The Newsletter of the National Weather Service in Green Bay, Wisconsin

www.crh.noaa.gov/grb

Packerland Weather News

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Inside this issue:

Tornadoes Rip Across State

Sixteen tornadoes struck Wisconsin during the evening of June 23, the largest outbreak of twisters to hit the state since June 8, 1993, when 18 tornadoes occurred. The strongest tornado in the state hit the city of Markesan in Green Lake County, where sadly, one person was killed. The storm was rated F3 on the Fujita damage scale, with winds estimated near 200 mph (see story on Fujita scale on page 2).

Five twisters affected the NWS Green Bay forecast area, producing nearly $8 million in damage. Ground surveys by NWS Green Bay meteorologists revealed one F2, two F1, and two F0 tornadoes. The hardest hit locations in the NWS Green Bay forecast area included rural sections of southeast Portage and southwest Waupaca counties, and the cities of Little Chute and Kaukauna in Outagamie County. Several homes and businesses sustained significant damage, some livestock were killed, semi-trailers were upended, 75 feet of asphalt was scoured off a road, many trees were snapped or uprooted, and debris was strewn for miles around. Thankfully, no one was killed or injured.

Volunteer severe storm spotters were instrumental in providing real-time information to the NWS Green Bay office during the storms. The spotters relayed reports of tornado locations and damage as the storms moved across the region. Without the reports from storm spotters, severe weather warning decisions would have been more difficult.

The severe thunderstorms that produced the twisters developed ahead of a deepening low pressure system and strong cold front, which moved east quickly across the region. The supercell thunderstorms that spawned the tornadoes in central and east-central Wisconsin were embedded in a line of storms which also produced hail and straight-line wind damage. Storm damage across the entire state will likely exceed $20 million.

The Kaukauna (Outagamie County) tornado, photographed at about 9:00 pm. Photo by Jeff Vandeleygraaf.

More information on this event is located on the NWS Green Bay web site:

www.crh.noaa.gov/grb

Comments or Suggestions?

If you have any suggestions for articles or have comments about the ***Packerland Weather News***, feel free to contact us at:

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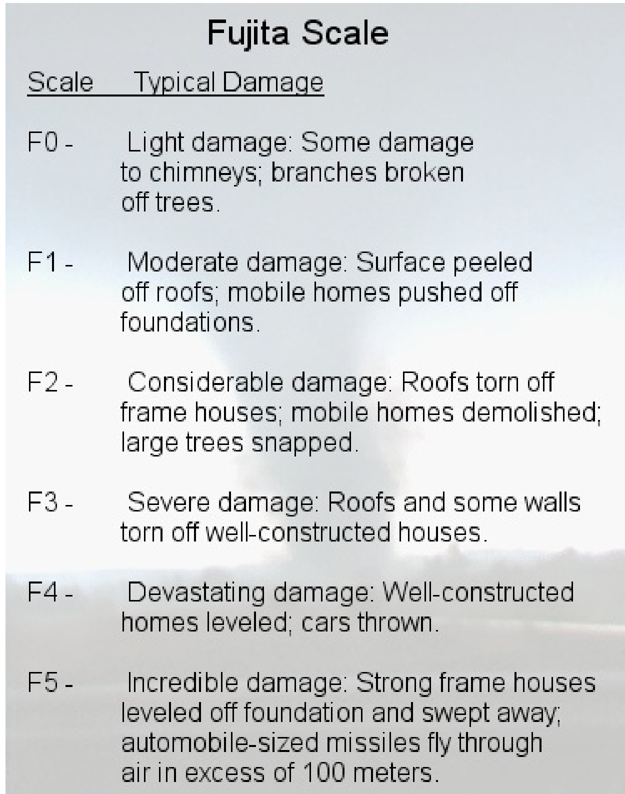
Determining Tornado Strength—The Fujita Scale

By Jeff Last, Warning Coordination Meteorologist, NWS Green Bay



Tornadoes are among the most violent storms on earth. Strong twisters can flatten brick buildings, toss cars and trucks like toys, and scour asphalt down to the underlying dirt. Wind equipment cannot sustain the force of a violent tornado, so meteorologists and researchers use the Fujita Tornado Damage Scale (F-scale) to estimate the intensity of the storm.

