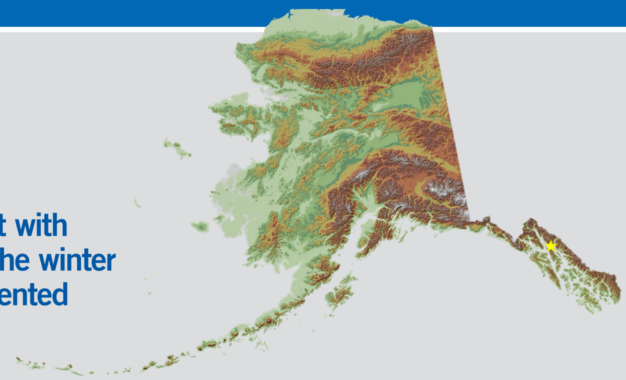


ALASKA

Temperatures in Alaska have increased by about 3°F since 1925 but with large multidecadal variations. Most of the warming has occurred in the winter and spring. Under a higher emissions pathway, historically unprecedented warming is projected during this century.

Annual average precipitation is projected to increase by 10% or more across all of Alaska by the middle of this century under a higher emissions pathway.

Late-summer arctic sea ice extent and thickness have decreased substantially over the last several decades. Climate models project that before 2050 arctic waters will be virtually ice-free by late summer.

Alaska's vast expanse and geographical variation lead to a variety of climate types. Four main factors influence the state's climate: its northerly latitude crossing the Arctic Circle; its large elevation range, from sea level to the highest peak in the United States; regional variations in proximity to the ocean; and the seasonal distribution of sea ice along its western and northern boundaries. Annual average (1991–2020 normals) temperatures range from the mid-40s (°F) in the south, where moderating maritime influences are strong, to about 13° to 20°F in the Arctic region north of the Brooks Range (Figure 2); the coldest long-term reporting stations are along and near the Arctic Ocean north of 70°N latitude, with an annual average temperature of less than 15°F. The greatest seasonal changes in temperature occur in the state's Interior region, where summer average maximum temperatures are in the upper 60s (F°) and winter average minimums are 15° to 25°F below zero. The highest temperature ever recorded in Alaska was 100°F at Fort Yukon, in the Interior (June 27, 1915), and the coldest was −80°F at Prospect Creek, also in the Interior (January 23, 1971).

Alaska's temperature climate is highly variable. It was moderately warm from the 1920s into the 1940s, much cooler from the late 1940s into the 1970s, and warmer thereafter. **Since 1925 (the beginning of reliable records), temperatures in Alaska have increased by about 3°F** (Figure 1), **compared to about**

