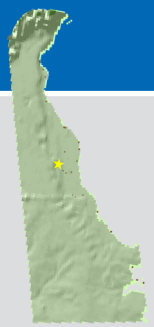

DELAWARE

Key Messages

Average annual temperatures have increased by more than 2°F in Delaware over the past century. Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century. Heat waves are projected to be more intense and cold waves less intense.

Precipitation is projected to increase, as are the number and intensity of extreme precipitation events.

Global sea level has risen by about 8 inches since reliable record keeping began in 1880. Delaware sea level rise has been higher due to land subsidence. The number of tidal floods has been increasing. Global sea level is projected to rise another 1 to 4 feet by 2100. The low elevation areas of Delaware are highly vulnerable to sea level rise.

Delaware's mid-latitude location and proximity to the Atlantic Ocean has great influence on its overall climate, which is characterized by cold winters and warm summers. The moderating influences of the Atlantic Ocean and Delaware Bay tend to lessen temperature extremes in the state compared to temperatures in the interior of adjoining states. There are only small variations in average temperatures across this small, relatively flat state, ranging from 54°F in the northern portion to 58°F along coastal Delaware in the south. The statewide average annual precipitation is about 45 inches with large inter-annual variability. Annual statewide precipitation has varied from 27.39 inches in 1930 to 60.01 inches in 1948. Average annual snowfall ranges from 19 inches in the north to 14 inches in the south.

Geography also plays an important role, specifically its position on the eastern coast of the North American continent. Delaware's mid-latitude location places the state in frequent close proximity to the jet stream, particularly in winter and spring. The storm systems tracking with the jet stream bring frequent precipitation and fluctuating temperatures. Strong winter storms that derive their energy from the contrast between cold air in the continental interior and warmer air over

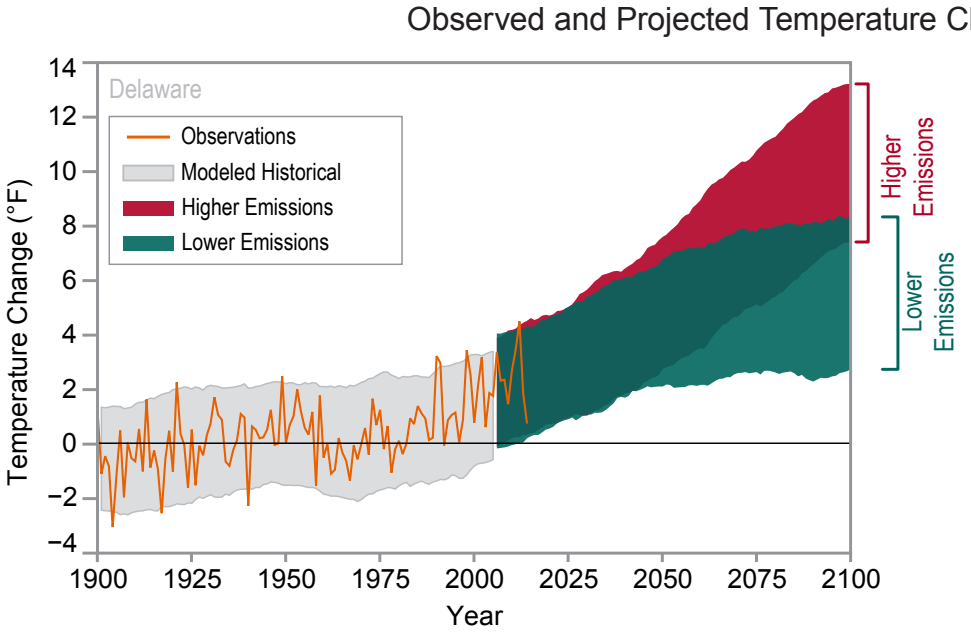

Figure 1: Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Delaware. Observed data are for 1900–2014. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions).[1] Temperatures in Delaware (orange line) have risen more than 2°F since the beginning of the 20th century. Shading indicate 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 3°F warmer than the long-term historical average; green shading) and more warming under a higher emissions future (the hottest years being about 13°F warmer than long-term historical average; 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/de.

the western Atlantic Ocean, otherwise known as nor'easters often affect the state. Delaware has the lowest elevation of all states and also experiences land subsidence. All of Delaware is also classified as a coastal zone due to the proximity of inland areas to tidal waters. The shoreline of Delaware spans more than 250 miles with no geographic location within the state more than 8 miles from tidal waters.

Temperatures in Delaware have increased more than 2°F since the beginning of the 20th century (Figure 1). The number of very hot days (maximum temperatures above 95°F) in Dover has been highly variable with no long-term trend since 1910 (Figure 2a). By contrast, the number of very warm nights (minimum temperatures above 75°F) in Dover has been increasing with the highest 5-year average (since 1910) in 2010–2014 (Figure 3). The number of days below freezing (maximum temperatures below 32°F) has been below average since the early 1990s (Figure 2b).

