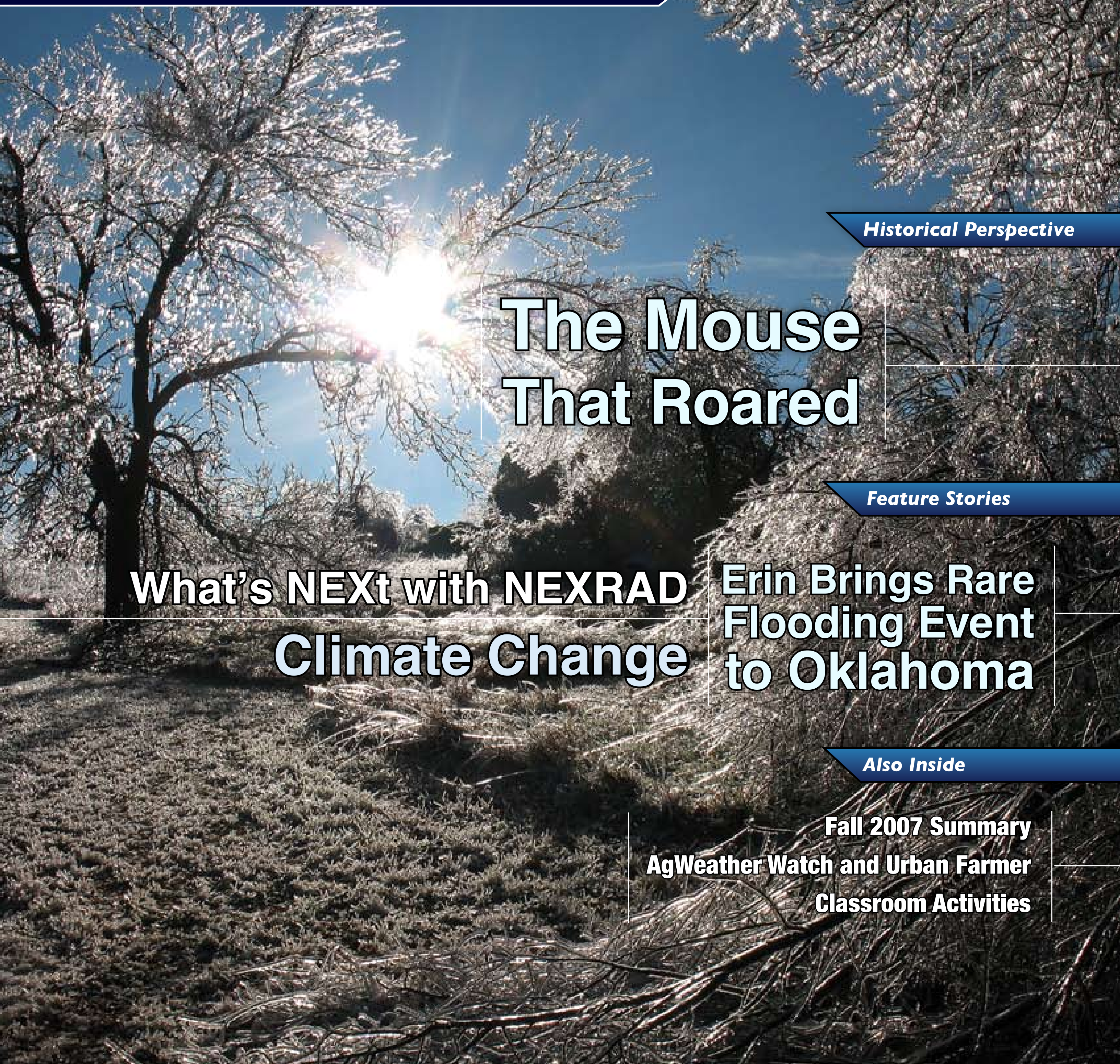
OKLAHOMA CLIMATE

Winter 2007-2008



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Cover Photo: by Rollins Goetzel. If you have a photo that you would like to be considered for the cover of Oklahoma Climate, please contact Gary McManus at gmcmanus@ou.edu.

MESSAGE FROM THE EDITOR

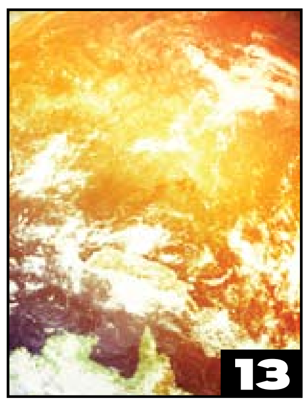
Gary McManus

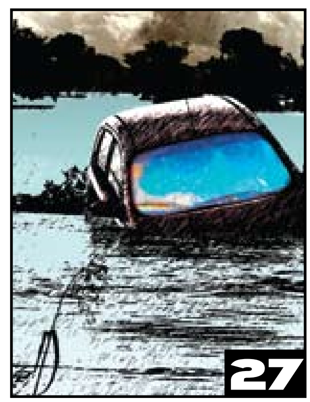
As Oklahomans, we love to rank our weather calamities, don't we (Gary McManus, proud survivor of Oklahoma's worst blizzard at Buffalo, Oklahoma, in February 1971...thank you very much!)? And just like in sports, with ranking come ranklings. Was May 3, 1999, the worst tornado disaster in Oklahoma history or does that unfortunate title fall to the Woodward tornado of April 1947? How about ice storms? Quick off the heels of the December 2007 ice storm which knocked power out to a significant portion of Oklahoma's population, it was summarily named the state's worst. How do we measure worst? Power outages, monetary damages, and deaths could all be the primary factor, or a combination of all. The truth of the matter is the rankings are very personal to those that were affected. It's hard to tell folks in McAlester, devastated by ice storms in December 2000 and January 2007, that the December 2007 ice storm was a single bit worse than theirs. So let's take a look at all the big ice storms that have struck since the turn of the millennium and we can all make up our own minds. By the way, why are we having all these big ice storms now? Could it be some sort of climate change? Dare we analyze this question? Yes, climate change is a prickly subject, but OCS has produced an official statement on global climate change and its implications for Oklahoma. Powered by the IPCC report and other assessments from the world's scientific community, you can see this statement in its entirety in this issue of Oklahoma Climate.

Also in this issue, check out a report on the newest radar technology, coming soon to a tornado warning near you... polarimetric radar! It's tough to say now, but eventually it'll roll off your tongue. In another feature story, we re-visit Tropical Storm Erin yet again, this time concentrating on the flooding aspect of that disastrous event. Erin was such a unique storm for Oklahoma, we suspect you'll be hearing a lot about her in the future. Finally, we hope you enjoy a new regular feature in this issue in which we interview a prominent meteorologist from the National Weather Center in Norman. It should be a lot of fun!

Our classroom exercise allows students to learn about ice storms and how they can affect trees and electricity. In addition, be sure to read our regular features dealing with agricultural weather, weather safety, and a weather summary of the fall months.

I sincerely hope you enjoy this issue of "Oklahoma Climate." If you have any questions or comments, please feel free to contact me at gmcmanus@ou.edu.





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Oklahoma Climatological Survey

the mouse that ROARED

Gary McManus
Assistant State Climatologist

The ice storm that struck Oklahoma in December 2007 has managed to usurp the crown as the state's worst from the previous disputed ruler – either the December 2000 or January 2002 storm. Does the most recent storm truly deserve that lofty ranking, or is it a pretender at best? After all, it did leave 640,000 residences and businesses without power, did hundreds of millions of dollars in damage, and contributed to 30 deaths. Those statistics are similar to the previous two "biggies" in 2000 and 2002 save for the lost power figures. Together, those two storms left "only" half of a million utility customers without power.

The truth of the matter, however, is that the two previous storms were much more potent meteorologically than the December 2007 storm. Ice accumulation due to the previous events was up to four inches with as much as 5-6 inches in places, while the December 2007 storm seems to have deposited at most two inches in localized areas. In fact, the January 2007 ice storm that struck southeastern Oklahoma probably eclipses the December 2007 storm in power and ferocity as well with its 4-5 inches of deposited ice. So how does the December 2007 storm, a welterweight in comparison, manage to KO the previous heavyweights from the past few years? The answer is the key in both real estate deals and ice storms: location, location, location.

Dodging an Icy Bullet

The state's two most populous cities, Oklahoma City and Tulsa, received glancing blows at best from the ice storms of 2000 and 2002. It was well understood what a heavy icing event would do should one blanket the state's most densely populated areas. With the December 2007 storm, that scenario became reality and the result was over a million Oklahomans being left without power. And yet, they were still the benefactors of good luck. Not for experiencing a major icing event, obviously, but for WHICH major icing event. Had this storm packed the punch of the previously mentioned storms, the magnitude and the scale of the destruction would have been multiplied many-fold.

An ice storm's damage potential is increased by two different factors. One is the volume of ice deposited on the power lines. As more and more ice accumulates, the added weight will eventually begin to snap lines and topple poles. Another factor is wind speed. Wind will cause the power lines to sway which adds even more stress. When the two factors work together, the result can be devastating. As more ice accumulates, not only does that add weight to the lines but also surface area. With more surface area to

December 2000

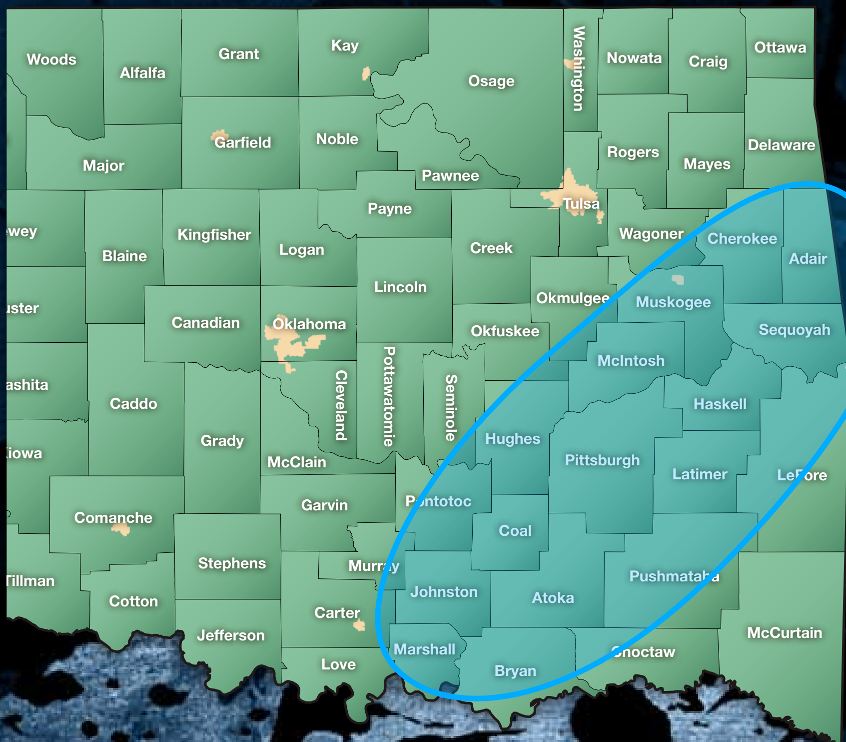
General area of most significant ice accumulation during the December 2000 ice storm.

January 2002

General area of most significant ice accumulation during the January 2002 ice storm.

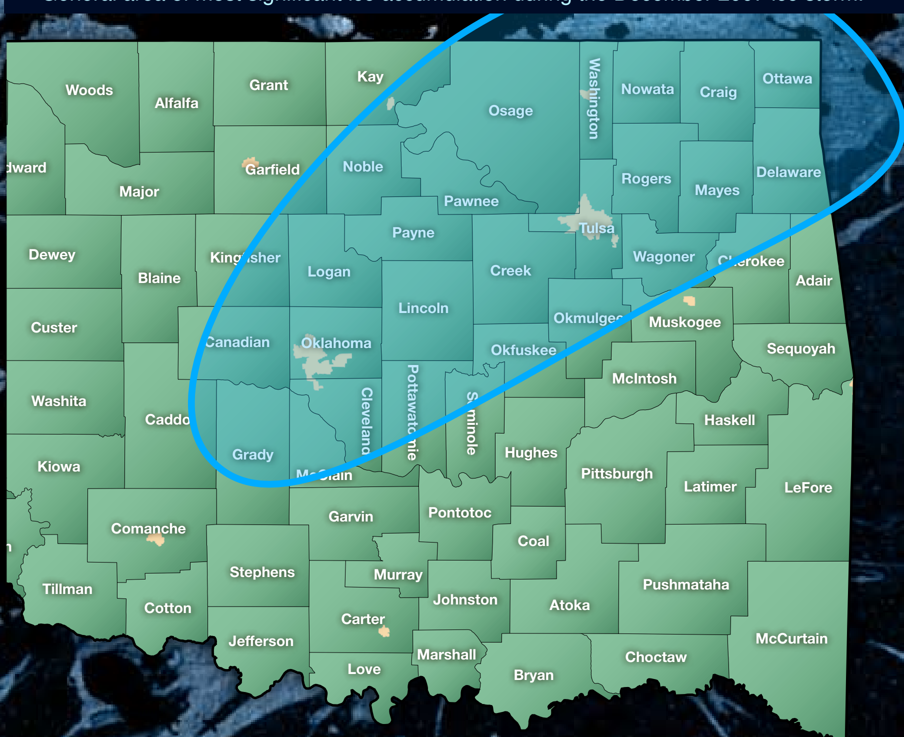
January 2007

General area of most significant ice accumulation during the January 2007 ice storm.



December 2007

General area of most significant ice accumulation during the December 2007 ice storm.



push against, the wind becomes much more effective at causing the power lines to sway. Strangely enough, neither of these factors became overly severe during the storm of December 2007. A different culprit was responsible for the massive loss of power: trees.