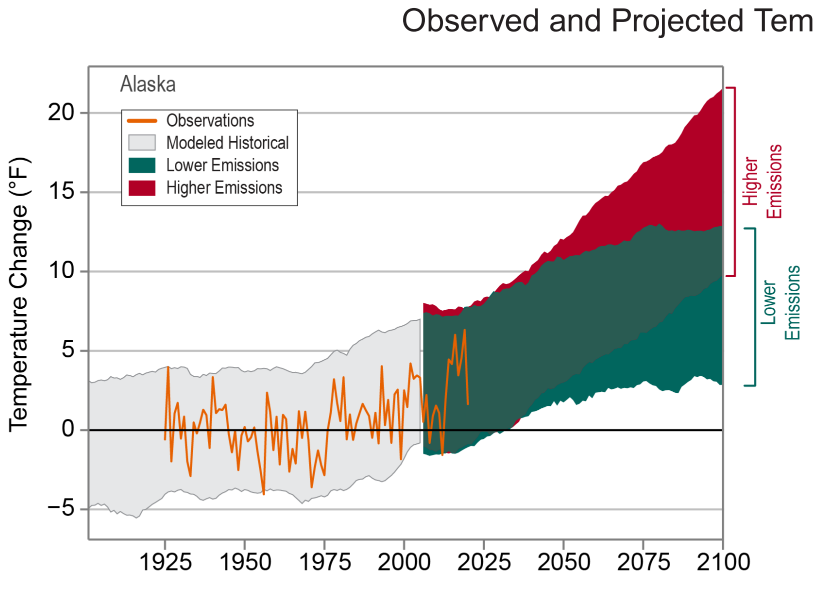


Figure 1: Observed and projected changes (compared to the 1925–1960 average) in near surface air temperature for Alaska. Observed data are for 1925–2020, while model simulations of the historical period are shown for 1901–2005. Projected changes for 2006–2100 are from global climate models for two possible 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). Temperatures in Alaska (orange line) have increased by about 3°F since 1925 but with large multidecadal variations. Shading indicates the range of annual temperatures from the set of models. Observed temperatures are generally within the envelope of the modeled historical simulations (gray shading). Historically unprecedented warming is projected during this century. Less warming is expected under a lower emissions future (the coldest end-of-century projections being about 2°F warmer than the historical average; green shading) and more warming under a higher emissions future (the hottest years being about 15°F warmer than the hottest year in the historical record; red shading). Sources: CISESS and NOAA NCEI.

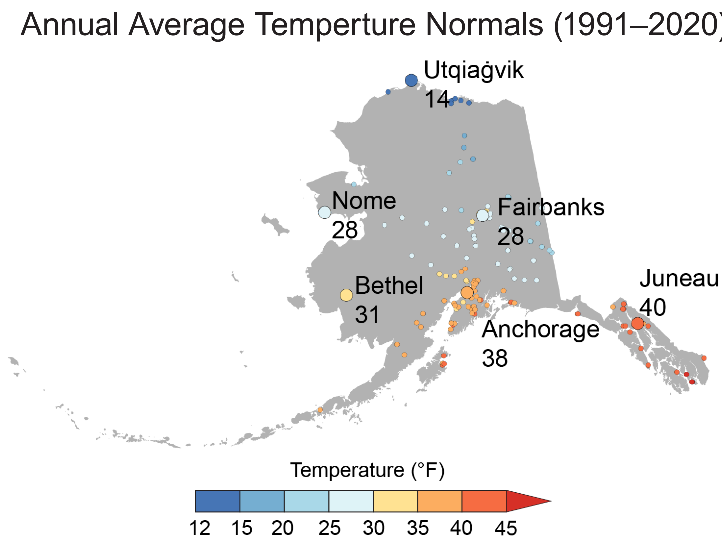
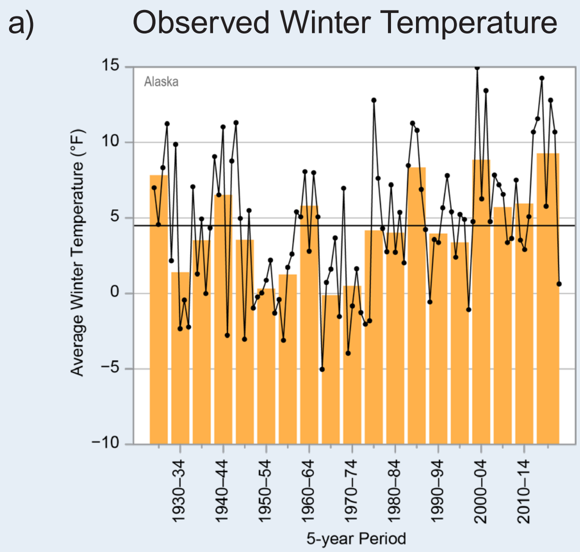
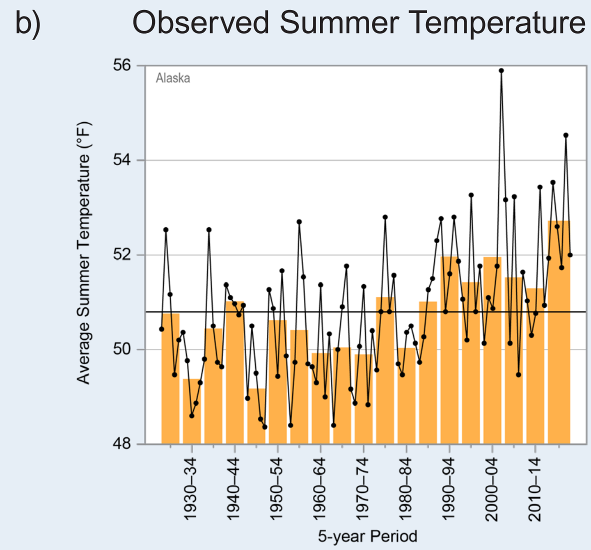


Figure 2. Annual average temperature normals (1991–2020) for long-term reporting stations in Alaska. Normals vary from less than 15°F in the far north to greater than 45°F at a few locations along the southeast coast. Sources: CISESS and NCEI. Data: NOAA NCEI U.S. Climate Normals.

