3.11: Climate Change/Sea Level Rise Risk Assessment

Hazard Description

The National Aeronautics and Space Administration (NASA) defines climate change (often referred to as global warming) as a long-term change in the average weather patterns that have come to define the Earth's local, regional, and global climates. The Wood's Hole Oceanographic Institution defines sea level rise as an increase in the ocean's surface height relative to the land in a particular location. Sea level rise is generally considered symptomatic of climate change or global warming. Two major factors typically influence sea levels on a regional or global basis. First, the warming of the ocean causes it to expand. This effect, confined mostly to the ocean's top 2,300 ft (701 m), is called thermal expansion or thermosteric expansion. Second, the melting of glaciers and other bodies of ice causes the total mass of water in the oceans to increase.

The heat energy causing both thermal expansion and ice melting comes from the warming of the atmosphere, which is primarily believed to be influenced in recent decades by human activities. Retention of liquid water on the continents by damming of rivers, for example, makes a small negative contribution to sea-level rise by withholding some water from the oceans.

Hazard Profile

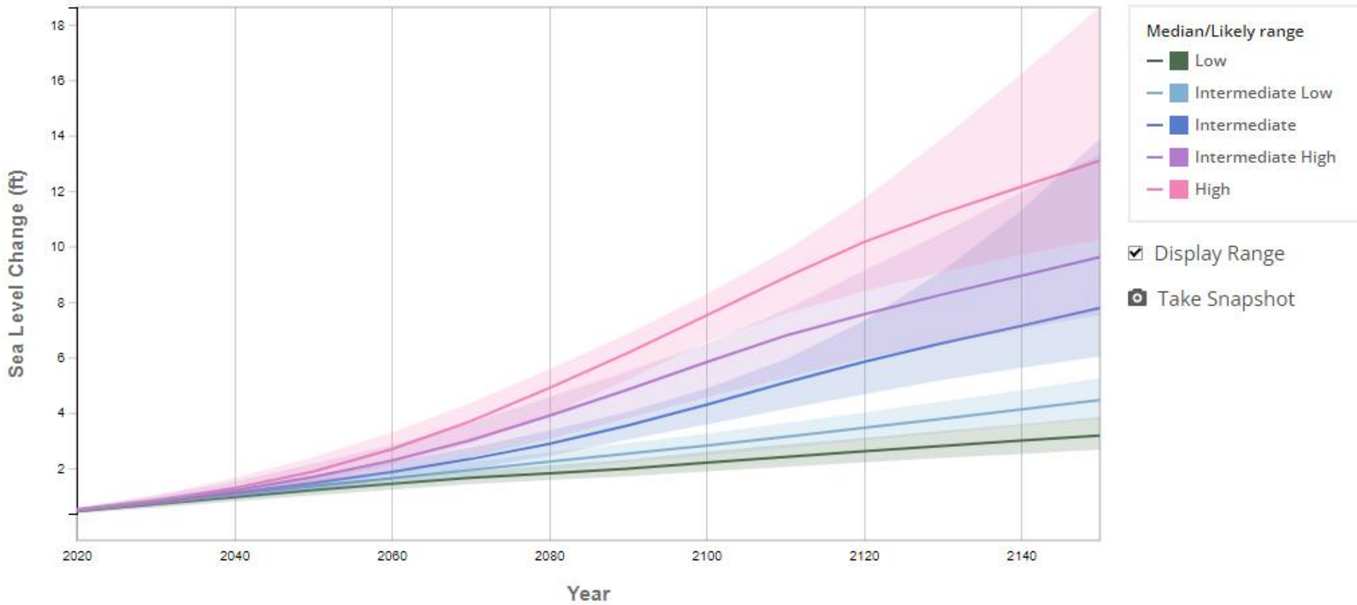
Scientists agree that the changes in climate that we are seeing today are largely caused by human activity and that climate change is driving increases in sea levels. Sea levels started rising in the late 1800s, and soon after we started burning coal, gas, and other fossil fuels for energy. When burned, these high-energy fuel sources send carbon dioxide up into the atmosphere. Carbon dioxide absorbs heat from the sun and traps it, warming the atmosphere and the planet.

As the planet gets warmer, the sea levels rise for two reasons. First, warmer temperatures cause ice on land like glaciers and ice sheets to melt, and the meltwater flows into the ocean to increase the sea level. Second, warm water expands and takes up more space than colder water, increasing the volume of water in the sea.

