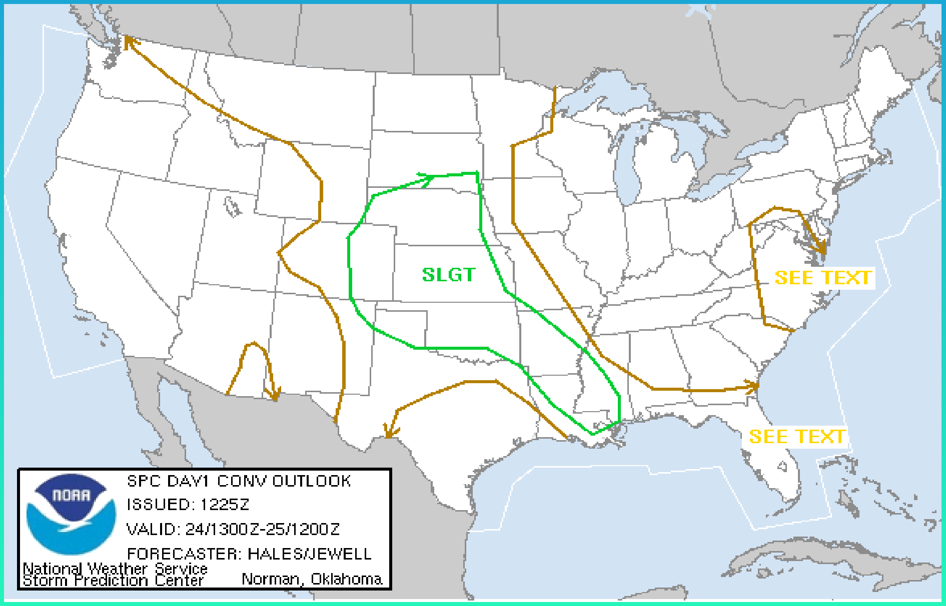
Advanced Spotter Training 2009

Lesson 3: What Conditions Produce a Thunderstorm?



From Last Time

- We reviewed the criteria for severe weather:
  - Winds of 50 knots (58 mph)+
  - Hail 1"+
  - Tornadoes and funnel clouds.
- We discussed what to report.
- We discussed severe winds, hail, flash flooding, and tornadoes.

This Lesson

We will be discussing the root causes of severe weather.

Homework Review

Go over the homework problems from last time:

- Make a list of the types of severe weather on a 3" x 5" card and carry it around with you until you memorize it.
- Speculate on how to estimate wind speed. If you do not have an anemometer (a device for measuring wind speed) list how you will make such estimates.

Homework Review *(continued)*

- Carry a tape measure with you to measure hail. Wrap the tape measure around the biggest hailstone you can find. Divide this number by 3 and you will have a rough estimate of the diameter. Why does this work?
- Hand draw a diagram of a thunderstorm. Make photocopies of it, or get some acetate overlays, or tracing paper.

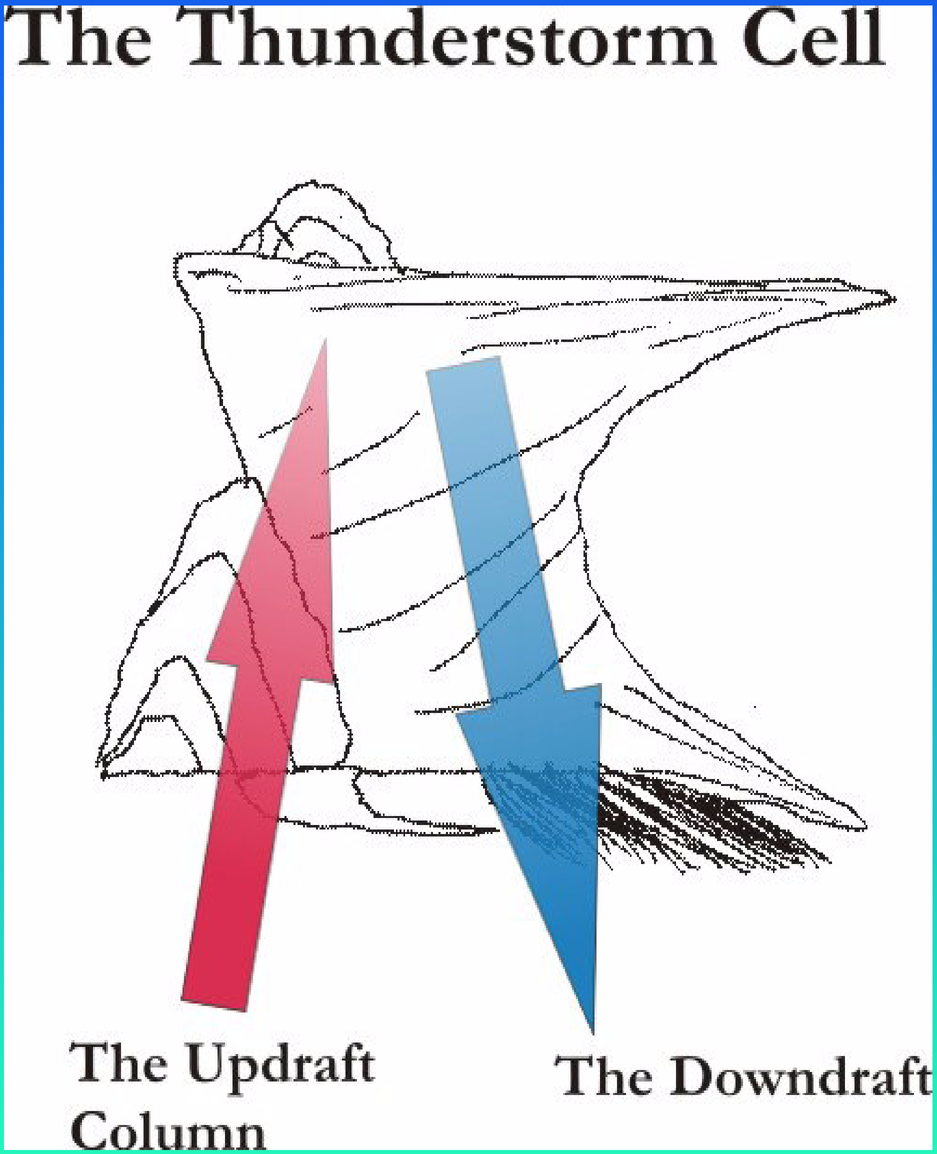
Homework Review *(continued)*

- Using a photocopy of your diagram, or an overlay, develop a diagram showing where you are most likely to find severe hail, severe winds, and tornadoes.

What causes severe weather?

The primary cause of all types of severe weather is the thunderstorm. To understand severe weather, we must first understand thunderstorms.

The Thunderstorm



If we look at the thunderstorm, we note:

- The thunderstorm is composed of two parts, the updraft and the downdraft.
- What clue does this give us as to how thunderstorms get started?

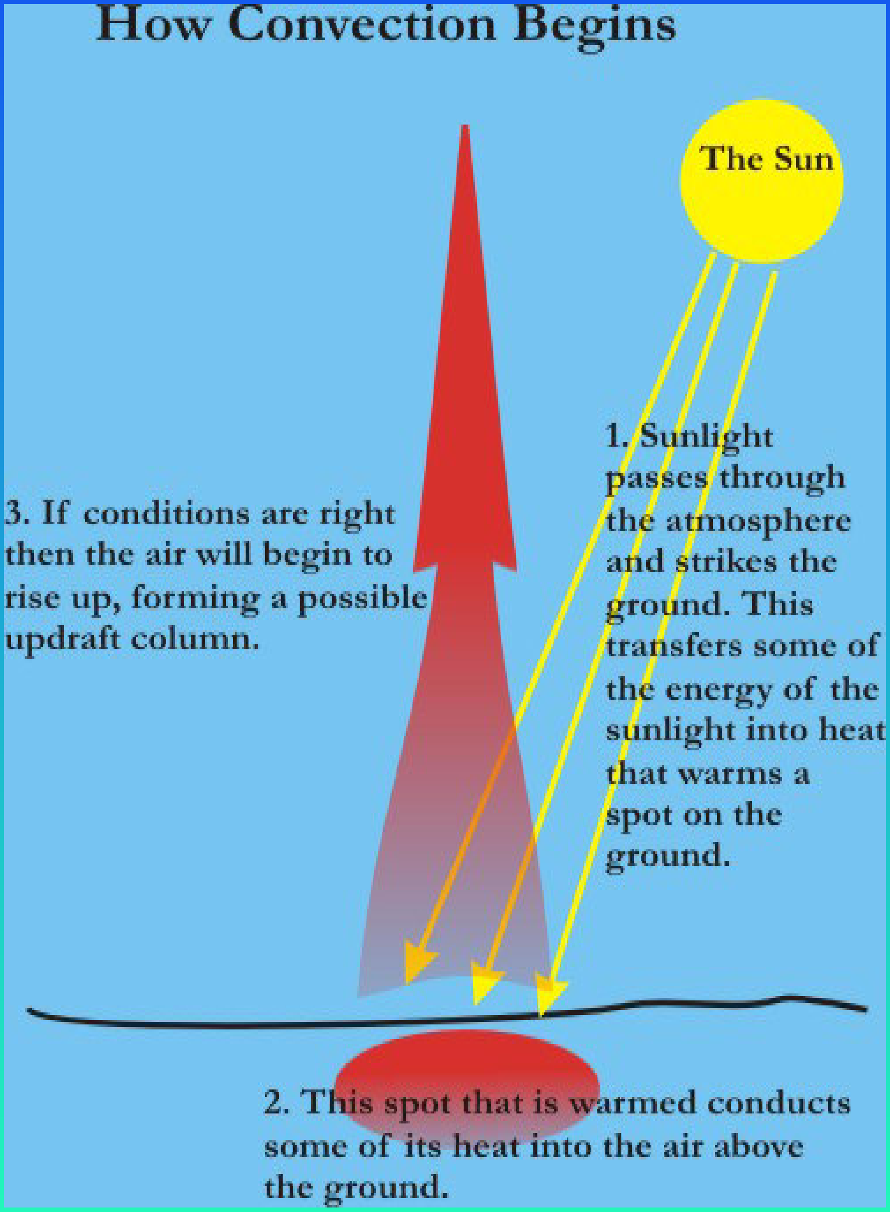
The Thunderstorm *(continued)*

- Which comes first, the updraft, or the downdraft, or both?
- The updraft seems to be what starts the thunderstorm going.
- We will discuss the life-cycle of a thunderstorm in the next lesson.
- Since the updraft is what starts a thunderstorm, what starts an updraft?

What makes the air rise?

