The Oakfield, Wisconsin, Tornado from 18-19 July 1996

Brett Berenz
Student at the University of Wisconsin

Abstract

On July 18th, 1996 an F5 tornado affected the region of Oakfield, Wisconsin. Leading up to the tornado, a warm moist air mass was in place at the surface. Along with veering winds and a cap the mesoscale pieces were in place for a spectacular event. The presence of a dry line as well as a cold front to trigger the severe weather was also in place. Further lifting was enhanced by a jet core aloft and diverging upper level winds. All in all, the storm cut a swath across southern Fond du Lac County and caused millions of dollars in damage while injuring 17 people.

1. Introduction

Wisconsin each year gets its fair share of severe weather. One of the most memorable severe events on record in Wisconsin occurred on July 18th, 1996. At 7:15 p.m. (0015Z) a powerful F5 tornado ripped through the tiny town of Oakfield, Wisconsin, about 5 miles southwest of Fond du Lac in Fond du Lac County. According to a CIMSS report damage estimates were around $40 million dollars and 47 of 320 homes in the Oakfield area were destroyed. According to a UWEX report, residents had problems with ears as the tornado moved into Oakfield and pressures dropped rapidly. A canning factory in the area was completely demolished and cans were spotted in towns falling from the sky nearly 50 miles away. Initially the tornado was placed under the F3-F4 category but later was upped to F5 status, the most severe of the tornado categories. After the storm moved through the National Weather service in Milwaukee/Sullivan (MKE) issued a statement describing 200 yard wide path of damage that was later decreases to 100 yards as the intensity increased to F5 status. MKE also reported corn sheared to within on inch of the ground and a clear cut path of for miles. This storm also brought bouts of heavy rain and some hail as it moved across east-central Wisconsin. Amazingly nobody was killed and only 17 people were injured as an entire town was nearly demolished. Personal accounts told of a story that most were caught completely off guard as it had been a bright, warm and sunny day, and sirens gave way only minutes before the actual tornado moved into Oakfield.

The main focus of this paper is to explore what triggered such an event. One hypothesis is that a cold front lifted a warm moist air mass through a mid level inversion causing free convection and a thunderstorm to build. Other factors such as the center of the jet stream aloft as well as upper level diverging winds could have enhanced the lift allowing for the storm to become even more powerful.

2. Data

Research incorporated into this paper was compiled from many sources. Gridded data used to form the background plots was utilized from the GARP program. Storm reports were gathered from NOAA/NWS (MKE) and

UWEX. CIMSS report information was also used as well as a few images such as the radar and radial velocities images. Hand made plots such as a conceptual model, theta-e cross-sections, and GARP aided surface plots were used. Finally some personal accounts were used as I lived near the storm and saw some of the damage and experienced the storm. All these sources attributed to the answers found in this paper.

3. Synoptic Overview

At 18Z on July 18th 1996 (1 p.m.), east-central Wisconsin was experiencing a warm and muggy midday. Temperatures in the area were around the lower 80's to upper 70's and a moist air mass was in place as dew points were in the mid to low 70's. As shown in **Figure 1** a surface low-pressure system was in place over northeastern Minnesota. As the streamlines show, air was being brought up from the south up and over the entire state of Wisconsin. Also shown is the warm moist air carried along these streamlines. Along with this low pressure system a cold front stretching from northeastern Minnesota down to central and eastern Minnesota into central Iowa and back through Nebraska and into Kansas. This cold front had weak temperature gradients but was evident in the strong dew point gradient. Unisys surface plots labeled this as a dry line but since some sort of gradient in temperature is observed, especially in a line from Rhinelander to Duluth, this paper analyzes this structure as a cold front with a dry line present. As professor Tripoli has stated with Wisconsin being a large corn growing state, the ability for the dew points to be even higher than areas to south exists as with July in the middle of the growing

