Temperature and Geography

Lecture 5

Ahrens, Chapter 3

Temperature: History and Applications

Origin of temperature scales: More on 2331 site

- Galileo Galilei invented a rudimentary water thermoscope in 1593
- **Fahrenheit Scale**
- **Kelvin Scale** in 1848
- **Celsius**

- History: Review text:
  pages 62 - 63 or 34 – 35

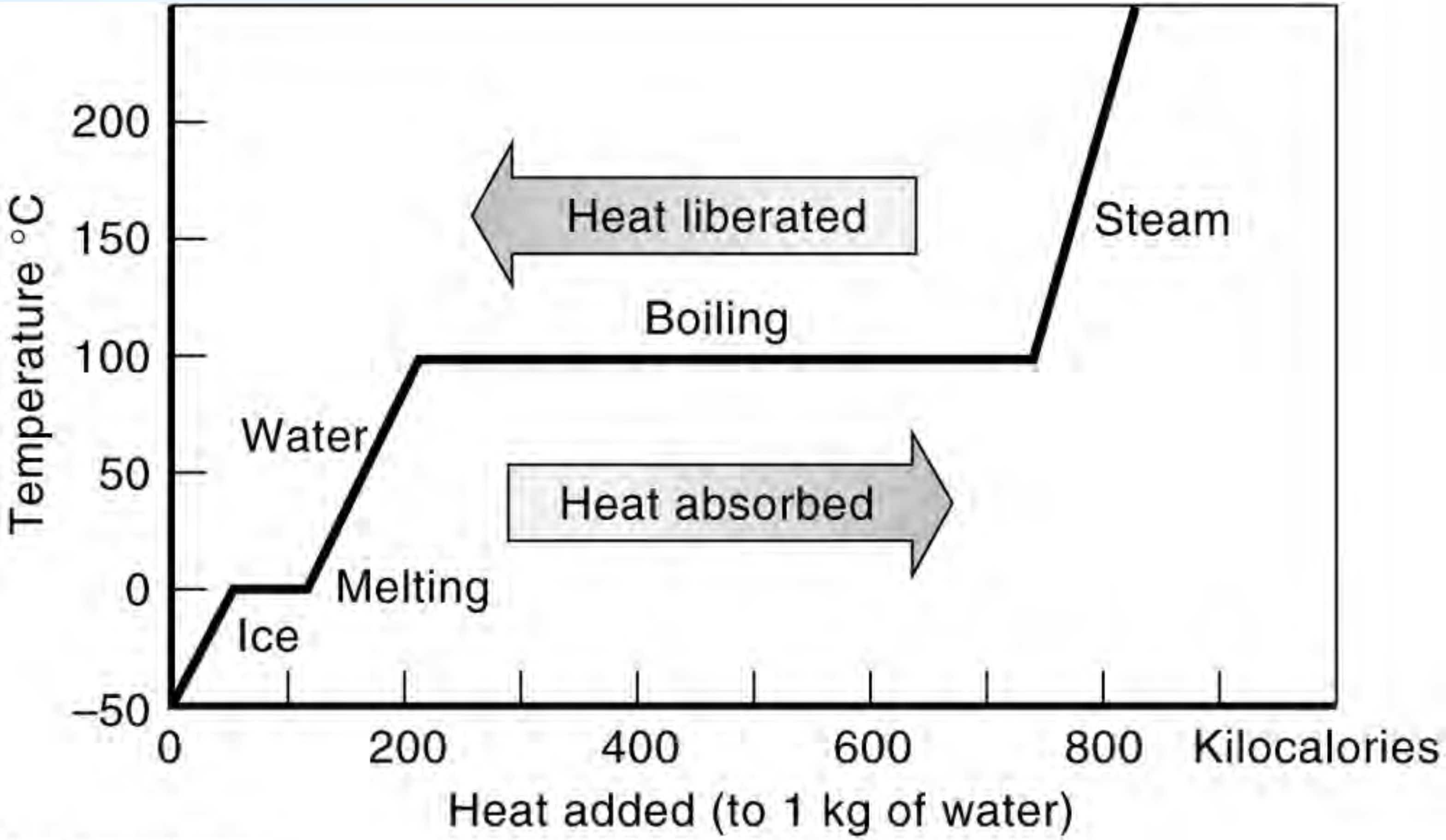
Temperature

- Profile in the atmosphere
- Today: begin with Latent heat
- Transfer of heat
- Sometimes reduced temperature! Frost, wind chill
- Heating degree days
- Isotherms