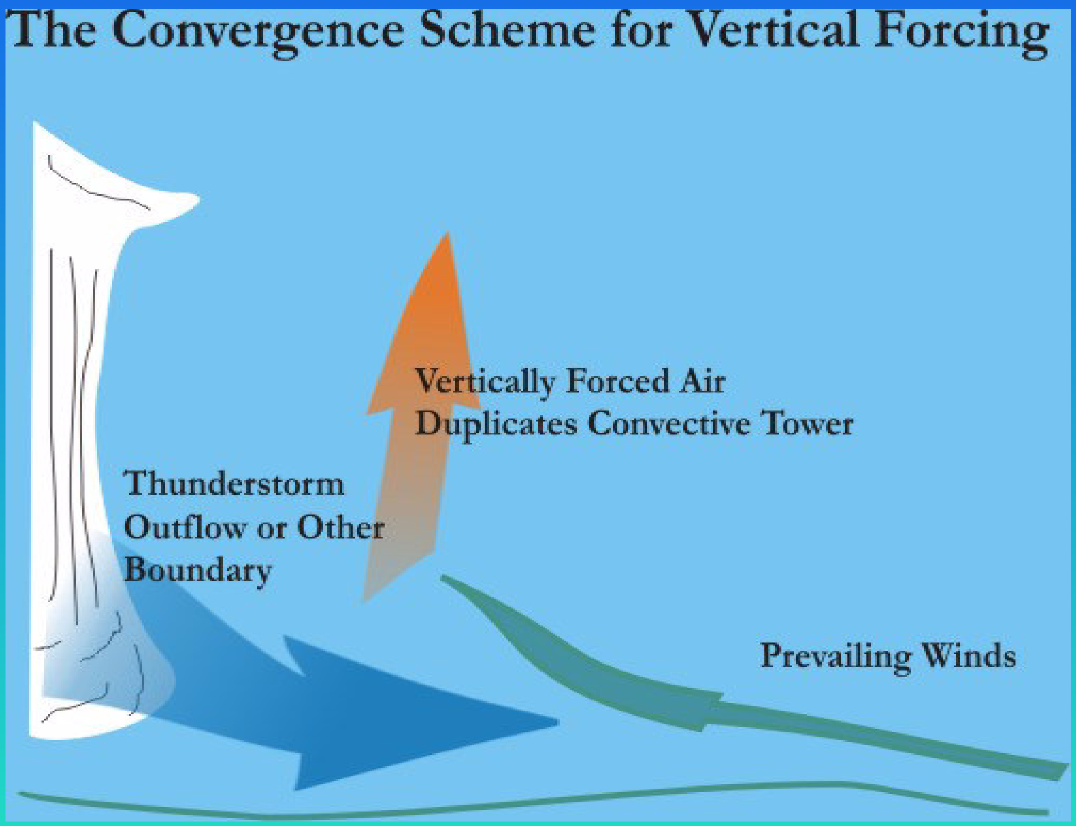
- Convection.
- Convergence.
- Fronts.
- Terrain.

Convection



- Convection occurs when the ground is warmed by the Sun.
- By the process outlined to the left, air begins to rise.

Convergence

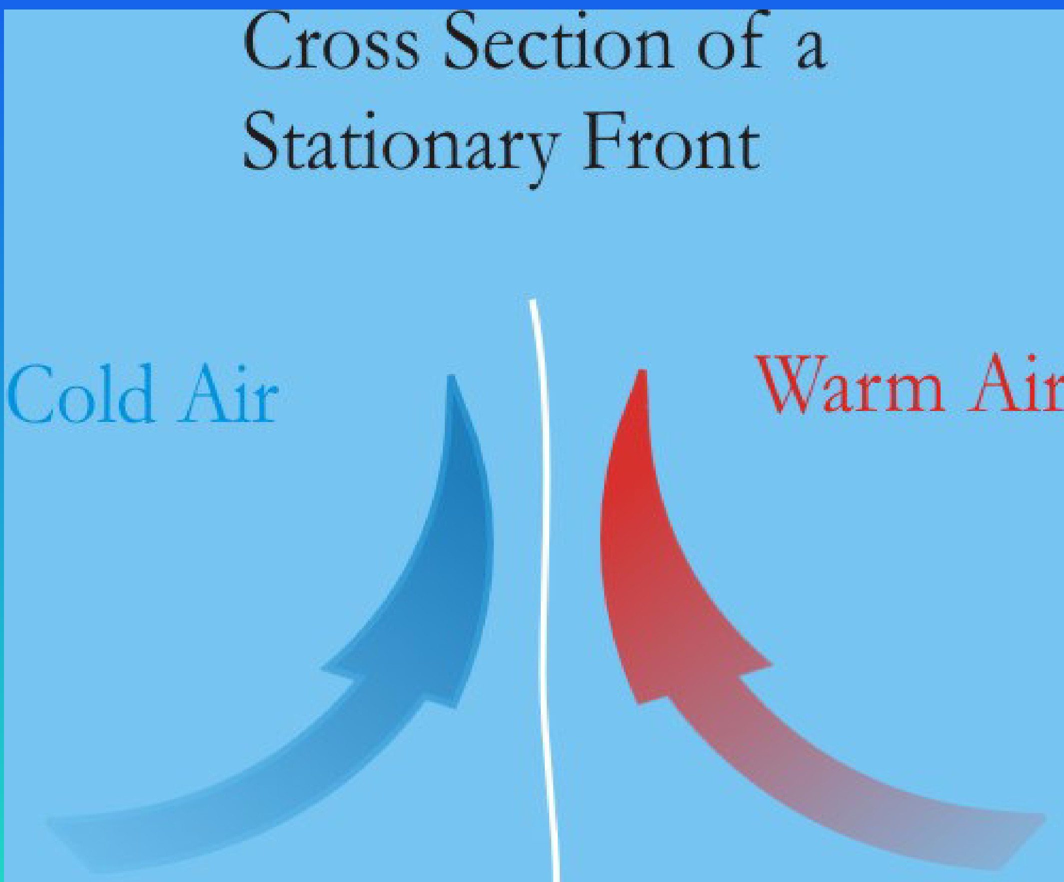


- When air from different directions comes together at ground level, it is called *convergence.*
- Some, or all, of this converging air will be driven upward.

Fronts

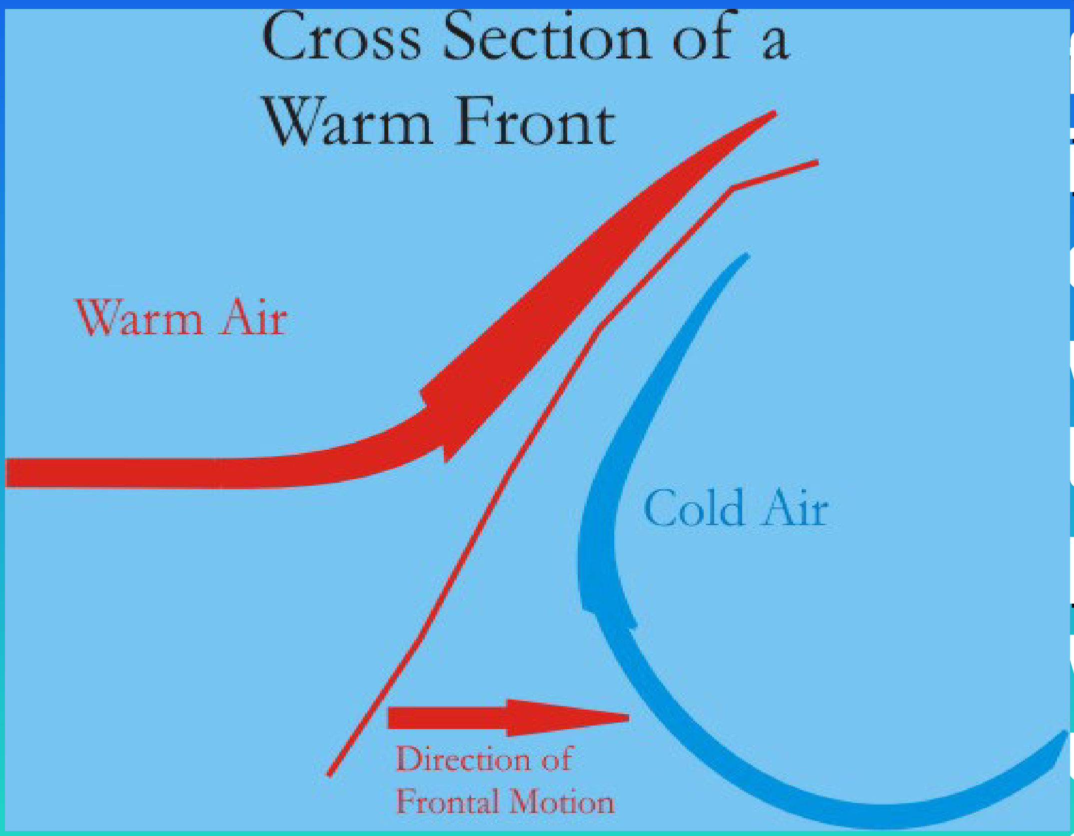
We have all seen fronts on weather maps. They represent the boundary between warm and cold air. These are often a focus of thunderstorm development.

The Stationary Front



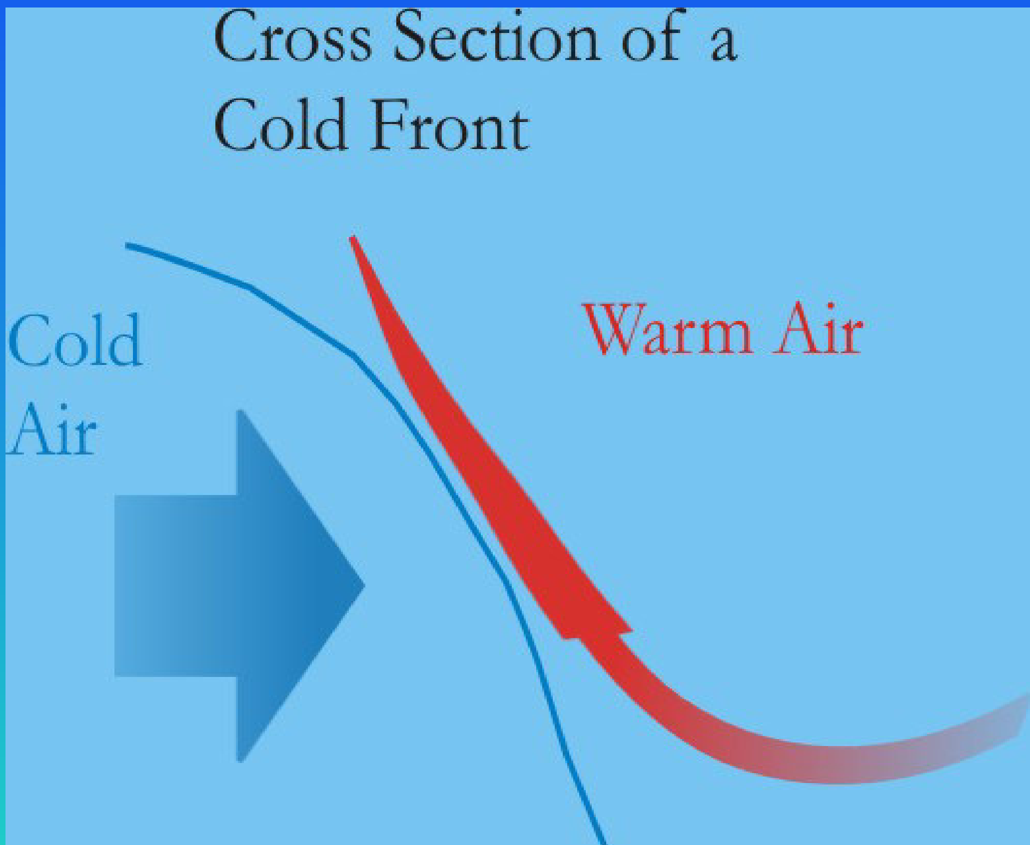
We will begin with a stationary front. Here we have two air masses that sit next to each other. There is very little movement in the position of a stationary front. Lows can travel along these fronts causing storms.

