Energy at the Earth surface

Three primary sources of energy driving processes at the Earth surface

Heat from the core
Solar radiation
Gravity

Energy from the Sun

Drives the hydrologic cycle

Provides chemical energy to sustain {almost} all life on the planet

Produces differential heating of the oceans and atmosphere that drives circulation and creates weather

Concepts of energy and heat

Force – pushing or pulling, mass x acceleration

Work – force applied over a distance

Power – the rate of work being done

example of different batteries driving a fan

Types of energy

Kinetic energy

energy of a mass in motion

Newton's First Law of Motion

An object at rest will remain at rest ...
An object in motion will remain in motion ...

UNLESS _____

Types of energy

Potential energy

stored energy

available to be converted to kinetic energy

Types of potential energy

(How can energy be stored?)

gravitational

chemical

electrical

elastic

Heat

Fundamentally, what is heat?

The kinetic energy of molecules
vibrating and moving (colliding)

A balloon as a physical model
forces pushing out
forces pushing in

Heat

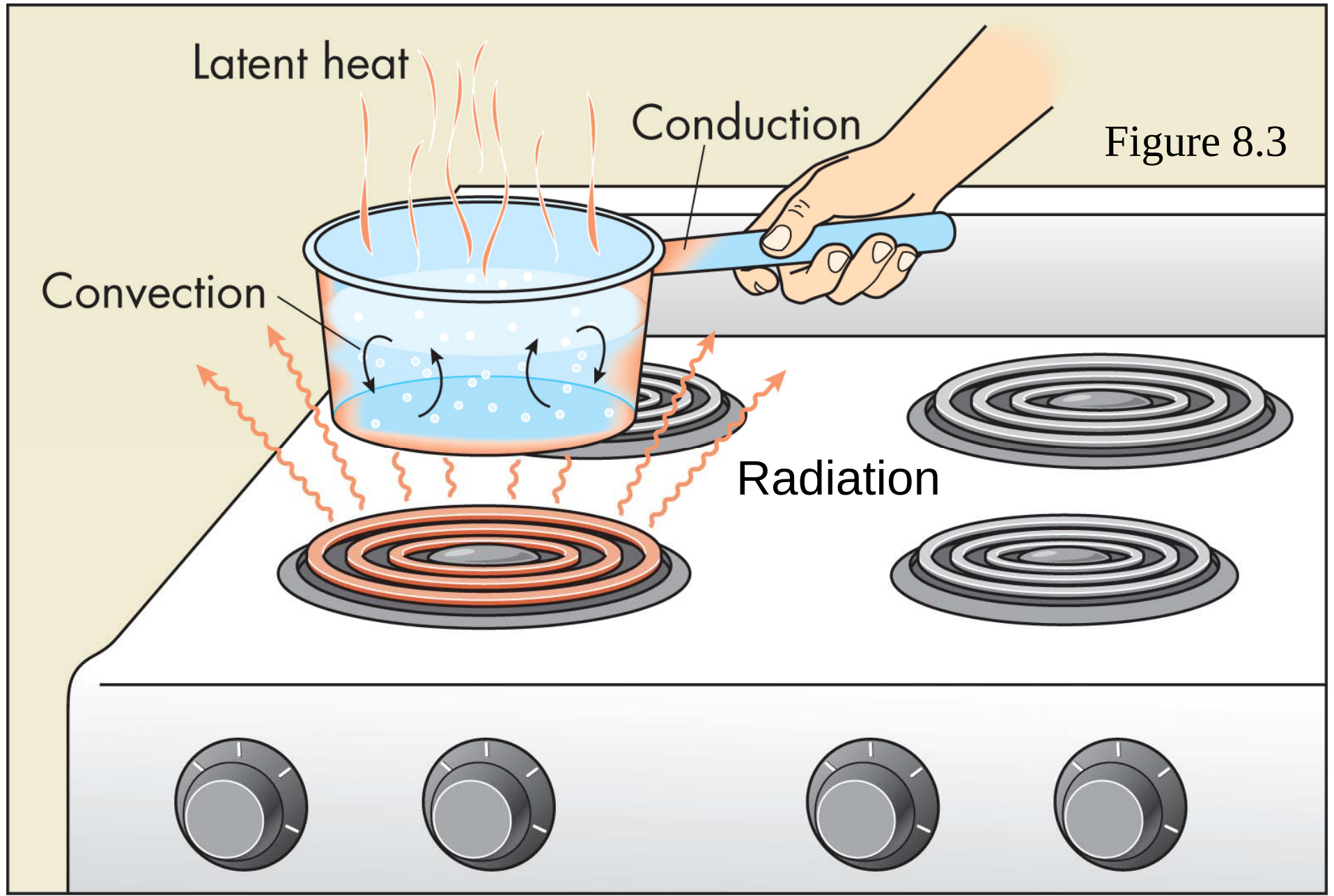
Ways of transferring heat

Conduction

Convection – convection cells

Radiation – electromagnetic energy

Transfer of heat

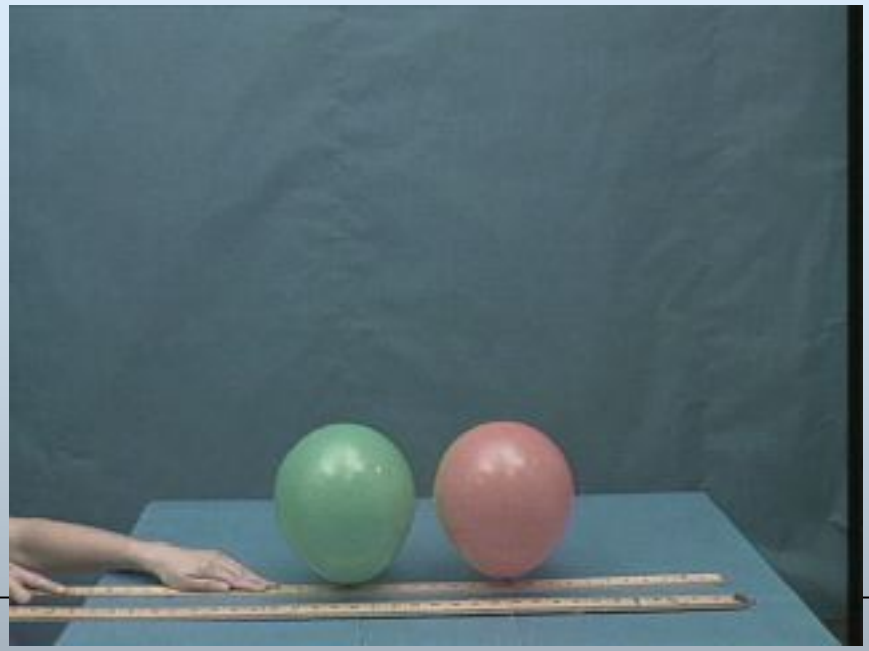


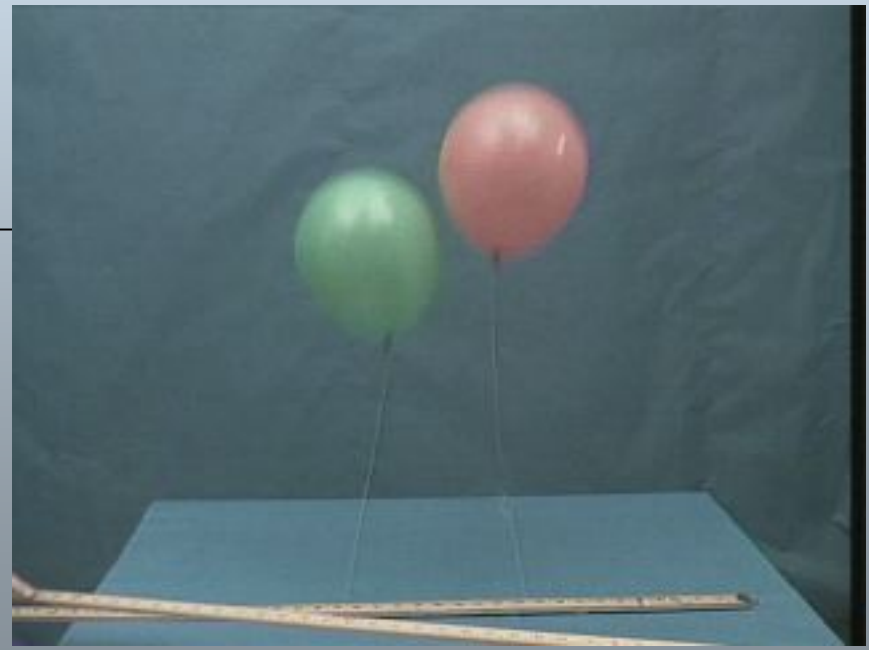
Density and buoyancy

In a *FLUID*, materials will rise or sink according to density

What is the driving force for buoyancy?

Density & Buoyancy





Composition: He H

Density & Buoyancy

Composition: SF_6 CO_2 O_2 N_2

Atmospheric physics

Atmospheric pressure

- Static at sea level
- High pressure
- Low pressure

Humidity, relative humidity, and dewpoint

Compressing and expanding air

Energy balance for the Earth

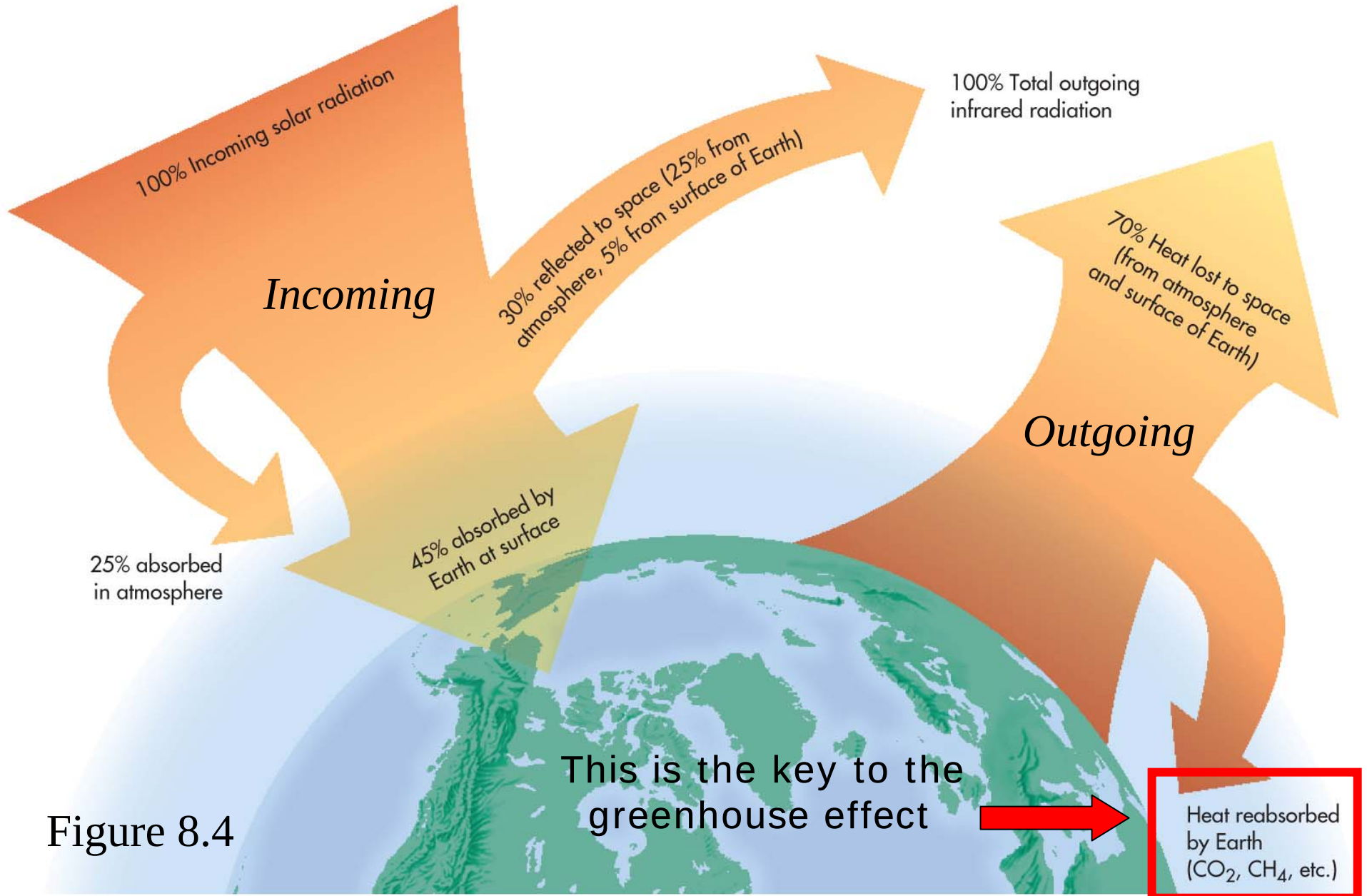
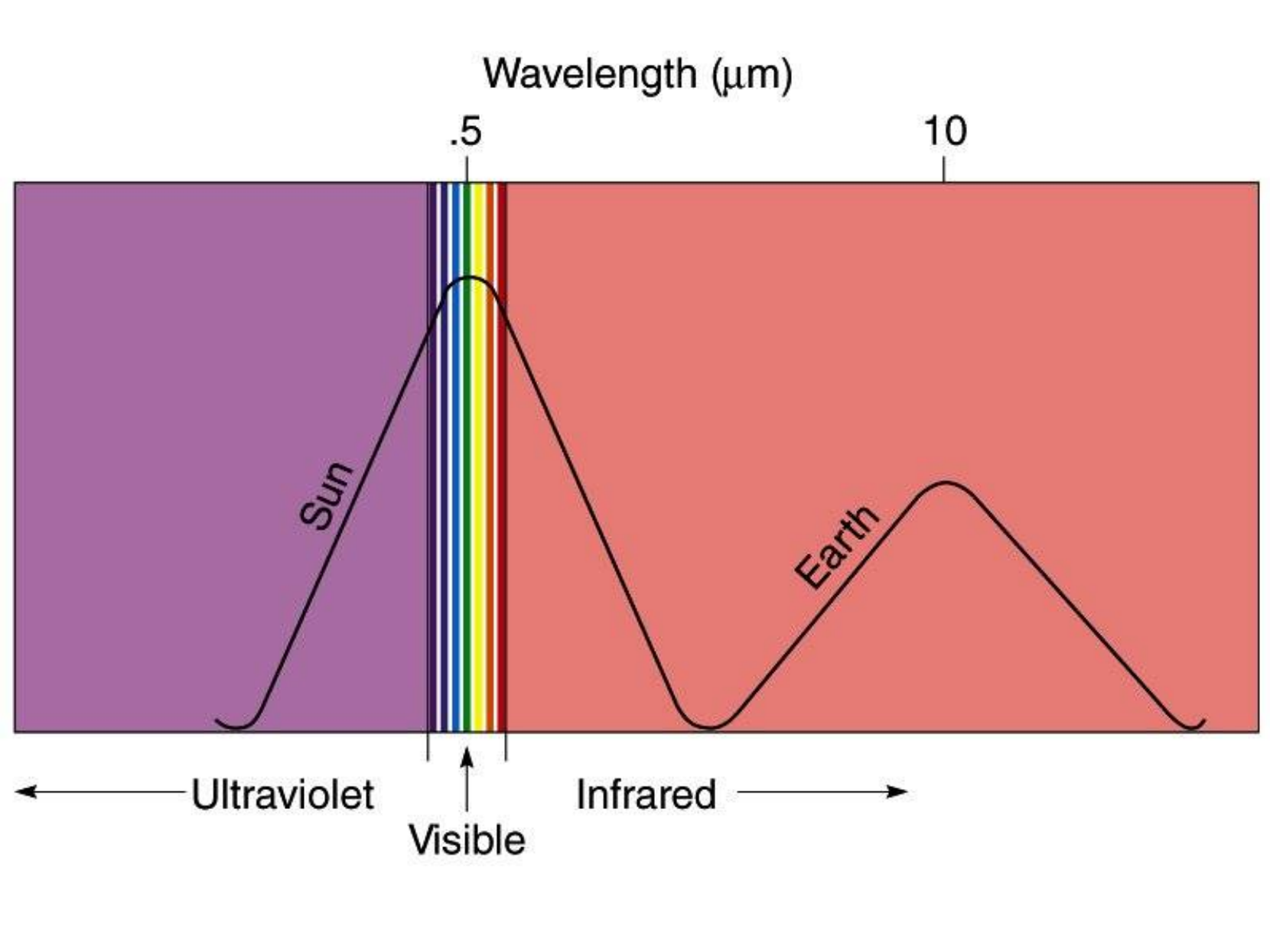


