Volume 1, Issue 1 Fall 2008

A Newsletter from the Chanhassen Weather Forecast Office and the North Central River Forecast Center

Twin Cities Forecaster

Did You Know?

Folklore relates many stories regarding the origins of the Aurora Borealis, better known as the Northern Lights. Norwegians believed the lights were the spirits of old maids dancing and waving, while Finns attributed the lights to a magical fox sweeping snow into the sky with its tail. Aurora are actually caused by Oxygen and Nitrogen atoms in the atmosphere reflecting red, green, and blue light from the sun's particles that reach the earth on the solar wind.

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Proudly Presenting the *Twin Cities Forecaster*

The staffs at the Chanhassen National Weather Service Weather Forecast Office and the North Central River Forecast Center are proud to bring you the first issue of their brand new newsletter, the *Twin Cities Forecaster*. In each issue, the latest weather and hydrology news will be brought to you by the experts. We hope to include reviews of big weather and river flood events in the recent and not-so-recent past, discussions of issues pertinent to weather and river forecasting, cooperative observer and storm spotter information, and much, much more. We hope you, our customers, find our publication useful and informative!

Face Time with our Customers

By: Karen Trammell

The Chanhassen Weather Forecast Office, the North Central River Forecast Center, and their building mates, the National Operational Hydrologic Remote Sensing Center participated in two major outreach events during the late summer and very early fall: the Minnesota State Fair and the National Weather Service's Scout Day. Both events provided the opportunity to educate customers of all ages about our operations, safety, and general weather and hydrology.

The Minnesota State Fair; August 21st to September 1st

For the second straight year, the National Weather Service, in conjunction with the Minnesota Department of Homeland Security and Emergency Management, manned an informational booth in the Education Building during the 12 days of the Great Minnesota Get Together. The 2008 State Fair provided an ideal opportunity for thousands of customers to ask questions and learn more about NWS operations, as according to fair officials, almost 1.7 million people attended this year's fair.

Although the 2007 edition of the NWS fair booth was quite the hit with fairgoers, the 2008 rendition was even bigger and better. The booth showcased some familiar attractions, including internet ready computers to surf NWS websites, action-filled severe

See "Face Time" on Page 11.

Andrea Holz, hydrologist at the North Central River Forecast Center, talks with customers at the NWS booth at the Minnesota State Fair.

Meet Your Weather and Water Forecasters

Each issue of the *Twin Cities Forecaster* will profile one staff member each from the Weather Forecast Office and from the River Forecast Center. We hope you enjoy learning a little more about the people behind the forecasts.

Dan Luna, Meteorologist-in-Charge

Dan Luna is the Meteorologist-in-Charge (MIC) for the Twin Cities/Chanhassen National Weather Service (NWS) Office. As MIC, he directs the forecast, development and outreach activities for central MN and eastern WI. Dan has been the MIC for the last 2 years, and until August 2008, he was also the Hydrologist-in-Charge. Dan came to Chanhassen in early 2001 to assume that role. Dan has held a variety of NWS positions across the US: Science Officer in WV; Radar Instructor in Norman, OK; hydrometeorologist in Tulsa, OK; Agricultural Forecaster in CA. Prior to his experience at NWS offices, Dan worked for the Department of Defense in the cartography/hydrography departments. Dan is originally from Rockford, IL and received his degree in Meteorology from St. Louis University.

My vision for the office is to provide the very best in customer service and information to our diverse customer base. We have some of the brightest, most energetic, and capable meteorologists and hydrologists, and there are service and information opportunities that we are now embracing and this report will highlight a few of these. Our intent is to focus on what we call high impact events - events that impact the customers in a significant manner. Since you are a customer, I hope you will find our activities demonstrate the sort of stewardship you expect from your public servants. I welcome your comments and suggestions as to how we can improve our services and information.

Scott Dummer, Hydrologist-in-Charge

Scott Dummer is the Hydrologist-in-Charge of the North Central River Forecast Center (NCRFC). He came to the NCRFC after serving as the Western Region Deputy Chief of the Hydrology and Climate Programs, in Salt Lake City, working in that position since 2006. Prior to his time in Salt Lake City, Scott was the Service Hydrologist at the St. Louis, Weather Forecast Office for 6 years, worked as a Hydrologic Forecaster at the Missouri Basin RFC in Pleasant Hill, MO, and was a hydrologist intern at Central Region Headquarters in Kansas City, MO. He began his NWS service as a hydrology trainee at the NCRFC in 1993. Scott earned a Bachelor of Science in Meteorology from the University of North Dakota and a Masters of Science in Water Resources from the University of Kansas. He has been at the NCRFC since July.

A Look at Weather History: The November 10th, 1998, Land Hurricane

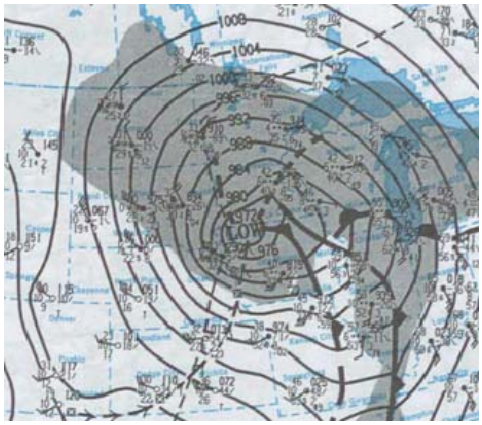
By: Anthony Zaleski

November 10th is an infamous date for citizens and mariners of the Great Lakes Region and one of intense fascination for meteorologists and other science buffs, as well. It is a date which is memorable for three significant storms, each separated from the other by decades, yet each producing significant damage and in some cases considerable loss of life.

The most recent of these historic storms occurred in the late fall of 1998. A major storm system developed over the Four Corners region of the United States on November 8th and marched rapidly eastward into the Oklahoma Panhandle by the morning of the 9th. By 10 am EST on the 9th, the storm had already deepened to a central pressure of 29.47 inches of mercury. Meteorologists expected the storm to deepen even further during the course of the next few days.

The storm moved quickly northeastward into Kansas and Iowa, and by the morning of the 10th, was observed over extreme southern Minnesota. The intense low pressure system then tracked across southern and central Minnesota, bringing heavy snow to portions of the West. Canby reported 13.5 inches of snow, accompanied by lightning and thunder. Madison recorded a solid 10 inches. Snowfall in excess of 5 inches occurred from Staples and Long Prairie, southward to Willmar and Granite Falls.

Strong winds followed the heavy snowfall, with wind gusts exceeding 60 mph in some western and central Minnesota locations. A gust of 69 mph was measured in Willmar, followed closely by 64 mph at St. Cloud State University, 62 mph in Mankato, and 61 mph in Madison. The strong winds blew a school bus off the road in Albert Lea, injuring two school children. Dozens of schools across the state were closed on the 11th. Interstates 35, 90, and 94 were closed for several hours due to blowing snow and or strong winds.



Surface weather map from the morning of November 10th, 1998.

A new all time Minnesota record low pressure reading was reached around the noon hour at both Albert Lea and Austin as the storm system passed overhead.

See "Weather History" on Page 9.

A Peek at Past Floods: September and October 1986

By: Dustin Goering

Hydrologists at the North Central River Forecast Center (NCRFC) often find themselves involved with flooding and potential flooding somewhere in its area of operations throughout the year. This workload is derived from the large areal extent the NCRFC is responsible for monitoring. Encompassing nearly 300,000 square miles and covering parts of nine states, the NCRFC issues river forecasts for over 400 points from Canada southward to near St. Louis, Missouri, and from the Dakotas eastward to Michigan.

