Concepts of energy and heat

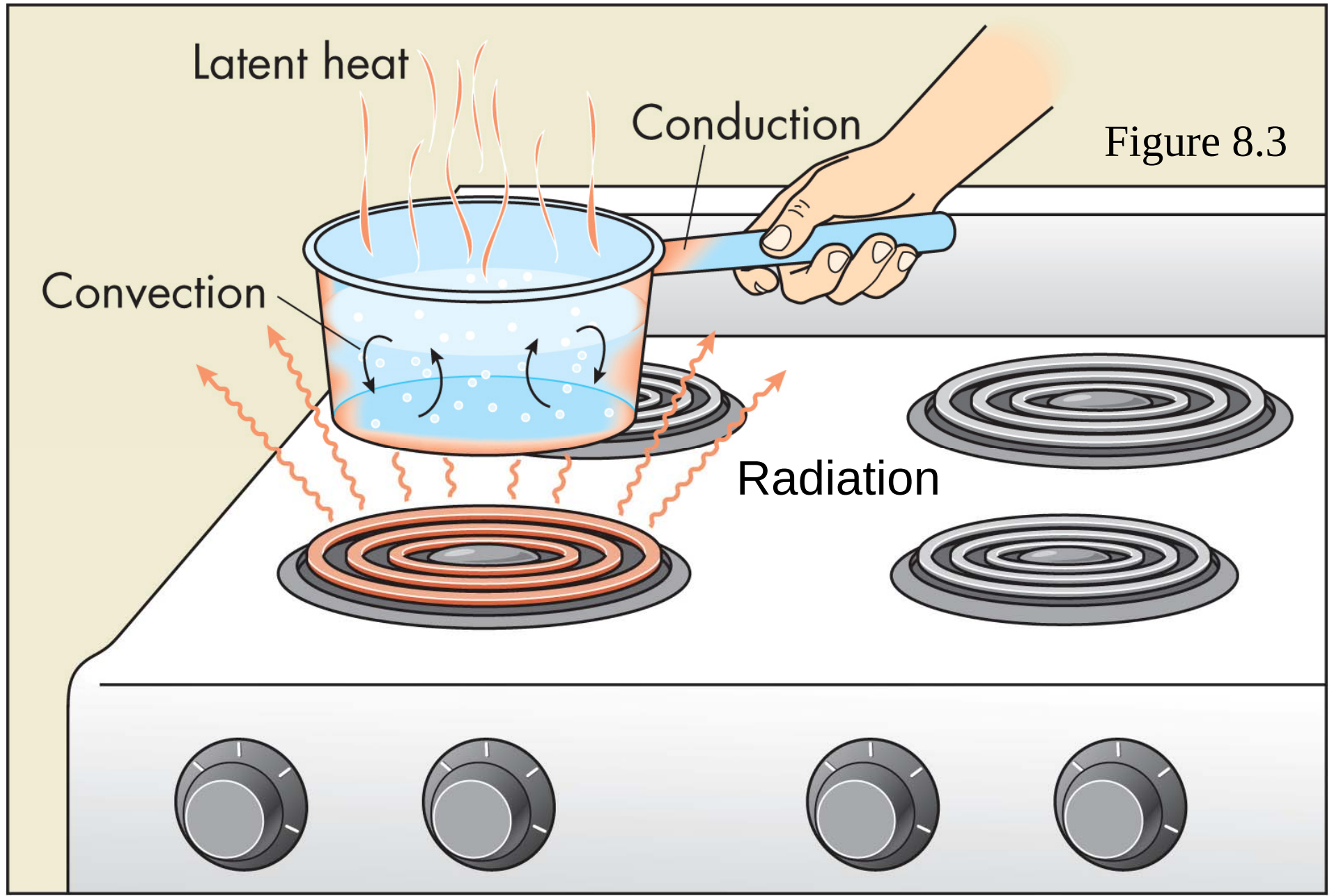
On the molecular level, what is heat?

Energy absorbed by the molecule
and converted to kinetic energy

How is heat transferred?

Conduction
Convection
Radiation

Transfer of heat



Energy balance for the Earth

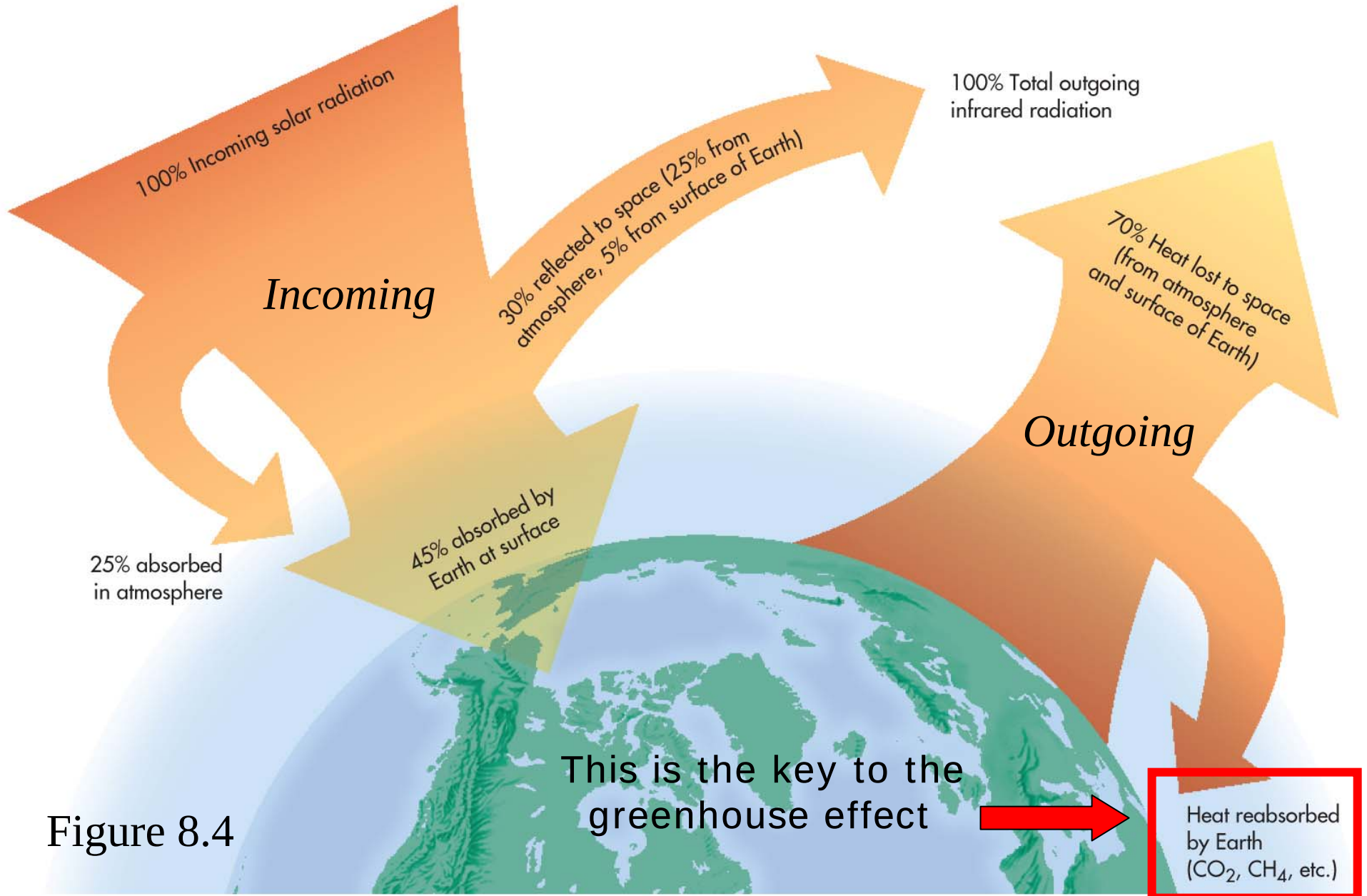


Figure 8.4

Electromagnetic radiation

Long wavelength – lower energy

Visible light

Short wavelength – higher energy

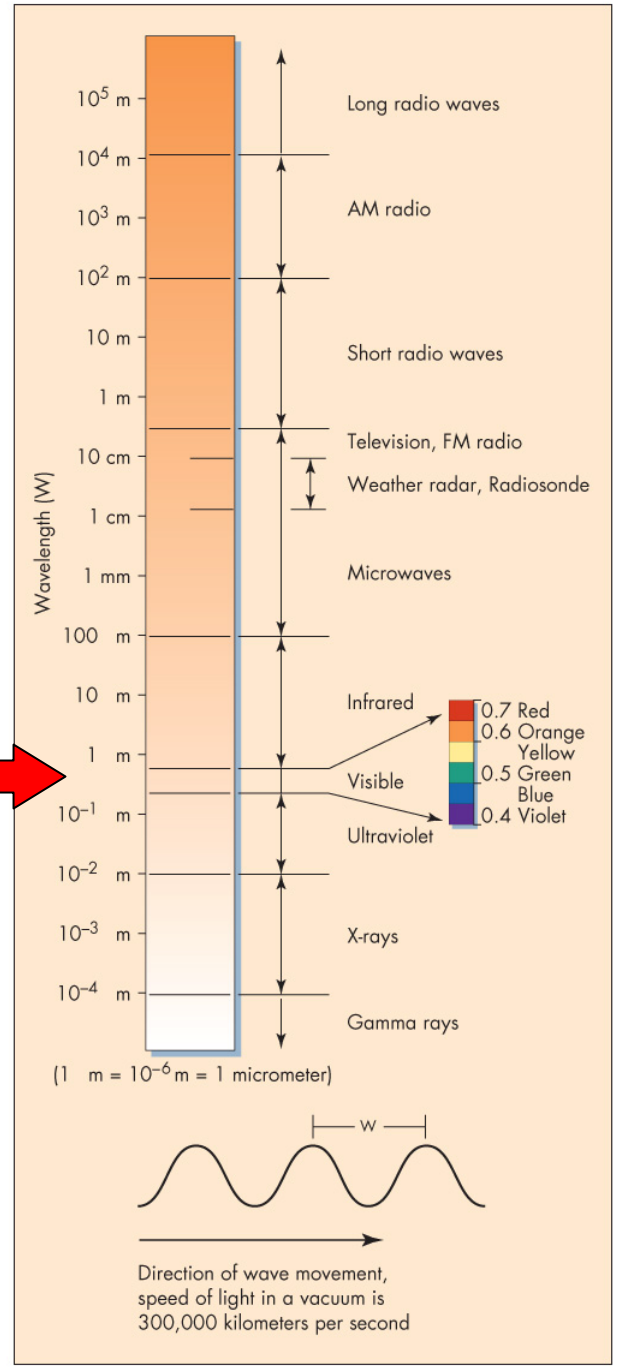
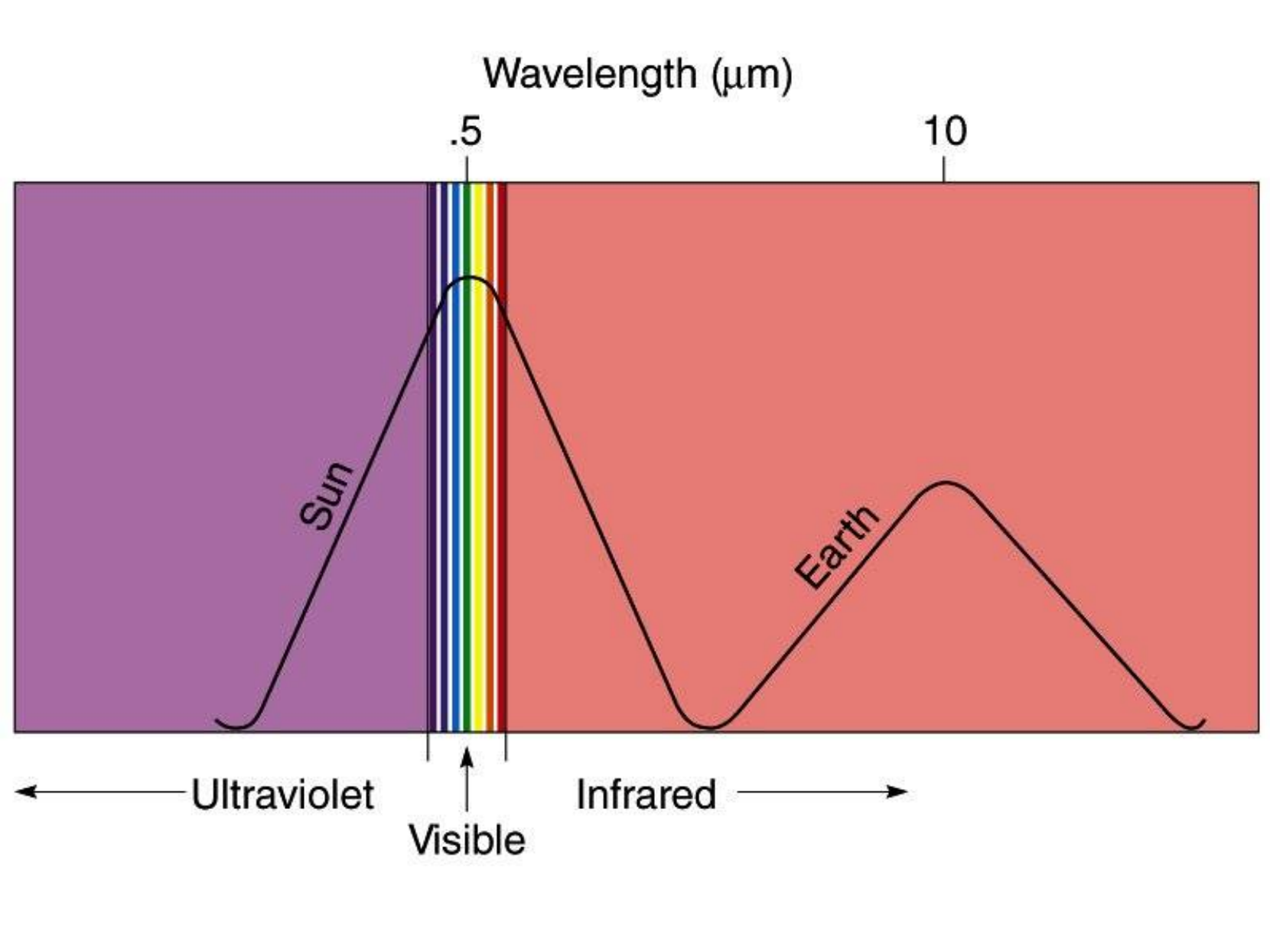
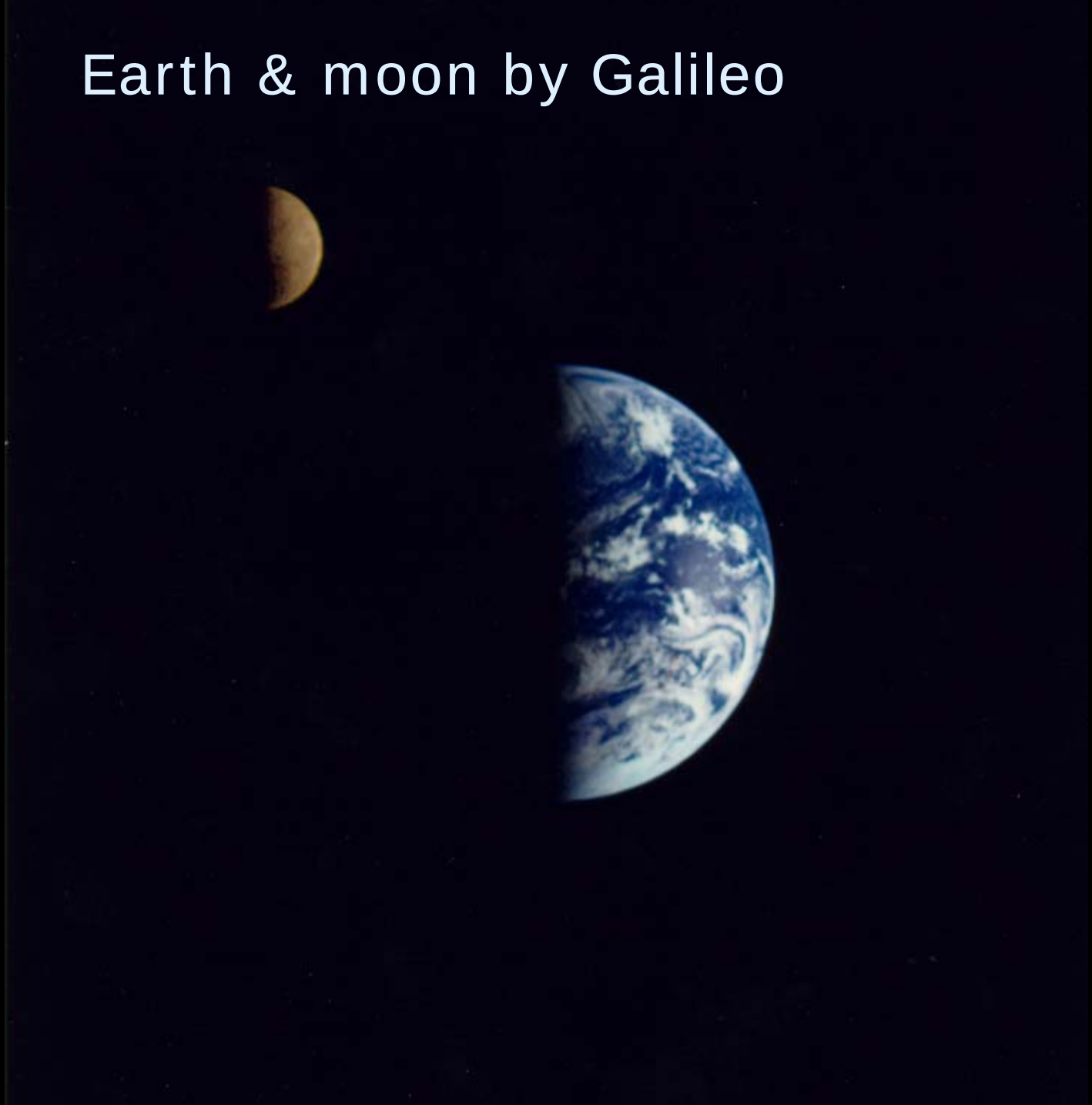