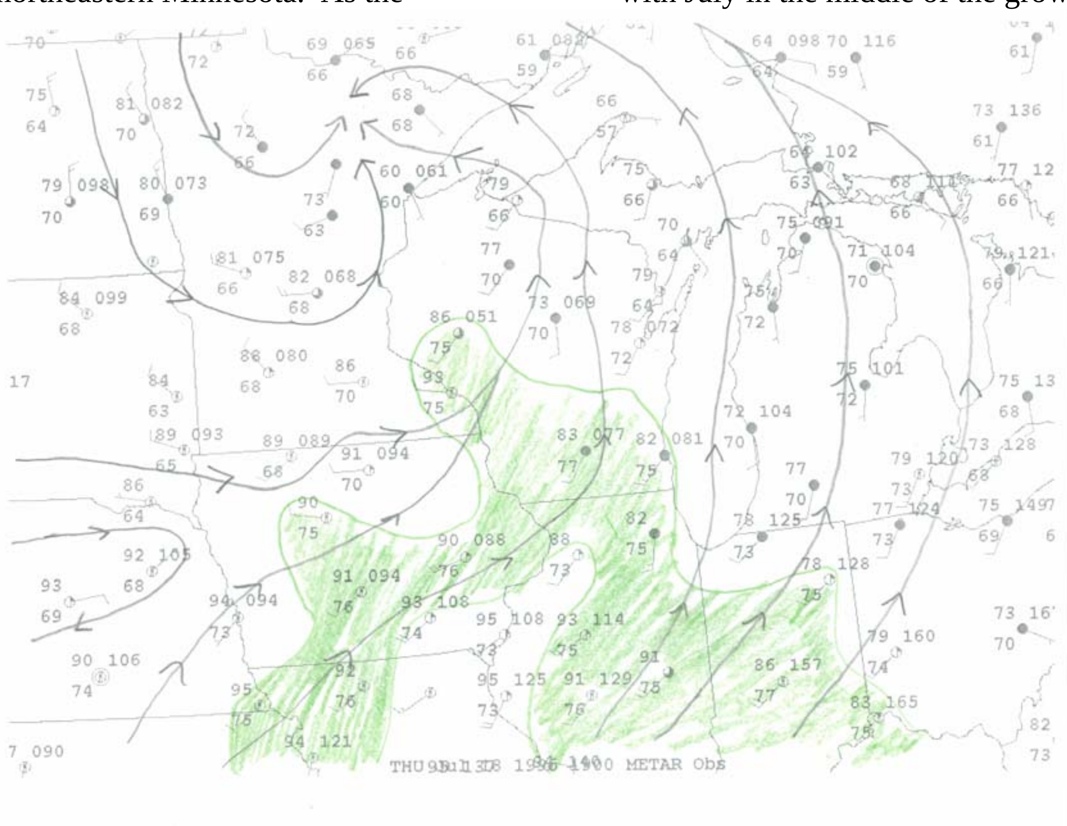

Figure 1 – Streamlines and Dewpoints 75 degrees+ shaded at 18Z July 18th 1996

season, water is transported from the vegetation into the air. Add that factor along with the warm, muggy air transported northward from the Gulf of Mexico, an approaching cold front and a dryline, and a few initial components are in place for the allowance of some big storms.

By 00Z on the 19th (7 p.m.), just minutes before the tornado had touched down, the surface low had moved in to the U.P. of Michigan. Streamlines in **Figure 2** show the continuance of warm moist air being brought into the east-central portion of Wisconsin. Dew points as high as the upper 70's and even close to 80 were reported in south-central Wisconsin. Also evident is the large dew point gradient between Wisconsin and Minnesota. A temperature gradient can also be seen cutting through central Wisconsin between Green Bay and Milwaukee. Aiding to these surface features a large and persistent jet streak was located over Minnesota and Wisconsin. As seen in **Figure 3** there is also some upper level divergence which could also enhance lifting over Wisconsin.

