Eye on the Sky

National Weather Service
Louisville, Kentucky

Summer 2001
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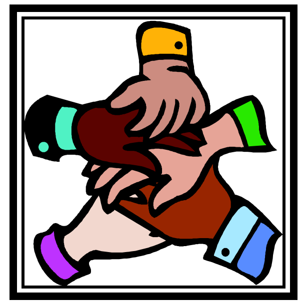
Telephone: (502) 969-8842 Email: W-LMK.webmaster@noaa.gov Web Site: www.crh.noaa.gov/lmk

A Newsletter for Emergency Mangers, Core Storm Spotters, Media, and Public Officials in our County Warning Area.

Teamwork and Dedication: A Winning Combination

by Michael Matthews, Meteorologist In Charge



Over the past several months, I have addressed a number of subjects in this newsletter, including outreach and safety preparedness activities throughout the counties and states we serve. I thank everyone for their ongoing support and significant contributions in making the warning and preparedness process work. This saves lives. I must acknowledge the hard working men and women at the National Weather Service (NWS) office in Louisville who dedicate themselves to protect lives and property 24 hours a day, 7 days a week. These folks truly place service above self and demonstrate a daily commitment to integrity, teamwork, and high standards in achieving our mission.

You may not be aware that our office has forecast and warning responsibilities for 59 counties encompassing nearly 20,000 square miles across central Kentucky and south-central Indiana. Put in other terms, our geographical area of responsibility spans over 40 percent of the commonwealth of Kentucky. In this same area, NWS Louisville serves approximately two million people, which represents about one-half of Kentucky's total population.

Our staff's contributions to the National Weather Service's overall mission is vital to the safety and economy of the counties and states we serve because weather is big business. In fact, one-seventh of our economy, about one trillion dollars a year, is weather sensitive. But none of this can work effectively without you. Working together as a dedicated team, with you as our partners, ensures the safety of those we serve. I thank you again for all of your tireless efforts in our common goal.

Heat: A Potential Killer

by Norm Reitmeyer
Warning Coordination Meteorologist

Each year heat kills more people in the United States than lightning, tornadoes, hurricanes, floods, or earthquakes. Only the cold of winter takes a greater toll from a weather standpoint. In 1980, 1250 people died from heat-related causes.

To alert the public of the hazards of heat waves, the National Weather

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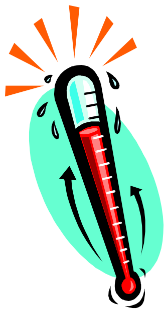
Service has devised the "Heat Index"

Inside this Issue:



(HI). The HI, given in degrees F, is an accurate measure of how hot it really feels when the effect of moisture (i.e., relative humidity) is added to the actual air temperature. In other words, for a given temperature, the higher the moisture content of the air, the higher the HI will be. When the HI is between 90 and 105 degrees, sunstroke, heat cramps, and heat exhaustion are possible with prolonged exposure and/or physical activity.

The NWS will issue a Heat Advisory when the HI is expected to exceed 105 degrees for at least two consecutive days. If the HI exceeds 120 degrees, the NWS will issue an Excessive Heat Warning. HI values may be included in Zone Forecasts, and Special Weather Statements and/or Public Information Statements will be issued to provide detailed information on the extent of the hazard, those who are most at risk, and safety rules for reducing the risk.

During very hot periods, there are some general steps a person can take to reduce risk. Slow down. Dress in lightweight light-colored clothing. Drink plenty of water or other non-alcohol fluids. Spend more time in air-conditioned places. Stay out of the sun, if possible. Check on the well-being of elderly persons, and pets as well.

What will this coming summer be like? Will Kentucky experience temperatures above 100 degrees, as was the case in 1999? No one really knows. But if prepared, we can deal with heat waves.

Drought 2001: An Update

by Mike Callahan, Service Hydrologist

Will the drought ever end? For the last 3 years, many portions of the lower Ohio Valley have been in a drought. Looking at the plants, one would think that conditions are not too bad. Lawns are green, gardens are growing, and the crops in the fields generally look OK, although they could be better. But if you dig down about a foot, however you will discover very hard soils with little available moisture.