Generally, meteorological conditions across the central United States change regularly due to easterly migrating low and high pressure systems. Conditions conducive to possible flooding often develop as these weather systems travel across the NCRFC's area. Fortunately, these conditions are often geographically limited and only a few of the NCRFC's sub-basins experience flooding at any one time.

However, there are plenty of examples in the past where abnormal meteorological conditions developed, resulting in prolonged heavy rainfall across a region causing widespread flooding. One particular devastating event occurred from mid September to early October 1986, affecting much of the central United States.

Meteorological Description...During the middle of September to early October of 1986 similar meteorological conditions combined across the central United States several times. A major upper level trough often setup just west of the Central Plains providing southwesterly flow into the plains states. Remnants of two tropical storms in the Pacific were transported northeastward, enhancing moisture in the region. A quasi-stationary surface front draped across the region acted as a trigger for diurnal storm development. Strong southerly low level winds that supplied additional moisture from the Gulf of Mexico were also often present.

This persistent setup resulted in 24-hour rainfall reports of least 2 inches somewhere in the central United States on 16 of the 24 days from September 10th to October 3rd. Many locations observed record amounts, with numerous reports of 8 to 10 inches in 24 hours. Some locations received over 20 inches of rain during the 4 to 5 weeks of flooding. This heavy band of rainfall occurred over a fairly wide area extending from eastern Kansas, through Missouri and northern Illinois, and across much of central lower Michigan.

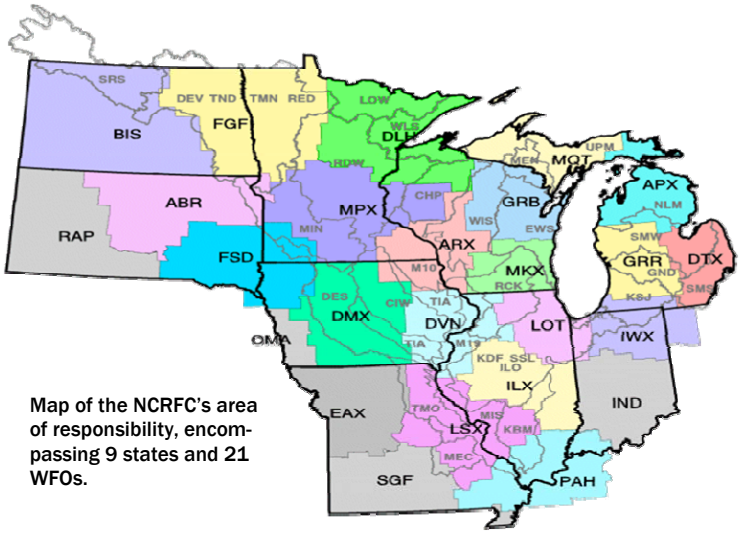
See "Flood History" on Page 10.

The Hydrologist's Corner: What Do We Do for You?

By: Bill Sites

The North Central River Forecast Center (NCRFC) is part of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS). The NCRFC is located in Chanhassen, Minnesota and has responsibility for preparing and issuing river stage and flow forecasts for the rivers, streams, lakes, and reservoirs in the Upper Midwest. It is one of 13 RFCs in the nation.

The NCRFC provides hydrologic forecasts and services to NWS Weather Forecast Offices (WFOs), federal and state agencies, such as the U.S. Army Corps of Engineers and U.S. Geological Survey, and private water resource organizations. These services are provided for sites within the upper Mississippi River, Great Lakes, and Hudson Bay drainage areas, which encompass a 9-state area, nearly 300,000 square miles, and 21 WFOs.



Map of the NCRFC's area of responsibility, encompassing 9 states and 21 WFOs.

River Models...River models are used to simulate water levels, water flow, and soil moisture conditions within the NCRFC region for up to 7 days into the future. These hydrologic models compute parameters for approximately 850 river basins, including about 400 official forecast points. The models use precipitation and temperature data from over 4,000 observation sites and predictions of precipitation amounts expected to fall over a specific area within a given time interval. Forecasts of future temperature conditions are also input into the models to determine the type of forecast precipitation and to calculate snowmelt runoff from winter snowpacks.

Products and Services...Hydrologic forecasts include forecasts of flood crests, daily stages and flows at selected locations, and long range (2 weeks) river stage predictions for navigation interests on the Mississippi. Spring Snowmelt Outlooks

See "Hydro Corner" on Page 9.

The Meteorologist's Corner: Forecasting Fog and Stratus and Its Impacts on Aviation

By: Mike Bardou

Weather has a significant impact on aircraft operations. Aircraft need sufficient visibility to be able to land and take off successfully. This visibility is not only the horizontal visibility that most of us think of but also the vertical visibility. More specifically, the base of the clouds, or ceiling height, needs to be a certain elevation above the ground for takeoff and landing. Aircraft and pilots require different minimum levels of ceiling height and visibility in order to operate. The minimum thresholds usually begin with cloud bases around 1,000 feet and visibility of around 3 miles and vary to as low as ceilings of 100 feet and visibility of 600 feet. Again, this is dependent on the aircraft equipment and pilot qualifications. Therefore, it is very important that pilots have the latest and the most accurate ceiling and visibility forecasts. NWS meteorologists forecast visibility and ceiling heights for hundreds of airports across the country. Forecasting these two elements is one of the toughest forecasts to make for even the most seasoned meteorologist.

Fog and low stratus clouds are the two main sources for reduced visibility and ceiling heights, with precipitation being the third. Fall, Winter, and Spring are the prime seasons for fog and low stratus development. A wide array of observed weather data from surface observation stations, radar, and satellites, as well as computer generated forecast guidance, are available to forecasters to supplement experience. Why are fog and stratus forecasts so difficult to make? It all starts with moisture.

Moisture is necessary to have cloud development. Moisture can be added and taken away by the ground or it can be brought in from surrounding areas. Transfer of air from near the ground to parts of the atmosphere well above the ground can affect the moisture content, as well. Forecast models have a very difficult time diagnosing and projecting moisture near the ground, thus their guidance can lead a forecaster astray. To account for this, the forecaster needs to recognize weather conditions and patterns that are favorable for the development of fog and low clouds.

There are several weather patterns that can lead to fog and low cloud development. Fog and especially low stratus will be common ahead of an approaching warm front to the northeast of the surface low pressure center. These warm fronts can move very slowly so it is not unusual to see the area socked in with fog and low ceilings for several days.

Another common setup seen across southern Minnesota and western Wisconsin involves having a high pressure system in the area during the overnight or early morning hours. High pressure results in light to calm winds and little if any cloud cover. The air can cool to the dew point very quickly, leading to very high relative humidity. As this occurs, fog can develop as the moisture in the air condenses, similar to what occurs when water droplets form on the outside of a cold glass on a warm day.

Low clouds, within a few hundred feet of the ground, can form in conjunction with or instead of the fog. While this may sound straightforward, just identifying these patterns is not a foolproof means of determining when reduced visibilities or ceilings will develop.

It is also very difficult to determine whether low clouds will develop instead of fog. If some wind is present, there may be a tendency for low stratus to develop instead of fog. With calm winds, fog is more likely but there will usually be a layer of stratus that develops within a few hundred feet of the ground.

