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Tulsa Tornado Tribune

Where People Who Know the Weather Get Their Weather

National Weather Service Tulsa, Oklahoma **Spring 2009**

Craig Sullivan - Editor

Another Winter... Another Ice Storm

For the third consecutive winter, a significant ice storm struck parts of eastern Oklahoma and northwest Arkansas. Like all winter storms of this magnitude, forecasters at the NWS Tulsa were presented with a series of challenges in determining where the storm's greatest impact would occur, and what type of precipitation would prevail. This event provides yet another example of how the expertise of forecasters is needed in critical weather situations.

An example of the extreme ice damage that occurred with the January 26-27 ice storm in northwest Arkansas.

Decade of Ice

Since 2000, six major ice storms have impacted portions of the NWS Tulsa forecast area.

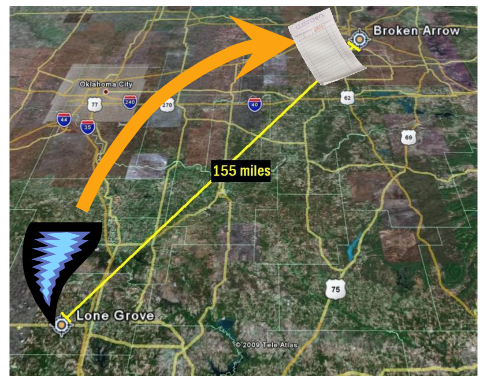
- December 25-27, 2000
- January 28-30, 2002
- December 3, 2002
- January 12-14, 2007
- December 9-10, 2007
- January 26-27, 2009

Initial Long Range Forecasts

The winter weather and ice storm moved into northeast Oklahoma late in the day Monday, January 26, and slowly spread east and into northwest Arkansas Monday night and Tuesday. The system was slow to move east, so some areas of southeast Oklahoma and west central Arkansas did not receive any freezing rain or sleet until Tuesday night. The 7 day forecast issued in the middle of the previous week called for seasonable temperatures, mostly in the 40s for the following Monday and Tuesday. However, by Thursday the 22nd, it was becoming more

Ice Storm *Continues on page 2*

Is it Possible?



As you know, the south central Oklahoma community of Lone Grove was devastated by an EF4 tornado during the outbreak of severe thunderstorms and tornadoes across central and eastern Oklahoma on February 10. Not long after, the NWS in Tulsa received a report of a check with a Lone Grove address found by a resident in Broken Arrow... about 150 miles away! Such tales abound in the aftermath of tornadoes, and it certainly is true that a tornado can pick up a TON of light weight debris. But is it really plausible that the check

Possible? *Continues on page 7*

Inside this issue:

Ice Storm

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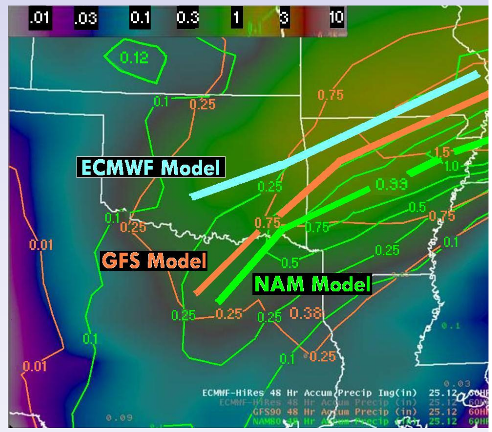
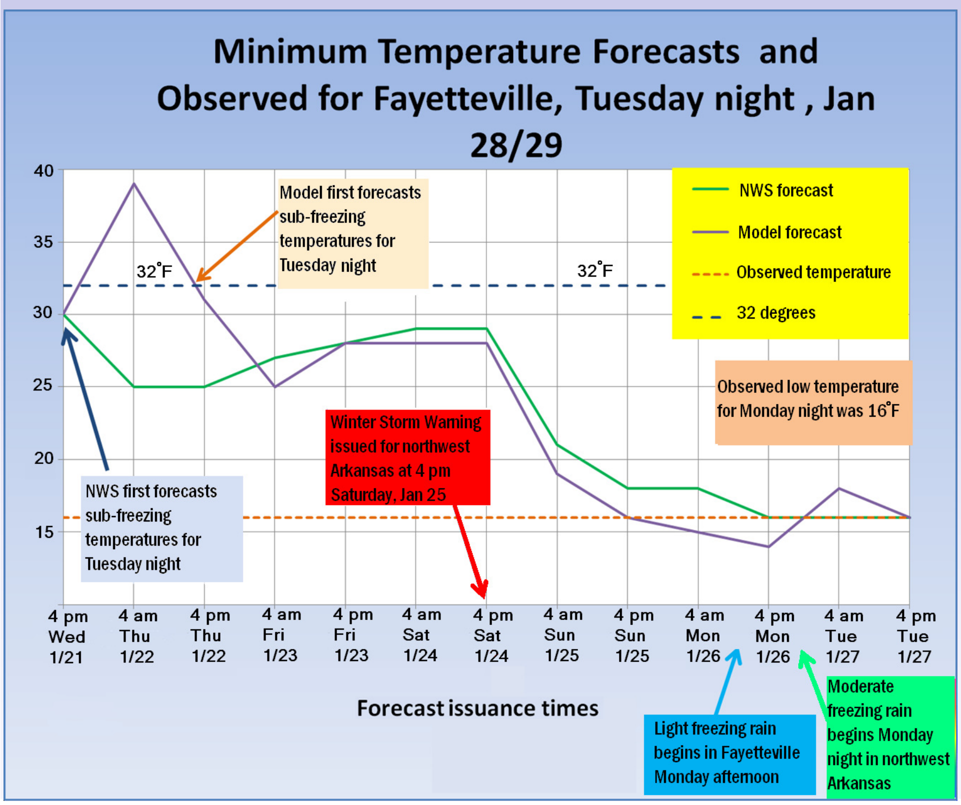
apparent that much colder air would move into the area, with a chance of significant ice accumulation. By Saturday the 24th, a winter storm watch was issued for eastern OK and northwest AR, emphasizing the threat of freezing rain and sleet. Sunday morning, an Ice Storm Warning was issued for northwest Arkansas. Ice Storm Warnings and Winter Storm Warnings were eventually expanded to include all of eastern OK and west Central Arkansas on Monday.