Precipitation amounts during the winter and early spring of 2001 were disappointing, especially April which typically is one of the wetter months. Both Louisville and Lexington received just a little over an inch total for April which was around three inches below normal. The rainfall deficit for the year to date by late May was around 4 inches in Louisville, 3 ½ inches in Lexington, and around 6 inches in Bowling Green.

As a result, the measure we use for determining long-term or water supply drought, the Palmer Drought Severity Index, indicates that both central Kentucky and the Bluegrass Region, including Louisville, Bowling Green, and Lexington are in a moderate drought. South-central Indiana also currently is experiencing a moderate drought this year for the first time.

What can we expect for the summer? The latest long-range prediction for the lower Ohio Valley calls for temperatures and precipitation to be near normal. While we are hopeful for above normal rainfall to recharge the supply, summertime rainfall often is scattered in the form of showers and thunderstorms. Thus, some locations will receive much needed moisture, while other locations may be less fortunate, which could aggravate current drought conditions.

Eye on the Sky is a quarterly newsletter published by the National Weather Service in Louisville, Kentucky for the benefit of Emergency Managers, core storm spotters, local media outlets, and certain public officials within our county warning area. Comments and suggestions are always welcome.

Please contact us by phone at **502-969-8842**, or send us an email at
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Or, you also may contact us by mail at
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Chief Editors: Ted Funk and Van DeWald

Tornado Safety Today

by Don Kirkpatrick, Meteorologist

Since the April 3, 1974 tornado super outbreak, much has changed regarding tornado safety. Advances in technology, communication, and education have resulted in a much improved plan to survive.

Shortly after the super outbreak, the National Weather Service in Louisville began broadcasting severe weather watches and warnings via the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) Weather Radio. In the last 25 years, NOAA Weather Radio, the voice of the National Weather Service, has saved countless lives. Watches and warnings are broadcast live and then retransmitted by many local radio and television stations. With this information, emergency management and public safety officials activate warning systems to alert communities of an impending tornado threat. Owners of a NOAA Weather Radio receiver equipped with a warning alarm tone have instant access to emergency information that can be life saving.

Everyone should have a plan to survive a tornado, whether you are in your home, at work or school, in your motor vehicle, at a store or mall, or in the outdoors.

At **home**, move to a pre-designated shelter, such as the interior part of a basement or underground cellar and get under something sturdy like a table. If an underground shelter is not available, go to an inside room on the lowest floor, i.e., a closet, hallway or bathroom with no windows. Put as many walls as possible between you and the outside. In addition, get under a sturdy piece of furniture and cover your body with a blanket or mattress. Tune to your battery operated NOAA Weather Radio while waiting out the storm.

At **work** or **school**, move to an emergency or pre-designated shelter. If a specific shelter does not exist, go to an interior hallway or small room on the building's lowest level. Avoid windows, glass doorways, cafeterias, auditoriums, and other areas with free-span roofs. Do not leave work or school if a tornado threatens. A school bus or car is a dangerous place to be in severe weather.

In your **motor vehicle**, leave it for safe shelter if possible. As a last resort, lie in a gully or ditch and protect your body or head with anything available. Do not stay in the vehicle. Never try to outrun a tornado. Do not search out a highway overpass; it can be a collection area for tornadic debris.

In a **store** or **mall**, go to a designated shelter or restroom if possible. The four inner walls and plumbing of a restroom offer greater safety than long-span buildings whose roof structure is supported solely by outside walls. If there is not time to go to a safe place, move to the center of the lowest level of the building, away from windows, and lie flat. Try to get under something that will support or deflect falling debris.

In the **open**, lie flat in a nearby ditch or low spot on the ground. Cover your head with your hands as you lay face down to protect against flying debris. However, be alert for possible rapidly rising waters.

Who's most at risk from tornadoes? The answer is people in mobile homes and automobiles. Mobile homes are quite vulnerable to high winds, and even mobile homes that are tied down cannot withstand the force of tornadic winds. If you live in a mobile home community, make arrangements to stay with friends or family who have basements. Put your plan in action when a tornado watch is issued.

There are several misconceptions regarding tornado safety. Below are a few common tornado myths versus facts.

MYTH... The southwest corner of a building is the best place to be during a tornado.
FACT... Stay away from outside walls. The southwest corner offers less protection than a small room in the middle of the house.