The Warm Front



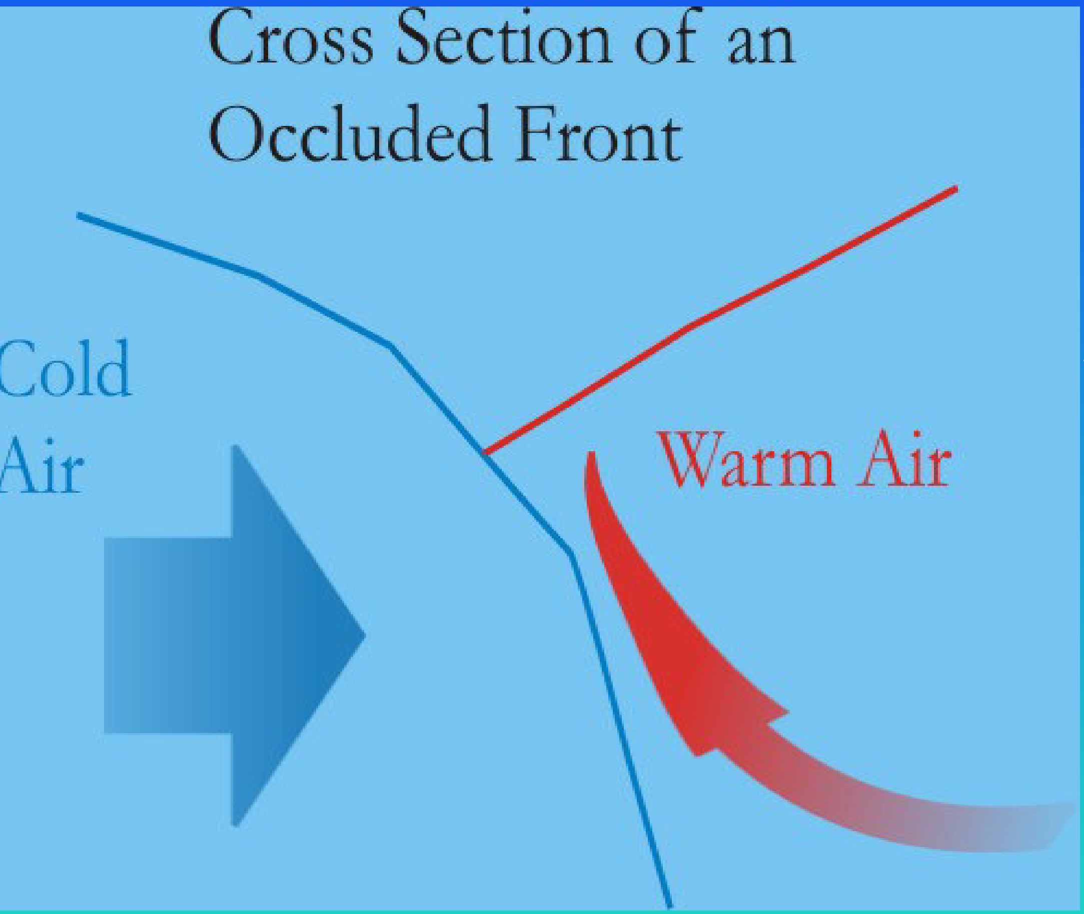
Next we have a warm front. Here warm air is pushing into and over cold air. This warm air overriding the cold air can produce very severe weather since there is usually an ample supply of heat in the rear of the storms to feed them.

The Cold Front



Here we have a cold front. Cold air is moving into an area of warm air. As the cold air slides under the warmer air, upward motion is created. Cold fronts are often associated with long-lasting downbursts, since there is cold air behind the front being driven downward.

The Occluded Front



An occluded front occurs when a cold front catches up to a warm front. This can result in the most vigorous upward motion of all of the types of fronts.

The Occluded Front *(continued)*

- In the picture above we see that the warm front is actually being lifted up over the top of the cold front.
- The rising air at the leading edge of the warm front will be forced to rise even faster now.
- A similar situation can result if the cold front rises up and over the warm front.

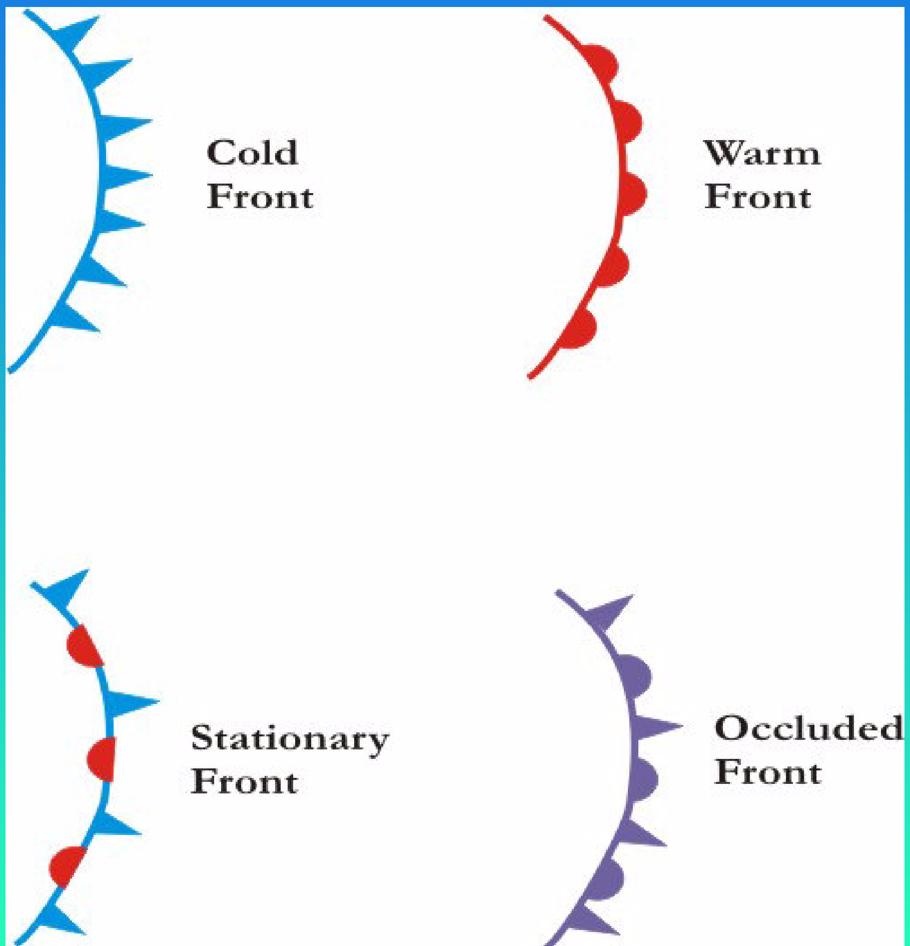
How Do You Find Fronts on a Weather Map?

There are two ways to do this:

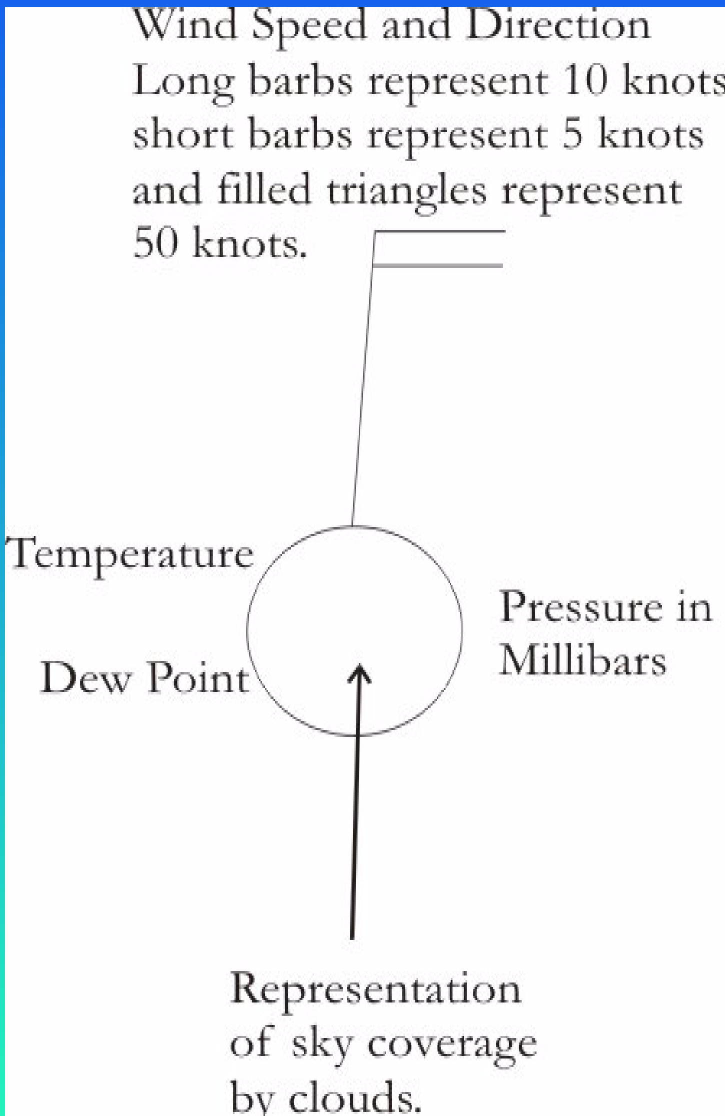
- Use an existing surface analysis map to find the fronts.
- Make your own analysis of a surface map.

How to find fronts on a surface map I: Pre-analyzed chart.

- Fronts are portrayed with specific symbols:



How to find fronts on a surface map II: Your own analysis.



- Look for station models on a map. They are of the form to the left.
- The wind barbs point into the direction the wind is coming from.

Your Own Analysis.

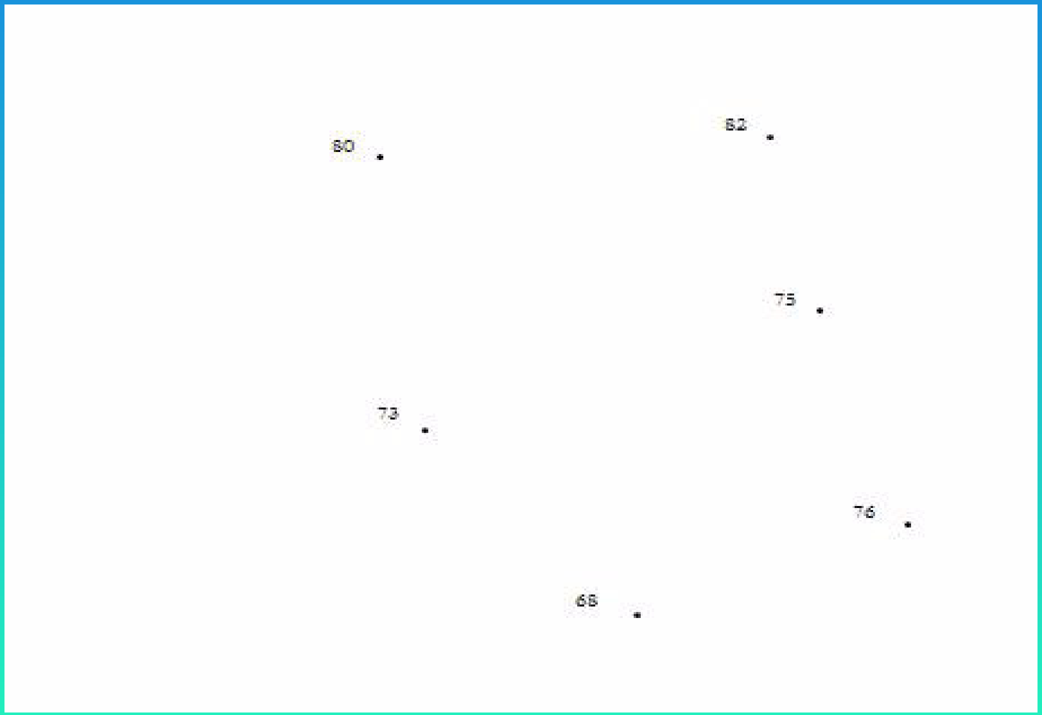
- Use a pencil and lightly draw lines between station models that have the same temperature.
- Boundaries are located where lines of different temperature are nearly parallel.
- Sharp differences in temperature between stations can indicate the presence of a front.

Your Own Analysis. *(continued)*

- To see good examples of this, look at a surface analysis that plots fronts alongside surface analyses that show only station models.

