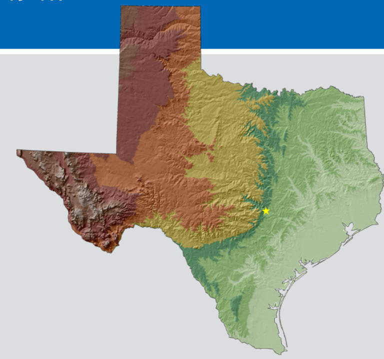

TEXAS

Key Messages

Mean annual temperature has increased by approximately 1˚F since the first half of the 20th century. Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century, with associated increases in extreme heat events.

Although projected changes in annual precipitation are uncertain, increases in extreme precipitation events are projected. Higher temperatures will increase soil moisture loss during dry spells, increasing the intensity of naturally occurring droughts.

The number of landfalling hurricanes in Texas is highly variable from year to year. As the climate warms, increases in hurricane rainfall rates, storm surge height due to sea level rise, and the intensity of the strongest hurricanes are projected.

The Texas climate is characterized by hot summers and cool to mild winters. Three geographical features largely influence the state's varied climate. The Rocky Mountains block intrusions of moist Pacific air from the west and tend to channel arctic air masses southward during the winter. The relatively flat central North American continent allows easy north and south movement of air masses. The Gulf of Mexico is the primary source of moisture, most readily available to the eastern part of the state. As a result of these factors, the state exhibits large east-west variations in precipitation and is subject to frequent occurrences of a variety of extreme events, including hurricanes, tornadoes, droughts, heat waves, cold waves, and intense precipitation. Increased demand for limited water supplies due to rapid population growth, especially in urban areas, may increase Texas' vulnerability to naturally occurring droughts.

Mean annual temperatures has increased approximately 1˚F since the first half of the 20th century (Figure 1). While there is no overall trend in extremely hot days (maximum temperature above 100°F) (Figure 2), the number of very warm nights (minimum temperature below 75°F) was a record high during the latest 2010–2014 period (Figure 3). This was due to very high values during the drought years of 2011 and 2012 when very warm nights were very frequent both along the coast (where they are a common feature of the climate due to warm waters) and in the interior (where they are less common). The urban heat island effect increased these occurrences in city centers. In 2011, Texas recorded its warmest summer on record (since 1895) and broke the record for the statewide-average highest number of days with temperatures of 100°F or more. The Dallas-Fort Worth area endured 40 consecutive days in excess of 100˚F, which was the second longest streak on record (1898–2011). The record dry conditions contributed to the higher temperatures.

