The 2010 North American Monsoon Forecast: A roundtable discussion with three monsoon experts

By Zack Guido

You can listen to the entire roundtable discussion by downloading the mp3 audio file on our Web site: www.climas.arizona.edu/feature-articles/june-2010. The following transcript is a slightly abridged version of the discussion.

Figure 1. Monsoon rains historically arrive in southern Arizona around the first week in July. They are often spotty and localized, delivering copious rains to one region while missing others. Figure courtesy of University Corporation for Atmospheric Research

The monsoon season officially began on June 15 in Arizona, prepping people for the intense thunderstorms, flooding, and high winds that accompany the towering cumulous clouds. While moisture from the Gulf of California has yet to waft into the region, the National Weather Service expects rains to begin around or slightly later than the average start date which tends to occur in the first week of July, but there is considerable uncertainty about the amount of precipitation the region will receive.

On June 11, CLIMAS staff scientist Zack Guido discussed the causes, forecast, and future of the monsoon with three monsoon experts: Eric Pytlak, science and operations officer at the National Weather Service in Tucson; Chris Castro, assistant professor at the department of atmospheric sciences at the University of Arizona; and Dave Gutzler, professor of earth and planetary sciences at the University of New Mexico.

Monsoon Basics

Question: What is the monsoon and how does it work in the Southwest?

Eric Pytlak: The North American monsoon is basically a large-scale climate weather pattern where two things go on, one at the upper levels [in the atmosphere] and one at the lower levels. In the upper levels, the subtropical high develops over Mexico in late May and early June. [It subsequently] strengthens and moves north into the United States. By early to mid-July it's centered over New Mexico but moves around a bit, where one day it might be out in Oklahoma, the next day it might be in the Four Corners. That high steers mid- and upper-level moisture and disturbances into the [Southwest] region.

On top of that, the land surface over Mexico and the Southwest heats up more than the oceans. The pressure difference between the land and the ocean causes wind to blow off the tropical Pacific Ocean on a daily basis. Eventually, you see moisture off the Gulf of California coast flowing into Sonora and eventually into Arizona [beginning on average around the first week in July].

New Mexico is slightly different because they don't have the Gulf of California influence, but they are more prone to the Gulf of Mexico influence. So between those two water bodies and the hot land surface, a series of events falls into place where, basically, Arizona and New Mexico receive tropical winds blowing from the east for a couple of months. So the storms move from west to east instead of from east to west.

Q: Are some areas in the Southwest more prone to monsoon rainfall than others?

Pytlak: Half of the annual rainfall in southern Arizona comes from the monsoon. North of Phoenix, especially into southern Utah, monsoon influence is about 20–30 percent of their annual rainfall.

Dave Gutzler: The complement to saying that the monsoon is more important in the southern halves of Arizona and New Mexico is that winter storms become more prevalent and more important as you get up to the Utah and Colorado borders.

Also, in New Mexico, the state is bisected by north–south trending mountains. On the eastern plains, moisture comes up from the Gulf of Mexico in the spring, so you don't have the dry spring conditions in the eastern third of New Mexico that

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you have across southern Arizona and southwestern New Mexico. This part of the state is out of what we think of as the monsoon-dominated region.

Q: How do El Niño and La Niña conditions shape the character of the monsoon on a seasonal basis?

Chris Castro: The sub-tropical ridge of high pressure, or the monsoon ridge, starts to evolve in Mexico in May and June and then moves into the Southwest by mid- to late July. This high is centered approximately over the Four Corners region at the end of July or beginning of August. Conditions in the Pacific Ocean tend to modulate the evolution and positioning of that ridge. In years when you have El Niño-like conditions, the ridge is depressed to the south and monsoon onset is delayed, at least in Arizona. In contrast, in more La Niña-like conditions, that ridge tends to develop early and is a little north and east of its average position [over the Four Corners region]. In this case, you have a wet and early monsoon.

Q: Are there other conditions that help forecasters understand how the monsoon may evolve?

Pytlak: One piece of the monsoon science that has held up over the past 20 to 30 years is that if above-average precipitation persists into the summer months, particularly June across the upper Midwest and anywhere from Texas northward into South Dakota, the monsoon high has a harder time moving north out of Mexico. The wet soil, while it makes the humidity extremely high, also keeps surface temperatures down. Snowpack also plays a role. If above-average snowpack exists in Colorado or Utah, for example, it takes time and energy to melt the snow, which can also delay that shift of the high north.

Q: What are the current moisture and snowpack conditions?

Pytlak: This year we had a normal snowpack in Colorado and Utah, but we have way above-normal [precipitation] conditions over the Midwest right now, and that, actually, is somewhat typical of the lingering effects of an El Niño like we had this winter. A monsoon after an El Niño winter, particularly a strong event [like the one we experienced this winter], tends to be a little weak.

