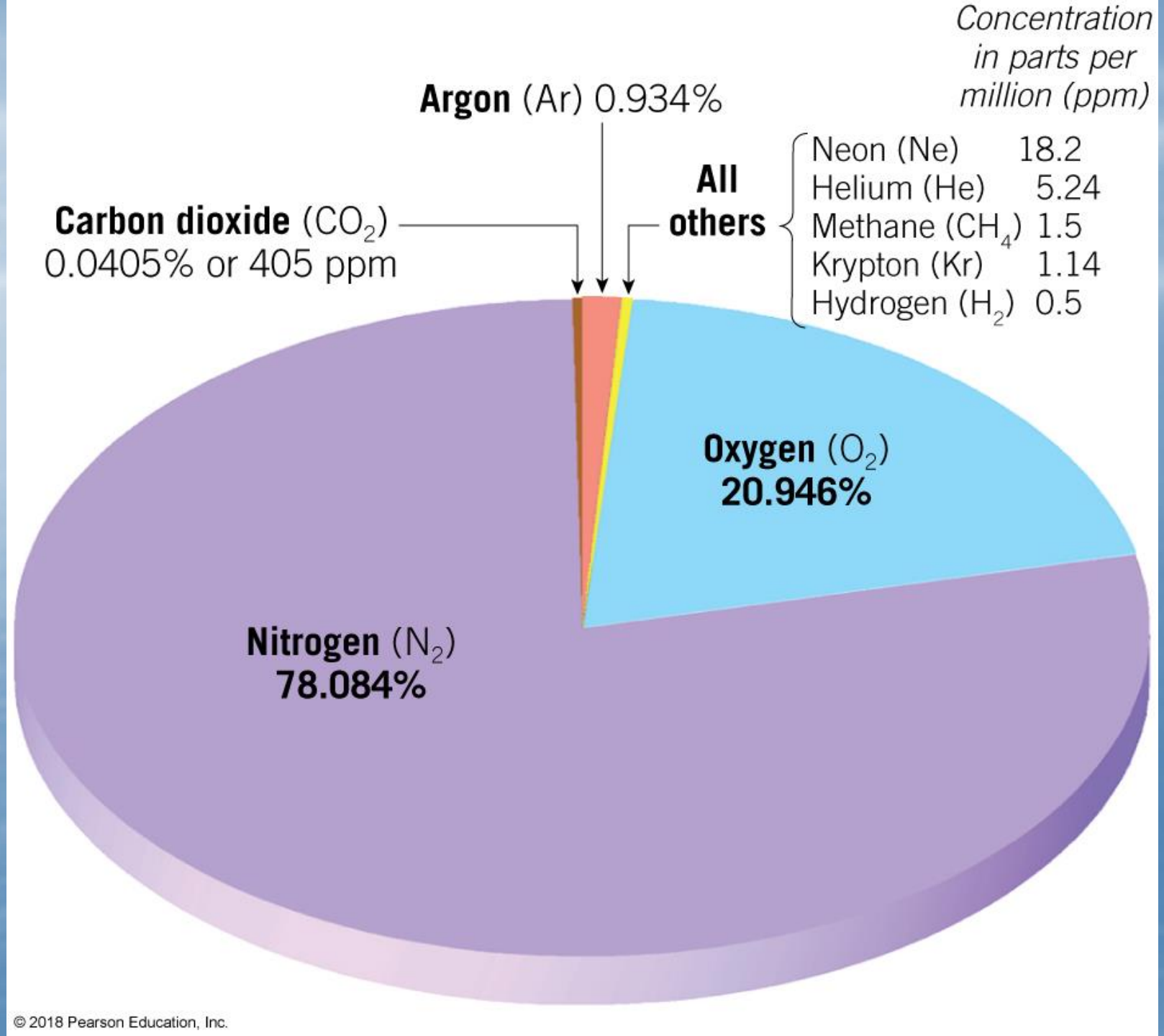
# THE ATMOSPHERE

Composition, Structure, and Temperature

# ELEMENTS OF WEATHER AND CLIMATE

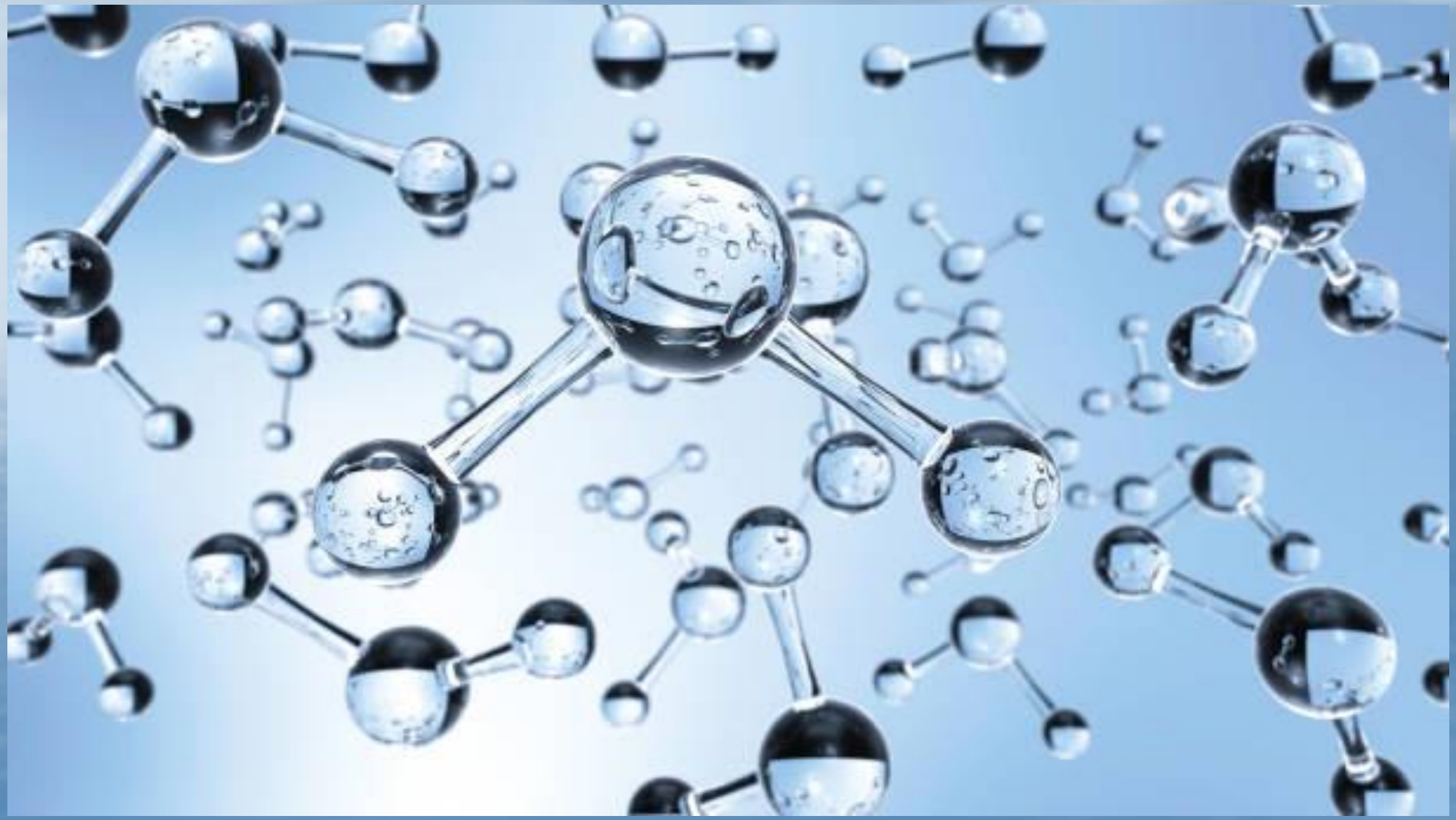
- Temperature – average energy of molecules
- Humidity – the amount of water vapor in the air
- Cloudiness
- Precipitation – moisture falling from the sky (rain, snow, hail, sleet, etc.)
- Air Pressure
- Wind Speed and Direction

