ASU launches Phoenix weather study to unlock secrets of monsoon storms

DOE-funded project will use weather balloons, radar and atmospheric sensors to study how extreme heat, urban growth and dust influence storm intensity

By Dolores Tropiano, ASU News
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Every summer, the monsoon brings severe storms that can sweep through the metropolitan Phoenix area like wrecking balls, taking trees, roads and roofs with them. Damage can range from downed tree limbs and power outages to destroyed vehicles, homes and widespread neighborhood disruption.

Scientists have linked the severity of the storms to rising global temperatures, a phenomenon not likely to subside any time soon, which means neither are the severe storms.

What does that mean for residents of Phoenix, and what can be done to keep people safe? That's what Arizona State University researchers are investigating over the next year and a half.

Why this research matters

Research is the invisible hand that powers America's progress. It unlocks discoveries and creates opportunity. It develops new technologies and new ways of doing things.

This month, one of the most comprehensive severe weather studies ever conducted in the Phoenix metro area kicked off on ASU's West Valley campus.

Learn more about ASU discoveries that are contributing to changing the world and making America the world's leading economic power at researchmatters.asu.edu.

The study, called DUSTIEAIM — Desert-Urban SysTem IntegratEd AtmospherIc Monsoon — is a major effort to analyze how severe weather begins and intensifies over one of the hottest urban regions in the United States. It is funded by the U.S. Department of Energy.

"This is an ambitious project in both scale and scope," said Vernon Morris, associate dean for knowledge enterprise and strategic outcomes in ASU's New College of Interdisciplinary Arts and Sciences. "Urban desert environments like Phoenix are incredibly complex. You have extreme heat, rapid development and monsoon systems interacting in ways we don't yet fully understand. This project allows us to study those interactions in real time."

The project will engage scientists from across the country, as well as ASU faculty and students, to better understand how Phoenix's heat, urban growth, dust and desert environment affect storms, rainfall and the water cycle — especially in relation to the monsoon.

Data from the study will help improve forecasting in the Valley and offer insights into other rapidly warming cities worldwide.

What are researchers studying?

At its core, DUSTIEAIM seeks to answer three major questions.

First, researchers want to understand how Phoenix itself influences weather. They will examine how buildings, roads, pavement and urban growth interact with the surrounding Sonoran Desert to affect heat, wind patterns, cloud formation and storm development.

Second, scientists will investigate the role of dust, pollution and wildfire smoke in weather systems. Researchers hope to determine how airborne particles affect cloud formation, rainfall and temperatures, and whether current climate models accurately capture those effects.

"The single most important question is how do aerosols (mostly dust) affect the formation and development of convective storms, particularly as manifested in the North American monsoon," said Jim Mather, director of the Atmospheric Radiation Measurement (ARM) User Facility, the DOE program that is sponsoring DUSTIEAIM.

Finally, the team wants to understand what factors control where and when rain falls across the Valley. They will study how mountains, land surfaces, dust and broader weather patterns work together to influence rainfall, flash flooding and storm intensity.

The study includes two major observation periods. One will focus on winter storms and precipitation from November through March. The second will concentrate on the North American monsoon from July through September, including dust storms, flash flooding and extreme heat.

(Video: {https://www.youtube.com/watch?v=kLvZuSPsY-w&feature=youtu.be})

Sky-high study

A project of this scale has taken months to build.

Since February, the outskirts of ASU’s West Valley campus have been transformed into sprawling outdoor laboratories filled with weather stations, atmospheric sensors, lasers, radar systems and weather balloons.

One of the five weather stations includes a 40-foot tower that continuously measures the movement of energy and chemical compounds through the atmosphere. Specialized laser instruments monitor particles in the air, helping researchers understand how dust interacts with storms.

Twice each day, teams of scientists launch weather balloons carrying instruments that measure temperature, humidity, wind speed and atmospheric particles. The balloons begin at just 2 to 3 feet in diameter but expand as they rise, eventually growing to roughly the size of a bus and reaching altitudes above 100,000 feet — three to four times higher than commercial airliners fly. As they float, they stream data back to researchers below.

Near the edge of the atmosphere, the balloons burst and return back to Earth by parachute. A typical flight lasts between two and four hours, and may carry the instruments 40 to 100 miles from campus before they land.

Nearby, a precipitation radar scans developing storms while mobile laboratories collect data at ground level. In total, researchers are operating roughly 50 instruments around the clock.

