Chapter 6 - Cloud Development and Forms

Understanding Weather and Climate
Aguado and Burt

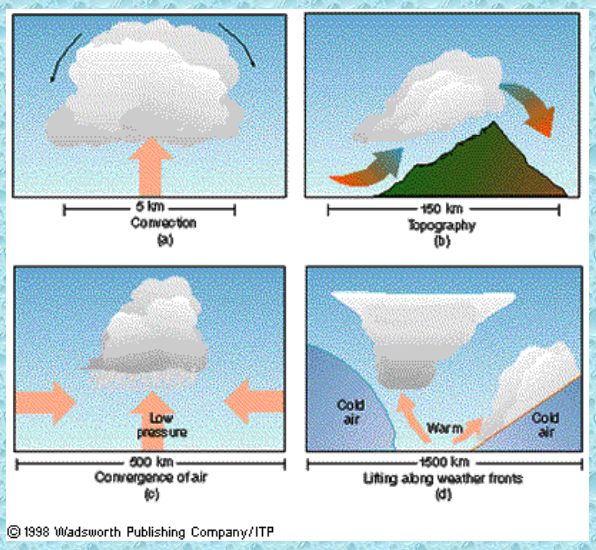
Interesting Cloud



Mechanisms that Lift Air

- Orographic lifting
- Frontal Lifting
- Convergence
- Localized convective lifting

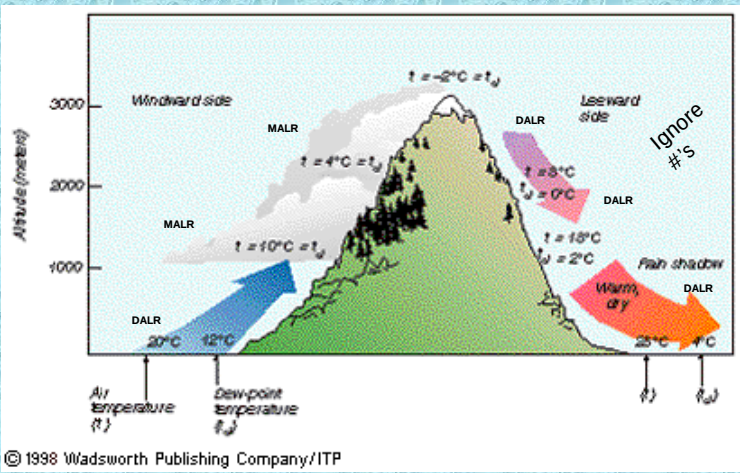
Mechanisms that Lift Air



Orographic Lifting

- Air flowing up a hill/mountain forces adiabatic cooling. This promotes precipitation.
- The opposite occurs downwind of a mountain (leeward side) as air descends and warms by compression. This inhibits precipitation.

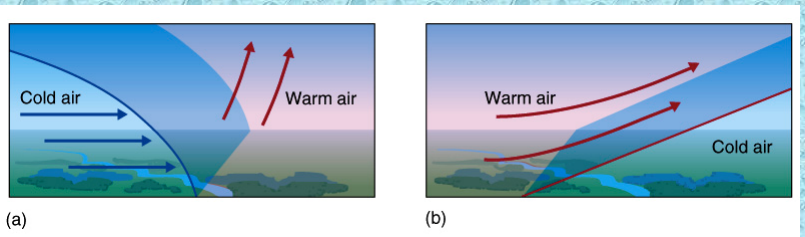
Orographic Lifting



Frontal Lifting

- Front – Transition zone between two different air masses
  - Cold front– cold air advances towards warmer air and displaces the lighter, warmer air upward.
  - Warm front – warm air advances towards cold air, the warm air is forced upward over the cold air.

Cold Front and Warm Front



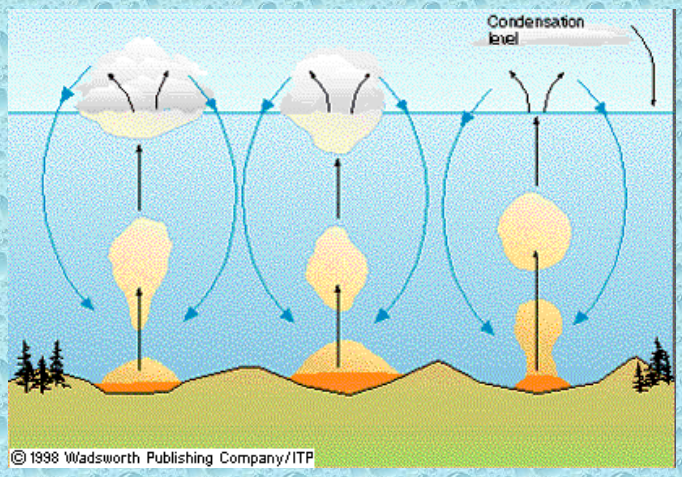
Convergence

- Horizontal movement (advection) towards a common location implies an accumulation of mass called convergence.
- Does not lead to an increase in air density, rather an increase in vertical motions carry the mass away.