There are no long-term trends in statewide annual precipitation since 1895, although relatively consistent above average precipitation has occurred since the mid-1990s (Figure 2c). **Heavy precipitation events (days with more than 2 inches) in Dover have generally been somewhat above the long-term average since the early 1990s** (Figure 2d).

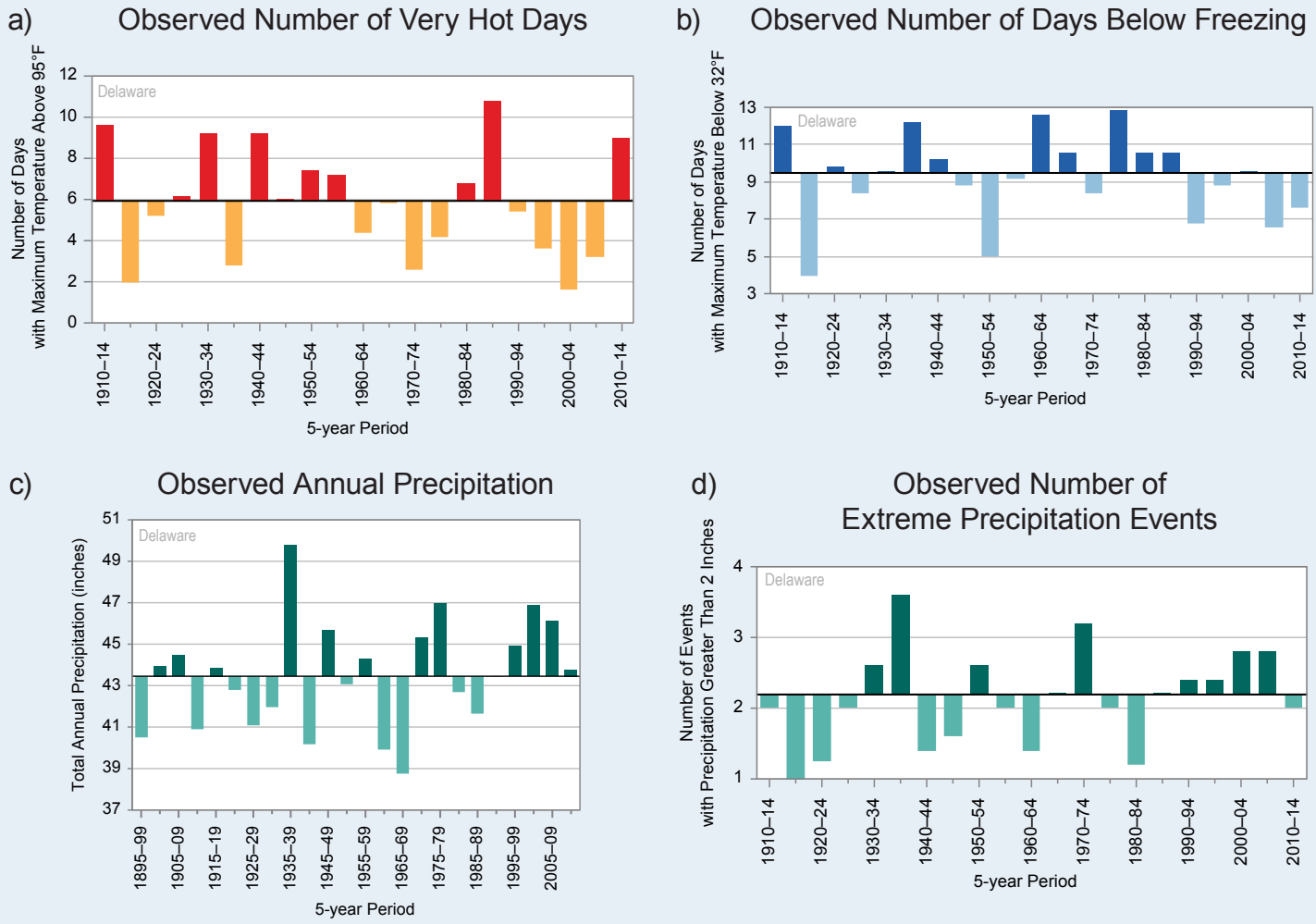

Figure 2: The observed (a) annual number of very hot days (maximum temperature above 95°F) at Dover, (b) annual number of days below freezing (maximum temperature below 32°F) at Dover, (c) total annual precipitation averaged for Delaware, and (d) annual number of extreme precipitation events (events with greater than 2 inches) at Dover, averaged over 5-year periods. The dark horizontal lines represent the long-term average. There is no overall trend in the number of very hot days at Dover. The number of days below freezing has been below average since the early 1990s. Above average precipitation has occurred since the mid-1990s. The number of extreme precipitation events has been mostly above average since the mid-1980s. Source: CICS-NC and NOAA NCEI.

