

How do Scientists Forecast Thunderstorms?

Objective

In the summer, over the Great Plains, weather predictions often call for afternoon thunderstorms. While most of us use weather forecasts to help pick out what we will wear each day some people may wonder how meteorologists actually make these predictions. The following theory and activities will provide some insight into how meteorologists forecast afternoon thunderstorms.

Why do Thunderstorms Form?

Thunderstorms are characterized by towering cumulonimbus clouds, gusty surface winds, heavy rain events and sometimes even hail. These storms are also often associated with lightning and thunder. Thunderstorms form when warm moist air is forced to rise high above the surface. The three main ingredients needed to make a thunderstorm are warm moist air, unstable atmospheric conditions and a mechanism that will help trigger the surface air to rise quickly through the atmosphere. These triggers include strong surface heating, uplift over mountains, convergence of surface winds, and uplift along weather fronts. (see figure). Although thunderstorms can occur year-round and at all hours of the day, they are most likely to occur during the spring and summer in the late afternoon and early evening.

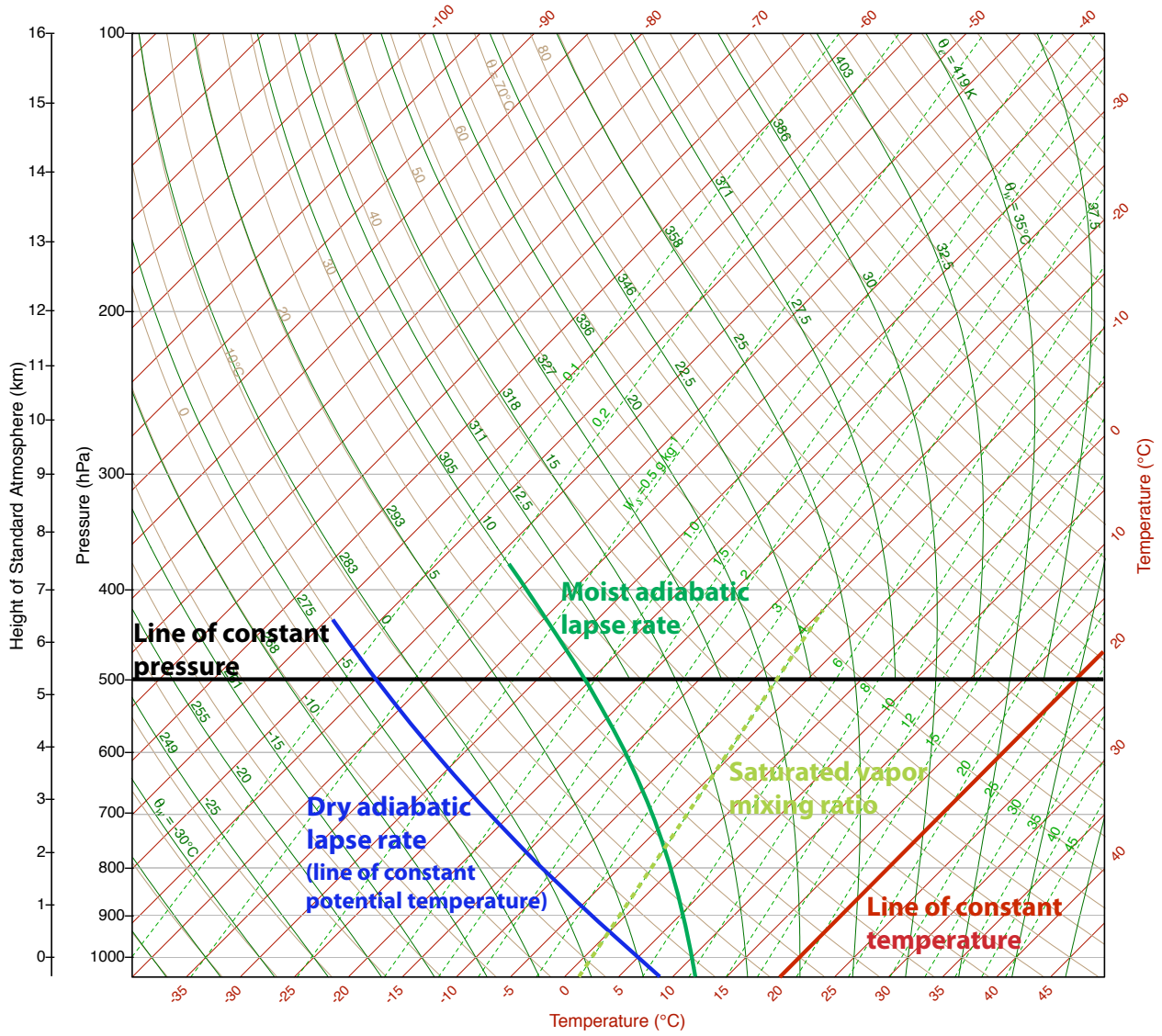
How do Meteorologists predict Thunderstorm Formation?