Local Convection

- Differential heating of the Earth's surface can produce free convection over limited areas.
- Buoyancy can initiate uplift by itself, but it can also speed or slow the uplift provided by orographic, frontal or convergence lifting.

Local Convection



Local Convection



Static Stability

- Static stability – The air's susceptibility to lift.
  - Unstable – Air will continue to rise if given an initial upwards push
  - Stable – Air resists the upward displacement and sinks back to original level.
  - Neutral – Air will neither rise on its own or sink back to its original level.



Types of Air (Static Stability)

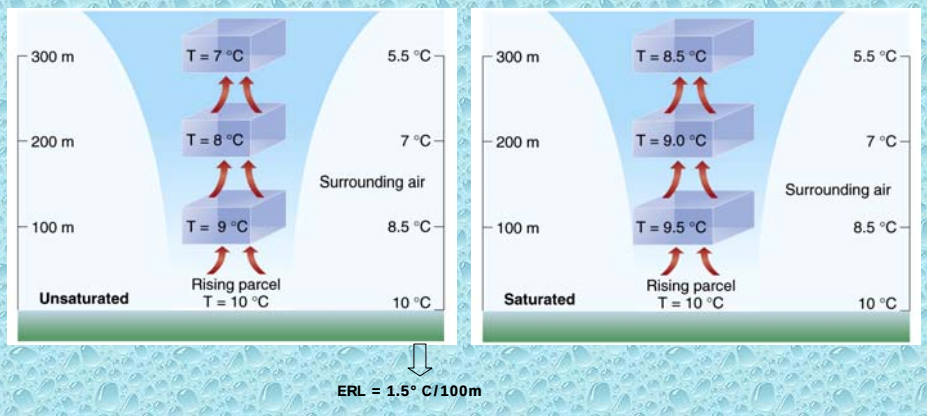
- Absolutely Unstable
- Absolutely Stable
- Conditionally Unstable



Absolutely Unstable Air

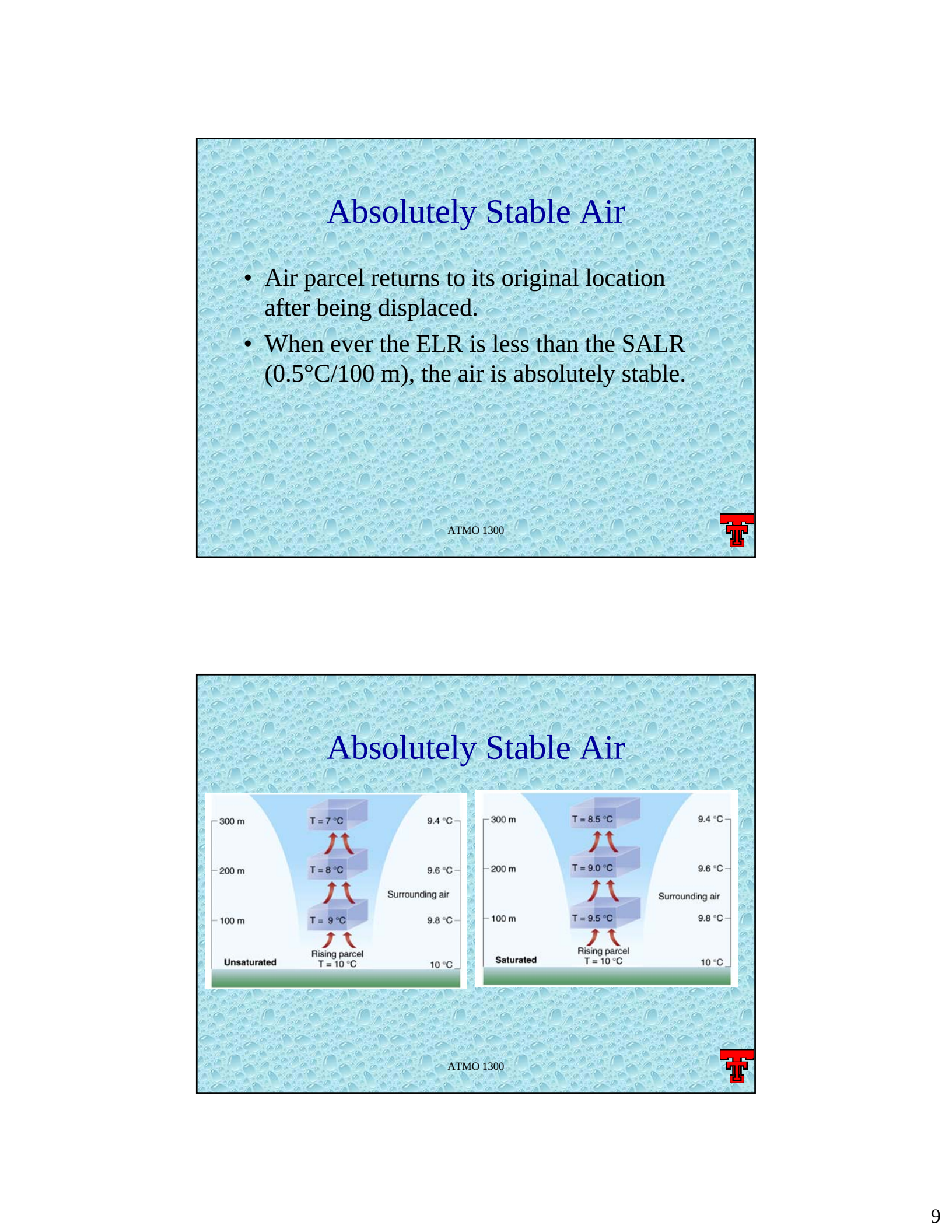
- Once a parcel is lifted it continues to move upward regardless of saturation.
- Whenever the ELR exceeds the DALR (1°C/100 m) the air is absolutely unstable.

