Monsoon forecasting could improve following study

NAME project targets summer rainfall in U.S. and Mexico

BY MELANIE LENART

Many Southwesterners greet the North American monsoon with joy, perhaps appreciating that half of some area's annual precipitation can come during this seasonal gathering of thunderclouds. But the timing of the monsoon's arrival and the length of its stay are just two of many factors that generally have eluded prediction, thus limiting opportunities for society to make plans around its visit.

This year, a host of scientists from 30 different institutions in the United States, Mexico, and Central America are hoping to improve future forecasts by intensively monitoring the monsoon's physical features as part of the North American Monsoon Experiment (NAME).

"The goal of NAME 2004 is to improve our understanding of the daily cycle of precipitation in the complex terrain of northwestern Mexico and the southwestern U.S.," explained Wayne Higgins, chair of the NAME Science Working Group and lead principal investigator on the project. "The dataset gathered this summer will be used to improve our ability to simulate and ultimately predict monsoon precipitation months to seasons in advance using state-of-the-art computer models."

Traditionally, weather forecasts address a week or less in the future, while climate forecasts apply to longer time frames such as months or seasons. Understanding how weather and climate are related can lead to improvements in climate forecasting, though.

Climatologists often issue seasonal forecasts, hoping to aid decision making by various members of society in sectors ranging from ranching to tourism. Firefighters count on the monsoon to give them a break from battling blazes, health officials relate its arrival to future valley fever outbreaks, and water managers cross their fingers that some runoff will reach reservoirs.

However, predictions for summer precipitation are less reliable than those for winter precipitation in the Southwest. This is largely because the patterns that influence winter precipitation are much weaker during the summer, Higgins said.

Erik Pytlak, science and operations officer for the Tucson National Weather Service office and U.S. rotational team leader for NAME, agreed that predicting summer rainfall remains challenging.

"Right now, the monsoon is probably one of the least understood weather phenomenon in North America. And what we're trying to do is change that fact," he explained. "We want to see improvements in the forecasts not only hours in advance, but months in advance."

Pytlak and a cadre of 30 meteorologists from around the West will be issuing weather forecasts on a daily basis during the field season from the NAME Forecast Operations Center in Tucson to help researchers located in western Mexico identify interesting features of the monsoon for enhanced monitoring.

These features, such as surges of tropical moisture or heavy precipitation events in Arizona and New Mexico, will be studied using an array of instruments, including surface weather stations, wind profilers, balloons, radar, research airplanes, and research ships. The ships are based in the Gulf of California, while the land-based systems are tracking the monsoon from more than 100 different locations.

NAME is also fostering a two-way exchange of information, technology, and training between U.S. and Mexican weather services. Mexico City serves as a base of operations for weather forecasting along with Tucson. The binational effort reflects the nature of the monsoon itself, which recognizes no political borders. The monsoon typically begins in Mexico in June, moving northward into the southwestern United States by July (Figure A).

Unfortunately, the timing of monsoon onset in Mexico doesn't necessarily help predict when it will arrive in the United States, as Higgins and others reported in the *Journal of Climate* in March 1999.

Although Arizona State Climatologist Andrew Ellis and Mexico's Servicio Meteorólógico Nacional (the Mexican

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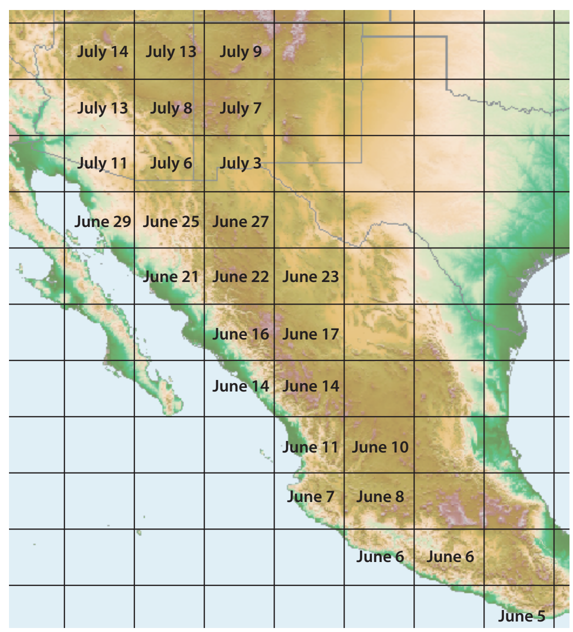

Figure A. The map shows the mean calendar date of monsoon onset, based on the time frame 1963–1988. Onset definitions vary depending on region because of differences in rainfall regimes (see Higgins, et al., *Journal of Climate,* March 1999). Although average onset date may change slightly if different time frames are used, the relative timing of the northward progression of the monsoon should remain intact.