(continued on page 4)

MYTH... Windows should be opened to equalize pressure and minimize damage.
FACT... Avoid windows. Flying glass can injure or kill. Houses do not explode and opening windows allows damaging winds inside.

MYTH... Areas near rivers, lakes, and mountains are safe from tornadoes.
FACT... No place is safe from tornadoes. The 1974 Brandenburg, Kentucky tornado crossed the Ohio River.

MYTH... Highway overpasses are safe tornado shelters.
FACT... A highway overpass is one of the worst places to be. It is a collection area for tornadic debris as well as a wind tunnel. Tornado winds squeezing under the overpass speed up by as much as 25 percent, e.g., 200 mph tornado winds could blow at 250 mph through the overpass.

55 Year Co-Op Observer Passes Away

If there ever was a dedicated cooperative (co-op) observer, it was Floyd Gray. As a boy, he dreamed of having his own weather station. Since there was already a co-op observer in Scottsburg, Indiana, he made his own cotton region shelter and obtained a rain gage so he could take observations. He did this for 11 years. When the co-op observer passed away, Floyd took over the official position. He never forgot those 11 years. When he was given his 45 year length of service award he joked, "You know, I've really been doing this for 56 years."

We know quite a lot about Floyd because when documenting the coveted Jefferson Award, the most prestigious award given to any co-op observer (only 5 observers are granted this award in the nation each year), letters from several individuals were received by the NWS concerning his character and accomplishments. Floyd was well deserving of the award. He had previously received the John Campanius Holm Award, the second most prestigious award for co-op observers.

Floyd did not have a notable position in life, never married, and never drove a car. He bicycled or walked wherever he went and was a God fearing man. He was a good gardener, loved Kentucky Fried Chicken, and lived in a very modest house in town. Many people knew him because his weather data was published in the local Scottsburg newspaper, and for 20-30 years he sold popcorn outside of the sale barn where auctions were held on Saturdays.

Floyd published a book about the weather over a 2 ½ year period in Scottsburg. He could recite from memory numerous weather events on specific dates. He particularly enjoyed talking about the heat waves of 1934 and 1936 (as well as other times). On August 8, 1992 Floyd measured over 10 inches of rain in a 10-hour period. Water closed Interstate 65 for several hours with severe flooding in the Scottsburg area. When something as historical as a 10-inch rain occurs, it's nice to know the observer is dependable.

He was about 70 years old when he was trained to put observations into an automated computer system using a telephone. He caught on very quickly. From that time on, the daily report was in the computer database at 8 AM everyday, 7 days a week.

Floyd was a quiet, reserved, and humble man. If you didn't initiate the conversation, there wouldn't be one. But if you talked with Floyd, you'd find him interesting and informative. Everyone that knew Floyd (and many did) had good things to say about him. In recent years, his right knee and back gave him problems so he was unable to get around town very well, but his observations were as good as ever.

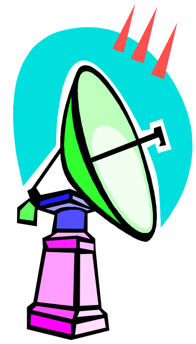
In his simple, down-to-earth manner, Floyd was someone to be respected. He had a sport coat with all of his NWS Length of Service pins on it. They were lined up on the lapel, 10, 15, 20, 25, 30, 35, 40, 45, and 50 years. Each time we gave him an award, he would proudly wear his jacket with the pins. In 1996, he was given the Stoll Award for 50 years as a co-op observer. Floyd took over 23,000 weather observations in his career. And to think, all of this as an unpaid volunteer!

In early 2001, Floyd's health deteriorated, and he moved into the nursing home in Scottsburg. The co-op station moved with him, and he continued to take daily observations. Sadly, Mr. Floyd Gray, the observer at Scottsburg for more than 55 years, passed away in his sleep on May 9. Mr. Gray had last reported to the NWS Louisville office on May 7. Mr. Gray, we thank you for your dependable, dedicated service to your community. You will be missed. God bless, may you rest in peace.