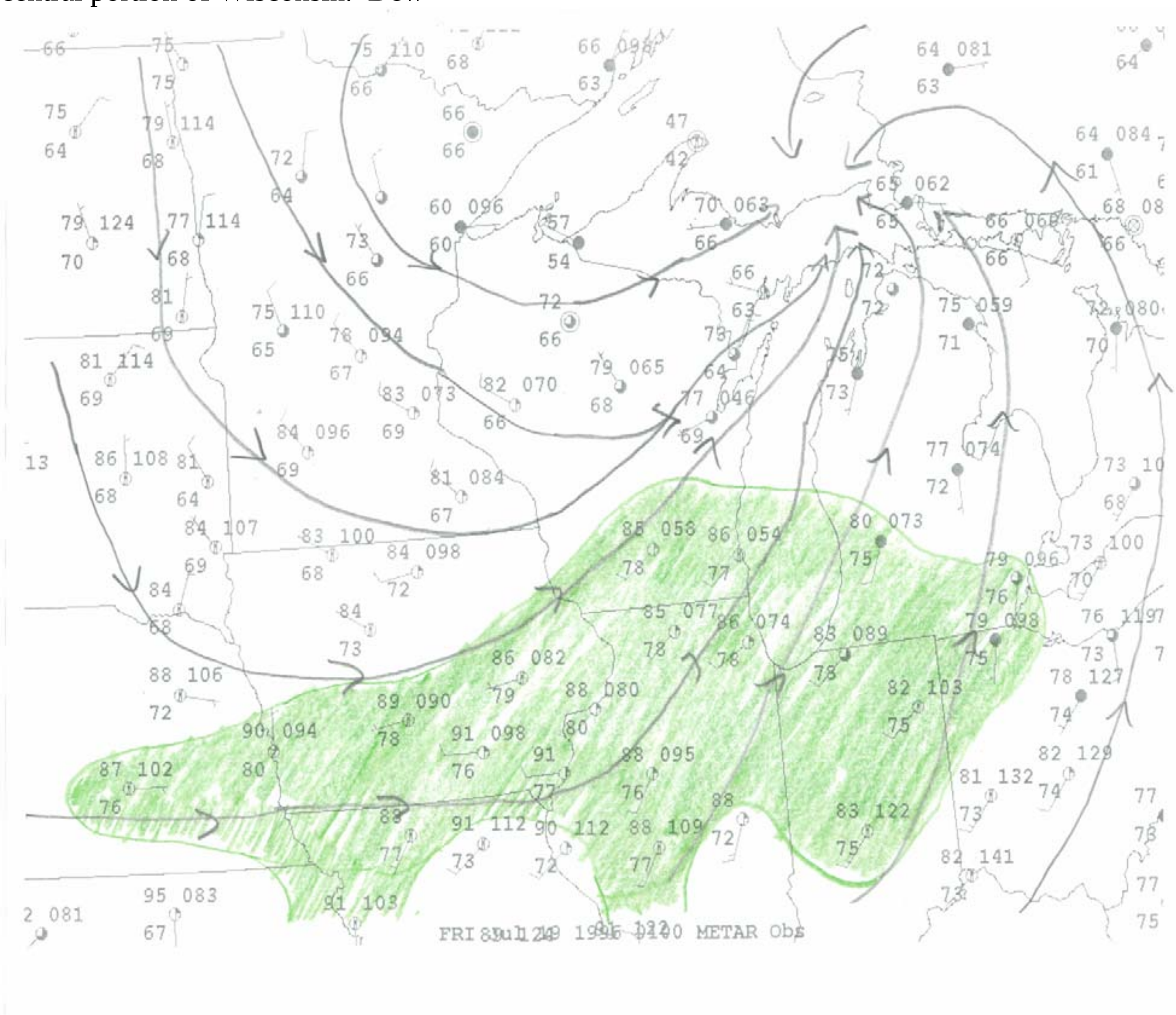

Figure 2 –Streamlines and Dew points 75+ shaded at 00Z 19th July 1996

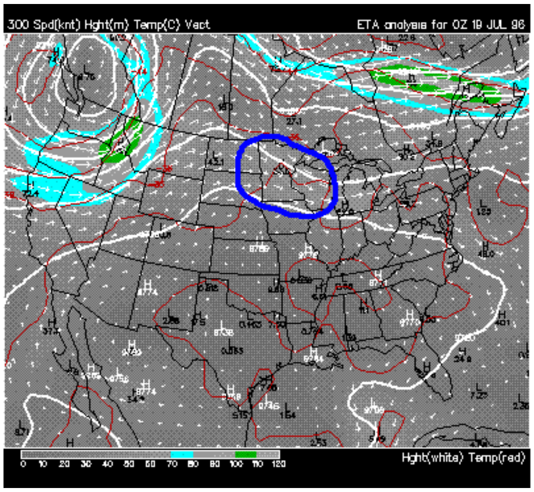

Figure 3 – 300mb Analysis at 00Z July 19th

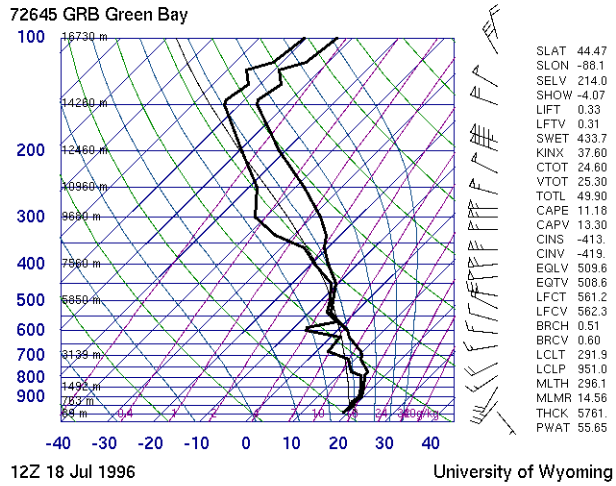

Figure 4 – Skew-T GRB at 12Z July 18th

4. Mesoscale Analysis

At 12Z on the 18th, (7 a.m.), as shown in **Figure 4** was very warm and very moist. Winds also showed a good veering profile from the surface to around 200mb. As shown on the skew-T, the SWEAT index was giving a value of about 433 which is conducive for tornadoes however at this time the lifted index and Total Totals values were very weak as was the CAPE value which was only about 11. However by 00Z on the 19th (7 p.m.), as **Figure 5** shows a profile more conducive to severe weather had developed. With a minor inversion near the 850mb level warm moist air was allowed to fester and continue to heat up. With southwesterly winds at the surface and westerly