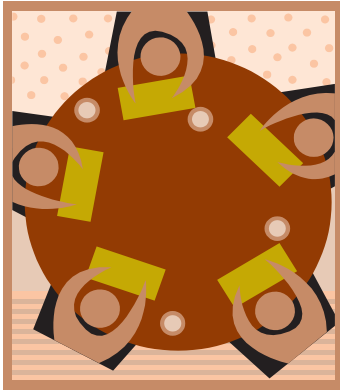


Climate experts discuss Southwest drought

The following is an abbreviated portion of a roundtable discussion on drought held on September 10, 2004. Some definitions and explanations are included within the discussion (in italics). Please see the CLIMAS online glossary (<http://www.ispe.arizona.edu/climas/forecasts/glossary.html>) for terms that are not defined here.



Roundtable Participants

Julia Cole, PhD, associate professor, Geosciences, University of Arizona

David Gutzler, PhD, professor, Earth and Planetary Sciences, University of New Mexico

David Meko, PhD, associate research professor, Laboratory of Tree-Ring Research (LTRR), University of Arizona

Klaus Wolter, PhD, meteorologist, Climate Diagnostic Center, Boulder and research associate, University of Colorado

Melanie Lenart, PhD, *roundtable moderator* research associate, Climate Assessment for the Southwest, University of Arizona

Lenart: Well, thank you so much everybody for participating in this roundtable discussion on drought. Let me just give you a little background before we begin. A version of this discussion will be published in our September packet of the Southwest Climate Outlook. We publish this every month, and it began as an El Niño-Drought initiative that we launched in the summer of 2002. At that time, an El Niño year was forecast and CLIMAS thought it would be

worthwhile to alert people to the concept that just because an El Niño winter was forecast, that doesn't mean the drought will end. It looks like we're in a similar situation again with an El Niño winter forecast while we're in the grip of intense drought in the Southwest. So, because all of you have some expertise with El Niño, drought and generally the monsoon as well, we thought you'd be an ideal group of people to address this topic for us. Let's get down to business now and get the scoop on where we're at with this drought. Do we have a megadrought on our hands now—maybe even a drought so severe that it comes around every 500 years, like some media reports maintain?

Meko: Looking at those [tree-ring] reconstructions back to, say, 1500, the current drought is not a 1-in-500 year event. There may be a handful of droughts that were as severe. It depends really on how you summarize statistically the severity of the drought, but say if you took five-year moving averages that embrace the current dry period, there are other droughts in the past 500 years that exceed it. It's a bad drought, but it's maybe one of a half a dozen.

Wolter: It certainly hasn't lasted as long as some of the megadroughts of the past.

Gutzler: And it seems to me that that's probably the most meaningful measure of severity of a long-term drought, more so than whether one particular year is astoundingly dry compared to previous records. And by that standard, we're still, in many cases, in a hydrological drought in the Southwest. In New Mexico, anyway, we haven't reached the [longest] duration of sub-normal precipitation years yet—in fact, we'll come in above average this year according to much of the state. You know, the 1950s drought was six or seven years long and this one, arguably, is four. So, we're not to that standard yet, in New Mexico

at least, although it's important to add there that over the last year or two, the center of the Southwest drought seems to have shifted westward somewhat. So that, where New Mexico might have been in the middle of it a year or two ago, it looks like the central part of the severe drought has moved farther west toward Arizona. Now, it's important to keep in mind that there are different aspects of drought. And so, what we're talking about here, is precipitation over the last year, and that has not been enough to fill up reservoirs or make streamflows anywhere near normal, so that from a hydrological perspective, despite relatively abundant rains recently, we're still locked in a very severe hydrologic drought in, say, the Río Grande valley. And it's certainly true farther west. Again, we have to make a distinction between the precipitation that's falling locally and what fills up the major rivers, for which we care a lot of about the precipitation that falls closer to where Klaus is sitting up in the headwaters regions in Colorado. But in New Mexico, over much of the state—and especially over much of the central and eastern parts—near-normal or even, to some extent, above-normal precipitation has extended back into last winter.

Lenart: And this brings up the point that people have emphasized, about how you can still have a good year of rainfall and snowfall within a drought. Does anyone want to address that? Getting back to the long-term drought question, does it seem like we could be coming out of it or do you think that we'll still be in it for another five or 10 years?

Wolter: I think with the drought, until you're really out of it, until the reservoirs are full again, you don't know. I think Kelly Redmond has a great phrase that getting out of a drought is like removing a fishhook: you know, you have to be very careful.

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Lenart: So, that would be your criterion for recognizing that we're out of the drought, when the reservoirs are full again?

