SUMMER 2009

OKLAHOMA CLIMATE

OKLAHOMA MESONET

A Peek into the History of the Mesonet

HAVE ARK WILL TRAVEL

Thunderstorms in Burneyville

Oklahoma Climate
Summer 2009

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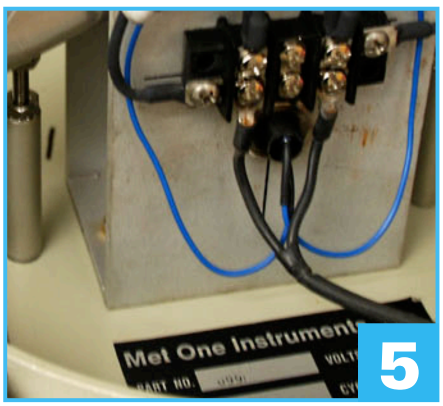

OKLAHOMA CLIMATOLOGICAL SURVEY

A Peek into the History of the Oklahoma Mesonet

By Renee McPherson Associate Director of the Oklahoma Climatological Survey

At a recent national conference of weather network operators and data users, the Oklahoma Mesonet was referred to as the "gold standard" of surface observing networks. So what did it take to earn this acclaim? In essence, it was a combination of (1) a state government that was forward-thinking enough to fund all start-up costs and a large portion of the annual maintenance costs and (2) a group of enthusiast scientists, engineers, and technicians who chose not to believe others when they were told, "You can't do that."

When the first formal meeting of the Mesonet Steering Committee met on August 15, 1990, the World Wide Web did not exist, a $75,000 computer had less disk space and memory than today's cell phone, and weather observations across Oklahoma were limited to hourly reports from major airports.

But some things have stayed the same. Oklahoma State University (OSU) and the University of Oklahoma (OU) still partner to operate and maintain the Oklahoma Mesonet. The Mesonet still partners with the Oklahoma Law Enforcement Telecommunications System to establish real-time communication links to each weather station. And the network still uses a central data facility to ingest data, manage a database of site and sensor information, quality assure and archive the data, and generate and disseminate products.

The first Manager of the Oklahoma Mesonet was Dr. Fred V. Brock, who was voted in as the technical leader of the network on January 9, 1991. Starting with a staff of zero, Dr. Brock began hiring electronics technicians, computer programmers, and meteorologists to create the network from scratch. Graduate students pitched in to help select locations for sites, write software, and quality assure the new data stream. Eleven temporary subcommittees were established by the six-member Mesonet Steering Committee to obtain advice from future users on issues such as site selection, instrumentation, user fees, and products.

Although Dr. Brock knew how big of a challenge it would be to create the nation's first multi-purpose, statewide surface observing system, he certainly didn't tell the employees. So these mostly twenty-somethings just assumed that a 100-plus-station mesonet could be built in a couple of years without a problem.

The first site, used for testing communications links, was installed in Stillwater on August 7, 1991. By the following January, fifteen 10-meter towers were installed across the state, marking the locations for atmospheric and soil sensors to be installed after they were purchased.

The first computer in the Mesonet's central data facility cost $74,518 (with a few peripherals) and had a processor speed of 36 Megahertz, 32 Megabytes of memory, and less than a Gigabyte of storage space. In contrast, Apple's low-end iPhone costs $99 and has a speed of 412 Megahertz, 128 Megabytes of memory, and 8 Gigabytes of storage.

In July and August of 1992, before any Mesonet data was flowing, 18 Oklahoma K-12 teachers attended a four-week workshop, called EARTHSTORM, to learn how to use Mesonet data in their classrooms. "Imagine if you will, a map with 100+ temperature observations…." Fortunately, teachers are patient, and they were the Mesonet's first "beta testers" for products, software, and learning materials.

In late December 1992, a computer bulletin board system was established for the teachers and other beta testers to get sample data files over their 2400- to 9600-baud modems. By July 1993, 108 Mesonet towers had been fully installed, including sensors, but only 64 of those were communicating to the central facility in Norman. At the same time, a new class of 15 teachers arrived to learn about Mesonet in the classroom (this time being able to use real data in their workshop).

As data arrived to OU and OSU during 1993, scientists observed several data quality problems, including three sources of error with air pressure measurements that eventually were traced to insufficient power to the sensor when it took a measurement and water in the air filter at the end of the tube to the barometer. Much time and energy was focused on resolving those problems before data were allowed to go beyond the beta testers.

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Operations Center: Before

The original operations center for the Oklahoma Mesonet, tucked in a corner of a converted data storage room at the Sarkeys Energy Center.

Operations Center: After

The Mesonet Operations Center of the Oklahoma Mesonet in the National Weather Center.

Calibration Lab: Before

The original calibration laboratory for the Oklahoma Mesonet in a converted teaching lab at the Sarkeys Energy Center.

Calibration Lab: After

The Fred V. Brock Standards Laboratory of the Oklahoma Mesonet in the National Weather Center.

In late 1993, automated quality assurance was tested, and a system to conduct manual quality assurance was added in early 1994. On March 10, 1994, the Oklahoma Mesonet was commissioned in a ceremony at the State Capitol. The following year the Mesonet shared 50,000 data files with its growing group of customers.

With the advent of the World Wide Web, more people could access more products and services much easier. So the Mesonet refocused its data dissemination to a web-based system. Using a "web browser plugin" developed by software engineers at the Oklahoma Climatological Survey, customized maps of Mesonet, radar, and other data suddenly could be provided to users. Thus, in 1996, public safety officials became a critical customer group of the Mesonet through the OK-FIRST outreach program.

Fast forward to today. The Oklahoma Mesonet has an archive of over 4 billion quality-assured observations, operates 120 Mesonet sites and 70 micronet sites (for partner networks), and provided 125 million data files (7 Terabytes of data and products) to customers in 2007. ■

FRED V. BROCK STANDARDS LABORATORY

By David Grimsley Calibration Laboratory Manager

The Oklahoma Climatological Survey's **Fred V. Brock Standards Laboratory** is responsible for maintaining the accuracy and operational status of the approximately 2700 sensors and associated data-logging equipment used by the 120 stations of the Oklahoma Mesonet. Between 750 and 1000 sensors pass through the facility each year. In 2008 alone, the lab performed 2351 separate sensor calibrations. In addition to calibrating sensors, the lab also refurbishes, repairs, and constructs sensors.

Wherever possible, a sensor is calibrated across the entire range of conditions it can expect when installed at a Mesonet station. Each sensor undergoes at least two calibrations. When a sensor first enters the lab (either from the field or from a manufacturer), an "As Found" calibration is performed. This test allows the Mesonet's Quality Assurance department to determine how a sensor might have changed over time while installed at a station. The "As Left" calibration is the final calibration performed on a sensor before field deployment.

Sensors are compared to traceable reference sensors during calibration that have been calibrated at specific intervals by accredited external laboratories. The term "traceable" refers to a sensor whose accuracy has been documented through a series of comparisons with other sensors that eventually leads to a universally recognized standard sensor. Most of the reference sensors used by the Brock Standards Lab are traceable to sensors maintained by the National Institute of Standards and Technology (NIST).

TEMPERATURE

Temperature sensors are calibrated using one of two systems. Sensors sealed against moisture, such as those used to measure soil temperature, are immersed along with a NIST traceable reference sensor in a container of propylene glycol. Propylene glycol can be cooled to very low temperatures while remaining in a liquid state. The propylene glycol is cooled to – 20°C and then slowly heated to 60°C over approximately 8 hours while being continuously stirred to create a homogeneous environment for accurate comparisons with the reference sensor.

Sensors that cannot be immersed in a liquid, such as the Mesonet's air temperature sensor, are calibrated in an environmental test chamber. The environmental test chamber used in this application is a combination freezer/oven that can accurately create and maintain temperatures as low as -40°C and as high as +200°C. The calibration technique is similar to the stirred propylene glycol bath except that the sensor and NIST traceable reference are compared in a small volume of air inside the environmental test chamber that is stirred by a fan. The test chamber slowly changes the air volume's temperature from -30°C to 60°C over 13 hours.

RELATIVE HUMIDITY

Relative humidity calibrations use a "two pressure" humidity generator manufactured by Thunder Scientific. The system uses NIST traceable temperature, pressure, and flow sensors to generate very accurate and stable NIST traceable humidity levels from 10 percent to 98 percent with an accuracy of ±0.5 percent. A complete calibration over the 10 percent to 98 percent range requires approximately 13 hours.

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PRESSURE

Barometer calibrations are performed using the Brock Pressure Controller and an environmental test chamber. The Brock Pressure Controller was designed and constructed by the lab's namesake, Dr. Fred Brock, and is the oldest calibration system still in use by Mesonet personnel. The system can produce and maintain atmospheric pressures ranging from 700 to 1100 millibars for calibrating barometers against a NIST traceable reference barometer. Barometers can be sensitive to temperature so the calibration takes place in an environmental test chamber. The chamber slowly varies the temperature from -20°C to 50°C over the 11 hours required for the pressure calibration. This insures accurate pressure measurements over the entire range of temperatures a barometer might experience at a station.

SOLAR RADIATION

The Mesonet uses silicon cell pyranometers to measure solar radiation. The calibration of this sensor type occurs indoors using an "artificial sun system". This device employs a 150-watt metal halide lamp as a substitute for the sun. The sensor to be calibrated is mounted alongside a reference sensor beneath the lamp. When powered, the lamp produces 450 W/m2 at the level of the sensors. A calibration factor is calculated for the test sensor so that its output matches that of the reference sensor. The National Renewable Energy Laboratory calibrates the reference sensor yearly with traceability to a set of radiation sensors known as the World Radiometric Reference (WRR).

PRECIPITATION

The Mesonet employs tipping bucket rain gauges for liquid precipitation measurement. The calibration of this sensor occurs in two steps. The first step is the "static" calibration. During the static calibration, mechanical adjustments are made to the pivot point of the gauge's tipping bucket so that the bucket will tip when filled with a volume of water equal to 1.13 cubic inches or 18.53 ml. This volume represents 0.01 inches of precipitation across the 12-inch circular collection area of the rain gauge. After the mechanical adjustment, each rain gauge undergoes a "dynamic" calibration. The dynamic calibration consists of testing the rain gauge at five rainfall rates ranging from 0.78 inches to 6.90 inches per hour.

WIND SPEED

The calibration of wind speed sensors (cup and propeller anemometers) occurs at the Mesonet's outdoor wind farm. The system is comprised of 18 sensor mounts arranged in a grid pattern along with a NIST traceable reference sensor. Sensors are installed at the site for up to two weeks, depending on the wind conditions, for comparison against the reference sensor. ■

interview with fred BROCK

Interview by Chris Fiebrich Oklahoma Mesonet Manager

Dr. Fred Brock is an Ohio native and attended graduate school at the University of Michigan and the University of Oklahoma. As luck would have it, he was a faculty member at the University of Oklahoma specializing in meteorological measurements and instrumentation at the same time the Oklahoma Mesonet was in its formative stages. I was able to have lunch with Dr. Brock a few weeks after the dedication of the Fred V. Brock Standards Laboratory and ask him about his early memories of the Mesonet.