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national weather service) both predict above-average rainfall this monsoon season, forecasting monsoon strength remains as much of an art as a science at this point.

"In our experience, northwestern Mexico is the most difficult region to forecast in the long term—one month to one season of rainfall. At this time we don't have a clear understanding of all the physical mechanisms that help to initiate rainfall in that part of the country," noted Miguel Cortez Vázquez, leader of the seasonal rainfall forecast for Servicio Meteorólógico Nacional and Mexico rotational team leader for NAME.

Researchers hope that will change in the years following this summer's intensive NAME field season, which is expected to extend from July 1 through August 15. During the season, researchers expect to capture interactions among several key features of the monsoon system, including tropical storms, surges of moisture from the eastern Tropical Pacific, and clusters of thunderstorms that organize into large-scale storms.

In addition, they will be using detailed measurements taken at different elevations in the Sierra Madre Occidental range to understand more clearly how mountains influence precipitation patterns, Cortez said.

Like northwestern Mexico, much of the U.S. West has mountain ranges that help swoop up potential storm clouds to higher altitudes, where the moisture they contain is more likely to condense into raindrops.

In the short-term, researchers want to understand how the complexities posed by mountainous landscape and the various monsoon features influence summer rainfall patterns. But in the longer time frame of the NAME project (2000–2008), some hope to place the monsoon

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Diary of a Monsoon Forecaster

by Rick Brandt

I recently finished a five-day shift as an assistant forecaster with the North American Monsoon Experiment (NAME). During that time, I worked with two other meteorologists at the forecast operations center at the Tucson National Weather Service office where we produced forecasts for the study region.

We focused on five periods: a summary of important weather features during the previous day and forecasts for 24 hours, 24–48 hours, 3–5 days, and 6–10 days. I wrote summaries of the previous day, describing information such as the approximate quantity of precipitation received in different areas and the pressure patterns. I also made 24-hour forecasts, while the other meteorologists worked on the remaining forecast periods. The predictions were developed using forecasting models, observations, radar and satellite imagery, and personal experience and education. The computer models calculated numerous atmospheric variables that we use to forecast the weather. The surface observations and radar and satellite imagery showed us the recent and current conditions. This information helped us decide how much to rely on the models before we issued a forecast.

At 2 p.m. each day, the forecasters, science directors, and several other participants attended a briefing, where the summary and forecasts were presented and discussed. This served to update everyone, discuss the opinions of others, and decide if we wanted to initiate additional data-gathering methods, such airplane measurements of humidity.

Rick Brandt in the NAME Forecast Operations Center.

The monsoon did not officially begin in Arizona during my time at the operations center. It was interesting, however, to watch the northward march of precipitation through Mexico. As the moisture moved farther north, each of the forecasters ventured an estimate of the official monsoon onset in southeastern Arizona. I wish I could say that I chose July 8, but my prediction of July 11 was too pessimistic by three days. Perhaps I fell into the all-too-common trap for meteorologists—relying too heavily on computer models and not paying enough attention to what was actually occurring. This experience was a good reminder that even when I think I know what is going to happen with the weather, Mother Nature can sometimes toss a curve ball at me.

The experience with NAME was quite enjoyable and educational. In addition to increasing my knowledge of the monsoon and testing my forecasting abilities, I collaborated with talented meteorologists and rubbed shoulders with some of the big names in monsoon research. It was fascinating to gather knowledge from them and at the same time realize that despite their years and decades of experience, they, too, are still learning.

Rick Brandt, a graduate student on the CLIMAS project, monitors monthly climate data and regularly contributes to the Southwest Climate Outlook.

