Topic 6 – Insolation and the Seasons

Vocabulary

Angle of Incidence – angle the Sun's rays strike the Earth's surface.

Deforestation – Removal of all trees from a forest leaving barren land behind.

El Niño – Weather changes caused by cold surface ocean water from the eastern Pacific to replace warm surface water on the western coast of South America.

Global warming – Warming of the Earth's troposphere possibly caused by human activities.

Greenhouse gases – Gasses such as carbon dioxide (CO_2), methane (CH_4) and water vapor (H_2O) in the atmosphere that absorb infrared radiation.

Heat Budget – A balance between the total energy received from the sun and the amount of energy emitted by earth.

Ice ages – Times of widespread glaciation on Earth, reducing the temperatures for several centuries, a cyclical event.

Insolation – The amount of incoming solar radiation received from the sun.

Ozone – O_3, the gas in the stratosphere that protects earth from harmful UV radiation, on Earth's surface it is a pollutant.

Sunspots – A darker and cooler region on the sun's surface responsible for increased electromagnetic energy emitted from the sun.

Transpiration – Water vapor released by plants into the atmosphere, greatest when plants are photosynthesizing sunlight into sugars.

Overview of Topic

- The sun and its interactions with Earth is the driving force of all energy transfer; effecting global wind patterns, ocean currents, seasons and the water cycle. Without the sun there would be no life, the gases that make up the atmosphere would be solid, and there would be no processes that shape the earth's surface.

I. Insolation (**IN**coming **SOL**ar radi**ATION**)

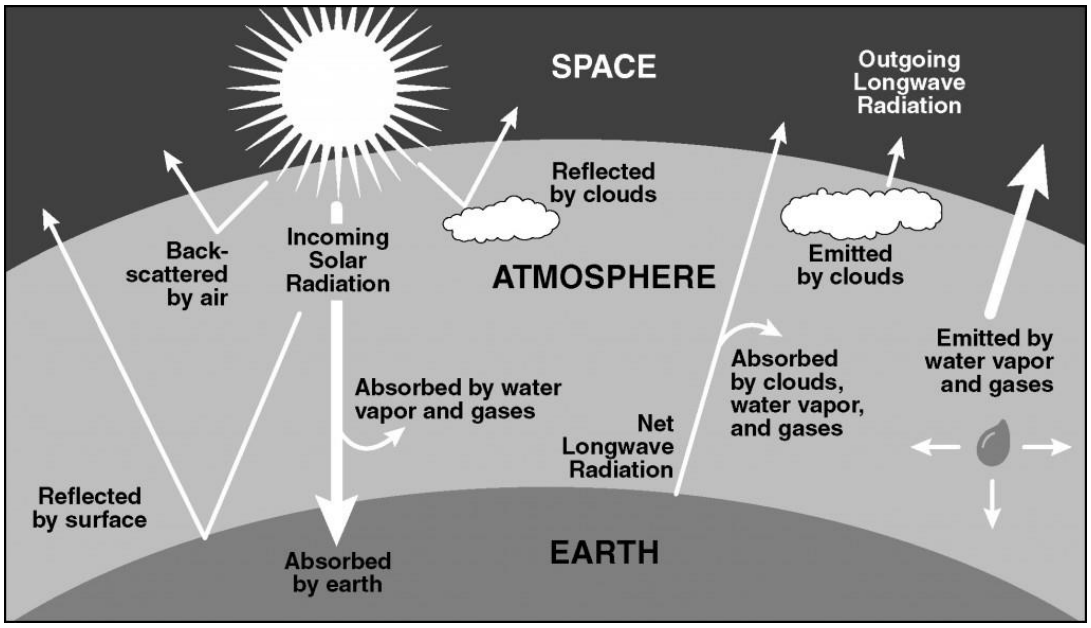
a. It is the sun's electromagnetic radiation that strikes the surface of the earth.

b. Surface of the Earth Effect on solar insolation.

- UV in Earth's atmosphere.
  - Ozone gas (O_3) absorbs UV light, without ozone life would not exist; too much UV causes skin cancer.
  - Found at an altitude of about 20 km
- Infrared (long wave radiation) in Earth's atmosphere
  - Absorbed by water vapor (H_2O), carbon dioxide (CO_2) and methane (CH_4).

