Warmer means drier: comparing the 2000s drought to the 1950s drought

By Zack Guido

Jeremy Weiss wears many hats as a senior research specialist for the Environmental Studies Laboratory in the Department of Geosciences at the University of Arizona. His interests include studying past and present vegetation in western North America, worldwide changes in sea level, and visual methods for communicating science. His research, however, has one thing in common: it focuses on climate.

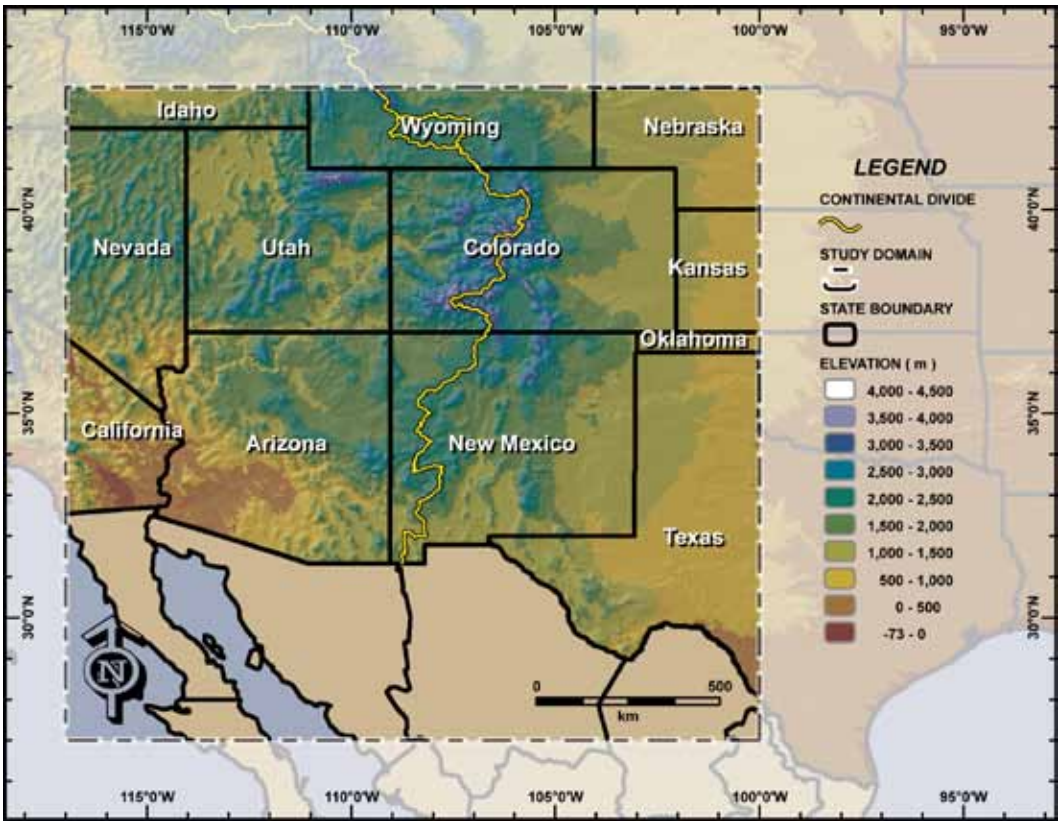

Figure 1. Area of study includes all of Arizona and New Mexico. Figure courtesy of Jeremy Weiss.

His latest research, with Christopher Castro, assistant professor of atmospheric sciences at the UA, and Jonathan Overpeck, a UA geosciences professor and lead principal investigator for the Climate Assessment for the Southwest (CLIMAS), dissected a hot topic in the Southwest—drought. Weiss and his team examined how recent drought has compared to past drought, the implications of warmer temperatures on drought severity, and how the combination of warmer temperatures and drought are mostly bad news for wildfire, air quality, and water demand.

In a February interview with Zack Guido, CLIMAS staff scientist, Weiss discussed his research results. His findings were published in the November 15 issue of the *Journal of Climate* in the paper, "Distinguishing Pronounced Droughts in the Southwestern United States: Seasonality and Effects of Warmer Temperatures."

Question: How does the title of your recent paper reflect the research?

Jeremy Weiss: The general topic of our article is drought in the Southwest. Drought is a normal part of the region's climate. We know this by looking at the last century of instrumental data, and we can identify drought periods using tree rings and other indicators stretching back hundreds of years. In this paper, we picked the two most recent droughts—the 1950s drought, which has been regarded as the most severe drought of the last 100 years, and the drought that we've experienced over the past decade.

The particular findings that came to the forefront during the research were the differences in temperatures between the droughts and the times of the year when these differences occurred. Quite convincingly, the 2000s drought was significantly warmer than the 1950s drought. Unfortunately for residents of the Southwest, these higher temperatures occurred during the warmer months of the year and were especially prevalent during the foresummer. This period right before the monsoon is exactly the time of year when you would not want hotter and drier conditions during a drought.