Chris Fiebrich: How did you come to be an instrumentation meteorologist?

Fred Brock: I was always fascinated with computers, both analog and digital. After I received my M.S. degree in Applied Meteorology, I decided to also pick up an M.S. in Instrumentation Engineering. That brought me to OU to do my Ph. D. work on the performance of propeller anemometers.

CF: What was the biggest challenge to establishing the Mesonet in the early days?

FV: Getting a good communication system was the big challenge. I can remember the meeting we had with OLETS [the Oklahoma Law Enforcement Telecommunications System infrastructure that serves as the communications backbone for the Mesonet] in the early 1990s. OLETS really impressed me. There was clearly nothing better. We were so relieved to find that our big challenge had a solution.

CF: When did you know that the Mesonet concept just might work in Oklahoma?

FV: After we had the communications issue solved, we needed a solid datalogger. When Campbell Scientific, Inc. won the datalogger contract, I knew we could make our system work.

CF: What was one of the most unexpected dividends you've seen from the Mesonet?

FV: That we could use the data for road weather conditions, even though we don't have sensors right there on the roadway. The Mesonet can help predict smoke conditions near wild fires and help identify where snow and ice may be causing slick roadways. The Mesonet was tested early on, with winds of over 113 mph at the Lahoma station in 1994. We didn't really know if our sites could take winds that high; when it did, we were pleasantly surprised.

CF: How do you spend your time now that you're retired?

FV: I enjoy travelling, most recently to Bolivia and Peru. We also have season tickets to all of the plays and concerts at OU. My wife and I have a cabin that we use near Breckenridge in the summertime. We installed a Davis weather station at our cabin. When we're in Norman, the weather station sends us an email twice each day with the current weather conditions and a digital picture looking out our cabin window. Once we got a picture of a fox sitting on a big pile of snow in our yard. I'm not real satisfied with the software that came along with the weather station, so my son and I are trying to design our own software to take the weather observations and digital pictures.

Given Dr. Brock's track record, I'm willing to bet his new software will monitor the weather and conditions at his mountain cabin like no other. ■

Have Ark, Will Travel

Gary McManus | Associate State Climatologist

April 2009 was a tumultuous month for weather even by the Oklahoma's crazy standards. A devastating freeze partially destroyed Oklahoma's wheat crop early in the month, followed soon thereafter by widespread wildfires. A total of 17 tornadoes added to the commotion, along with an unusual amount of severe hail and wind reports. Mother Nature was not finished, however, and another momentous weather event sent the month off in style with a deluge of Biblical proportions down by the Red River.

Between 10:50 a.m.-5:10 a.m. on April 29-30, 2009, the Oklahoma Mesonet site at Burneyville recorded 12.89 inches of rainfall with 12.42 inches of that total falling on the 29th. An approaching upper-level storm system supplied the trigger for the training thunderstorms that continued over the Burneyville area nearly continuously for 24 hours. The storms were fed by a surge of low-level moisture in the wake of a warm front and a strong low-level jet. Heavy rain-producing storms continued forming to the west of Burneyville and travelling east, directly over the small town. The result was another extreme event in a month with plenty of extreme events already: a slew of record-breaking rainfalls, not only for the amounts but also for the short duration in which they fell.

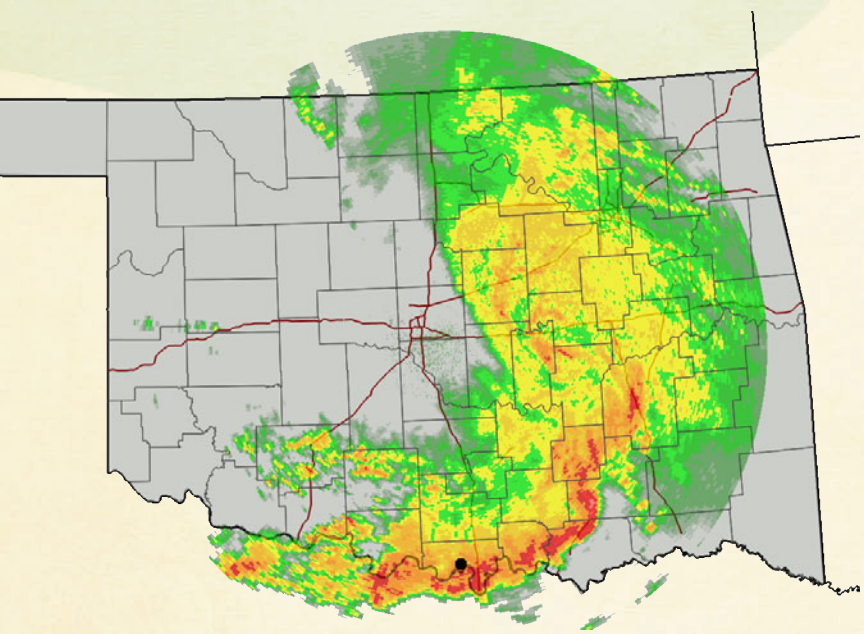


Figure 1. Radar image from 11:48 a.m. on April 29, 2009. The image shows a line of training thunderstorms moving parallel to Burneyville (black dot).

Records that were broken:

1. Burneyville Mesonet daily rainfall – Without an official long-term National Weather Service cooperative (COOP) station in Burneyville, the Mesonet site is the official site for all records.

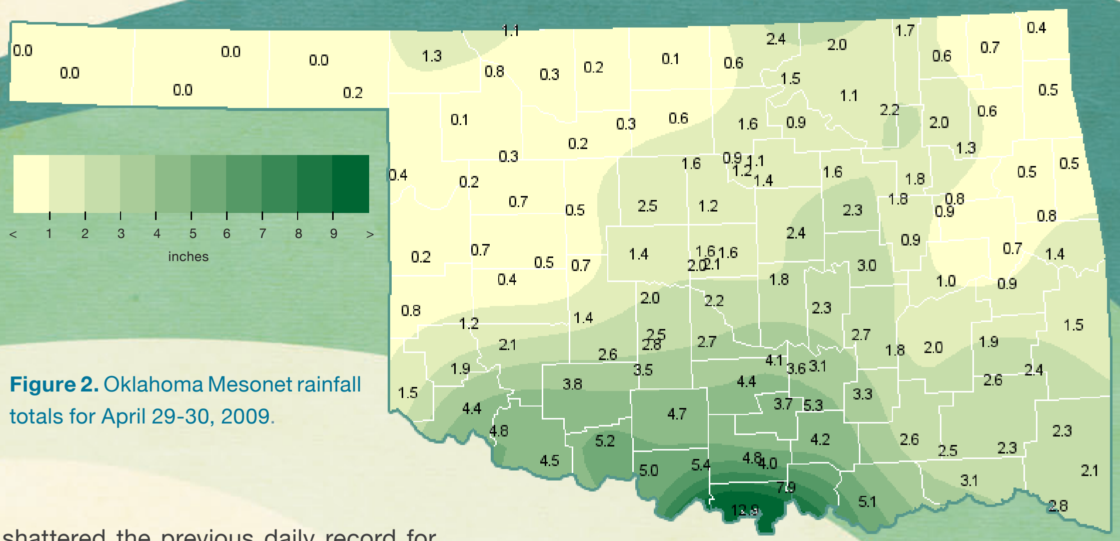


Figure 2. Oklahoma Mesonet rainfall totals for April 29-30, 2009.

The total obviously shattered the previous daily record for Burneyville Mesonet, 6.62 inches set on April 28, 2006. Burneyville Mesonet records go back to 1994.

2. Burneyville monthly rainfall – The single day total was enough to best the previous monthly total of 12.01 inches from June 2004. Add in rain from earlier in the month and you have a monthly total of 15.36 inches.

3. Mesonet daily rainfall – The total shatters the previous daily rainfall mark recorded by the Mesonet of 9.89 inches at Cheyenne on June 14, 1996. The only other totals in view of this one would be the 9.13 inches at Fairview on September 12, 2008, and the 9.00 inches recorded at Fort Cobb during Tropical Storm Erin's recovery on August 18, 2007. A more thorough investigation shows the Burneyville event broke the 24-hour rainfall event for the Mesonet as well. No 24-hour period in the history of the Mesonet had a greater total than 12.89 inches.

4. Oklahoma daily rainfall amount, any network – The total of 12.84 inches has been bested only three times in our recorded history. The rankings:

Enid (COOP), October 11, 1973	15.68 inches
Cheyenne (COOP), April 4, 1934	13.79 inches
Purcell (COOP), May 11, 1950	13.58 inches
Burneyville (Mesonet), April 29, 2009	12.89 inches
Eufaula 2 SW (COOP), October 31, 1941	12.86 inches
Stigler 1 SE (COOP), May 10, 1943	12.32 inches
Hee Mountain Tower (COOP), October 13, 1972	12.30 inches
Seminole (COOP), April 14, 1945	12.20 inches
Meeker (COOP), June 3, 1932	12.18 inches
Seminole (COOP), June 22, 1948	12.00 inches

5. Recurrence-interval totals - While these are not records, they are a good indicator of extreme rainfall events. These are taken from Tortorelli's "Depth-Duration Frequency of Precipitation for Oklahoma" maps, estimated for the Burneyville area.

Recurrence Interval	Tortorelli	Total
500-Year 1-Day	12.20	12.89
500-Year 24-Hour	12.00	12.89
500-Year 12-Hour	10.80	11.73
100-Year 6-Hour	6.80	8.58
100-Year 3-Day	11.60	12.89
50-Year 7-Day	11.80	12.92

The rains would continue in full force for another couple of weeks in Oklahoma before stopping abruptly on May 16. Through the spring, Oklahoma's weather never ceased to amaze, whether that be through fire, tornadoes or lakefulls of water falling in a single day. ■

Classroom Answers

1. The raindrop will fall faster because it is bigger. Using Table 1, we find that the raindrop's speed is approximately 437 times that of the cloud droplet (13.1 ft/sec for a 1 mm drop divided by 0.03 ft/sec for a 0.02 mm drop)!