Figure 8.5

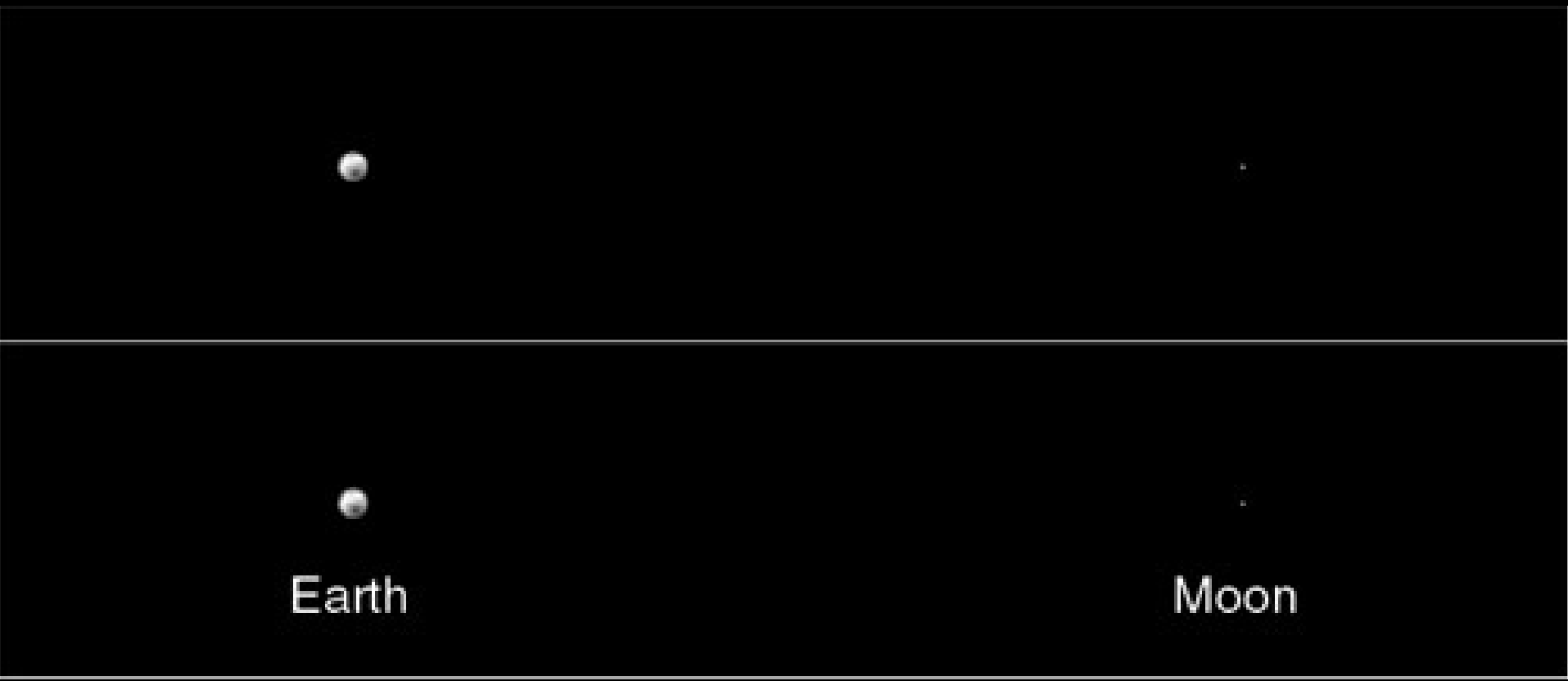
Spectra of incoming vs. outgoing radiation



Earth & moon by Galileo



Earth and moon from Mars



Ionosphere
(100-1000 km)

Thermosphere
(part of ionosphere)

Mesosphere

Stratosphere

Troposphere

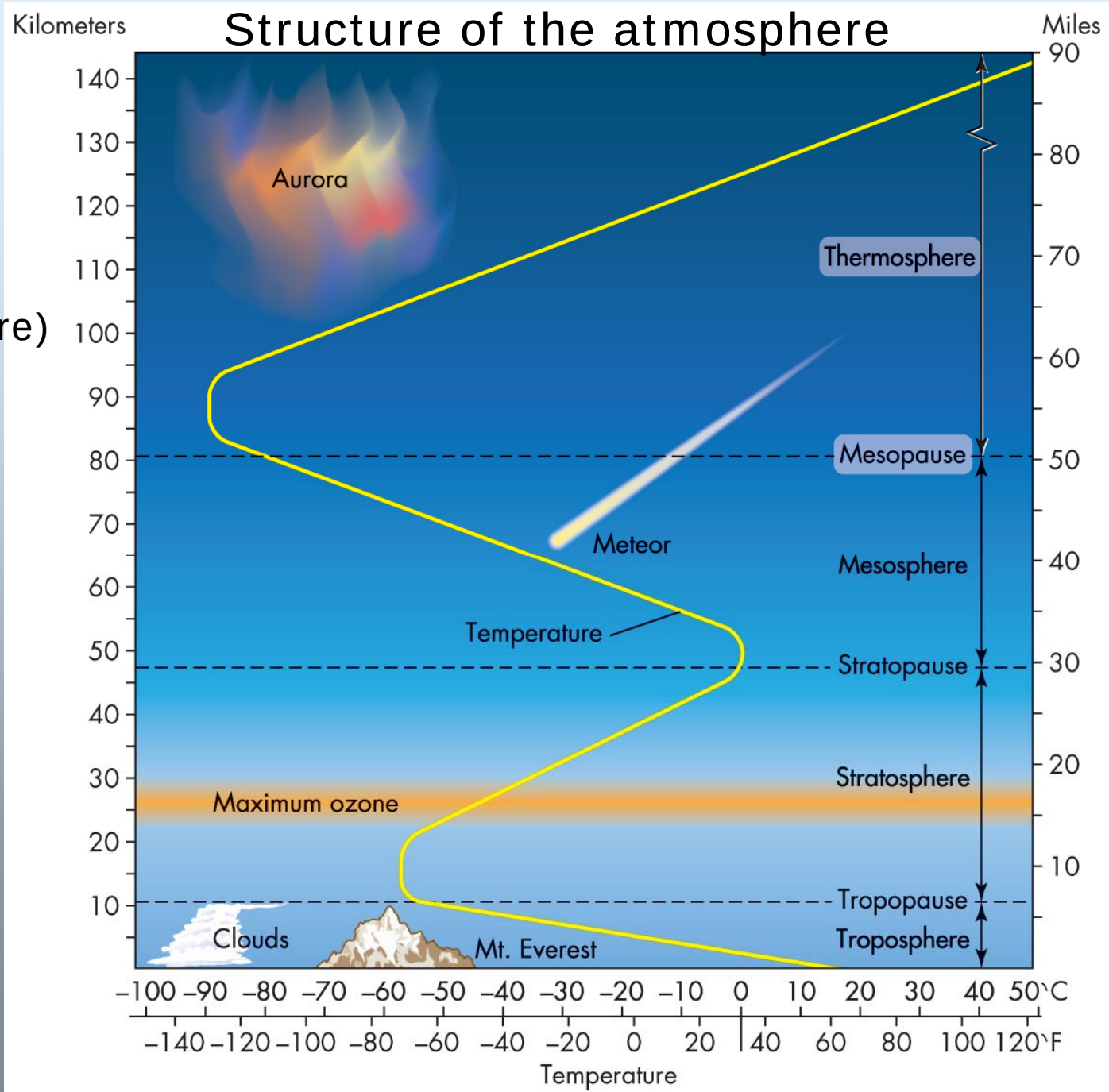
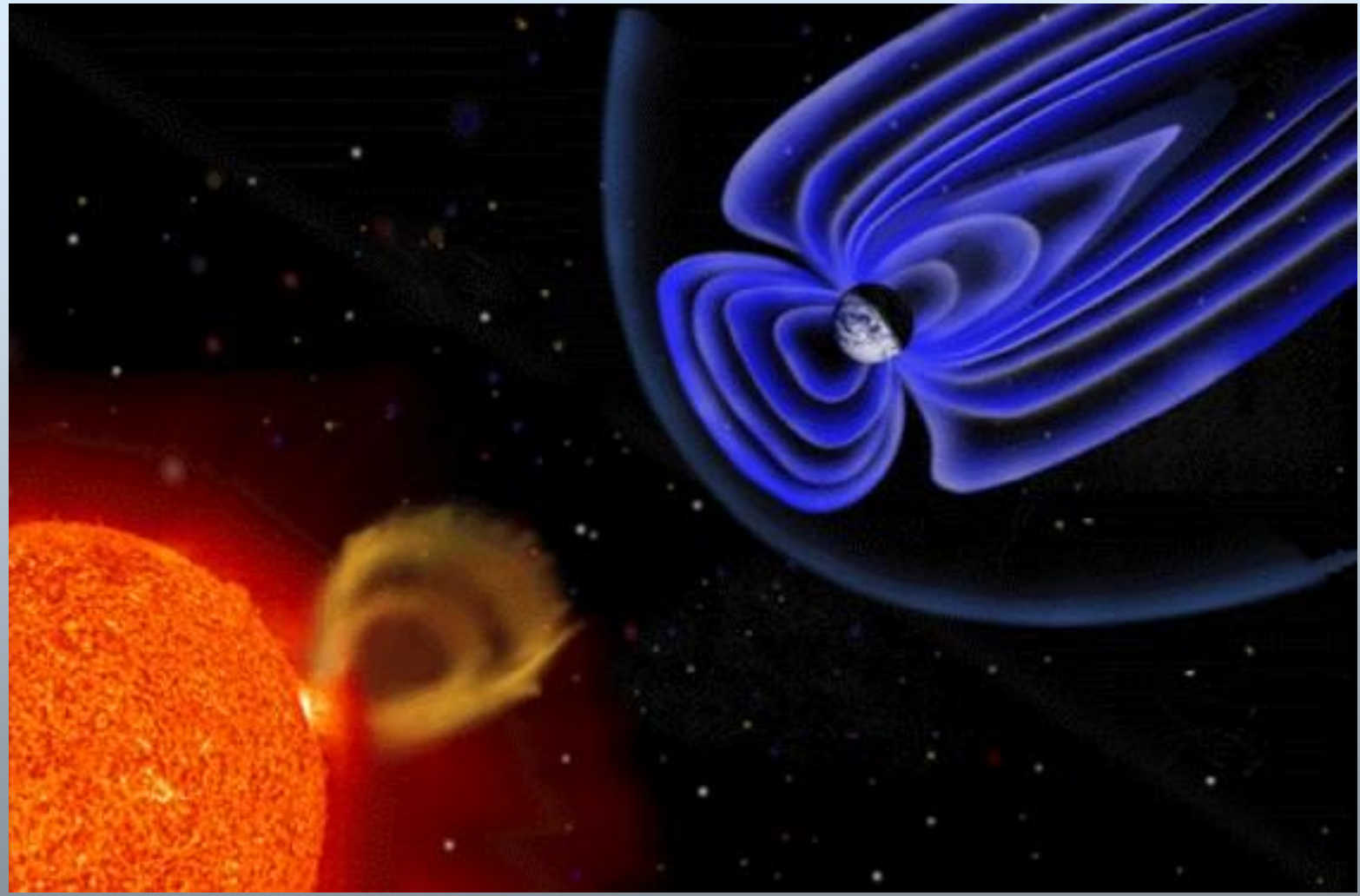


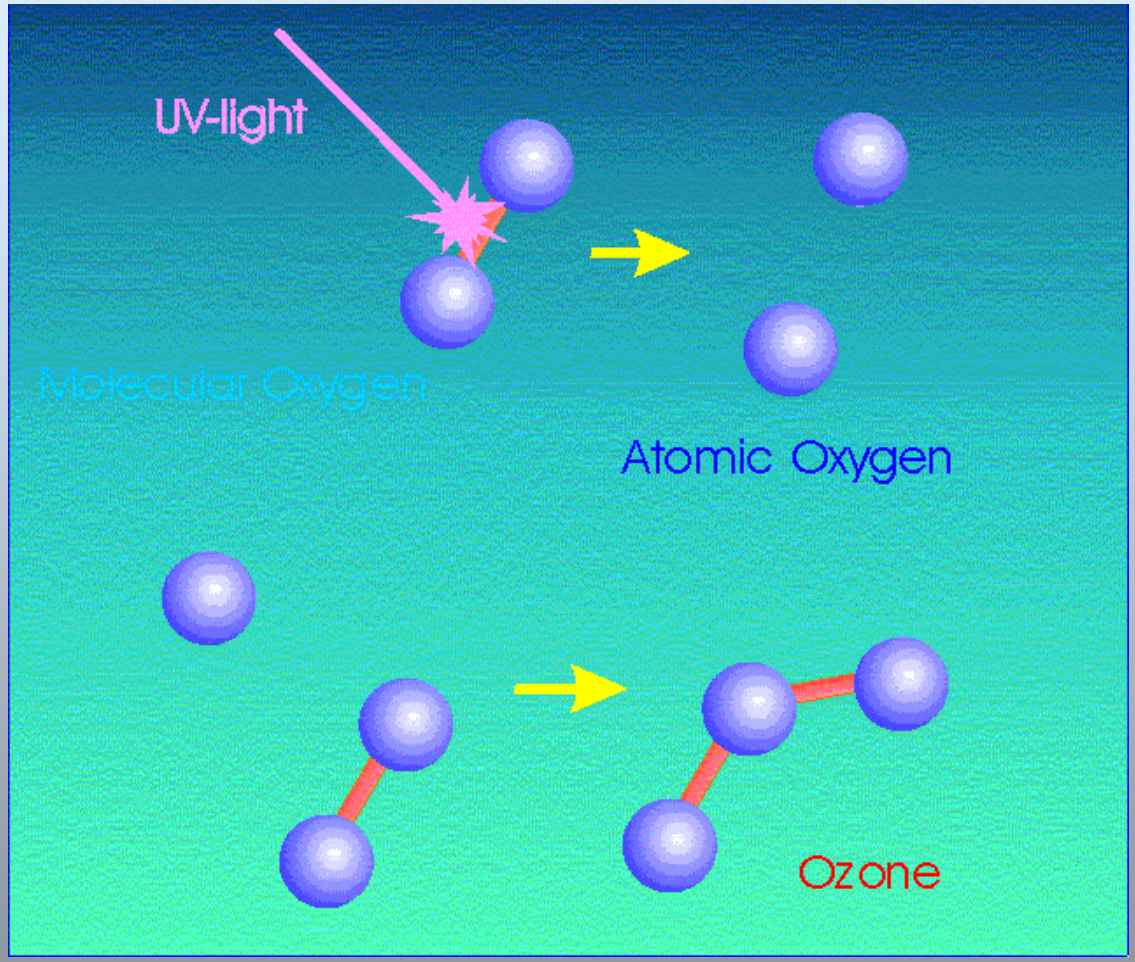
Figure 8.7

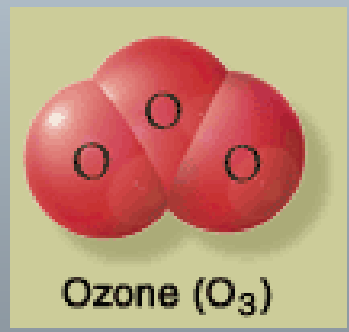
The Earth's magnetosphere



10 Earth radii to 1000 Earth radii

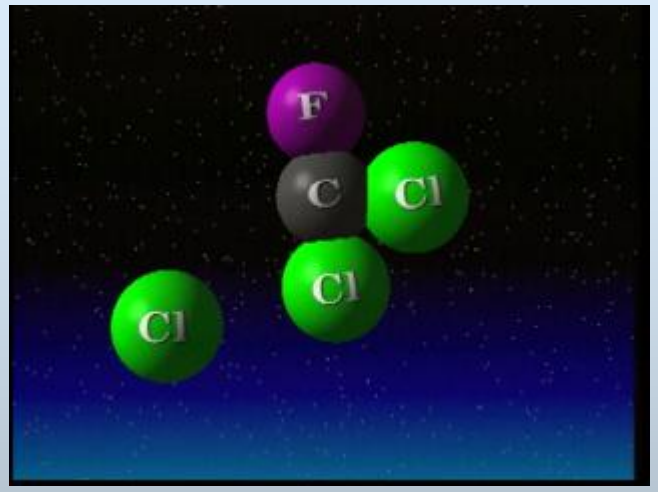
The Earth's ozone layer



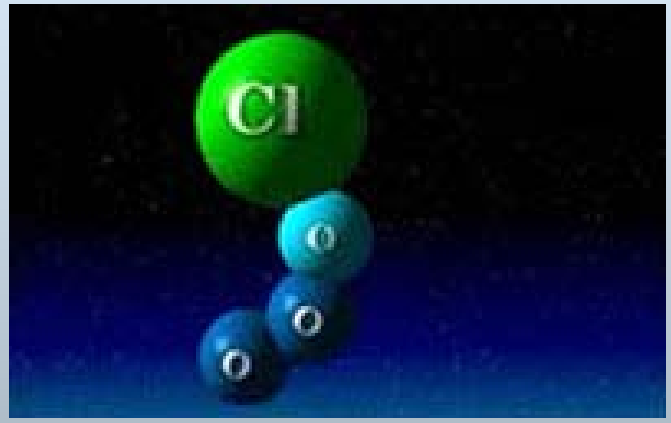


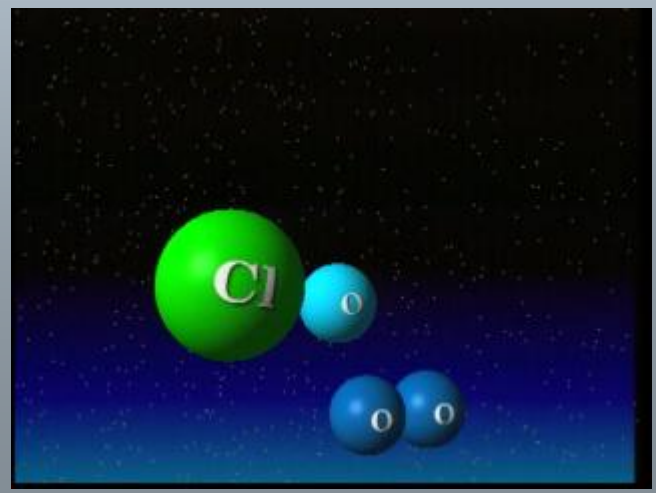
Ozone is produced in the stratosphere and absorbs incoming UV from the Sun

