CLIMATE

Future Climate: Projected Average

"Human-induced climate-change impacts on temperature, snowpack, and the timing of streamflow over the western United States have already been detected, and as climate continues to warm, there will be serious impacts on the hydrological cycle and water resources of the southwestern United States."

The North American monsoon season, characterized by summertime thunderstorms and increased rainfall in the Southwest, accounts for a large portion of the region's annual precipitation. © Daniel Griffin

Key Messages

1

Temperatures at the earth's surface in the Southwest will rise substantially (by at least 4°F above the 1971–2000 average) over the twenty-first century from 2001–2100. The amount of this temperature rise is projected to be higher in summer and fall than in winter and spring.

2

Climate models project a reduction of Southwest mountain snowpack during February through May from 2001 through 2100, mostly because of the effects of warmer temperatures.

3

Major southwestern river basins, including the Colorado, the Rio Grande, and the Sacramento–San Joaquin region are projected to experience reductions in runoff and streamflow from the mid- to end of the twenty-first century.

The sixth chapter of the *Assessment of Climate Change in the Southwest United States* covers climate-model projections of average atmospheric and hydrologic conditions. The projections use the same set of global climate models as the upcoming *National Climate Assessment.* These projections are compared with other scientific studies to give an overview of key factors, such as temperature, streamflow, and snowpack. Regional climate-change projections—driven by global climate models—allow scientists to predict how climate change might affect climate in the Southwest during the twenty-first century, using two emissions scenarios ("A2" or "high emissions" and "B1" or "low emissions"). The high-emissions scenario assumes a future with relatively high greenhouse gas (GHG) emissions that continue to rise throughout this century at an increasingly high rate. In the low-emissions scenario, GHG emissions peak in the mid-twenty-first century and then decline.

For more information about *Assessment of Climate Change in the Southwest United States*, see: www.swcarr.arizona.edu, www.cakex.org, www.islandpress.org/NCAreports.
This fact sheet developed by Institute of the Environment, University of Arizona.

The Southwest will remain susceptible to unusually wet spells but will also remain prone to occasional drought episodes, according to climate projections.

Projected Temperatures

High-emissions model projections show that the progressive warming over the southwestern United States will continue and accelerate over the twenty-first century. Temperature projections in the low-emissions scenario show warming ranges between 1°F and 3°F for 2021–2050, 1°F and 4°F for 2041–2070, and 2°F and 6°F for 2070–2099. For the high-emissions scenario, values range slightly higher, from about 2°F to 4°F for 2021–2050, 2°F to 6°F for 2041–2070, and 5°F to 9°F for 2070–2099.

Warming will be fairly uniform across the Southwest, except for the coastal zone where warming is noticeably less than inland areas and the north—especially in Nevada, Utah, and Colorado—where warming tends to be slightly greater than the rest of the region. The largest temperature increases are projected to occur in summer, while the least warming will occur in winter.

The escalating effect of warming, coupled with a tendency toward annual precipitation decreases, would result in lower spring snowpack across much of the western United States.

Projected Precipitation

The Southwest will remain susceptible to year-to-year and decade-long variations, such as unusually wet spells and drought episodes. Precipitation is projected to decrease in the southern portion of the Southwest region and remain the same or increase in the northern portion. This north-south gradient is especially large in the high-emissions scenario. The California region will exhibit the greatest reduction in precipitation, while Colorado River Basin total precipitation is projected to be nearly the same as historical levels. There will also be precipitation differences between seasons, with winter precipitation projected to increase and the other three seasons (especially spring) showing the greatest precipitation reductions.

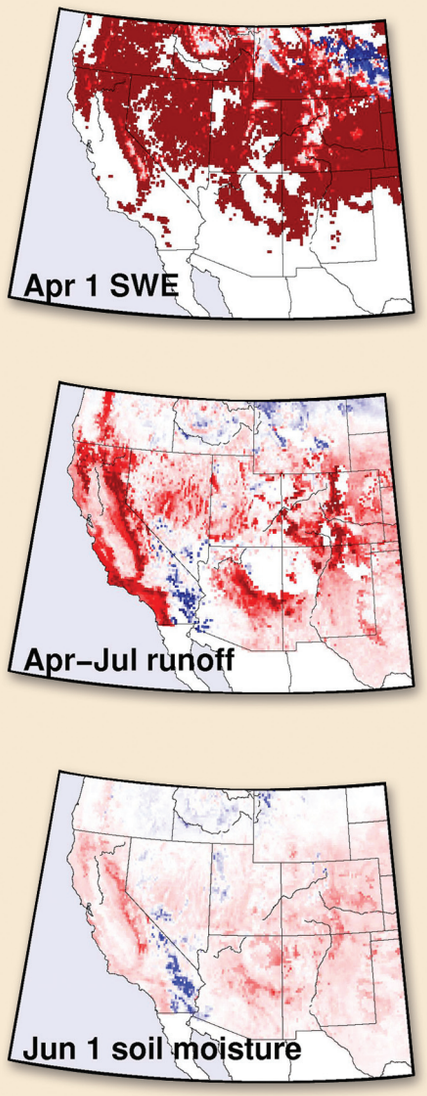
Monsoon Projections

During the monsoon season (June through September) temperatures are projected to increase between 2°F and 6°F throughout most of the western United States by the middle of this century (2041–2070), with the largest temperature increases in the central Rocky Mountains. How monsoon precipitation may change is not yet clear as there is still weak agreement among the models that precipitation during these months will decrease by about 10 to 20 percent overall in the Southwest.

Projected Runoff

Spring snow accumulation will become markedly reduced in mountain watersheds across the Southwest. More precipitation falling as rain than snow, earlier snowmelt, and, to some extent, drying tendencies will cause a reduction in late-spring and summer runoff. Together these effects, along with increases in evaporation, will result in lower soil moisture by early summer. Projected streamflows, also driven by changes in precipitation and temperature, show 10–15 percent reductions in runoff by the end of this century.

High-Emissions Scenario (2041–2070)



Predicted changes in the water cycle

Mid-century (2041–2070) percent changes from the simulated historical median values (calculated for the period 1971–2000) for April 1 snow water equivalent (SWE, top), April–July runoff (middle), and June 1 soil moisture content (bottom), as obtained from sixteen simulations using a high-emissions scenario (A2).

Information from: Cayan, D., M. Tyree, K. E. Kunkel, C. Castro, A. Gershunov, J. Barsugli, A. J. Ray, J. Overpeck, M. Anderson, J. Russell, B. Rajagopalan, I. Rangwala, and P. Duffy. 2013. "Future Climate: Projected Average." In *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 101–125. A report by the Southwest Climate Alliance. Washington, DC: Island Press.