The skew-T log-P diagram

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Weather balloons & the radiosonde

- Launched twice daily, at 5:00 am/pm CST
- Inflated with hydrogen
- Carry a "radiosonde," which transmits readings of temperature, relative humidity & winds
- Usually reach heights exceeding 100,000 feet, or 18 miles, in around 100 minutes

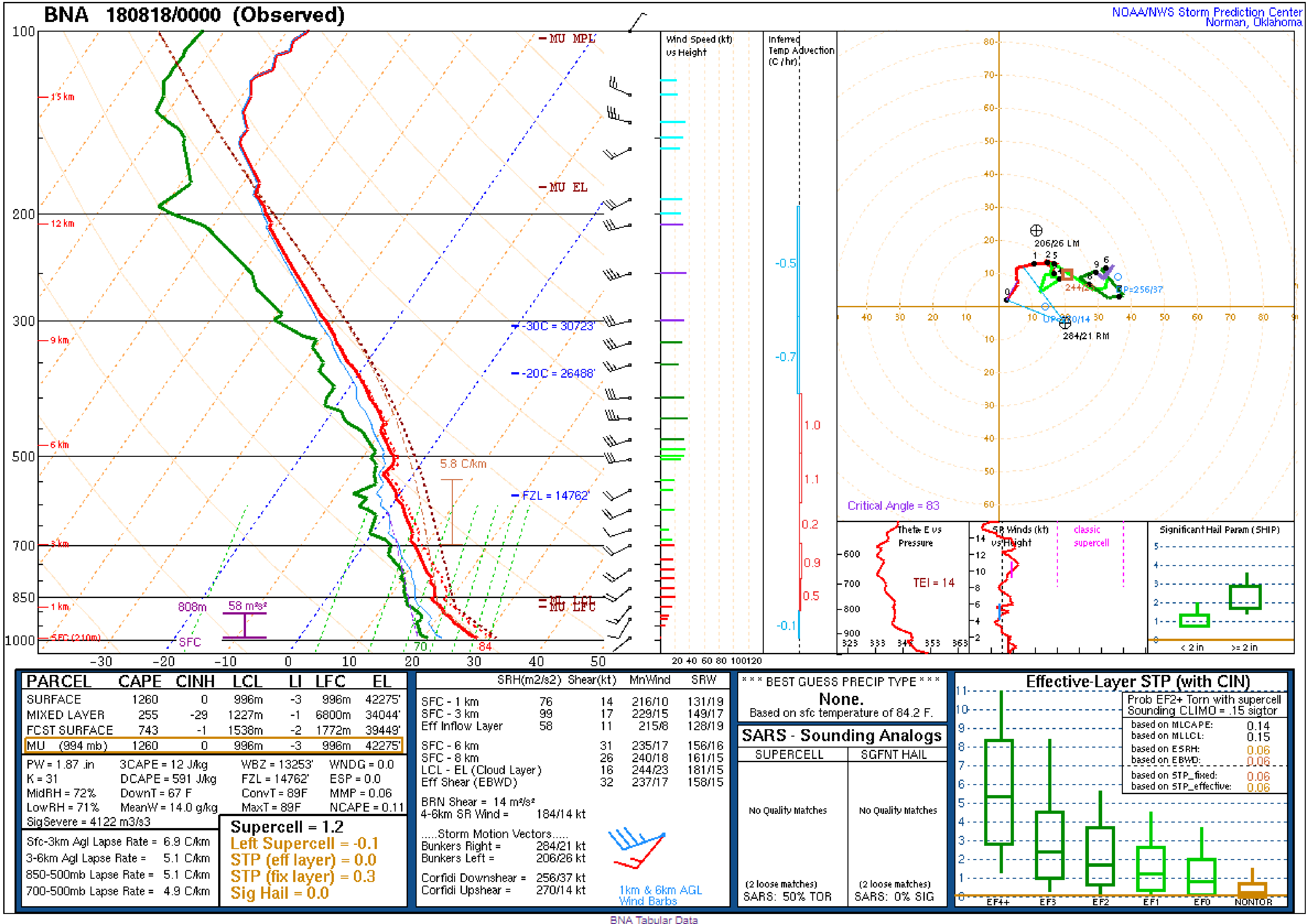
What is a skew-T log-P diagram?

- A thermodynamic diagram commonly used in weather analysis and forecasting
  - pressure plotted on the horizontal axis, with a logarithmic scale (thus the "log-P" part of the name)
  - temperature plotted skewed, with isothermal lines at 45° to the plot (thus the "skew-T" part of the name)
  - used for plotting radiosonde soundings, which give a vertical profile of the temperature and dew point throughout the troposphere and lower stratosphere

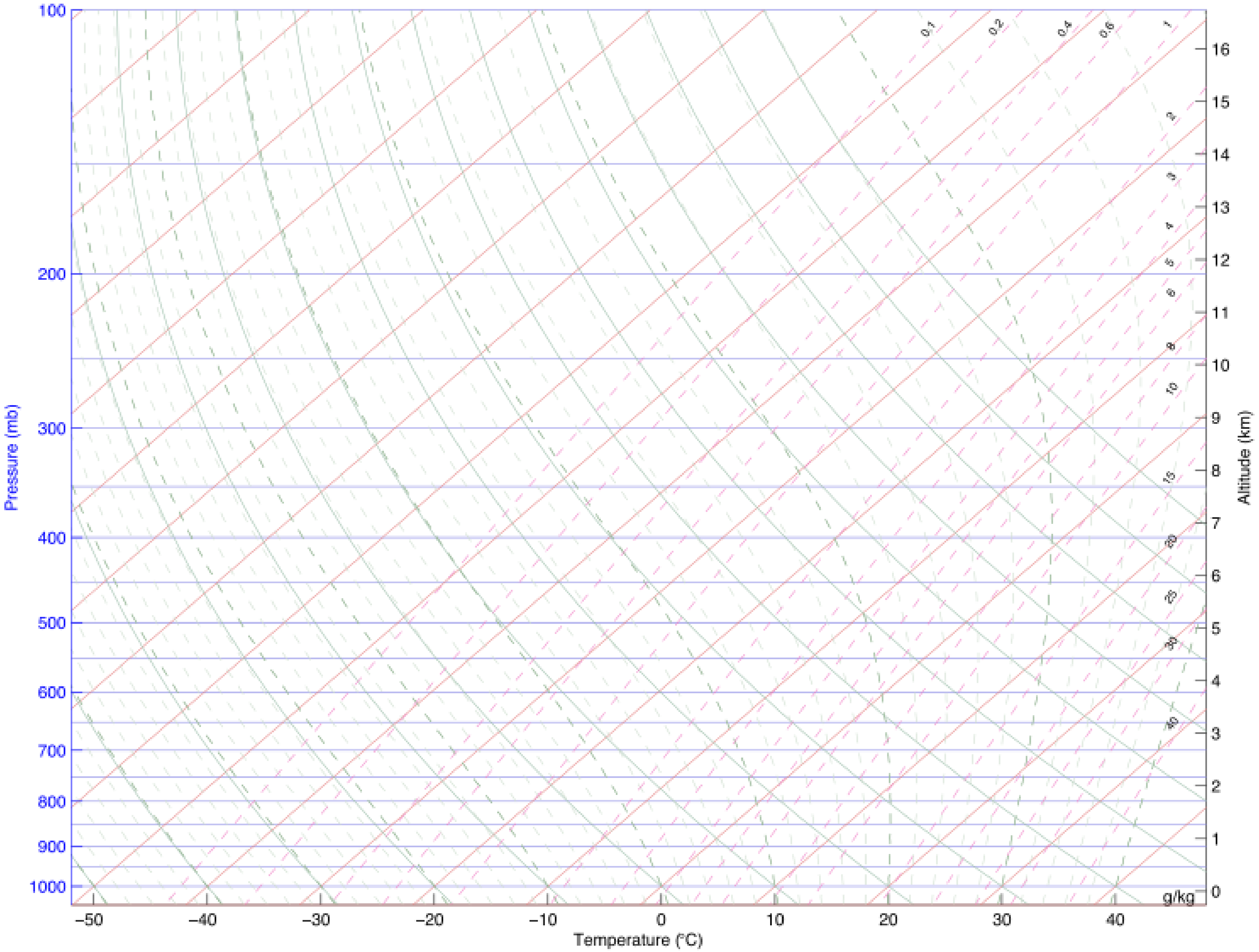
A few definitions

- When the air contains little water, this lapse rate is known as the **dry adiabatic lapse rate**: the rate of temperature decrease is 9.8 °C/km (5.38 °F/1,000 ft).
- The temperature decreases with the dry adiabatic lapse rate, until it reaches the dew point, where water vapor in the air begins to condense. Above that altitude, the adiabatic lapse rate decreases to the **moist adiabatic lapse rate** as the air continues to rise. The moist adiabatic lapse rate varies with temperature. A typical value is around 5 °C/km (2.7 °F/1,000 ft).
- **Mixing ratio** is the amount of water vapor in the air. Mixing ratio is measured in grams of water vapor per kg of dry air.

What does a skew-T log-P diagram look like?



What does a skew-T log-P diagram look like?