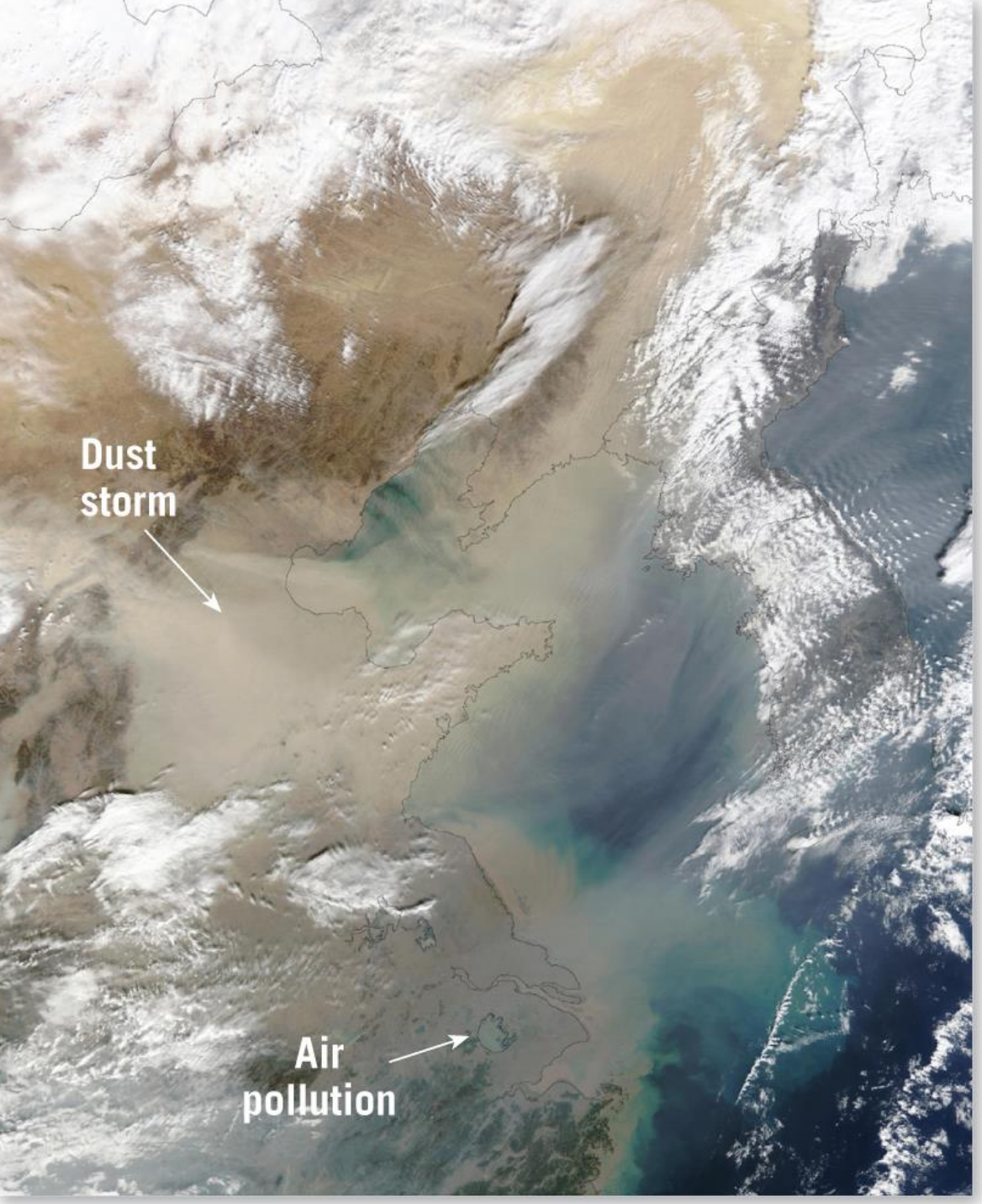




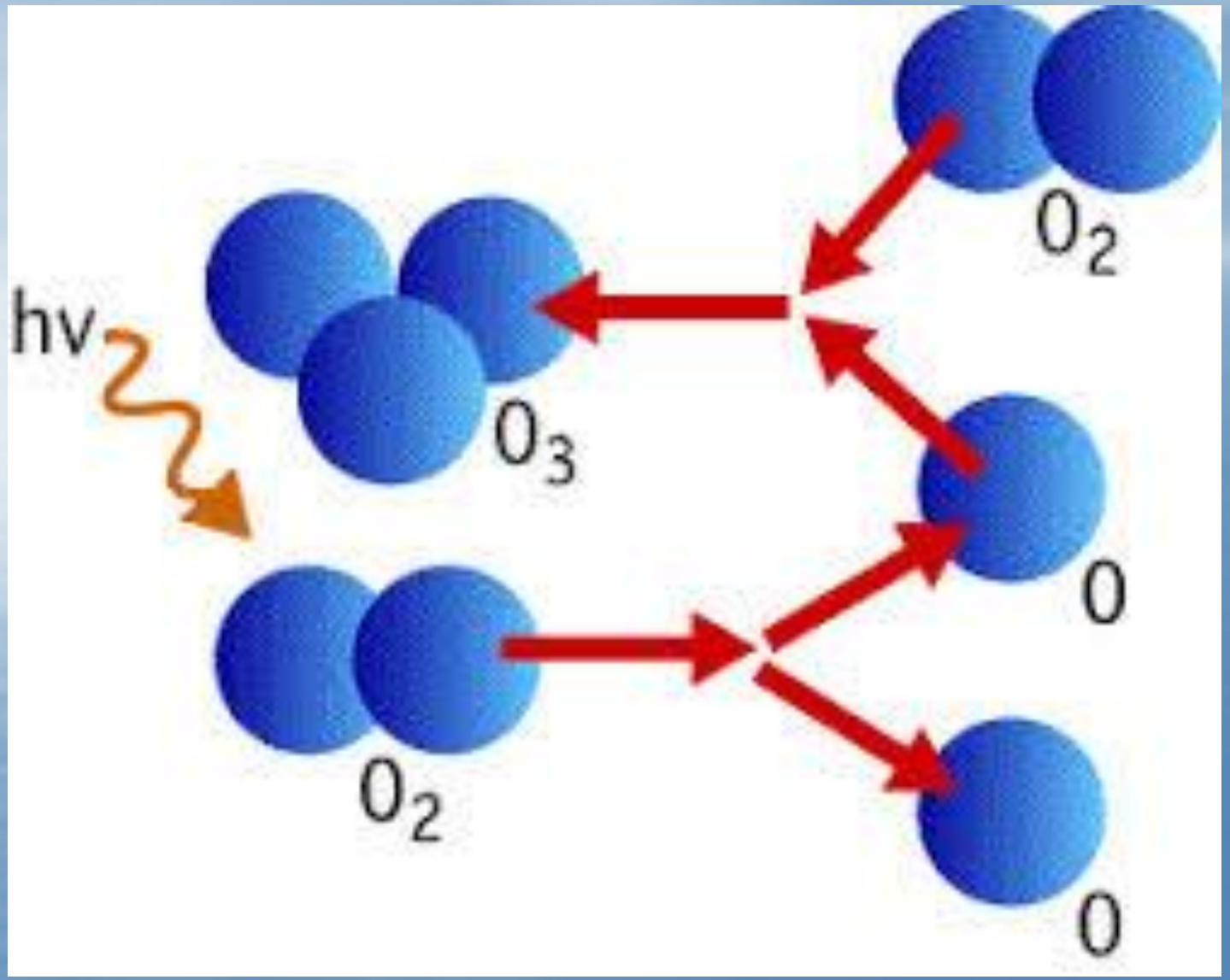

Daily $CO_2$

**The amount of water vapor in the air varies from 0 to 4% by volume.**





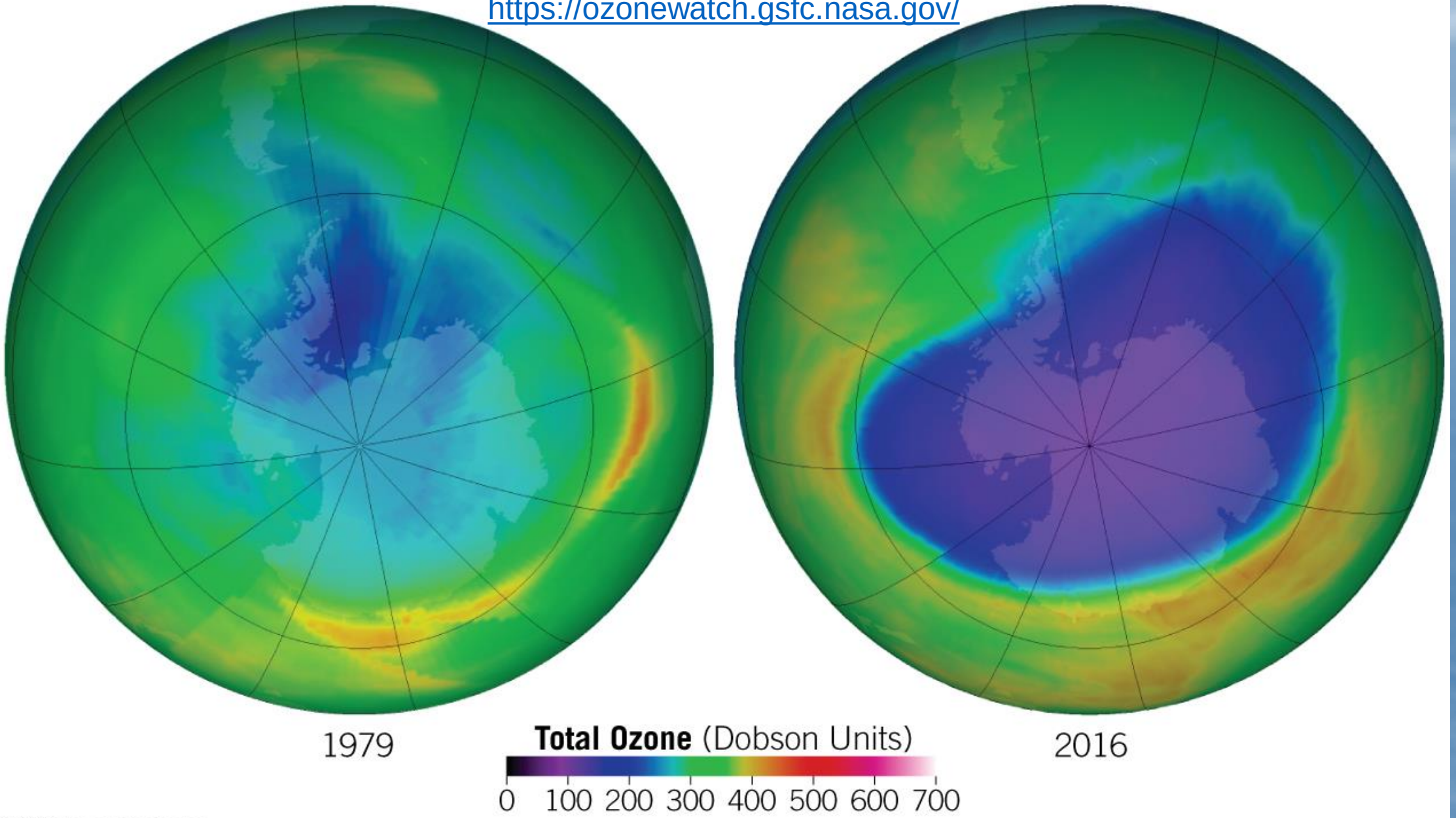

Air Quality: https://www.airnow.gov/

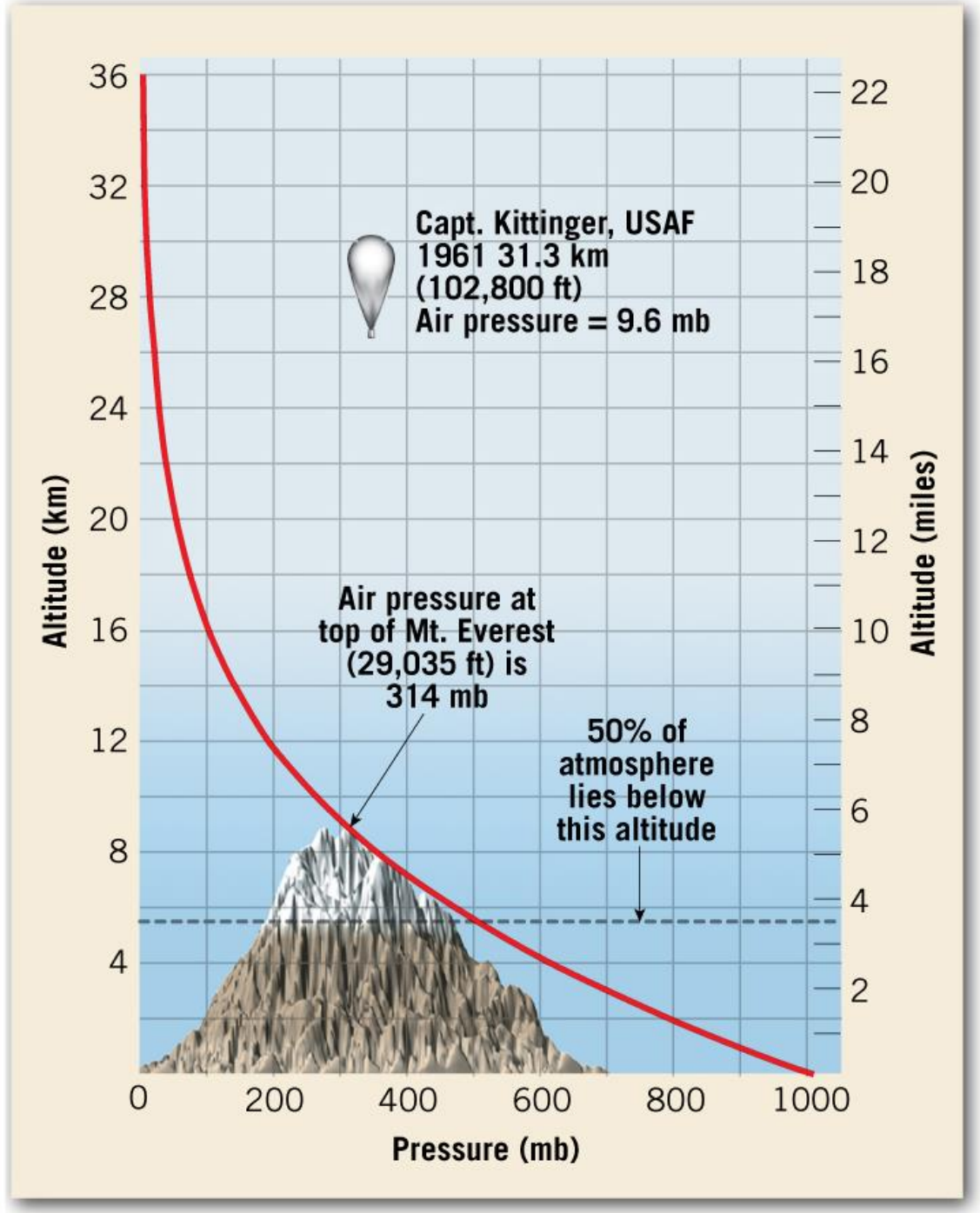



# Ozone

**The ozone hole on October 1, 2016, reached 23 million km² (8.9 million mi²)—an area nearly as large as North America.**

https://ozonewatch.gsfc.nasa.gov/





# Environmental Lapse Rate

**In the Troposphere the temperature decreases with altitude**

**6.5 degrees Celsius per kilometer (average)**

**3.5 degrees Fahrenheit per 1000 feet (average)**

**6.5 degrees Celsius per 1000 meters (average)**

**3.5 degrees Fahrenheit per 1000 feet (average)**

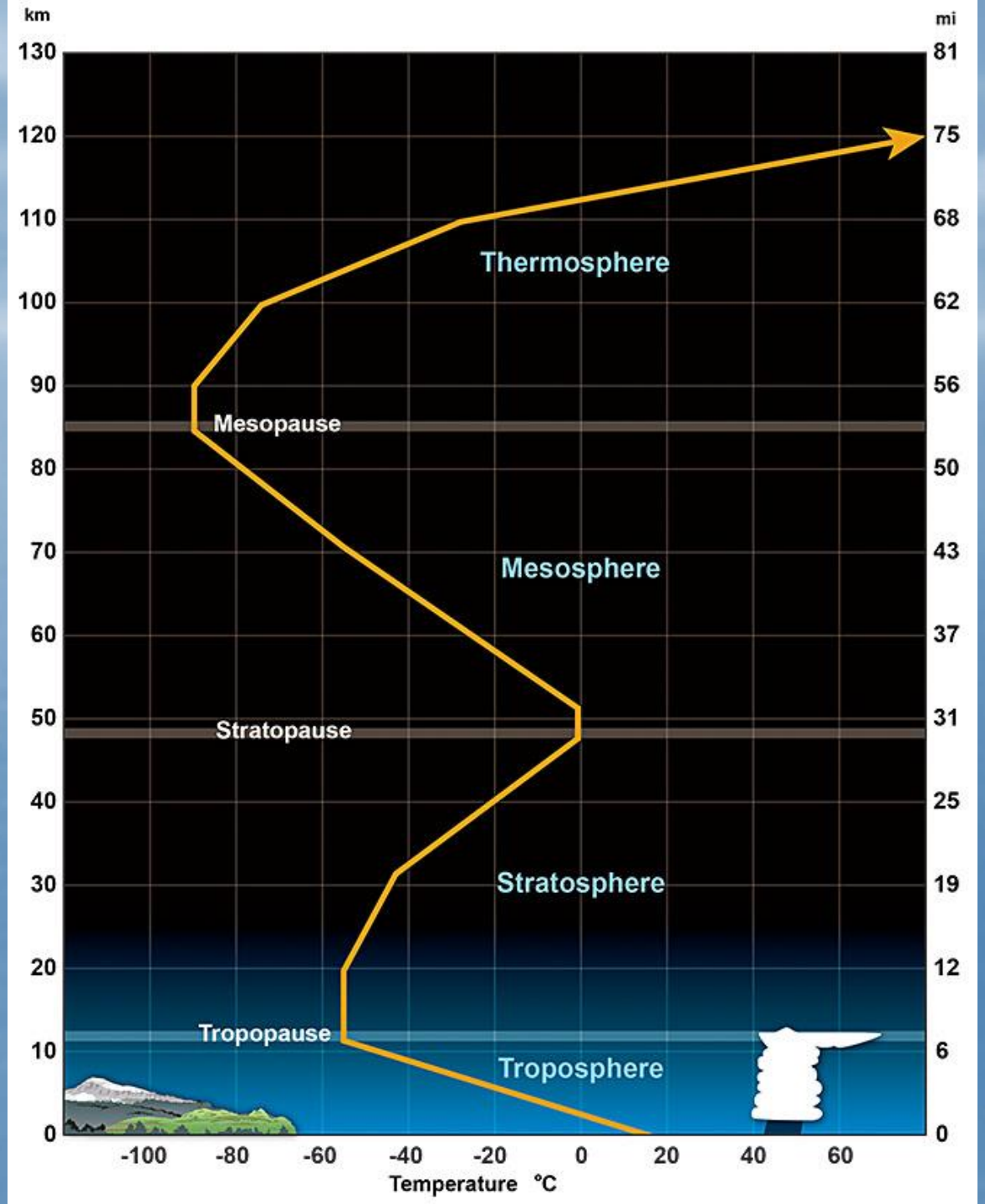
Begin in Colorado Springs
Altitude is 6,000 feet (1830 meters)
Temp: 70 degrees Fahrenheit, 21 degrees Celsius