The next big question is how dense the fog will get. The amount of moisture in the air tends to dictate this. If rain has fallen in the previous day or so, there is extra moisture available to help thicken the fog. If dew points are very low or there is drier air moving in, the fog tends to be less dense if it is able to form at all. In many situations, the layer of air that saturates near the ground will be very shallow and only dew will develop. Fog tends to be less likely if dew has formed first. During colder conditions dew would develop as frost and any fog that forms may be freezing fog.

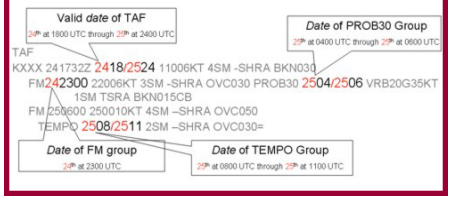
See "Met Corner" on Page 11.

A Change to the TAF Format

Beginning with the November 5th 0000 UTC (November 4th, 6 pm CST) routine Terminal Aerodrome Forecast (TAF) issuance, the format will look a little different to those used to looking at them. At the request of the airlines, the valid TAF period for 32 large airports across the country will increase from 24 hours to 30 hours; Minneapolis/St. Paul International Airport (MSP) is one of these airports. In order to support the new valid TAF period, a two-digit date group will be added to every time group in the TAF.

Although the TAFs for Alexandria (AXN), St. Cloud (STC), Redwood Falls (RWF), Eau Claire (EAU), and New Richmond (RNH) will continue to be 24 hour forecasts, their format will also change in order to have format consistency between all TAFs.

For more information, see: *aviationweather.gov/notice/taf30.php.*



Weather in Review: Central Minnesota's Two 2008 EF-3 Tornadoes, Hugo and Willmar

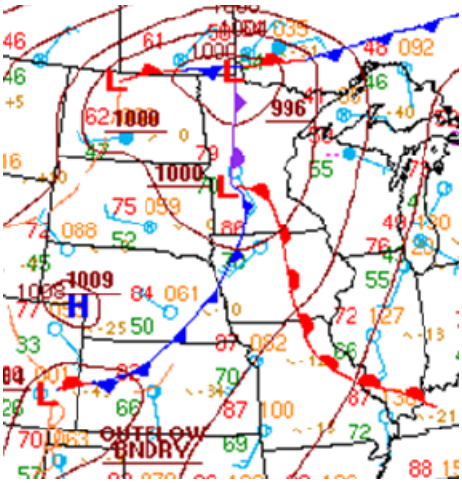
The Hugo Tornado; May 25th

By: Rick Hiltbrand

The morning began with a strengthening low pressure system over North Dakota. A cold front trailed south across the plains from the low pressure system, while a warm front curved across eastern South Dakota and far southern Minnesota. A powerful jet stream stretched from Colorado to Minnesota, with wind speeds over 120 mph.

Thunderstorms developed early in the morning across west central areas of Minnesota. The storms became severe by 830 am, with nickel size hail reported near Appleton. The cluster of storms continued to grow and spread into central Minnesota during the late morning hours. Around 1030 am, hail 2 inches in diameter was reported in St. Cloud. The morning storms finally moved out of the Chanhassen forecast area of responsibility around noon.

In the wake of the storms, considerable cloudiness covered eastern Minnesota. As the afternoon progressed, the warm front, over far southern Minnesota, gradually pushed north toward the Twin Cities. As this occurred, sunshine developed over southern areas of the state, while considerable cloudiness prevailed over the Twin Cities. This helped to create a strong temperature gradient along the warm front. This boundary would ultimately be the focus for tornadic development later in the afternoon.

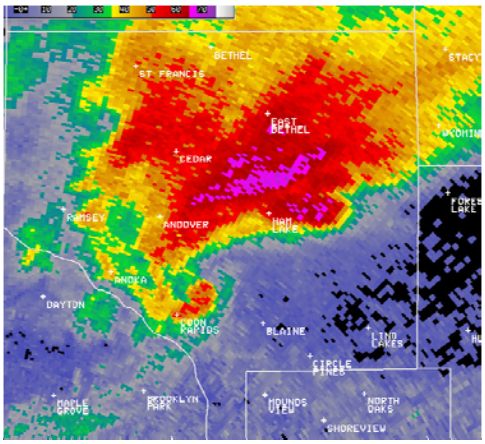


Surface weather map from May 25th at 4 pm CDT. The Hugo tornado touched down about 55 minutes after this map was valid.

The aforementioned cold front spread into western Minnesota early Sunday afternoon. More severe thunderstorms were expected to develop along and ahead of the front during the mid to late afternoon hours, due to the strong winds aloft and the warm front across the region. Around 2 pm, tornado watch number 359 was issued for much of central and southern Minnesota and west central Wisconsin. The tornado watch was valid until 9 pm.
It did not take long for the thunderstorms to begin developing. The first one to sprout was over Kandiyohi county around 215 pm. The thunderstorm quickly grew into a cluster, and by 3 pm, they were moving across northern Meeker, southeastern Stearns, and western Wright counties. Severe weather warnings were issued for large hail and damaging winds.

A hook echo began to show itself over northern Wright county around 345 pm, to the north of the advancing warm front. The first tornado warning was issued at 349 pm for south central Sherburne and northern Wright counties. The hook echo continued moving eastward, and another tornado warning was issued at 403 pm for eastern Wright and northern Hennepin counties. No tornadoes were reported. The hook echo advanced into Coon Rapids, with a tornado being reported at 435 pm. A third tornado warning was issued for parts of Anoka, Ramsey and Washington counties, including the community of Hugo, through 5 pm.

As it would turn out, there would be four tornadoes touchdown during the late afternoon and evening hours over east central Minnesota and west central Wisconsin. There would be one fatality, a 2 year old boy in Hugo.



Radar reflectivity from the Chanhassen WSR-88D showing a hook echo feature near Coon Rapids on May 25th at 438 pm CDT.

Tornado Number One...At 435 pm, the first tornado of the day touched down in Coon Rapids, at the northeast corner of the intersection of Highway 10 and Main street, and moved east-southeast. It lifted in central Blaine, near the TPC golf club, just east of Highway 65 and north of 109th avenue. The total path length was 6 miles, and the width was about 100 yards. Numerous trees were toppled or snapped, and some roof damage was noted. One house was pushed off its foundation. A number of sheds and garages were destroyed. This tornado produced EF-1 damage, with winds between 86 and 110 mph and was confined to Anoka county.

Tornado Number Two...The most damaging tornado of the day touched down in the eastern side of Lino Lakes, at the eastern shore of Peltier Lake, in eastern Anoka county. The time was 455 pm according to the Lino Lakes police. It knocked over trees and lifted boat docks, then tracked east and crossed Interstate 35E. A few barns, grain bins and silos were damaged. The tornado then intensified as it moved into northwestern Washington County and a subdivision just north of downtown Hugo. This was about 501 pm. It was at this point that the tornado caused EF-3 damage, with winds in the

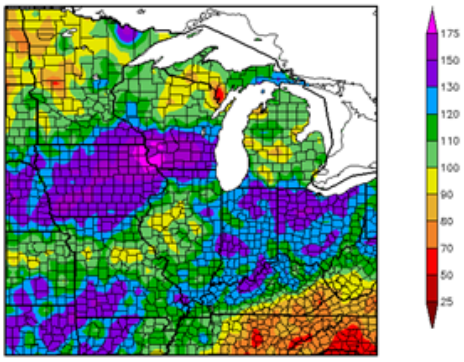
See "Weather in Review" on Page 12.

