

**ESCI 241 – Meteorology**  
**Lesson 8 - Thermodynamic Diagrams**

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**References:** *The Use of the Skew T, Log P Diagram in Analysis And Forecasting*, AWS/TR-79/006, U.S. Air Force, Revised 1979  
*An Introduction to Theoretical Meteorology*, Hess

**GENERAL**

- Thermodynamic diagrams are used to display lines representing the major
- processes that air can undergo (adiabatic, isobaric, isothermal, pseudo- adiabatic).
- The simplest thermodynamic diagram would be to use pressure as the y-axis and temperature as the x-axis.
- The ideal thermodynamic diagram has three important properties
  - The area enclosed by a cyclic process on the diagram is proportional to the work done in that process
  - As many of the process lines as possible be straight (or nearly straight)
  - A large angle (90° ideally) between adiabats and isotherms
- There are several different types of thermodynamic diagrams, all meeting the
- above criteria to a greater or lesser extent. They are the Stuve diagram, the emagram, the tephigram, and the skew-T/log p diagram
- The most commonly used diagram in the U.S. is the Skew-T/log p diagram.
  - The Skew-T diagram is the diagram of choice among the National Weather Service and the military.
  - The Stuve diagram is also sometimes used, though area on a Stuve diagram is not proportional to work.

**SKEW-T/LOG P DIAGRAM**

- Uses natural log of pressure as the vertical coordinate
  - Since pressure decreases exponentially with height, this means that the vertical coordinate roughly represents altitude.
- Isotherms, instead of being vertical, are slanted upward to the right.

- **Adiabats are lines that are semi-straight, and slope upward to the left.**
  - **The adiabat-isotherm angle is near  $90^\circ$ .**
- **Pseudoadiabats (moist adiabats) are curved lines that are nearly vertical at the bottom of the chart, and bend so that they become nearly parallel to the adiabats at lower pressures.**
- **Mixing ratio lines (isohumes) slope upward to the right.**

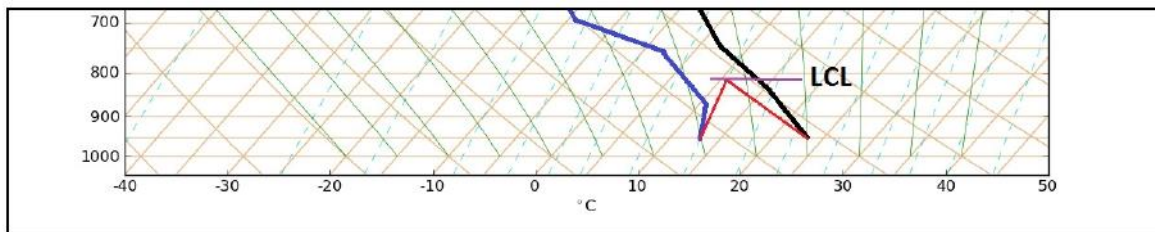
#### **BASIC PARAMETERS FOUND FROM SKEW-T DIAGRAM**

- **The skew- $T$  diagram can be used to determine many useful pieces of information about the atmosphere.**
- **The first step to using the diagram is to plot the temperature and dew point values from the sounding onto the diagram.**
  - **Temperature ( $T$ ) is usually plotted in black or blue, and dew point ( $T_d$ ) in green or red.**
- ***Stability***
  - **Stability is readily checked on the diagram by comparing the slope of the temperature curve to the slope of the moist and dry adiabats.**
- ***Mixing ratio ( $r$ )***
  - **Mixing ratio at a given level in the atmosphere is determined by locating the value of the mixing ratio line that runs through the dew point value at that level.**
- ***Saturation mixing ratio ( $r_s$ )***
  - **Saturation mixing ratio is determined by locating the value of the mixing ratio line that runs through the temperature value at that level.**
- ***Relative humidity***
  - **The relative humidity is determined by dividing the mixing ratio by the saturation mixing ratio.**

#### **LIFTING CONDENSATION LEVEL (LCL)**

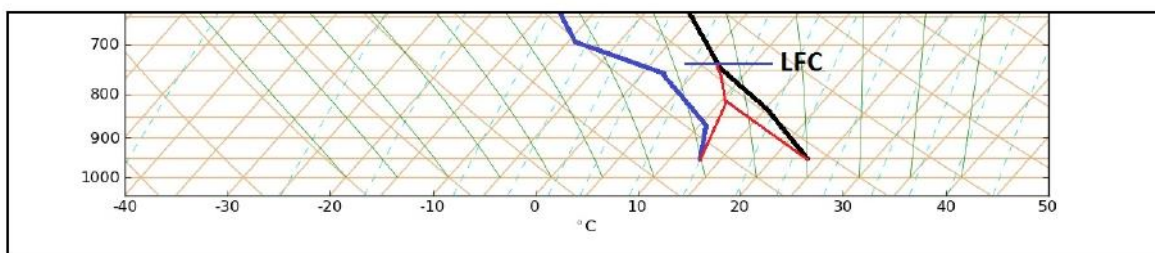
- **The lifting condensation level is defined as the level at which an air parcel at the surface, if lifted dry adiabatically, would reach saturation.**
- **The LCL is roughly where you would expect cloud bases to be if the mechanism for upward motion were due to mechanical lifting (such as through orographic lifting, frontal wedging, or convergence).**

- To find the LCL, begin with the surface temperature, and follow the adiabat through the surface temperature upward to where it would cross the isohume (mixing ratio line) that runs through the surface dew-point temperature. The pressure at which they cross is the *lifting condensation level*.