CFCs and ozone depletion

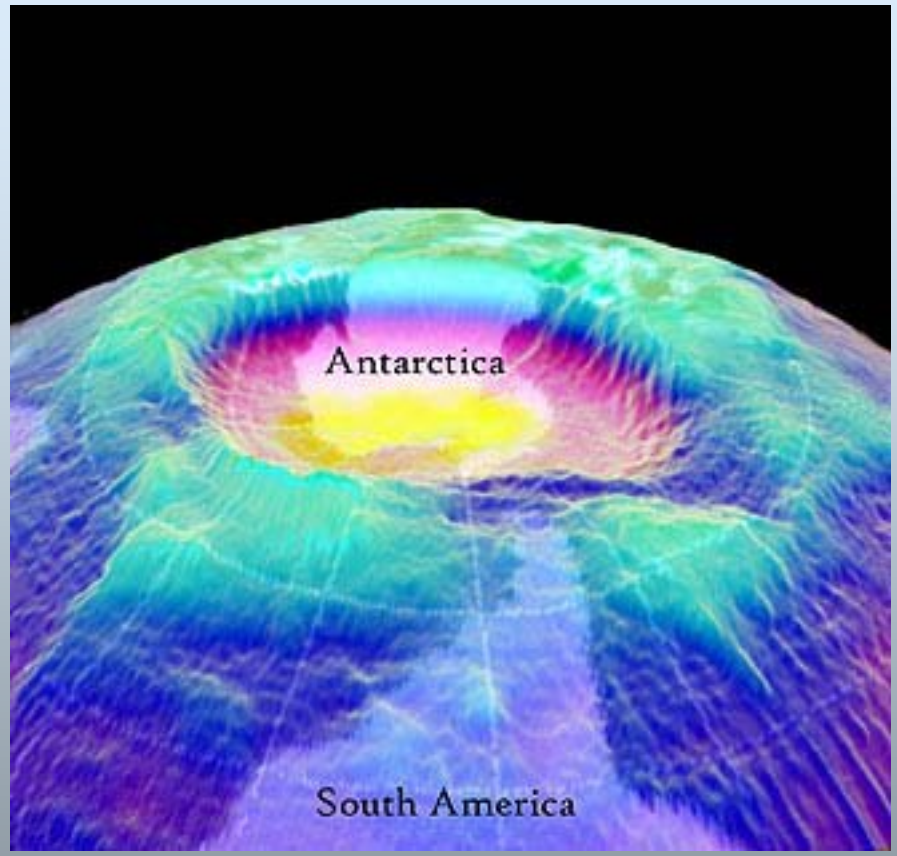


CFC = chloro fluoro carbon



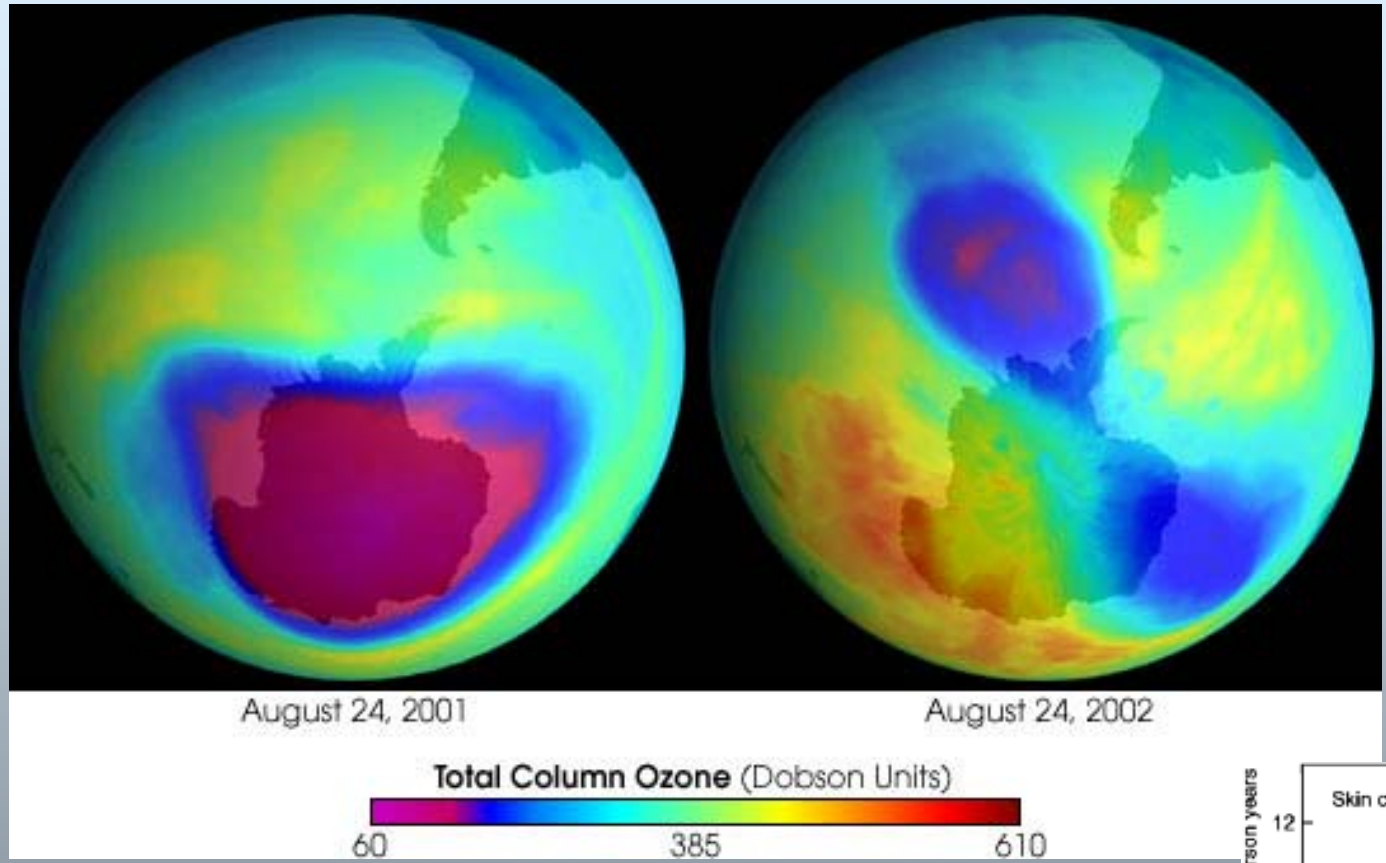


The Earth’s ozone layer

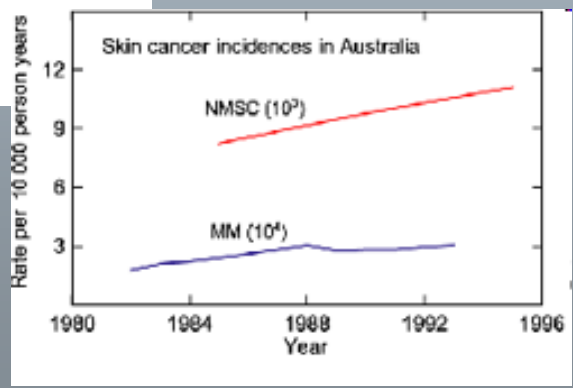


The ozone hole over Antarctica

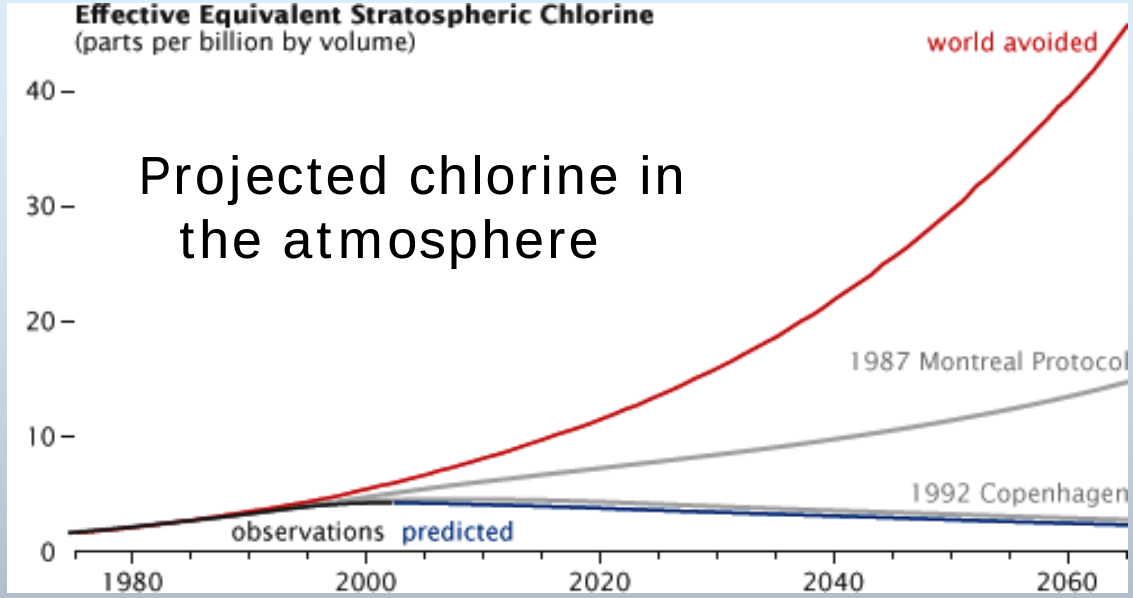
The Earth's ozone layer



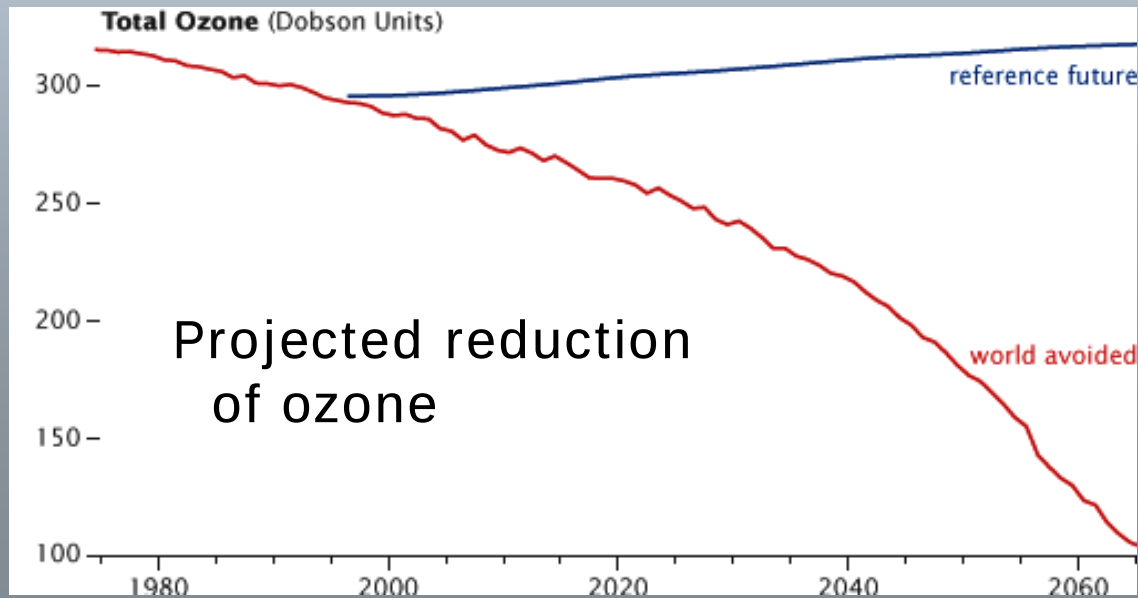
The ozone hole splits and moves



The Earth's ozone layer

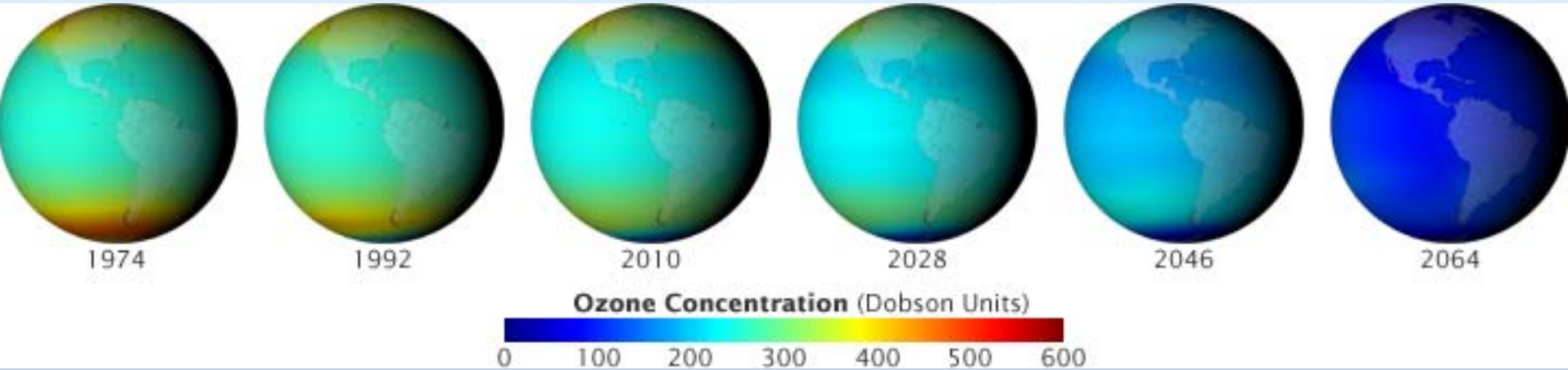


Projected chlorine in the atmosphere

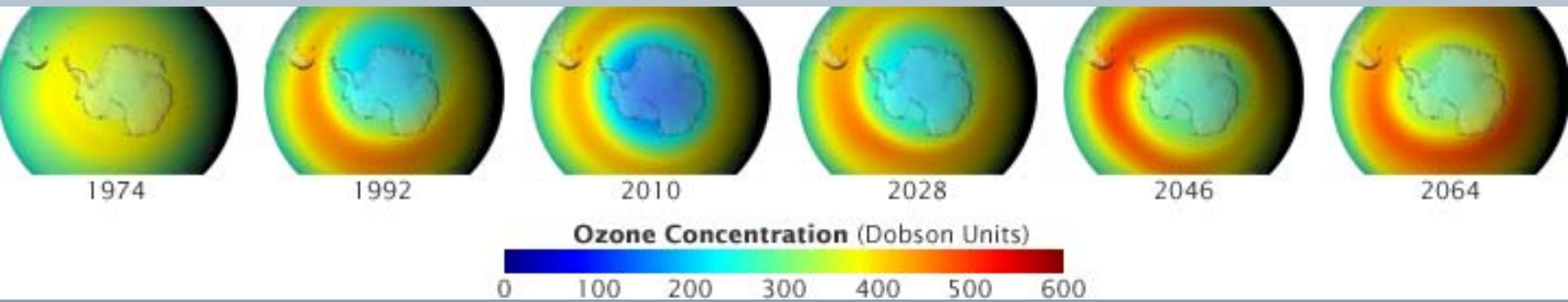


Projected reduction of ozone

The Earth’s ozone layer



Projected ozone depletion with no action



Projected ozone recovery because of restrictions

Ozone depletion avoided

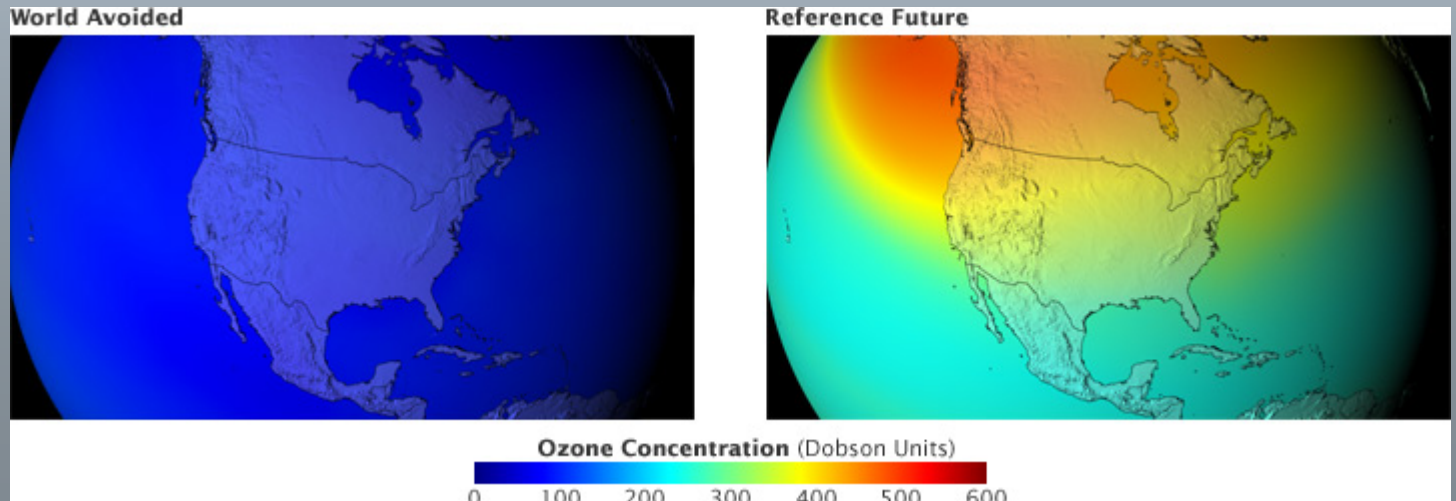
The year is 2065.