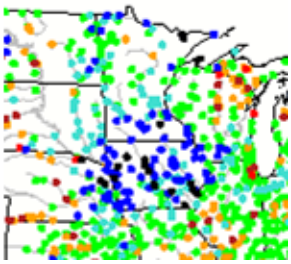
Flooding in Review: Summer of 2008 Record Breaking Flooding in the Midwest

By: Andrea Holz

The floods of 2008 made headlines for weeks across the United States, as the magnitude of the flooding reached record proportions, affecting hundreds of thousands of people in the Midwest. The conditions that created the catastrophic flooding did not just start with record breaking rainfall in early June; instead, the story begins around this same time last year.

Late Summer and Early Fall, 2007...Record breaking daily rainfall totals, along with above normal to record breaking rainfall set the stage for snowmelt flooding in the spring. August 2007 precipitation totals were 2 to 3 times normal across the Midwest. Saturated soils were common in southern Minnesota, Iowa, southern Wisconsin, and Illinois going into the winter. Spring flood potential was elevated due to these wet prewinter soil conditions, as any snowmelt would have a difficult time soaking into the ground in the spring.





Above: **Percent of normal rainfall from July 1st, 2007 to June 30th, 2008. Image courtesy of the High Plains Regional Climate Center.** ***Left:*** **The blue dots indicate Fall 2007 streamflow much above normal in Iowa, southern Minnesota, and southwest Wisconsin. Image courtesy of the United States Geological Survey.**

Above...**Ice jamming caused a new record crest on the Rock River at Moline on March 6th, 2008. Photo courtesy of the Civil Air Patrol.** ***Below***...**Flood water from the Iowa River rages through farmland June 15th, 2008, near Oakville, Iowa. The Iowa River broke through a levee yesterday completely flooding the town of Oakville and the surrounding farmland. Photo by Scott Olson/ Getty Images.**

Winter 2007-2008…Seasonal snowfall totals were much above normal across the Midwest, and 4 to 6 times normal from eastern Iowa to eastern Wisconsin. Many locations in northern Illinois and Wisconsin, with records dating back to the 1800s, reported seasonal snowfall totals in the top 10. Ice storms, combined with periodic warm temperatures, contributed to multiple ice layers in the unusually dense snowpack. Water content of the snowpack was 3 to 6 inches across Iowa and Wisconsin just prior to melt.

Summer 2008...Repeated summer storms brought heavy rainfall over the Midwest. As many areas were already saturated, most of the June rainfall went directly into the river systems, resulting in record breaking flooding across the Midwest. The Cedar River at Cedar Rapids, Iowa, reached a crest of 31 feet, 11 feet above the previous record. Many towns were evacuated due to the unprecedented river flooding and accompanying levee failures. Hydrologic forecasters at the North Central River Forecast Center collaborated with hydrologists from the United States Army Corps of Engineers, the United States Geological Survey, and many other federal, state, and local agencies to obtain the most up-to-date information when producing these major flood forecasts.

Above...**Flooding inundates the University of Iowa campus in Iowa City, Iowa, on June 16th, 2008. The Iowa Advanced Technology Laboratory and the Iowa Memorial Union are pictured.** ***Middle and Below***...**A levee failure emptied Lake Delton into the Baraboo River in Wisconsin on June 9th, 2008.**

See "Flooding in Review" on Page 13.

What YOU Need to Know About Observing Wintertime Precipitation

By: Michelle Margraf

Snow Measurement Guidelines

Where to measure the official snowfall and snow depth..."Look for a flat, somewhat open area away from buildings and trees. Some trees in the distance may be helpful in breaking the wind, preventing drifting, and thus, providing for a more even distribution of snow."

In the area chosen for snow measurements, sample the depth of the snow with a ruler in 4 to 6 locations. Average the readings together, and round to the nearest inch.

Snow core measurements should be taken at a location where the depth of the snow is equal to the reported snow depth. Snow core measurements should be taken when the recorded snow depth is 2 inches or greater.

Where official snowfall and snow depth measurements should not be taken...As a general rule, do not measure snowfall or snow depth in areas where man-made structures would influence the measurement. Stay away from buildings and walls where drifts form or snow collects. Do not measure in areas where shoveled or plowed snow could be piled onto existing snow.

Heavily wooded areas are not good areas for snow measurement. The dense branches can prevent snow from collecting on the ground during the storm. The branches also block the sun and cause the snow to melt at a slower rate than surrounding areas.

How to deal with different snow depths at an observing location...Use good judgment to visually average and then measure snow depths in exposed areas within several yards surrounding your weather station. For example, if half the exposed ground is bare and half is covered with 6 inches of snow, the snow depth should be entered as the average of the two readings, or 3 inches.

When, in your judgment, less than 50 percent of the exposed ground is covered by snow, even though the covered areas have a significant depth, the snow depth should be recorded as a trace (T). When no snow or ice is on the ground in exposed areas—snow may be present in surrounding forested or otherwise protected areas—record a "0".

Helpful Hints for Winter Weather Observing

* Record a zero for snowfall (instead of leaving the entry blank) if it does not snow on a particular day. If the entry is blank, it may be recorded as missing data in the climate record.

* If flurries are noted, put a T (for trace) in both the precipitation and snowfall column, assuming that flurries were the only precipitation that fell at your site that day.

* Snowfall should be recorded to the nearest tenth of an inch.

* Snow depth should be recorded to the nearest inch. If less than 1/2 inch is on the ground, record it as a T (for trace).

* Snow depth is an average of the snow around the observing site. Take snow depth measurements in a handful of locations to get an average amount. Do not take measurements in snow drifts.

* Remove the plastic tube and rain gage funnel in the winter to prevent the plastic pieces from cracking when liquid freezes inside. Leave the can outside to catch the snowfall.

* The snow that falls into the can should be melted and poured into the plastic tube to measure the water equivalent. The water equivalent should be reported as the precipitation amount to the nearest hundredth of an inch.

* If the snow has melted or has blown away before it could be measured, do your best to estimate the snowfall. Do not report zero if it snowed. If you have no other means to estimate the snow, multiply the precipitation amount by 13. Example: 0.10" liquid = 1.3" snow. Note in the remarks that the snowfall total was estimated.

* If sleet falls, record the amount under the snowfall category. The depth of sleet also counts as snow depth. Mention sleet in your remarks.

* If freezing rain falls, melt down what fell into the can and record it in the precipitation column. Do not include ice accumulations under snowfall or snow depth, but mention ice accumulations in your remarks.

* If you have questions about your observation, please give us a call.

Help us and the local media out during a winter storm!

