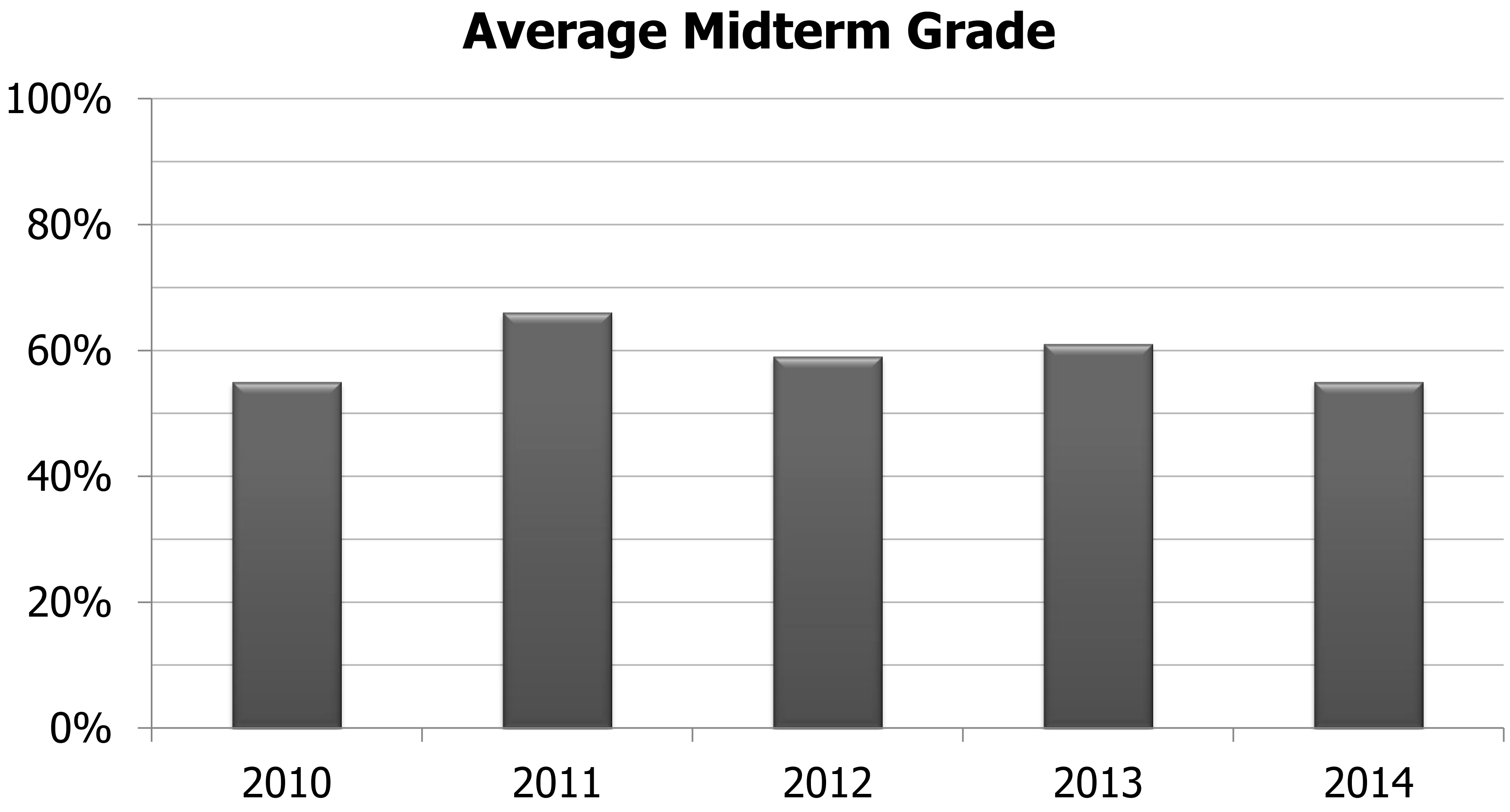
Midterm Review

GEOG/ENST 2331 – Lecture 13
Ahrens et al., Chapters 1-8
Labs 1-3

Midterm

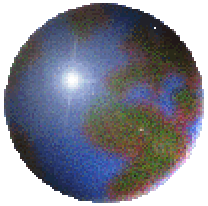
- Wednesday:
  - 30 multiple choice, three short answer
  - Bring a pencil for Scantron cards
  - Bring a non-programmable calculator
  - If equations are necessary they will be provided
- Lab quiz next week
  - See manual

Warning


Average Midterm Grade
100%
80%
60%
40%
20%
0%
2010
2011
2012
2013
2014

Subject Review

- **The Atmosphere** (Chapter 1)
- **Solar Radiation** (Chapter 2)
- **Energy Balance and Temperature** (Chapter 3)
- **Atmospheric Pressure and Wind** (Chapter 8)
- **Atmospheric Moisture** (Chapter 4)
- **Cloud Development** (Chapters 5 and 6)
- **Precipitation** (Chapter 7)

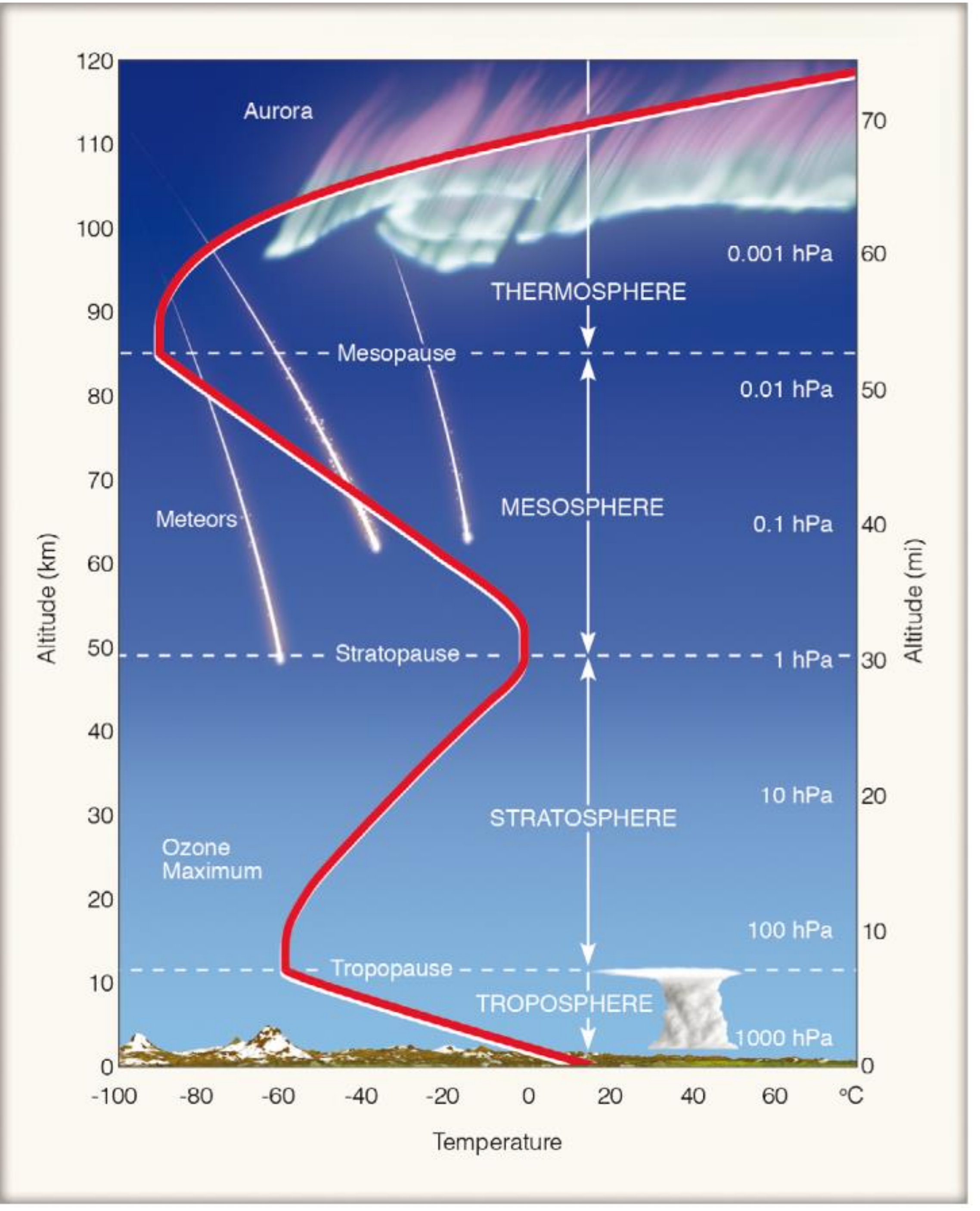


The Atmosphere

Structure and Composition

Chapter 1

Thermal Layers of the Atmosphere



Ahrens: Fig. 1.11

Gases

- ‘Permanent’ Gases
  - Reservoir much larger than flux
  - Concentration stable over time
  - N_2, O_2, Ar

- ‘Variable’ Gases
  - Reservoir similar to or smaller than flux
  - Concentration can readily change
  - H_2O, CO_2, O_3

State variables

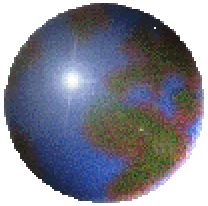
- Density
  - kg/m^3
- Temperature
  - °C or K
- Pressure
  - mb or hPa
  - Atmosphere: 1013.5 mb = 1013.25 hPa

Example

1) In a gas, which of the following will increase given an increase in pressure:

a) Mass
b) Density
c) Volume
d) None of the above

$$\rho = \frac{P}{TC}$$



Solar Radiation

Energy and Radiation

Chapter 2

Radiation Laws

- Stefan-Boltzmann Law
  - $I = \varepsilon \sigma T^4$
- Wien's Law
  - $\lambda_m = 2897 / T$
- Kirchhoff's Law
  - $\varepsilon_\lambda = a_\lambda$

