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Precipitation

21st Century Precipitation Changes over the Los Angeles Region is the third in a series to consider regional climate impacts throughout Los Angeles. The UCLA study projects precipitation for the coming mid-century and provides the most detailed and advanced scientific predictions of how climate change will affect rain and snowfall in the Southern California region.

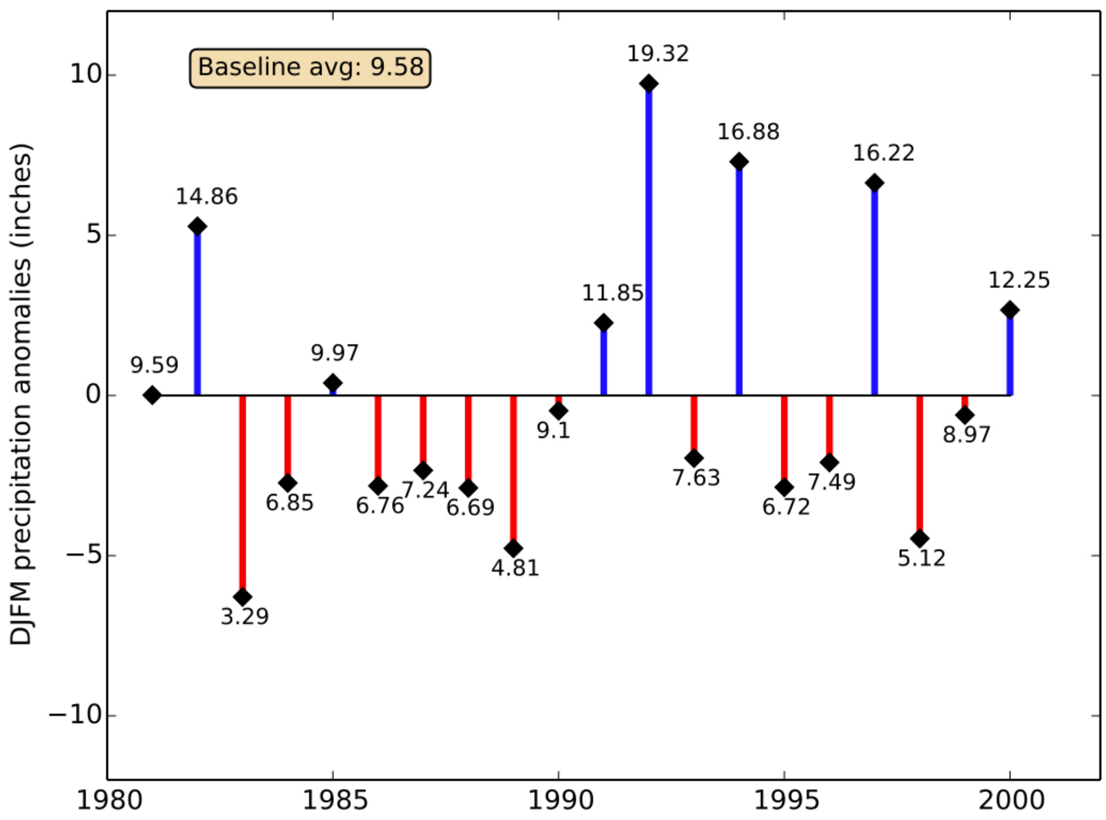
OVERVIEW

In the UCLA Department of Atmospheric and Oceanic Sciences study released December 2014, Dr. Alex Hall and his research team looked at the total amount of precipitation—rain and snow—that falls in the Los Angeles region's wet season, during the months of December through March. To do this, the team of scientists employed powerful climate simulation tools called global climate models (GCMs) to investigate how climate change will affect precipitation in Southern California. GCMs are very low in resolution, so the team developed a novel technique to produce high-resolution projections that take the region's microclimates into account. First, the team produced a simulation of local climate from 1981 to 2000, as a baseline to compare future climate to. Then, they projected climate for two future periods—2041-2060 and 2081-2100—assuming that emissions of greenhouse gases (gases such as carbon dioxide that trap heat in the atmosphere, leading to global warming) continue unabated. They found that some of the GCMs show a slight decrease in total wet-season precipitation in the future periods, whereas others show a slight increase. But the scale of the potential changes is small.