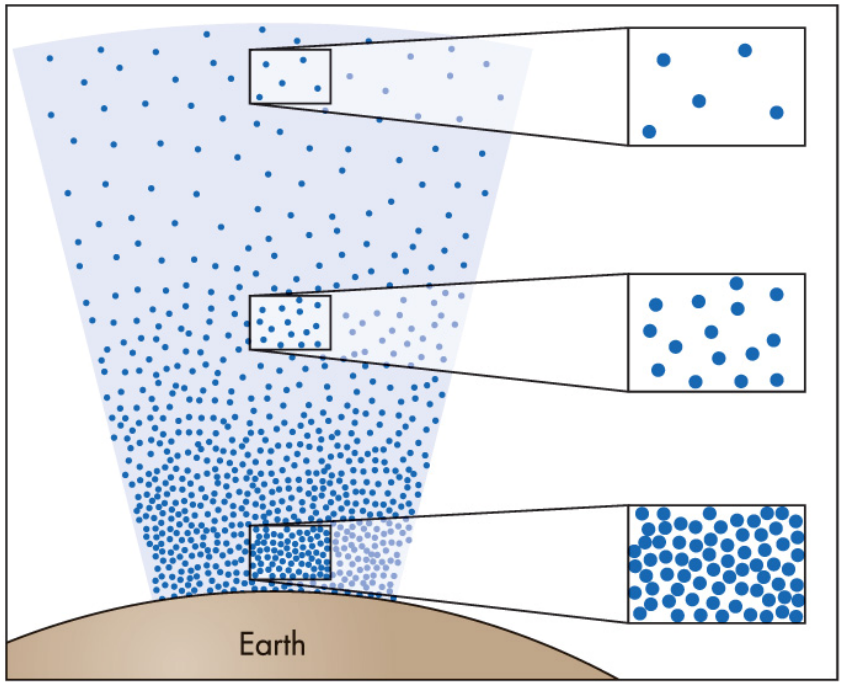
Two-thirds of Earth's ozone is gone – not just over the poles, but everywhere.

The ozone hole over Antarctica has a twin over the North Pole.

The UV radiation on mid-latitude cities like Columbus is strong enough to cause sunburn in 5 minutes.

DNA-mutating UV radiation is up more than 500 percent, with harmful effects on plants, animals, and human skin cancer rates.



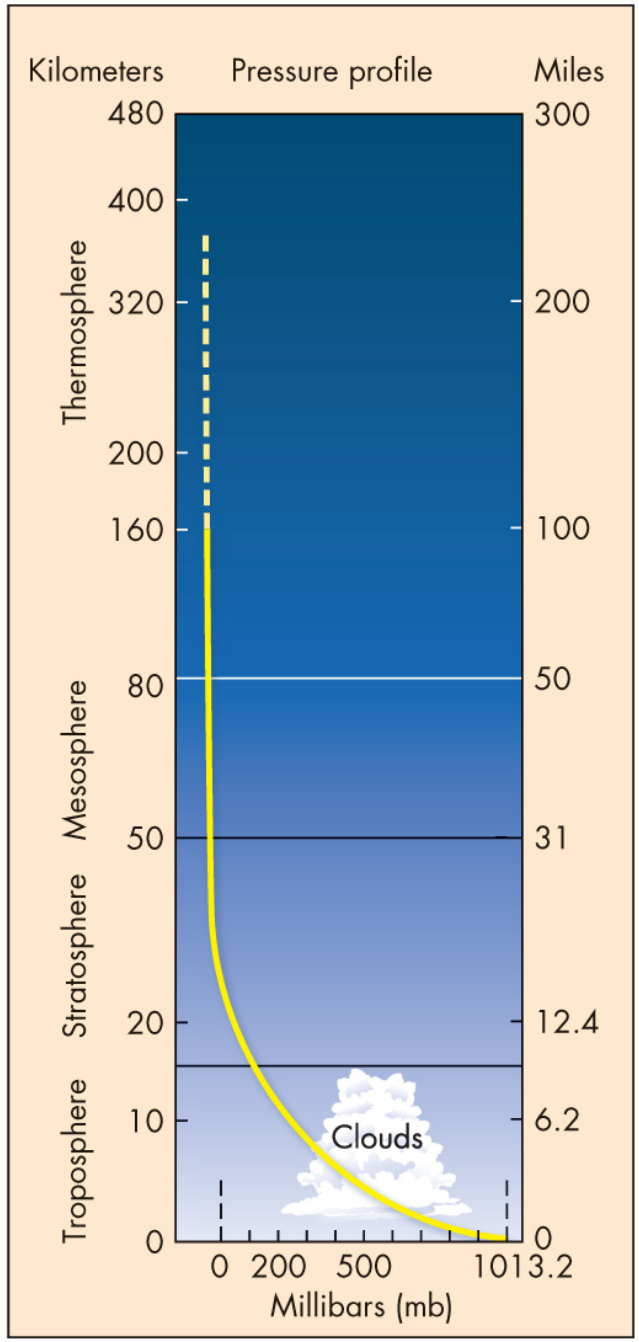


(a)

Atmospheric pressure

About 90% of the mass is in the troposphere

Figure 8.10



(b)

Atmospheric pressure

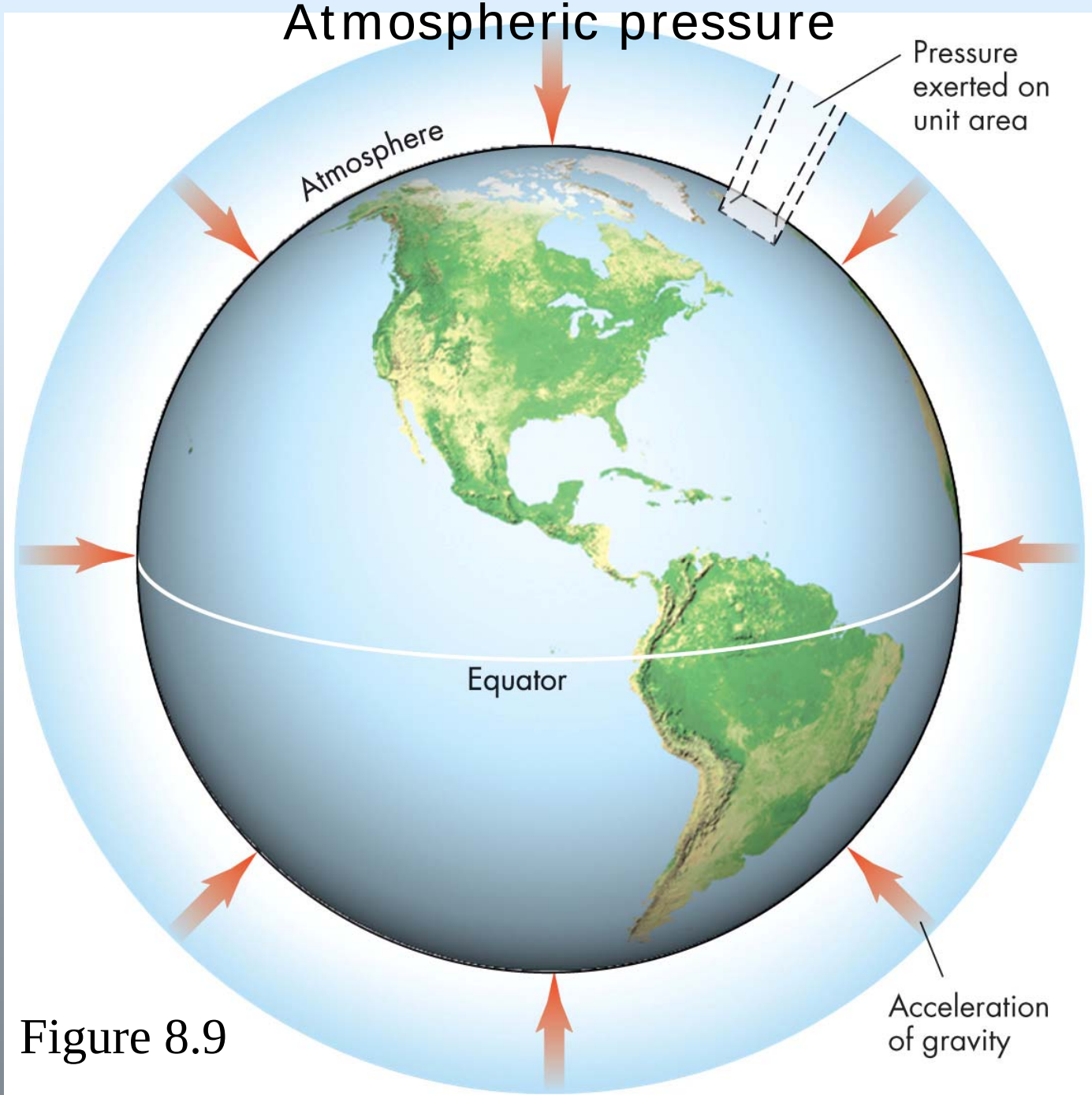
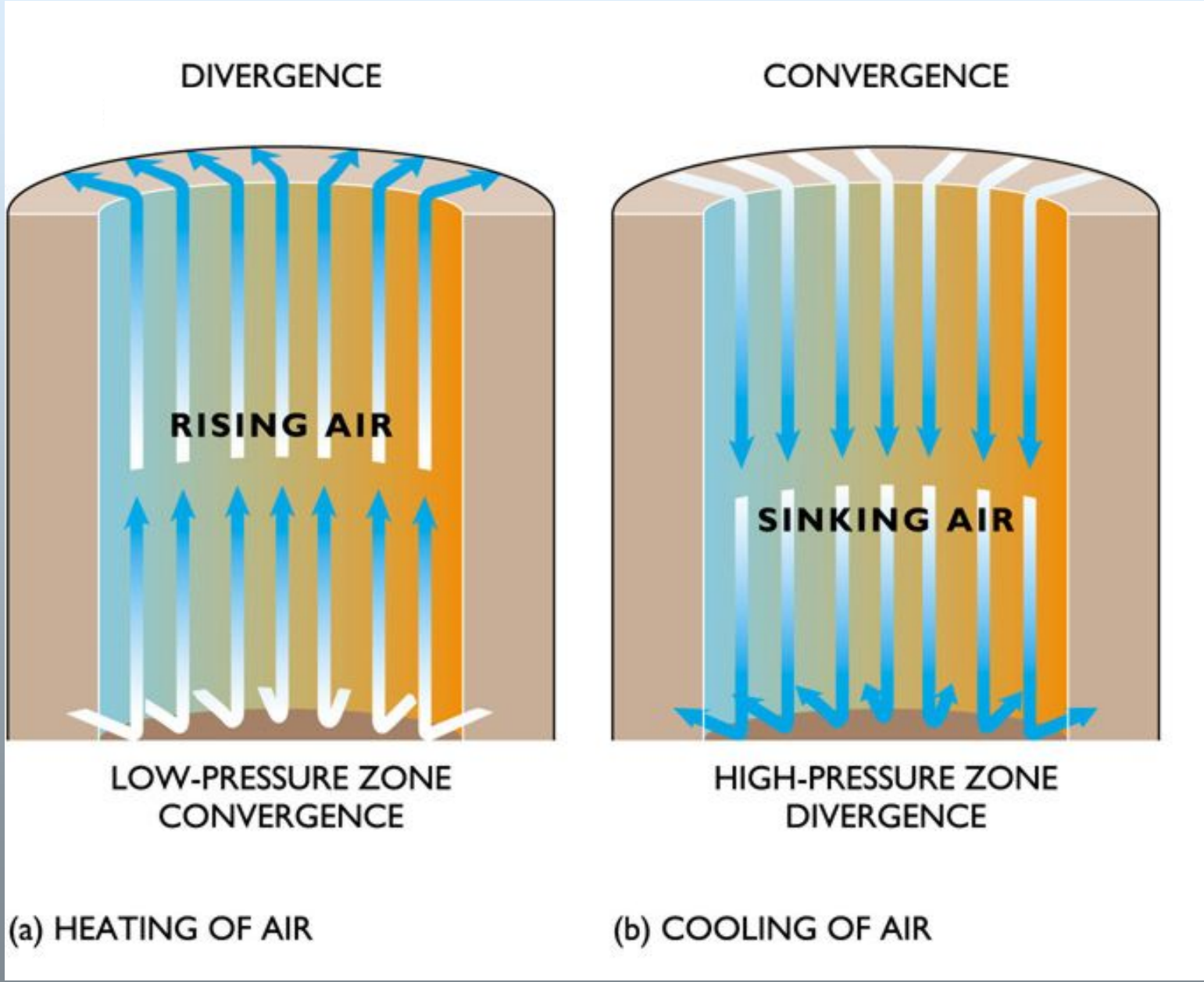