Ice storms have a way of "weeding out" weaker trees, just as predators will weed out weaker prey. Those trees could be old, diseased, or just not meant for areas in which ice storms pop up from time to time. Since the I-44 corridor had enjoyed a lengthy period without a significant freezing rain event, possibly since the Christmas Storm of 1987, many trees were ripe for damage. With most accumulations ranging from a half of an inch to an inch, the ice itself was not enough to cause widespread losses of power lines or poles. Instead, the ice began to cause significant damage to the area's trees, and as the debris fell on power lines, the power lines began to fall as well.

The Biggies

The Christmas Ice Storm of 2000 might be the most powerful ice storm since statehood, meteorologically speaking. A very deep layer of moisture fueled long-lasting heavy precipitation over much of the Arklatex and neighboring regions. More than four inches of ice were deposited on much of southern and eastern Oklahoma and western Arkansas. Because the pre-storm environment was very cold, soil temperatures were near or below freezing and ice accumulated on the ground and roadways throughout the event. Travel was next to impossible in the hours after the event, limiting emergency response. In the region, 26 people lost their lives. More than $200 million in damages were incurred in Oklahoma alone, much of it related to timber losses and damages from falling limbs in the heavily-forested southeast. More than 90 percent of the residents of Oklahoma's southeastern-most counties were without power for days. The storm was a standout in two ways: the sheer size of the area impacted by icing (parts of four states, including large portions of Oklahoma and Arkansas), and in the magnitude of accumulated ice in affected areas.

The state's most powerful ice storms since 2000, by the numbers.

Storm	Widespread Ice Accumulation	Maximum Ice Accumulation	Power Outages	Fatalities
December 2000	3-4 inches	5-6 inches	170,000	26
January 2002	3-4 inches	5-6 inches	255,000	9
January 2007	2-3 inches	4-5 inches	120,000	32
December 2007	1-2 inches	2 inches	640,000	30

Just 13 months later, on January 28, 2002, a two-day ice storm occurred across much of central, western and northern Oklahoma. While the storm's footprint of two-inch-plus accumulations was smaller than the Christmas 2000 storm, local ice accumulations rivaled that of its predecessor. The most severe icing occurred in more densely populated counties than the previous storm also. Thus, the primary impact was catastrophic damage to electrical distribution lines. Forty-thousand poles and similar structures were lost by the rural electric cooperatives alone. The amount of electrical line downed by the storm would have stretched from Oklahoma City to New York – and back. Because the pre-storm environment was quite warm, soil temperatures were too high to support freezing of precipitation on the ground and roadways. This allowed a quick response by emergency personnel and by electric linemen from Oklahoma and many other states. Only a handful of weather-related traffic accidents occurred. Nine Oklahomans lost their lives in the storm and more than $100 million in damages was reported.

Stacking Them Up

It is hard to say whether the ice storm that struck Oklahoma on December 9-11, 2007, can legitimately accept the title of "Oklahoma's Worst Ice Storm". Based upon the sheer number of power outages, it easily qualifies as the worst. But for other factors, such as amount of ice or monetary damages, it just as easily falls back in the pack. The most prudent course would probably be to add this storm to the December 2000 and January 2007 events as a legitimate contender. After all, the winner is probably in the eye of the beholder.

The Forgotten Storm

Somehow overlooked, the ice storm that struck southeastern Oklahoma in January 2007 deserves its own day in the sun. Perhaps because it was confined to the southeastern corner of the state while other areas lay encased in several inches of sleet, this storm has gone largely unmentioned in discussions of previous ice storms. The storm left 120,000 electric utility customers without power and contributed to the deaths of 32 Oklahomans. Ice accumulated on power lines up to five inches thick in localized areas. Had this storm, even though it's "footprint" was much smaller than the other storms, struck the densely populated central Oklahoma region, the damage would have been catastrophic. Location, location, location...

CLASSROOM ACTIVITY ANSWERS [from page 25]

1. a. Approximately 50% of Tree A was damaged. There is only one tree in this picture—it has three segments to its trunk (the bottom is hidden by the hill). The best way to tell the amount of damage is to look at how much is on the ground.
   b. Approximately 25% (or less) of Tree B was damaged. A few limbs are snapped off, but most of the top is intact.
   c. Approximately 80% of Tree C was damaged. This tree has already been trimmed to remove most of the damage.
2. a. The damage category for Tree A is Moderate Damage.
   b. The damage category for Tree B is Light Damage.
   c. The damage category for Tree C is Severe Damage.
3. Answers may vary. Sample answer: I would recommend that the client keep Trees A and B because they are not badly damaged. Tree B could experience infection because many lower branches are damaged, but it will likely survive. Tree C should be removed because it has a low chance of survival, since it will be susceptible to disease or infection.
4. Some larger branches are broken, so it is possible that up to 1/2 to 1-inch of ice fell on this area. The photographs were taken in central McClain county (just east of Newcastle), so Figure 4 supports the estimated ice total.

What's NEXt AFTER NEXRAD

By Terry Schuur - Research Meteorologist,
National Severe Storms Laboratory

In the early morning hours of December 7, 1941 – a day that President Franklin Delano Roosevelt would later declare to be a "date which will live in infamy" – Privates George Eliot and Joseph Lockard manned a lonely radar outpost on the Hawaiian Island of Oahu. Radar, as it had been referred to for the first time only a year earlier, had undergone rapid development in the years leading up to World War II. At 7:02 am, as the Islands were awakening to a beautiful Sunday morning, Privates Eliot and Lockard noted a blip on the radar screen, providing the first evidence of an approaching wave of Japanese fighters, the impending attack on Pearl Harbor, and the United States entry into World War II.

Borne of military applications, radar technology has advanced much over the years. Soon after World War II, research into the use of radars to detect clouds and precipitation began in earnest. Since then, the field of meteorology has never been the same. Weather radars are now an accepted part of our everyday lives. Early demands of weather radars were quite simple, that is, to provide the location and path of approaching storm systems. The 1980's saw the introduction of Doppler capabilities, which finally allowed meteorologists to track wind speeds within storms. Now, forecasters are preparing for the introduction of the latest technology – an innovation that promises to improve their ability to discriminate between different precipitation types within storms and, through better radar-based rainfall estimates, provide more accurate flash flood warnings: Polarimetric radar.

Weather Radar 101

The word radar is actually an acronym for radio detection and ranging. As implied by the name, energy transmitted by weather radars is a radio wave. The radio frequency used by weather radars, however, unlike those transmitted by radio stations, is specifically chosen for its ability to "interact" with clouds and precipitation. Weather radars transmit short pulses of these radio waves. After each pulse, there is a short time period during which the radar listens for a "reflected signal". This reflected signal, in turn, is the result of a portion of the transmitted energy interacting with each individual raindrop, crystal, snowflake, ice pellet, and hail stone to be illuminated by the radar's beam. Unfortunately, understanding the origin of the reflected energy – or, in other words, the type of precipitation being observed by the radar – is often complicated by the fact that the reflected power is a complex function of the size, shape, and ice density of each cloud and precipitation particle. In short, from the perspective of the radar, clouds consist of millions of tiny "targets" that all interact with the radar's energy in their own unique way.

When you consider the wide variety of precipitation types, shapes, and sizes, it is easy to see how the interpretation of reflected radar signal can become quite complicated. In addition to making it hard to determine precipitation type, the strong dependence of the reflected power on raindrop size means that, at times, it is also difficult to obtain an accurate estimate of rain accumulation from the radar. Using a new pulse transmission scheme, polarimetric radars are designed to eliminate many of these problems.

Oklahoma – a Center for Radar Research

When driving to Norman from Oklahoma City, one is immediately drawn to the soccer ball shaped domes that dot the horizon of north Norman. Since the early 1970's, when an old missile defense antenna was moved to Norman and used to construct one of the first Doppler weather radars, Oklahoma has been at the center of the weather radar revolution. The next generation of radars, aptly named NEXRAD, that evolved out of research conducted on that early Doppler radar now dominate the north Norman skyline. Over 160 NEXRAD radars have now been deployed worldwide. The first still resides in Norman and, since the mid 1990s, research conducted at the National Severe Storms Laboratory has lead to its upgrade to include polarimetric capabilities.

Polarimetric radars take advantage of the fact that most forms of man-made "electromagnetic" energy, whether microwaves or radio waves, can be transmitted with a specific polarization, which refers to its orientation – usually either horizontal or vertical – as it travels through space. The word polarization itself is probably not new to most people. For example, we have polarized sunglasses and polarized filters for our cameras, both of which are commonly used to eliminate polarized light, commonly known as glare, as it comes off of shiny surfaces. For weather radar applications, being able to transmit and receive radio frequency energy at two polarizations provides an opportunity to essentially see each individual raindrop, crystal, snowflake, ice pellet, and hail stone in two dimensions. This helps eliminate some of the radar measurement uncertainties that come from the dependence of the reflected power on the size, shape, and ice density of each cloud and precipitation particle.

Benefits of Polarimetric Radar

Polarimetric weather radars provide several benefits over existing weather radars. Broadly, these benefits can be grouped into three categories, 1) improved rainfall estimation, 2) the ability to better determine precipitation type, and 3) better data quality.

Rainfall estimation

All rain is not alike. If you could take a snapshot of every raindrop falling at a particular location, measure its size, and count up how many drops of each size fell at that location – something that radar meteorologists actually do, by the way, with an instrument called a disdrometer – you would find that the "distribution" of rain drop sizes varies quite a bit from one storm to the next. These variations even occur at different locations within the same storm. Because the power reflected back to the radar from each raindrop is not "linearly related" to the size of that drop, this natural variability in drop sizes can make estimating rain accumulation with a non-polarimetric radar very challenging. For example, let's look examine the case of a very small raindrop of approximately 1 millimeter in diameter, or about 1/25th of an inch. If that raindrop grows in size to 2 millimeters, the power reflected to the radar increases by a factor of 64; if grows to 3 millimeters, the power reflected to the radar increases by a factor of 729. And so on. As one can see, strictly using reflected power to estimate rainfall can result in errors.

Polarimetric radars, on the other hand, provide information on drop size by taking advantage of the radars ability to measure drop shape. That is, as a raindrop grows in size, it tends to take on a more flattened appearance – eventually acquiring a hamburger bun shape at very large raindrop sizes. Using both horizontal and vertical polarizations, polarimetric radars can measure power reflected back to the radar in two dimensions, thereby providing information on average raindrop size. This leads to better rainfall estimation and flood warnings.

Precipitation type

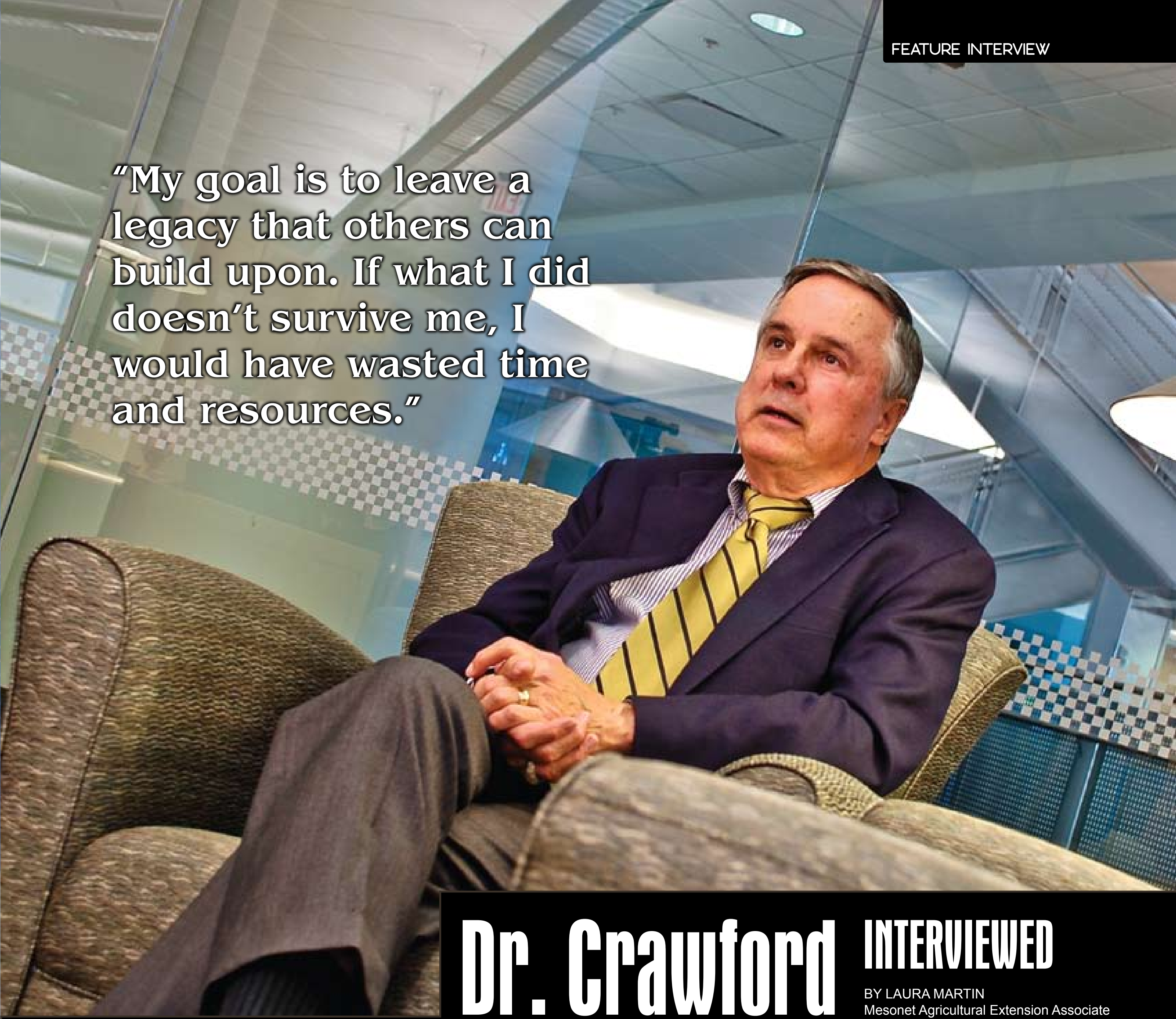
Looking at a radar image and identifying the type of precipitation is not always as easy as it might first seem. In the summer, we may look at a radar image and ask where the hail is located within a line of storms. In the winter, we may ask whether the precipitation consists of rain, sleet, ice pellets, or snow. Some of the same challenges described above for estimating rainfall apply to determining the type of frozen precipitation. Identifying frozen precipitation type, however, is complicated by the fact that it comes in a much wider variety of sizes, shapes, and ice densities. Snow, for example, can take the shape of small needle-like crystals, six-armed star-shaped crystals, referred to as stellars and dendrites, or large globs of smaller crystals all stuck together, referred to as aggregates. As far as ice densities go, some types of frozen precipitation have more air trapped inside of them than others and are fluffier. Snow might be described as fluffy. Hail, probably not. All of these factors, as well as a variety of others, impact the amount of power reflected to the radar. With the additional information provided by polarimetric radars, meteorologists are better equipped to assess precipitation type.