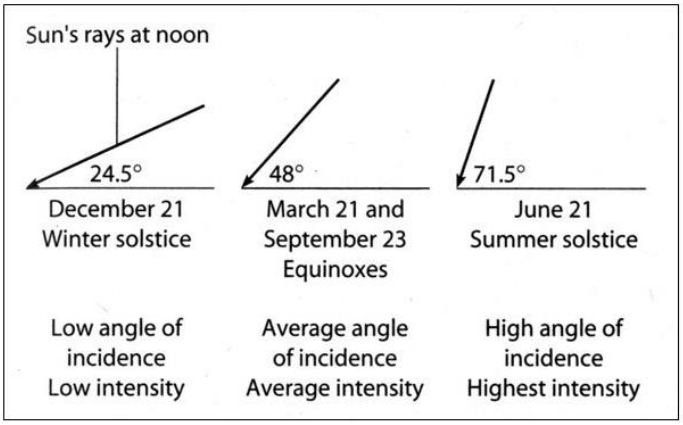
c. Atmosphere reflects and scatters insolation

- About 46% of the insolation reaches the Earth's surface as visible light.



- The remaining 54% is reflected and/or scattered back into space.
    - Clouds absorb and reflect
    - Dust reflects
    - Gases absorb
    - Volcanic ash reflects (can cause global cooling)
- Longwave radiation (infrared) is the heat that is generated by interactions of light on the Earth's surface.
    - Greenhouse gases: carbon dioxide (CO_2), methane (CH_4) and water vapor (H_2O) trapped long wave radiation warming the surface.

d. Energy Balance and Factors Affecting Energy Balance
- Angle of Incidence
    - A low angle of incidence results in lower average temperatures.
    - A high angle of incidence results in higher average temperatures.



Illustrates for a New York State

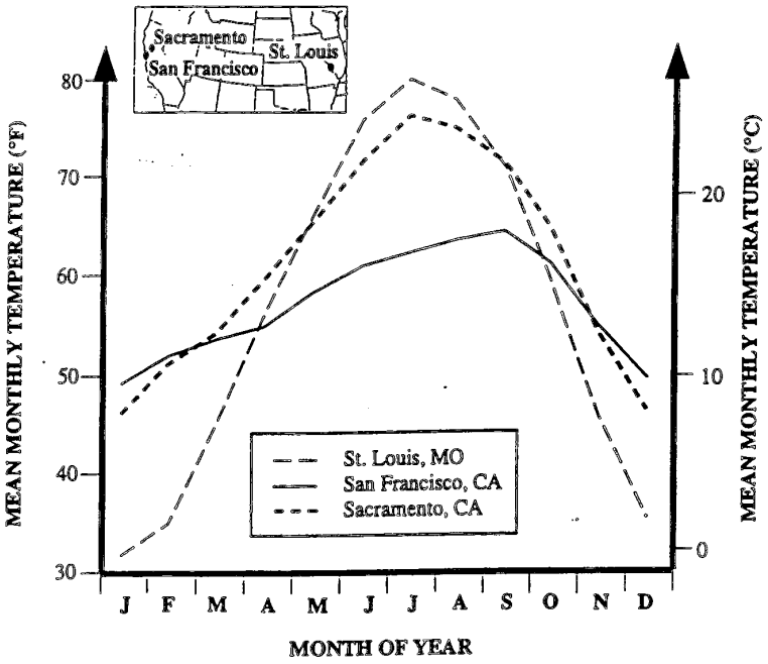
- Surface

Surface color and texture	Heating
Light	Low – light is reflected
Dark	High – light is absorbed
Smooth	Low – less light absorbed
Rough	High – more light absorbed

- A combination of texture and color also affects light absorption then heating.