Model Precipitation Forecasts

Meteorologists use computer models of the atmosphere to help them forecast the expected weather. Although this technology has allowed for more accurate and longer range forecasts, there are still difficulties to overcome in making the final forecasts. As good as they are, models cannot always resolve finer details that can make all the difference between a good soaking rain and a destructive ice storm. The models, for example, often have difficulty in forecasting the amount of precipitation...and the difference between a tenth inch of ice and one inch of ice can be huge! So, the meteorologist must first correctly interpret the models, and then use her, or his experience to adjust the model output for known biases. Finally, in the case of freezing rain, the meteorologist must decide how much of the rain may actually freeze to trees and power lines. This can be extremely important when heavy amounts of precipitation are expected.

The chart to the right shows three different model forecasts of total precipitation for the ice storm. These models were seen by the meteorologist on Sunday...or 24 to 36 hours before the event. Contours of precipitation amounts from the North American Model (NAM) are shown by the thin green lines. The axis of precipitation extends from western Tennessee to southeast Oklahoma. This model shows less than a quarter inch of precipitation in northwest Arkansas and northeast Oklahoma. The Global Forecast System model (GFS) has orange contours of precipitation amount and is farther north, with around one-half to one and a half inches of precipitation over northwest Arkansas and adjacent portions of northeast Oklahoma. The thick orange line shows the axis of heaviest precipitation. The ECMWF model, from the European Centre, is shown in the shading, with its axis of heaviest precipitation even farther north. The yellow shading indicates between 1 and 2 inches of rain over most of northwest Arkansas and adjacent northeast Oklahoma. This model was preferred by the forecasters and turned out most correct.