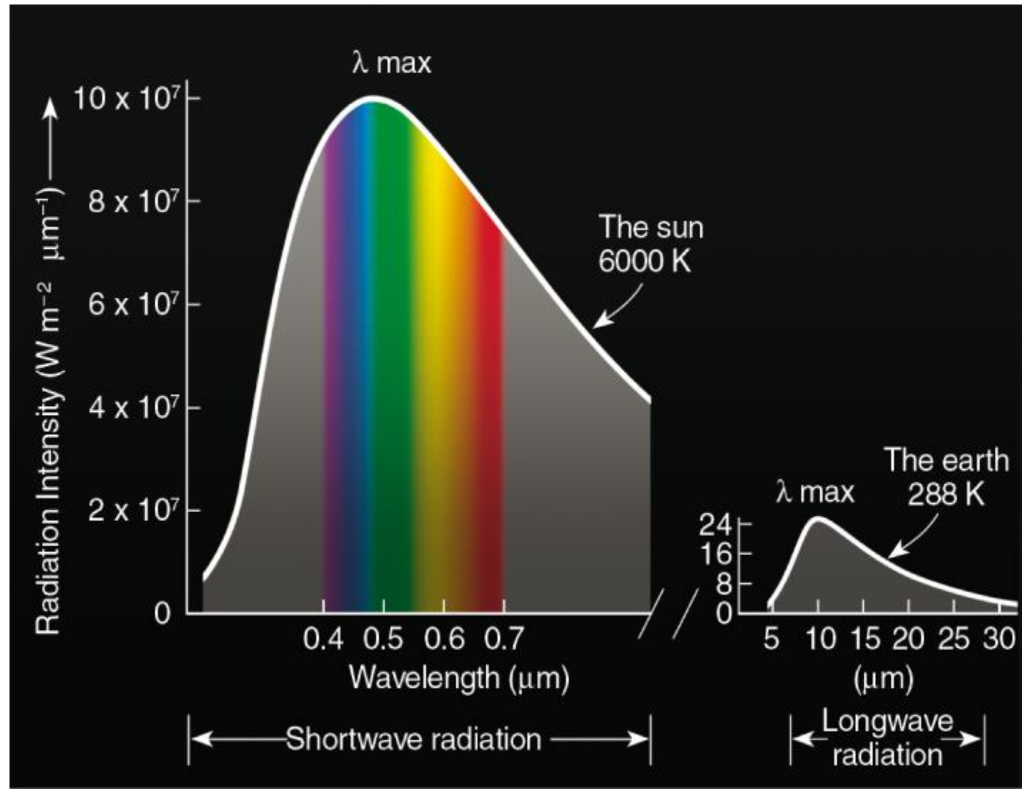
Wavelength of radiation (Wien)

Sun

$$\lambda_m = \frac{2897}{6000} \approx 0.50\ \mu m$$

Earth

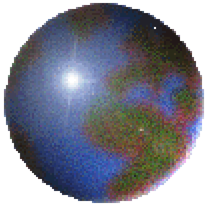
$$\lambda_m = \frac{2897}{288} \approx 10\ \mu m$$



Ahrens, Fig. 2.9

Example

2. The Stefan-Boltzmann Law:
   a) Demonstrates that all objects emit radiation
   b) Demonstrates that hotter object tend to radiate at shorter wavelengths
   c) Only applies to blackbodies
   d) All of the above

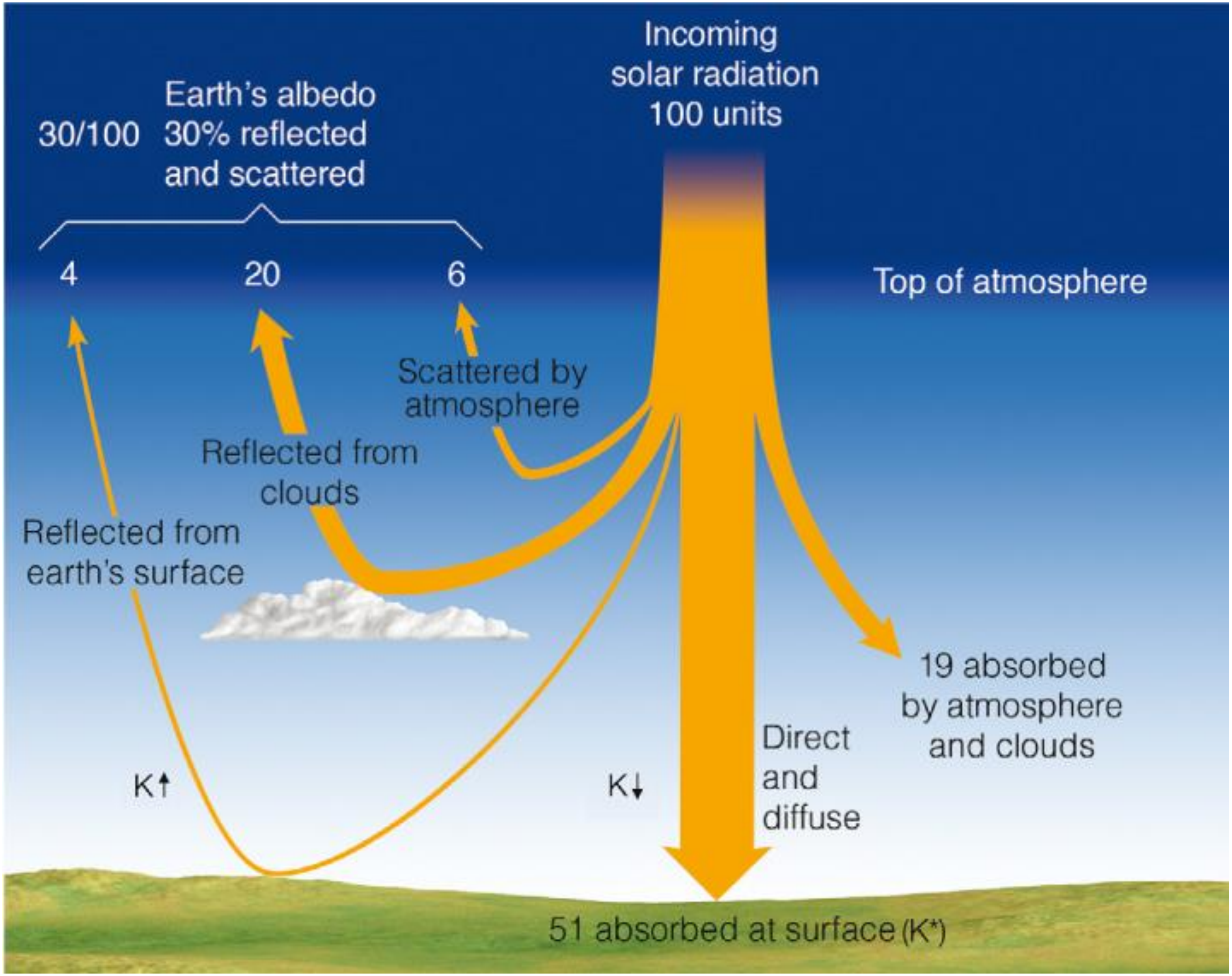


Energy Balance and Temperature

Energy Transfer Processes Between the Surface and Atmosphere

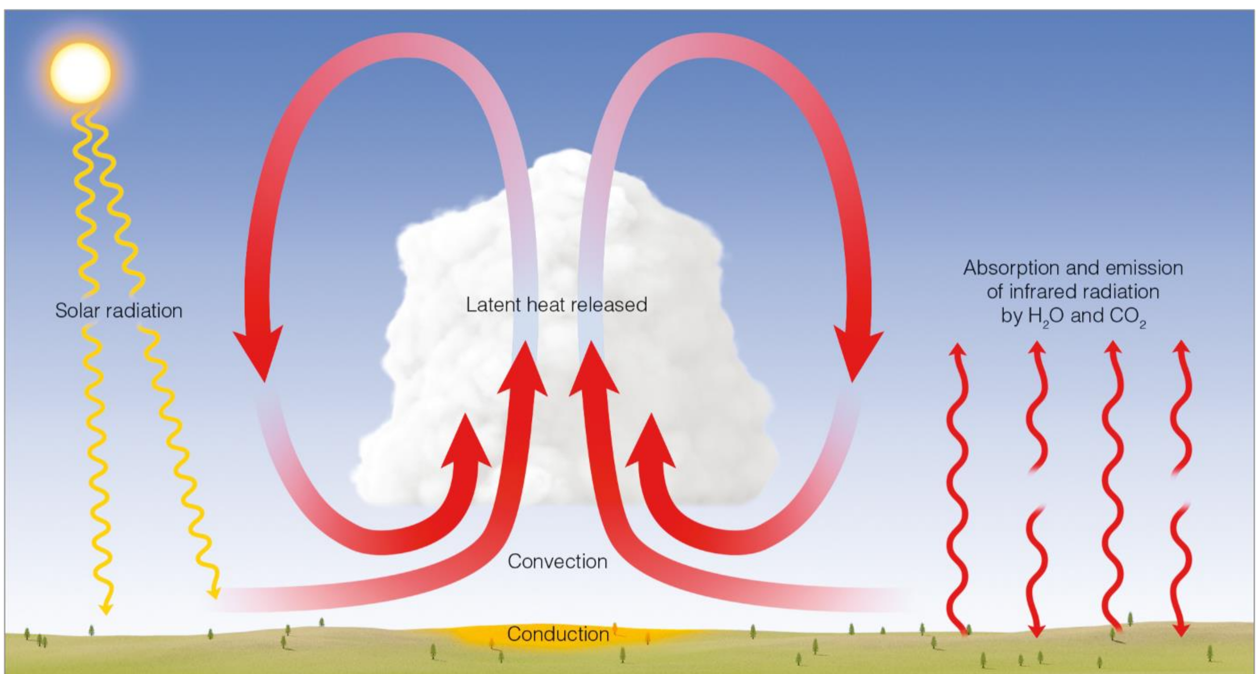
Chapter 3

Insolation (incoming shortwave radiation)