- Phase changes (page 1 ESRT)
  - Condensation releases energy to atmosphere
  - Vaporization takes energy from atmosphere
  - Melting releases energy to atmosphere
  - Freezing takes energy from atmosphere

e. Land and water
- Specific heat (page 1 ESRT)
  - Water has a high specific heat; resists heating or cooling.
    - Areas near large bodies of water such as the Great Lakes, oceans or seas, tend to be warmer in the winter months and cooler in the summer months.
    - This is due to the high specific heat of water
  - Land has a lower specific heat; changes temperature easily.
    - Areas in the middle of a land mass have very large seasonal changes in temperature

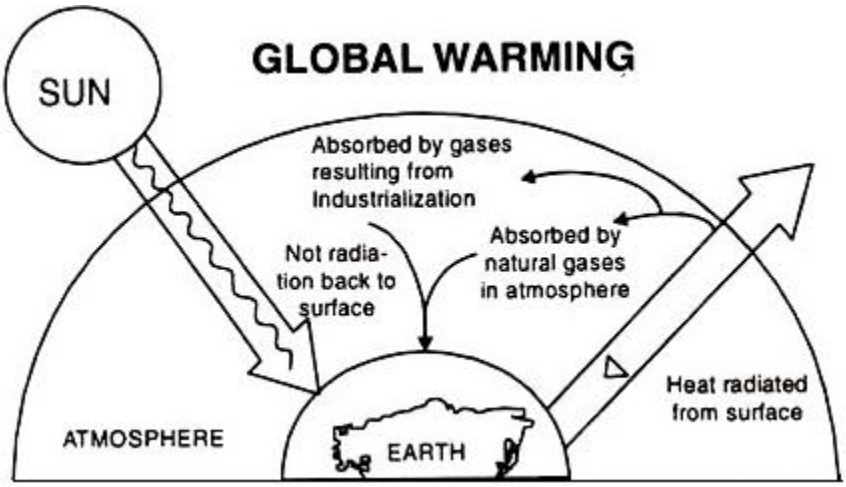


San Francisco I located on the coast whereas Sacramento and St. Louis are located inland. The closeness to a large

body of water does affect the annual temperature of coastal regions.

d. The Greenhouse Affect

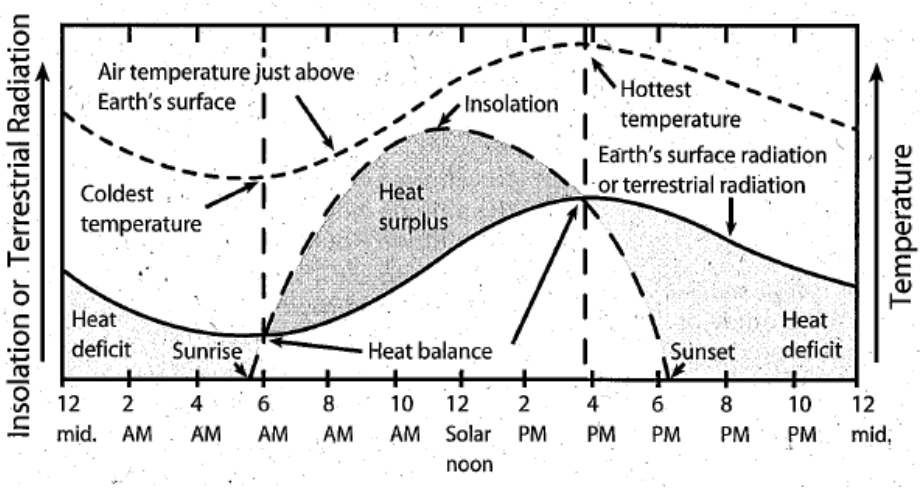
- Shortwave radiation is light reaches surface heats ground
- Longwave radiation is infrared (heat) radiated back to space, however some is redirected towards Earth when greenhouse gases are present.
- It is natural
- Goes through a cycle of high greenhouse gases to low greenhouse gases.
    - Global warming during times of high greenhouse gases
    - Global cooling (ice ages) times of low greenhouse gases