The Intergovernmental Panel on Climate Change (IPCC), a key body that publishes the scientific consensus on global warming, has suggested that average global sea levels have risen by around .12 inches annually since the early 1990s. That number is expected to increase in the coming decades as the effects of climate change continue, leading to an increase of somewhere between 2.5 feet and 6.2 feet by 2100, according to an analysis of IPPC projections published in the journal *PNAS* (Proceedings of the National Academy of Sciences).

In the late 1800s, after two or three thousand years of stability, the sea level began to rise steadily at about 0.07 inches per year. From 1993 to 2007, the rate of sea-level rise increased to about 0.12 inches per year. Recent data compiled by The Water Institute indicates that sea levels specific to the Gulf of Mexico and the Mississippi Gulf Coast may be increasing at a rate faster than that indicated in earlier IPCC reports. **Figure 3.11.1** illustrates a variety of projected sea level increase scenarios through the year 2140 at the Bay Waveland Yacht Club located in Bay St. Louis, Mississippi.

Figure 3.11.1
Sea Level Projections 2020-2140
Bay Waveland Yacht Club, Mississippi



In addition, **Figure 3.11.2** illustrates the potential impacts of an additional 3' of sea level rise on the Mississippi Gulf coast.

Figure 3.11.2
3' of Sea Level Rise
Mississippi Gulf Coast

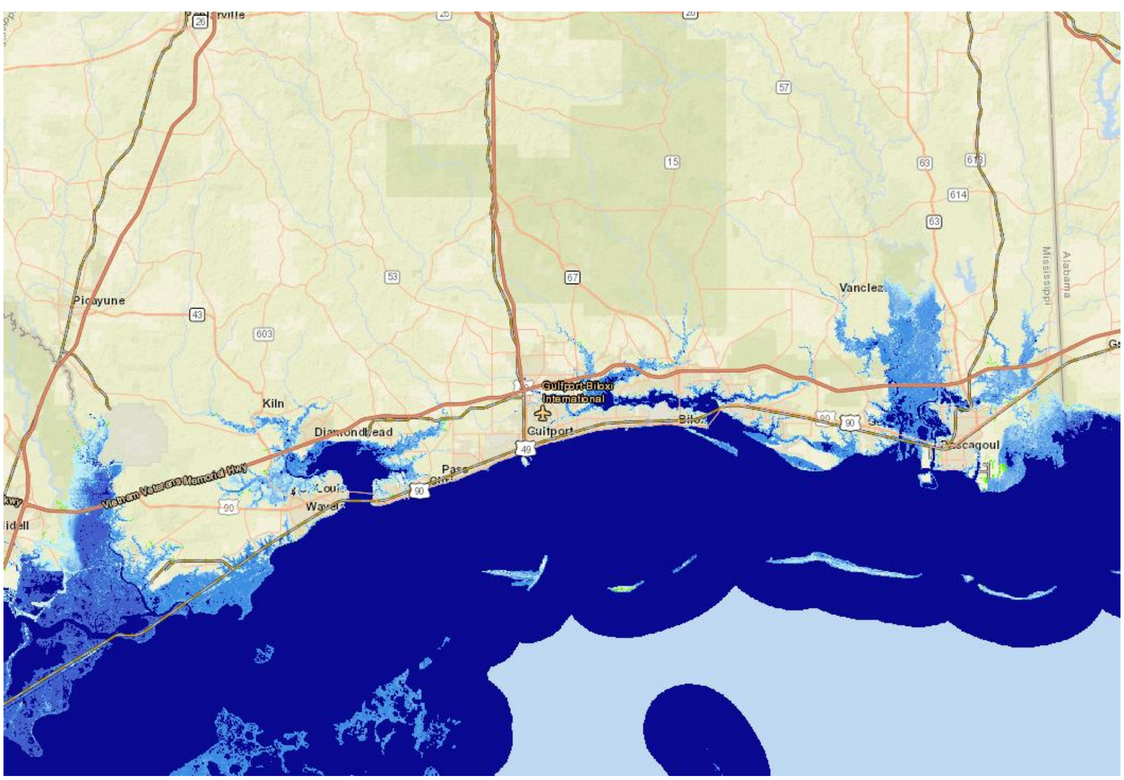
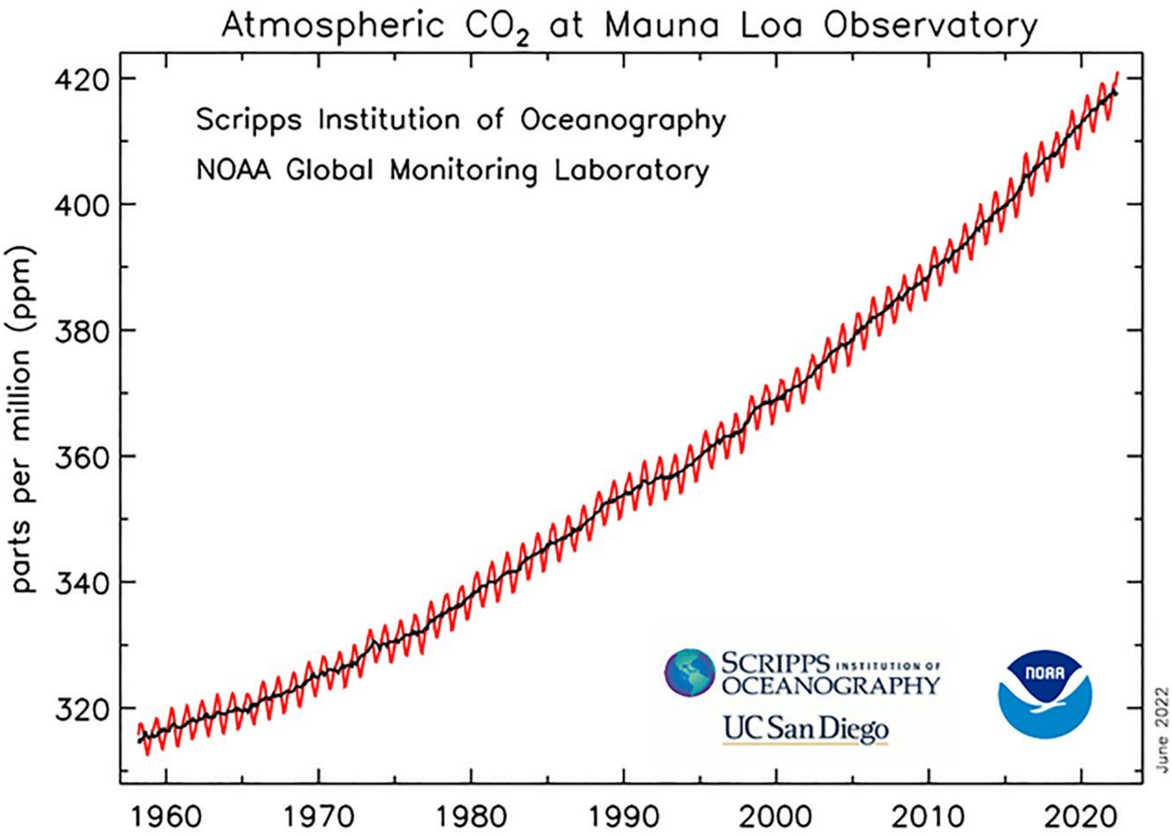