Figure 8.9

Low pressure High pressure



Atmospheric high and low pressure

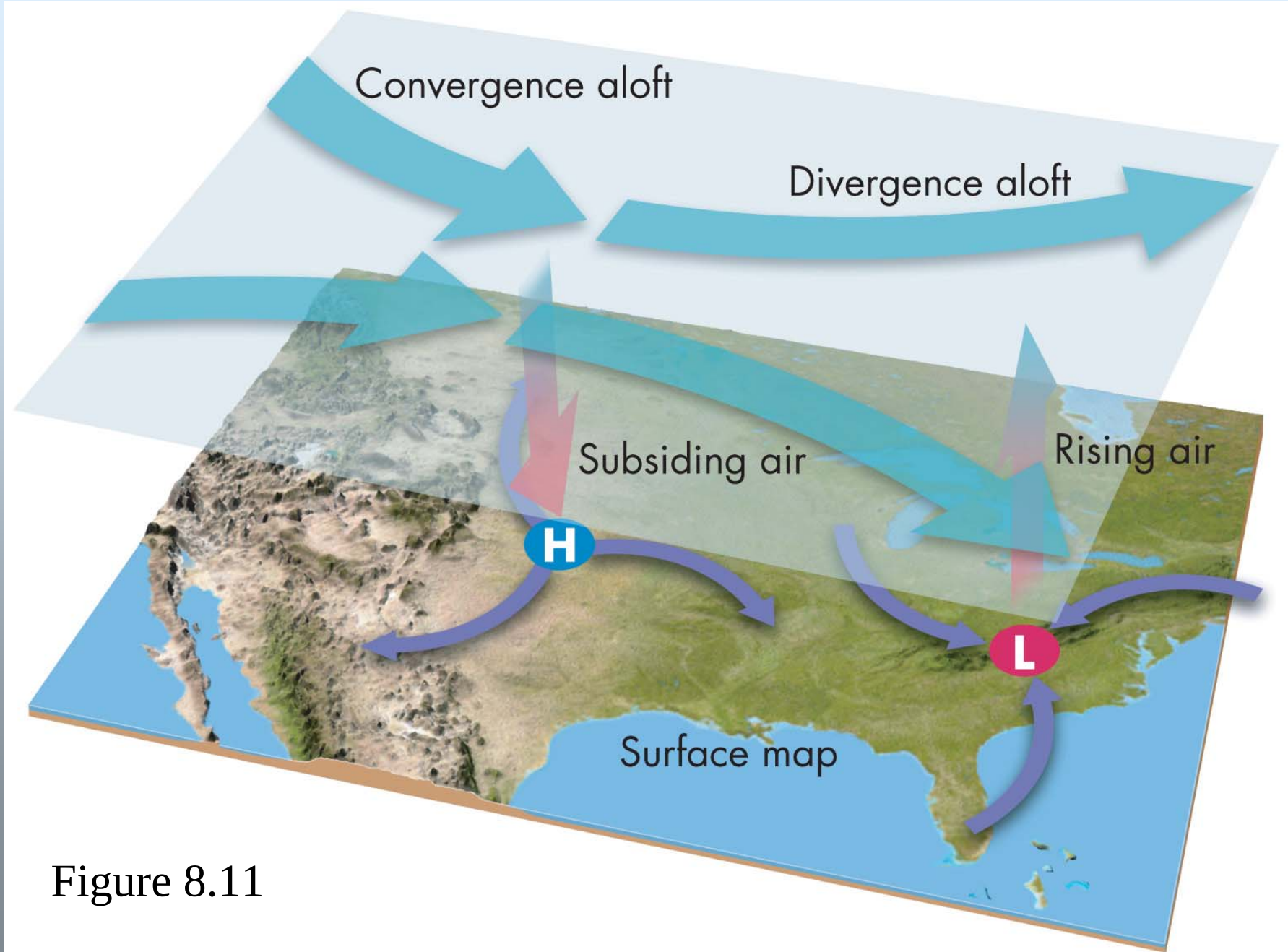


Figure 8.11

Rising air, low pressure, precipitation

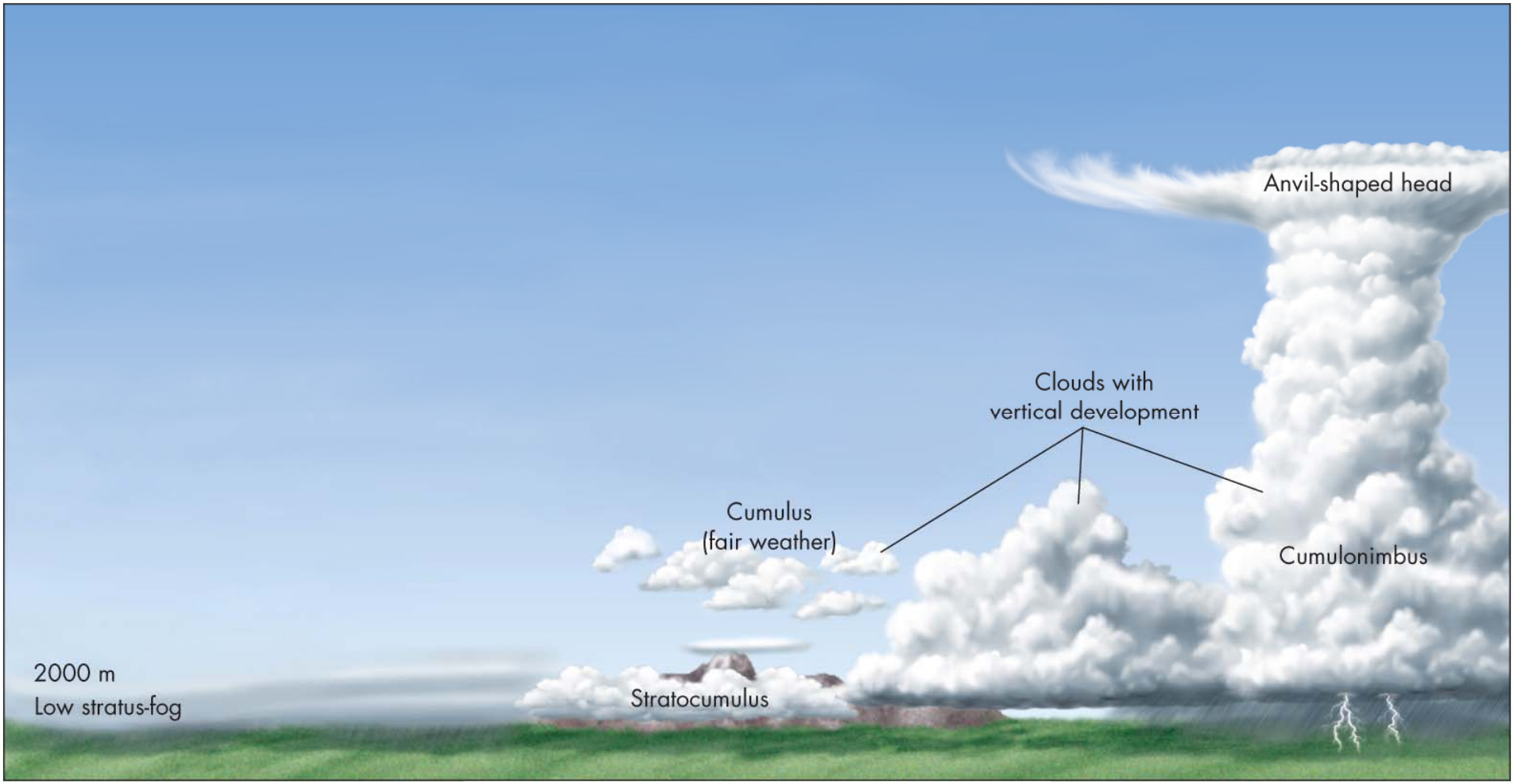


Figure 8.8

Rising air, low pressure, precipitation

Concepts and processes:

Absolute humidity
Relative humidity
Dewpoint

Sensible heat

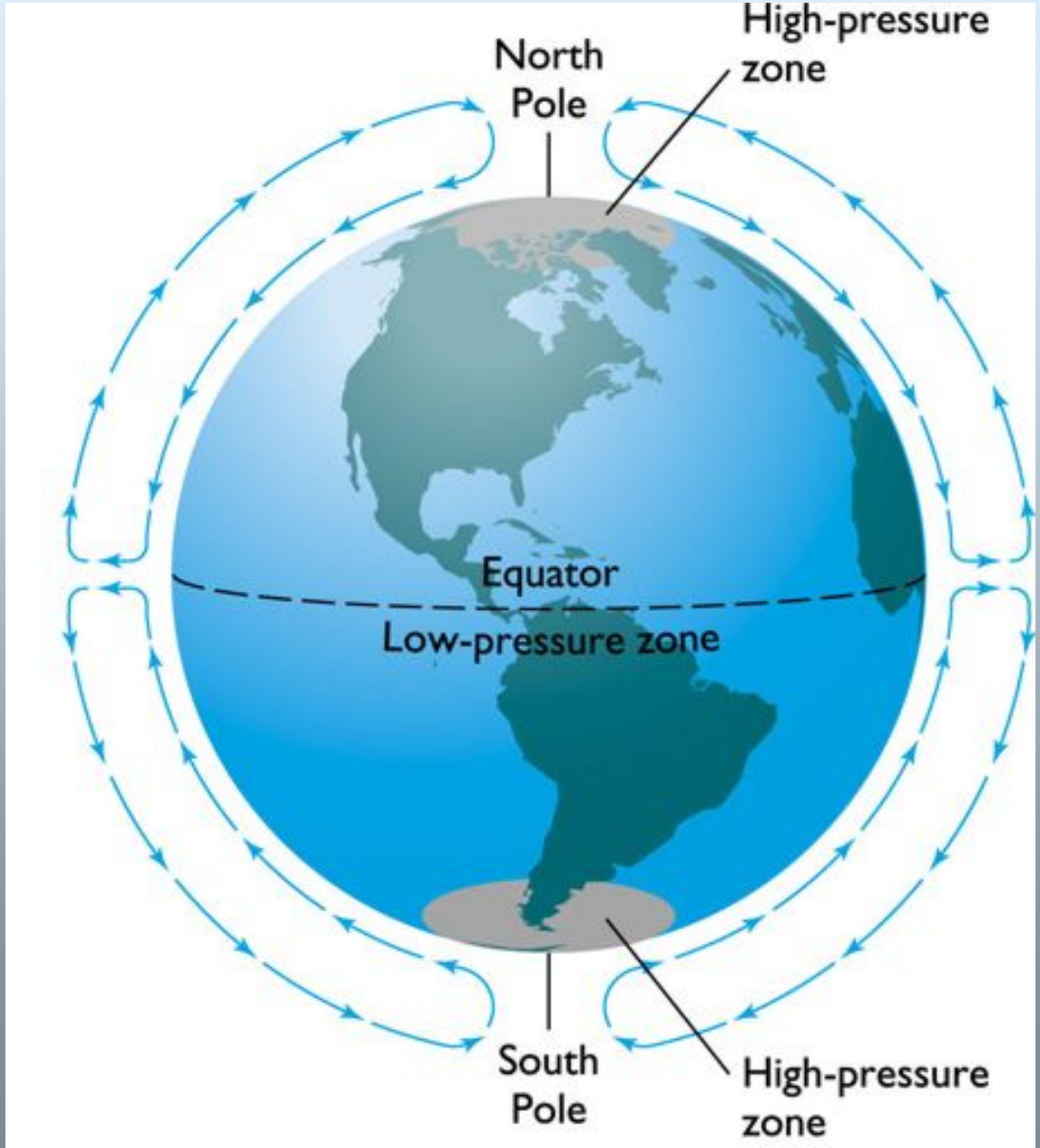
Latent heat
of vaporization – from liquid to vapor 540 cal
of melting – from solid to liquid 80 cal

Compression and expansion of a gas

Atmospheric circulation

without rotation of the Earth

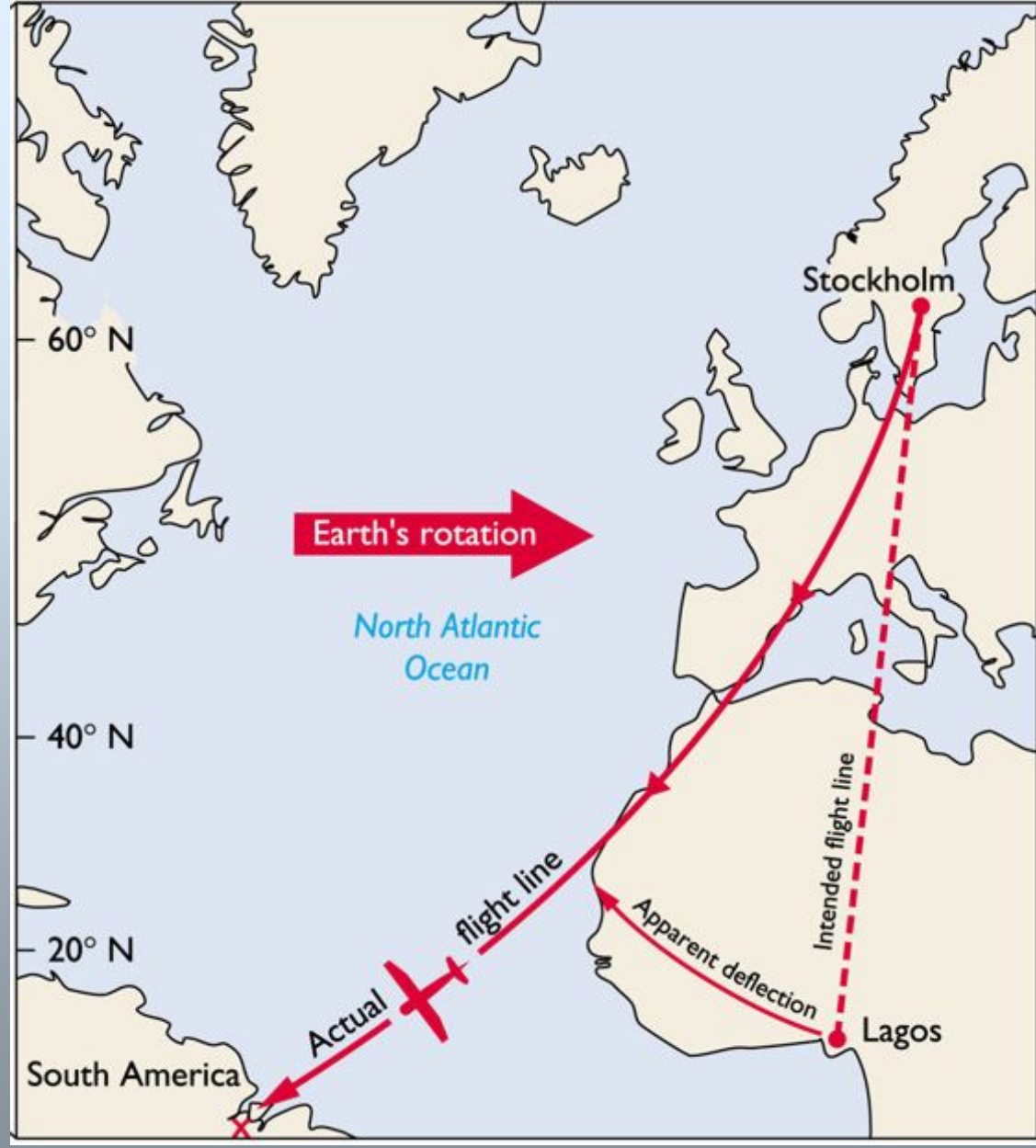
driven by density differences between air masses



Coriolis effect

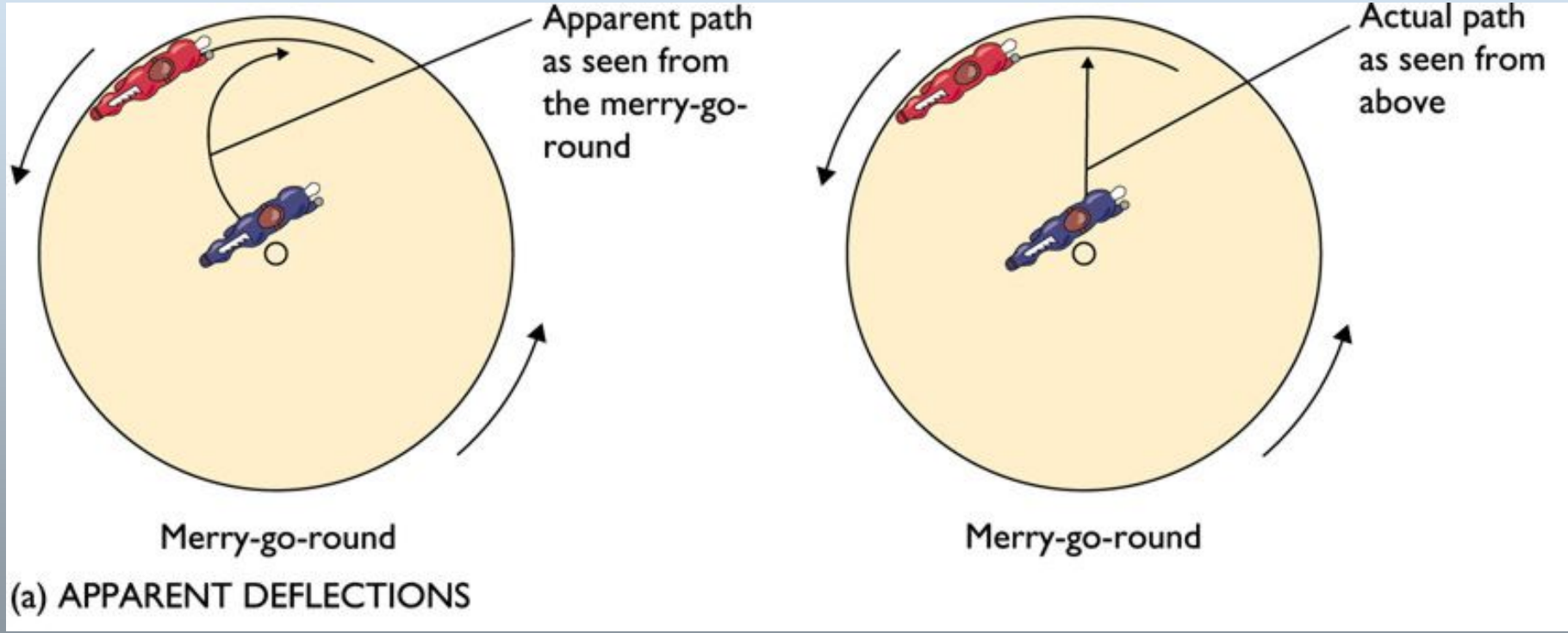
Coriolis is an *apparent* deflection caused by the rotation of the Earth