Observed and Projected Temperature Change

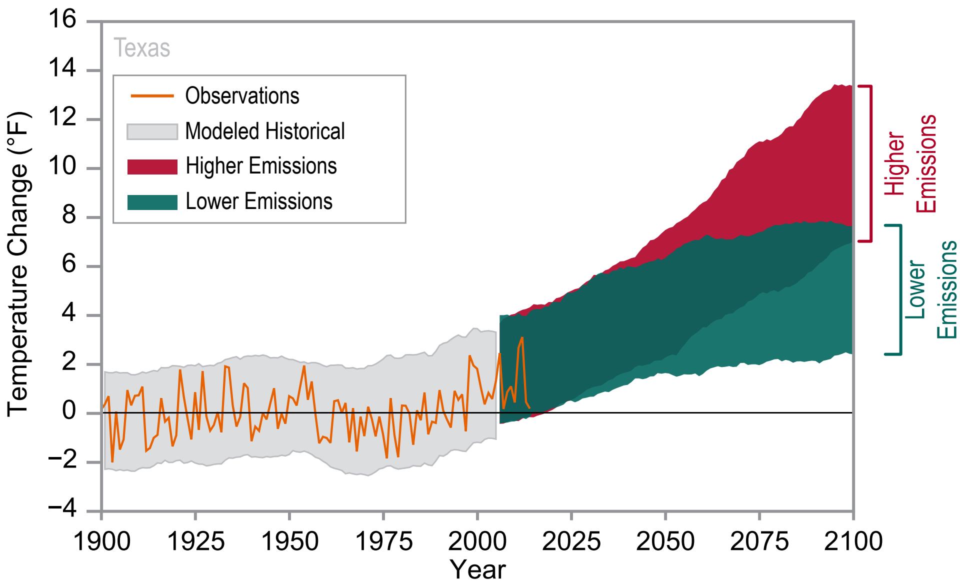

Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Texas. Observed data are for 1900–2014. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions)[1]. Temperatures in Texas (orange line) have risen about 1°F since the beginning of the 20th century. Shading indicates the range of annual temperatures from the set of models. Observed temperatures are generally within the envelope of model simulations of the historical period (gray shading). Historically unprecedented warming is projected during the 21st century. Less warming is expected under a lower emissions future (the coldest years being about as warm as the hottest year in the historical record; green shading) and more warming under a higher emissions future (the hottest years being about 11ºF warmer than the hottest year in the historical record; red shading). Source: CICS-NC and NOAA NCEI.

[1]Technical details on models and projections are provided in an appendix, available online at: https://statesummaries.ncics.org/tx.

Daily minimum temperatures in January typically range from about 20°F in the northern Panhandle to about 50°F near the mouth of the Rio Grande River. The annual number of days of extreme cold (maximum temperatures below 32°F) was well above average in the 1970s and 1980s but since then has fluctuated near the long-term average (Figure 4a).

Average annual precipitation varies from less than 10 inches in the far west to greater than 50 inches in the far east. The driest multi-year periods were in the 1890s, 1950s, and 2000s, and the wettest in the 1940s and mid-1990s (Figure 4b). **The driest 5-year period was 1952–1956 and the wettest was 1990–1994**. In the 1990s and early 2000s, the number of extreme precipitation events was well-above average, but the state has experienced below average rainfall and extreme precipitation events over the last five years (Figure 4c). However, this extended dry period was interrupted in May 2015 with a statewide monthly average rainfall total of 9.05 inches, breaking the previous all-time monthly record by well over two inches (Figure 5a). During one specific late-May episode, the Blanco River at Wimberly (south-central Texas) experienced historic flash and river flooding following a 1- to 2-day rainfall of 4–12 inches (Figure 5b), rising 35 feet in approximately 3 hours.

Texas is consistently ranked in the top 10 states affected by extreme events. In 2011, Texas was hit by eight of the Nation's billion dollar disasters. The three most impactful events were drought, extreme heat, and wildfires. The warmest and the driest summer in the historical record (Figure 6) helped fuel the worst wildfire season since statewide records began (approximately 1990), with nearly 4 million acres burned and $750 million in damages. Since the creation of the United States Drought Monitor Map in 2000, Texas has been completely drought-free for only approximately 8% of the time (2000–2014), and at least half of the state has been under drought conditions for approximately 42% of the time over the same period. Paleoclimatic records indicate that droughts of the severity of 2011 have occurred occasionally in the pat 1000 years (Figure 6). Higher temperatures in combination with drought conditions are likely to increase the severity, frequency, and extent of wildfires in the future posing significant harm to property, human health, and the livelihood of residents.

Over the period of 1900 to 2010, the Texas coastline endured more than 85 tropical storms and hurricanes (about 3 storms every 4 years), with approximately half of them hurricanes (Figure 4d). Since 2000, Texas has experienced 12 named storms, including 5 destructive hurricanes, with Hurricane Rita (Category 3) and Hurricane Ike (Category 2) causing the most significant damage. While Hurricane Rita holds the designation as causing the largest U.S. evacuation in history, Hurricane Ike is the costliest hurricane in Texas history, with an estimated $19.3 billion in damages. Along the southern coast, surges of between 11 and 13 feet typically have return periods of 25 years (Figure 7).