Wolter: Well, that's certainly the easiest. It's a very reasonable and easy to gauge. Obviously, in terms of ecosystems and the like, one would like to assess that too, but I'm not that quick to do that. It's very complex and I think there's some debate, really, on how to define the end of the drought.

Cole: Reservoir filling, in a sense, is a nice integrator because it doesn't respond to those little blips you would probably see in a climate data record, and that you certainly see in a paleodata record (*a record that goes back beyond instrumental records*).

Wolter: I guess a caveat is that you have to look at reservoirs that take more than one year's runoff to fill up.

Meko: Yeah, with some of these reservoirs, it really depends on how wet conditions get in individual years. Water managers talk about it taking decades of normal rainfall to refill, say, Lake Powell, but if you have extremely wet years, like we had in the 1980s, it can refill reservoirs fairly fast. You can have a tremendously wet year and refill the reservoirs and alleviate hydrologic drought in that way, but that still probably wouldn't alleviate environmental drought as far as stress on trees and on forests go because it's just rapid runoff to them.

Lenart: Do you want to talk about your preliminary findings at all on the Salt River? This seems like a good context for that.

Meko: With the Salt River project, some work that Katie Hirschboeck [also of the LTRR] and I are doing, we're looking at the joint drought occurrence on the Upper Colorado River Basin and

the Salt River drainages in Arizona. And just looking at the Salt River flow itself, which is kind of a really nice hydrologic indicator of moisture conditions, integrating conditions over a mountainous area in eastern Arizona, during the last few years, there were a couple of very low years: 2002 and 2000 were lower than anything in the previous record of Salt River.

Cole: And that's instrumental data?

Meko: That's instrumental data, yeah. That's definitely disturbing to water managers to see that. Now, if you go to longer periods, it also all depends on how you analyze the drought, but if you go to five-year moving averages or 10-year moving averages, then it's still no more severe than the 1950s drought yet. So, you know, if this thing lasts a few more years, yeah, then it's going to start reaching at least all-time severity in the instrumental record.

Lenart: Okay, and what about this, do you think it will last? Klaus, maybe you can fill us in on some of the most current El Niño forecasts?

Wolter: Well, before I get to that, one comment. I'm not sure whether that applies to any other region, but here in the Colorado Front Range, over the last year, we have definitely seen that the general public...actually consumed consistently less water. It was like 27 percent less than they expected from the normal statistics. And it was partially because they had very severe restrictions [on using water], partially because it was expensive, costlier than usual, but we also happen to have had a very wet, consistently cloudy, cool summer. So they were actually able, last year, with a near-normal snowpack, to refill the reservoirs even though all the public predictions were, "Oh, it will take at least three years of near-normal [precipitation] to do that." So, I'm really not sure if this applies anywhere else, but this is actu-

ally an example where the human factor played a role. [Regarding the El Niño forecast,] there are quite a few people there who have actually come out publicly, saying there's no way there's going to be an El Niño this year. Famous last words...So it basically kicked in at the beginning of July and, the way it's looking right now, is going to continue. Incidentally, two year ago, you mentioned that earlier, the 2002–2003 El Niño, it was actually still a little bit warmer too [regarding sea surface temperatures in the region of the tropical Pacific known as Niño-3.4, Figure A]. I'm just pointing out that if you, and NOAA is kind of committed to this, if you use Niño-3.4 as your benchmark to define El Niño, that index, that particular index, has one of the strongest signals right now. So, in terms of how you speak about this event, if you go with the official NOAA definition, we already have a moderate event.

Cole: Regarding the current El Niño, although [sea surface] temperatures in the Pacific are warming up, there does not seem to be much response in the atmosphere, and the atmosphere's response in the Pacific is what drives the connections to climate in North America. Klaus, can you comment on why you think that's happening and whether you think that's going to make a big difference for its impact on U.S. climate, particularly Southwest climate?

Wolter: Well, I can get to the point right away. Arizona, for instance, the way I understand Arizona teleconnections to ENSO [the El Niño-Southern Oscillation], it has a very reliable, very robust wet signal in the winter if El Niño is very strong. So, if you take the top five or six events, it's almost a one-to-one relationship. As soon as you go below those strong events, it really, I wouldn't say it falls apart, but becomes much weaker. In fact, if you look at different model projections for the next six

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months, the amount of moisture that comes into southern California and Arizona really depends on the degree of warming in the eastern Pacific, which has been on the cool side so far. So, for you guys, it makes a huge difference. I'm actually still running my own forecasts. I have carried a shift in the odds towards wet, not a big shift, but, you know, 5 to 10 percent in Arizona the last two months and that stayed. As best as I can tell, at least for the early winter, there definitely are better-than-normal odds for wet fall. My forecast for January through March continues this trend towards wetness in Arizona, while remaining undecided for New Mexico.

