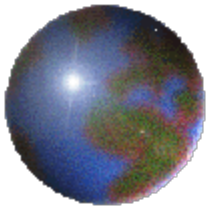
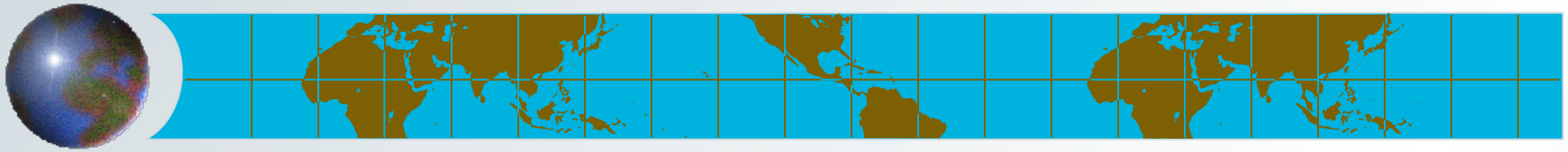


Seasons: Temperature and Time

GEOG/ENST 2331 – Lecture 5

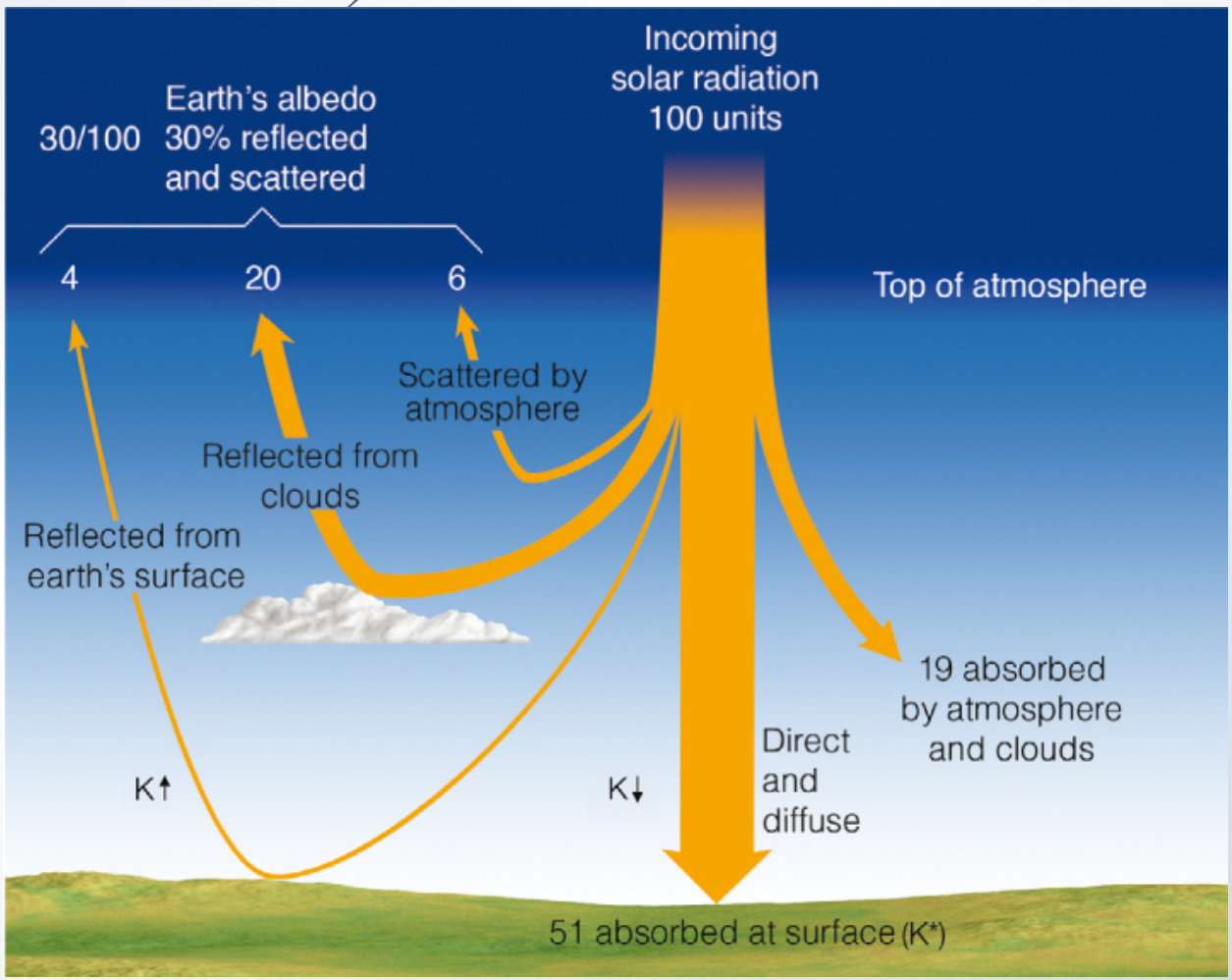
Ahrens: Chapters 2 and 3



Energy Balance and Temperature

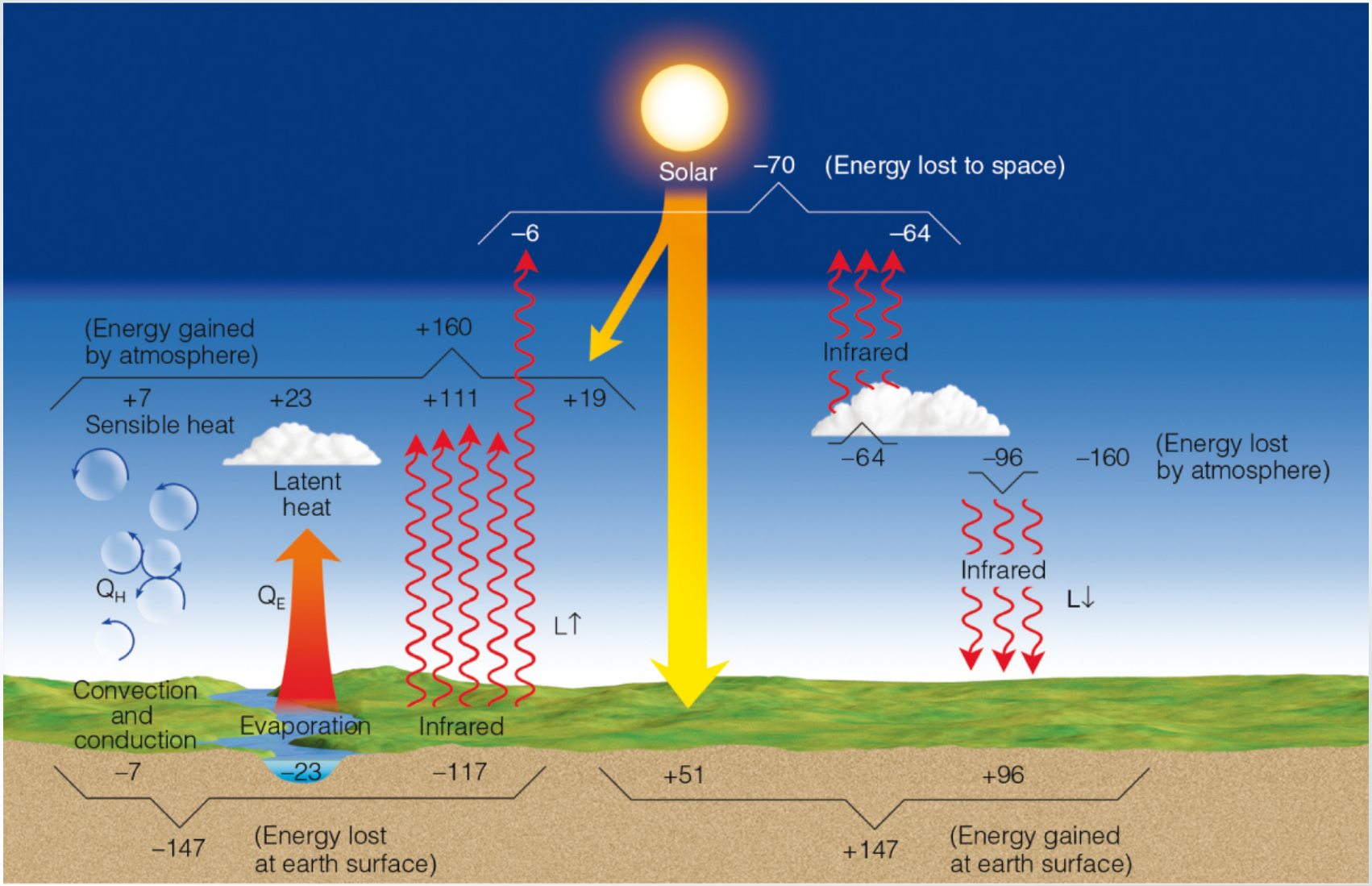
- Global energy budget
  - Incoming solar radiation must be balanced by outgoing terrestrial radiation
  - Temperature of Earth is determined by energy stored in the system
- Earth-atmosphere exchange