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

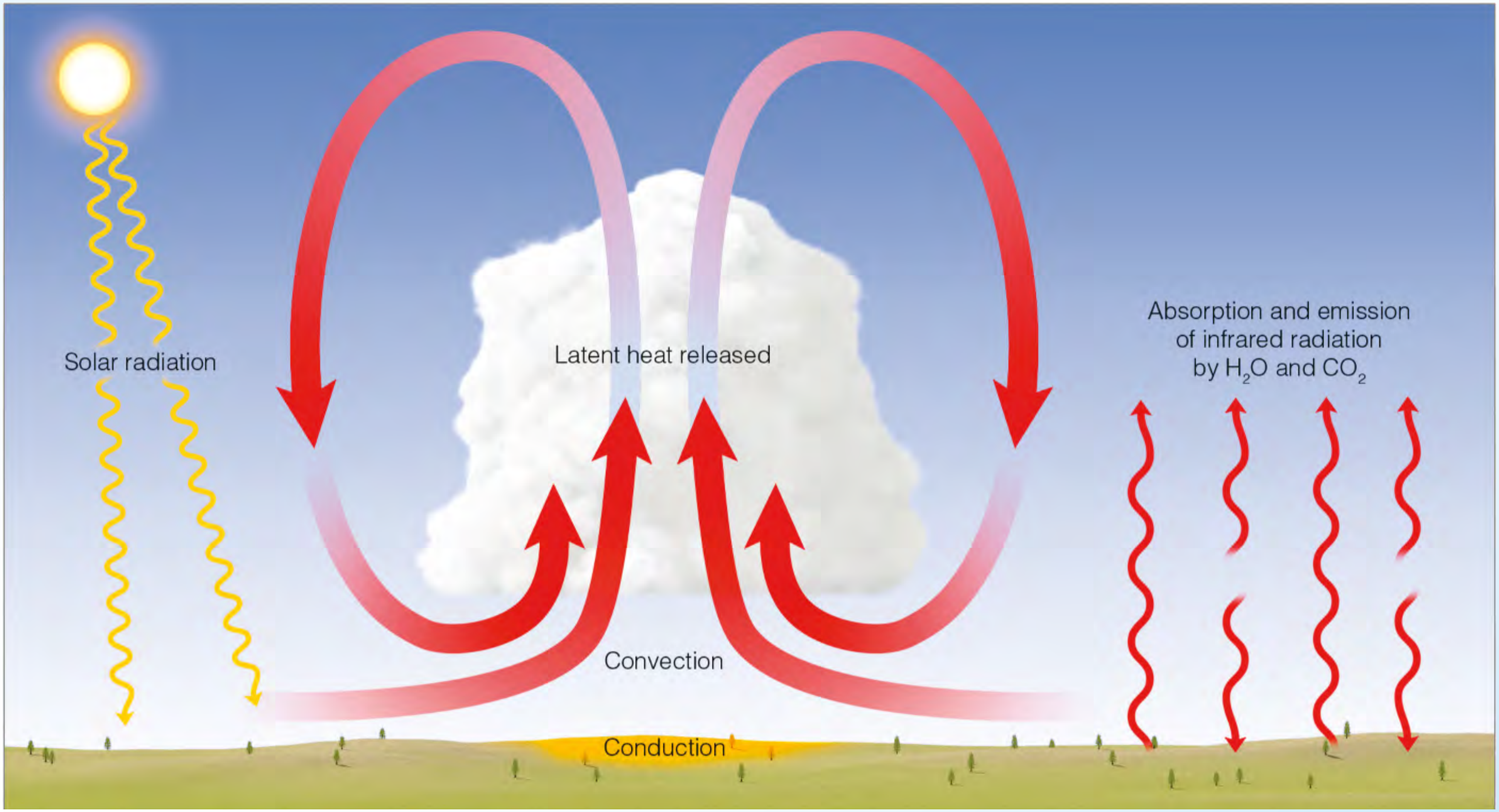
Thermal Storage and phase change



Latent heat

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

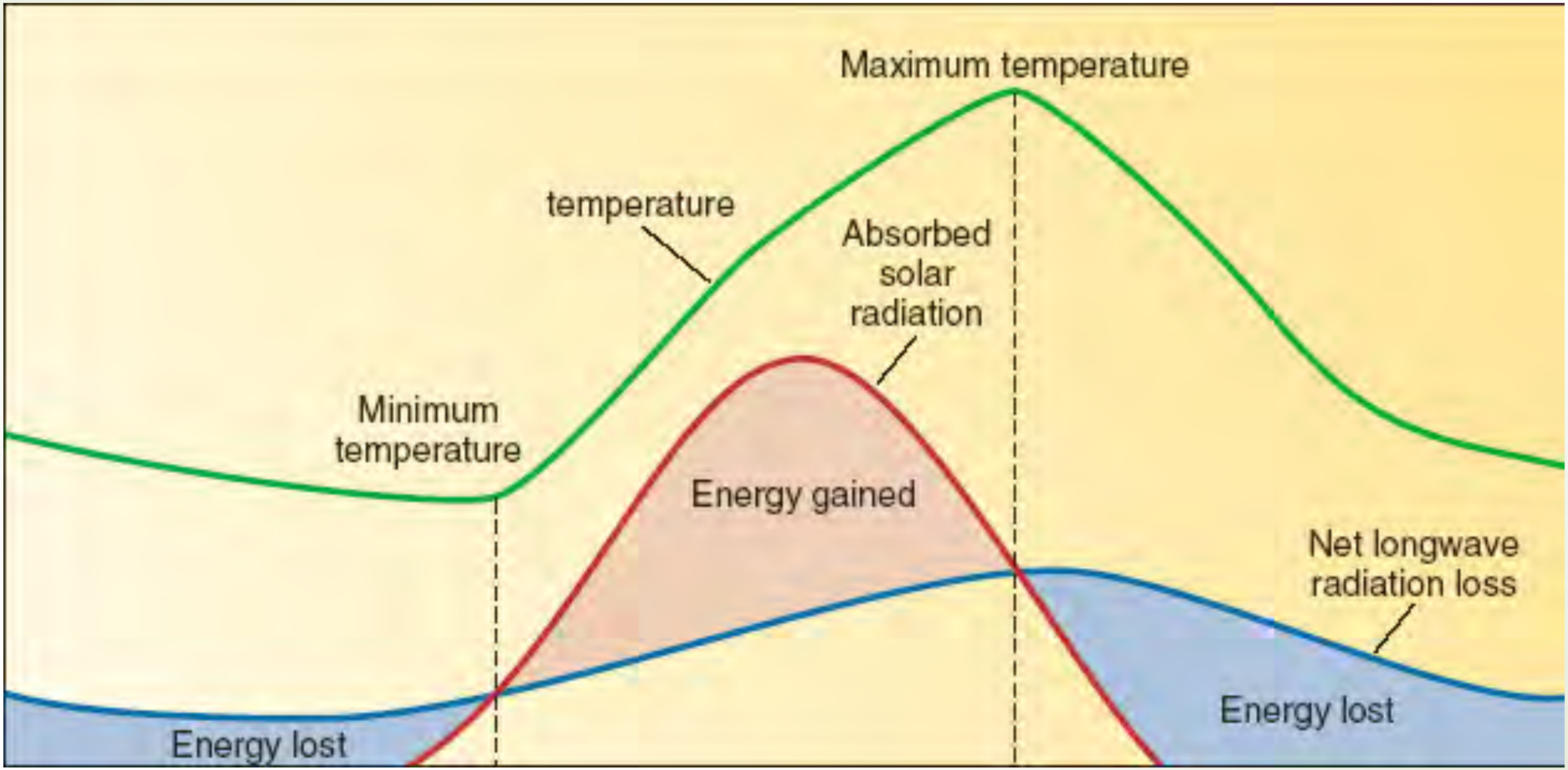
Radiative, convective and latent transfers



Geographic controls of temperature

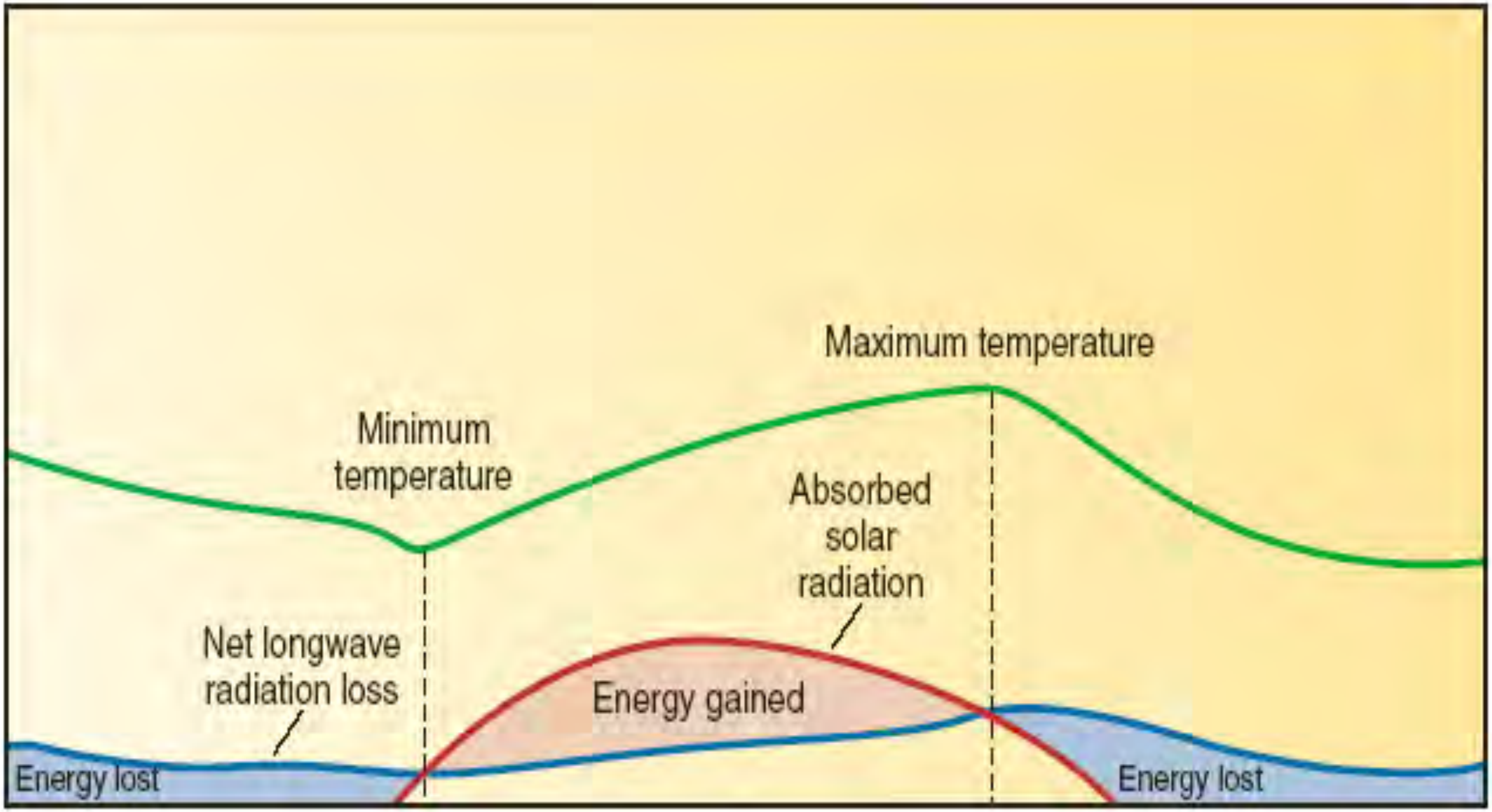
- Latitude
- Land and water distribution
- Ocean currents
- Elevation