in the Northern Hemisphere, an object in motion will “bend” to the right



Coriolis effect

Frame of reference and apparent deflection



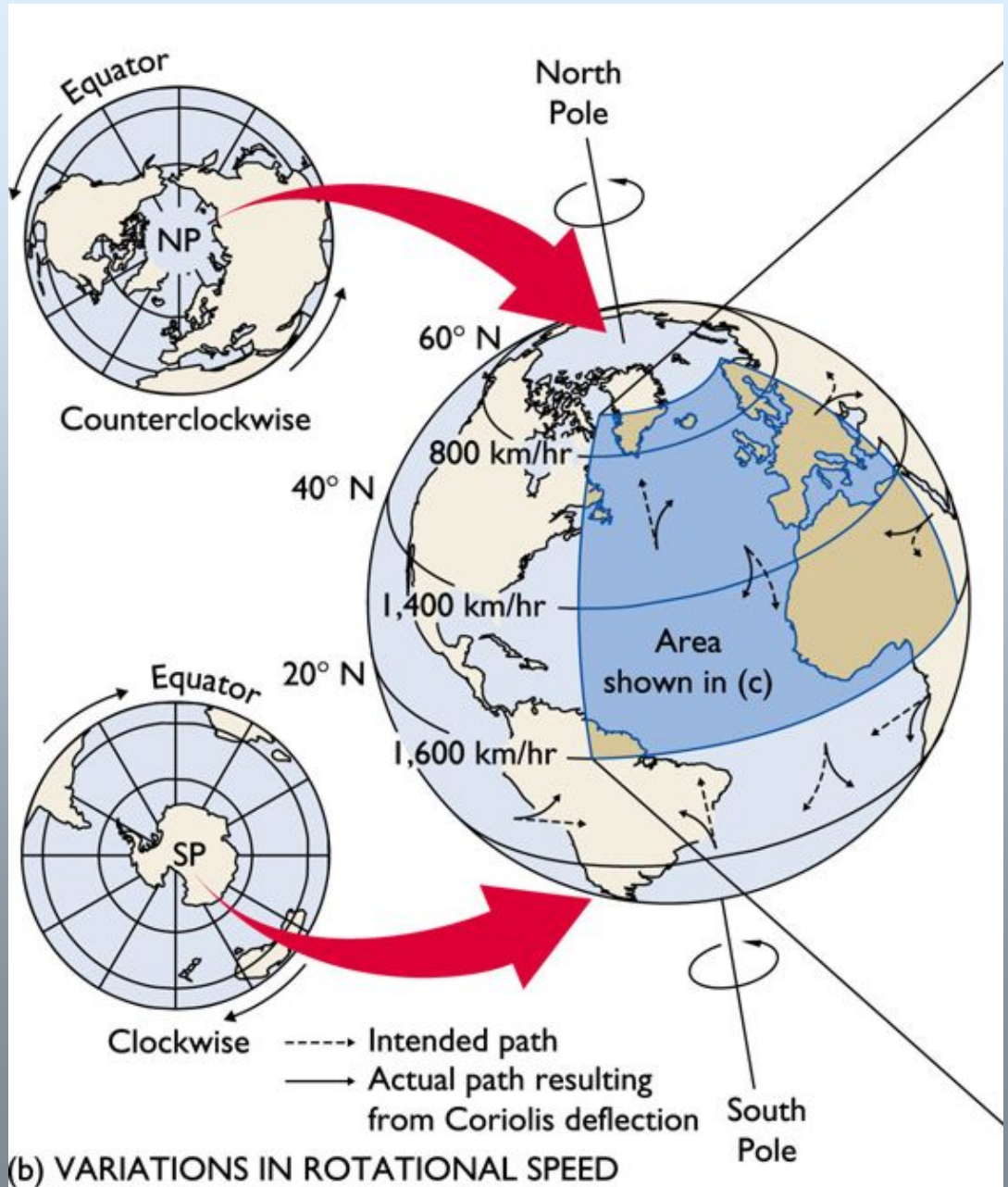
Coriolis effect from a rotating Earth

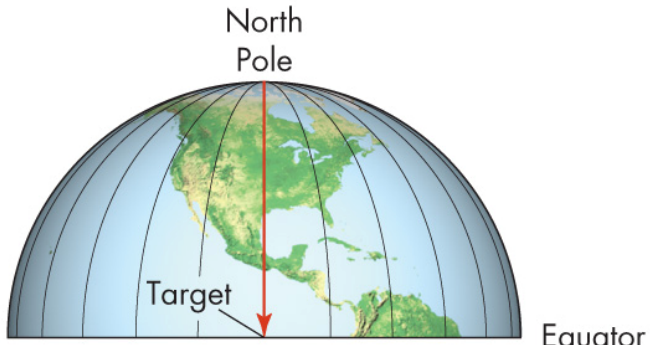
same ***angular*** velocity

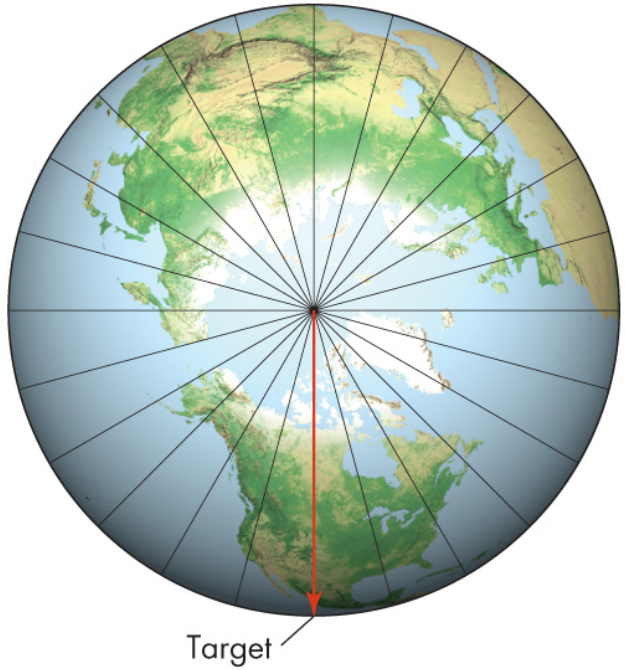
but different ***tangential*** velocities

at pole:
0 km/hr

at equator:
1600 km/hr

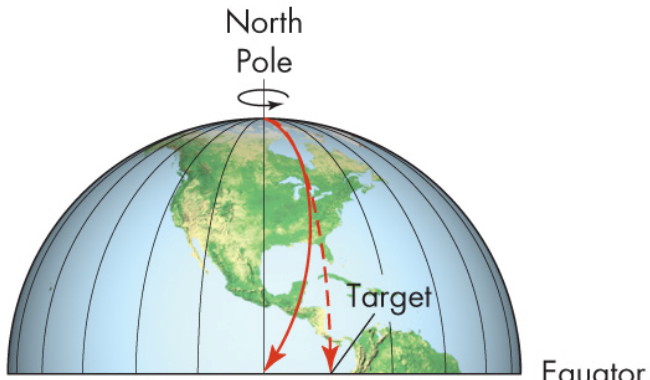


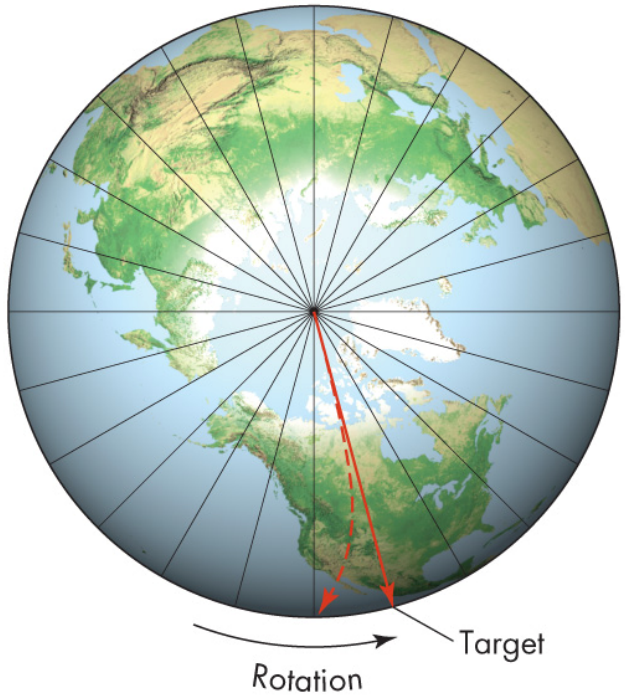




(a) Nonrotating Earth

Figure 8.12





(b) Rotating Earth

Coriolis effect – deflection of moving objects

Deflection to the right in Northern Hemisphere

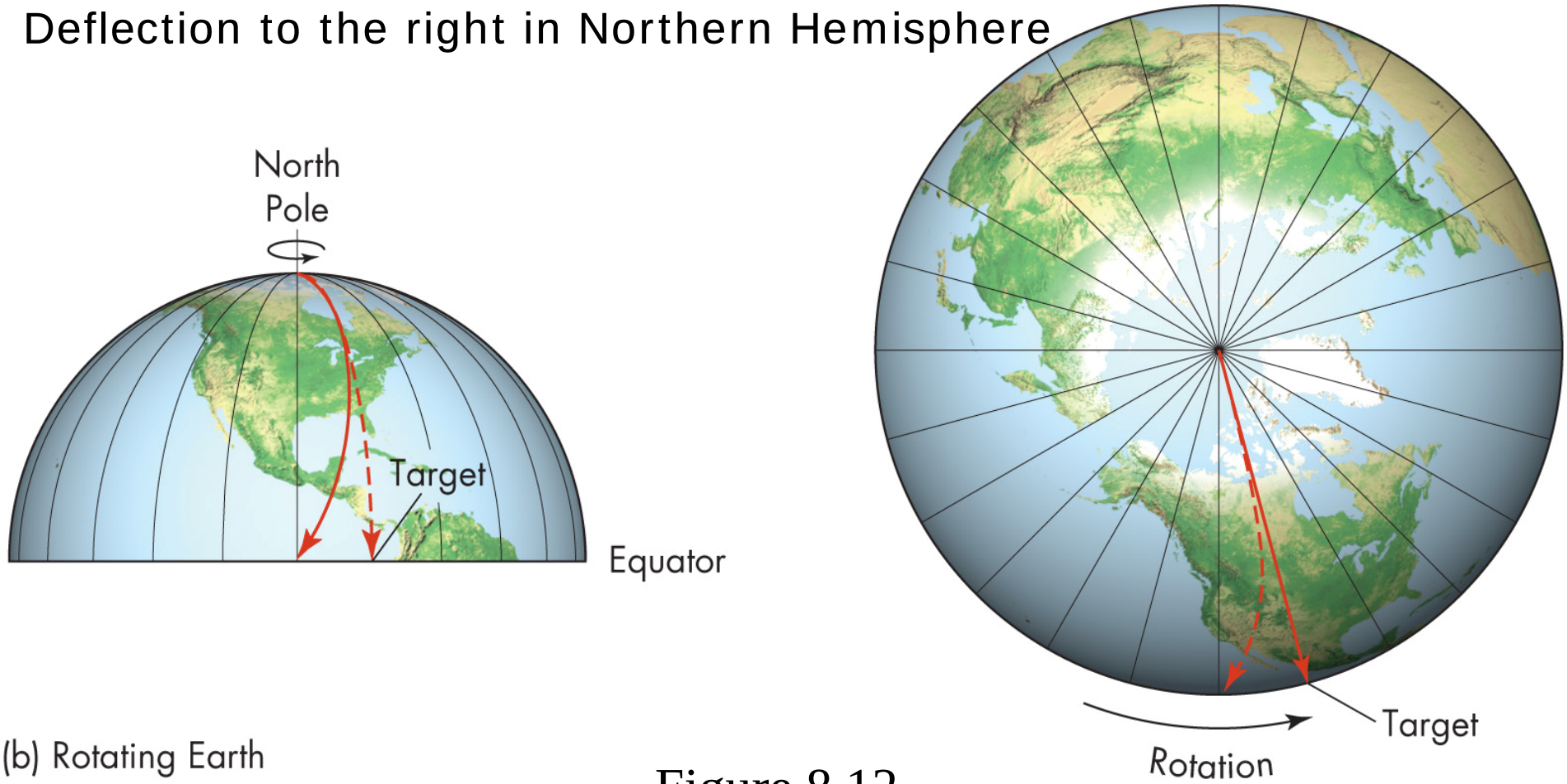
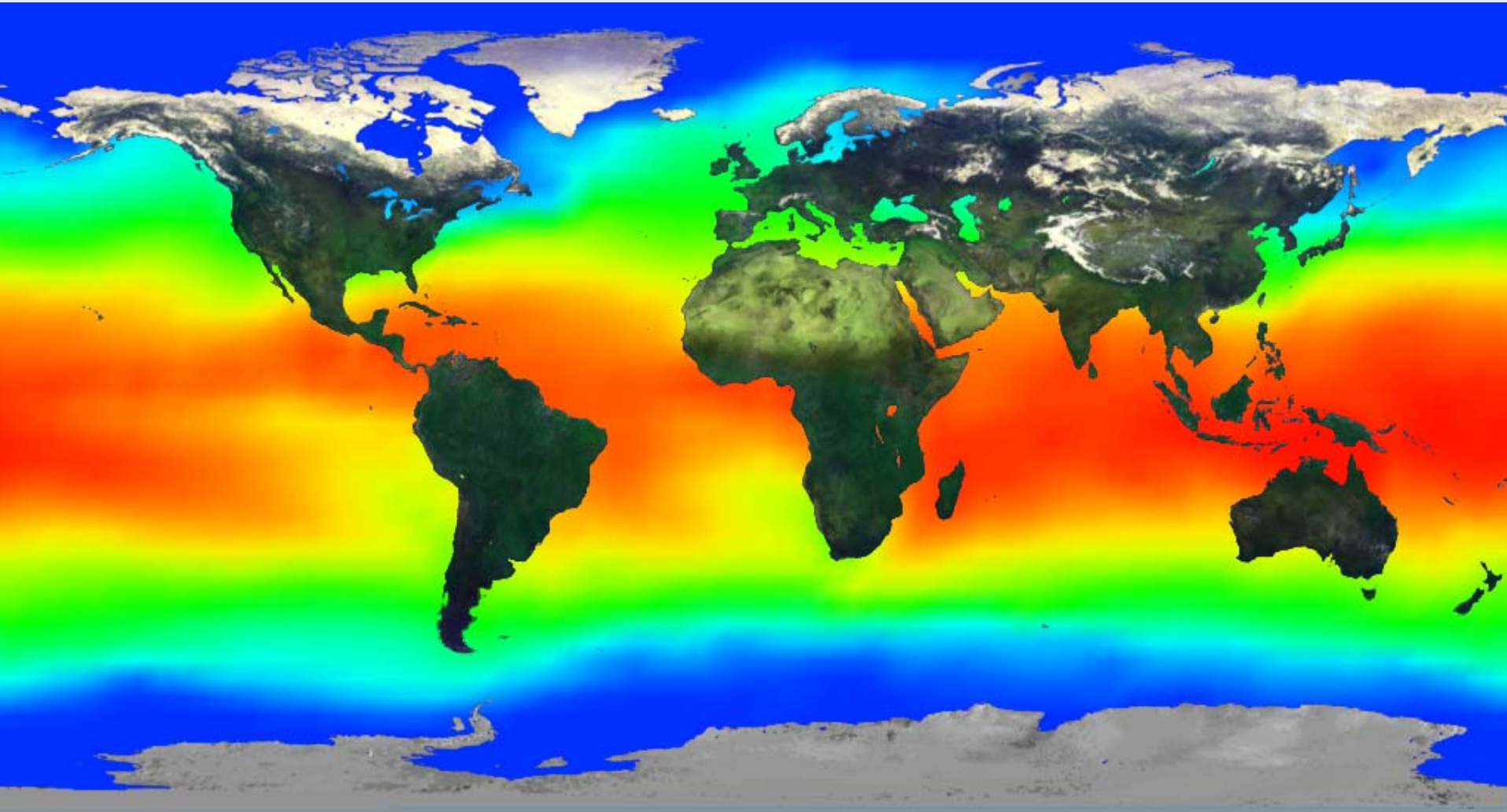
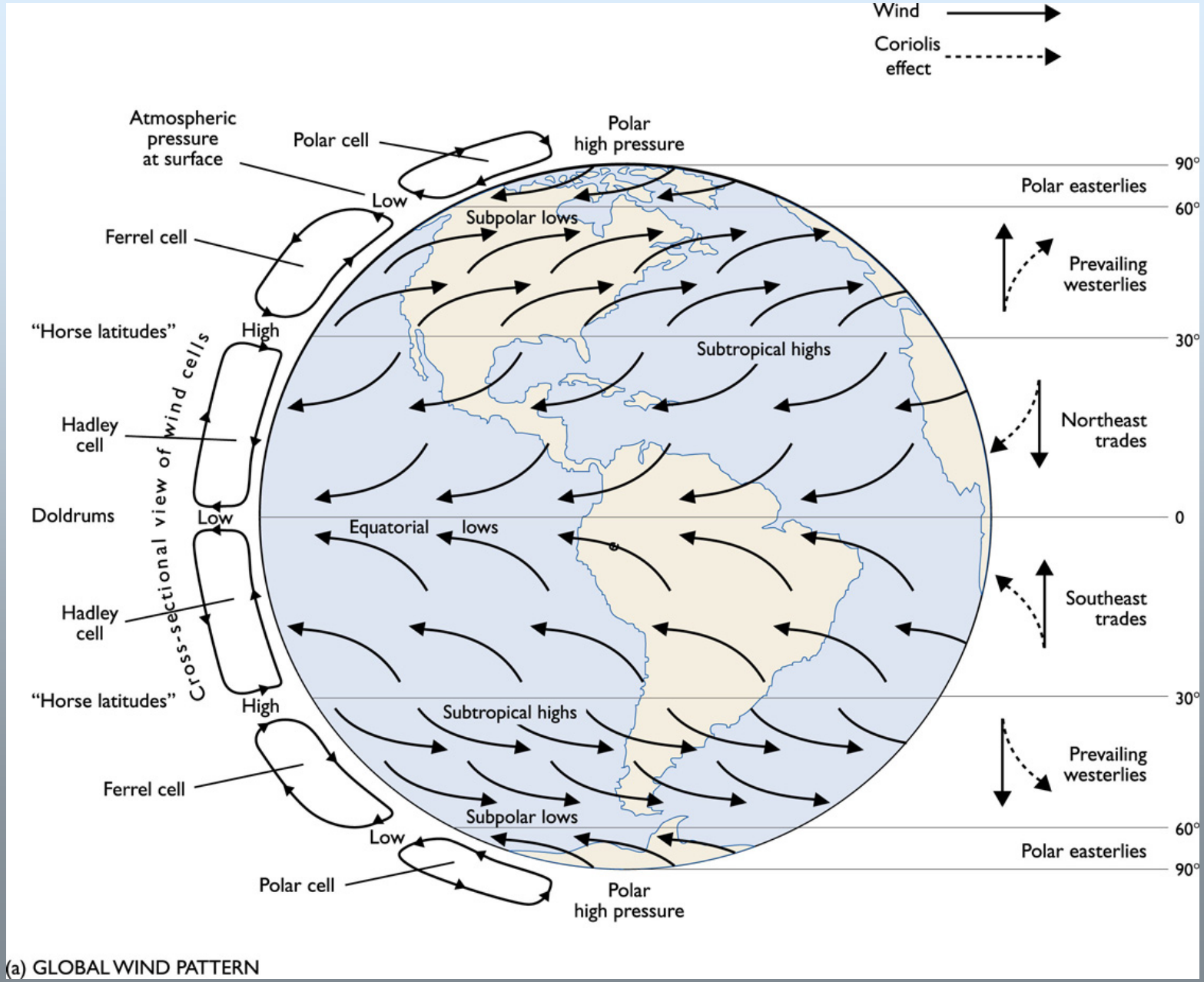