The F-scale ranges from 0 to 5, and is based on the amount of damage to structures. It was developed by Dr. T. Theodore Fujita in 1971, as a means to classify tornado intensity.

In Wisconsin, on average, about 80% of tornadoes in any given year are rated F0 or F1 (also known as "weak" tornadoes). F5 twisters are rare in Wisconsin. The last F5 storm to strike the state was on July 18, 1996, when the small town of Oakfield (Fond du Lac County) was hit. Across the U.S., F4 and F5 tornadoes ("violent" tornadoes) make up only about 1% of all twisters annually.

Was it a Tornado or Straight-Line Winds?

Determining whether a tornado or straight-line thunderstorm winds, or both, impacted an area can be a challenging task. National Weather Service staff and local emergency management officials survey damaged areas and attempt to determine exactly what happened when thunderstorms move through. In many ways, it is like a detective going in after the event, using clues and evidence left over by the storm to piece together what caused the damage, and estimate how strong the storm was. Sometimes it is a relatively easy task; many times it is not.

After a significant storm event, the NWS will dispatch a storm survey team. The team is usually comprised of two or three people, including a team leader that is experienced in conducting damage surveys. The team brings along many tools to help in the investigation. A survey kit, including detailed maps, a digital camera, tape measures, and a compass, is among one of the most important items taken to a site.

At the damage site, team members will talk with storm victims, take dozens of photographs, and take notes on everything they see. For example, the appearance of the damage, the trajectory of the debris, and the quality of the construction are all important in determining what caused the damage, and how strong the winds were.

Upon returning to the office, the team meets with other experienced storm survey staff members to discuss their findings. After careful analysis of the evidence gathered during the survey, a thorough review of radar data, and a review of eyewitness accounts, a determination is made as to what happened. The final determination can take several days following a severe weather outbreak.

Spring Flooding Across Northeast Wisconsin

By Roy Eckberg, Forecaster, and
Tom Helman, Senior Forecaster
NWS Green Bay

Two significant flooding events occurred in northeast Wisconsin this spring, causing damage to hundreds of homes and businesses.

Fifteen to 30 inches of snow remained on the ground over northern Wisconsin at the beginning of the third week of March. As warm air and rain surged north into the state, a significant snow melt occurred, beginning what would be a long spring flood season in Wisconsin.

Up to an inch of rain fell during the last week of March, increasing the flood potential. On March 28, the combination of rapid snow melt and rainfall produced a flash flood in the city of Antigo. Nearly 100 homes and 32 businesses were affected by the flood. Damage was estimated at $1 million in the city. Nearby Marinette County also experienced flood damage to roads and a few homes and businesses.

Heavy rains occurred across the southern half of Wisconsin in May. Record rainfall was reported across Winnebago County during the month. The Oshkosh airport received 9.26 inches of rain, a record for the month. The record rainfall pushed the Fox River to near flood stage during the month.

On the morning of June 11, a band of heavy rain set up across central and south-central Wisconsin, with the heaviest rain across Winnebago and Waushara counties. In Oshkosh, 3.20 inches of rain was recorded on the 11th, with a three day total (June 10-12) of 4.48 inches. The heavy rains resulted in hundreds of flooded basements in Oshkosh, while several businesses reported significant flood damage. Sawyer Creek also went out of its banks, flooding homes along the raging creek.

The heavy rains of May and June caused the Fox River from Berlin (Green Lake County) to Omro (Winnebago County) to flood. The river remained above flood stage into early July. Locations between Eureka and Omro were especially hard hit. Several homes in the Eureka and Omro area were inundated, while the city park in Omro was under water. The high waters even over-topped the Eureka Dam near Eureka.

Estimates on the flood damage will likely exceed $1 million in Winnebago County alone.