Figure 3.11.3
Carbon Dioxide Emissions



Source : NOAA.gov

Figure 3.11.3 depicts measurements of carbon dioxide in the atmosphere since 1958. The amount of carbon dioxide (CO2) in the atmosphere has been measured at Mauna Loa Observatory in Hawaii since the 1950s. There has been a steady rise in carbon dioxide since the measurements began, and you can see the rise and fall yearly due to plants growing and absorbing CO2 every spring and summer. In 2015, the annual growth rate jumped by 3.05 parts per million, the largest year-to-year increase in their 56 years of measurements.

Some scientists surmise that over the past 20,000 years or so, sea levels have increased approximately 400 feet. As the climate warmed as part of a natural cycle, the ice melted, and glaciers retreated until ice sheets remained only at the poles and at the peaks of mountains. Early on, the sea rose rapidly, sometimes at rates greater than 10 feet per century, and then continued to increase in periods of rapid sea level rise until about 7,000 years ago. Then, the climate stabilized and sea level rise slowed, holding largely steady for most of the last 2,000 years, based on records from corals and sediment cores. Now, however, sea levels are on the rise again, rising faster than it has in the past 6,000 years**.** The oldest tide gauges and coastal sediment preserved beneath swamps and marshes show that sea levels began to rise around 1850, which is consistent with the time people started burning coal to propel steam engine trains. The climate likely started warming as a part of a natural cycle, but the accelerated warming in the last two hundred years is due to a rise in atmospheric carbon dioxide. The resulting rise in sea level is likely twice what we would have seen without the increase in greenhouse gasses due to human activities.[1]