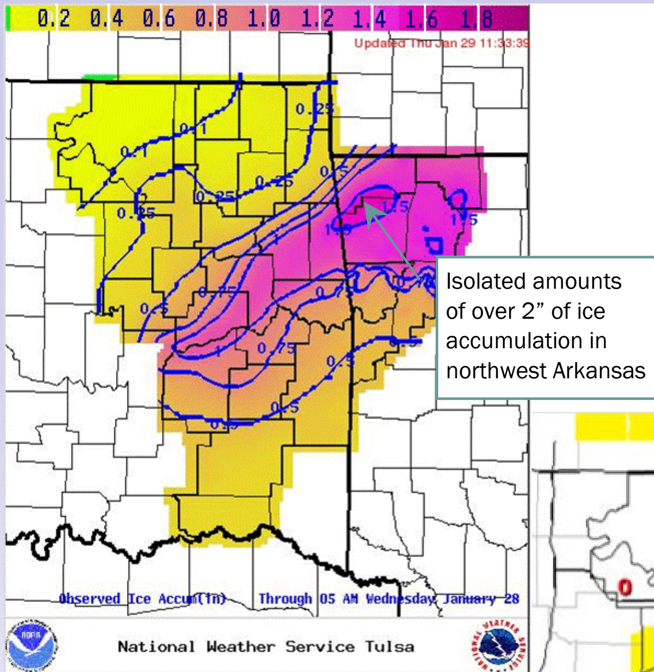
Departing From the Models

Here is a time-line for the high temperature forecasts in northwest Arkansas...specifically at Fayetteville. The green line shows the forecast highs issued by forecasters at this office, while the purple line shows high temperature forecasts for Tuesday the 27th from computer model guidance. The forecast for that period was first issued on Tuesday afternoon, January 21. With the exception of the model forecast at 4 am the previous Thursday, there was good agreement that freezing conditions would be present the following Monday night into Tuesday. By Saturday morning, confidence for significant rain was sufficient to warrant the Winter Storm Warning for northwest Arkansas and Winter Storm watch for the remainder of west central Arkansas and most of eastern Oklahoma. Light freezing rain began in Fayetteville Monday afternoon, with moderate rain starting Monday evening.

Ice Storm

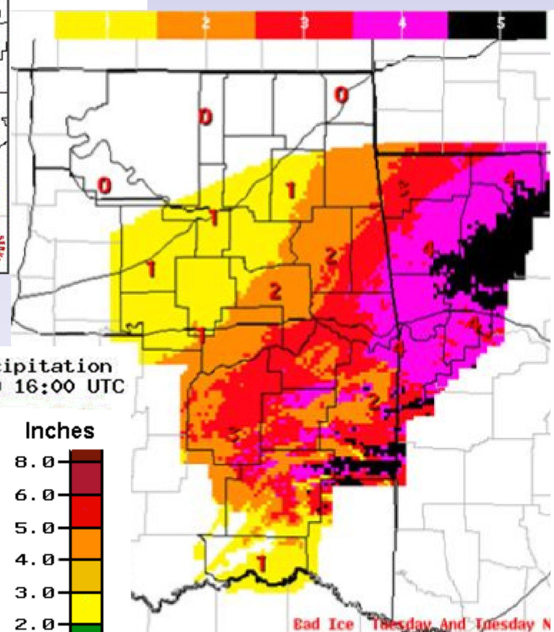
(Continued from page 2)

What Happened?



The map to the left shows the estimated accumulations of ice for the event. These are created by combining ground-truth reports and radar derived precipitation data. This illustrates how the more northern computer model (ECMWF) provided the best solution.

The image at bottom left is from the National Weather Service River Forecast Centers, and shows the total amount of precipitation that occurred during the event. Fortunately, not all the precipitation froze on contact. The red areas are where total amounts of three to six inches of rain or water equivalent were observed.



Sperry-Piltz Index

Category 1:

Local outages for 1 to 2 hours.

Category 2:

Scattered outages for up to 12 hours.

Category 3:

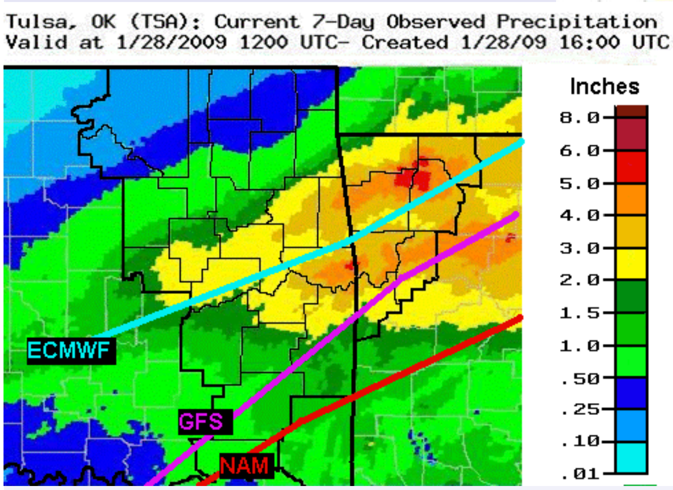
Numerous outages, lasting a few days.

Category 4:

Prolonged, widespread outages, lasting 5-10 days.

Category 5:

Catastrophic damage, with outages lasting several weeks.



Above is the Sperry-Piltz Ice Damage Index forecast of storm impacts through Tuesday night, January. 27. The index takes into account the forecast ice accumulation and wind speed. This graphic was produced by the NWS Tulsa on Monday and showed a high probability of catastrophic damage across much of northwest Arkansas.

