Oakfield, WI Tornado of July 18th, 1996:

"Everything in its Right Place"

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ABSTRACT

This paper will serve the purpose of proving that the storm that produced the 1996 Oakfield Tornado was different from other storms in the way that *so many* atmospheric phenomena lined up to create it. Many atmospheric circumstances have the characteristic that they make it difficult to predict the occurrence of weather events, supercell thunderstorms to be exact. On July 18th, 1996, however, it should have been clear to any meteorologist with any amount of experience that things were to "blow up" in a quite electrifying way. This was extremely clear due to the amazing amount of atmospheric phenomena that fell in to place at exactly the right time.

1. Introduction

In today's day and age, it still proves difficult to predict the occurrence of tornadic thunderstorms. This is so because even with all of the supercell indexes that have been created, atmospheric phenomena really have to "cooperate" with the forecaster in order for him to make a solid forecast. Early in the morning on July 18th, 1996, short term quasi-geostrophic and mesoscale forecasting was made easy by the arrangement of the atmosphere. It is difficult to explain just how many things went right in order that these monster supercell storms flared up in the evening.

2. Data

A wide variety of tools were utilized in the creation of the information to be presented. The tools implemented ETA forecast information (surface and upper air), GOES-8 (Geostationary Operational Environmental Satellite) infrared data at 4km resolution, NCDC storm reports, CIMSS case study information, NEXRAD composite radar data at 1km resolution, surface observations, and radiosonde data plotted in skew-T form. The combination of these mechanisms made it possible to create an in depth analysis of the Oakfield, WI tornado of July 18th, 1996.

3. Synoptic Overview

The state of the troposphere, on the synoptic scale, will be investigated on many levels. To begin, the nucleus of the upper level flow was strewn across the northern end of the United States. This is clear to see in figure 1 due to the strong gradient of geopotential height at 500mb over the northern US. This point is further proven by figures 2 and 3, in which jet streams at 500mb and 200mb, respectively, are shown. In both of these plots, it is clear to see that the prevailing winds cover the northern half of the country, with the most intense winds, in fact, being just west of the area of interest. The fact that these plots were analyzed ten hours prior to the formation of the supercell of interest, coupled with the fact that the major features in the jet were centered over northeastern MN and northwestern WI, means that at the time of interest (22Z-00Z), the upper level vertical motion forcing associated with the jet streaks certainly must have been a factor in the creation of the supercells formed on that day.

Allow us to analyze the 250mb jet streak (figure 3) in depth. At 12Z, the right entrance region (favorable for vertical ascent) is centered over southern MN. The left exit region, at this time, is centered over the northwestern edge of the upper peninsula of MI. If we follow the general flow of the area, it is clear to see that the left exit region does not come into the area of interest, so it is therefore thrown out as a possible cause for vertical lifting. The right entrance region, however, follows the flow to be directly centered over central WI at the time of interest. The upward vertical motion associated with the upper level ageostrophic wind divergence eventually "broke" the capping inversion (which will be discussed later) which had built up to be so strong throughout the day.

In addition to upward vertical motion associated with the upper level jet streaks, synoptic forcing also provided the right type of air mass collision to occur in exactly the right spot. Referring to figure 4, we can clearly see two major features. A low pressure system is centered over central Minnesota, while a strong High pressure system is centered over central Georgia. As the low pressure system pushed through, it brought cold air from the north behind the cold front associated with the cyclone. At the same time, the western tier of the anticyclone advected warm, moist air from the Gulf of Mexico into the northern Midwest. The clash of these two types of air masses certainly gives way to the development of intense convection, as air stability is dramatically lowered.

4. Mesoscale Discussion

In the presence of a nearly perfect synoptic setup for the occurrence of thunderstorms, mesoscale dynamics also played a huge role in the formation of the ever famous supercells of July 18, 1996. To begin, allow us to investigate 850mb dewpoint contours at 12Z (figure 5). Because a strong gradient of dewpoint characterizes a dryline, it is clear to see a concentrated dryline ranging from northeastern Nebraska all the way through northeastern Wisconsin. At the time analyzed by this figure, the dryline sat west of the area of interest, but in the radar loop, it is clear to see that a large amount of supercells form along this dryline, as it progresses to the east, while tilting counterclockwise. Drylines represent the area between two clashing air masses (warm moist, and cool dry), and thunderstorms typically form along them in the spring and summer due to the intense instability of the air associated with the dryline.

Also worth mentioning, surface winds converged heavily over central Minnesota at 12Z. This can be seen clearly in figure 10, where surface level streamlines are analyzed. Surface convergence is associated with upper level divergence, and consequently can be linked to convection.

Another mesoscale tool used worth mentioning is the radiosonde data from 12Z on July18th. Shown on figure 6 are an intensely moist boundary layer, and an equally as moist layer all the way up to 350mb. The most important piece of information gained from this sounding, however, is the extreme inversion at low levels. This inversion caused a capping effect, which means that due to the inversion, air is trapped at the bottom of the atmosphere and collects for hours, making the air more and more unstable.

The inversion itself does not cause supercell thunderstorms to occur. Rather, the forcing provided by an outside source which breaks the inversion is responsible for causing the explosion associated with capping inversions, and ultimately causing severe weather. In this case, the right entrance region of the jet triggered the explosion with upward vertical motion. I believe that in the case of the Oakfield supercell, the inversion was so strong, and the amount of trapped air so great, that the events of July 18th, 1996 were unique compared to other thunderstorm outbreaks.