winds aloft, a veering profile had formed. The hodograph in **Figure 6** shows this veering profile. Although the aiding lift from the divergent winds at 250mb and the jet core were weak enhancers it would not take much to break the weak cap and allow the parcels of air to freely convect. This would only enhance the lifting however as storms would begin to fire along the dry line and cold front that

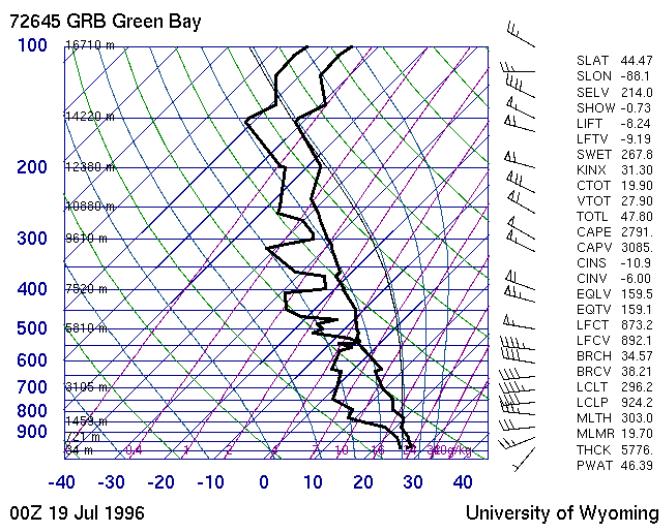

Figure 5 – Skew-T GRB at 00Z July 19th

continued to march along. The stability indicies in **Figure 5** helps show how conducive this area was to the possibility of severe weather. The K-index was placed around 31 which allows for possible MCC's to develop. CAPE values as well as SWEAT values called for strong convection. And shown in **Figure 7** is the lifted indicies which were at about -8. This situation in Green Bay was only used due to the closest proximity to Oakfield, where conditions were likely even more ideal.