Figure 8.4

Spectra of incoming vs. outgoing radiation



Ionosphere
(100-1000 km)

Thermosphere
(part of ionosphere)

Mesosphere

Stratosphere

Troposphere

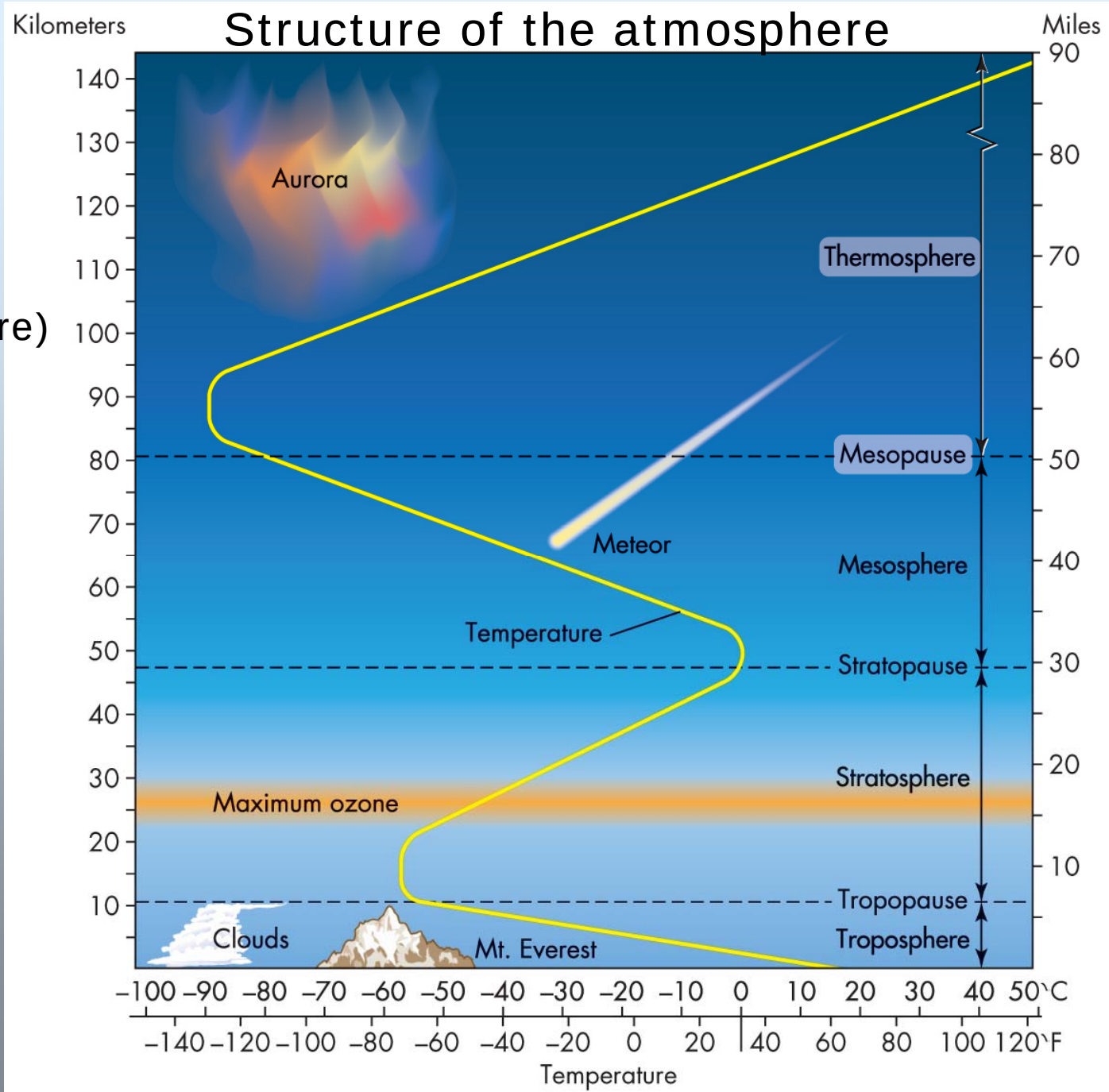
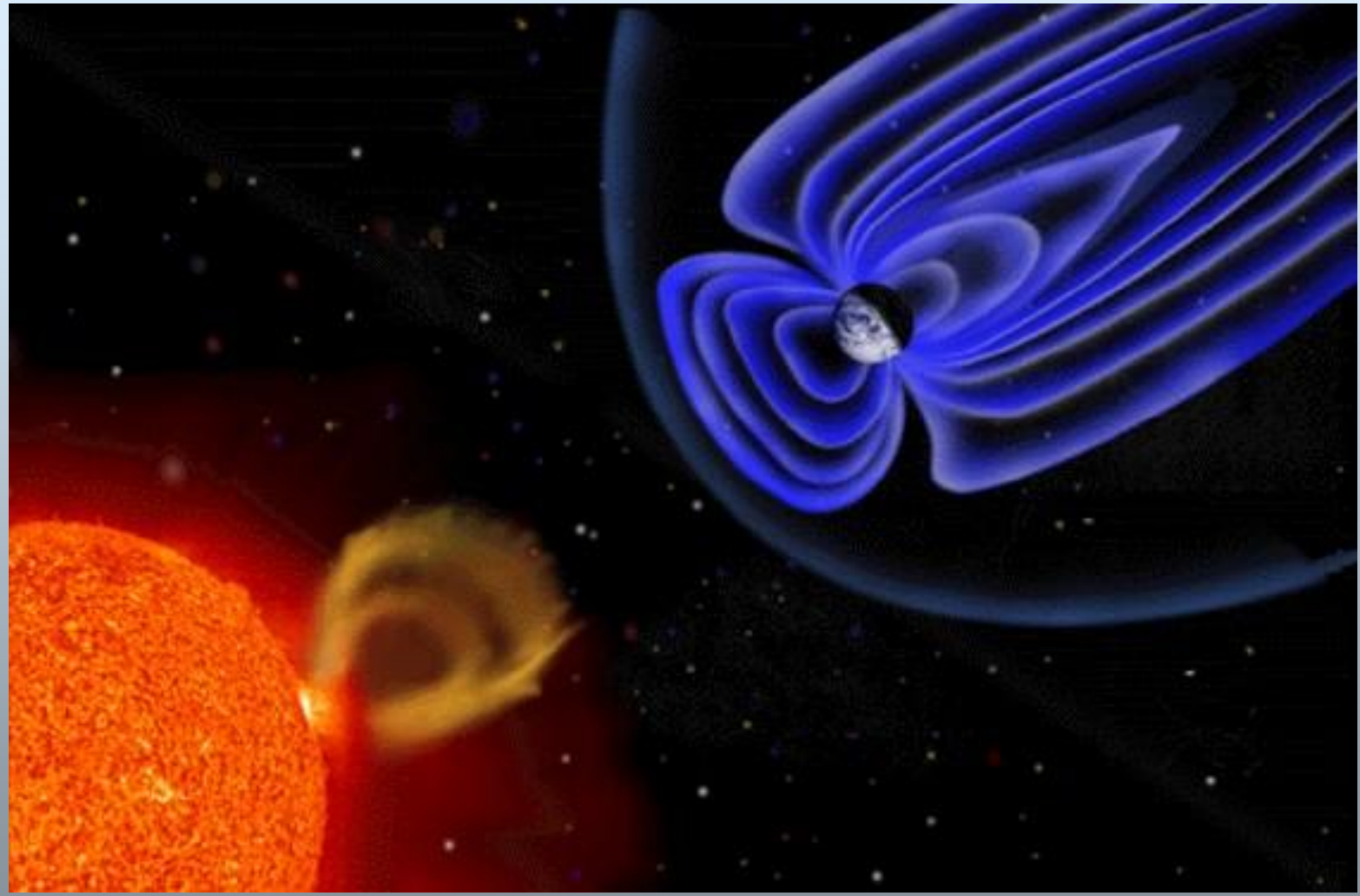


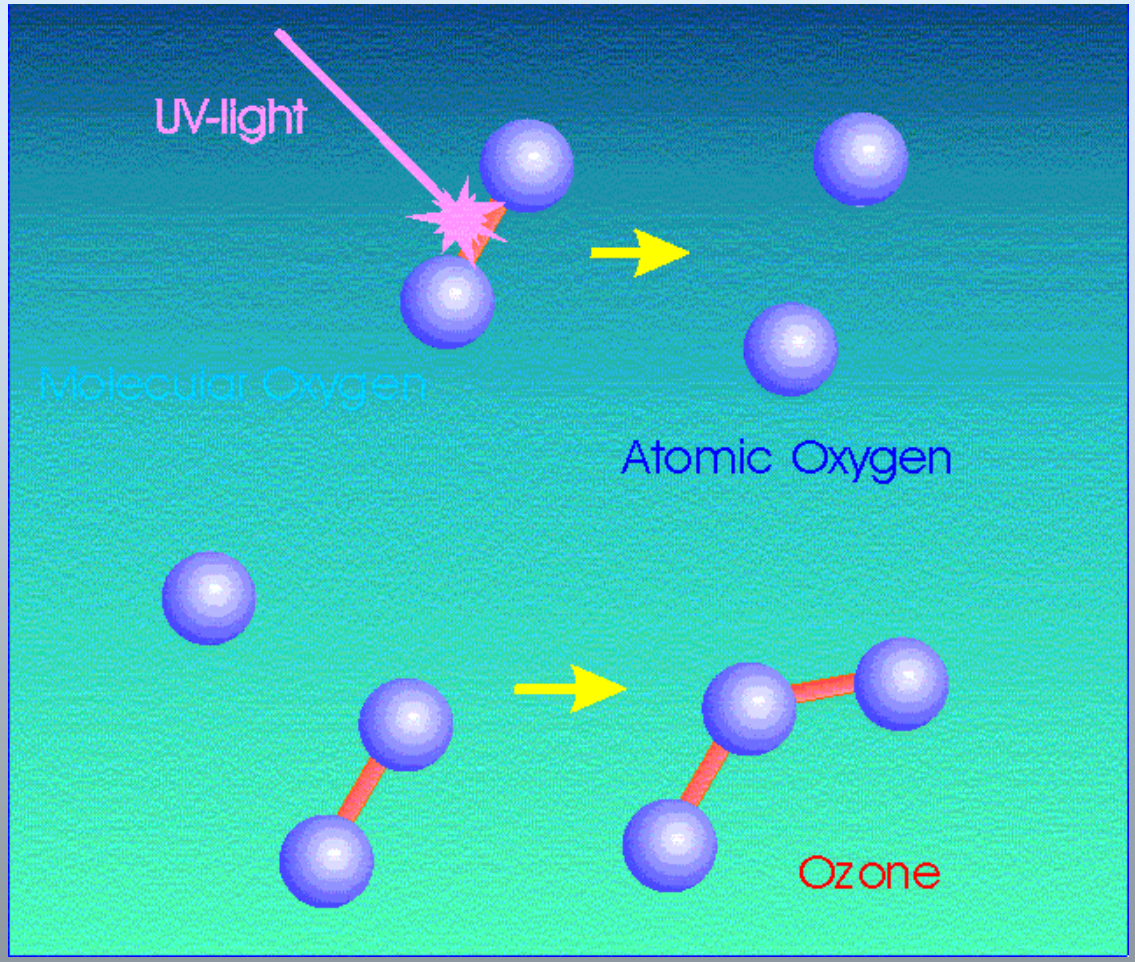
Figure 8.7

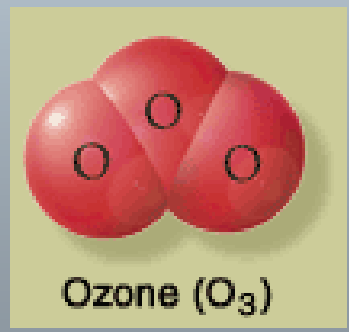
The Earth's magnetosphere



10 Earth radii to 1000 Earth radii

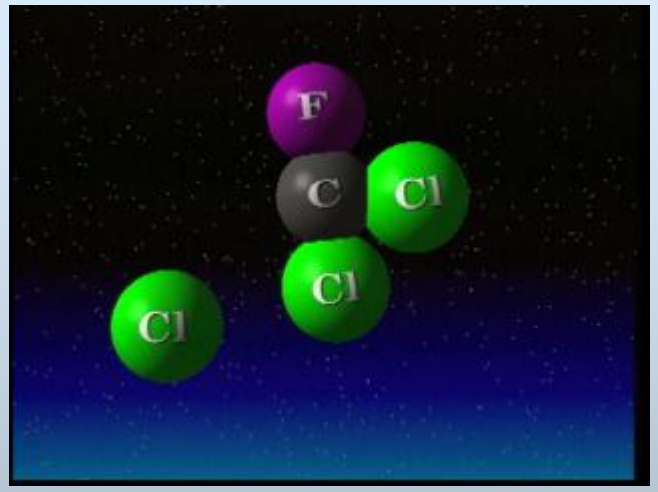
The Earth's ozone layer



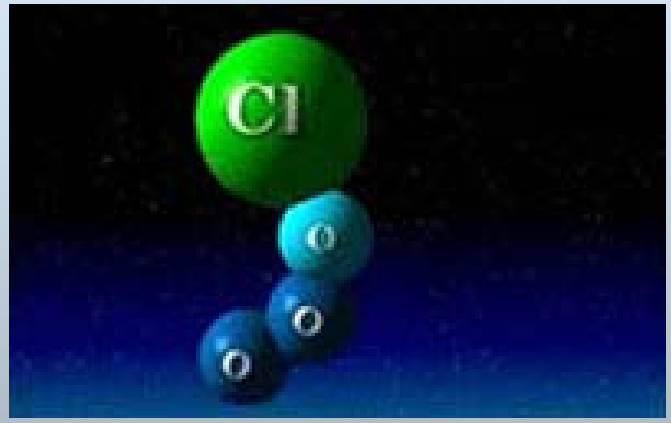


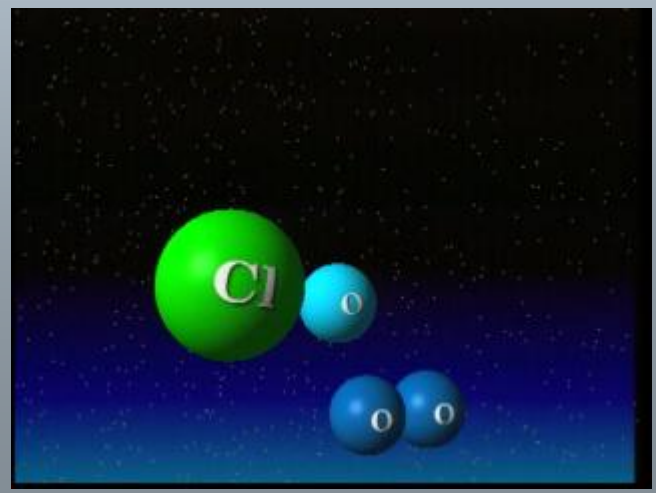
Ozone is produced in the stratosphere and absorbs incoming UV from the Sun