Absolutely Unstable Air



Absolutely Stable Air

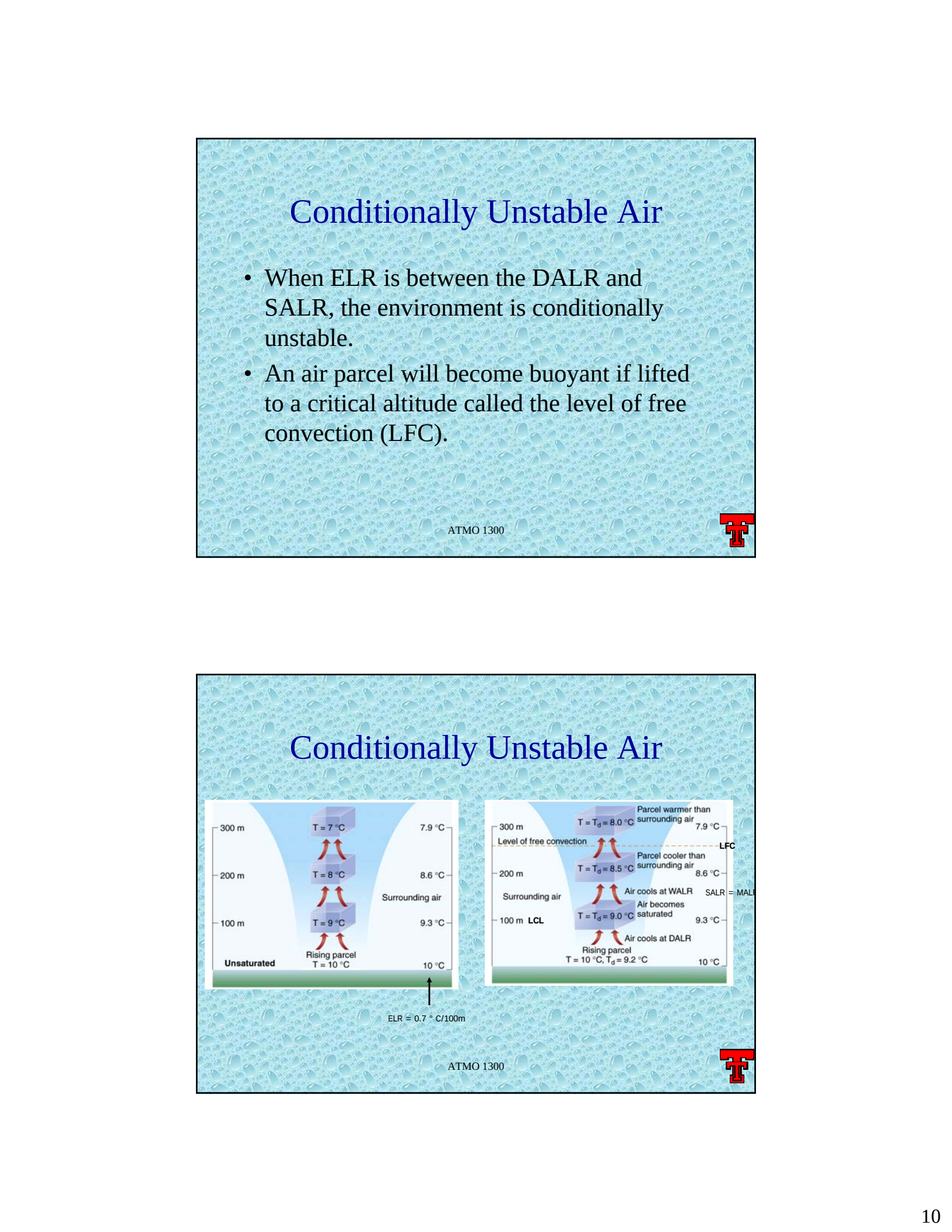
- Air parcel returns to its original location after being displaced.
- When ever the ELR is less than the SALR (0.5°C/100 m), the air is absolutely stable.