Let us know when:

* **You receive your first inch, 3, and 6 inches of new snow.**
* **You have a storm total snowfall and snow depth.**
* **You experience any freezing rain, or blowing or drifting snow.**

Winter 2007-2008 the Snowiest and Coldest Since 2000-2001

By: Byron Paulson

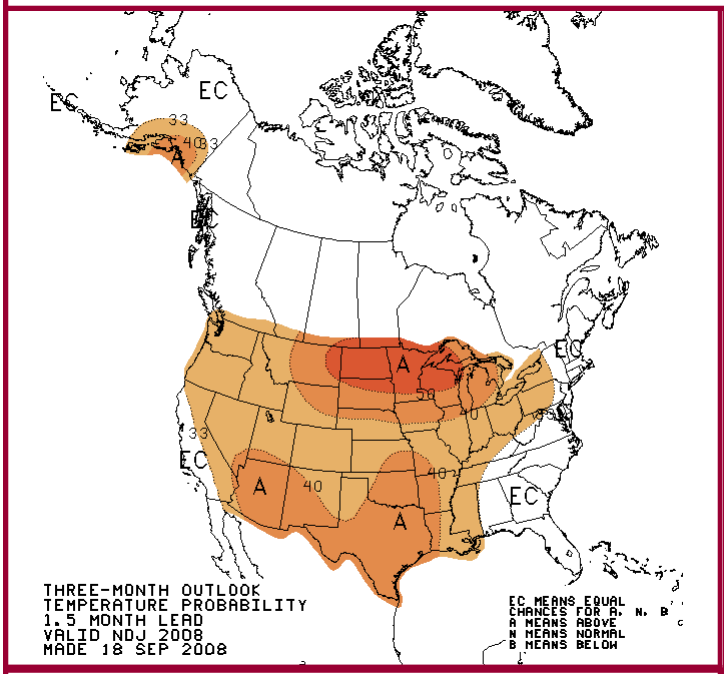
As soon as we turned the calendar into December, winter arrived right on schedule. Most of southern and central Minnesota and west central Wisconsin accumulated 4 to 6 inches of snow on the very first day of the month. The area remained in a cold and snowy pattern throughout the month with most reporting stations receiving from a foot to around two feet of snow. The snow machine shut off with the arrival of the new year, as the main storm track set up across Iowa, southeast Minnesota, and Wisconsin. Areas around Eau Claire and Rochester shoveled a foot or better of snow in January, but the remainder of the southern half of the Gopher State only picked up a couple of inches. Heavy snows continued across southeast Minnesota into Wisconsin in February, with around 4 to 6 inches falling across the remainder of the area. March brought a return to a snowy pattern with widespread 10 to 18 inch accumulations. The snow season ended with respectable snow totals of 45 to 60 inches in most locations across southern and central Minnesota and west central Wisconsin. As you may recall, record or near record snowfalls were measured last winter across much of Iowa into Wisconsin, with areas around Madison and Milwaukee on the receiving end of 100 inch snow totals.

There were some January thaws which numbed the snow pack somewhat, but the months of December, February and March were cold with temperatures in February averaging around 5 degrees colder than normal. We saw several "old –fashioned" 20 below zero mornings. This allowed a continuous snow cover to remain for an extended period of time. In the Twin Cities, a snow cover of 1 inch or more was recorded for 103 days, from December 1st through March 12th, with a snow depth of 3 inches or more for 85 straight days.

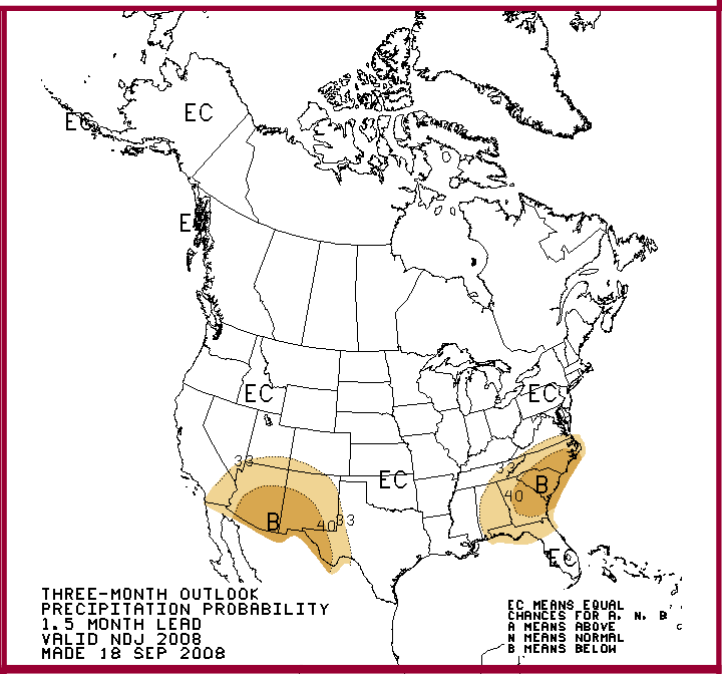
Incredible temperature extremes occurred with the passage of an Arctic cold front on January 28th and 29th. Most communities reported high temperatures on the afternoon of the 28th in the 40s. By the following day, thermometers were reading 10 below zero or more—better than a 50 degree temperature drop!

November-December-January Temperature and Precipitation Outlooks

www.cpc.noaa.gov



The 3-month temperature outlook for the months of November, December, and January, features a high likelihood of greater than normal temperatures across much of the Continental United States. For much of Minnesota and Wisconsin, there is a greater than 50 percent chance that warmer than average temperatures will be seen.



The 3-month precipitation outlook for the months of November, December, and January, shows an increased likelihood of below normal precipitation across the southwestern and southeastern United States. There is not a strong climate signal across the Midwest, with equal chances of above, below, or nearly normal precipitation occurring.

Weather History: From Page 2

The automated weather equipment at both airports measured a barometric pressure of 28.43 inches, which shattered the previous record of 28.55 inches set on January 11th, 1975, in the city of Duluth. The new records parallel the typical pressures in a Category 3 hurricane. In addition, a new all time record low pressure reading was recorded at the Minneapolis/St. Paul International Airport, plummeting to 28.55 inches, easily shattering the previous record of 28.77 inches set on April 13th, 1964. To put these measurements in an historical perspective, the minimum pressure of the infamous Edmund Fitzgerald storm was 28.95 inches. Barometric pressure records have been compiled in Minnesota since October of 1870.

The storm then proceeded into northeast Minnesota by the evening hours of the 10th. However, mariners on Lake Superior began to feel the effects of this intense storm system on the night of the 9th. Gale warnings were posted at 10 am EST on the 9th for Lake Superior. Winds of 35 knots were forecast to increase to 45 knots by the 10th. Waves of 6 to 8 feet were forecast to build to 8 to 12 feet during this same time frame. Storm warnings were then issued by the NWS at 4 pm EST on the 9th for the eastern two thirds of Lake Superior as winds were expected to reach 50 knots by the 10th. Waves of 7 to 12 feet were anticipated during the day of the 10th, building further to an amazing 12 to 20 feet on the night of the 10th. Storm warnings were posted for the remainder of Lake Superior by 4 am EST on the 10th, with winds expected to increase to 60 knots on the 11th.

Observations from several reporting stations on Lake Superior indicated the strongest sustained winds on the 11th of 50 knots with gusts over 60 knots. The highest recorded wave height was 15 feet. This wave height, however, was likely not the highest crest to occur, as reporting sites were sparse, especially on the downwind end of the lake, where the greatest fetch occurred. Although this November gale crossed the western extent of Lake Superior, its effects were felt across all of the Great Lakes. The tallest measured waves, reaching 20 feet high, were actually reported on both Lake Michigan and amazingly, Lake Erie, some hundreds of miles to the southeast. Lake Huron and even Lake Ontario had wave heights of 14 and 13 feet, respectively. Luckily, no ships or persons were lost on the Great Lakes during this horrendous storm, due to advance Gale and Storm warnings from the NWS, continuous dissemination of the warnings by the media, and to the professional captains and crew of large vessels who heeded warnings and remained in safe harbor until the storm had passed.

The final track of the storm system took it from western Lake Superior to James Bay, and then eventually into Hudson Bay by the late morning hours on the 11th. This ferocious storm's central pressure maintained an average of 28.70 inches as it travelled from northern Lake Superior to Hudson Bay.