Data quality

Unfortunately, weather radars see more than precipitation. It is not uncommon for power to be returned to the radar after being reflected from trees, buildings, and power lines that are in close proximity to the radar and, at greater distances, birds, bats, and insects. In fact, the growing donut-shaped pattern that is frequently seen on the radar loop on the 10 pm newscast on a hot summer evening is likely due to power being returned to the radar from insects. At times, these non-meteorological images can obscure clouds and storms. Polarimetric radars provide additional information that allows meteorologists to easily identify areas of precipitation that might be embedded within a background of reflected power from trees and tall buildings, as well as that from flying critters of all shapes and sizes.

The Future

Weather radar has come a long way since the 1940's. In the early days, clouds and precipitation were merely "noise" on the radar screen, something that might obscure what the radar was really meant to observe. These days, words such as Doppler – from the 19th century scientists Johann Christian Doppler, who discovered the Doppler effect – are now part of everyday vocabulary. Soon, polarimetric radar will be joining that nomenclature.



Dr. Crawford INTERVIEWED

BY LAURA MARTIN
Mesonet Agricultural Extension Associate

As a child, he had no dreams of becoming an accomplished meteorologist. Rather, Dr. Ken Crawford simply wanted to succeed.

"My dad was sick my whole life and my mother was thrust upon the work world. In Texas, in the 1950s, women could not own property and were not paid much. She made a life for myself and my 2 brothers," said Crawford. "I figured if she could make it, I could make it. She was a good example."

After high school graduation, Crawford was accepted as a student trainee with the National Weather Service. This position would ultimately shape his entire career.

"For me, it was a way to pay for school because my mother couldn't afford to. She did what she could, but I needed to be independent," he said.

Crawford stayed with the National Weather Service for 28 years, working his way through college and then some. In 1961, he enrolled in the meteorology program at the University of Texas at Austin. He graduated with a bachelor of science in 1966 and immediately enrolled in the meteorology master's program at Florida State University.

After graduating with his master's degree in 1967, Crawford enrolled in the Ph.D. program at the University of Oklahoma, but dropped out after two years. He said he quit because he wasn't able to answer the question "Why do I want a Ph.D.?"

"When you get discouraged and there seems to be no end in sight, you will not finish if you can't answer that question. I had to answer it before I developed the motivation to complete the degree," said Crawford.

He waited until 1975 before attempting the Ph.D. program again. Crawford received his doctorate in 1977 and ultimately joined the faculty at the University of Oklahoma.

As Crawford moved forward in his professional career, one childhood memory shaped his desire to help people. When he was 10 years old, the Waco tornado of 1953 ripped through his home state.

"I was about an hour's drive north of Waco in my hometown. The tornado killed 114 or 115 people. Downtown Waco took a direct hit. It was sort of like May 3 in Oklahoma City," said Crawford. "The reaction in my neighborhood was that we know these people that were affected. I just remember them all talking about it."

Crawford said he recalled this tragedy on the night of the Tulsa floods in 1984.

"The fatalities were not quite as high, the damage was higher and the human impact was roughly the same. People did not respond well," said Crawford.

In the wake of these disasters, Crawford and several colleagues were hoping to develop an effective weather warning system for Oklahoma. It was not enough for meteorologists to produce good forecasts and warnings if those warnings never made it to the people who needed it, said Crawford.

Their brainstorming helped spawn the Oklahoma Mesonet, a statewide weather monitoring network that offers its information freely to the public. The organization also trains emergency managers, teachers and fire officials how to interpret the weather data and make informed decisions.

The Oklahoma Mesonet, a joint program between OU and OSU, took years of planning.

"When the weather network was in its early stages, we thought 'Are we dreaming or are we being realistic?'" Crawford said. "And then when we got money to launch the network, it was, 'Do we know what we're doing?' Well, we've been funded, so we've got to do it and we did it well. It was because there was a good team in place."

In addition to the Oklahoma Mesonet, Crawford is most proud of his involvement with meteorology students. He has been teaching since 1989 and has been the committee chair for almost 30 graduate students. He considers these students his biggest legacy and enjoys seeing student's personal growth.

"I influenced their life. They will influence tens of thousands of lives," said Crawford. "My goal is to leave a legacy that others can build upon. If what I did doesn't survive me, I would have wasted time and resources."

As the director of the Oklahoma Climatological Survey, a Regents' Professor of meteorology at the University of Oklahoma and co-leader of the Oklahoma Mesonet, Crawford has certainly left a legacy.

"It's been a fun ride. There have been a lot of interesting talented people along the way…a lot of going against the grain. 'Oh, you can't do that, it's too big.' I'd do it even bigger if I could do it again," Crawford said.

"When the weather network was in its early stages, we thought 'Are we dreaming or are we being realistic?'"

Statement on Climate Change

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."

– the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC).

That statement reflects the essence of a vast amount of observational data and climate research: the earth's climate has warmed on average during the last 100 years and will continue to warm through the 21st century. Further, ample evidence from observational data and climate modeling studies indicates that this global-scale warming is not attributable to natural variability. The Oklahoma Climatological Survey (OCS) has been mandated by the Oklahoma legislature to provide climate information and expertise which could be of value to the public, as well as to state policy- and decision-makers. In accordance with that directive, OCS has conducted a review of the current assessments of climate change research and concludes the following to be true:

- The earth's climate has warmed during the last 100 years;
- The earth's climate will continue to warm for the foreseeable future;
- Much of the global average temperature increases over the last 50 years can be attributed to human activities, particularly increasing greenhouse gases in the atmosphere;
- Oklahoma will be impacted.

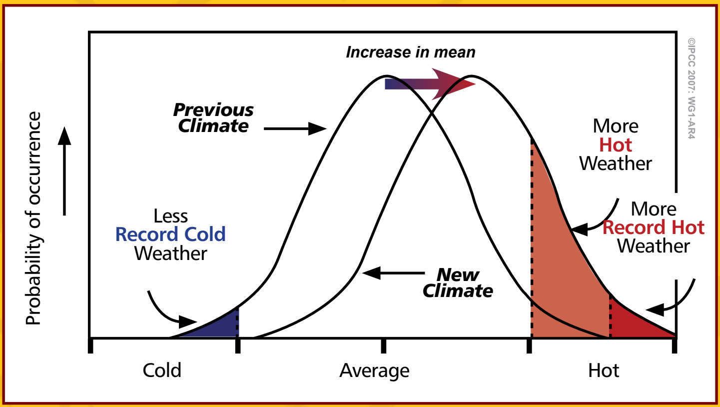
Across the globe, a warming climate will be beneficial to some and detrimental to others. Anticipating how this climatic shift will impact Oklahoma is of vital importance to state decision-makers. One of the greatest impacts will be the exposure of Oklahoma's growing population and economy to water stress. Oklahoma's future requires access to fresh water. Thus, due diligence in protecting our water resources and adapting to future climate variability is paramount if we are to maintain and improve the quality of life and the economy of Oklahoma.

The Science of Global Climate Change

The earth's climate is always changing. Evidence such as tree ring and ice core studies indicates large and sometimes abrupt climate changes have occurred in the earth's distant past, lasting centuries to millennia. These climate swings are attributed to natural variations, such as changes in the output of the sun or shifts in the earth's orbit. Oklahoma has exhibited distinct climate periods attributable to natural variability in the last 100 years, from the decadal-scale droughts of the 1910s, 1930s and 1950s to an extended period of abundant precipitation during the 1980s and 1990s. Mounting evidence continues to indicate, however, that human activities have begun to impact the earth's climate through the release of greenhouse gases. Ice core studies show carbon dioxide and methane are at their greatest levels within the last 650,000 years. Due to the extended periods required for these gases to be removed from the atmosphere, further emissions during the 21st century will cause additional warming for more than a millennium. In fact, even if greenhouse gas concentrations were held steady since the year 2000, the earth is committed to decades of warming from heat already absorbed by the oceans.

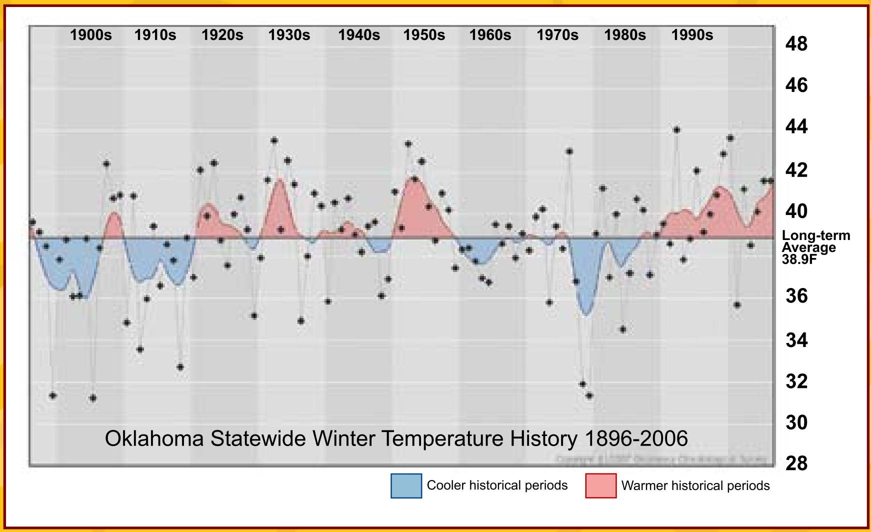
Global Climate Change Impacts for Oklahoma

The continued warming of the climate averaged across the globe will create a cascade of climatic shifts which could impact Oklahoma's climate. These shifts will not mean an end of year-to-year natural variability – hot years and cold years will continue, as will wet years and dry years. The projected changes will be seen at time scales averaged over a decade or more. Little is known of the effects climate change will have on severe weather. The ingredients required for severe weather involve complex combinations that do not exhibit clear changes in a warming climate. Further, global climate models are unable to accurately simulate small scale weather events like thunderstorms or tornadoes.



The effect on the frequency of extreme temperatures in a warming climate.

Oklahoma statewide average winter temperatures since 1896. The warming trend evident since the late 1980s has occurred during an extended drought-free period.



OCS expects the following climate change scenarios and the associated impacts to be realistic should the projected range of warming materialize for the remainder of the 21st century:

- The frequency of hot extremes and heat waves will increase.
- Cold extremes and cold air outbreaks will decrease.
- Atmospheric water content will increase.
- The jet stream and its associated storms will move poleward.