Absolutely Stable Air

Conditionally Unstable Air

- When ELR is between the DALR and SALR, the environment is conditionally unstable.
- An air parcel will become buoyant if lifted to a critical altitude called the level of free convection (LFC).



Conditionally Unstable Air

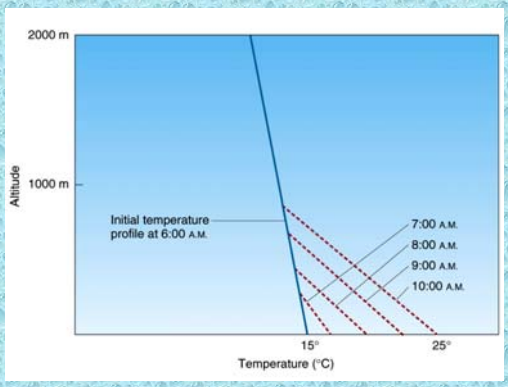
ELR = 0.7 ° C/100m

Changes to the Environmental Lapse Rates

- Changes can occur in 3 ways:
  - Heating or cooling of the lower atmosphere
  - Advection of cold or warm air at different levels
  - Advection of air mass with a different ELR

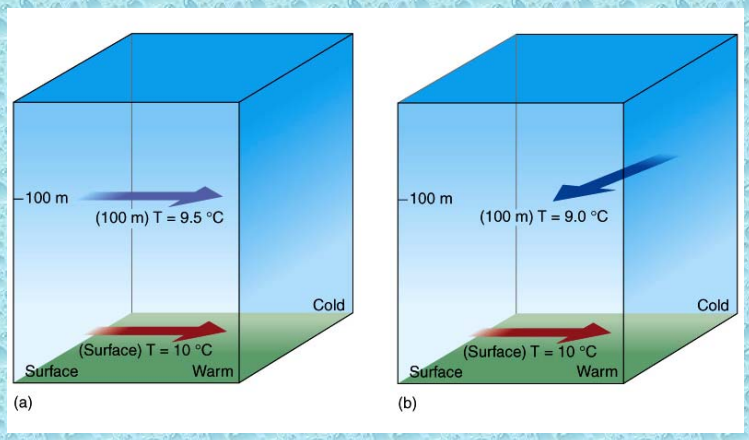
Heating or Cooling of the Lower Atmosphere

- Heating of the Earth's surface occurs rapidly and leads to a steep ELR near the surface.
- The opposite occurs at night as cooling promotes the development of an inversion in the lowest portion of the atmosphere.

