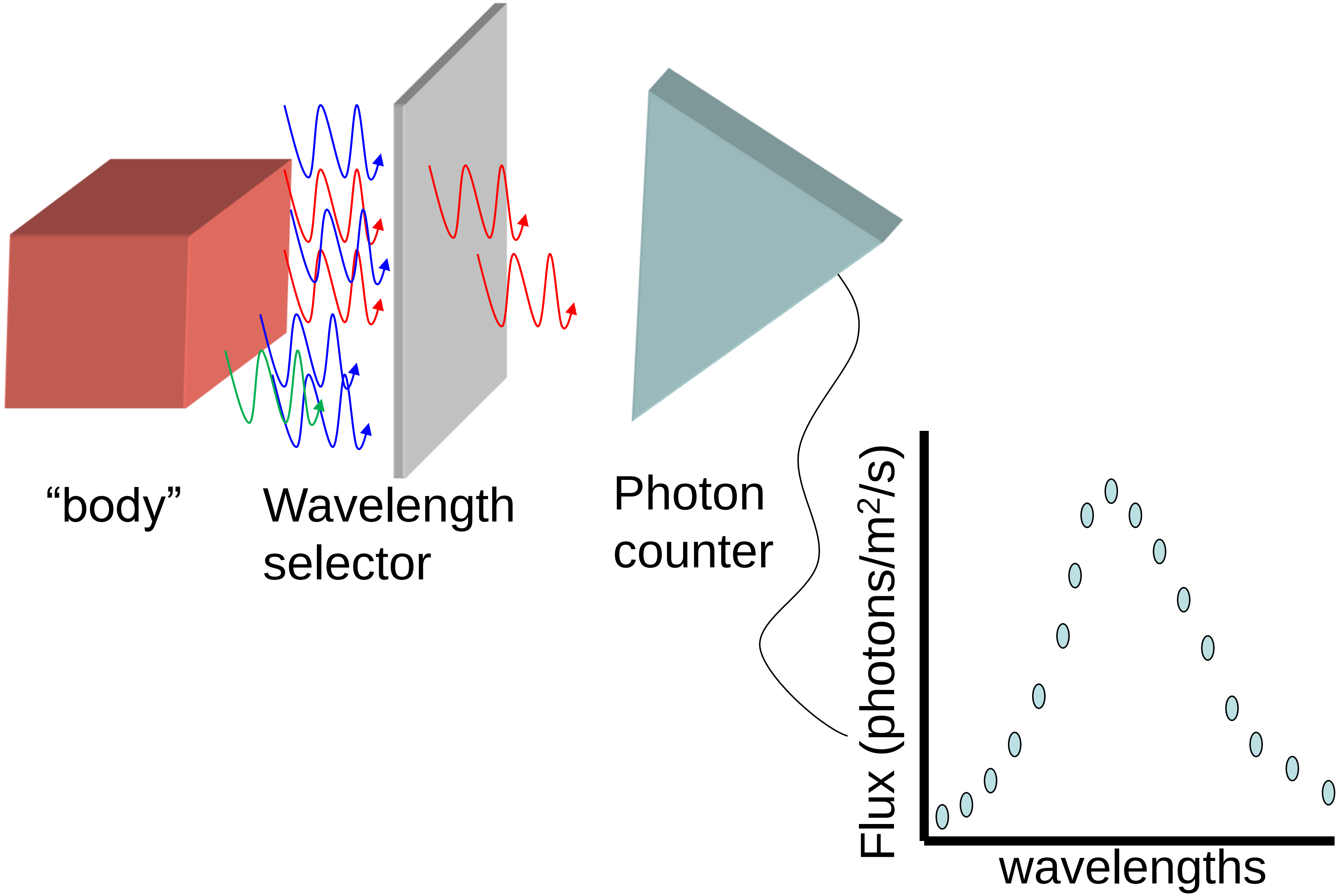
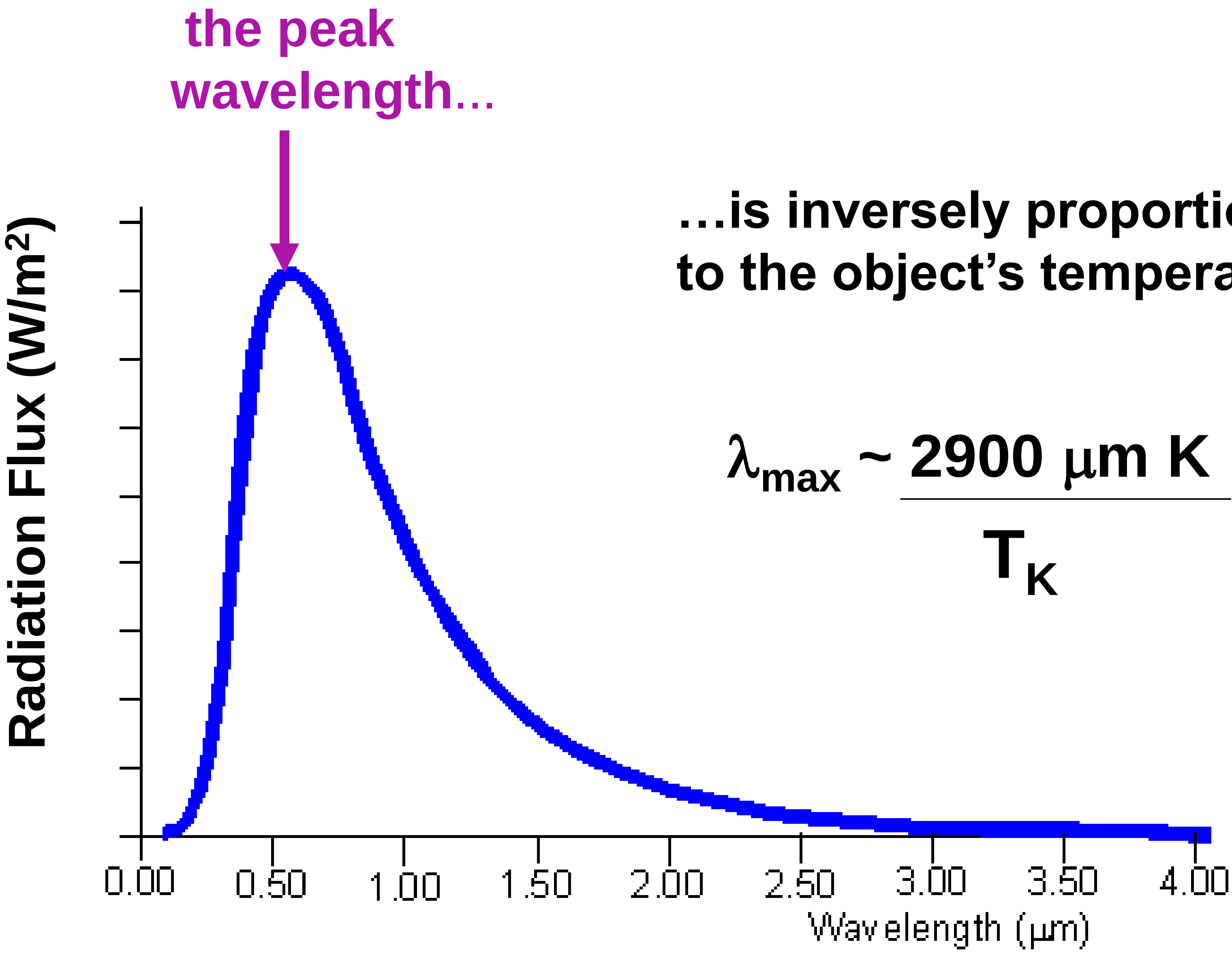
Emission Spectrum: energy distribution



