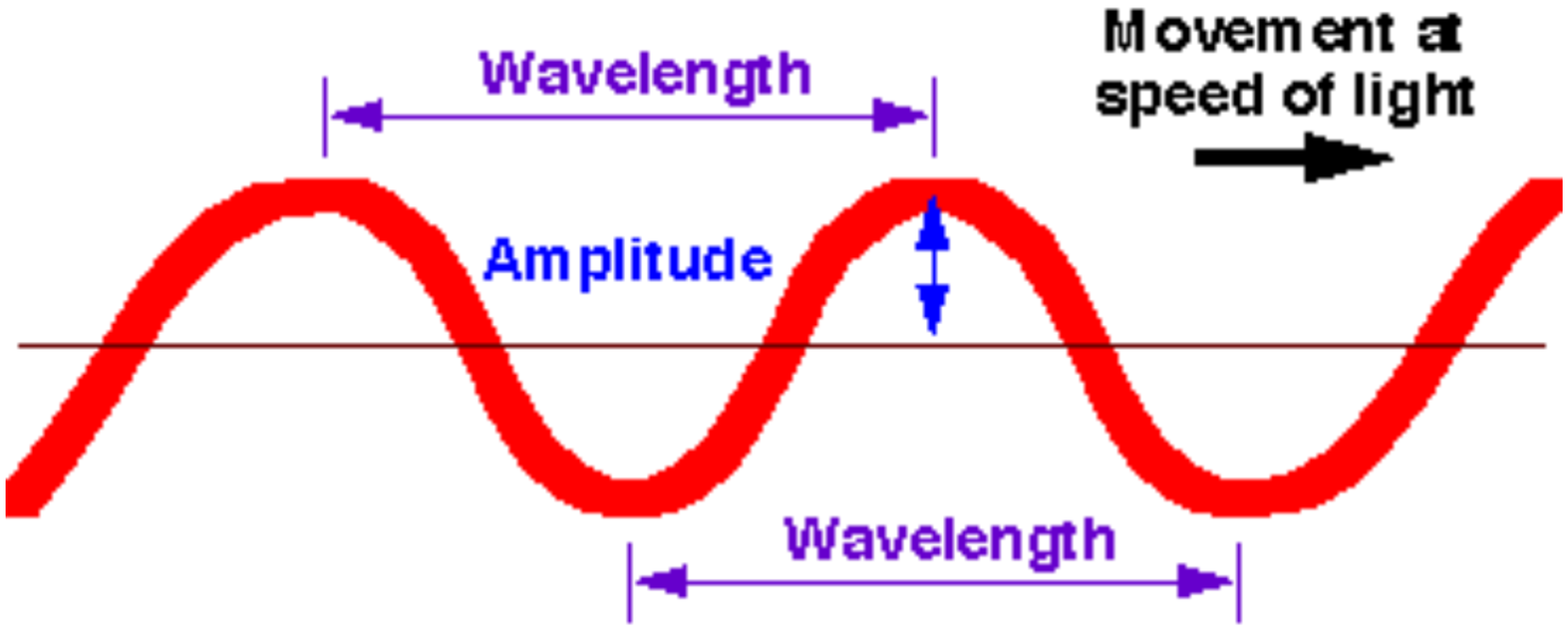
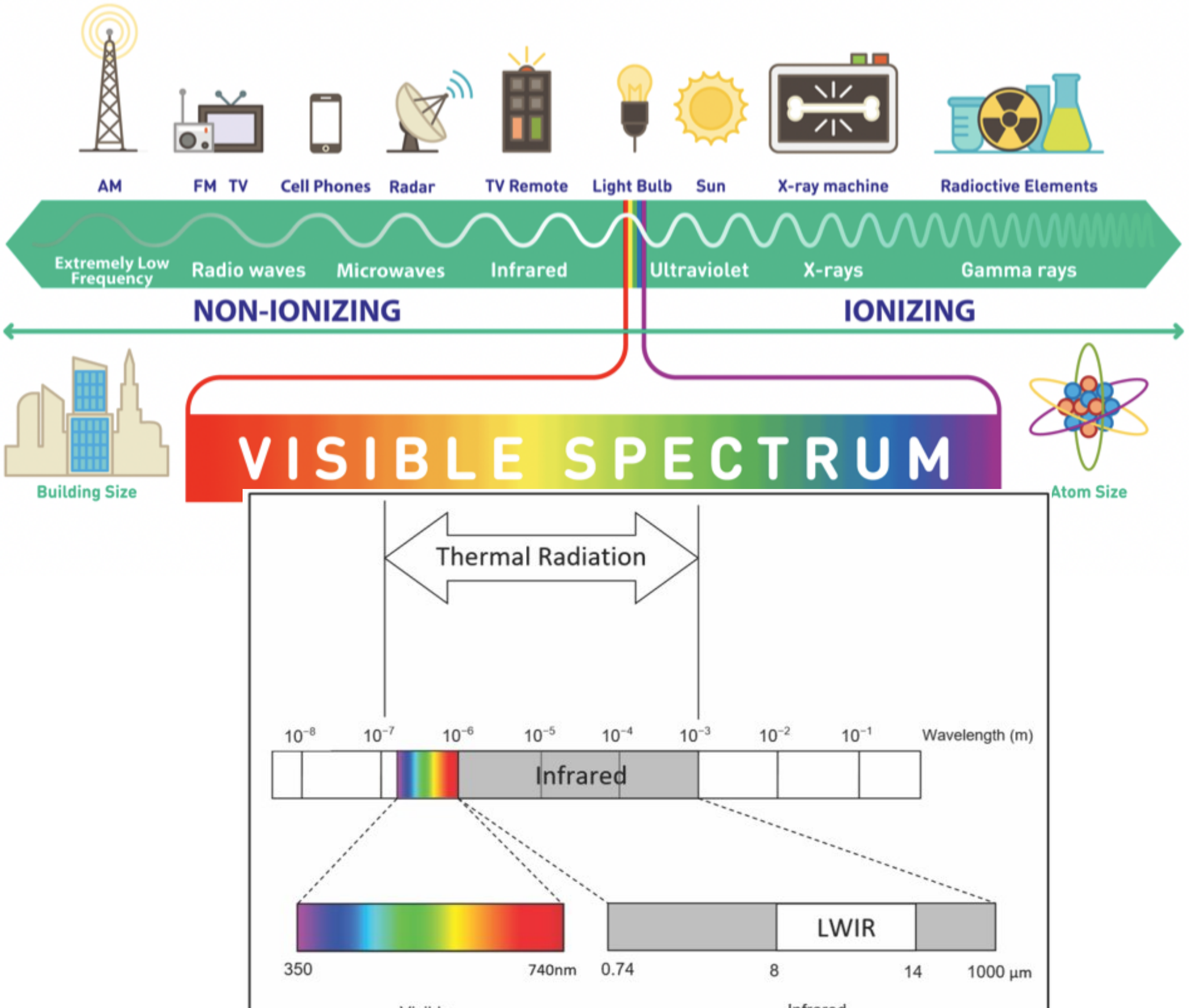
The Balance of Energy on Earth

- Almost all of the energy that the earth receives to power most life and cycles comes from the sun.
- What are the characteristics of solar energy?
- How does the earth absorb this energy?
- What are the effects of this energy on the biotic and abiotic systems?
- The sun's energy is electromagnetic and the amount entering the earth is the same as how much leaves earth.