Gutzler: I believe that's consistent, qualitatively at least, with what the Climate Prediction Center is calling for. They have called for some slight chance of "better than climatology" (*better than average*) for a wetter than normal winter across much of the Southwest.

Lenart: David Gutzler, I wonder if you could give us a little bit of information, getting away from the official forecast, from your research on how El Niño relates to some of the decadal-scale oceanic variability and what that might mean for us this winter?

Gutzler: One of the uncertainties in making these El Niño-based forecasts is that not all El Niños are alike and, although we don't understand in a theoretical way what determines the differences in teleconnections and precipitation from one year to the next very well, there are some hints in the data that there may be long-term modulations in how El Niño affects storm tracks, for example. So, there are several people, and I'm one of them, who have looked at whether decadal-scale oceanic variations could modulate the predictability of precipitation in the Southwest based on El Niño. There's some indication that, back in the '50s and '60s when conditions were relatively drier across

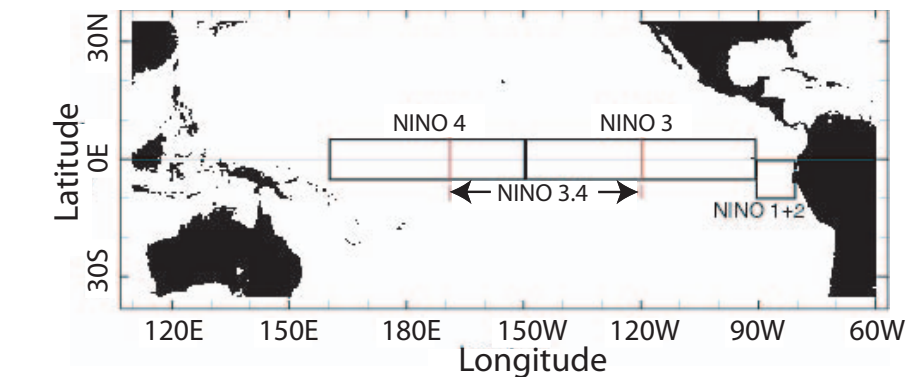


Figure A. ENSO observation areas in the equatorial Pacific region used to determine El Niño conditions by the National Oceanic and Atmospheric Administration.

the Southwest, that El Niño provided somewhat less of a basis for predicting a wet winter and spring across the Southwest than in the subsequent decades after the Pacific Decadal Oscillation—the PDO—shifted in the late '70s. So, there may be some basis for saying that during some decades, El Niño reliably produces wet, cold-season precipitation in the Southwest, whereas in other decades that forecast is less reliable.

Lenart: And what kind of a decade are we in now?

Gutzler: Well, now there's yet another source of uncertainty. It's actually difficult to define what the state of the Pacific Decadal Oscillation is now because it has flip-flopped on shorter time scales itself. So there was some indication, that, a few years ago, after the 1997–1998 El Niño event, the Pacific Decadal Oscillation made a shift back to its so-called "negative" phase, which is what things were like in the 1950s and '60s. But it's hovered around zero back and forth since then. If you look at the index itself that we use, it's back positive, which is the wet phase for the Southwest. But, because it's flip-flopping a bit, it's a little hard to tell how that's working.

Cole: I had a comment on the Pacific Decadal Oscillation, too. First, there is a paper out recently that actually looked at the precipitation correlations in the Southwest with El Niño during PDO warm and cool phases. This is something that David Brown and Andrew

Comrie here at the UA did [published in the May 2004 issue of *Geophysical Research Letters*]. They found that when they looked at the cool phase of the Pacific Decadal Oscillation, which was the period like we had in the '50s, that if you have warm El Niño-like conditions in the fall, you actually had drier conditions in the following winter during the cool phases of the Pacific Decadal Oscillation. And only when you went into the warm phase of the Pacific Decadal Oscillation, did you see this more canonical (*typical*) connection with warmer El Niño conditions being associated with wetter conditions here. And I had never heard that before, but it struck me as interesting because it goes exactly against what we've all been assuming about El Niño in the Southwest.