It is also necessary to characterize the storm's appearance as having an intense hook-echo structure, which is a basically sure sign that a mesoscale circulation with the power to produce a tornado is takes place just prior to the tornado's touchdown (figure 7).

When diagnosing the stability of the atmosphere, it is essential to calculate stability indices, as each tells you something different about the strength of the instability. The K index was calculated to be 38, meaning that there was an 80-90% chance of thunderstorms. Total Totals were at 51, meaning that a few isolated tornados would be possible. Also, the SWEAT index indicated, with a value of 434, that severe T-storms were probable, and tornados were possible.

All of these stability indices pointed at the chance of tornadic thunderstorms as probable; however, the CAPE value measured at 12Z was slightly above 10. This is an extremely low value for CAPE, so the question must be asked: why? The only feasible explanation that can be that the inversion, at the time measured (12Z), was not in place long enough to destabilize the atmosphere enough to produce a high CAPE value.

5. Conclusion

The Oakfield Tornado of July 18th, 1996 created a large amount of damage and caused a large economical disaster. Many tornados create damage, and many storms create tornados. What sets this weather event apart from other similar events is that in the case of the Oakfield Tornado, an extremely large amount of convection-inducing factors took place on the synoptic, and mesoscale level. The combination of synoptic scale flow being directed along the upper US, synoptic scale upward vertical motion, the collision warm, moist air with cool, dry air, the sub sequential formation of a dryline, and most importantly, the extremely strong capping inversion that took place on July 18th made it so unique.

REFERENCES

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"Thunderstorms." Weatherbuff: Backyard Meteorology on the Web. Weatherbuff. Apr.-May 2006 <http://www.weatherbuff.com/Pages/t-storms.html>.