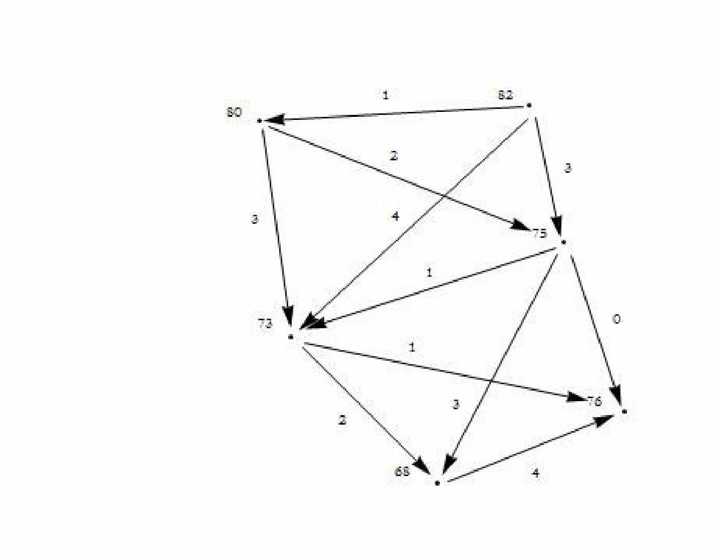
Your Own Analysis. *(continued)*

I will give an example of a temperature analysis. Begin by choosing a station that has the data you are looking for. In this example there are six stations.



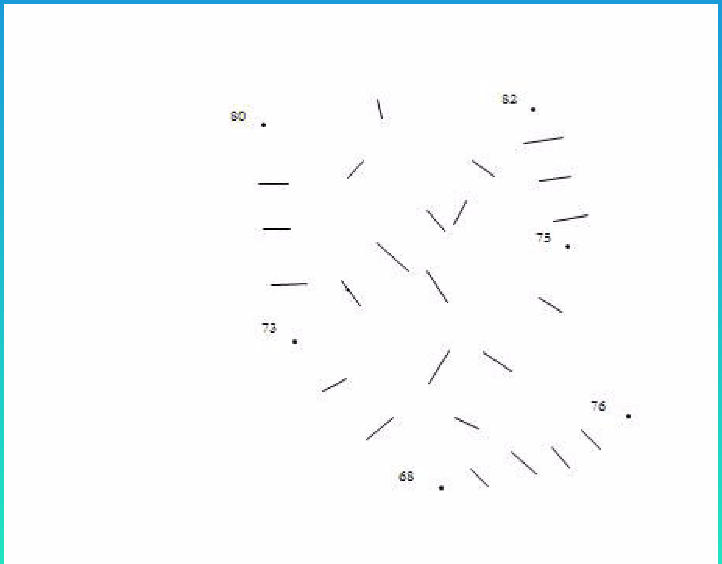
Your Own Analysis. *(continued)*

Look at each adjacent station and determine how many contours would lie between them. The figure below has the example of this analysis. For temperature or dew point, this can be either every 2° F, or every 5° F; for pressure every 4 millibars.



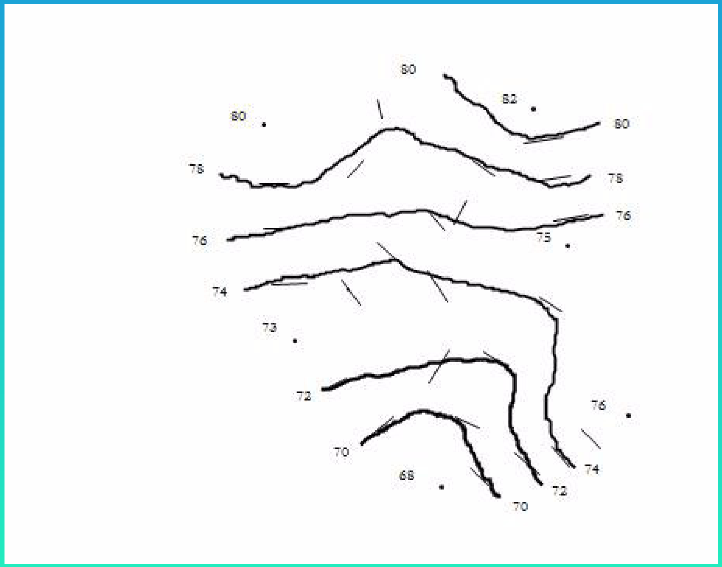
Your Own Analysis. *(continued)*

Place a dot or tick mark for every contour as evenly as possible between the stations. The figure below shows how the tick marks are placed.



Your Own Analysis. *(continued)*

Draw a continuous curve connecting all equal dots beginning with the coldest and moving up to the warmest. The figure below shows the contour lines drawn over the example.



Your Own Analysis. *(continued)*

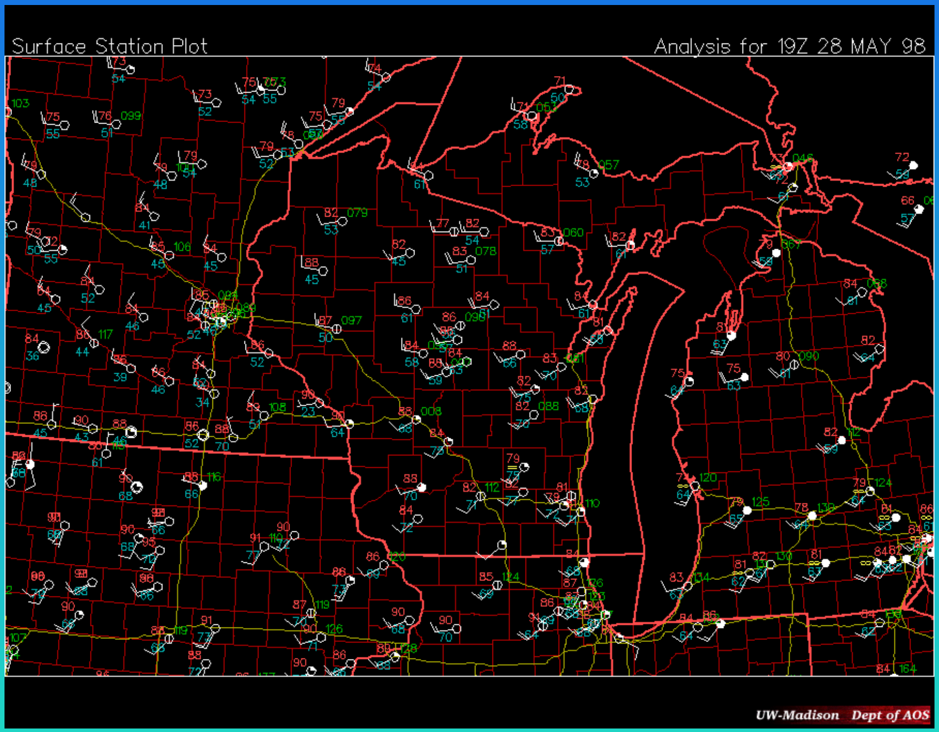
Use some intelligence, if six stations surrounding a central seventh station all have the same values, then there is likely no contour line in the center.

Here are some suggestions:

1. Do not assume data that is not there.
2. Label all closed lines and all end points.
3. Be sure to include all points, on one side of a line you have a lower value, on the other a higher value.
4. The data you have is only a representation of the atmosphere, it is not the actual atmosphere.

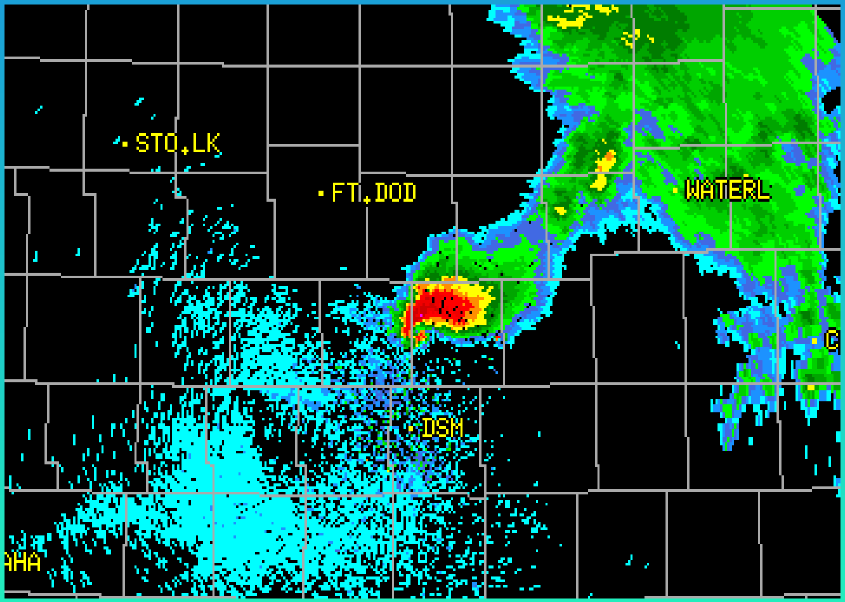
First Discussion!

- Think about the definitions of fronts and why storms form along them.



Section 2

The Local Wind Field

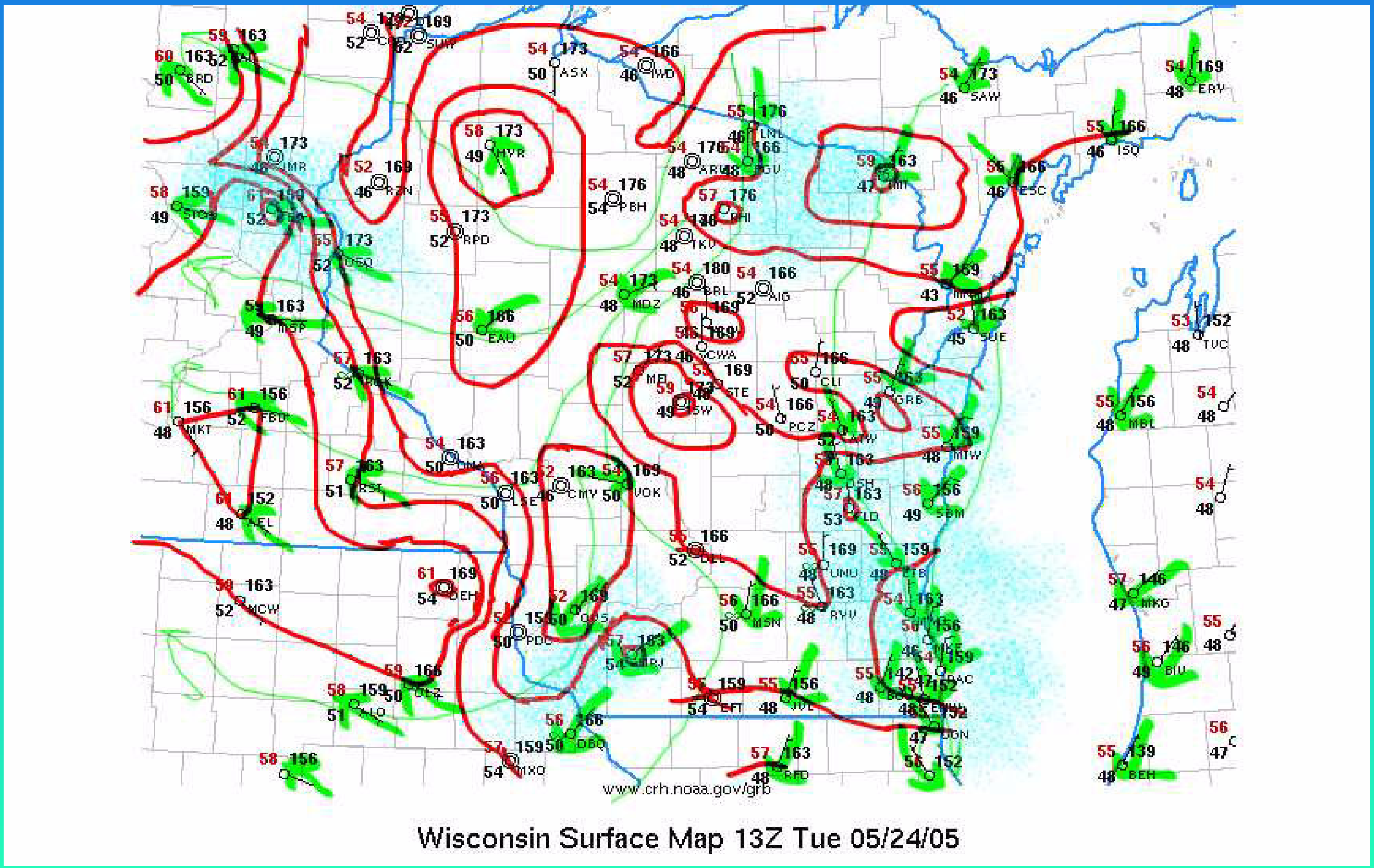


How Do We Locate Convergence on the Surface Analysis?