What are all those crazy lines?

isobars – line of equal pressure

isotherms- line of equal temperature

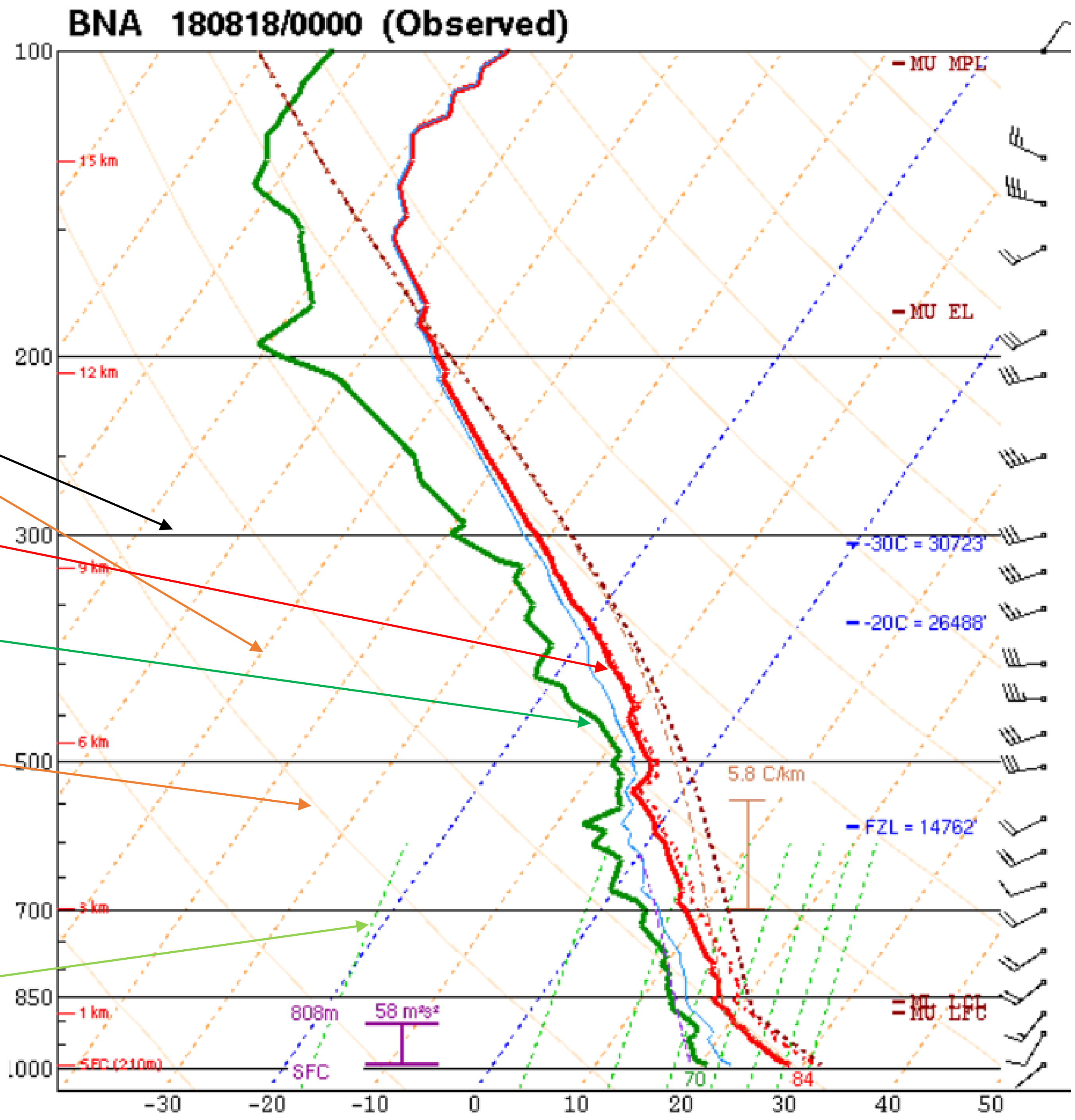
temperature curve – observed temperatures from radiosonde

dew point curve – observed dew points from radiosonde

dry adiabats – slightly curved, solid brown lines that slant from lower right to upper left

saturation adiabats – slightly curved, solid green lines sloping from lower right to upper left

saturation mixing ratio lines – dashed green, slightly curved lines sloping from lower left to upper right

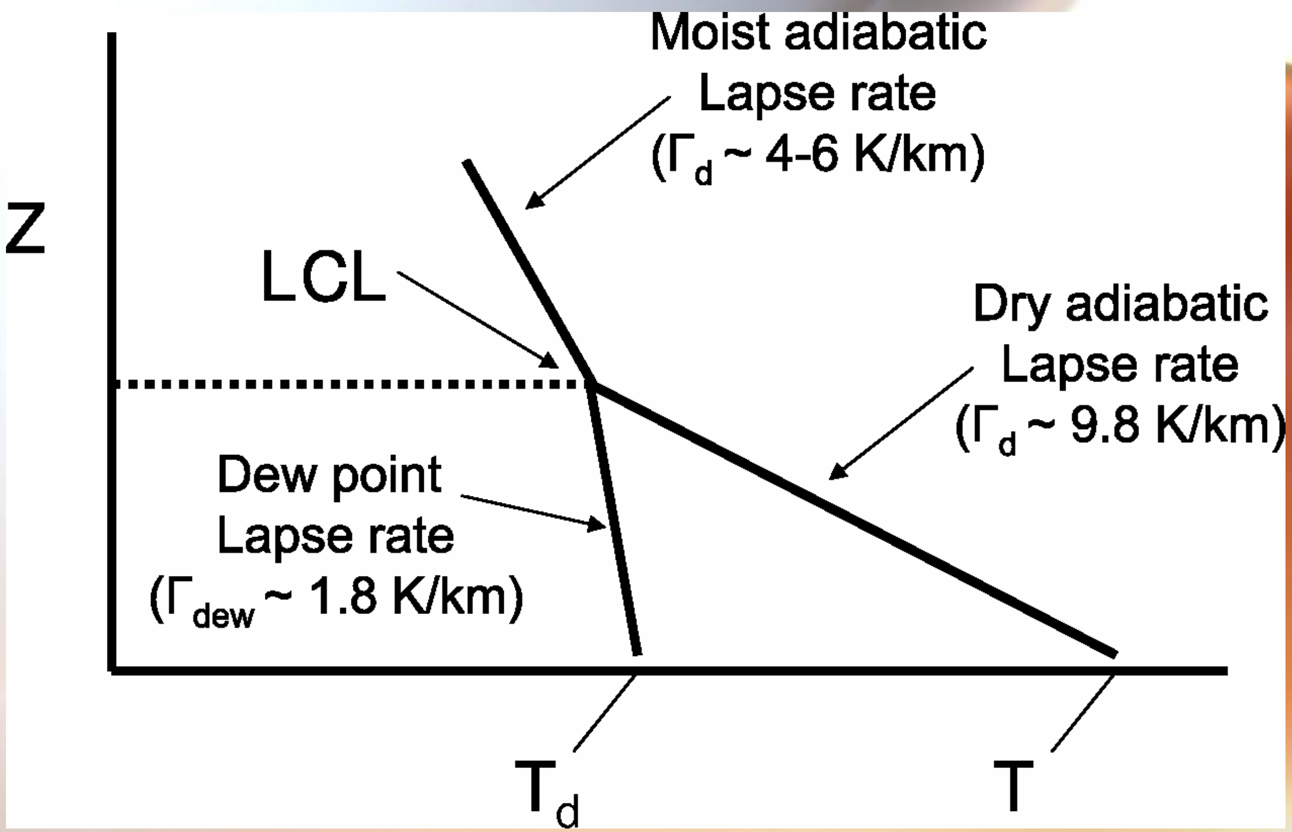


What can the skew-T log-P diagram tell us?

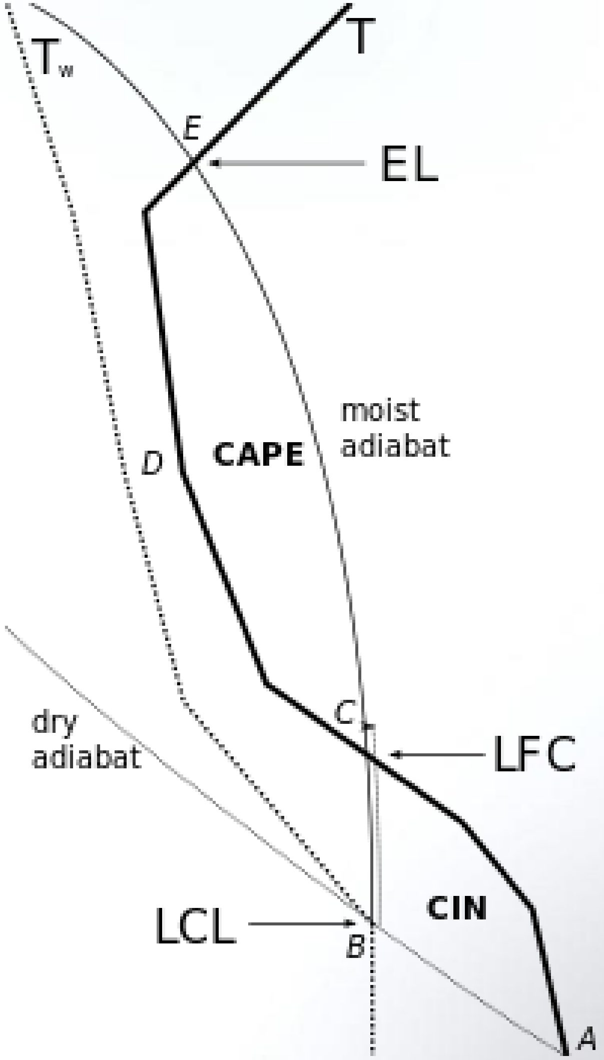
- Instability parameters can tell us the atmosphere’s potential for thunderstorms, supercells, downbursts, heavy rain, etc.
- The hodograph, which is a plot of wind direction and wind speed with height, helps us determine wind shear and storm-relative helicity, which is a measure of the atmosphere’s tornado-producing potential.
- In winter, the temperature and dew point profile can help us determine whether expected precipitation will fall as rain, snow, sleet, freezing rain, or a mixture.