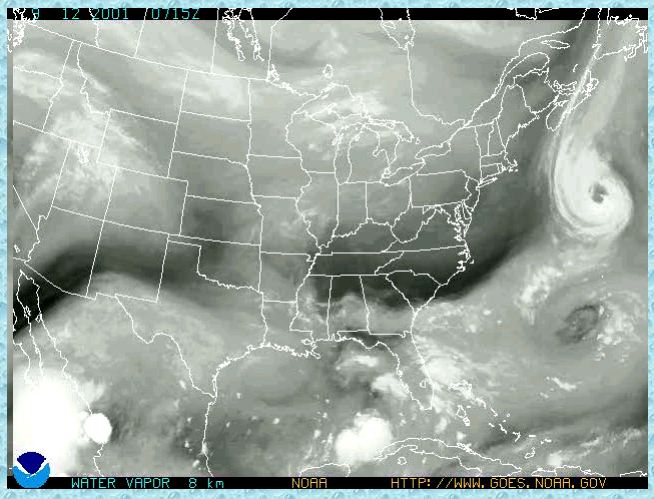




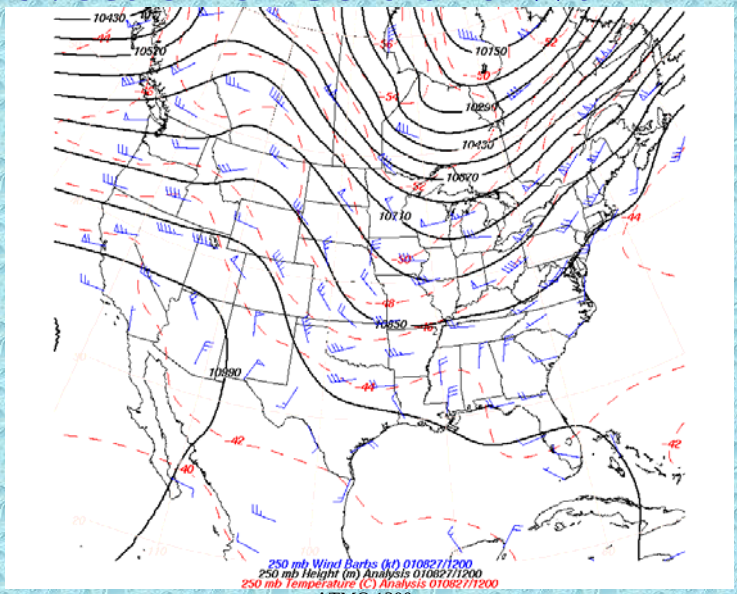
Advection of Cold and Warm Air



Advection of Cold and Warm Air

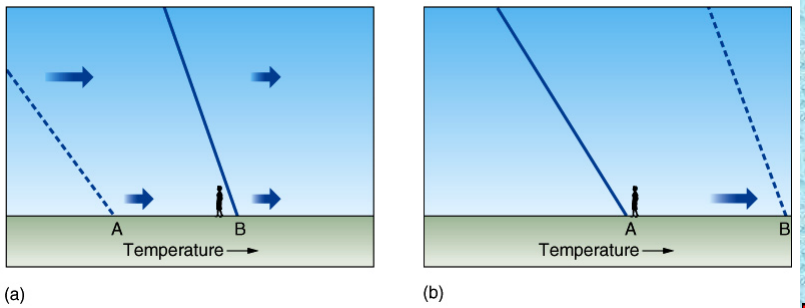


Advection of Cold and Warm Air



Advection of an Air Mass with Different ELR

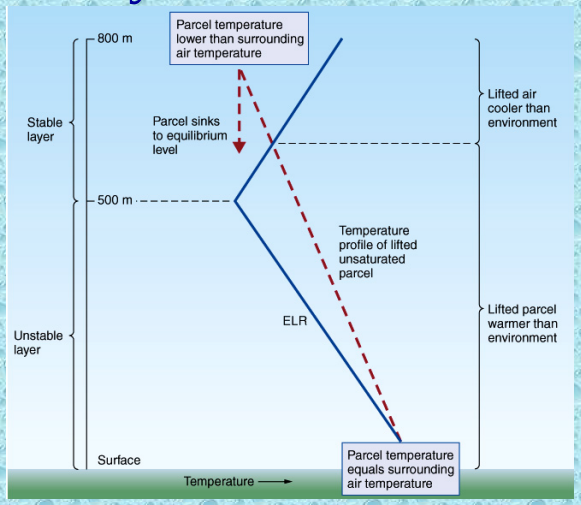
- Air masses maintain their temperature and humidity profiles as they move from one location to another.