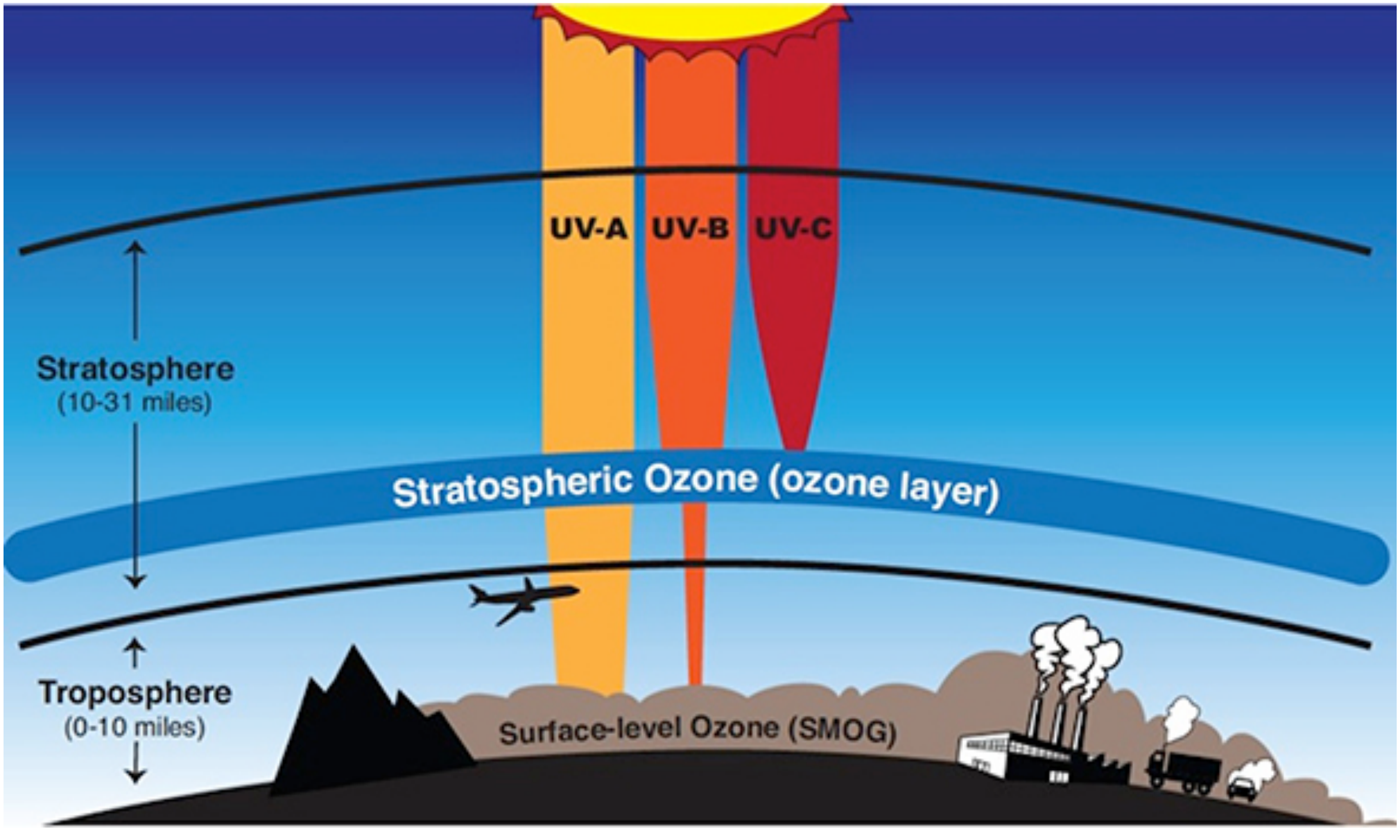


Electromagnetic Spectrum



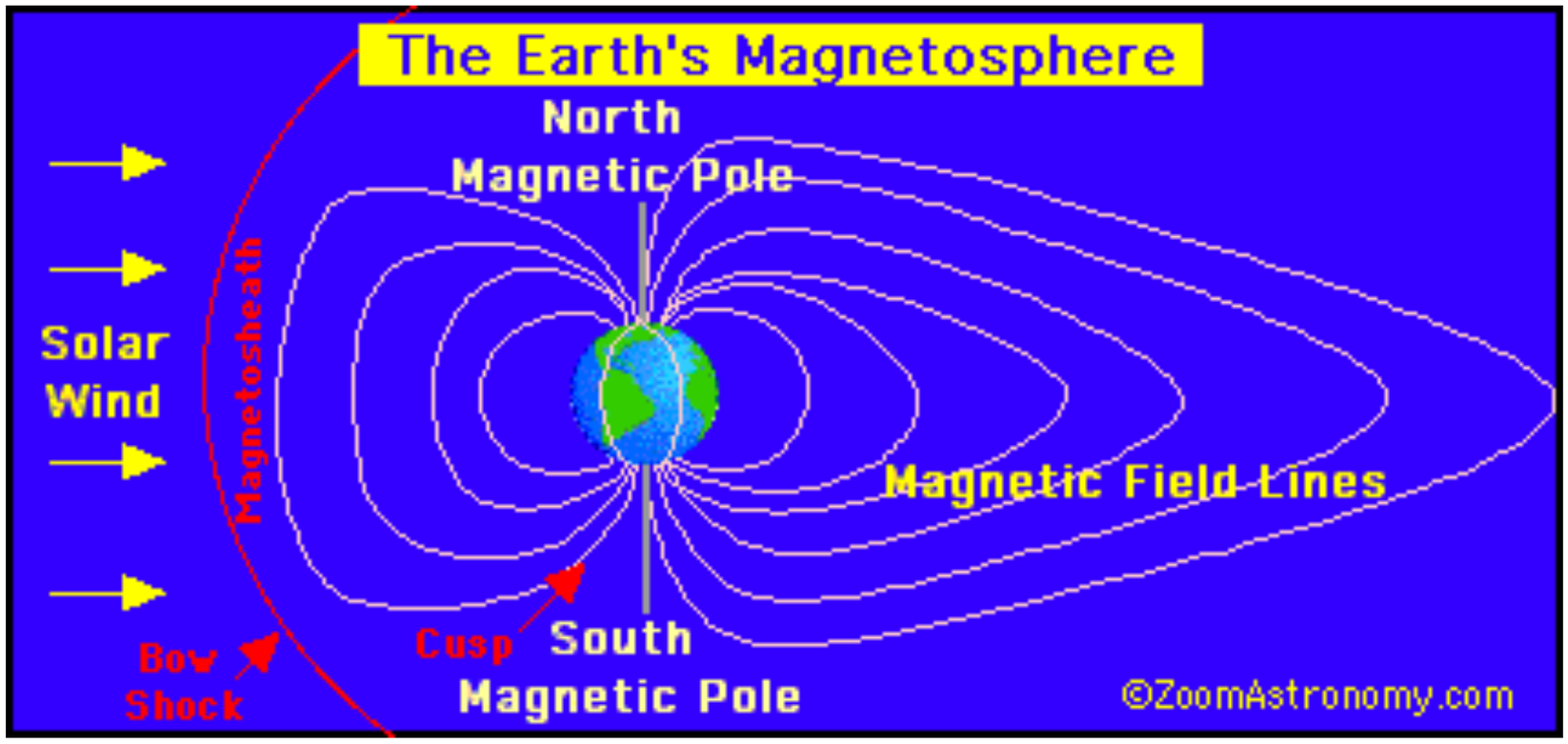
Earth's Protective Zones

- The earth has 2 main protection zones from some of the sun's energy. The Ozone Layer & the Magnetosphere.
  - The Ozone Layer: Is made up of 3 Oxygen atoms that is toxic to life but in the Stratosphere it reduces the amount of UV radiation that reaches the Earth's surface.



- In the 1970's it was discovered that chlorofluorocarbons CFC's (refrigerants and aerosols) were destroying the Ozone level. Most aerosols have been replaced with CO2 and refrigerants have improved and the Ozone layer should be back to past levels in about 30 years.

- Magnetosphere: Magnetic energy that is emitted from the earth's core which shield the earth from much of the solar wind (solar particles). It is believed that Mars lost most of its magnetosphere a long time ago that that is what caused it to lose its atmosphere.



Characteristics of Solar Energy

- Radiation & Temperature: Hotter objects radiate more energy than cooler objects. The amount of radiated energy is directly related to the temperature of the surface to the 4th power. When the temperature is doubled the object will radiate 16 times more energy.

- The hotter an object is the shorter the wavelength emitted. Therefore the sun emits light and the earth emits thermal infrared energy.

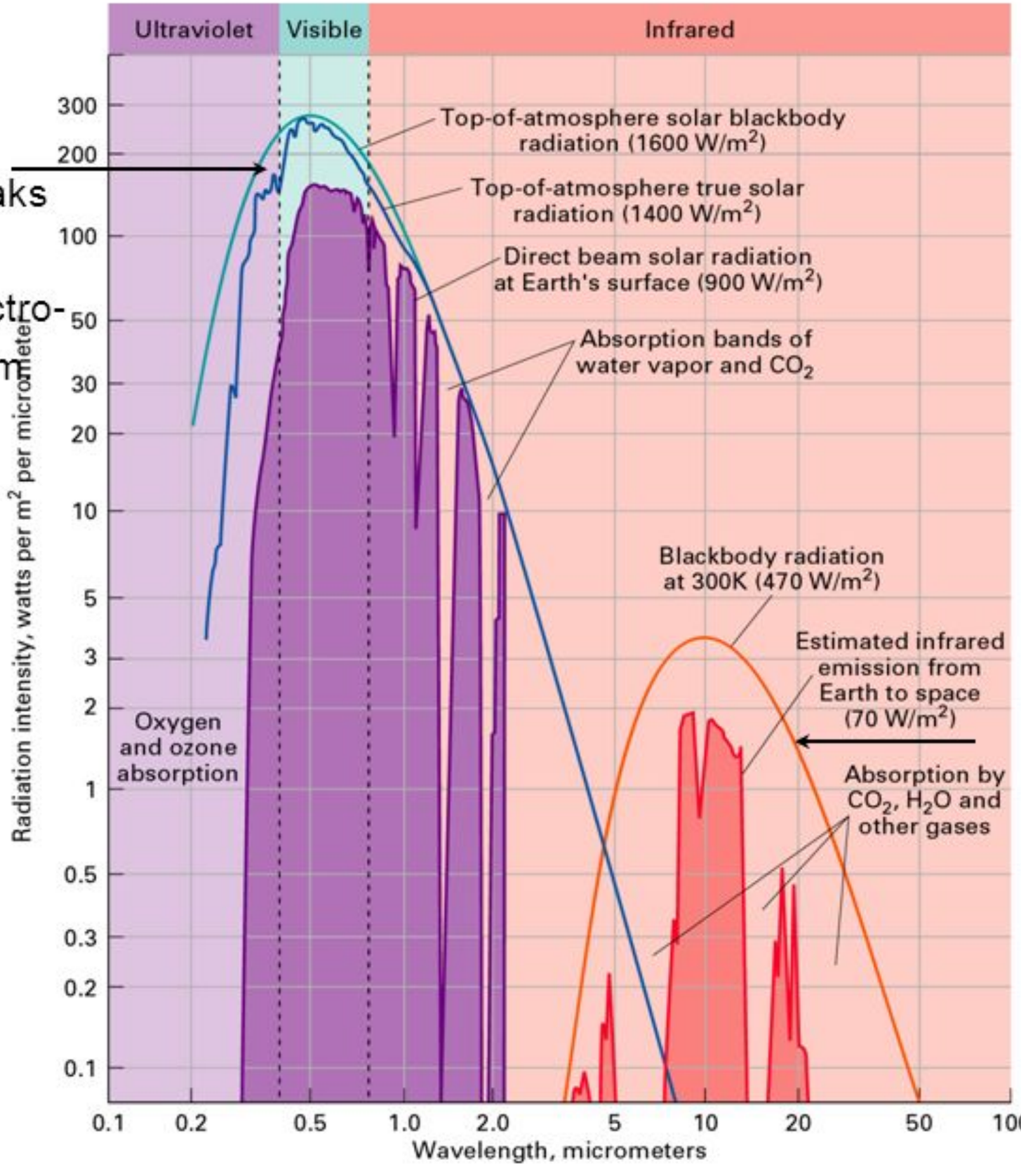
- The sun is a constant nuclear fusion (H to He) reaction that has a surface temp of 11,000 F with its energy taking about 8.5 minutes to reach earth. The rays travel in a straight line which means that Mars gets less energy per square meter than the earth.

- As solar energy enters the atmosphere it scatters & is absorbed where some is selected and some becomes shortwave radiation that warms the earth.

Wavelengths of Sun and Earth Radiation

•Solar Energy

–Sun's output peaks in the visible light portion of the electro-magnetic spectrum



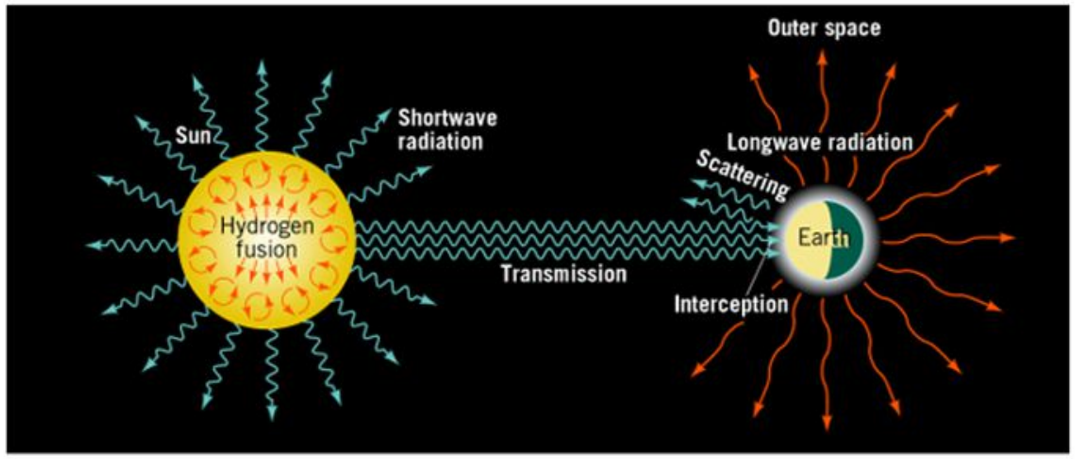
•Earth Energy

–Earth's output peaks in the thermal infrared portion of the electro-magnetic spectrum