Convection

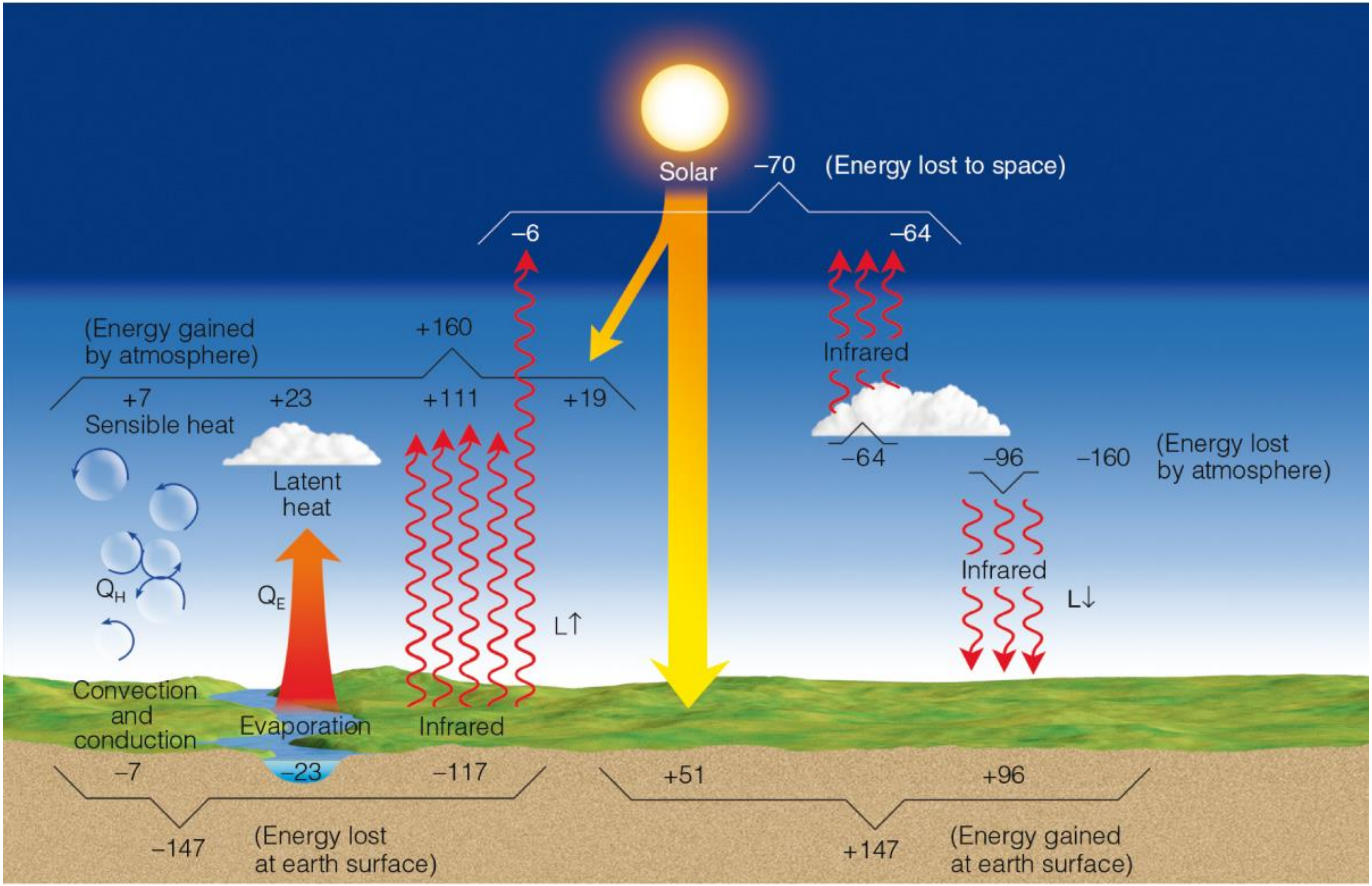
- Conduction: direct heat exchange
  - Warm air becomes less dense
- Convection:
  - Rising air carries heat away from the surface

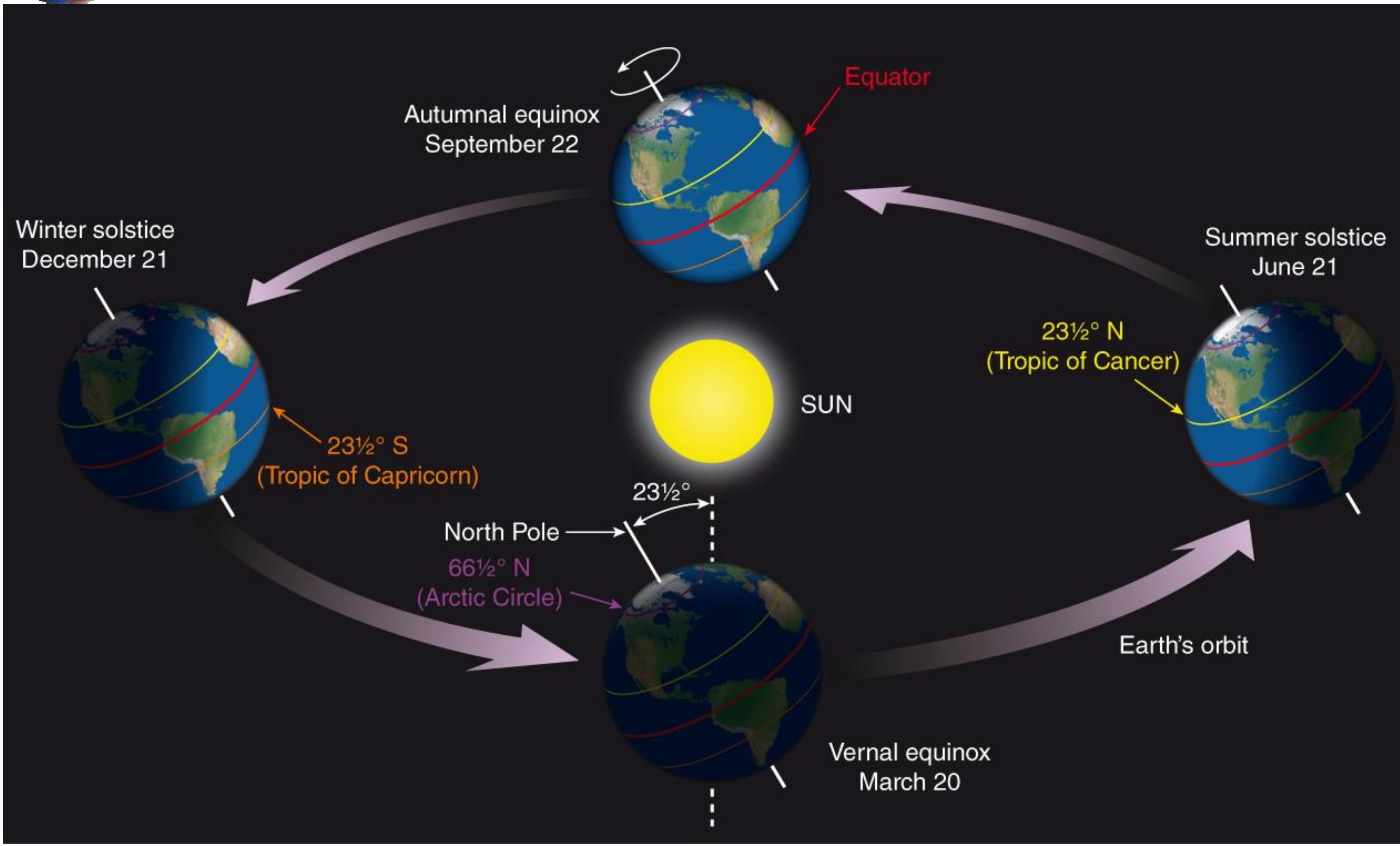


Latent heat

- Liquid to gas
  - Absorbs sensible heat at surface
- Gas to liquid
  - Releases sensible heat in the atmosphere

Energy Balance





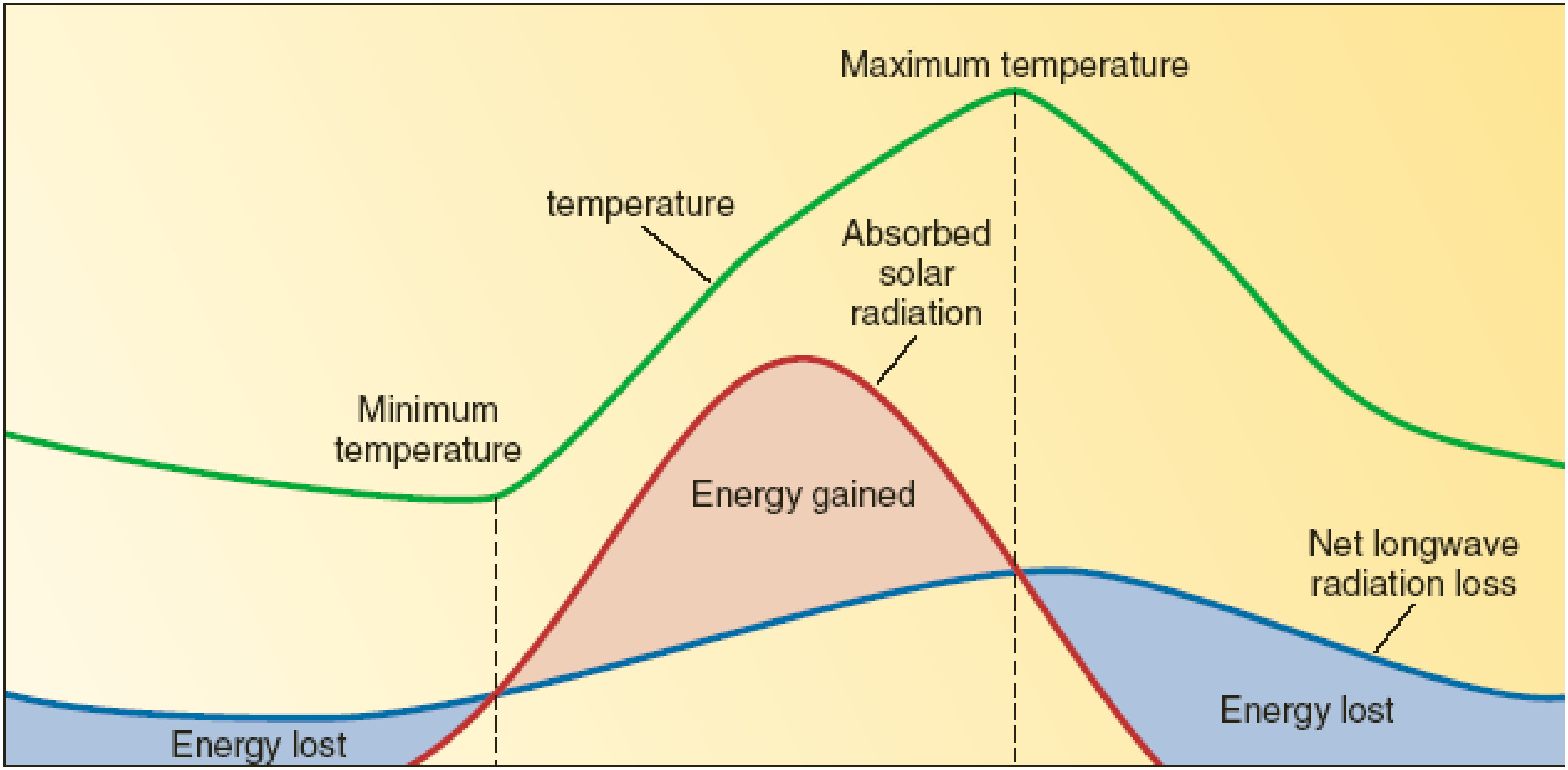
Ahrens: Fig. 3.3

Example

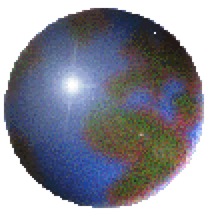
3) The reason that the daily maximum temperature is **after** the maximum solar heating is because:

a) The Sun has more energy when shining from the west.
b) The atmosphere is "thinner" in the afternoon.
c) Temperature continues to rise until outgoing energy equals incoming energy.
d) There is no relationship between the maximum amount of sunshine and the time of maximum daily temperature.

Diurnal heat budget



A&B: Figure 3-23

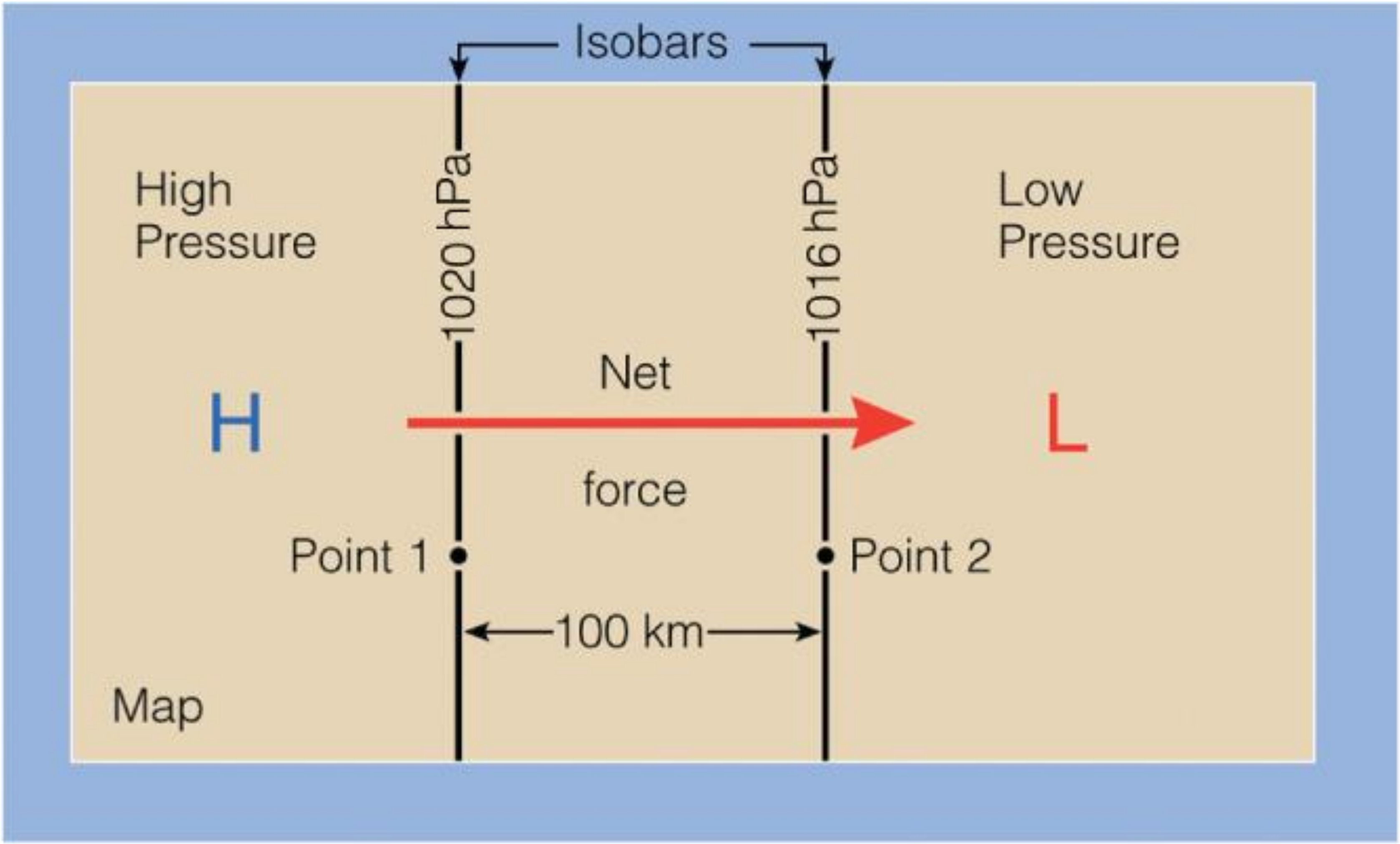


Atmospheric Pressure and Wind

Vertical and Horizontal Changes in Pressure

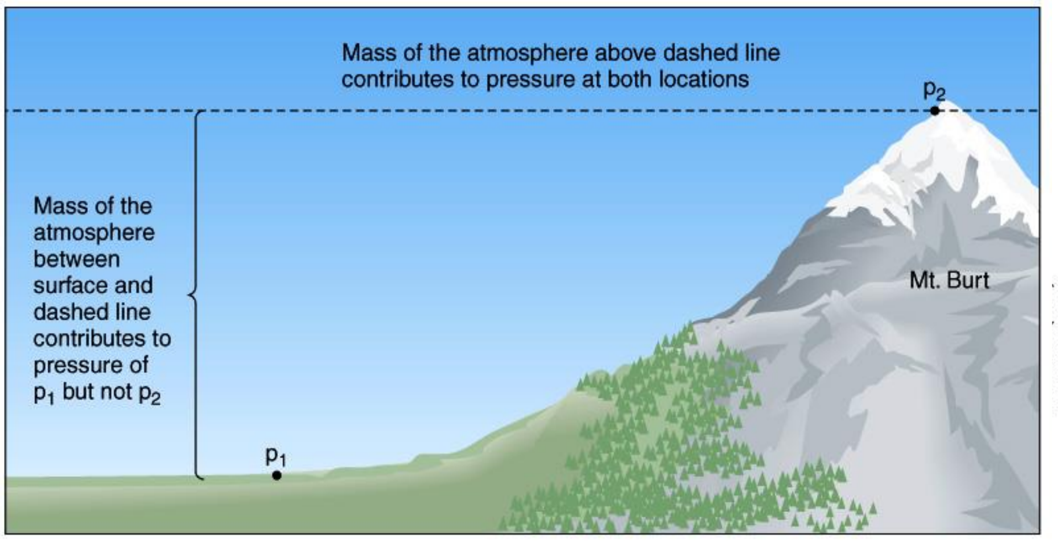
Chapter 8

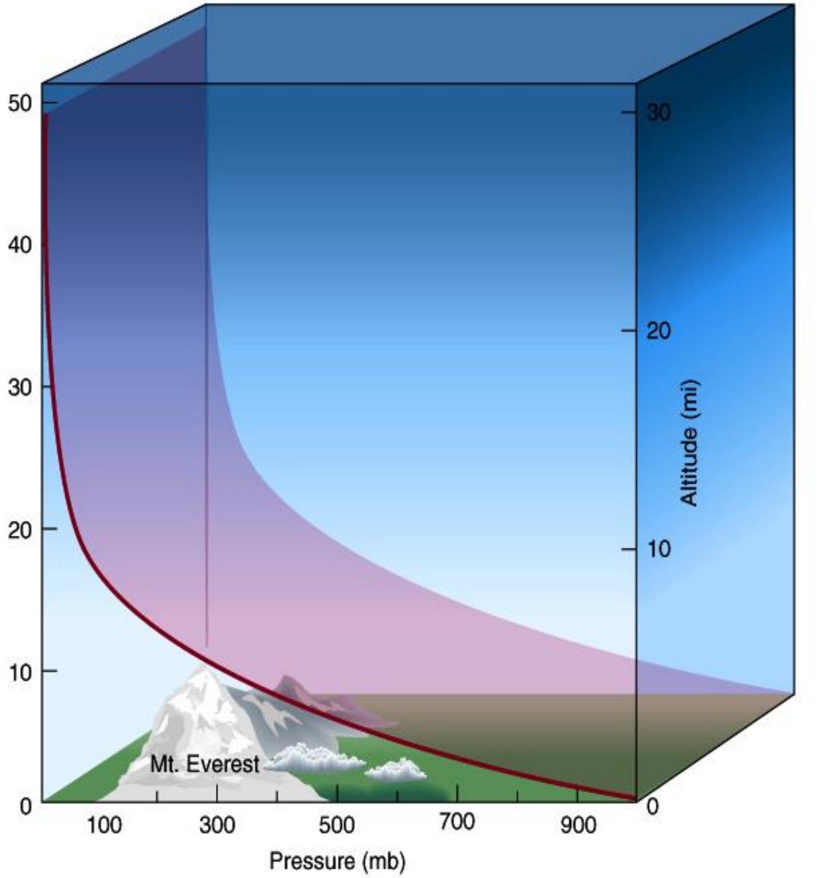
Pressure gradient force



Vertical Changes in Pressure