- Use a pencil and lightly draw arrows extending in the direction of the wind flow on the station model.
- When these arrows angle towards each other you have convergence.
- You can find flows of the surface winds on maps that display what are called streamlines.
- When you see these streamlines getting closer together, you have convergence.

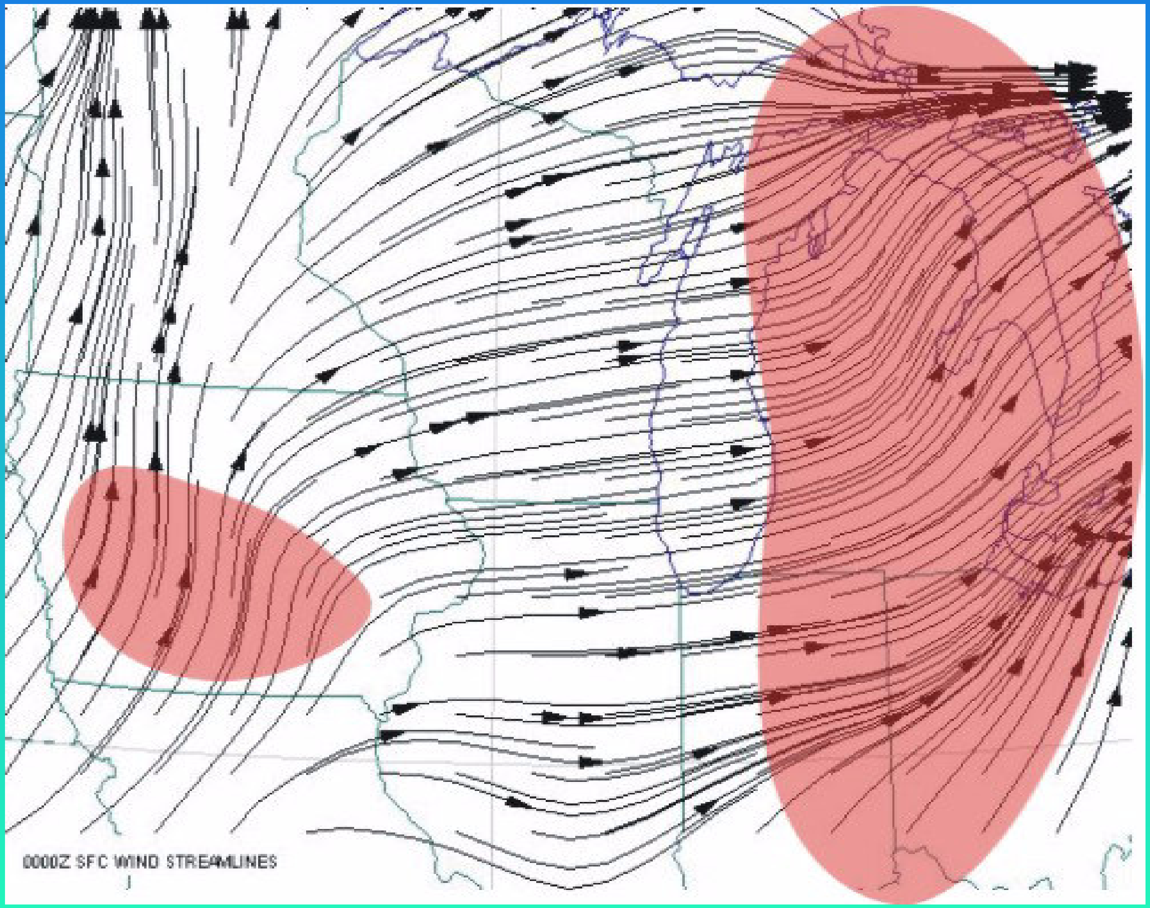
How Do We Locate Convergence on the Surface Analysis? *(continued)*

- Here is an example. The shaded areas are convergence.



How Do We Locate Convergence on the Surface Analysis? *(continued)*

- Here is an example of finding convergence using streamlines.

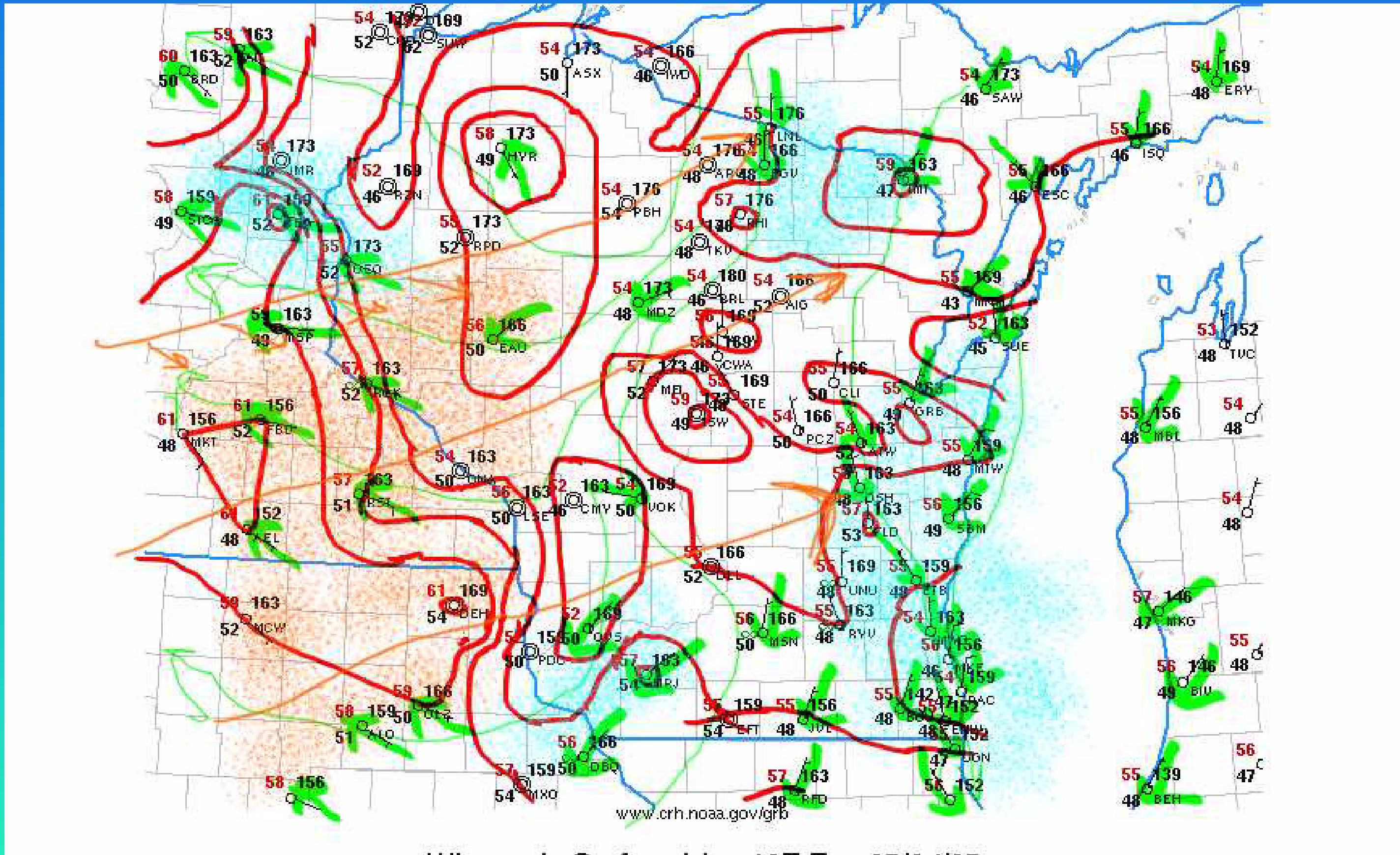


Finding Storm Outflow Convergence

- By examining the wind field at the anvil level, you can find out how any thunderstorms that form will move.
- This will show you where you can expect low-level convergence between the existing wind field and outflow from storms to form.

Finding Storm Outflow Convergence *(continued)*

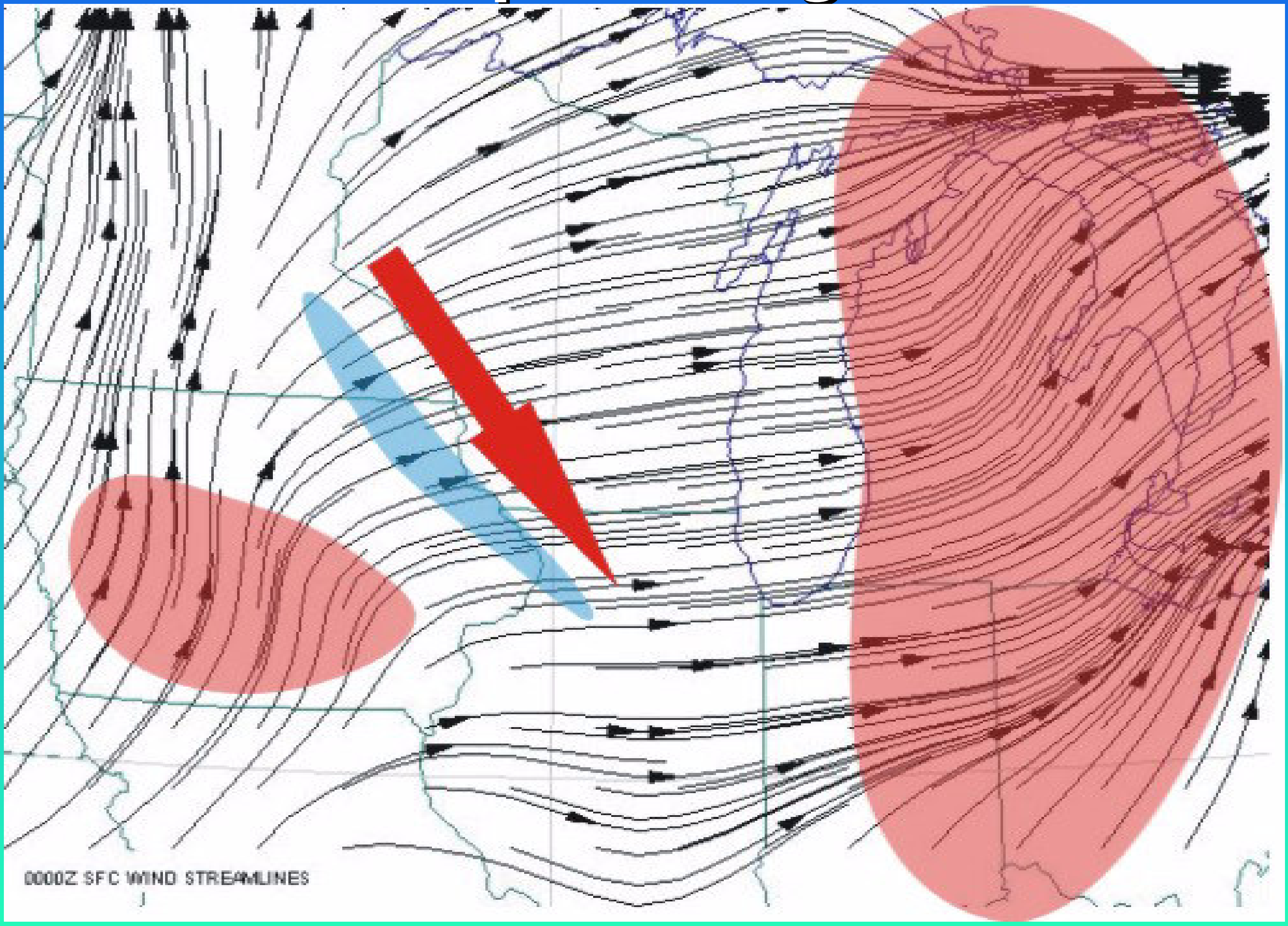
- Here is an example.