Diurnal heat budget



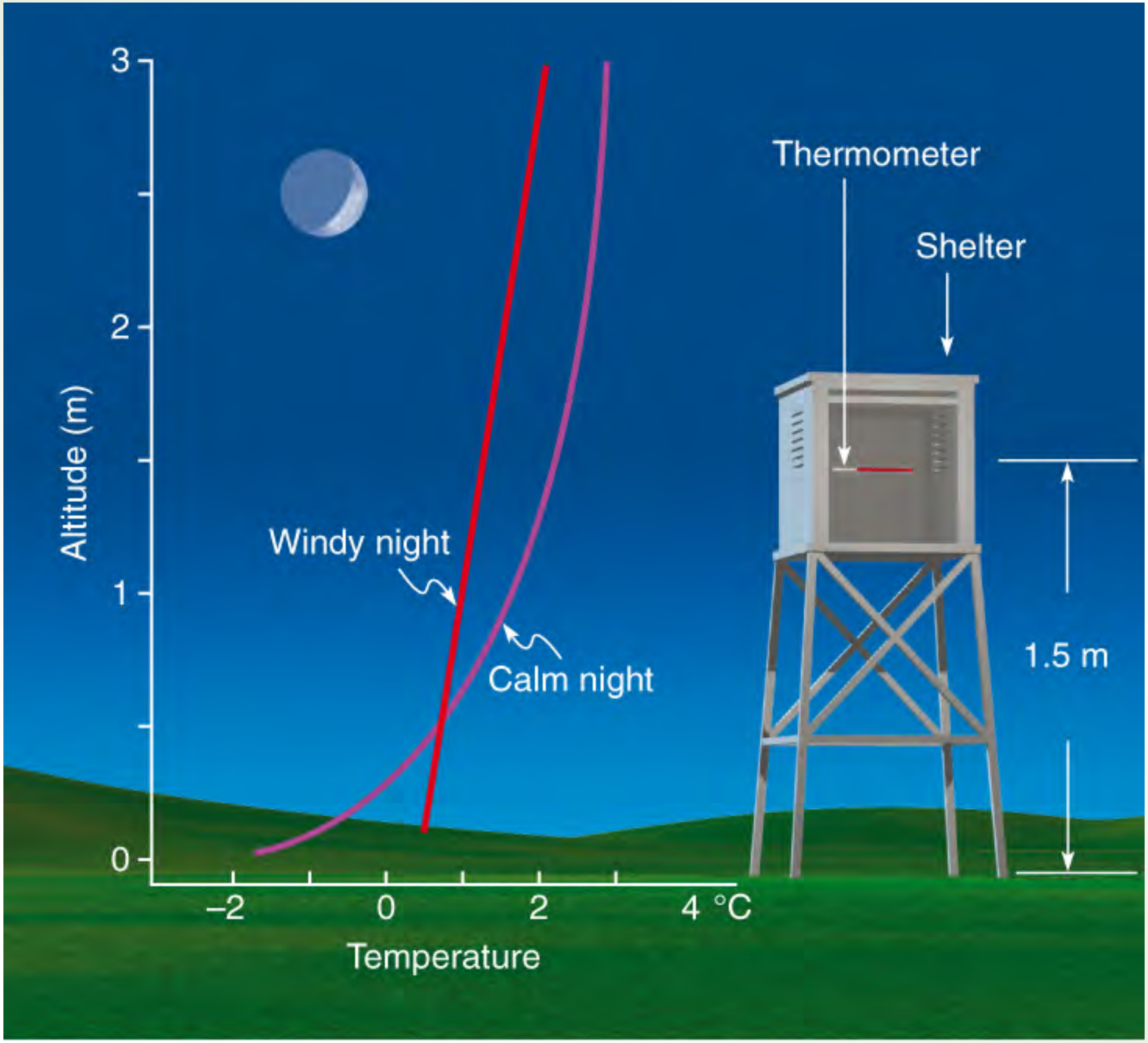
A&B: Figure 3-23

Cloudy days



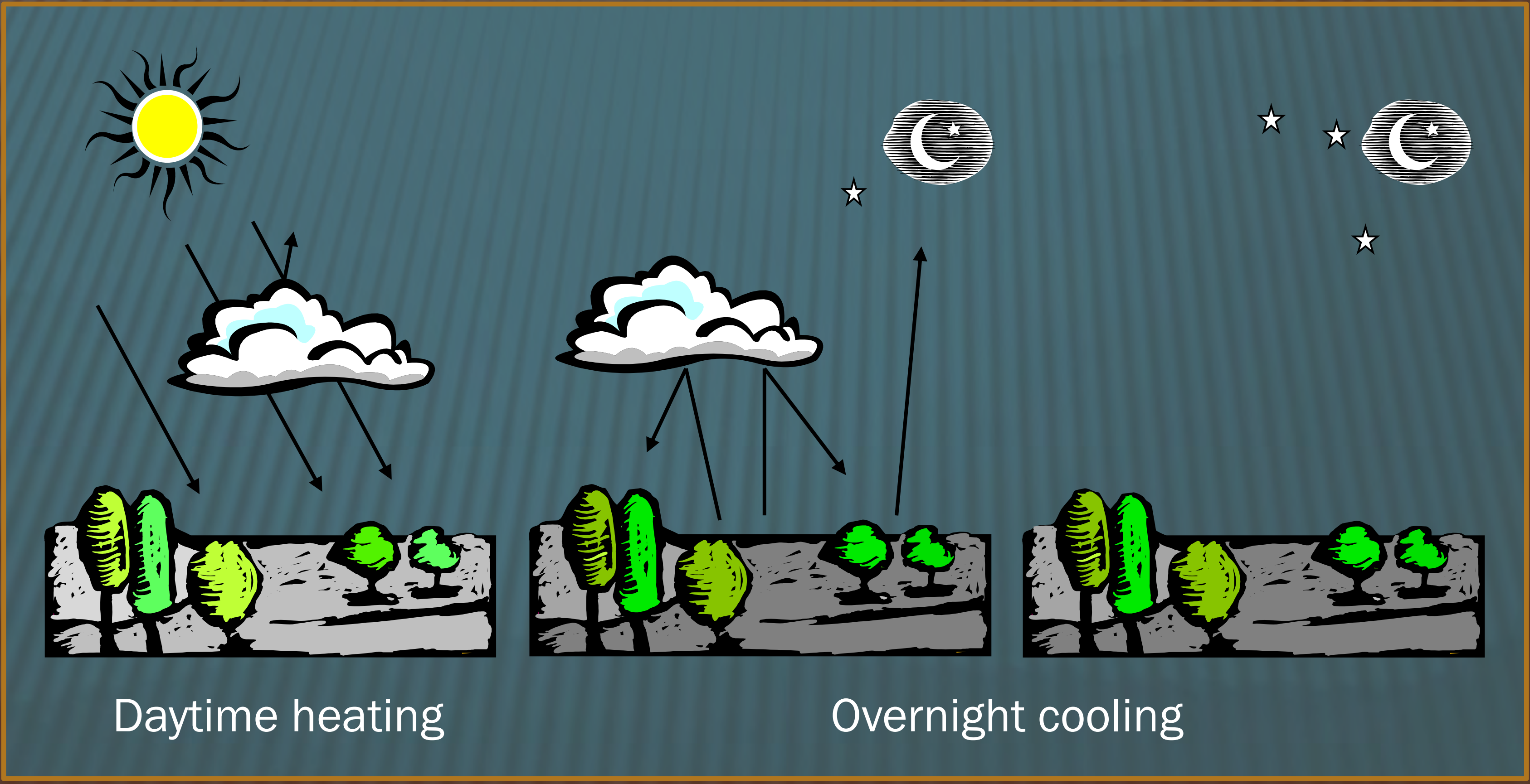
A&B: Figure 3-23

Diurnal surface air temperature

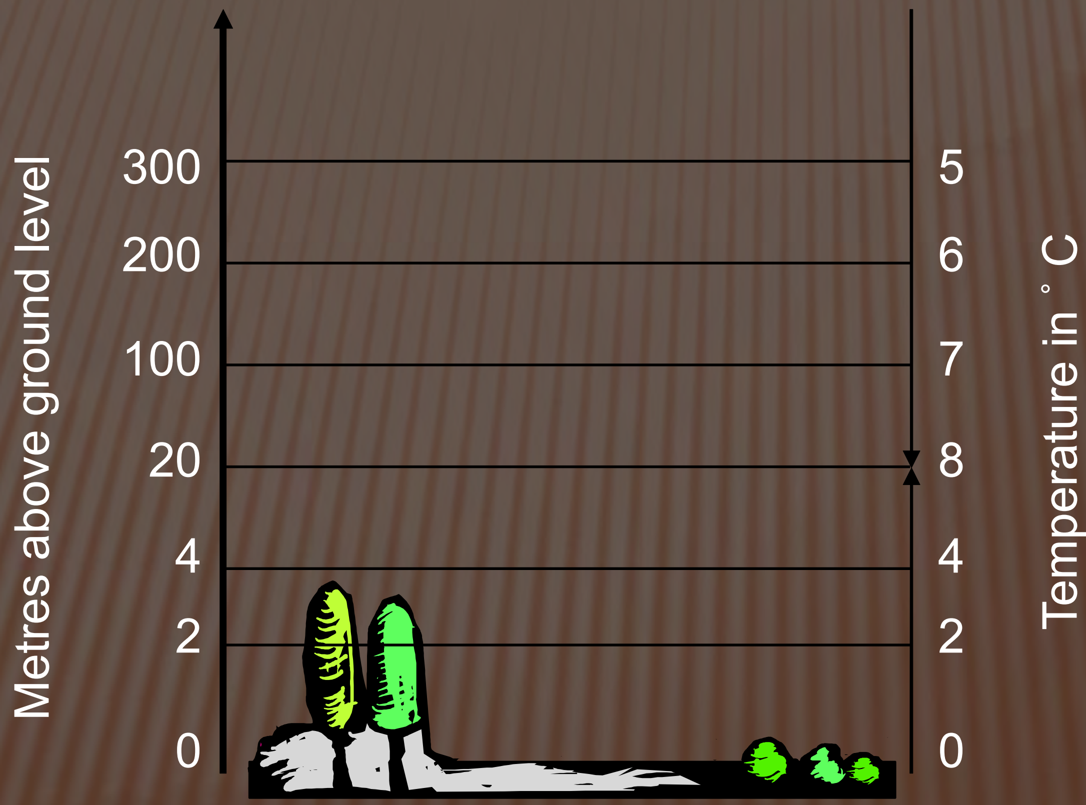


Ahrens: Fig. 3.14

PRINCIPLES OF FROST

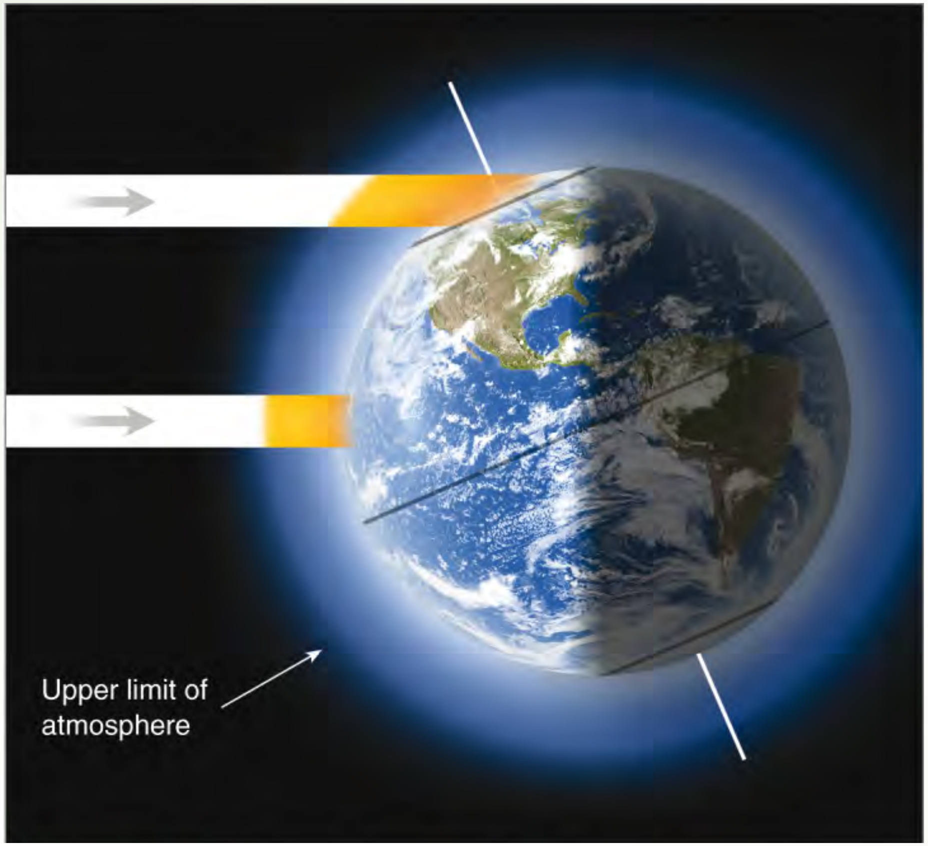


PRINCIPLES OF FROST