Severe flooding in Antigo on March 28. The white area on the river is ice floating on the flood waters. Photo courtesy Langlade County Emergency Management.

Flooding at the park in Omro in mid-June. Photo courtesy Omro Chamber of Commerce.

The Cooperative Observer Corner

By Pat Hein, Hydrometeorological Technician,
NWS Green Bay

Which program is better to transmit volunteer weather observations – *WxCoder* or *WxCoder II*? Cooperative Observer Program (COOP) Manager Pat Hein has been gradually moving all COOP observer sites over to *WxCoder II*. The main reason for observers to migrate to the newer version is that *WxCoder* will be taken off-line at the National Weather Service's regional headquarters on September 1. Switching programs is not always a welcome change. However, *WxCoder II* does have improved features, with more promised in the future. Any COOP observer still using *WxCoder* that would like to try the newer version now should contact Hein via e-mail at pat.hein@noaa.gov. All that is needed is the COOP observer's e-mail address that will be used in transmitting observations; Hein will take care of the set up.

As dedicated as the National Weather Service's COOP observers are, occasionally they may have to miss days due to vacation or illness. A frequently asked question is how to complete the B-91 or E-22 forms for missed days. The best way to handle this is to reset the Max/Min Temperature System (MMTS) and line through the days that were missed. Temperatures should not be entered. For precipitation, a diagonal line should be drawn through the precipitation columns and the total precipitation for the period should be entered. (This is the total amount of precipitation from the 8-inch gage.) Snowfall should not be included unless the amount of snowfall is known (for example, from a neighbor). Better yet, observers can ask a neighbor or relative to take the temperature and precipitation readings while the observer is away.

Thanks to our COOP observers for the many hours volunteered throughout the year.

On the Web

www.crh.noaa.gov/grb/coop.html

Severe Weather Season is Upon Us

The recent outbreak of tornadoes is a vivid reminder that Wisconsin is not immune from significant severe weather. It's never too late to prepare for severe summer storms.

Each year across the U.S., many people are killed or seriously injured by tornadoes and severe thunderstorms despite advance warning. Some do not hear the warning, while others receive the warning but do not believe it will happen to them. Preparing before the storms strike could save your life.

Here's what you can do before severe weather hits:

- Develop a plan for you and your family at home, work, school, and outdoors.
- Identify a safe place to take shelter.
- Have frequent drills.
- Know the county name in which you live or visit.
- Keep a highway map nearby to follow storm movement from weather bulletins.
- Have a NOAA Weather Radio with a warning alarm and battery back-up.
- Check the weather forecast before leaving for extended periods outdoors.
- When going outdoors, bring along a portable weather radio. Watch for signs of approaching storms.

When conditions are favorable for severe weather to develop, the National Weather Service issues a severe thunderstorm or tornado WATCH. When a watch is issued, keep an eye to the sky and stay tuned to weather radio or local media for weather updates. When severe weather begins to develop, WARNINGS are issued to alert the public and emergency officials. When a warning is issued for your area, put your emergency weather plan into action.

On the Web

www.crh.noaa.gov/grb/prep.html

Winter 2003-04: Mild Start, Cold in the Middle

By Roy Eckberg, Forecaster,
NWS Green Bay

Little snow fell during the fall (September through November), and this trend continued through the first week of December. The first widespread winter storm of the season moved across the area on December 9 and 10. Snowfall totals of 4 to 8 inches were reported north and west of a line from Wautoma to Marinette, with amounts around 10 inches along the Michigan border across Vilas, Florence, and Forest counties. Rhinelander recorded 5.5 inches and Wausau 5.1 inches on the 10th. From Green Bay and Oshkosh east to the lake, temperatures were warm enough to limit snowfall totals to a few inches, with little or no accumulation along the lakeshore. The remainder of the month was relatively quiet with no significant winter storms.

