

# Anticipating summer heat

## A look at the impacts and extreme temperatures in the Southwest

By ZACK GUIDO

Our bodies are like car engines. We produce heat as we move. As long as we dissipate that heat as fast as it accumulates, all runs well. But when the internal heat builds, our cars end up on medians with steaming radiators and our bodies and minds break down.

When the mercury shoots up during summers in the Southwest, prolonged exposure to the heat can be deadly. With temperatures already hitting 90-plus degrees Fahrenheit in some areas and warmer-than-average temperatures forecast for summer, officials from the National Weather Service (NWS) are reminding people to hydrate and heed heat safety guidelines and advisories.

“People in the Southwest know that summers will be hot, but some days are unusually hot. And while other forms of dangerous weather are visual, like thunderstorms and hurricanes, extreme heat is not,” said Tony Haffer, a NWS meteorologist in Phoenix. “On these days, people should not maintain business-as-usual routines. They should take it easier.”

### An invisible threat

There is no simple formula to determine how long to remain in the heat because each person is different. An individual’s susceptibility to heat is determined in part by activity, fitness, clothes, and awareness. Regardless of whether an individual is at football practice in August or walking in downtown Phoenix in June, the body tries to maintain an internal temperature near 98.6 degrees F by varying the rate and depth of blood circulation. During exercise and hot days, when the body temperature begins to rise, the heart pumps more blood and circulates it closer to the skin so that excess heat is lost to the cooler atmosphere. The body also sweats, inducing evaporative cooling. Heat exposure

| Medical Condition        | Symptom  | Responses   |
|--------------------------|--|---|
| Heat Cramps              | Painful muscle cramps and spasms, usually in muscles of legs and abdomen. Heavy sweating.  | Apply firm pressure on cramping muscles or gently massage to relieve spasm. Give sips of water; if nausea occurs, discontinue water intake.   |
| Heat Exhaustion          | Heavy sweating, weakness, cool skin, pale, and clammy. Weak pulse. Normal temperature possible. Possible muscle cramps, dizziness, fainting, nausea, and vomiting.   | Move individual out of sun, lay him or her down, and loosen clothing. Apply cool, wet cloths. Fan or move individual to air-conditioned room. Give sips of water; if nausea occurs, discontinue water intake. If vomiting continues, seek immediate medical attention.  |
| Heat Stroke (Sun Stroke) | Altered mental state. Possible throbbing headache, confusion, nausea, and dizziness. High body temperature (106°F or higher). Rapid and strong pulse. Possible unconsciousness. Skin may be hot and dry, or patient may be sweating. Sweating likely especially if patient was previously involved in vigorous activity. | Heat stroke is a severe medical emergency. Summon emergency medical assistance or get the individual to a hospital immediately. Delay can be fatal.<br><br>Move individual to a cooler, preferably air-conditioned, environment. Reduce body temperature with a water mister and fan or sponging. Use air conditioners. Use fans if heat index temperatures are below the high 90s. Use extreme caution. Remove clothing. If temperature rises again, repeat process. Do not give fluids. |

**Table 1.** The three most severe stages of the body being subjected to extreme heat.

Sources: CDC, 2004a; Kunihiro and Foster, 2004; NWS, 2004

becomes serious when the body cannot regulate its internal temperature.

When subjected to extreme heat and unable to cool down, the body progresses through six stages of physical debilitation: heat stress, heat fatigue, heat syncope, heat cramps, heat exhaustion, and heat stroke. The symptoms range in severity (Table 1).

High heat is nothing new to Arizona. In 2007, Phoenix endured one hundred-thirteen days with temperatures exceeding 99 degrees F, while Tucson experienced 65. Fortunately, research shows that both cities and people adapt and acclimatize to high temperatures—100-degree temperatures in August feel less hot than they do in June. But each year, Arizona suffers high numbers of heat-related deaths and even greater numbers of illnesses. In 2005, for example, 51 U.S. residents died in Arizona from exposure to excessive heat, nearly a third of the total U.S. deaths reported from extreme heat. Last year, in Maricopa County alone, 50 people died.

Compared with more humid regions, the Southwest’s dry climate may make heat-related illness more likely because people don’t feel uncomfortable until problems such as dehydration have already started.

Erik Pytlak, science officer at the NWS in Tucson, doesn’t mince words when describing the dangers of heat exposure: “Extreme heat is the number one weather-related killer in Arizona.”

### Who is at risk?

The trend in total number of deaths in Arizona is in lock-step with the trend in the number of migrants who die while crossing the Mexican-American border, Pytlak said. In 2005, roughly 80 migrants died in the Tucson sector alone from heat exposure, while more than 180 total deaths occurred from heat exposure along the border. Since 1994 the number of migrant deaths each year has generally increased, reflecting the switch in the point of entry from more urban areas to the sweltering Arizona desert.