Figure 8.12

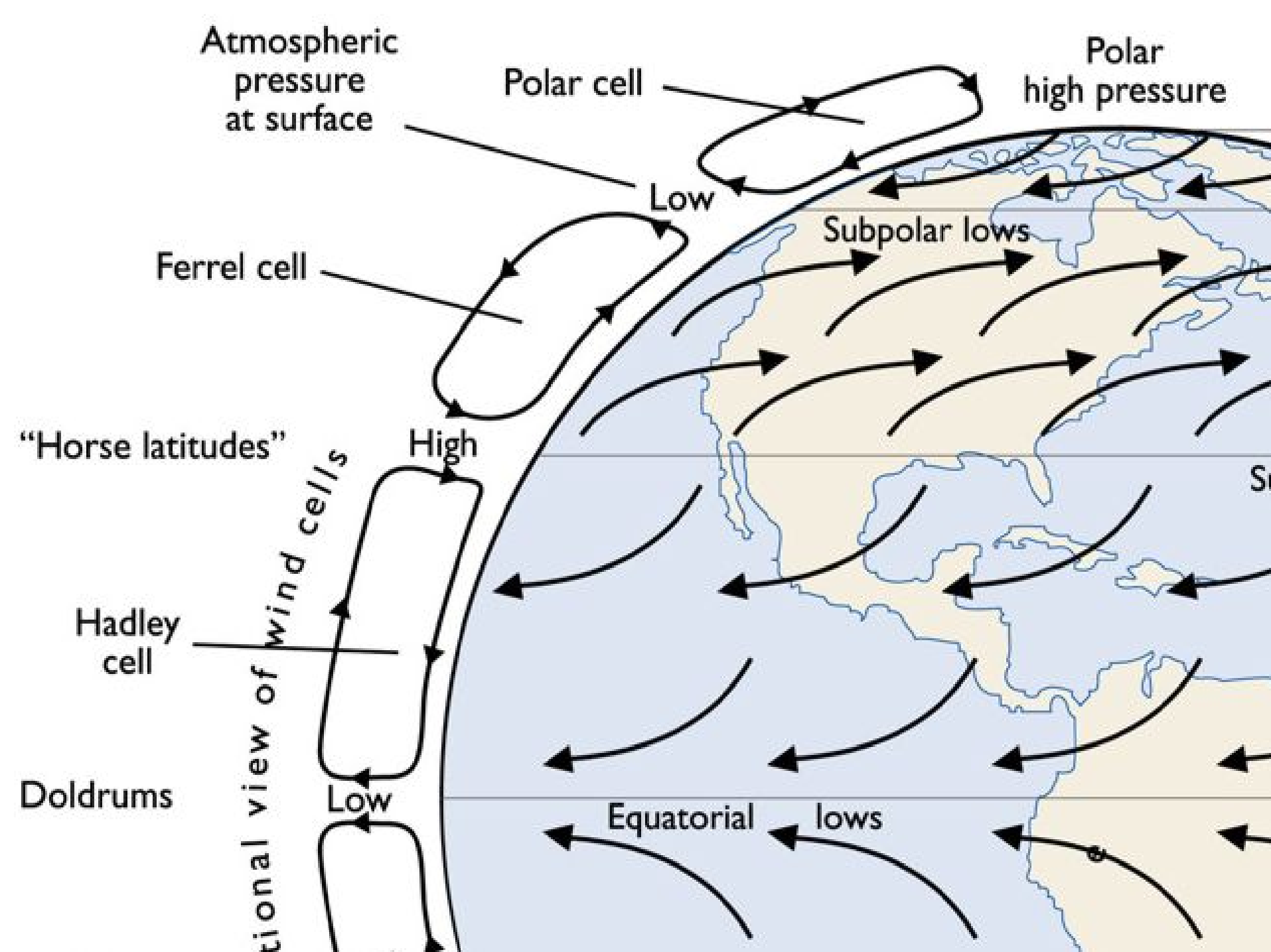
Global distribution of heat



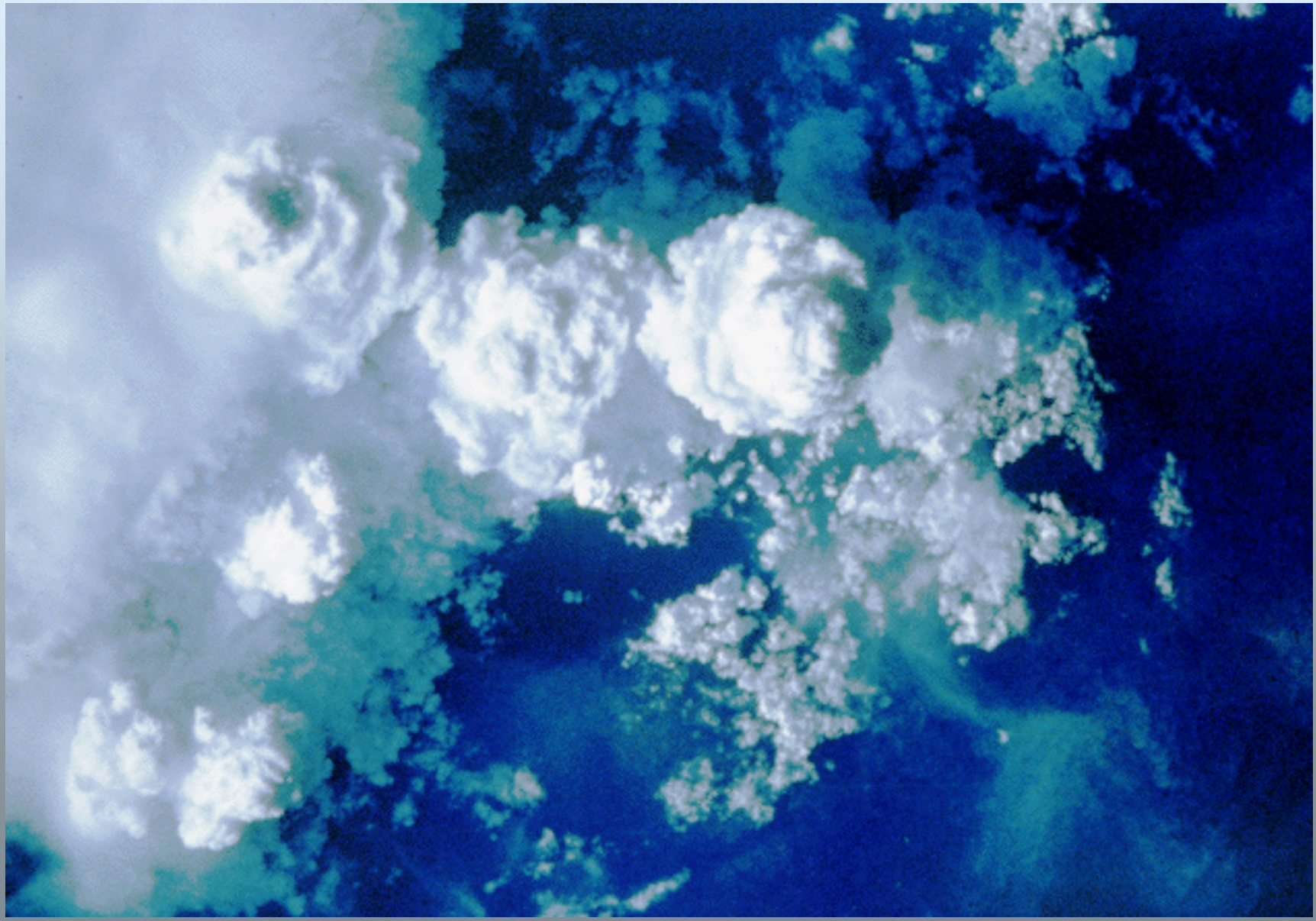
Global wind pattern



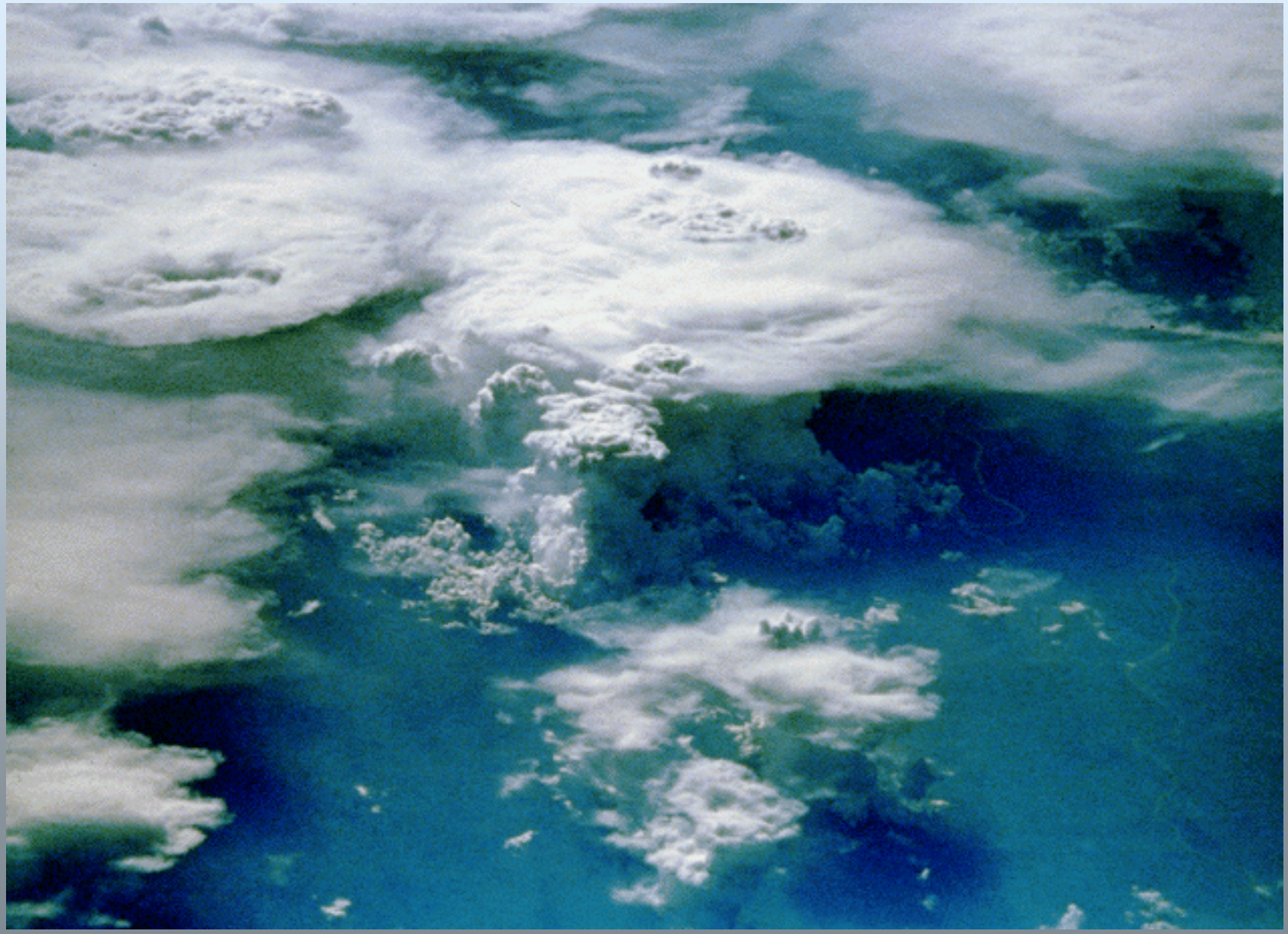
(a) GLOBAL WIND PATTERN


Atmospheric pressure at surface
Polar cell
Polar high pressure
Low
Subpolar lows
Ferrel cell
"Horse latitudes"
High
Hadley cell
Doldrums
Low
Equatorial lows
tional view of wind cells