During December, only one true arctic intrusion made its way across the entire region. Rhinelander bottomed out at -13 F on the 12th, Wausau at -5 F on the 13th, and Green Bay fell to 3 F on the 12th. The latter half of the month was mild with highs in the 20s and 30s over the north, and 30s and 40s across central and east-central Wisconsin. For the month, December ended up being very mild, with Green Bay 6.8 F above normal, Wausau 5.7 F above normal, and Rhinelander 5.0 F above normal. Precipitation was near normal for the month while snowfall totals were at or below normal. It should be noted that Green Bay experienced a "brown Christmas" as only a trace of snow was on the ground Christmas morning.

In January, several winter storms hit the region. On the 14th, snowfall totals of 4 to 8 inches were reported in the north with Rhinelander reporting 5.5 inches. Another winter storm on the 26th brought 6 to 10 inches of snow over eastern Wisconsin. Some snowfall totals included: Ephraim 10.5 inches, Marinette and Baileys Harbor 8.5 inches, Two Rivers 7.5 inches, and Bellevue 5.8 inches. Unlike December, January was very cold. From the 18th to 31st, Green Bay, Rhinelander, and Wausau reported temperatures at or below zero during most of the period. One of the coldest arctic air masses in several years was felt on the 22nd, as Green Bay recorded a high of 0 F and Wausau and Rhinelander only reached -6 F. For the month, Green Bay averaged 3.4 F below normal, Wausau 3.8 F below normal, and Rhinelander 4.2 F below normal. Snowfall for the month was above normal.

Frequent snowfalls were recorded during February, as well. Two of the more significant snowstorms to hit the region occurred on February 5-6 and 19-20. The first snowstorm in February brought snowfalls of 4 to 8 inches for locations southeast of a line from Wisconsin Rapids to Wausaukee. There were local snowfall totals of 8 to 10 inches across northern Door County and along the bay in Marinette and Oconto counties.

The snowstorm on the 19th and 20th was an extremely difficult storm to forecast, as there was enough warm air in place to change the precipitation over to rain south of a Green Bay to Wausau line. This scenario did develop, as snowfall amounts of 6 to 10 inches were reported over the north, while central and east-central Wisconsin reported a snowfall of 1 to 4 inches. For example, totals varied greatly across Door and Marathon counties. Across these two counties, snowfall of 6 to 8 inches was reported over the northern portion of the counties, while only an inch or two was reported over the southern sections. Overall, snowfall for February was above normal across much of the area. Rhinelander recorded 24.5 inches, Wausau had 23.6 inches, and Green Bay reported 16.6 inches.

For the winter of 2003-04, average temperatures were about a degree above normal. Snowfall was above normal for locations west and north of Green Bay and the Fox Cities, while locations from Green Bay and the Fox Cities east to the lake were several inches below normal.

Radar Enhancements Aid Forecasters

By Phil Kurimski, Forecaster,
NWS Green Bay

Last summer, forecasters got a taste of higher resolution radar data that aided in the warning decision making process. The high resolution radar products (also known as "8-bit") contain 256 data levels. These replaced the older, 16 data-level version of the radar products. The high resolution data allows forecasters to pick out subtle features in reflectivity and velocity data which can lead to earlier warnings. An example of the new high data level resolution reflectivity product is pictured in Figure 1, and the older, low resolution image in Figure 2. Notice how the high resolution product highlights the strongest part of the storm better than the low resolution data. Researchers and meteorologists will have access to the raw, high-resolution data from the entire national network of NEXRAD Doppler weather radars via high-speed Internet2 and commercial Internet this year. Due to their size, however, the high resolution images will not be made available on the NWS radar web pages anytime soon.

Additional radar volume coverage patterns (VCP) were implemented in June. Previously, VCP 11 was the fastest coverage pattern, completing a scan in five minutes with 14 elevation angles (Figure 3). The new VCP 12 will complete a scan in 4.1 minutes, with more slices in the lower levels of the atmosphere (Figure 4). The faster VCP will allow radar meteorologists to receive radar scans more often and at higher vertical low-level resolution. The increased resolution in the lower levels of the atmosphere could lead to earlier warnings, as downbursts and tornadoes may be seen as they descend down through the storm.