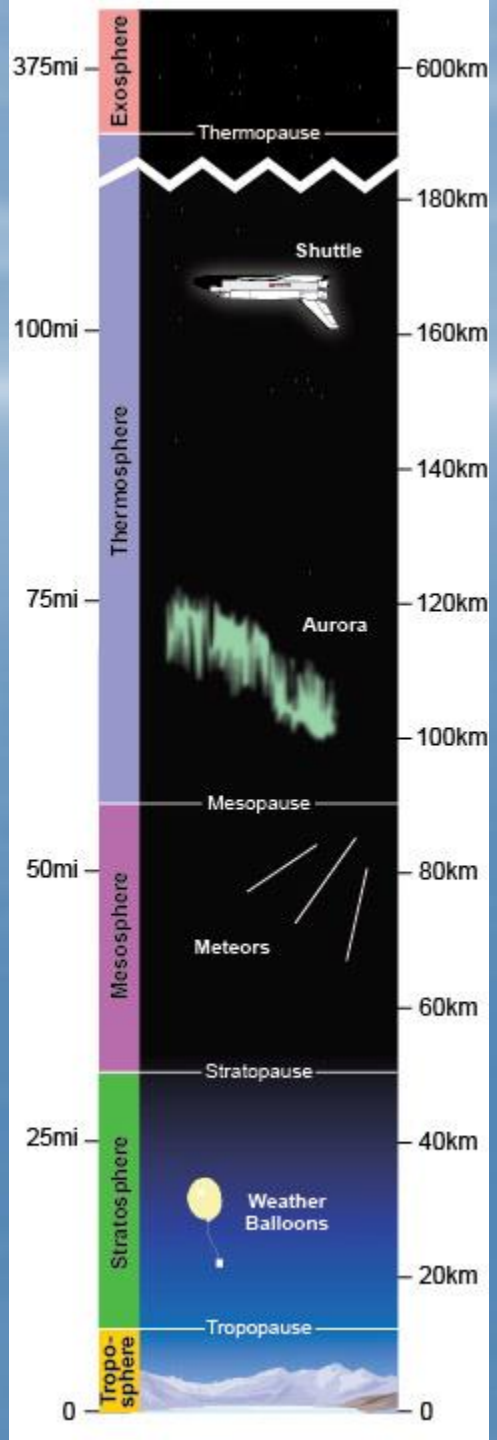
Go to Pikes Peak and climb to the top
14,000 feet (4,300 meters)
What temperature is expected?

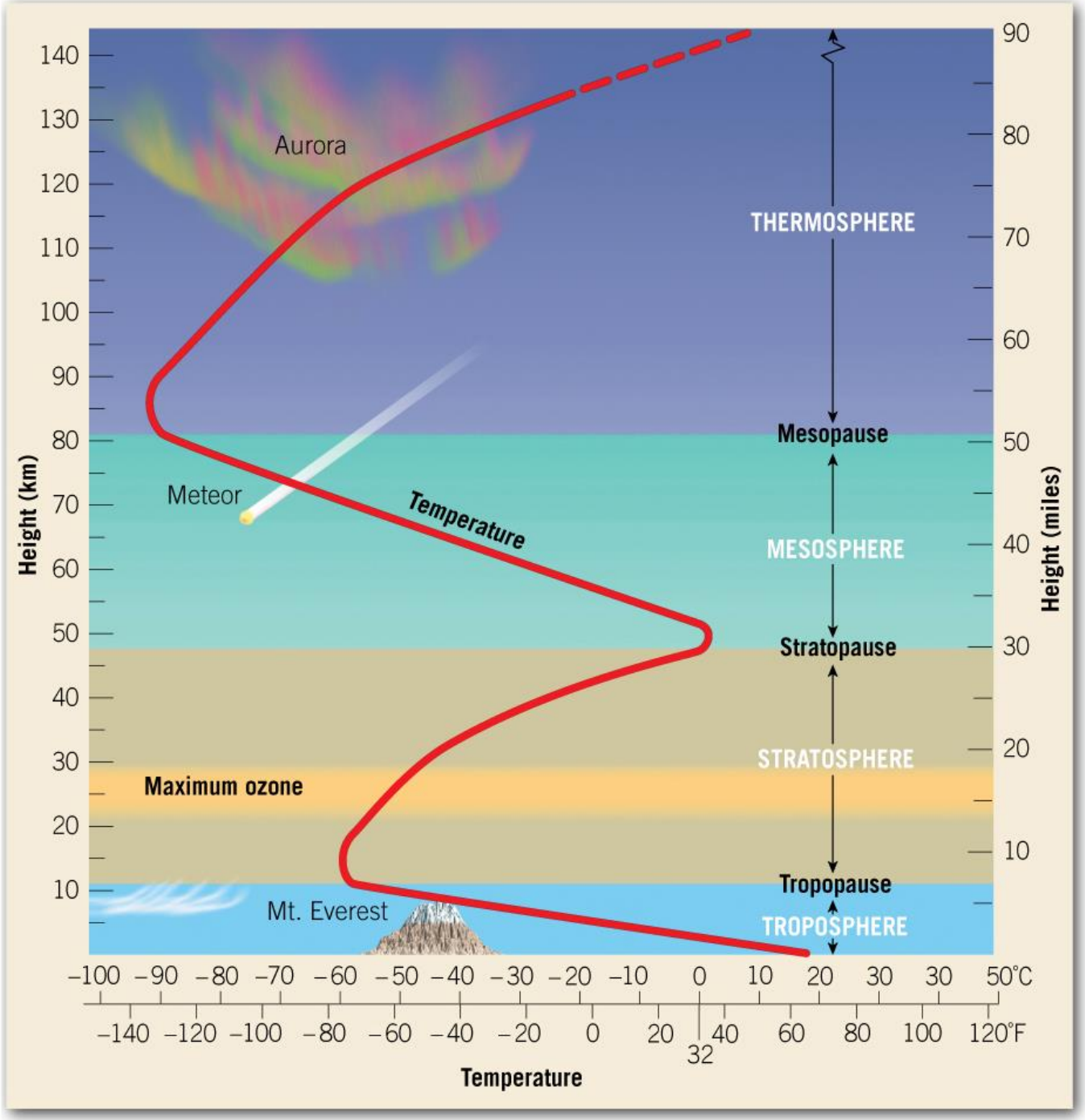
# CALCULATION

- 14,000 – 6,000 = 8,000 feet higher
- 8 X 3.5$^{o}$F = 28$^{o}$F colder
- 70$^{o}$F – 28$^{o}$F = 42$^{o}$F

- 4,300 – 1,830 = 2,470 meters higher
- 2.470 X 6.5$^{o}$C= 16$^{o}$C colder
- 21$^{o}$C - 16$^{o}$C = 5$^{o}$C

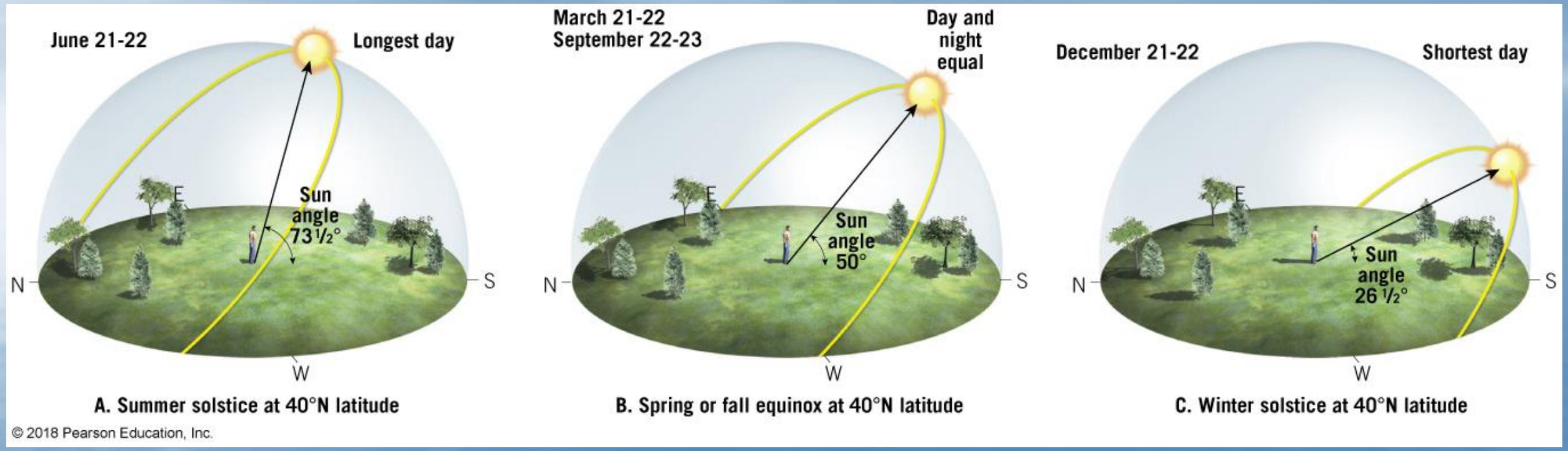

km
mi
130
120
110
100
90
80
70
60
50
40
30
20
10
0
81
75
68
62
56
50
43
37
31
25
19
12
6
0
Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere
-100
-80
-60
-40
-20
0
20
40
60
Temperature °C


375mi
100mi
75mi
50mi
25mi
0
600km
180km
160km
140km
120km
100km
80km
60km
40km
20km
0
Exosphere
Thermopause
Thermosphere
Shuttle
Aurora
Mesopause
Mesosphere
Meteors
Stratopause
Stratosphere
Weather Balloons
Tropopause
Tropo-sphere



# EARTH SUN MOTIONS

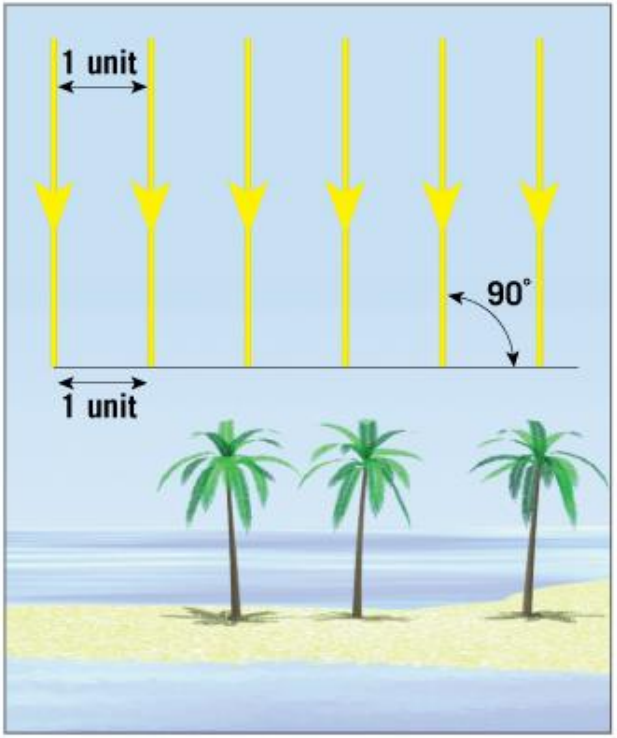
https://www.youtube.com/watch?v=WgHmqv_-UbQ

