Concepts for Thermal Climate (Day 2) 5/7/17

Means of Heat Transfer:

Conduction - Molecules vibrate & transfer this energy to adjacent molecules (vibration of molecules)

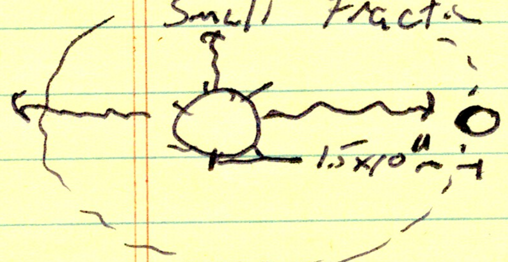
Convection - Molecules flow toward a location of lower density (Flow of molecules)

Radiation - Transfer of heat by emitting electromagnetic radiation (usually infrared) ie. Sun

Solar Radiation

Total Power emitted by the sun is 3.8×10^{26} W

Small Fraction hits the earth



Surface area of a sphere $4\pi R^2$

Intensity $= \frac{Power}{Area} = \frac{Power}{4\pi R^2}$

Power per m^2 (intensity) @ Earth is $\frac{3.8\times10^{26}\,W}{4\pi(1.5\times10^{11}\,m)^2} = 1340\frac{W}{m^2}$

Solar Constant = 1340 W/m^2

Due to elipitical nature of orbit it varies between 1030 to 1398 $\frac{W}{m^2}$

Reductions: Clear Day Atmosphere blocks 30%

So Cloudy Day 2 $\frac{W}{m^2}$ to 1000 $\frac{W}{m^2}$

On Avg (Day/night clear/cloudy) about 170 $\frac{W}{m^2}$ reaches earth surface

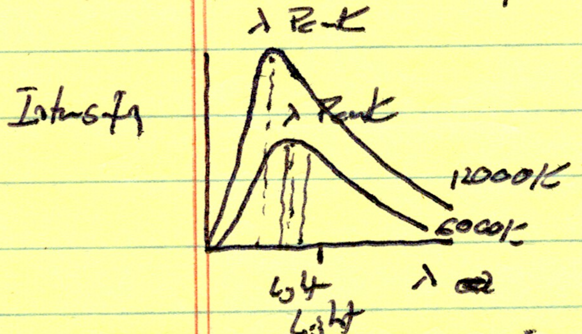
Ex. How much solar radiation (energy) does 1 m^2 of the earth's surface recieve per day

unit of Energy

$$170 \frac{W}{m^2} \rightarrow 170 \frac{W}{m^2} \cdot 24\,hr = 4.1 \frac{kWh}{m^2}$$

P.E

6:17 Radiation from sources that glow is because of Black body Radiation (ie. Sun)



As you get hotter you get more radiation given off → more Area under the curve

Vein Displacement Law

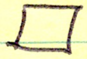
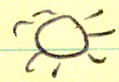
Allows us to determine the temp of a black body given its peak wavelength.

$$T\,(\text{Kelvin}) = \frac{2.9 \times 10^{-3}\ mK}{\lambda\ peak}$$

Ex Find the peak wavelength of 483 nm?

$$T = \frac{2.9 \times 10^{-3}\ mK}{483 \times 10^{-9}\ m} = 6000K$$

Blackbody - All the radiation is being emitted, absorbed, not reflected
Any color will be due to glow not reflection

White Paper  vs white Sun 

Emissivity - How good a black body material is

Emissivity = $\frac{\text{Power Radiated by material}}{\text{Power Emitted by perfect black body @ same temp}}$

(between 0 & 1
(Perfect Reflector) (Perfect Absorber)

General Rule: low for shiny objects (good reflector)
Objects black (emissivity ≈ 1 - Good absorber)

Earth: Clouds - Low emissivity Terrain - Large value
Generally Accept .64 for Earth

Stephan - Boltzman Law
$P \propto T^4$ - Total power radiated by a body varies as T^4 (Kelvin)

$P = \sigma A T^4$ Case of an ideal black body
$\sigma = 5.67 \times 10^{-8} \frac{W}{m^2 K^4}$ Stephan - Boltzman constant
(Instructor handout)

If written in terms of Intensity $I = \frac{P}{A}$

$A = 4\pi r^2$ - Surface Area of a sphere
(ie. Earth)

$I = \frac{\sigma A T^4}{A}$

$I = \sigma T^4$ units for I = Watts/m^2

α <u>Albedo</u> - Fraction of incident radiation that is reflected from the surface

Since all incident radiation is either reflected or absorbed
Fraction absorbed = $1 - \alpha$

$\alpha_{Earth} = 0.3$ (70% of the light is absorbed)

Ex. What does melting glaciers have on earth's Temp
① ICE has higher Albedo than ~~[illegible]~~ soil
Move toward lower albedo
→ Move to more infrared absorption
→ More radiation emitted
→ Raise temp

Ex. 50% of Area is covered by water. As ice melts, now 60% is covered by water. Find the change in albedo
Given sea water $\alpha_S = .20$ land $\alpha_L = .40$

Original $\alpha = 0.3$ (Halfway between .2 & .4
After $\alpha = .28$ ≈ $.6(.2) + .4(.4)$
Melting will lower albedo by .2

Surface Heat Capacity

Regular Specific Heat Capacity $c = \frac{Q}{m\Delta T}$

Energy needed to raise 1g by 1°C

Surface Heat Capacity C_s $C_s = \frac{Q}{Area\,\Delta T}$ or

Energy need to raise surface Area of a planet by 1°C

(ρ) density $= \frac{m}{v}$ $m = \rho v$ Volume = Area × depth

$m = \rho A \cdot depth$

ρ · depth $C = \frac{Q}{\rho A\, depth\, \Delta T}$ ~~ρ · depth~~ $C \cdot \rho \cdot depth = \frac{Q}{A \Delta T}$ Surface Heat Capacity

15:30 Ex. Radiation of intensity $340 \frac{W}{m^2}$ is incident on a lake with a surface heat capacity of 4.2×10^8 J/m²K. Calc. the time required to inc. the temp by 2K

① $C_s = \frac{Q}{A \Delta T}$ $Q = P \cdot t$ ② $C_s = \frac{P\, t}{A\, \Delta T}$ (P/A = Intensity)

③ $C_s = \frac{I t}{\Delta T}$ ④ $t = \frac{C_s \Delta T}{I} = \frac{4.2 \times 10^8 (2K)}{340}$

⑤ $t = 2.5 \times 10^6$ s

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