VCP 121 is another new volume coverage pattern. It uses the same angles as the current VCP 21, but completes a scan in five minutes instead of six minutes. This VCP is useful for hurricanes and squall lines when velocity data is more difficult to compute. Like all VCPs, radar products from new VCPs 12 and 121 will be available on the Internet.

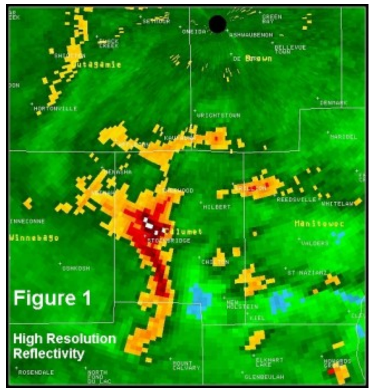
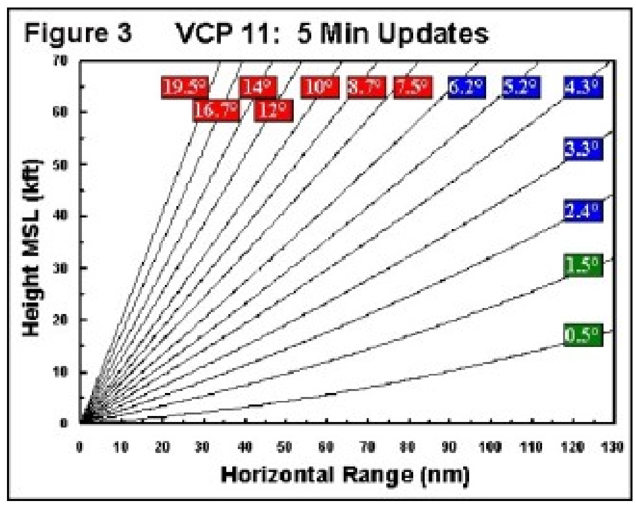
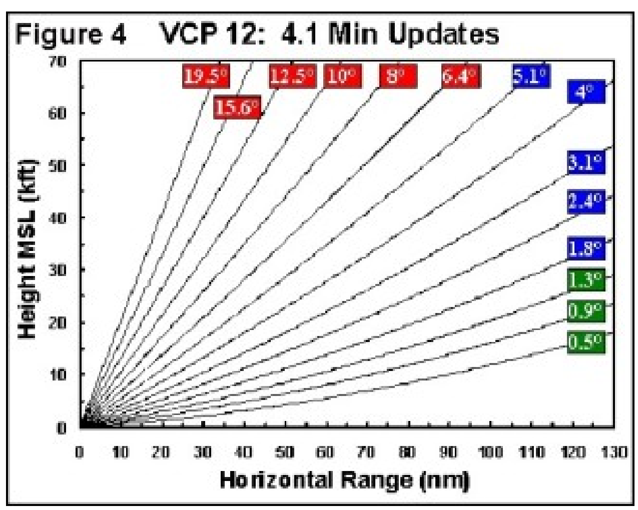


Figure 1. High resolution reflectivity image. Note enhanced detail of thunderstorm.

Figure 2. Low resolution reflectivity image of same storm.





Very Wet Spring Across Northeast Wisconsin

By Roy Eckberg, Forecaster,
NWS Green Bay

The spring of 2004 was one of the wettest in Wisconsin weather history. During March and April, the spring rain and snow was heaviest across central and north central Wisconsin, while the heavier rains shifted to east central Wisconsin in May.

In March, winter made one last stand on the 22nd. Rhinelander plummeted to -8 F and Wausau fell to 3 F. Several days later, the first 60 degree readings of the season were reported across east-central Wisconsin, with Appleton reporting 61 F, Green Bay 63 F, and Manitowoc 68 F. Temperatures for the month averaged 1.5 F to 4.0 F above normal.

