National Weather Service

Gaylord Michigan

The WFO Gaylord Science Corner

Volume 1, Issue 1 4 March 2008

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Welcome and an Introduction

Welcome to the first installment of the WFO Gaylord Science Corner...a newsletter that is designed to promote science sharing between the National Weather Service office in Gaylord, and our various user groups and partners.

It is our goal to use this newsletter to accomplish several purposes. One is to be able to share local research results with the wider user community. Another is to examine significant weather events (case studies) in more meteorological detail. Another possibility will be the ability to present articles that look at meteorological concepts from more of a theoretical background, such as topics dealing with summertime convection, or lake induced convection during the winter, using some of the material used in training sessions here at WFO Gaylord.

These goals also serve as an opportunity for members of the WFO Gaylord staff to participate in science projects and to gain experience in performing research and case studies, and sharing the results with a wide audience. This in turn supports the ongoing professional development of our contingent of meteorologists.

The content of this newsletter will be technical in nature. That is to say, we will pull no punches in presenting forecasting concepts that may be somewhat advanced. In doing so, we are looking to produce a publication that appeals to an audience that has a strong interest or background in meteorology. We also hope that professionals among our audience may be able to gain some new insights into various forecasting topics, and learn from some of our experience.

Our initial goal in developing this publication is to issue at least two versions per year. One issuance in late March to review some of the more interesting events of the prior cold season, and to present some topics related to the coming summertime convective season, and another in late September to review warm season events and cover some winter related topics. We may also use this newsletter as a vehicle to do an initial post-event analysis after major weather events impact northern Michigan. This first issue will be a short one simply to allow us to test the concept, and look at some layouts and other features. We currently anticipate another issuance by late April.

We believe there is a lot of potential in presenting a science-based publication, and we hope to provide you with information and topics that are both interesting and insightful, and increase your meteorological knowledge. So enjoy...and be sure to let us know if you have any comments you'd like to share with us, or perhaps suggest some topics you would like to see covered. Information on how to contact us is provided on the next page.

John Boris, Senior Forecaster

Bruce Smith, Science and Operations Officer

A Look at the 18 October 2007 Northern Michigan Tornado Outbreak

During the afternoon and evening of Thursday, October 18, 2007, an historic tornado event impacted northern Lower Michigan. Six confirmed tornadoes occurred in the NWS Gaylord County Warning Area (CWA) during a 4 hour period, resulting in more than 3 million dollars worth of damage. This was the largest single-day tornado outbreak in Northern Michigan in the past 50 years. Unfortunately, a tornado near Kalkaska resulted in one fatality. This was the first tornado related fatality in the area since March 1976.

Following is a chronological listing of the tornadoes:

4:25 pm An EF1 tornado with estimated winds of 95 mph touched down approximately 4 miles west of Tower in Cheboygan County. The tornado moved northeast to Black Lake before dissipating. This tornado was on the ground for over 10 miles, with a maximum width of approximately 215 yards.

5:25 pm An EF2 tornado with estimated winds of 120 mph touched down approximately 4 miles west-southwest of Long Rapids in Alpena County, and then moved northeast to just northwest of Long Rapids. This tornado was on the ground for 4 miles, with a maximum width of approximately 430 yards.

6:35 pm An EF2 tornado with estimated winds of 120 mph touched down between Kalkaska and South Boardman in Kalkaska county, then moved northeast to near the Kalkaska County airport. This tornado was on the ground for approximately 4 ½ miles, with a maximum width of approximately 430 yards. This tornado resulted in one fatality.

7:12 pm An EF2 tornado with estimated winds of 115 mph touched down just west of Luzerne in Oscoda County, then moved northeast to approximately 8 miles north of Mio. This tornado was on the ground for nearly 12 miles, with a maximum width of approximately ½ mile.

7:42 pm An EF1 tornado with estimated winds of 105 mph touched down near McCollum Lake in Oscoda county, then moved northeast to McCollum Lake Road. This tornado was on the ground for over 2 miles, with a maximum width of 150 yards. This tornado stemmed from the same storm that produced the previous tornado near Luzerne and Mio.

8:00 pm An EF2 tornado with estimated winds of 110 mph touched down 4½ miles north-northeast of the town of Hubbard Lake in Alpena county. This tornado was on the ground only briefly, with a maximum width of approximately 230 yards. This tornado stemmed from the same storm that produced the previous tornado near McCollum Lake.

In addition to the unusually high number of tornadoes, this event was very anomalous since it occurred in mid October – a time when forecasting concerns for meteorologists in northern Michigan typically shift to "lake effect". In total, 22 Severe Thunderstorm and 6 Tornado Warnings were issued by the NWS Gaylord staff.

Six confirmed tornadoes occurred in the NWS Gaylord County Warning Area...resulting in more than three million dollars in damage, and one fatality in Kalkaska County.