Strahler & Strahler 2003

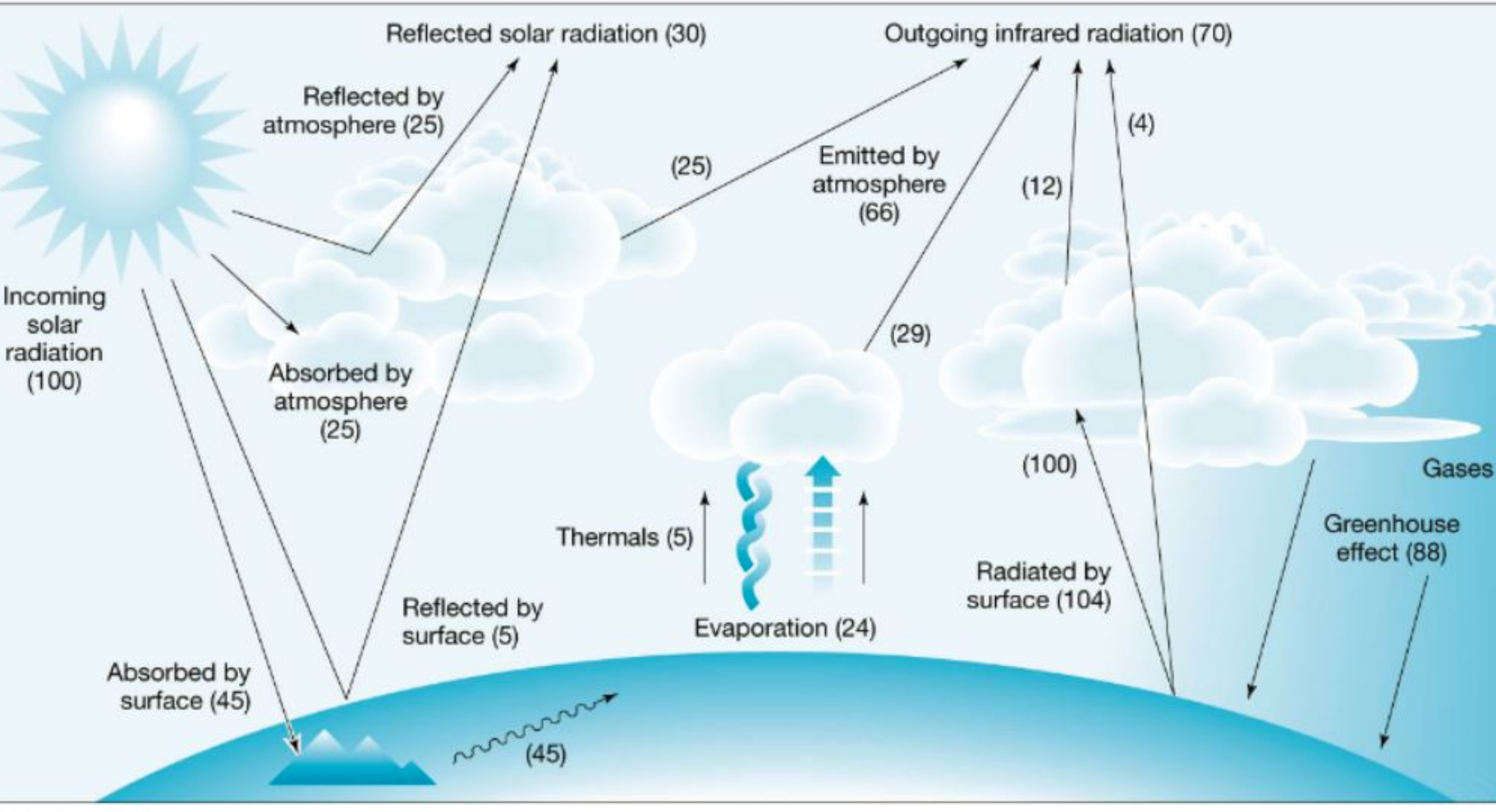
Global Radiation Balance

- Scattering of shortwave vs. longwave radiation
- Insolation-interception of solar energy (shortwave radiation) by an exposed surface
  - W/m^2



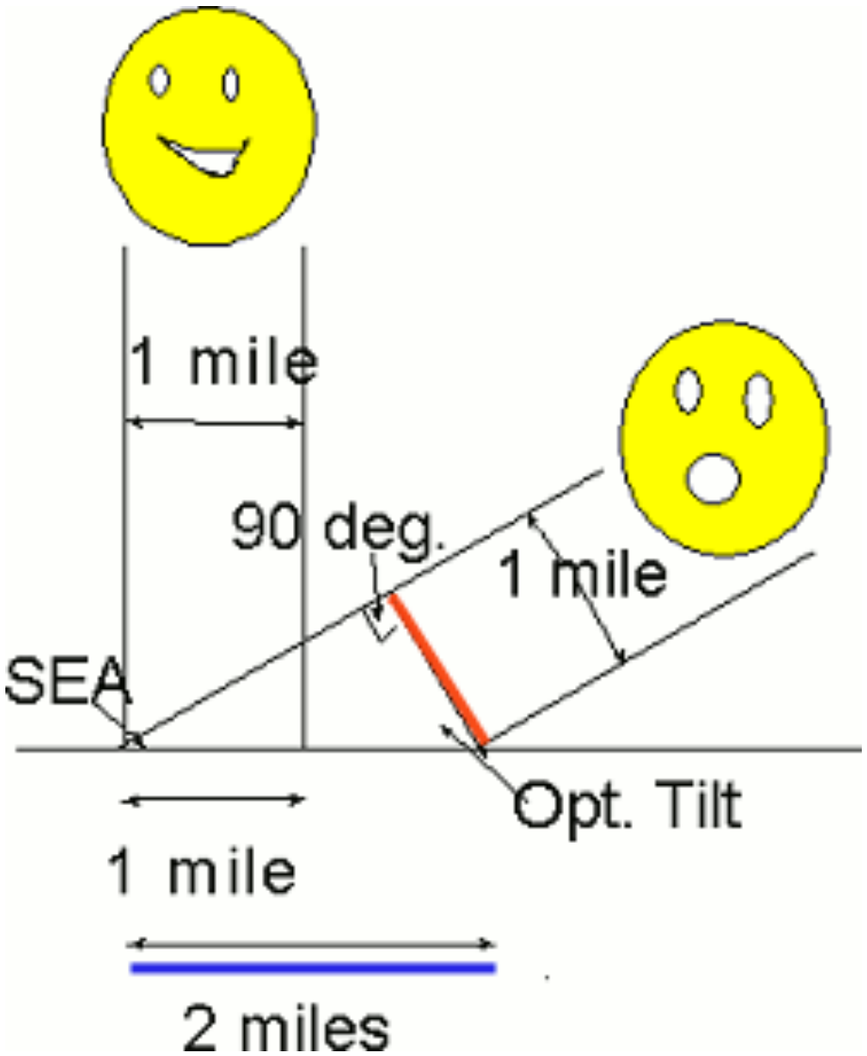
- Earth's Longwave Radiation: Since the earth's average surface is much cooler than the sun (11,000-73 F) it emits longwave radiation. Some of this reflected energy leaving earth makes it into space and some is absorbed by the earth's atmosphere.

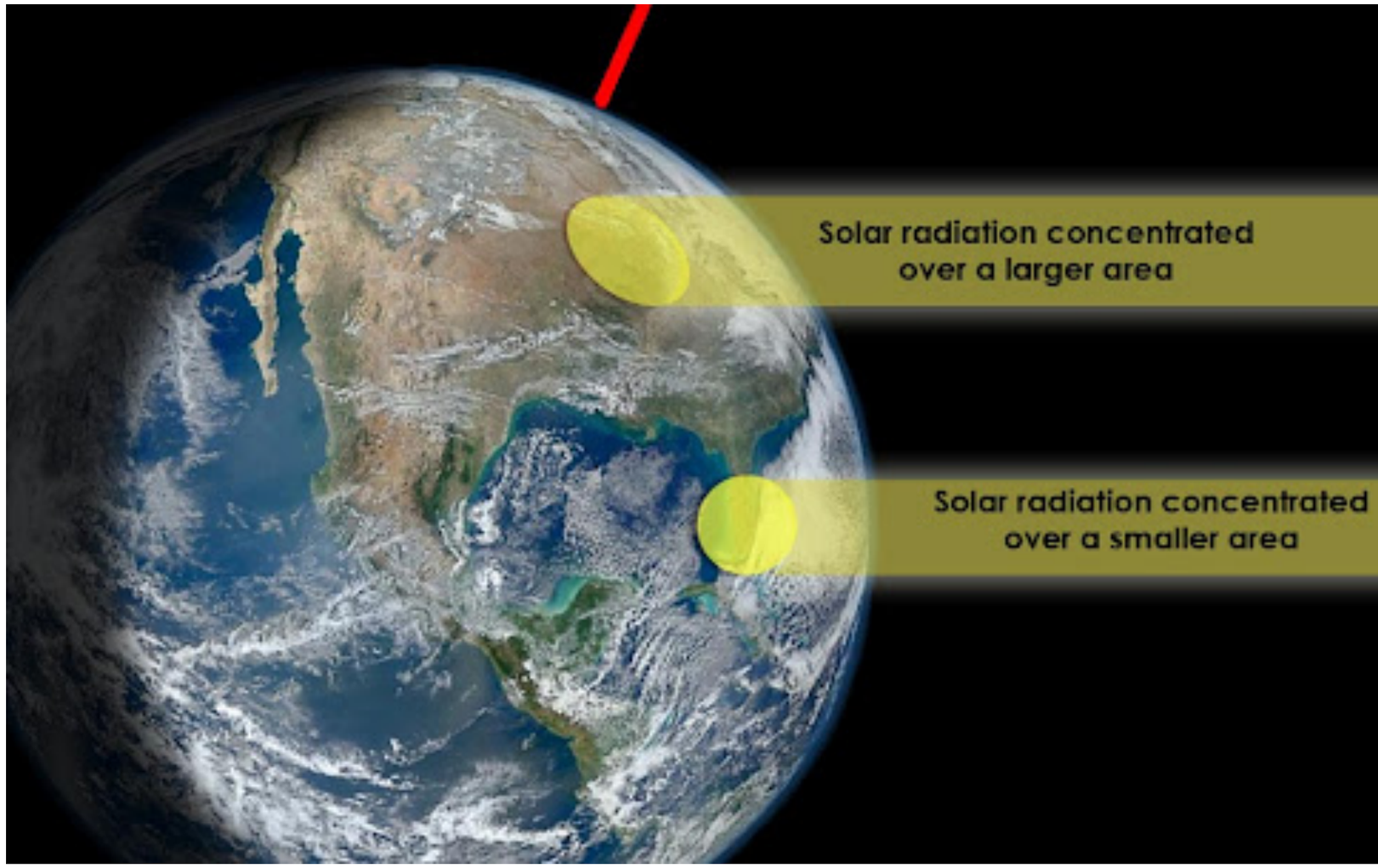
- The Global Radiation Balance: The earth is constantly absorbing short wave sun radiation and emitting longwave radiation. This balance keeps the earth's temperature fairly constant (less than 10F fluctuation).