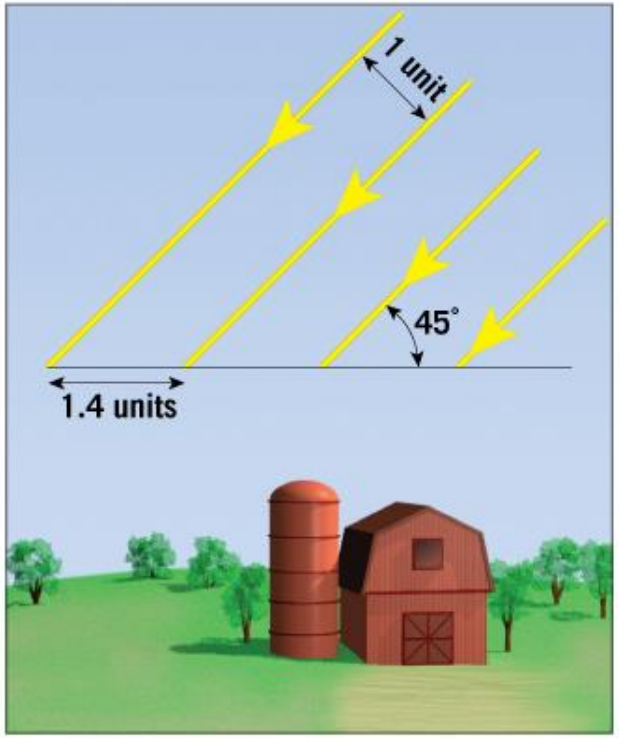


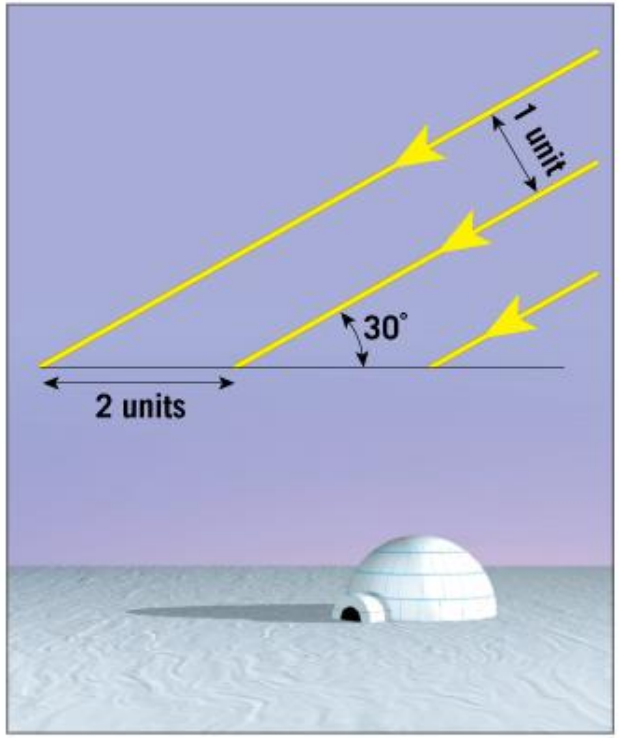

A. Summer solstice at 40°N latitude

B. Spring or fall equinox at 40°N latitude

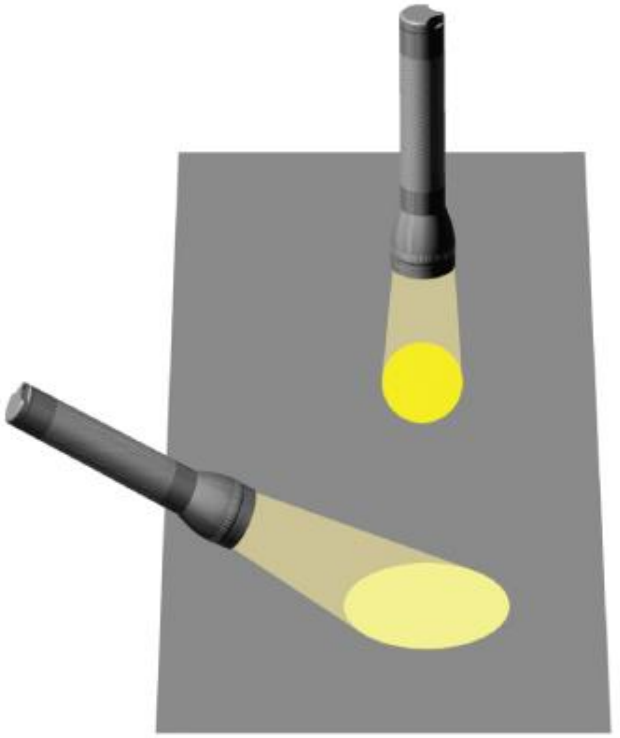
C. Winter solstice at 40°N latitude



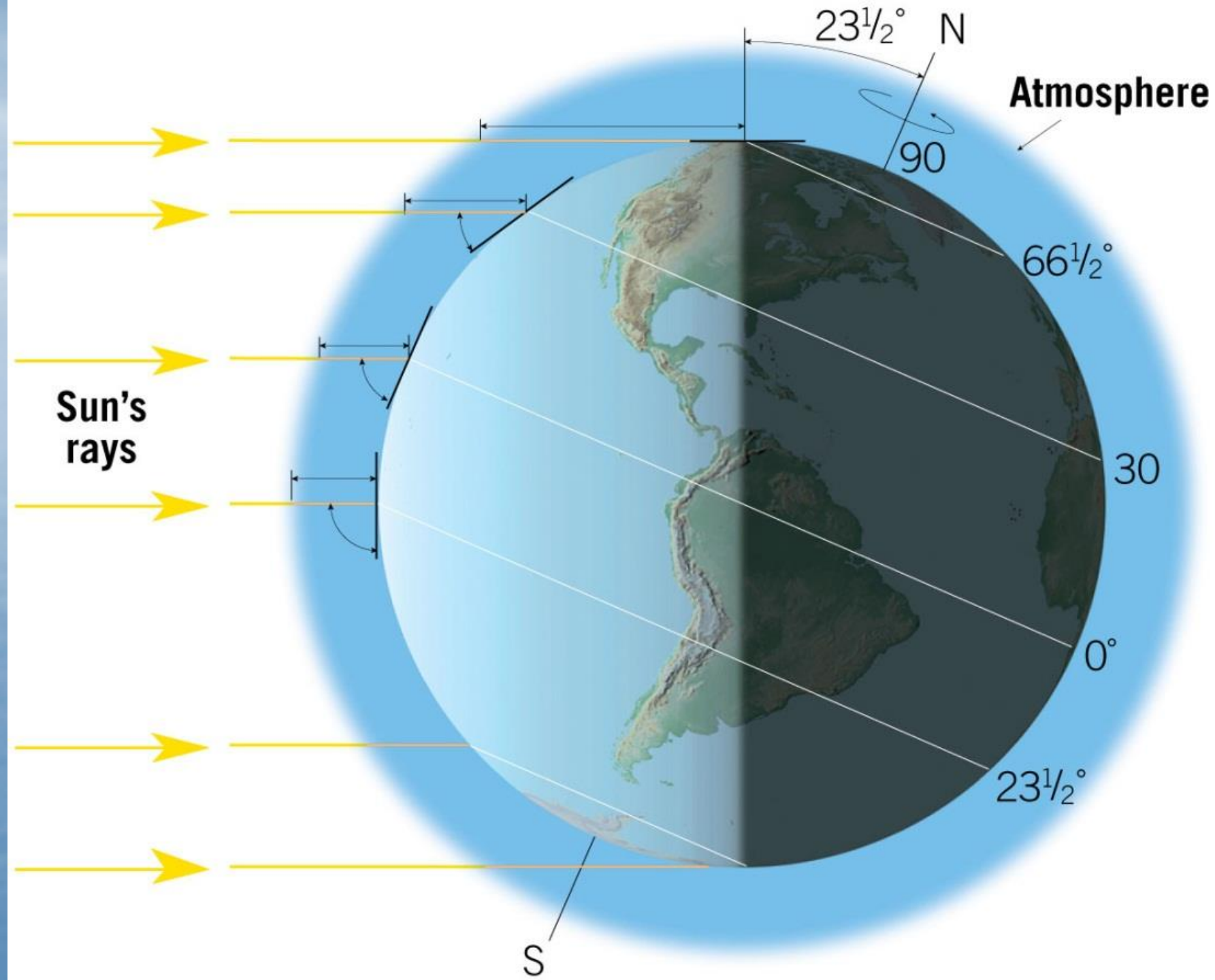



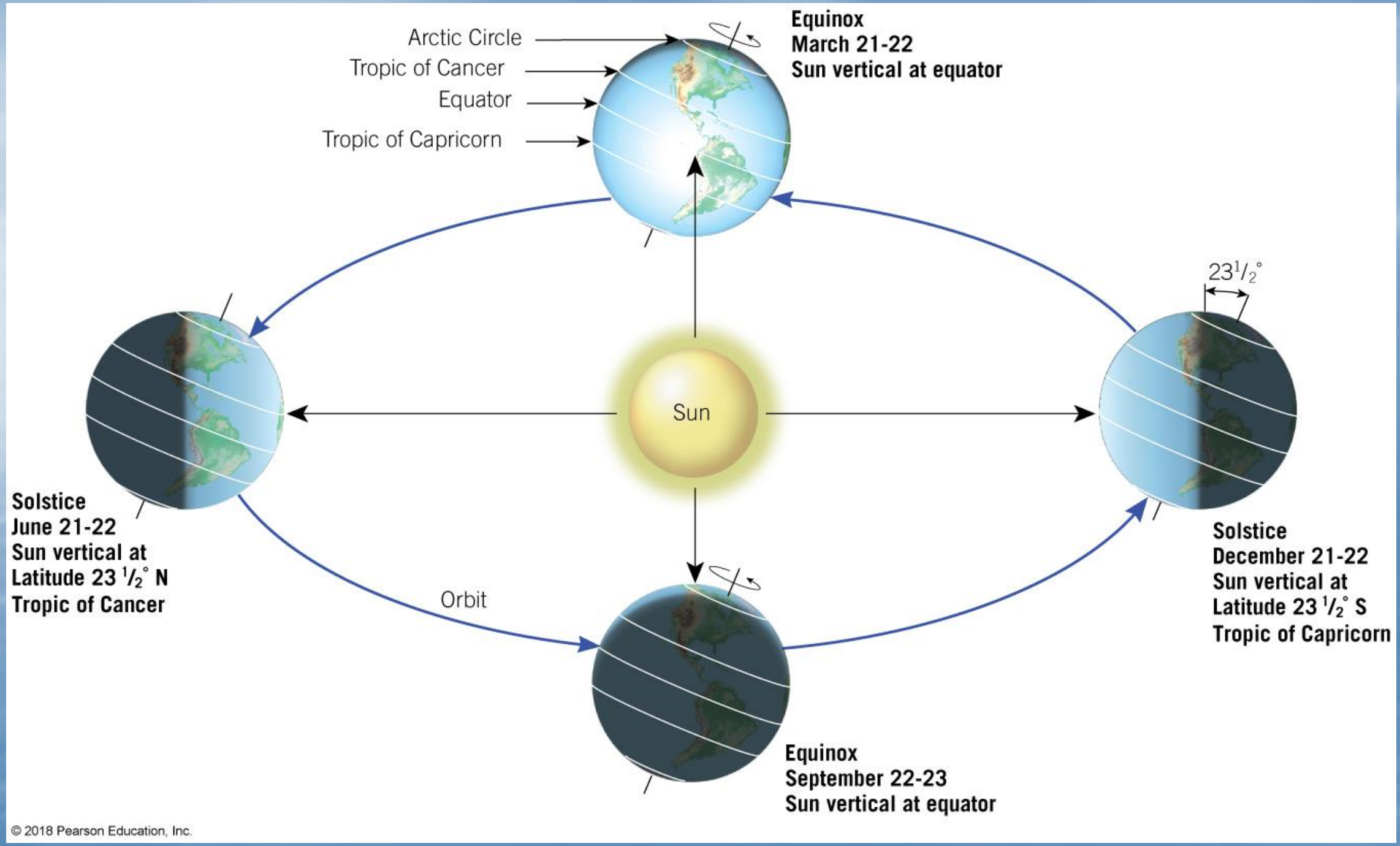



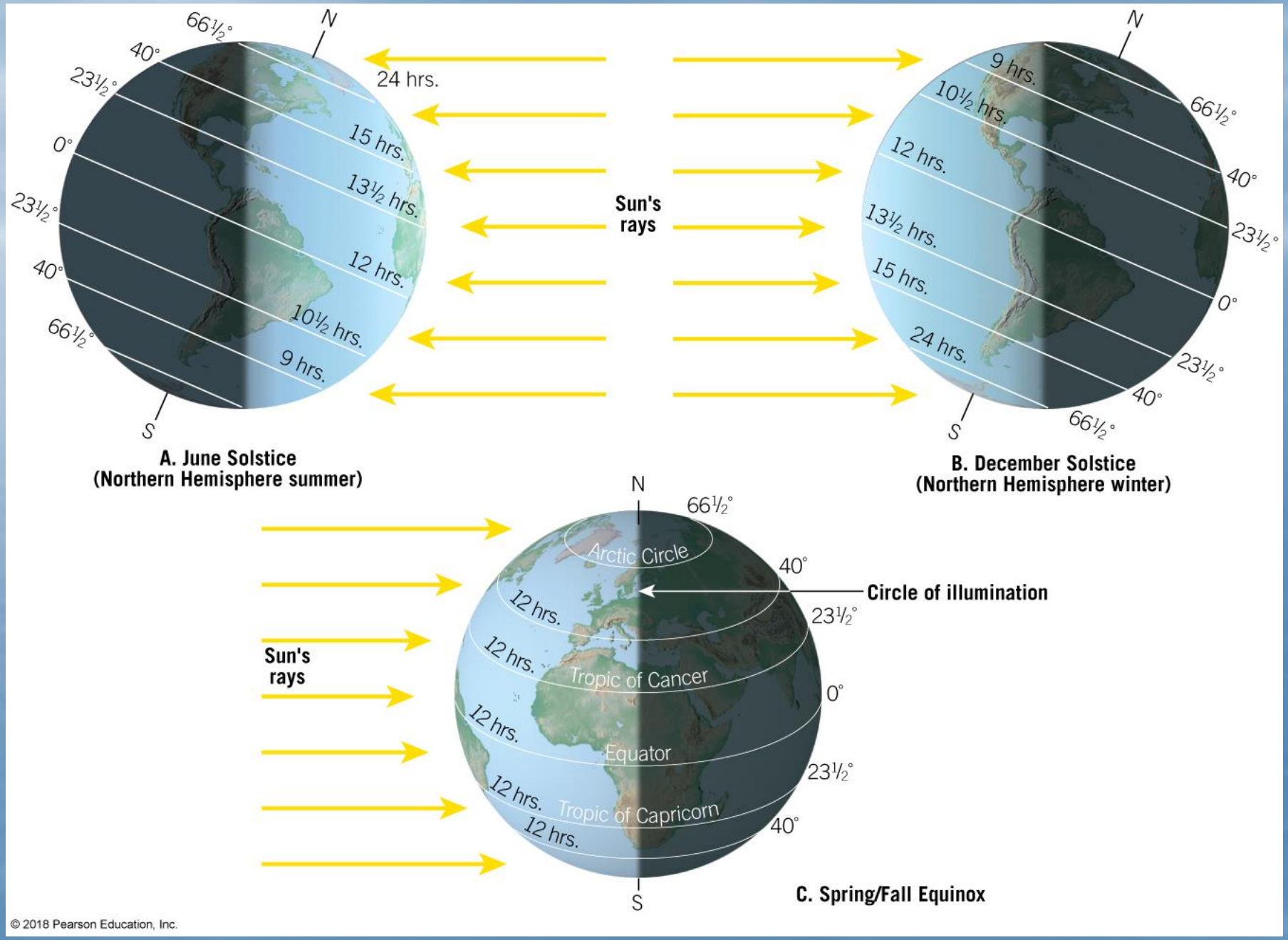

A.



B.


23½°
N
Atmosphere
90
66½°
Sun's rays
30
0°
23½°
S




N
66½°
40°
23½°
0°
23½°
40°
66½°
S
24 hrs.
15 hrs.
13½ hrs.
12 hrs.
10½ hrs.
9 hrs.
Sun's rays
A. June Solstice
(Northern Hemisphere summer)
N
9 hrs.
10½ hrs.
12 hrs.
13½ hrs.
15 hrs.
24 hrs.
66½°
40°
23½°
0°
23½°
40°
66½°
S
B. December Solstice
(Northern Hemisphere winter)
N
66½°
Arctic Circle
40°
Circle of illumination
23½°
12 hrs.
12 hrs.
Tropic of Cancer
0°
12 hrs.
Equator
23½°
12 hrs.
Tropic of Capricorn
12 hrs.
40°
S
Sun's rays
C. Spring/Fall Equinox