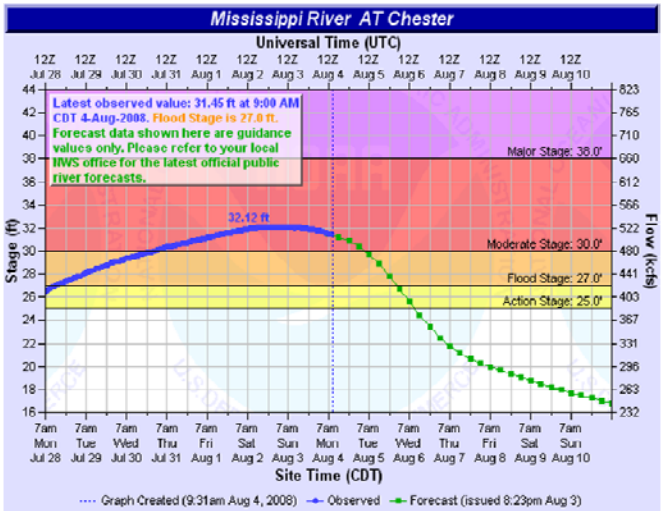
Although the November 10th-11th, 1998, land hurricane produced no loss of life, as compared to the November 1975 Edmund Fitzgerald Storm or the horrendous Great Lakes Storm of 1913, it remains one of the most astonishing storms to lash the Great Lakes region during the past century. Hopefully, a storm of this magnitude will not be seen for some time to come.

Hydro Corner: From Page 3

are prepared during the late winter and early spring to identify the potential for spring flooding, assuming normal snowmelt conditions. Long Range (90 day) probabilistic outlooks are issued once per month throughout the year.

Flash Flood Guidance is provided to the WFOs for use in providing short-term flash flood warnings in response to heavy rainfall. Daily Headwater Guidance values are also sent to the WFOs for use in short-fused flood warnings at selected headwater sites. Specialized services include low flow forecasts during dry periods, ice advisories on navigable rivers, reservoir inflow forecasts for operational decisions in reservoir pool regulation and reservoir release, and dam break hydrologic analysis and information.

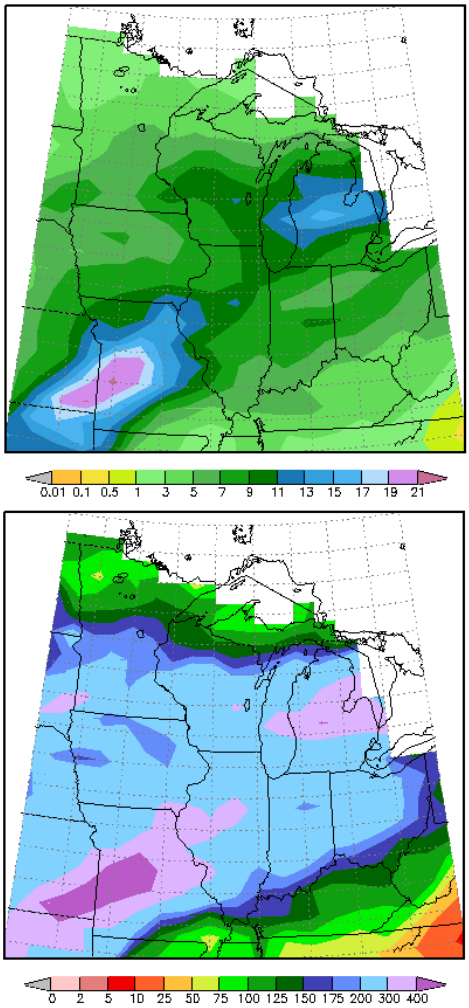
Staffing...The NCRFC has a staff of 19 which consists of a Hydrologist-in-Charge, a Development and Operational Hydrologist, a Service Coordination Hydrologist, an Information Technology Officer, 3 senior hydrologists, 1 senior Hydrometeorological Analysis and Support (HAS) forecaster, 2 HAS forecasters, 8 hydrologists, 1 hydrological technician and when the NWS budget permits, a student trainee. In addition, the NCRFC shares an Electronic Systems Analyst and 2 electronic technicians with the Twin Cities WFO.



A hydrograph depicting observed and forecast river stages for a forecast point within the NCRFC's area of responsibility.

The NCRFC maintains routine daily operational staffing from 6 am to 10 pm Central time. The NCRFC is also staffed 24-hours a day when widespread flooding is occurring or forecast. Forecast activities are usually completed by 11 am. The remainder of the day is spent on developmental activities, which can include model maintenance, model calibration, systems administration, radar analysis, forecasted precipitation verification, data quality control, web page updates, product quality control, and river forecast verification.

Flood History: From Page 3



***Above*: Rainfall amounts from September 10th to October 10th, 1986. *Below*: Percent of normal rainfall from September 10th to October 10th, 1986. Both images courtesy of the Midwest Regional Climate Center.**

Showers were almost a daily occurrence in Missouri with 4 to 17 inches of rain falling in a 6-day period. The eastern two-thirds of Iowa received 7 to 13 inches of rain in mid to late September. The Sioux Falls, South Dakota, area had its wettest September on record at that time. Southeast Minnesota saw rainfall totals 6 to 8 inches higher than normal.

In northern Illinois and southeast Wisconsin, 8 to 14 inches of rain fell from August to mid September. This was followed by an additional 6 to 15 inches of rain the last two weeks of September across the same area. The combined total rainfall of 13.5 inches for September and October 1986 in Indiana exceeded the totals for those two months on record, going back to 1871.

Central Michigan saw an intense precipitation event in mid September where 8 to 13 inches fell over two days across an area 60 miles wide and 180 miles long. Parts of central Michigan received rainfall for 26 days straight during this event. Approximately 5,000 square miles of land received at least 10 inches of rain. According to technical reports, a 2-day total of 5 inches for an area 400 square miles would be expected to occur once every 100 years.

Flood Response and Impacts...As a result of the tremendous amount of widespread rainfall, record flooding - for that time - occurred in Michigan, Illinois, Missouri, and Kansas. Additional flooding occurred in Iowa, Wisconsin, Nebraska, South Dakota, North Dakota, Minnesota, and Indiana. The areal extent of the flooding (11 states), the length of flooding (4 to 6 weeks), and the time of the year combined to create one of the most significant flood events in the recorded history of the Central United States.

In what was a challenging situation with so much flooding, NCRFC forecasters focused most of their attention to the areas with severe flooding: central Michigan, northeast Illinois, and the mainstem Mississippi River near the confluence of the Missouri River.

In Michigan, a majority of river gaging stations in the affected areas went above flood stage, and eleven river forecast points had their record stages greatly exceeded. Eleven dams failed, and another 19 were threatened with failure. Thousands of people were evacuated, and 30,000 homes suffered basement or structural damage. Hundreds of miles of roads were impassable due to bridge closures. Approximately 1.5 million of the 18 million acres of crops were lost. Unfortunately 5 flood related deaths occurred, damage estimates were in excess of $400 million, and 22 counties were declared federal disaster areas.

In northeast Illinois and southern Wisconsin, intense localized storms produced record flooding on the Des Plaines River, and near record flooding on the Fox River. The Des Plaines River flooded over 1,200 homes and 150 businesses. More than 3,300 people were displaced from their homes due to the flooding. Damage estimates totaled around $35 million.