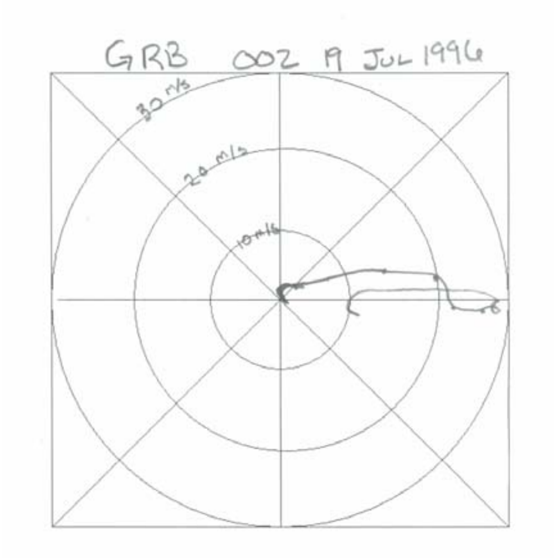

Figure 6 – Hodograph GRB at 00Z July 19th

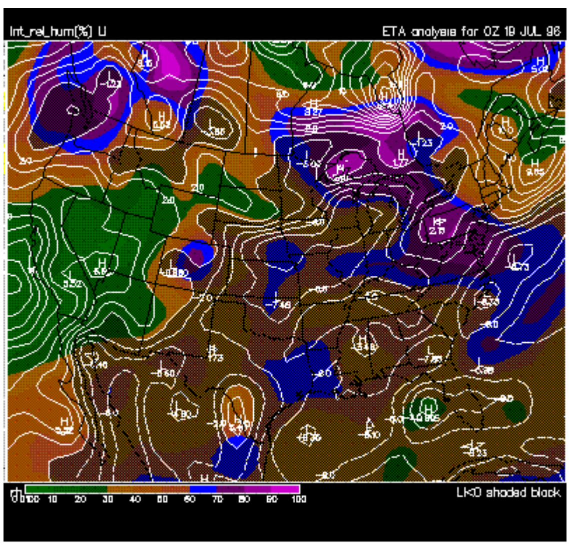

Figure 7 – Lifted Index at 00Z July 19th

Along the dryline that had moved into Wisconsin, storms were beginning to fire. A large complex of storms had formed over central Wisconsin and had moved east-southeast toward the Lake Winnebago region. As the storms approached east-central Wisconsin a smaller cell had formed just to the south of the large complex. With the cap broken and a streaming supply of moisture, the cell quickly grew. With the veering wind profile in place the storm began to rotate as it moved to the east-southeast. The cell within an hour had become a supercell thunderstorm with complimentary parts such as an updraft and downdraft regions. In **Figure 8** a conceptual model is shown which can help understand the various parts of the thunderstorm. As seen, the quick and intense nature of the updraft allows the air to poke through the usually unpenetratable barrier of the tropopause. As air flows out once it hits this ceiling, forms the anvil and eventually a downdraft in which precipitation falls. The top view of the conceptual supercell also shows how the rain and precipitationless updraft are coupled in the storm. Inside the thunderstorm theta-E values are pulled up through the updraft and create a tree trunk like structure. This can be seen in the idealized cross-section in **Figure 9**. As the storm continued to strengthen, rotation and a wall cloud formed. Eventually the updraft became smaller and smaller as a tornado had formed and winds were sucked up through the tornado like a straw. With the pressure dropping and the need for air to be continually supplied through this small tornado, winds increased to nearly 158 mph creating an F3 tornado, which later F5 status was observed and winds around 260 mph occurred. This tornado can also be seen in the radar as in **Figure 10**. This shows the Fond du Lac county region where the storm was at the time of 7:07 pm. The radar shows a signature “hook echo” which many tornadic supercells express on radar. The little hook on the southwestern edge of the storm shows the wrapping around of the rain shield around updraft region. This radar coupled with the radial velocity image shown in **Figure 11** help the