Reflected solar radiation (30)
Outgoing infrared radiation (70)
Reflected by atmosphere (25)
(25)
Emitted by atmosphere (66)
(4)
(12)
Incoming solar radiation (100)
Absorbed by atmosphere (25)
(29)
(100)
Gases
Thermals (5)
Greenhouse effect (88)
Radiated by surface (104)
Reflected by surface (5)
Evaporation (24)
Absorbed by surface (45)
(45)

Solar Insolation

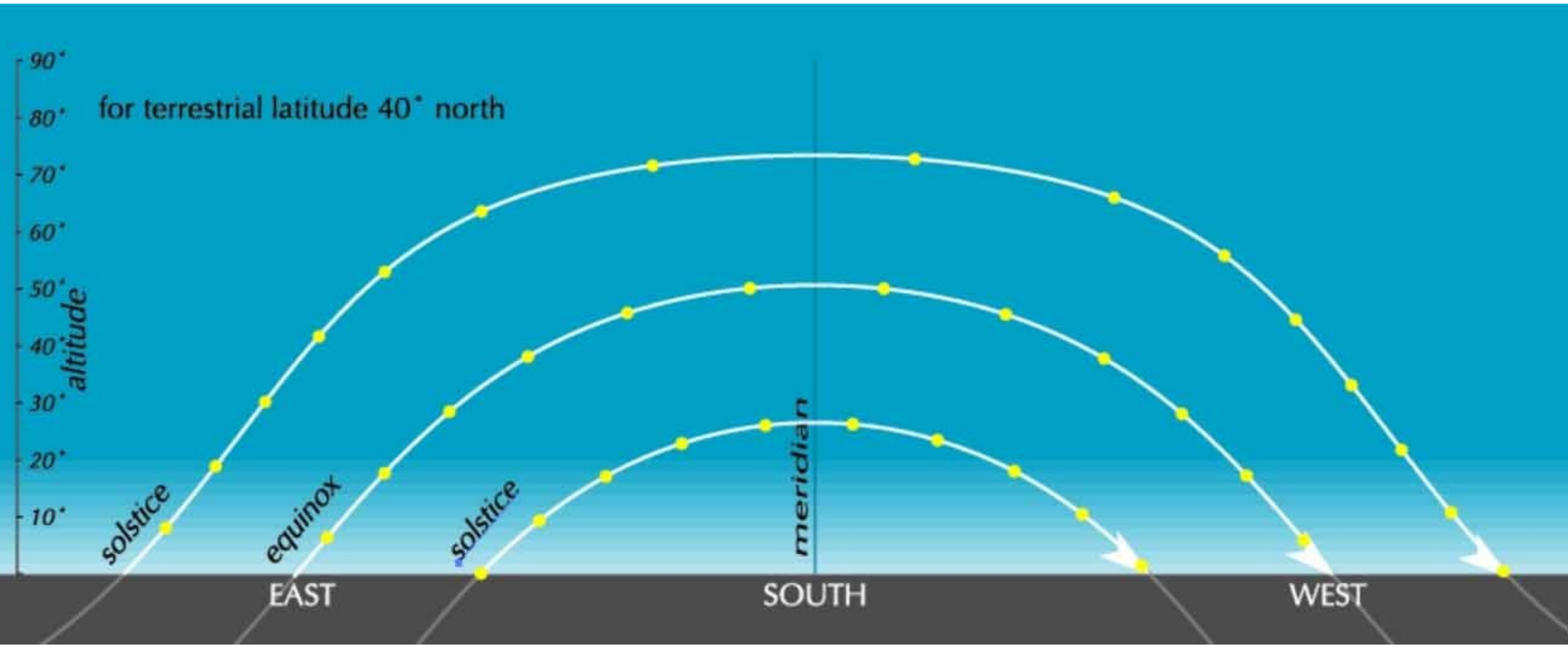
- S I is the incoming solar radiation to the top of the atmosphere. This varies at different parts of the earth at different times. It's greatest when the sun is directly overhead & decreases as the sun is lower in the sky.





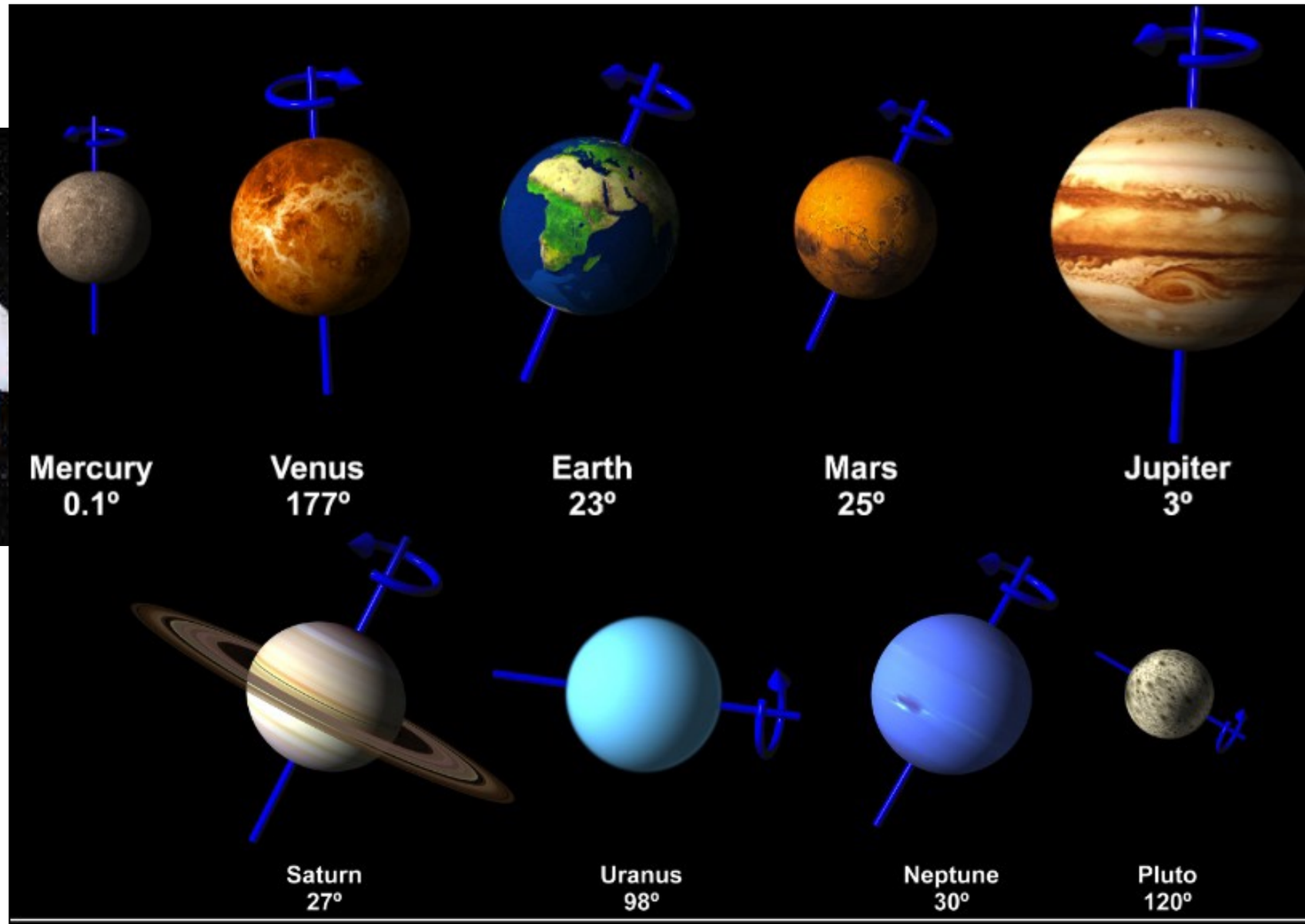
Daily Insolation Changes

- This is the average insolation (sun energy) at a specific location during 24 hours. It depends on the angle of the sun and how long the sun is in sky. It is the greatest at the summer solstice and the least at the winter solstice.



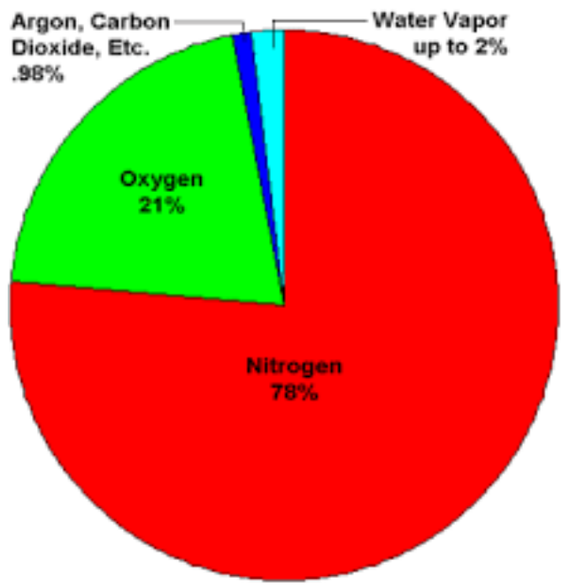
Annual Insolation by Latitude

- The tilt of the earth's axis allows the poles to get about 40% solar insolation as what the equator gets. Without the tilt the poles would get Zero Insolation. The poles would be colder and the equator would be warmer without the tilt. The axis tilt is another factor that distributes heat around the earth.



Composition of the Atmosphere

- A mixture of gases held in place by gravity makes up our atmosphere. About 97% of our atmosphere is located in the lower 19 miles. Dry air is 78% Nitrogen (N2) & doesn't react with many substances. Bacteria in the soil helps plants use it for growth. Oxygen is 21% & is very active in biotic & abiotic reactions. Water vapor makes up 1-2% of the atmosphere.



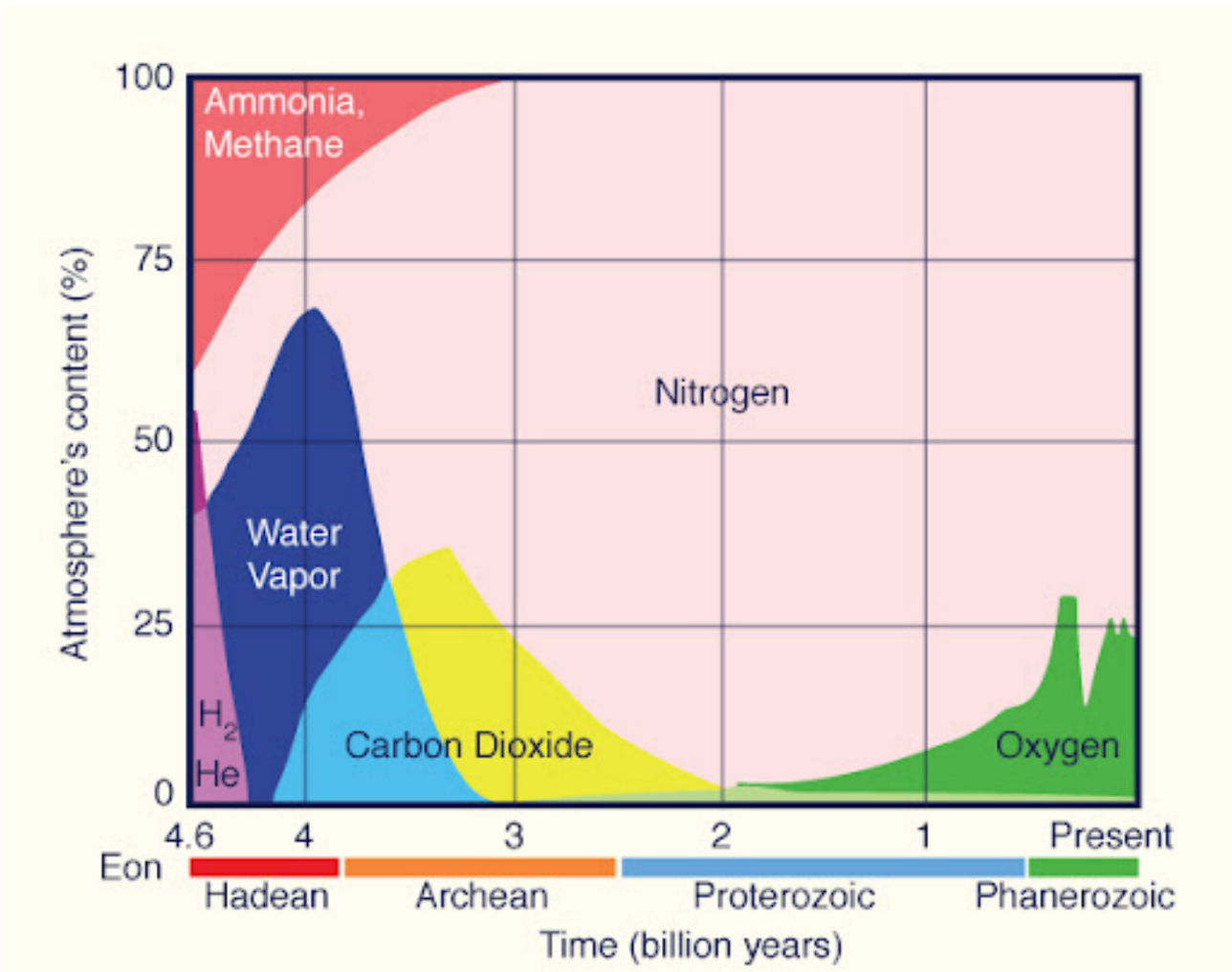


Table 1–2 Principal gases of dry air

Constituent	Percent by Volume	Concentration in Parts Per Million (PPM)
Nitrogen (N_2)	78.084	780,840.0
Oxygen (O_2)	20.946	209,460.0
Argon (Ar)	0.934	9,340.0
Carbon dioxide (CO_2)	0.036	360.0
Neon (Ne)	0.00182	18.2
Helium (He)	0.000524	5.24
Methane (CH_4)	0.00015	1.5
Krypton (Kr)	0.000114	1.14
Hydrogen (H_2)	0.00005	0.5