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# Matching

*For each item on the right – what is going on in the northern hemisphere?*

*Answer choices*

**Winter Solstice (WS)**

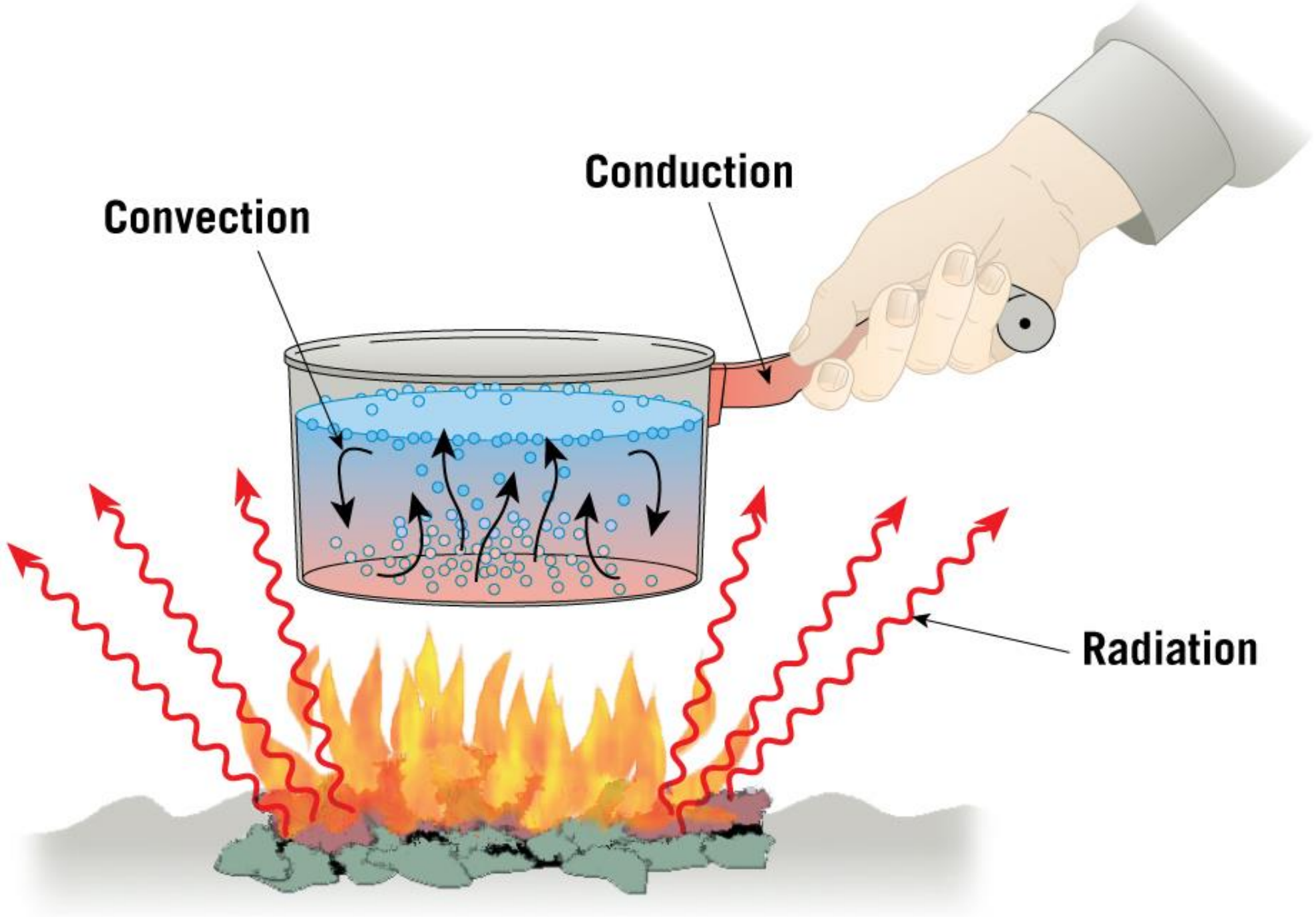
**Vernal Equinox (VE)**

**Summer Solstice (SS)**

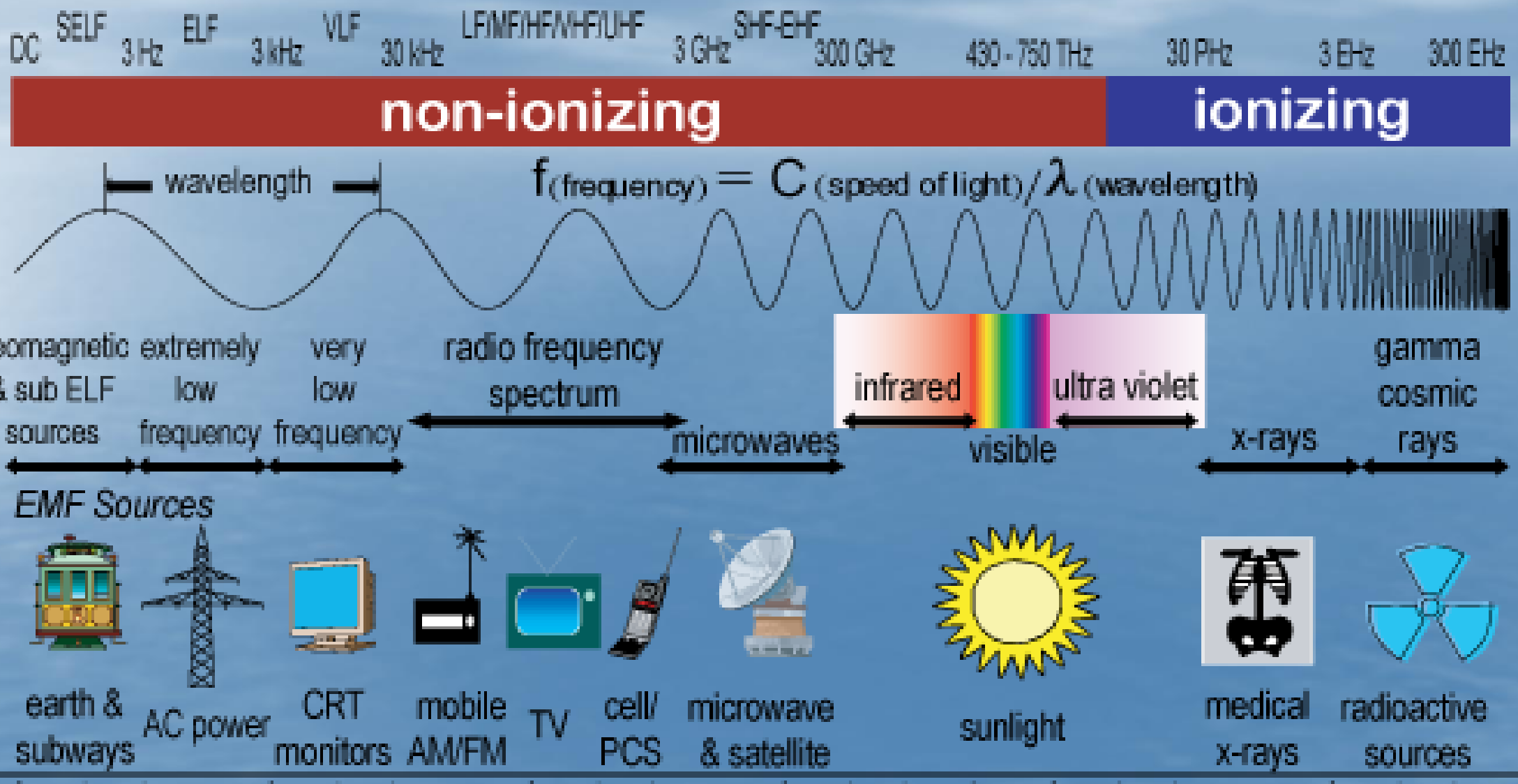
**Autumnal Equinox (AE)**

1. Longest Day of the Year in the Northern Hemisphere
2. Direct Rays of the Sun fall on the Tropic of Capricorn
3. Everywhere on the globe receives 12H or day and 12H of night
4. Shortest Day of the Year in the Northern Hemisphere
5. Direct Rays of the Sun fall on the Tropic of Cancer
6. The Arctic circle experiences a day without sunset
7. The Antarctic circle experiences a day without sunset
8. The sun never rises on the North Pole (24-hour night)
9. The sun never rises on the South Pole (24-hour night)
10. Direct Rays of the Sun fall on the Equator