Gutzler: Melanie, this all pertains to drought because one of the mechanisms that some of us think about for really breaking a long-term drought is to have a really wet year, especially a wet winter to drive a big snowpack at the headwaters of the rivers and just fill up the reservoirs and drench the Southwest. In recent decades, we've come to think that the way to do that is with a big El Niño. So, one thing that people look at... was a big El Niño in 1957, which was near the end of that drought period. What we're starting to learn is that there are these modes of variability that make it difficult for the climate system to produce a big El Niño-driven wet year in ways that we still don't understand well

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enough to make confident predictions. This does not look like its going to be an especially strong El Niño event compared to the really big ones like '97–98 or '82–83, when we really had tremendous warm anomalies in the ocean (*i.e., unusually warm sea surface temperatures in the region that indicates an El Niño*).

Meko: A comment on the El Niño and the drought. We could look back at just a few years in Arizona at the severe drought '94 through '96 and then coming into the El Niño of '97. And I guess there are a couple ways to look at it. You could say that the '97 El Niño ended that short drought of a few years or maybe it's just a little El Niño in a blip that's breaking a drought up into two—now we're just in the second phase of that drought.

Wolter: Did you actually have drought conditions in '94–95?

Meko: We had a severe drought in '94. We had one of the driest years down here in winter of '95–96.

Wolter: Yeah, I mention that because there was an El Niño in late '94 going into early '95 and, at this time of the year, it was actually stronger than the one [El Niño] we have right now. In Colorado, it ended up being quite wet. Actually, one of the hallmarks, I think, of the weaker El Niños is that you don't get precipitation anomalies quite as coherent and connected as with the bigger events.

Lenart: Julia, did you want to add something to this discussion?

Cole: Yeah, just that the discussion of the Pacific Decadal Oscillation always has me a little bit uneasy because I feel like this is a phenomenon that has been recognized for all of about 10 to 15 years. The PDO itself has time scales that are quite long—20 or 30 years between being in one mode or

another—and yet we're talking about it as if we understand it as a natural mode of the system. And I worry about that, primarily because when we look at paleoclimate records that are sensitive to that system in the 20th century and try to understand how it's behaved prior to the 20th century, we find that those records don't give us answers that we might feel comfortable with. An example of that is, when you look at different people's reconstructions of the Pacific Decadal Oscillation before about 1910, they simply don't agree. And these are reconstructions developed using the best available records for 20th century sensitivity, which match the 20th century very well, but they simply don't carry back in time looking like a coherent system. So I worry that we're hanging a lot on the PDO issue without really knowing what it's all about and the fact that, for five years, it's kind of been flip-flopping back and forth right now and, some people have argued, shows characteristics of being both strongly positive and strongly negative. It makes me think that it might not be very helpful for prediction.

Meko: I'd like to make a comment about the importance of the seasonality of the rainfall in this area and the drought. Winter drought is not always occurring at the same time as summer drought, but sometimes they do occur in the same year and the stress on ecosystems, in particular, might depend on that strongly, that if you get failure of the summer rains and the winter rains, that is really going to hurt, say, tree growth. And we saw a lot of die-back of trees in the 1950s. That seemed to coincide with a failure of summer and of winter rains. So, it depends on the season and we might have to look at the cold season and warm season rains separately in summarizing drought for some purposes. Well, this year in particular, it seems the monsoon's not very good so far. I mean, we've had a very dry rainfall total from the cold season and it's at best

spotty. We've had some summer rains, but in a lot of places it's 75 percent of normal or less for the summer. Those circumstances are really going to stress the trees in the mountains in Arizona.

Gutzler: As David Meko mentioned, it seems to me that, thinking back about drought, a really stressful drought period is one in which you have year-round dryness. That is one of the things that tended to characterize the big Southwest drought of the '50s and that, by definition almost, was a period of time when the sort of out-of-phase relationship we see between winter precipitation and summer precipitation broke down. So, in wetter periods, there does seem to be some tendency for wet winters to be followed by dry summers and the other way around. Which, again almost by definition, would tend to mitigate drought somewhat since we get most of our precipitation in the summer. If you have this flip-flop between winter and summer it's tough to have terribly long, persistent anomalies because one dry season gets followed by a wet season. One of the major puzzles for drought dynamics, from my perspective, is what breaks this down, what makes a wet anomaly or a dry anomaly persist across the seasonal cycle because, as Julia suggested, a lot of our understanding of how these teleconnection-driven anomalies work is mostly a cold season picture. There's not a good, strong correlation between El Niño indices and summer precipitation. So, what is it that makes dry conditions persist from winter to summer? We simply don't know that. So understanding dynamically how that process works seems to me would help us go a long way toward understanding the dynamics of long-term drought. That's hardly an answer; I'm just posing a question.

Lenart: Does anybody else want to add anything to that? Ok, well let's call that a wrap then. Thanks again for participating.