Some useful meteorological parameters

Lifting Condensation Level (LCL) is the height at which a parcel of air becomes saturated when it is lifted dry-adiabatically. From the dewpoint curve at the given pressure level, follow a line upward along a saturation mixing-ratio line. Then from the temperature curve at the given pressure level, follow a line upward along a dry adiabat. The intersection of these two lines is the LCL.



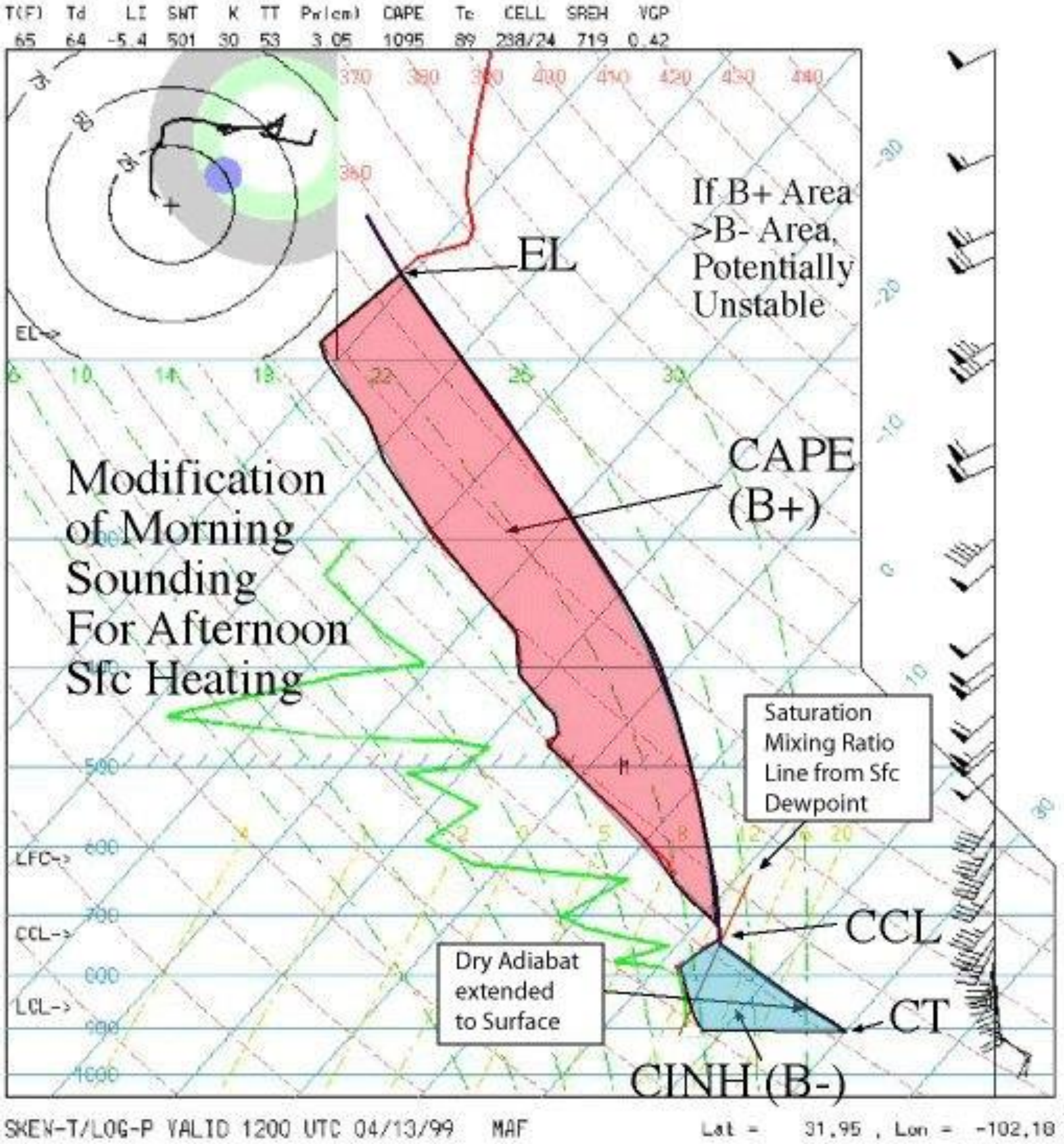
Some useful meteorological parameters

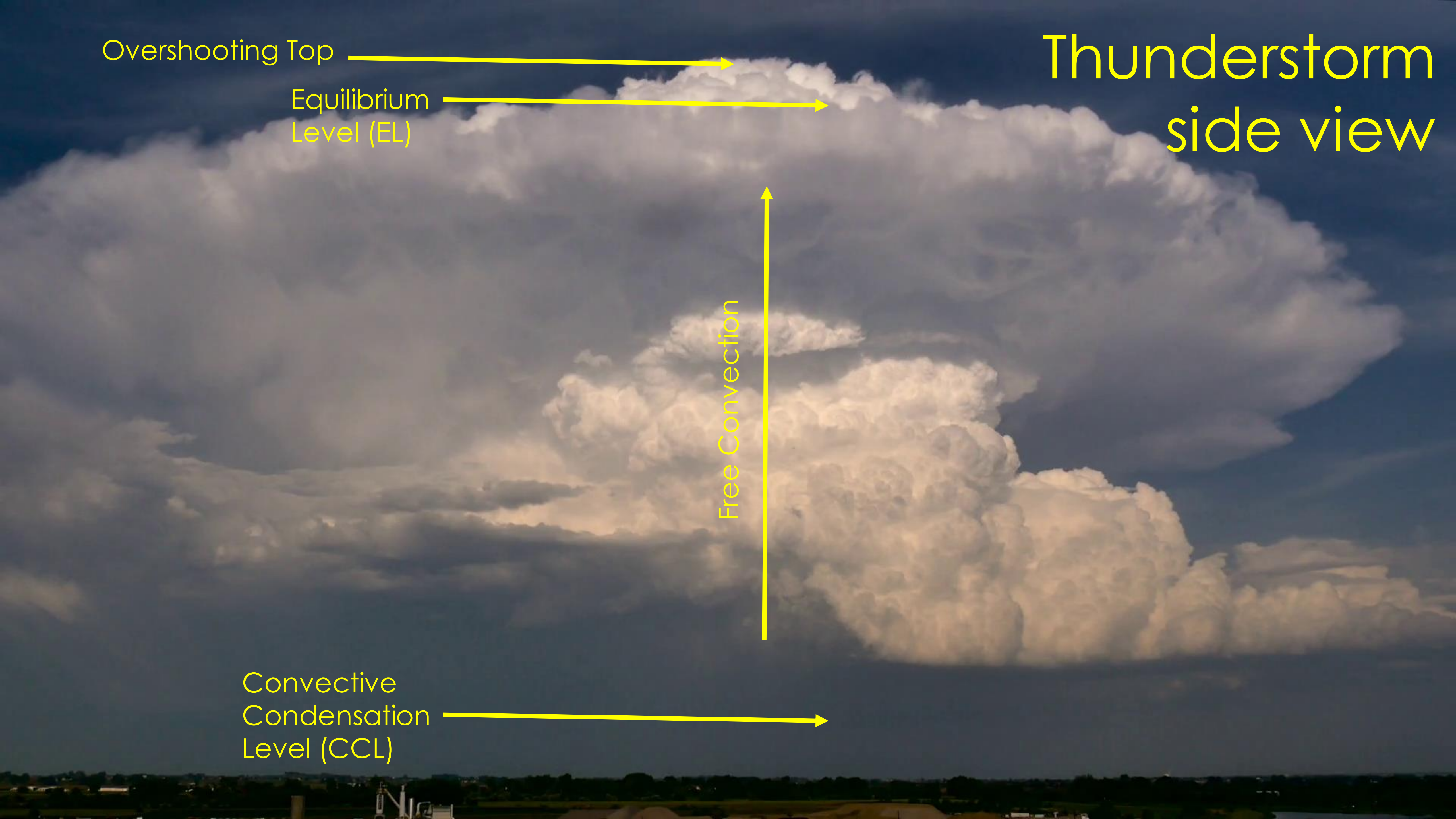


Level of Free Convection (LFC) is the height at which a parcel of air that is lifted dry or moist adiabatically becomes less dense (warmer) than the surrounding air. Find the region of positive area on the sounding. The pressure level at the bottom of the positive area that is closest to earth's surface is the LFC. Just below this point, the temperature of the parcel and the temperature of the environment should be equal.

Some useful meteorological parameters

Convective Condensation Level (CCL) is the height to which a parcel of air, if heated sufficiently from below, will rise adiabatically until it is just saturated. This is the height of the base of cumuliform clouds produced by surface heating. Find the average mixing ratio in the lowest 50 mb and follow this mixing ratio line up to where it intersects the temperature sounding. This point is the height of the CCL.




Thunderstorm side view
Overshooting Top
Equilibrium Level (EL)
Free Convection
Convective Condensation Level (CCL)

Some useful meteorological parameters

Equilibrium Level (EL) is the height where the temperature of a positively buoyant parcel of air becomes equal to that of the surrounding atmosphere and above this level the parcel becomes negatively buoyant. Locate the positive area on the sounding. The equilibrium level is the point at the top of the positive area where the temperature curve and the saturation adiabat that goes through the LFC meet.