But this year we have an interesting situation. Moisture conditions in the atmosphere are looking El Niño-like across the U.S. [suggesting a weak monsoon], while conditions in the western Pacific Ocean are starting to look very La Niña, [which would favor a stronger monsoon]. The question is which one is going to win out.

2010 Monsoon Forecast

Q: What is the official forecast from the National Oceanic and Atmospheric Administration?

Figure 2. The intense monsoon rain storns often cause streets to flood. Photo courtesy of Ashley Coles.

Pytlak: First of all we are going to have a hotter-than-usual summer. We're expecting the monsoon high to move north a little late and be a little stronger, which is an expectation based on the climatological trend—the Southwest has been heating up over the past 20 years. Those longer-term trends are part of the forecast we have pretty high confidence in. Right now we're saying equal chances of above- or below-average precipitation this summer because of the contradictions that we're seeing—[a switch to La Niña conditions

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will enhance the monsoon, while wet conditions over the Midwest will suppress it]. Having said that, in the past years where we've gone from a strong or moderate El Niño to a La Niña very rapidly, we tend to have pretty average summer rainfall.

Q: Is equal chances a forecast for near-normal rainfall or is it a "we don't know" forecast?

Gutzler: It's a forecast of climatological probabilities. So that's not the same as a forecast of near normal. It's really important to make that distinction—it's very confusing to a lot of people.

The [NOAA]-Climate Prediction Center lumps all the summers into the top-third, bottom-third, and middle-third of either temperature or precipitation. So, if you were just rolling dice, there would be a one-third chance that the upcoming forecast period would be either above, below, or near normal. When they forecast equal chances, they are saying they have no basis for changing those odds.

Q: Are there conditions that may cause NOAA to revise that forecast one way or the other?

Pytlak: I don't expect the forecast to change, unlike last year when we said, "Wow, things are changing really fast, we're going through this rapid El Niño–La Niña evolution," and we were changing our forecast on the fly. This year all of us are just kind of hanging on the equal chances forecast because of the uncertainties out there, and we haven't seen the uncertainties clear up.

So far, what we are seeing in the long-range models is confirming what we were suspecting last month: there's no sign that the monsoon moisture is going to arrive early in Arizona and New Mexico. We're expecting pretty much an on-time start, or maybe a little late.

Q: What conditions would facilitate an early arrival of monsoon rains?

Pytlak: First of all, I would like to see the Plains really dry out. Right now, there are floods from Colorado all the way across Iowa into Indiana and Ohio. It's not going to dry out in the next two weeks up there.

Q: Do tropical Pacific Ocean storms influence the monsoon season, and what is the forecast for these storms?

Pytlak: Right now the official forecast is for a below-average season in the Pacific. This is because we're pretty confident that a La Niña is going to develop, which will mean colder-than-normal water temperatures over the west coast of Mexico. Now, tropical systems can play a significant role in the monsoon, but it is very hard to project the effect of these storms because you need the right storm to move into the right place at the right time to be picked up by the right storm system and turned toward Arizona or New Mexico. That's a forecasting problem; if we see it one week in advance we are probably doing pretty good.

Climate Change and the Future Monsoon

Q: How will climate change affect future monsoon seasons?

Pytlak: My thought is that we don't have the model resolution in the Intergovernmental Panel on Climate Change (IPCC) to really make a firm determination one way or another, but we're getting there. Between IPCC 5, which is starting to be worked on now, and Chris's work downscaling climate models, I think we're going to have a better understanding of what we might expect in a few years.

Q: Is there a theoretical basis for the monsoon changing one way or another?

Gutzler: In a nutshell, the canonical paradigm is that warm climates tend to promote strong monsoons. [In warmer climates] the whole hydrologic cycle ramps up, the tropical oceans become a little warmer, and it's easier to generate a monsoon of stronger intensity, with all else being equal. Now, the current generation of global climate models doesn't come to any consensus as to what the expectation is for a changed monsoon.

Castro: My additional comment would be that a major conclusion in the last IPCC report [published in 2007] was that during the last 30 years, approximately since 1980, we have been experiencing anthropogenic climate change. One of those trends is an increase in temperature…, which has been the most rapid in the Southwest. Another tendency which has been observed in precipitation records is an increase in precipitation intensity. If you take those observations and superimpose them on the climatological evolution of the monsoon, you might project that the period before the monsoon might become hotter and drier. Then once you get a monsoon, which is influenced by the natural variability that we've discussed, the monsoon may experience more intense precipitation. If you look at the intense monsoons in 2006, 2007, and 2008, they seem to fit that pattern, at least anecdotally.