Twice daily, at 0Z and 12Z (Z stands for Greenwich Mean Time) weather balloons are launched from locations all over the globe. These balloons carry with them an instrument package called a radiosonde that measures temperature, pressure, moisture, and windspeed and direction at multiple levels throughout the atmosphere. As these balloons ascend through the atmosphere they transmit this information back to computers at the surface. Meteorologist then plot this information on special diagrams called skew-t log-p diagrams (or just skew-t for short). From these few variables we can gain an enormous amount of information about the state of the atmosphere including, stability, vertical velocity, cloud base height, cloud top height etc. This information can also be used to help forecast whether or not thunderstorms will happen in the afternoon.

Goals

- Learn how to read/use a Skew-T diagram
- Find the cloud layer with a Skew-T. (Where dew point and temperature are the same)
- Be able to identify inversions with a Skew-T (strong drop off in dew point and strong increase in temperature)
- Find the Lifted Condensation Level (expected cloud base height)
- Find the Level of Free Convection (the height at which a parcel of air becomes positively buoyant)
- CINH - Convective Inhibition
- CAPE - Convective Available Potential Energy

Skew T - ln p Chart



Courtesy of Jennifer Adams, COLA

What is a skew-t log-p diagram?

The Skew-T Log-P diagram offers a way to look at the measurements made with a Radiosonde.

Isobars - Lines of constant pressure. They run horizontally from left to right and are labeled on the left side of the diagram. Pressure is given in increments of 100 hPa and ranges from 1050 to 100 hPa. The spacing between the isobars increases logarithmically in the vertical (thus the name log-p)

Isotherms - Lines of constant temperature. They run from the southwest to the northeast (thus the name skew) across the diagram. Temperature is given in increments of 10° Celsius. These lines are labeled on the bottom of the diagram.

Saturated vapor mixing ratio lines - lines of equal mixing ratio (mass of water vapor divided by mass of dry air) given in units of grams of water vapor per kilogram of dry air. These lines run from the southwest to the northeast and are dashed. The slope of the saturated vapor mixing ratio lines are steeper than the isotherms. They are also labeled in the bottom of the diagram.

Wind barbs - Wind speed and direction are given on the right side of the diagram and are plotted as wind barbs.

Dry adiabatic lapse rate (DALR) - These lines represent the rate in which a rising **unsaturated** parcel of air will cool (10° Celsius per kilometer) These lines slope from the southeast to the northwest and gradually arch to the North with height.

Moist adiabatic lapse rate (MALR) - These lines represent the rate in which a rising saturated parcel of air will cool (depends on moisture content of air). These lines slope from the south toward the northwest. The MALR increases with height since cold air has less moisture content than warm air.

Environmental sounding - The temperature of the air measured with a radiosonde. This is the jagged line running south to north on the diagram. This line is always to the right of the dewpoint plot.

Dewpoint plot - This is the jagged line running south to north. It is the vertical plot of dewpoint temperature. This line is always to the left of the environmental sounding.

Parcel lapse rate - The temperature path a parcel would take if it raised from the surface through the atmosphere without mixing with the surrounding environment. The lapse rate follows the DALR until saturation, then follows the MALR. This line is used to calculate the LFC, the LCL, CAPE, and CINH.