The Science Corner

by Ted Funk, Science and Operations Officer

Editor's Note: *This is the second installment of "*The Science Corner*," a more scientific and technically-oriented article than the remainder of the newsletter. Comments and suggestions are always welcome! Thank you.*



Nature's Fury: The Structure and Dynamics of Supercell Thunderstorms

Although less common than other convective storm types, supercell thunderstorms are perhaps the most violent of all types, capable of producing damaging winds, very large hail, and weak-to-violent tornadoes. They are most common during the spring across the central United States (but can occur anytime and anywhere, including the Ohio Valley) when moderate-to-strong atmospheric wind fields, vertical wind shear (change in wind direction and/or speed with height), and instability are present. The degree and vertical distribution of moisture, instability, lift, and wind shear have a profound influence on convective storm type, including supercells, multicells (such as squall lines and bow echoes), ordinary/pulse storms, or a combination of storm types. Once thunderstorms form, small/convective-scale interactions also influence storm type and evolution.

Supercells are not defined by their depth or volume, and include the variations "classic," "miniature/low-topped," "high precipitation (HP)," and "low precipitation (LP)." Instead, the supercell class of storms is defined by a quasi-steady, strongly rotating updraft (i.e., mesocyclone) which promotes storm organization, maintenance, and severity.

Supercell Dynamics/Environmental Factors

The interaction between updrafts and downdrafts and the vertically-sheared environment strongly controls the degree of convective organization and severity. Supercells are associated with moderate-to-strong deep-layered (0-6 km) vertical wind shear and moderate-to-high convective available potential energy (CAPE, i.e., instability). Strong 0-6 km wind shear (at least 40 kts) and CAPE (2000 J/kg or more, but lower for miniature storms) can result in significant updraft rotation (mesocyclone) in the storm, and lead to internal dynamic processes that affect the evolution, strength, longevity, and motion of the supercell. As a result, the storm likely will produce large hail and damaging winds. However, this does not guarantee the development of tornadoes, which are related to dynamical forces and low-level processes, as described below. Dynamical processes within supercells can create a steady-state, vertically-tilted system, allowing it the potential to continue well into the night despite the loss of heating, weaker instability, and dissipation of ordinary cells.

Tornado Mechanisms

Nearly all supercells produce some sort of severe weather (large hail or damaging winds) but only 30 percent or less produce tornadoes. Thus, it is crucial to be able to differentiate between tornadic and non-tornadic supercells. Tornado development is dependent on the storm's dynamical nature and strength of the mesocyclone. However, tornado formation appears to be related to low-level processes, including the amount of 0-2 km shear, storm-relative inflow, and convergence into the storm, and the effect of low-level boundaries. Such boundaries, sometimes visible on satellite and Doppler radar, help focus this inflow and convergence, creating a horizontally rotating axis of air that tilts vertically and rapidly accelerates into the storm's updraft as the mid-level mesocyclone dynamically "sucks up" low-level air. This can result in a more prominent low-level mesocyclone and tornadogenesis.

Radar Reflectivity Signatures

A schematic of a typical classic supercell at different levels in the atmosphere is shown in Figure 1, while Figure 2 shows a vertical cross-section of the supercell (along line C-D in Figure 1). For classic supercells, a **low-level pendant** or **hook echo** often is present on the right rear side of the storm (Figure 1). Within the hook, a **weak echo region** (**WER**) signifies the location of a strongly rotating updraft (mesocyclone). The hook is formed through the interaction of the forward flank and rear flank downdraft boundaries within the updraft area. The maximum reflectivity core, producing very heavy rain and large hail, usually is located just north and/or east of the WER. Above the WER, a persistent **bounded weak echo region** (**BWER,** i.e., donut hole) may be present at higher altitudes (Figures 1 and 2), indicating the location of the rotating updraft. High reflectivity often caps off the BWER above it. The top part of the storm (echo top) is shifted (tilted) over the low-level reflectivity gradient or the WER with significant anvil debris clouds extending downwind. Also, a **V-notch** or **enhanced V** severe signature may be evident in the downwind (weaker) portion of the low-level reflectivity pattern (Figure 3), indicating blocking flow aloft as some environmental air moves around the storm.