KEY FINDINGS

Highs and Lows, But Little to No Change in Total Precipitation

Los Angeles can expect roughly the same amount of total precipitation throughout the 21st century as it received in the last few decades of the 20th century. In the present-day climate, the region experiences wide swings in precipitation from year to year, and the UCLA researchers behind the study expect this variability to continue under climate change.



Precipitation in Southern California varies from year to year. (At left, December, January, February and March precipitation anomalies).

More Rain Than Snow

Over this century, Southern Californians may be at an increased risk of flooding and will have smaller windows of time to capture local water because, although the UCLA researchers found that the amount of precipitation is expected to remain nearly the same, more will fall as rain instead of snow. "Although we don't expect the total amount of precipitation to change much, we know from the snowfall study that warmer temperatures will cause less of that precipitation to fall as snow," says Dr. Hall.

Preparing for the Future

While snow stored in the mountains generally melts in the spring, rainfall runs off the mountains immediately, which poses a greater risk of flooding and shortens the chance to capture water. The previous snowfall study's findings indicate that more precipitation falling as rain instead of snow will result in higher wintertime flows. Neither the precipitation nor the snowfall study quantified these potential flows, but it is possible they would require new infrastructure to bolster the region's ability to control floods and capture water.

ADDITIONAL INSIGHTS

"Will there be rain in LA's future? Unquestionably yes. The Los Angeles region resides in between a wetter northern rain regime and a dryer southern one. These two influences have been in a tug-of-war for millenia, and our analysis suggests this pattern will continue. It's also important to look at these results in the context of our past findings on snowfall [Mid- and End-of-Century Snowfall in the Los Angeles Region, 2013]. Although we don't expect the total amount of precipitation to change much, we know from the snowfall study that warmer temperatures will cause less of that precipitation to fall as snow. Instead, it will fall as rain, which runs off our mountains much more quickly."—Dr. Alex Hall, lead scientist on UCLA's *21st Century Precipitation Changes over the Los Angeles Region* study "The study, frankly, helps us move forward with our plans. [It] gives us confidence to proceed with our utility's plans to increase local water supply from 11% this year to 36% by 2035." —Martin Adams, Senior Assistant General Manager, Water Systems, Los Angeles Department of Water and Power "The UCLA study echoes the early findings of the LA Basin Stormwater Conservation Study, which is being developed jointly by the County and Bureau of Reclamation. From flood protection to recharge of the region's groundwater aquifers, both studies point to the critical need for increased investments in the County's stormwater capture infrastructure as a way of ensuring healthy watersheds and a sustainable, local water supply."—Gary Hildebrand, Deputy Director of LA County Public Works "Every inch of rain we fail to capture results in the loss of 3.8 billion gallons of water. The recent rain event on December 2 and 3 – these two days alone, if captured, could have supplied over 4% of the city's annual water needs. The UCLA study suggests we can indeed rely on local rain for our water needs—and we must be willing to make the investment."—Dr. Shelley Luce, executive director of Environment Now

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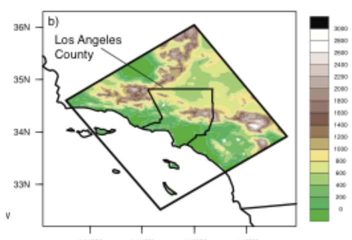
FREQUENTLY ASKED QUESTIONS