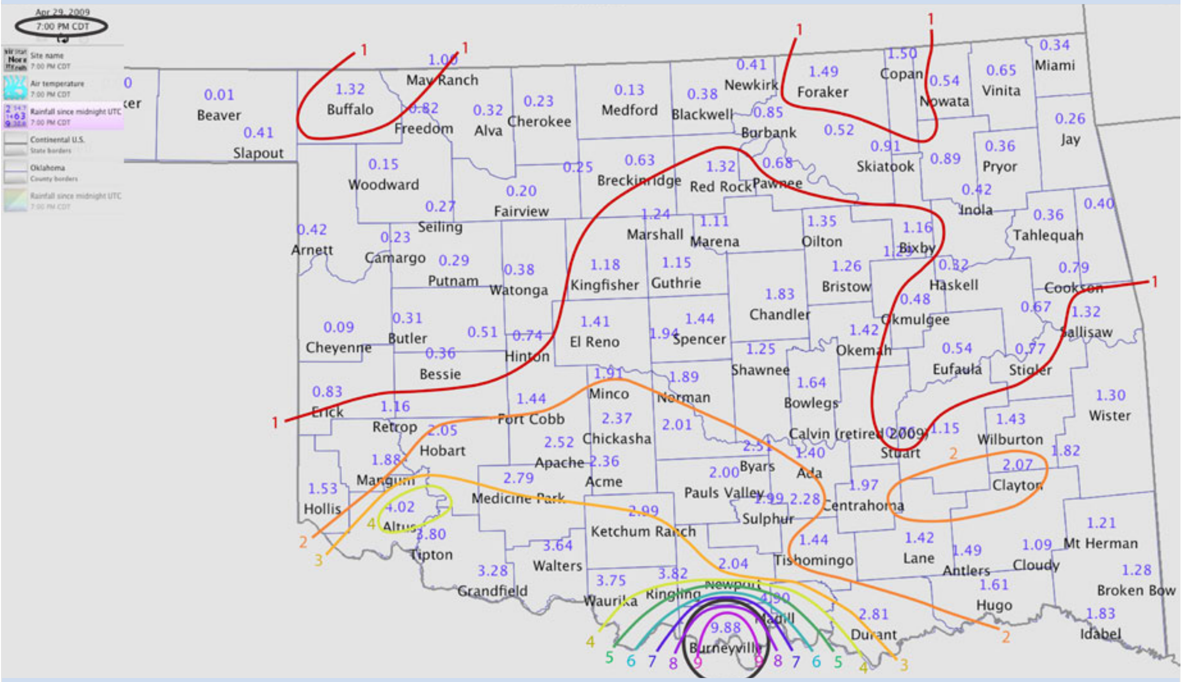
2. Large cloud droplets collide with small cloud droplets as they fall. Many, but not all, of these small droplets merge with the large droplet (coalescence), making the droplet bigger. The bigger the droplet, the faster it falls, and the more water it collects through its collisions.

3. The total rainfall amount at Burneyville was 9.88 inches (at 7pm). We can calculate the average rainfall rate by subtracting 0.19 inches (at 11 am) from 9.88 inches, then dividing the rain amount during the period (9.69 inches) by the time period (8 hours). The average rainfall rate is approximately 1.21 inches of rain per hour.

4. No more rain has fallen during the 11 am to 7 pm time period, so the accumulation value remains the same.

5. See Answer Figure 6 for the plot. The rain is not evenly spread across the state, probably because the storms are not evenly spaced, nor do they release the same amount of precipitation. One tool that we can use to check our theory is radar, which can be added to WeatherScope by clicking on Products -> New Radar -> and then choosing your radar (Oklahoma City or Frederick in this case).

■ **Figure 6**



SPRING 2009 SUMMARY

Gary McManus

The spring weather was typical for Oklahoma in that it was tumultuous and unpredictable, but out of the ordinary with the number of extreme events. March started things rolling with a near record-setting blizzard late in the month that brought over two feet of snow to the northwest. The snow drifted more than 10 feet in places. April continued the fun, or lack thereof, with a wheat-damaging extreme freeze event early then a 500-year rainfall event in southern Oklahoma later on. Drought conditions also led to a devastating wildfire outbreak during the month. May finished off the festivities with a season's worth of severe weather during the first two weeks of the month. Following that outburst, the remainder of spring could not have been quieter. In all, the statewide average precipitation total for spring was over 12 inches, about a half of an inch above normal, to rank as the 30th wettest since 1895. The statewide average temperature for spring was about a half of a degree below normal and ranked as the 58th coolest on record. Twenty-two tornadoes touched down during the March-May period, 13 less than the 1950-2008 average for spring.

MARCH DAILY HIGHLIGHTS

March 1-3: March began with unseasonably cool air on the first with low temperatures dipping into the single digits and teens across most of Oklahoma. The month's lowest temperature of 7 degrees was recorded at the Beaver Mesonet site on this day. Temperatures moderated over the next couple of days as winds kicked up from the south as high as 35 mph. By the third, temperatures were in the 60s and 70s across much of the state.

March 4-7: Lots of extreme warmth occurred in this four day period, courtesy of strong south winds kicked up by surface and upper-level low pressure systems. The winds, gusting to 40 mph at times, brought temperatures in the 80s and 90s into all parts of Oklahoma. Altus and Fairview both recorded 92 degrees on the fifth to lead state temperatures for the month. A cold front brought cooler air into the northwest on the sixth, but the warm air returned across the state on the seventh in the form of a warm front. A few scattered storms brought fractional rainfall amounts to a few areas on the seventh.

March 8-14: A cold front early on the eighth brought northwesterly winds gusting to 40 mph, but high temperatures still rose into the 60s and 70s that afternoon. The front moved back to the north on the ninth as a warm front, bringing south winds and moisture from the Gulf of Mexico with it. Showers and storms kicked up along the frontal boundary that evening with a few becoming severe. Hail to the size of golf balls fell in central Oklahoma near El Reno, and wind gusts of 60 mph were scattered across northwestern sections of the state. A strong cold front passed through the state the following two days, bringing temperatures well below seasonal normals. A very cold rain fell across most portions of the state on the 11th, with heavier showers in the extreme southeast. That rain turned to snow in the northwest on the 12th as an upper-level system moved closer to the state. Freezing drizzle occurred further to the south, with a cold rain in southern Oklahoma. High temperatures rose into the 30s and 40s, but wind chill values were in the 20s and 30s. The weather became a bit more seasonable during the 13th and 14th, but still a bit on the chilly side. Highs on the 14th rose into the 40s and 50s across the state as the low clouds eventually began to dissipate.

March 15-22: The next eight days were mostly on the warm side, but very windy. A few showers struck here and there, but very little rain fell across the state, with no severe weather. Moisture began streaming back into the state on the 22nd with strong southerly winds and highs in the 70s.

March 23-24: An upper-level storm moving towards the state kicked winds up from the south, gusting to 45 mph at times. Moisture from the Gulf streamed northward into the state. A dry line in western Oklahoma kicked off a round of storms on the 23rd that quickly became severe. Lots of large hail reports filtered in from across the state, including a 2.75-inch report near Stillwater. A tornado was confirmed by NWS survey near Pawnee early on the 24th. The EF-0 twister destroyed a barn and significantly damaged a nursery and trees. The storms eventually moved out of the state and cold front moved through, whipping winds around from the northwest with gusts of 50 mph. Highs climbed into the 60s and 70s following the front.

March 25-28: The 25th and 26th set the scene for possibly the greatest springtime snowstorm the state has ever seen. Some rain did fall on those two days, mostly in southern sections as the moisture began to stream back into the state. A few of the storms in south central Oklahoma exceeded severe levels the evening of the 26th. Thunder snow began about that same time in the Oklahoma Panhandle along a very strong cold front. The precipitation for the body of the state on the 27th began early in southern Oklahoma with a few heavy thunderstorms firing up. The snow then began in the northwest around 5 a.m. and started spreading to the east. Freezing rain and sleet occurred out ahead of the snow. Parts of north central Oklahoma eventually lost power due to ice accumulating on lines being blown by strong winds. By the afternoon, temperatures ranged from the 20s in the northwest to the 60s in the southeast. A blizzard warning issued earlier for the northwest verified quite easily as the heavy snow and strong winds gusting to over 40 mph caused white-out conditions across the area. The heavy snow and strong winds continued for much of the 28th before exiting the state to the northeast later that day. The storm totals reported by the various NWS offices, while preliminary, indicate more than 2 feet of snow fell in the Panhandle and northwestern Oklahoma, with drifts at times higher than 5 feet. The snow totals decreased to the south and east. Northeastern Oklahoma was hit by wrap-around precipitation with some areas recording up to 10 inches of snow. High temperatures ranged from the 20s in the areas with snowpack to the 50s in the southeast. The storm brought travel to a standstill over much of northwestern Oklahoma, stranding many along the very roads they were travelling.

March 29-31: A surface low pressure system began moving towards the state, bringing with it warm southerly winds for the next couple of days. The temperatures warmed into the 70s and 80s over parts of the state, but areas still bound by snow were 20-30 degrees cooler. A cold front late on the 30th kicked off rain showers in the southeast and cooled temperatures down to below seasonable territory. High temperatures on the 31st were in the 50s and 60s with a northwesterly wind of 20-30 mph making it feel much cooler.

APRIL DAILY HIGHLIGHTS

April 1-4: Wind was a central theme during the month's early days. Strong pressure gradients produced winds gusting to 60 mph or more on the second after picking up from gusts in the 40s on the first. A strong cold front that moved through late on the first produced a bit of snow and rain early on the second. Lows on the third dropped into the 20s and 30s due to the light winds associated with high surface pressure following the front. Strong southerly winds returned in the afternoon, however, which helped temperatures climb into the 70s. The lows on the fourth were 25 degrees higher than those of the previous day, falling into the 50s. Highs on the fourth rose into the 70s and 80s. Gusty southerly winds to 60 mph in advance of a cold front created extreme fire danger for the state.

April 5-7: A strong cold front overnight brought cool weather back to the state on the fifth with lows in the 30s and 40s. High winds gusting to 50 mph dropped wind chills into the 20s. A few strong-to-severe storms formed along the cold front with golf ball size hail near Tishomingo. A dome of surface high pressure following the cold front allowed for record-breaking cold temperatures in some areas. Oklahoma City broke its record-low temperature mark on the seventh with a reading of 22 degrees. Similar record lows were reported in Tulsa and McAlester. Low temperatures dropped into the teens in southern Oklahoma. Highs rebounded on the seventh into the 60s and 70s, with a few 80s being reported in southwestern Oklahoma.

April 8-9: High winds, low humidity and warm temperatures combined to create extreme fire dangers for much of the state on the eighth and ninth. Winds gusted to more than 70 mph in the west on the ninth. Smoke and blowing dust created a hazy afternoon for the western half of the state. The winds were generated by a storm system that arrived from the west. A dryline and trailing cold front were focal points for winds, and many damaging wildfires broke out and remained out of control for much of the day. Midwest City was particularly hard hit by the fires with approximately 100 homes destroyed. Showers and storms had formed along the cold front in eastern Oklahoma as it swept through the state. The storms quickly went severe and produced two significant tornadoes, both rated EF-2 on the Enhanced Fujita scale, to go along with reports of hail to the size of baseballs. Four injuries occurred with one of the tornadoes near Big Cedar in Le Flore County. The second tornado occurred near Eagletown in McCurtain County. Preliminary reports have four other tornadoes touching down in eastern Oklahoma on the ninth – two rated EF-1 and the remaining two rated EF-0.

April 10-12: The month's first real rainy period began on the 10th and continued through the 12th. An upper-level trough approached the state on the 10th and kicked up winds from the south gusting to 25 mph. Highs rose into the 60s following seasonable lows in the 30s and 40s. A few showers on the 10th gave way to heavier storms on the 11th and 12th. Severe weather reports were mostly due to large hail on the 12th. Every part of the state received rain during this period, but the largest totals were in southern Oklahoma where more than two inches fell. A weak cold front traveled across the state late on the 12th and ended the rainfall.