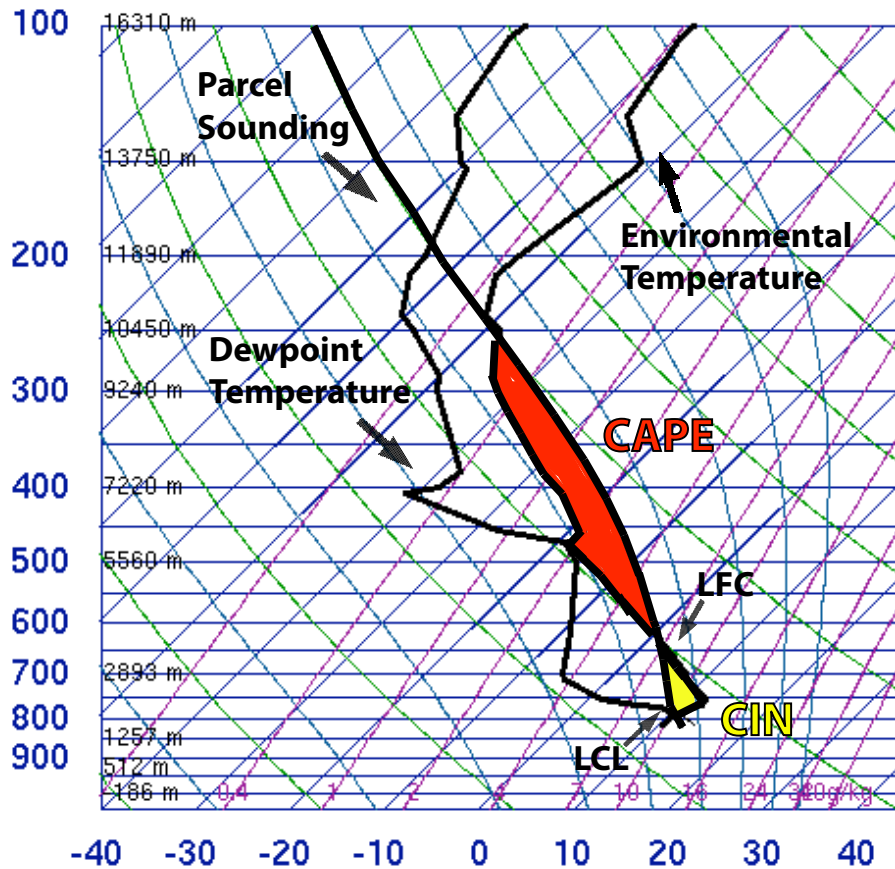
Lifted Condensation Level (LCL) - If you lift a parcel of air from the surface through the atmosphere and you do not allow this parcel of air to interact with its surrounding environment, the LCL is the level where the idealized parcel of air will become saturated and clouds will form.

Level of Free Convection (LFC) - Following the same parcel of air, the LFC is the level at which the temperature of the parcel surpasses the environmental temperature. At this point, the parcel of air will become positively buoyant and can freely convect (or rise) without mechanical forcing.

Convective Available Potential Energy (CAPE) - CAPE is the amount of energy a parcel of air would have if lifted vertically through the atmosphere. CAPE is effectively the positive buoyancy of an air parcel and represents atmospheric instability. CAPE can be calculated using the Skew-T Log-P diagram, where CAPE is the area between the Environmental Sounding and the Parcel Sounding when the parcel is warmer than its environment.

Convective Inhibition (CIN) - indicates the amount of energy that will prevent a parcel of air from rising from the surface to the LFC. CIN can be considered negative CAPE

72469 DNR Denver



12Z 22 May 2008

6) Is there a cloud layer in the sounding from Denver? What about Dallas/Fort Worth? How can you tell?

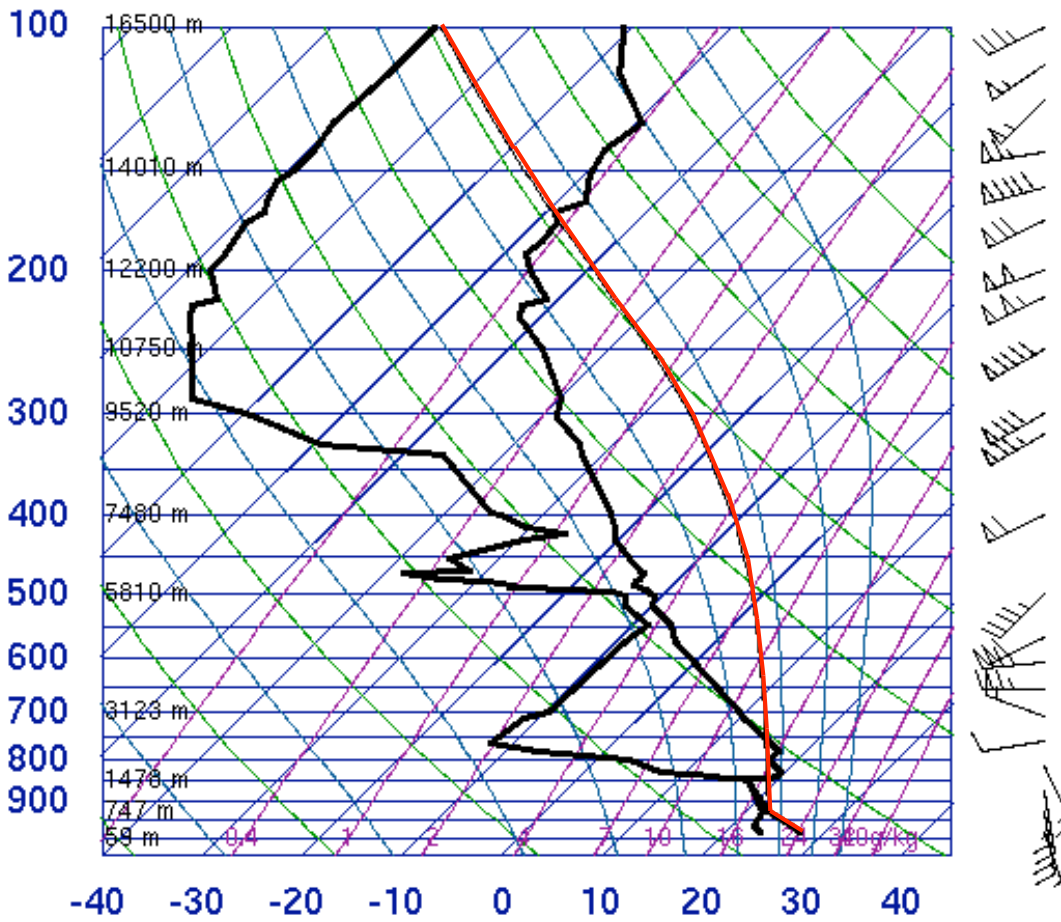
7) Is there an inversion in the “snap shot” of the atmosphere for Denver? What about for Dallas/Fort Worth? How can you tell?