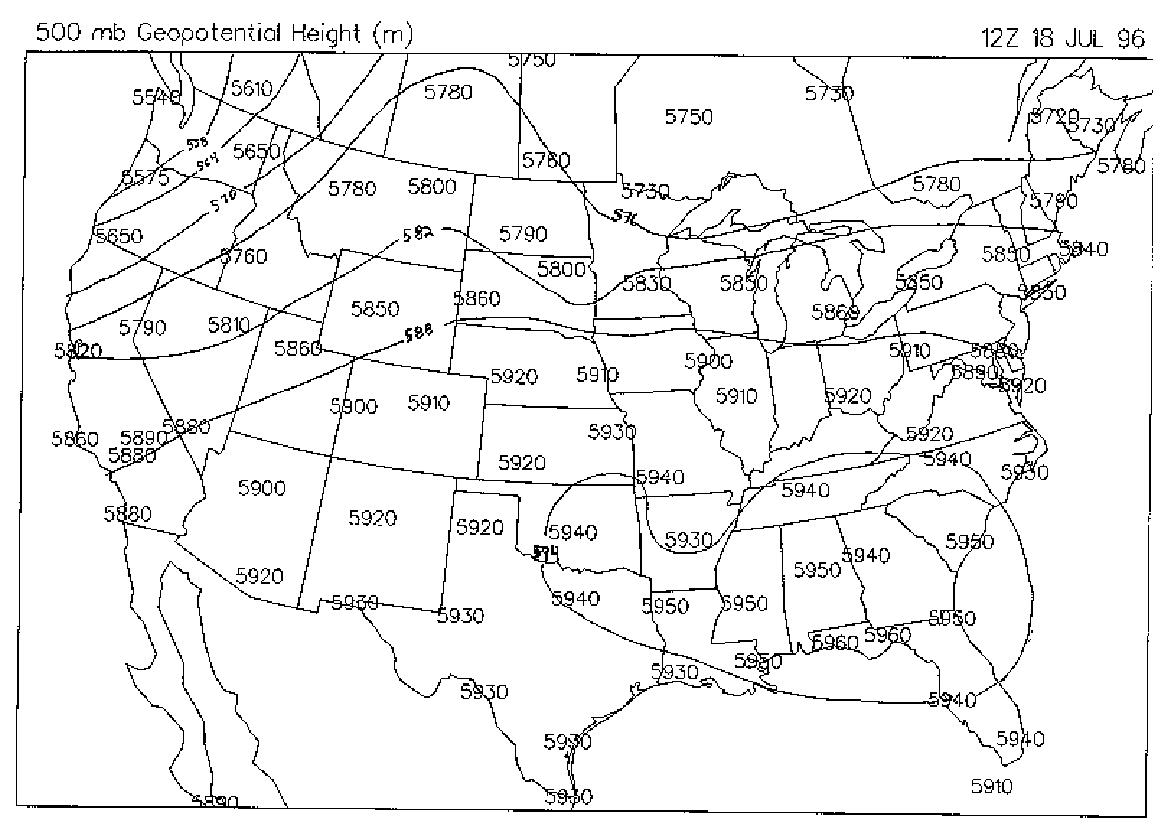


figure 1