1.8°F since 1900 for the contiguous United States. There is considerable regional variability in the warming, with the greatest warming occurring in the North Slope (about 4°F) and the least warming (less than 2°F) occurring in the Panhandle and the Aleutians. Most of the warming has occurred in the winter and spring and the least amount in the summer and fall. Summer temperatures have been above average since the late 1980s (Figure 3b), and winter temperatures have been mostly above average since 2001 (Figure 3a). The increase in summer temperatures is primarily due to a large increase in summer minimum temperatures (Figure 3c). The large decadal variability is caused in part by changes in hemispheric climate patterns. For example, a substantial increase in annual average temperature occurred around 1976, followed by gradual additional warming through 2020. Specifically, annual average temperature increased by about 1.5°F from the 1970s to the 1980s and then by about 2°F from the 1980s to the 2010s, with much higher values locally. At Utqiaġvik, annual temperature has increased by more than 12°F since 1976. This warming coincided with a shift in a climate pattern known as the Pacific Decadal Oscillation (PDO). In the past, during the warm phase of the PDO, increased atmospheric flow from the south brought warm air into Alaska during the winter. Accelerated warming has occurred since mid-2013: 2016 and 2019 were the second-warmest and warmest years on record, respectively. The shift to warmer temperatures in the 1970s can be seen in the number of extremely cold nights (Figure 4), which has generally been below the long-term (1930–2020) average since 1980, with the lowest multiyear averages occurring in the 2000–2004 and 2015–2020 periods. The number of warm days was high during the early 1990s, early 2000s, and late 2010s; 2019 experienced the second-highest number of warm days, after 2004 (Figure 5). Over the past 100 years, the length of the growing season in Fairbanks has increased by 45%, and the number of snow-free days has increased by 10%.

Total annual precipitation amounts vary greatly across Alaska. Coastal mountain ranges in the southeastern Panhandle receive more than 200 inches per year, while totals drop to 60 inches south of the Alaska Range, 12 inches in the Interior, and less than 6 inches in the North Slope. The highest 24-hour rainfall total was 15.05 inches in October 1986 at Seward, in Southcentral Alaska. The highest 24-hour snowfall total was 78 inches on February 9, 1963, at Mile 47 Camp along Highway 4 in the southeastern portion of the state. The driest multiyear periods were in the 1950s, late 1960s, and early 1970s, and the wettest were in the late 1920s (Figure 6a). The driest consecutive 5-year interval was 1968–1972, and the wettest was 1928–1932. Since the late 1980s, total annual precipitation in Alaska has been near to above average, except for a dry period in the late 1990s. There is considerable regional variability, however, as portions of Interior and Arctic Alaska have observed a long-term