Energy (heat) Transfer

- Temperature: The amount of Kinetic (moving/vibrating) energy. More kinetic energy = higher temps & more movement. Solid=vibration, liquid=rolling around, gas=random

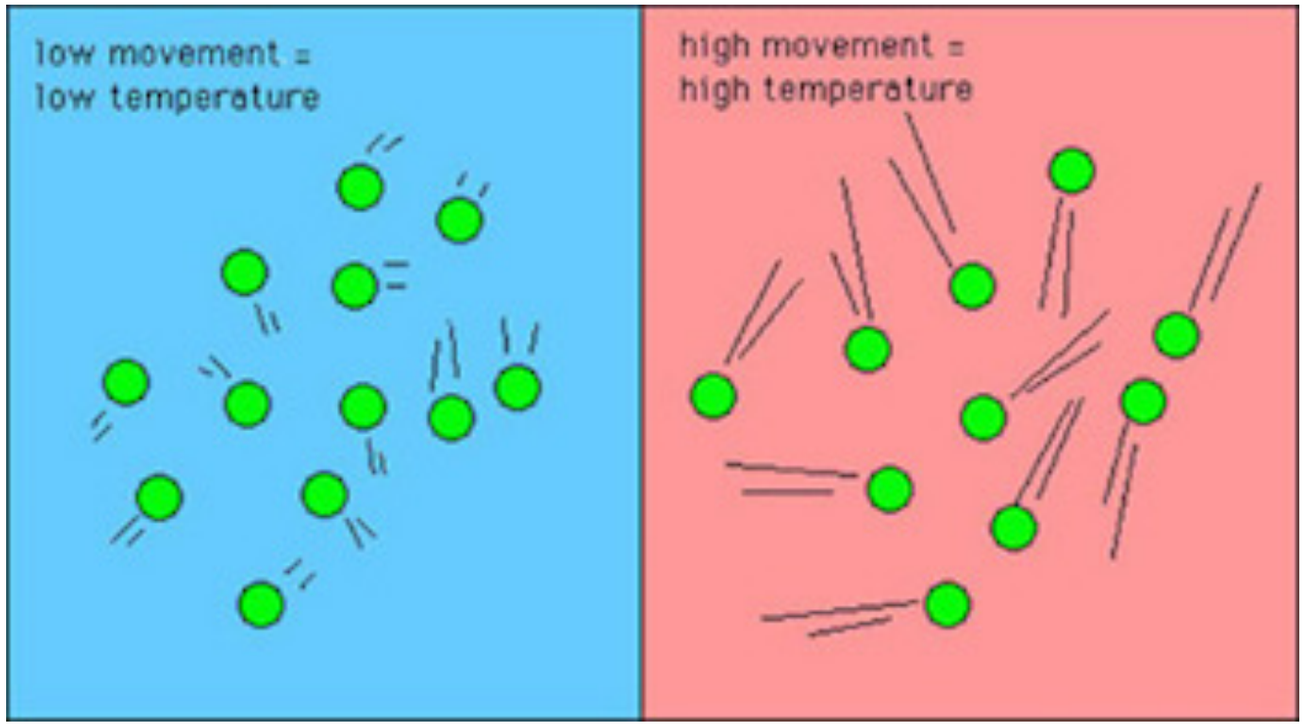
- Heat: The flow of internal energy from one object to another.

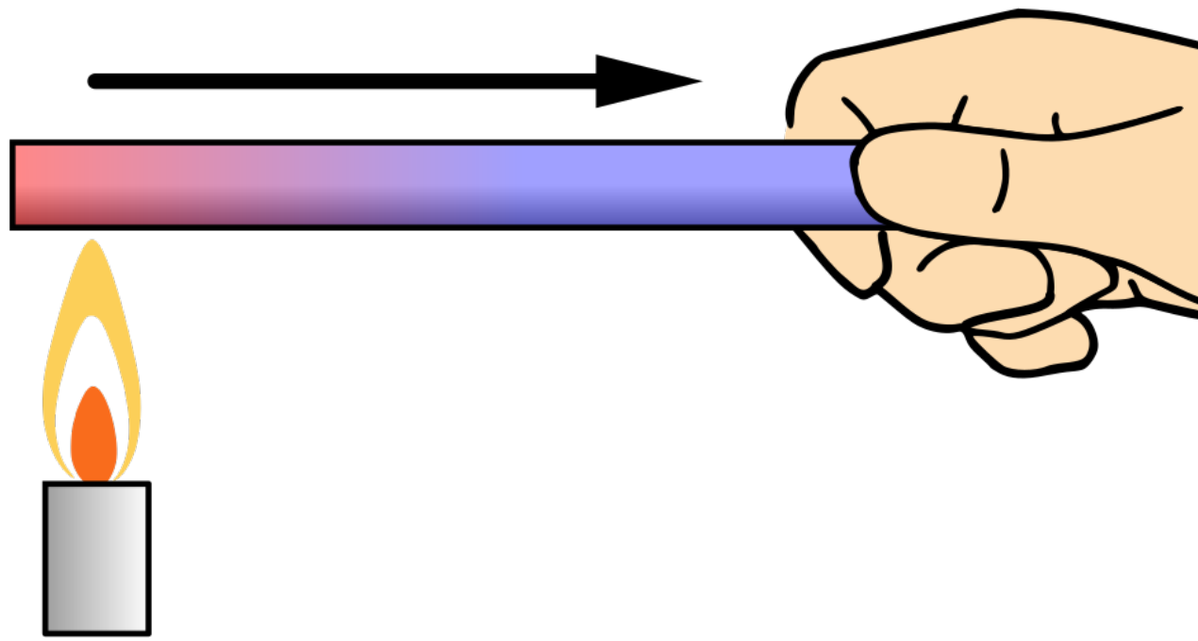
- Conduction: Transfer of heat from warmer to colder

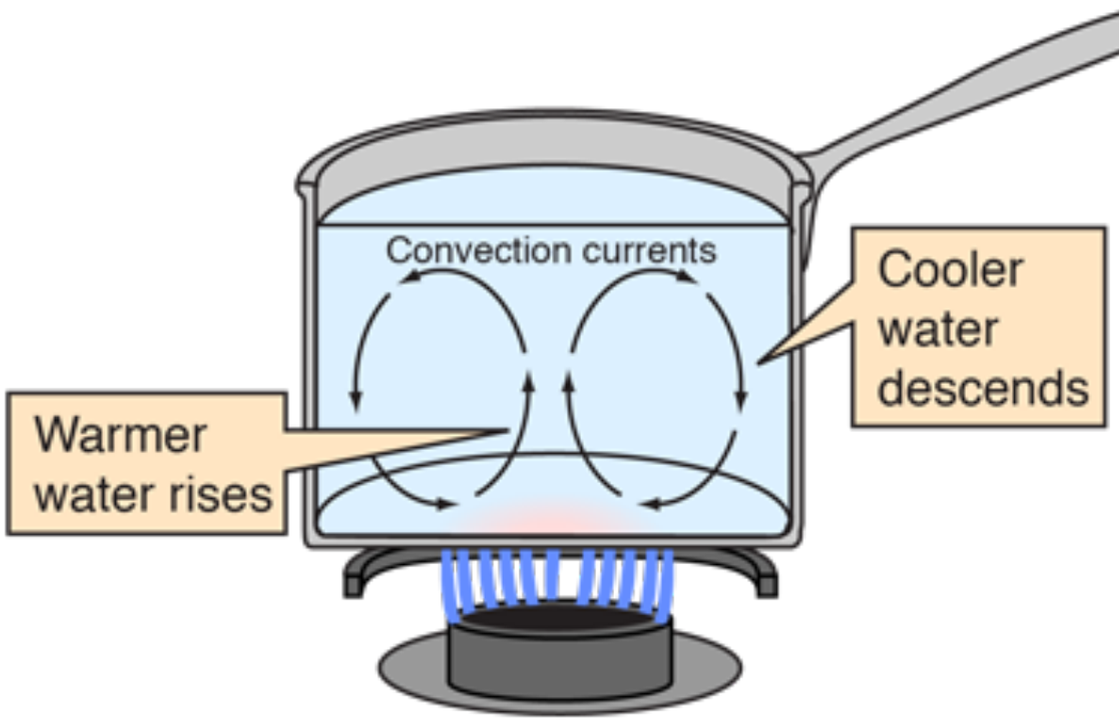
- Convection: The flow of energy when matter moves (liquid or gas). EX. heated air rising or a boiling pot of water.