Sample temperature profile during an inversion

Beam spreading

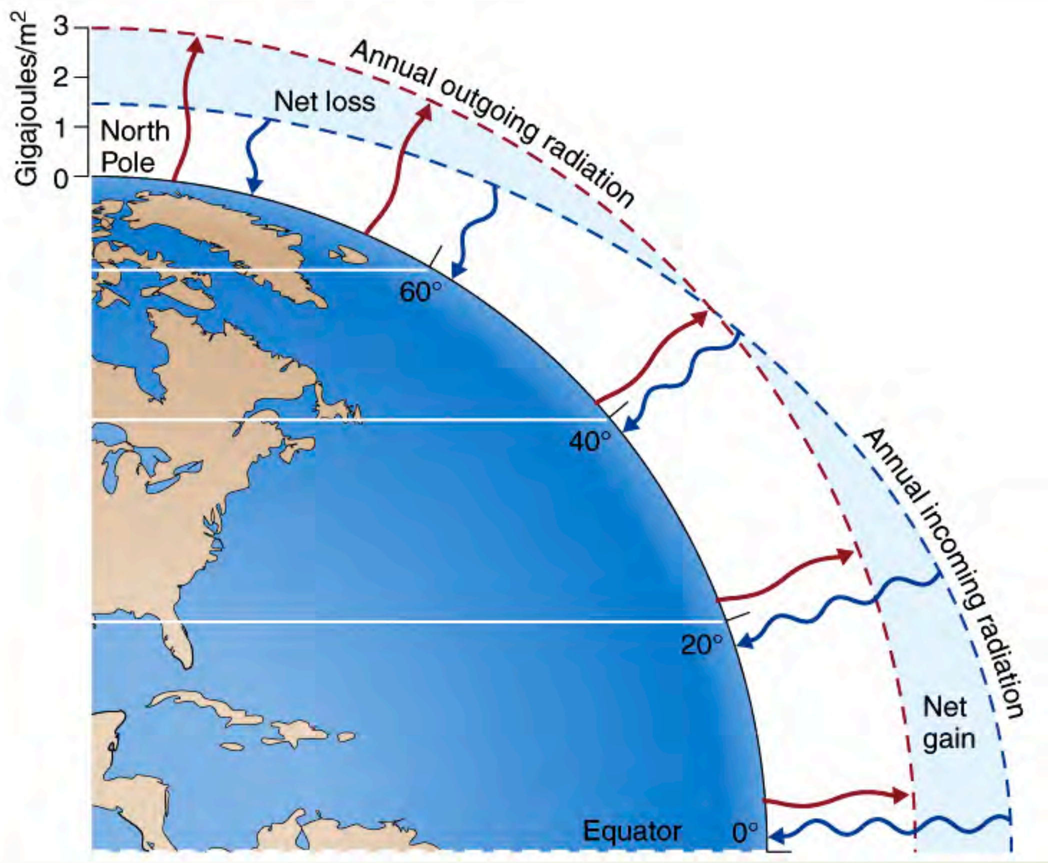


Ahrens: Fig. 3.7

- 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

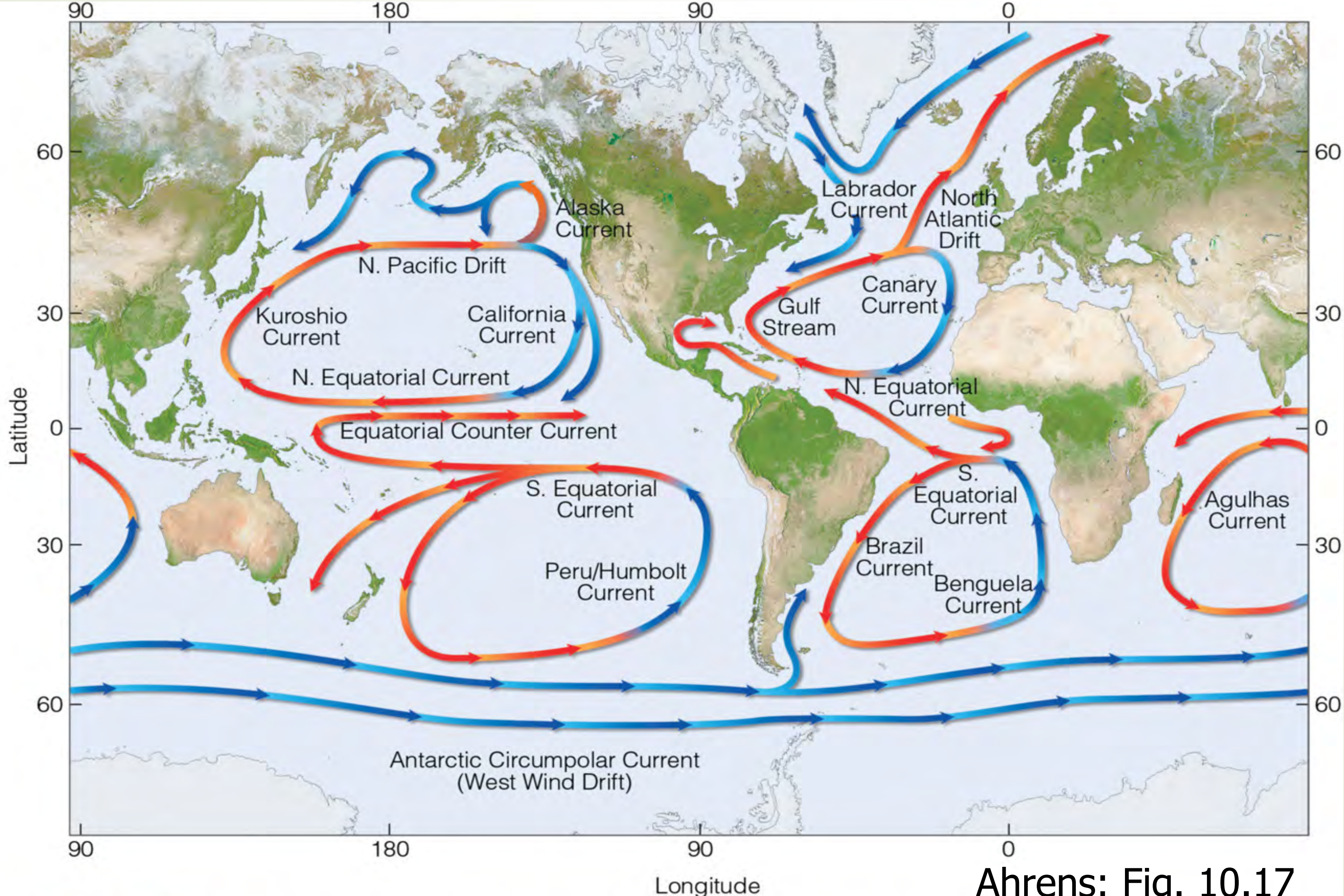
Net radiation vs. latitude

- Net energy gain
  - 38°N-38°S
  - Migrates seasonally
- Energy difference creates winds and currents



