# Error correction means California's future wetter winters may never come

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Winter precipitation includes more than just rain. Winter moisture levels influence snowpack in mountainous areas, like this California waterway, and other factors that shape climate processes throughout the year. Credit: 12019 | Pixabay.com)

California and other areas of the U.S. Southwest may see less future winter precipitation than previously projected by climate models. After probing a persistent error in widely used models, researchers at the Department of Energy's Pacific Northwest National Laboratory estimate that California will likely experience drier winters in the future than projected by some climate models, meaning residents may see less spring runoff, higher spring temperatures, and an increased risk of wildfire in coming years.

Earth scientist Lu Dong, who led the study alongside atmospheric scientist Ruby Leung, presented her findings at the American Geophysical Union's fall meeting on Tuesday, Dec. 1, and will answer questions virtually on Wednesday, Dec. 16.

As imperfect simulations of vastly complex systems, today's climate models have biases and errors. When new model generations are refined and grow increasingly accurate, some biases are reduced while others linger. One such long-lived bias in many models is the misrepresentation of an important circulation feature called the intertropical convergence zone, commonly known as the ITCZ.

The ITCZ marks an area just north of the Earth's equator where northeast trade winds from the northern hemisphere clash with southeast trade winds from the southern hemisphere. Strong sunlight and warm water heat the air here, energizing it along with the moisture it holds to move upward.

As the air rises, it expands and cools. Condensing moisture provides more energy to produce thunderstorms with intense rainfall. From space, one can even see a thick band of clouds, unbroken for hundreds of miles as they move about the region.

"The ITCZ produces the strongest, long line of persistent convection in

the world," said Dong. "It can influence the global water cycle and climate over much of the Earth," including, she added, California's climate.

## Doubling down on climate model bias

Many climate models mistakenly depict a double ITCZ: two bands appearing in both hemispheres instead of one, which imbues uncertainty in model projections. Scientists refer to this as the double-ITCZ bias. Variations in the wind and pressure systems that influence the ITCZ add to that uncertainty.

"There's a lot of uncertainty in California's future precipitation," said Dong, who described climate models that project a range of winter wetness in the state averaged over multiple years, from high increases to small decreases. "We want to know where this uncertainty comes from so we can better project future changes in precipitation."

To peer through the effect of the double-ITCZ bias and create more accurate projections, Dong and atmospheric scientist Ruby Leung analyzed data from nearly 40 climate models, uncovering statistical and mechanistic links between the bias and the models' outputs. The lion's share of the models they analyzed projected a sharpening of California's seasonal precipitation cycle, bringing wetter winters and drier fall and spring seasons.

Soft, white snow rests on either side of a California waterway. Winter precipitation includes more than just rain, encompassing snowpack in mountainous areas and other factors that influence climate processes throughout the year.

## Less water, more fire

Those uncovered relationships, Dong said, now cast doubt on estimations from CMIP5 models that projected wetter winters in the future. Models saddled with a larger double-ITCZ bias, it turns out, tend to exaggerate the U.S. Southwest's wetter winters. They also understate the drier winters in the Mediterranean Basin, which also features pronounced wet winters and dry summers similar to California, under warming climate scenarios.

Correcting for the bias reduces winter precipitation projections to a level that's roughly equal to California's current winters, amounting to little change and no future wetter winters. In the Mediterranean Basin, said Dong, the correction means winter drying will be intensified by 32 percent.

"An important implication of this work," said Dong, "is that a reduction in estimated winter precipitation will likely mean a reduction in spring runoff and an increase in spring temperature, and both increase the likelihood of wildfire risk in California."

## Learning from climate models

Though the study's focus was restricted solely to winter precipitation, said Leung, its implications reach to all seasons.

"The implications aren't just about how wet things will or won't be," said Leung. "When people think about precipitation, they tend to think about how much rain they'll get. But precipitation has a lot of implications, like snowpack in mountainous areas, for example, and that means whatever changes we see in winter precipitation will have subsequent implications for springtime or even summertime. The impacts don't just affect winter ; they'll be felt throughout the year."

The findings do not bode well for agricultural production, as over one

third of the country's vegetables are grown in California soil, and two thirds of its fruits and nuts are grown on California farms, according to the California Department of Food and Agriculture. Almonds and grapes, two especially water-hungry crops, were among the state's top producing commodities, bringing in a combined $11.5 billion in 2019.

Over 4 million acres and nearly 10,500 structures burned in the state's 2020 wildfire season. The fire season has grown longer, according to Cal Fire, which cites warmer spring temperatures as one of the reasons forests are now more susceptible to wildfire.

Dong and her research partners hope the findings will better inform resource management groups as they prepare for coming wildfire seasons and plan for drier-than-expected winters.

The double-ITCZ bias is prominent in all CMIP5 climate models, said Leung, as well as CMIP6 models, the most recent generation, though the latter were not considered in this work. "If you look at the whole ensemble of models," said Leung, "you see quite similar biases."

Provided by Pacific Northwest National Laboratory