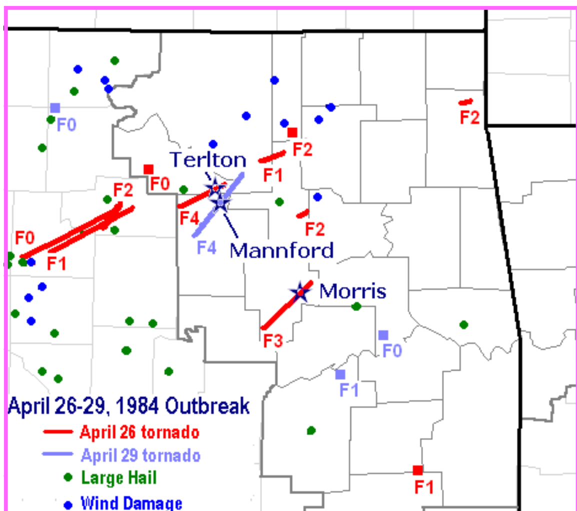
The January , 2009 ice storm would end up being one of the worst natural disasters to ever hit northern Arkansas. In the aftermath, the Electric Cooperatives of Arkansas estimated about 187,000 customers were without power in the northern sections of the state. About 28,000 homes and businesses in Oklahoma lost power as well. Some areas did not get power restored for more than two weeks.

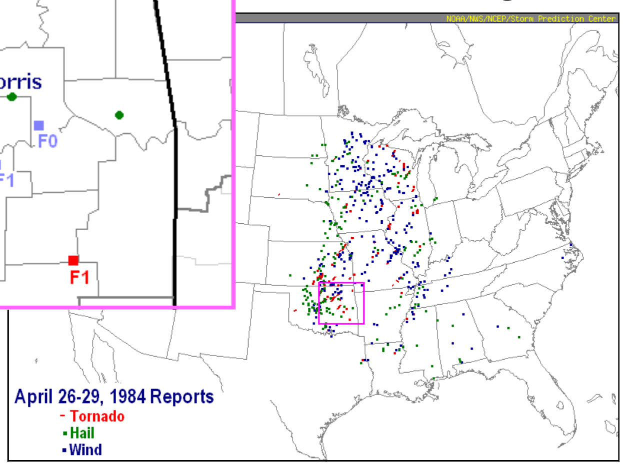
Thanks to the efforts of forecasters at NWS Tulsa, much of the hardest-hit area received more than 36 hours of lead time from the issuance of the initial Winter Storm Warning. By effectively utilizing, and departing from, model guidance, and providing frequent updates as conditions changed, forecasters were better able to provide quality service.

25 Years Ago - A Deadly Week

Two outbreaks of severe weather on the 26th and the 29th of April, 1984, claimed 12 lives in eastern Oklahoma, injured dozens of others, and left four communities devastated.

While severe weather can occur at any time of the year in this area, the peak of significant tornadoes tends to occur from late April through early May. True to form, the spring of 1984, a slightly below average spring for Oklahoma tornadoes, reached a deadly climax during the last week of April.





Severe storms affected much of the country from April 26-29, 1984

April 26-27, 1984

The first event took place as a strong low pressure system moved across the northern and central plains, producing severe weather from eastern Oklahoma to Wisconsin and Minnesota on April 26-27. A total of 47 tornadoes were reported during this event. The same system produced widespread blizzard conditions in Wyoming, Montana and the Dakotas, with over 5 feet of snow in the Black Hills, and up to 6 feet in Absaroka and Big Horn ranges of Wyoming and Montana.

Eleven tornadoes touched down in central and eastern Oklahoma during the evening of April 26 and very early morning of the 27th. The first to affect eastern Oklahoma proved to be deadly. The violent tornado touched down near Oilton just after 11 pm, eventually tracking 23 miles to near Westport. The town of Terlton, OK was hardest hit by this F4 tornado. Three area residents were killed, while 37 were injured. A total of about 120 structures were damaged or destroyed...around $2.5 million in damage.

There were two mobile homes destroyed 1 mile southwest of town, where one fatality occurred along with several injuries. The other two deaths occurred when a double-wide mobile home was completely destroyed 1 mile north of town. Debris from this home was swept from 100 to 300 yards away. Other significant damage occurred at an oil gathering and shipping facility on the southeast side of Terlton, where one 50 foot tall and 30 foot wide tank was overturned and moved about 75 feet. Oil from this tank spilled into and polluted a nearby creek for several miles downstream.