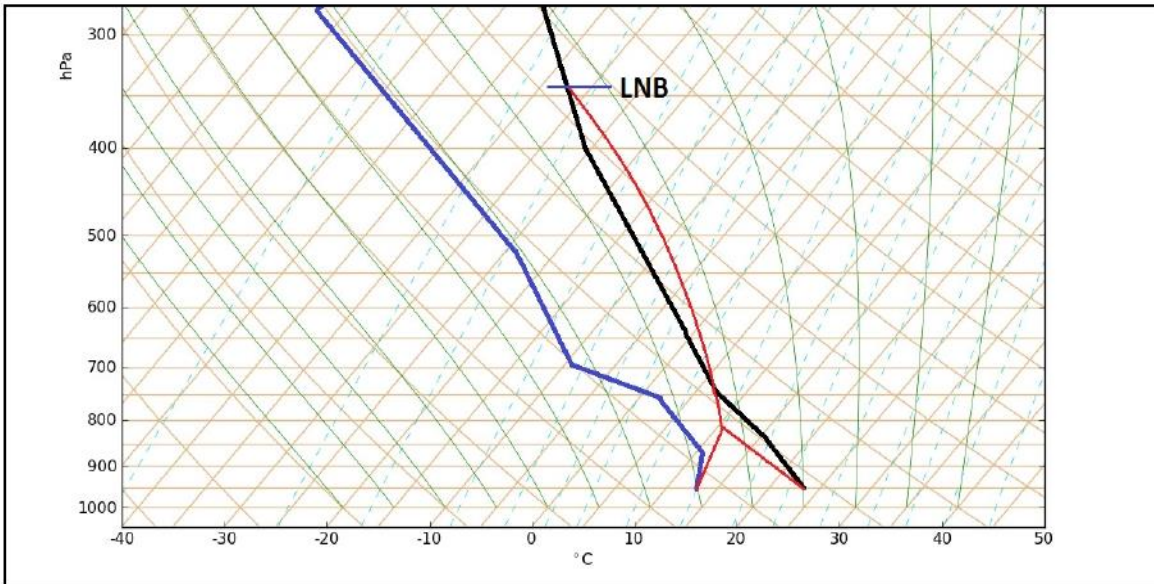
### LEVEL OF FREE CONVECTION (LFC)

- The level of free convection is the level that the parcel would have to be lifted to in order for it to be warmer than its environment and start rising on its own. There may not be an LFC.
- The LFC is found by first finding the LCL and then following a pseudoadiabat upward until it crosses the environmental temperature sounding.



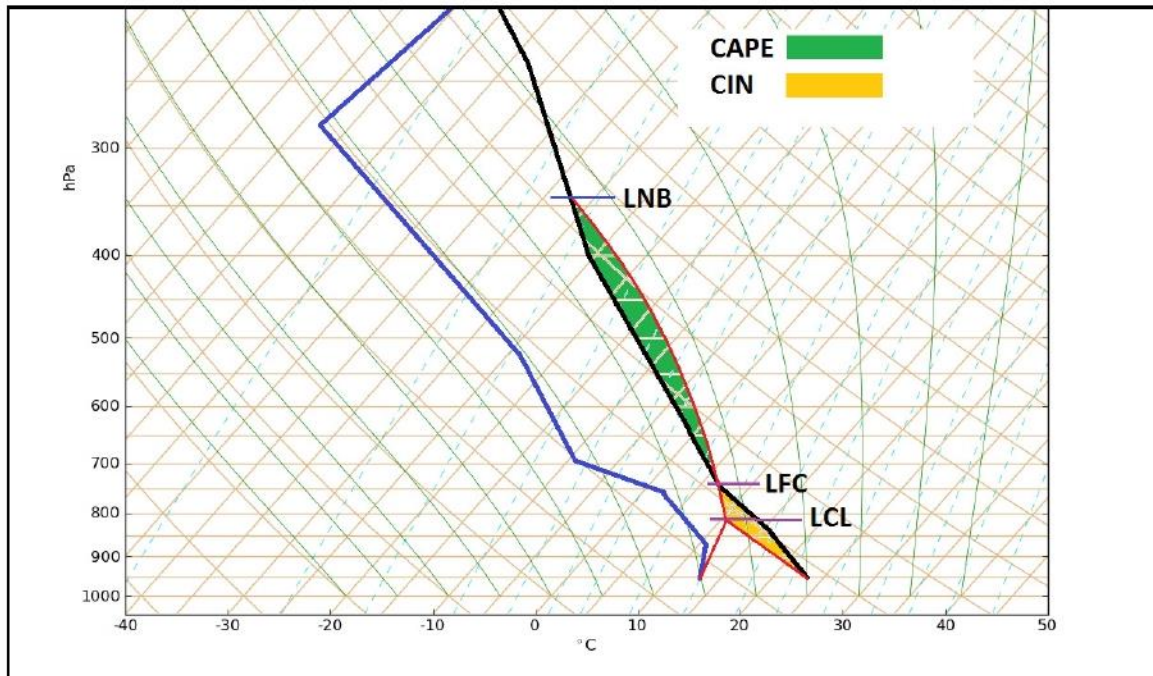
### LEVEL OF NEUTRAL BUOYANCY (LNB)