8) Comparing the idealized parcel trajectories in each sounding (the red curves), in which sounding do you think deep convection was more likely to occur?

Sounding #1 Dallas/Fort Worth Texas May 14 2008 00Z (7 pm local time)

**** The red curve represents the path an idealized parcel of air would follow if kicked up from the surface ****

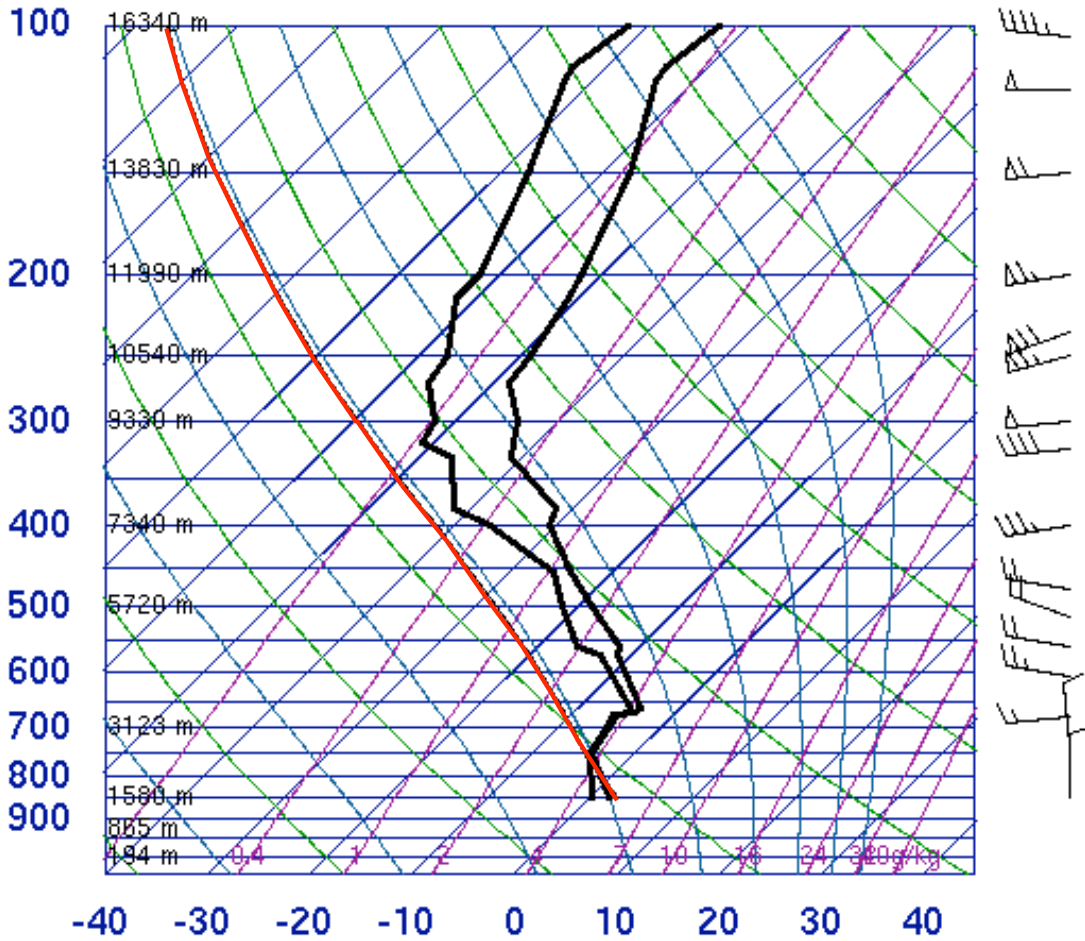
72249 FWD Ft Worth



00Z 14 May 2008

**Sounding #2
Denver Colorado
October 31 2007
12Z (5 am local time)**

72469 DNR Denver



12Z 31 Oct 2007