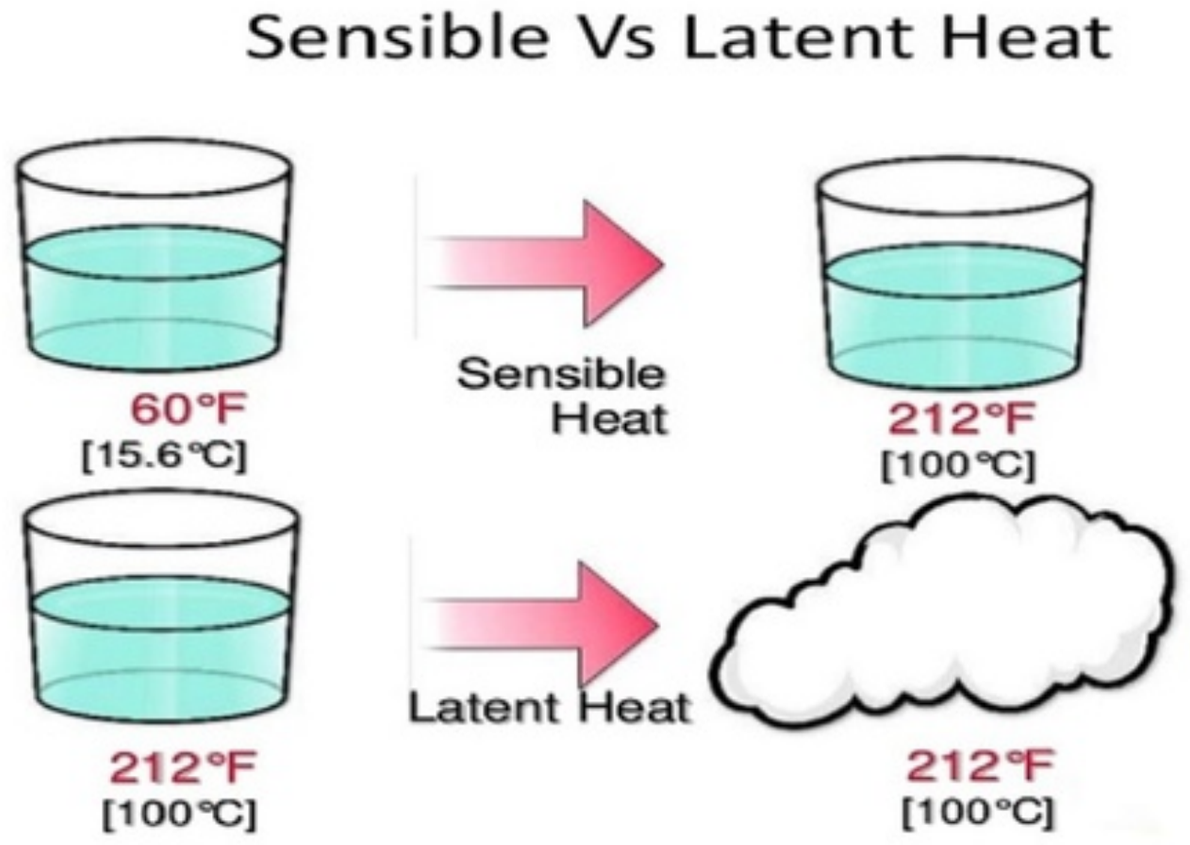
- Sensible Heat: The flow of internal energy between 2 substances that results in a temp change. Stove burner gets hot

- Latent Heat: The flow of heat that results in a change of state but not increasing temperature. Water turning to water vapor.


low movement =
low temperature
high movement =
high temperature



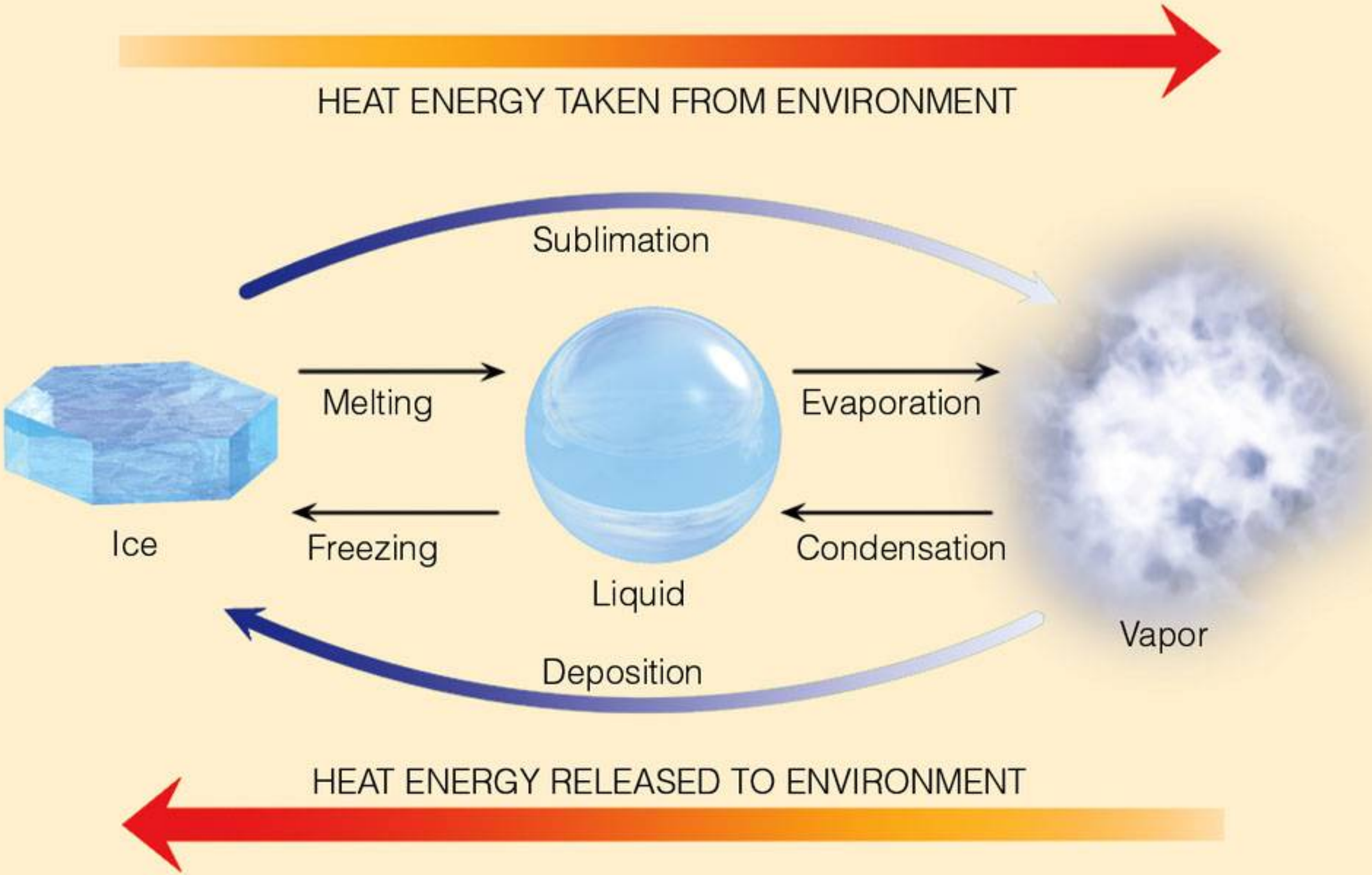

Convection currents
Cooler water descends
Warmer water rises


Sensible Vs Latent Heat
60°F
[15.6°C]
Sensible Heat
212°F
[100°C]
212°F
[100°C]
Latent Heat
212°F
[100°C]

Earth's Heat Transfer

- Sensible Heat Transfer: When air is heated or cooled by ocean or land & when currents of warm water or air mix with cooler water or air.

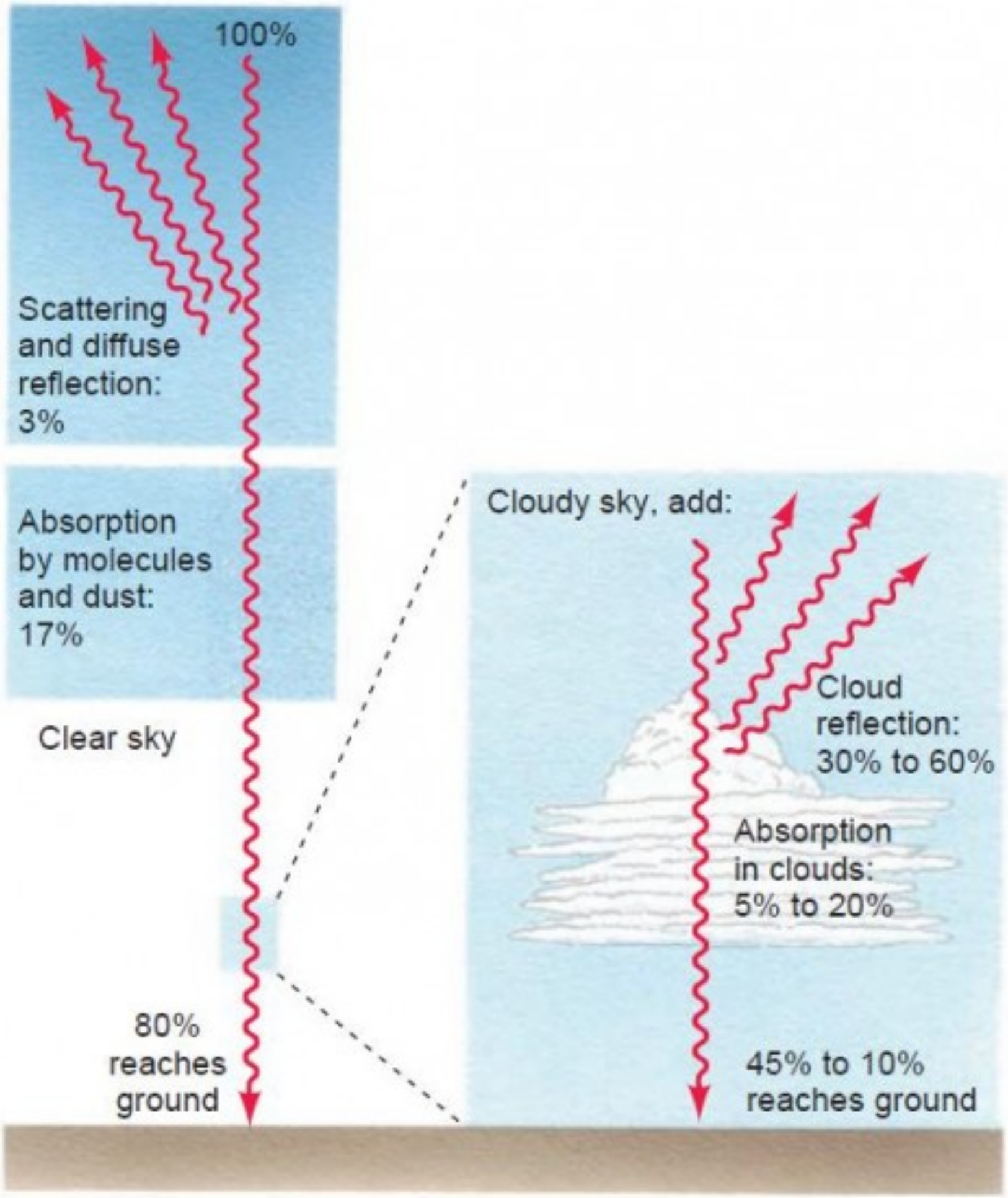
- Latent Heat Transfer: When water evaporates from land or ocean transferring energy from the surface to the atmosphere. This energy is later released as sensible heat when the water vapor condenses to form rain drops or snow crystals. This process allows our atmosphere to have a warmer polar region and cooler equatorial region.



- In the past 200 years human population has grown from 1 to almost 8 billion & humans have changed the planet's surface. This has changed the earth's energy balance.

- Flow of insolation (sun energy) through the atmosphere to the surface. This is what happens to the sun's energy.

  - Gamma & X Rays are absorbed by upper atmosphere
  - UV Rays are absorbed by the Ozone Layer.
  - Diffusion causes about 3% to go back into space.
  - Absorption by CO_2 and water takes 17% of the energy.
  - Clouds can reflect or absorb 5-60% of the sun's energy.
  - 10-80% reaches the surface depending on weather.


100%
Scattering
and diffuse
reflection:
3%
Absorption
by molecules
and dust:
17%
Clear sky
80%
reaches
ground
Cloudy sky, add:
Cloud
reflection:
30% to 60%
Absorption
in clouds:
5% to 20%
45% to 10%
reaches ground

Albedo

- The amount of energy that is reflected upward from the surface. Snow & ice have a high albedo while black pavement & cities have a low albedo. Forrests have an intermediate albedo.

- The earth's surface & atmosphere sends back almost 1/3 of all the solar energy that reaches us. That means that 2/3 of the sun's energy is absorbed by earth which forms our climate.