CFCs and ozone depletion

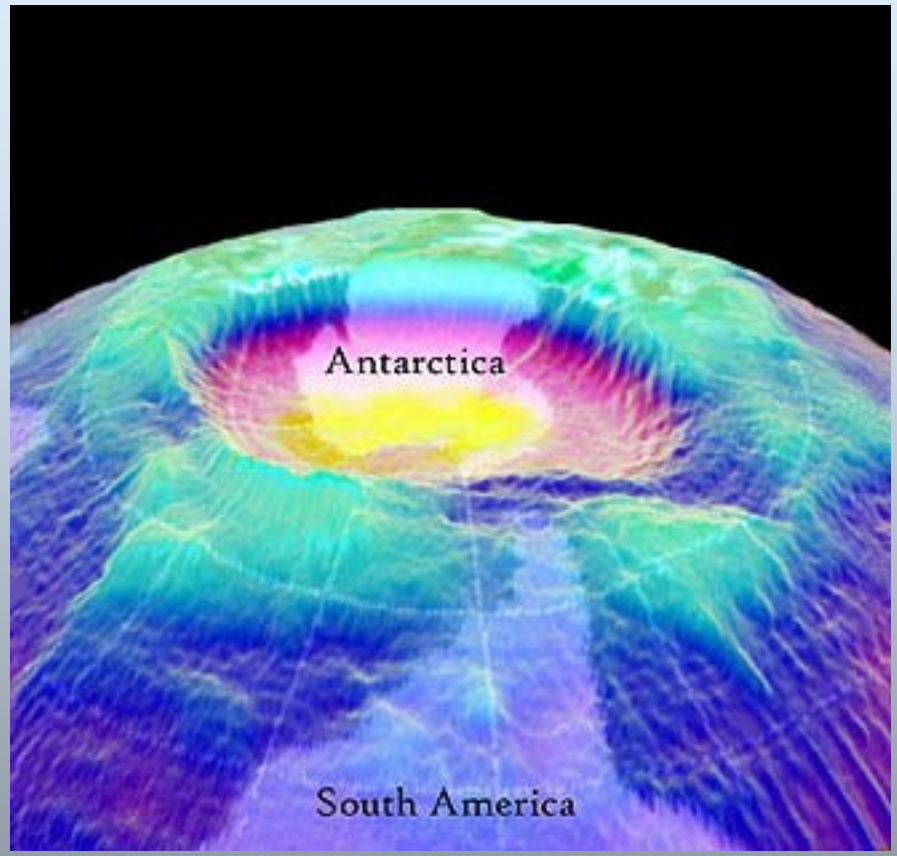


CFC = chloro fluoro carbon



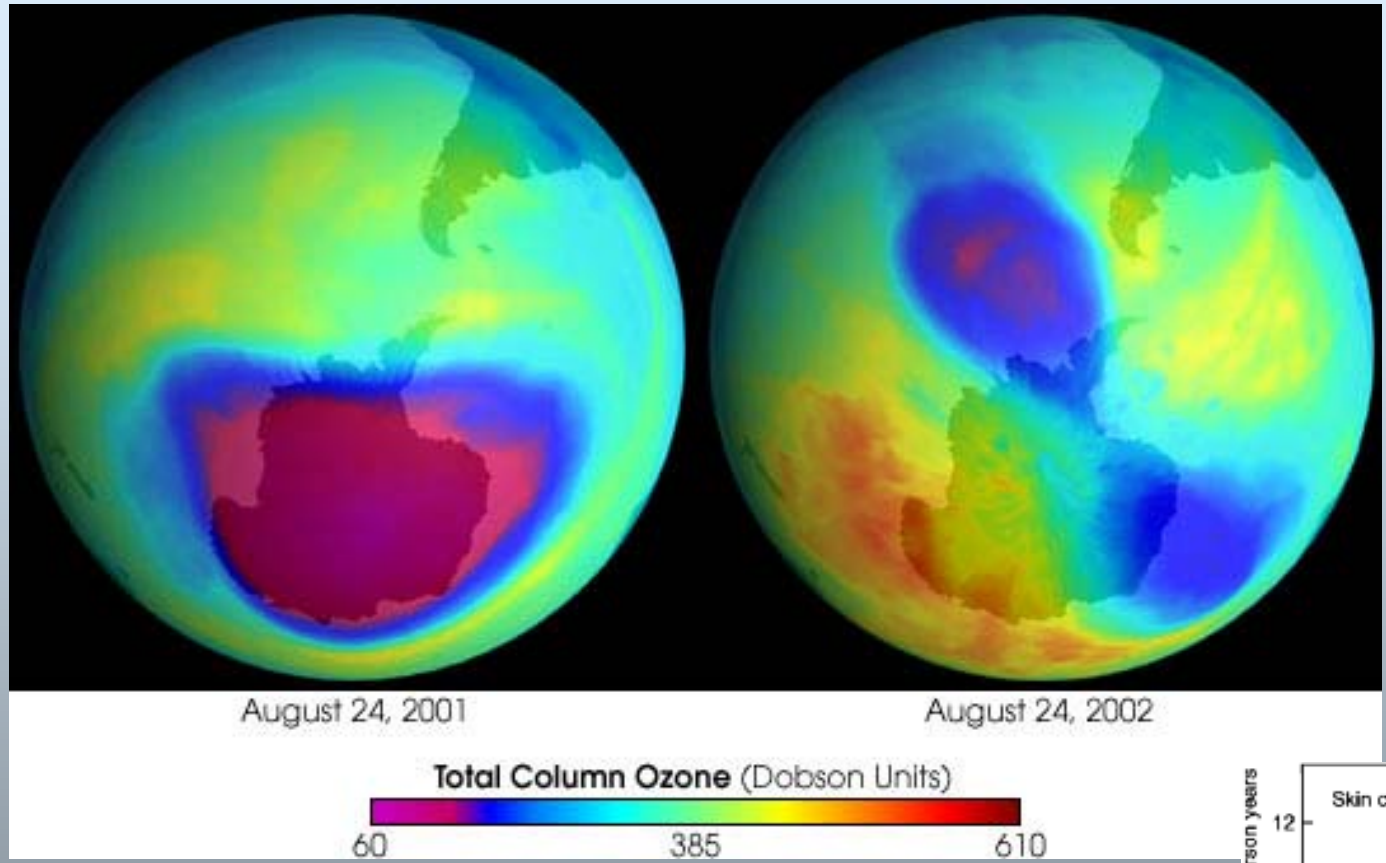


The Earth’s ozone layer

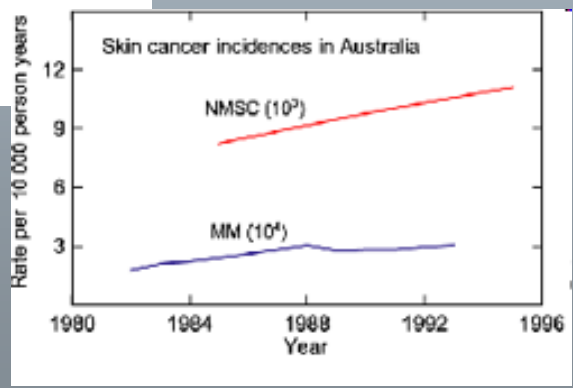


The ozone hole over Antarctica

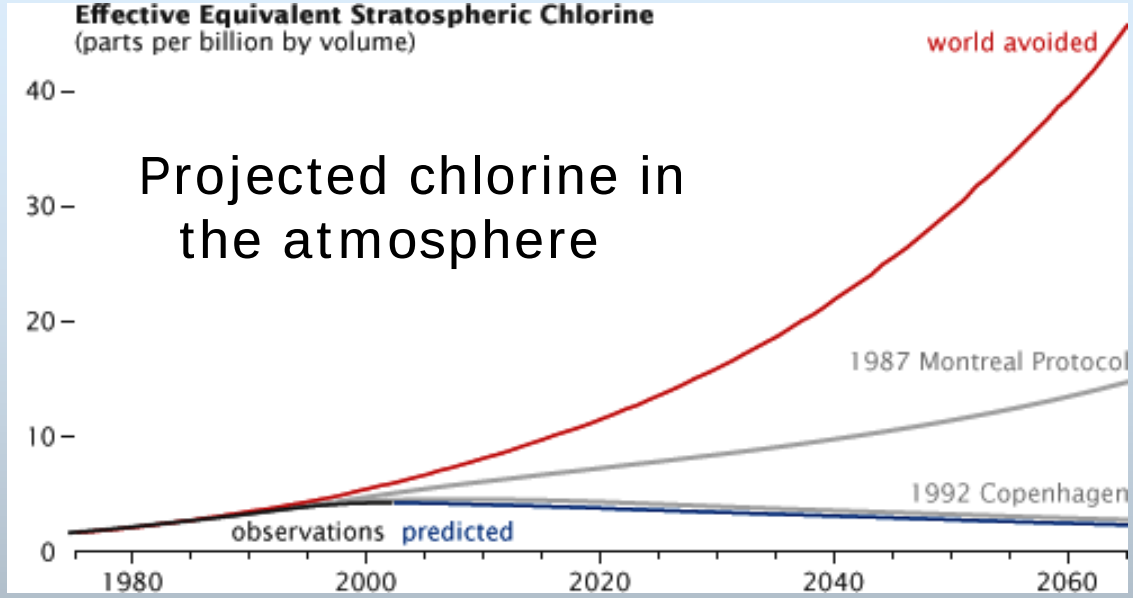
The Earth's ozone layer



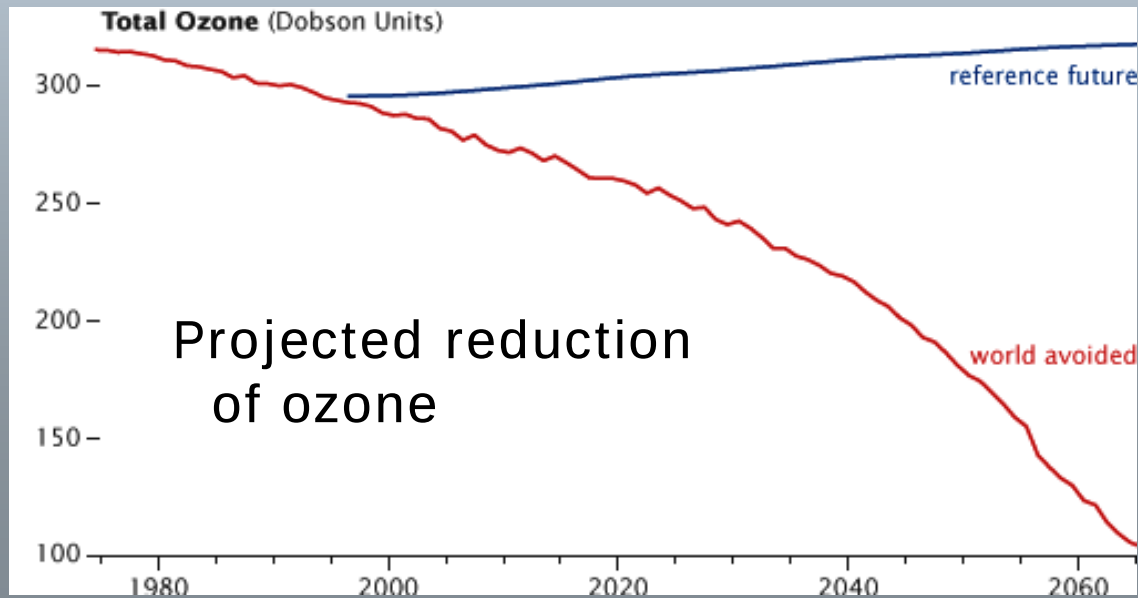
The ozone hole splits and moves



The Earth's ozone layer

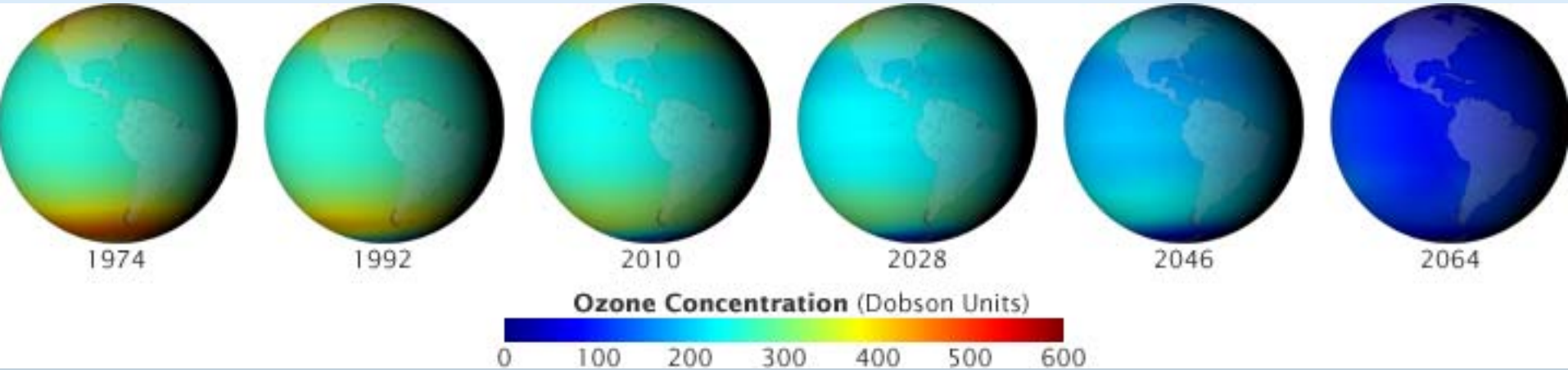


Projected chlorine in the atmosphere

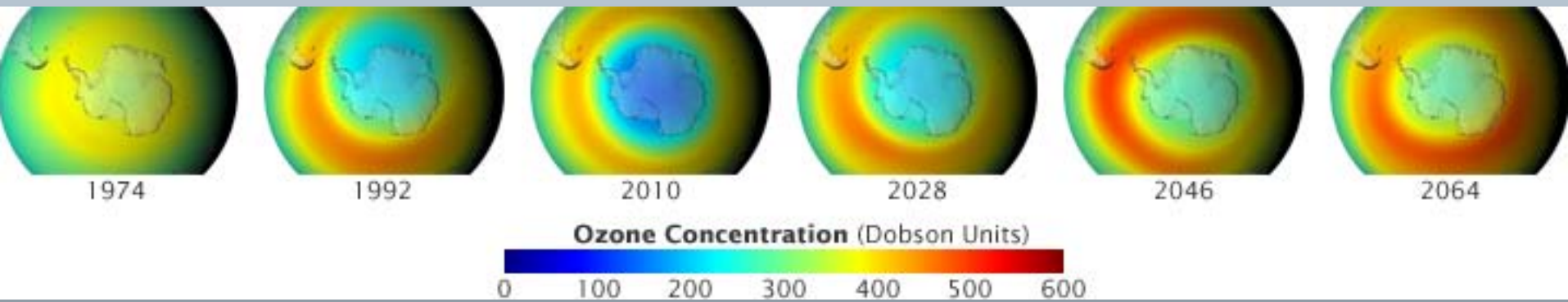


Projected reduction of ozone

The Earth’s ozone layer



Projected ozone depletion with no action



Projected ozone recovery because of restrictions

Ozone depletion avoided

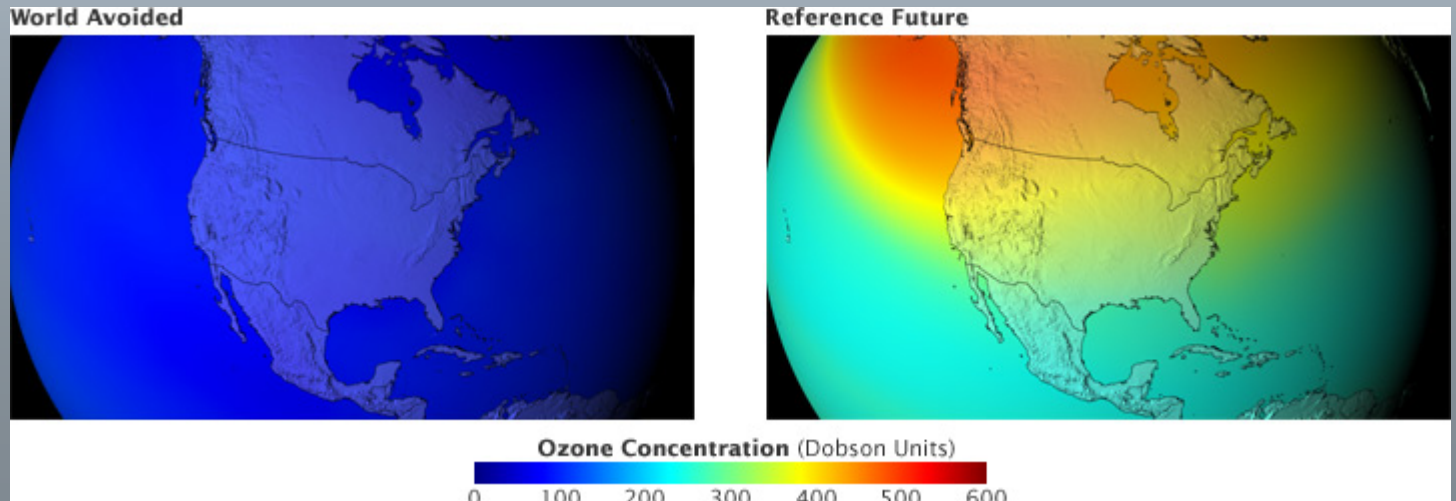
The year is 2065.

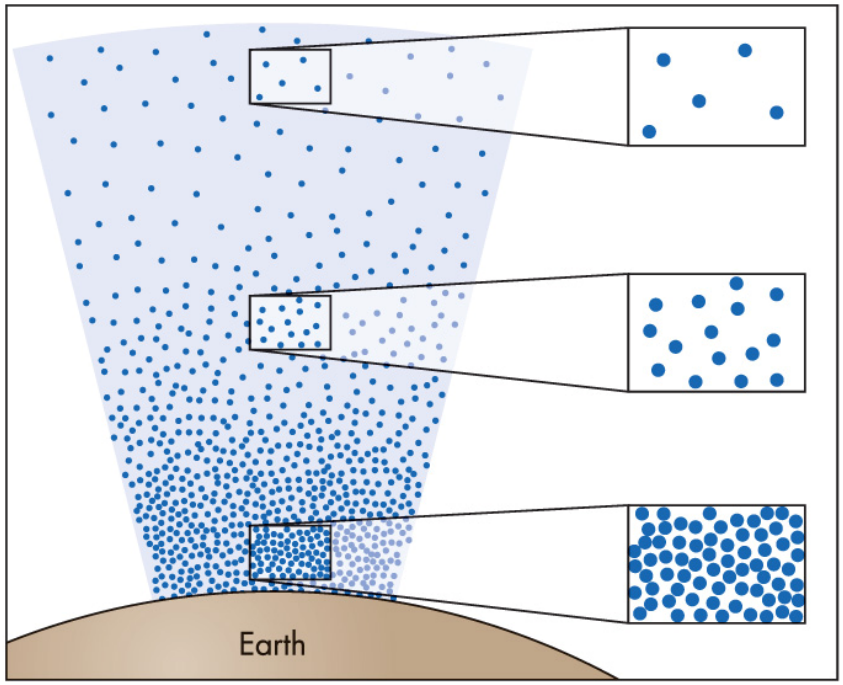