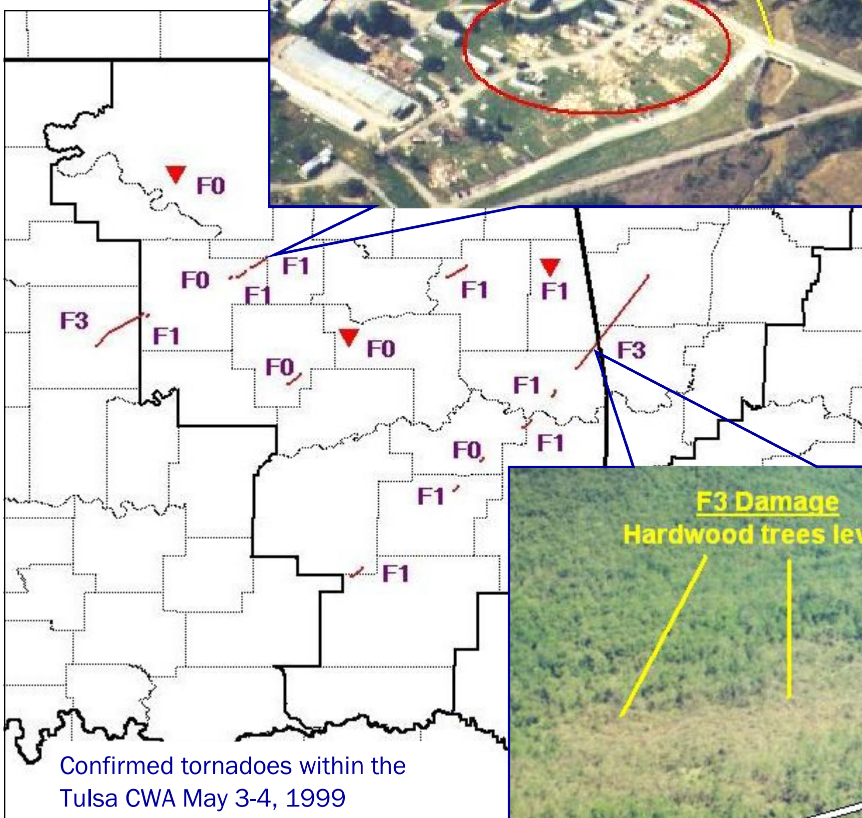
Shortly after midnight, an F2 tornado touched down 1 mile north of Vera, downing a 243 foot tall microwave tower, which knocked out phone service to much of the 918 area code for about 16 hours. Another F2 tornado caused about 2 million dollars in damage and one injury on the northeast side of Broken Arrow.

The worst was yet to come however, as the season's deadliest tornado was bearing down on the community of Morris, in Okmulgee County. Although technically not a "violent" tornado (rated an F3 on the Fujita Scale), it devastated the central business district as it tore through the center of town just before 1 a.m., heavily damaging or destroying about 70 percent of the structures in town. The town's water tower collapsed as all four supporting columns were "uprooted" from the foundation. Unfortunately, this became one of the deadliest tornadoes in eastern Oklahoma during the past 30 years as 8 people lost their lives. One death occurred southwest of town, five more in Morris, and two others in a trailer park 3 miles southeast of Okmulgee.

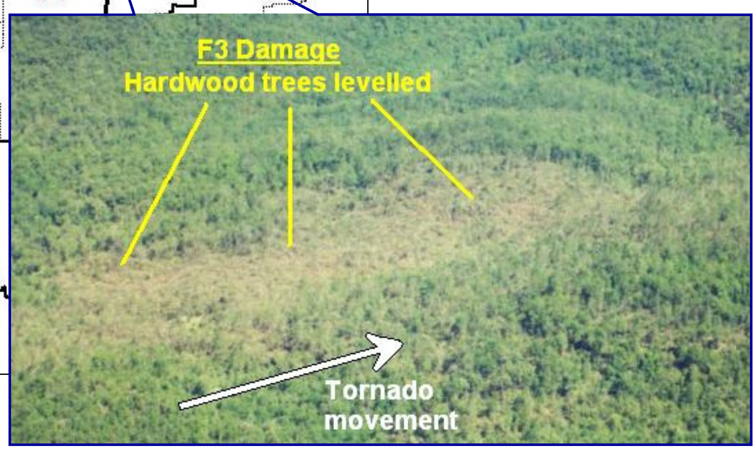
Deadly Week *Continues on page 7*

May 3, 1999

It may be hard to believe, but May 3 will mark the ten year anniversary of the most devastating tornado outbreak in Oklahoma in recent memory. The event will always be remembered for the F5 tornado that moved through southern parts of the Oklahoma City metro area. While the loss of life and the heaviest property damage was limited to central Oklahoma, eastern Oklahoma got into the act with a significant number of tornadoes.