POSITIVE FEEDBACK MECHANISM

a chain reaction where small change creates an effect that causes an even bigger change

THE ALBEDO EFFECT

ability of a surface to reflect light

REFLECTED 40%

SOIL ALBEDO

Exposed land is darker coloured and absorbs more energy. As the ice melts, more land is exposed. As a result it absorbs more heat, melting more ice.

REFLECTED 90%

SNOW ALBEDO

A small amount of snow melt exposes darker ground which absorbs more radiation, leading to more snow melt.

REFLECTED 10%

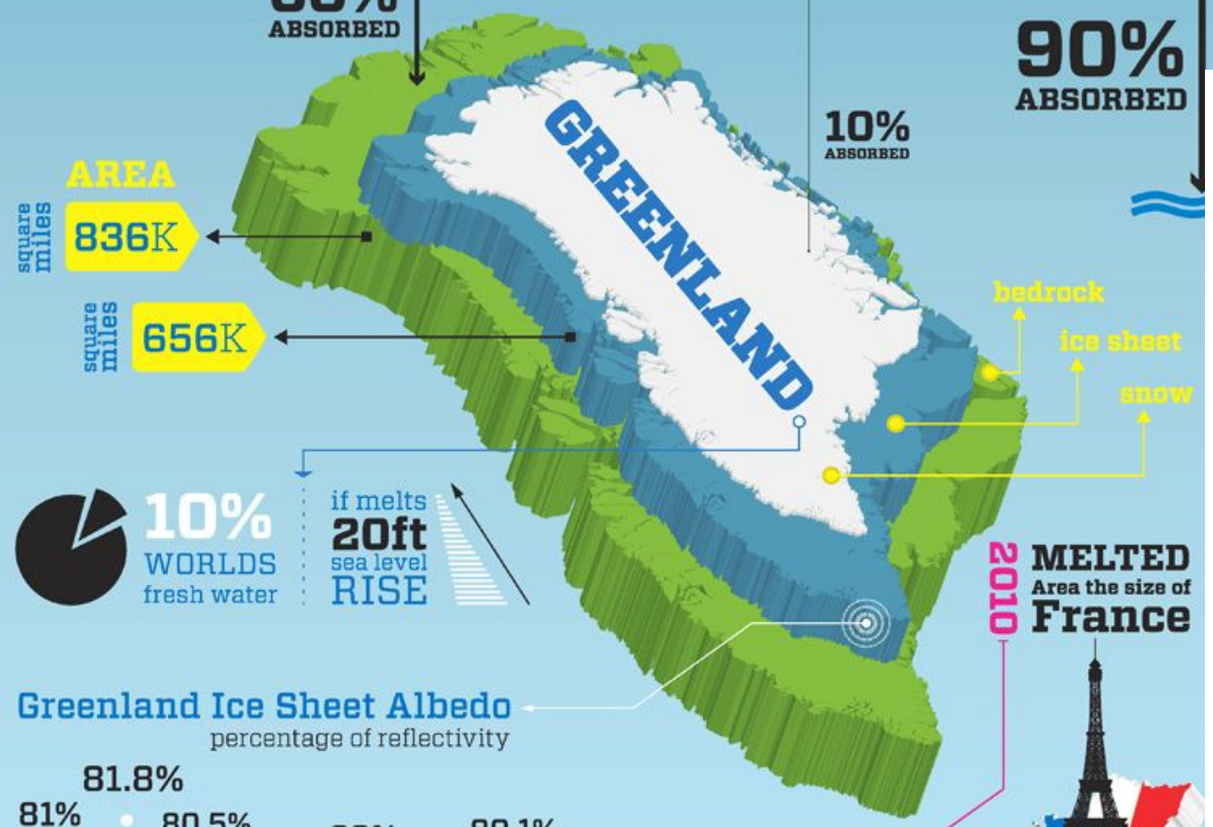
OCEAN ALBEDO

The albedo of ocean water is much lower, so it absorbs the rays, trapping the heat. The more sea water is exposed, and the less sunlight is reflected, causing temperatures to rise, and causing more ice to melt.

60% ABSORBED

90% ABSORBED

10% ABSORBED



10% WORLDS fresh water

if melts 20ft sea level RISE

2010 MELTED Area the size of France

Greenland Ice Sheet Albedo

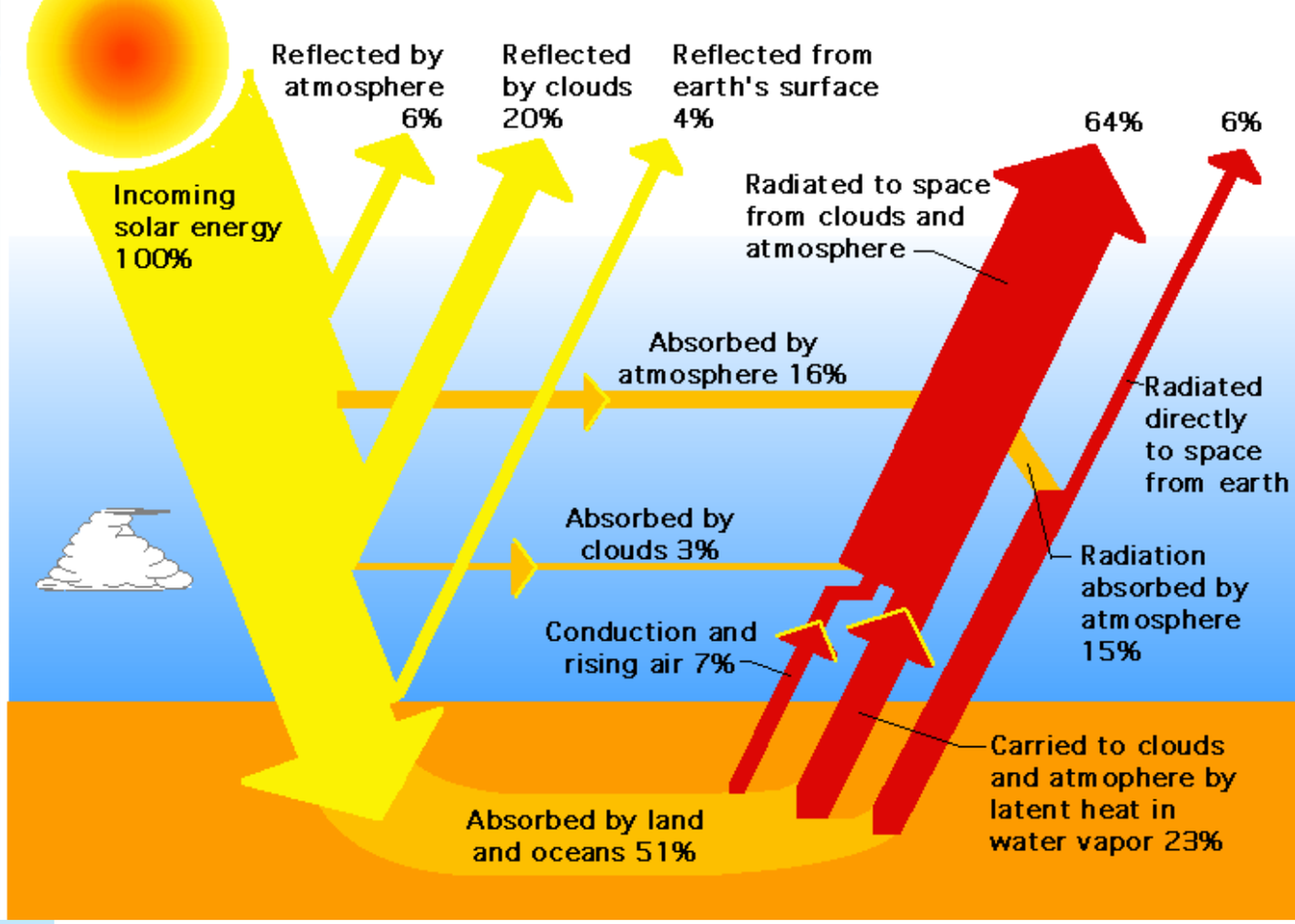
percentage of reflectivity

INCREASING MELTING RATE 6600 SQUARE MILES PER YEAR

13 WREX YOUR WEATHER AUTHORITY

ALBEDO EFFECT

EARTH'S ENERGY BUDGET



Counterradiation & Greenhouse Effect

- The atmosphere emits longwave radiation in all directions, some returns to earth. This counterradiation replaces some of the heat emitted by the surface.

- The process that absorbs this counterradiated heat is called the Greenhouse Effect. This process is dependent on how much water, CO2 & other GE gases are in the atmosphere. More of these gases equals more counterradiation. As these gases increase it causes more counterradiation

- Many Green House gases are a direct result of human activity.

Greenhouse Gases

TABLE 4a: Anthropogenic (man-made) **Contribution to the "Greenhouse Effect," expressed as % of Total (water vapor INCLUDED)**

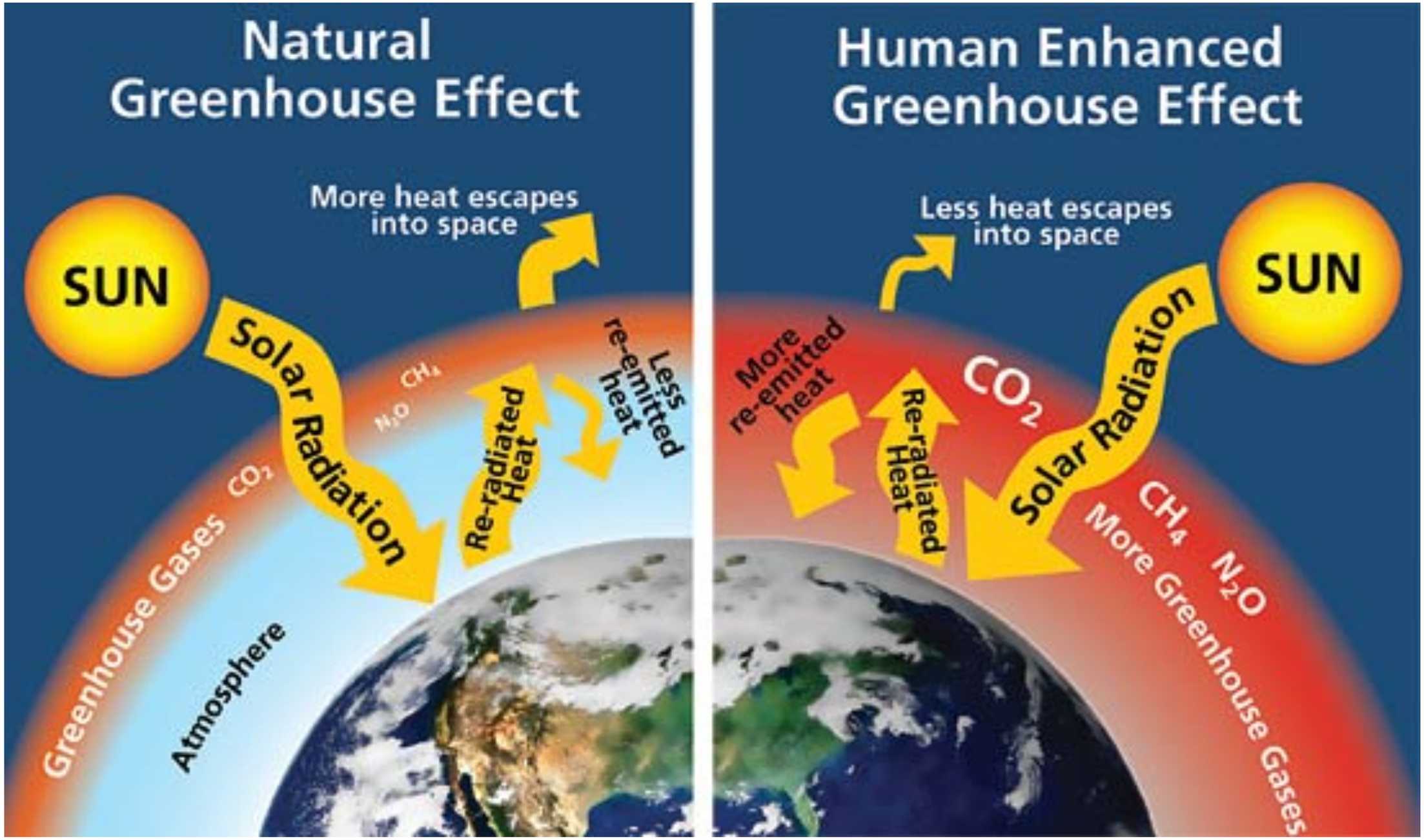
Based on concentrations (ppb) adjusted for heat retention characteristics % of Greenhouse Effect% Natural% Man-made