Precipitation for the month averaged an inch or two above normal while snowfall was significantly above normal across central and north-central Wisconsin. Between the 5th and 7th, two winter storms hit northern Wisconsin, bringing over a foot of snow to the area. Snowfall totals for the month of March were generally from 20 to 30 inches north of a Wausau to Marinette line.

Location	March Snowfall
Goodman	30.0
Laona	29.9
Florence	26.0
Eagle River	25.7
Wausaukee	25.0
Lakewood	21.5
St. Germain	21.0
Wausau	20.2
Rhinelander	19.0

The significant snows of March and additional rainfall in early April led to flooding across northern Wisconsin through the middle of April. Temperatures in the 70s returned to the area on the 15th and 16th, with another mild spell at the end of the month. Readings on April 28 topped out at 81 F at Stevens Point, 79 F at Green Bay and Wausau, and 77 F at Rhinelander. For the month, temperatures averaged near normal over the north, and about a degree above normal over central and east-central Wisconsin. Precipitation was near normal over the north, and below normal over central and east-central Wisconsin.

In May, the weather pattern shifted as high pressure dominated the southeast United States. The shift in the weather pattern allowed for cold fronts to stall just south of Wisconsin, while areas of low pressure moved along the front bringing cloudy, cool, and wet weather to the region for most of May. When the front pushed far enough south, Canadian high pressure brought cold conditions to the region. On May 3, record lows were reported at many locations. Another cold spell on the 28th brought a late season frost or freeze across north-central Wisconsin. There were only a few days of warmth, with Green Bay topping out in the 80s on the 12th (83 F) and the 20th (82 F). As a matter-of-fact, temperatures averaged well below normal from the 21st through the 30th. High temperatures during these dates were well below the daily normal due to cloud cover, easterly winds, and rainfall.

For May, temperatures averaged 2 F to 4 F below normal. Green Bay recorded 8.31 inches of rain, which made it the second wettest May on record. The wettest May on record is 9.70 inches set in 1918. Records for Green Bay date back to September of 1886. The rainfall total of 9.26 inches at Oshkosh made it the wettest May on record, smashing the old record of 7.35

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Very Wet Spring

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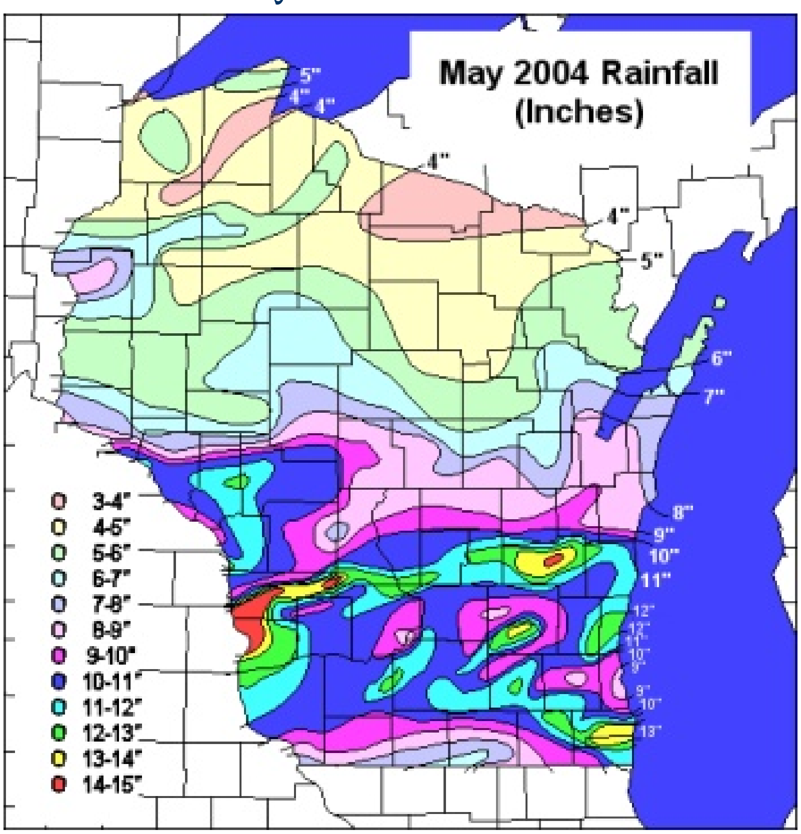
inches set in 1973. Records for Oshkosh date back to 1893. The table below lists rainfall totals for northeast Wisconsin locations for May.