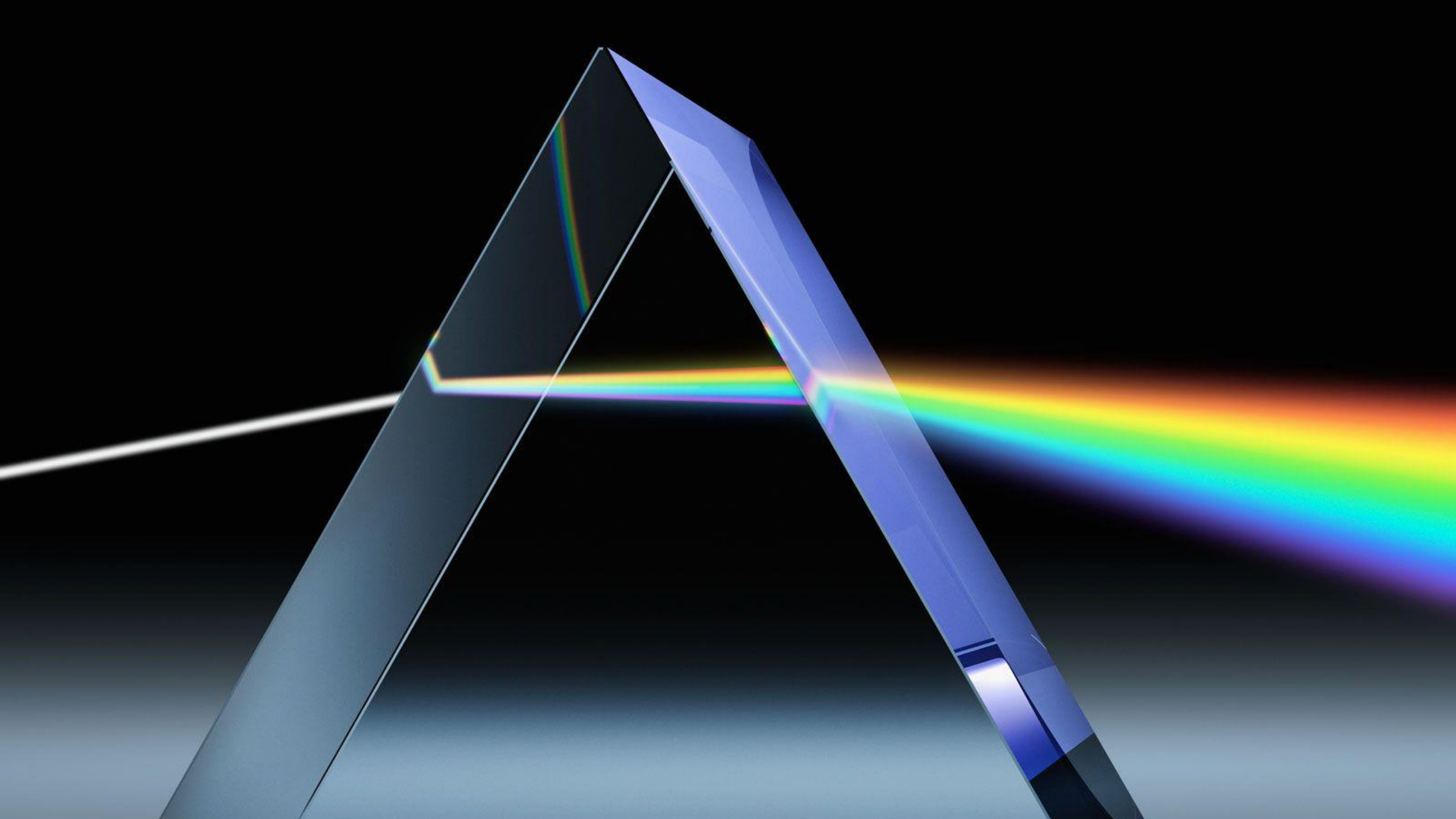
# ENERGY, HEAT AND TEMPERATURE

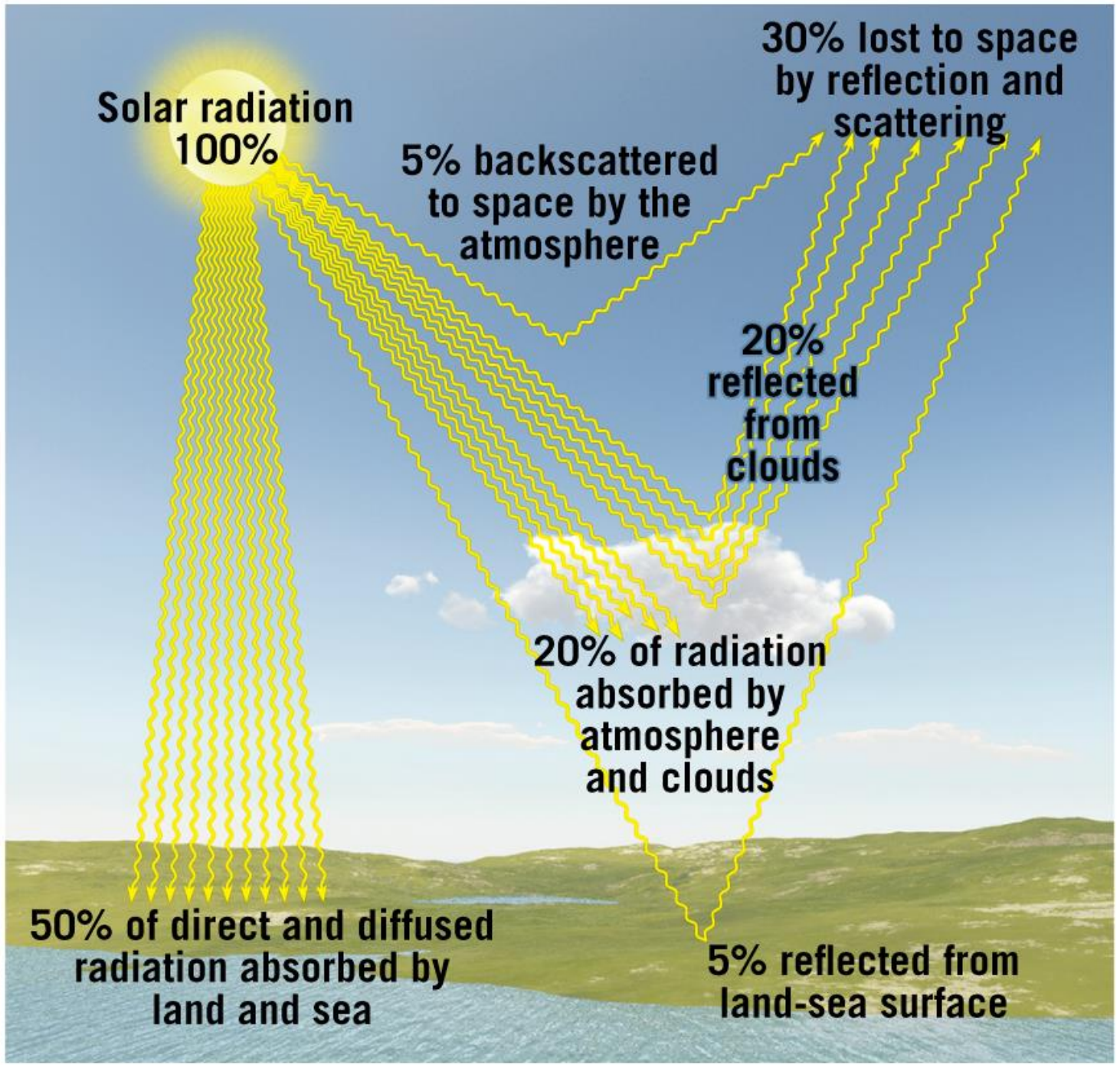


# THE ELECTROMAGNETIC SPECTRUM




Gigahertz (GHz) 10-9 Terahertz (THz) 10-12 Petahertz (PHz) 10-15 Exahertz (EHz) 10-18 Zettahertz (ZHz) 10-21 Yottahertz (YHz) 10-24







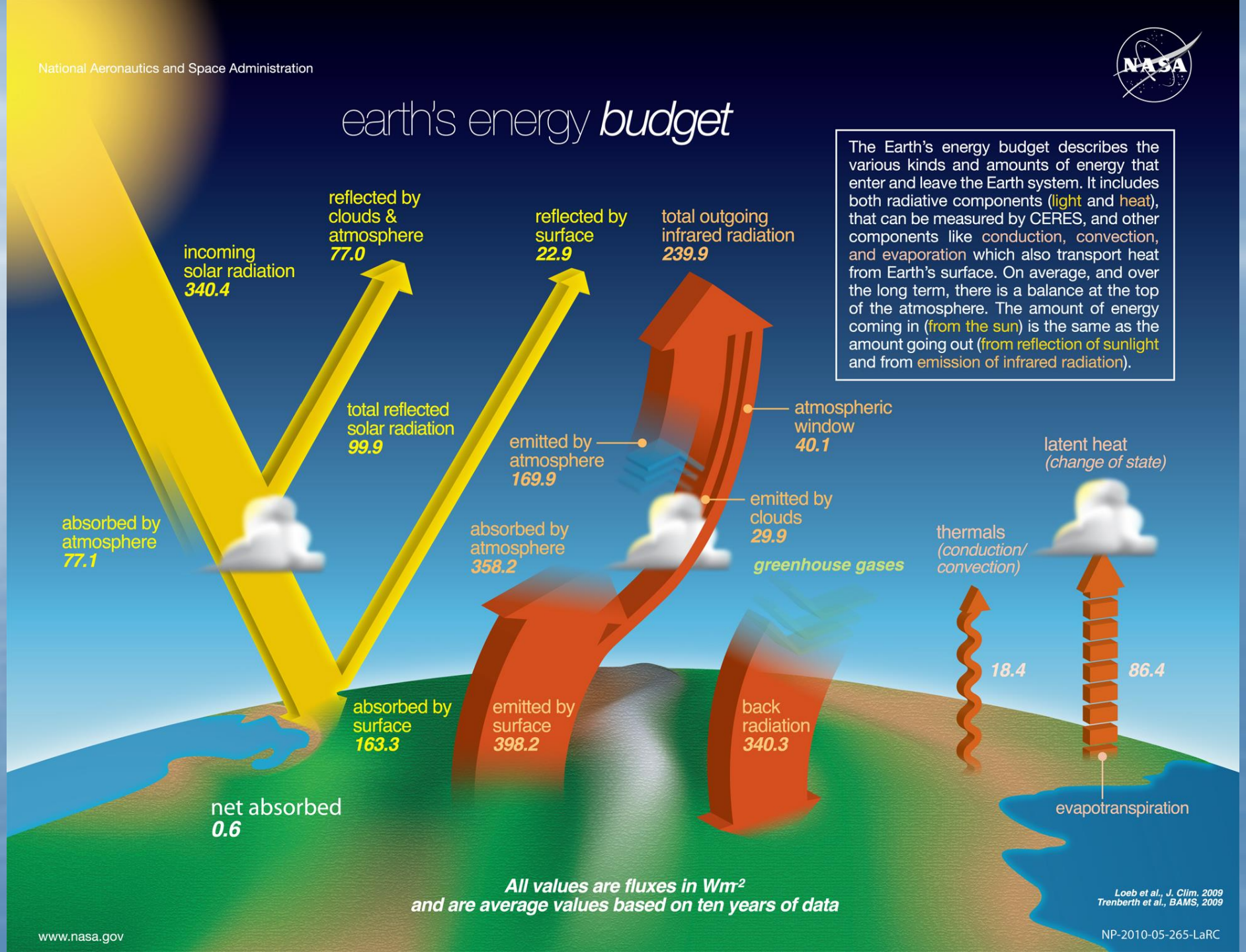

# Light and Matter

Absorb
Reflect
Refract
Scatter
Emit

National Aeronautics and Space Administration

# earth's energy *budget*

The Earth's energy budget describes the various kinds and amounts of energy that enter and leave the Earth system. It includes both radiative components (light and heat), that can be measured by CERES, and other components like conduction, convection, and evaporation which also transport heat from Earth's surface. On average, and over the long term, there is a balance at the top of the atmosphere. The amount of energy coming in (from the sun) is the same as the amount going out (from reflection of sunlight and from emission of infrared radiation).

