Precipitation is not significant but, for some scenarios and time periods, summers will dry while winters/falls become wetter (up to +/-10%)
- Average annual maximum 3-day precipitation total increases ~0.5” in winter, fall, spring across scenarios

Projected Climate Data—Temperature and Precipitation



NEW: A request to Mobile Stakeholders:

- By Monday, August 15, 2011, a series of figures illustrating both the 30-year projections and the observed climate effects will be provided.

Please send any comments to Kevin Harrison by August 29, 2011.

Projected Climate Data—Runoff & Storm Events



- The USGS Monthly Water Balance model (modified Thornthwaite model) provide monthly projections of:
 - Runoff,
 - Soil moisture,
 - Evapotranspiration,
 - Soil moisture storage

There is a lot of uncertainty with runoff!

- A literature review serves as the basis for projecting anticipated changes in local storm events (ex., change in intensity and frequency of Atlantic hurricanes).

Projected Climate Data—Temperature, Precipitation, and Runoff



Any questions on projected data for temperature, precipitation, or runoff?