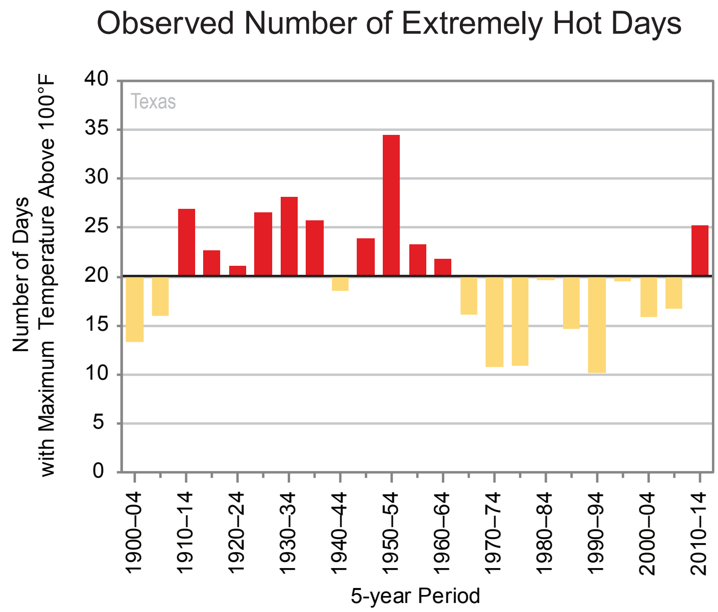

Figure 2: The observed number of extremely hot days (annual number of days with maximum temperature above 100°F) for 1900–2014, averaged over 5-year periods; these values are averages from twenty-six long-term reporting stations. The number of extremely hot days in Texas was mostly above average between 1910 and 1960, below average between the 1960s and early 2000s, and above average again in the last 5 years. The dark horizontal line is the long-term average (1900–2014) of about 20 days per year. Source: CICS-NC and NOAA NCEI.

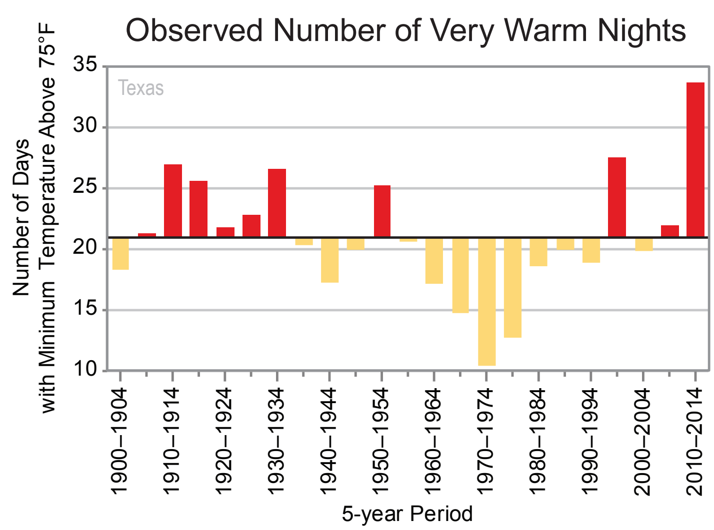

Figure 3: The observed number of very warm nights (number of days with minimum temperature above 75°F) for 1900–2014, averaged over 5-year periods; these values are averages from twenty-six long-term reporting stations. The 1970s saw a record low number of very warm nights. That number increased in the early 21st century, with the record highest number occurring in 2010–2014. The dark horizontal line is the long-term average (1900–2014) of about 21 days per year. Source: CICS-NC and NOAA NCEI.