Shortwave Radiation (imagine 100 total units)



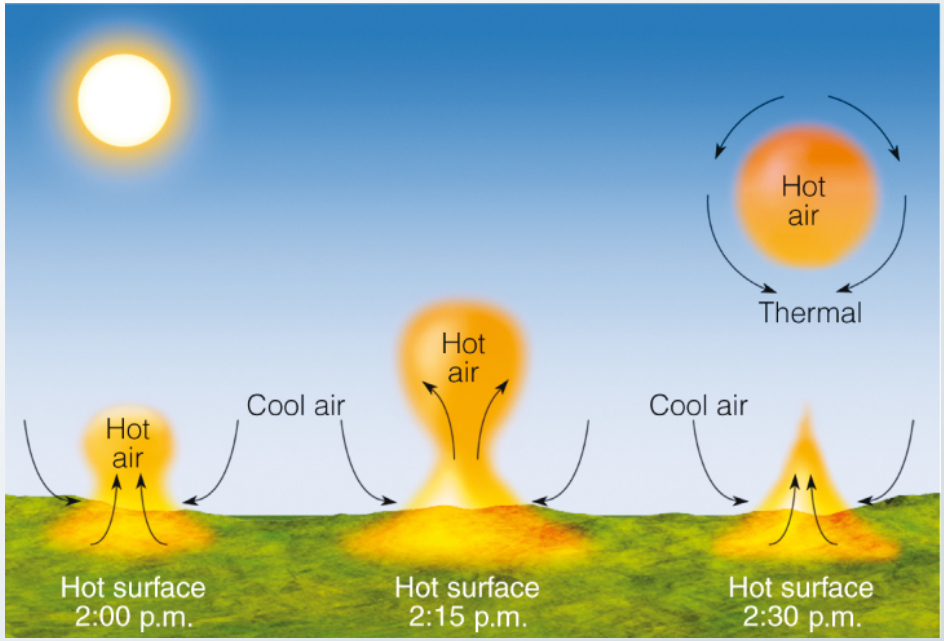
Ahrens: Figure 2.17

Earth-atmosphere energy balance



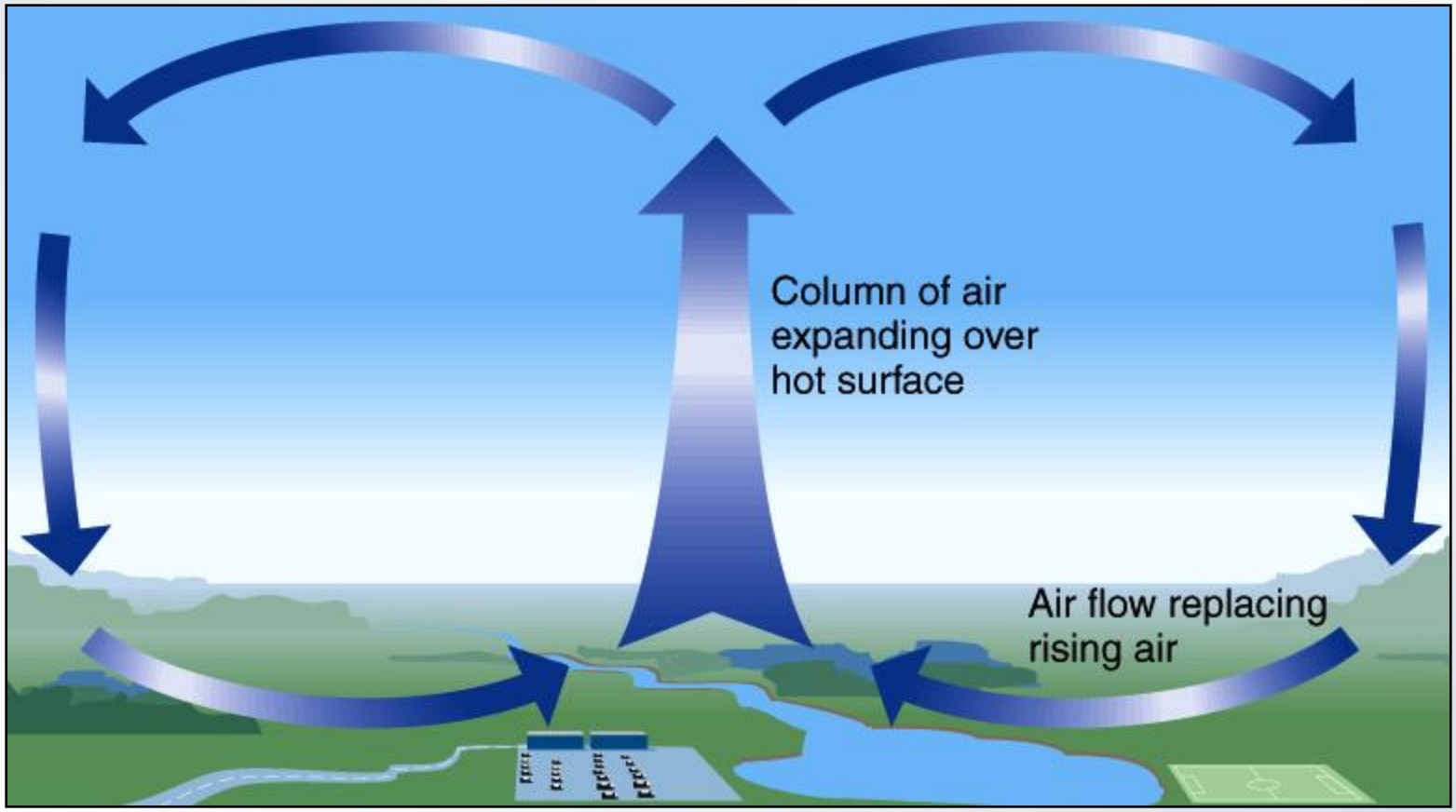
Convection

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



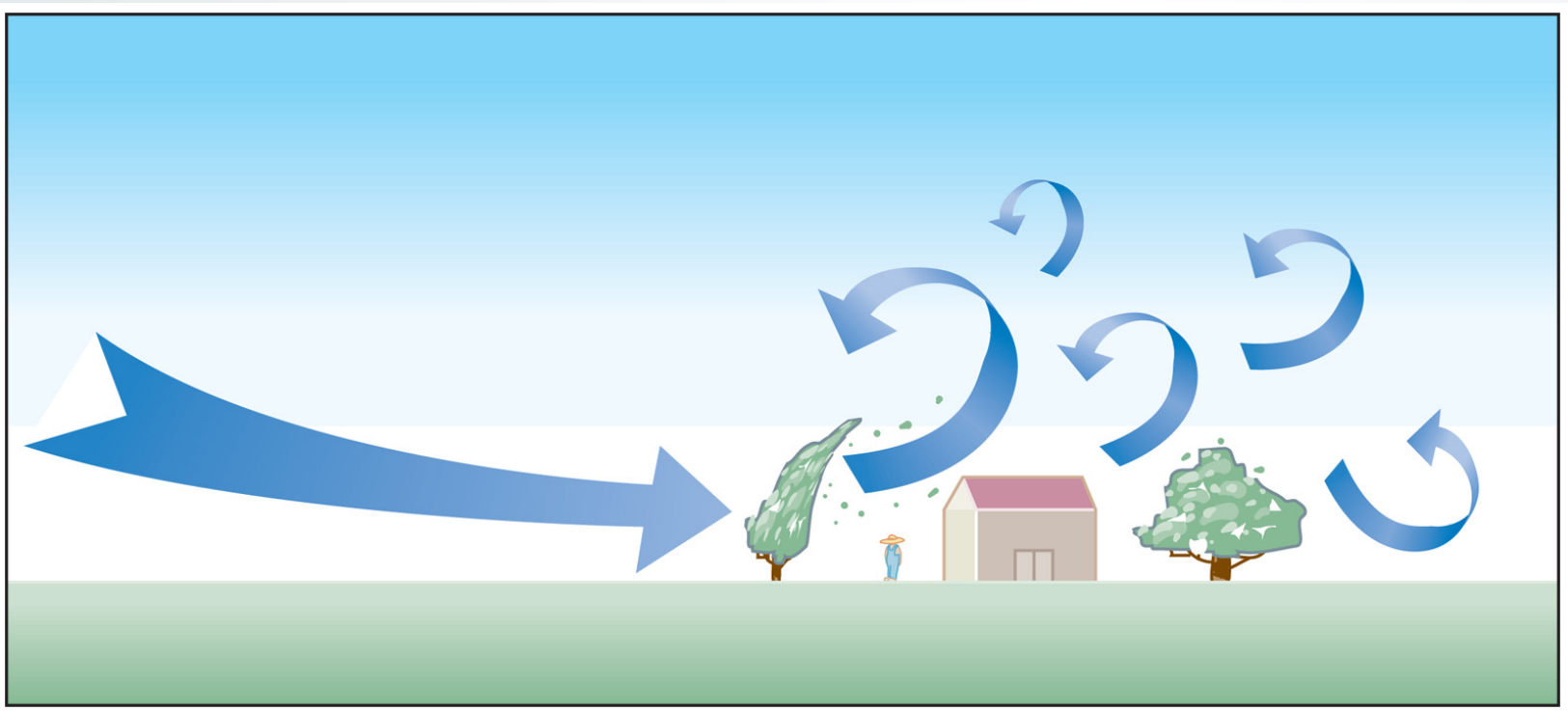
Ahrens: Fig. 2.6

Free Convection