Implications for Oklahoma:

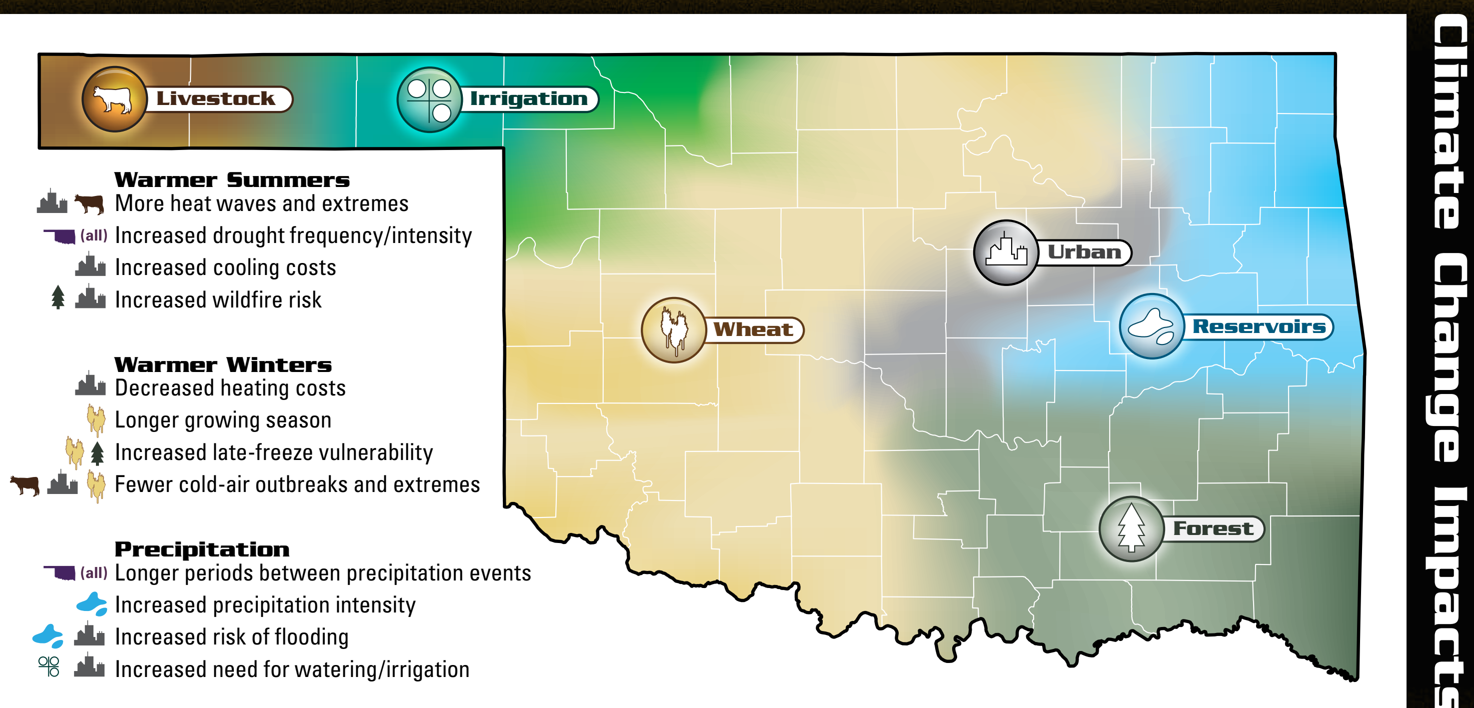
- The warm season becomes longer and arrives earlier.
- The cool season warms and shortens which leads to a longer frost-free period and growing season.
- Earlier maturation of winter wheat and orchard crops leave them more vulnerable to late freeze events.
- Increased year-round evaporation from the ground and transpiration from green vegetation.
- Drought frequency and severity increases, especially during summer.
- Drier and warmer conditions will increase the risk of wildfires.
- Rain-free periods will lengthen, but individual rainfall events will become more intense.
- More runoff and flash flooding will occur.

Recommendations

OCS recommends that Oklahoma aggressively pursue four initiatives to address the risks of both climate variability and climate change. First, the state should undertake a comprehensive assessment of Oklahoma's social and economic vulnerability to climate variability as well as climate change. Learning to adapt to nature's extremes now will yield benefits in reduced disaster losses, regardless of the future trajectory of climate change. Climate change may also bring economic opportunities that would be identified in such an assessment. Second, OCS recommends immediate funding of the Oklahoma Water Resources Board's Comprehensive Water Plan study to identify existing as well as projected needs for water. Third, OCS encourages efficiency programs to reduce our growing demand for energy. Fourth, OCS recommends investment in renewable energy technology and production. Oklahoma has already demonstrated the successes of wind energy; similar efforts should be undertaken to advance development of solar and sustainable bio-energy as well as fostering further research and development of wind energy.

Even if climate does not evolve as expected, these steps will yield long-term benefits to Oklahoma's society and economy through reduced losses to existing climate and weather threats and cost-savings through reduced energy use. If climate does evolve as expected, Oklahoma will be better positioned to adapt to those changes without rapid social upheaval. Furthermore, building resilience to climate and weather events will help position Oklahoma at a relative advantage to neighboring states, especially in attracting businesses that are dependent upon a continuous water supply.

This statement is the first in a series issued by OCS which delineates the impacts, both beneficial and detrimental, of a warming climate system on the economy of Oklahoma and the quality of life for Oklahomans. Future statements will illuminate possible impacts to specific industries, such as water management and agriculture.



FALL 2007 SUMMARY

By: Gary McManus

Fall saw the change from our wonderfully wet – for those that weren't flooded – to painfully dry weather during 2007. Where once the water poured from the Heavens in prodigious amounts, it now fell sporadically and ushered in a return to droughty conditions across some parts of the state. That lack of rain was accompanied by extra warmth and the statewide average precipitation and temperature readings finished as the 31st driest and 19th warmest on record, respectively. The Panhandle, which missed out on the abundant rainfall of the previous months, still languished far behind the rest of the state with its 5th driest fall on record. Severe weather was limited with only one tornado reported in the state from September-November.

Precipitation

Very few parts of the state saw close to normal rainfall during the fall. Most of southern Oklahoma was very hard hit, from 4-8 inches below normal. The average rainfall for the south central area was more than seven inches below normal. The state as a whole finished at nearly four inches below normal. Cookson recorded over 14 inches of precipitation over the three-month period while Hooker had trouble mustering even a half inch of rainfall.

Temperature

The statewide average temperature was more than two degrees above normal. All regions of the state were similarly above normal. The highest temperature of the fall, 101 degrees, occurred September 6 at Hooker. The lowest temperature was nine degrees, measured at Beaver on November 25.

September Daily Weather

September 1-3: The month's first three days were dominated by surface high pressure, which meant sunny skies and warm temperatures. Highs during these three days were mostly in the upper 80s and low 90s. The dry air allowed temperatures to fall into the 50s and 60s during the nighttime hours. A few showers popped up in southern Oklahoma on the third, but precipitation amounts remained light.

September 4-10: An upper-level low moving across northeastern Texas fired off showers and thunderstorms across much of the state from the fourth through the sixth. Fueled by abundant tropical moisture, the storms were mainly rain producers on the fourth and fifth. The storms that struck on the sixth were a bit more powerful. Small hail and wind gusts greater than 60 mph were common in southwestern Oklahoma that evening. A cold front moved in from the north on the seventh and stalled across central Oklahoma. That front lingered and the showers and storms remained for the next several days. Flooding was a problem with these storms, mostly in the north and east. A storm on the tenth struck the Oklahoma City metropolitan area and dropped more than six inches of rainfall at Will Rogers Airport in about six hours. The front passed through the remainder of the state late on the tenth.

September 11-16: MCooler weather moved in after the front's passage. The 11th was 10-20 degrees cooler than average with highs in the 70s and 80s to go along with winds from the north at 20 mph. The month's coldest temperature of 39 degrees was recorded that morning by the Beaver Mesonet site. The next few days were seasonable with lows in the 50s and 60s and highs in the 80s. Very little rain occurred through this period, although a few showers on the 15th left about a half of an inch of rainfall in the rain gauges in northeastern Oklahoma.

September 17-19: An approaching storm system from the west triggered storms in the Panhandle on the 17th. Those storms moved into western Oklahoma that afternoon but rainfall amounts remained on the light side. Highs were in the 80s and 90s and winds gusted to over 25 mph. More of the same on the 18th as the storm system remained out west. The system finally moved across the state on the 19th, triggering strong storms in the northwest. More than an inch fell in some locales across the area. Some small hail accompanied these storms, which never reached severe limits.

September 20-22: Another warm and dry period, these three days were marked by clear skies and highs in the 80s and 90s. A cold front approached from the north on the 22nd.

September 23-26: A return of tropical moisture meant a return of showers and thunderstorms. Most of the rain during this period occurred in east central Oklahoma. Nearly five inches fell at the Eufaula Mesonet site over the four days. Not much severe weather to speak of, other than hail to the size of golf balls near Shattuck on the 26th which destroyed windshields and even injured one person. High temperatures were in the 80s and 90s on both the 23rd and 24th, but dropped to more seasonable levels in the 70s and 80s following a cold front passage on the 25th. Low temperatures were in the 40s and 50s on the 25th and 26th.

September 27-30: The month's final four days were mostly dry and warm, although a few showers did pop up from time to time – mainly on the 28th and 30th. Outflow boundaries from storms in Kansas triggered storms across the west on the 28th. Some of the storms reached severe levels each day, with winds and small hail being the biggest threat. A cold front entered the state on the 30th, ending the month with a few showers and winds from the north at 20-25 mph, gusting as high as 40 mph. High temperatures that day were in the 80s and 90s, 10 degrees warmer than normal for that day.

October Daily Highlights

October 1-3: The month began with a cold front in the early morning hours sweeping through northwestern Oklahoma before stalling in central portions of the state. The front generated showers and thunderstorms in the southeast later that day. High temperatures ahead of the front were in the 90s with 80s behind the front. The boundary retreated overnight on the second as a warm front. Low temperatures were 10-15 degrees above normal in the 60s and 70s. The front swept to the south once again that afternoon and once again showers and thunderstorms formed ahead of it. Some of the storms exceeded severe limits with winds measured at 75 mph by the Medicine Park Mesonet site. The font managed to push across the rest of the state overnight on the third bringing more rain and cooler weather. Low temperatures that morning dropped to 38 degrees at Buffalo. High temperatures that afternoon rebounded into the 80s. Most of the heavy rainfall during this period was confined to east central Oklahoma where more than three inches fell in localized areas.

October 4-5: The next two days were dominated by surface high pressure. Highs were mainly in the 80s and 90s with winds gusting to 35-40 mph from the south. Low temperature held in the 60s and 70s with the aid of the strong winds.

October 6-8: Moisture streamed north into Oklahoma on strong southerly winds as the remnants of a weak tropical disturbance moved northward into Oklahoma. Light rain and a few storms popped up across the state that morning in central Oklahoma with amounts generally less than an inch. More storms on a muggy and moist day on the seventh. A cold front moved into western Oklahoma on the eighth and generated another round of showers and storms. Well over two inches of rain fell in eastern Oklahoma as the front progressed through the southeast. Rainfall totals of more than two inches during this three-day period were recorded in the far northeastern and east central sections of the state.

October 9-13: This five day period was devoid of precipitation as drier and cooler air moved in following the cold front's passage. Low temperatures ranging from the 40s in the northwest to the 60s in southern sections gave way to highs in the 70s and 80s during the afternoon. Winds kicked up in response to an approaching storm system on the 13th.

October 14-17: A powerful upper-level low pressure system to the west of Oklahoma helped push a cold front into the state, generating showers and storms. The 14th was a violent day weather-wise as storms went severe in the moist environment. A squall line of strong to severe storms marched across the state that day and into the next morning. Numerous reports of high winds and hail were the result, to go along with heavy rainfall. A couple of days of respite as the upper-level low spun to the west gave way to more severe weather on the 17th as the storm system finally moved over the state. A classic springtime dryline set up in western Oklahoma to act as a trigger for storms. Many reports of hail and strong winds were the result. Winds gusted to 90 mph at the Eufaula Meosnet site in McIntosh County, and wind speeds of 86 mph and 85 mph were recorded at Kingfisher and Tulsa, respectively. The winds destroyed a large tent at the Oktoberfest celebration in Tulsa, injuring 50. The winds also destroyed 15-20 mobile homes near Oologah in Rogers County, injuring five. The rainfall during this period was generally 3-5 inches across central and north central Oklahoma, as well as more than two inches in the southeast.

October 18-20: The weather was much more pleasant on the 18th and 19th as the upper-level storm moved to the northeast. Sunny skies with highs in the 70s eventually came to an end as another upper-level low approached from the west on the 20th. Winds increased to 30-35 mph that day with increasing cloudiness.

October 21-22: A strong cold front moved through the northwest on the 21st which cooled down the unseasonably warm weather already being experienced that day. Highs soared into the 80s and 90s ahead of the front and dropped into the 50s and 60s behind the front. Storms fired later that night along the front. The 22nd saw the storm system move over the state and supply Oklahoma with widespread precipitation and unseasonably cool air. Highs were 10-20 degrees below normal across the state, barely reaching the 40s and 50s.

October 23-31: The final nine days of the month were filled with pleasant fall weather. Sunny skies and highs in the 60s and 70s were the norm to go along with low temperatures in the 40s. A few ups and downs during this period culminated on Halloween with a cold front cooling things down in time for trick-or-treating later that night.

November Daily Highlights

November 1-4: The month's first few days were dry with cool mornings and pleasant afternoons. By the fourth, high temperatures were in the 80s, 15 degrees above normal.

November 5-11: A strong cold front entered northwest Oklahoma on the fifth. The front divided warm temperatures in the 80s in the south from the 60s in the north. Winds behind the front were from the north at 25-30 mph, with some gusts as high as 45 mph. The cold front cleared the state that night and brought the first freeze to a lot of Oklahoma that morning. High pressure at the surface built in after the front's passage to produce clear skies and seasonable high temperatures for the next couple of days. Low temperatures were downright cold, however, dropping into the 20s and 30s over much of the state. Unseasonably weather quickly returned by the eighth, and temperatures were once again into the 70s and 80s. A surge of low-level moisture on the 11th kept low temperatures 20-25 degrees above normal in the 50s and 60s. Winds gusted from the south in western Oklahoma to 40 mph.

November 12-14: Rains of consequence finally fell on the 12th after a cold front entered the state from the northwest. The rain was not heavy, with just over a half of an inch falling in localized areas of the southeast. The front did little to cool temperatures off as highs were once again in the 70s and 80s on the 13th. An even stronger surge of cold air arrived early on the 14th. No rain fell with this front, but winds gusted to over 50 mph.

November 15-20: The 15th was certainly cool compared to the rest of this five-day period, with lows in the 20s and 30s and highs mainly in the 50s. The weather warmed with highs once again into the 70s and 80s through the 20th. Lows were mild as well in the 40s and 50s. The state's highest temperature for the month of 86 degrees at Buffalo was set on the 19th. Oklahoma City set a new record high temperature for the 20th with a reading of 82 degrees.

November 21-25: The bottom dropped out of the warm weather parade on the 21st just in time for the Thanksgiving holiday. A significant cold front dropped temperatures well below normal. High temperatures struggled to reach the 40s. Thanksgiving was mostly cloudy and cold, and the state's first significant snowfall of the season fell the next day on the 23rd. One-to-three inches fell in far northwestern Oklahoma. Isolated amounts of four inches were reported near Erick and Stillwater. Scattered snow and rain showers lingered for a couple more days. The month's lowest temperature occurred at Beaver on the 25th with a reading of nine degrees.

