ATM 10 Severe and Unusual Weather

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http://atm.ucdavis.edu/~grotjahn/course/atm10/index.html

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: $P = \rho R T$

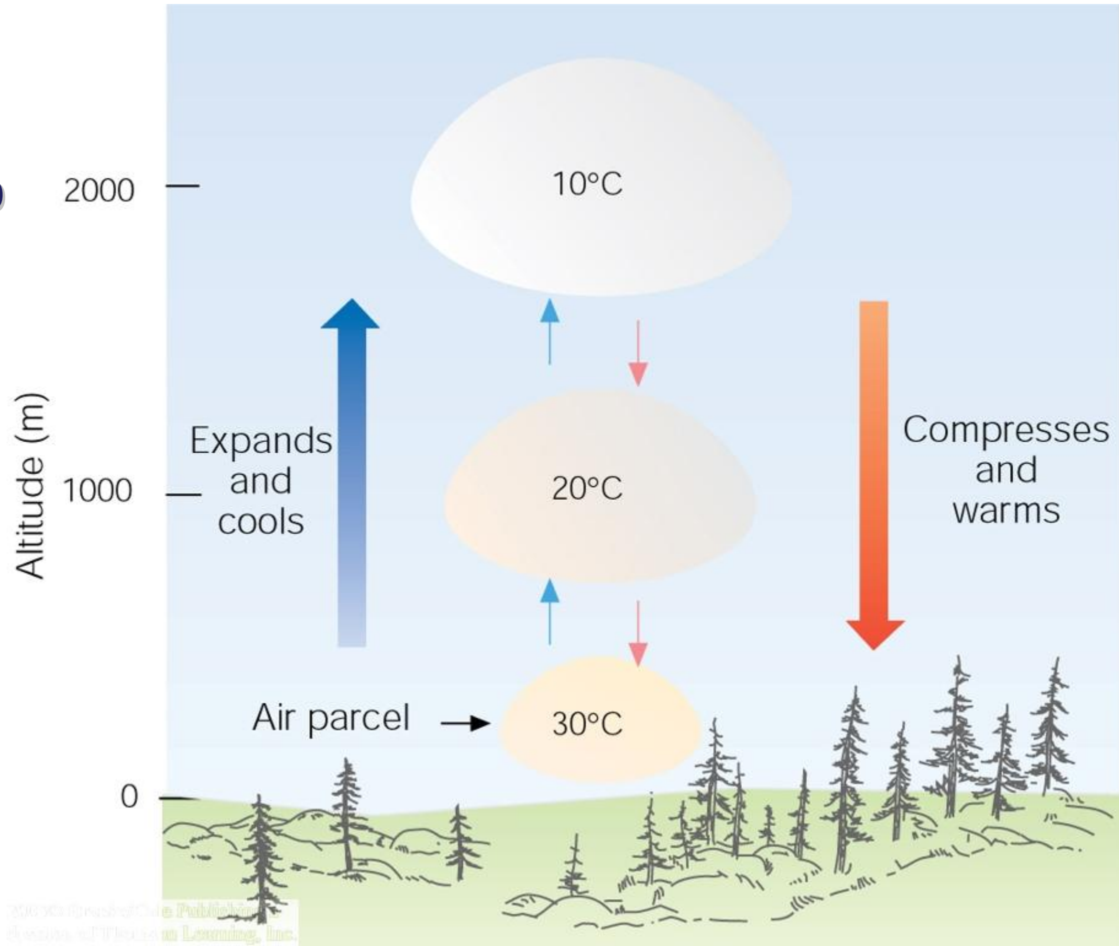


Figure 7.2

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

stratiform

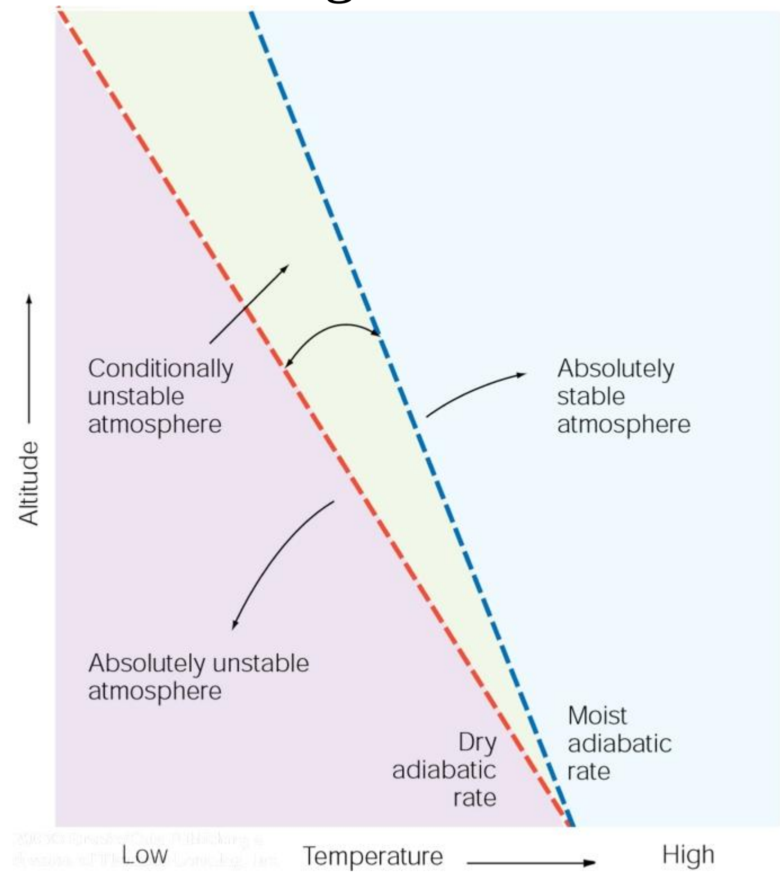
cumuliform

lenticular

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 Γd (red line) and Γm (blue line)
- Figures 7.3, 7.6, and 7.7 work out the three categories.
- Figure 7.8 is a summary:

Figure 7.8



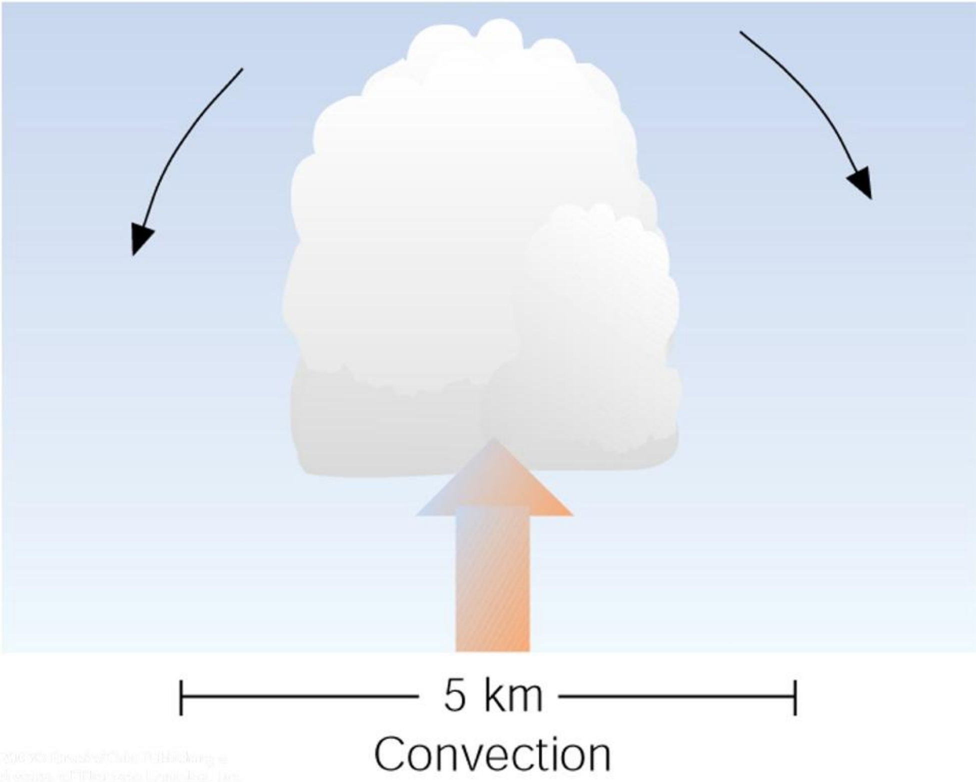
Recall: absolutely unstable air can be created 7 ways

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)

Photo © R. Grotjahn

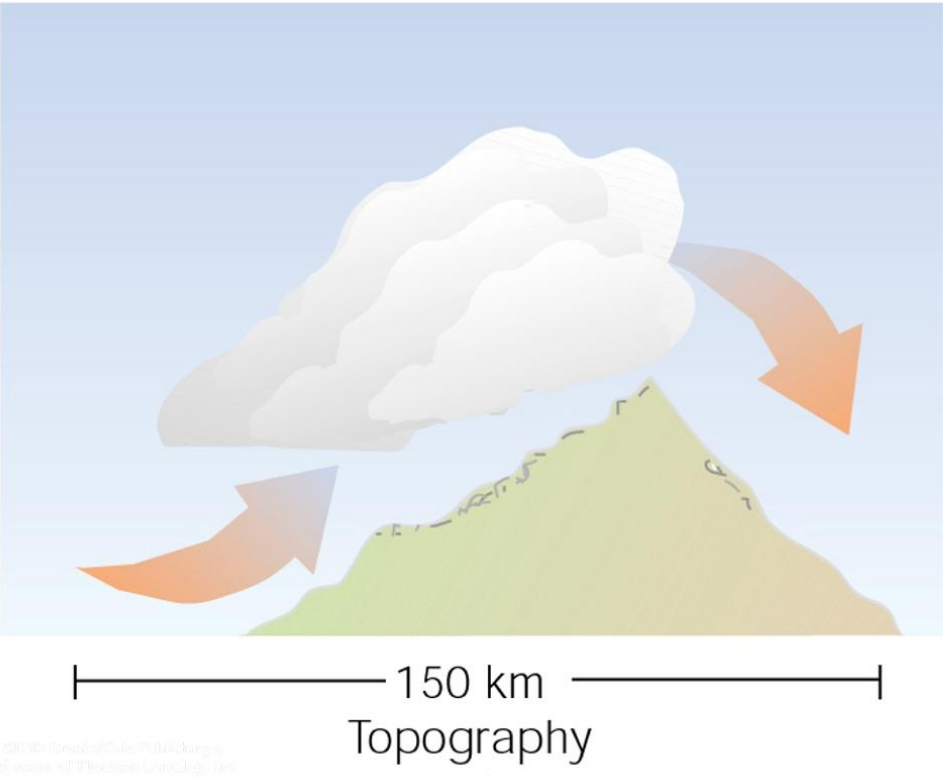
Causing Air to Rise: Convection

- Result of a process that makes the layer of air unstable
- Recall there are 7 ways this can happen
- All cumuliform clouds



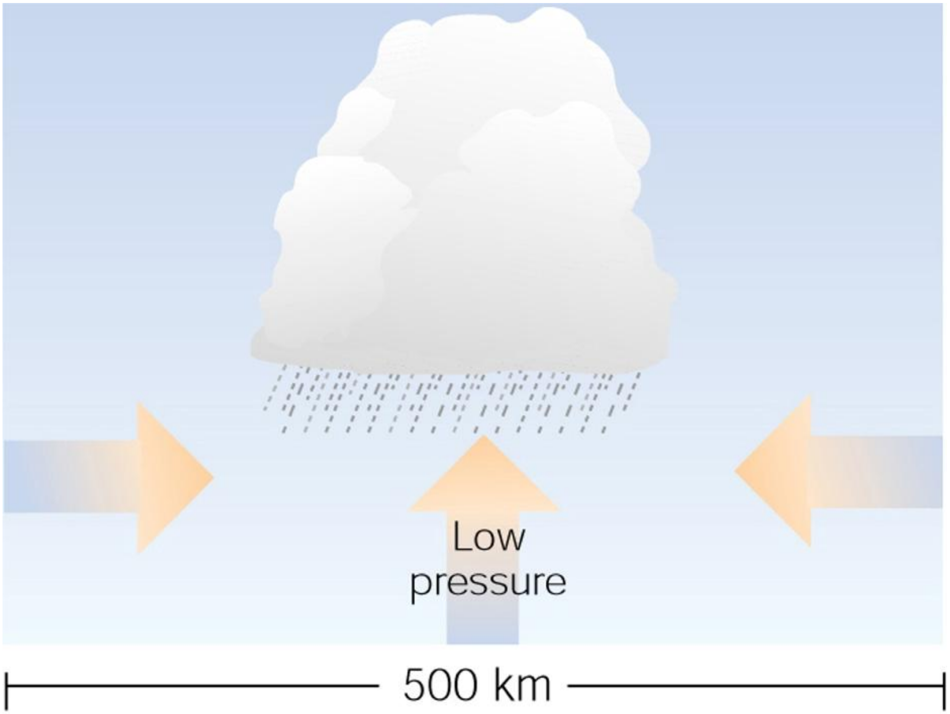
Causing Air to Rise: Topographic Lifting