Two-thirds of Earth's ozone is gone – not just over the poles, but everywhere.

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.



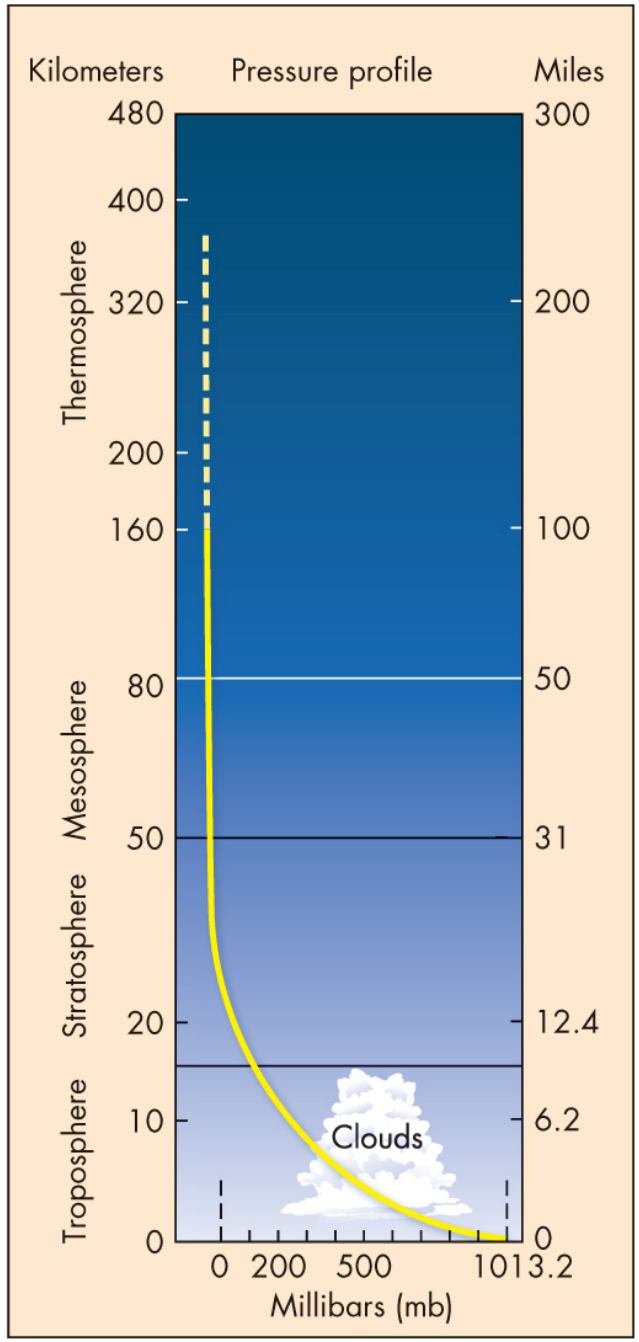


(a)

Atmospheric pressure

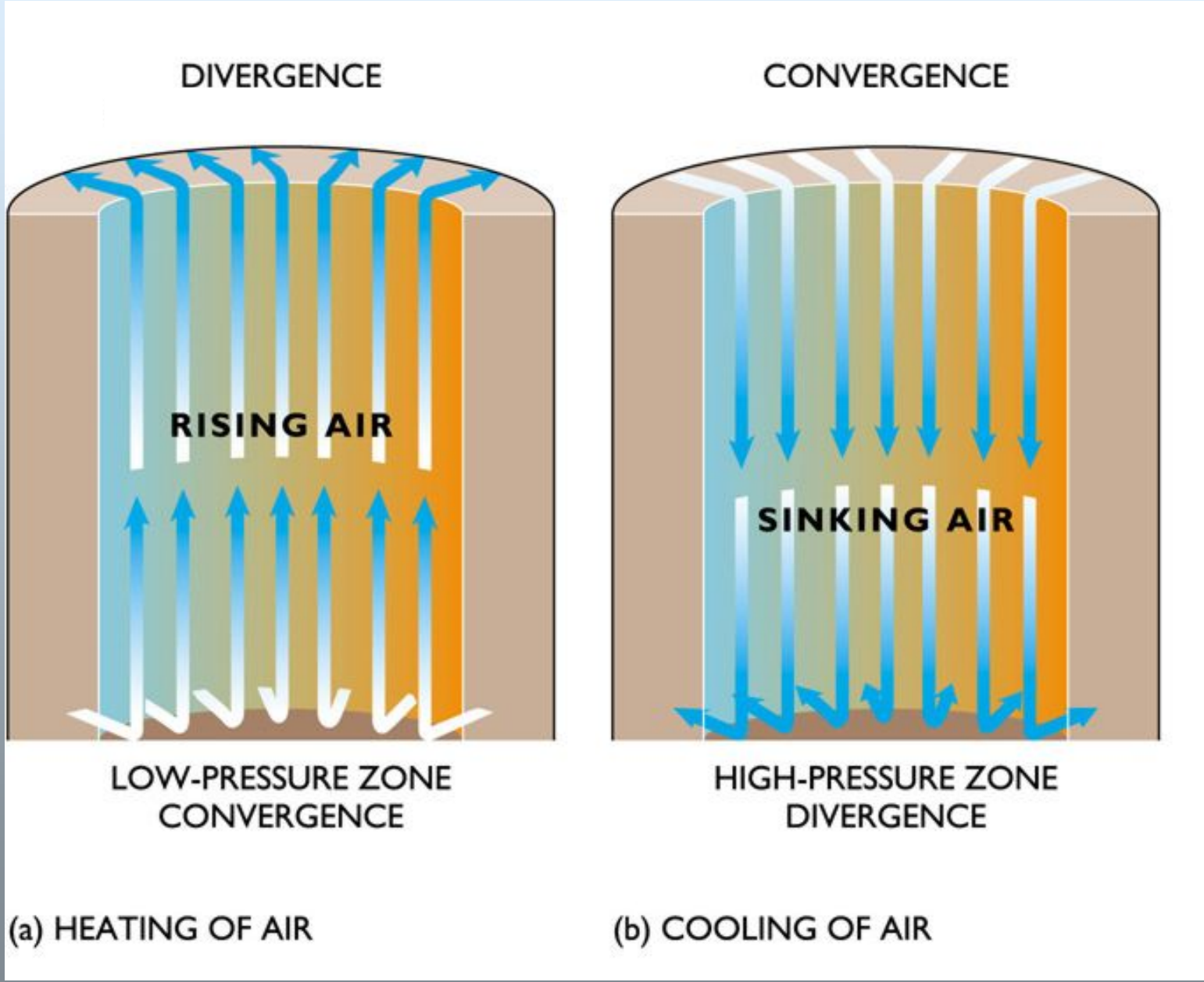
About 90% of the mass is in the troposphere

Figure 8.10



(b)

Low pressure High pressure



Atmospheric high and low pressure

In the Northern Hemisphere:

Low pressure – rising air, moving inward,
condenses to produce clouds and precipitation,
counter-clockwise circulation,
these are the storms
hurricanes & extratropical storms

Atmospheric high and low pressure

In the Northern Hemisphere:

High pressure – sinking air, moving outward,
compresses and heats,
clockwise circulation,
associated with clear skies, dry conditions