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Volume 1, Issue 1 (March 2008)
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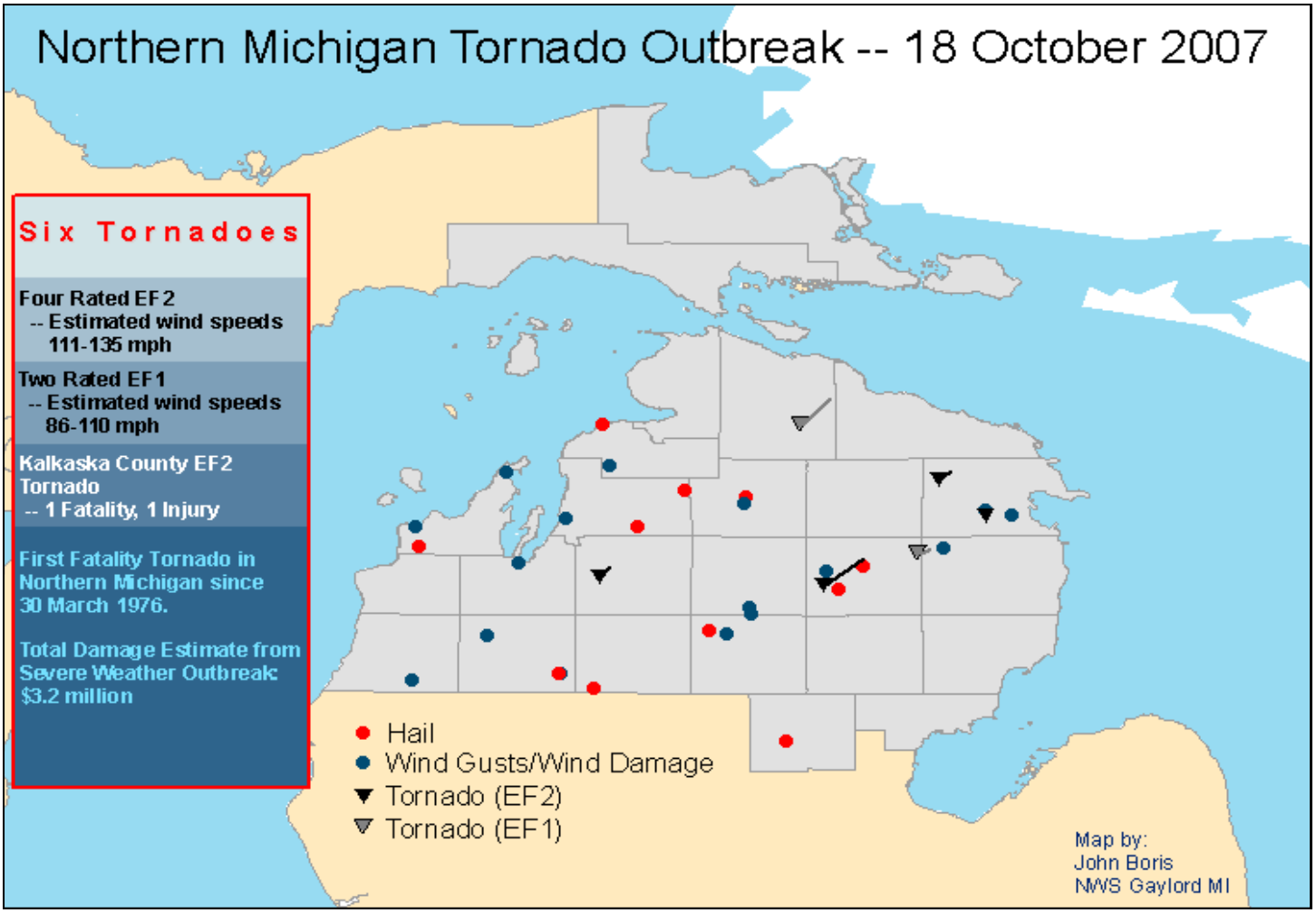
Bruce Smith

Questions? Comments?
E-mail us at:
w-apx.webmaster@noaa.gov
Use "Science newsletter" in the subject line.



Synoptic Overview

The overall synoptic weather regime on October 18 strongly supported the potential for severe convection (Figure 1). Though the day started out cool and rainy, a warm front lifted north through the region during the day, and placed northern Michigan in the warm sector of a potent mid latitude cyclone. Aided by afternoon sunshine, temperatures warmed into the 70s, as dew points rose above 60°F. Aloft, a powerful 100 kt upper level jet pushed into the region from the southwest, and a strong 45 kt low level jet stretched from Indiana to western Lower Michigan. These extreme winds aloft resulted in very significant deep layer shear, with 0 to 6 km bulk shear values around 70 kts.

A significant forecast challenge on this day was whether appreciable sunshine, and therefore surface based instability, would occur behind the warm front. This was critical since given the magnitude of the deep layer shear, *any* amount of surface based instability would promote long-lived convection, rotating updrafts, supercell thunderstorms, and potentially tornadoes.

The dark area of the water vapor image shown in Figure 1 reveals impressive mid level drying across the Ohio Valley and central Great Lakes. This dry slot – void of synoptic cloudiness – together with the passing warm front, were