A&B: Figure 3-16

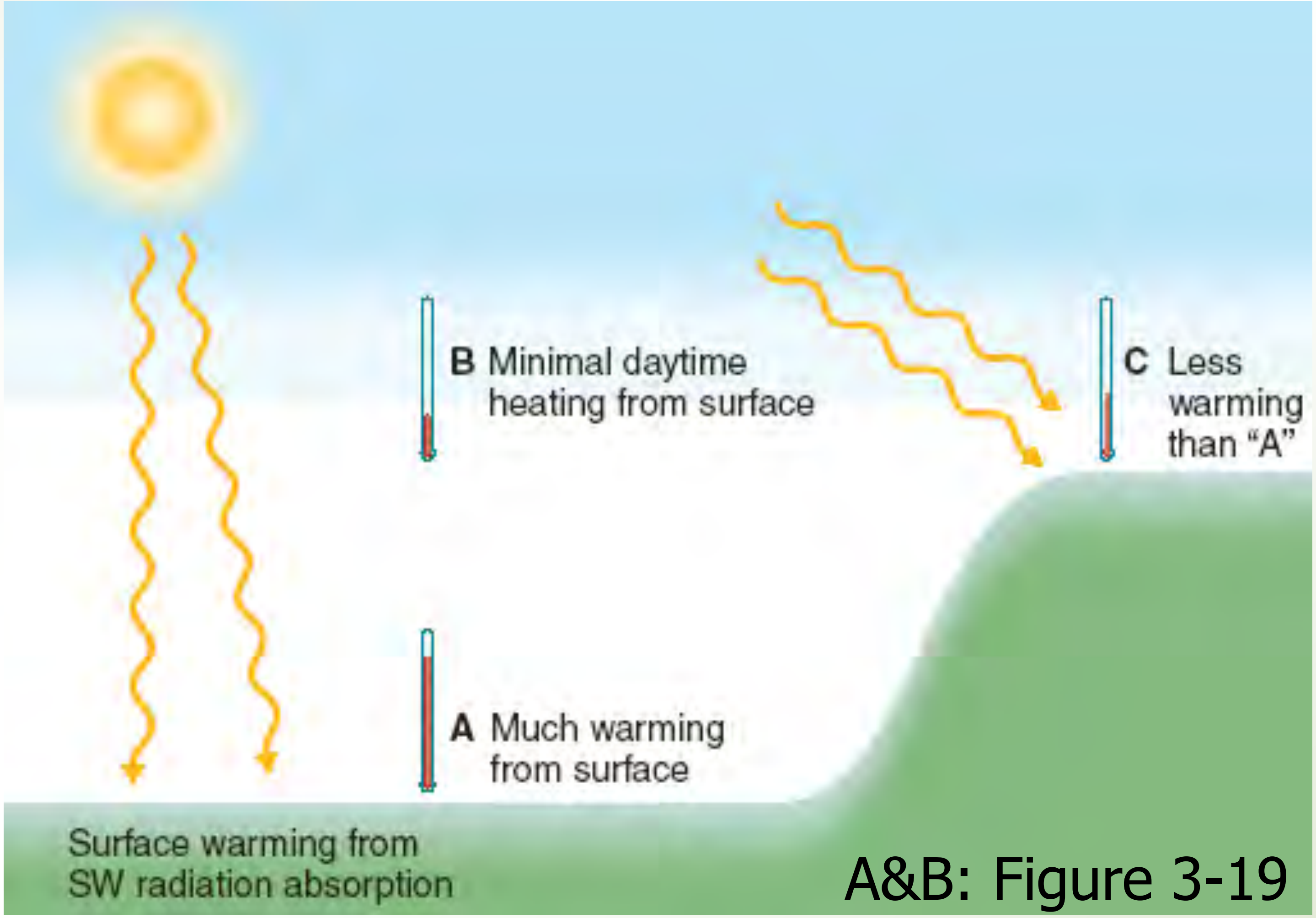
Ocean currents



Ahrens: Fig. 10.17

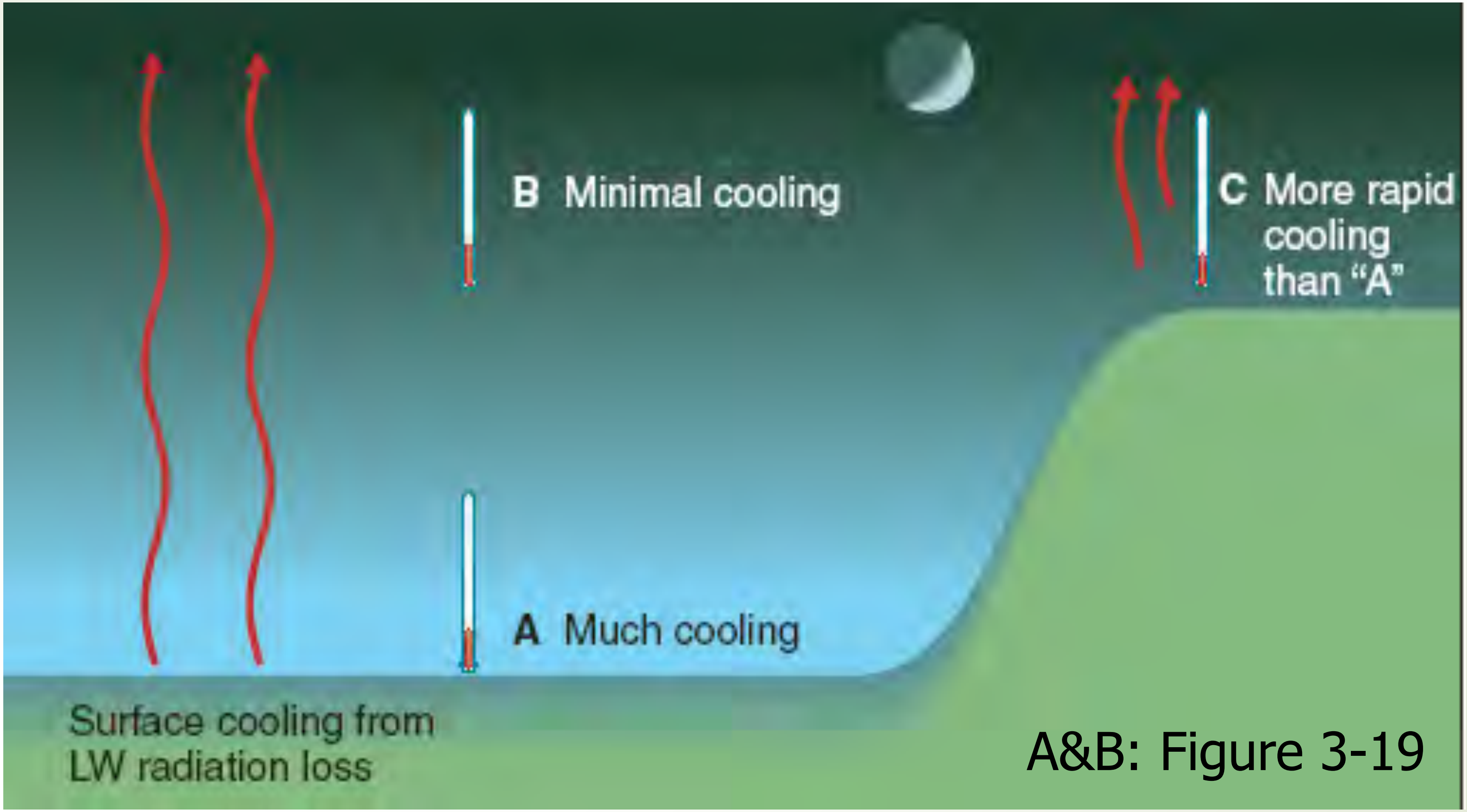
Altitude and temperature

A: 0 m
B: 3000 m
C: 3000 m



A&B: Figure 3-19

Altitude



A&B: Figure 3-19

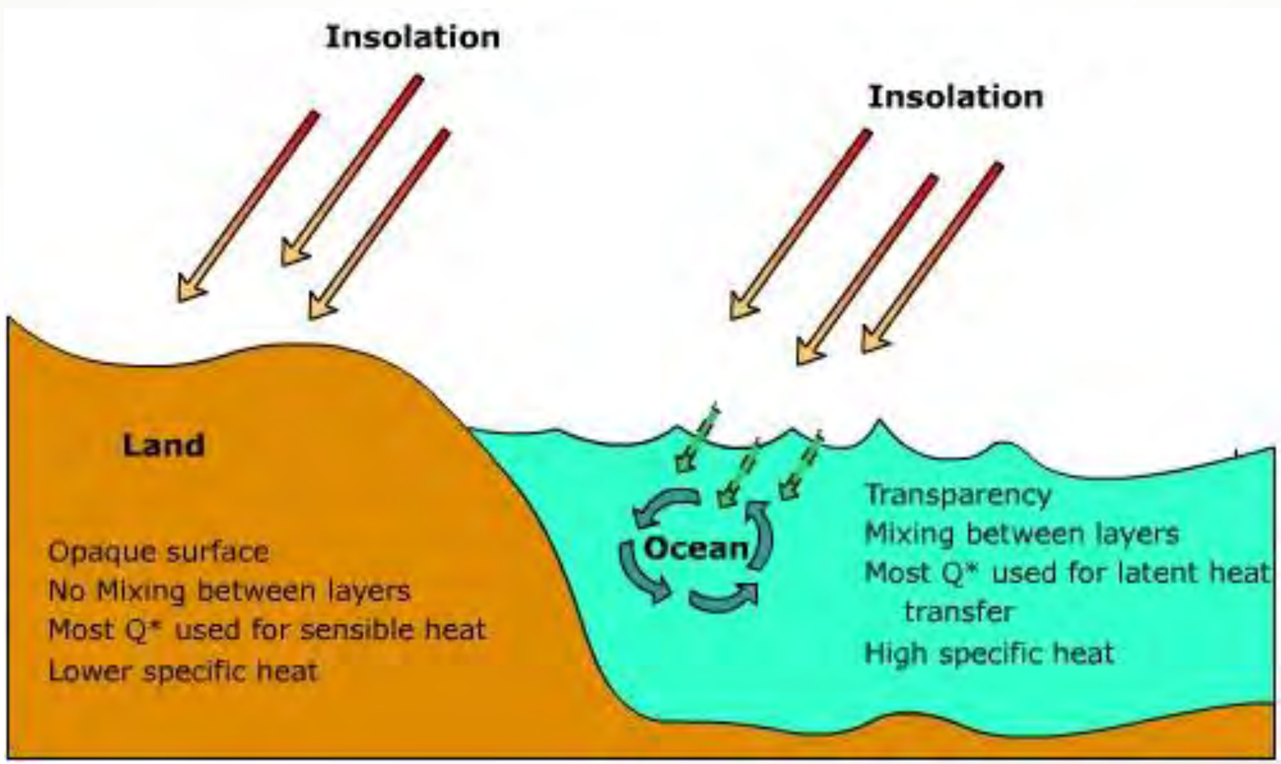
Specific heat

- How much energy does it take to raise the temperature of a substance by 1 degree?