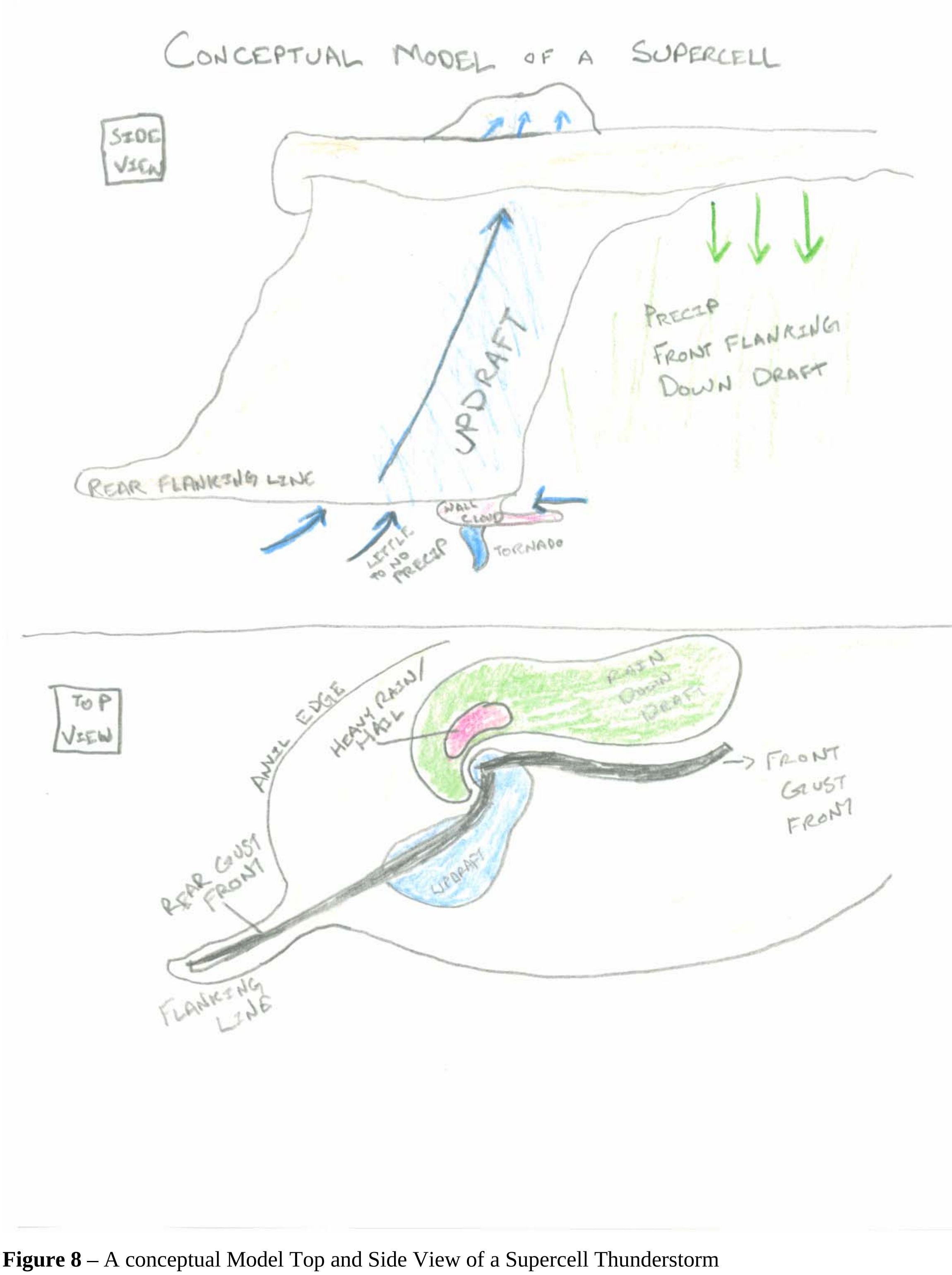

Figure 8 – A conceptual Model Top and Side View of a Supercell Thunderstorm

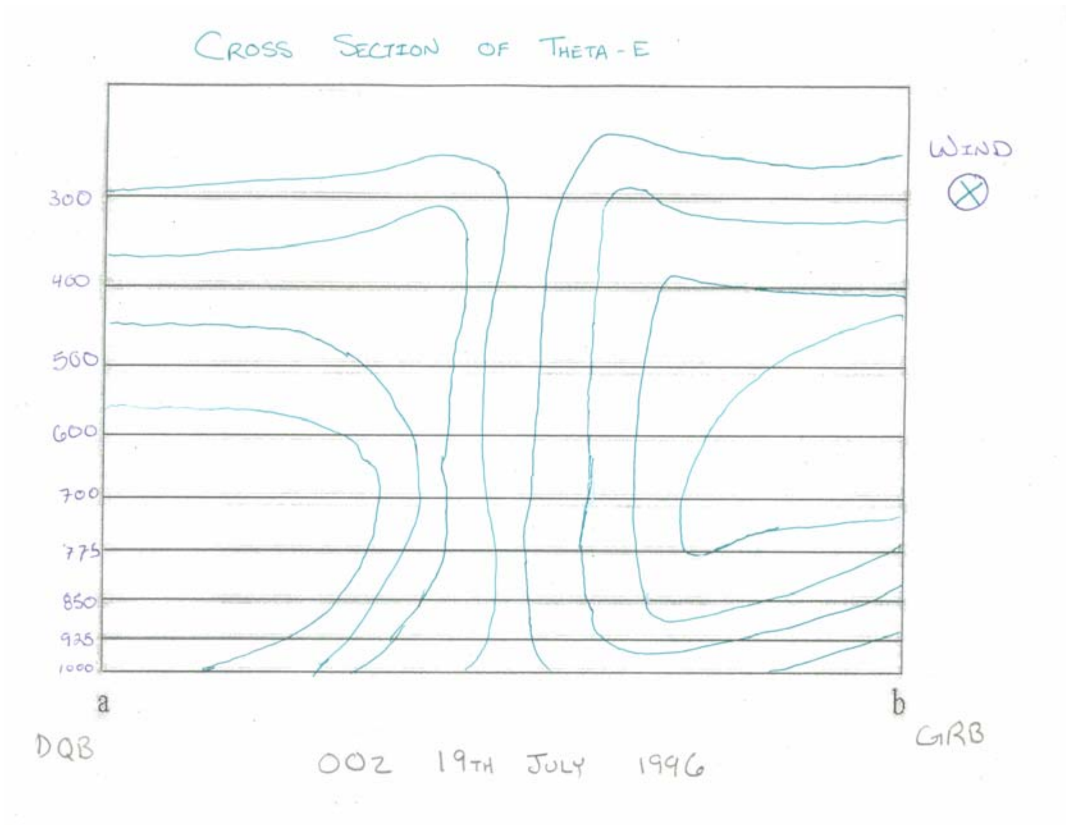

Figure 9 – Idealized Theta-E cross-section between Green Bay and Dubuque at 00Z July 19th