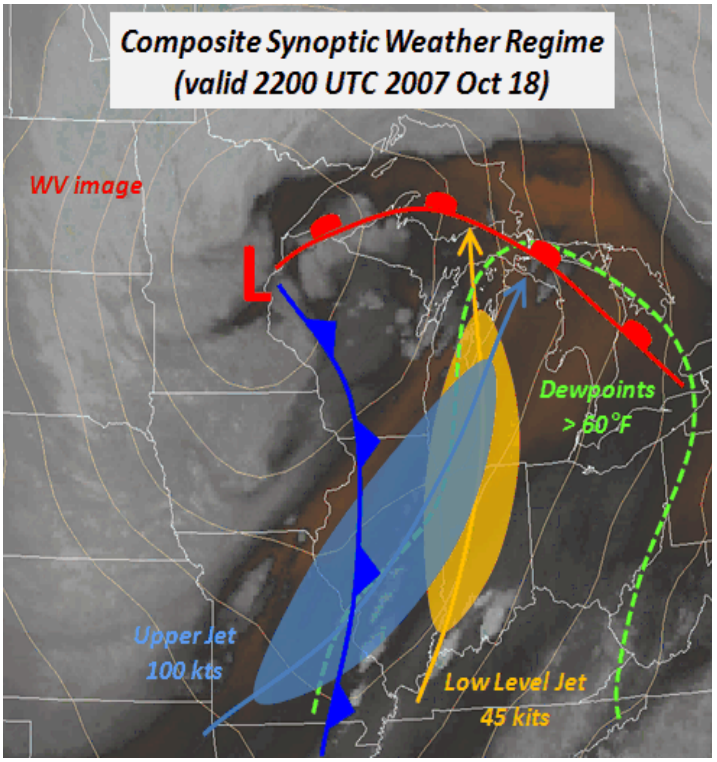


Figure 1 — Water vapor image overlaid with a composite chart depicting the synoptic setting at 22Z 18 October 2007.

significant in allowing sunshine and surface based instability to occur during the afternoon. In addition to promoting sunshine and destabilization, mid level drying would also serve to enhance mid level convective instability and updraft strength.

Figure 2 shows the observed APX sounding for October 19 0000 UTC, modified for conditions at the time (surface temperature of 72°F, surface dew point of 63°F). This lifted parcel resulted in only 600 J/kg MLCAPE. However, with steep lapse rates through 600 mb the majority of the CAPE was quite low. This "shallow CAPE" likely supported rapid low level parcel acceleration which, together with the extreme deep layer shear resulted in supercell development and tornadogenesis. Lastly, freezing levels near 10.6 kft, wet-bulb zero heights around 8.2 kft, and supercell-induced vertical pressure perturbations increased the likelihood for large hail – even in the presence of only modest instability.

The tornadic storms developed in an area of 0 to 3 km Storm Relative Helicity (SRH) over 500 m^2/s^2, and resulted from modest south-southeast winds at the surface and very strong south-southwest winds aloft. Clearly, the combination of strong deep layer shear and even modest surface based instability made supercell tornado development very likely.

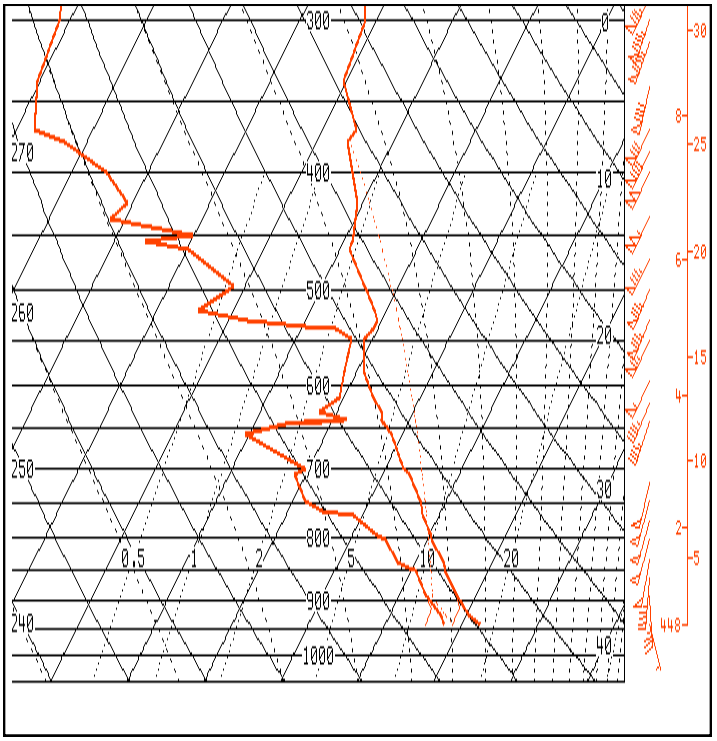


Figure 2— Skew T/Log P diagram showing the upper air sounding taken at WFO Gaylord at 00Z 19 October. Temperature curve is on the right...dew point curve on the left...observed winds plotted along the right axis. Dotted red line indicates vertical trajectory of a parcel using the mean temperature and dew point in the lowest 100mb of the sounding.

Event Anticipation

This event was well anticipated, and thunderstorms were forecasted several days prior to the actual event. As the event approached, forecasters did an excellent job describing how the strong dynamics, deep layer shear, associated fronts, instability, and dry slot that would promote severe weather. Following as an excerpt from an Area Forecast Discussion (AFD) issued by NWS Gaylord approximately 24 hours prior to the event.

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AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE GAYLORD MI
438 PM WED OCT 17 2007

THIS IS A VERY STRONG AND DYNAMIC SYSTEM...AND
EVEN THOUGH INSTABILITY WILL BE MARGINAL...
THERE WILL BE DESTABILIZATION OCCURRING BELOW
650MB...STEEPER ACROSS AREAS WEST OF I-75 WHERE
THE UPPER LEVEL COOLING WILL BE GREATEST. MORE
IMPORTANTLY...45-50KTS OF SOUTH H8 WINDS...
COMBINED WITH 75-80KTS OF H5 WINDS OUT OF THE
SW WILL RESULT IN TREMENDOUS WIND SHEAR WITH
CORRESPONDING BULK SHEAR VALUES REACHING AS
HIGH AS 70KTS ACROSS THE GTV BAY REGION DURING
THE EVENING.