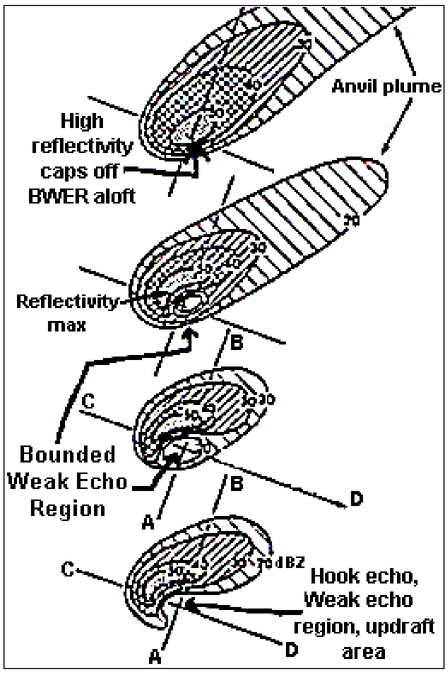


Figure 1 (left): *Plan view drawing of a typical classic supercell as viewed in radar reflectivity data. Bottom (top) picture represents low-level (upper-level) reflectivity.*

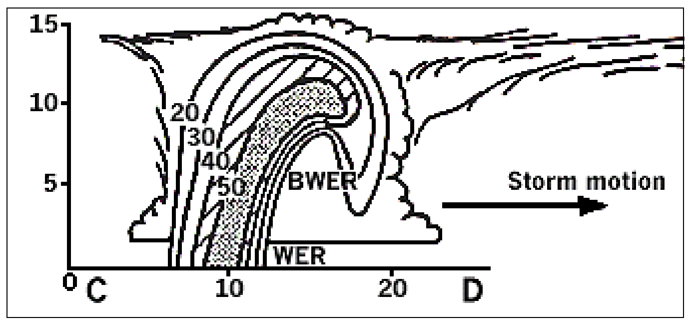


Figure 2 (right): *Vertical cross-section of a typical classic supercell along line C-D in Figure 1. The x-axis (y-axis) is horizontal (vertical) distance in km. Reflectivity values in dBZ are shown within the storm. The low-level WER, elevated BWER, echo overhang, and downwind anvil debris clouds clearly are evident.*

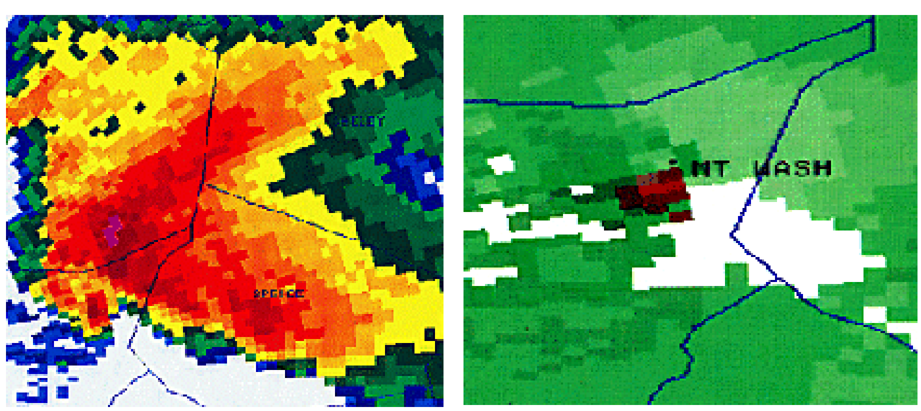


Figure 3. *Corresponding WSR-88D Doppler radar reflectivity (right) and storm-relative velocity (far right) images of a large supercell over north-central Kentucky on May 28, 1996. In reflectivity, dark red color represents very heavy rain and hail. A hook echo appears on the southwest flank of the storm, coincident with a tornado on the ground at this time, as evident near Mt. Washington in velocity data (red-green couplet). The area of light green color northeast of Mt. Washington represents strong low-level storm-relative inflow along the front flank downdraft boundary directed into the hook and mesocyclone area. This inflow apparently enhanced and maintained the tornado near the hook echo. Finally, a V-notch is evident in reflectivity data northeast of the hook.*

Heavy Precipitation (HP) Supercells

HP storms exhibit similar features as classic supercells. However, the low-levels frequently show a broad reflectivity pendent or front flank notch (i.e., kidney bean shape) on the leading edge of the storm, indicating the location of the WER and rotating updraft (Figure 4). Mesocyclones for HP storms may be embedded in heavy rain. HP supercells are not as isolated as "classic" storms, and may be embedded within organized squall lines. HP supercells occur in environments with rich low-level moisture and moderate-to-strong wind shear, and are a threat for tornadoes, large hail, damaging winds, and flash flooding. Classic and HP supercells sometimes can evolve into bow echoes as the rear flank downdraft or a rear inflow jet causes the storm to accelerate outward, resulting in a bowing storm with damaging straight-line winds (Figure 5).