April 13-15: High pressure at the surface followed the cold front. A few light showers occurred in the southeast, but the state remained dry through the 15th. Temperatures began to increase through this period until peaking in the 70s to near 80 on the 15th.

April 16-19: Another wet and stormy four days for the state as an upper-level low moved in from the Four Corners area. Rains began in the Panhandle on the 16th with 1-2 inches falling across the area. More storms, at times severe, cropped up through early on the 19th. An EF-1 tornado touched down near Langston on the 18th. Heavy rains were common in east central and northern Oklahoma. Low temperatures were mostly in the 40s and 50s with highs in the 60s and 70s.

April 20-24: Wonderful weather occurred for the most part during these five days, if not a bit hot from time to time. High temperatures rose into the 80s and 90s from the 22nd-24th. Gusty southerly winds on the 23rd and 24th brought a stream of moisture into the state from the Gulf of Mexico. Only a couple of storms struck the state during this period, which was mostly rain-free.

April 25-30: The stormiest period of the year thus far began with low-level moisture streaming back into the state in response to a powerful upper-level storm system approaching from the west. A cold front entered far northwest Oklahoma where it promptly stalled out. A dryline also extended to the south from the cold front. Storms formed later that evening and quickly became severe in the warm, soupy air. A tornado watch was issued and the severe reports began to flow in. Hail up to 3 inches in diameter was reported across western Oklahoma where the storms were located. Two significant tornadoes rated EF-2 touched down in Garfield County and resulted in damage in Enid. The storms continued severe well into the morning hours and dropped several more possible tornadoes before finally dying out, only to see more storms form along the stationary front in the far northwest. The storms became more numerous and severe as the day wore on. A severe storm in Ellis County dropped an EF-2 rated tornado later that day while softball size hail was reported near Lamont. Lots of flooding occurred with the storms in north central Oklahoma. The storms eventually moved on and the weather calmed for a couple of days. Cloudy drizzly days on the 27th and 28th were replaced with yet another round of big storms on the 29th. Three more possible tornadoes touched down, but the big story was the rainfall in southern Oklahoma. The Mesonet station at Burneyville recorded 12.42 inches of rainfall on the 29th and 30th, breaking several records. Other stations in the area had upwards of 7 inches during the same event. More flooding was reported, this time in southern Oklahoma to go along with several reports of large hail. Rainfall amounts during this six-day period were quite heavy in north central and south central Oklahoma. The only areas that were largely devoid of rainfall were the Panhandle and east central Oklahoma. The month ended with a nice day on the 30th where high temperatures ranged from the 60s in the north to the 90s in the far southwest.

MAY DAILY HIGHLIGHTS

May 1-2: A wet start to the month was a continuation of the rains which began at the end of April. Storms in the early morning of the first dropped nearly 8 inches of rainfall in about 10 hours at the Pryor Mesonet site. Rains of more than 3 inches surrounded that total and produced 20 instances of flash flooding. Baseball ball size hail was reported near Okarche soon after midnight with other severe storms. Other reports of quarter- to golfball-size hail were scattered about central Oklahoma with those storms. More severe storms formed in Texas and moved into southwestern Oklahoma later that afternoon with quarter size hail. The storms continued overnight in the northeast with more heavy rainfall, then again in the southeast later that afternoon. More than 2 inches fell in the southeast with those storms.

May 3-7: The heavy rains held off for a couple of days on the third and fourth, as did the warmth. Highs rose in to the 50s and 60s after lows in the 40s and 50s. Severe storms and heavy rainfall returned on the fifth and sixth thanks to a stalled cold front along the Red River. Large hail and heavy rains were again a frequent culprit with these storms. A complex of severe storms the morning of the fifth began in western Oklahoma and marched east. Hail to the size of tennis balls was reported near Carnegie and flash flooding occurred near Turner Falls. More flooding occurred on the sixth in the southeast. The Broken Bow Mesonet site recorded over 3 inches of rain on that day. The state received a much-needed break on the seventh as skies cleared and the warm front in northern Texas moved into Oklahoma. Temperatures on the hot and humid day rose into the 80s and 90s.

May 8-11: The warm front that had moved north created a very unstable atmosphere on the eighth. Storms struck northern Oklahoma early on the eighth with very heavy rains and damaging winds. The roof was blown off a school gym in Picher and wind gusts of 75 mph were reported in Ottawa County. Baseball size hail was reported in Sequoyah County. Storms formed along the warm front, now moving south as a cold front, later that evening. Baseball size hail fell in Love County with wind gusts of 70 mph. Heavy rains caused flash flooding near Turner Falls yet again. The storms continued overnight on the ninth along the cold front. More than 2 inches of rain fell in the southeast after midnight. With the rain and cloudiness, highs rose only into the 60s and 70s across the state. More storms overnight on the 10th brought more than 5 inches of rain to Idabel and 4 inches in Broken Bow. Flash flooding was reported in Choctaw County with the rains. The 11th saw more storms across the state with more than 2 inches falling in southeast Oklahoma. The rains brought cool weather with highs in the 40s and 50s, more than 10-15 degrees below seasonal normals.

May 12-16: The 12th was rather quiet compared to the weather of the previous days. A weak upper-level disturbance produced a few showers and storms over extreme eastern Oklahoma. The highest totals were around an inch. A cold front overnight on the 13th produced severe weather in central Oklahoma. Severe winds and some large hail were reported with the storms. Some of the highest wind gusts were associated with dying storms during heat burst events. More storms formed in northern Oklahoma that night and moved south, quickly exceeding severe limits. Anadarko was struck by an EF-2 tornado to go along with baseball size hail and flash flooding. Southeastern Anadarko was hit by the tornado while even more damage was done to other parts of the city by rear flank downdraft winds. Much of Anadarko was without power for days after millions of dollars in damage to its electric power infrastructure. Preliminary estimates indicate 40 homes and businesses were either damaged or destroyed by the tornado and straight-line winds. An EF-1 tornado that touched down near Billings left damage in its wake as well. Three other weak tornadoes touched down on the 13th but did little damage. Bartlesville was struck by a severe storm with winds estimated between 70-100 mph that tore the roof off of a homeless shelter and left many damaged trees and out-buildings in its aftermath. Davis had an estimated wind gust of 89 mph as the storms continued overnight into the 14th. The cold front of the 13th returned as a warm front on the 14th and the state received a brief lull in the severe weather with highs in the 70s and 80s, but the front's passage also brought more moisture which fueled more severe storms on the 15th and 16th. The storms began in the evening of the 15th on the returning cold front, producing more heavy rains with severe winds and hail. The storms eventually died down early on the afternoon of the 16th. Sunshine and light winds brought more mild weather with highs in the 60s and 70s. Total rainfall over this 5-day period ranged from 4-5 inches in the southeast to less than an inch in the northwest.

May 17-21: An upper-level ridge and surface high pressure brought tranquil, if not cool, weather for the next few days. Lows were well below seasonal normals during this period with 40s and 50s being registered at most Mesonet sites. High temperatures were seasonable, however, in the 70s and 80s.

May 22-26: Moisture streamed back into the state on southerly winds on the 22nd, with a few showers scattered about. A summer-like pattern set up with a dome of high pressure over the state and a storm system approaching from the Gulf of Mexico and the southeastern U.S. Heavier rains fell on the 23rd with storms moving from the southeast to the northwest. A few of those storms contained dime-to-quarter size hail. Low temperatures during this period were warm, generally in the 60s. As the low pressure system curved northeastward in Arkansas, the rainfall in Oklahoma tapered off, only to return as a low pressure system moved in from the west. Most of the rain on the 25th and 26th occurred in the west and central portions of Oklahoma. The storms continued overnight into the 26th before dissipating. A strong cold front moved into Oklahoma the afternoon of the 26th and generated a few storms. Northerly winds gusting to 40 mph trailed the front and the weather cooled considerably following its passage.

May 27-31: The strong cold front meant a much cooler day on the 27th. Lows were in the 40s and 50s for the next few days, well below seasonal normals. Highs rebounded quickly into the 70s and 80s, however, peaking on the month's last day with readings well into the 90s.

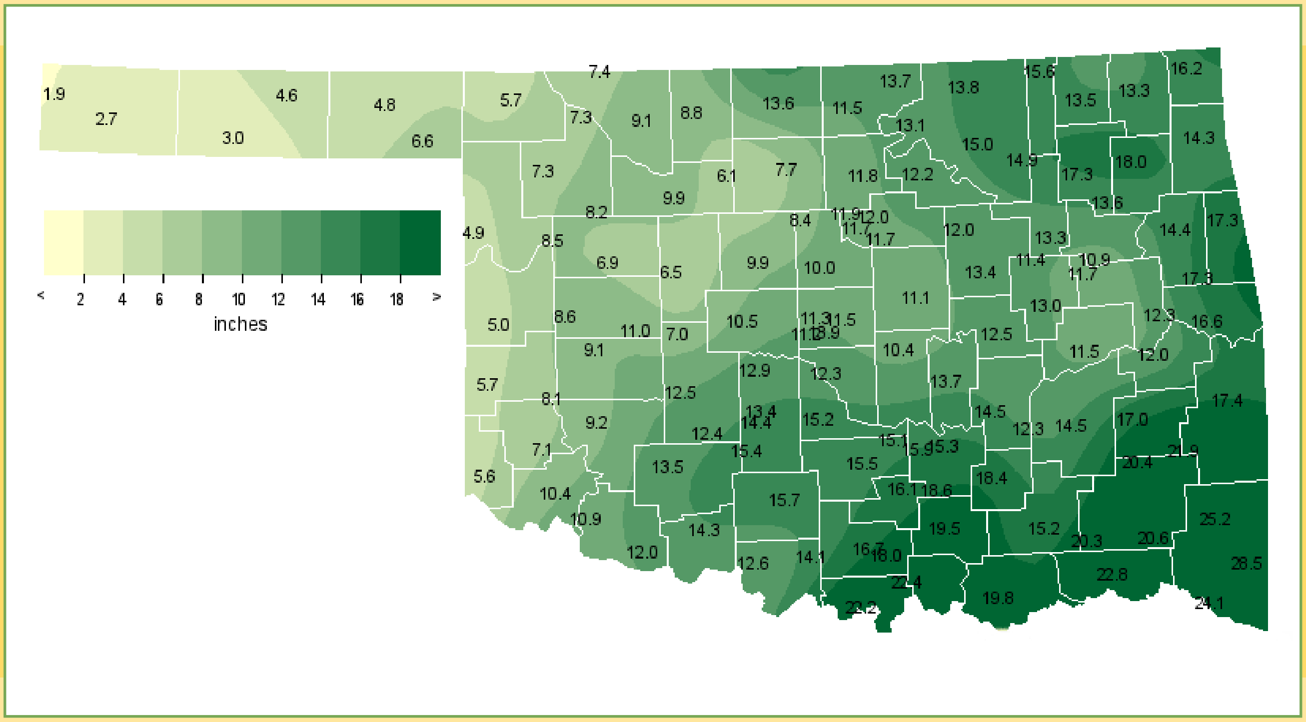
Spring 2009 Statewide Extremes

Description	Extreme	Station	Date
High Temperature	91°F	Madill	February 26
Low Temperature	-1°F	Buffalo	January 28
High Precipitation	7.65 in.	Sallisaw	
Low Precipitation	0.21in.	Slapout	