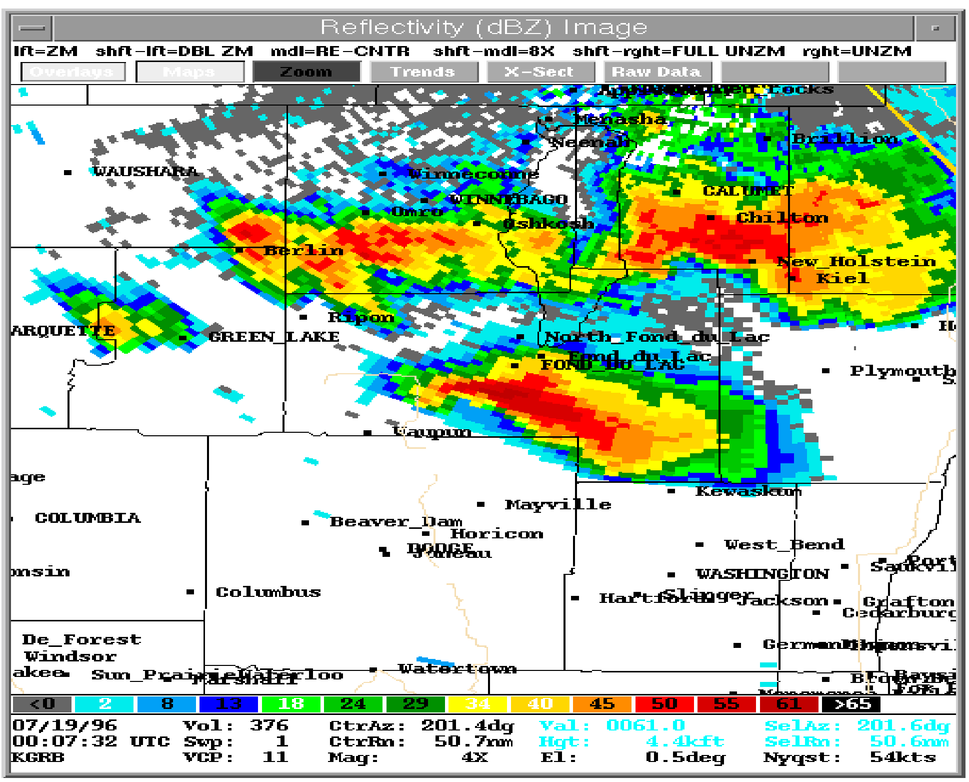

Figure 10 – Radar Image at 00:07Z July 19[th] 1996, showing hook echo

national weather service issue warnings and watched based on imagery rather than observations which can be too late. The radial velocity shows winds moving toward and away from the radar. As seen in the figure the region in south-central Fond du Lac County shows winds that rapidly change direction couple next to each other. This is signified by the change from green right to red.