Currently, the global sea level is 5 to 8 inches higher on average than it was in 1900. Between 1900 and 2000, the global sea level rose between 0.05 inches and 0.07 inches per year on average. In the 1990s, that rate jumped to around 0.12 inches per year. In 2016 the rate was estimated to be 0.13 inches per year and the rate is expected to increase by the end of the century. Scientists with the IPCC predict that sea levels will rise approximately 0.10 inches for every degree (°F) that climate change warms the planet. What scientists do not know is how long it will take for the sea level to catch up to the temperature increase. Whether it takes another 200 or 2000 years largely depends on how quickly the ice sheets melt. Even if global warming were to stop today, sea levels would continue to rise.

Location and Extent

As climate change and sea levels increase, storms and flooding will happen more frequently. The closer the sea is to communities, the greater the risk is for these impacts to affect areas of human habitation and activity. Flooding over roads, which is already becoming more common in some places during high tides, can affect the safety of motorists and prevent the passage of emergency vehicles.

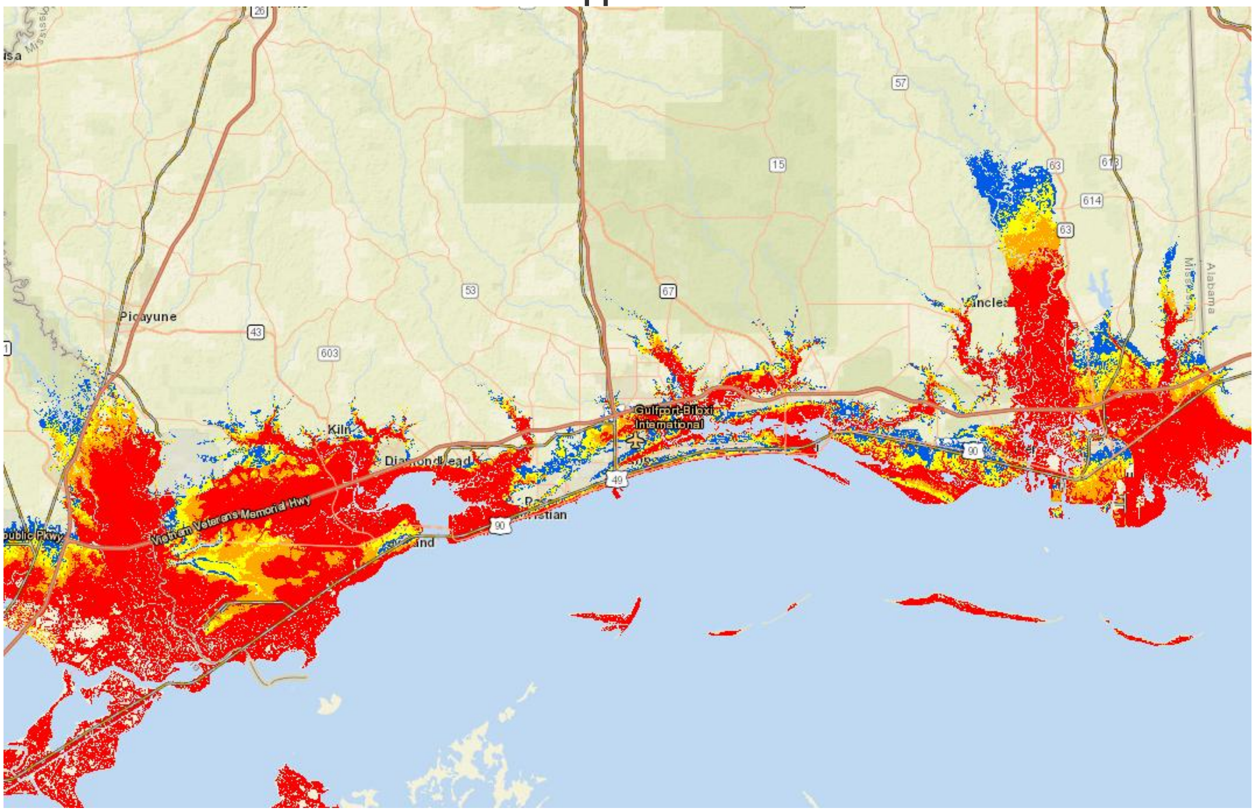
A 2014 Reuters analysis found that before 1971, water reached flood levels no more than five days every year (on average) in several U.S. east coast cities. Since 2001, however, that number has risen to 20 days or more (on average). These tidally and seasonally influenced events are currently considered a nuisance. However, as they become more frequent and increase in intensity, these inconveniences will have more dramatic impacts on the economy, people's lives, and daily activities.