Wisconsin Surface Map 13Z Tue 05/24/05

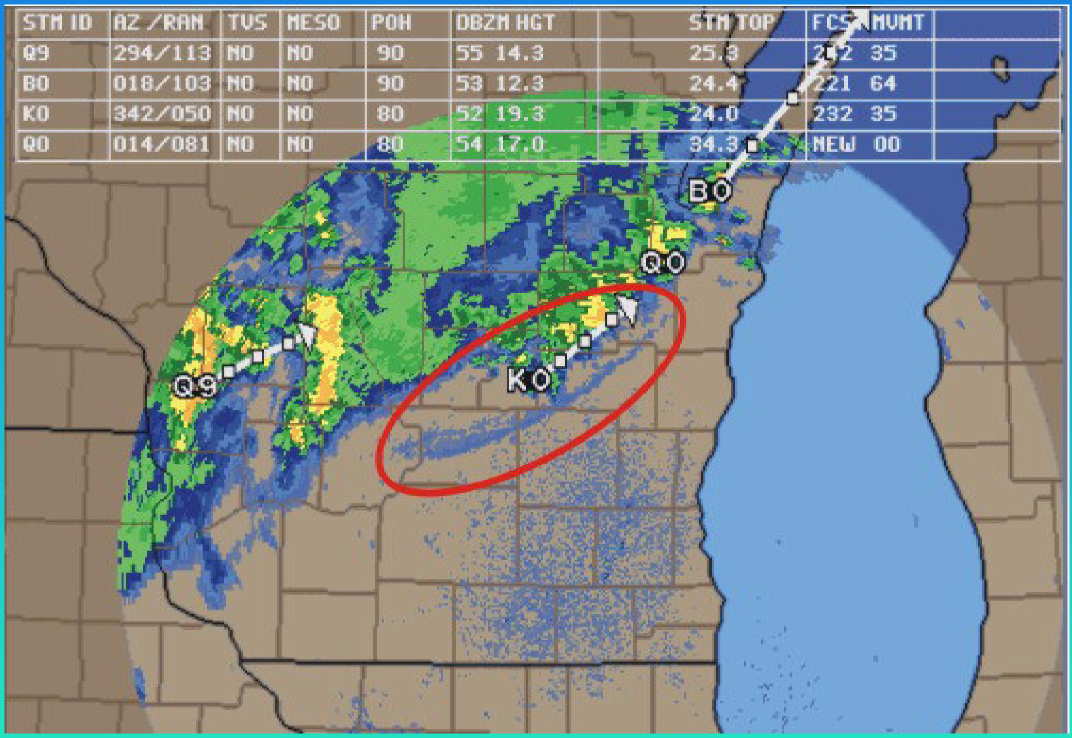
Finding Storm Outflow Convergence *(continued)*

- Here is an example using streamlines.



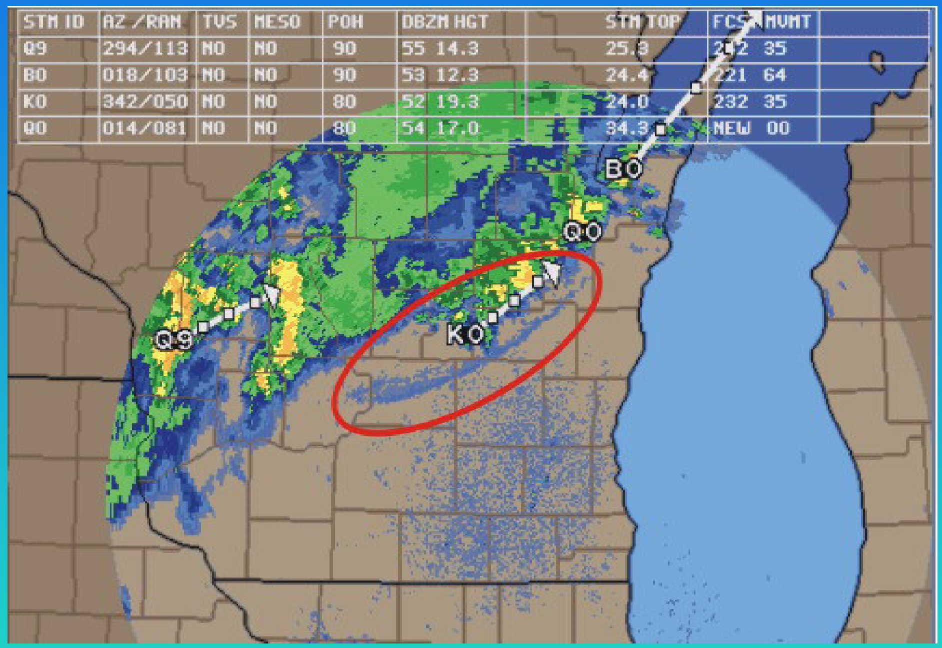
Finding Storm Outflow Convergence *(continued)*

- **You can find the actual presence of outflow boundaries using the WSR88D.**



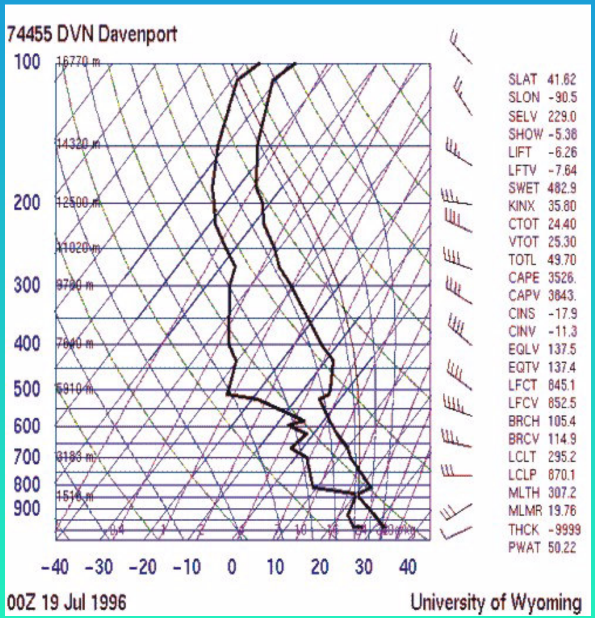
Second Discussion!

- Discuss the significance of storm outflow when anticipating where convergence will occur.