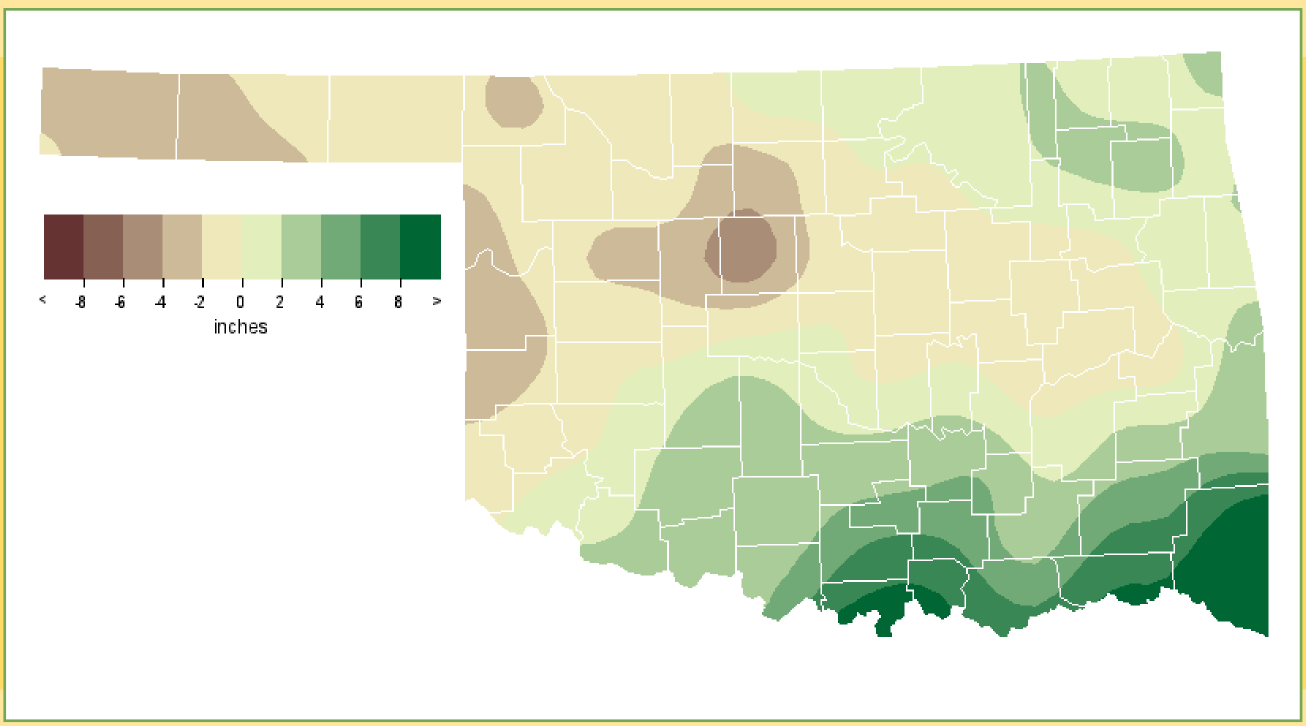
Spring 2009 Statewide Statistics

	Average	Depart.	Rank (1895-2009)
Temperature	40.5°F	1.7°F	31st Warmest
	Total	Depart.	Rank (1895-2009)
Precipitation	2.77 in.	-2.46 in.	16th Driest

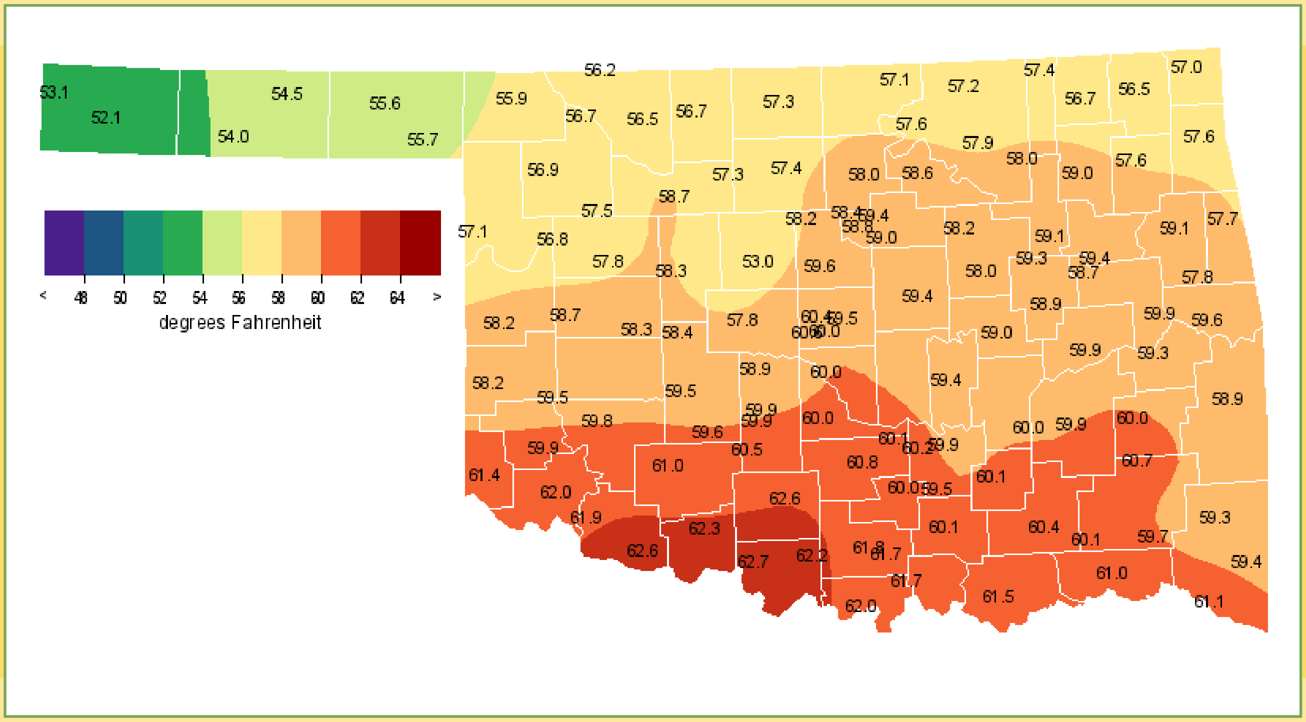
OBSERVED RAINFALL



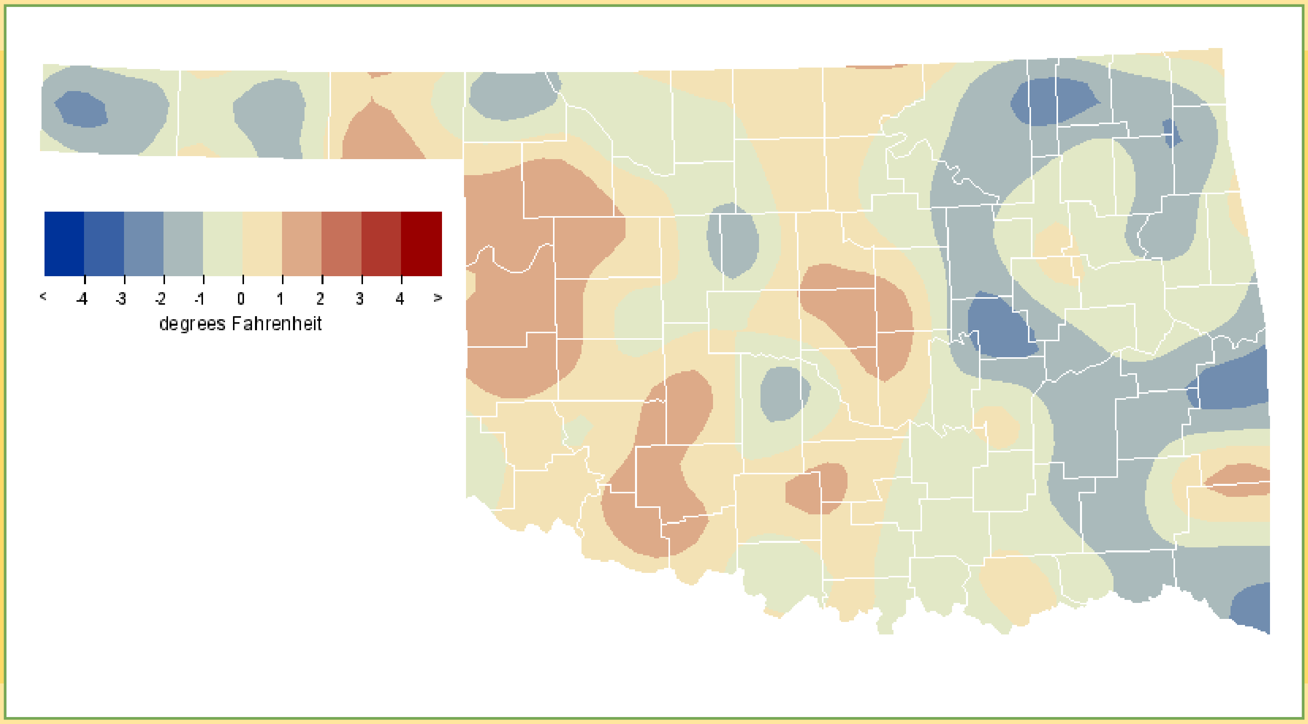
RAINFALL DEPARTURE FROM NORMAL



AVERAGE TEMPERATURE



TEMPERATURE DEPARTURE FROM NORMAL



SPRING 2009 MESONET PRECIPITATION COMPARISON

Climate Division	Precipitation (inches)	Departure from Normal (inches)	Rank since 1895	Wettest on Record (Year)	Driest on Record (Year)	2008
Panhandle	54.8	-0.5	54th Warmest	59.5 (1963)	49.4 (1915)	55.2
North Central	57.2	-0.4	54th Coolest	61.6 (1963)	52.8 (1924)	56.7
Northeast	57.8	-0.7	50th Coolest	62.2 (2006)	53.5 (1924)	58.2
West Central	58.2	0.2	52nd Warmest	62.6 (2006)	52.9 (1915)	58.7
Central	59.0	-0.5	57th Warmest	63.8 (2006)	54.5 (1924)	59.5
East Central	59.2	-0.8	44th Coolest	64.1 (2006)	55.1 (1931)	60.2
Southwest	60.8	0.3	44th Warmest	65.0 (2006)	55.1 (1915)	60.7
South Central	61.0	-0.3	57th Coolest	65.2 (2006)	56.5 (1931)	60.9
Southeast	60.0	-0.7	39th Coolest	64.3 (1938)	56.8 (1924)	58.9
Statewide	58.6	-0.4	58th Coolest	62.8 (2006)	54.3 (1924)	58.8