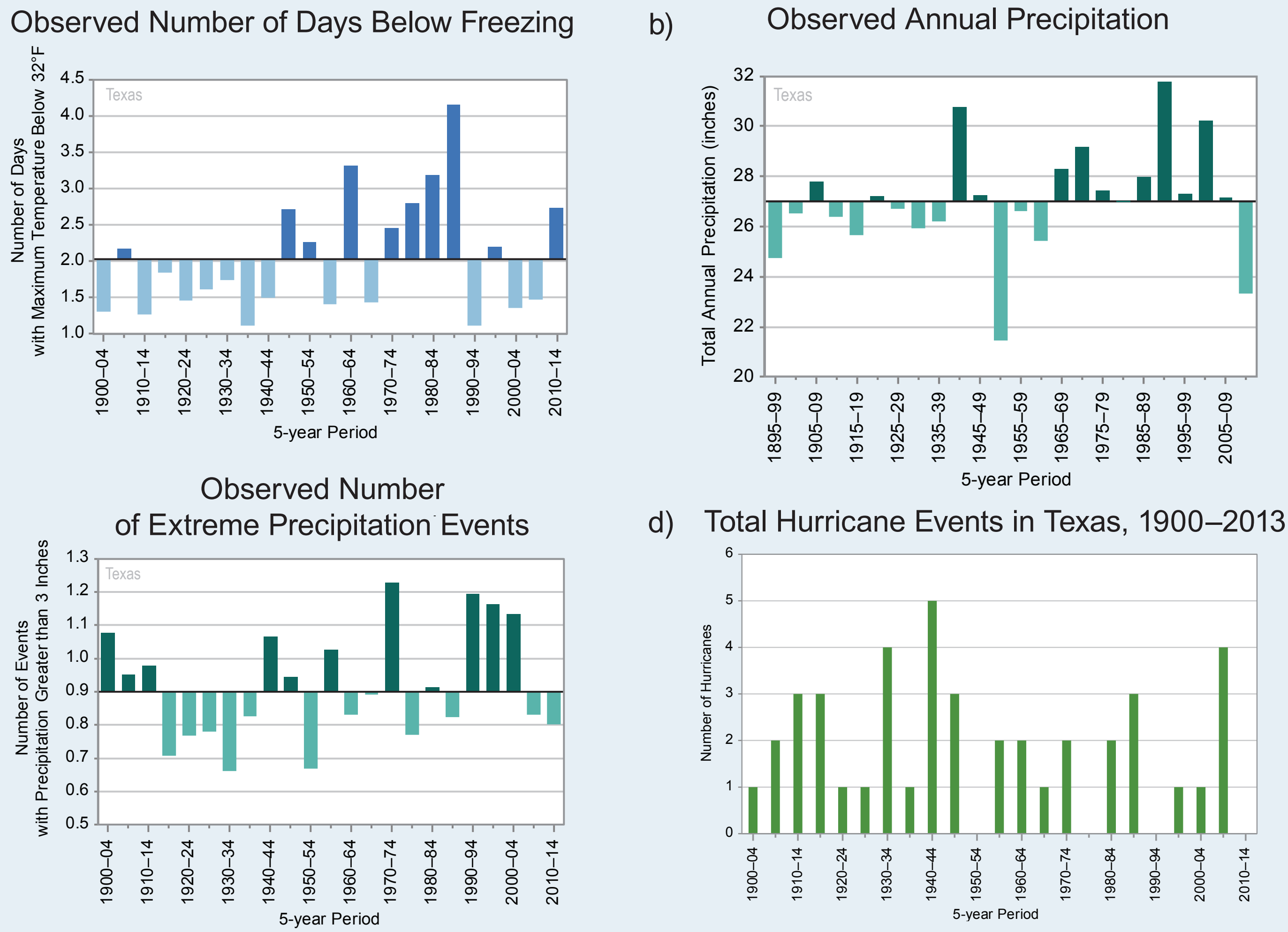

Figure 4: Observed (a) number of days below freezing (maximum temperature below 32°F), (b) annual precipitation, (c) extreme precipitation events (days with more than 3 inches), and (d) annual number of hurricanes affecting Texas, averaged over 5-year periods. The values in Figures 4a and 4c are averages from twenty-six long-term reporting stations for temperature and thirty-six long-term reporting stations for precipitation. The number of days below freezing was above average in the 1970s and 1980s; since then it has fluctuated near the long-term average. Annual precipitation varies widely between years and has been generally below average during the most recent 5-year period of 2010–2014. The number of extreme precipitation events was well above average during the 1990s and early 2000s and slightly below average since then. There is no long-term trend in the number of hurricanes. Source: CICS-NC and NOAA NCEI.