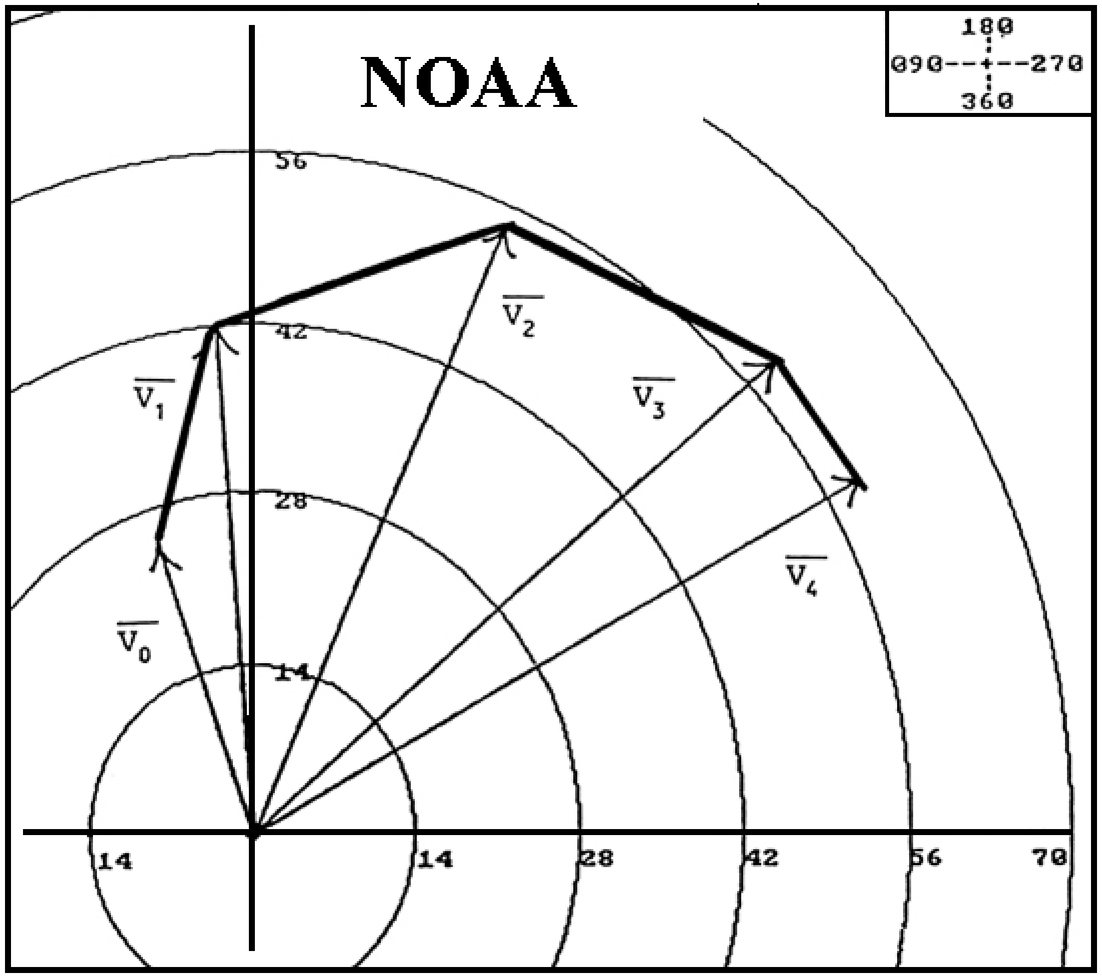
Convective Available Potential Energy (CAPE) is measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather.

Convective Available Potential Energy (CAPE)

- Given in J/kg
- However, a Joule is equal to a kg m^2/s^2
- Therefore, J/kg can also be written as m^2/s^2
- Taking the square root of the CAPE gives a value that is reported in m/s
- The square root of CAPE is equal to the maximum theoretical updraft speed
- A CAPE of 2,500 J/kg would therefore translate to a maximum theoretical updraft speed of 50 m/s, or 112 mph

Hodographs

A hodograph is a diagram that uses vectors to give a visual representation of wind at various levels in the atmosphere. Hodographs are used to plot winds from atmospheric soundings.



Winds / Vents

Height / Hauteur (km)	Dir	Speed / Vitesse
Sfc	161°	25
1	175°	42
2	204°	54
3	229°	59
4	241°	59

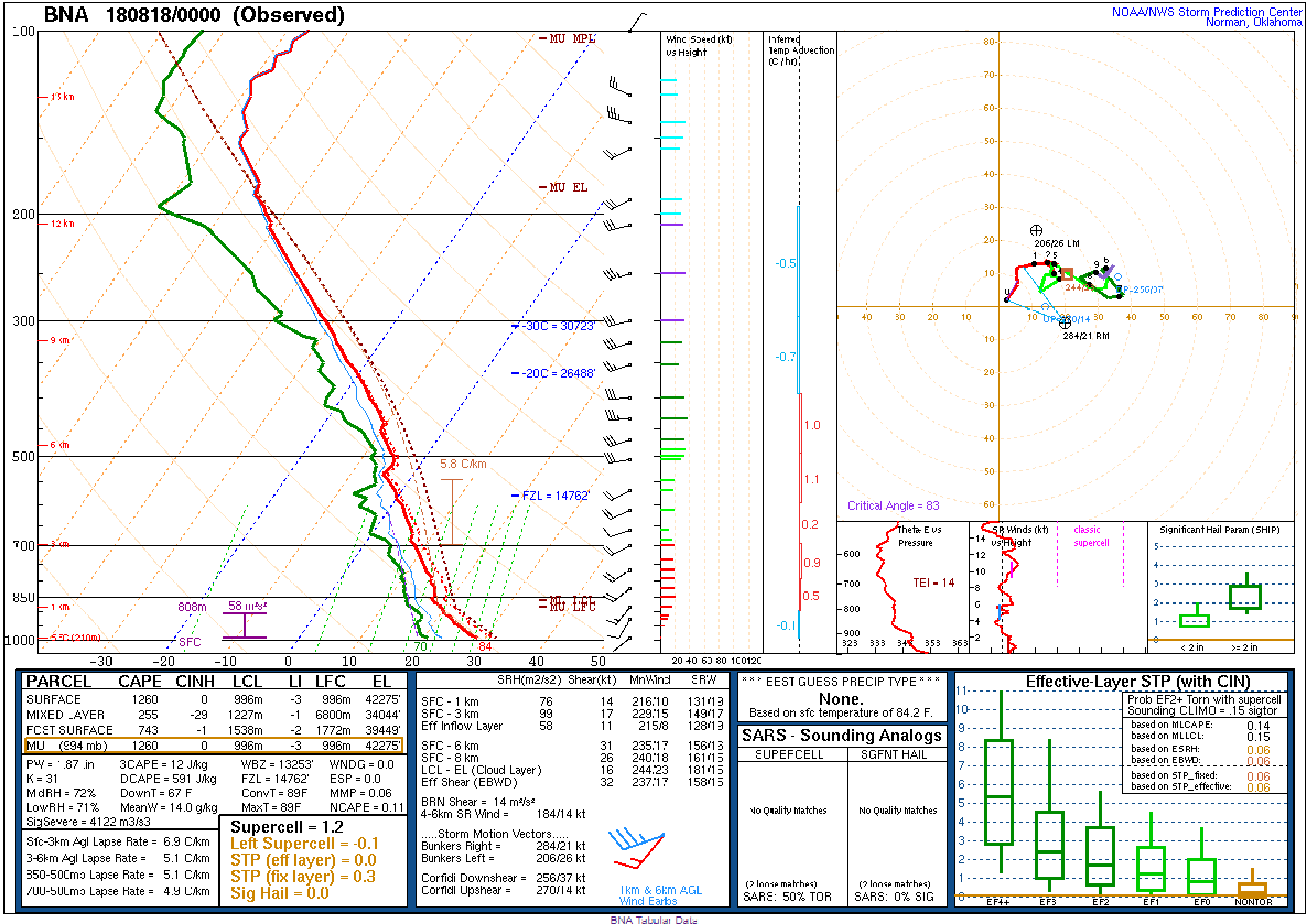
What is a hodograph used for?

- Wind shear: The lines uniting the extremities of successive vectors represent the variation in direction and value of the wind in a layer of the atmosphere. Wind shear is important information in the development of thunderstorms and future evolution of wind at these levels.
- Turbulence: Wind shear indicates possible turbulence that would cause a hazard to aviation.

Storm-relative helicity

- Storm Relative Helicity (SRH) is a measure of the potential for cyclonic updraft rotation in right-moving supercells, and is calculated for the lowest 1-km and 3-km layers above ground level.
- There is no clear threshold value for SRH when forecasting supercells, since the formation of supercells appears to be related more strongly to the deeper layer vertical shear.
- Larger values of 0-3-km SRH (greater than 250 m^2/s^2) and 0-1-km SRH (greater than 100 m^2/s^2), suggest an increased threat of tornadoes with supercells.