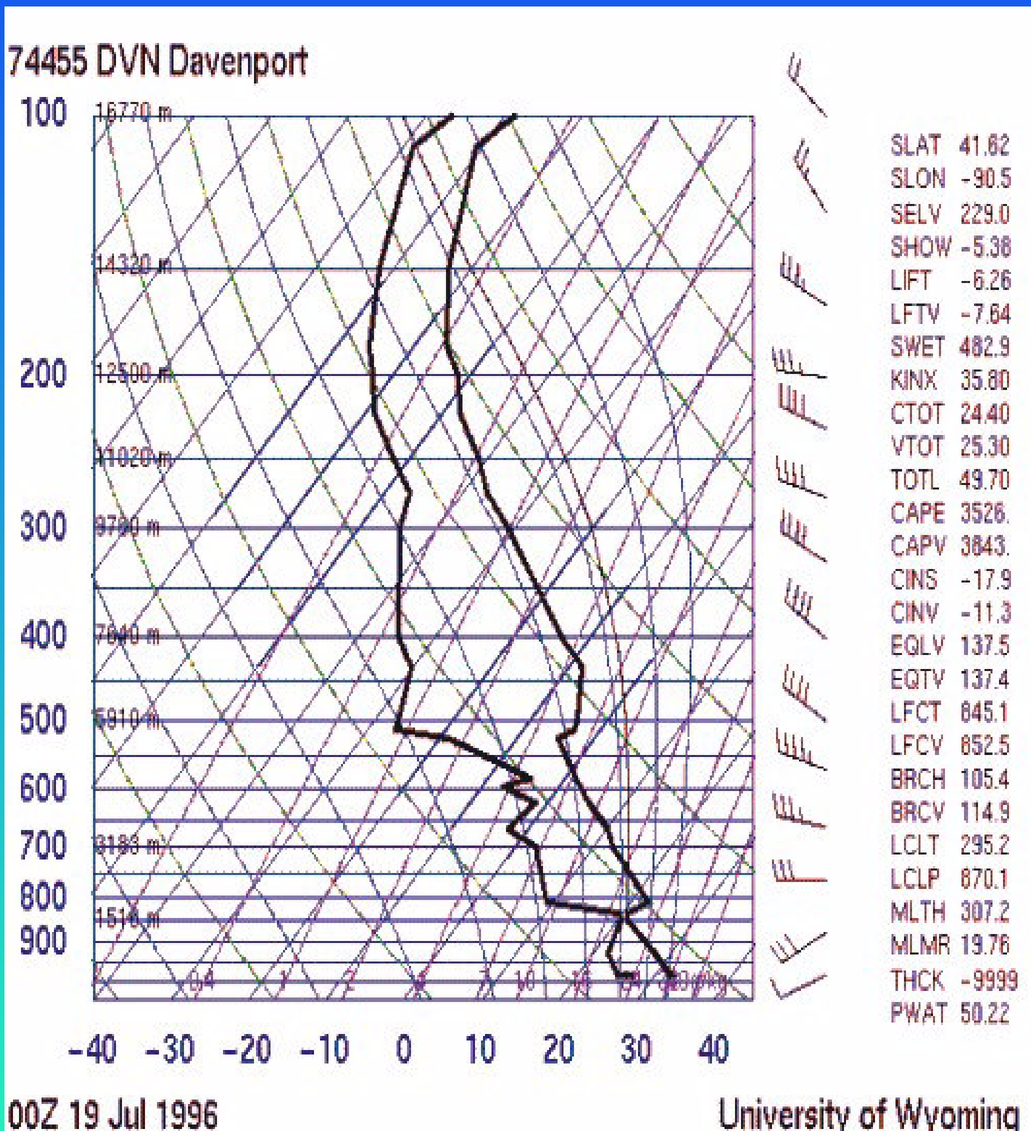


Section 3

Vertical Structure



The Skew-T Diagram

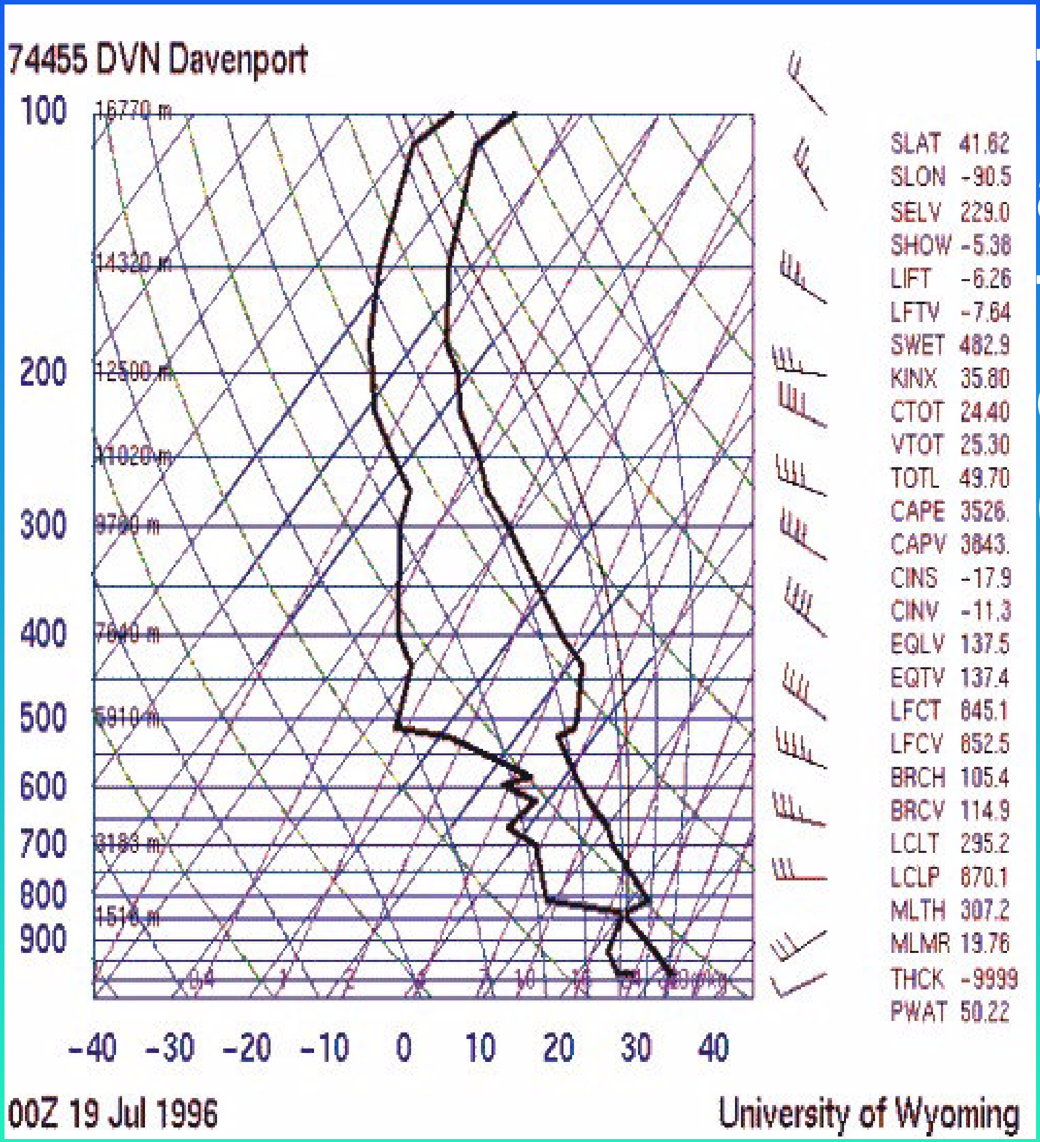


- Here is the vertical sounding plot for the night of the Oakfield Tornado in Wisconsin.

The Skew-T Diagram *(continued)*

- This type of plot gives us the temperature (right-most thick line), dew point (left-most thick line), and wind profiles (wind barbs on the right) with height.
- Skew-T diagrams use the millibar scale for altitude on the far left side.
- Temperatures use the Celsius scale.

The Shear Environment



Two types of shear are usually required for severe development (though one will do).

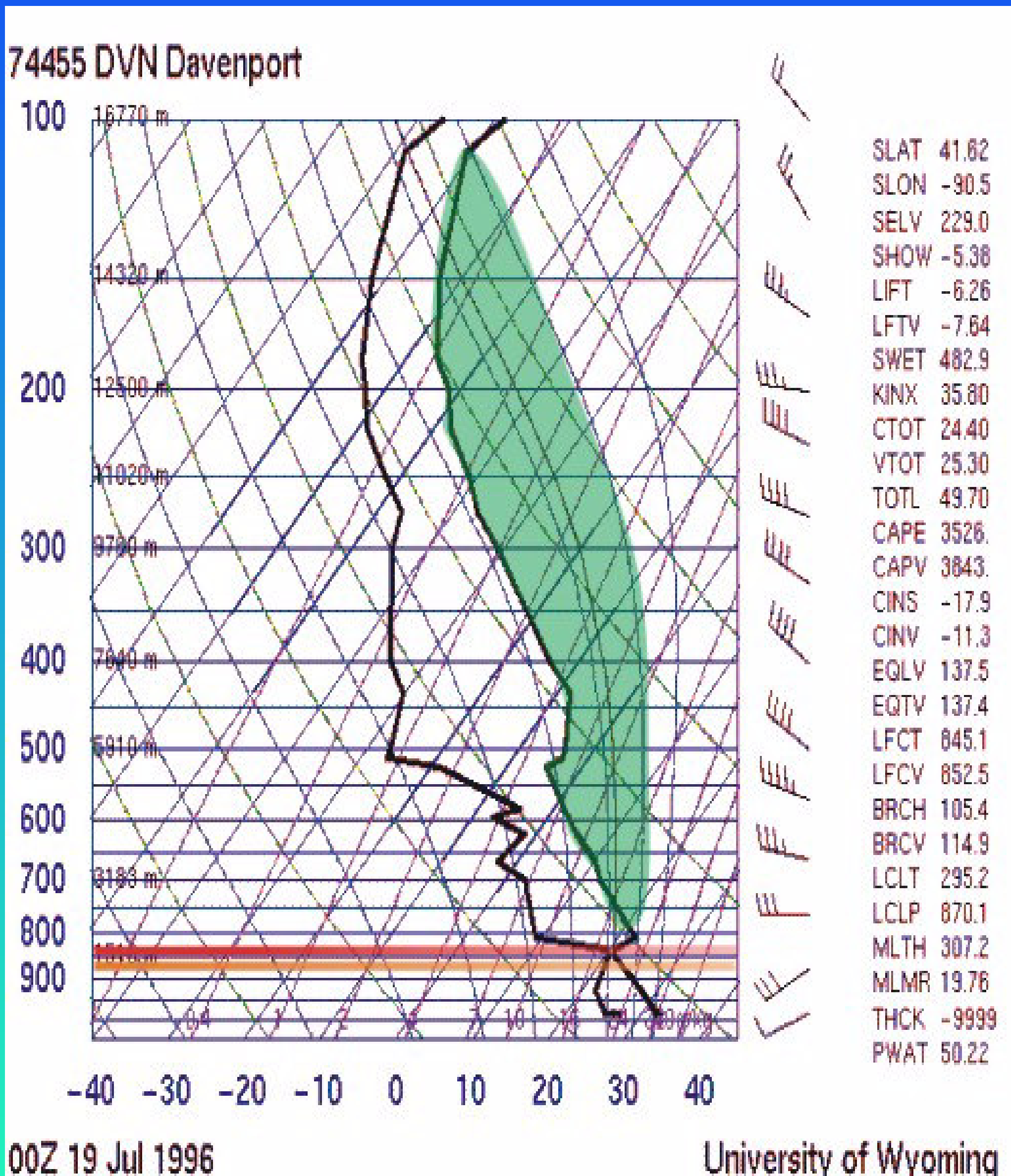
The Shear Environment *(continued)*

- The first is directional shear (winds at the surface are moving in a different direction than winds at 700 or 600 millibars).
- The second kind is called vertical speed shear (winds increase with altitude).
- Note the wind barbs on the right-hand side, between the surface and 600 millibars, have about 30 degrees of directional shear.

The Shear Environment *(continued)*

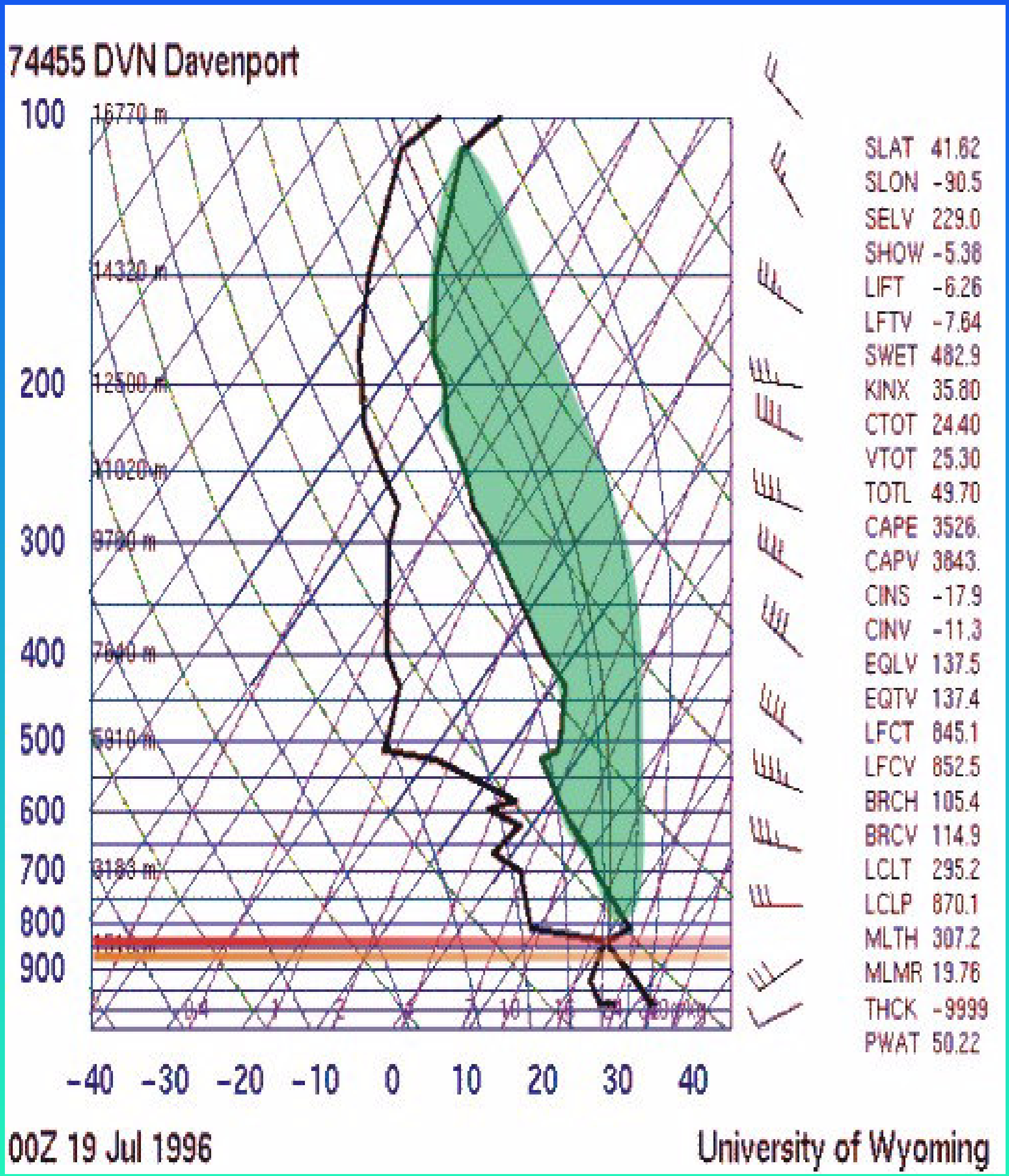
- The surprising thing about this Skew-T is that speed falls off with height.
- Severe storms usually require speed to increase with height (we will explain why in the next lesson).