Over the past 30 years (1985–2014), Texas has averaged 140 tornadoes and 4 tornado fatalities per year. Events can occur all year, though activity typically peaks between April and June.

Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century (Figure 1). Even under a pathway of lower greenhouse gas emissions, average annual temperatures are projected to most likely exceed historical record levels by the middle of the 21st century. However, there is a large range of temperature increases under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records. Increases in the number of extremely hot days and decreases in the number of extremely cold days are projected to accompany the overall warming. By 2055, an estimated increase of 20–30 days over 95°F is projected under one pathway, with the greatest increase in southwestern Texas.

Future changes in annual average precipitation are uncertain (Figure 8), but an increase in intense rainfall is likely. Furthermore, even if average precipitation does not change, **higher temperatures will increase the rate of soil moisture loss and thus naturally occurring droughts will likely be more intense**. Longer dry spells are also projected.

Increased drought severity combined with increased human demand for surface water will cause changes in streamflow, with extended reductions of freshwater inflow to Texas bays and estuaries. Such reductions in streamflow will cause temporary or permanent changes to bay salinity and oxygen content, with potentially major impacts to bay and estuary ecosystems, such as negatively affecting organism growth, reproduction, and survival.

Future changes in the frequency and severity of tornadoes, hail, and severe thunderstorms are uncertain. However, **hurricane intensity and rainfall are projected to increase for Texas as the climate warms**.

Since 1880, global sea level has risen by about 8 inches.Along the Texas coastline, sea level rise has been measured between 5 and 17 inches per century, causing the loss of an average of 180 acres of coastline per year. **Sea level is projected to rise another 1 to 4 feet by 2100 as a result of both past and future emissions from human activities** (Figure 9). Sea level rise has caused an increase in tidal floods associated with nuisance-level impacts. Nuisance floods are events in which water levels exceed the local threshold (set by NOAA's National Weather Service) for minor impacts. These events can damage infrastructure, cause road closures, and overwhelm storm drains. As sea level has risen along the Texas coastline, the number of tidal flood days has also increased, with the greatest number occurring in 2008 and 2015 (Figure 10). Future sea level rise will increase the frequency of nuisance flooding (Figure 9) and the potential for greater damage from storm surge.

Total Rainfall Amounts in May 2015

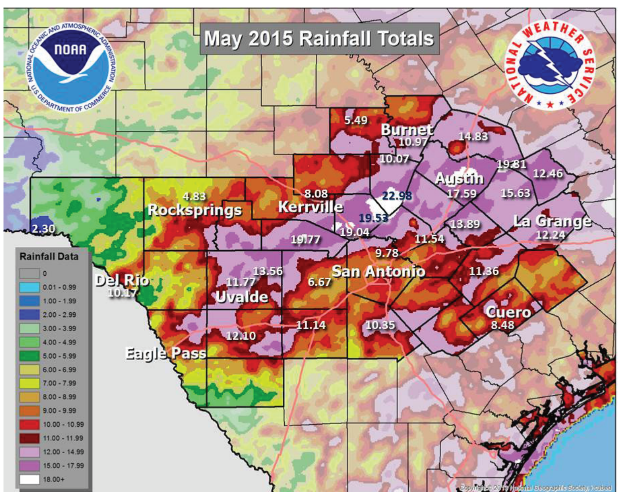

Figure 5: Monthly rainfall totals for May 2015 in south-central Texas. Large areas received more than 10 inches of rainfall and nearly the entire state was 2 to 4 times above normal. In late May 2015, south-central Texas experienced historic flash and river flooding following a 1- to 2-day rainfall of 4–12 inches and locally higher amounts. During this extreme precipitation event, the Blanco River at Wimberly, halfway between Austin and San Antonio, rose 35 feet in about 3 hours. Source: NOAA's National Weather Service.