Confirmed tornadoes within the Tulsa CWA May 3-4, 1999



While there were dozens of individual storms on May 3 and 4, two storms were mainly responsible for the tornadoes in eastern Oklahoma. The first moved northeast along the I-44 corridor late in the evening of May 3, causing F3 damage to Stroud in Lincoln County, including the destruction of the Tanager Outlet Mall. The same storm went on to produce an F1 tornado which first touched down in the north side of Sapulpa near the junction of Oklahoma Highway 97 and Interstate 44. The tornado skipped through an industrial area before moving across I-44. From there, the tornado moved northeast, nearly parallel to and just south of the New Sapulpa Road (OK Highway 66), severely damaging a dozen homes, 20 mobile homes and 25 businesses. The Hilton Mobile Home Park was especially hard-hit, where about 15 mobile homes were damaged or destroyed. Twenty-four residents of the mobile home park were treated on the scene for minor injuries, but none required a hospital visit.

The tornado then tracked into Tulsa County, where it caused considerable damage in several neighborhoods on the southwest side of Tulsa. The most publicized damage occurred at the Carbondale Assembly of God Church, where the second story of the building was reduced to rubble. Remington Elementary School was damaged to the point where students had to finish the last two weeks of class elsewhere. The West Regional Library lost about one-third of its roof, and Fire Station #26 sustained minor damage. Four industrial businesses sustained damage, and 70 homes were damaged by the tornado.

The second storm got its start in southeast Oklahoma, south of McAlester the next morning. This storm moved northeast across Pushmataha, Latimer, Haskell, LeFlore and Sequoyah Counties, producing several damaging tornadoes along the way. The final tornado touched down west of Short, OK in Sequoyah County and turned out to be the most significant, tracking 39 miles to a point about 7 miles southwest of Fayetteville, AR.

May 3, 1999 *Continues on page 8*

Severe Weather Terminology

When severe weather is forecast, you may often hear a number of different meteorological terms thrown around to describe what is responsible for the threat. There are, of course, three basic things needed to make a thunderstorm: moisture, instability and lift. And, in order for a storm to be severe, add wind shear to the list. Following are some terms that describe instability and wind shear, and a brief explanation of what they mean.

Cap (or Capping Inversion): A layer of relatively warm air aloft (usually several thousand feet above the ground) which suppresses or delays the development of thunderstorms. Air parcels rising into this layer become cooler than the surrounding air, which inhibits their ability to rise further. As such, the cap prevents thunderstorm development even in the presence of extreme instability. Something has to happen in order for the cap to finally break and allow storms to develop; the temperature profile can change sufficiently through the day, or more often, a lifting mechanism (e.g. low level air convergence near a front or dry line) will be able to force a parcel through the cap and initiate deep convection. What makes a cap important to severe weather, then? In most severe thunderstorm episodes, it serves to separate warm, moist air below and cooler, drier air above. With a cap in place, potential instability can increase either through warming and/or moistening of the lower atmosphere, or cooling the upper levels (or both). Once the cap is removed or overcome by lifting, explosive thunderstorm development can occur. Without a cap, any of the aforementioned processes will result in a faster release of available instability - often before instability levels become large enough to support severe weather development.

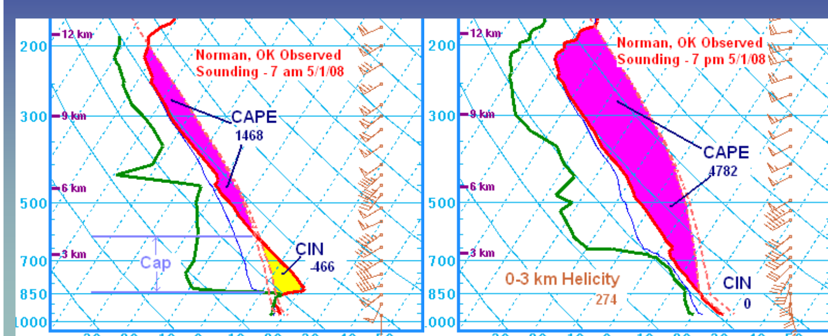
CAPE (Convective Available Potential Energy): A measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather. Observed values in thunderstorm environments often may exceed 1,000 joules per kilogram (j/kg), and in extreme cases may exceed 5,000 j/kg. There are no "set" values that correspond to the likelihood of severe weather, however. A CAPE of 1000 in January might well produce severe storms, while similar values are nearly a daily occurrence in June. The important thing to look for is where it is maximized or how much it changes on days when severe weather is forecast.