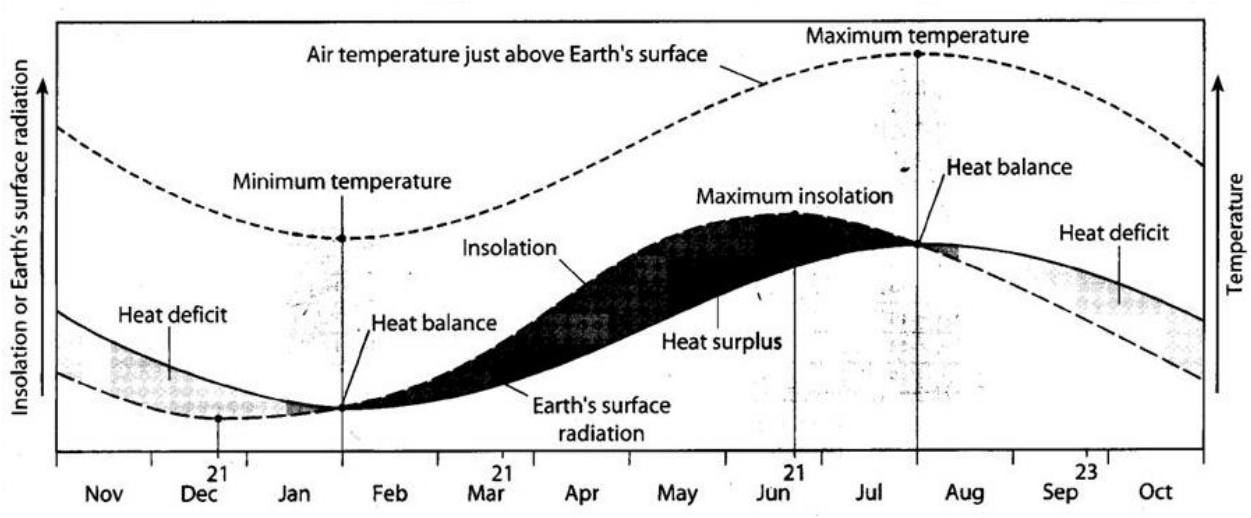
- Greenhouse gases
    - CO_2 – Carbon Dioxide
    - CH_4 – Methane
    - H_2O vapor – Water vapor (increases as heating increases)

f. Heat Budgets

- Daily



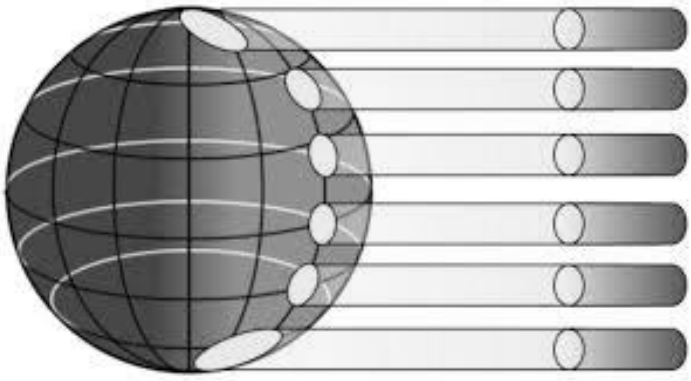
- Yearly



II. Insolation Variables

a. Angle of Insolation Affected by:

- Earth's shape



- Latitude
    - Further from the equator the less direct insolation causing a decrease in heating.

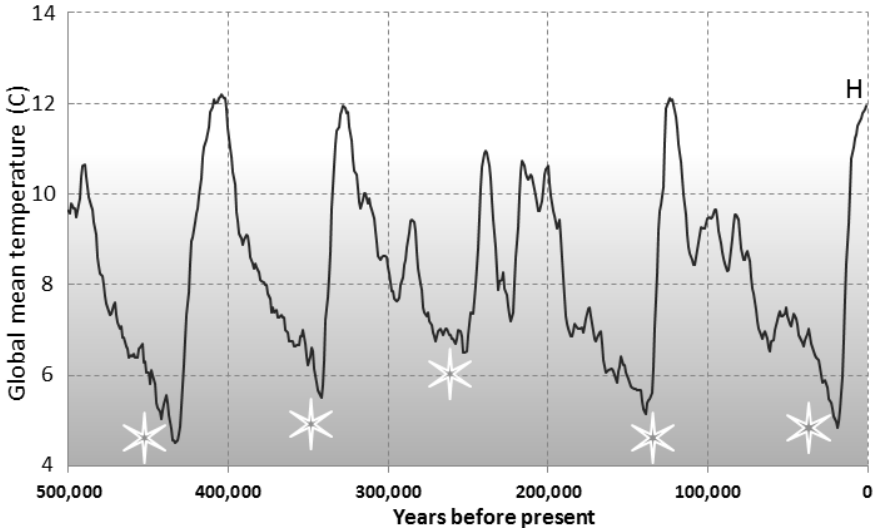
- Seasonal
    - Most direct insolation is during the summer months resulting in greater heating.