Texas Palmer Drought Severity Index

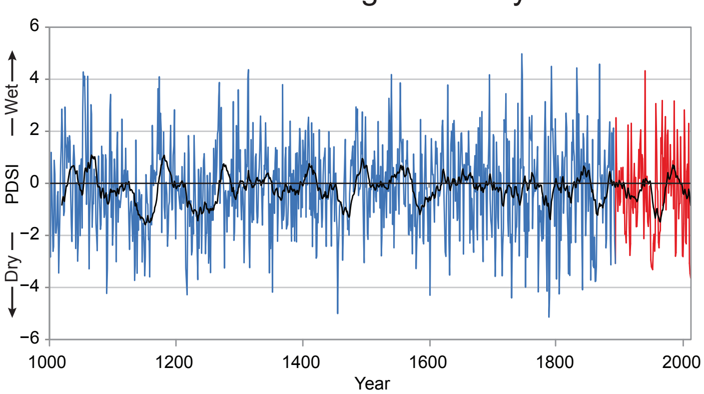

Figure 6: Texas Palmer Drought Severity Index. While periods of drought are common in Texas, the severity of the 2011 drought exceeded that of any previous drought throughout the history of the instrumental record (1895–2013 shown in red). Reconstruction of drought using proxies (blue) indicate droughts of the 2011 severity have occurred occasionally in the past. Source: NOAA NCEI.

Galveston Bay Coastal Surge Return Periods

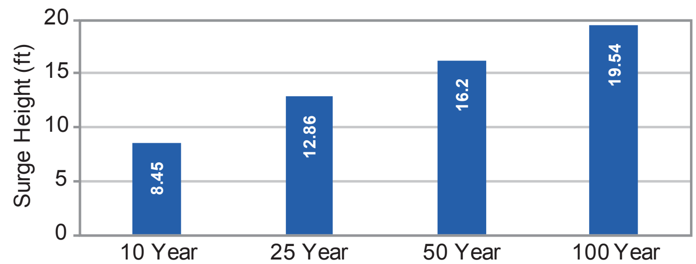

Figure 7: Coastal storm surge levels for 10-year, 25-year, 50-year, and 100-year return periods for (a) Galveston Bay. (Supplied by Luigi Romolo from the SURGEDAT database, Needham and Keim 2012)

Projected Change in Annual Precipitation

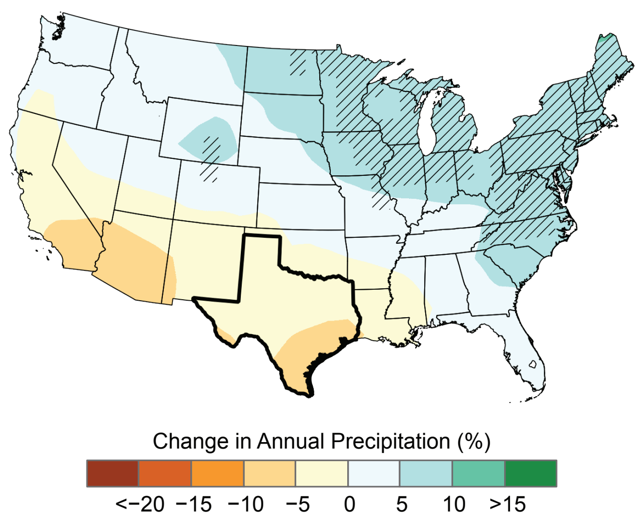

Figure 8: Projected changes (%) in annual precipitation for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Texas is part of a large area in the southwestern and central United States with projected decreases in annual precipitation, but most models do not indicate that these changes are statistically significant. Source: CICS-NC and NOAA NCEI.