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within a larger context so that they can better predict future seasons using global atmospheric circulation patterns and sea surface temperatures as a guide.

Previous research by Higgins and others, published in the *Journal of Climate* between 1997 and 2001, identified several important factors that can influence monsoon onset and intensity, including: 1) Monsoons that arrive early tend to stay longer and produce more rainfall. 2) There was a tendency for summer rainfall to be higher than average during years when it was lower than average in the U.S. Great Plains and vice-versa. 3) Above-average summer rainfall tends to follow below-average winter precipitation here as well as above-average precipitation in the Pacific Northwest.

The first finding was supported by a paper published earlier this year by Ellis and colleagues in the *International Journal of Climatology.* Their analysis of the monsoon seasons from 1950 through 2001 indicated that season length basically defines whether it's a relatively wet or dry season.

Using Phoenix as a case study, they found that, on average, a wet season lasts from about June 25 through Oct. 1, while a dry season runs from about July 12 through Sept. 1. Interestingly, the fraction of "monsoon days," defined by moisture in the air as well as rainfall events, remained consistent at about two-thirds within either type of season.

The third finding by Higgins and his colleagues hints at an El Niño connection, because the Southwest and Pacific Northwest tend to respond in opposite ways to El Niño. However, correlation of monsoon strength with El Niño is very weak in the southwestern United States, researchers agree.

El Niño is identified by year-to-year fluctuations in sea surface temperature (SST) in the tropical Pacific. Higgins and others are also considering how SST changes in the northern Pacific, northern Atlantic, and Gulf of California relate to southwestern summer rainfall.

"The importance of the relationship between long period fluctuations in the North Pacific SST and variability in the Arizona-New Mexico monsoon cannot be overemphasized, since understanding it potentially could lead to improved prediction of abnormal weather over spells of years," Higgins stated in a 2000 paper he co-wrote.

Sea surface temperatures in the Gulf of California also influence the monsoon, as Cortez pointed out. A team of researchers led by David Mitchell of the Desert Research Institute in Nevada reported in 2002 in the *Journal of Climate* that monsoonal rains begin in some regions only after an SST threshold is reached in specific parts of the Gulf of California, the dominant source of monsoonal moisture.

Meanwhile, other researchers have found correlations between monsoon strength and snow levels. Once Himalayan Mountain snowpack was identified as a factor influencing the strength of the Asian monsoon, researchers began to explore how the North American monsoon relates to snowpack.

Winters with abundant snowfall near the monsoon region can dampen the land-heating that pulls in monsoonal winds, researchers hypothesized. A monsoon system is defined by the shift in wind direction that occurs when average land temperatures surpass sea temperatures long enough to draw in moisture-laden winds from the sea.

David Gutzler of the University of New Mexico found that low April 1 snowpack tended to correlate with strong monsoon seasons in the southwestern United States. However, the relationship is weaker for Arizona than it is for New Mexico, he reported in 2000 in the *Journal of Climate,* and is inconsistent within the full time frame he examined.

Similarly, research led by Timothy Hawkins of Arizona State University and colleagues found summer snow cover in the northwestern United States appeared linked to monsoon strength in the Southwest in their 2002 *Journal of Climate* paper. Again, less snow often meant more monsoon rainfall.

Incidentally, both southwestern and northwestern snowpack fell below-average this past winter, a situation which helps fuel hopes for a strong monsoon season in the Southwest.

"Snowpack in the Rockies seems to play an important role in rainfall in Arizona and New Mexico. But it looks to me like snowpack in the Rockies is not an important issue for Mexico," Cortez noted. "In my opinion, soil moisture and vegetation play an important role."

In northwestern Mexico, lower soil moisture correlates with a weaker monsoon season, Cortez said. This indicates that other factors besides land heating are at play, and further illustrates the challenge in untangling different influences on monsoon strength.

Every year, it seems, researchers find interesting new correlations between monsoon strength and timing and other factors. Perhaps in the years to come, the NAME project will provide insights that allow researchers to relate their findings to physical mechanisms and use their understanding to improve forecasts for summer precipitation. If that happens, Southwesterners may be able to prepare better for the anticipated annual visit from their eccentric old friend, the North American monsoon.

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