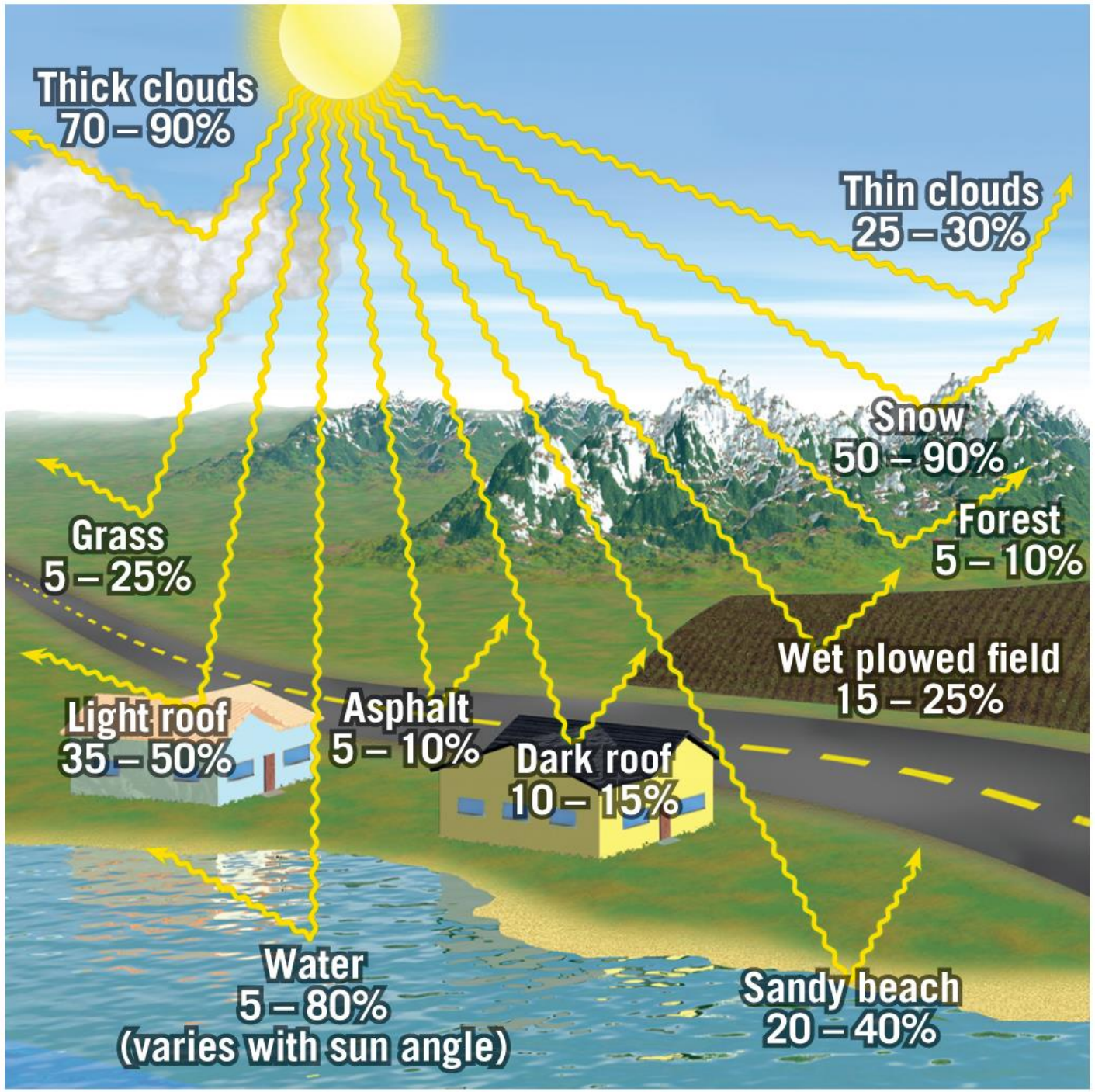



***All values are fluxes in $Wm^{-2}$ and are average values based on ten years of data***

*Loeb et al., J. Clim. 2009*
*Trenberth et al., BAMS, 2009*

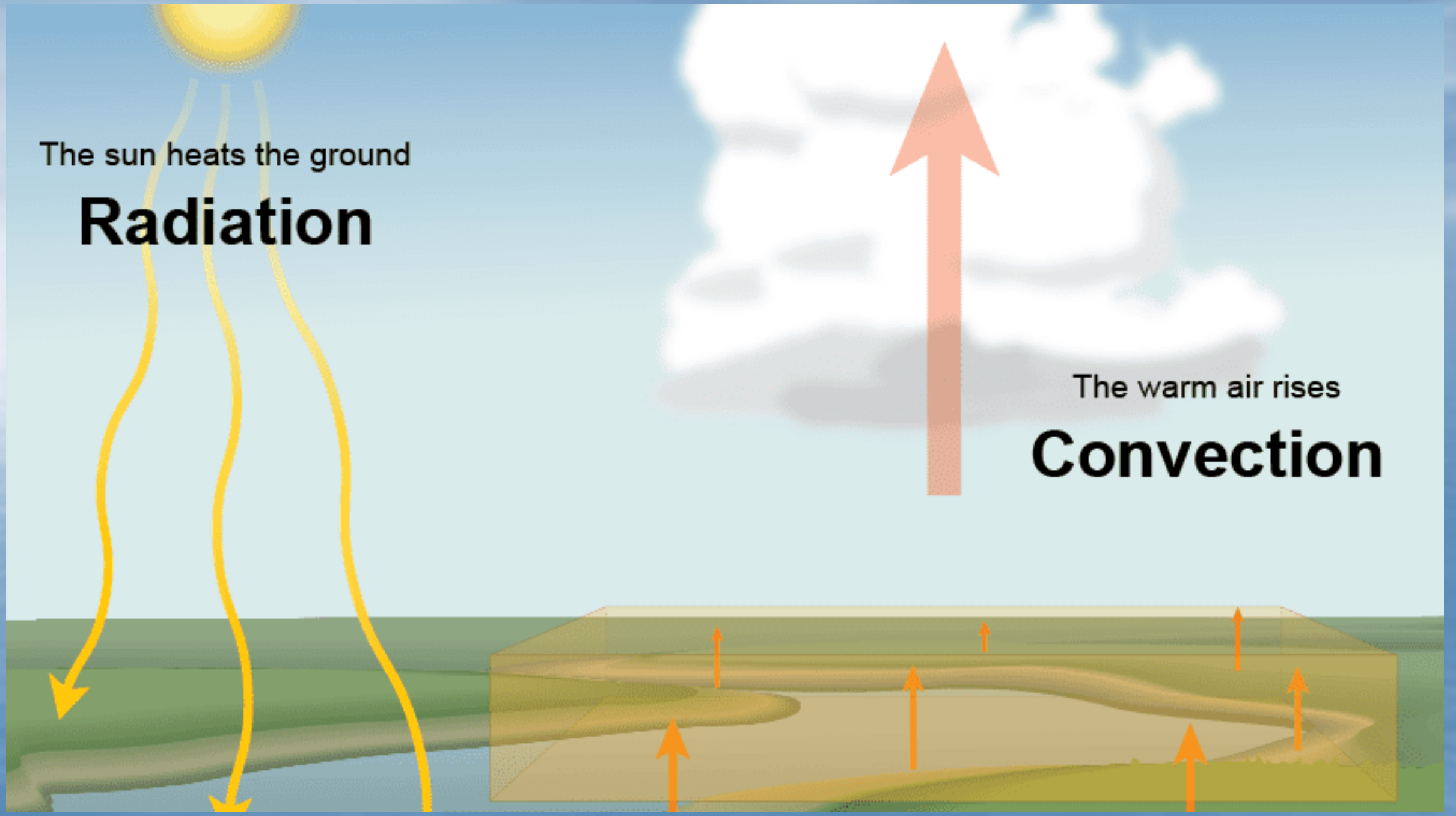
www.nasa.gov

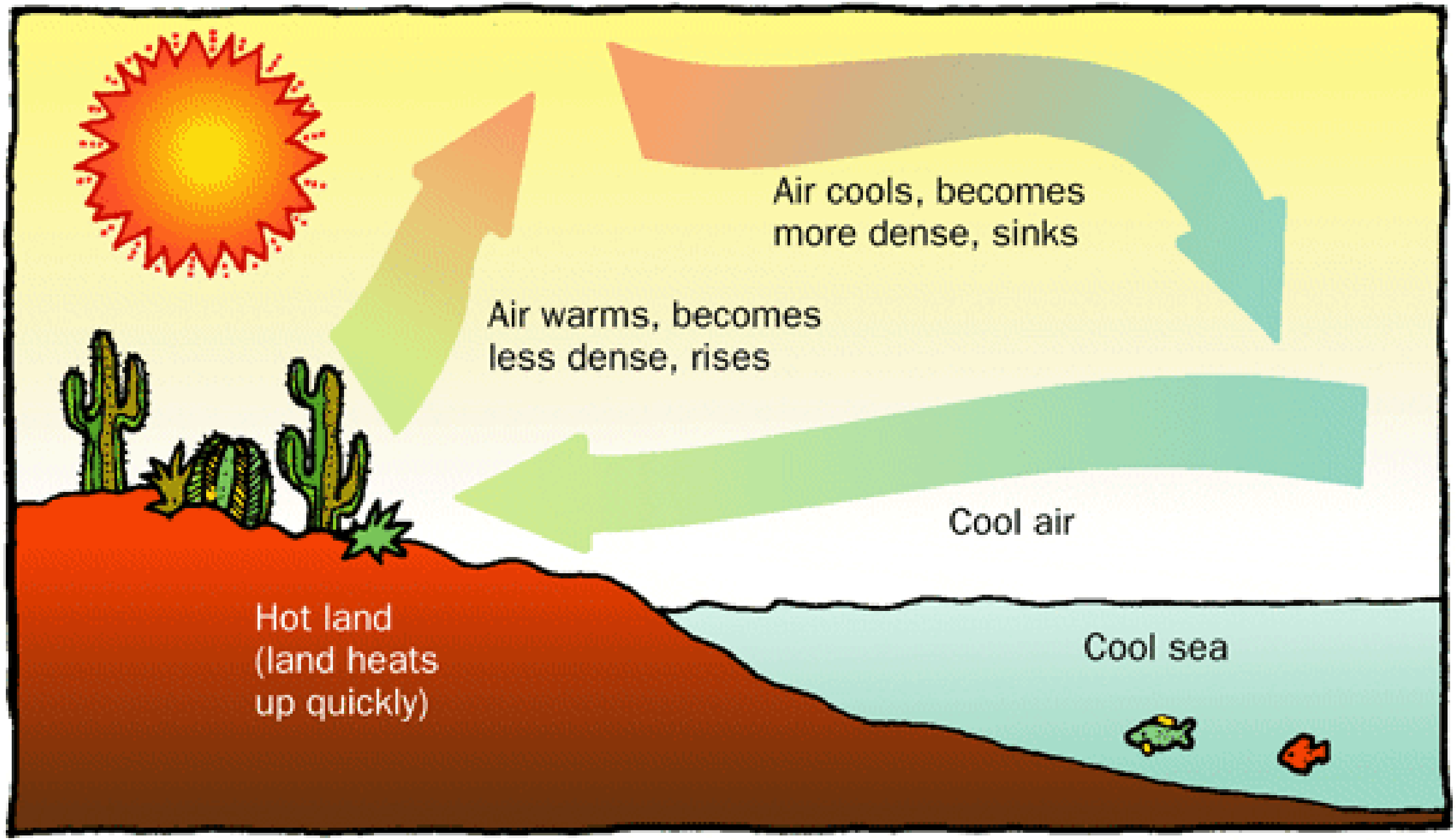
NP-2010-05-265-LaRC

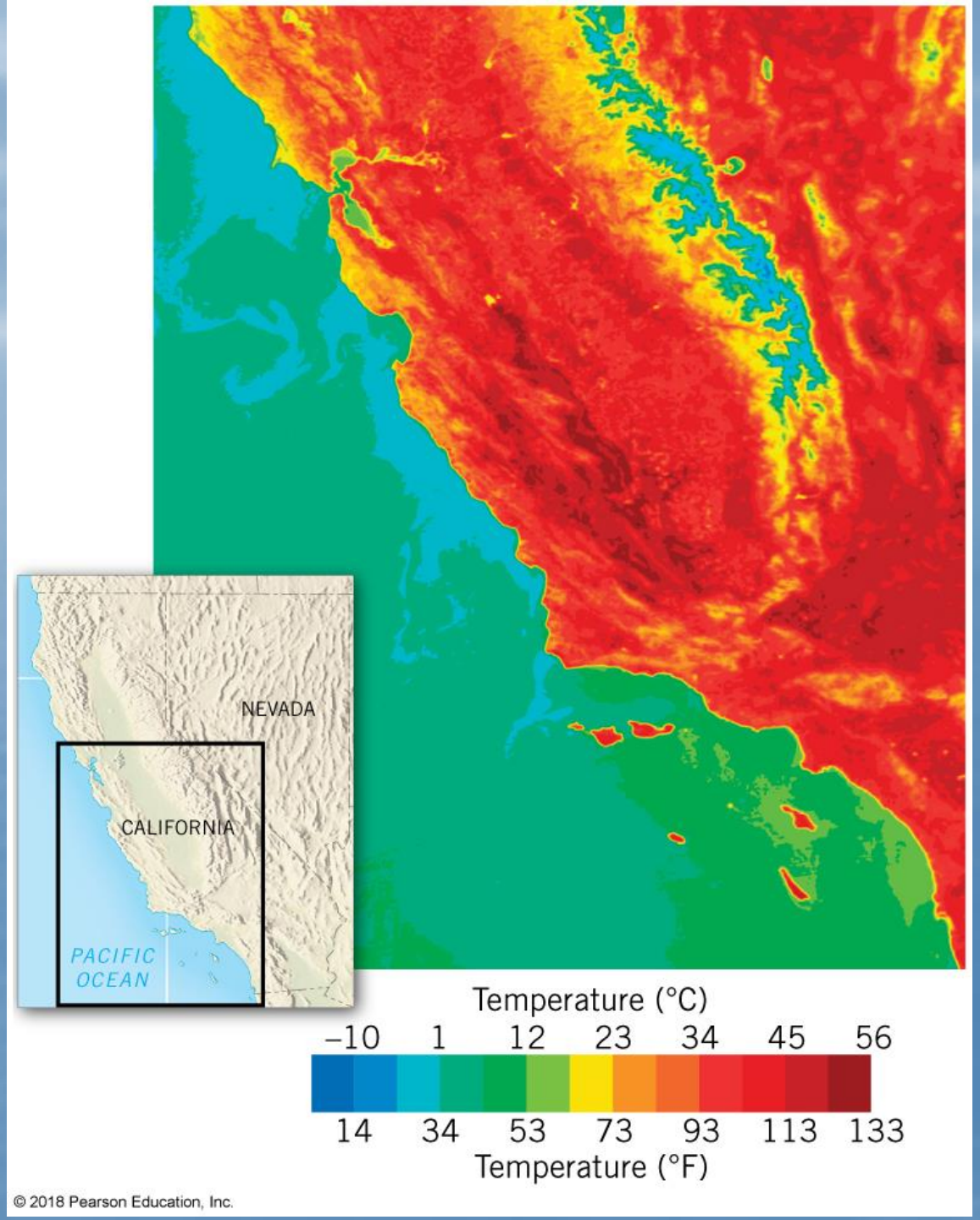




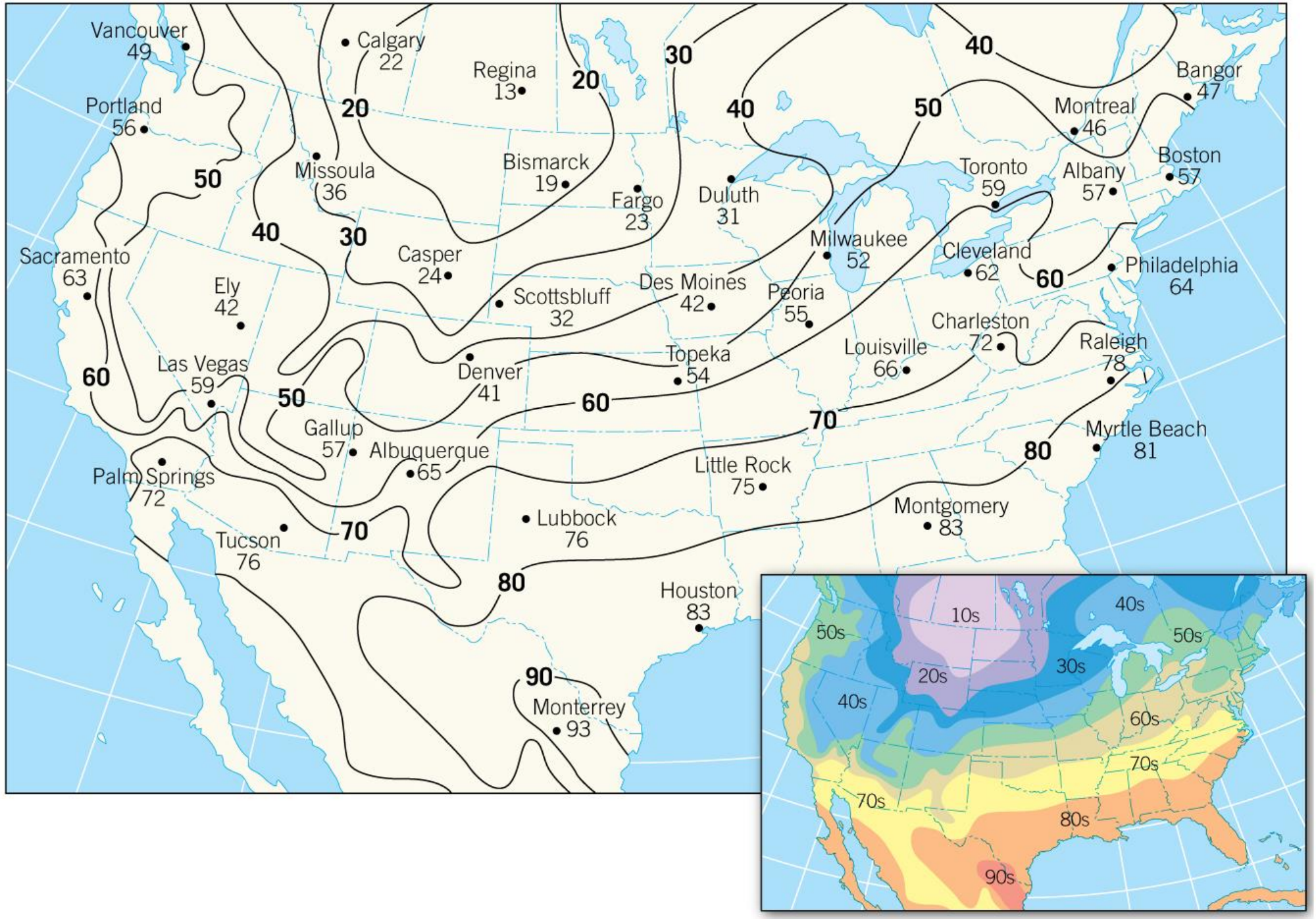

# Albedo

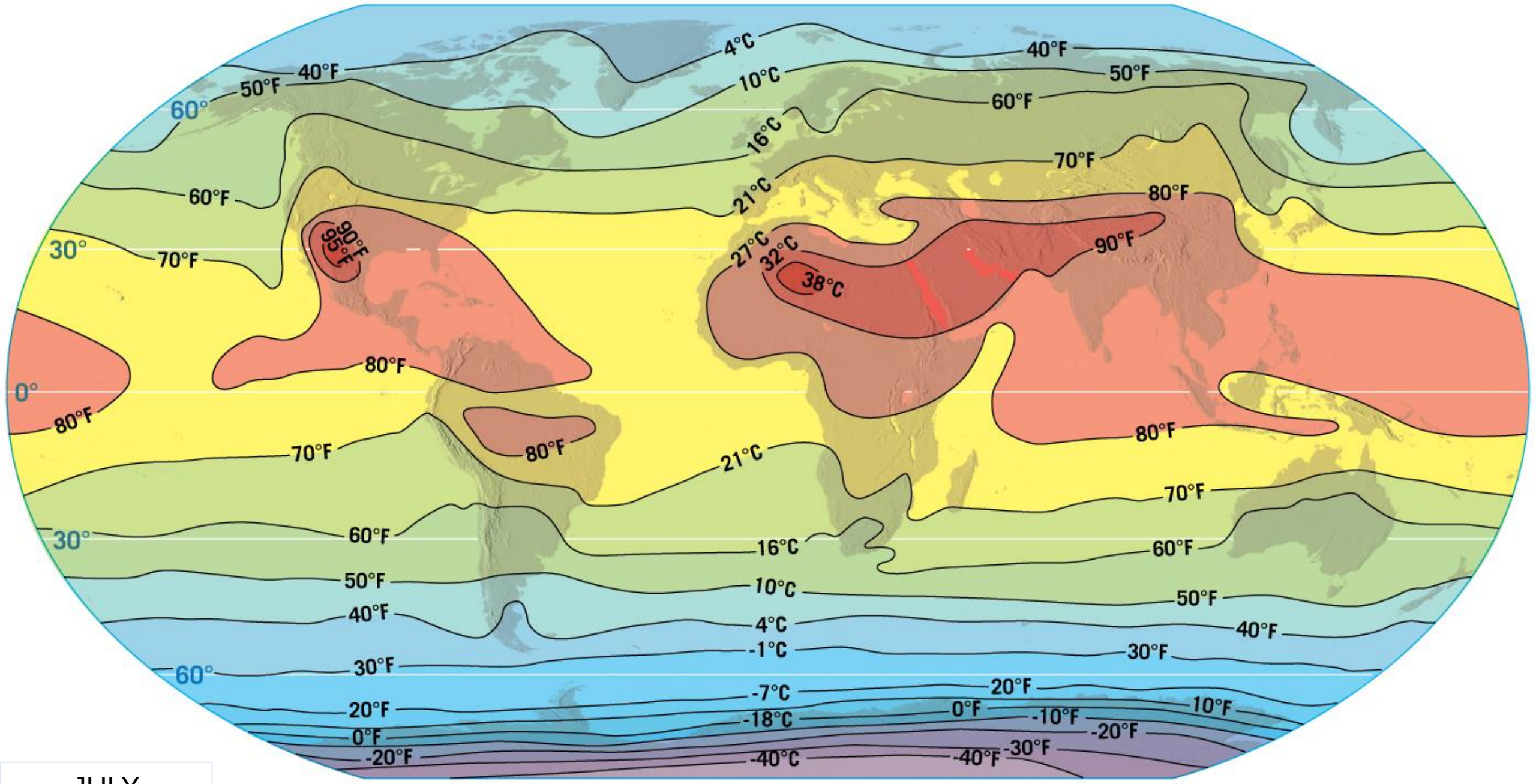

The sun heats the ground
Radiation
The warm air rises
Convection


Air cools, becomes
more dense, sinks
Air warms, becomes