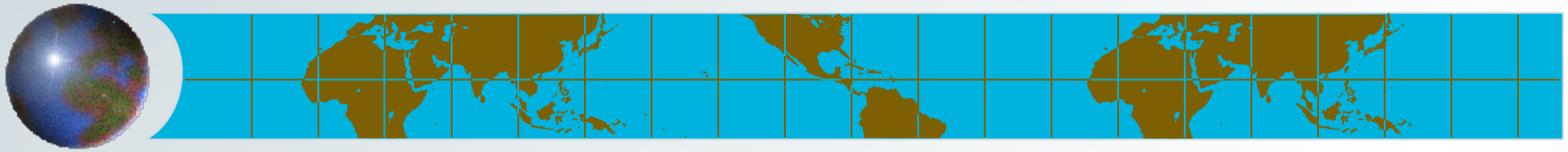


A&B: Figure 3-12

Forced Convection



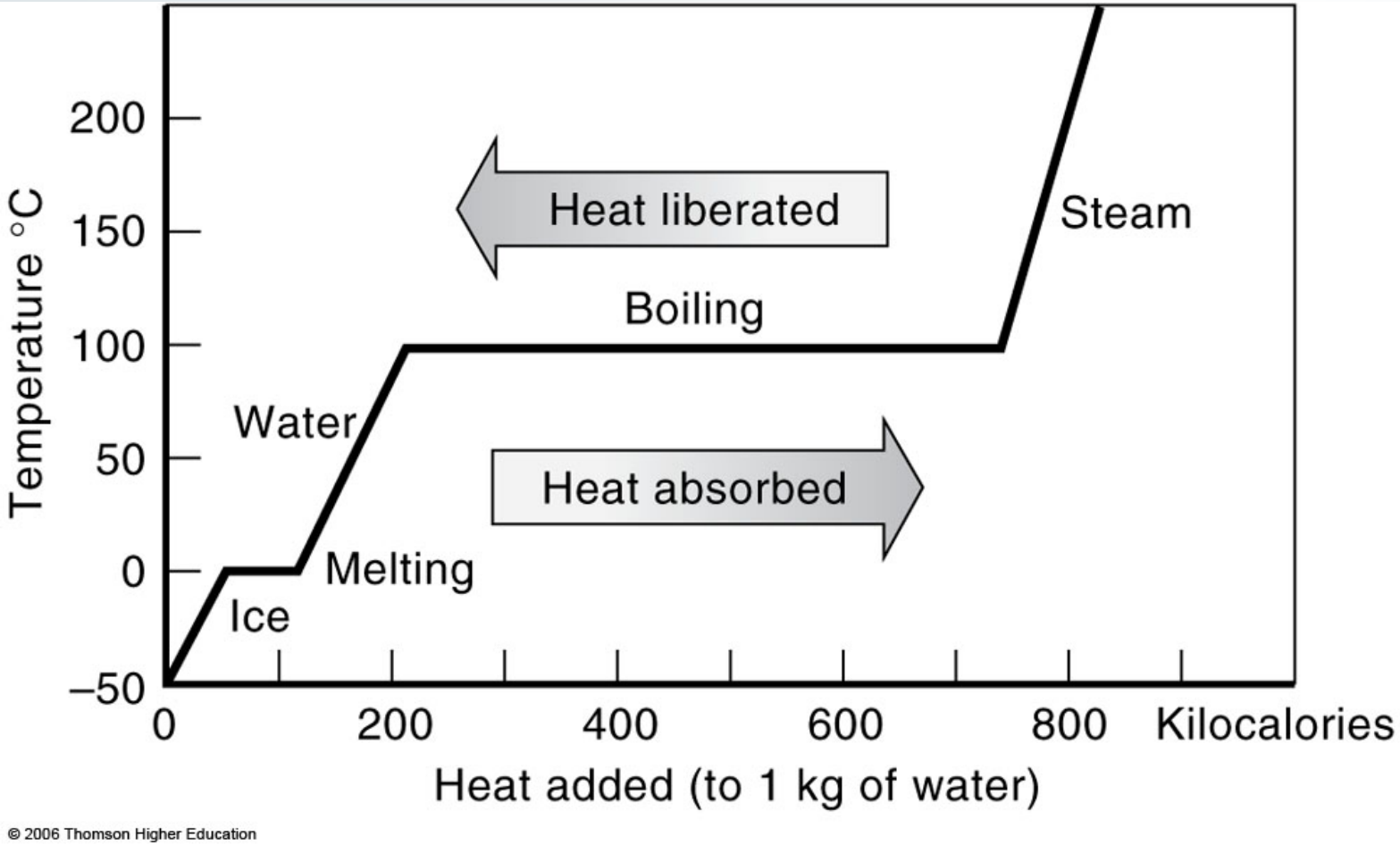
A&B: Figure 3-13

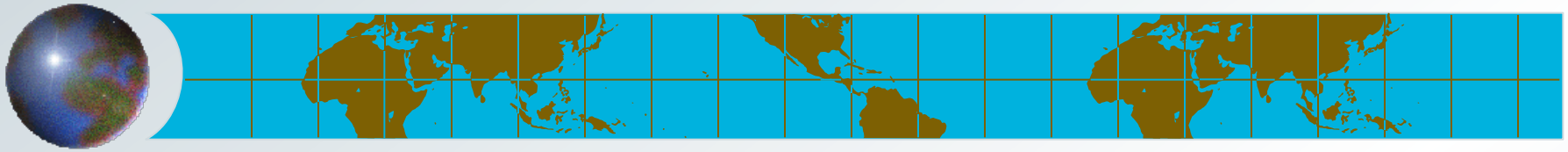


Latent heat

- Energy required to change the state of a substance
  - Liquid to gas: heat of evaporation
  - Solid to liquid: heat of fusion
- Heat is ‘hidden’
  - No change in temperature