CAPE and Other Thermodynamic Aspects of the Thunderstorm Environment



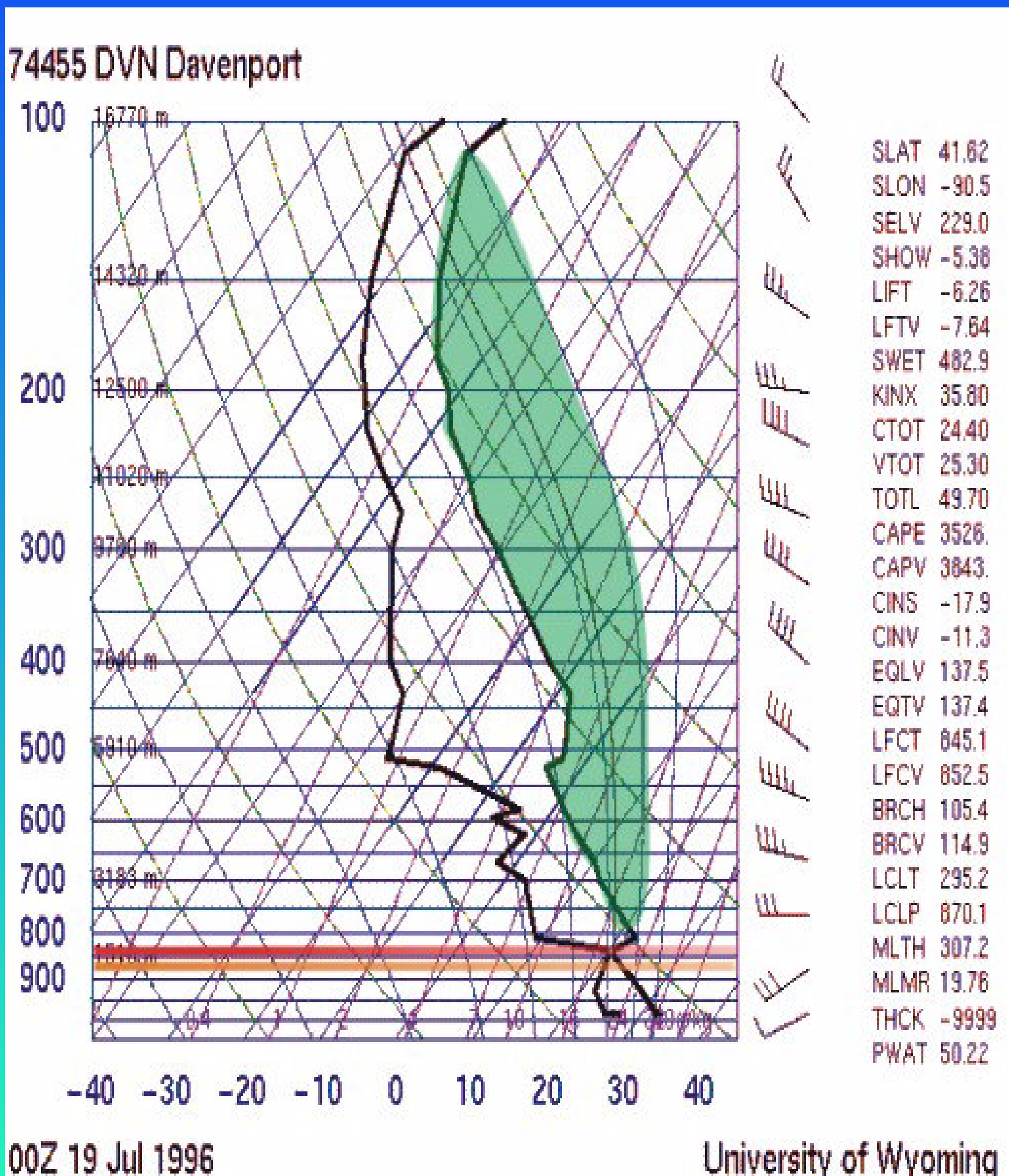
The amount of energy available for convection in the atmosphere is called the CAPE (Convective Available Potential Energy).

CAPE and Other Thermodynamic Aspects of the Thunderstorm Environment *(Continued)*



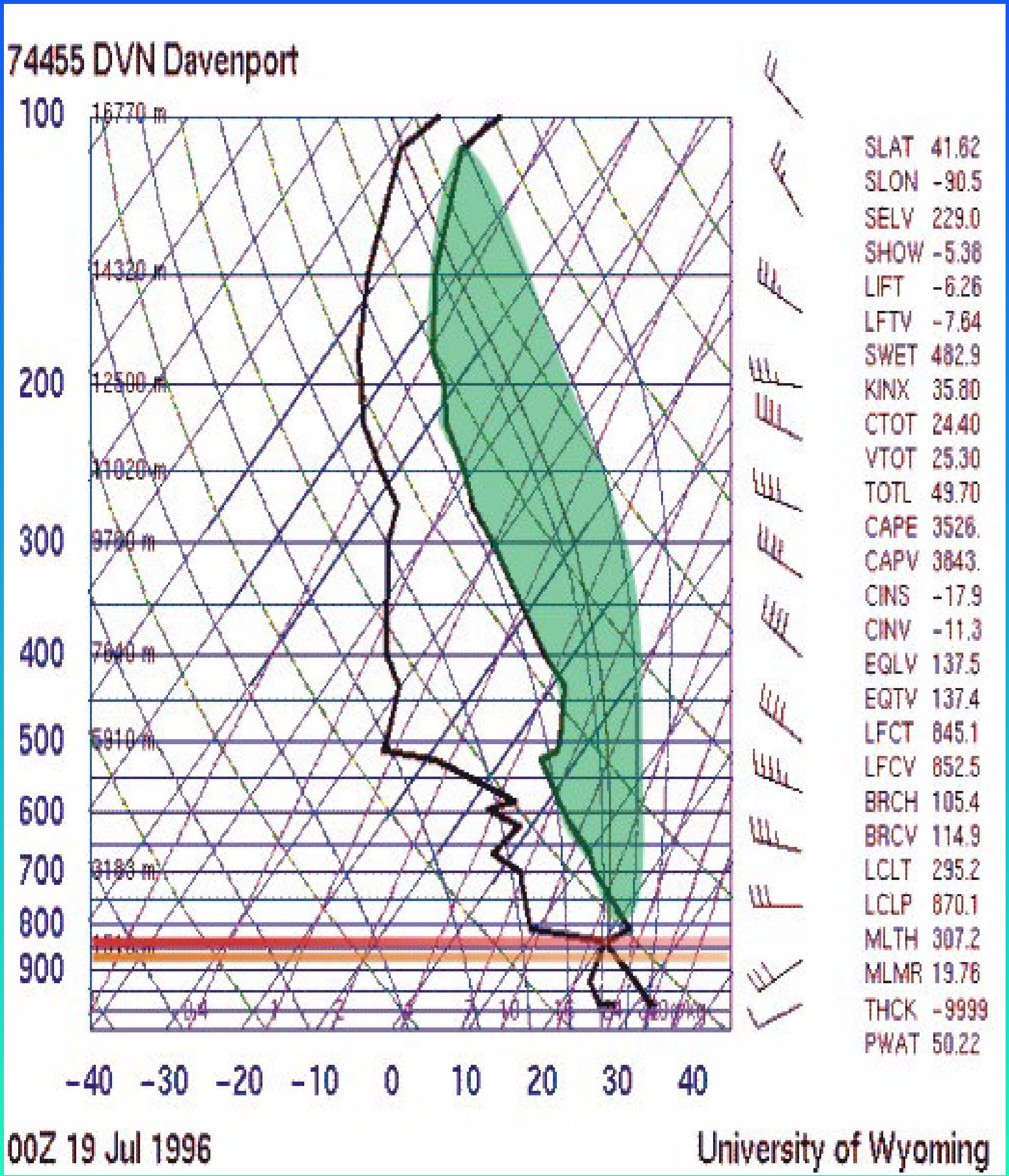
- **On the chart to the left, the CAPE is the area of the region in green.**
- **The larger this area, the more energy is available for convection.**

CAPE and Other Thermodynamic Aspects of the Thunderstorm Environment *(Continued)*



- **The more energy, the stronger storms will be (assuming this region can be reached by an ascending convective column).**

CAPE and Other Thermodynamic Aspects of the Thunderstorm Environment *(Continued)*



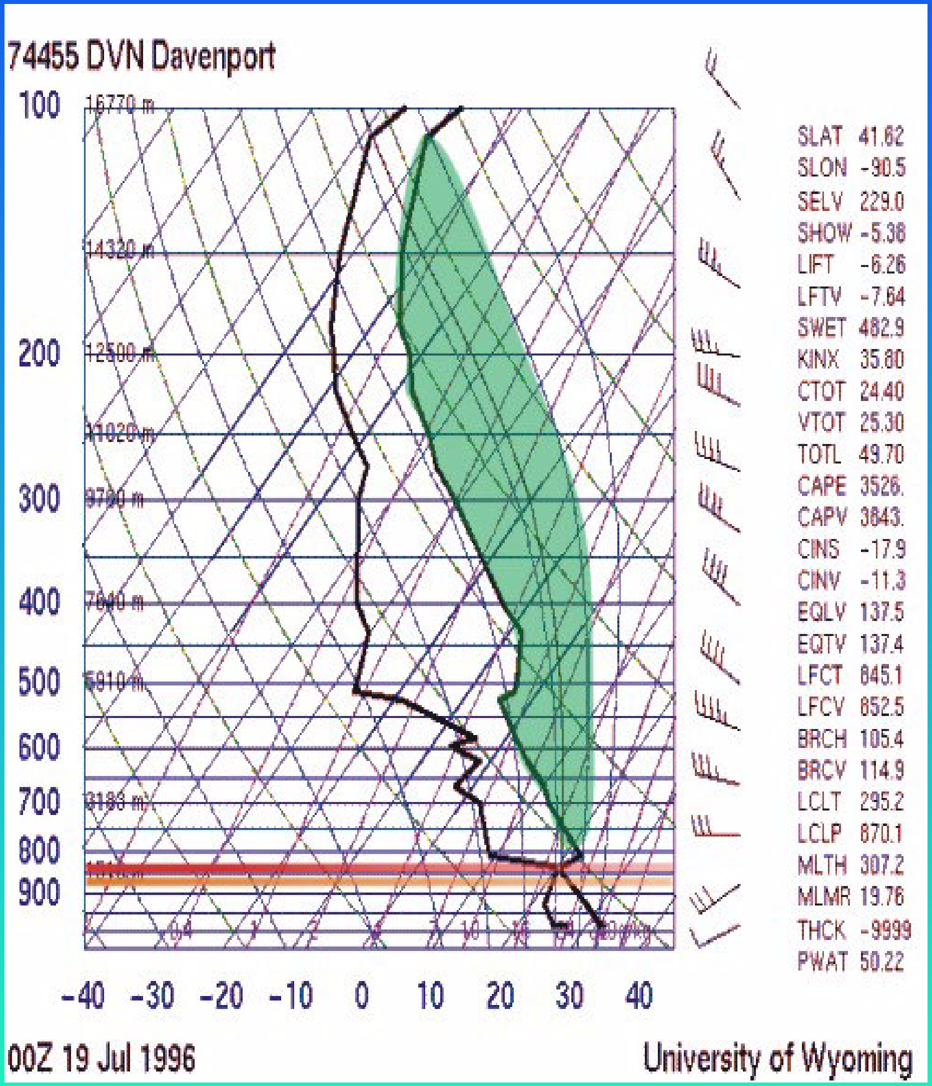
- The area bounded by the orange and red lines is called the Cap.
- This cap is a region of stable air and can stop convection.

CAPE and Other Thermodynamic Aspects of the Thunderstorm Environment *(Continued)*

- The thicker the cap is, the harder it will be for convection to get through it.

Final Discussion!

- Speculate on the significance of thick and thin caps with regards convection.



Homework Due Next Week

- Make a diagram of each source of vertical motion.
- Explain how terrain can cause vertical motion.
- Analyze a current surface map for the position of fronts.
- Analyze a current surface map for regions of convergence.
- Analyze a local map for fronts and convergence at the surface.

Homework Due Next Week *(continued)*

- Write at least a paragraph on your understanding of how a thunderstorm producing outflow will influence its environment, even well removed from the thunderstorm.
- Analyze a current Skew-T diagram for severe weather potential. Explain your results.

Homework Due Next Week *(continued)*

- Explain why high-level speed shear is a favorable environment for the development of thunderstorms.
- Explain why CAPE might not be such a good indicator of severe weather potential, and describe when it is a good indicator.