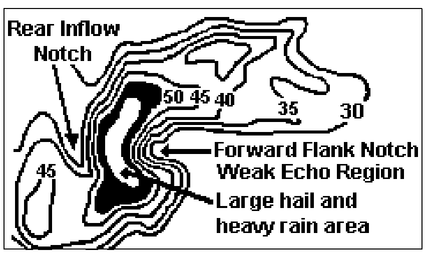
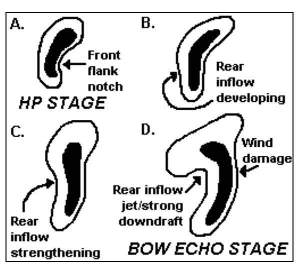


Figure 4 (left). *Low-level plan view drawing of an HP supercell. Numbers are reflectivity values in dBZ (highest values are shaped like a kidney bean). The mesocyclone usually is located in the weak echo region with large hail and the heaviest rain just behind this area.*

Figure 5 (right). *Low-level reflectivity drawing showing the transition that can occur from an HP supercell (sketch "A") to a bow echo (sketch "D") due to development of a strong rear inflow jet and/or rear flank downdraft.*



Mesocyclone Signatures

Supercell mesocyclones are solid body rotations associated with convective updrafts; they meet or exceed thresholds for shear, vertical extent, and persistence. Tornadoes are most likely during the period of maximum mesocyclone core strength. Mesocyclones with the smallest diameters and highest rotational velocities extending over a deep layer represent the greatest tornadic threat.

Mature idealized mesocyclones exhibit the following structure in WSR-88D storm-relative velocity data: **Low-levels:** Cyclonic (counter-clockwise) convergence (assuming the storm is close enough to the radar). **Mid-levels:** Pure cyclonic rotation (maximum inbound/outbound velocities are on neighboring radials at the same distance from the radar). **Upper-levels:** Cyclonic divergence. **Storm Top:** Pure divergence (maximum inbound/outbound velocities are along the same radial, i.e., updraft air is diverging and exiting out of the top of the storm).

Some supercells produce a single mesocylcone core; others produce a series of cores in a periodic fashion. The first mesocyclone core has a relatively long organizing and mature stage. However, subsequent cores (if any) can develop and mature much faster, resulting in a series of mesocyclones and possibly a family of tornadoes, given favorable low-level processes.

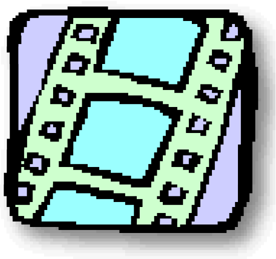
The **Tornado Vortex Signature (TVS)** is strong, tight shear associated with tornadic scale rotation that meets or exceeds established criteria for shear, vertical extent, and persistence. Identification of a low-level TVS suggests that a tornado may be occurring or may soon develop assuming a favorable reflectivity pattern. However, an identified TVS need not be present to issue a tornado warning.

Warning Guidance

Forecasters at NWS Louisville integrate as much data as possible when considering severe thunderstorm and tornado warnings, including 1) pre-storm and near-storm environment; 2) radar reflectivity structure and trends; 3) base and storm-relative velocity, including mesocyclone structure and trends; 4) other pertinent radar products; 5) storm-scale interactions causing cell and boundary mergers, enhanced shear and rotation, etc.; and 6) spotter reports.

A severe thunderstorm warning is issued anytime a supercell is identified. If a "moderate" or "strong" mesocyclone is indicated and is supported by favorable reflectivity structure and the presence of enhanced low-level storm-relative inflow, a tornado warning likely will be issued. Accurate, real-time storm spotter and public official reports are invaluable to the warning decision making process as well.