- 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

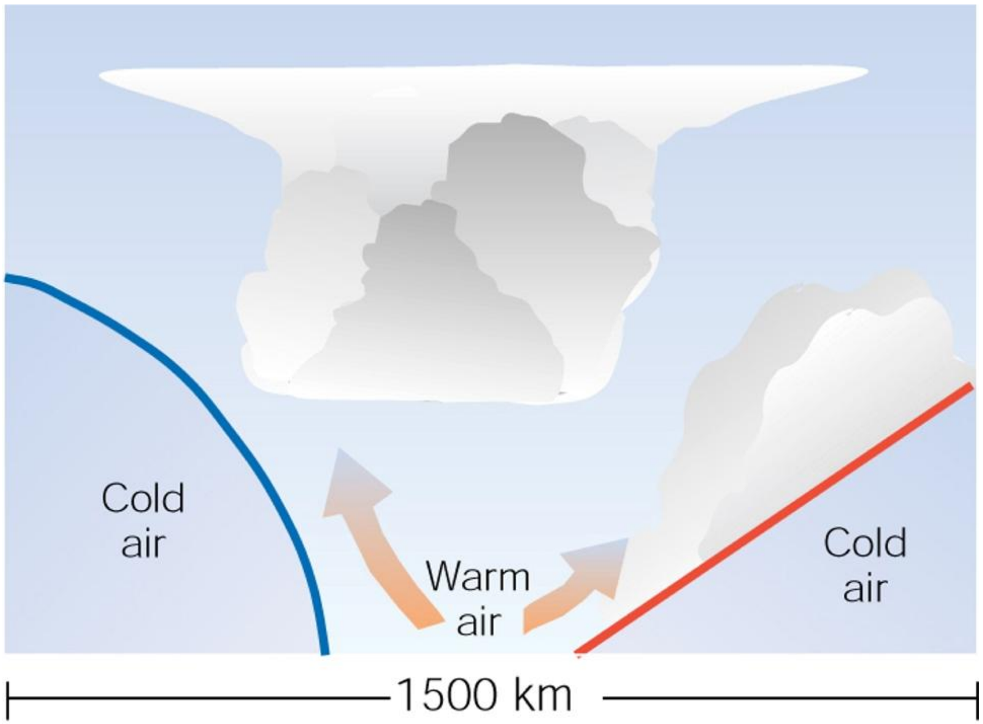
- large scale winds cause air to converge near the surface
- Occurs along fronts, the center of a hurricane, etc.



Convergence of air

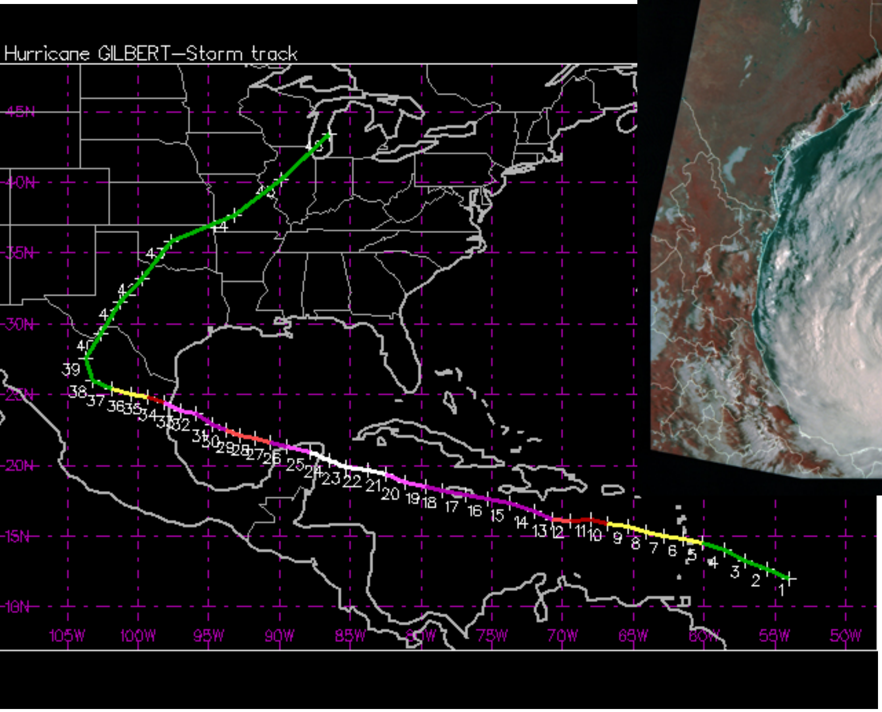
Causing Air to Rise: Frontal Lifting

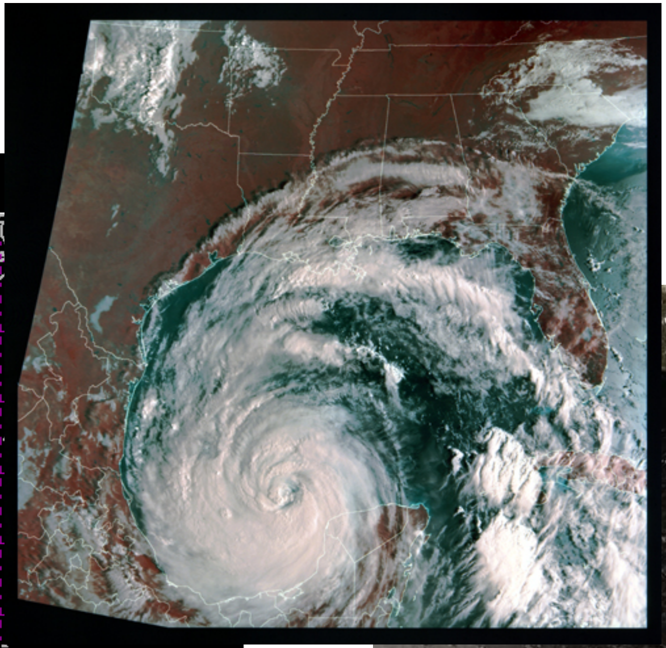
- Fronts act like obstacles that can force air to rise.
- Blue line is cold front
- Red line is warm front

