Stanford Woods Institute for the Environment

Research Brief

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Atmospheric Conditions Associated with the 2013-14 California Drought Are 'Very Likely' Linked to Human-caused Climate Change

California currently is facing a historically unprecedented drought, with 2013 proving to be the driest year since at least 1895. **As solutions are being sought to address the current crisis, a critical question is whether the atmospheric conditions linked to the drought are to be expected to occur with increased frequency as a result of the climate change that has already occurred.** In a new study, Stanford researchers have placed recent conditions into historical context, and explored the role of climate change in affecting the probability of events similar to the ongoing drought in California.

Background

The central cause of California's 2013-14 drought is a persistent region of high atmospheric pressure—nicknamed the "Ridiculously Resilient Ridge." This very unusual atmospheric feature displaced the Pacific storm track well to the north of its typical location, ultimately leading to record-low precipitation in California. Extremely low rainfall and mountain snowfall—combined with record-high temperatures—have exacerbated drought conditions throughout the state.

In early 2014, state and federal water agencies announced that agricultural water users in the Central Valley would receive no irrigation water during 2014, and that a number of smaller communities throughout California were at risk of running out of water entirely. Low rainfall, unusually warm temperatures, and stable atmospheric conditions adversely affected fisheries and other ecosystems, led to poor air quality, and dramatically increased wildfire risk.

About the Researchers

This brief summarizes findings from an interdisciplinary team of researchers in Stanford's School of Earth Sciences and School of Humanities and Sciences. The work was a collaboration between the climate research group led by Woods Senior Fellow **Noah Diffenbaugh** (Assoc. Prof. Environmental Earth System Science) and the statistics research group led by Woods Affiliated Faculty **Bala Rajaratnam** (Assist. Prof. Statistics and Environmental Earth System Science). The first author of the paper is **Daniel L. Swain** (graduate candidate, Environmental Earth System Science).

Such impacts ultimately resulted in a state-level drought emergency being declared. Policy-makers across all levels of state and federal government have proposed or implemented measures to address the worst effects of the drought and alleviate the impacts on the hardest hit communities—including the agricultural sector—in the short term.

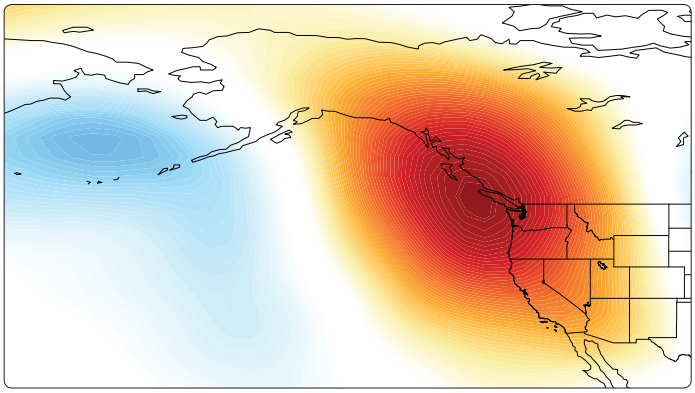
Key Findings about the Current 2013-14 California Drought

- The 1-year intensity of the 2013-2014 drought (in terms of precipitation) exceeded that of any previous California drought of at least the last century, including the notable droughts of 1976-1977 and 1987-1992
- The scale and duration of the atmospheric ridge linked to the drought was greater in 2013-2014 than during any previous event of at least the last half-century

Key Findings about Climate Change Influence on the California Drought

- Human emissions of heat-trapping greenhouse gases have greatly increased the probability of certain atmospheric conditions similar to those experienced during the 2013-2014 drought
- The probability of extremely high atmospheric pressure associated with ridging over the North Pacific Ocean—which is linked to decreased precipitation in California—has "very likely" increased by a factor of at least three due to human activities

The Ridiculously Resilient Ridge in January 2014



Conclusions

The 2013-2014 California drought was (and continues to be) an exceptional climate event. A highly persistent large-scale meteorological pattern over the northeastern Pacific led to record-breaking low precipitation over a broad region. The very strong ridging near the West Coast of North America in 2013-2014 was structurally similar to—but more extensive in duration and scale—than atmospheric conditions that have been previously linked to extreme dryness in California.

The research team's findings indicate extreme atmospheric high pressure in this region—which is strongly linked to unusually low precipitation in California—is much more likely to occur today than prior to the human emission of greenhouse gases that began during the Industrial Revolution in the 1800s. This finding strongly suggests that global warming has already increased the risk of some of the atmospheric conditions that create severe drought in California.

Recommendations

The new research findings strongly suggest that global warming has substantially increased the probability of key atmospheric conditions associated with the current drought in California. Given the severe impacts of the current drought on multiple sectors, the findings suggest increasing risk of such conditions in coming years. Recognizing this increased probability has the potential to improve the effectiveness of decisions that rely on assumptions about drought frequency, including resource management and infrastructure design.

Further work will be required to more directly address the question of whether extremely low precipitation in California—and thus severe droughts—will become more likely in the future due to climate change. More still needs to be known about the changing character of precipitation and its relationship to broader atmospheric patterns—an issue that is currently being investigated in ongoing work.

This brief is based on "The Extraordinary California Drought of 2013-14: Character, Context, and the Role of Climate Change," published as part of the Extreme Events of 2013 special section of the Bulletin of the American Meteorological Society. To receive a copy of the full report, including citations, visit: *http://www.ncdc.noaa.gov/bams-state-of-the-climate/extreme-events/*

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