Rising air, low pressure, precipitation

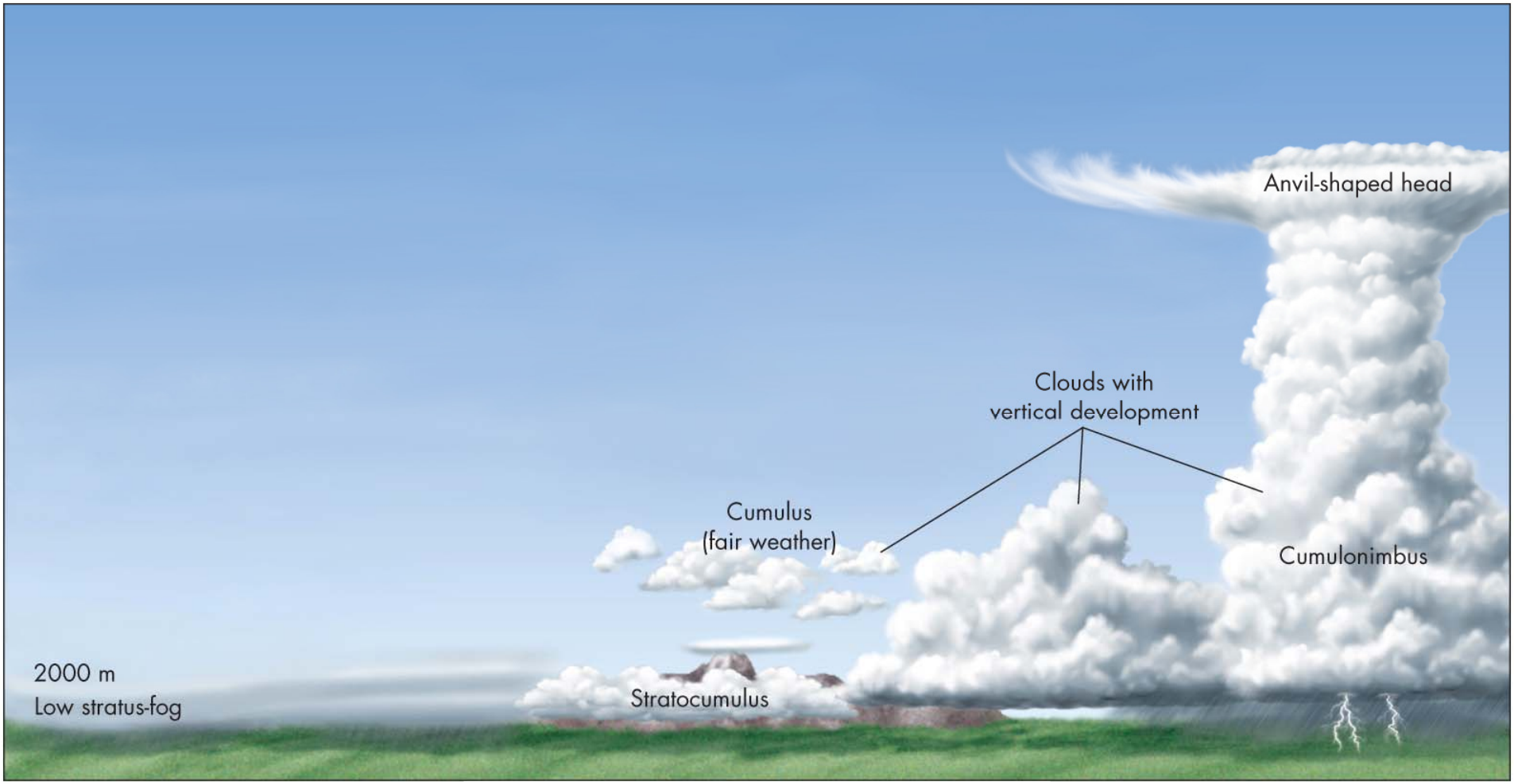


Figure 8.8

Rising air, low pressure, precipitation

Concepts and processes:

Absolute humidity
Relative humidity
Dewpoint

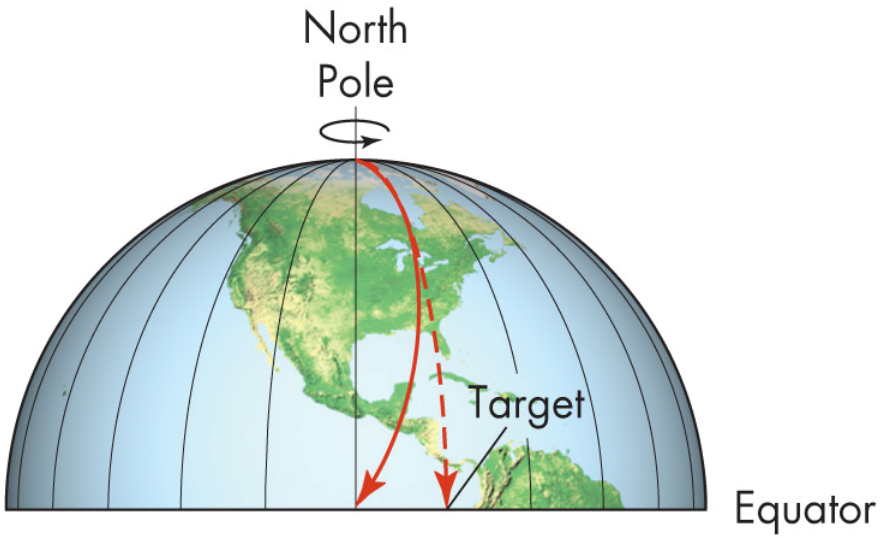
Sensible heat

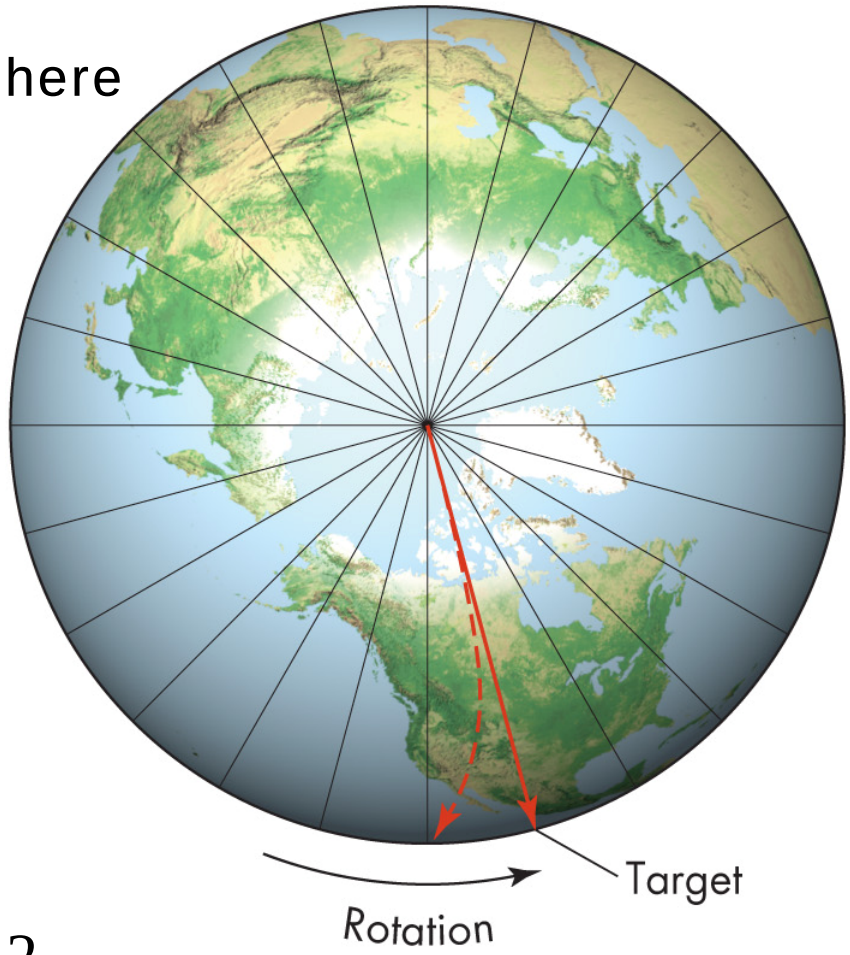
Latent heat
of vaporization – from liquid to vapor 540 cal
of melting – from solid to liquid 80 cal