November 26-30: November ended with a string of uneventful days. Temperatures were more seasonable up until the final day when another strong cold front entered the state. Temperatures remained near the freezing mark in the northwest with a chilly rain falling in central Oklahoma.

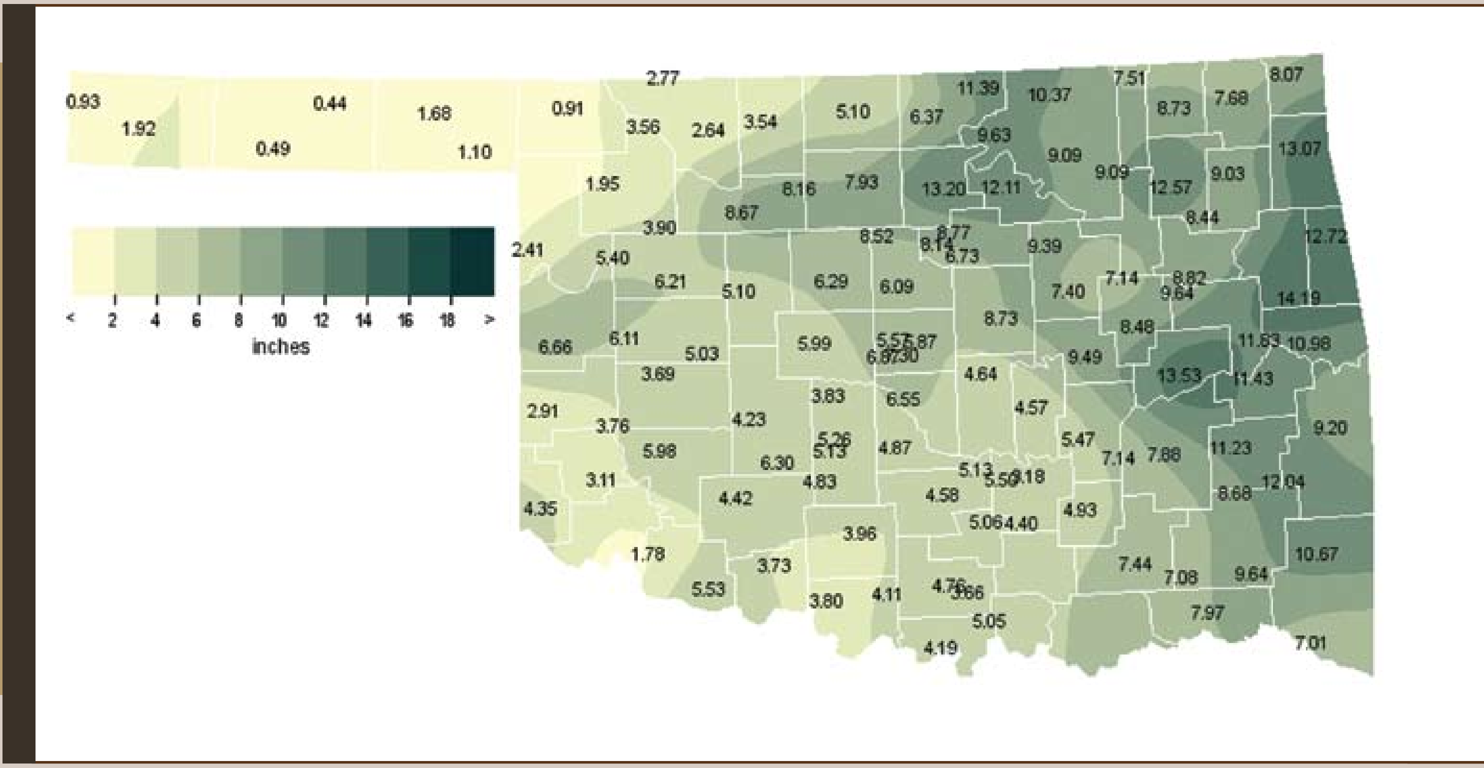
Fall 2007 Statewide Extremes

Description	Extreme	Station	Date
High Temperature	101°F	Hooker	Sept. 6th
Low Temperature	9°F	Beaver	Nov. 25th
High Precipitation	14.19 in.	Cookson	
Low Precipitation	0.44 in.	Hooker	

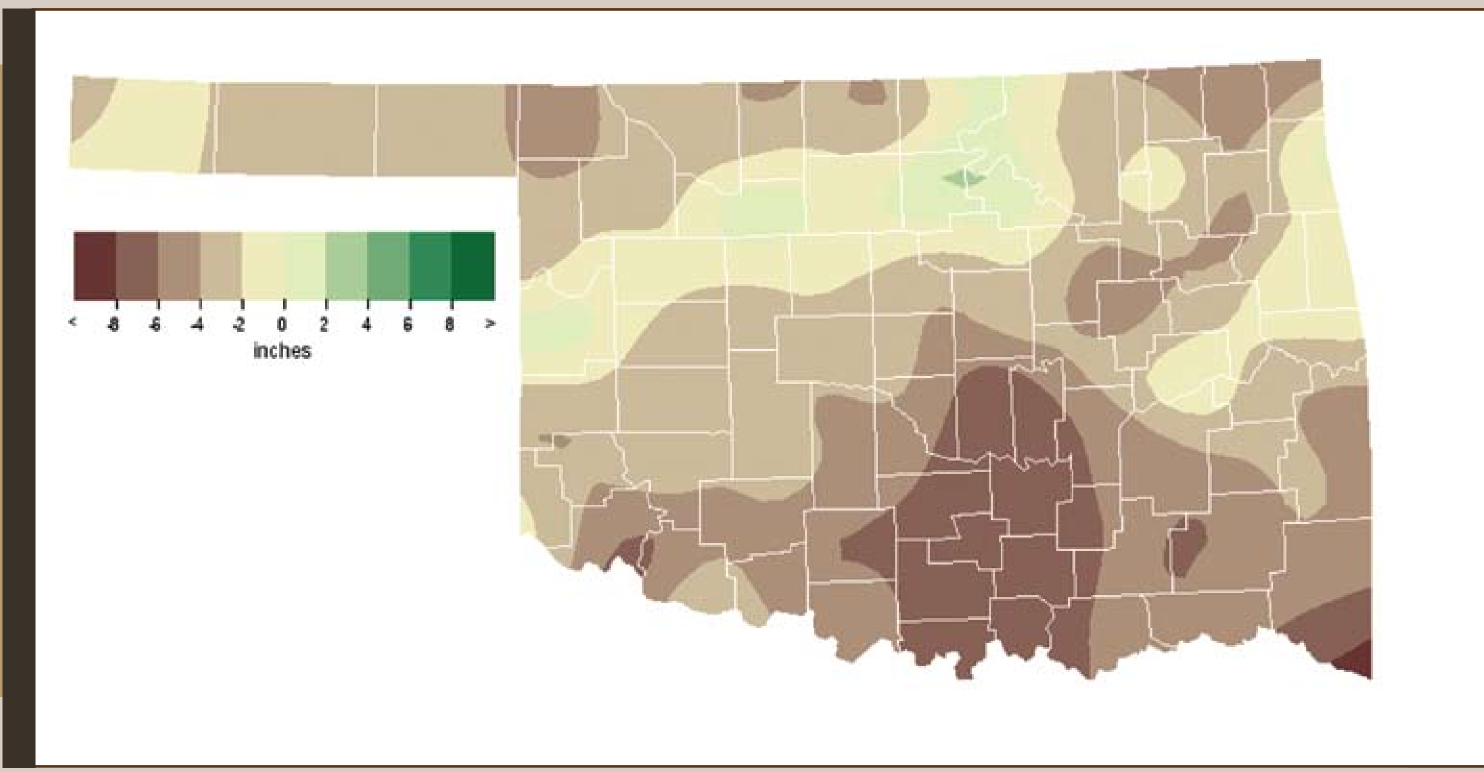
Fall 2007 Statewide Statistics

	Average	Depart	Rank (1895-2007)
Temperature	62.8°F	2.2°F	19th Warmest
	Total	**Depart**	**Rank (1895-2007)**
Precipitation	6.28 in.	-3.73 in.	31st Driest