In Missouri, heavy rain caused flooding throughout the state resulting in 9 new records at river gaging stations. Flooding caused many roads to be washed out, over 6,000 people were left homeless, and 3 deaths were recorded. Numerous levees along the Missouri River failed - over 100 were damaged - and the Missouri River cut a new 12 mile channel and entered the Mississippi River 18 miles upstream of its normal confluence. The Army Corps of Engineers estimated $246 million in damages were avoided by the storage of flood waters in the Truman reservoir, which was filled to within 1 foot of its maximum capacity in the event. Damage estimates were around $30 million for homes and over $75 million for crops. At Hermann, Missouri, a new record crest occurred on the Missouri River, and both the lower Missouri and Mississippi Rivers were over flood stage for more than 35 days.

The devastating details described above demonstrate why hydrologists at the NCRFC strive to produce the most accurate river forecasts possible. Most of the time, challenging river forecasts occur only on portions of the area of responsibility at any one time. However, from time to time, there are unique events which provide unique challenges. The flooding in the early fall of 1986 was one such event. An extraordinary amount of rainfall over such a large area produced flooding in numerous states over several weeks resulting in total costs exceeding $1 billion (1986 dollars) and 10 lives lost.

Valuable knowledge and experience gained from these unique events, combined with increased technology and a focus on inter and intra-agency cooperation help the NCRFC ensure it can provide the most accurate information to local emergency managers, media, and the public in a timely manner to help negate future losses and damages.

Met Corner: From Page 4

The location of the airport can also play a role as to whether it will be affected by fog or low clouds. Some airports are near ponds or lakes, in river valleys, or on high flat terrain. Those located in valleys are especially prone to fog development because cold air will drain or accumulate into them, allowing the moisture to condense. Nearby lakes and ponds can add moisture to and modify the temperature of nearby air which can lead to fog development. Over time, a base of experience builds up for each airport and typical conditions for fog and low cloud development will stand out.

There are a few specific tools that the forecaster can use to determine the amount of moisture in the lower layers of the atmosphere. Vertical profiles of temperature, humidity, and wind, known as soundings, are the most useful tool to use when forecasting fog and low clouds. They are available from weather balloons, aircraft as they ascend and descend, and even from satellites. Data from these sources are actual observed data. Soundings from forecast models are projections of what the atmosphere will look like in the future. Since forecast soundings are produced from model data, they may have a tough time accurately depicting the moisture in the atmosphere. The forecaster must sort through all of the available observed and forecast data and use his/her knowledge of the weather pattern and past experience to determine if fog and/or low clouds will develop and how restrictive conditions will become.

Fog and low cloud development can have a significant impact on aircraft operations. Delays are possible if the conditions persist for many hours, and some aircraft will be grounded because they are not equipped to fly in such conditions. Aviation forecasts, which include forecasts for fog and low clouds, are critical so that these delays can be mitigated as much as possible and safe flight can take place. These forecasts are very difficult to make but the forecaster has many tools available to supplement his/her experience and create the best forecast possible.

Face Time: From Page 1

storm and flooding videos, weather and preparedness trivia games, a tornado simulator, and the ever popular hydrologic model. Outside of the Weather Forecast Office and River Forecast Center websites, the most popular NWS website to visit during the 12-day run of the fair was the National Hurricane Center's site. Quite a bit of attention was turned to the tropics during the fair, with Gustav and Hanna threatening the United States and Ike and Josephine developing in the Atlantic.

A new and exciting addition to the booth this year was the Mitigation House, provided by the Minnesota Department of Homeland Security and Emergency Management. The dollhouse-sized exhibit was designed and decorated to display ways to prepare a home for any in-home hazards that may occur, such as having a NOAA All Hazards Radio. A poster display featuring information about the Hugo, Park Rapids, and Willmar tornadoes, Climate Change, and NOAA All Hazards Radio rounded out the NWS booth.

Thanks to those of you who visited the NWS booth, and we look forward to seeing you again next year!

National Weather Service Scout Day; October 4th

The 2nd annual National Weather Service Scout Day was held on Saturday, October 4th from 830 am to 400 pm. The event was designed to help Boy and Girl Scouts earn weather merit badges and patches. Almost 400 scouts attended the 2008 Scout Day.

The day was broken into two identical sessions, with each scout attending either the morning or the afternoon session. Each session featured six 30-minute stations designed to address a separate badge requirement. The 6 stations involved a tour of the Weather Forecast Office, a Jeopardy-style weather safety trivia game, a hydrology and sandbagging exercise, instruction on cloud identification and the water cycle, reading a weather map, and building a barometer. The activities were all interactive, providing a great learning environment for the scouts.

During the lunch break from noon to 115 pm, the scouts were treated to a couple of other exhibits: a midday weather balloon launch and a truck and firefighters from the Chanhassen Fire Department. The scouts were given their own "weather" balloon - actually a party balloon - to release along with the real weather balloon. A tag was attached to each balloon in order to track where each ended up once it popped. The tag requested that the finder notify the NWS where the balloon was found so the information could be posted on the Chanhassen NWS website.

During and after the afternoon session, scouts were also able to inspect a real storm chase vehicle and talk with Nick Elms, Skywarn coordinator for Wright County.

The 2008 edition of Scout Day was another huge success, and we hope everyone had as much fun as we did!

Above: Student Volunteer, Shawn DeVinny, instructs scouts on how to properly build a sandbag levee at the hydrology and sandbagging station. ***Below***: Retired Science and Operations Officer, Rich Naistat, talks to scouts about weather balloons during the office tour activity station.

Weather in Review: From Page 5

136 to 165 mph range. The tornado dissipated in the eastern portion of Hugo, a little north of Irish Avenue and 140th Street. The total path length was 6.5 miles, with a width of about 1/8 mile.

Tornado Number Three...This tornado developed in northeastern Washington County, in the northern edge of Marine on St. Croix. It crossed the St. Croix River, and moved into St. Croix County and then Polk County in Wisconsin. It dissipated 3.5 miles southwest of East Farmington, just north of the Polk and St. Croix county line. The tornado was rated an EF-0 and was found to have a path length of 1.25 miles and a maximum width of 50 yards. The damage was confined to a few hundred trees, some of which fell on homes in Marine on St. Croix. This tornado was estimated to have touched down at 515 pm and dissipated at about 517 pm.

Tornado Number Four...A 4 mile long EF-0 tornado was determined to have touched down in extreme northwestern Dunn County. It touched down at about 555 pm, 3.5 miles northwest of Connorsville, and dissipated 5 miles north-northeast of Connorsville. Numerous trees were downed, along with a couple barns, silos, and outbuildings.

At roughly the same time that the tornadoes moved through the northeast suburbs of the Twin Cities and adjoining areas of west central Wisconsin, a violent tornado moved through the Parkersburg, New Hartford and Dunkerton areas of northern Iowa causing 6 fatalities and destroying hundreds of homes. The tornado was rated an EF-5 with wind speeds of 205 mph. This was the first EF-5 tornado in Iowa since June 13, 1976.

The Willmar Tornado; July 11th

By: Matt Friedlein

Like Hugo and Park Rapids earlier in the summer, the area immediately south of Willmar would be the next in Minnesota to be struck by a powerful tornado on July 11th. This EF-3 tornado destroyed several structures and caused 2 injuries, but thankfully, no fatalities. This storm was not of the stereotypical nature of producing a strong tornado and developed extremely rapidly. Because of this, reports from Skywarn spotters in the field proved vital.