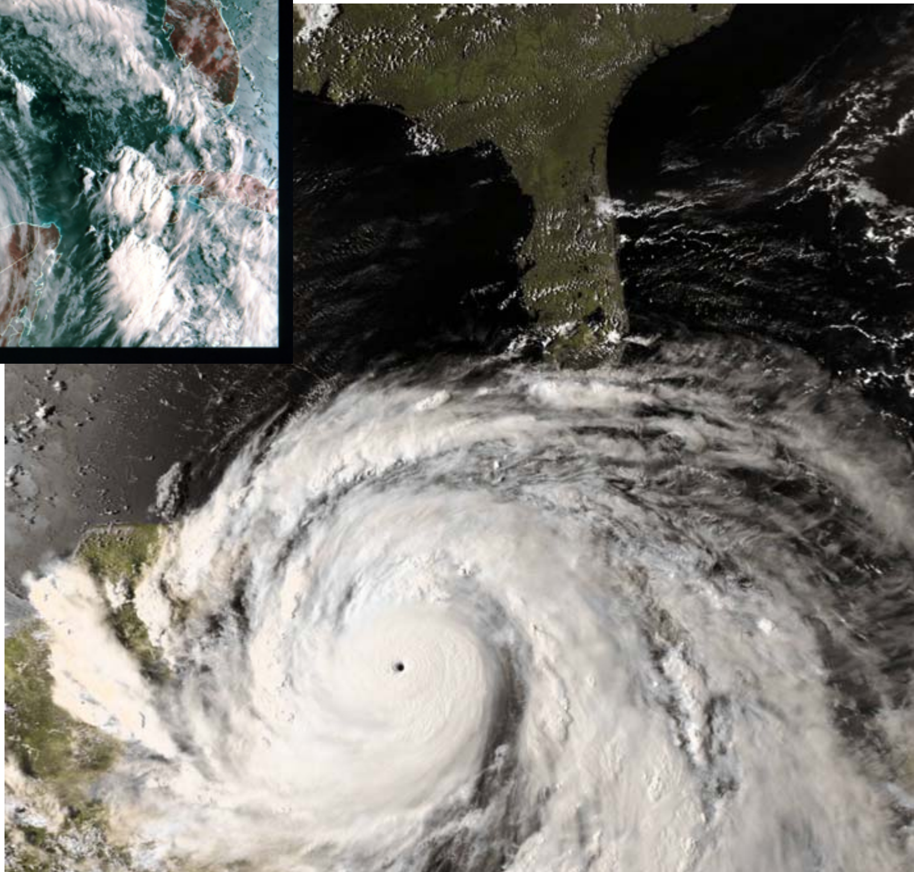


Lifting along weather fronts

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

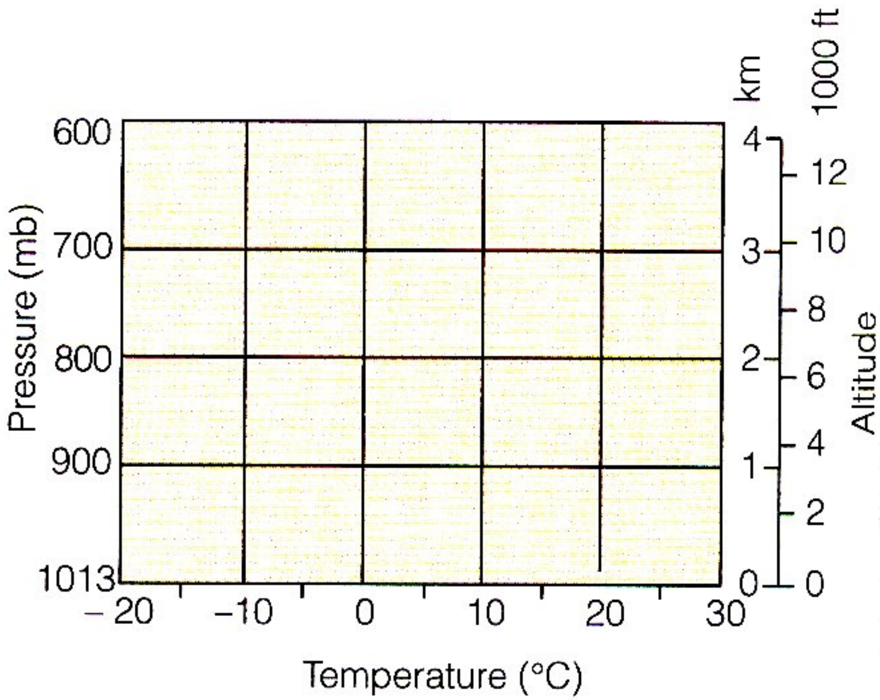


Figure 2

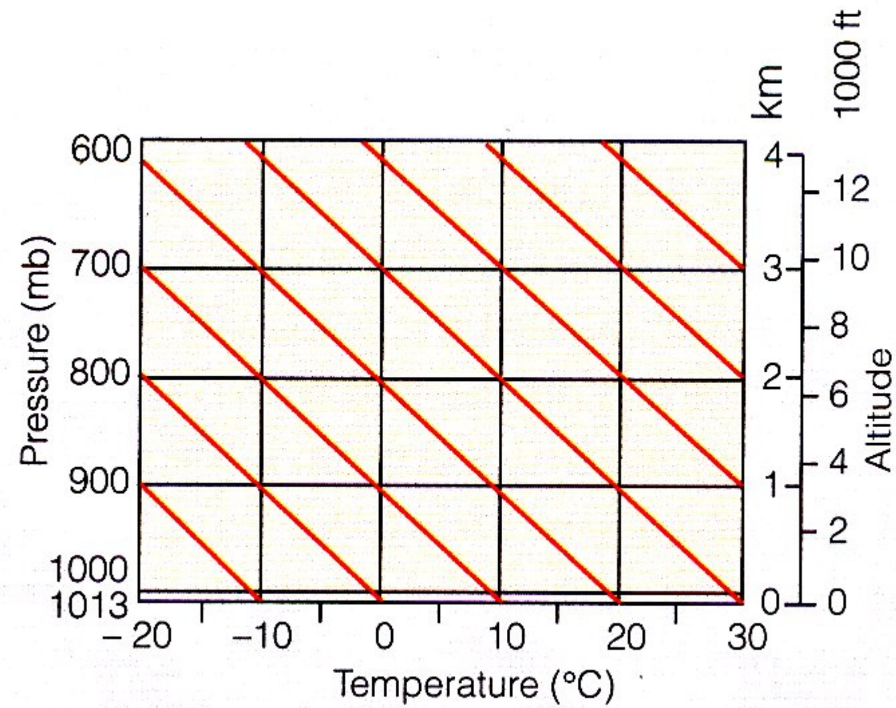


Figure 3

- See pages 180-181

Adiabatic chart – part 2

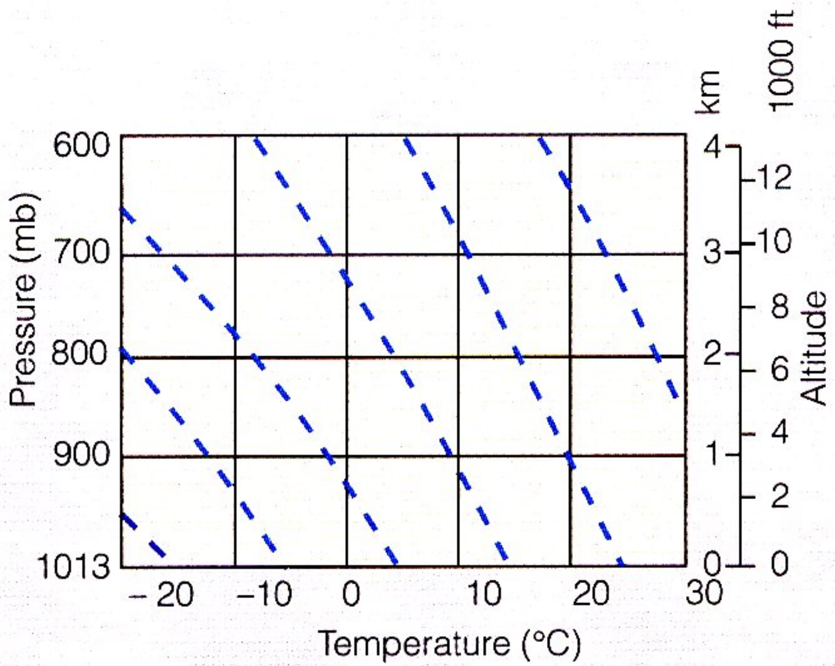


Figure 4

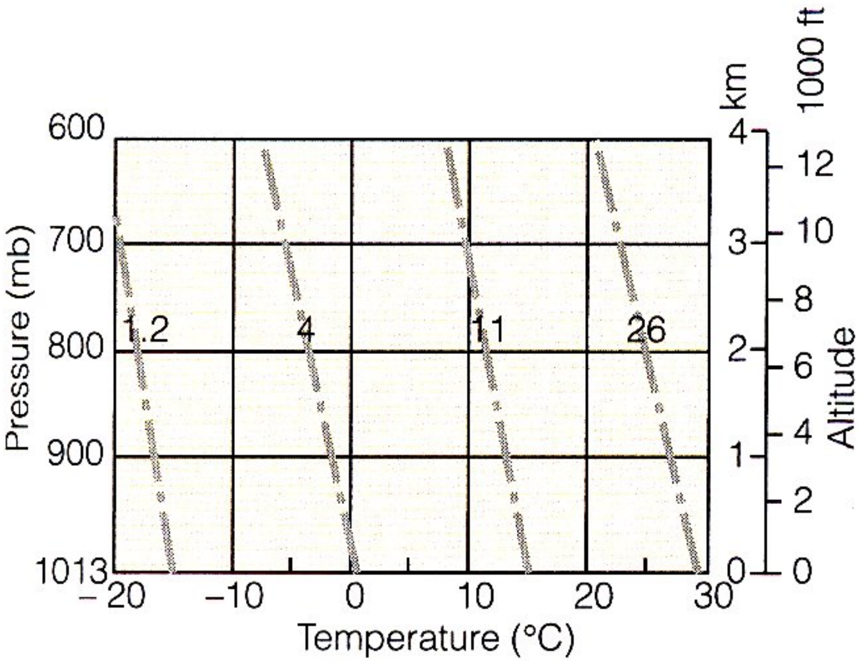


Figure 5

- See pages 180-181

Adiabatic chart – 3 rules