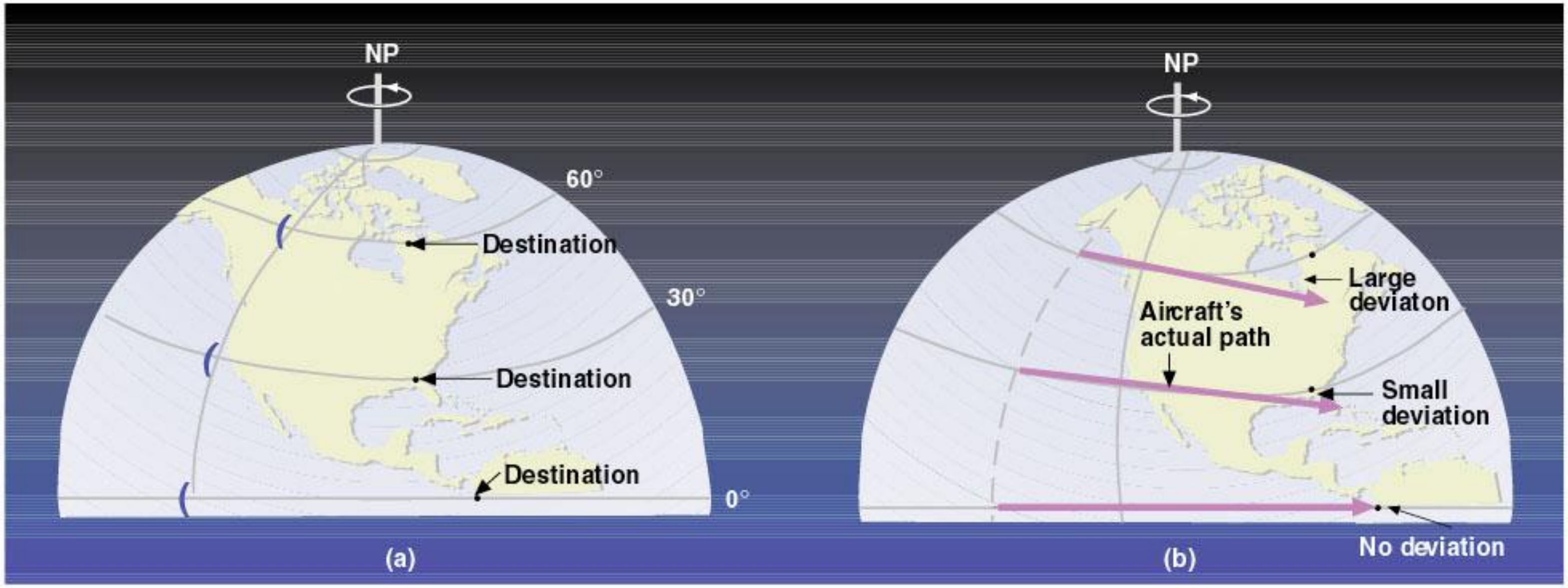
- Pressure decreases with height
- Exponential: roughly 50% every 5.5 km

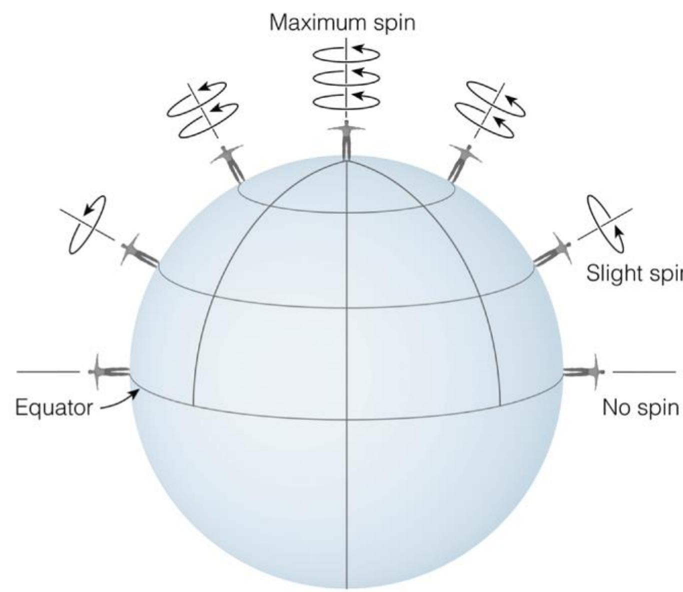




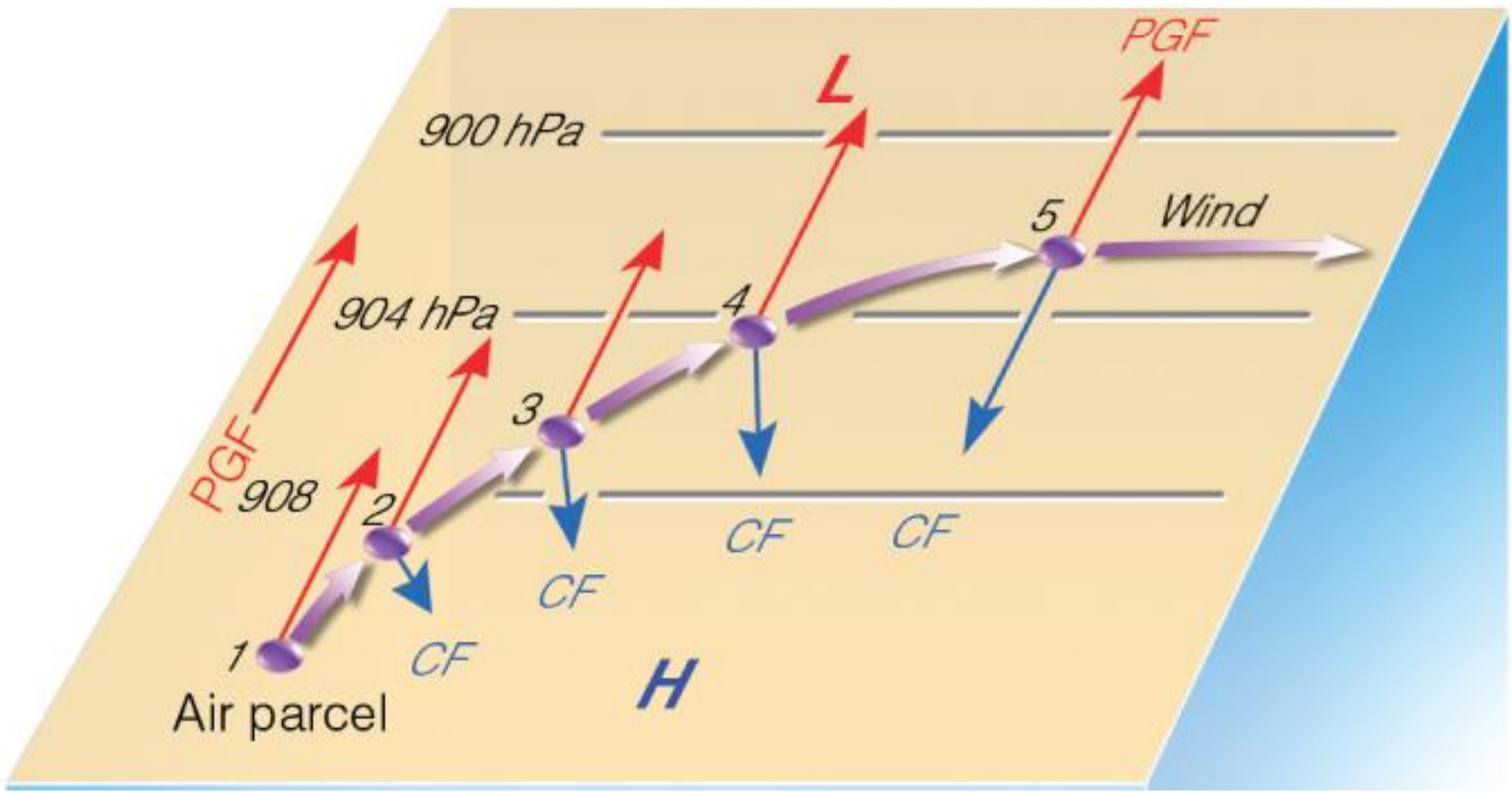
A&B: Figures 4-2 and 4-3

Coriolis 'force'





Geostrophic Wind

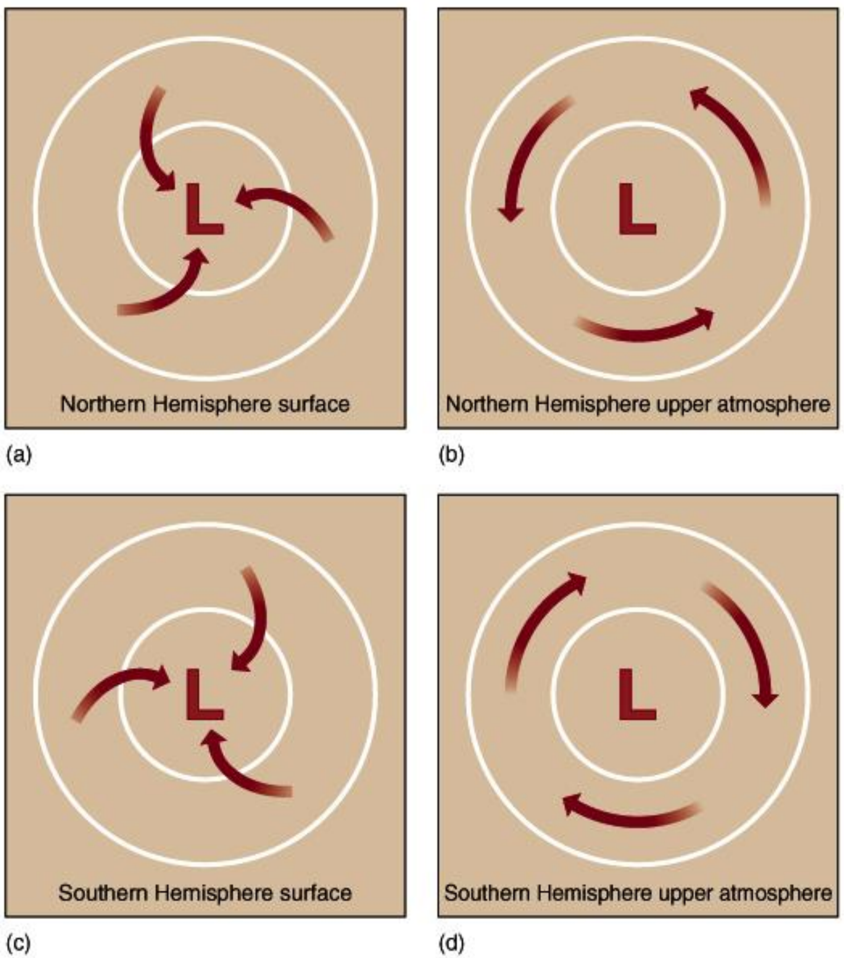


Example

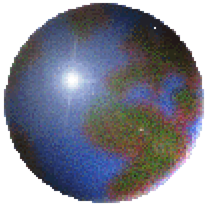
4. In the Northern Hemisphere, a surface low pressure system:

   a) has clockwise flow in at the surface.
   b) has clockwise flow out at the surface.
   c) has counterclockwise flow in at the surface.
   d) has counterclockwise flow out at the surface.