Sea level rise will also increase the impact of storm surges associated with hurricanes and other tropical systems, causing the surges to increase and potentially rather farther inland. As the ocean warms from climate change, it will provide more energy to hurricanes, potentially making them stronger. Data from NOAA indicates that hurricanes may increase in intensity from 2 to 11 percent over the next century.

Figure 3.11.4 shows the potential impacts of storm surge from a Category 3 hurricane and **Figure 3.11.5** illustrates the existing impacts of high tide flooding without the consideration of additional sea level increases.

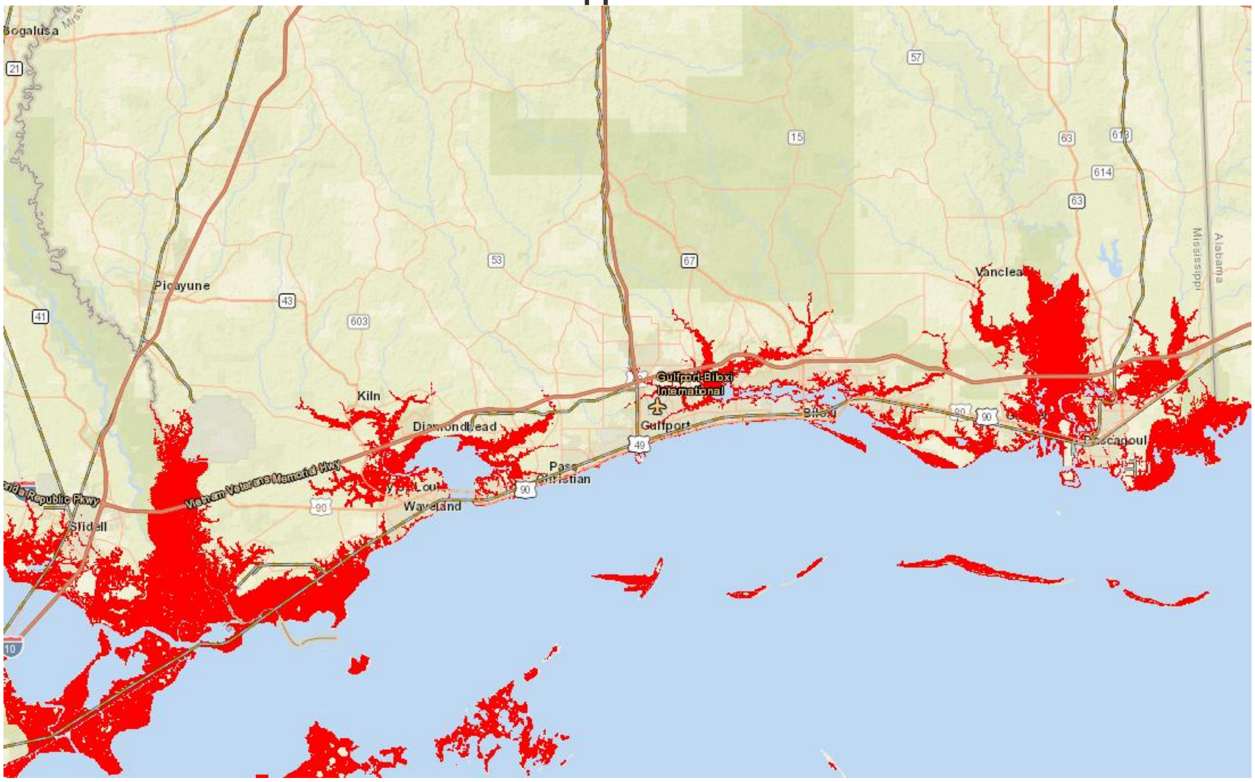
[1] Sea Level Rise by The Ocean Portal Team; Reviewed by Dr. Joshua K. Willis, NASA-JPL; Dr. Andrew Kemp, Tufts University; and Dr. Benjamin H. Strauss, Climate Central.