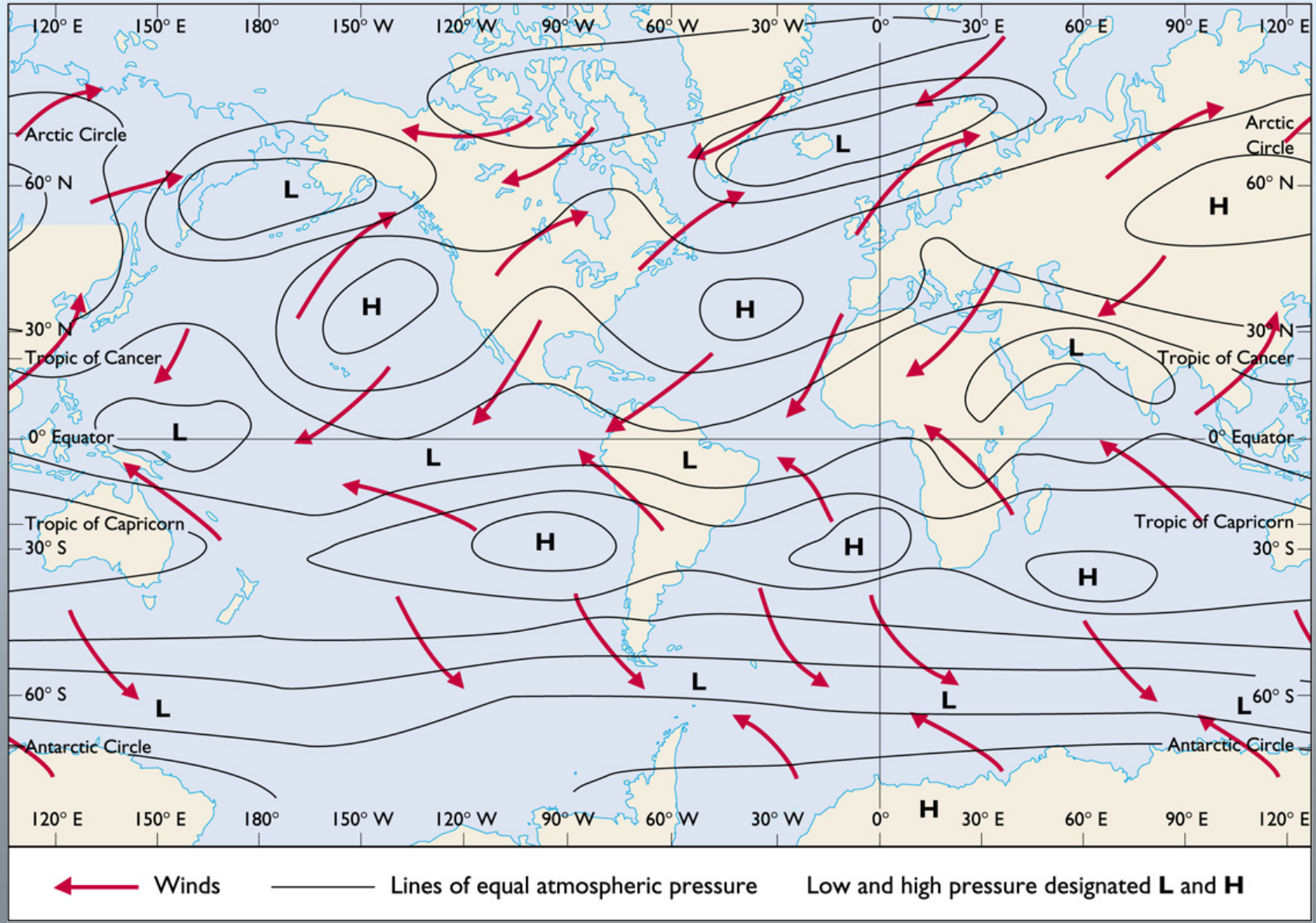
Tropical convection cells



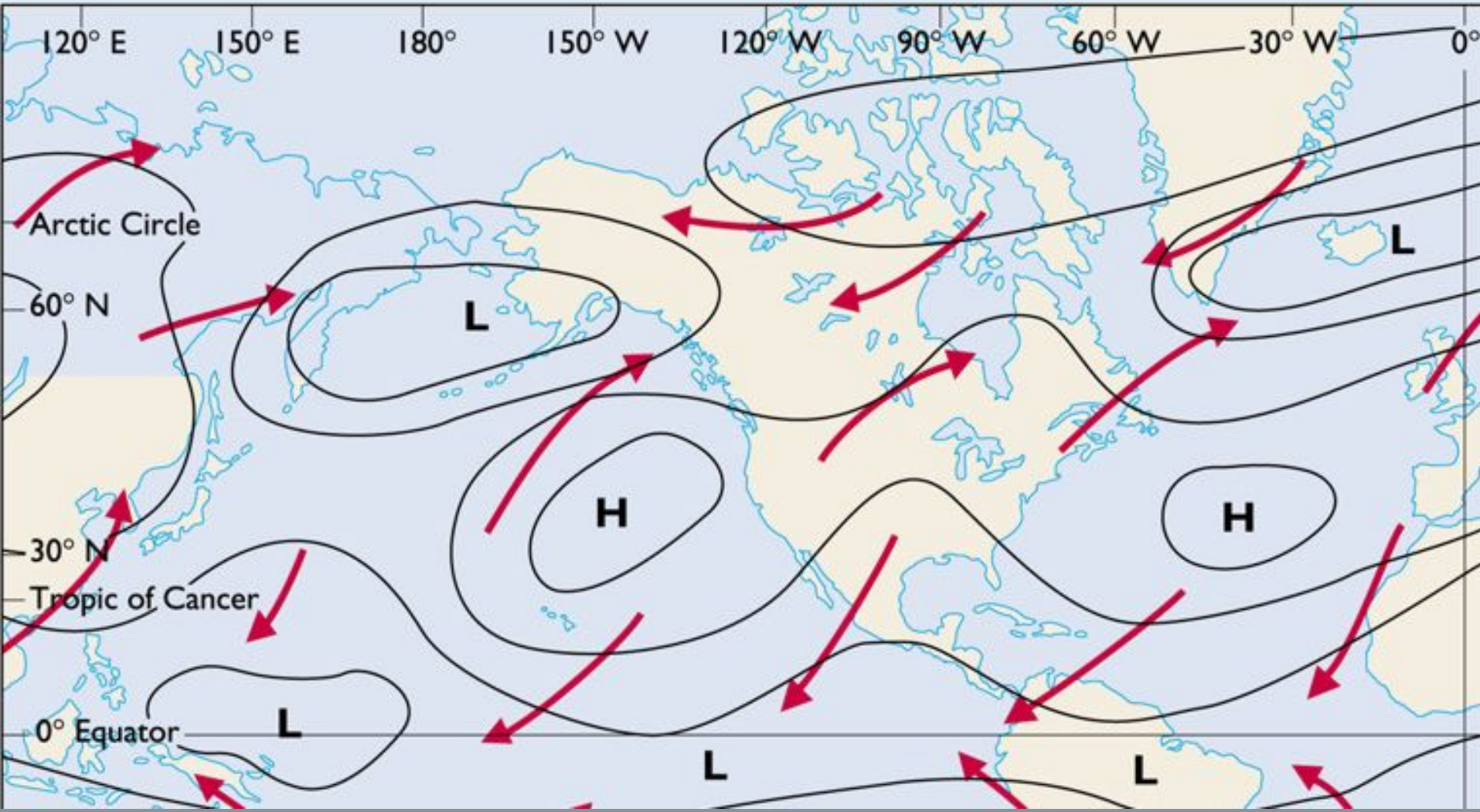
Tropical convection cells



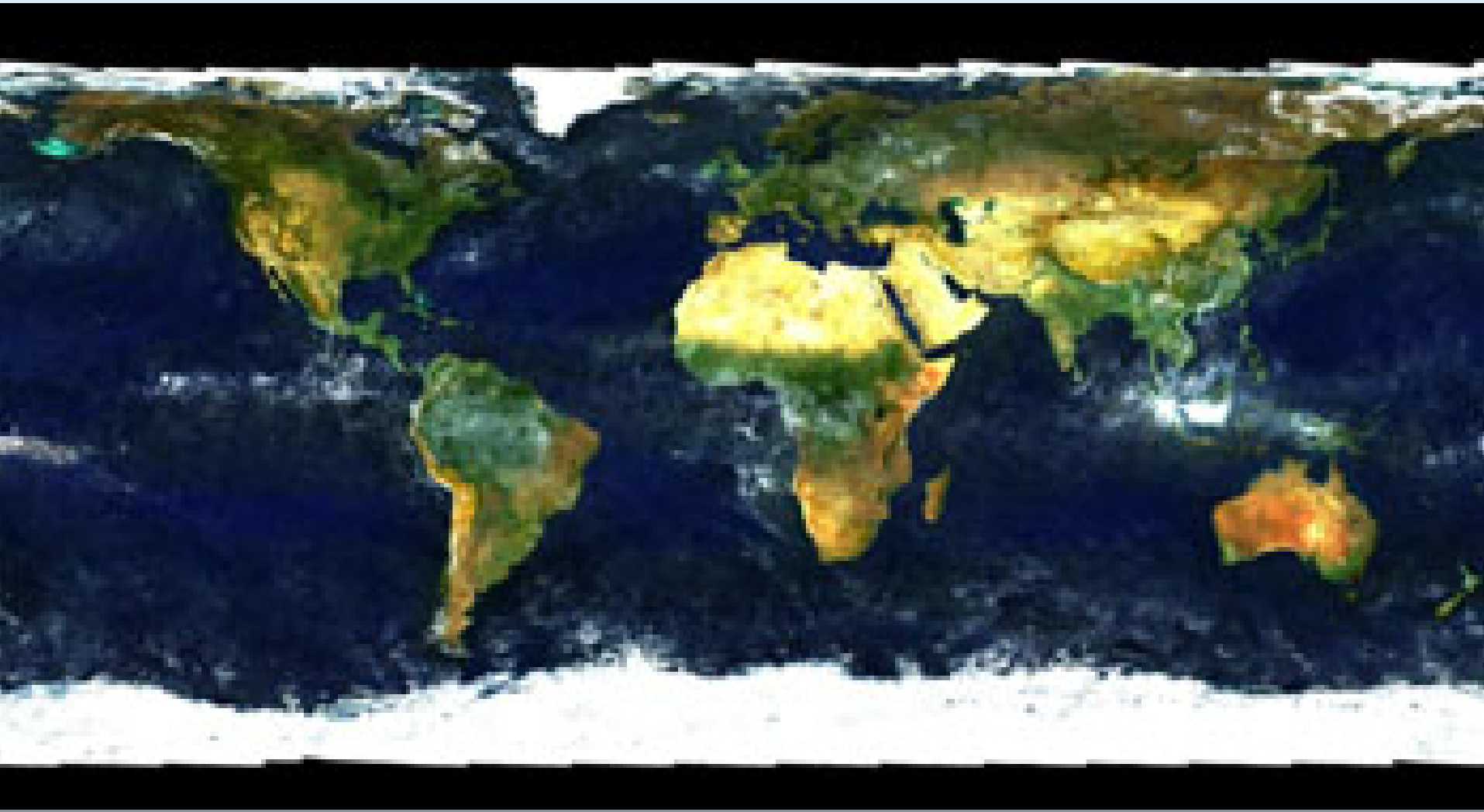
Global atmospheric pressure



Northern Hemisphere



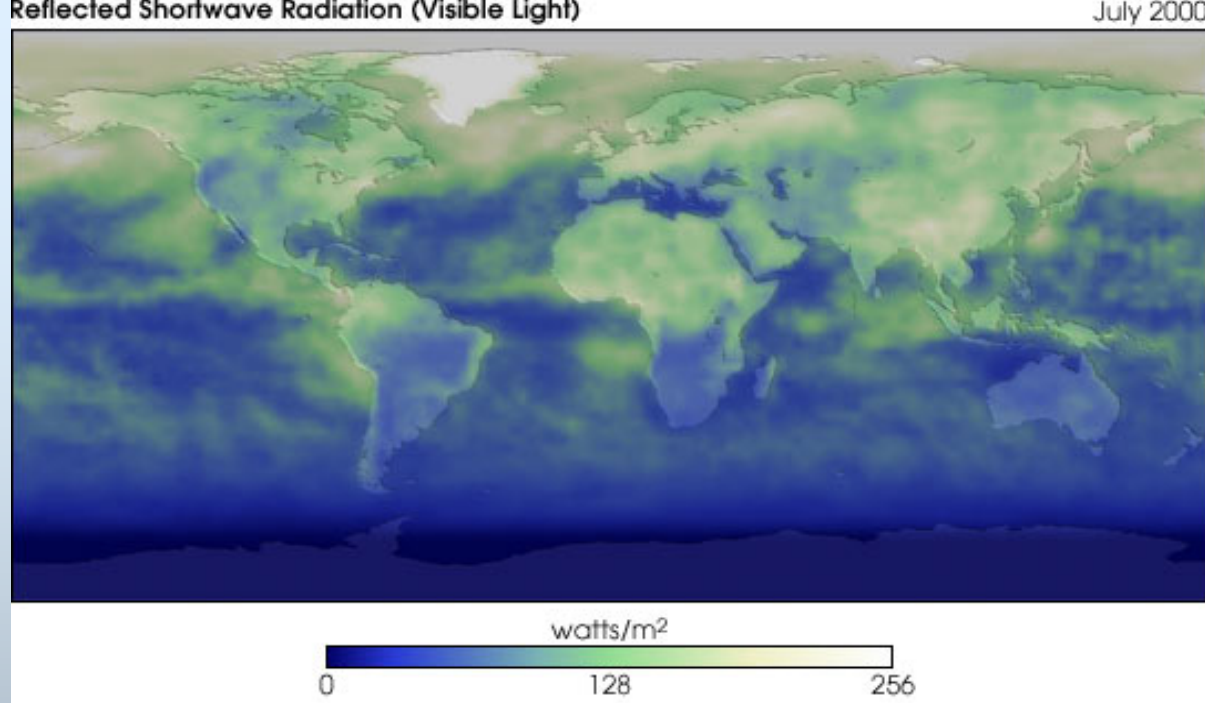
Earth surface – true color

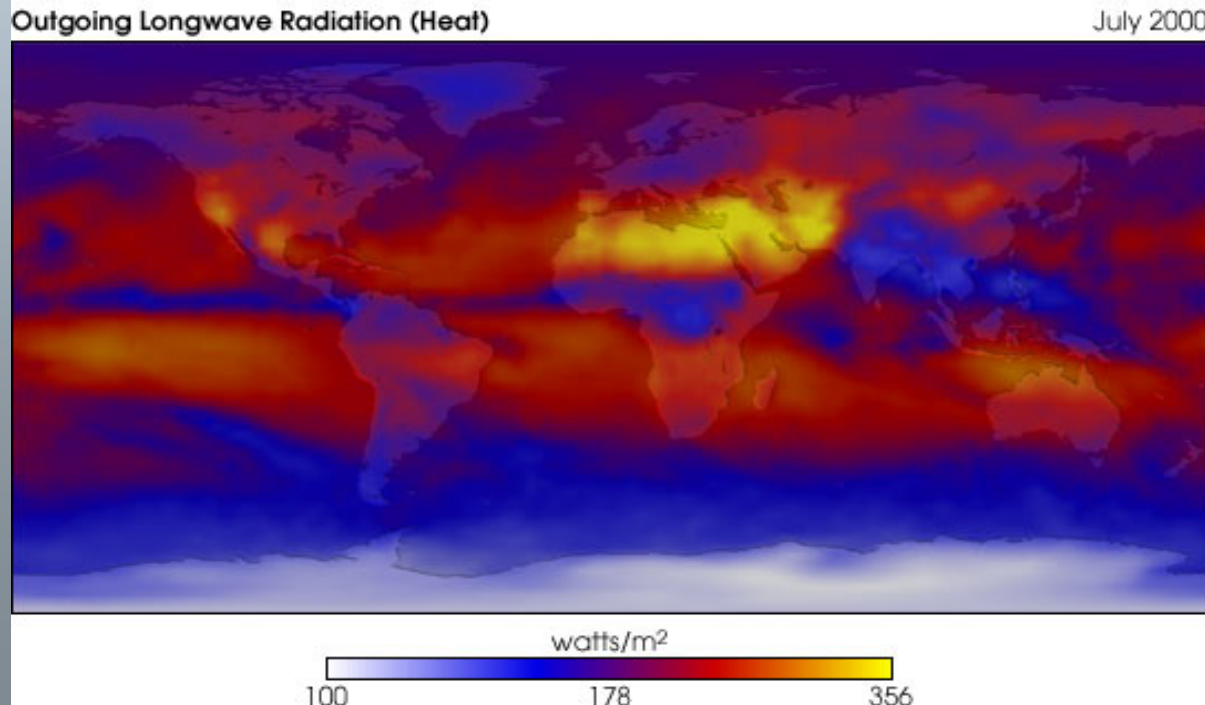


Outgoing radiation

shortwave radiation

longwave radiation





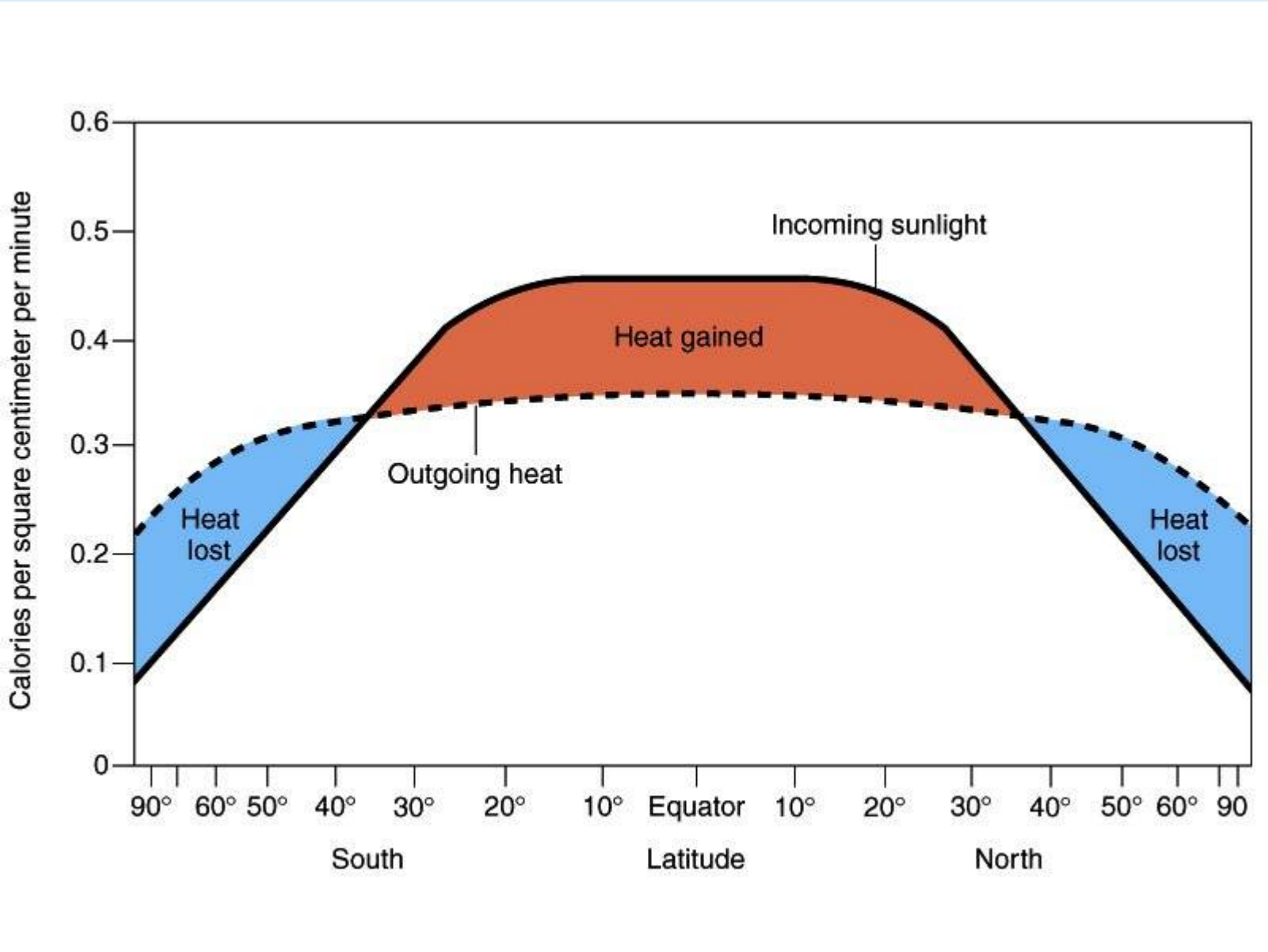
Concept of albedo

Albedo is the reflectivity of the Earth surface

Compare:

snow
hardwood forest
prairie – wet versus dry grasses
desert sand
ocean water

Heat loss and gain from the oceans



Atmospheric circulation