SPRING 2009 MESONET TEMPERATURE COMPARISON

Climate Division	Average Temp (F)	Departure from Normal (F)	Rank since 1895	Hottest on Record (Year)	Coldest on Record (Year)	2008
Panhandle	4.29	-2.56	36th Driest	13.27 (1957)	1.15 (1966)	2.80
North Central	9.42	-0.94	46th Wettest	21.31 (1957)	1.77 (1895)	11.03
Northeast	14.34	1.19	28th Wettest	25.15 (1957)	3.12 (1895)	21.52
West Central	7.57	-2.33	53rd Driest	19.30 (1957)	1.86 (1971)	9.14
Central	11.70	-0.70	42nd Wettest	22.89 (1957)	3.74 (1932)	15.35
East Central	13.70	-0.61	51st Wettest	30.36 (1990)	4.49 (1936)	19.60
Southwest	10.45	0.55	33rd Wettest	20.48 (1957)	3.28 (1971)	7.16
South Central	17.12	4.21	11th Wettest	27.30 (1957)	4.50 (2005)	15.33
Southeast	21.45	6.11	10th Wettest	30.18 (1990)	7.12 (1936)	22.14
Statewide	12.18	0.50	30th Wettest	22.74 (1957)	4.89 (1895)	13.86

SPRING 2009 MESONET EXTREMES

Climate Division	High Temp	Day	Station	Low Temp	Day	Station	High Monthly Rainfall	Station	High Daily Rainfall	Day	Station
Panhandle	96	May 30th	Beaver	7	Mar 1st	Beaver	6.64	Slapout	1.78	Apr 16th	Beaver
North Central	96	May 30th	Alva	10	Mar 1st	Freedom	13.70	Newkirk	4.84	Apr 25th	Medford
Northeast	92	Apr 22nd	Pawnee	13	Mar 1st	Vinita	18.00	Pryor	7.70	May 1st	Pryor
West Central	93	May 31st	Weatherford	14	Mar 1st	Butler	10.99	Weatherford	2.58	May 11th	Retrop
Central	93	Apr 22nd	Oklahoma City	13	Mar 1st	Marshall	15.39	Acme	3.41	Apr 29th	Acme
East Central	92	Apr 22nd	McAlester	14	Mar 2nd	Cookson	17.34	Cookson	3.17	Apr 18th	Tahlequah
Southwest	98	Apr 22nd	Grandfield	15	Mar 1st	Tipton	14.28	Walters	5.22	Apr 29th	Walters
South Central	95	Apr 22nd	Waurika	17	Mar 2nd	Centrahoma	22.36	Madill	12.42	Apr 29th	Burneyville
Southeast	93	Apr 22nd	Wilburton	16	Mar 2nd	Wister	28.48	Broken Bow	5.62	May 10th	Idabel
Statewide	98	Apr 22nd	Grandfield	7	Mar 1st	Beaver	28.48	Broken Bow	12.42	Apr 29th	Burneyville

AgWatch

by Albert Sutherland, CPA, CCA
Mesonet Assistant Extension Specialist
Oklahoma State University

The early months of summer 2009 were generally kind ones for Oklahoma farmers and ranchers. May started off with excellent soil moisture across the vast majority of Oklahoma. Rains in May kept soil moisture levels high in eastern and south central Oklahoma. Those not so fortunate were in areas in north central, northwest and the Panhandle, that came in short of normal rainfall.

Pasture and rangeland quality in May followed these rainfall trends, with better pasture to the east and south. The delays in planting row crops in April continued into May.

June was warmer and drier than normal, making it ideal for wheat harvest. While the weather for harvesting was good, the crop was poor to downright terrible. Winter drought, followed by a devastating April 2009 freeze dropped the estimated wheat yield to 73.5 million bushels. That is 58% of the 5-year average of 127.7 million bushels and a mere 44% of the bumper wheat crop in 2008 of 166.5 million bushels.

Except for a few isolated areas, the majority of Oklahoma received below normal rainfall in June. The driest areas were between Arnett and Fairview, central Oklahoma, Durant to Ardmore and most of McCurtain County. Mesonet sites in these drier areas recorded less than 40% of normal June rainfall. This stressed row crops, just as they were getting started for the summer. The heat and low rainfall caused pasture growth and quality to drop off.

July provided a dose of heat early, then cooled off as it progressed. Along with cooler temperatures came a series of storms that brought spotty, heavy rain to the state. The difference in June (Figure 1) and July (Figure 2) rainfall was dramatic. The cooler temperatures in the later part of July mixed with beneficial rainfall was the perfect recipe for thirsty row crops. Early planted corn suffered from late June and early July heat, but mild temperatures and rain came at just the right time for many fields of Oklahoma row crops.

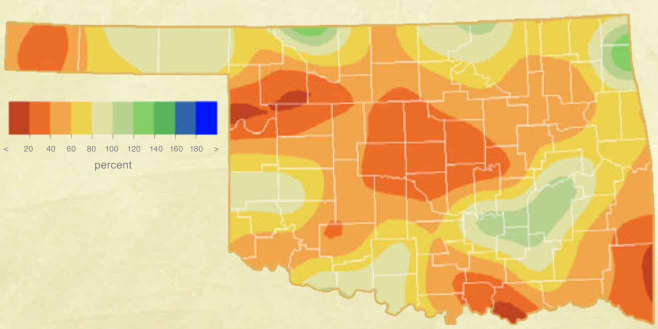


Figure 1: June 2009 Percent of Normal Precipitation

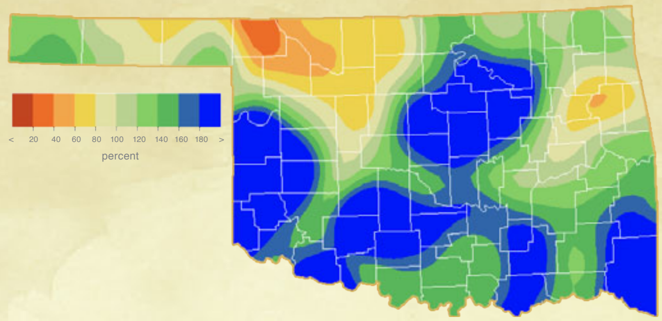


Figure 2: July 2009 Percent of Normal Precipitation

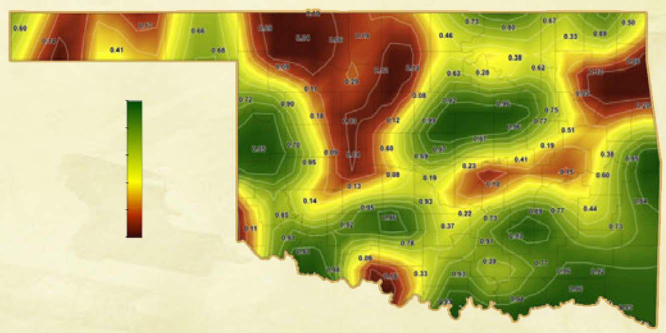


Figure 3: 25-cm (10") Fractional Water Index soil moisture August 1, 2009

While rain delayed hay cutting and baling, good moisture is needed for the next cutting. So July rains were a welcome commodity in Oklahoma. Pasture and rangeland quality improved markedly from June for many ranchers.

A large area in Oklahoma that missed out on the late July rainfall was an area roughly from Woodward to Hinton to Enid and north to the Kansas border. The intensity of the dryness in this area can be seen from the map of 10-inch soil moisture as of August 1, 2009 in Figure 3. The Fractional Water Index values at the Mesonet sites in this area are in the very low category. Plants throughout this area were under severe water stress as August kicked off. ■

To access the products highlighted in AgWatch go to Oklahoma AgWeather at **http://agweather.mesonet.org**.

Data on the Oklahoma Agweather Web site is from the Oklahoma Mesonet, managed in partnership by the University of Oklahoma and Oklahoma State University and operated by the Oklahoma Climatological Survey.

Urban Farmer

by Albert Sutherland, CPA, CCA
Mesonet Assistant Extension Specialist
Oklahoma State University

August

- Keep up with water demand. The height of the watering season is a great time to decide if you need a new drip or sprinkler system.
- Plan for new plantings with water efficiency in mind. Group plants with similar water needs together. Reserve areas closer to the water valve for high water demand plants.
- Children head back to school in mid-August. Make sure they are safe by trimming shrubs or trees near streets to maintain good driver visibility.
- Continue control of rose black spot with an approved fungicide.
- If you missed or skipped white grub control in July, you can apply an approved fast acting insecticide in August.
- Divide iris and replant or share the rhizomes with a friend.
- Plant frost hardy and short season vegetables. In August, plant cucumber, beet, broccoli, cabbage, Chinese cabbage, carrots, cauliflower, collards, Irish potatoes, leaf lettuce, parsnip, green peas, radish, Swiss chard and turnip.
- Prepare new garden areas by: 1) watering, 2) spraying weeds with glyphosate, 3) waiting 7-10 days; and 4) tilling the area.
- If a moderate to heavy rain event occurs, check pecan trees for emerging pecan weevil.

September

- Apply a lawn pre-emergent by mid-September for winter annual weed control; popular products include Princep, Barricade, Balan, Surflan or Team.
- Fertilize tall fescue in late September. Tall fescue needs nitrogen in the fall, as it grows more in cooler air temperatures. Use a quick release fertilizer at a rate of 1 pound of actual nitrogen per 1,000 square feet.
- Broadcast tall fescue seed mix for grass in shady areas or to thicken existing stands. Mix ¼ to ½ pound of improved Kentucky bluegrass with 4 pounds of tall fescue per 1,000 square feet.
- After mid-September, plant pansies for fall, winter and spring color. Pansies will produce new blooms throughout the winter, when the air temperature goes above 40°F.
- Divide and replant spring-flowering perennials.
- In the garden, plant garlic, rutabaga and spinach. You can still plant radish, Swiss chard and turnip.
- To increase garden soil organic matter, plant Austrian winter peas, vetch, wheat or rye as a winter cover crop. Mark your 2009 calendar to till green plants into the soil a couple of weeks before you want to plant next spring.

October

- Plant deciduous trees and shrubs. Fall planting gives young shrubs and trees all winter to develop new roots leaving them in better condition to deal with summer heat and drought.
- Plant most bulbs. Wait until November to plant tulips.
- Take a soil test to determine soil nutrients. Take your soil sample to your county OSU Cooperative Extension Service office for analysis. There is a fee for analysis.
- Rake leaves as they fall. This is especially true for fescue lawn areas, as the leaves can smother the grass if left too long. Raked leaves can be composted.