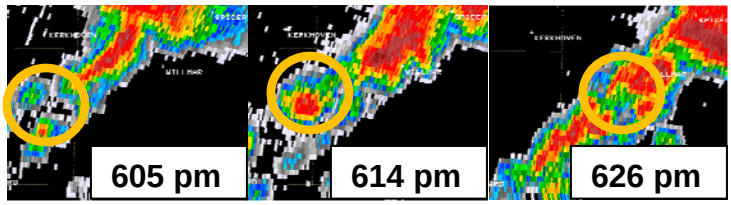
The weather pattern on July 11th was one conducive for severe thunderstorms, including tornadoes. A strong cold front at the surface was moving east into the state by late afternoon on that day, which correlated to just after the maximum heating time. Temperatures ahead of the front had warmed into the lower to mid 90s, with Willmar reaching 91 degrees and nearby Olivia hitting 95 degrees. The air mass was not only warm but also rich with moisture. This combination produced large instability, which thunderstorms not only fuel on to develop, but to become severe. Increasing and turning wind speeds with height were also present, a condition that can aid in tornado development within severe thunderstorms.

Near 605 pm, the storm which would end up producing the tornado began to develop about 20 miles west southwest of Willmar. Relative to the severe storms further northeast, the storm of interest did not look particularly intense at first. However, by 626 pm, the radar reflectivity showed a hook-like appearance, a signature reflective of potential rotation. Doppler radar velocity fields also indicated that rotation quickly developed between radar scans and was visible at 626 pm.

While meteorologists in our office were observing these radar trends, further information was coming into our office about the storm from the eyes and ears of the NWS during severe weather: Skywarn storm spotters. In that portion of Minnesota, these spotters were activated at 230 pm when a tornado watch was issued, which indicated an environment favorable for tornadoes. When the storm near Willmar increased in intensity, Skywarn spotters relayed their observations in real time through ham radio of a developing tornado 6 miles southwest of Willmar, near the small town of Priam. This was just prior to the radar revealing strong rotation, indicating just how quickly developing this storm was. Knowing what they did about the environment that day, NWS meteorologists acted on these spotter reports and issued a tornado warning for this storm. Spotters stayed with the storm, watching the tornado through its lifecycle with continual relay of tornado positioning, appearance, and other characteristics to our office.

The tornado path and associated damage was surveyed the day after by a team from the NWS. Estimated wind speeds were in the 136 to 150 mph range, or in the low to middle end of the 3 category on the Enhanced-Fujita (EF) tornado rating scale. The path length was near 8 miles, with the touchdown 6 miles southwest of Willmar and the dissipation about 4.5 miles south southeast of Willmar. Multiple structures were damaged or destroyed, including several homes. In some of these were people whom had taken cover in the basement and survived the tornado.

Skywarn storm spotters always aid in the NWS mission to protect life and property, but on this particular day their reports were of the utmost importance. Spotters are required to take a training class taught by NWS personnel every other spring. In that course, they learn how to identify storms of interest, locations relative to a storm to observe from, and most importantly, how to stay safe when in the field. We greatly thank our 8,000 plus local storm spotters for their continual efforts each year in helping the NWS severe weather warning and forecasting responsibility.



Radar reflectivity images from the Chanhassen WSR-88D showing how rapidly the supercell that produced the Willmar tornado developed. The orange circles denote the developing supercell.

Flooding in Review: From Page 6

A Selection of the Numerous 24-Hour Precipitation Records Set Across the Midwest June 1-9, 2008

Springfield, IL	4.71	June 3
Decatur, IL	4.63	June 3
Paris Water Works, IL	4.65	June 4
Lees Summit, MO	4.04	June 4
Creston, IA	5.75	June 5
Randolph, IA	5.20	June 5
Grand Portage, MN	3.04	June 6
Hutsonville, IL	7.20	June 7
Casey, IL	6.32	June 7
Effingham, IL	5.70	June 7
Bowling Green, IN	9.50	June 7
St. Ansgar, IA	5.64	June 8
Waucoma, IA	4.58	June 8
Greensburg, IL	5.00	June 8
Portage, WI	6.21	June 8
Ontario, WI	6.10	June 8
Prairie Du Sac, WI	4.74	June 9
New Hampton, IA	4.11	June 9

Winter Hazard Awareness Week is Coming

It's that time of year again, when preparations for cold and snowy weather and associated hazards should begin. Winter Hazard Awareness Week in Minnesota will be November 10th-14th, and Winter Weather Awareness Week in Wisconsin will also be held during that week. See *www.winterweather.state.mn.us* for more information.

Record River Crests Set During the Summer Midwest Floods of 2008

Forecast Point	River	Past Record Crest	Flood 2008 Preliminary Crest
Charles City, IA	Cedar	22.81', 7/21/1999	25.55', 6/9
Janesville, IA	Cedar	17.15', 7/22/1999	~20.2', 6/11
Finchford, IA	W. Fork Cedar	18.45', 7/29/1990	20.82', 6/10
Mason City, IA	Winnebago	15.70', 3/30/1933	18.74', 6/9
Shell Rock, IA	Shell Rock	17.70', 4/1/1856	20.1', 6/10
New Hartford, IA	Beaver Creek	13.50', 6/13/1947	15.43', 6/9
Cedar Falls, IA	Cedar	96.20', 7/23/1999	102.13', 6/11
Waterloo, IA	Cedar	21.86', 3/26/1961	25.40', 6/11
Vinton, IA	Cedar	19.3', 3/31/1961	~24.7', 6/12
Cedar Rapids, IA	Cedar	20.0', 6/1/1929	31.12', 6/13
Conesville 3NE, IA	Cedar	17.11', 4/6/1993	23.40', 6/15
Marshalltown, IA	Iowa	20.77', 8/17/1993	21.79', 6/13
Marengo, IA	Iowa	20.31', 7/19/1993	21.38', 6/13
Iowa City, IA	Iowa	28.52', 8/10/1993	31.53', 6/15
Lone Tree 5SW, IA	Iowa	22.94', 7/7/1993	23.12', 6/16
Columbus Jct., IA	Iowa	28.30', 7/7/1993	32.42', 6/15
Wapello, IA	Iowa	29.53', 7/7/1993	32.15', 6/14
Anamosa 2SE, IA	Wapsipinicon	22.73', 5/26/2004	26.18', 6/13
Ames 3N, IA	S. Skunk	15.87', 6/17/1996	16.93', 6/9
Ames 5SE, IA	S. Skunk	25.82', 7/9/1993	26.08', 5/30
Grimes 3E, IA	Beaver Creek	13.50', 6/13/1947	~14.21', 6/13
Stratford 4WSW, IA	Des Moines	15.81', 4/1/1993	27.32', 6/9
Des Moines, IA	Des Moines	34.29', 7/11/1993	35.27', 6/13
Ottumwa, IA	Des Moines	22.15', 7/12/1993	~22.59', 6/17
Burlington, WI	Fox	12.50', 8/21/2007	13.54', 6/15
New Munster 2N, WI	Fox	14.98', 8/24/2007	15.18', 6/15
Watertown, WI	Rock	6.96', 1/17/1997	7.81', 6/13
Milford, WI	Crawfish	11.15', 4/6/1959	13.59', 6/17
Jefferson, WI	Rock	12.84', 4/2/1979	15.64', 6/18
Fort Atkinson, WI	Rock	7.33', 4/16/2008	10.87', 6/22
Newville, WI	Rock	12.23', 4/15/1993	15.12', 6/22
Afton 5SW, WI	Rock	13.05', 2/5/1916	13.51', 6/21
Keithsburg, IL	Mississippi	24.15', 7/9/1993	24.49', 6/17
Gladstone 4WNW, IL	Mississippi	21.54', 7/10/1993	22.27', 6/17
Burlington, IA	Mississippi	25.20', 7/10/1993	25.73', 6/17