Q&A: Study reveals long-distance levers behind US Southwest drought, and a dry future

September 26 2023, by Kevin Krajick

The U.S. Southwest has suffered a historic drought over the past two decades. A new study elucidates the drivers, and says conditions will never return to those of the relatively wet 20th century. Credit: Kevin Krajick/Earth Institute

The U.S. Southwest has been suffering a drought that began at the close of the 20th century—now officially known as a megadrought, due to its intensity and longevity. Climate scientist Richard Seager has been studying it since the start. Much of his research has been on the role of natural variability versus human-induced climate change.

In a new study in the journal *npj Climate and Atmospheric Science*, Seager and his colleagues at Columbia University's Lamont-Doherty Earth Observatory connect much of the drying to natural atmospheric cycles over the Pacific and Atlantic oceans. Modeling these cycles into the future, they say that in the best-case scenario, conditions could ease a bit in coming years, but with climate change, will never return to their pre-2000 state. In a worst-case scenario, the drought will become even fiercer and more persistent. We spoke with Seager about the study, and what led up to it.

What has been happening in the US Southwest? Has the region ever seen anything like this?

The Southwest has not experienced a megadrought like this since the advent of European settlement, although we know from tree rings that events just as severe did occur earlier in the last millennium. However, this is now occurring when regional population and resulting water needs have boomed. That includes demand from agriculture, which is far and away the main user. So already the challenges are immense. Now the question is how that situation is going to evolve in coming decades with intensifying climate change.

What are the natural mechanisms at work here?

Using climate modeling, we have shown that the megadrought, defined in terms of summer soil moisture, has been driven by a reduction in

precipitation in the cool December–May season. That reduction was forced by decade-scale variations of sea surface temperatures in the tropical Pacific Ocean. This so-called Pacific Decadal Oscillation, or PDO, is presumed to be a natural oscillation.

In the late 20th century, it was in a phase where the eastern waters were relatively warm. This affected atmospheric circulation in a way that brought wet winters and springs to the Southwest. After an El Niño episode in 1997–98, the PDO switched into its cool phase; this caused a switch in the atmospheric circulation, and dry winters and springs, which kept down moisture all the way through to summer.

Many of your colleagues say that warming climate has played the main role in the drought, in that higher temperatures have been the main factor in sucking moisture out of soils. Are they right, wrong, or somewhere in between?

They are almost certainly right. However, they have focused on changes that have taken place over the last century. In our study, we focused on the dramatic swing from the wet decades of the late 20th century to the megadrought of the 21st century. That swing is almost entirely driven by a drop in cool-season precipitation.

Will the megadrought continue?

We used some novel climate modeling to see how things will evolve out to 2040 under the influence of potential variations of ocean temperatures in the Pacific and Atlantic oceans. A best-case scenario would be if the tropical Pacific switches back to being warm, and also if the North Atlantic went into one of its cooler phases. However, due to how climate

change influences precipitation and warms the surface of the Southwest itself, not even under this scenario does water availability return to late 20th century levels. Under a worst-case scenario, with a continued cool tropical Pacific and a warm phase of the North Atlantic, the megadrought will continue and even intensify.

There has been a lot of recent discussion about the fact that global warming was expected to produce a warmer tropical Pacific, yet, as you point out, we are seeing the opposite. Does this mean the models we use to predict the future are off?

To look at this, we produced two sets of future projections. In one, the natural decadal variations of sea-surface temperature were imposed upon a background trend in which the eastern tropical Pacific warms up, as state-of-the-art climate models indicate it should. In the other case, we extrapolated out the actual trend. As I said, cool-season precipitation in the Southwest tends to be less when the eastern tropical Pacific is cool.

Hence, if the eastern tropical Pacific continues to not warm, the best- and worst-case scenarios will both be drier than what state-of-the-art climate models would predict. We have argued that these models erroneously assume the eastern tropical Pacific will warm because of chronic model biases, and that in the real world the tropical Pacific responds to rising greenhouse gases by warming most everywhere, but not in the east. So, yes, the state-of-the-art climate models might well be underestimating how dry it will get. Continued lack of warming in the eastern Pacific will make the worst-case scenarios more likely.

How will overall warming affect conditions in the future?

Although we think decadal ocean variability is the greater influence on the Southwest, we think that overall warming of the oceans also reduces cool-season precipitation in the Southwest. Plus, global warming is increasing temperatures over the Southwest's surface. This allows the atmosphere to hold more water, and this can reduce soil moisture. In our projections, this drying-by-warming effect is clear over the next two decades. This will occur regardless of the pattern of sea-surface temperature change.

Will we see shifts in precipitation in other parts of the world?

There certainly will be! We intend to use these same model experiments to examine how decadal ocean variability and greenhouse gas-driven changes in sea-surface temperature will impact precipitation in other regions. Further, right now we are looking into how continued lack of warming of the eastern equatorial Pacific would impact trends in tropical cyclones in the Pacific and Atlantic basins. We also need to look at other regions of the world that the tropical Pacific exerts a strong influence over, including South America, Africa and Asia.

More information: Richard Seager et al, Ocean-forcing of cool season precipitation drives ongoing and future decadal drought in southwestern North America, *npj Climate and Atmospheric Science* (2023). DOI: 10.1038/s41612-023-00461-9