Material	J/kg°C
Water	4186
Granite	790
Soil	800
Wood	1700
Air	1012

Land/sea contrast

- Water has higher *specific heat* than soil or rocks
- Water experiences greater evaporative cooling
- Water allows more horizontal and vertical mixing



Impact on air temperatures

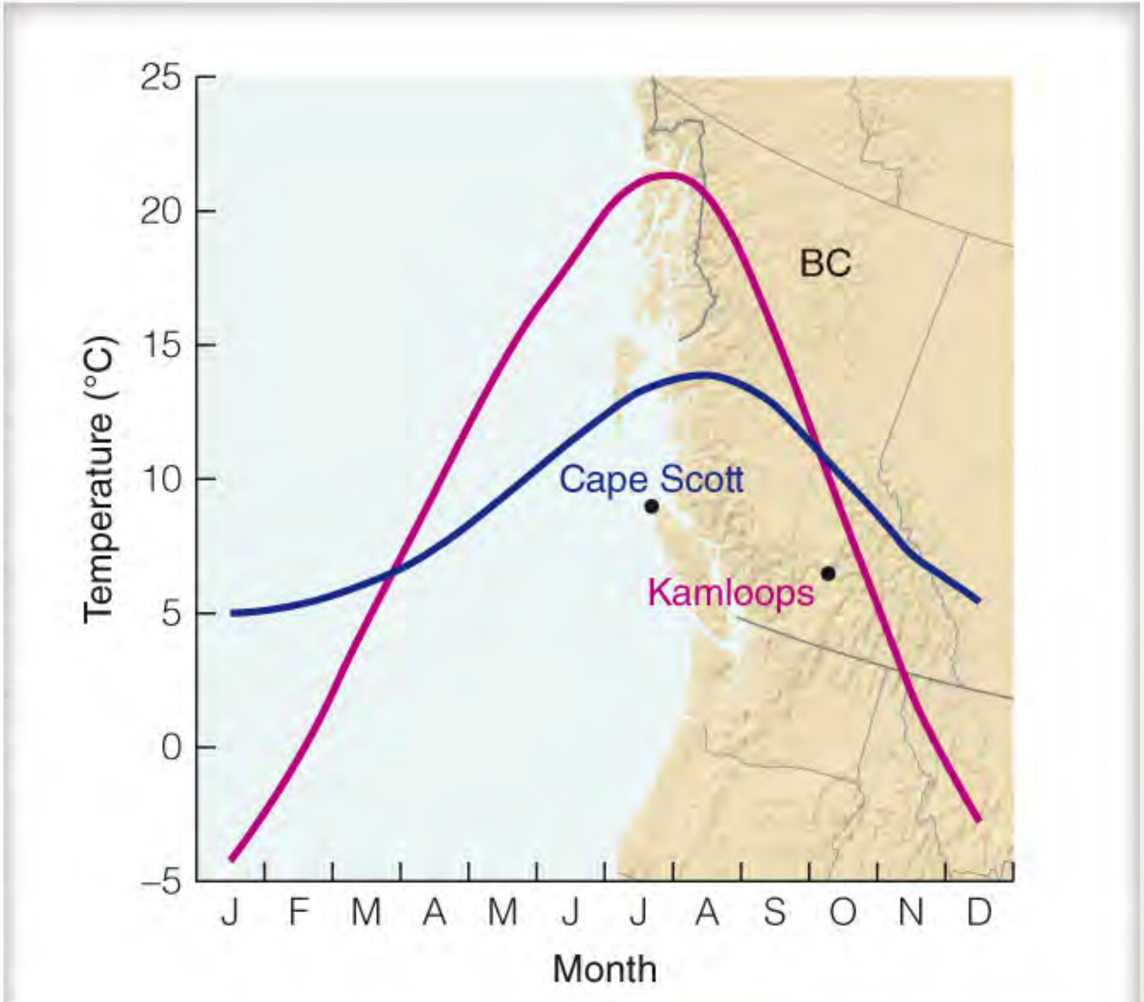
- Water surfaces change temperature more slowly than land given similar insolation.
  - Temperature ranges are smaller
  - Seasonal temperature lags are longer

- *Continentality* is the exacerbation of seasonal temperature extremes experienced by continental interiors

Coastal Climates

Same latitude

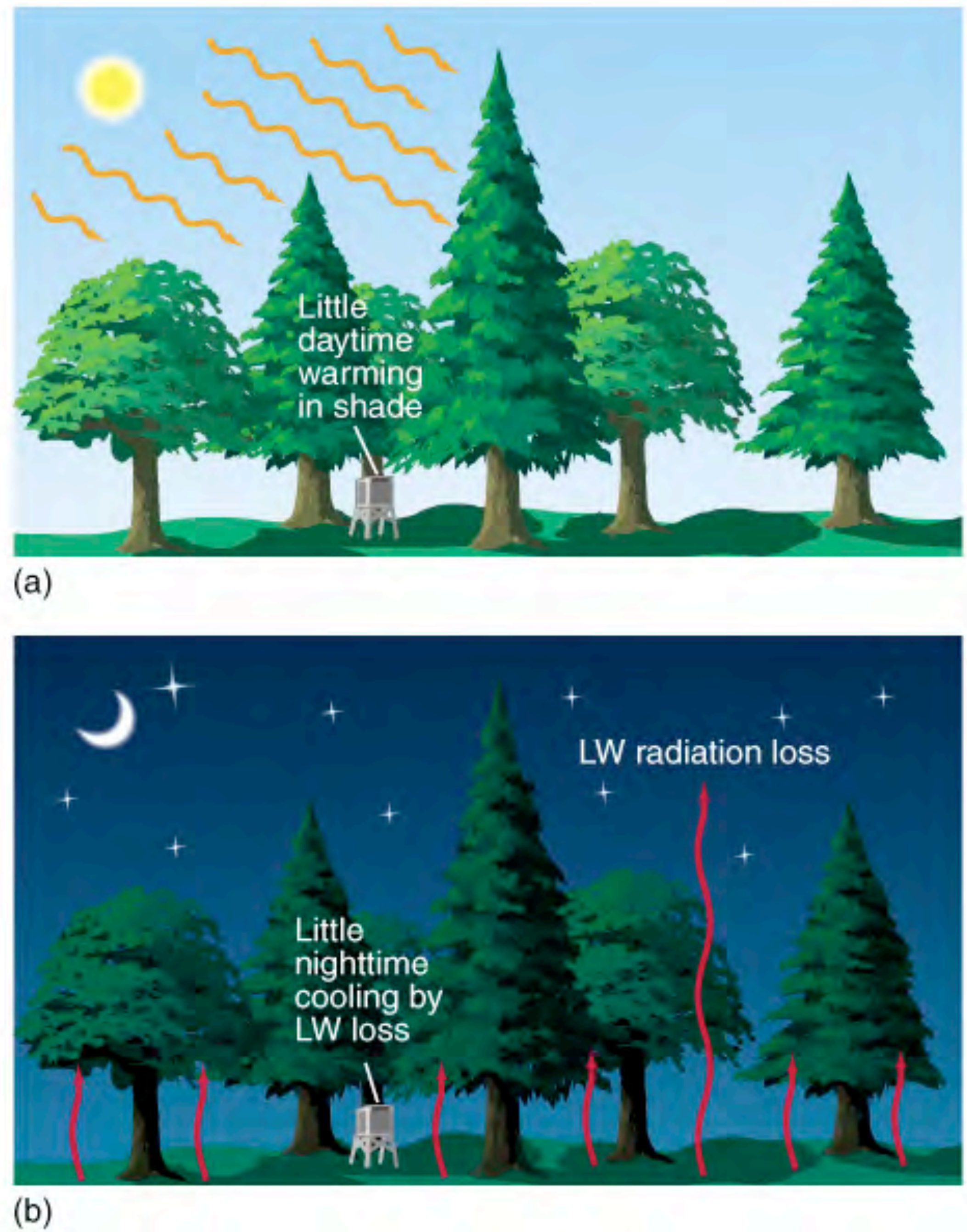
Same average T



Ahrens: Fig. 3.23

Vegetation

Vegetation reduces surface warming during the day and reduces radiation at night



A&B: Figure 3-21

Topography

South-facing slopes are typically more vegetated than north-facing slopes.