Request for Weather-Related Photos



Do you have any weather-related photos that you'd like to share with us here at the National Weather Service? We'd like to create a photo album of weather-related pictures taken across central Kentucky and south-central Indiana, to be used for training purposes during volunteer storm spotter training, and also to display on our web site.

Perhaps you've taken a picture of a fantastic sunset, or you've snapped a photo of a raging river or a flooded roadway. Did you get a shot of that huge snowdrift in your back yard a few years ago, or of the sagging trees during the ice storm last year? How about interesting, unusual, or remarkable cloud formations? Do you have any thunderstorm, tornado, or lightning images in your gallery? If so, we'd like to post them on our web site so that others may enjoy them as well. Each week, we'll post a new and exciting picture of an image that is local to central Kentucky or south-central Indiana.

You can email us your snapshots with descriptions, either black and white or color images to W-LMK.Webmaster@noaa.gov, or if you prefer, you can mail your pictures via regular mail to the National Weather Service, 6201 Theiler Lane, Louisville, KY 40229. We'll digitally scan them and send them back to you as quickly as possible. Did you recently purchase or receive a new digital camera? If so, this is perhaps the easiest and most efficient way to capture and email us your images. Do you have a digital scanner at home? If so, scan the pictures yourself at 72 dots per inch and email the images to us. We will provide full credit if your picture is used.

We look forward to viewing the exciting weather-related images that you may have taken, and are anxious to share them with others across central Kentucky and south-central Indiana! Don't delay, send us your photos today!

Weather on the Web

by Van DeWald, Webmaster

On January 1, 2001, the National Weather Service began offering a limited suite of WSR-88D Doppler radar products directly on the Internet, updated in real-time from all locations across the country. Previously, weather radar imagery was available for free through commercial web sites, but on a delayed basis, with updates 2 to 4 times per hour.

Check out the NWS Doppler radar web site at **www.crh.noaa.gov/radar.html**, where you will find links to any radar within the national network. Images are updated every 5 to 6 minutes, depending upon the operating mode of individual radars. Numerous products are available, including base and composite reflectivity, on both 124 and 250 nautical mile scales. Estimated one-hour and storm-total precipitation images also are available, along with one hour loops of both reflectivity and precipitation products. In the future, additional products will be added to the web site, including base and storm-relative velocity products and volumetric products as well.

Also, please do not forget to send us your storm reports. The National Weather Service in Louisville needs to know what is going on in your home town! We would like as much detail as possible, especially if you have experienced tornadoes, wall clouds, funnel clouds, high wind, wind damage, hail, lightning damage, heavy snow, sleet or freezing rain, heavy rain, flooding, dense fog, or any other unusual weather phenomena. This information is extremely important and will be used for verification and training purposes so that we may provide more accurate warnings and forecasts in the future. With all of the technology that we now possess, your reliable storm reports still are perhaps our greatest asset. You may call us with your report, email us, or submit it online at **www.crh.noaa.gov/lmk/storm_report.htm**.

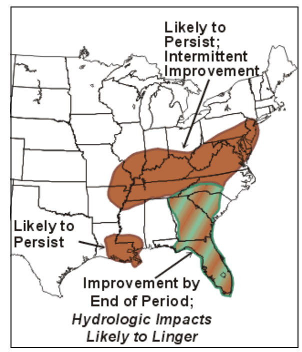
Our Mission: The National Weather Service provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community.

It is accomplished by providing warnings and forecasts of hazardous weather, including thunderstorms, flooding, hurricanes, tornadoes, winter weather, tsunamis, and climate events. The NWS is the sole United States OFFICIAL voice for issuing warnings during life-threatening weather situations.