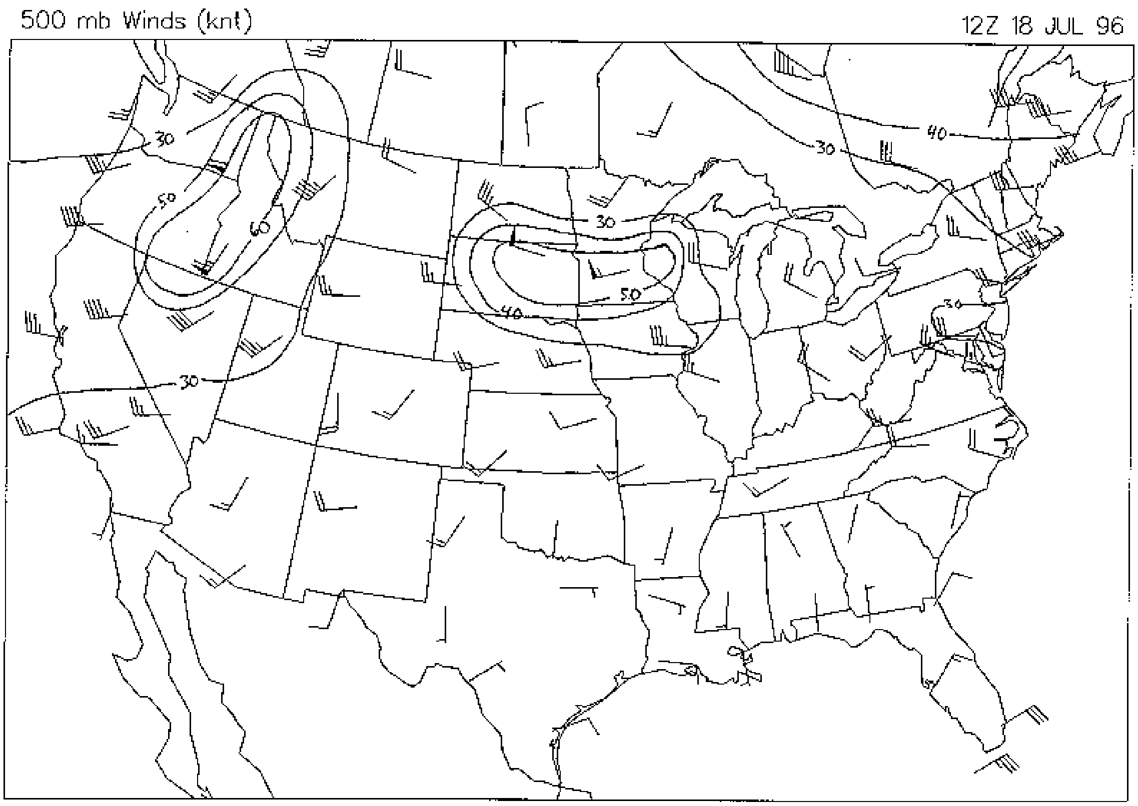
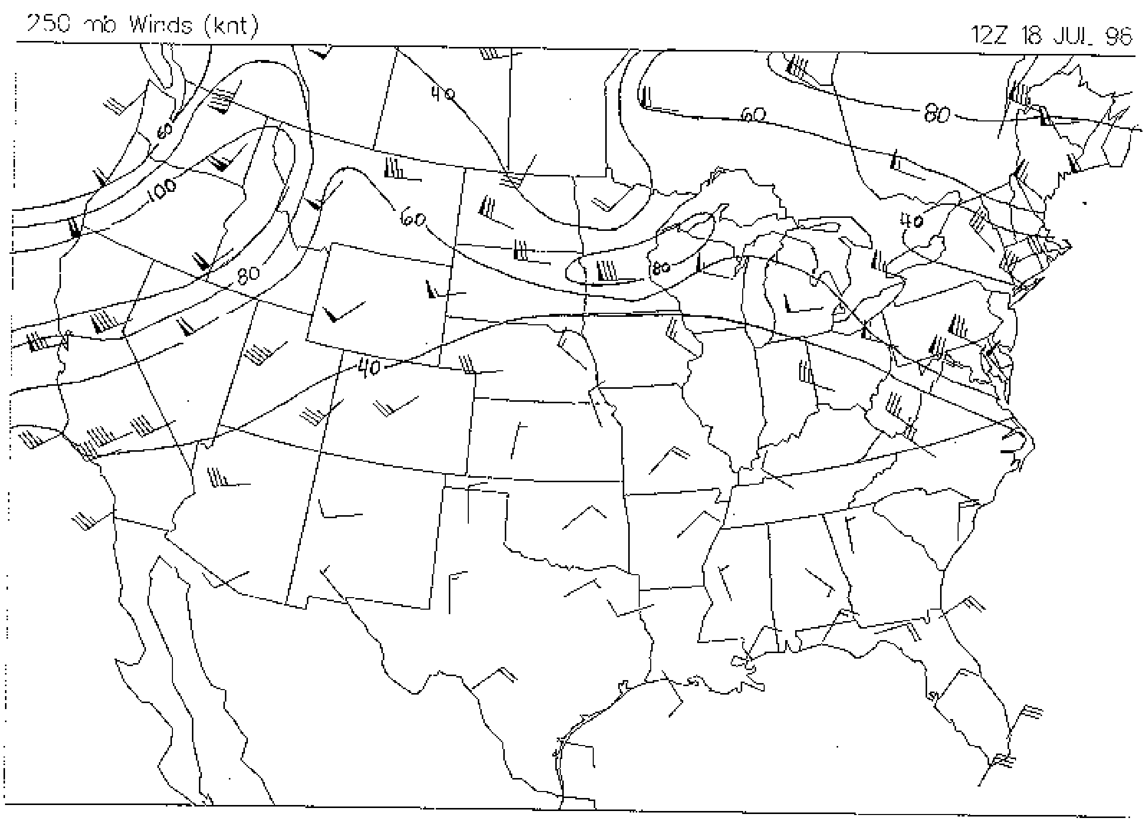