- Time of Day
    - Greatest heating is at solar noon when insolation is most direct

III. Climate Change

a. Ice Ages

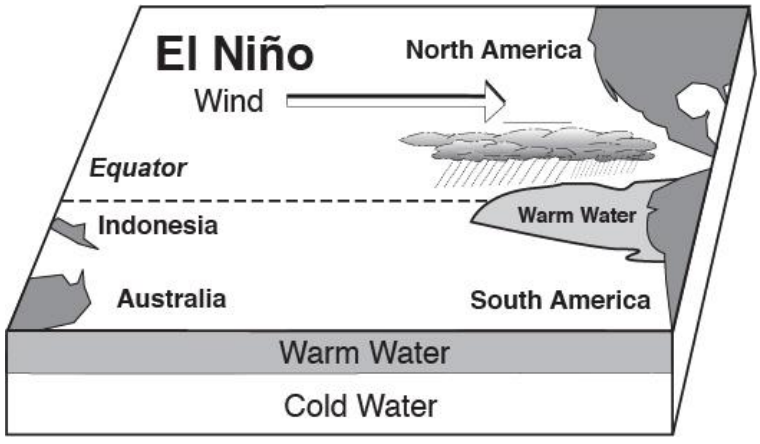
- Cycles of global cooling resulting in glaciers forming at mid-latitude.



- Last ice age ended about 12,000 years ago.
- Cycle based on trapped carbon dioxide gas in Arctic ice and Antarctic ice.

b. El Niño –

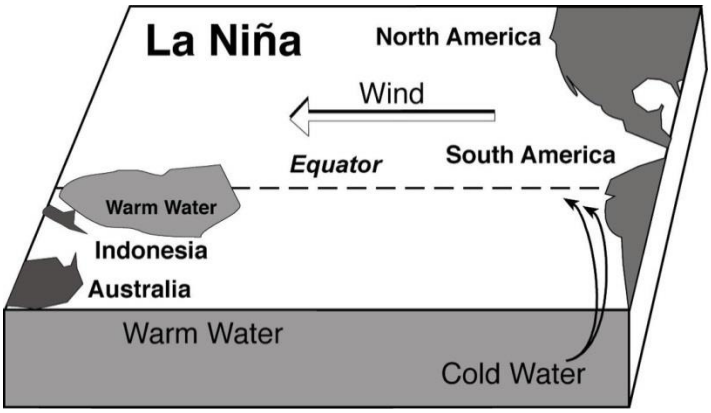
- Difficult topic – search internet for guidance
- http://oceanservice.noaa.gov/facts/ninonina.html
- http://www.conserve-energy-future.com/what-is-el-nino.php



- El Niño is the warm phase of the El Niño-Southern Oscillation cycle (ENSO). The ENSO cycle is the way scientists describe the fluctuations in temperature between the atmosphere and the ocean in the east-central Equatorial Pacific.

- El Niño is a naturally occurring phenomenon that is linked to a periodic warming in sea surface temperatures across the central and east-central Equatorial Pacific.
- El Niño occurs every 2-7 years, and can last anywhere between nine months and two years.
- Typically begins in the winter often in December.
- Affects are felt world wide
- In United States
    - Pacific Northwest – warmer winter
    - New England (New York) – warmer winter
    - Southern US – wet and cooler winter

c. La Niña
    - NOT opposite of El Niño!