The state's coastline is highly vulnerable to damage from coastal and tropical storm events. Nor'easters are the most common coastal storm, bringing strong winds, heavy precipitation and coastal flooding. They are most active from mid-winter through spring, with peak activity occurring each year in March. The worst Nor'easter in Delaware history is the Ash Wednesday storm of 1962 (March 6–8) and illustrates the potential danger of such storms. The strong northeast winds caused record flooding and beach erosion in Delaware and up and down the eastern seaboard extending from New England to Florida. The strong northeast winds, broad fetch, and high angle of wave approach caused record flooding and beach erosion down the eastern seaboard extending from New England to Florida. Most houses near the beach not protected by a wide beach and dunes were destroyed. Tropical storms and hurricanes occasionally affect Delaware in the late summer and fall. Densely populated areas in New Castle County located along major streams are at significant risk of flooding related to heavy precipitation and from possible surges up Delaware Bay. The state was severely affected by Hurricane Sandy (commonly known as Superstorm Sandy) and Hurricane Irene, causing significant economic and infrastructure damage. Hurricane Sandy made landfall in New Jersey as a post-tropical storm and caused record flooding along the Atlantic and Delaware Bay coasts. Tornadoes and heavy rains trailing Hurricane Irene resulted in power outages for at least 119,000 residents and economic damage estimates totaling $43.2 million for the state.

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 (Figure 1). According to a recent state-level analysis, annual maximum (daytime) temperature is projected to increase by an average of 2°F to 2.5°F and annual minimum (nighttime) temperature by an average of 1.5°F to 2.5°F by 2039. In the near-term (2020–2039) projections are for heat waves to occur 3 out of every 5

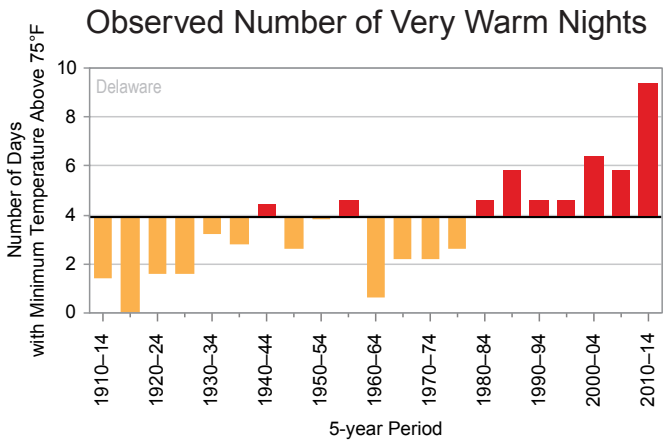

Figure 3: The observed number of very warm nights (annual number of days with minimum temperature above 75°F) for 1910–2014 at Dover, averaged over 5-year periods. The number of very warm nights in Dover has consistently been above average since the 1980s with the greatest number of warm nights occurring during the most recent 5-year period of 2010–2014. The dark horizontal line is the long-term average. Source: CICS-NC and NOAA NCEI.

years. Projections for mid-century show an average of 1 heat wave per year and up to 10 extreme heat waves occurring each year by the end of the 21st century. Higher temperatures and extreme heat events in the future may result in decreased air quality and affect the health of Delaware residents. However, future cold waves are projected to be not as cold.

Annual average precipitation is projected to increase for Delaware, with the increases occurring in winter and spring (Figure 4). This change is characteristic of a large area of the Northern Hemisphere in the higher middle latitudes projected to see increases in total precipitation, as well as increases in heavy precipitation events. On average, the state experiences 2 days each year with 2 or more inches of rain. State-level projections show an increase of 0.5 to 1 day each year with 2 inches of rainfall by the end of the century. Projections of above average precipitation amounts and more frequent extreme precipitation events may also result in increased flooding risks throughout the state.

Since 1880, global sea level has risen by about 8 inches. The rise on Delaware's coasts has been greater due to land subsidence. 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 Delaware coastline, the number of tidal flood days (all days exceeding the nuisance level threshold) has also increased, with the greatest number occurring in 2009 and 2011 (Figure 5). **Global sea level is projected to rise another 1 to 4 feet by 2100 as a result of both past and future greenhouse gas emissions from human activities** (Figure 6). Findings from the 2012 Sea Level Rise Vulnerability Assessment for the state show projections for increases in sea level rise based on three levels of global warming: (1) 1.6 feet rise for low levels of global warming; (2) 3.3 feet for moderate levels; and (3) 4.9 feet for high levels of global warming (see Delaware Climate Change Impact Assessment for more Sea Level Rise Resources). Sea level rise has important future cross-sector implications for public health, water resources, coastal ecosystems and wildlife, agriculture, and transportation infrastructure. Demographic trends may increase the risks of coastal flooding. Coastal communities are experiencing an increase in the vulnerable elderly population, due to relocation of retirees.