How to use a hodograph operationally



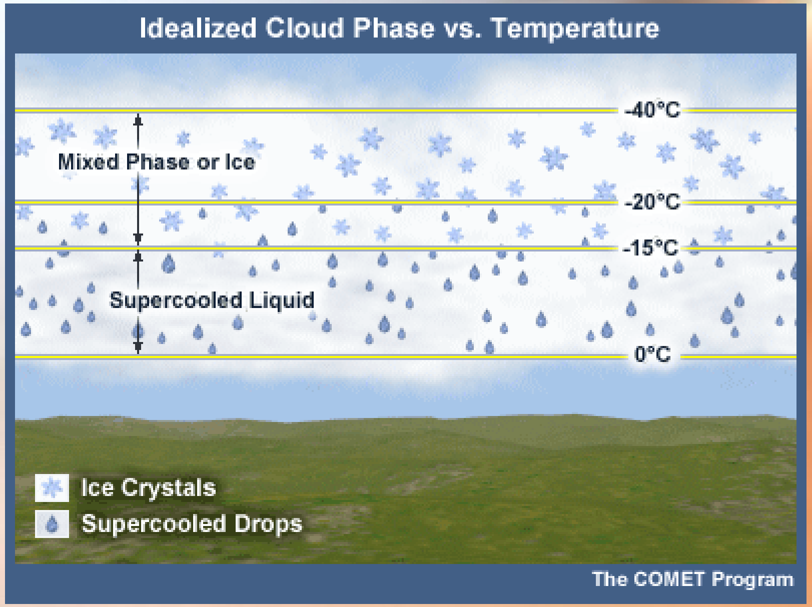
The top-down approach to winter-weather forecasting

Original research paper by Dan Baumgardt at NWS La Crosse, Wisconsin

http://www.meteor.iastate.edu/classes/mt417/powerpoint/RogerSnowMicrofinal.pdf

Snow microphysics and the top-down approach to forecasting winter weather precipitation type

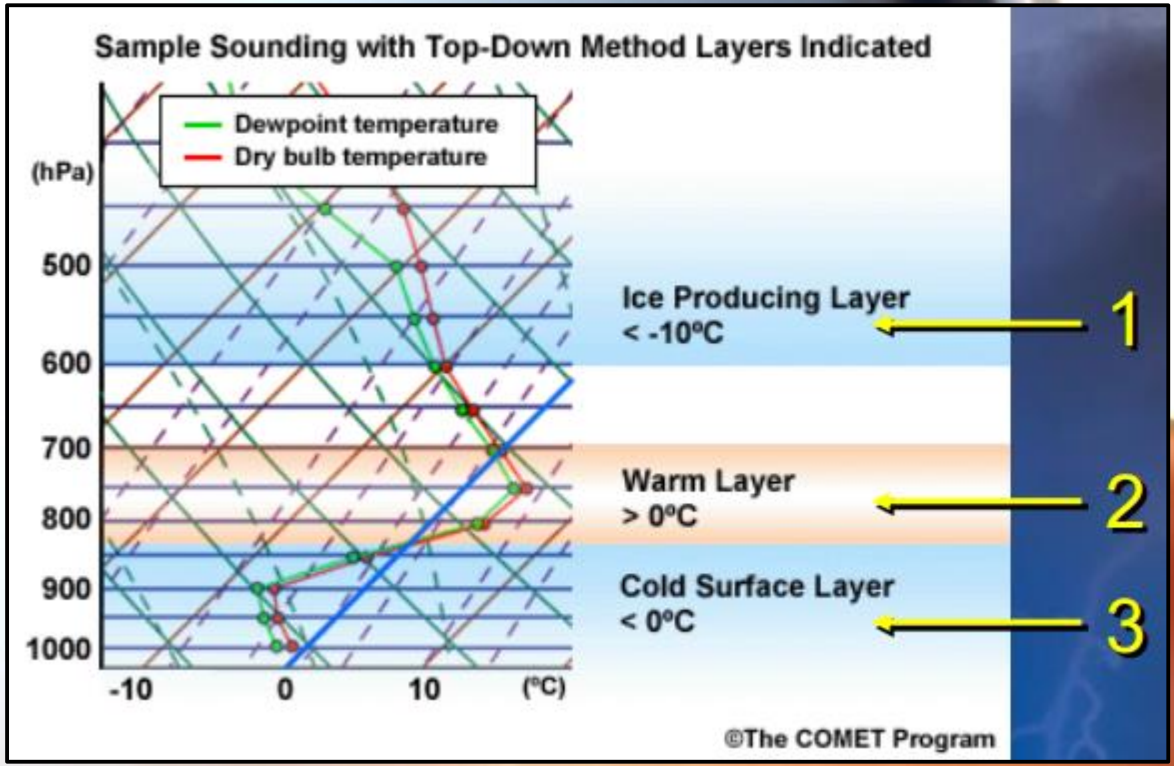
All sub-freezing clouds contain supercooled water droplets that can exist at temperatures as cold as -40C without freezing when in the absence of ice nuclei.



Snow microphysics and the top-down approach to forecasting winter weather precipitation type

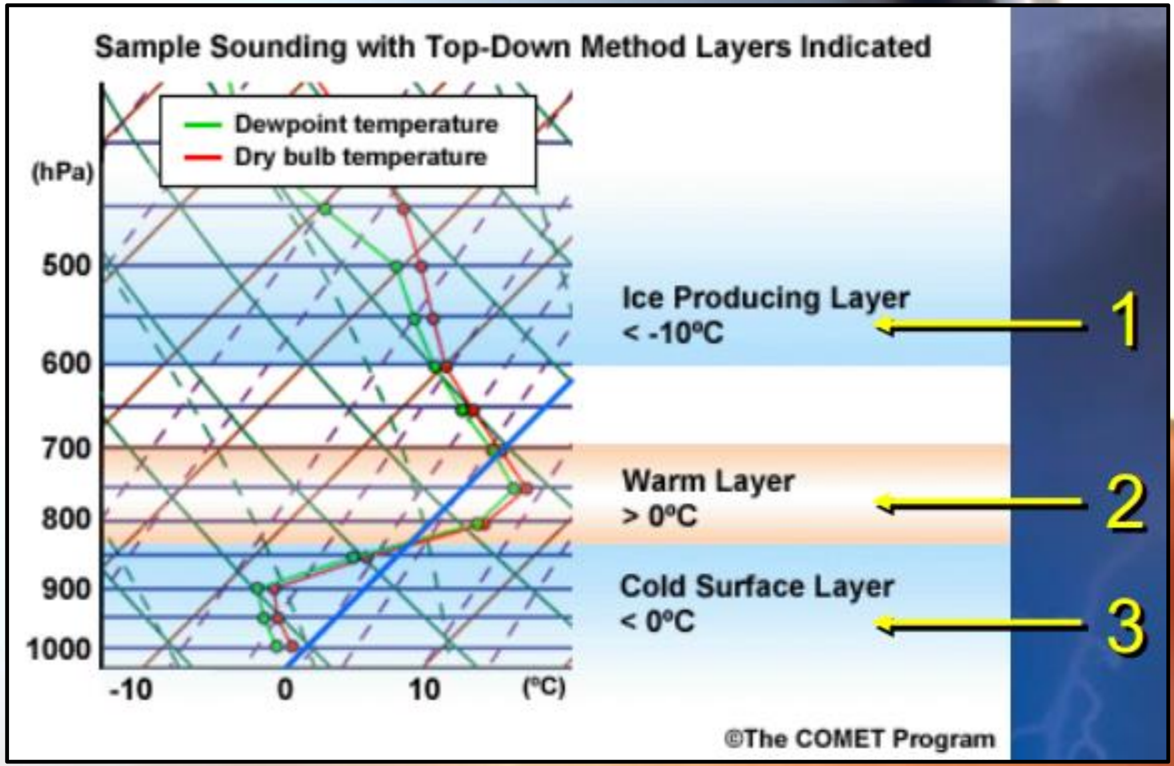
- Maximizing snowfall efficiency involves three things
  - Snow production in the "dendritic layer" from -12C to -18C, centered around –15C.
  - Sufficient moisture within the layer with relative humidity greater than 90%
  - Sufficient and sustained lift within the column cutting through the dendritic layer.

Snow microphysics and the top-down approach to forecasting winter weather precipitation type



Layer	Air Mass	Hydrometeor Impact
Ice Producing Layer	Cold, midlevel air mass	Ice crystal nucleation and growth
Warm Layer	Elevated, warm tropical air mass	Warming, melting
Cold Surface Layer	Surface Arctic or modified air mass	Refreezing/contact freezing

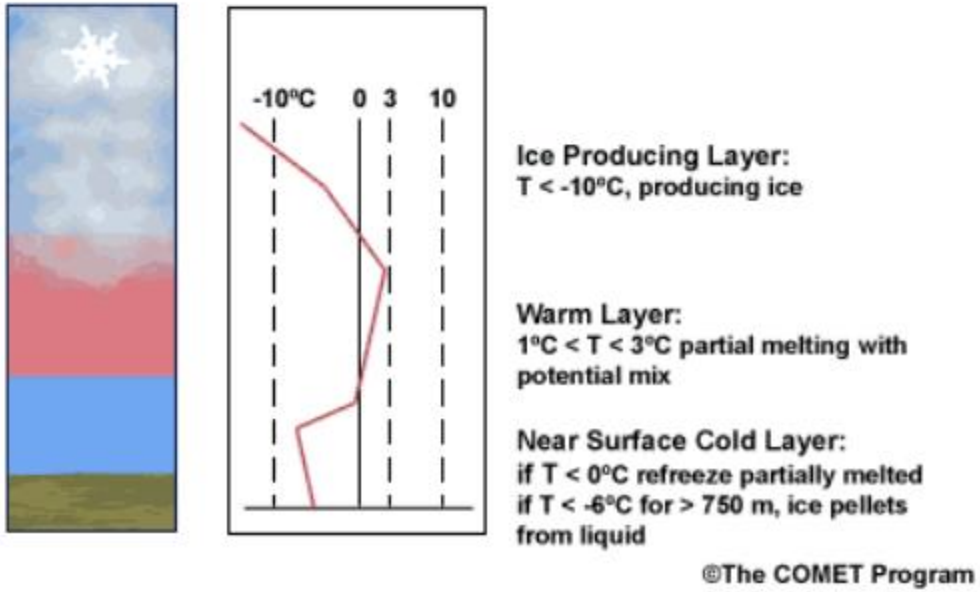
Snow microphysics and the top-down approach to forecasting winter weather precipitation type