Location	May Rainfall (Inches)
Brillion	9.88
Oshkosh	9.26
Wisc. Rapids	8.95
Appleton	8.92
Babcock	8.91
Stevens Point	8.76
Marshfield	8.66
Manitowoc	8.65
Green Bay	8.31

Overall, the spring of 2004 will go down in the record books as very wet with temperatures near normal. At Green Bay, the precipitation total of 13.45 inches made spring 2004 the 3rd wettest on record. The wettest spring was in 1918, when 14.12 inches fell. Temperatures averaged 0.7 F above normal, mostly due to cloud cover keeping low temperatures up at night. In Rhinelander, the total of 10.63 inches of precipitation made it the 7th wettest spring on record. Temperatures in Rhinelander averaged almost a degree below normal. It wasn't quite as wet in Wausau, but the total of 9.35 inches made it the 22nd wettest spring on record. Wausau's temperatures averaged about a half degree below the spring normal.

Wisconsin's May Rainfall



Rainfall in May was excessive not only in northeast Wisconsin, but across much of the state as well. Record amounts of rain fell in May across much of central and south-central Wisconsin. Mapping by Brian Hahn, Service Hydrologist, NWS Milwaukee/Sullivan.

First Tornado of 2004 in Manitowoc County

By Roy Eckberg, Forecaster, and
Gene Brusky, Science and Training Meteorologist
NWS Green Bay

Introduction

During the early morning of Sunday, May 23, 2004, a small but relatively long-lived bowing line segment developed over southwest Wisconsin shortly before midnight, then moved northeast across south-central and northeast Wisconsin during the subsequent six hour period. As the storm moved into northern Manitowoc County, it managed to produced a very brief tornado, rated F0, about three miles east of Reedsville, followed by some minor downburst wind damage. What made this thunderstorm rather unusual was that it was able to produce a brief tornado despite the fact that it was located above a very cool, deep and stable air mass nearly 200 miles north of a surface warm front. This discussion will simply provide a brief meteorological and radar overview of the event.

Synoptic Situation

Widespread severe convection broke out over the Central Plains during the early evening of May 22, 2004 and moved northeast into the upper Midwest and western Great Lakes region during the night. The storms broke out along and north of a surface warm front that stretched from a low in northwest Iowa, east across northern Illinois. Cool thunderstorm outflow associated with the widespread convection prevented the surface front from making much northward progress. The surface warm front remained south of the Wisconsin-Illinois border overnight. North of the front, northeast winds kept temperatures unseasonably cool with readings in the 40s and 50s; south of the front temperatures were mainly in the 70s. The 1100 UTC Rapid Update Cycle (RUC) forecast sounding located over central Calumet County indicated a deep easterly flow beneath the frontal inversion with the depth of the cool stable layer of about 4500 feet above the ground (Figure 1). Above the inversion, the elevated instability was not particularly impressive. However, there was considerable directional shear in the lowest 10,000 feet and substantial deep layer shear through 20,000 feet. Thus, despite the rather modest instability, the deep layer shear was substantial and supportive of maintaining strong updrafts.