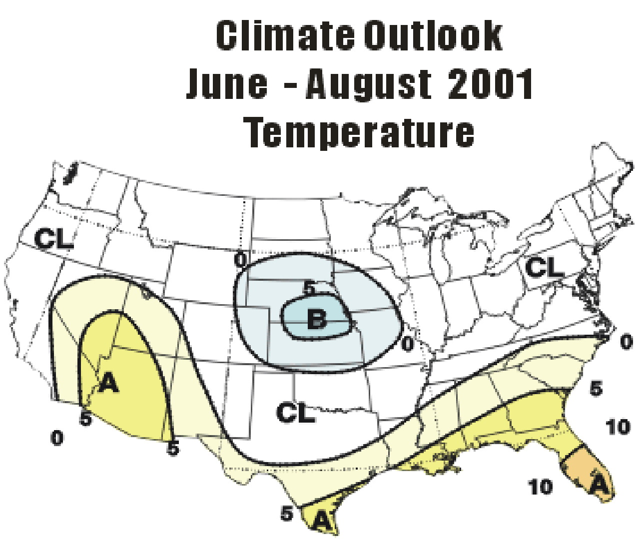
Climatological Overview

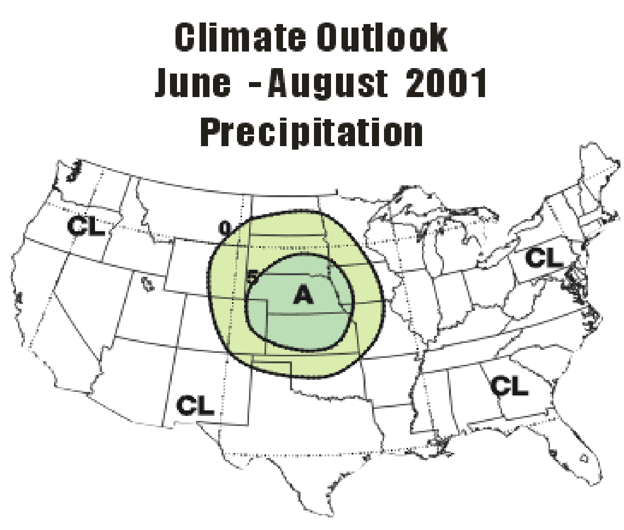
The Summer 2001 outlook shows little relief for the moderate drought in our region, however intermittent improvement may occur with near-normal precipitation across the lower Ohio Valley. Above normal rainfall is forecast for the Midwest states.

NOAA's climate specialists base the summer outlook on statistical and dynamic models, which include soil moisture content and long-term trends. "Currently, the tropical Pacific Ocean temperatures are near normal," said Vernon Kousky, a CPC specialist. NOAA's scientists indicate the possibility of a weak-to-moderate El Niño event in the late fall or next winter.



Drought Conditions June - August 2001





A = Above Normal CL = Climatology B = Below Normal

	Normal High/Low Temperatures				Normal Monthly Precipitation			
Location	**June 1**	**July 1**	**August 1**	**September 1**	**June**	**July**	**August**	**September**
Louisville	80/59	86/66	87/67	84/63	3.46"	4.51"	3.54"	3.16"
Lexington	79/58	85/65	86/66	82/62	3.66"	5.00"	3.93"	3.20"
Bowling Green	82/59	88/66	89/67	85/63	4.17"	4.74"	3.51"	3.72"

Astronomical Calendar

Moon Phases

Month	**New Moon**	**First Quarter**	**Full Moon**	**Last Quarter**
June	June 21	June 28	June 6	June 14
July	July 20	July 27	July 5	July 13
August	August 19	August 25	August 4	August 12
September	September 17	September 24	September 2	September 10

Sunrise / Sunset

	Louisville		**Lexington**		**Bowling Green**	
Date	**Sunrise**	**Sunset**	**Sunrise**	**Sunset**	**Sunrise**	**Sunset**
June 1	6:21 AM EDT	9:01 PM EDT	6:17 AM EDT	8:55 PM EDT	5:28 AM CDT	8:00 PM CDT
July 1	6:24 AM EDT	9:10 PM EDT	6:19 AM EDT	9:05 PM EDT	5:30 AM CDT	8:09 PM CDT
August 1	6:46 AM EDT	8:52 PM EDT	6:41 AM EDT	8:47 PM EDT	5:51 AM CDT	7:53 PM CDT
September 1	7:13 AM EDT	8:12 PM EDT	7:08 AM EDT	8:07 PM EDT	6:17 AM CDT	7:14 PM CDT

Summer Solstice (Start of Summer): June 21 at 3:38 AM EDT (2:38 AM CDT)
Aphelion (Earth closest to Sun): July 4

DOC/NOAA/National Weather Service
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