figure 2



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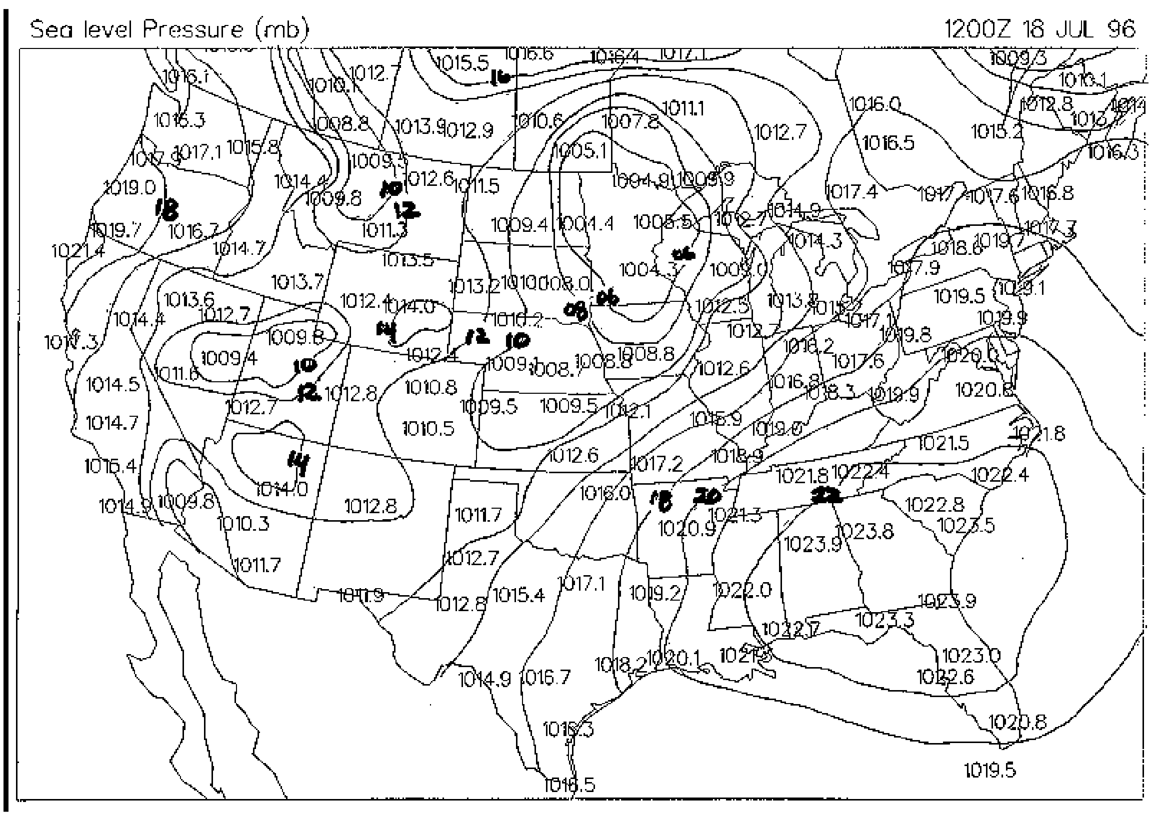
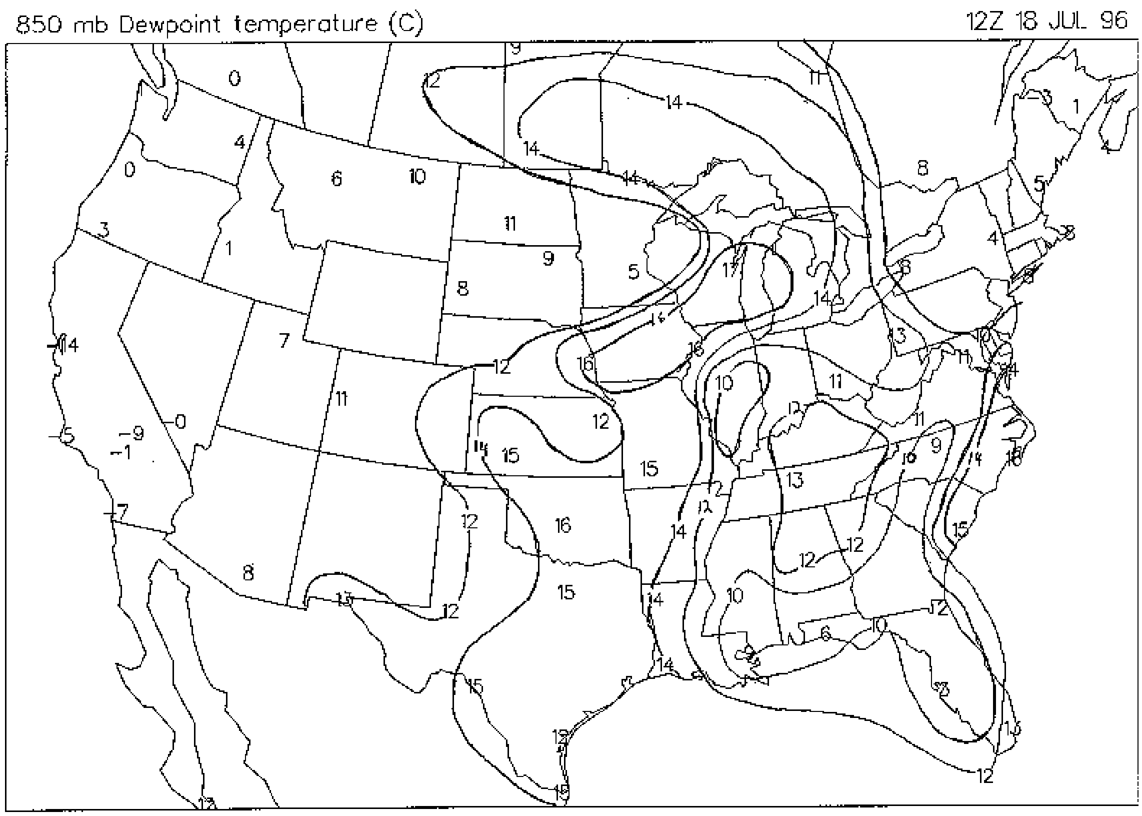