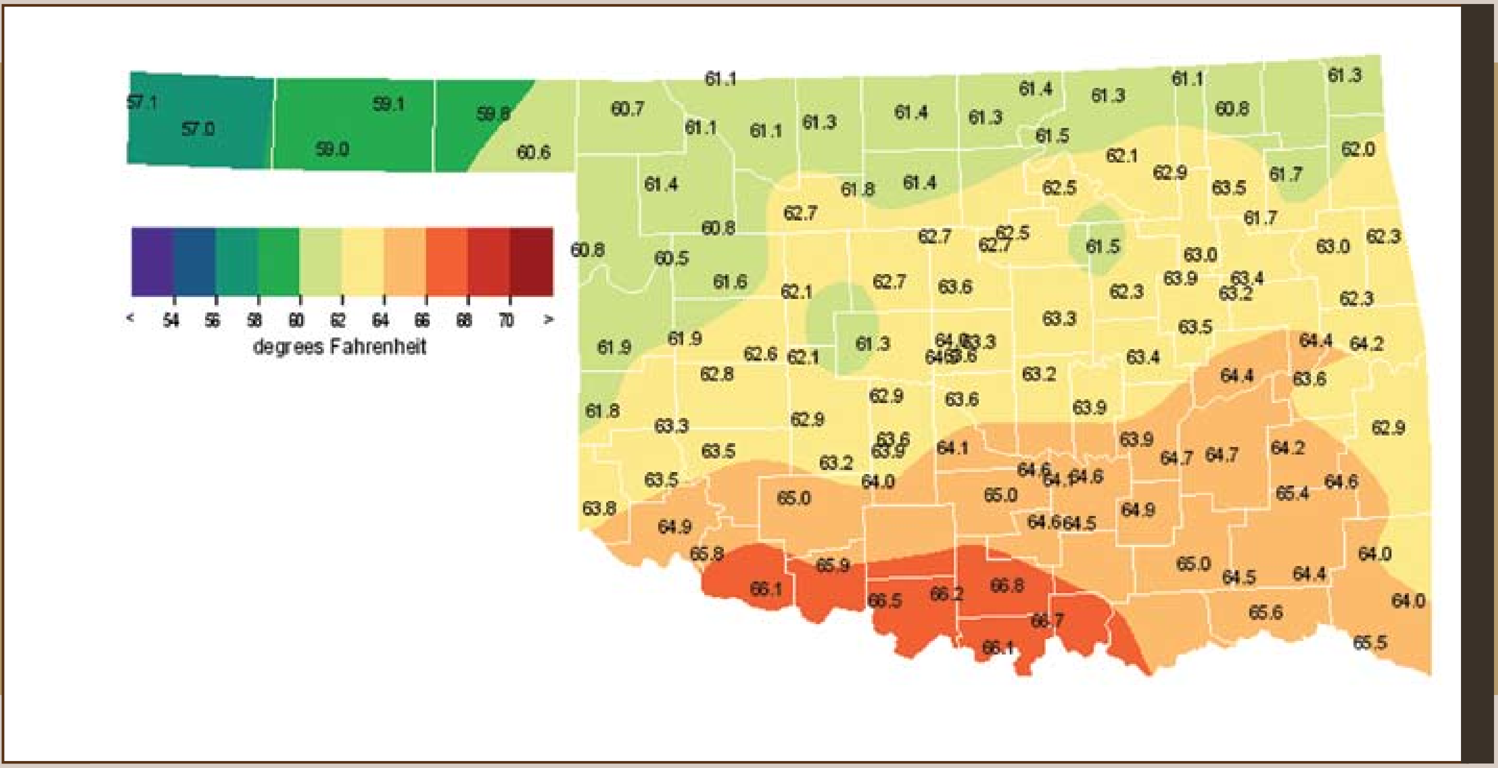
Observed Rainfall



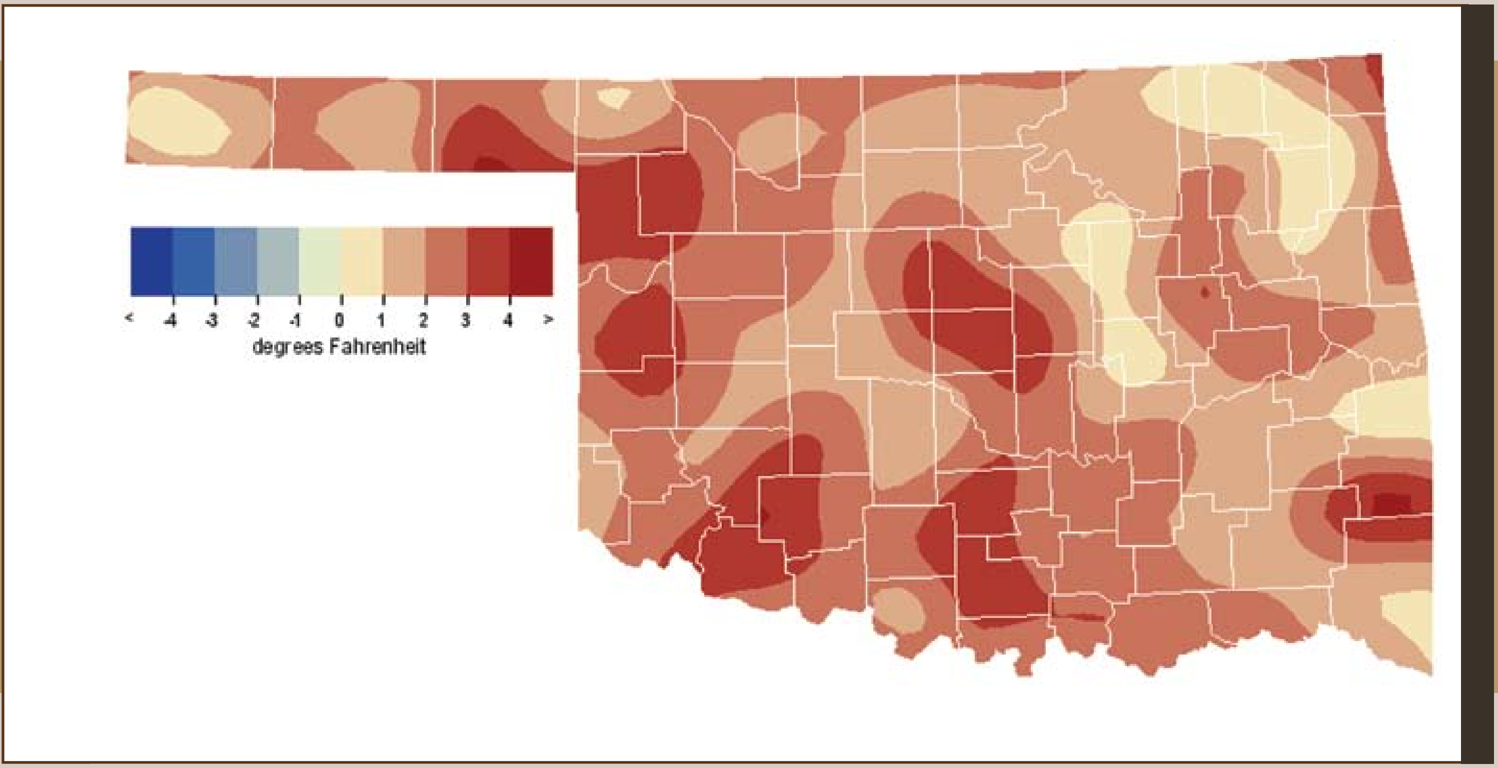
Rainfall Departure from Normal



Average Temperature



Temperature Departure from Normal



Fall 2007 Mesonet Precipitation Comparison

Climate Division	Precipitation (inches)	Departure from Normal (inches)	Rank since 1895	Wettest on Record (Year)	Driest on Record (Year)	2006
Panhandle	1.23	-3.19	5th Driest	10.34 (1941)	0.70 (1956)	2.67
North Central	6.09	-1.78	50th Driest	17.19 (1986)	0.97 (1910)	2.04
Northeast	9.59	-2.44	56th Driest	27.94 (1941)	2.60 (1948)	5.35
West Central	4.99	-2.33	39th Driest	20.71 (1986)	1.01 (1954)	4.53
Central	6.56	-4.02	37th Driest	20.42 (1923)	2.11 (1910)	6.43
East Central	10.04	-3.49	51st Driest	22.86 (1923)	2.40 (1948)	12.68
Southwest	4.38	-3.72	25th Driest	18.40 (1986)	0.95 (1910)	8.35
South Central	4.65	-7.04	16th Driest	24.03 (1923)	2.18 (1948)	10.17
Southeast	9.28	-5.32	32nd Driest	25.15 (1984)	3.11 (1963)	15.68
Statewide	6.28	-3.73	31st Driest	18.15 (1923)	2.44 (1910)	7.32

Fall 2007 Mesonet Temperature Comparison

Climate Division	Average Temp (F)	Departure from Normal (F)	Rank since 1895	Hottest on Record (Year)	Coldest on Record (Year)	2006
Panhandle	59.3	2.2	15th Warmest	62.7 (1963)	53.6 (1976)	55.9
North Central	61.4	1.8	28th Warmest	65.8 (1931)	56.0 (1976)	59.4
Northeast	62.1	1.9	23rd Warmest	66.6 (1931)	55.3 (1976)	59.7
West Central	62.1	2.3	17th Warmest	65.7 (1931)	55.9 (1976)	59.8
Central	63.2	2.0	19th Warmest	67.3 (1931)	56.9 (1976)	60.8
East Central	63.7	2.1	21st Warmest	67.6 (1931)	56.7 (1976)	60.9
Southwest	64.3	2.5	13th Warmest	66.9 (1931)	57.1 (1976)	61.2
South Central	65.4	2.5	14th Warmest	68.3 (1931)	57.8 (1976)	62.8
Southeast	64.5	2.4	22nd Warmest	68.3 (1931)	56.8 (1976)	61.5
Statewide	62.8	2.2	19th Warmest	66.3 (1931)	56.2 (1976)	60.2

Fall 2007 Mesonet Extremes

Climate Division	High Temp	Day	Station	Low Temp	Day	Station	High Monthly Rainfall	Station	High Daily Rainfall	Day	Station
Panhandle	101	Sep 6th	Hooker	9	Nov 25th	Beaver	2.41	Arnett	1.22	Sep 23rd	Boise City
North Central	97	Sep 6th	Alva	12	Nov 23rd	Seiling	13.20	Red Rock	3.90	Sep 8th	Lahoma
Northeast	94	Sep 3rd	Wynona	11	Nov 23rd	Nowata	13.07	Jay	3.32	Sep 8th	Nowata
West Central	96	Sep 6th	Camargo	11	Nov 23rd	Camargo	6.66	Cheyenne	4.64	Sep 8th	Cheyenne
Central	94	Sep 21st	Chickasha	13	Nov 23rd	El Reno	9.49	Okemah	2.87	Sep 25th	Okemah
East Central	94	Sep 3rd	Westville	15	Nov 23rd	Cookson	14.19	Cookson	3.78	Sep 25th	Eufaula
Southwest	96	Sep 6th	Hollis	15	Nov 23rd	Mangum	6.30	Apache	3.18	Sep 9th	Grandfield
South Central	96	Oct 1st	Waurika	17	Nov 23rd	Vanoss	7.44	Lane	1.46	Oct 22nd	Centrahoma
Southeast	96	Sep 2nd	Clayton	16	Nov 23rd	Wister	12.04	Talihina	3.66	Sep 9th	Talihina
Statewide	101	Sep 6th	Hooker	9	Nov 25th	Beaver	14.19	Cookson	4.64	Sep 8th	Cheyenne

AGRICULTURE WEATHER WATCH

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

The big news in Oklahoma agriculture in early 2008 isn't the weather! It's prices! As of February 6, 2008, prices in Kansas City were wheat at $10.40, soybeans at $12.34 and corn at $4.94. With prices so high, it's easy to think that the biggest problem Oklahoma farmers and ranchers have is where to stack all their money.

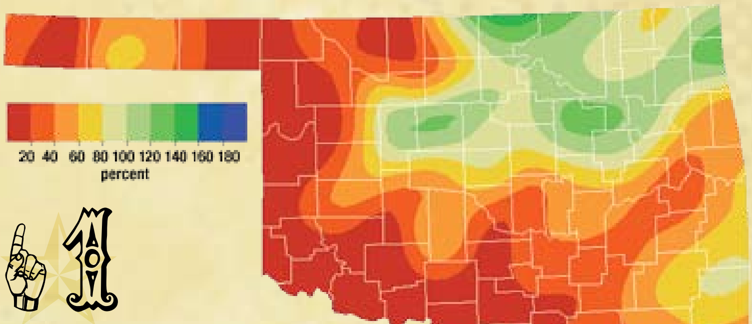


Figure 1 - Percentage of Normal Rainfall from Jan 8, 2008 to Feb 6, 2008

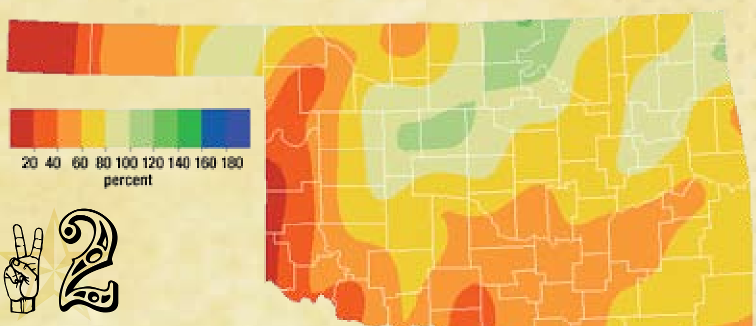


Figure 2 - Percentage of Normal Rainfall from Oct. 1, 2007 to Feb. 6, 2007

Table 1 - Rainfall by Oklahoma Climate Region from Oct. 1, 2007 to Feb. 6, 2008

Climate Division	Total Rainfall	Departure from Normal	Pct of Normal	Driest since	Wettest since	Rank since 1921 (86 periods)
Panhandle	1.98"	-1.92"	51%	2001-02 (1.79")	2005-06 (2.76")	24th driest
N. Central	5.83"	-1.39"	81%	2005-06 (4.11")	2004-05 (12.78")	42nd driest
Northeast	10.20"	-1.31"	89%	2005-06 (4.29")	2004-05 (16.74")	41st wettest
W. Central	3.70"	-2.85"	56%	2005-06 (3.52")	2004-05 (12.60")	22nd driest
Central	7.30"	-2.94"	71%	2005-06 (2.98")	2004-05 (15.62")	29th driest
E. Central	9.32"	-4.86"	66%	2005-06 (4.02")	2004-05 (21.78")	26th driest
Southwest	4.09"	-3.33"	55%	2005-06 (2.66")	2004-05 (14.13")	17th driest
S. Central	5.90"	-6.34"	48%	2005-06 (4.87")	2004-05 (20.92")	13th driest
Southeast	11.28"	-6.28"	64%	2005-06 (6.98")	2004-05 (23.01")	20th driest
Statewide	6.64"	-3.39"	66%	2005-06 (3.96")	2004-05 (16.11")	20th driest

But the weather is a reality check. We only have to look at 2006 and 2007 to remember that when weather turns bad, so do the yields. And poor yields mean farmers have little to sell. A stock may double or triple in price, but only those who own that stock have something to sell. The grain prices may be at record levels, but a farmer has to get the grain out the field before a penny is made.

So where are we at with the weather? The map in Figure 1 shows the percentage of normal rainfall for the 30 days from January 8-February 6, 2008. It provides a picture of dry conditions in the western third of Oklahoma and the Panhandle.

When looking at moisture available over the time when winter wheat is in the ground, it's helpful to turn to rainfall maps and tables for the "Water Year." The water year begins on October 1 and ends the following September 30. Figure 2 is a map of the current water year's percent of normal rainfall. It shows that the current pattern of low moisture in western Oklahoma and the Panhandle has been in place since the beginning of the wheat season. It also shows that the rainfall collected at the majority of Oklahoma Mesonet locations is below normal.

Table 1 shows the actual inches of rainfall below normal for the water year for each climate area in Oklahoma. Note that the rain quantities for every Oklahoma region are below normal. These numbers emphasize how quickly we moved from the floods in the summer of 2007 to a dry fall and winter in 2008.

Low rainfall in the west has delayed wheat emergence in many western Oklahoma fields. This has kept a large number of these fields from being grazed. The percentage of grazed wheat fields this year is only 25%, while a year ago in 2007 it was 43% of the total Oklahoma wheat acreage. The 5-year average of fields grazed is 42%. Lack of wheat pasture has only added more pressure to the high supplemental feed costs cattle producers are facing. Cattle prices, while high, are not staying ahead of increases in feed costs, so the lack of wheat for grazing cattle is really putting a squeeze on ranchers.

Slow wheat emergence will also lead to lower grain yields. So even with great prices and a good spring these fields will not yield as much as wheat that got off to a better start. It just goes to prove that even when the prices are high it still comes down to the weather. The weather, good or bad, is the biggest factor of how much money a farmer or rancher has to feed their own family.

To access the products mentioned 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.

BY: ALBERT SUTHERLAND, CPA, CCA
MESONET ASSISTANT EXTENSION SPECIALIST
OKLAHOMA STATE UNIVERSITY

FEBRUARY

- Test lawn and garden soils. Contact your local County OSU Extension office for soil testing bags, pricing, and sampling information.
- Prune fruit trees.
- Spray peach trees with lime-sulfur soon after pruning and before bud swell to control peach leaf curl.
- Fertilize pecan and fruit trees based on a soil test. Without a soil test, the general recommendation is to apply one tenth of a pound of actual nitrogen per year of tree age per tree, up to a maximum of 3 pounds of actual nitrogen per tree for pecan, 1 pound of actual nitrogen per tree for apple and plum, and 0.5 pound of actual nitrogen per tree for peach, pear, and cherry.
- Fertilize ornamental trees and shrubs. Use a quick release fertilizer at a rate of 1 pound of actual nitrogen per 1,000 square feet of root area. Tree and shrub roots extend out 2-3 times the distance from the trunk to the branch ends (tree dripline).
- Trim dead blades from ornamental grasses. Trim as close to the ground as possible for the grass being grown.
- Fertilize fescue after mid-February. Use a quick release fertilizer at a rate of 0.5 to 1 pound of actual nitrogen per 1,000 square feet.
- Plant seeds for tomatoes and peppers for transplanting in early April and for flowers, such as wax begonia, seed geraniums, impatiens, lobelia, salvia, verbena, and vinca, to be transplanted in late April.
- Shear evergreen shrubs and prune summer-flowering shrubs. Do NOT prune spring-flowering shrubs in February. Prune spring-flowering, just after they bloom.

MARCH

- March is an excellent month to plant trees and deciduous shrubs. This can help you tame the “planting bug.” You’ll have something to plant that can handle late March freezes.
- Fill in shady lawn areas by seeding with a blend of tall fescue and Kentucky bluegrass.
- Divide and replant summer-flowering perennials.
- Trim liriope, commonly referred to as monkey grass, in early March by hand clipping or with a mower on its highest cut setting.
- Control weeds in flower beds.
- Spread compost or aged manure.
- Plant frost tolerant vegetables, such as beet, broccoli, cabbage, carrot, Swiss chard, kohlrabi, lettuce, onion, green peas, potato, radish, spinach, and turnip.
- Make plans for perennial and annual flowerbeds.