Thermal Storage and phase change

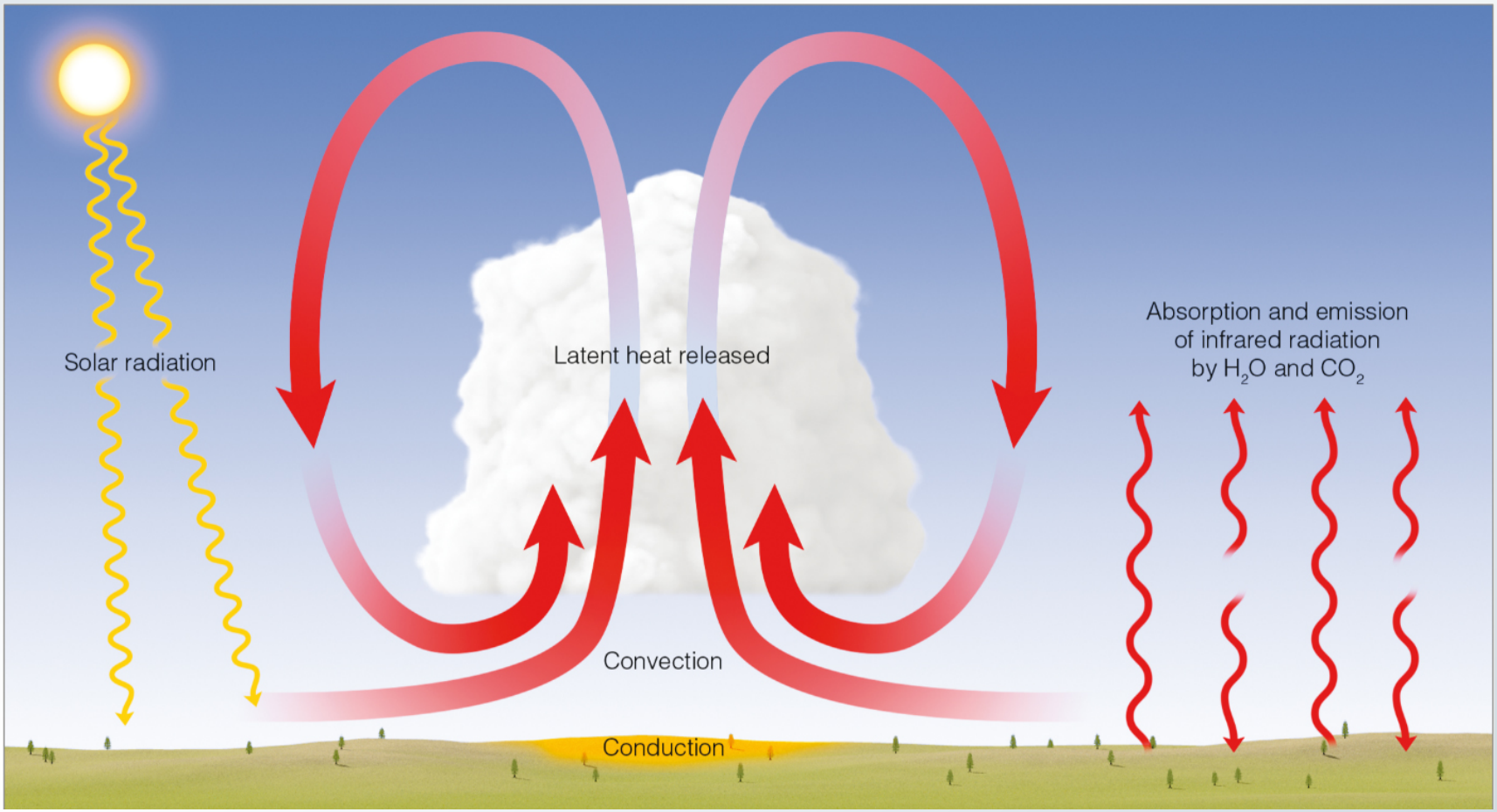


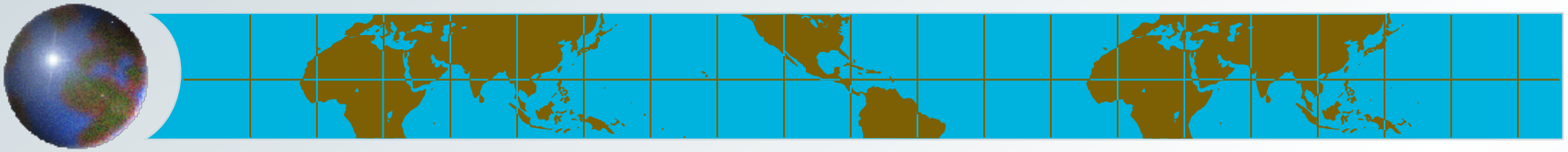


Latent heat

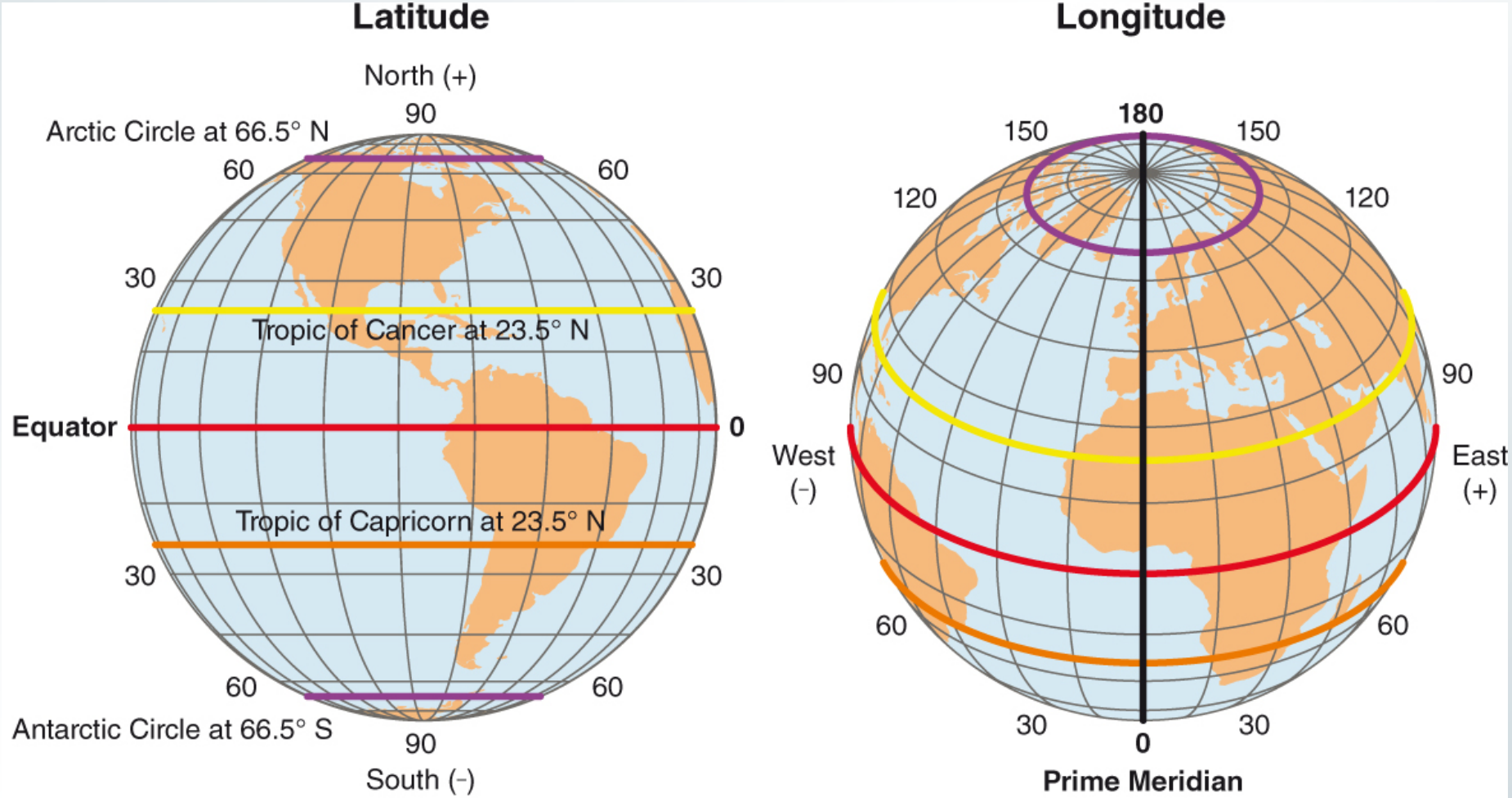
- Liquid to gas
  - Absorbs heat (at the surface)
- Gas to liquid
  - Releases heat (in the atmosphere)