- See pages 180-181
- Three rules for moving air on this chart:

1. T changes follow Γd if UNsaturated, Γm if saturated;
2. Td changes follow constant w if unsaturated, Γm if saturated.
3. When moving a layer, move the top and bottom like separate air parcels. Keep ΔP fixed

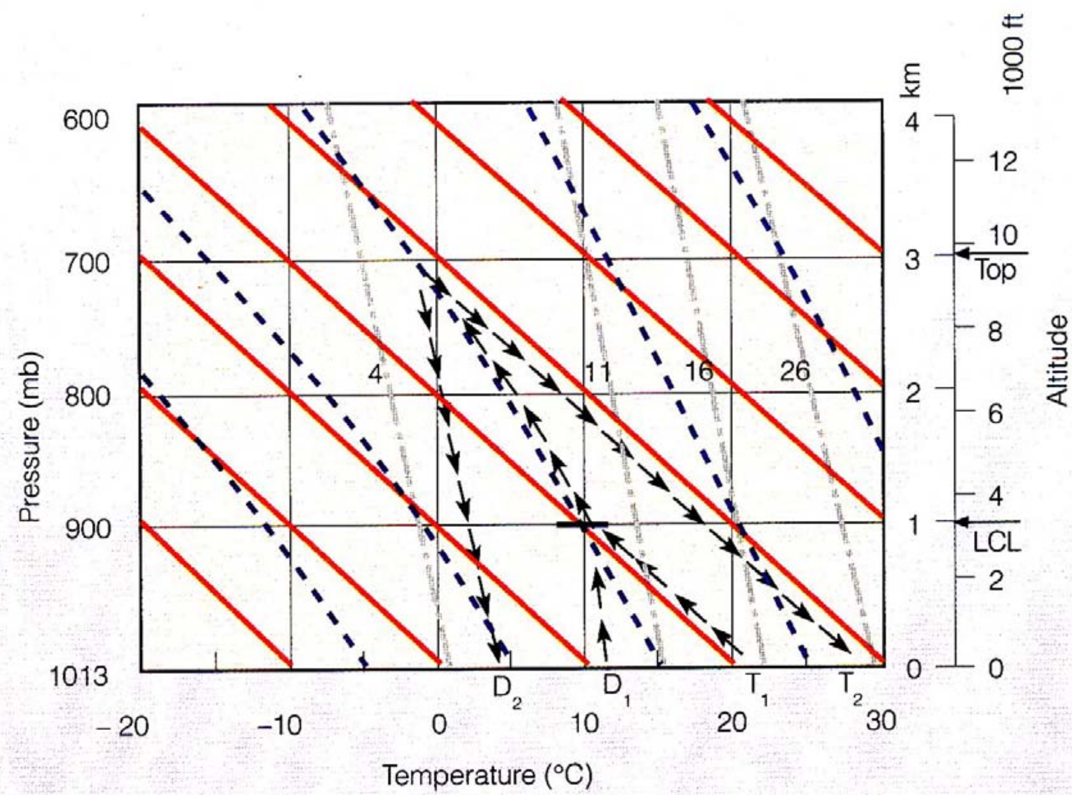


Figure 6
The adiabatic chart. The arrows in the chart illustrate the example given in the text.