Based on concentrations (ppb) adjusted for heat retention characteristics	% of Greenhouse Effect	% Natural	% Man-made
Water vapor	95.000%	94.999%	**0.001%**
Carbon Dioxide (CO2)	3.618%	3.502%	**0.117%**
Methane (CH4)	0.360%	0.294%	**0.066%**
Nitrous Oxide (N2O)	0.950%	0.903%	**0.047%**
Misc. gases (CFC's, etc.)	0.072%	0.025%	**0.047%**
Total	**100.00%**	**99.72**	**0.28%**

Assignment # 3

- Name 6 different activities that you can do, not do, or reduce that will reduce one of the greenhouse gases and ID that gas for each activity.

- Ex: If I plant a tree that will reduce the CO2 because the tree will use it for growth.


Natural
Greenhouse Effect
More heat escapes
into space
SUN
Solar Radiation
Re-radiated
Heat
Less
re-emitted
heat
CH_4
N_2O
CO_2
Greenhouse Gases
Atmosphere
Human Enhanced
Greenhouse Effect
Less heat escapes
into space
SUN
Solar Radiation
More
re-emitted
heat
Re-radiated
Heat
CO_2
CH_4
N_2O
More Greenhouse Gases

Assignment #4

- If the climate is warming, explain 2 ways it will effect you personally.

- EX: There will be more traffic in our area as more people move here because of rising sea level.

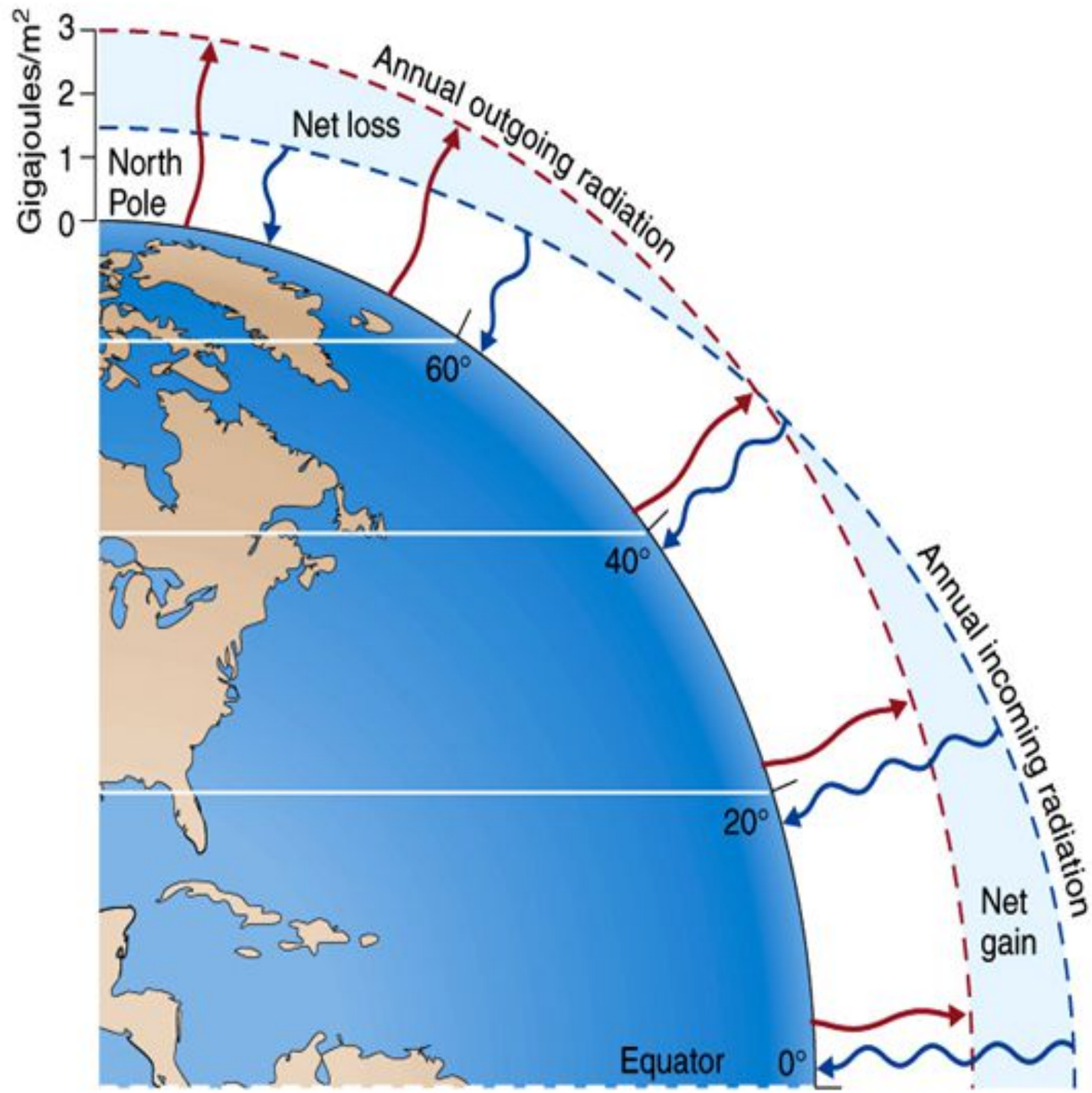
Earth's Net Energy Balance

- The earth's overall energy coming in and being radiated out is in balance. That makes the Net Radiation at zero.

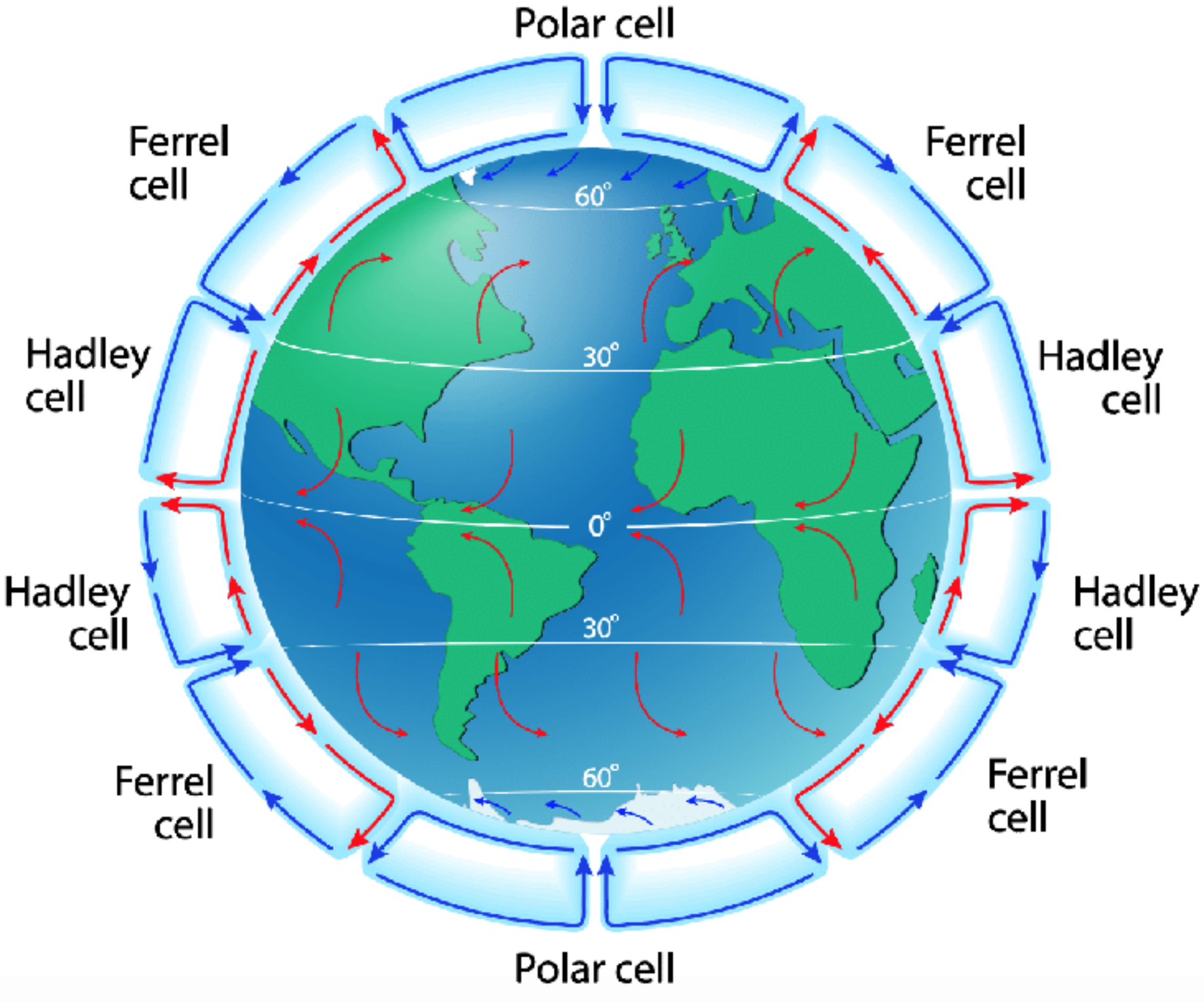
- The net energy balance at a specific location will depend on location and conditions. It can be positive when more energy flows in like near the equator and negative at the poles. This causes the energy flow to be towards the poles. Hurricanes, wind patterns, and ocean currents cause this flow to even out our local climates.

Annual Average Net Radiation at Different Latitudes

- Between 38°N and S = net energy surpluses
- Poleward of 38° = net energy deficits
- Winter hemispheres have net energy deficits poleward of 15°, but mass advection neutralizes energy imbalances



GLOBAL ATMOSPHERIC CIRCULATION



25 to 40 cm/sec

Greater than 40 cm/sec

750 1500 mi

1000 2000 km

NORTH AMERICA

EUROPE

Labrador Current

Greenland

Irminger Current

Norway Current

"Cold Wall"

North Atlantic Drift

Gulf Stream

Florida Current

Antilles Current

Gulf of Mexico

Caribbean

NORTH ATLANTIC OCEAN

Canary Current