WOULD NOT BE TOO SURPRISED TO SEE LOW-TOPPED
SUPERCELLULAR ACTIVITY IN THIS REGION WITH
BOWING SEGMENTS ALONG A LINE OF CONVECTION.
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The NWS Storm Prediction Center (SPC) was also closely monitoring the event, and recognized the potential for severe weather from the Great Lakes to the Gulf Coast. The Day 1 Outlook issued by SPC at 1123 am CDT follows on page 5, along with the accompanying map graphic (Figure 3).

DAY 1 CONVECTIVE OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
1123 AM CDT THU OCT 18 2007

VALID 181630Z - 191200Z

...THERE IS A MDT RISK OF SVR TSTMS FROM LOWER MI INTO WRN TN...
...THERE IS A SLGT RISK OF SVR TSTMS FROM THE CENTRAL GULF COAST SURROUNDING THE MDT RISK TO THE U.P. OF MI...

...POTENTIALLY SIGNIFICANT SEVERE WEATHER EVENT UNFOLDING ACROSS THE GREAT LAKES SOUTHWARD INTO THE NRN GULF STATES...

VERY MOIST AND BUOYANT AIRMASS IS RETURNING NWD ACROSS THE MID MS AND LOWER OH RIVER VALLEY REGION INTO THE UPPER GREAT LAKES THIS MORNING. THIS NWD SURGE IS IN RESPONSE TO AN INTENSE AND DEEPENING LOW PRESSURE SYSTEM OVER MN. DAYTIME HEATING WILL PROVE INSTRUMENTAL IN AFTERNOON THUNDERSTORM DEVELOPMENT...INITIALLY OVER WI...THEN ARCING SWD ACROSS ERN IL INTO EXTREME NERN AR BY EARLY EVENING. STRONG VERTICAL SHEAR WILL LEAD TO SUPERCELL DEVELOPMENT... ESPECIALLY EARLY IN THE CONVECTIVE CYCLE WITH AN EVOLUTION TOWARD DAMAGING BOW ECHOES DURING THE OVERNIGHT HOURS. A FEW LONG-TRACK TORNADOES ARE POSSIBLE IN ADDITION TO DESTRUCTIVE WINDS...ESPECIALLY ACROSS THE MODERATE RISK AREA.

EARLY MORNING DIAGNOSTIC DATA AND SATELLITE TRENDS SUGGEST STRONG HEATING WILL CONTINUE ACROSS MO INTO IL WHERE ABUNDANT SUNSHINE AND SLIGHTLY VEERED LOW LEVEL FLOW SHOULD BE MAINTAINED THROUGH THE AFTERNOON HOURS. THIS PLUME OF STEEPENING LOW LEVEL LAPSE RATES WILL UNDOUBTEDLY ASSIST THUNDERSTORM INITIATION LATER THIS AFTERNOON ALONG CONFLUENCE AXIS ACROSS IL WHERE SFC DEW POINTS ARE RISING THROUGH THE 60S INTO THE LOWER 70S. LATEST HIGH RES WRF-NMM4 AND WRF-NSSL4 MODELS SUGGEST INITIAL DEVELOPMENT WILL OCCUR ACROSS PORTIONS OF WI WHERE THERMAL PROFILES ARE SOMEWHAT COOLER. THIS SEEMS REASONABLE GIVEN THE LARGE SCALE FORCING ACROSS THIS REGION. HOWEVER... POTENTIALLY MORE SIGNIFICANT DEVELOPMENT IS EXPECTED FARTHER SOUTH BUT EARLIER THAN 22-23Z TIME FRAME SUGGESTED BY THESE SOLUTIONS. GIVEN THE STRONG HEATING IT SEEMS REASONABLE THAT CONVECTION SHOULD DEVELOP BY MID AFTERNOON ACROSS SERN MO/ERN IL. FORECAST SOUNDINGS ACROSS THIS REGION SUGGEST CONVECTIVE TEMPERATURES ARE BREACHED BY 19Z. GIVEN THE STRONG SHEAR CONVECTIVE UPDRAFTS COULD STRUGGLE INITIALLY BEFORE ORGANIZED UPDRAFTS EVOLVE INTO SUPERCELL STRUCTURES. ONCE THIS OCCURS ACTIVITY SHOULD SPREAD QUICKLY NEWD INTO WRN IND AND LOWER MI. IF CONVECTION REMAINS DISCRETE...TORNADO THREAT WILL REMAIN ENHANCED. HOWEVER...ANY LINEAR EVOLUTION COULD RESULT IN VERY DAMAGING BOW ECHO STRUCTURES GIVEN EXPECTED STORM MOTIONS IN EXCESS OF 50KT. THESE FAST STORM MOTIONS COULD LEAD TO A FEW LONG-TRACK SUPERCELLS/TORNADOES.