less dense, rises
Cool air
Hot land
(land heats
up quickly)
Cool sea

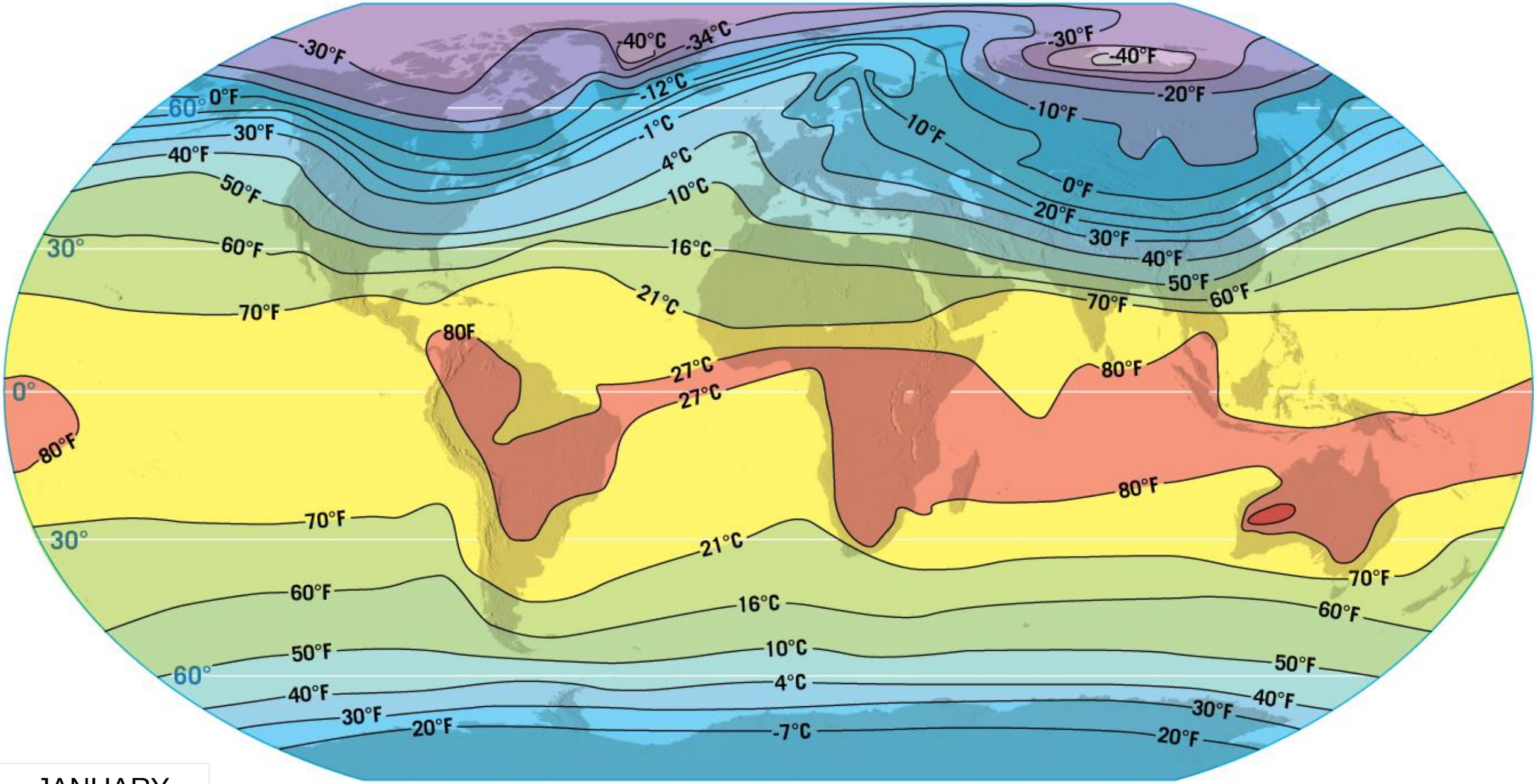


# ISOTHERMS




4°C
40°F
50°F
10°C
60°F
16°C
70°F
21°C
80°F
27°C
90°F
32°C
38°C
95°F
35°C
60°
30°
0°
-1°C
30°F
-7°C
20°F
-18°C
0°F
-10°F
-20°F
-40°C
-40°F
-30°F
10°F

JULY


-30°F
-40°C
-34°C
-30°F
-40°F
-20°F
-12°C
60°
0°F
-10°F
-1°C
10°F
30°F
4°C
40°F
10°C
0°F
50°F
20°F
30°F
30°
60°F
16°C
40°F
50°F
60°F
21°C
70°F
70°F
80F
27°C
80°F
0°
27°C
80°F
80°F
70°F
30°
21°C
70°F
60°F
16°C
60°F
50°F
10°C
50°F
60°
4°C
40°F
40°F
30°F
30°F
20°F
-7°C
20°F

JANUARY