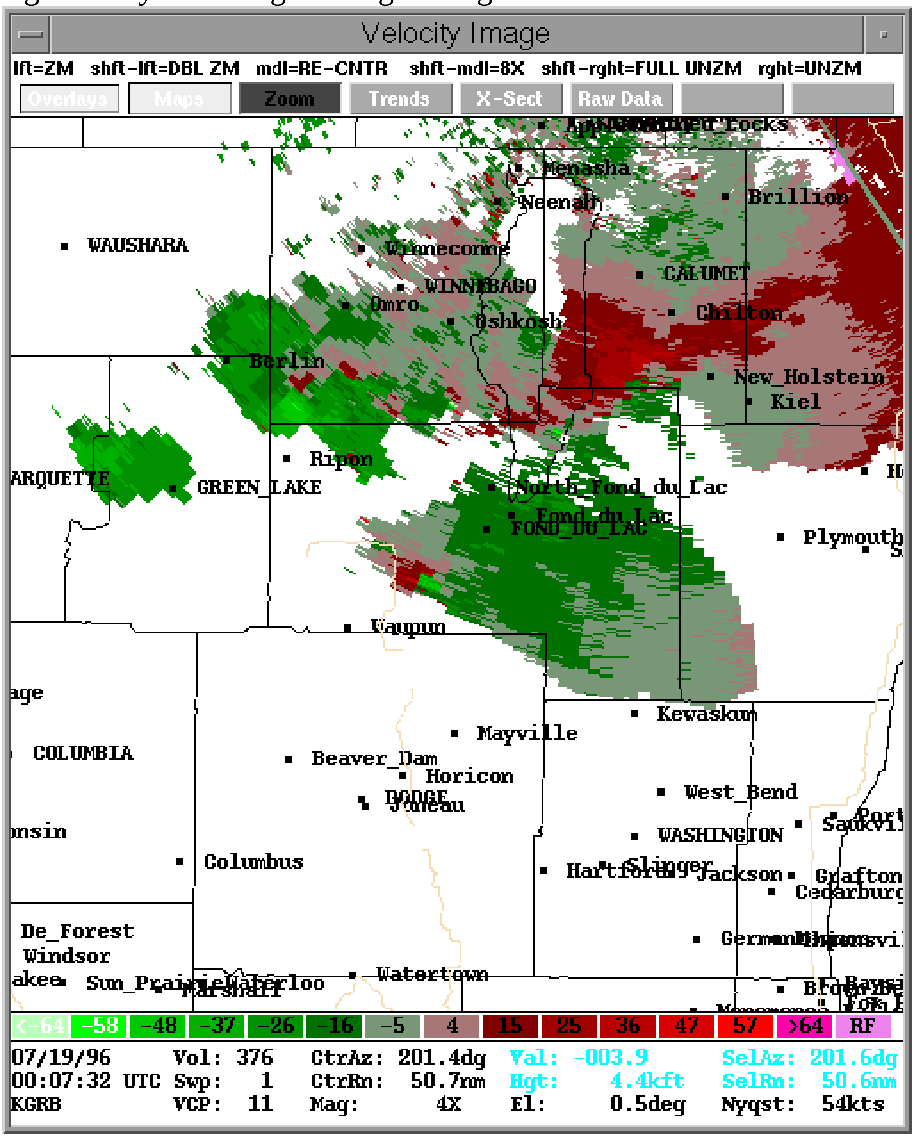

Figure 11 – Radial Velocities 00:07Z July 19th 1996

After the Tornado terrorized the Oakfield region it moved on through the south end of Fond du Lac County. Eventually it ended at around 7:35 p.m., just north of Eden, Wisconsin, which is southeast of Fond du Lac. **Figure 12** shows the path that the tornado took as it formed at about 7:05 and lasted until 7:35.

5. Conclusion

Every year Wisconsin experiences tornadoes. Typically they are short lived and rarely very strong. However in July of 1996, and extraordinary tornado ripped through Oakfield, Wisconsin leaving incredible damage and injuring 17 people. Copious amounts of low level moisture as well as features such as a cold front and dry line were in place to allow such a storm to form and grow. Other mesoscale features such as a veering wind profile and a cap inversion were in place. Enhanced lifting due to a jet streak aloft and upper level divergent winds increased the opportunity for a severe weather event. After all these pieces came together a Tornado was spawned and lasted for nearly 30 minutes. Studying weather events such as these will further allow forecasters to understand the synoptic and mesoscale situations that lead up to a severe event, and can better prepare the public of the nature of severe and tornadic storms.

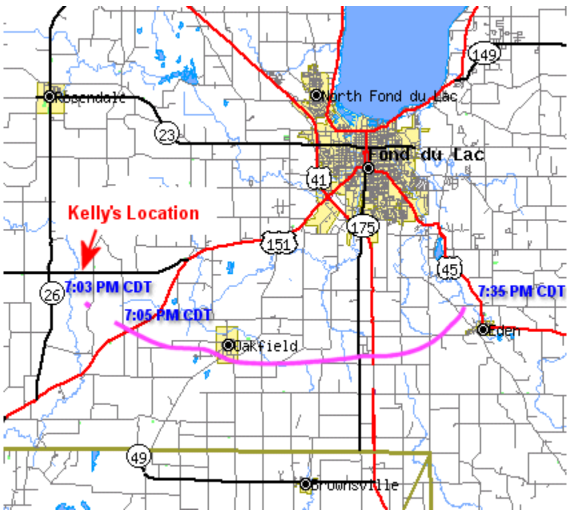

Figure 12 – Tornado Path on July 18th-19th 1996

6. Acknowledgements

The websites of the AOS 453 homepage was used. Also the University of Wyoming webpage of skew-T diagrams was also used. Some archived maps from Unisys as well as figures and information from the CIMSS site were also used. Finally some report data from the NOAA and NWS in Milwaukee Sullivan was used.

References

CIMSS (wisc)
Oakfield Tornado Case Study

NWS (MKE)
Storm Report

Unysis
Archived Maps

UWEX
http://www.uwex.edu/sco/oakfield.html

NOAA/NWS (mke)
Tornado Path

Lecture Notes from Professor Tripoli