Compression and expansion of a gas

Coriolis effect – deflection of moving objects

Deflection to right in Northern Hemisphere

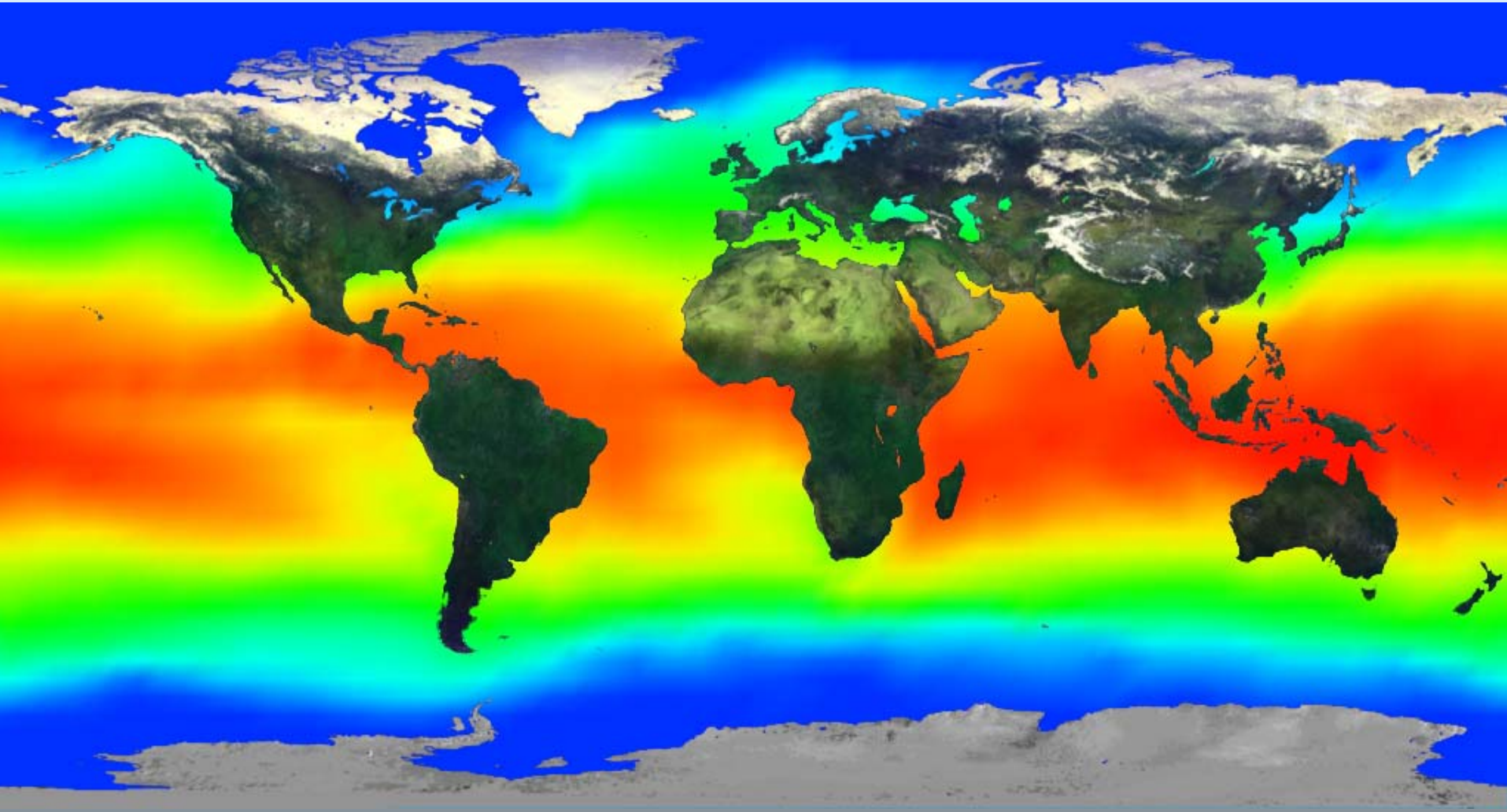


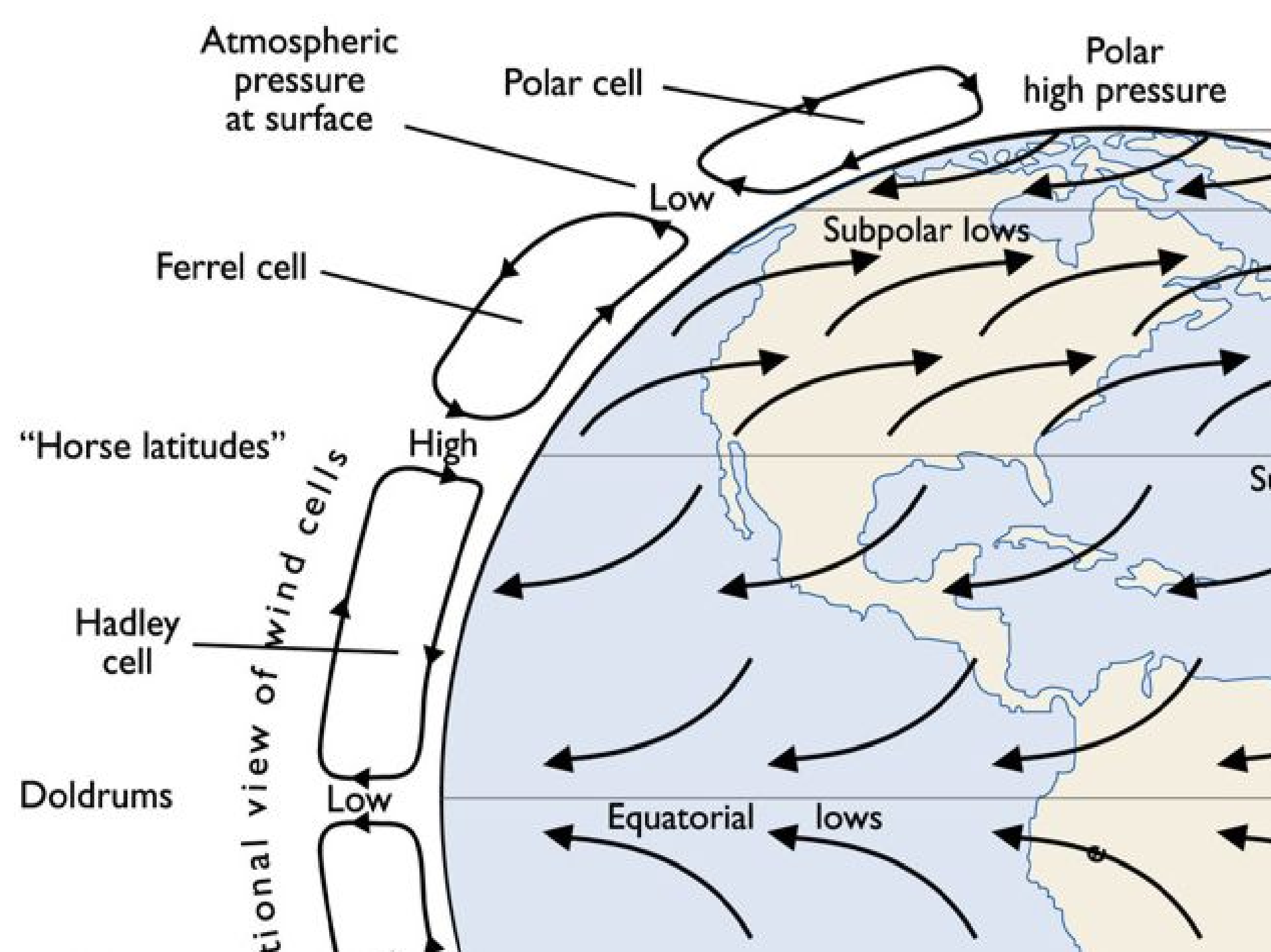


(b) Rotating Earth

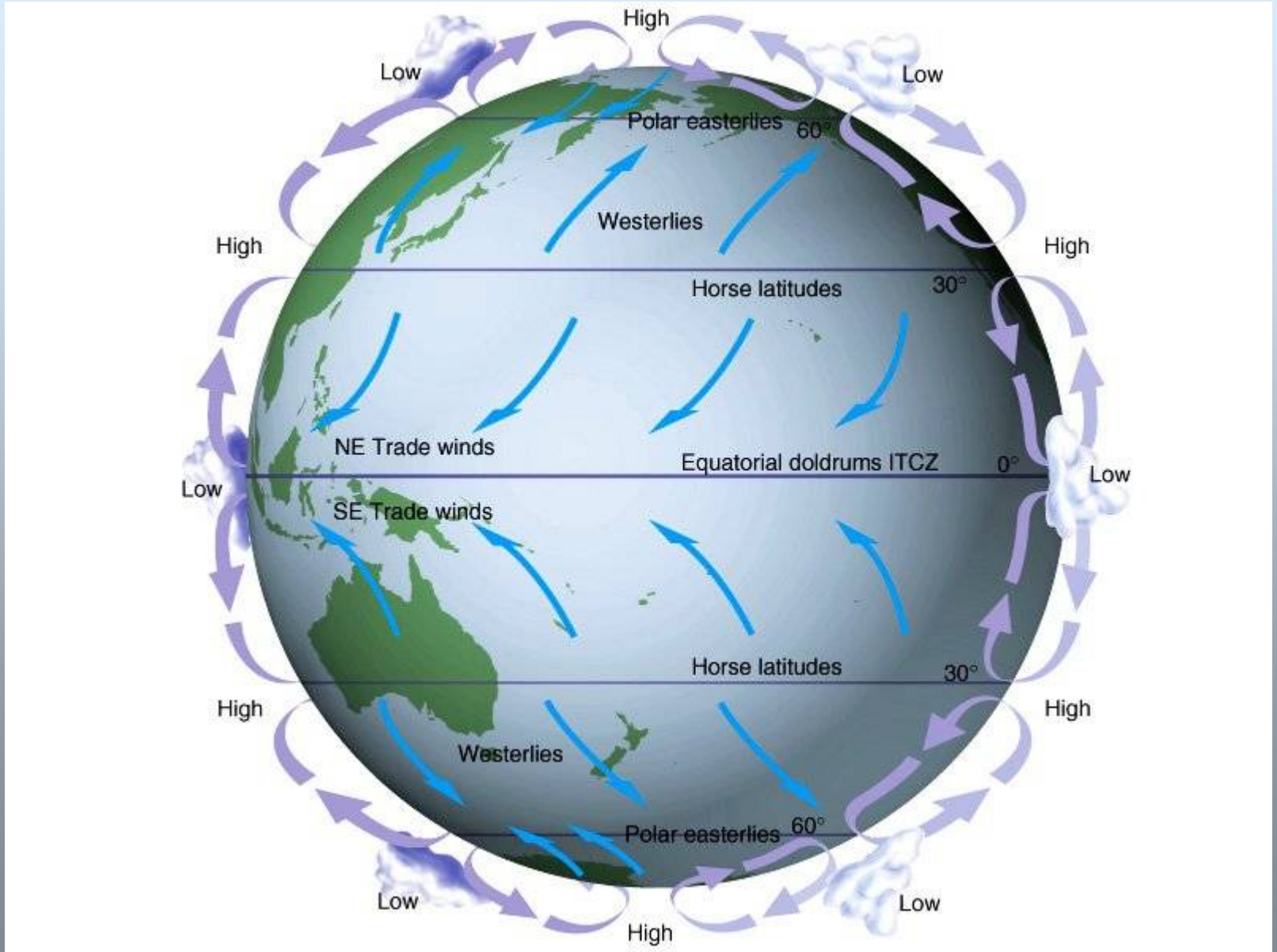
Figure 8.12

Global distribution of heat

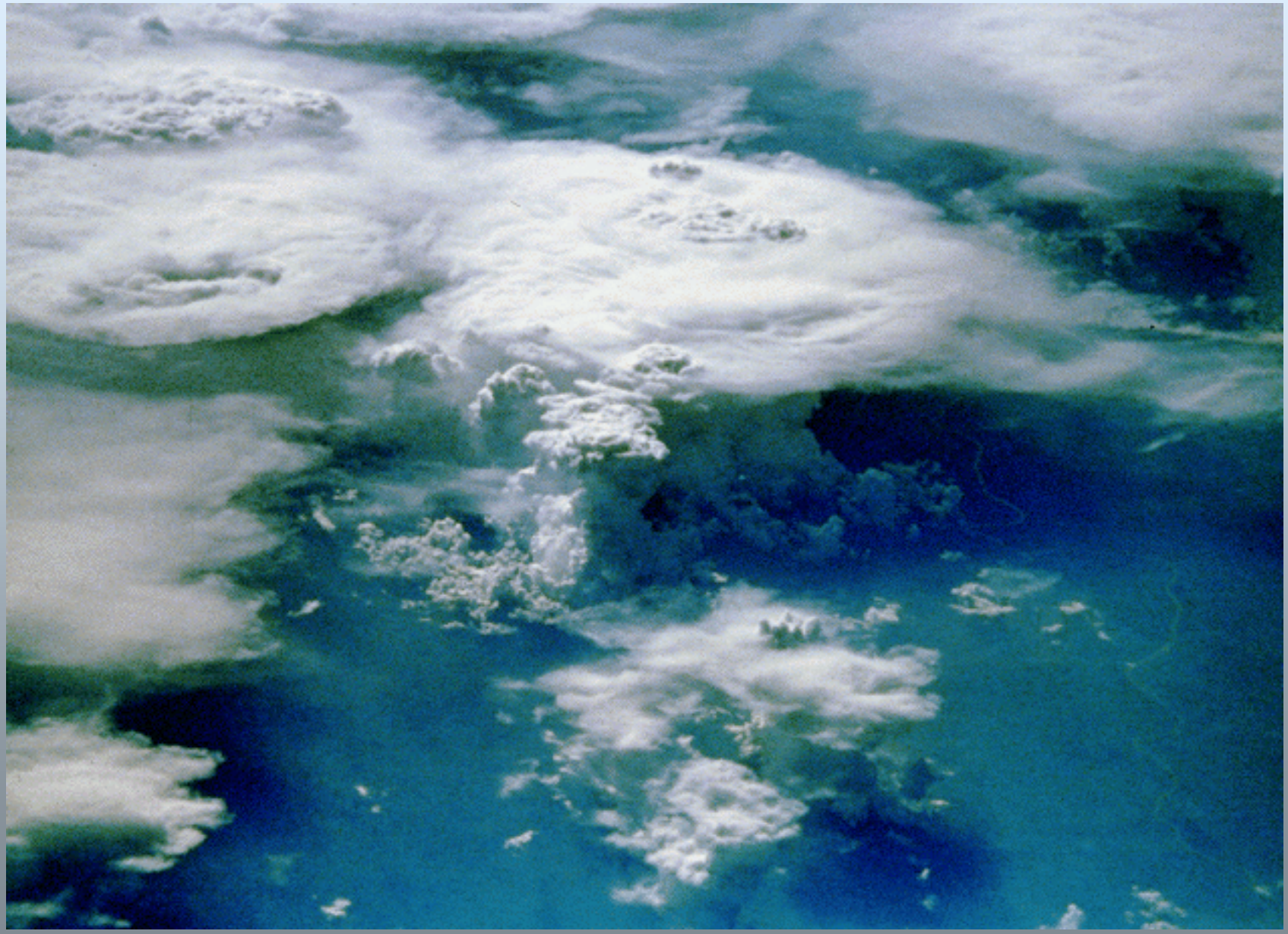



Atmospheric pressure at surface
Polar cell
Polar high pressure
Low
Subpolar lows
Ferrel cell
"Horse latitudes"
High
Hadley cell
Doldrums
Low
Equatorial lows
tional view of wind cells

