CLIMATE

Future Climate: Projected Extremes

"The Southwest appears prone to abrupt shifts in climate regimes . . . that, coupled with enhanced heat wave activity, could lead to irreversible impacts."

Santa Ana winds, accelerating down the west slopes of Southern California's coastal ranges, are notorious for spreading uncontrollable fires. Research projects Santa Ana winds will become less frequent, albeit drier and hotter.

Key Messages

1

Heat waves are projected to increase in frequency, intensity, duration, and spatial extent. Wintertime cold snaps are projected to diminish in frequency, but not necessarily in intensity, into the late-twenty-first century.

2

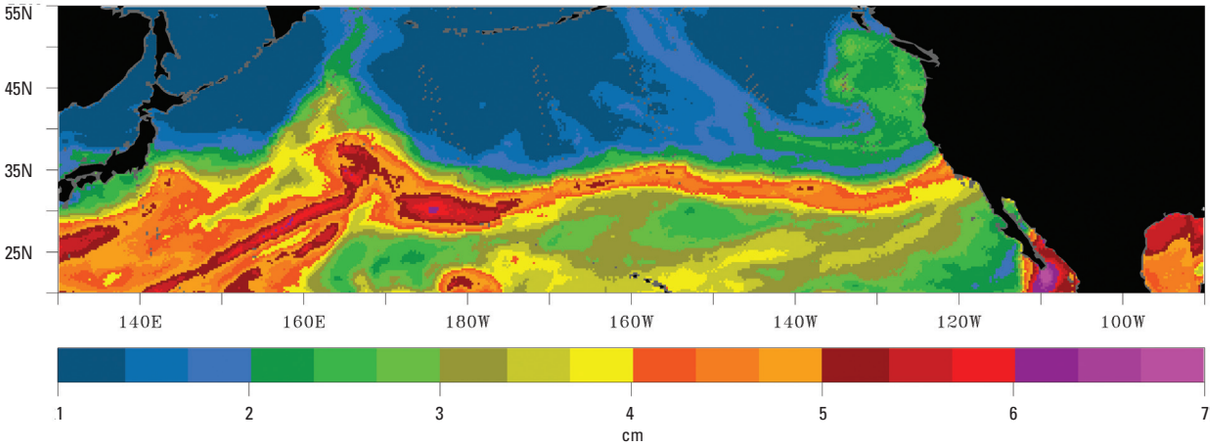
Enhanced precipitation extremes are expected due to greater moisture availability in a warming atmosphere, even if average precipitation declines. Most climate models project enhanced precipitation specifically associated with enhanced wintertime bursts of airborne moisture, called atmospheric rivers.

3

Snowmelt-driven spring and summertime floods are expected to diminish in both frequency and intensity.

The seventh chapter of the *Assessment of Climate Change in the Southwest United States* summarizes current scientific understanding about how specific weather and climate extremes are expected to change in the Southwest as global and regional temperatures increase. "Future Climate: Projected Extremes" examines heat waves, cold snaps, drought, floods, and weather related to wildland fires. The chapter also examines possible changes in weather patterns associated with climate extremes, such as "atmospheric rivers" and Santa Ana winds.

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.



This satellite image from October 2009 shows an atmospheric river hitting the California coast. The color bar shows, in centimeters, the amount of water vapor in the air if all the water vapor were condensed into one layer of liquid. The light orange river in the middle registers nearly two inches. Image courtesy of Darren Jackson, NOAA/ESRL/PSD.

Heat Waves

Much of the projected increase in heat wave activity is expected to be from average temperatures exceeding local thresholds by larger margins, more often, for more consecutive days, and over larger parts of the Southwest. Heat waves over California and Nevada are increasing in frequency and intensity and are also becoming more humid; therefore, they more strongly affect nighttime temperatures. These changes started in the 1980s and appear to have accelerated since 2000. Heat waves are projected to increase at an accelerating rate, with nighttime heat waves projected to increase faster than daytime heat waves.

Cold Outbreaks

Wintertime cold spells are projected to diminish in both maximum (daytime) and minimum (nighttime) temperatures. However, as warming continues into the late-twenty-first century, less frequent, if not always less severe, cold outbreaks should occur. Climate projections for California and Northern Baja California show that the more frequent occurrence of high-pressure systems that produce the cold snaps may increase the chances that some future cold snaps will be nearly as cold as those in the past.

A dry lake bed in Gunlock State Park, Utah.

Precipitation

Increased humidity, due to projected climate warming, is expected to generate more extreme precipitation events in the Southwest. Climate models show that extreme precipitation events that currently occur on average once in a twenty-year period are projected to occur up to twice as frequently, even in regions projected to have decreased precipitation. Climate projections show a 13 to 14 percent increase, on average, in the intensity of wintertime extremes under the high-emissions scenario. The same simulations project average precipitation to decrease over the Southwest.

Atmospheric Rivers

Atmospheric rivers (ARs) are storms in which enormous amounts of water vapor are delivered to the Southwest from over the Pacific Ocean in relatively low, long, narrow corridors aloft. When ARs encounter the mountains of the Southwest—most often in California, but occasionally penetrating as far inland as Utah and New Mexico—they produce many of the most intense regional precipitation events and floods. A preliminary study of AR occurrences and intensities, in response to the high-emissions scenario, indicates that in a warmer climate, ARs in California will carry more water vapor. By the mid-twenty-first century, the number of ARs is projected to increase by about 30 percent per year, increasing the risks of storm and flood hazards in the Southwest.

Flooding

Increased intensities and temperatures of winter storms are projected to lead to increased winter floods, especially in the Sierra Nevada, where winter storms are typically warmer than those farther inland. Even in areas where climate models project decreased total precipitation, flood magnitudes are projected to increase. Warming plays an important role, as it results in wintertime precipitation falling more as rain, which runs off more quickly than snow. A projected increase in Sierra Nevada flooding is due to wintertime storm-driven runoff, whereas spring and early summer snowmelt-driven floods are expected to wane.

Drought

Global climate models project more dry days and drier soils in the future, for the southern part of the Southwest. Along with projected warming and increased evapotranspiration, this can only mean that droughts will become more severe. Research findings, based on a high emissions scenario, suggest that the current hundered-year drought will become commonplace in the second half of this century, and that future droughts will be much more severe than those previously recorded.

Drought, as expressed in Colorado River flow, is projected to become more frequent, more intense, and longer-lasting, resulting in water deficits not seen during the historic record. Projected intensified Colorado River drought conditions are not due to changes in precipitation, but to warming, which leads to reduced snowpack and soil moisture and increased evapotranspiration.

Information from: Gershunov, A., B. Rajagopalan, J. Overpeck, K. Guirguis, D. Cayan, M. Hughes, M. Dettinger, C. Castro, R. E. Schwartz, M. Anderson, A. J. Ray, J. Barsugli, T. Cavazos, and M. Alexander. 2013. "Future Climate: Projected Extremes." 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, 126–147. A report by the Southwest Climate Alliance. Washington, DC: Island Press.

Disclaimer: This document does not represent a federal document of any kind and should not be interpreted as the position or policy of any federal, state, local, or tribal government or non-governmental entity.