The storm that produced the damage in Manitowoc County originated from a north-south line of convection that developed over northeast Iowa before midnight. As the convection moved northeast across southwest Wisconsin, it quickly evolved into several bowing line segments (Figure 2). Note also the small line of thunderstorms that extended east across southeast Wisconsin into southern Lake Michigan. This line of convection appeared to be associated with an 850 millibar (mb) warm front that was lifting north across this area. The northernmost bowing line segment (circled area) appeared to be moving northeast along the 850 mb front. Other than a report of wind damage in northern Grant County around 0735 UTC, no other severe weather was reported with this storm through 0943 UTC. It was not until the storm moved into northern Manitowoc County almost four

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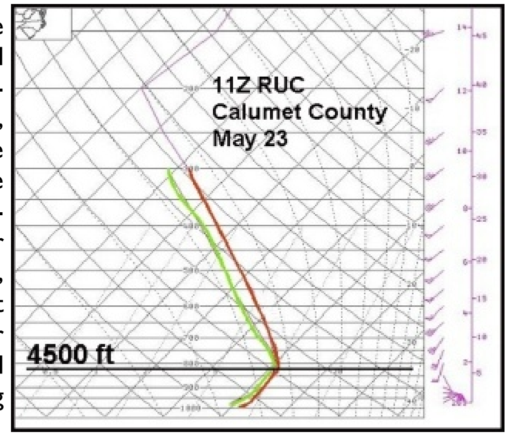

Figure 1. RUC sounding for Calumet County.

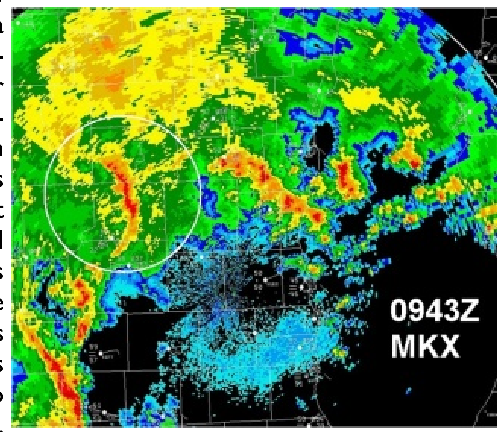

Figure 2. 0.5 degree reflectivity image at 0943 UTC. Circled area is bowing line segment over Marquette and Columbia counties.

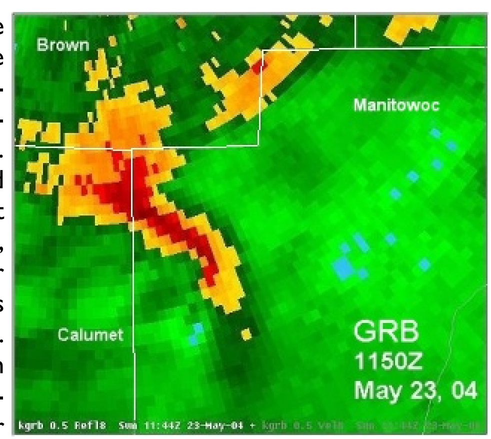

Figure 3. 0.5 degree reflectivity image at 1153 UTC.

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The ***Packerland Weather News***
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First Tornado of Season

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hours later that it produced a brief tornado near the city of Reedsville (Figure 3). Radar reflectivity data continued to show a bowing structure as it moved across northern Manitowoc County. The velocity data revealed some weak wind shear near the southern flank of the storm (not shown). However, with no severe weather reported with this storm over the last four hours, and the fact that the storm was located in a deep, cool, surface-based stable air mass, it seemed unlikely that this storm would be able to produce a tornado.

In fact, the storm did produce a brief tornado, along with some relatively minor downburst wind damage as it continued to move across the remainder of northern Manitowoc County during the next 30 minutes before finally weakening.

Summary and Conclusion

It was not clear why this storm did not produce damage over most of its path across southern and east central Wisconsin, but was able to produce a brief tornado just east of Reedsville where it appeared to be moving into an even cooler, more stable environment. It is possible that the storm's proximity to the strong 850 mb thermal contrast may have contributed to the brief tornadic spin-up in northern Manitowoc County.

This case illustrates a very challenging warning decision problem sometimes faced by forecasters. Even in strongly elevated environments (i.e, a very cool, deep surface-based stable layer) some storms can still manage to produce brief, weak tornadoes.