Nicole Giuliano, Mesonet Outreach Program Manager

Creating Rain *with* Collisions

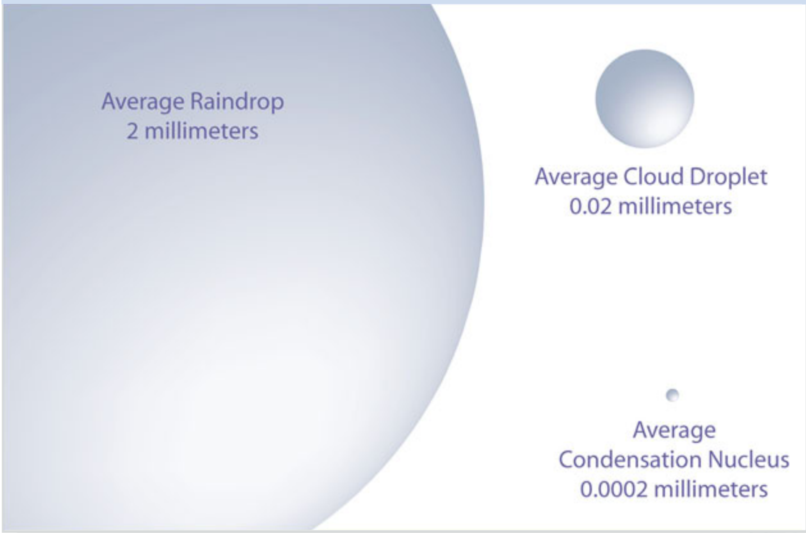
At some point in your life, you have probably lain on the grass and watched the clouds float by on a warm, lazy day. As you found shapes in the puffy cumulus, did you wonder how these clouds form? Basically, clouds form when the temperature falls to near the dewpoint temperature (the temperature at which dew forms) and condensation occurs. During condensation, water vapor (a gas) changes into tiny droplets of liquid water.

In order for cloud droplets to form in less than 100% relative humidity (when air temperature and dewpoint temperature are the same), cloud condensation nuclei (CCN) need to be present. Condensation nuclei are microscopic bits of dust, smoke, salt, clay, and other particles that water vapor can condense upon. Have you ever noticed that during humid weather, table salt can be hard to pour from a shaker? This is because water vapor in the air condenses onto the salt crystals, making them stick together. In the atmosphere, water vapor condenses on tiny ocean salt particles (or other condensation nuclei) floating in the air, becoming cloud droplets.

Some clouds eventually produce precipitation; during the summer, this is usually in the form of rain. So, how does a cloud droplet become a raindrop? [See Figure 1 for relative sizes.]

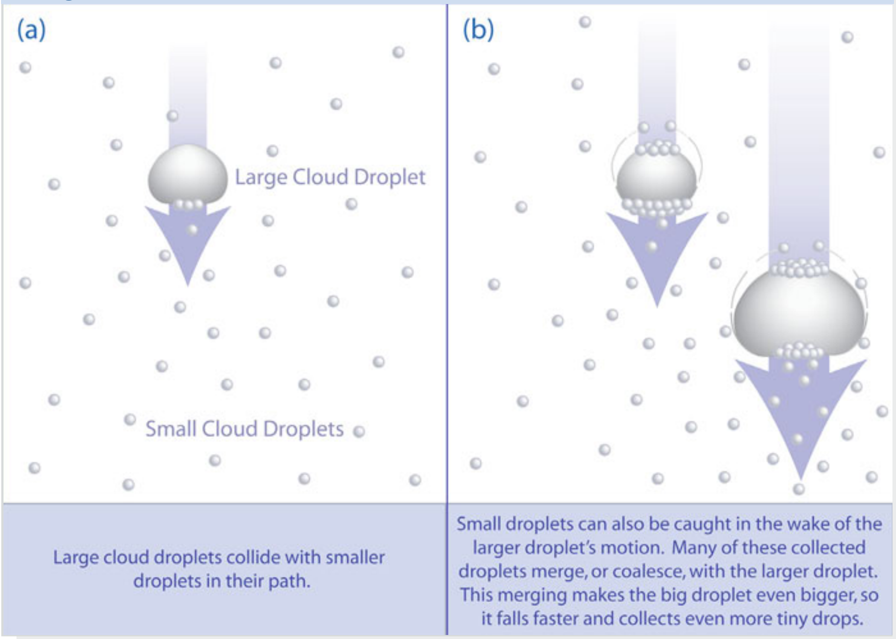
In order for a small cloud droplet to fall as rain, it needs to gain more mass (water, in this case). Let's pretend that a ping pong ball is a cloud droplet. If we put the ball above a hairdryer pointed upwards, the ball is suspended in the air. Then, if we wrap rubber bands all around the ping pong ball, it becomes too heavy to be suspended by the hairdryer. A droplet has to overcome the updraft of the cloud (air that moves upward rapidly), which will keep it suspended in the air until it becomes too heavy for the updraft to hold. As you can see in Table 1, the bigger the droplet, the faster it falls through the air. Also, the bigger the droplet, the more likely that it will fall fast enough to overcome the updraft and eventually hit the ground as rain.

Figure 1: Relative Diameters of Droplets and Condensation Nuclei



Classroom >>

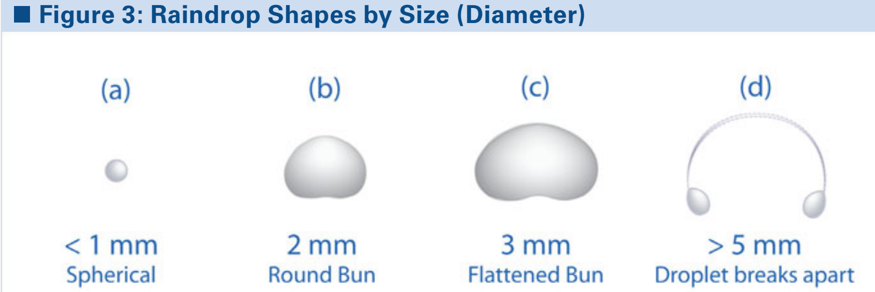
■ Figure 2: Collision and Coalescence Process



One way that a cloud droplet can gain more mass (water) is through the process of collision and coalescence. As shown in Figure 2, there are various droplet sizes within a cloud. Large cloud droplets fall faster than the smaller droplets, so the large droplets collide with the slow-moving small droplets (2a). Some of the small cloud droplets are not captured by collision, but can be caught by eddies in the wake of the large droplet, similar to the swirls formed by a boat's motion. These droplets trapped by the wake collect on the top of the droplet. Most of the small droplets that are caught merge (coalesce) with the larger droplet, making the droplet bigger (2b). Remember, the larger the droplet, the faster it falls. So, this larger droplet will collect even more tiny drops until it is a few millimeters in diameter (a raindrop) and heavy enough to fall to the ground. Additionally, the longer a droplet is in a cloud, the bigger it can potentially grow. The bigger it grows, the faster it can become a raindrop.

Do you know the real shape of a raindrop? Rain never looks like a teardrop; instead, it is round (spherical) or similar to a hamburger bun (see Figure 3). The smaller the droplet, the more likely it is round (3a). The larger the droplet, the more bun-like it becomes (3b and 3c), up to a point. Around 5 mm or larger (3d), the large raindrop cannot stay together—it becomes a thin tube of water, then breaks apart into smaller droplets.

■ Figure 3: Raindrop Shapes by Size (Diameter)



Nicole Giuliano, Mesonet Outreach Program Manager

Questions

Read the preceding interpretation article and answer the following questions:

1. Which falls faster: a cloud droplet (0.02 mm) or a raindrop (1 mm)? Why? How much faster is the rapidly-falling drop than the slower-falling drop? (Hint: Use Table 1 and divide the fall speed in feet/second of the fast drop by that of the slow drop. Make sure to use the diameters listed in this question.)

2. How do cloud droplets grow in the collision and coalescence process?

Using Figures 4 and 5 (WeatherScope maps), we can calculate the rain rate (in inches per hour) for a given Mesonet site. The plotted parameter is "Rainfall since midnight UTC", which is the total amount of rain that has fallen since 7 pm CDT/6 pm CST the day before. For instance, let's choose the Newport Mesonet site (in southern Oklahoma) from Figure 4, where the rainfall accumulation is 0.76 inches at 11 am on April 29, 2009. This means that 0.76 inches of rain fell between 7 pm on the 28th and 11 am on the 29th. Just after 7 pm, the total rainfall value will return to zero and the accumulated amount of rain will start over again, assuming that rain falls. Let's look at the 7 pm rainfall total (Figure 5). The total is now at 2.04 inches. If we want to find the average hourly rainfall rate (how many inches of rain fell during the time period), we must follow these steps:

A. Subtract the first rainfall number (0.76 inches) from the final total (2.04 inches), which equals 1.28 inches.

B. Calculate the difference in time. From noon to 7 pm it is 7 hours, add in one more hour (since we started at 11 am, not at noon), and we get 8 hours total.

C. Divide the rain amount (1.28 inches) by the time period (8 hours) and we get approximately 0.16 inches of rain per hour.

3. What was the total rainfall amount at the Burneyville Mesonet site (as of 7 pm)? What was the average hourly rainfall rate at this site (between 11 am and 7 pm)?

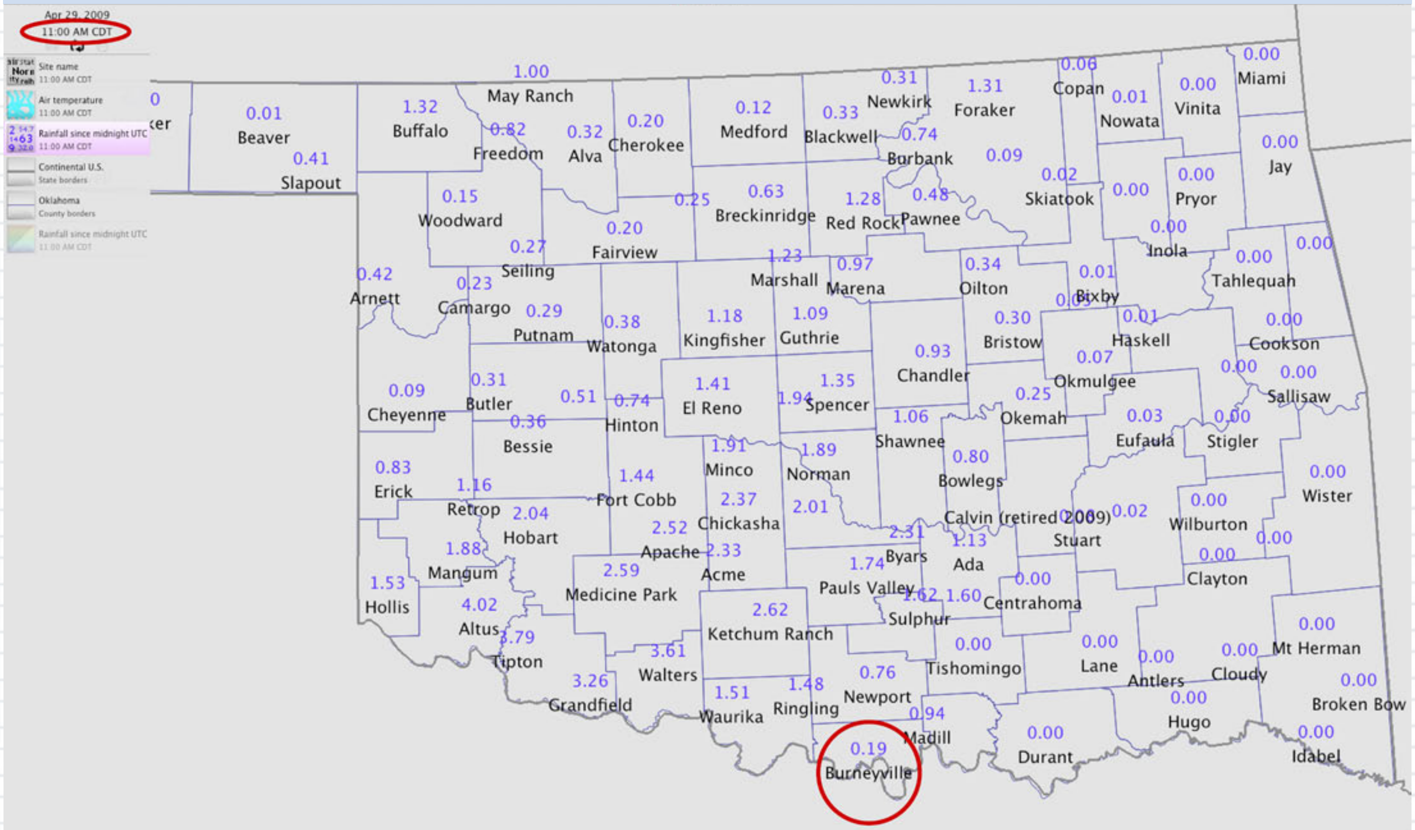
4. Why did the rainfall amount at sites like Mangum stay the same?