Radiative, convective and latent transfers

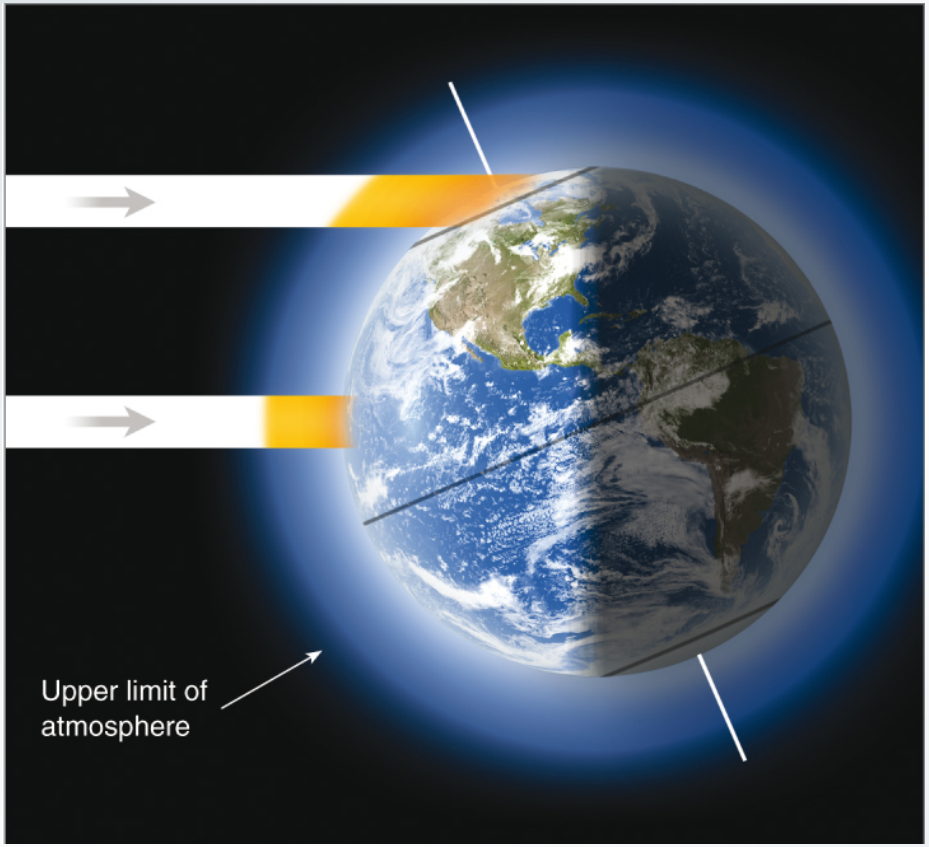




Global coordinate system



Beam spreading

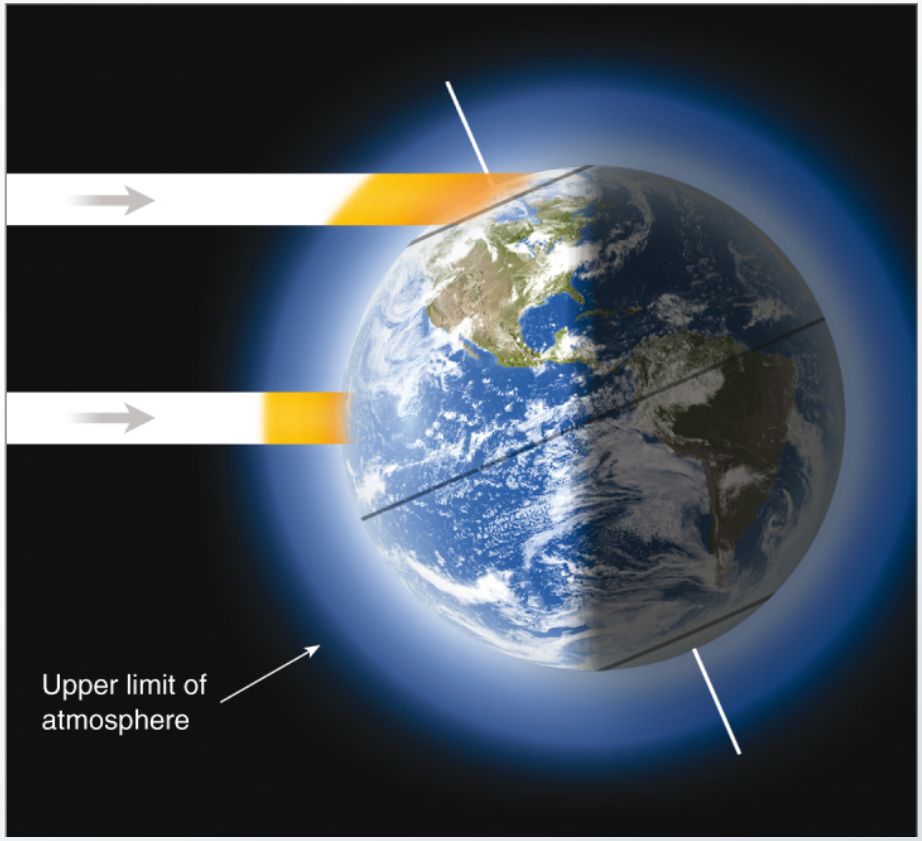


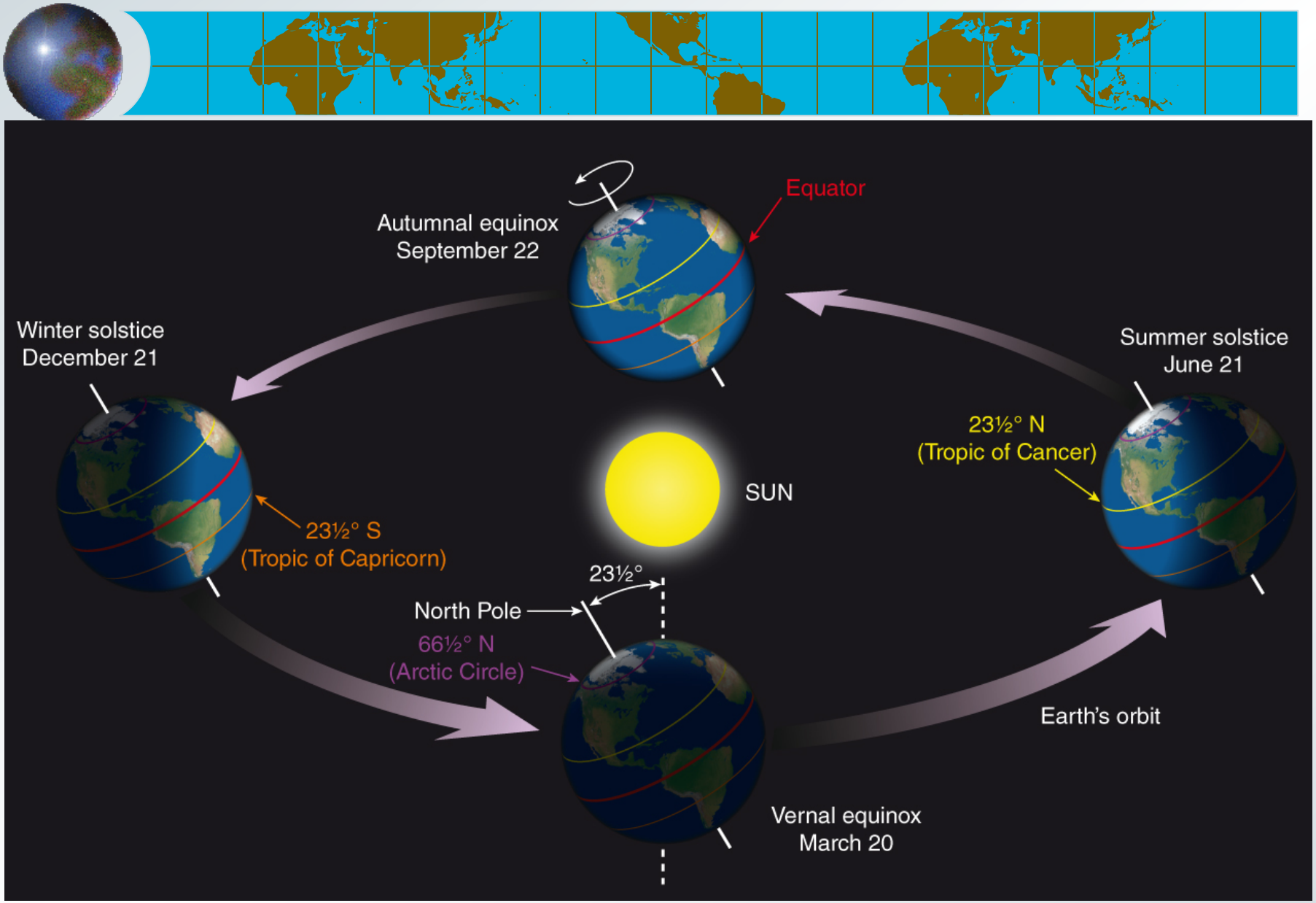
- A beam of sunlight spread over a large area is less intense
- Higher latitudes receive less solar energy per unit area
- Also passes through more air

Ahrens: Fig. 3.7

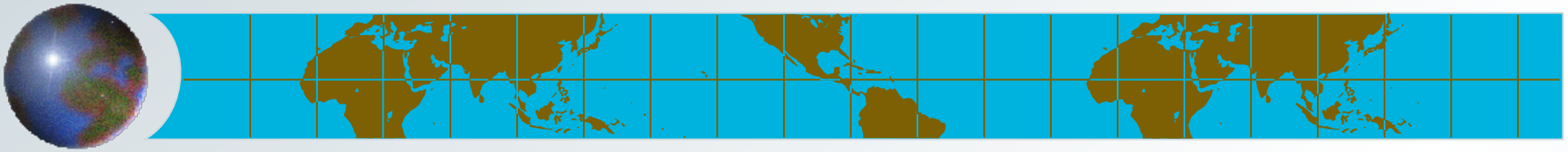
Axial tilt

- Axis of rotation is offset **23.5°** from being perpendicular to the orbital plane
- Hemispheric orientation changes as the Earth orbits the Sun