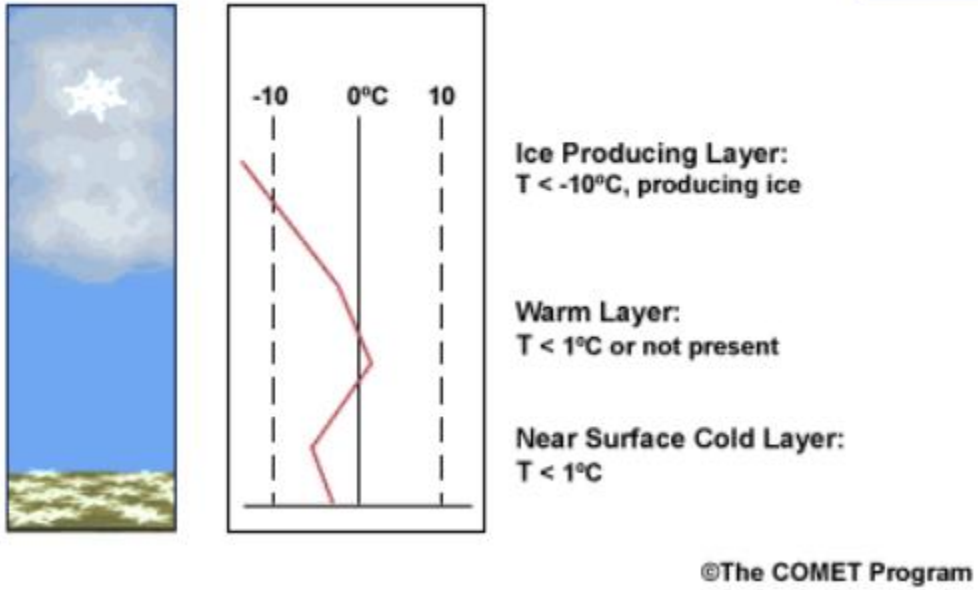
Warm Layer Max Temp ^{0}C	Precipitation Type with ice introduced	Precipitation Type without ice introduced
< 1^{0}C	snow	freezing rain or drizzle
1 to 3^{0}C	snow/ice pellet mix (1^{0}C) to ice pellets (3^{0}C)	freezing rain or drizzle
> 3^{0}C	freezing rain or drizzle	freezing rain or drizzle

Winter precipitation profiles

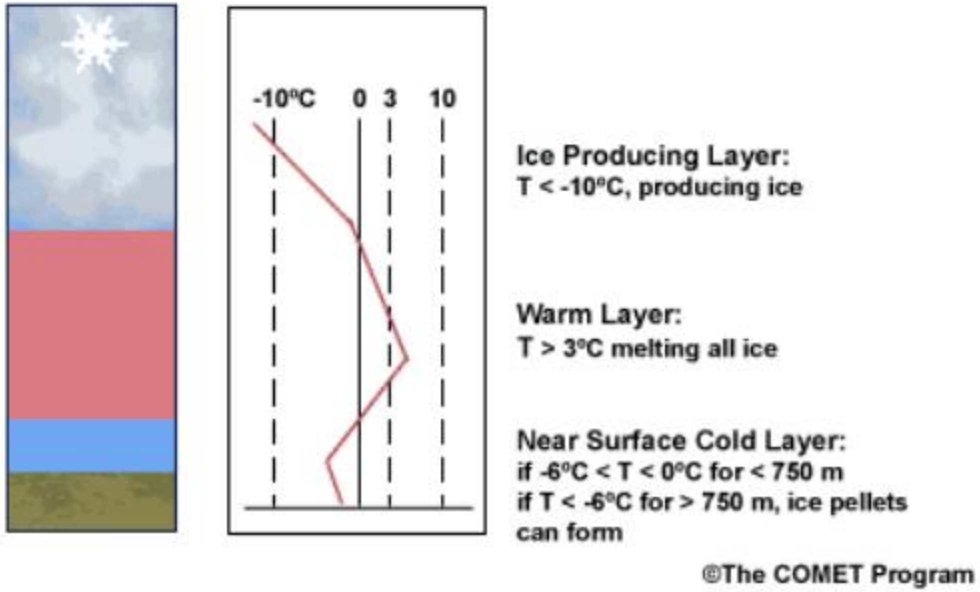
Precipitation Type and Temperature Profile: Ice Pellets/Sleet



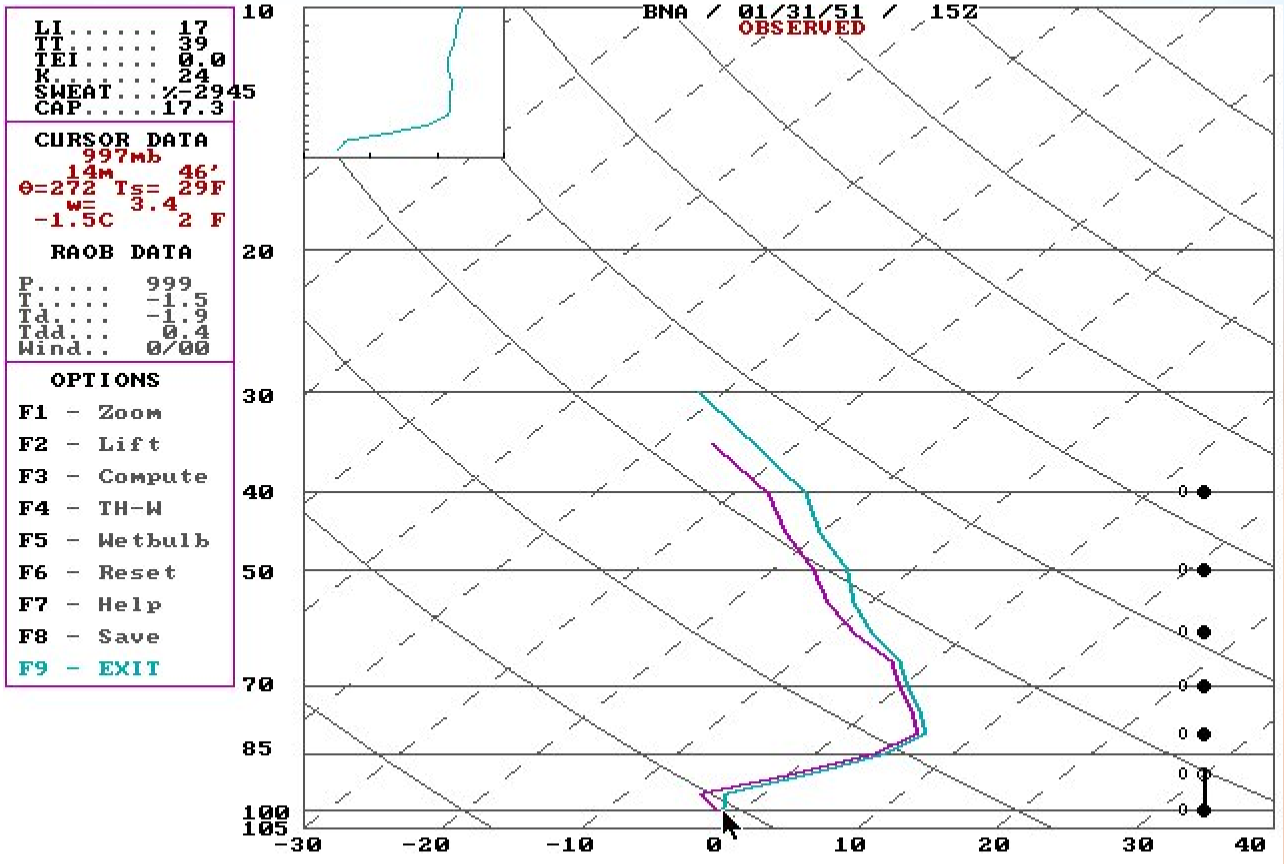
Precipitation Type and Temperature Profile: Snow