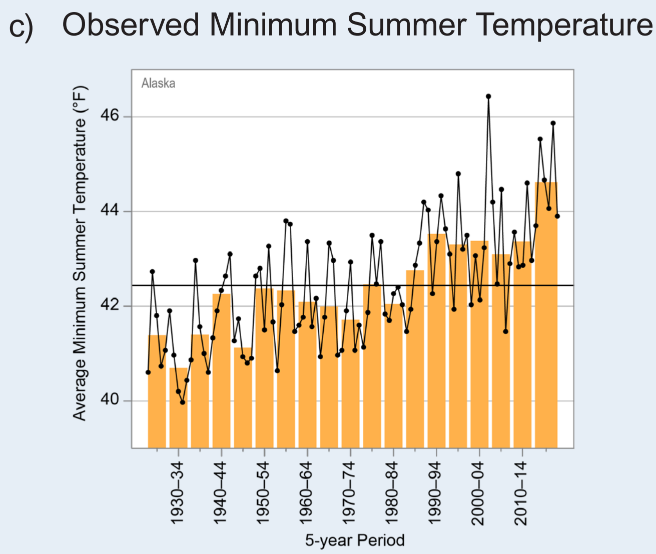


Figure 3: Observed (a) winter (December–February) average temperature, (b) summer (June–August) average temperature, and (c) summer minimum average temperature for Alaska from (a) 1925–26 to 2019–20 and (b, c) 1925 to 2020. Dots show annual values. Bars show averages over 5-year periods (first bar in Figure 3a is a 4-winter average, last bar in Figure 3a is a 6-winter average, and last bar in Figures 3b and 3c is a 6-summer average). The horizontal black lines show the long-term (entire period) averages: (a) 4.4°F, (b) 50.8°F, (c) 42.4°F. Winter and summer temperatures have been above average since 2000 and 1990, respectively. Summer minimum temperatures have been above average since 1985. Sources: CISESS and NOAA NCEI. Data: nClimDiv.

decrease in precipitation. Also, for the summer season, the 2010–2014 period was the wettest on record (Figure 6b). As with average precipitation, the occurrence of extreme precipitation events is highly variable and is both regionally and seasonally dependent. Most of Alaska has seen an increase in the heaviest 1% of 3-day precipitation totals since the mid-20th century; however, the number of daily precipitation events of 1-inch or more has been near to below average since 1990, and the highest values occurred in the 1930s (Figure 6c).

Late-summer arctic sea ice extent and thickness have decreased substantially over the last several decades, and the ice extent is approximately one-half of that observed at the beginning of satellite monitoring in 1979. The lowest minimum arctic sea ice extent occurred in 2012 (Figure 7). Arctic sea ice plays a vital role in the climate of Alaska, the lives of its inhabitants, and the functionality of its ecosystems. Warming linked to ice loss influences atmospheric circulation and precipitation patterns both within and beyond the Arctic region. Alaskans rely on sea ice for hunting and fishing and as a protective barrier against severe coastal storms. With the late-summer ice edge located farther north than it used to be, storms produce larger waves and cause more coastal erosion. A significant increase in the number of coastal erosion events has been observed, as the protective sea ice embankment is no longer present during the fall months. In response to the increased erosion, several coastal communities are seeking to relocate.

Much of the Alaska Interior (between the Brooks and Alaska Ranges) is a zone of discontinuous permafrost, and the area north of the Brooks Range is a zone of continuous permafrost. **Increasing temperatures result in permafrost thawing, which causes substantial repercussions for the ecology and infrastructure (e.g., damage to buildings, pipelines, roads, airports, and water supply and sewage systems from ground subsidence [sinking]), as well as an increase in greenhouse gas emissions**. As the climate continues to warm, snow in Alaska melts earlier each spring, lengthening the snow-free summer season.

Wildfires are also a particular concern for the state, especially in recent years. Drying of wetlands, increased frequency of warm, dry summers, and associated thunderstorms have led to a greater number of large fires during the 2000s than in any previous decade since record keeping began in the 1940s. From 2000 to 2020, the frequency of large (more than 2,000 square miles burned) wildfire seasons (35%) more than doubled compared to the 1955–1999 period (15%). The largest wildfire seasons (since 1955) were 2004 (10,500 square miles) and 2015 (8,000 square miles). **The area burned by wildfires may increase further under a warming climate**.

Under a higher emissions pathway, historically unprecedented warming is projected during this century (Figure 1). Even under a lower emissions pathway, annual average temperatures are projected to most likely exceed historical record levels by the middle of the century. However, a large range of temperature increases is projected under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records.

While historical precipitation trends are mixed, average precipitation is projected to increase in all seasons during this century, with the greatest increases expected in winter and spring. By the middle of the century, annual precipitation increases are projected to exceed 10% over the majority of the state (Figure 8).