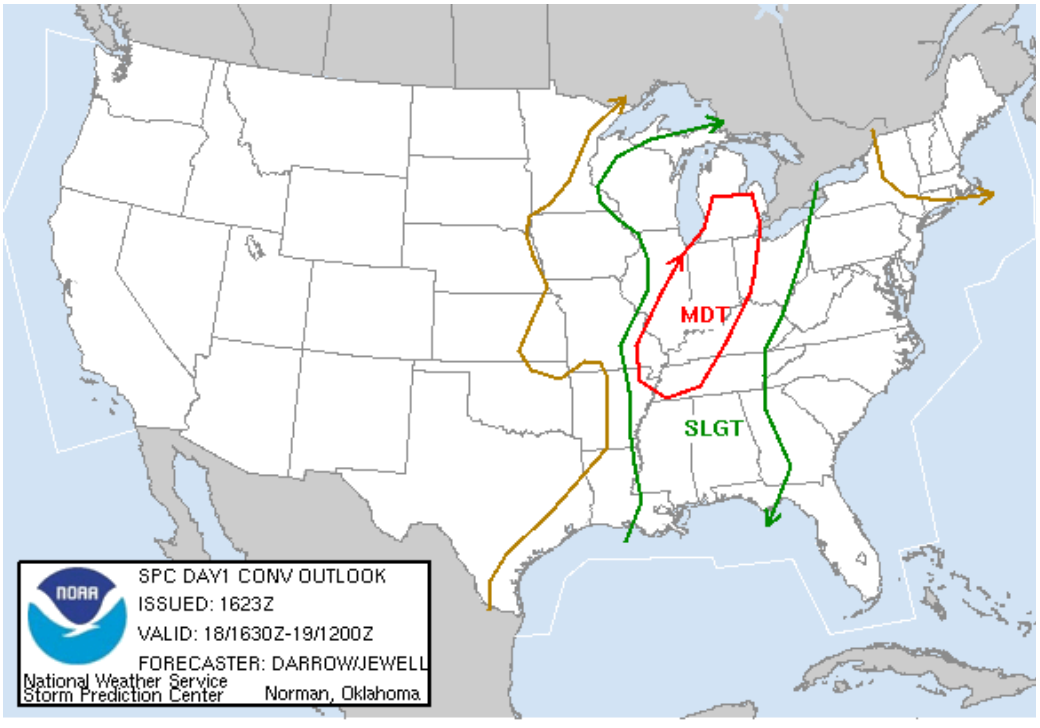


Figure 3— Storm Prediction Center Day 1 Convective Outlook accompanying the above text product.

Radar Signatures

During the mid afternoon and evening of October 18, several rounds of discrete, rotating, supercell thunderstorms impacted the region. In addition to rotation, these storms exhibited several other severe storm characteristics, including: Significant tilt with height, Weak Echo Regions (or WERs), and in some cases Bounded Weak Echo Regions (BWERs).

Perhaps the strongest tornado of the day – from a path length and longevity standpoint – impacted areas just west and north of Mio in Oscoda County. With winds estimated at 115 mph, this storm was on the ground for nearly 12 miles and was approximately a half mile wide. This storm damaged many homes and cabins, and uprooted or downed tens of thousands of trees along its path.

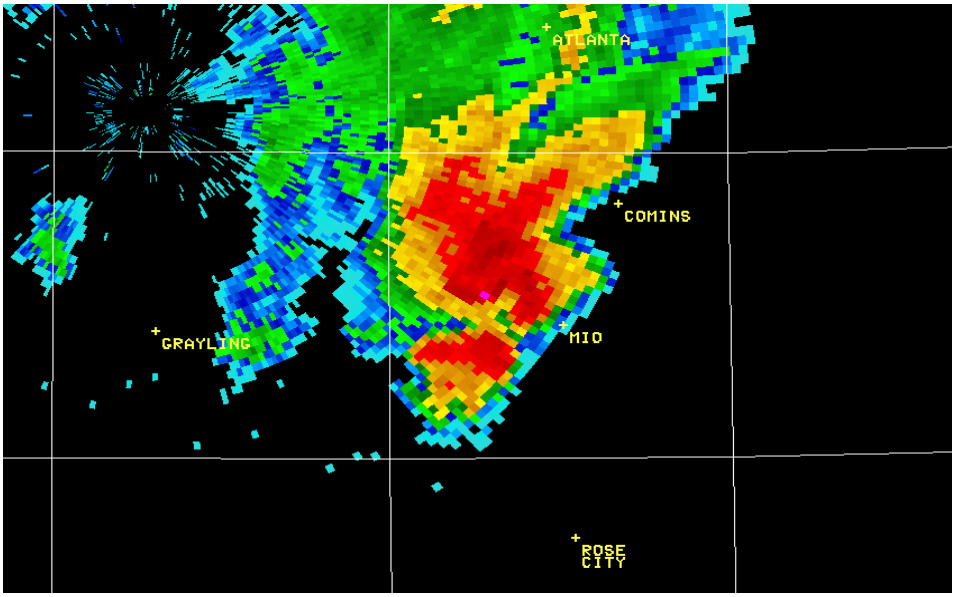


Figure 4 (left) shows base reflectivity for this powerful storm (valid at 8:21 pm EDT) when the storm was over western Oscoda County (just northwest of Mio). The tornado had been on the ground for approximately 9 minutes at this time.