Cyclonic motion



- Counterclockwise in NH
- Clockwise in SH
- Convergence of winds at the surface
- A&B: Figure 4-17



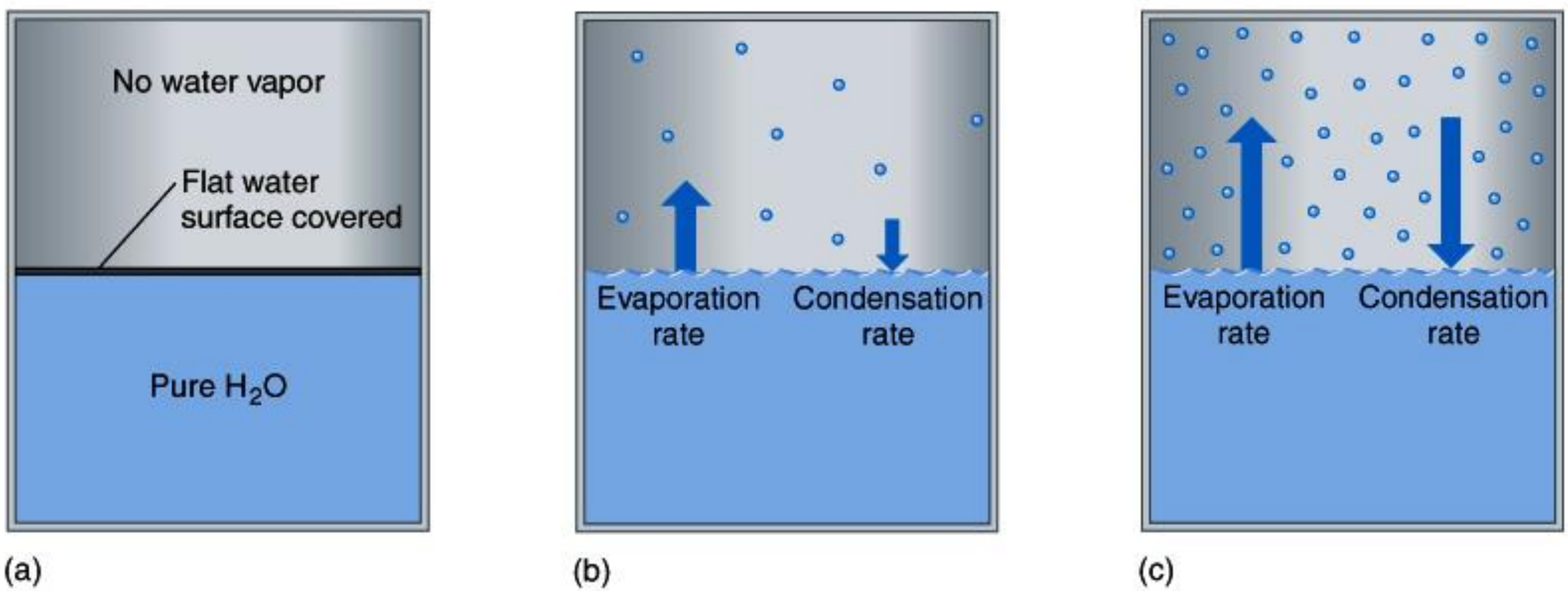
Atmospheric Moisture

Evaporation and Condensation

Chapter 4

Saturation and equilibrium

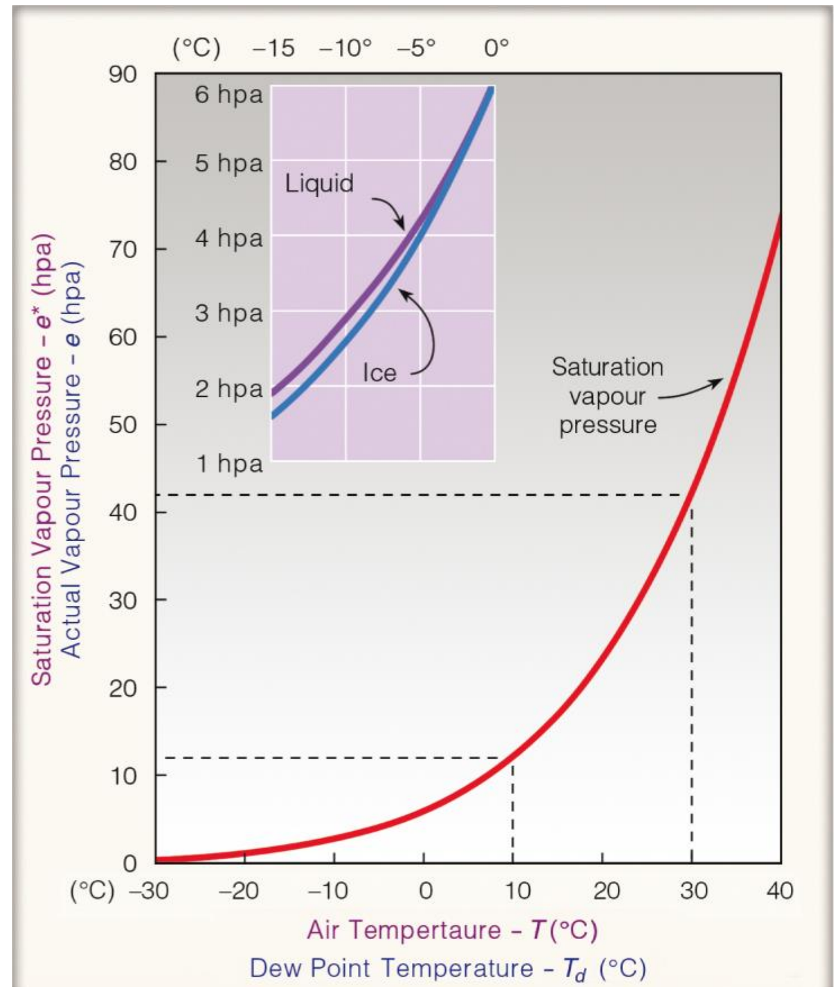
- Water exposed to a gas (or vacuum) will evaporate into it
- Water vapour will bond together and condense
- *Saturation* is the point at which the evaporation and condensation rates are equal



A&B: Figure 5-2

Indices of Water Vapor Content

- Absolute Humidity
- Specific Humidity
  - Saturation specific humidity
- Vapour Pressure
  - Saturation vapour pressure
- Relative Humidity
- Dew Point



Example

5. Of the following, which is *not* affected by a change in temperature?

   a) specific humidity.
   b) relative humidity.
   c) saturation specific humidity.
   d) saturation vapour pressure

Cloud Development

Mechanisms that Lift Air

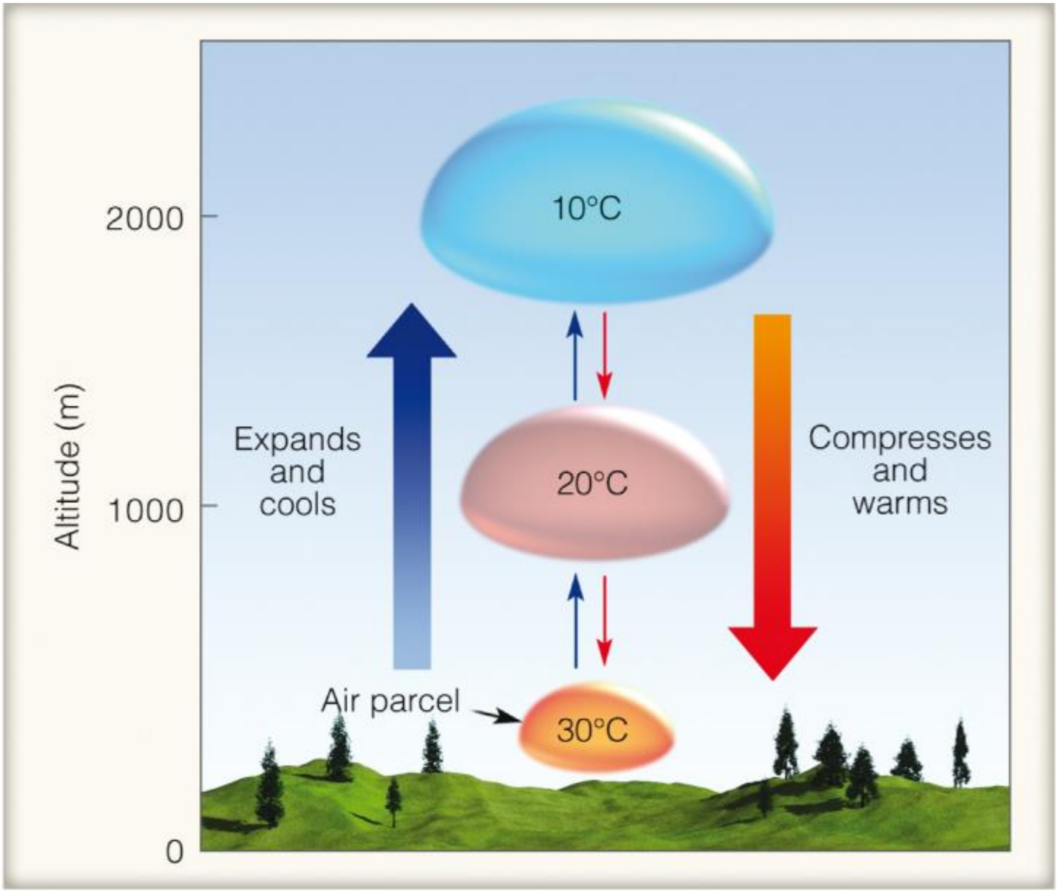
Stability and the Environmental Lapse Rate

Factors Influencing the Environmental Lapse Rate

Limitations on the Lifting of Unstable Air

Cloud Nomenclature

Chapters 5 and 6



Dry Adiabatic Lapse Rate (DALR)

Air warms or cools at 1°C / 100 m

Ahrens: Active Fig. 6.2

Example

6. Once a parcel of air rises above the lifting condensation level, **the rate of cooling slows** because:

a) latent heat is released when water vapor condenses.
b) the air surrounding the parcel is cooler.
c) the parcel of air continues to cool at the dry adiabatic lapse rate.
d) water droplets absorb visible light much better than water vapor does.