figure 4



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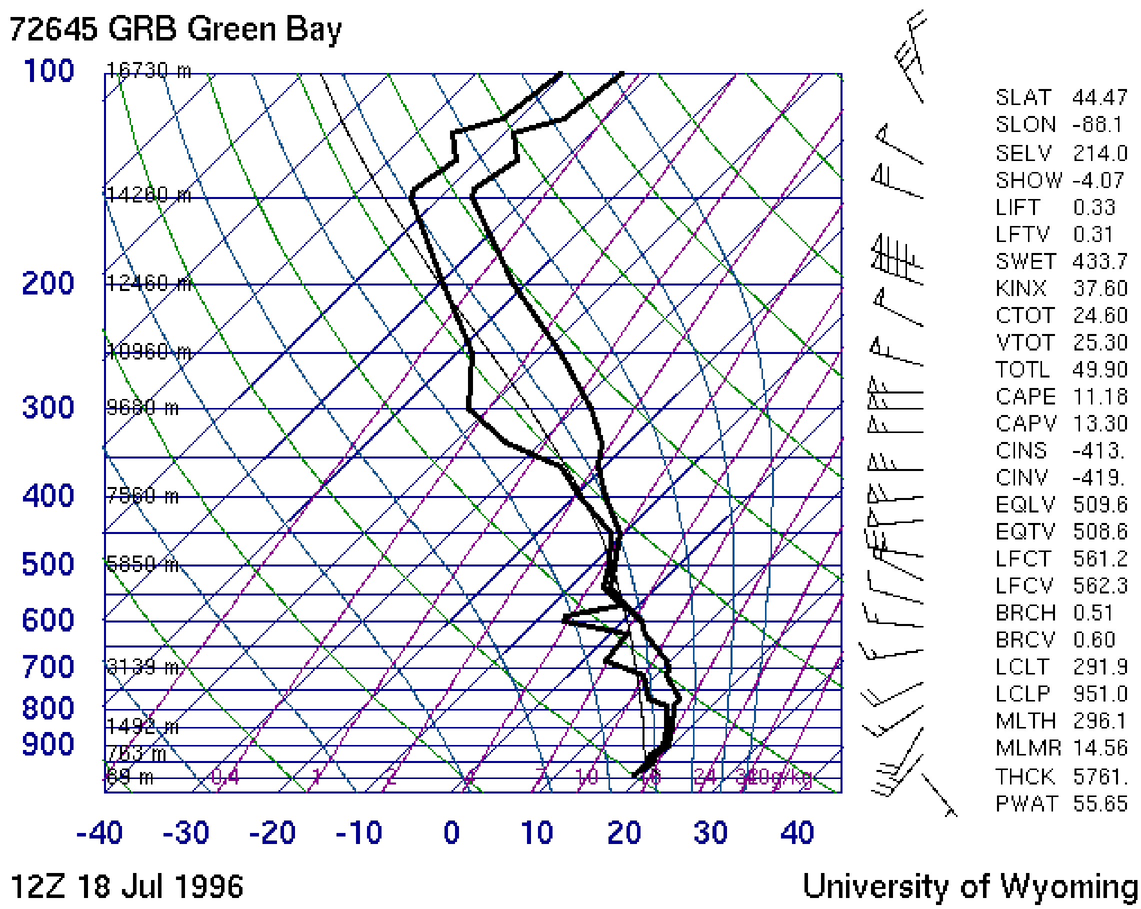
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5850 m
3139 m
1492 m
753 m
69 m
0.4
1
2
4
7
10
16
24
32
40g/kg
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-30
-20
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10
20
30
40
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SLON -88.1
SELV 214.0
SHOW -4.07
LIFT 0.33
LFTV 0.31
SWET 433.7
KINX 37.60
CTOT 24.60
VTOT 25.30
TOTL 49.90
CAPE 11.18
CAPV 13.30
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CINV -419.
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EQTV 508.6
LFCT 561.2
LFCV 562.3
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BRCV 0.60
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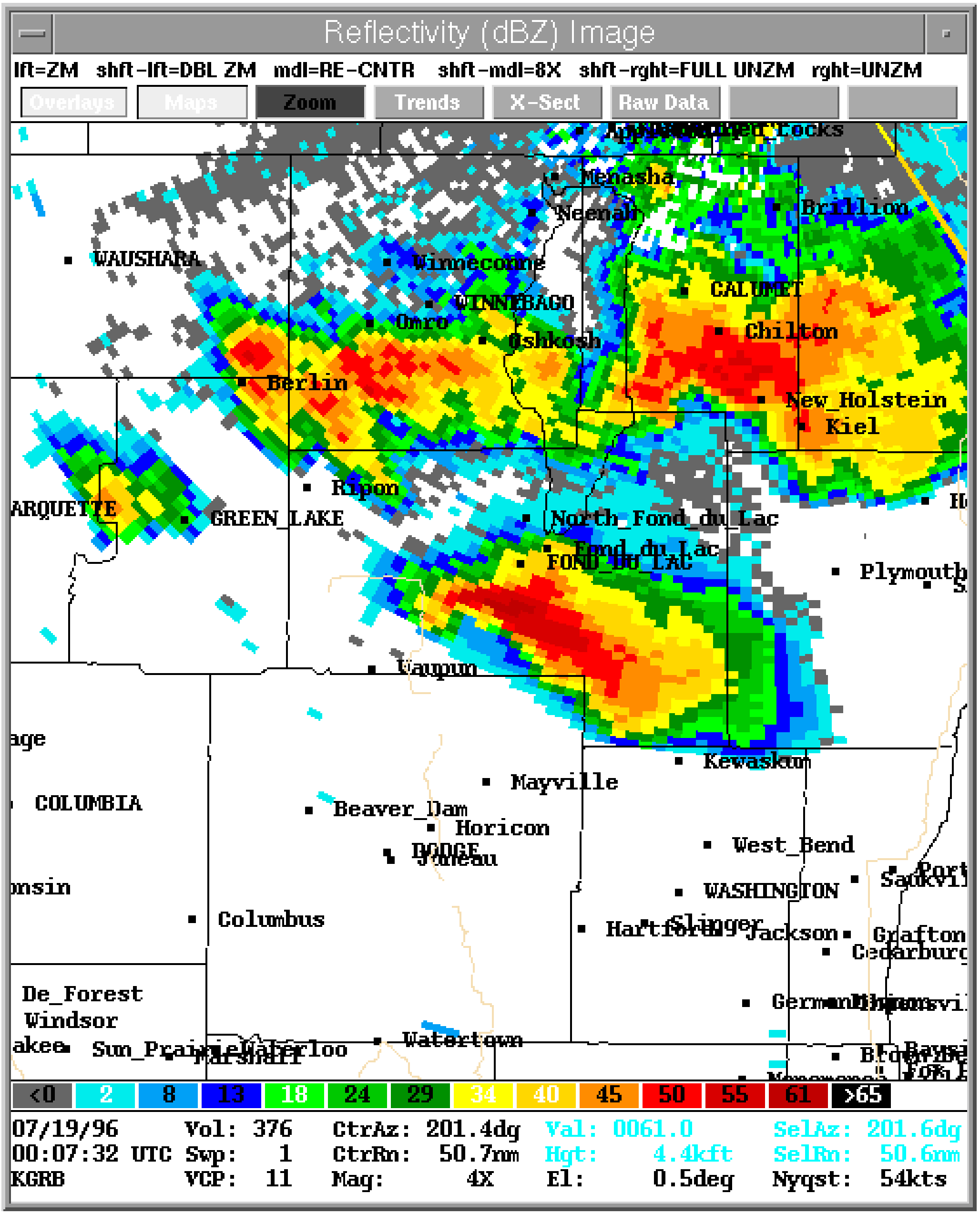
12Z 18 Jul 1996
University of Wyoming

figure 6



Reflectivity (dBZ) Image
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Overlays
Maps
Zoom
Trends
X-Sect
Raw Data
Menasha
Neenah
Brillion
WAUSHARA
Winneconne
CALUMET
WINNEBAGO
Omro
Oshkosh
Chilton
Berlin
New_Holstein
Kiel
Ripon
ARQUETTE
GREEN_LAKE
North_Fond_du_Lac
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Plymouth
Waupun
Kewaskum
Mayville
COLUMBIA
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CtrRn: 50.7nm
Mag: 4X
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Nyqst: 54kts

