Lecture topics:

- Cloud Development
- Two Odd clouds
Recall: **Vertical Movement & Temperature**

A rising air parcel encounters less pressure so it expands. Expansion uses energy to push out, adiabatically cooling the air.

A sinking parcel encounters greater pressure and that higher pressure does work on the parcel thereby heating it up.

Recall: \[ P = \rho RT \]
Recall: Stability & Clouds

- Three examples of weather related to stability:
  - Clouds types linked to stability of the air. *Stratus clouds* found in stable conditions, *cumulus* are in unstable conditions. Thunderstorms in very unstable conditions.
  - *Lenticular* wave clouds form in stable air
Recall: the stability classes

- Yes! but it is easier to do this using a chart
- Compare the actual $T$ change with height to the lapse rates $\Gamma d$ (red line) and $\Gamma m$ (blue line)
- Figures 7.3, 7.6, and 7.7 work out the three categories.
- Figure 7.8 is a summary:
Recall: absolutely unstable air can be created 7 ways

1. Bring colder air aloft
2. Radiation cools top of layer
3. Daytime heating
4. Bring warmer air below
5. Air moves over a warmer surface
6. Mixing the air (fig. 7.10)
7. Moving the whole column of air upwards (figs. 7.11 & 7.12)
Causing Air to Rise: Convection

• Result of a process that makes the layer of air unstable
• Recall there are 7 ways this can happen
• All cumuliform clouds
Causing Air to Rise: Topographic Lifting

- Air is forced to rise because the large scale wind pattern drives the air up the slope of mountains and hills.
Causing Air to Rise: Convergence

- large scale winds cause air to converge near the surface
- Occurs along fronts, the center of a hurricane, etc.
Causing Air to Rise: Frontal Lifting

- Fronts act like obstacles that can force air to rise.
- Blue line is cold front
- Red line is warm front
Causing Air to Rise: Gilbert -- Combines All Four Mechanisms

Hurricane Gilbert when it set a record low pressure at sea level of 885 mb →
Cloud development – will the rising air reach saturation?

• When air parcel rises, dewpoint and temperature of the parcel changes.
  – Cloud will form when the air parcel becomes saturated
  – Stability of the air may change
• Easiest to use an adiabatic chart:
• See pages 180-181
Adiabatic chart – part 1

- See pages 180-181
Adiabatic chart – part 2

- See pages 180-181
Adiabatic chart – 3 rules

- See pages 180-181
- Three rules for moving air on this chart:
  1. T changes follow $\Gamma_d$ if unsaturated, $\Gamma_m$ if saturated;
  2. Td changes follow constant $w$ if unsaturated, $\Gamma_m$ if saturated.
  3. When moving a layer, move the top and bottom like separate air parcels. Keep $\Delta P$ fixed.

*Figure 6* The adiabatic chart. The arrows in the chart illustrate the example given in the text.
Adiabatic chart – moving a parcel

1. T changes follow $\Gamma_d$ if UNsaturated, $\Gamma_m$ if saturated;
2. $T_d$ changes follow const $w$ if unsaturated, $\Gamma_m$ if saturated.
3. When moving a layer, move the top and bottom like separate air parcels. Keep $\Delta P$ fixed

$T$ change follows arrows to the right: $T_1$ to $T_2$

$T_d$ change follows arrows to the left: $D_1$ to $D_2$

LCL, lifting condensation level estimates base of cloud

*Figure 6*
The adiabatic chart. The arrows in the chart illustrate the example given in the text.
Adiabatic chart – moving a parcel

Example consistent with the air parcel track on the adiabatic chart
Adiabatic chart – moving a layer

**Initial Profile**

1. $T$ changes follow $\Gamma_d$ if UNsaturated, $\Gamma_m$ if saturated;
2. $Td$ changes follow const $w$ if unsaturated, $\Gamma_m$ if saturated.
3. When moving a layer, move the top and bottom like separate air parcels. Keep $\Delta P$ fixed
Adiabatic chart – moving a layer

Lifting
The layer

1. T changes follow $\Gamma_d$ if UNSaturated, $\Gamma_m$ if saturated;
2. $T_d$ changes follow const w if unsaturated, $\Gamma_m$ if saturated.
3. When moving a layer, move the top and bottom like separate air parcels. Keep $\Delta P$ fixed.
Adiabatic chart – moving a layer

Lifted Layer
Saturated &
Very Unstable

1. T changes follow $\Gamma_d$ if UNSaturated, $\Gamma_m$ if saturated;
2. Td changes follow const w if unsaturated, $\Gamma_m$ if saturated.
3. When moving a layer, move the top and bottom like separate air parcels. Keep $\Delta P$ fixed
Cloud Development - Two Unusual Clouds

• Mammatus clouds
• Cap clouds
Cloud Development - Mammatatus Clouds

- Only cloud that grows by downward moving air
- Down motion caused by evaporation of drops that cools the air until it reaches saturation (and also sinks)
Cloud Development - Cap Clouds

- Stable atmosphere
- Strong winds
End of lecture 5