Since 1900, global average sea level has risen by about 7–8 inches. However, in Alaska, sea level is actually falling along much of the southern coast

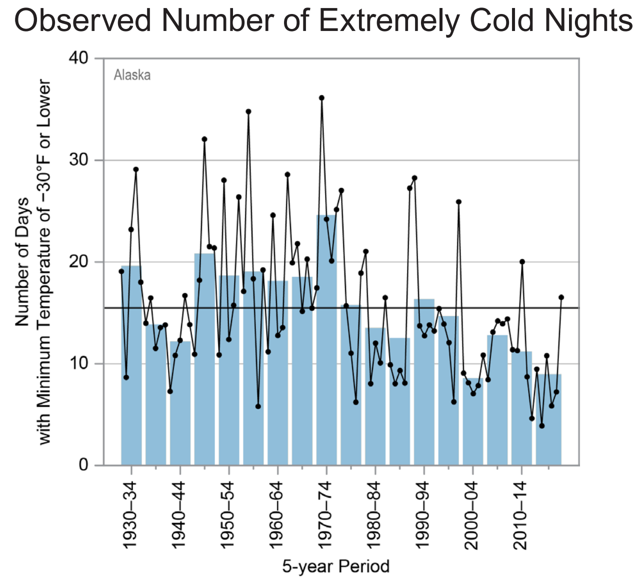


Figure 4: Observed annual number of extremely cold nights (minimum temperature of –30°F or lower) for Alaska from 1930 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 16 nights (note that the average for individual stations varies greatly because of the state's large elevation range). These values are averages from 10 of 14 long-term reporting stations. Four long-term stations located near the western and southern coasts have been excluded from the averaging because the moderating effects of the oceans prevent the occurrence of such low temperatures. Since 2000, all 10 stations have experienced numbers lower than the long-term average. The lowest multiyear averages occurred in the early 2000s and late 2010s. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily.

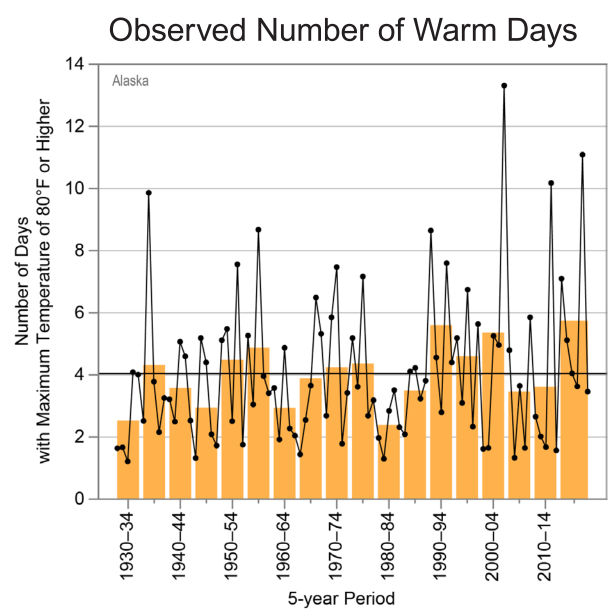
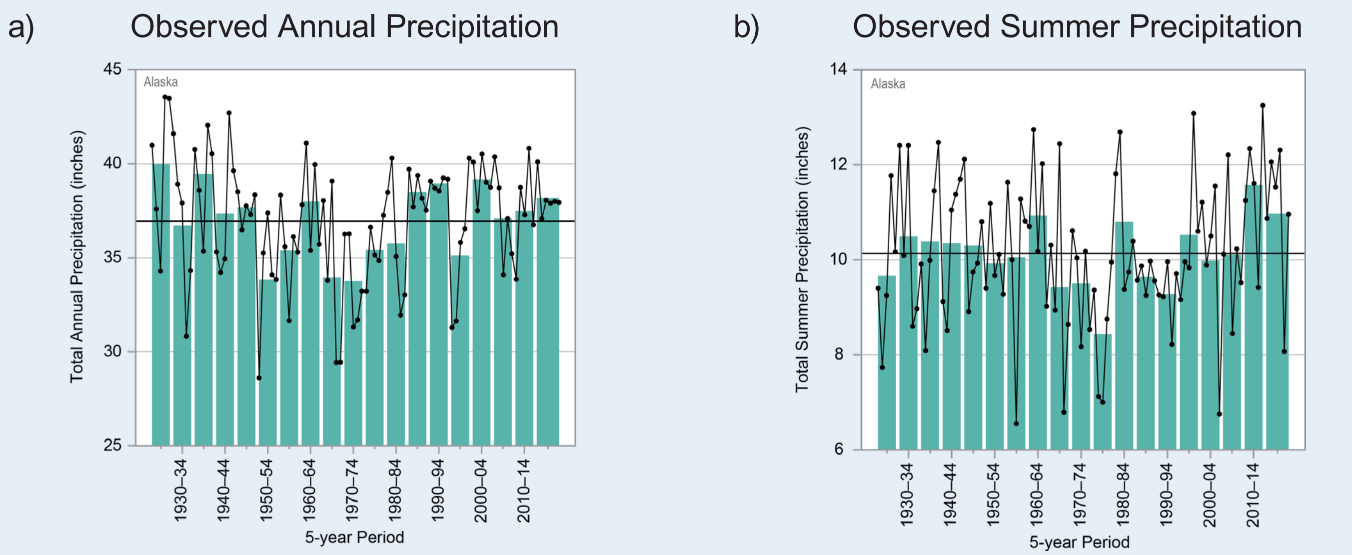