figure 7

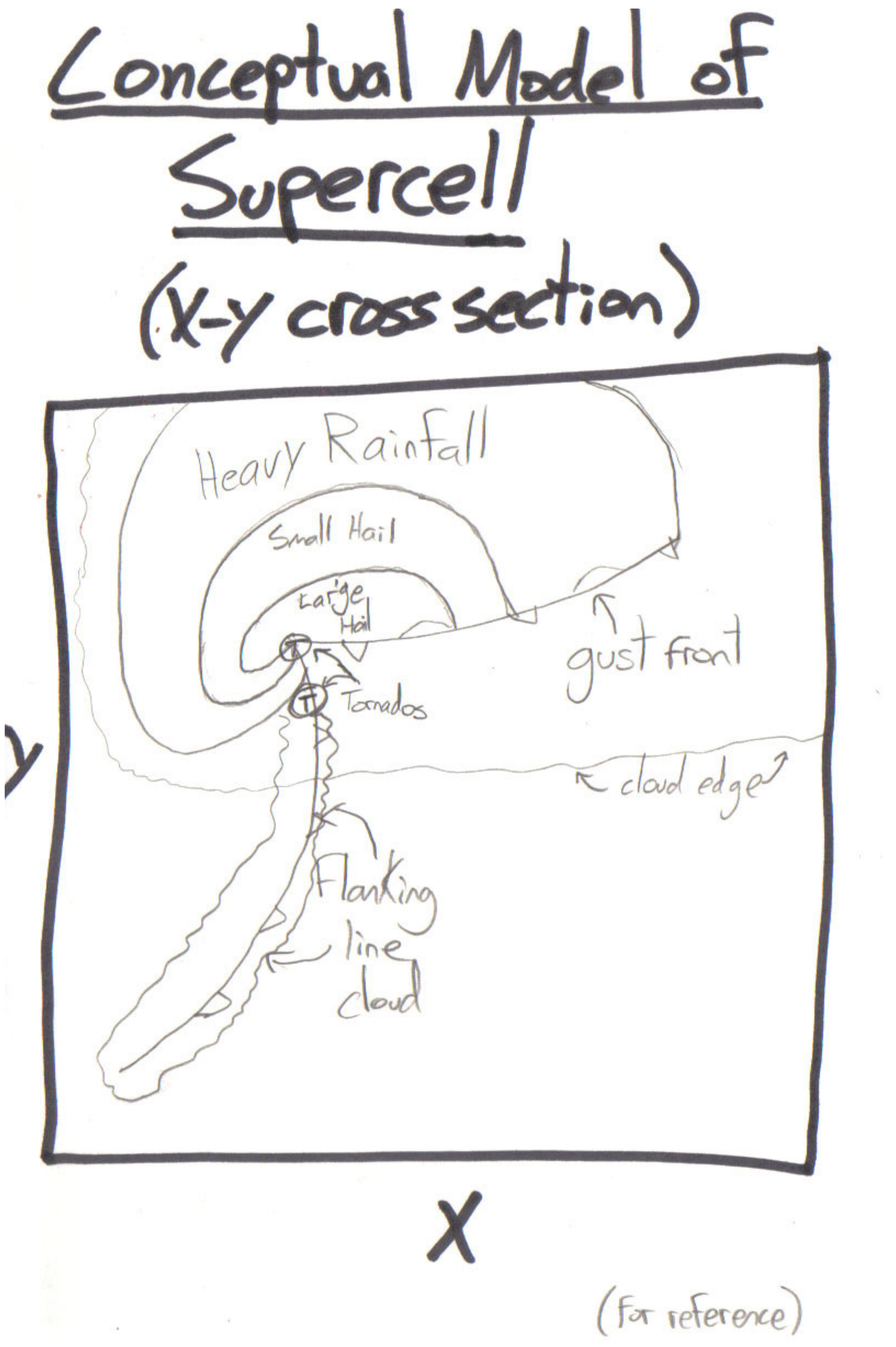
Conceptual Model of Supercell
(X-y cross section)
Heavy Rainfall
Small Hail
Large Hail
Tornados
gust front
cloud edge
Flanking line cloud
y
X
(For reference)