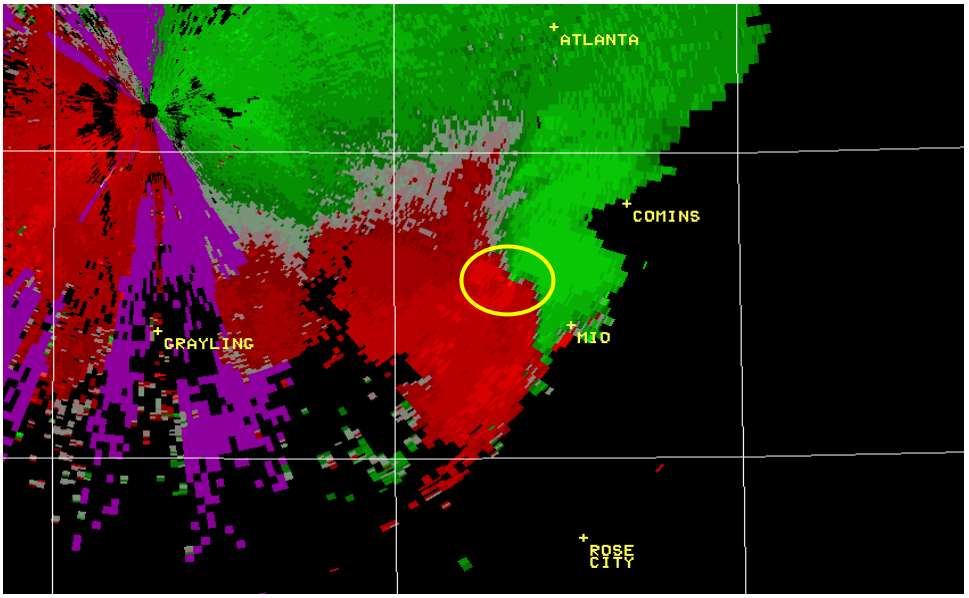


Figure 5 (right) shows storm relative velocity for the storm at the same time. Note the strong rotation, with bright red outbound velocities on the west side of the storm, and bright green inbound velocities on the east side of the storm (note the location of the radar in the upper-left portion of the image). The storm's rotational velocity at this time was over 56 kt. Doppler radar estimated the depth of this circulation in excess of 20,000 feet.

Summary

An historic tornado event impacted northern Lower Michigan on October 18, 2007. The event was unusual not only because six tornadoes occurred in a single day, but because it occurred in mid October. The impacts were tremendous, and a life was lost near Kalkaska. By reviewing events such as this, meteorologists can continue to learn how to accurately anticipate and better communicate the full impact of such storms.