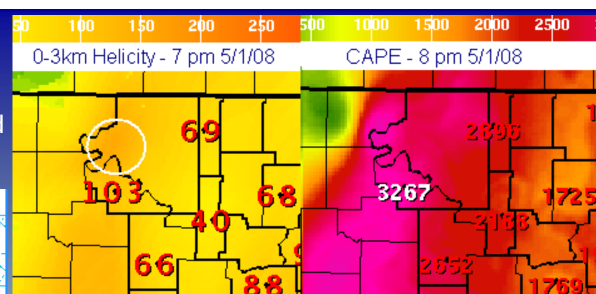
Lifted Index (or LI): A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to some higher level (around 18,000 feet, usually) and comparing that temperature to the actual temperature at that level. Negative values indicate instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms. As with CAPE, there are no "magic numbers" or threshold LI values below which severe weather becomes imminent.

CIN (Convective Inhibition): A measure of the amount of energy needed in order to overcome the cap and initiate convection. Sort of the opposite of CAPE, values of CIN typically reflect the strength of the cap. Again, the actual values are not as

Terminology *Continues on page 8*

Here is an example of how the parameters changed during a significant severe weather event on May 1, 2008. The morning sounding shows a strong cap at around 4000 feet and large area of CIN above it. The cap was eroded by the evening through low level warming and convergence along the dry line, leading to very high CAPE values.





The above graphics are from the Convective Indices Monitor on the NWS Tulsa web page. While Helicity values were not extreme, there was a local maximum (circle) in a very high CAPE area. Tornadic supercells affected Osage and Pawnee counties around the same time.

Possible?

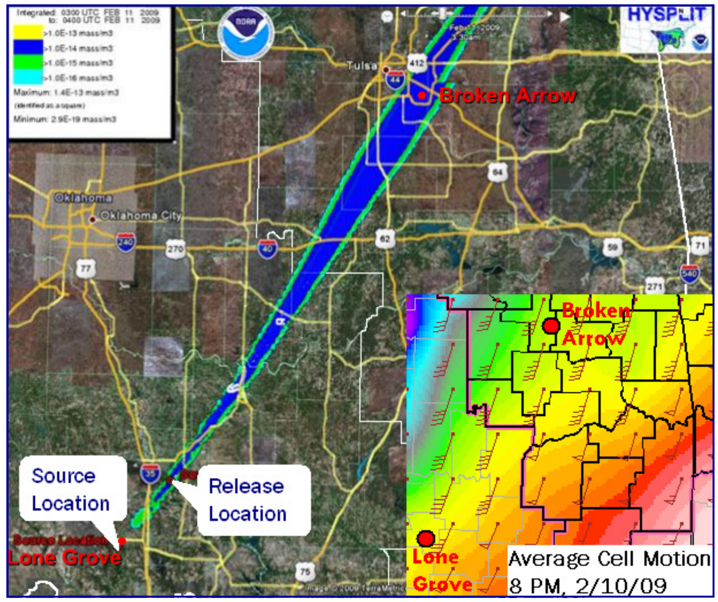
(Continued from page 1)

came from the Lone Grove tornado debris and ended up in Broken Arrow?

We decided to put this idea to the test using the HYSPLIT computer model. The HYSPLIT model is a “plume” model used by the NWS to estimate where chemicals released during a hazardous materials spill will move. The model includes several atmospheric parameters such as the wind, temperature and humidity in its calculations of fallout.

The idea here was to use the model and the known atmospheric data from the evening of February 10 to try and approximate the movement of a lightweight piece of paper.

The basic assumption made was that the check was lifted in the strong updraft of the storm (Source Location at right), then became caught up in the upper level winds near the top of the updraft...in this case about 30 thousand feet. We also assumed that the check remained within the updraft (not yet affected by upper level winds) until the storm weakened significantly about 30 minutes later (Release Location at right). Once that occurred, the upper level winds would carry the check as it slowly descended back down to the ground. The tornado occurred around 730 pm, so we examined the observed upper level flow at 8 pm (inset at right).



Amazingly enough, the projected “fallout” plume...or in this case, the check, passed right over Broken Arrow! While this was by no means the most scientific study ever done by this office, with many assumptions made (this was necessary since the actual air motion within a tornadic supercell is EXTREMELY complex), since the HYSPLIT model did indicate that a hazardous material release would follow a path from Lone Grove to Broken Arrow, it seems reasonable that a small piece of tornado debris such as a check, would do likewise.

