# Extreme Events in the Southwest

By Zack Guido

Raging fires, mile-high walls of dust, bone-dry drought, and pipe-bursting freezes wreaked havoc across the Southwest this year. By the end of August, drought and fires alone cost New Mexico, Arizona, Texas, and other western states more than $5 billion, which does not include the recent blazes that destroyed more than 1,000 of houses in Texas. Ten disasters across the country have cost more than $1 billion already this year, breaking the previous record of nine set in 2008, according to the National Oceanic and Atmospheric Administration (NOAA). In fact, CNN dubbed 2011 the year of billion-dollar disasters (August 20).

Viewed through the lens of global warming, the weather events of the year beg the question: Is the intensity, frequency, and duration of extreme events increasing? Research suggests a link between rising temperatures and increasing trends in extreme events for some climate-related phenomena, but natural variability also comes into play.

**Figure 1.** Fires in the Southwest have run rampant this year and have run up an enormous fire-fighting bill in an unprecedented year of disasters. Texas, where the fire in this photo burned on July 5, has had a particularly active fire season. Photo credit: Zack Guido.

## A year of wacky weather

This year has shaped up to be unprecedented in Arizona and New Mexico for extreme weather and climate conditions. January was the driest on record, which dates back to 1895. In February, frigid Arctic air swept into the Southwest, sending temperatures in Tucson plummeting to 18 degrees Fahrenheit on February 3—only one degree warmer than the coldest February day in the city's history. The mercury in Albuquerque dipped to -7 degrees F, an all-time record there for that date.

By the end of the winter, persistent dry weather had caused widespread and intense drought across the region, including exceptional drought in southeastern Arizona and New Mexico, the kind of drought that occurs, on average, only once in every 50 years. In the spring, the parched landscape conspired with blustery conditions to fuel rampant fires, priming the land for the largest fire in the recorded history of Arizona. By September 12, more than 2.1 million acres had burned in the two states combined, surpassing the previous record of about 1 million acres set in 2006.

The monsoon also has brought rare weather. Six dust storms raced through the Phoenix metropolitan region, with sand billowing as high as a mile into the sky. New Mexico had its driest August on record, and temperatures were hotter in August in both Arizona and New Mexico than they were during the previous 117 years. Average temperatures for the June–August period also were the hottest on record in New Mexico.

Elsewhere in the U.S., 180 tornados ripped across the Midwest in a six-day period, killing 177 people. Heavy rain and melting snow in the Ohio Valley caused historic flooding along the Mississippi River and its tributaries. And Hurricane Irene drenched the northeast in late August and led to the deaths of more than 40 people in 13 states.

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# *Extreme Events, continued*

## Are extreme events increasing?

Extreme weather and climate events, by their nature, generally have not occurred within collective memory, and there can be a tendency to explain these events by linking them to human-caused climate change. There is scientific reason to make this connection.

Temperatures in most places have been climbing, giving rise to expectations that temperature-related events such as heat waves and cold snaps will increase and decrease, respectively. Also, warmer air can hold more moisture. According to the physical principle known as the Clausius-Clapeyron relation, the air can hold about 7 percent more moisture for each 1 degree Celsius increase, or about 4 percent for every degree Fahrenheit increase. This relationship implies that precipitation and attendant hydrological events will intensify in a warming world.

Single extreme events, however, cannot be attributed simply to anthropogenic climate change. The event may have occurred naturally as a consequence of inherent fluctuations in the climate system. When a pattern of extreme weather persists for some time, however, it may be classified as an extreme climate event, according to the Intergovernmental Panel on Climate Change (IPCC).

Observations in the U.S. suggest the link between recent climate change and extreme events is discernable for some climate phenomena, but not all. The most recent synthesis of extreme events in the U.S. was published in 2008 by the U.S. Global Change Research Program (USGCRP), which coordinates and integrates 18 federal institutions studying changes in the global environment and their implications for society. Their key findings:

- Heat waves lasting longer than four days and characterized by average temperatures that exceed the warmest 10 percent of all the four-day periods on record have significantly increased since 1960.
- The number of days in which temperatures exceeded the warmest 10 percent of days on record has increased since 1950 for both maximum (daytime highs) and minimum (warmest nighttime lows) temperatures when averaged over all of North America. The largest increases have occurred in the West, from northern Mexico through the western U.S. In most of Arizona, the number of days exceeding the warmest 10 percent of days has increased by five to 10 days, or between 0.9 and 1.8 days per decade.
- The number of frost days decreased by four days per year in the U.S. during the 1948–1999 period, with the largest decreases—as many as 13 days per year—occurring in the western U.S.
- There are recent regional tendencies toward more severe droughts in the southwestern U.S.
- Atlantic tropical cyclone (hurricane) activity—which can help feed the monsoon in the Southwest—has increased substantially since about 1970. However, there have not been clear trends in monsoon rainfall for Arizona or New Mexico.
- Heavy downpours have become more frequent and intense in recent decades than during any other time in the historical record in many parts of the U.S. This trend, however, has not been observed in the Southwest.

Human-caused climate change is influencing these trends to some degree, but natural climate variability also plays a role. The El Niño–Southern Oscillation (ENSO) cycle that brings recurring La Niña and El Niño events affects extreme precipitation in the Southwest. A paper published in the *Journal of Climate* in 1999 by Daniel Cayan and co-authors stated that winter precipitation and streamflow events greater than the highest 10 percent of flows on record occur more often during an El Niño, and the frequency of storms lasting two and three consecutive days increased by as much as two times during these events. As a result, several basins in the Southwest are at least 10 times more likely to experience extremely high flows during El Niño than La Niña years.

## More extreme events to come

A few perfect storms that create sudden, catastrophic events such as the flood of the century or more slowly developing conditions such as an extreme drought will undoubtedly occur each year regardless of climate change. The expectation, however, is that a warming world will cause more of some of these events, particularly the ones tied to temperature, according to the IPCC.

The changing frequency and duration of extreme events may be the largest consequence of climate change. As a result, more emphasis is being placed on spotting and diagnosing these events. Most of the research has characterized extreme events using peak values or values greater than a threshold, such as the highest daily precipitation total and number of days above 100 degrees F.

In recent years, however, more sophisticated statistical theories have crept into analyses that have facilitated the better use of existing observations. Also, these extreme values may or may not be relevant to society, and more effort is being placed on analyzing those most useful for assessing and projecting impacts.

The upshot of this attention is that as extreme events continue to destroy lives and property, more information on past, present, and future extremes will surface, helping better prepare and forecast these events.