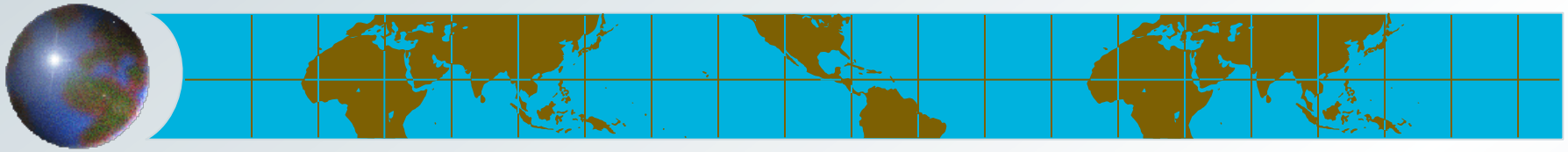


Ahrens: Fig. 3.3



Solstices

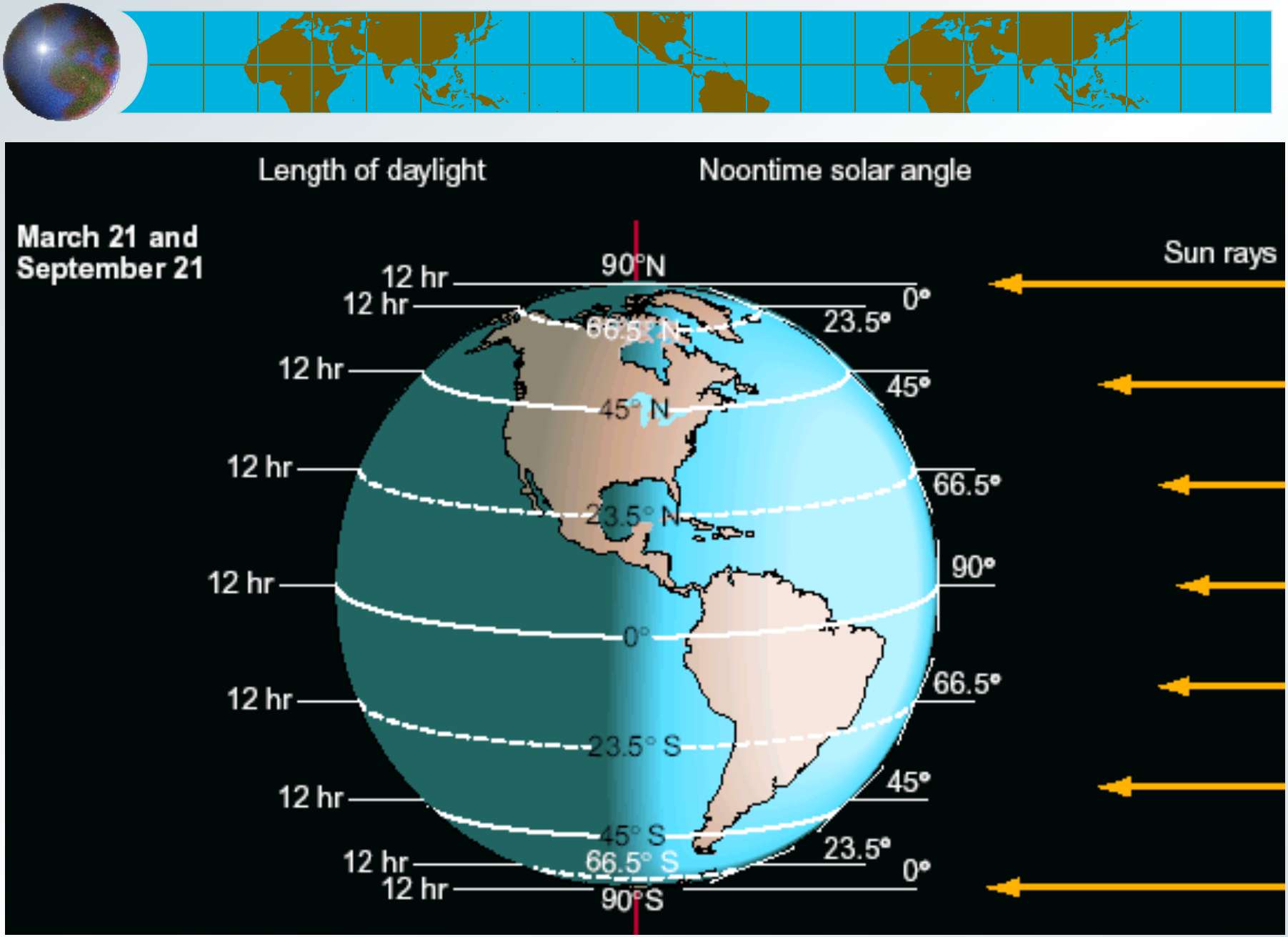
- One hemisphere axis of rotation is pointed toward the Sun; the other is pointed away
- The hemisphere pointed toward the Sun receives its maximum insolation on this date
- Astronomically, these dates designate the first day of winter or summer



Equinoxes

- March (Vernal) Equinox
  - On or about March 20
- September (Autumnal) Equinox
  - On or about September 22
  - September 23 this year

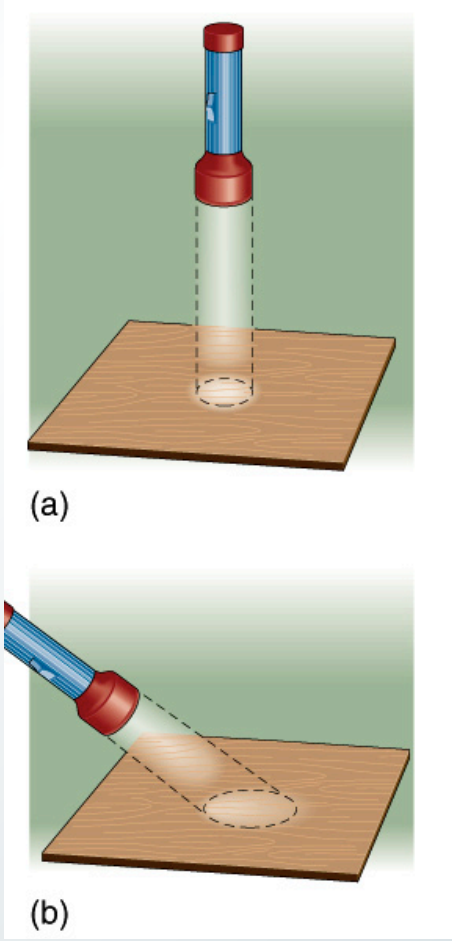
- The sun is visible for 12 hours everywhere

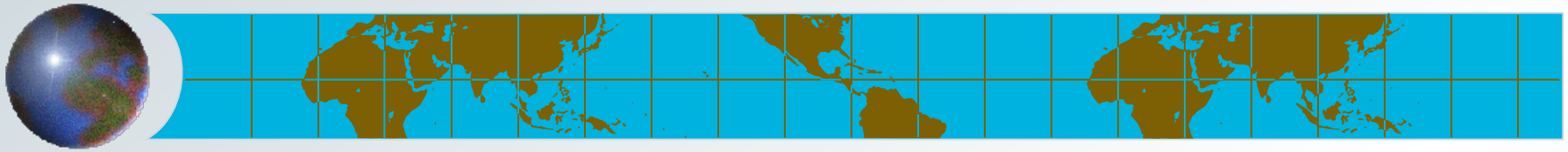

Length of daylight
Noontime solar angle
March 21 and
September 21
Sun rays
90°N
12 hr
0°
12 hr
23.5°
66.5° N
12 hr
45°
45° N
12 hr
66.5°
23.5° N
12 hr
90°
0°
12 hr
66.5°
23.5° S
12 hr
45°
45° S
12 hr
23.5°
66.5° S
12 hr
0°
90°S

Intensity of Radiation

Beam spreading

- Incident radiation is directly proportional to solar angle
- Higher solar angles incorporate reduced ***beam spreading***
- Lower angles induce less intense illumination and heating per unit area





- Beam depletion
  - Solar radiation is diminished relative to the *amount* of atmosphere the radiation passes through (distance through the air)
  - Significant beam reduction occurs at low solar angles

- Period of Daylight
  - Axial tilt influences day length
  - Days are longer in summer and shorter in winter
  - Effect is more pronounced at high latitudes

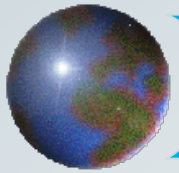


Table 3.1 Length of Time from Sunrise to Sunset for Various Latitudes on Different Dates in the Northern Hemisphere

Latitude	March 20	June 21	September 22	December 21
0°	12 hr	12.0 hr	12 hr	12.0 hr
10°	12 hr	12.6 hr	12 hr	11.4 hr
20°	12 hr	13.2 hr	12 hr	10.8 hr
30°	12 hr	13.9 hr	12 hr	10.1 hr
40°	12 hr	14.9 hr	12 hr	9.1 hr
50°	12 hr	16.3 hr	12 hr	7.7 hr
60°	12 hr	18.4 hr	12 hr	5.6 hr
70°	12 hr	2 months	12 hr	0 hr
80°	12 hr	4 months	12 hr	0 hr
90°	12 hr*	6 months	12 hr*	0 hr

*The sun rises on March 20 and sets on September 20.