Q: What questions did you initially set out to answer?

JW: We wanted to detail how the most recent drought compared to the 1950s drought, get a better understanding of the relative severities of each, and look at what seasonal differences might have occurred. For example, we wanted to know which drought had less precipitation during the winter months and which had less precipitation during the summer months.

Q: What periods in the 2000s and 1950s did you compare?

JW: For the sake of being able to compare to other published studies, we looked at the four-year periods of 2000–2003 and 1953–1956. These years also arguably

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represent when the most severe conditions occurred during each of the droughts.

Q: How did you analyze drought conditions?

JW: We looked at seasonal precipitation amounts, maximum and minimum temperatures, dew point temperatures, and vapor pressure deficits throughout the Southwest. The last two measures both can be thought of as an indication of moisture conditions in the atmosphere. The latter can be thought of as the atmosphere's ability to act like a sponge and take up moisture from soil and vegetation. In this study we strictly compared the state of the atmosphere near the Earth's surface, and not ground conditions such as reservoir levels or vegetation health.

Q: What is new and exciting about the results of this study?

JW: Hands down, the 2000s drought was significantly warmer than the 1950s drought, in particular maximum temperatures during the summer months and minimum temperatures from spring through early fall. These warmer conditions were widespread throughout the Four Corners region of the Southwest (Figure 1). If you were to draw a line basically straight down through the middle of Colorado and New Mexico, everything west of that line was 1–4 degrees Celsius (about 2–7 degrees Fahrenheit) warmer during the 2000s drought.

Warmer temperatures are important because temperature is a hydrologic variable. If you think of the atmosphere as a sponge, warmer temperatures allow that sponge to become larger, which means more moisture then can be taken up from soils, vegetation, and reservoirs. So, if you want a season to be drier, a good way to do that simply would be to make it warmer. And that is essentially what happened during the summers of the 2000s drought.

Q: How was precipitation different between the two droughts?

JW: There were differences between the two droughts, but it wasn't all drier or all wetter in one drought or the other. The differences were mixed, and here is where seasonality comes into play. The 2000s drought had less precipitation in early winter and from late spring through early summer in northern Arizona and nearby areas of neighboring states. The 1950s drought was significantly drier in Arizona and western New Mexico during fall and over most of New Mexico in early winter. Now, we didn't pinpoint the exact causes of the precipitation differences. But knowing at what time of year these differences occurred and being familiar with seasonal precipitation sources, one can begin to figure out such causes. For example, in the 2000s drought, it is possible that westerly frontal systems in late spring or the start of the monsoon in early summer didn't give us as much precipitation as during the 1950s drought. And in the 1950s drought, it is possible that the end of the monsoon or tropical cyclones from the Pacific Ocean in early fall didn't give us as much precipitation as during the 2000s drought.

Q: Why is temperature an important component of drought?

JW: Temperature can control the amount of moisture that the atmosphere can hold—that is, the size of the sponge that can take up moisture from soils and vegetation. As the atmosphere becomes warmer, the size of the sponge grows, and the atmosphere can take up more moisture. Now, there is an interesting twist to this relationship between temperature and the ability of the atmosphere to pull moisture from the surface. The size of the sponge grows faster when warming occurs during our summer than during the other cooler seasons. So, the relatively higher temperatures at the hottest time of the year during the 2000s drought made the sponge grow a lot and take up a lot of moisture from soil and vegetation.

Q: What are the impacts in the Southwest of warmer temperatures during droughts?

JW: We do not want a hotter and drier foresummer during drought. These conditions increase water demand. For example, I know that I used more water in recent years to keep the trees in my yard healthy. Air quality can suffer because hotter and drier conditions can lead to more dust in the air. Wildfire danger increases because hotter and drier conditions are better at drying out vegetation. And, what's worse, if you add a dry monsoon to the end of a hotter and drier foresummer, the wildfire season can continue further into the summer.

Q: Will warmer and therefore drier droughts in the Southwest be common in the future?

JW: First, drought is a normal part of our climate, and I have no reason to think that it will not occur in the future. The only question is when drought will occur. Second, I would bet on temperatures continuing to warm in the region, primarily due to human-caused climate change. So, I expect that any drought in the future would be warmer, and that the ability of the atmosphere to take up moisture from the surface – the size of the sponge – would be greater.

Q: What is the take-home message of your research?

JW: I'd like to think that we are helping people understand what a few degrees of warming means for the Southwest, in particular during drought. Given that the societal impacts of drought under warmer temperatures are mostly bad, and that the typically hottest and driest time of the year is hotter and drier, I haven't particularly enjoyed the 2000s drought, and I certainly would not look forward to the next one.