Figure 5: Observed (a) annual number of warm days (maximum temperature of 80°F or higher) for Alaska from 1930 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 4.0 days (note that the average for individual stations varies greatly because of the state's large elevation range). The highest number of warm days occurred during the early 1990s, early 2000s, and late 2010s. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 14 long-term stations.

due to isostatic rebound (rising ground) from ice mass loss. In other parts of the coast, tectonic activity results in subsidence, exacerbating the effect of sea level rise. Although global sea level is projected to likely rise another 1 to 4 feet by 2100 as a result of both past and future emissions from human activities (Figure 9), the changes in coastal erosion due to the combined effects of sea ice loss and permafrost thaw are likely to cause larger impacts well before the inundation associated with sea level rise. **Climate models project that Alaska's northern waters in late summer could be virtually ice-free before 2050**.



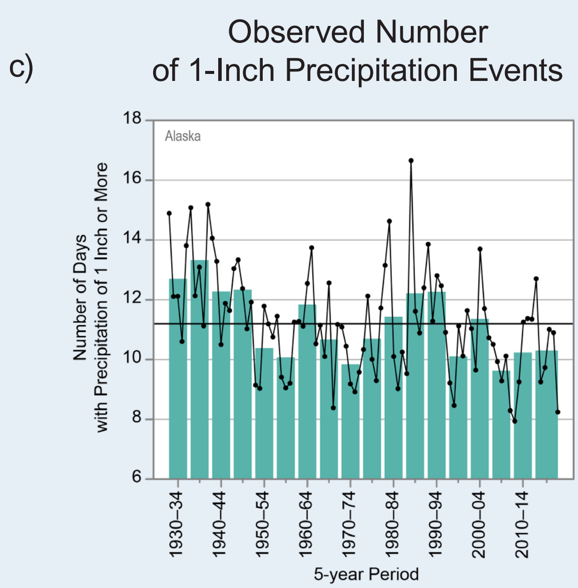


Figure 6: Observed (a) total annual precipitation, (b) total summer (June–August) precipitation, and (c) annual number of 1-inch extreme precipitation events (days with precipitation of 1 inch or more) for Alaska from (a, b) 1925 to 2020 and (c) 1930 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar in Figures 6a and 6c is a 6-year average, last bar in Figure 6b is a 6-summer average). The horizontal black lines show the long-term (entire period) averages: (a) 37.0 inches, (b) 10.1 inches, (c) 11 days. Annual precipitation has been variable with no long-term trend. For summer precipitation, the 2010–2014 period was the wettest on record.The number of 1-inch extreme precipitation events has been near or below average since the late 1990s. A typical reporting station experiences about 11 events per year, but in the diverse climate of Alaska, this number is highly variable from station to station. Sources: CISESS and NOAA NCEI. Data: (a, b) nClimDiv; (c) GHCN-Daily from 14 long-term stations.