Precipitation Type and Temperature Profile: Freezing Rain



Winter weather forecasting exercise



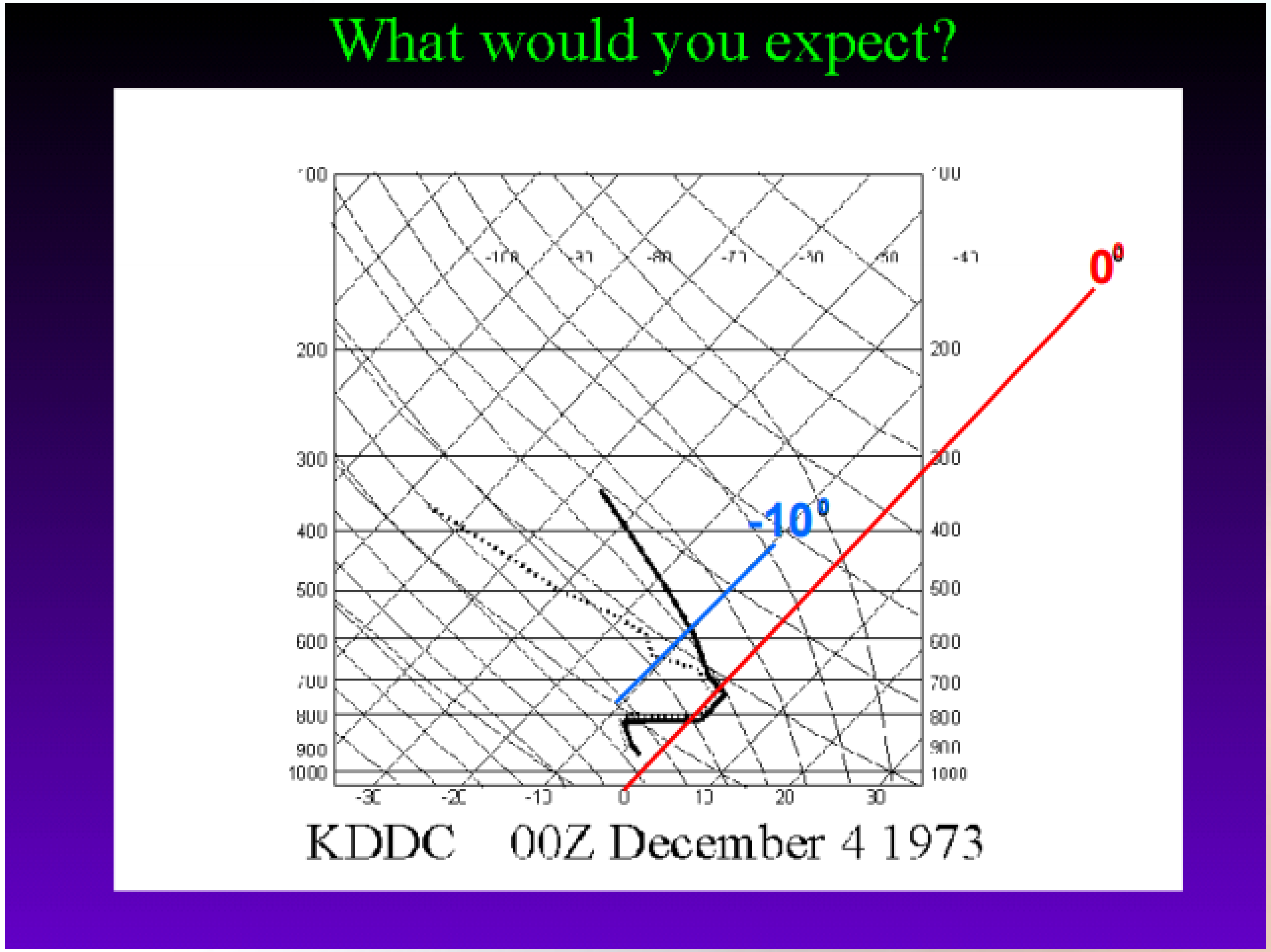
We have ice at -10C.

We have a pronounced elevated warm layer.

We have a subreezing surface layer.

This was the famous ice storm of 1951.

Winter weather forecasting exercise



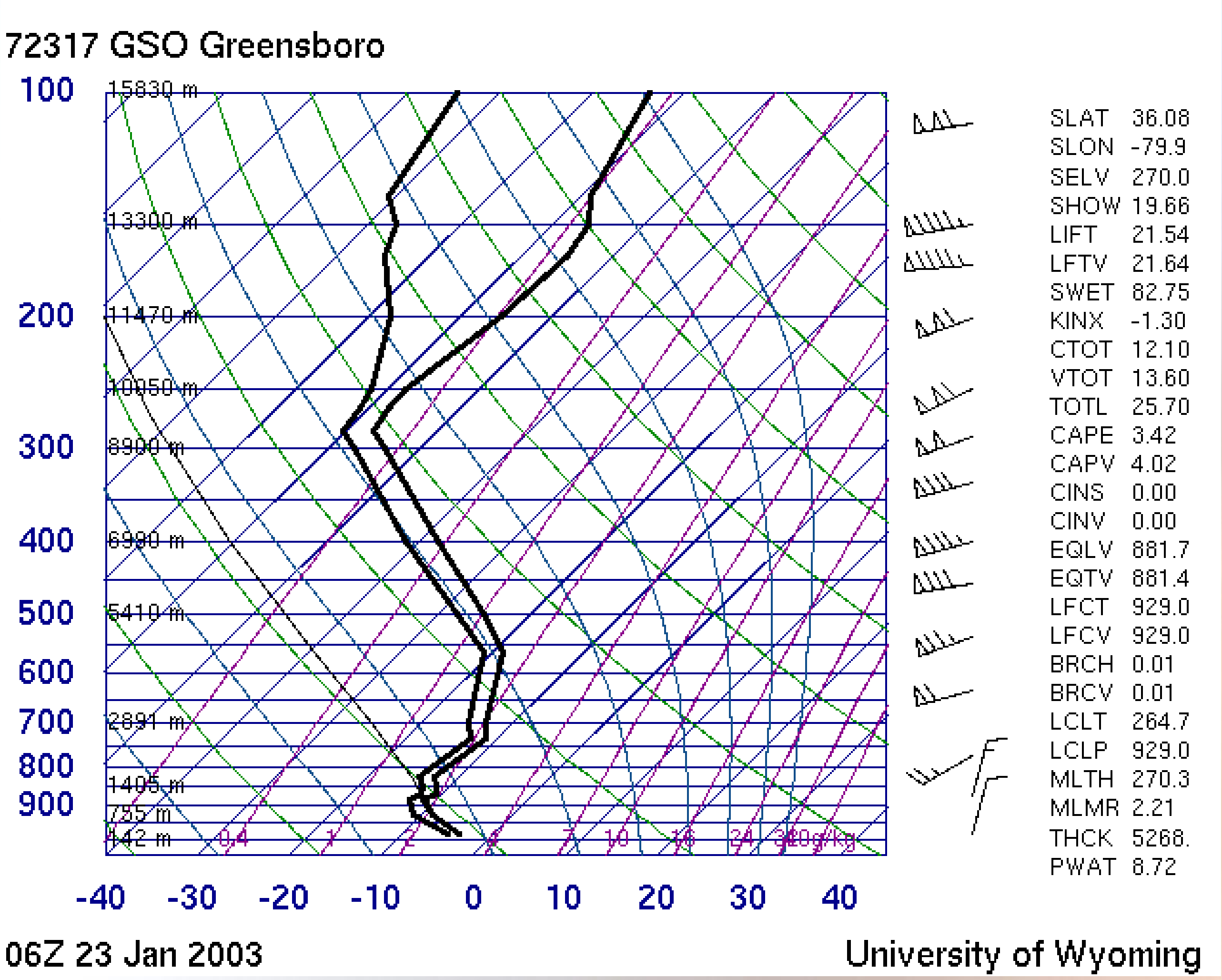
We have no ice at -10C.

We have an elevated warm layer.

We also have a cold surface layer which is below 0C.

Freezing drizzle fell here!

Winter weather forecasting exercise

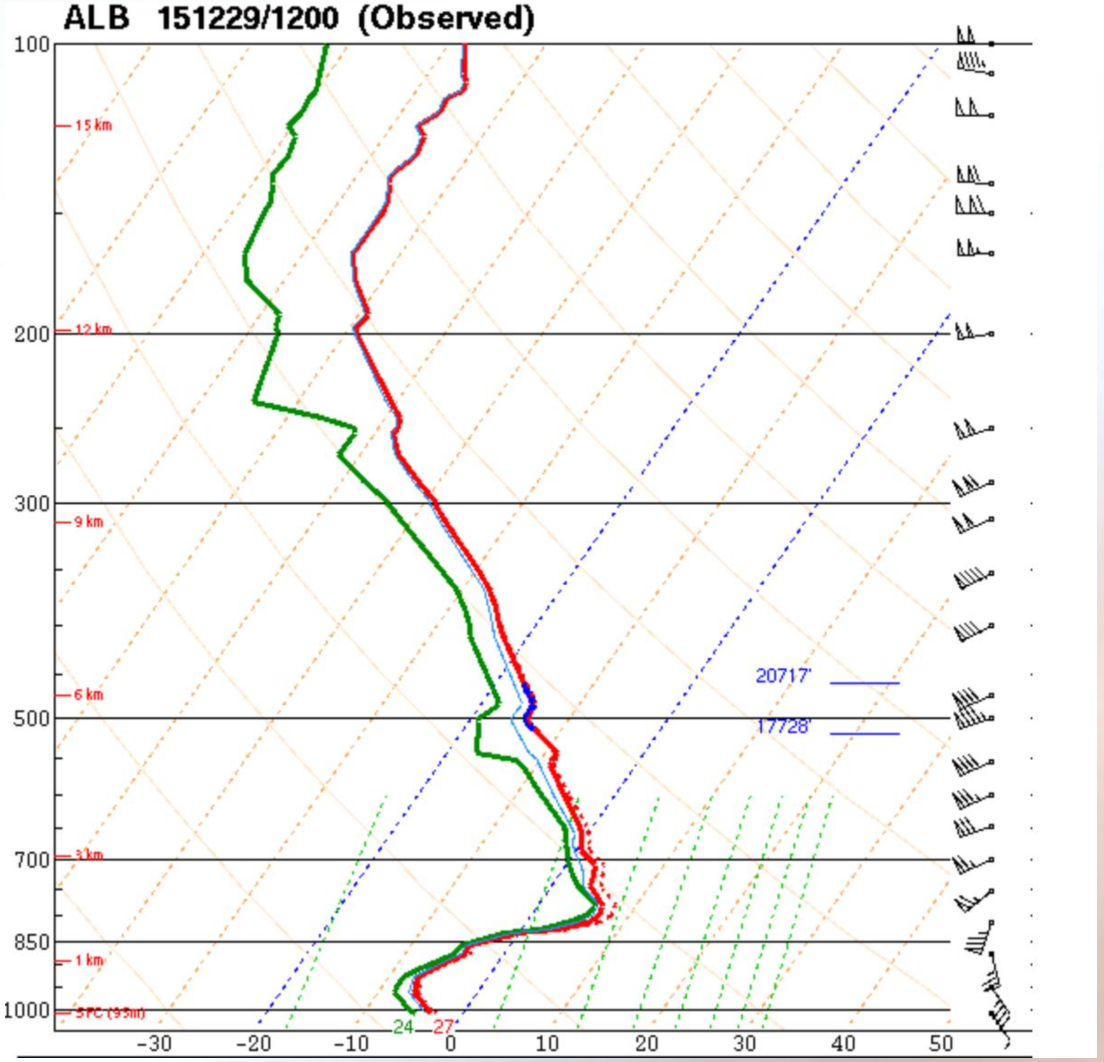


We have ice at -10C.