Limitations on Lifting

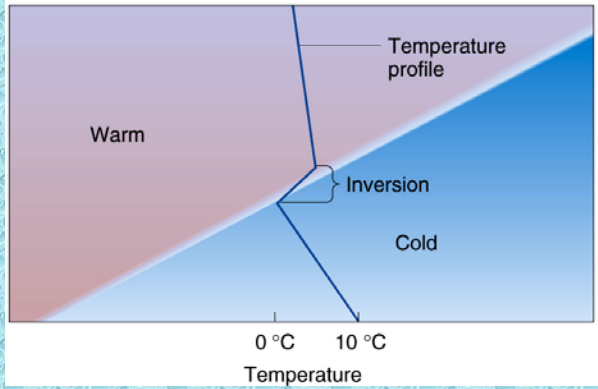
- What causes air to quit rising?
  - Stable air
    - Inversions
  - Entrainment (mixing)

Layer of Stable Air



Inversions

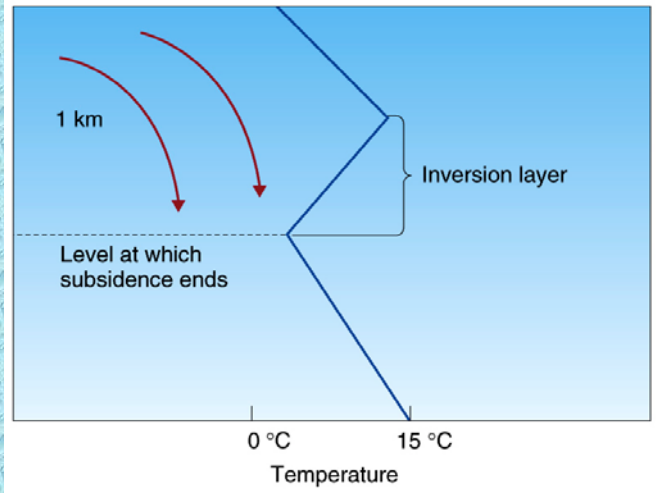
- Inversion – A layer of extremely stable air where temperature increases with height.



Inversions

- Radiation Inversion – Cooling of the surface
- Frontal Inversion – Interface of two air masses
- Subsidence Inversion – Sinking air aloft

Subsidence Inversion



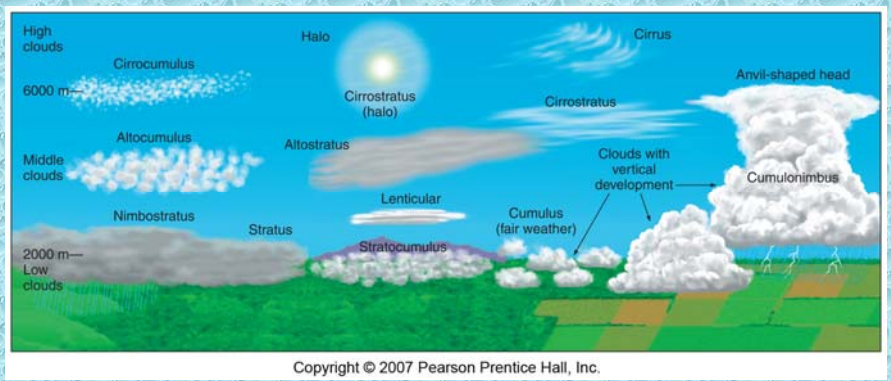
Entrainment

- When air rises considerable turbulence is generated. This entrainment draws in environmental air into the parcel and suppresses further growth.

Cloud Types

- High Clouds – Cirrus, cirrostratus, and cirrocumulus
- Middle Clouds – Altostratus and altocumulus
- Low Clouds – Stratus, stratocumulus, nimbostratus
- Clouds with Vertical Development – Cumulus and cumulonimbus

Cloud Types



High Clouds (cirro)

- Located above 6,000 m (19,000 ft).
- Composed of ice crystals
- Low water content because of low temperatures (-35°C)

Cirrus



Cirrostratus



Cirrocumulus



Fall Streaks



Middle Clouds (alto)

- Located between 2000 - 6,000 m (6,000 - 19,000 ft).
- Composed mainly of liquid droplets

Altostratus



Altocumulus



Low Clouds

- Located below 2000 m (6,000 ft).
- Composed mainly of liquid droplets

Stratus



Clouds with Vertical Development

- Cumuliform Clouds
  - Can have violent updrafts
  - Can have heavy precipitation
  - Can have vast temperature differences

Cumulus Humilis



Cumulus Congestus



Cumulonimbus



Cloud Coverage

- Overcast – Above 90% of the sky is covered with clouds.
- Broken - Between 60 and 90% of the sky is covered.
- Scattered – Between 10 and 60% of the sky is covered.
- Clear – less than 10% of the sky is covered.