Figure 8

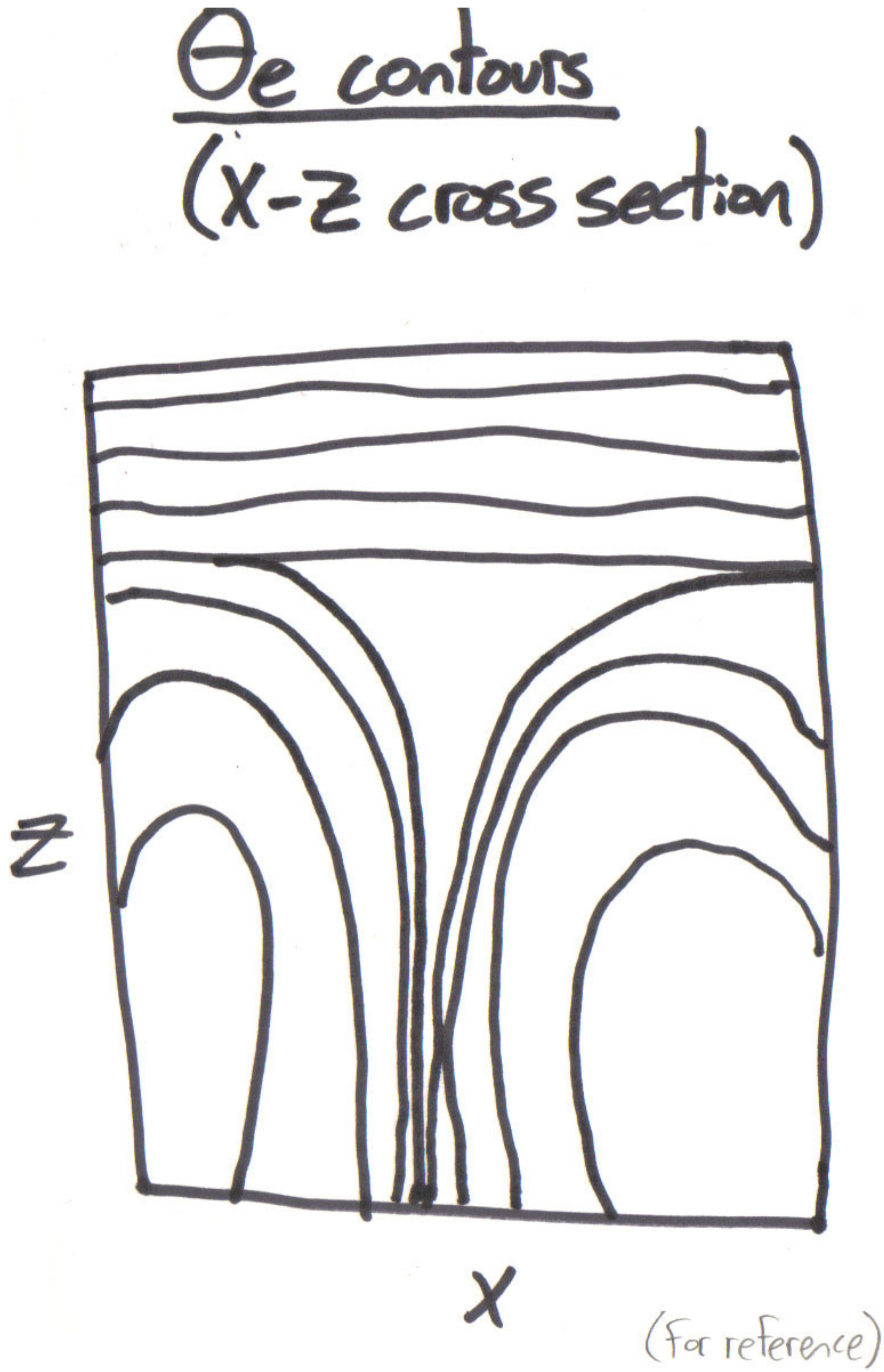

Figure 9

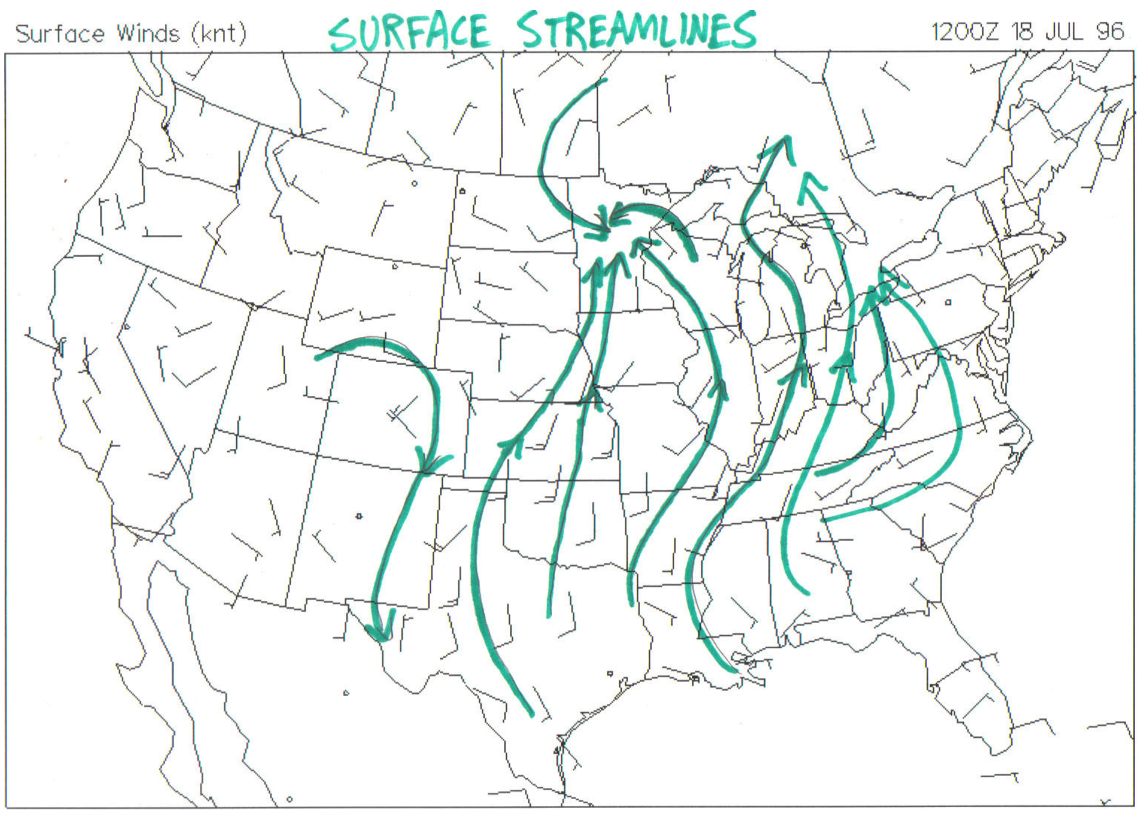

Figure 10