Who conducted the study? This study is part of the Climate Change in the Los Angeles Region Project, of which Professor Alex Hall is the lead scientist. Neil Berg conducted the analysis for this paper, under the guidance of Dr. Hall and with contributions from Fengpeng Sun, Scott Capps, Daniel Walton, Baird Langenbrunner, and David Neelin. All co-authors are current or former members of UCLA's Department of Atmospheric and Oceanic Sciences. **Where is it published?** The study, *21st-Century Precipitation Changes over the Los Angeles Region*, has been peer-reviewed and accepted for publication by Journal of Climate, a publication of the American Meteorological Society. It is available online and you can also download it below. **Who funded the study?** Initial funding was provided by the City of Los Angeles through a grant made by the United States Department of Energy. Additional funding came from the National Science Foundation and the Southwest Climate Science Center. **What were the methods employed to make the projections of future precipitation?** The main tools for projecting future climate are global climate models (GCMs), which simulate the climate system's response to emissions of the greenhouse gases that contribute to global warming. GCMs are very useful for understanding global or large-scale changes, but they are too low in resolution to help us understand changes in smaller regions—particularly those, like the Los Angeles region, that have a complex topography and microclimates. To understand climate change on the local scale, researchers use a set of techniques collectively called downscaling to bring GCM output to a higher resolution. The present study uses a new hybrid dynamical-statistical downscaling approach to project mid- and end-of-21st century precipitation changes at a high resolution over the Los Angeles region. Dynamical downscaling, which involves running GCM output for a specific area through a regional climate model, was performed on UCLA supercomputers for 5 GCMs. From the dynamical simulations, the researchers developed a statistical model that allowed them to downscale output from another 31 GCMs. The GCM simulations used were from the Coupled Model Intercomparison Project, Phase 5; these are the same simulations used in the Intergovernmental Panel on Climate Change 5th Assessment Report. **What makes this study unique?** Previous studies have used either a dynamical or empirical statistical downscaling technique. The current study is novel in that it used both types of downscaling, and employed the relationships observed in the dynamically downscaled projections to develop the statistical downscaling model. The benefit of this approach is that it allows researchers to produce physically credible high-resolution projections from a large number of GCMs, thus taking into account a range of possible futures. This study employed 36 GCMs, generating a large range of precipitation outcomes. No previous study on local precipitation has used this dynamical-statistical approach, nor employed so many GCMs. **What are the geographic boundaries covered by the study?**