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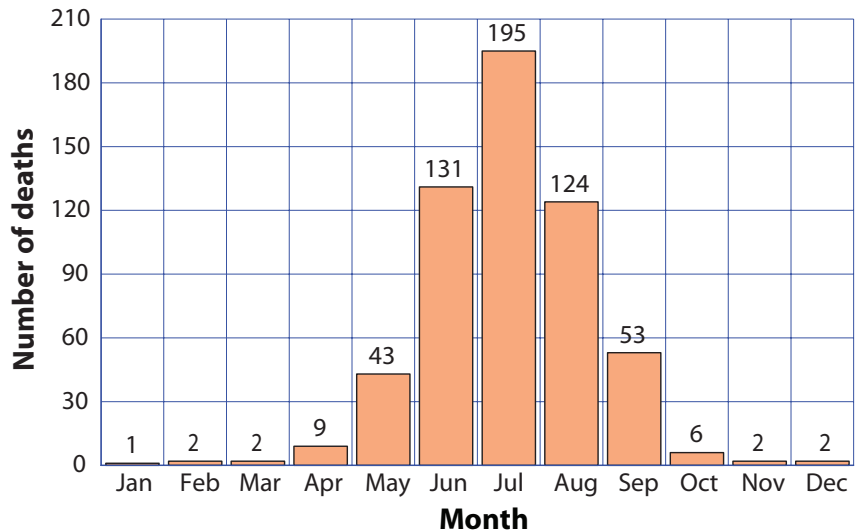


## Summer heat, continued

Within U.S. citizen demographics, intuitively the most at-risk people are those who work outdoors. However, national studies break down illness and mortality more in terms of social class and physical location than occupation. The greatest risk of heat stress falls on people who live in cities, with a disproportionate number of deaths falling within marginalized groups such as the poor, minorities, and elderly.

In 2006, Sharon Harlan, associate professor in the School of Human Evolution and Social Change at Arizona State University, and others studied this by measuring temperatures in socially distinct neighborhoods in Phoenix. They found that during the summer of 2003, the mean temperature at 5:00 p.m. varied by as much as 7 degrees F across eight different neighborhoods and a heat wave exacerbated the measured temperature difference by as much as 14 degrees. The lowest temperatures occurred in a wealthy, city-central neighborhood that had low population density and more vegetation. The highest temperatures were recorded in the poorest neighborhood, which was partially characterized by having the highest population density and sparse vegetation. In the poor neighborhood, virtually every house was without air conditioning. Inside temperatures were routinely higher than outside temperatures, forcing many people to sleep outside.

The most plausible explanation for the statistically significant difference in neighborhood temperatures is the urban heat island effect (UHI). The UHI is caused primarily by dense concentrations of buildings and asphalt that absorb more heat during the day and release it more slowly at night compared with natural ground cover such as soil and vegetation. The most noticeable human-caused impact on excessive heat exposure may not be from the greenhouse gases injected in the air, but from the extra buildings and roads, Pytlak said.



**Figure 1.** Deaths from exposure to excessive natural heat occurring in Arizona by month in 1992–2002. Source: Arizona Department of Health Services

As urban expansion gobbles-up farmland and desert, it amplifies temperature and places more people under the urban temperature magnifying glass.

### The Heat Index

Providing expedient severe weather warnings to save lives and property is the most important mission provided by NWS offices in Arizona and New Mexico. In an effort to raise awareness and provide warnings during elevated-risk days, NWS forecasts and disseminates Heat Advisories and Excessive Heat Warnings at the local level. NWS offices in Arizona and New Mexico issue these alerts when certain weather thresholds are exceeded. These thresholds are based on a heat index in New Mexico; in Tucson and Phoenix, they are based more on locally calibrated temperatures.

The heat index is a common metric used to conceptualize the dangers of high heat. It is a measure of how hot it feels when relative humidity is added to the actual air temperature. At a higher humidity, the temperature feels hotter because sweat evaporates more slowly. Evaporative cooling works because heat from our skin is lost in the process of converting liquid sweat to vapor. It is an effective cooling mechanism, felt

by those who have bounded out of a swimming pool on a hot, low humidity day and experienced a quick chilling. At high temperatures, the evaporation of sweat is the body's most effective mechanism for heat loss. It is the same physical process that makes swamp coolers effective in June when humidity is low. It is also the same process that renders evaporative cooling ineffective during the monsoon in July and August. During these months, higher humidity reduces evaporation and the body's ability to release heat. This may contribute to the higher incidence of heat-related illness and death during July and August than during June and September (Figure 1).

The monsoon both exacerbates and reduces risk to heat illness, Haffer said. On one hand, perspiration stays longer and provides a visual reminder that it is hot. On the other hand, temperatures are typically lower, giving people a false sense that the heat is not as dangerous.

Although the heat index neatly boils down the perception of heat to reflect a combination of temperature and humidity, it is a poor guide for people and decision makers in the Southwest.