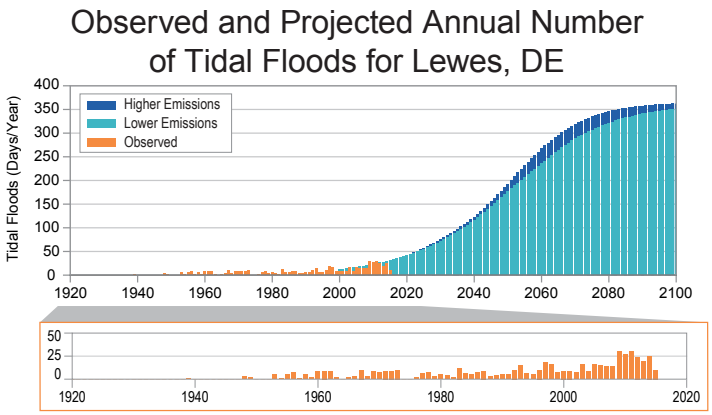

Figure 5: Number of tidal flood days per year for the observed record (orange bars) based on observations at a tidal gage and projections for two possible futures: lower emissions (light blue) and higher emissions (dark blue) per calendar year for Lewes, DE. Sea level rise has caused an increase in tidal 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 (all days exceeding the nuisance level threshold) occurred in 2009 and 2011 in Lewes. 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/de). Source: NOAA NOS.

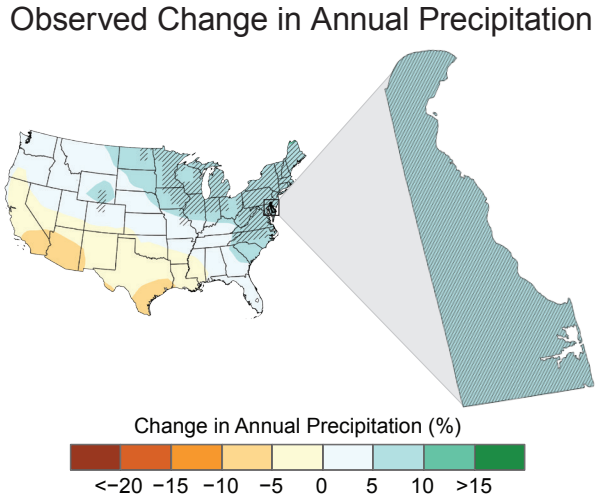

Figure 4: Projected changes in annual precipitation (%) by the middle of the 21st century relative to the late 20th century under a higher emissions pathway. Hatching represents portions of the state where the majority of climate models indicate a statistically significant change. Delaware is part of a large area of projected increases in the Northeast. Source: CICS-NC and NOAA NCEI.

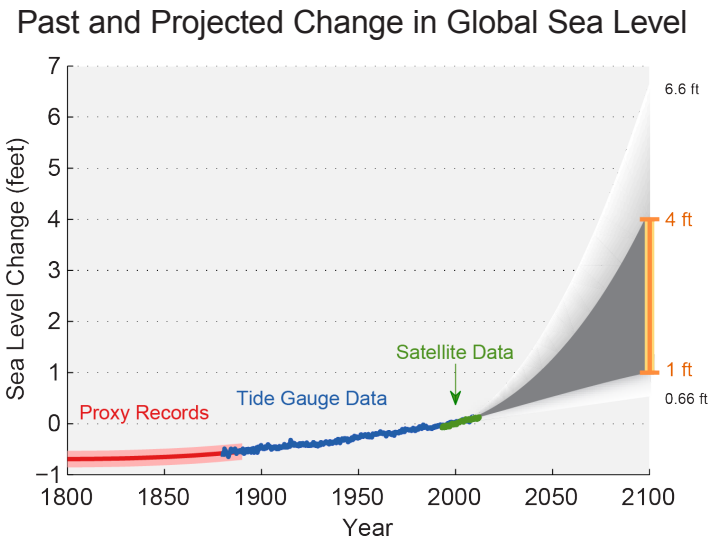

Figure 6: Estimated, observed, and possible future amounts of global sea level rise from 1800 to 2100, relative to the year 2000. The orange line at right shows the most likely range from climate models of 1 to 4 feet by 2100 based on an assessment of scientific studies, which falls within a larger possible range of 0.66 feet to 6.6 feet. Source: Melillo et al. 2014 and Parris et al. 2012.