The highest-resolution projections produced in this study are at a resolution of 2 kilometers, or 1.2 miles (as opposed to about 100 miles in the typical GCM). The area studied at this resolution ranges from Santa Barbara at the west to Tehachapi (north) to Palm Desert (east) to San Clemente Island (south). The area fully encompasses counties of Los Angeles, Ventura and Orange and includes parts of Kern, San Bernardino and Riverside. **What are the study's main findings?** The study looked at the total amount of precipitation (rain and snow) that falls in the Los Angeles region's wet season, during the months of December through March. The researchers calculated the average wet-season precipitation total for a baseline period of 1981–2000 and compared it with the corresponding averages for two future periods (2041–2060 and 2081–2100), as projected by each downscaled GCM simulation. Some GCMs showed a slight decrease in average total wet-season precipitation in the future, and others showed a slight increase. It isn't clear which set of GCMs is more likely to be correct.But either way, the change they project is small, especially when compared with the wide year-to-year swings in precipitation levels that the region currently experiences. **So rain and snow in Southern California are essentially going to stay the same?** No. Although the total amount of precipitation in Southern California is not expected to change much throughout the century, increased temperatures due to human-caused climate change will cause a greater portion of that precipitation to fall as rain instead of snow. UCLA's previous study, Mid- and End-of-Century Snowfall in the Los Angeles Region, released in June 2013, projected a 40% decrease in snowfall in Southern California mountains by mid-century. Whereas snow is stored in the mountains until it gradually melts in the spring, rainfall runs off the mountains right away. Therefore, the snowfall study's findings indicate that more precipitation falling as rain instead of snow will result in higher wintertime flows. Neither the precipitation nor the snowfall study quantified these potential flows, but it is possible they would require new infrastructure to bolster the region's ability to control floods and capture water. A forthcoming study, conducted by the Los Angeles County Flood Control District and U.S. Bureau of Reclamation, will characterize future flood risk. **If we dramatically reduce greenhouse gas emissions, can we avert some of the warming, and its effects on snowfall and runoff?** In the analysis toward the present study, the researchers assessed whether precipitation outcomes were different between a business-as-usual greenhouse gas emissions scenario and a scenario of curtailed emissions. Finding there was little difference in the two scenarios, they focused on the business-as-usual results in their paper. Past studies of temperature and snowfall did show a difference between the business-as-usual scenario and the curtailed-emissions scenario at the end of the century, suggesting that reductions in global emissions of greenhouse gases will not stave off warming in the short term but would make a big difference over the long-term. In their 2012 study, Mid-Century Warming in the Los Angeles Region, the UCLA researchers found only a small difference between business-as-usual and curtailed emission scenarios by the middle of the century. It takes the climate system several decades to respond to changes in greenhouse gas emissions. (Think of a bringing a pot of water to boil on a gas stove; it takes several minutes after the flame is applied to the pot for the water to heat. Conversely, an already-boiling pot of water takes time to cool after the flame is turned off.) By contrast, the researchers found a dramatic difference between the two scenarios by the end of century: Warming levels off under curtailed emissions but continues to increase substantially under business-as-usual. Reducing greenhouse gas emissions is critical for preventing the most severe impacts of climate change in the long term. **Does the precipitation study look at frequency and severity of storms?** No. The study does not assess the frequency or severity of individual storm events. Do these studies have implications for wildfire? Many factors influence the length and severity of the fire season, including temperature, precipitation, soil moisture, and the Santa Ana winds. A forthcoming study, a collaboration between UCLA and UC Irvine, will characterize future changes in wildfire in the Los Angeles region. **What about the current drought in California? Isn't it caused by climate change?** Climate change probably didn't start this drought, but it may be making it worse. A drought starts with lower-than-usual levels of precipitation, and there have been many periods of low precipitation in California's recent and distant past. A recent study by conducted by researchers at the University of Minnesota and the Woods Hole Oceanographic Institution and published in Geophysical Research Letters found that the current drought is the worst in about 1,200 years. But what makes this drought exceptional is not the low precipitation leading to it, which is within the bounds of natural variability. Instead, the researchers say that increased temperatures are contributing to the drought's severity, by increasing evaporation and decreasing soil moisture. **How certain are these results?** The authors acknowledge that, as with any study projecting future climate, there is some uncertainty in their results. As mentioned above, it isn't clear which outcome—a slight decrease in average precipitation, or a slight increase in average precipitation—is more likely. In addition, the GCMs are prone to errors when they simulate the El Niño/La Niña phenomenon, which influences precipitation over California by affecting the position of the jet stream. El Niño years tend to be wetter in Southern California, and La Niña years tend to be drier. Possible changes to El Niño/La Niña are not considered in the current study. The UCLA scientists estimate that including these changes could increase the range and uncertainty of projected precipitation changes up to 25%, but these additional uncertainties are not large enough to alter the main conclusions of the study.

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Learn more about what you can do to help mitigate climate change.

Download the Precipitation Study

The Climate Change in the Los Angeles Region Project This study is the third in a series being conducted by atmospheric scientists at UCLA, employing an innovative technique for applying global climate models to the Los Angeles region to provide detailed projections of climate change. The first study in the series, *Mid-Century Warming in the Los Angeles Region*, was released in 2012; the second study, *Mid- and End-of-Century Snowfall in the Los Angeles Region*, was released in 2013. Learn more about the science behind these ground-breaking reports.

ADDITIONAL CLIMATE ASSESSMENTS

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