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## Summer heat, continued

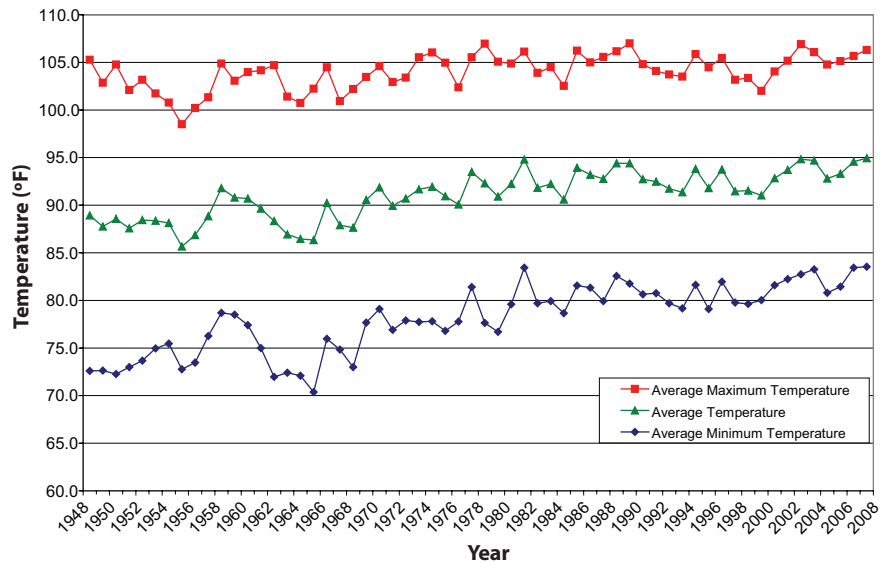
“Even on the most humid monsoon days, afternoon humidity is usually 20 to 30 percent,” Pytlak said. “[With lower humidity] the heat index is almost always lower than the temperature in Arizona, and also most of the western U.S. The heat index was designed to alert people of heat waves in humid climates, not the western U.S.” As a result, NWS in both Phoenix and Tucson have designed warning systems that use better measures of dangerous heat conditions.

### Heat advisories and warnings

NWS broadcasts digital and vocal alerts when certain weather conditions are met. In Tucson, a Heat Advisory is issued if either the temperature or the heat index rises to the point where people need to take extra precautions. The threshold is not, however, static throughout the year. It is based instead on a sliding scale that takes into account time of year and location, in part recognizing that people acclimatize to the heat as summer progresses. The extra precautions recommended may include drinking more water, shifting outdoor activities to cooler parts of the day, paying more attention to the higher risk populations like the elderly and young, and avoiding prolonged exposures to the heat.

While an advisory urges caution, an Excessive Heat Warning alerts people and decision makers that the heat will be life-threatening, even to those who are well-acclimated and healthy. In Tucson, warnings are issued when either the temperature or the heat index rises to a value of 110. Last year, NWS issued Heat Advisories seven times in Tucson and for 29 days in Phoenix. Phoenix also declared Excessive Heat Warnings for an additional eight days.

Phoenix does not use the same guidelines for their alerts. In 2001, Phoenix launched a customized method for assessing dangerous weather conditions. Researchers collaborated with NWS and numerous local agencies in Phoenix to



**Figure 2.** Average June, July, and August temperatures at Sky Harbor Airport in Phoenix, Arizona. Sources: CDC, 2004a; Kunihiro and Foster, 2004; NWS, 2004

establish threshold temperatures beyond which human mortality significantly increases. This statistical correlation implicitly incorporates human adaptation and acclimation. Phoenix’s warning criteria also incorporates a maximum temperature threshold; a Heat Advisory is issued if the forecasted daily high is projected to be near the historical temperature record for that day.

Fortunately for residents of New Mexico, it is uncommon for temperatures to remain above critical levels for prolonged periods. As a result, the NWS office in Albuquerque has never issued an advisory or warning, and the Santa Teresa office has not issued them for at least the past eight years. That is not to say that residents can ignore precautions for heat-related illnesses. Under the right circumstances on a hot day, it doesn’t take long to experience the first stages of excessive heat exposure, and the responsibility for staying heat-healthy ultimately falls on the individual. The most effective action is to limit exposure by periodically returning to air conditioned or cooled buildings. For construction workers, landscapers, police, and others who work outdoors, it’s important to keep hydrated, wear comfortable clothes, pay attention

to what the body says, and seek cooler conditions upon feeling ill.

### Anticipating Summer

A cursory look at temperatures at Phoenix Sky Harbor International Airport suggests that average summer temperatures may slightly increase (Figure 2). Wiggles in the data render this type of simple forecast foolhardy. Nonetheless, since 1948, the average June, July, and August temperature as well as the average minimum and maximum temperatures have all increased. The three-month average minimum temperatures have increased at the fastest rate, rising roughly 0.15 degrees F per year. This has contributed to the increase in the number of days when the minimum temperature does not fall below 90 degrees F. A similar trend in the increase in minimum temperatures has been observed in Tucson. This is important because sustained elevated temperatures are taxing on the body. If temperatures continue to rise, future occurrences of heat illness may increase.

For more information on temperature forecasts see Figures 10a–d under Forecasts in this month’s *Southwest Climate Outlook*.