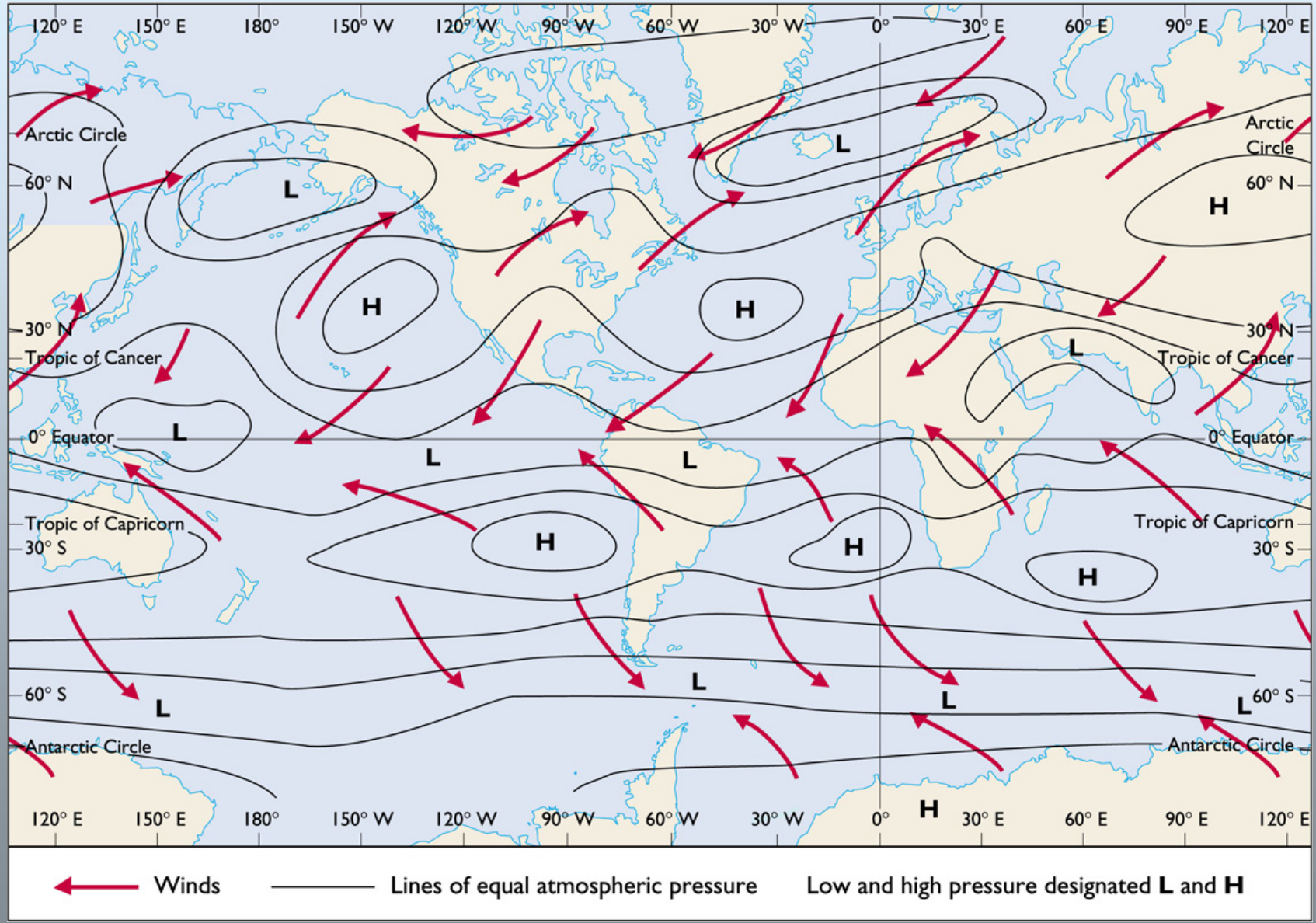
Atmospheric circulation



Tropical convection cells



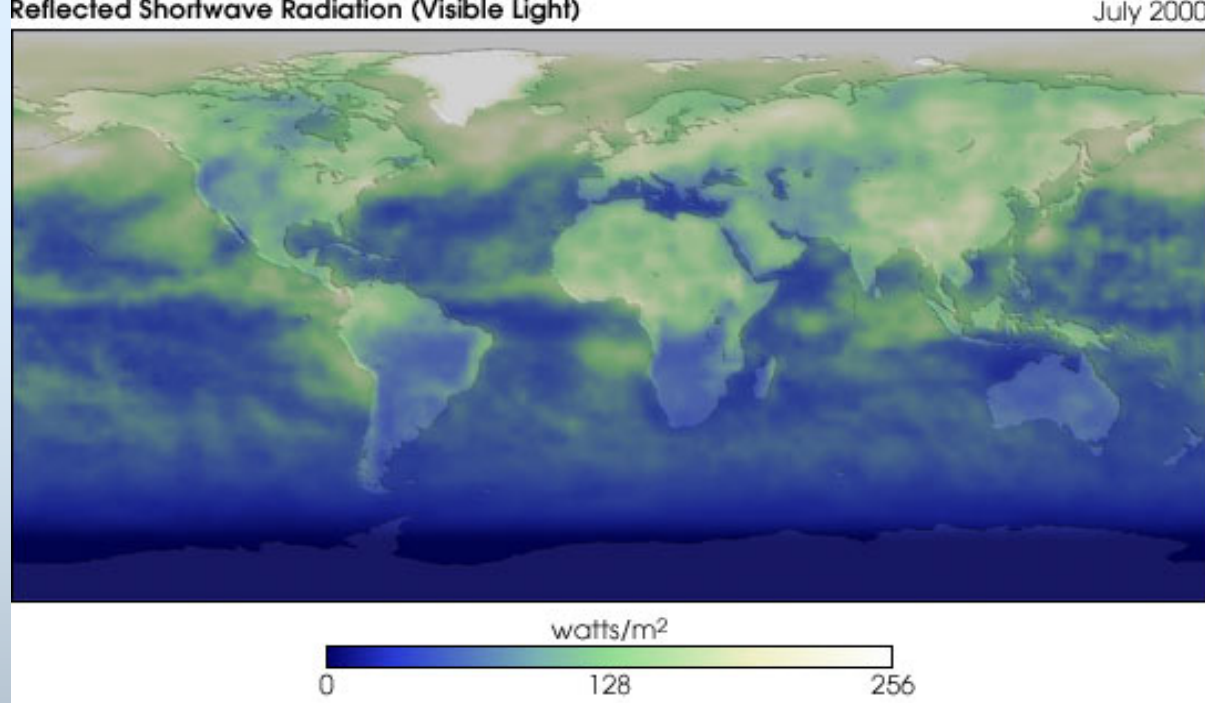
Global atmospheric pressure

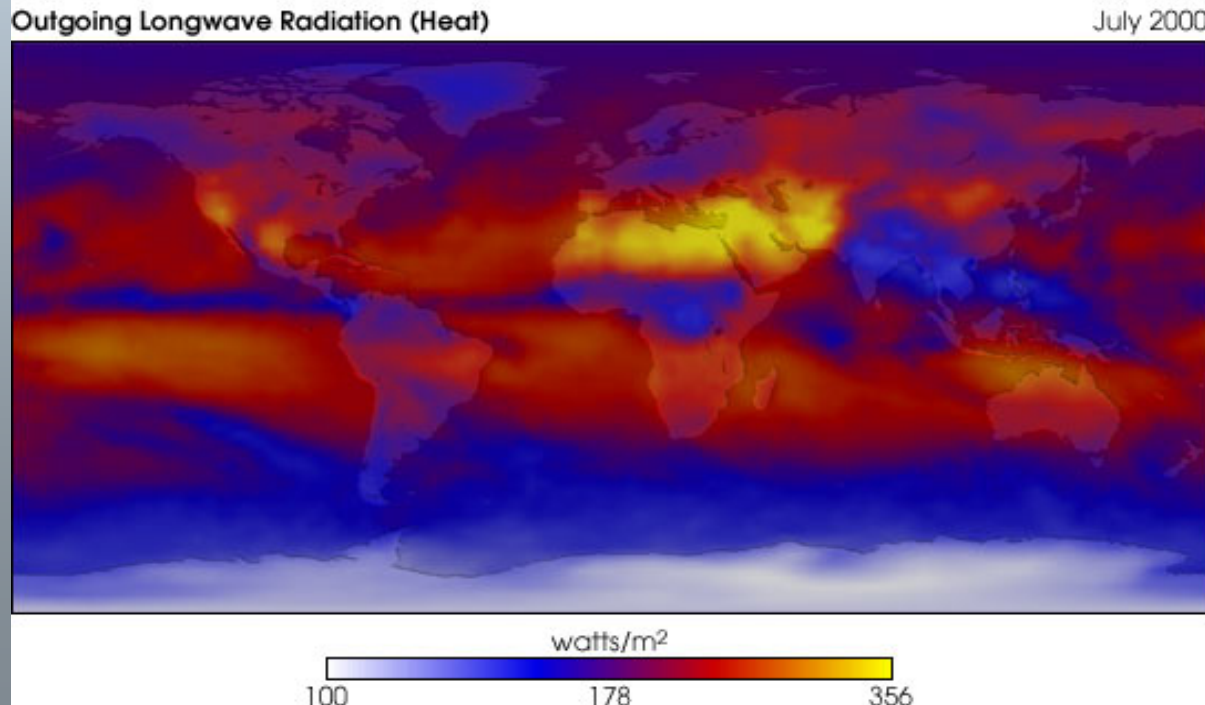


Outgoing radiation

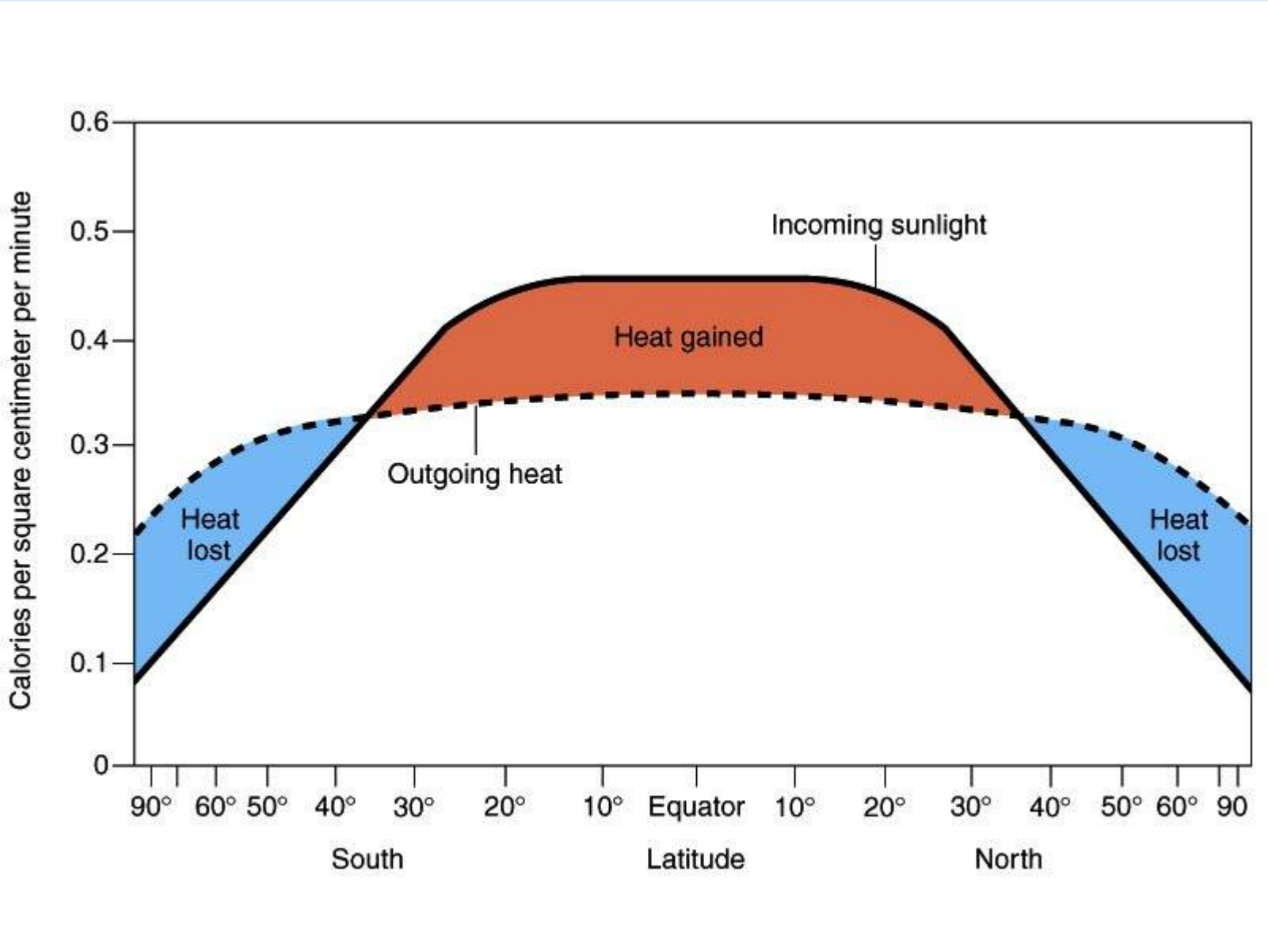
shortwave radiation

longwave radiation





Heat loss and gain from the oceans



Weather fronts

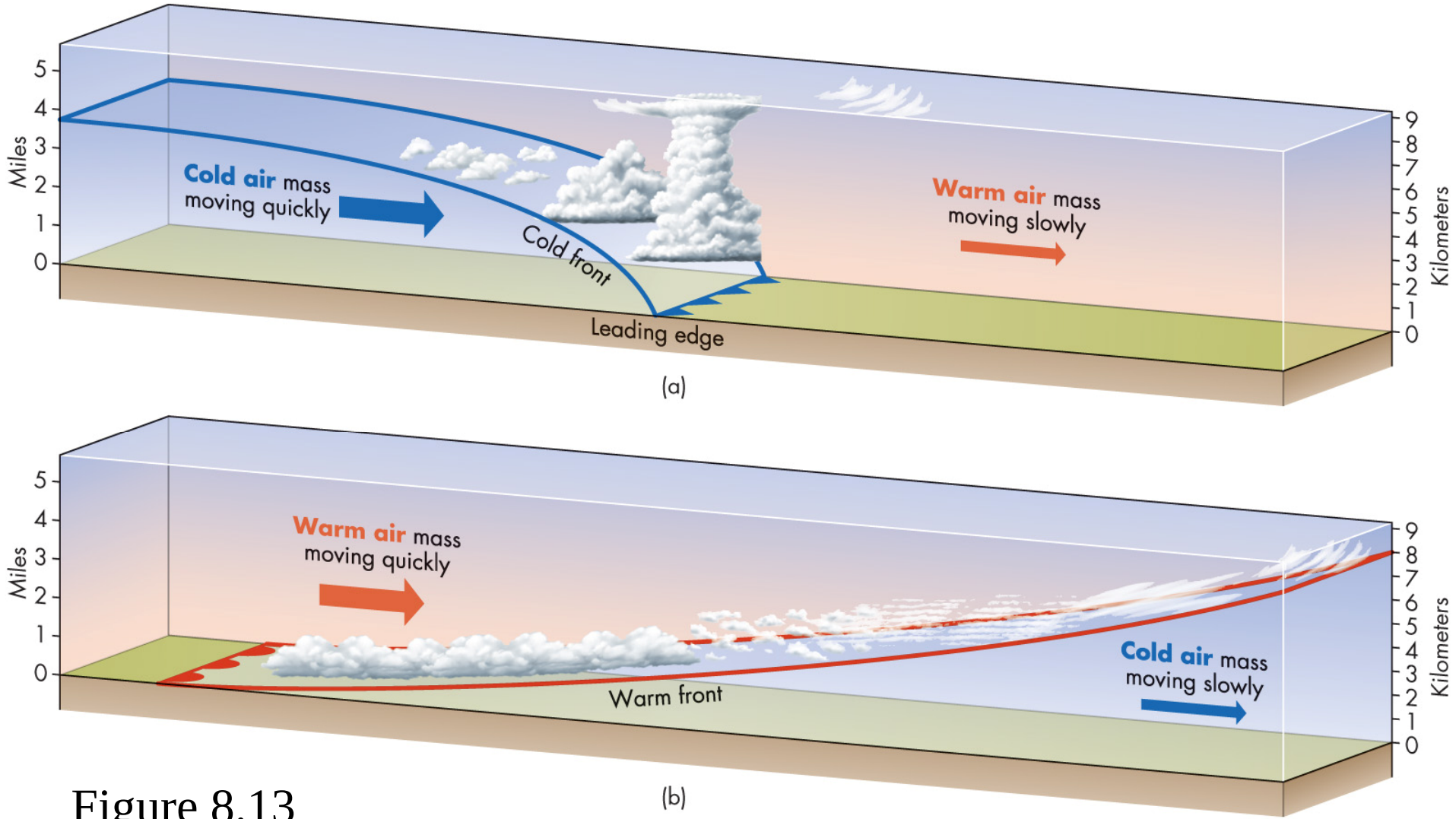
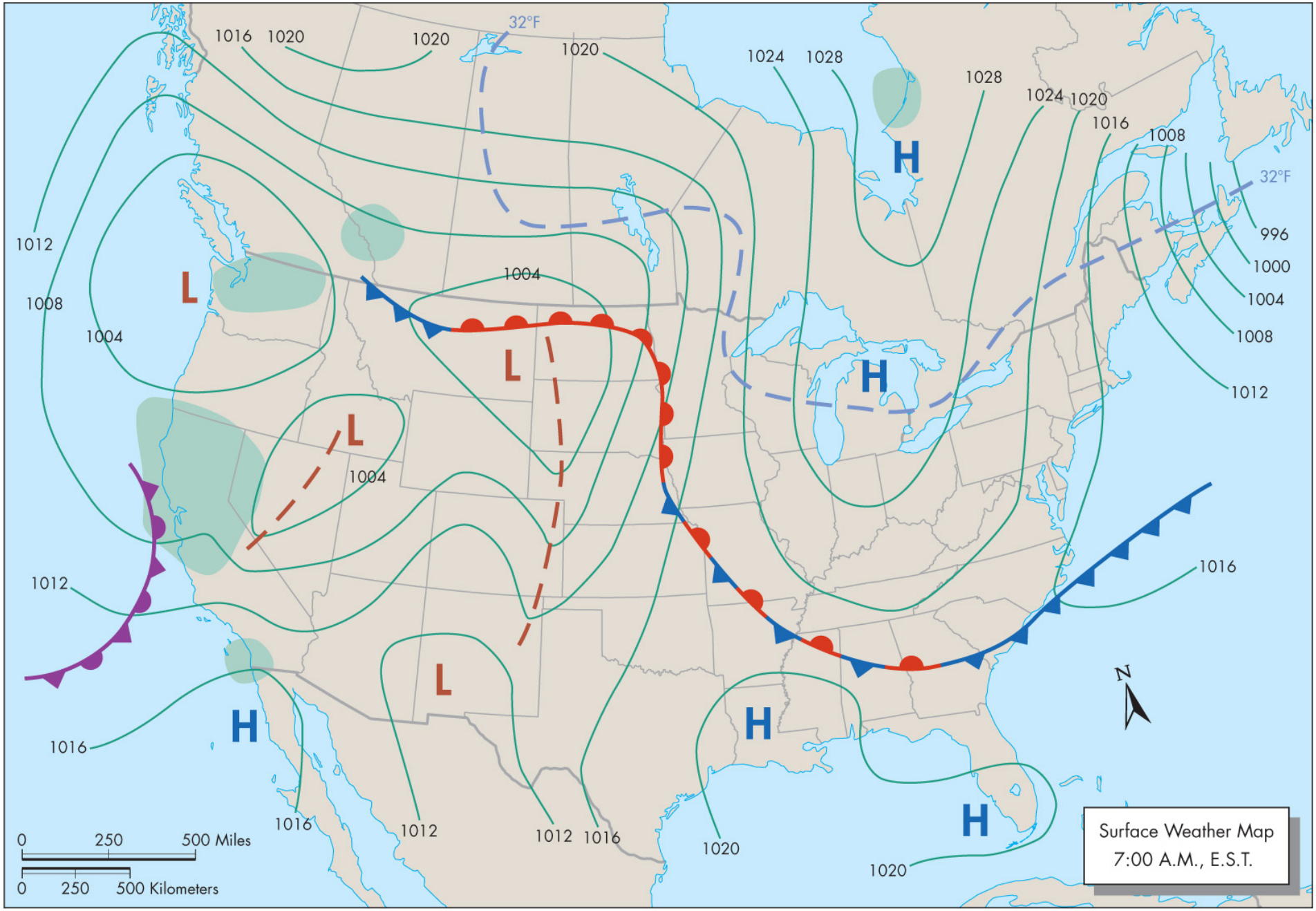


Figure 8.13


1016
1020
1020
32°F
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1024
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32°F
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1004
1008
1012
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1016
L
H
H
H
1016
1016
1012
1012
1016
1020
1020
N
0
250
500 Miles
0
250
500 Kilometers
Surface Weather Map
7:00 A.M., E.S.T.