5. BONUS: Using the 7 pm plot (Figure 5), draw 1, 2, 3, 4, 5, 6, 7, 8, and 9 inch rainfall total contours. Remember, the values between the 1 and 2 lines should be values like 1.0, 1.1, 1.8, etc. Is the rain evenly spread across the state? Why or why not?

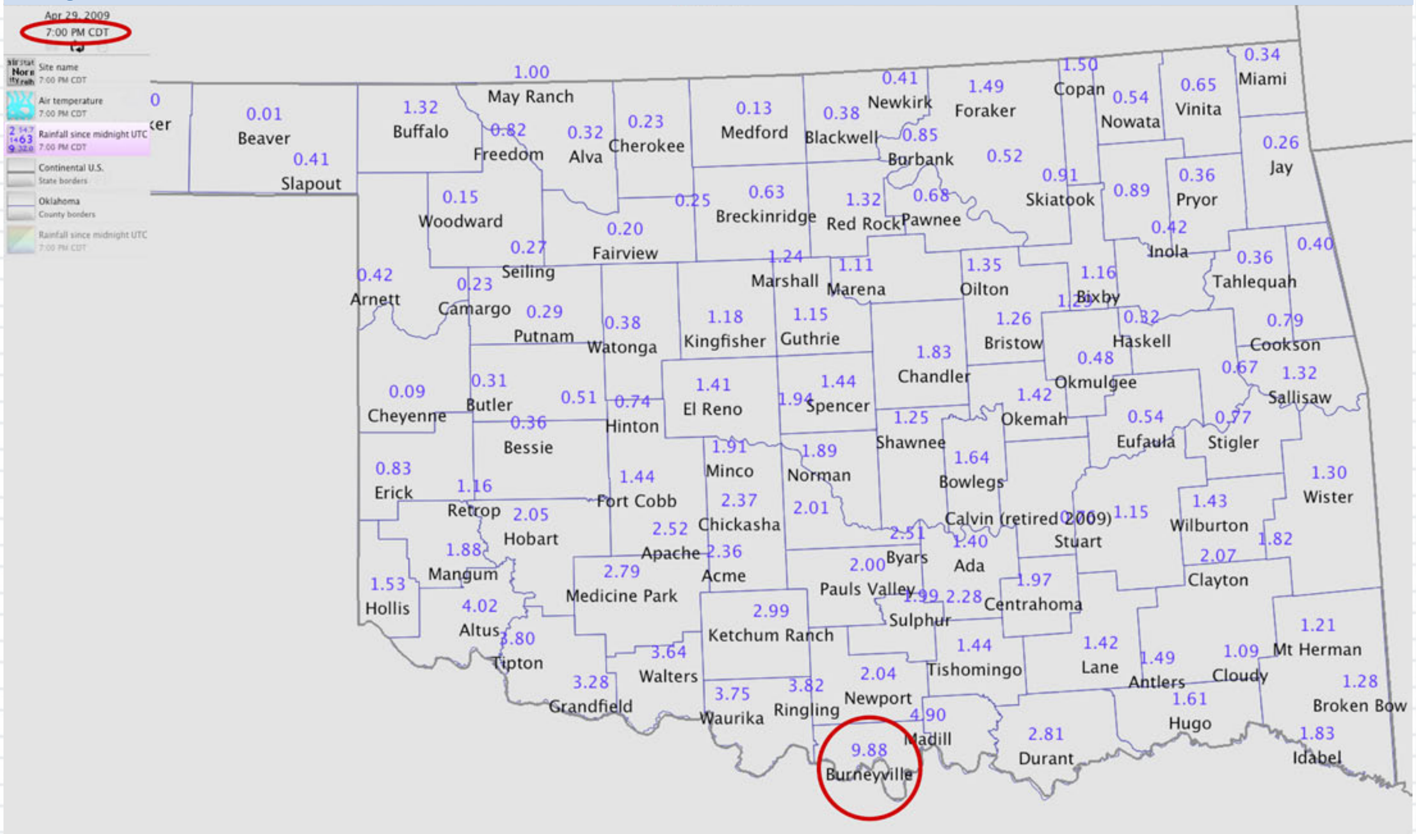
Answers on page 10

Figures 4 & 5 >>

■ Figure 4



■ Figure 5


Apr 29, 2009
7:00 PM CDT
1.00 May Ranch
0.01 Beaver
0.41 Slapout
1.32 Buffalo
0.82 Freedom
0.32 Alva
0.23 Cherokee
0.13 Medford
0.38 Blackwell
0.41 Newkirk
0.85 Burbank
1.49 Foraker
0.52
1.50 Copan
0.54 Nowata
0.65 Vinita
0.34 Miami
0.26 Jay
0.15 Woodward
0.25
0.63 Breckinridge
1.32 Red Rock
0.68 Pawnee
0.91 Skiatook
0.89
0.36 Pryor
0.42 Inola
0.20 Fairview
0.27 Seiling
1.24 Marshall
1.11 Marena
1.35 Oilton
1.16 Bixby
0.36 Tahlequah
0.40
0.42 Arnett
0.23 Camargo
0.29 Putnam
0.38 Watonga
1.18 Kingfisher
1.15 Guthrie
1.83 Chandler
1.26 Bristow
0.48 Okmulgee
0.32 Haskell
0.79 Cookson
0.67
1.32 Sallisaw
0.09 Cheyenne
0.31 Butler
0.51
0.74 Hinton
1.41 El Reno
1.94 Spencer
1.44
1.25 Shawnee
1.42 Okemah
0.54 Eufaula
0.77 Stigler
0.36 Bessie
1.91 Minco
1.89 Norman
1.64 Bowlegs
0.83 Erick
1.16 Retrop
1.44 Fort Cobb
2.37
2.01
2.05 Hobart
2.52 Chickasha
Apache
2.36 Acme
2.51
Calvin (retired 2009)
1.15
1.40 Ada
Stuart
1.43 Wilburton
1.30 Wister
1.82
2.07 Clayton
1.88 Mangum
2.79 Medicine Park
2.00 Byars
Pauls Valley
1.99 2.28 Centrahoma
1.97
1.53 Hollis
4.02 Altus
2.99 Ketchum Ranch
Sulphur
1.21 Mt Herman
3.80 Tipton
3.64 Walters
1.44 Tishomingo
1.42 Lane
1.49 Antlers
1.09 Cloudy
3.28 Grandfield
3.75 Waurika
3.82 Ringling
2.04 Newport
1.61 Hugo
1.28 Broken Bow
4.90 Madill
9.88 Burneyville
2.81 Durant
1.83 Idabel

IF A HEAT WAVE IS PREDICTED OR HAPPENING...

- Avoid strenuous activity. If you must do strenuous activity, do it during the coolest part of the day, which is usually in the morning between 4:00 a.m. and 7:00 a.m.
- Stay indoors as much as possible. If air conditioning is not available, stay on the lowest floor. Try to go to a public building with air conditioning each day for several hours.
- Wear lightweight, light-colored clothing. Light colors will reflect away some of the sun's energy.
- Drink plenty of water regularly and often, even if you do not feel thirsty. Your body needs water to keep cool.
- Avoid drinks with alcohol or caffeine in them. They can make you feel good briefly, but make the heat's effects on your body worse.
- Eat small meals and eat more often. Avoid foods that are high in protein, which increase metabolic heat.
- Avoid using salt tablets unless directed to do so by a physician.

SIGNALS OF HEAT EMERGENCIES

- **HEAT EXHAUSTION:** Cool, moist, pale, or flushed skin; heavy sweating; headache; nausea or vomiting; dizziness; and exhaustion. Body temperature will be near normal.
- **HEAT STROKE:** Hot, red skin; changes in consciousness; rapid, weak pulse; and rapid, shallow breathing. If the person was sweating from heavy work or exercise, skin may be wet; otherwise, it will feel dry.

TREATMENT OF HEAT EMERGENCIES

- **HEAT CRAMPS:** Get the person to a cooler place and have him or her rest in a comfortable position. Lightly stretch the affected muscle and replenish fluids. Give a half glass of cool water every 15 minutes. Do not give liquids with alcohol or caffeine in them, as they can make conditions worse.
- **HEAT EXHAUSTION:** Get the person out of the heat and into a cooler place. Remove or loosen tight clothing and apply cool, wet cloths, such as towels or sheets. If the person is conscious, give cool water to drink. Make sure the person drinks slowly. Give a half glass of cool water every 15 minutes. Do not give liquids that contain alcohol or caffeine. Let the victim rest in a comfortable position, and watch carefully for changes in his or her condition.
- **HEAT STROKE:** Heat stroke is a life-threatening situation. Help is needed fast. Call 9-1-1 or your local emergency number. Move the person to a cooler place. Quickly cool the body. Immerse victim in a cool bath, or wrap wet sheets around the body and fan it. Watch for signals of breathing problems. Keep the person lying down and continue to cool the body any way you can. If the victim refuses water or is vomiting or there are changes in the level of consciousness, do not give anything to eat or drink.

The Dangers of Heat and Humidity | The National Weather Service – Norman
http://www.srh.noaa.gov/oun/wxsafety/summerwx/heathumidity.php

Summer Safety Rules | The National Weather Service – Norman
http://www.srh.noaa.gov/oun/wxsafety/summerwx/summersafety.php

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