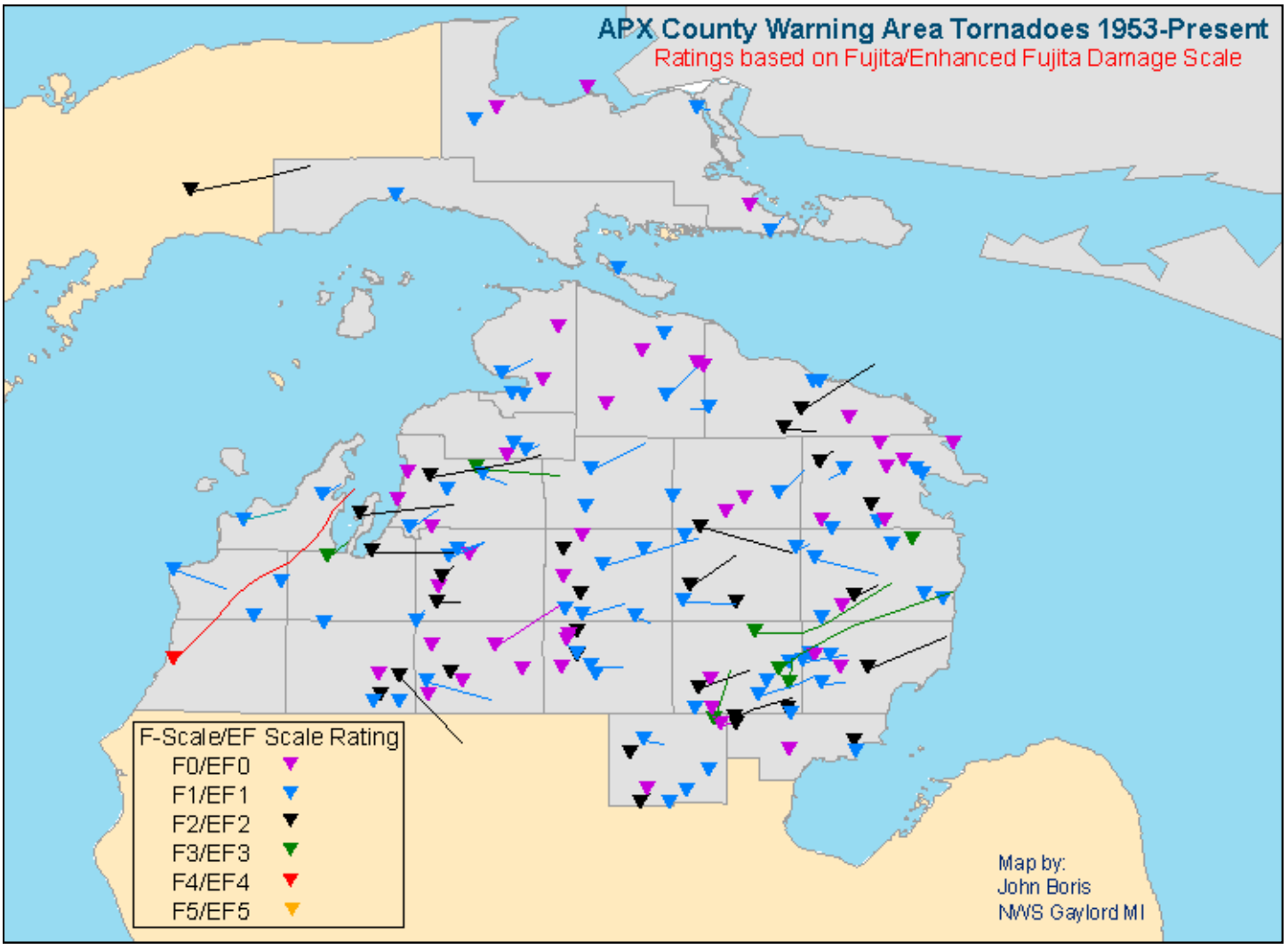
Bruce Smith

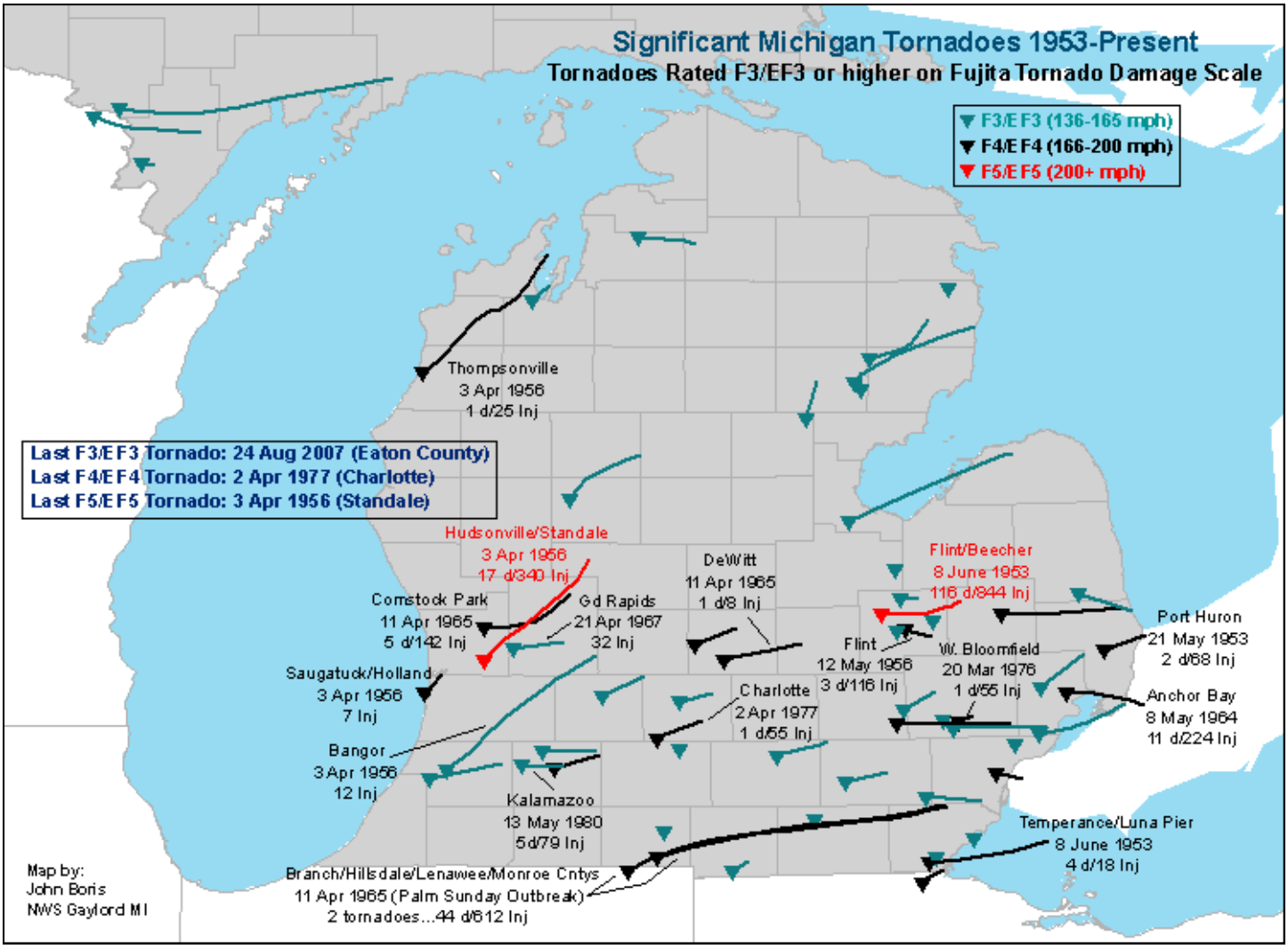
Various Tornado Maps of Interest

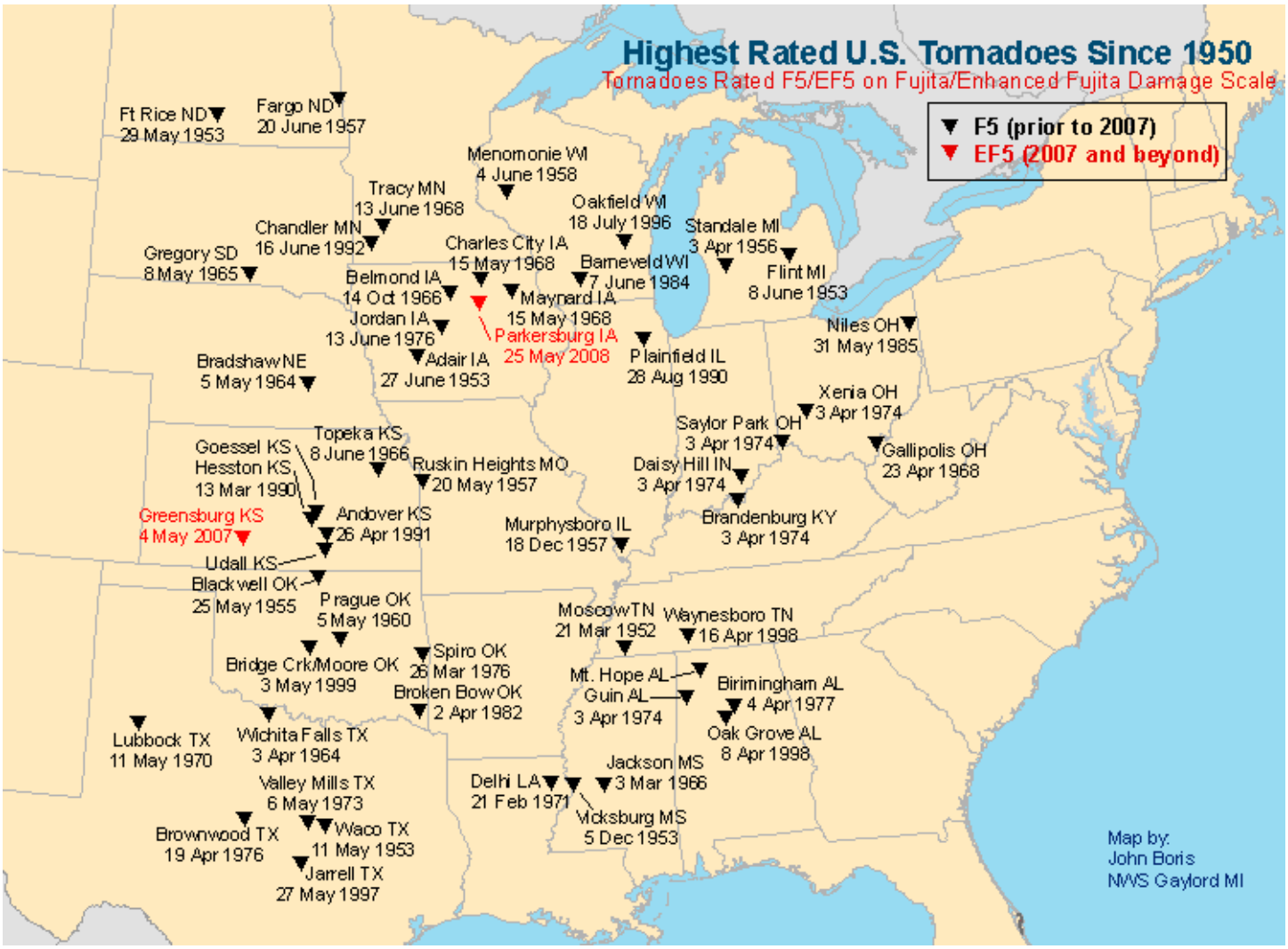
Geographic Information System (GIS) software is utilized at WFO Gaylord to create geographically based databases and maps to support several programs within the office, including hydrology, marine, and the cooperative observing network. In addition, databases have been created to map severe storm reports, including several tornado related databases.

Continuing with the tornado theme within this issue, we've reproduced here three maps derived from the tornado databases kept at WFO Gaylord. The first map shows all tornadoes within the WFO Gaylord CWA since 1950, coded by Fujita scale rating. The second map depicts all tornadoes that were rated F3/EF3 or greater in Michigan since 1953. Some of the more notorious and well known events are noted. The last map shows all tornadoes rated F5/EF5 in the United States since 1950, taken from the Storm Prediction Center tornado database and cross-checked with data from the book Significant Tornadoes 1680-1991 written by Thomas P. Grazulis. Note: In your PDF browser, these maps are best viewed at a "zoom" setting of 100%.