"We are using some of the most in-depth, high-time-resolution measurements that have ever been made in a large desert urban area," said Allison Aiken, lead scientist for DUSTIEAIM and a staff scientist at Los Alamos National Laboratory, a DOE national laboratory in New Mexico.

"Those measurements both complement each other as well as provide continuity across our understanding of the atmospheric system from surface soil moisture through measurements of the top of the atmosphere," Aiken added. "Basically, from a few inches below the surface of the Earth to about 20 miles above the Earth."

Bringing the community into the science

The unusual equipment and daily weather balloon launches have already attracted attention from the local community.

“It’s not every day you see research balloons rising into the sky from a university campus,’’ Morris said.

To keep nearby residents informed, ASU will distribute flyers explaining the project and its activities on the West Valley campus.

"We want to demystify it," Morris said. "It's not alien. It's not surveillance. It's purely a scientific endeavor."

In addition, the DUSTIEAIM project includes a community ambassador program employing local citizens as team members and spokespersons for the community. Not only will they be able to explain the project and its goals to the community, they were also trained in weather observations and will serve on the science team of the project.

Students will also benefit from the initiative. Morris, an ASU Foundation Professor, was awarded more than $2.5 million for the project, which will double as a learning opportunity for students to train in environmental measurements and other research.

Why Phoenix?

Phoenix was chosen for many reasons.

It is the fifth-largest city in the United States and one of its hottest. In 2023, the city endured a record 31 consecutive days of temperatures reaching at least 110 degrees.

As the region grows hotter, drier and increasingly vulnerable to wildfires and extreme weather, researchers believe Phoenix offers important clues about the future of many cities.

"You get some of the most interesting weather in the United States," Aiken said. "You have these large dust storms, the North American monsoon and occasionally devastating events like flash flooding."

Mather said Phoenix was selected because it represents a wide range of science questions.

“It seems most likely to have the greatest science impact,” Mather said.

The observations and high-quality data collected through DUSTIEAIM could help improve weather forecasting, guide future infrastructure planning and provide policymakers with better information about heat, water and growth.

One feature that distinguishes the DOE’s ARM user facility is its commitment to open science. Researchers around the world can access the data, along with detailed information about how it was collected and who operated each instrument.

“We will make our data available to the research community,” Mather said. “And then we will work with the modeling community to understand how to make this data most useful to them.”

The approach encourages collaboration across agencies and scientific disciplines, allowing researchers from different fields to use the data for studies that may extend far beyond the original goals of the project. ARM also prioritizes making data available quickly while maintaining rigorous quality controls, helping scientists accelerate research and expand opportunities for discovery.

"One of the things that sets ARM apart is that anyone can become an ARM user and access the data," Aiken said. "... It's really designed to be a community tool that supports collaborative science across agencies and disciplines."

Aiken believes the impact will extend far beyond Arizona.

"With the rate of population growth and the stresses on infrastructure, water and heat, Phoenix is a model," she said. "The information we're gathering here is going to be critical not only for other cities in the Southwest but for places around the world that are dealing with increasing heat stress."

This story originally appeared on ASU News.

Main image

ASU Foundation Professor Vernon Morris (left) and field engineer Mark Manriquez prepare to launch a 4-foot, helium-filled latex meteorological balloon on Thursday, June 18, from the West Valley campus. The balloon carries instruments that will collect data on how urban and desert environments influence monsoon storms, part of the Desert-Urban SysTem IntegratEd AtmospherIc Monsoon (DUSTIEAIM) campaign in the Southwest. Photo by Charlie Leight/ASU News

Text image(s)

Morris and field engineer Mark Manriquez monitor a 4-foot, helium-filled latex meteorological balloon launched an hour earlier on Thursday, June 18, from ASU's West Valley campus. Photo by Charlie Leight/ASU News

Gallery

ASU Foundation Professor Vernon Morris (left) and field engineer Mark Manriquez take a couple of minutes to fill a latex meteorological balloon with helium on Thursday, June 18 on the West Valley campus. The balloon carries instruments that measure atmospheric conditions. It expands as it ascends, eventually growing to roughly the size of a bus before bursting and returning back to Earth by parachute.

Workers assemble a protective cover for weather radar instruments on the east side of the West Valley campus.

Equipment and support for the study are supplied by the U.S. Department of Energy, with scientists from Los Alamos and Sandia National Laboratories, ASU and other institutions.

Workers assemble the weather radar site platform on Thursday, June 18, on the east side of the West Valley campus.