Deadly

(Continued from page 4)

April 29, 1984

Three days later, another strong system moves across the plains. This time, however, the severe weather occurred in the morning. The most significant tornado initially touched down around 920 am northeast of Shamrock and followed a 26 mile path, causing extensive damage in the communities of Mannford and Prue. The tornado was rated an F4.

Four churches filled with parishioners were hit that Sunday morning in Mannford. Parishioners had a warning about three to five minutes before the twister hit. Some hid in closets, others crawled under pews, and many children were taken into a hallway. The four churches - all within a block of each other - were either in the midst of services or about to start them when the twister hit. At least 20 people were injured in Mannford, and 30 others were hurt when a tornado hit the nearby town of Prue.

Dozens of vehicles in church parking lots in Mannford were picked up by the storm and smashed down on top of each other. Some were left unrecognizable because they'd been rolled into a huge, steel ball. One man was killed when his pickup truck was lifted by the tornado and thrown into nearby Mannford Elementary School. He had been on his way to church to pick up his wife because of the tornado warnings.

Destruction in Mannford was mostly within a six-block area. The First Baptist and Assembly of God churches were destroyed, while Mannford Church of the Nazarene was heavily damaged. Mannford High School and Mannford Elementary School also suffered significant damage.

May 3, 1999

(Continued from page 5)

In Sequoyah County, this tornado travelled across a sparsely-populated part of the county, causing mostly tree damage. The tornado clipped the extreme southeast portion of Adair County as it reached its peak strength. While structural damage was limited along the tornado's path through mainly wooded and undeveloped areas, an aerial damage survey by NWS personnel over extreme southeast Adair County revealed that every tree in a hardwood forest was completely leveled. This tree damage was enough to rate the tornado an F3.

As the tornado continued into Washington County, AR, the first real property damage took place between the Hogeye and Strickland communities, where the tornado peeled off the roof to a home, shattered windows, uprooted trees, destroyed two barns, and wiped a porch off of its stone foundation. Numerous trees were blown down along County Roads 212 and 214.

Only a few miles away in the Cove Creek community, south of Prairie Grove, the tornado blew off a home's roof, demolished an enclosed garage, and destroyed a barn. A flagpole was bent almost in half, and a road sign ended up wrapped around a mailbox. The tornado uprooted a 200-year old walnut tree which then fell onto a pickup truck. About a half-dozen other oak and cedar trees on one property dating back at least 150 years were snapped or uprooted. The Washington County Judge's Office supplied a picture of a church near Cove Creek that was moved off of its foundation. Several poultry buildings along the tornado's path were also damaged. Fortunately, this tornado lifted before it reached heavily-populated Fayetteville.

Following a very wet April that saturated area grounds, this same weather system made flash flooding a serious problem to deal with as most rainfall quickly ran off into creeks, streams and mainstem rivers. One flash flood in Vinita caused millions of dollars in damage following the flooding of dozens of homes.

1999 would go on to be a record-breaking year for tornadoes, as both Oklahoma and Arkansas broke their all time records, with 145 and 107, respectively.

Local News

Employee Milestones

Electronics Technician Paul Pinson was recently recognized for 30 years of federal service. Also, Senior Meteorologist Robert Darby was recognized for 15 years in the National Weather Service. Congratulations to Paul and Robert!

Outreach

For the second year in a row, the National Weather Service Tulsa office teamed up with Wal-Mart stores in the greater Tulsa area to promote NOAA Weather Radio. Booths were set up at several stores, where NWS and RFC personnel from the Tulsa office helped program the NOAA Weather Radio consoles.

Terminology

(Continued from page 6)

important as how it evolves through an event.

Shear: Variation in wind speed (speed shear) and/or direction (directional shear) over a given distance. Most often, we refer to vertical wind shear in severe weather forecasting; i.e., the change in wind speed and direction with height. The term also is used in Doppler radar to describe changes in radial velocity over short horizontal distances.

Helicity: A property of a moving fluid which represents the potential for helical flow (i.e. flow which follows the pattern of a corkscrew) to evolve. In other words, this represents the potential for a storm updraft to rotate. Helicity is proportional to the strength of the flow, the amount of vertical wind shear, and the amount of "turning" in the flow. Atmospheric helicity is computed for the lower part of the atmosphere (usually from the surface up to 3 km or 1 km), and is measured relative to expected storm motion. Higher values of helicity (generally, around 150 m^2/s^2 or more) favor the development of mid-level rotation (i.e. mesocyclones), and can indicate an enhanced tornado potential.

Hourly values of these and other parameters are available on the Decision Support Page. Select either the tornado or severe thunderstorm threat for the first period, then select the "Related Products" tab at the top.