Ahrens: Table 3.1

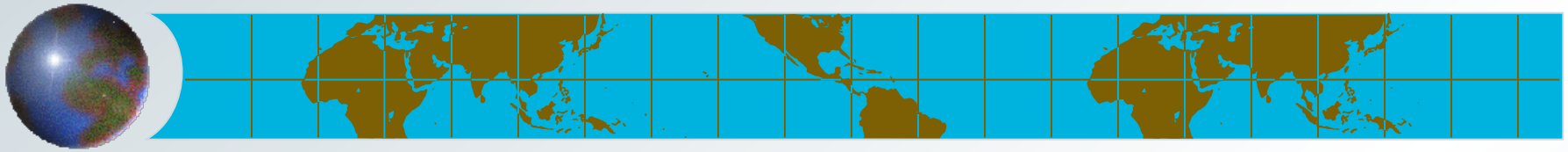
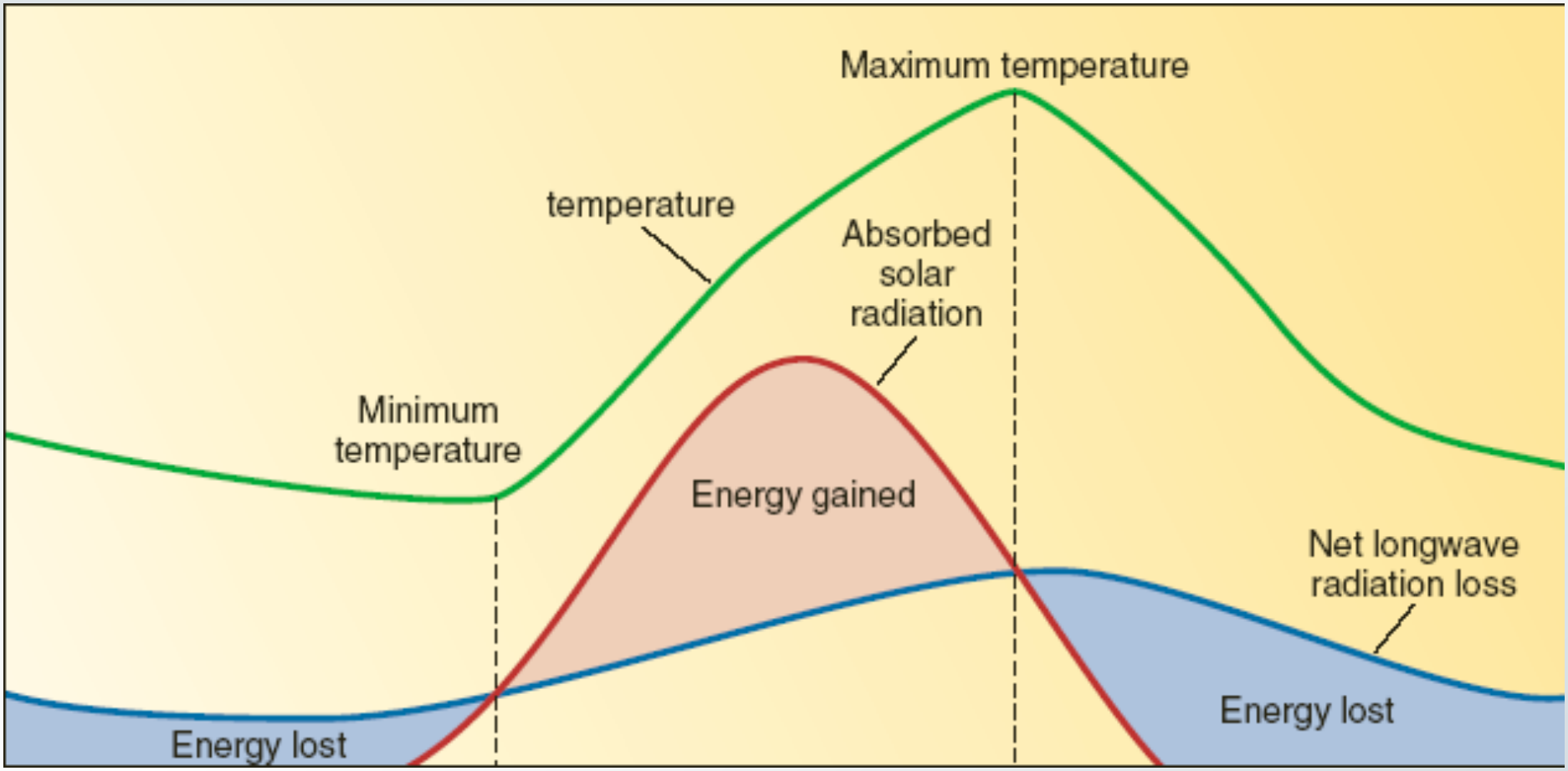


Table 2–2 Variations in Solar Angle and Daylength

	Solar Angle at Noon	Length of Day	Total Radiation for Day (Megajoules/m^2)
December 21			
Winnipeg	25.5°	8 hr, 34 min	7.44
Austin	45.5°	10 hr, 04 min	12.18
June 21			
Winnipeg	63.5°	16 hr, 10 min	37.15
Austin	83.5°	13 hr, 56 min	35.97