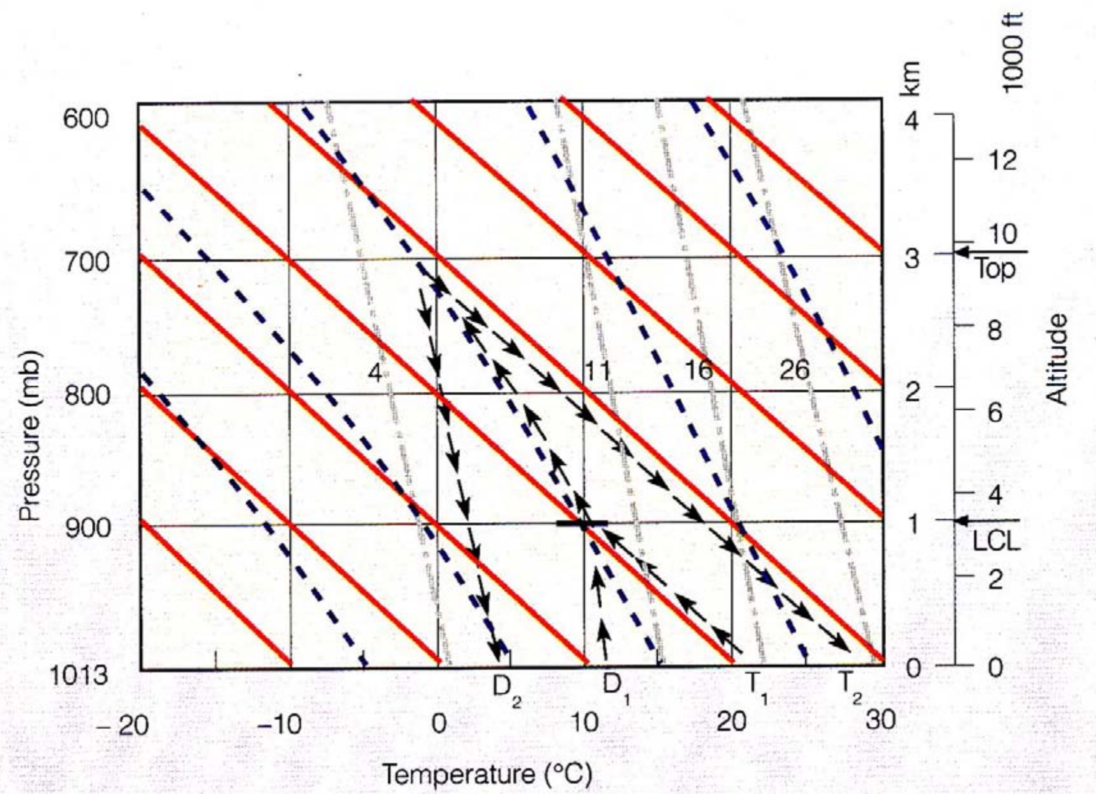
Adiabatic chart – moving a parcel

1. T changes follow Γd if UNsaturated, Γm if saturated;
2. Td changes follow const w if unsaturated, Γm if saturated.
3. When moving a layer, move the top and bottom like separate air parcels. Keep ΔP fixed

T change follows arrows to the right: T_1 to T_2

Td change follows arrows to the left: D_1 to D_2

LCL, lifting condensation level estimates base of cloud



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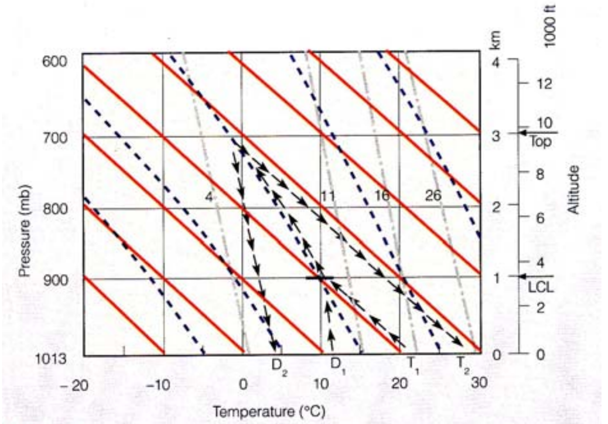
The adiabatic chart. The arrows in the chart illustrate the example given in the text.

Adiabatic chart – moving a parcel

Example consistent with the air parcel track on the adiabatic chart



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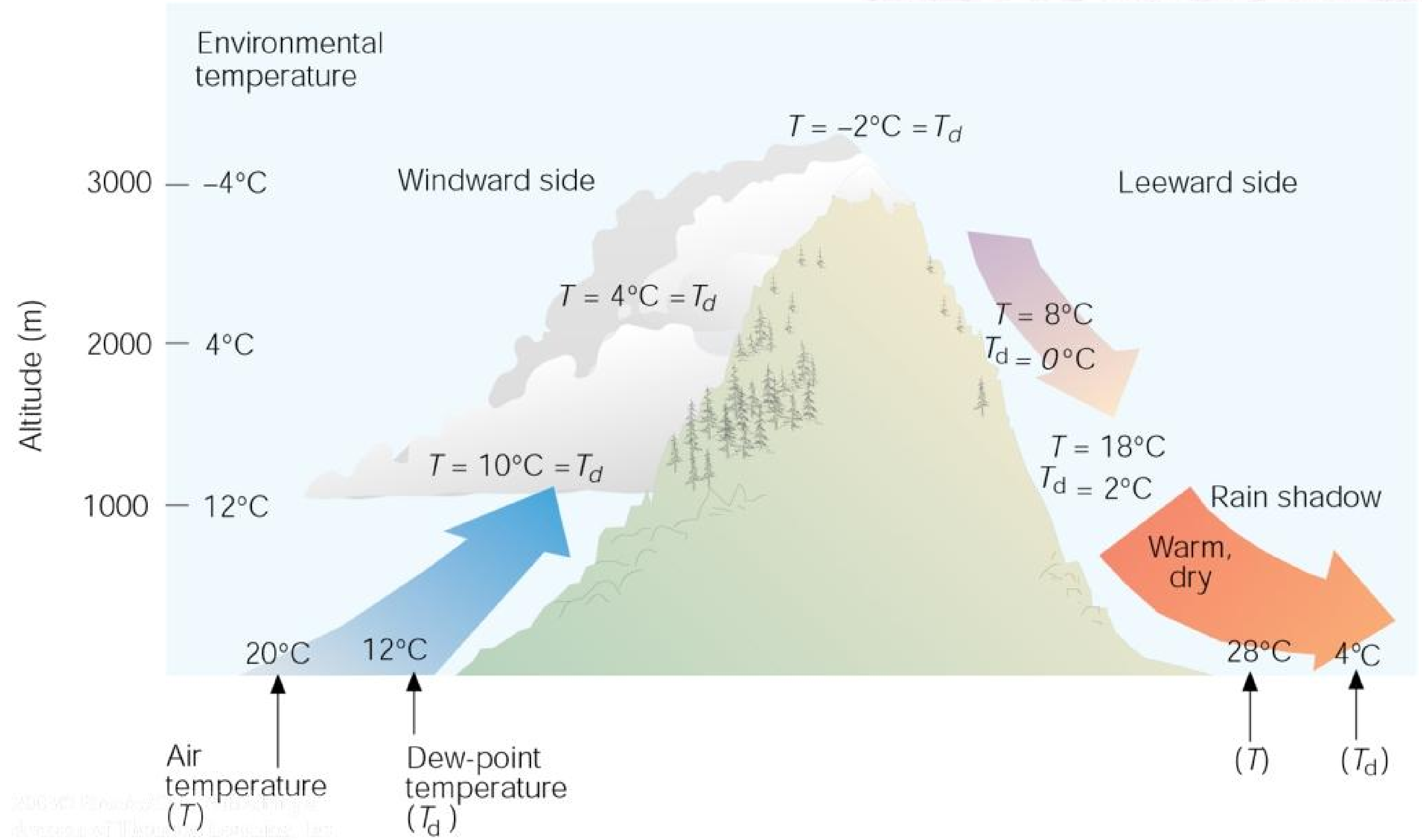
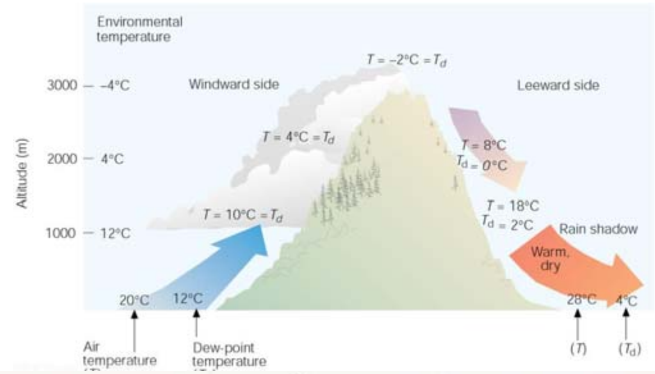
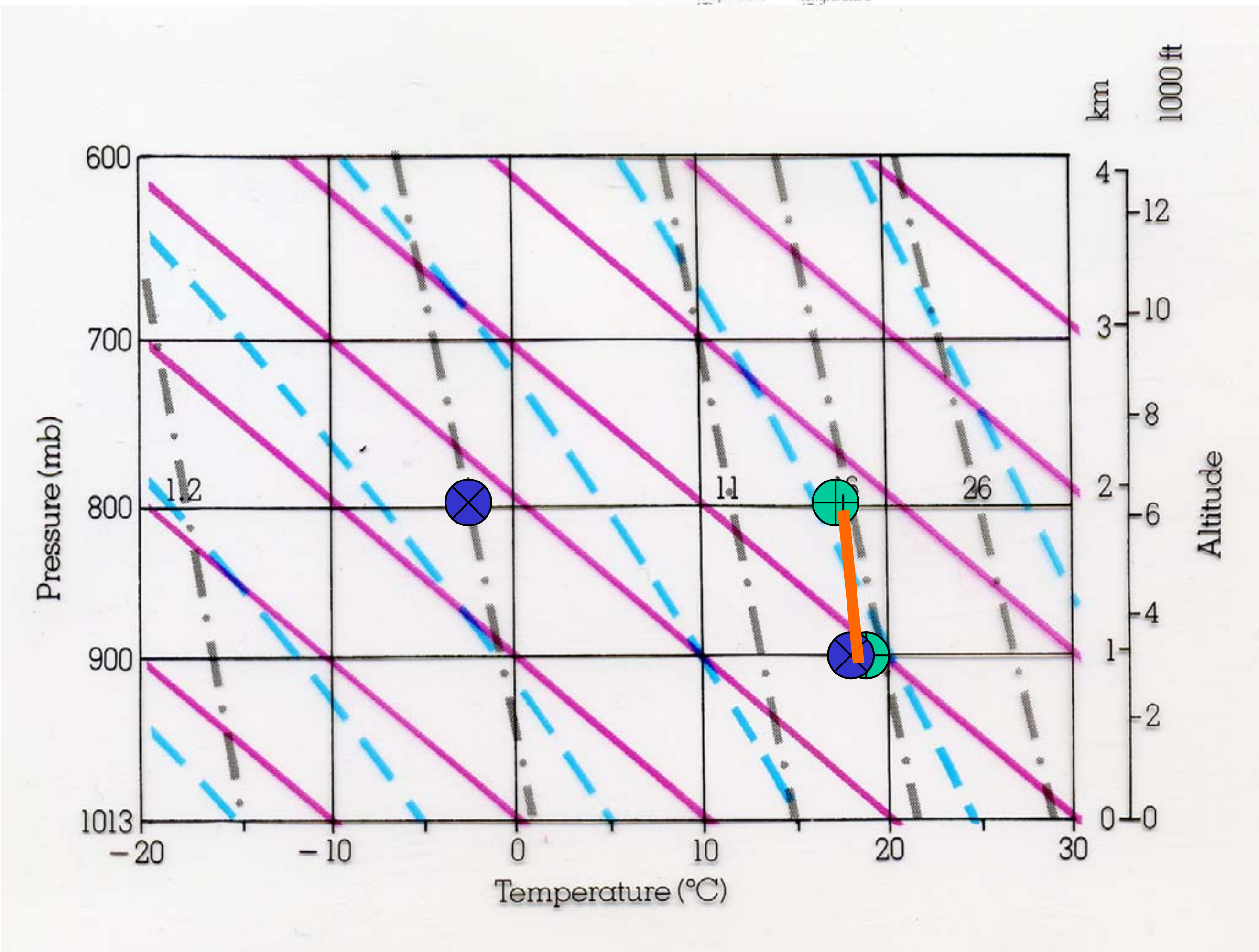