APRIL

- After mid-April, there is little danger of frost for most of Oklahoma. This is an excellent time to make a trip to your favorite nursery for annual and perennial plants.
- April is the month for planting evergreen shrubs. Planting evergreens in April avoids March freezes that can damage young, tender foliage.
- Apply a labeled fungicide to pine trees to control the devastating disease, Diplodia Tip Blight. Make the first application when pine tip candles have expanded to half their full size. When the disease is severe, make three applications at 10-14 day intervals.
- In the garden, set out tomato, pepper, and eggplant transplants. Plant sweet corn during the last week of March or in early April. Lima bean, green bean, cucumber, and squash do better once warmer temperatures arrive, typically after April 10.
- In the later part of April, fertilize bermudagrass turf areas with one pound of actual nitrogen per 1,000 square feet of lawn area. For zoysiagrass, cut this rate in half.

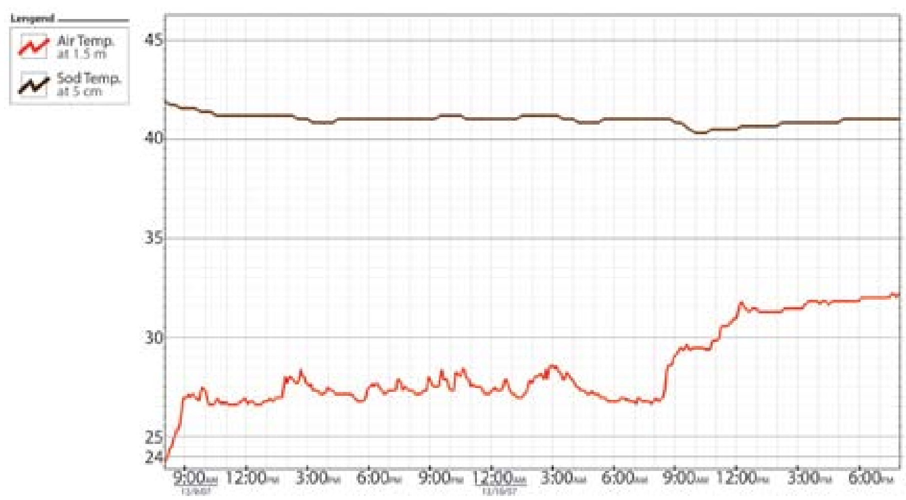
INTERPRETATION ARTICLE

Glazed Over

by Nicole Giuliano
Outreach Program Manager

For two days this past December, a large part of Oklahoma along I-44 was encased in ice while air temperatures were below freezing (Figure 1, red line). This ice coating caused widespread power outages and destroyed many trees, causing them to fall on homes, vehicles, and power lines. The ice storm occurred on December 9-10, 2007 and took power away from nearly 1 in 5 Oklahomans. Even more sobering, this storm also took the lives of twelve people. All of the fatalities were due to motor vehicle accidents caused by the hazardous weather. Despite the severity of this event for some areas, it could have been much worse. Ground temperatures during this event were in the lower 40s (Figure 1, brown line), which kept most roads from freezing and becoming "ice-skating rinks."

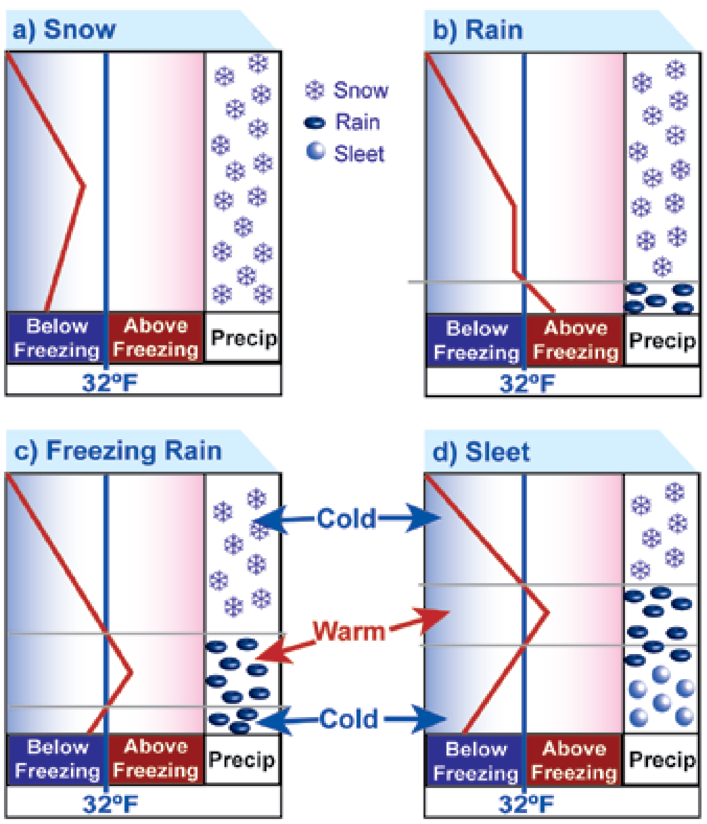
Figure 1 - Mesonet Sod and Air Temperatures in Oklahoma City December 9-10, 2007



All of this destruction was caused by a form of precipitation known as freezing rain. Nearly all precipitation starts as snow, which then forms all other types by falling through different temperature layers. As shown in Figure 2a, if the snow falls only through below-freezing (below 32ºF) air, we see snowflakes and begin to hope for a day off from school. However, if the snow falls through a layer that is warmer than freezing near the ground, the snow melts into rain (Figure 2b).

When a snowflake falls through a warm layer and then goes through a cold layer near the ground, freezing rain or sleet can occur. The main difference between freezing rain and sleet conditions is the size (or depth) of the below-freezing layer near the ground. A thick (or deep) cold layer gives plenty of time for melted snowflakes (raindrops) to refreeze into little pellets of ice known as "sleet" (Figure 2d). Freezing rain (Figure 2c) forms when the raindrops have a temperature below freezing, but do not have enough time to freeze into ice pellets. These very cold raindrops are called supercooled droplets—they have a temperature below freezing, but they are not frozen into ice. Once these droplets hit a surface that is below freezing (such as a tree or a power line), they immediately freeze into ice. ➔

Figure 2 - Precipitation Type Profiles



Let's follow a single snowflake as it falls and becomes a droplet of freezing rain. The snowflake starts in a below-freezing layer where it can stay a unique ice crystal. Next, it falls into a layer of above-freezing air, where it melts into a raindrop. The raindrop then falls into a shallow below-freezing layer near the ground. At this point, the raindrop cools to a temperature below freezing—it is now a supercooled droplet. As soon as the droplet hits a below-freezing surface—such as a tree, a car, or a power line—it freezes into ice. Over time, other freezing rain droplets will join our droplet and create a layer of ice. If the ice layer becomes very thick and heavy, the weight of the ice can bend and break trees.

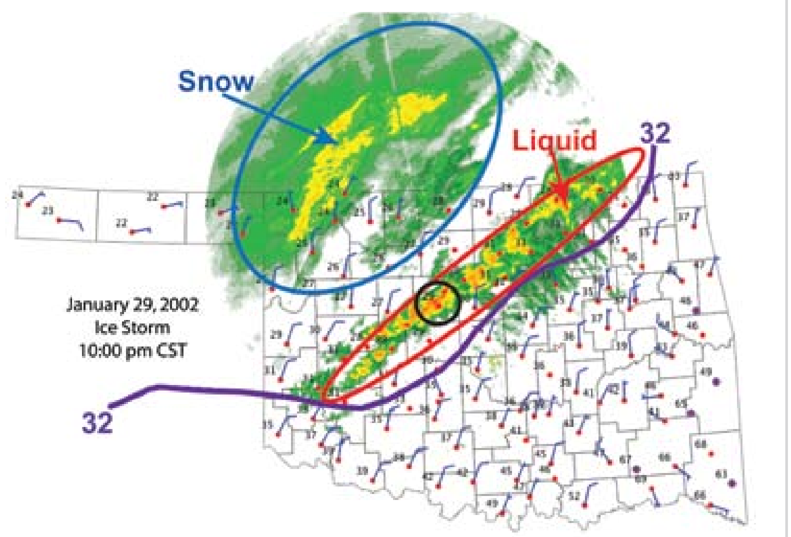
There are several tools that meteorologists in Oklahoma can use to tell the difference between freezing rain and the other forms of precipitation. Two common tools include radar and Oklahoma Mesonet data. A radar "sees" liquid and frozen precipitation differently, so meteorologists can tell the difference between snow and rain. Snow looks like smooth, fuzzy, or feathery blobs on the radar. In contrast, rain (liquid precipitation) typically has a sharper, more cell-like appearance. These shapes, whether they are created by areas with falling snow or rain, are called "echoes" because they are the signals that the radar receives back. Both snow and rain echoes appear on the radar in Figure 3. Also shown on this plot are surface temperature, wind speed, and wind direction. If you look closely at the area with rain echoes (for example, the Mesonet station that has a black circle around it), you may notice that the surface temperature is below freezing. Therefore, it is probably freezing rain, and not ordinary rain, that is falling!

Hazards associated with winter storms include:

- **Automobile accidents**
- **Slipping on the ice when walking**
- **Falling tree branches and power lines**
- **Power outages**
- **Hypothermia**

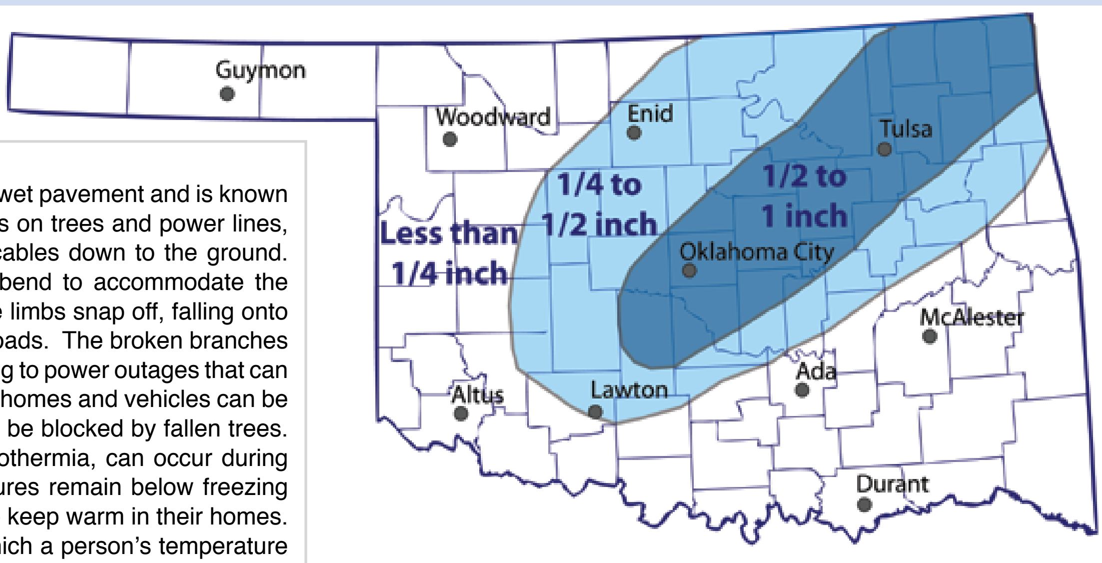
It doesn't take much ice to create hazardous driving conditions. Even a very thin, transparent layer of ice can cause a car accident. This thin ice looks like wet pavement and is known as black ice. As ice accumulates on trees and power lines, the weight pulls branches and cables down to the ground. When the trees can no longer bend to accommodate the extra weight, branches and large limbs snap off, falling onto power lines, cars, houses, and roads. The broken branches can tear down power lines, leading to power outages that can last days or weeks. Additionally, homes and vehicles can be badly damaged, while roads can be blocked by fallen trees. The last hazard on our list, hypothermia, can occur during long power outages if temperatures remain below freezing and there is no way for people to keep warm in their homes. Hypothermia is a condition in which a person's temperature drops at least 2 degrees below normal temperature (98.9ºF) because more heat escapes from the body than the body can produce. Left untreated, severe hypothermia can lead to death.

Figure 3 - Radar, Mesonet air temperature (F) and winds (mph), and Freezing Line for the January 29, 2002 Ice Storm



As mentioned above, the recent ice storm could have been worse. Remember, if ground temperatures are above freezing (warmer than 32ºF), rain is not likely to freeze to roads, though bridges and overpasses may still be slick. But if ground temperatures are below freezing, roads quickly become hazardous, trees and power lines accumulate ice, and the likelihood of the hazards listed above increases. Another condition not present in the December ice storm that can make an ice storm more severe is strong wind. When strong winds accompany an ice storm, ice accumulates more on one side of an object than on the opposite side, resulting in more weight on one side. This imbalance can topple trees and poles, creating even more damage than if ice accumulates more evenly on objects.

Figure 4 - December 9-10, 2007 Ice Storm (Approximate Ice Accumulation Totals)



CLASSROOM ACTIVITY

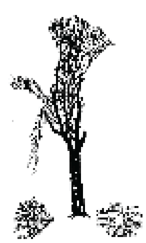
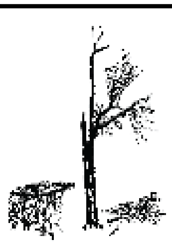
Ice and Trees

Have you noticed that tree branches often snap off in ice storms? One reason for this damage is that ice accumulation can increase tree branch weight by 30 times or more. If you tried to pick up a 30 pound weight with one hand, you would probably not be able to hold it up very long and you would drop the weight when your muscles become tired. The same happens with a tree branch—the weight of the ice becomes too much for it to hold up and so the branch wants to drop down. Unfortunately, a tree is often not flexible enough to keep its branches from breaking off.

