

## Chapter 7, Part 1

### Atmospheric Stability

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### Parcel of Air

- Air inside can freely expand or contract, but heat and air molecules do not cross the boundary.
- **Adiabatic process** = no exchange of heat with the environment.

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### Air Expansion and Contraction

- A rising parcel of air expands because the air pressure falls with elevation.
- This expansion causes the air to cool.
  
- A falling parcel of air contracts because the air pressure increases.
- The contraction causes the air to warm.

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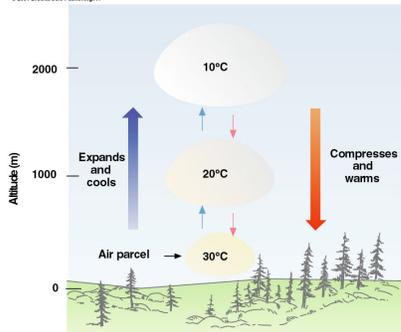
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## Picture of Expansion/Contraction



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## Lapse Rate

- **Lapse rate** = rate at which temperature changes with elevation.
- **Dry adiabatic rate** = rate at which unsaturated (< 100% humidity) air changes temperature with elevation. 10C/1000m
- **Moist adiabatic rate** = rate at which saturated (100% humidity) air changes temperature with elevation. 6C/1000m  
This difference is due to the latent heat as the water condenses or evaporates.

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## Air Stability

- If rising air is cooler than surrounding air, it will be more dense and tend to sink back (**stable**).
- If rising air is warmer than surrounding air, it will be less dense and tend to continue rising (**unstable**).

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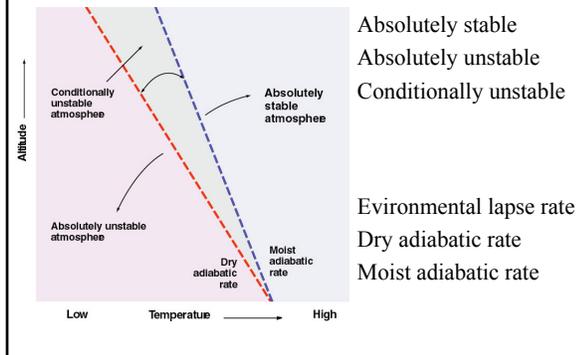
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## Summary of Atmospheric Stability




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## Causes of Stability

- Air aloft warms
  - Replaced by warmer air (advection)
- Surface air cools
  - Radiation cooling
  - Replaced by cooler air (advection)
  - Air moving over a cold surface

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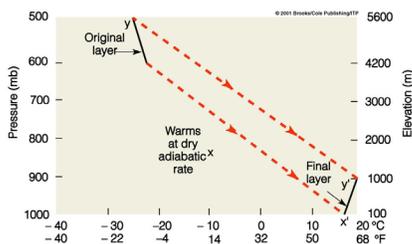
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## Subsidence Inversion



- A layer slowly subsides (falls), compresses, and warms
- The upper part sinks further and hence warms more.

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## Causes of Instability

- Air temperature drops more rapidly with increasing height (lapse rate increases).
- Cooling air aloft
  - Winds bring in colder air (advection)
  - Clouds emit infrared radiation to space
- Warming surface air
  - Daytime solar heating of surface
  - Winds bring in warmer air (advection)
  - Air moving over a warm surface

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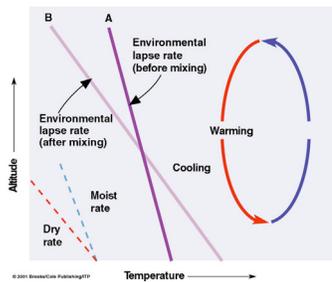
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## Instability by Mixing



- Mixing increases the lapse rate, making the difference between surface air and higher air larger.

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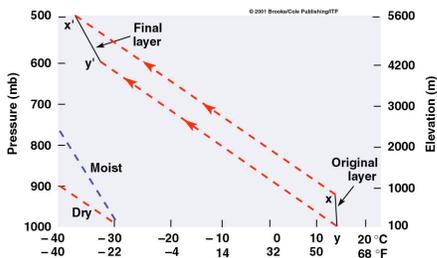
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## Instability by Lifting



- As the air layer rises, it expands and cools.
- The top of the layer expands more and hence cools more.

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## Summary

- The air may be characterized as absolutely unstable, absolutely stable, and conditionally stable
- depending on the environmental lapse rate, the dry adiabatic rate, and the moist adiabatic rate.
- Warming the surface air and cooling the air above tends to make the atmosphere more unstable.

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