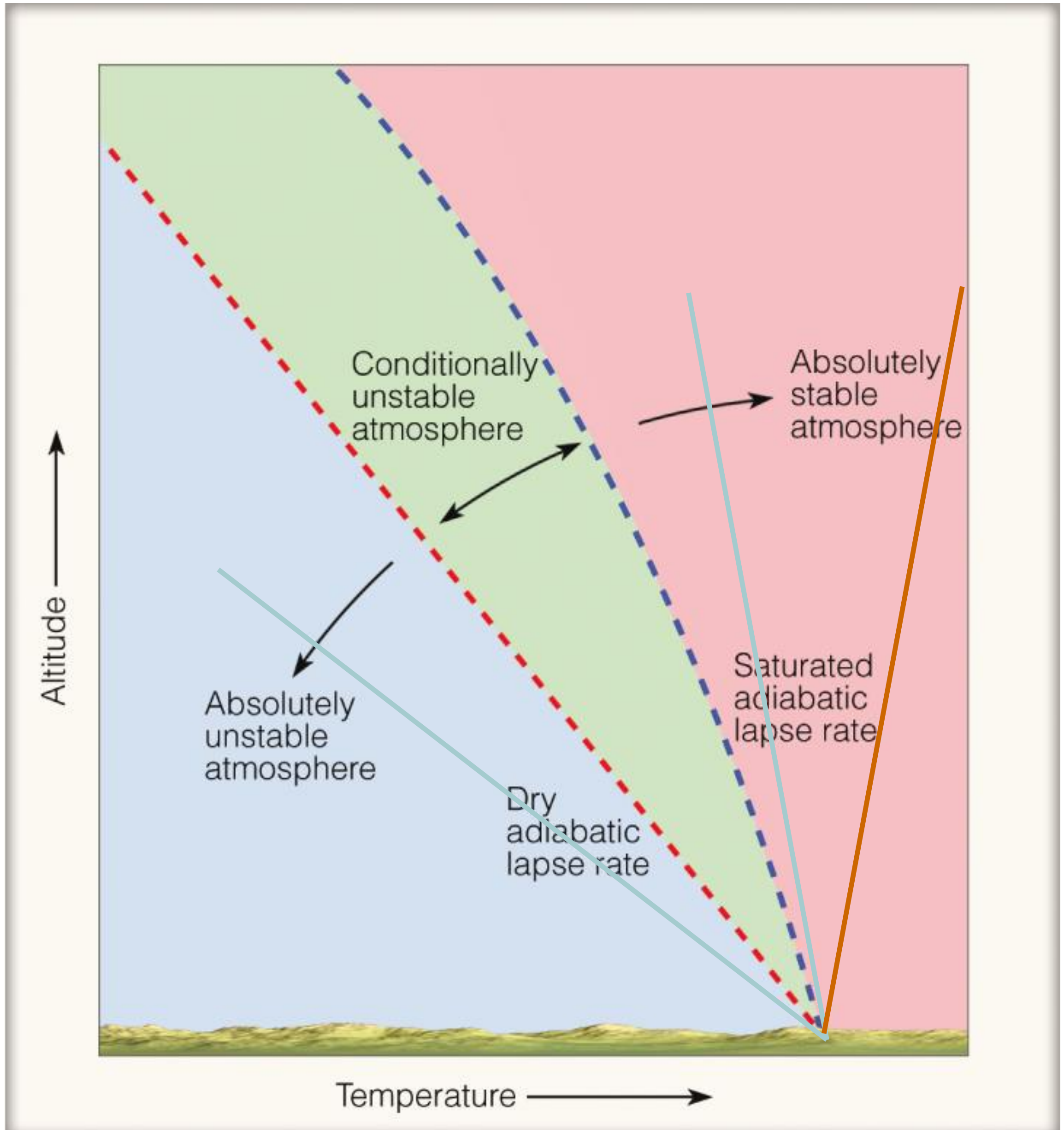
Stability categories

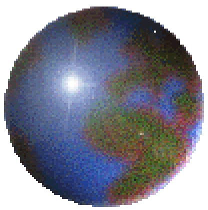
Absolute stability

Absolute instability

Conditional instability

Neutral stability





Precipitation

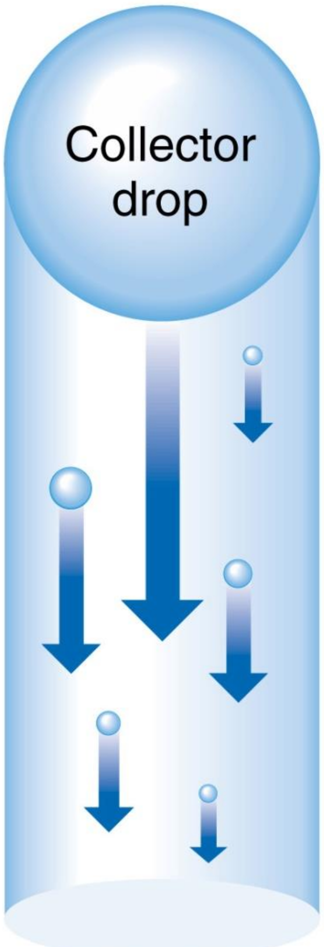
- Collision-coalescence
- Bergeron process
- Ice pellets and freezing rain
- Hail

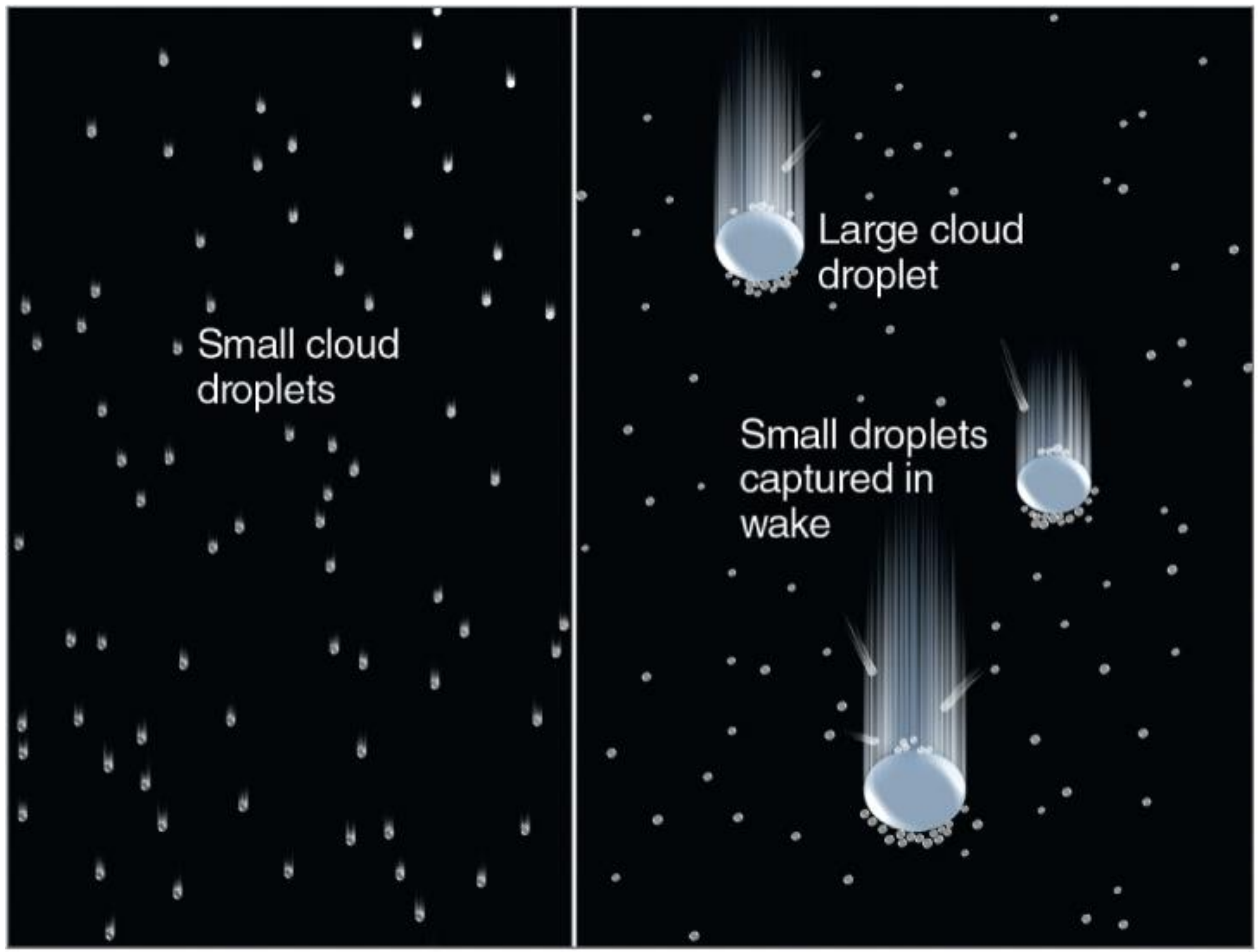
Cloud condensation nuclei

- Aerosols particles that water can condense around
  - *Hygroscopic* material aids droplet formation
  - Solution effect reduces rate of evaporation
- If no CCN are available:
  - RH can exceed 100% - *supersaturation*
  - Liquid molecules evaporate again before they can collect together and form droplets