Occurrence of thunderstorms

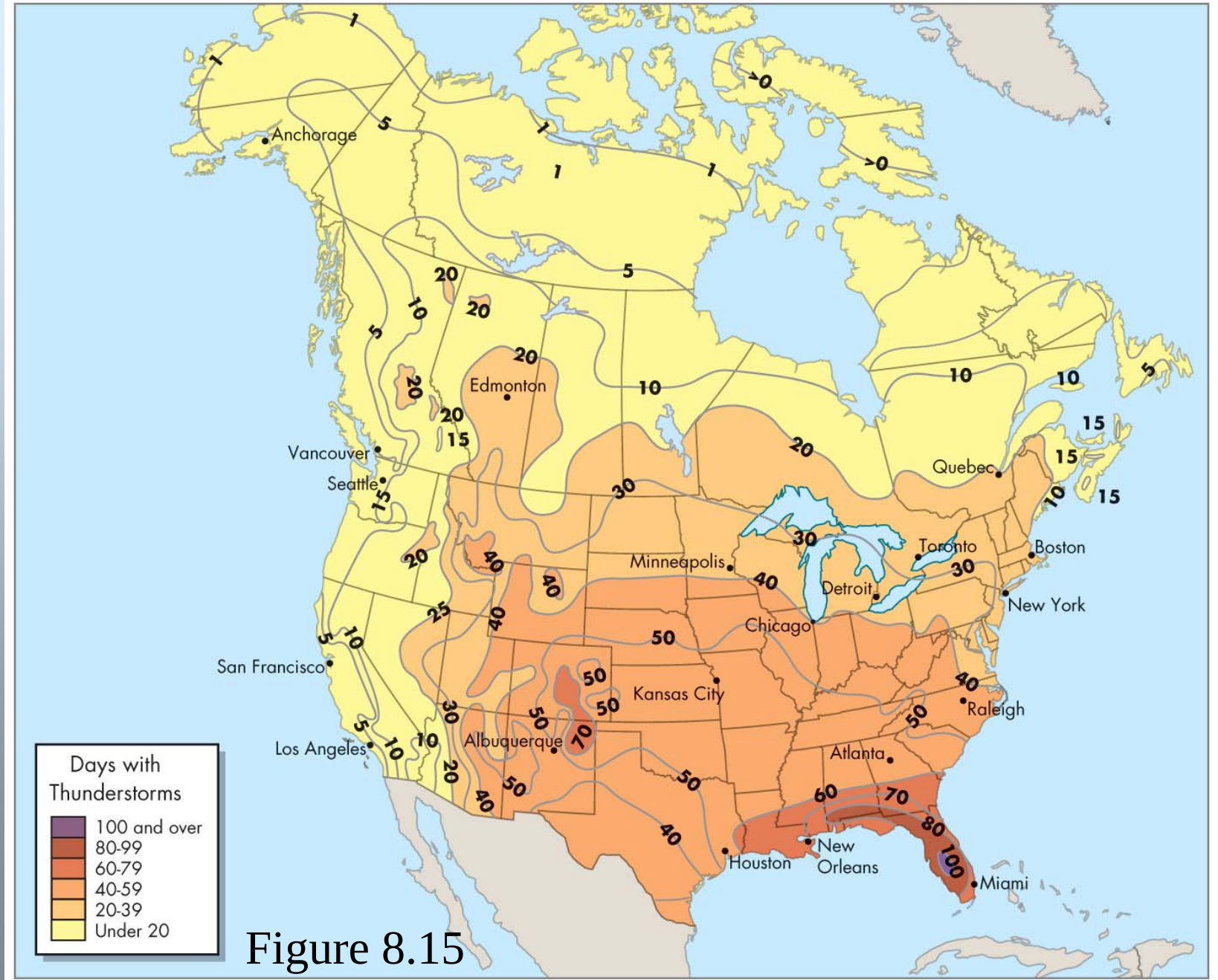


Figure 8.15

A developing thunderstorm

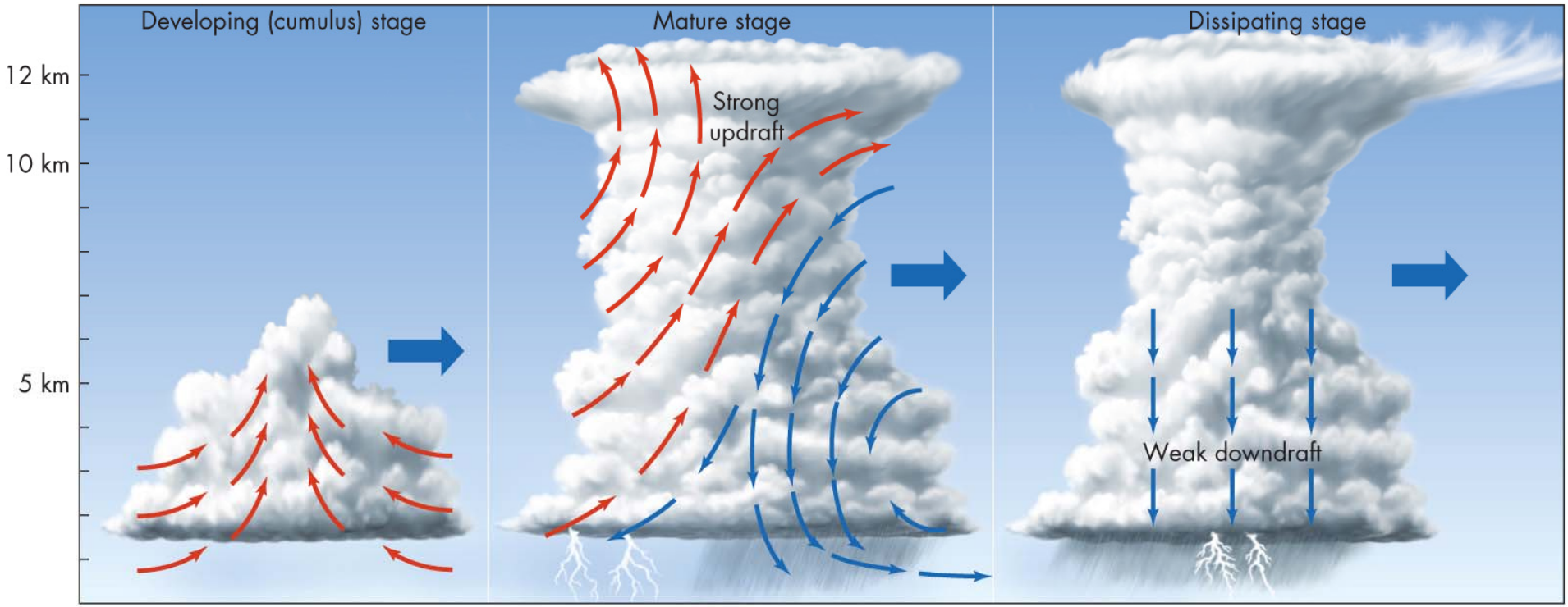
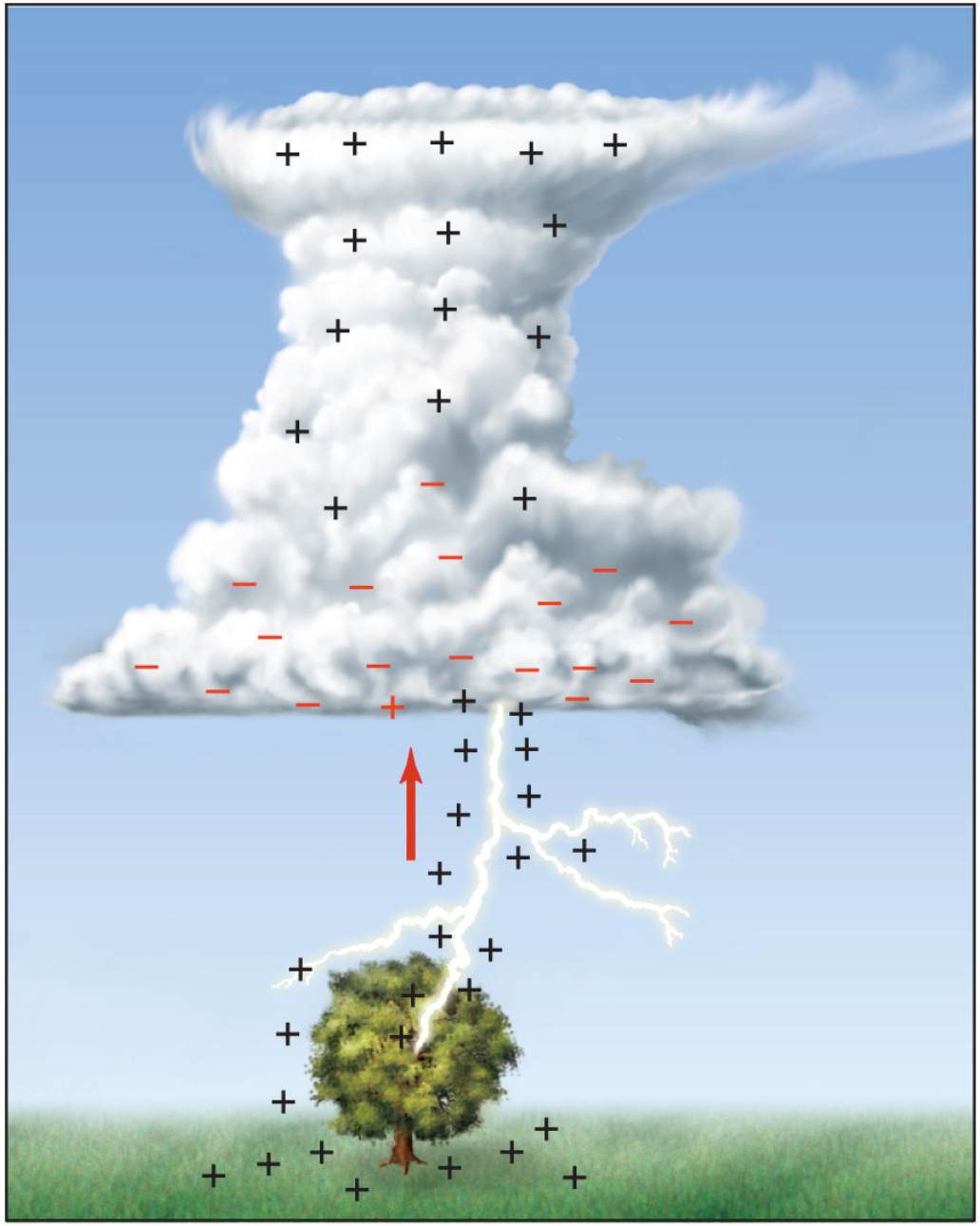


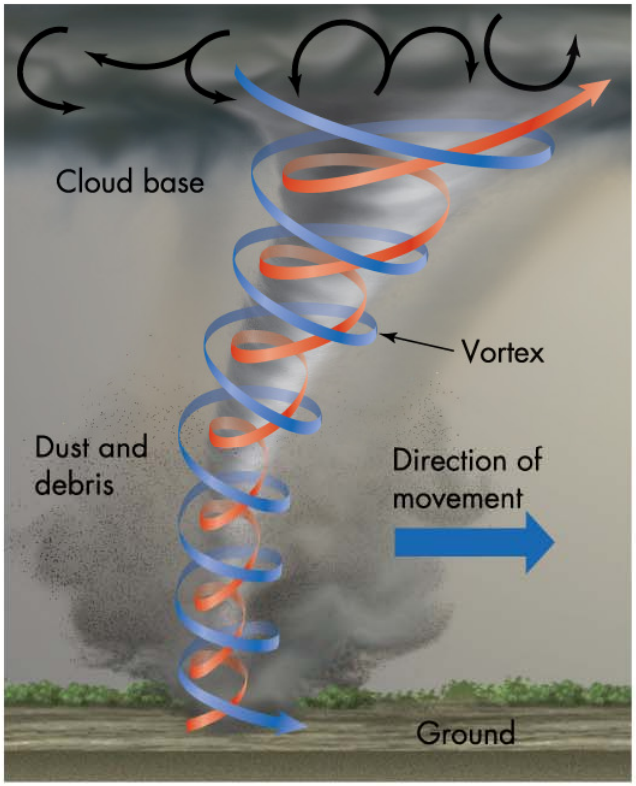
Figure 8.16



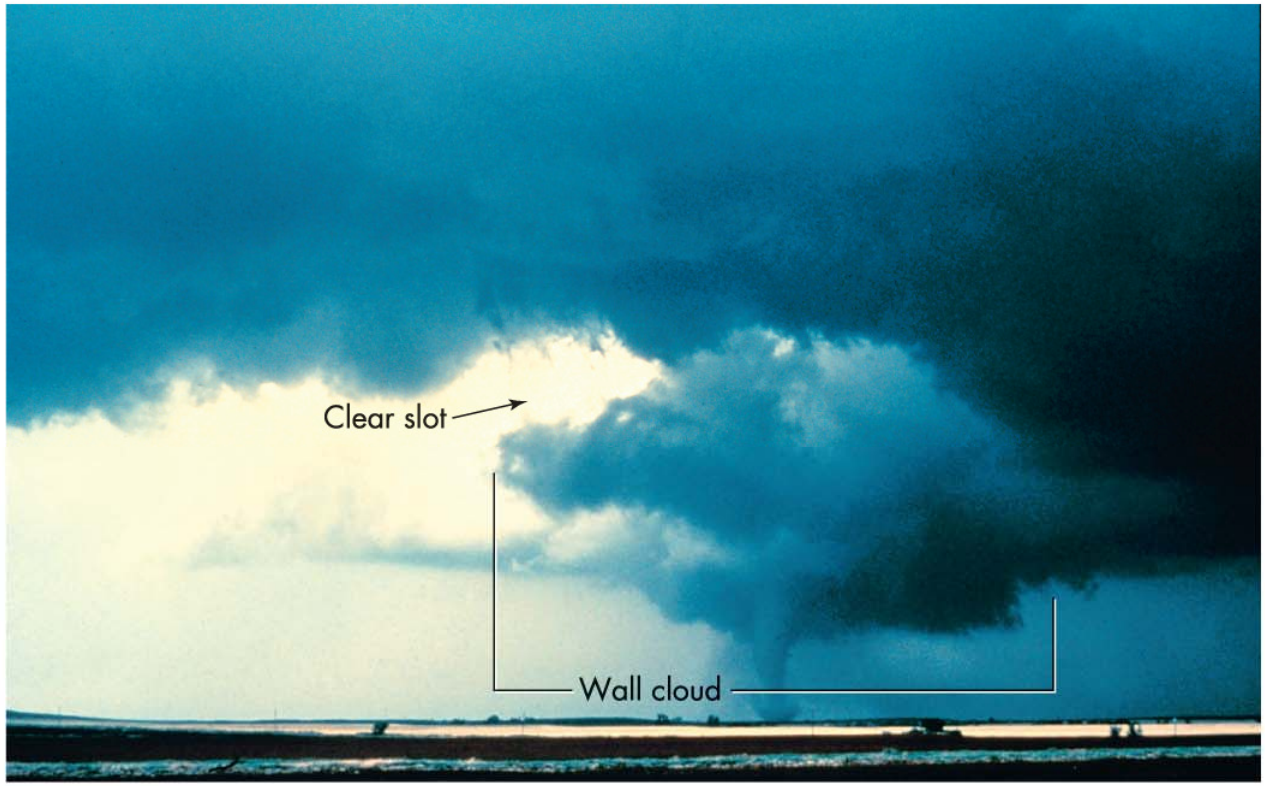
(d)


Cloud-to-cloud lightning
Cloud-to-ground lightning

Producing a tornado



(a)



(b)

Figure 8.19

(d)