Temperature remains below freezing all the way to the surface.

Greensboro, NC measured 3.1” of snow.

Winter weather forecasting exercise



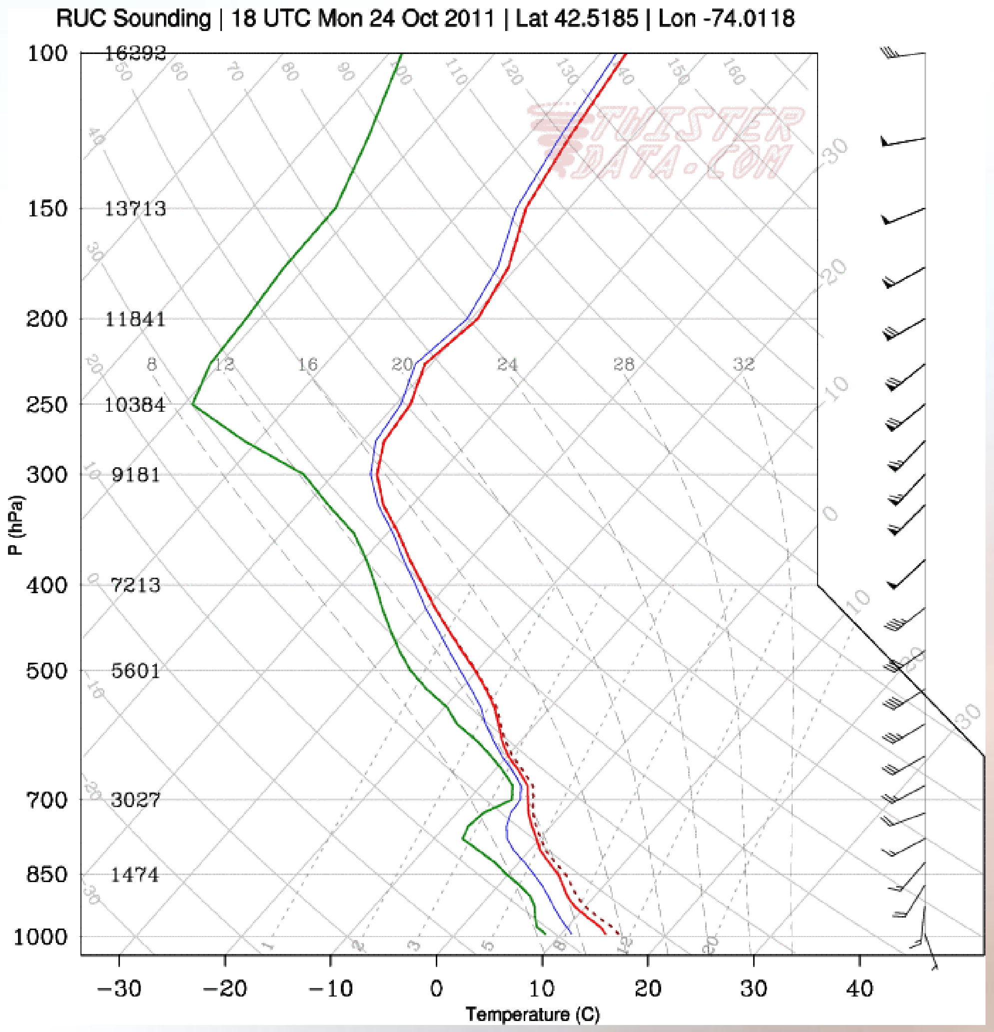
We have ice at -10C and colder.

We have a pronounced elevated warm layer.

We have a deep surface-based freezing layer.

Significant sleet accumulation occurred.

Winter weather forecasting exercise



We have ice at -10C and colder.

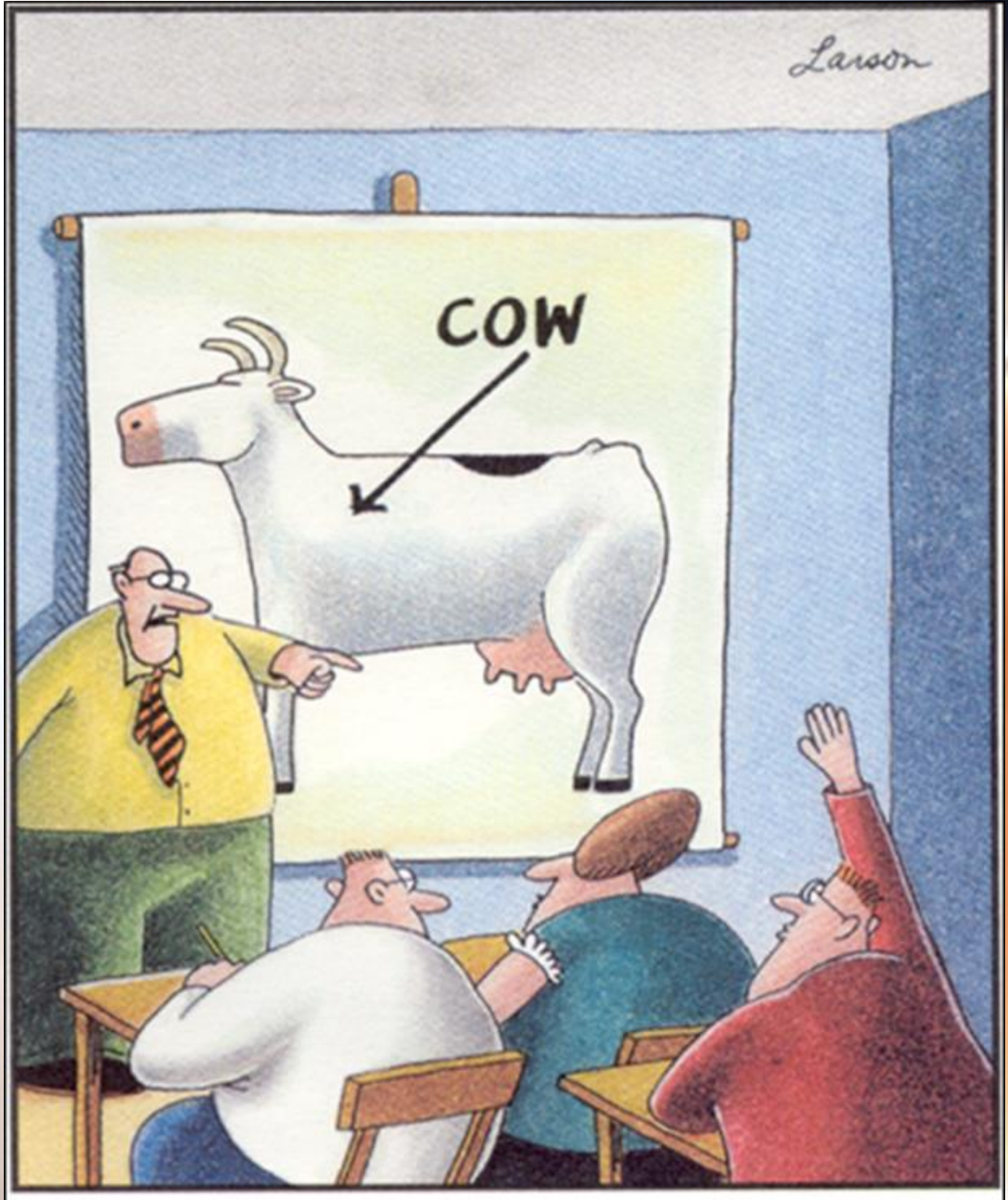
There is a deep surface-based warm layer.

This is just rain.

Summary

- The skew-T log-P diagram can depict a wide array of useful data and parameters using temperature, relative humidity and wind data gathered from a radiosonde.
- Skew-T's help forecasters gage thunderstorm potential and tornado threat during convective events, and also help us determine precipitation type in winter-weather forecasting.
- Data from radiosondes is also plotted on upper air maps, which enables meteorologists to locate high and low pressure, shortwaves and ridges aloft.

Questions?



"Yes ... I believe there's a question in the back."

Contact: mark.a.rose@noaa.gov

A .pdf copy of this presentation can be found at weather.gov/Nashville/weather101presentations