Collision-coalescence

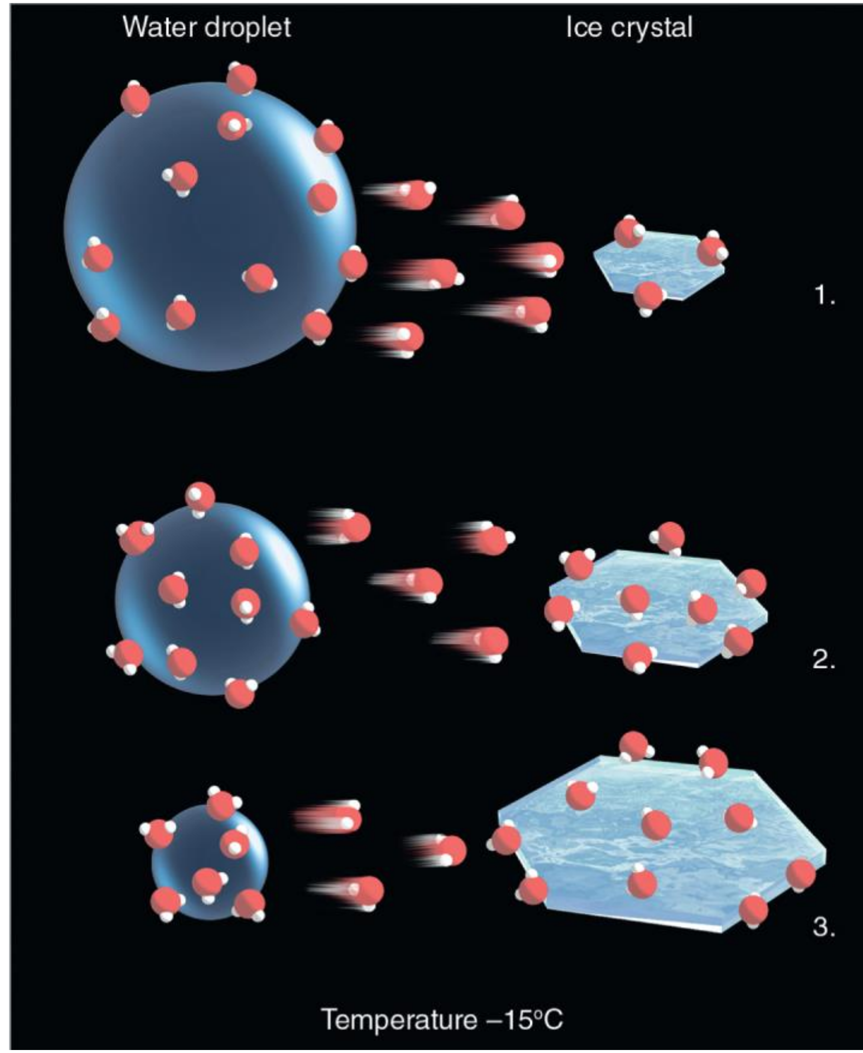
Ahrens: Fig. 7.5





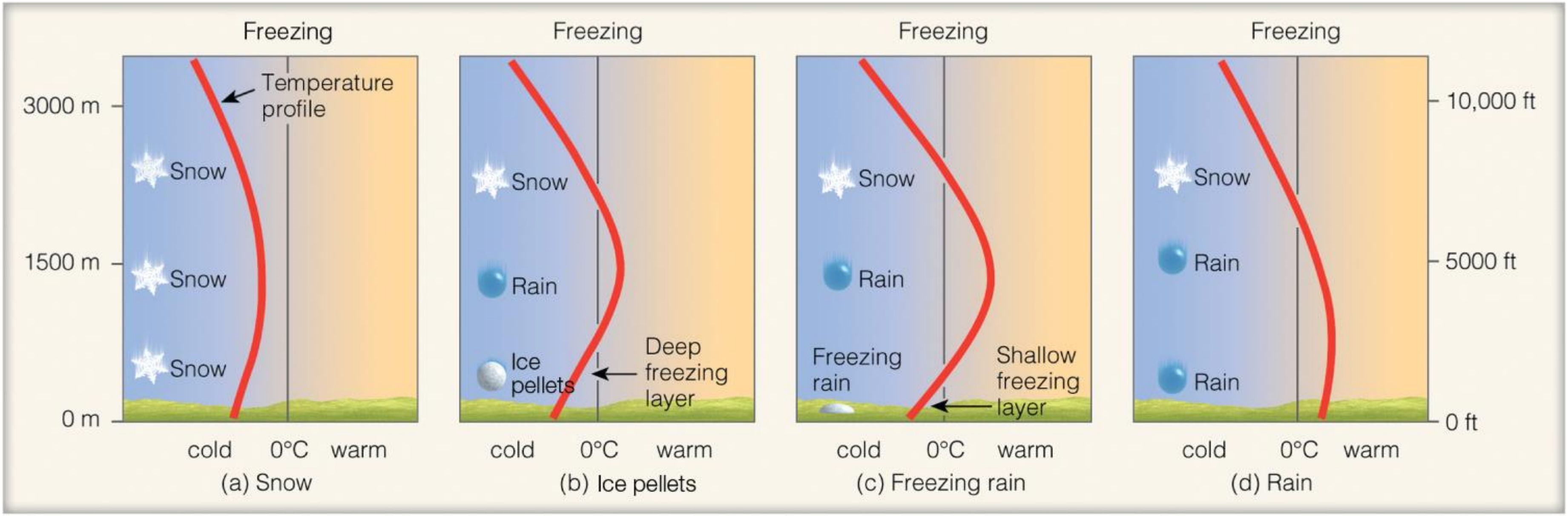
Bergeron process for ice crystals

- Ice has a lower saturation vapour pressure than water
- Net evaporation from water
- Net deposition to ice
- Ice crystals grow while supercooled water droplets shrink



Ahrens: Fig. 7.10

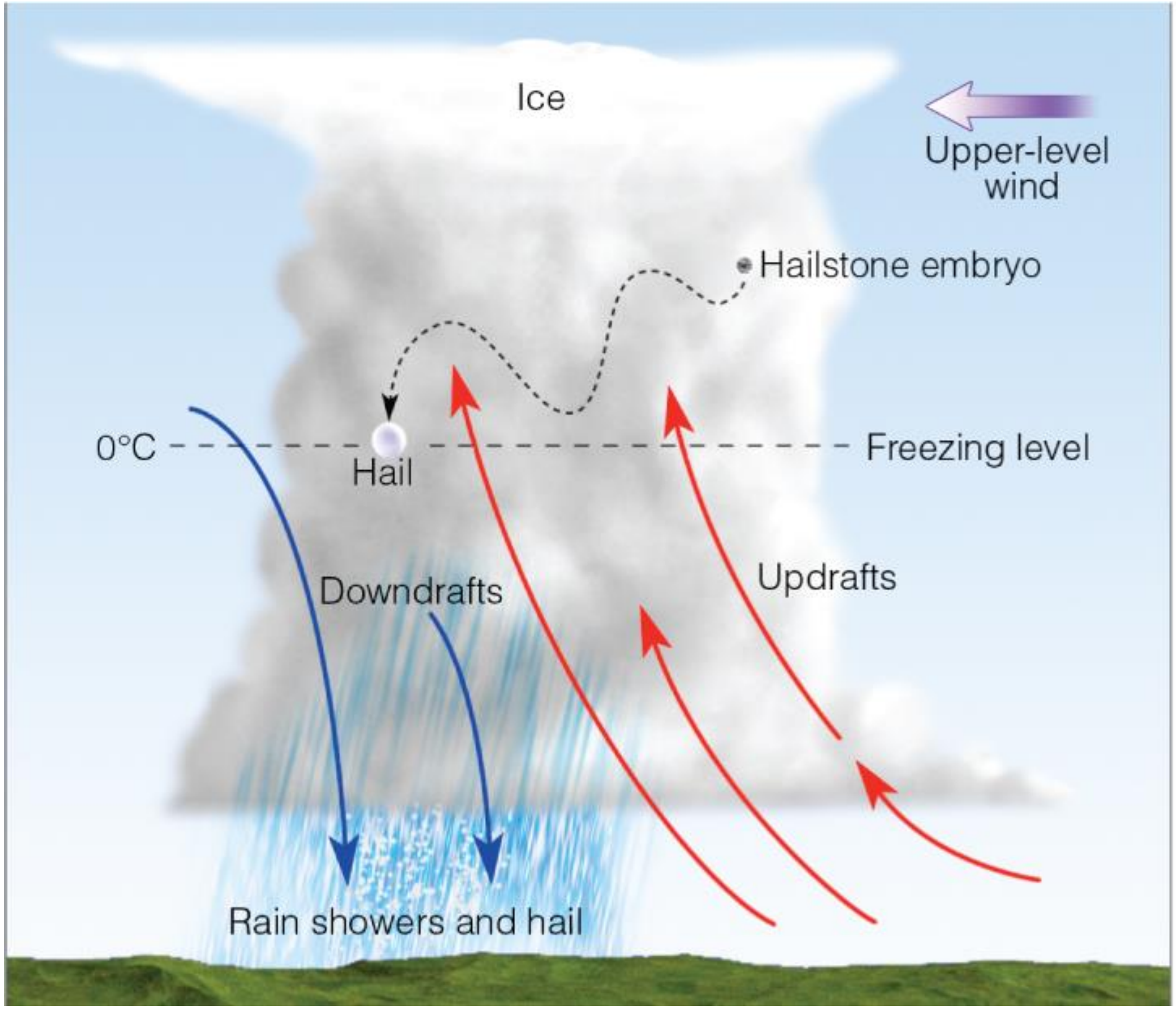
Temperature and precipitation



Ahrens: Fig. 7.23

- Precipitation often starts as snow
  - Melts as it falls into warmer air
  - In an inversion, it may melt and re-freeze

Hail



Ahrens: Active Fig. 7.28

Example

6) Which of the following statements best describes the curvature effect?

a) small droplets evaporate more quickly than large droplets.
b) small droplets collide and coalesce more easily than larger droplets.
c) small ice crystals have a six-sided shape.
d) large cloud droplets fall faster than small droplets.

Midterm

- Wednesday:
  - 30 multiple choice, three short answer
  - Bring a pencil for Scantron cards
  - Bring a non-programmable calculator
  - If equations are necessary they will be provided
- Lab quiz next week
  - See Lab 5 in manual