Adiabatic chart – moving a layer



Initial Profile



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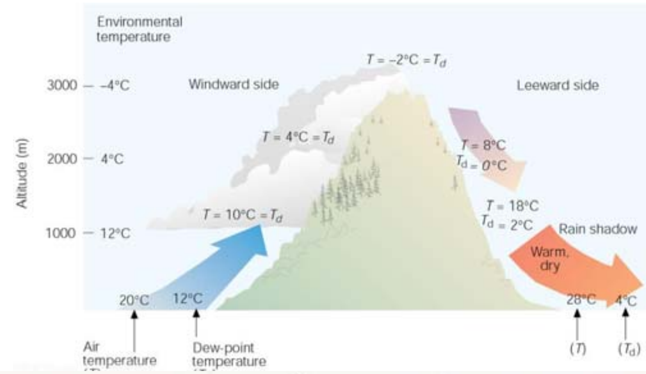
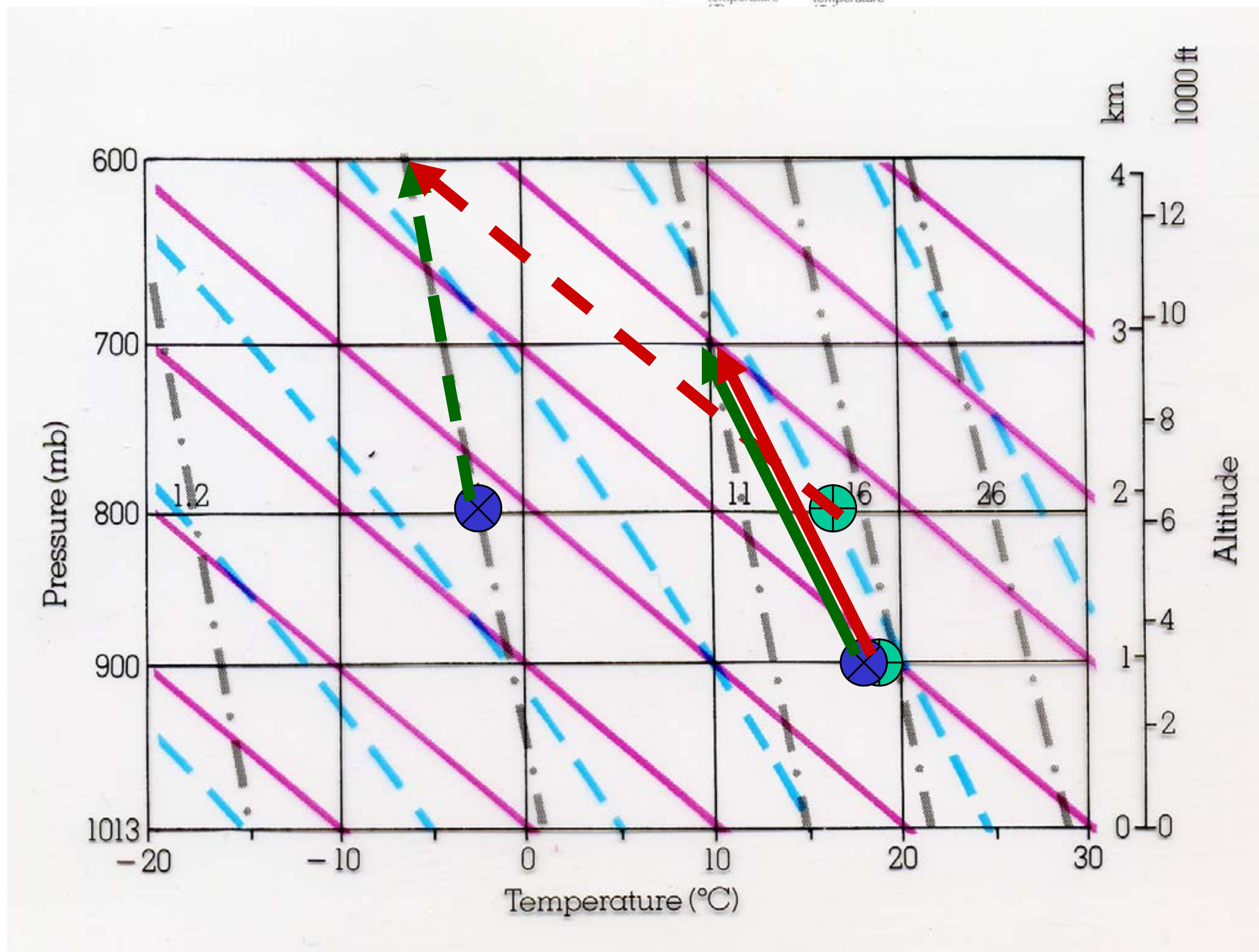
Adiabatic chart – moving a layer