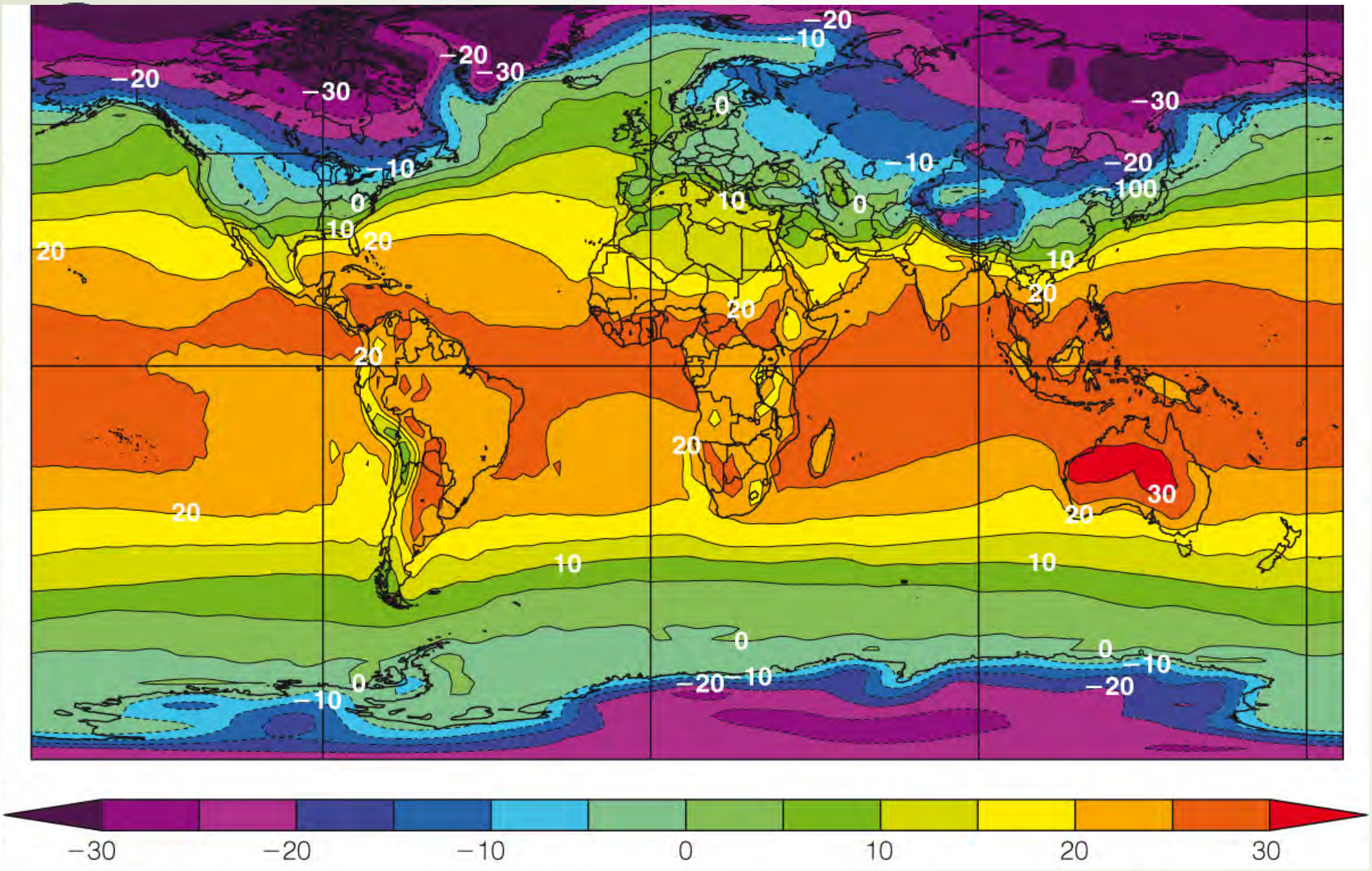
Geography and temperature

- Latitude
- Altitude
- General circulation
- Continentality
- Vegetation
- Topography

Temperature distribution

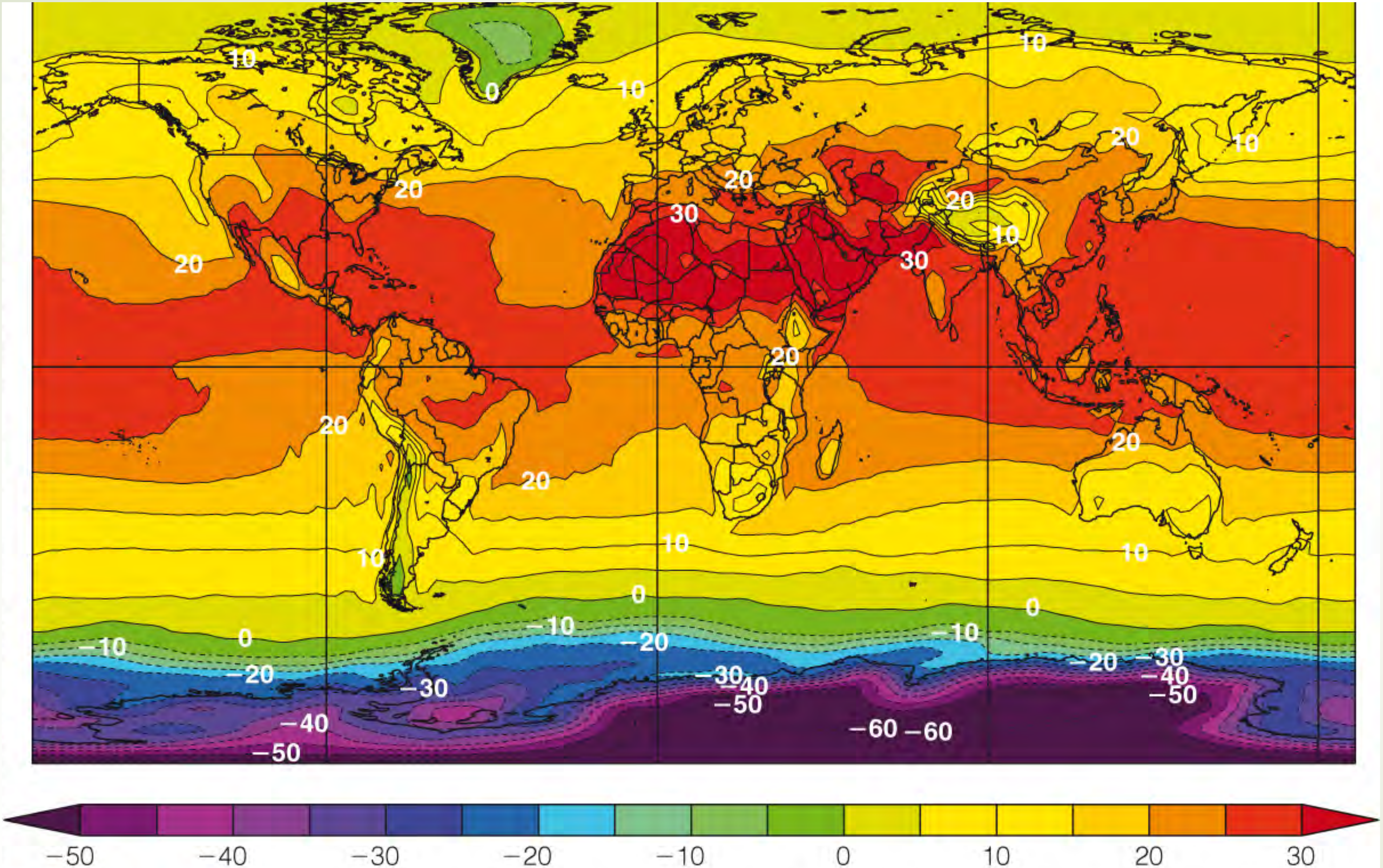
- *Isotherm*
  - A line of constant temperature
  - Used to create contour plots
  - Everywhere between two contours, temperature is between those two values

- Will see several more types of ‘iso-line’ (*isopleth*)