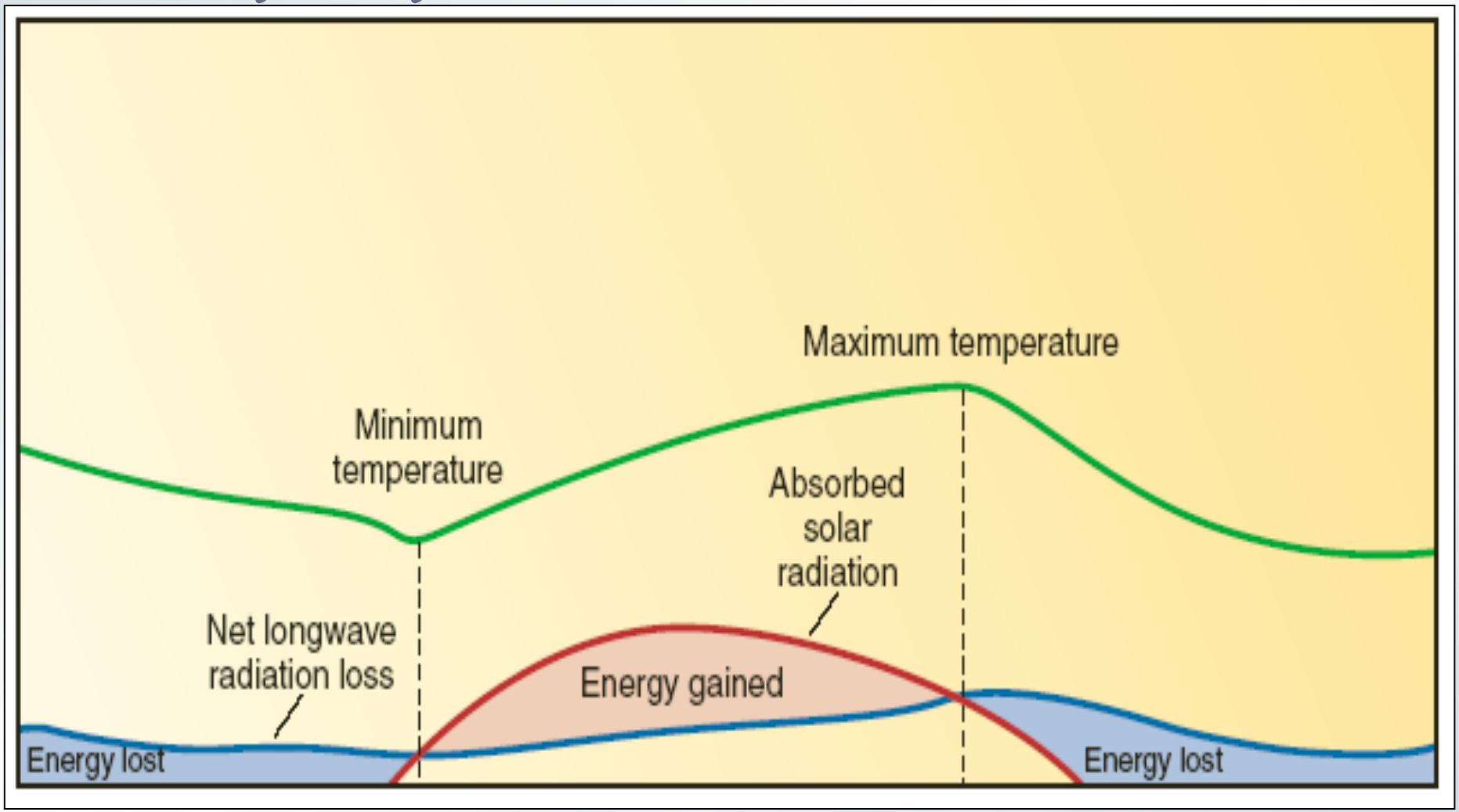
A&B: Table 2-2

Diurnal heat budget



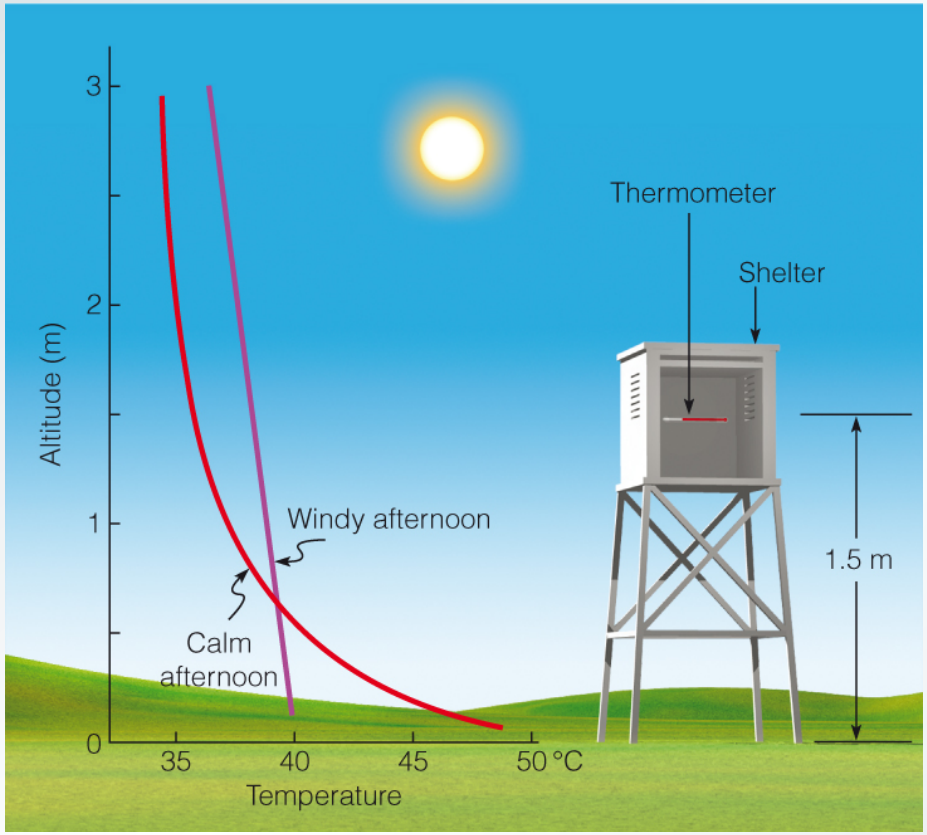
A&B: Figure 3-23

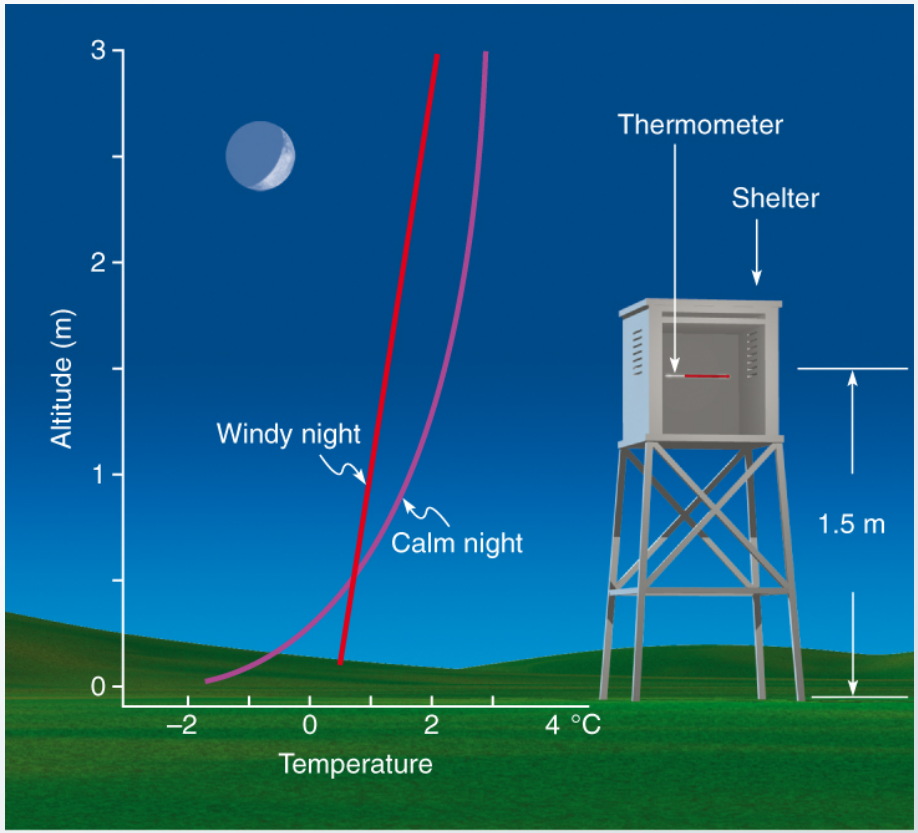
Cloudy days



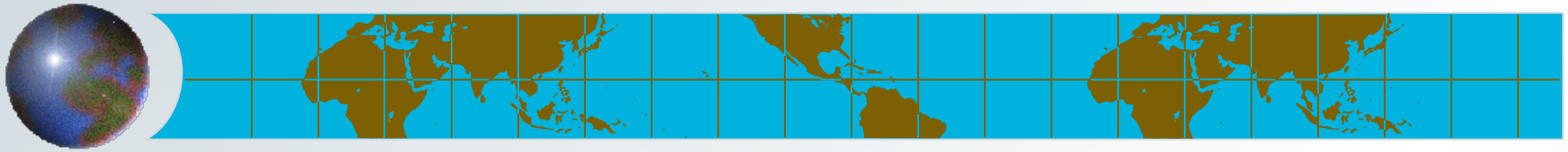
A&B: Figure 3-23

Diurnal surface air temperature



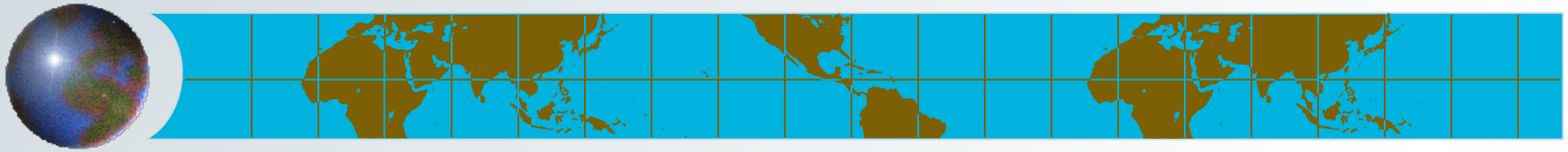


Ahrens: Fig. 3.12 and 3.14



Extemes of Temperature in Thunder Bay

Heat	Cold
40.3° C	-41.1° C
August 7, 1983	January 30, 1951



Next lecture

- Temperature and Geography
- Ahrens: Chapters 2 and 3