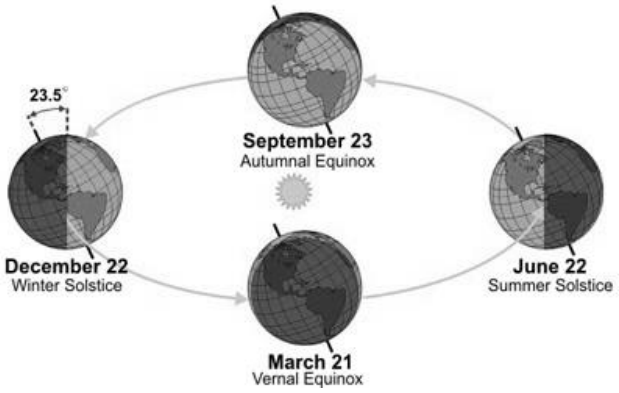
d. Volcanic Eruptions
    - Increased volcanic ash in the atmosphere decreases annual temperature.
    - Affects from ash is temporary, usually less than a year.
    - Carbon dioxide from volcanic eruptions is longer lasting and may cause temperatures to increase depending on amount of CO_2 being emitted.

e. Human
    - Global climate change
        - Increase carbon dioxide emissions for burning fossil fuels, increases global temperatures (global warming)
        - Increased methane (CH_4) from landfill waste and burning fossil fuels also increases global temperatures.

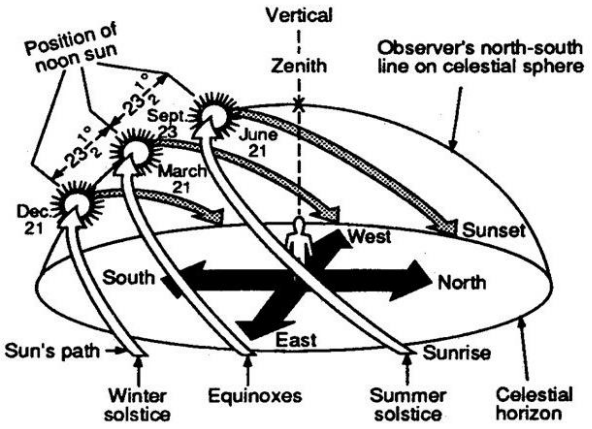
IV. Seasons

a. Earth's Tilt and Position in Orbit Around the Sun

- Tilt
  - The major reason for the seasons.
  - North Pole tilts towards sun during summer solstice (summer), northern hemisphere receives intense insolation
  - Both north and south pole receive equal amounts of insolation during the equinoxes (autumn and spring)
  - North pole tilts away from sun during winter solstice (winter), northern hemisphere receives least intense insolation



- Seasonal changes in the sun's path in the sky
  1. **New York State is the example below**
  - Dec 21st – Winter solstice
    - Rises southeast sets southwest
    - Shortest path
    - Lowest altitude at noon
    - Less than 12 hours of light
    - Coldest temperatures
  - Sep 23rd and Mar 21st – Autumnal and Vernal equinoxes
    - Rises due east and sets due west
    - 12 hours of light everywhere on earth.
  - Jun 21st – Summer solstice
    - Rises northeast sets northwest
    - Longest path
    - More than 12 hours of light
    - Warmest temperatures


Vertical
Zenith
Observer's north-south line on celestial sphere
Position of noon sun
23½°
23½°
Sept. 23
June 21
March 21
Dec. 21
West
Sunset
South
North
East
Sun's path
Sunrise
Winter solstice
Equinoxes
Summer solstice
Celestial horizon

Earth Science Reference Table – (ESRT)

Pages used from the ESRT (page 1)

Specific heat

Specific Heats of Common Materials

MATERIAL	SPECIFIC HEAT (Joules/gram • °C)
Liquid water	4.18
Solid water (ice)	2.11
Water vapor	2.00
Dry air	1.01
Basalt	0.84
Granite	0.79
Iron	0.45
Copper	0.38
Lead	0.13

- Table used to find specific heat of water and land materials.
- Notice that water has the highest specific heat at 4.18 $\frac{J}{g*C^0}$ which slowly gains loses energy.
- Earth materials which represent the land have much lower specific heats, very quickly they gain and lose energy.

Properties of water

Properties of Water

Heat energy gained during melting	334 J/g
Heat energy released during freezing	334 J/g
Heat energy gained during vaporization	2260 J/g
Heat energy released during condensation	2260 J/g
Density at 3.98°C	1.0 g/mL

- Both melting and freezing have the same energy requirements.
- The same is true for evaporation and condensation.

- Evaporation is referred to as a cooling process and condensation as a heating process.