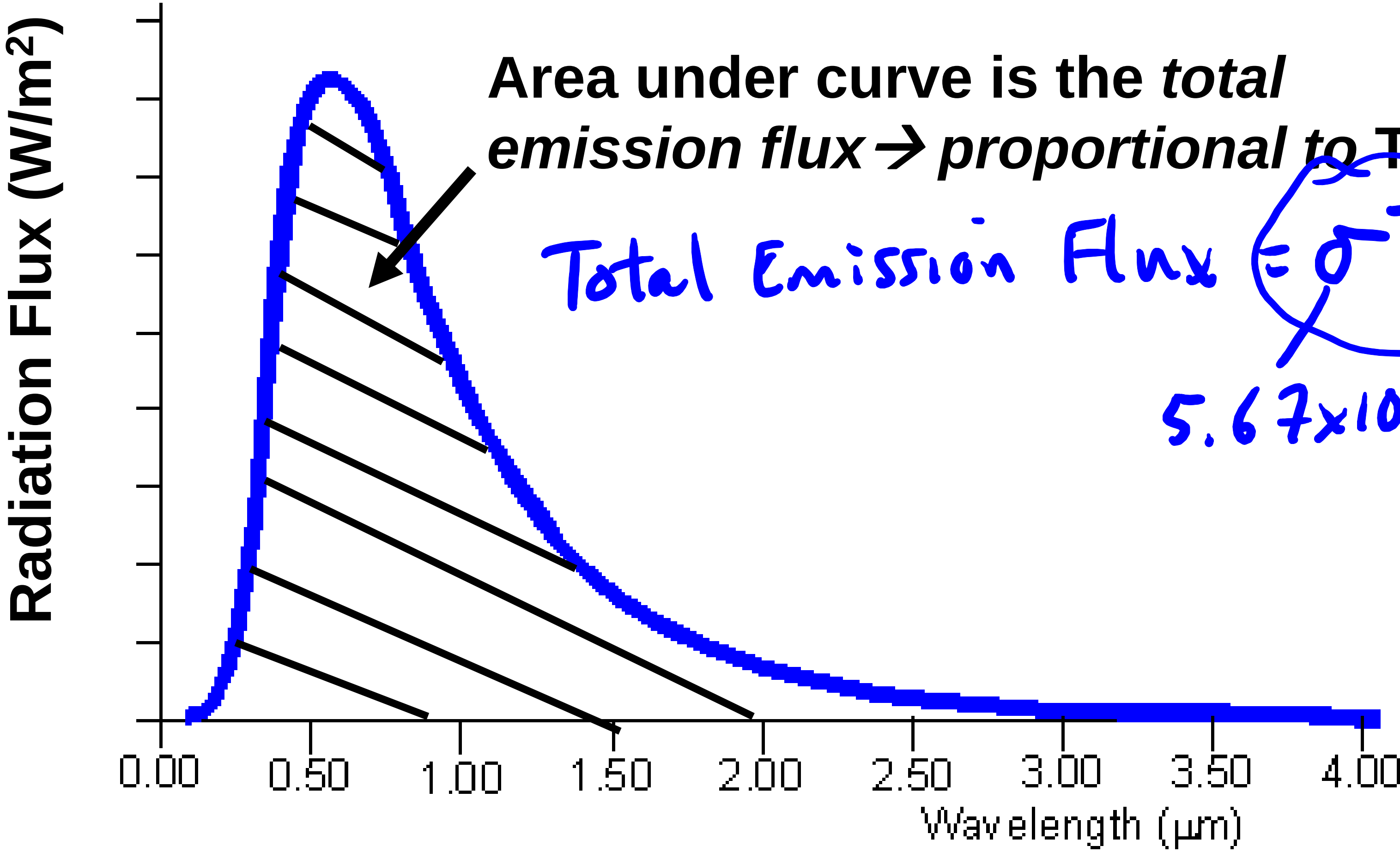
Blackbody Radiation: Wien's Law



…is inversely proportional to the object's temperature

$$\lambda_{max} \sim \frac{2900\ \mu m\ K}{T_K}$$

Blackbody Radiation: Stefan-Boltzmann's Law



Area under curve is the *total emission flux* → *proportional to* T^4

Total Emission Flux $= \sigma T^4$

$\sigma = 5.67 \times 10^{-8} \frac{W}{m^2 K^4}$

The global average temperature of Earth's surface is ~ 15 oC. What wavelength carries the most radiant energy emitted by Earth's surface?