By looking at tree damage, we can estimate how much ice has fallen. 1/4 to 1/2 inch accumulations can break small branches and weak limbs, while 1/2 to 1-inch accumulations can cause larger branches to snap off. Whether or not a tree will merely bend over with the weight of the ice, or if it will break, depends on the structure, flexibility, and health of the tree. A flexible, healthy tree is much more likely to bend over and survive an ice storm than a less flexible, diseased tree. However, even the strongest trees can be susceptible to uprooting, which can kill the tree. One way that a tree may be uprooted in an ice storm is when the top of the tree is covered with heavy ice, while the roots and the bottom of the trunk are in above-freezing temperatures (above-freezing ground temperatures). This makes the tree top-heavy, so it wants to fall over. Instead of just bending over, the tree is uprooted because the roots cannot hold the tree in the soil with the extra weight, and the center of balance, near the top of the tree.

A tree can have a lot of damage on its top and still survive. A tree's top is similar to the "flower" part of a piece of broccoli, while the stem is like the trunk of the tree. To determine whether or not a tree is likely to survive, we can use three major tree damage categories: Light, Moderate, and Severe Damage. Table 1 shows each category, along with a sketch for each.

Table 1 - Tree Damage Categories

 35% damage	Light Damage	Less than 50% of the top is damaged. High chance of survival.
 50% damage	Moderate Damage	50% to 75% of the top is damaged. Many trees will survive, though they may experience disease or infection in breakage areas. Torn bark, breakage at the very top, and breakage of low branches may increase the chance of infection.
 80% damage	Severe Damage	More than 75% of the top is damaged. Low chance of survival. The few trees that do survive are likely to become infected.

Tree A	Tree B	Tree C
		

Questions:

1. Compare the three photographs to the three damaged tree sketches.
   a. Approximately how much of Tree A was damaged?

   b. Approximately how much of Tree B was damaged?

   c. Approximately how much of Tree C was damaged?

2. Using the damage categories in Table 1, what is the damage category for:
   a. Tree A?

   b. Tree B?

   c. Tree C?

3. Imagine that you are an arborist (trained tree expert). One of your clients wants you to trim his damaged trees (Trees A, B, and C). Would you recommend that he keep all of the trees, or would you try to convince him that he should not keep all of the trees? Why? If you chose to remove a tree (or two or three), which tree or trees would you remove?

4. Looking at the amount of tree damage, how much ice do you think fell in this area? (Hint: What is the maximum amount of breakage in the area, e.g., are only small branches broken or are there larger branches broken as well?)

Erin Brings Rare Flooding Event To Oklahoma

By: Steve Kruckenberg, Service Hydrologist
and Patrick Burke, Forecaster, National Weather Service, Norman Oklahoma

Meteorologists and hydrologists in the National Weather Service draw a distinction between areal floods and flash floods. Here are some helpful definitions:

Flood [fluhd] ***noun,***

1. The inundation of a normally dry area caused by an increased water level in an established watercourse, such as a river, stream or drainage ditch; or may also be the ponding of water at or near the point where the rain fell.

Flash Flood [flash fluhd] ***noun,***

1. A flood which is caused by heavy or excessive rainfall in a short period of time, and occurring generally less than six hours after the causative event. A dam failure may also cause a flash flood depending on the time period.

Flooded, Flooding [fluhd-ed, fluhd-ing] ***verb,***

1. To cover or submerge with or as if with a flood; inundate: *My desk is flooded with paper.* **2.** To fill with an abundance or an excess: *flood the market with cheap goods.* To pour forth; overflow; To become inundated or submerged. ▶

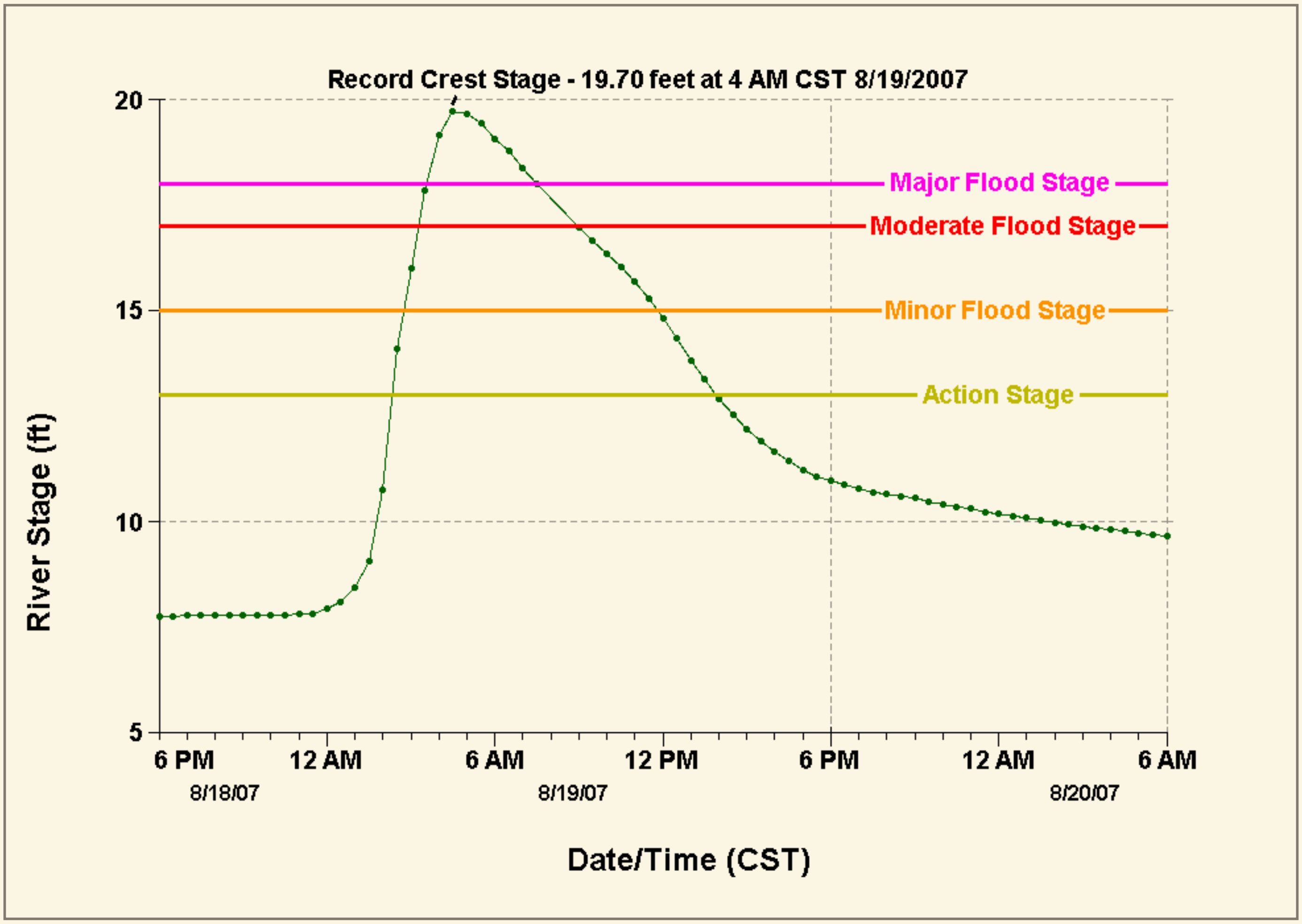
We tend to associated rivers with a flood, as the wide channels respond gradually (usually much longer than six hours) to the accumulation of rain upstream. Flash flooding, on the other hand, develops much faster, usually because an intense rain falls over a small area. Flash floods typically occur where water cannot penetrate the earth’s surface such as urban areas and deserts - or in the mountains where gravity and terrain influence the behavior of flood waters.

If flash floods occur in an established watercourse, it is typically a smaller, narrow tributary rather than a main stem river. Along the much wider mainstem rivers such as the Washita, Canadian, and North Canadian in Oklahoma, to produce a flash flood requires a larger volume of water. This makes the events of August 19, 2007, when all three of these mainstem rivers rose to record or near record levels in a matter of hours, nothing less than astounding.

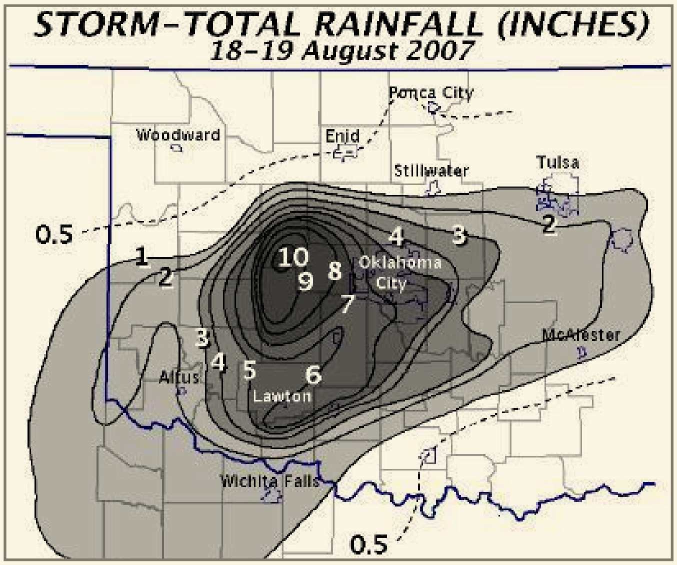
During the early morning hours of August 19th the remnants of Tropical Storm Erin tracked from southwestern into central Oklahoma. Extremely heavy rain occurred and was nearly continuous over much of the area west of Oklahoma City toward Watonga, Hydro, and Anadarko. Rain totals of 8 to 11 inches were observed. Soil conditions were already abnormally wet from heavy flood events during the spring and early summer of 2007, resulting in unusually rapid and high volume runoff.

While most of the flash flooding occurred along smaller creeks, streams and low-lying locations, some of the flash flooding actually occurred along main stem rivers. The flash flooding produced rapid, sharp rises which took these rivers from several feet below flood stage into major and even all-time record flood stages in less than six hours!

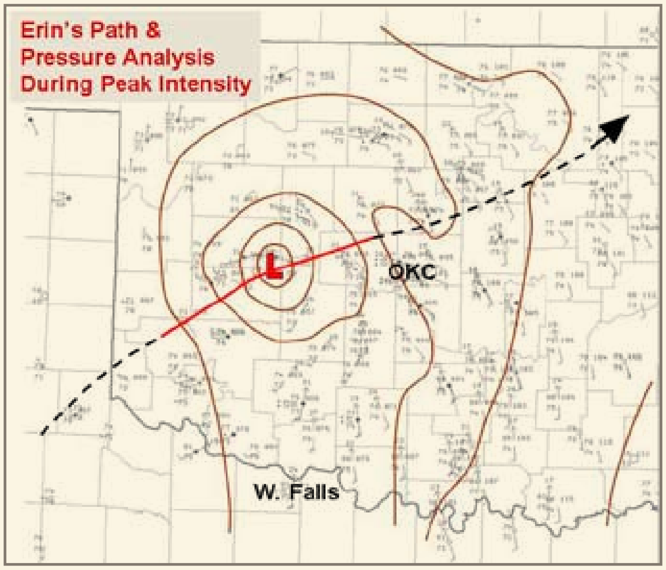
The Washita River measured near Clinton rose from 6.61 to 21.66 feet in five and a half hours. Major flood stage at Clinton begins at 24 feet. The Canadian River at Bridgeport rose from 9.97 to 18.75 in six hours, and eventually reached 21.03 feet after twelve hours. The instrument at Bridgeport then failed, but 21.03 feet will stand as the new all-time record stage at that location. Similarly, a new all-time record was set at along the North Canadian River measured at Watonga, where the stage rose from 7.95 to 19.70 feet in only four and a half hours! The volume of water that accumulated along these three rivers in such a short time is truly remarkable.



River levels of the North Canadian River at Watonga.



Storm-total rainfall due to Tropical Storm Erin.



Extreme Weather:
Winter Myths and Myth-Conceptions

Andrea Melvin – Outreach Programs Coordinator and
Gary McManus – Assistant State Climatologist

As with any type of myth or legend, those of the weather variety can be quite entertaining. Who knew that sticking a knife in the ground in front of a tornado would cause it to split and bypass your area? Of course, with Oklahoma's proclivity for weather extremes, some of those myths can lead to disaster if taken at face value. When it comes to weather safety, it's always important to separate fact from fiction. And remember, if a tornado hits while you are reading this, don't bother opening any windows...TAKE COVER IMMEDIATELY!

True or False: A large heavy coat is the best way to stay warm outdoors in the winter.

False! It's not the thickness of the coat but the number of layers that can trap air between your clothes and your body. You must also cover your head, hands and as much of your face as possible.

True or False: Rub your hands together to warm them up from frostbite.

False! False! Rubbing frostbitten hands together will cause more damage to the tissue. Instead, warm your hands by running warm (not hot) water over them for 15 to 30 minutes and seek medical attention as soon as possible.

True or False: Treat frostbite with fire or ice. Warm your hands with the heat of a fire.

False! Do not use any heating devices, stoves, or fires to treat frostbite. Victims cannot feel the frostbitten tissue and can be burned easily.

True or False: Beverages with alcohol can warm you in the winter.

False! Alcohol provides a false sense of warmth and can actually increase the risk of hypothermia. Alcohol numbs the senses and thins the blood.
Thinner blood increases skin heat loss.

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