John Boris




Significant Michigan Tornadoes 1953-Present
Tornadoes Rated F3/EF3 or higher on Fujita Tornado Damage Scale
F3/EF3 (136-165 mph)
F4/EF4 (166-200 mph)
F5/EF5 (200+ mph)
Last F3/EF3 Tornado: 24 Aug 2007 (Eaton County)
Last F4/EF4 Tornado: 2 Apr 1977 (Charlotte)
Last F5/EF5 Tornado: 3 Apr 1956 (Standale)
Thompsonville
3 Apr 1956
1 d/25 Inj
Hudsonville/Standale
3 Apr 1956
17 d/340 Inj
Comstock Park
11 Apr 1965
5 d/142 Inj
Gd Rapids
21 Apr 1967
32 Inj
DeWitt
11 Apr 1965
1 d/8 Inj
Flint/Beecher
8 June 1953
116 d/844 Inj
Flint
12 May 1956
3 d/116 Inj
W. Bloomfield
20 Mar 1976
1 d/55 Inj
Port Huron
21 May 1953
2 d/68 Inj
Anchor Bay
8 May 1964
11 d/224 Inj
Saugatuck/Holland
3 Apr 1956
7 Inj
Charlotte
2 Apr 1977
1 d/55 Inj
Bangor
3 Apr 1956
12 Inj
Kalamazoo
13 May 1980
5 d/79 Inj
Temperance/Luna Pier
8 June 1953
4 d/18 Inj
Branch/Hillsdale/Lenawee/Monroe Cntys
11 Apr 1965 (Palm Sunday Outbreak)
2 tornadoes...44 d/612 Inj
Map by:
John Boris
NWS Gaylord MI



Map updated 29 May 2008 to add Parkersburg, IA EF5 tornado from 25 May 2008.