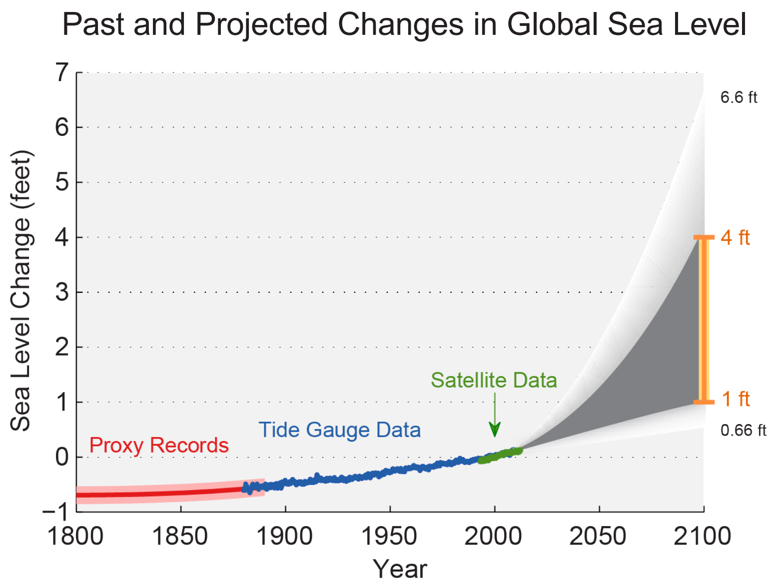

Figure 9: Estimated, observed, and possible future amounts of global sea level rise from 1800 to 2100, relative to the year 2000. The orange line at right shows the most likely range of 1 to 4 feet by 2100 based on an assessment of scientific studies, which falls within a larger possible range of 0.66 feet to 6.6 feet. Source: Melillo et al. 2014 and Parris et al. 2012.

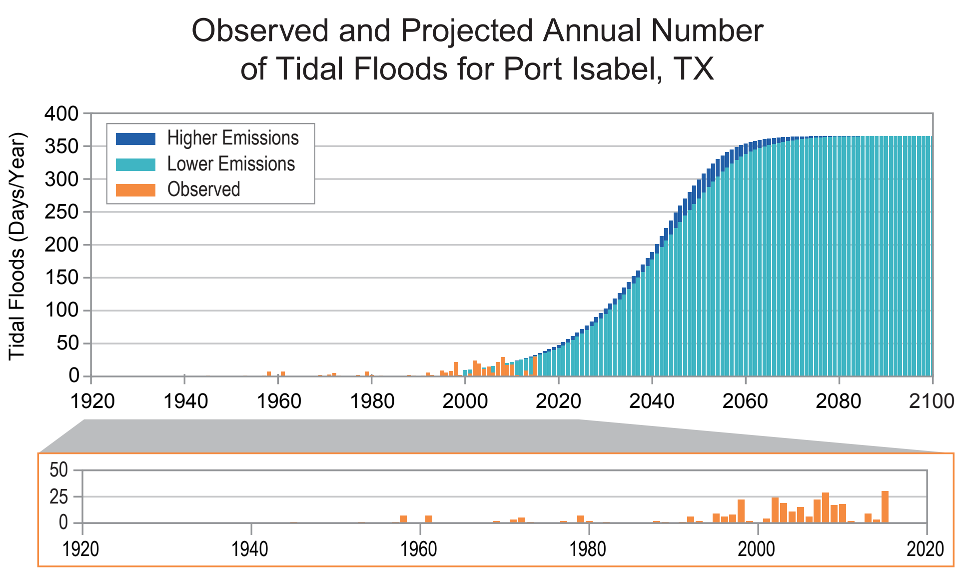

Figure 10: Number of tidal flood days per year for the observed record (orange bars) and projections for two possible futures: lower emissions (light blue) and higher emissions (dark blue) per calendar year for Port Isabel, TX. Sea level rise has caused an increase in tidal floods associated with nuisance-level impacts. Nuisance floods are events in which water levels exceed the local threshold (set by NOAA's National Weather Service) for minor impacts, such as road closures and overwhelmed storm drains. The greatest number of tidal flood days occurred in 2008 and 2015 in Port Isabel. Projected increases are large even under a lower emissions pathway. Near the end of the century, under a higher emissions pathway, some models project tidal flooding nearly every day of the year. To see these and other projections under additional emissions pathways, please see the supplemental material on the State Summaries website (https://statesummaries.ncics.org/tx). Source: NOAA NOS.