Figure 3.11.4
Category 3 Storm Surge
Mississippi Gulf Coast



Source: Coast.noaa.gov

Figure 3.11.5
High Tide Flooding
Mississippi Gulf Coast



Source: Coast.NOAA.gov

Previous Occurrences

Since studies show that sea level rise increases coastal flood risk, that global warming contributes to sea level rise, and that global warming effectually multiplies flood risk. We can conclude then we can logically attribute the increases in frequency and intensity of storm events to sea level rise/climate change.

As sea levels rise, dangerous storm surges will become more frequent and powerful and coastal flooding will become more frequent. Storm surges already present the biggest danger associated with hurricanes. During Hurricane Katrina in 2005, storm surges of 10 to 28 feet destroyed buildings in Louisiana and Mississippi, flooded parts of New Orleans, and were responsible for approximately 1,200 fatalities.

Probability of Future Occurrences

Predicting future climate change-related sea level rise is difficult because scientists do not know how quickly the planet will respond to the warming climate.

The IPCC is the International United Nations group tasked with summarizing climate change research every few years. Their 2013 report projected that the sea level will rise by 2 to 3 feet by the year 2100 if we do not slow our carbon dioxide emissions by using less energy or the use of renewable energy. However, more recent and more local projections indicate that sea levels in the northern Gulf of Mexico (directly affecting the Mississippi Gulf Coast) could increase from between 2.2 to 7.5 feet by the year 2100. This projected sea level rise is enough to pose a significant threat to critical resources and infrastructure along the Mississippi Gulf Coast. Even if we reduce our emissions, the report predicts that by the year 2100 sea levels will rise by 1 to 2 feet, enough to cause significant increases in coastal flooding and erosion.

Vulnerability Assessment

Because of its relatively flat topography, Coastal Mississippi is potentially more susceptible to sea level rise than other coastal regions with more relative topographic increases. The majority of the people, property, and infrastructure potentially affected by sea level rise in Mississippi are in Jackson, Hancock, and Harrison counties. Within the State of Mississippi, some $1.5 billion in property values plus more than 14,500 people living in more than 8,000 homes sit on 131 square miles of land less than 6 feet above the local high tide line. The exposure of populations with high social vulnerability is disproportionately high, 50% greater than would be expected by chance alone. Of the exposed high-vulnerability population, more than 60% live in just one zip code, in Bay St. Louis. Compared to 6 feet, more than double the total property, population, and housing sit on land below 10 feet: $3.7 billion and nearly 44,000 people living in more than 22,000 homes, across 227 square miles.[2]

Based on estimates gathered by Climate Central, nonresidential buildings and infrastructure are at risk as well. All told, 386 miles of roads lie on land below 6 feet in the state; 2 museums; 2 schools; 9 houses of worship; 2 power plants; and 57 EPA-listed sites, screened to include mostly hazardous waste sites, facilities with significant hazardous materials, and wastewater generators. At 10 feet, these numbers amount to 898 miles of road, 4 museums, 6 schools, 60 houses of worship, 2 power plants, and 112 EPA-listed sites.

Figure 3.11.6 shows the Coastal Flood Hazard Composite including areas prone to flooding from one or more of the following hazards:

- High tide flooding,
- High-risk flooding (1% A and V Zones),
- Storm surge for Category 1-3 hurricanes, and
- Sea level rise scenarios for 1-3 feet.

The map also shows critical facilities and infrastructure potentially at risk from these hazards including fire stations, public safety facilities, hospitals, and schools.

Discussions of climate change often center around coastal environments. However, climate change impacts will also potentially affect other elements of life in Mississippi including inland flooding and river transportation, agricultural production, forest resources, and human health. Vicksburg, Natchez, and Port Gibson are vulnerable to high water levels on the Mississippi River. Since 1958, the amount of precipitation during heavy rainstorms has increased by 27% in the Southeast, and this trend is likely to continue. Climate change-induced droughts create a different set of challenges. During severe droughts in the Mississippi River Watershed, low flows can restrict commercial navigation. For example, low water levels in 2012 forced the

[2] Mississippi and the Surging Sea a Vulnerability Assessment with Projections for Sea Level Rise and Coastal Flood Risk, published by Climate Central.