March and September Arctic Sea Ice Extent

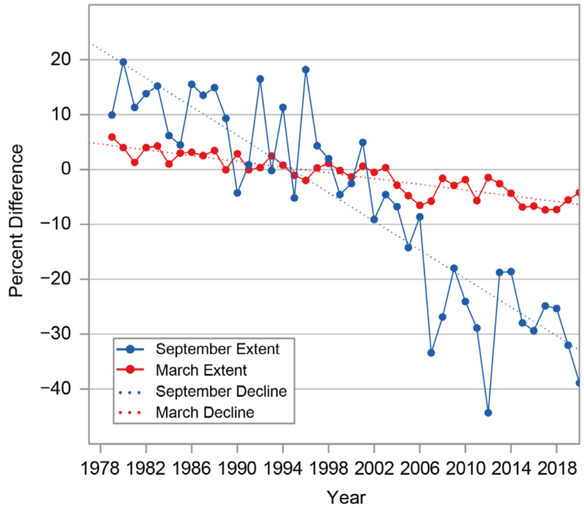


Figure 7: Time series of arctic sea ice extent anomalies in March (the month of maximum ice extent) and September (the month of minimum ice extent) from 1979 to 2020. The anomaly value for each year is the difference (%) in ice extent relative to the average values for the period 1981–2010. The red and blue dashed lines indicate ice losses of −2.6% and −13.4% per decade in March and September, respectively. Both trends are significant at the 99% confidence level. Sources: CISESS and NOAA NCEI. Data: NSIDC.

Projected Change in Annual Precipitation

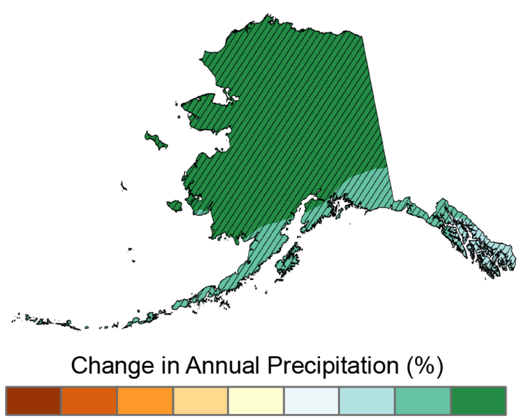


Figure 8: Projected changes in total annual precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Projected increases in Alaska's annual precipitation are consistent with a large pattern of projected increases at high latitudes Sources: CISESS and NEMAC. Data: CMIP5.

Observed and Projected Change in Global Sea Level

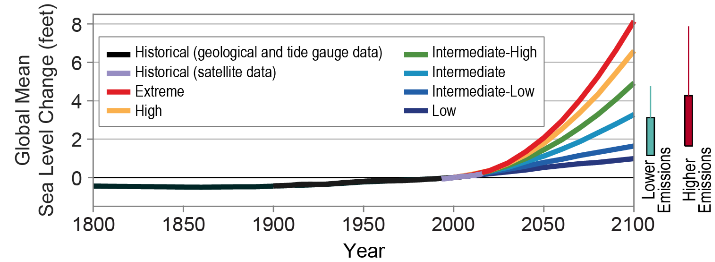


Figure 9: Global mean sea level (GMSL) change from 1800 to 2100. Projections include the six U.S. Interagency Sea Level Rise Task Force GMSL scenarios (Low, navy blue; Intermediate-Low, royal blue; Intermediate, cyan; Intermediate-High, green; High, orange; and Extreme, red curves) relative to historical geological, tide gauge, and satellite altimeter GMSL reconstructions from 1800–2015 (black and magenta lines) and the very likely ranges in 2100 under both lower and higher emissions futures (teal and dark red boxes). Global sea level rise projections range from 1 to 8 feet by 2100, with a likely range of 1 to 4 feet. Source: adapted from Sweet et al. 2017.

Technical details on observations and projections are available online at https://statesummaries.ncics.org/technicaldetails.

WWW.NCEI.NOAA.GOV | HTTPS://STATESUMMARIES.NCICS.ORG/CHAPTER/AK/ | LEAD AUTHORS: BROOKE C. STEWART, KENNETH E. KUNKEL
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