- If there is an LFC then as the parcel rises and follows a pseudoadiabat it will eventually cross the environmental temperature sounding again. Past this point the parcel will be colder than its environment and quit rising.
- This level is called the level of neutral buoyancy, and gives an indication as to where the tops of any convective clouds will be located.



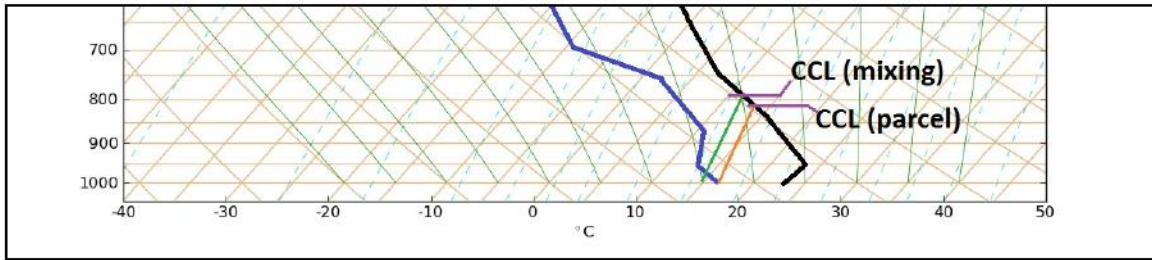
### CAPE AND CIN

- Convective available potential energy or CAPE is the energy available to be converted into kinetic energy of an updraft. The more CAPE, the stronger the potential for a vigorous updraft and stronger thunderstorm.
- CAPE is proportional to that area on the skew- $T$  diagram between the environmental sounding and the pseudoadiabat connecting the LFC and the LNB.
- Convective inhibition, or CIN, is the amount of work that an air parcel must overcome in order to reach the LFC.
- CIN is proportional to that area on the skew- $T$  diagram between the environmental sounding and the path that a parcel from the surface would take to reach the LFC.

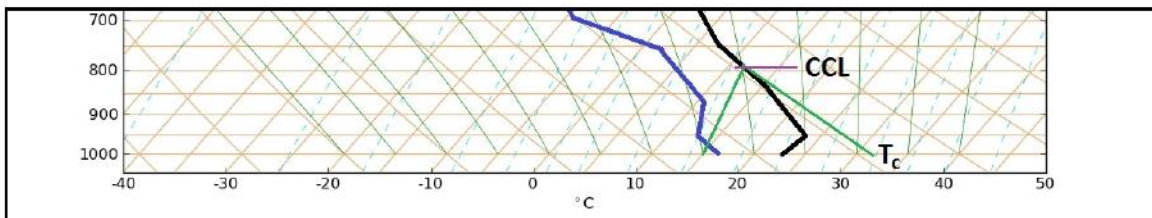


### CONVECTIVE CONDENSATION LEVEL (CCL)

- The convective condensation level is the level at which you would expect to find the bases of convective clouds.
- There are two methods for finding the CCL
  - *Method 1 - The mixing method*
    - Find the average mixing ratio in the lowest 50 mb or so (by inspecting the dew-point line), and follow this mixing ratio line up to where it intersects the temperature sounding.
  - *Method 2 - The parcel method*
    - Follow the mixing ratio line that passes through the surface dewpoint up to where it intersects the temperature sounding.
- These two methods will give you roughly the same answer, but not exactly the same answer.
- The mixing method is more appropriate for finding the bases of deep convective clouds, such as thunderstorms
- The parcel method is appropriate for finding the bases of shallow convective clouds.



- The convective temperature is found by following the adiabat from the CCL to the surface.
- The convective temperature is the temperature at which the surface would have to reach in order for convective clouds to form.



*Potential temperature ( $\theta$ )*

- The potential temperature is defined as the temperature the parcel would have if it is moved dry-adiabatically to 1000 mb.
- It is found by following a dry adiabat through the temperature at a given level to a pressure of 1000 mb.