Lifting
The layer



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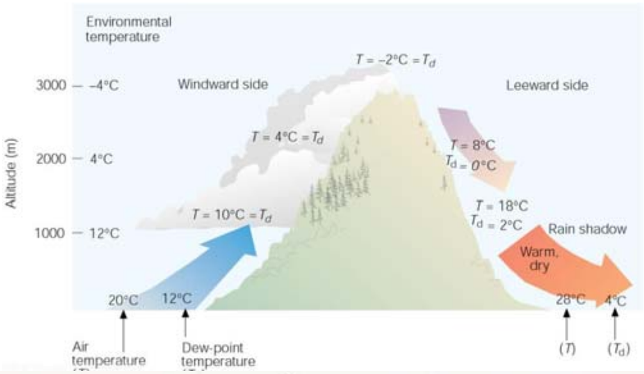
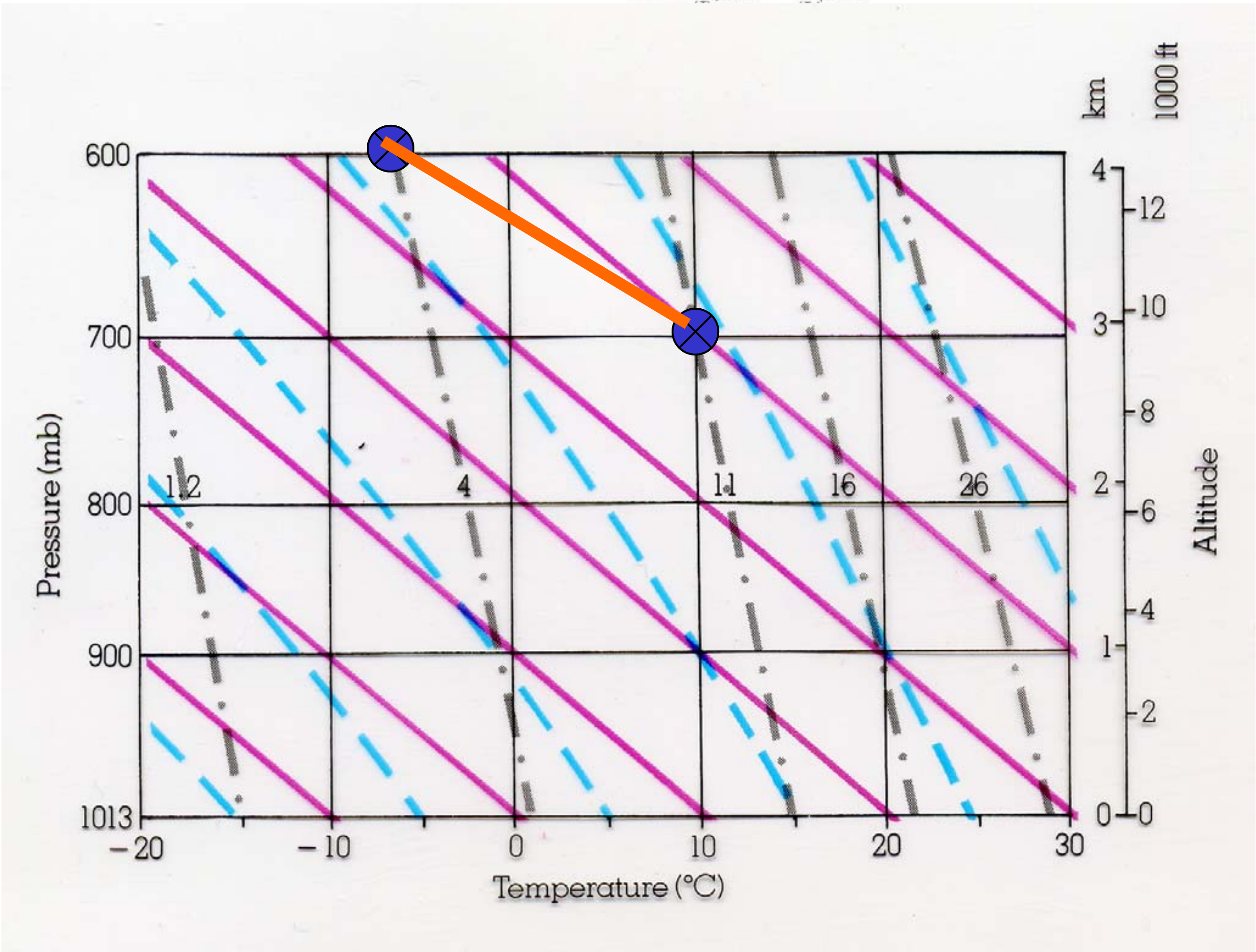
Adiabatic chart – moving a layer



Lifted Layer
Saturated &
Very Unstable



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Cloud Development - Two Unusual Clouds

- Mammatus clouds
- Cap clouds

Cloud Development - Mammatus Clouds

Photo © R. Grotjahn

- 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

Photo © R. Grotjahn

End of lecture 5