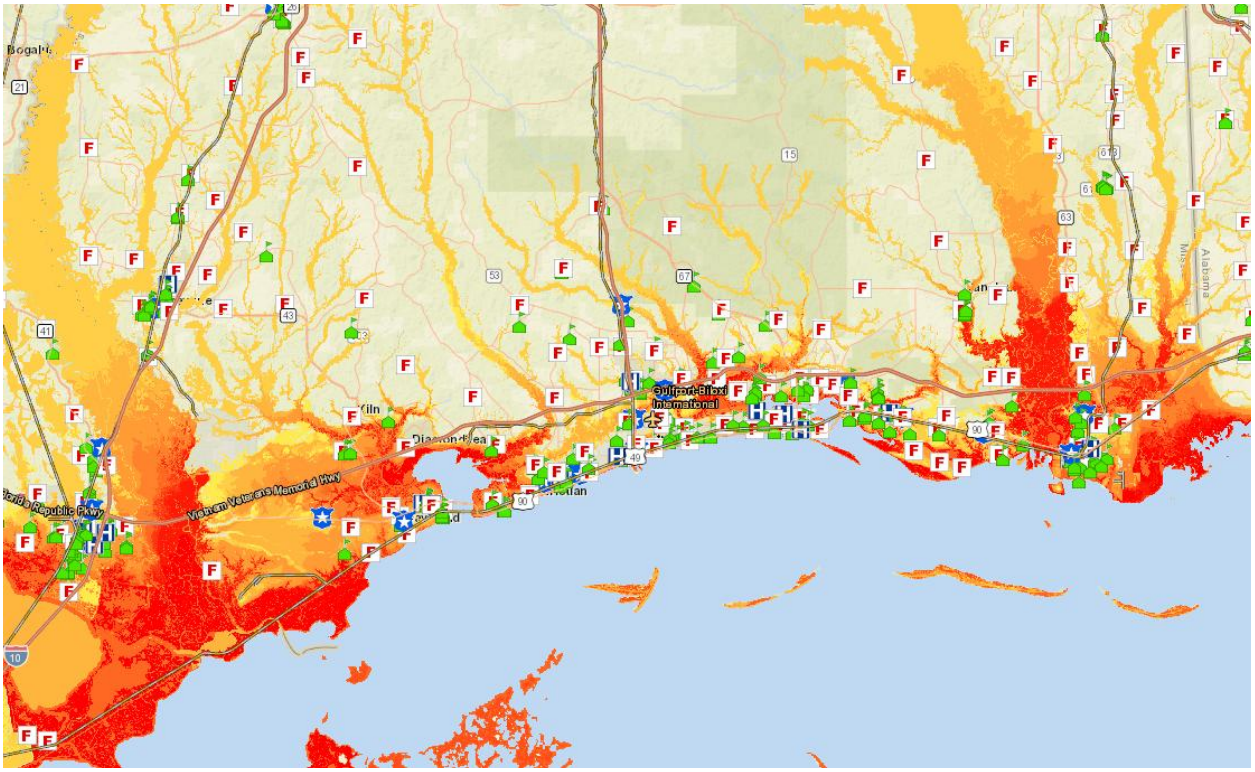
U.S. Army Corps of Engineers to reduce allowable barge sizes on the Mississippi River and close the river at Greenville for more than a week, delaying approximately 100 barges.

Changing climates will potentially have both harmful and beneficial effects on farming. The number of hot weather days (>95 degrees F) will likely increase. Hotter summers may reduce yields of corn. However, higher concentrations of atmospheric carbon dioxide increase crop yields, and the fertilizing effect is likely to offset the harmful effects of heat on soybeans, cotton, wheat, and peanuts – if enough water is available. Higher temperatures are also likely to reduce livestock productivity because heat stress disrupts the animals' metabolism.

Higher temperatures and changes in rainfall are unlikely to significantly reduce forest cover in Mississippi, although the composition of trees in the forests may change. More frequent droughts would reduce forest productivity and increase potential damage from insects and diseases. As the climate warms, forests in southern Mississippi are likely to have more oaks and white pines, and fewer loblolly and longleaf pines.

Hot days can be unhealthy, and even dangerous to human populations. Children, the elderly, the sick, and the poor are particularly susceptible to the effects of prolonged high temperatures. Heat stroke, dehydration, and impacts on cardiovascular and nervous systems are all human impacts from long-term exposure to extreme heat.

Figure 3.11.5
Coastal Flood Hazard Composite
At-Risk Critical Facilities



Source: coast.NOAA.gov