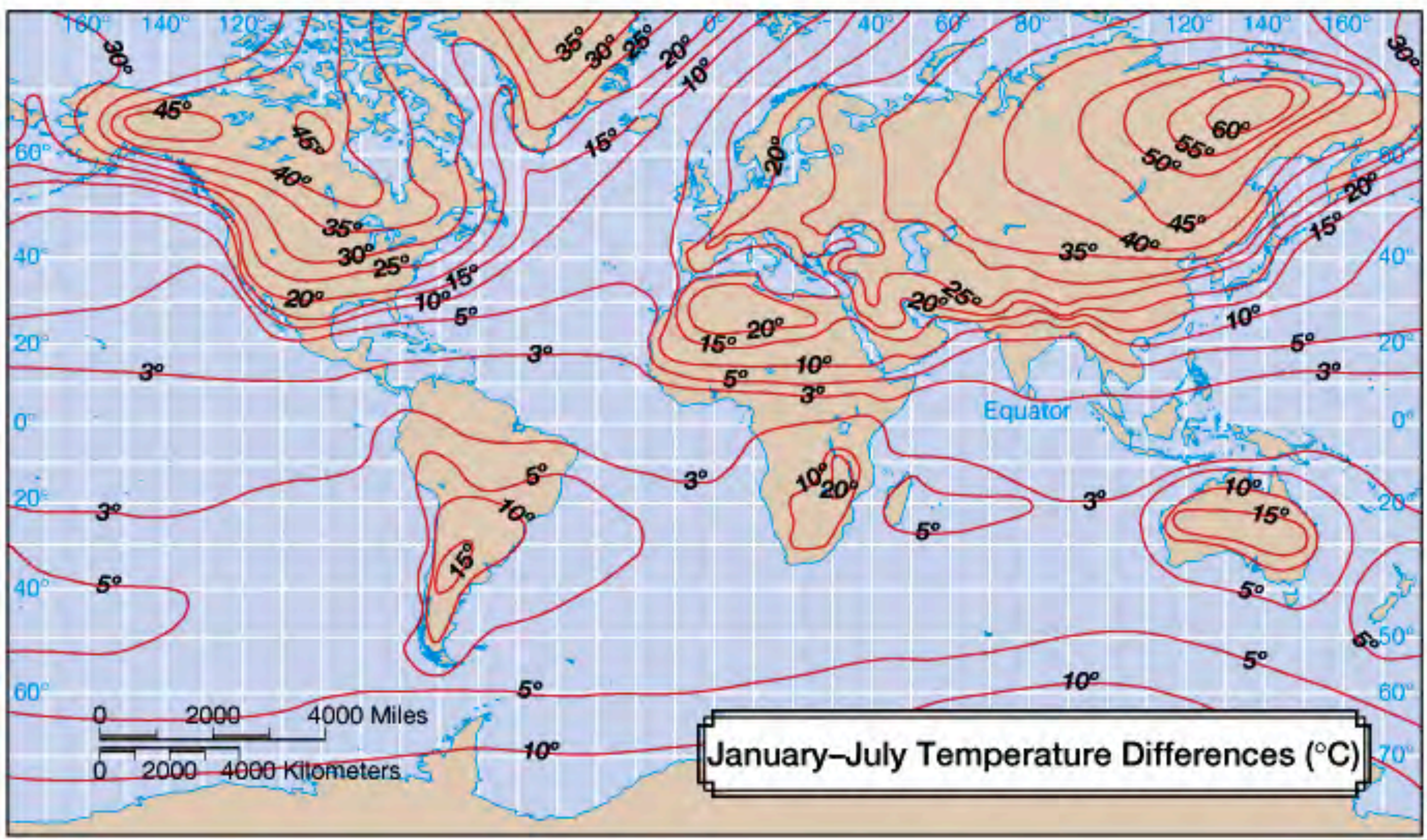
Average January surface air temperature

Ahrens: Figure 3-19



Average June surface air temperature

Ahrens: Figure 3-19



Difference in July/January Temperatures

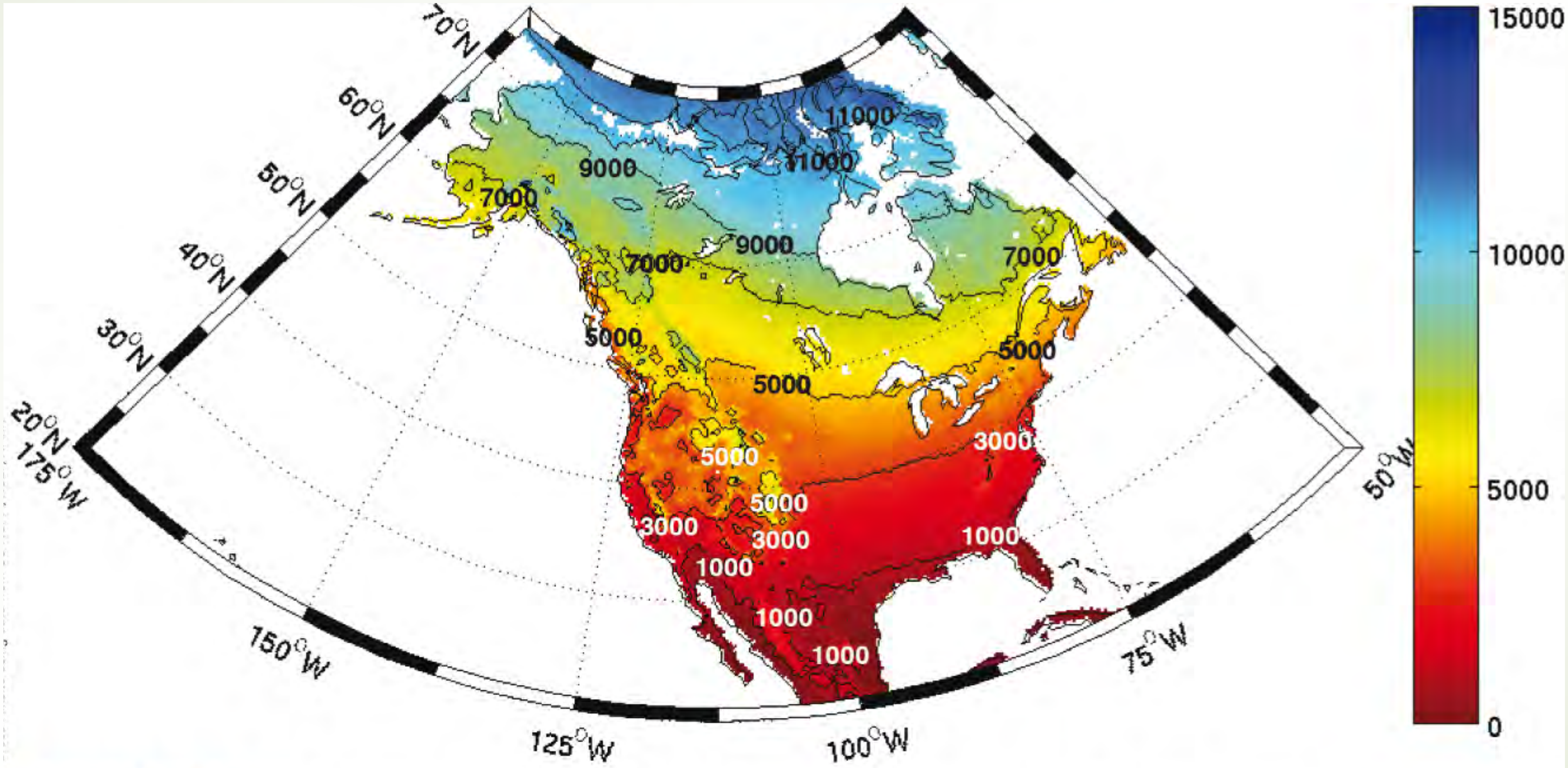
A&B: Fig. 3-18

Heating Degree-Days

- A seasonal total representing the demand for home heating
- For each day in the season:
  - Start with 18C°
  - Subtract that day's mean temperature
  - *If the result is larger than zero*, add it to the total

- Example: daily mean temperatures for five days
  - 18, 17, 19, 12, 10°C
  - 0 + 1 + 0 + 6 + 8
  - Total of 15 heating degree-days

Heating Degree-Days



Ahrens: Fig. 3.24

Wind Chill

- How cold does it feel?
  - Combination of temperature and wind speed
  - Wind does **not** reduce the temperature but it **does** increase the heat loss
  - Changes the skin's *epiclimate*

Wind Chill and Epiclimate

- An *epiclimate* is a very small scale climate surrounding an object
- A small insulating layer near the skin
  - Air is a good insulator (poor conductor)
  - Heat transfer by molecular diffusion
- Wind disrupts the epiclimate

Wind Chill Calculation Chart

/T air (°C)	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
V_{10} (km/h)												
5	4	-2	-7	-13	-19	-24	-30	-36	-41	-47	-53	-58
10	3	-3	-9	-15	-21	-27	-33	-39	-45	-51	-57	-63
15	2	-4	-11	-17	-23	-29	-35	-41	-48	-54	-60	-66
20	1	-5	-12	-18	-24	-31	-37	-43	-49	-56	-62	-68
25	1	-6	-12	-19	-25	-32	-38	-45	-51	-57	-64	-70
30	0	-7	-13	-20	-26	-33	-39	-46	-52	-59	-65	-72
35	0	-7	-14	-20	-27	-33	-40	-47	-53	-60	-66	-73
40	-1	-7	-14	-21	-27	-34	-41	-48	-54	-61	-68	-74
45	-1	-8	-15	-21	-28	-35	-42	-48	-55	-62	-69	-75
50	-1	-8	-15	-22	-29	-35	-42	-49	-56	-63	-70	-76
55	-2	-9	-15	-22	-29	-36	-43	-50	-57	-63	-70	-77
60	-2	-9	-16	-23	-30	-37	-43	-50	-57	-64	-71	-78
65	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79
70	-2	-9	-16	-23	-30	-37	-44	-51	-59	-66	-73	-80
75	-3	-10	-17	-24	-31	-38	-45	-52	-59	-66	-73	-80
80	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81

where Tair = Actual air temperature in °C

V_{10} = Wind speed at 10 metres in km/h (as reported in weather observations)

Approximate Thresholds:

Risk of frostbite in prolonged exposure: windchill below	-25	
Frostbite possible in 10 minutes at	-35	Warm skin, suddenly exposed. Shorter time if skin is cool at the start.
Frostbite possible in less than 2 minutes at	-60	Warm skin, suddenly exposed. Shorter time if skin is cool at the start.

Coming up

- Lab 2: Isotherms and Isobars
- Atmospheric mechanics
  - Forces, pressure and wind
- Ahrens: Chapter 8