When poll is active, respond at **PollEv.com/thornton211**

Text **THORNTON211** to **22333** once to join

- 0.1 micrometer
- 1 micrometer
- 10 micrometer

Visual settings

Activate

Show results

Show correct

Lock

Clear results

Fullscreen

Next

Previous

Total Results: 0

The sun's emission flux maximizes at a wavelength of ~ 0.5 micrometer. The sun's surface temperature is

Visual settings
Activate
Show results
Show correct
Lock
Clear results
Fullscreen

When poll is active, respond at **PollEv.com/thornton211**
Text **THORNTON211** to **22333** once to join

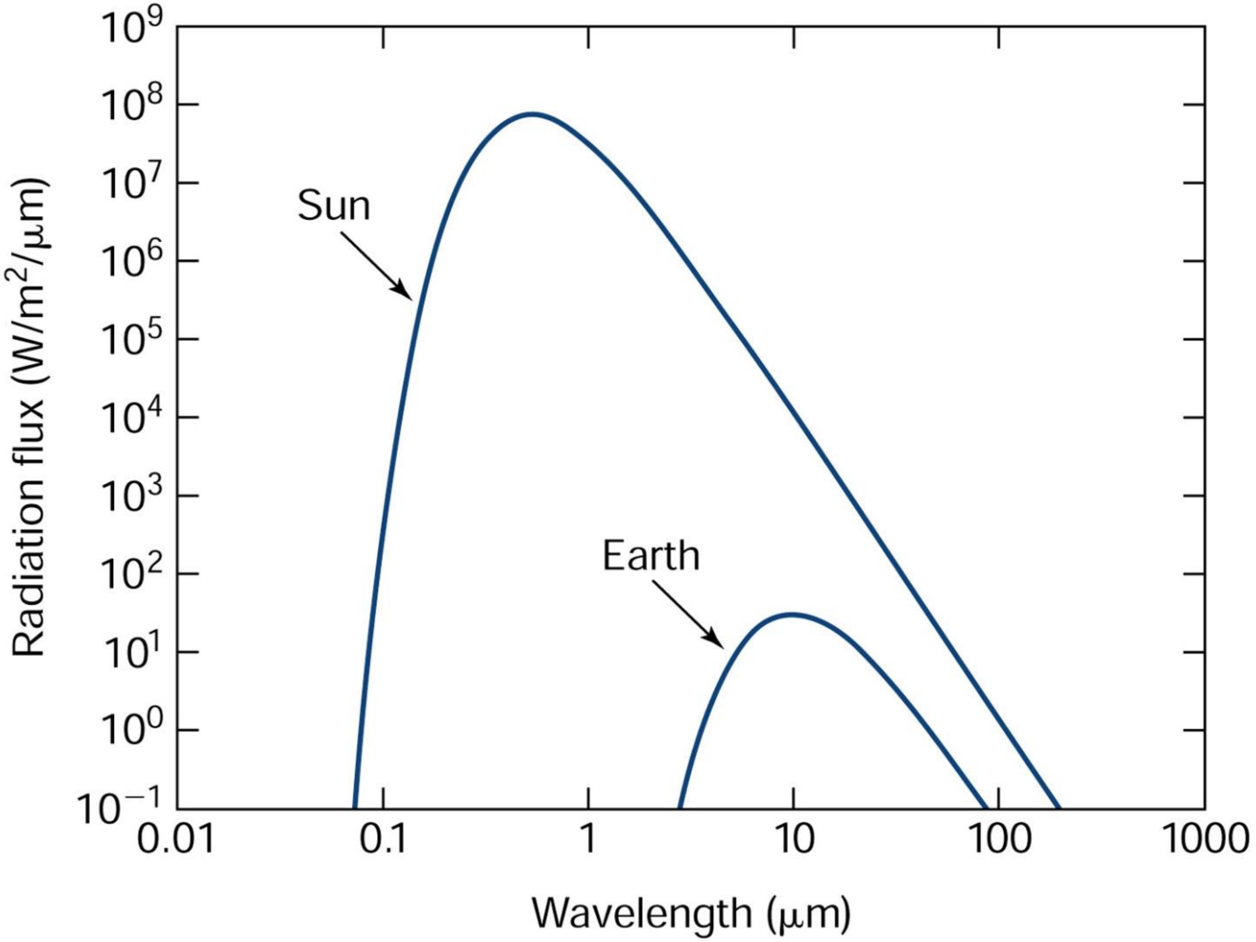
- ~ 1500 K
- ~ 6000 K
- ~ 15,000 K

Next
Previous

Total Results: 0

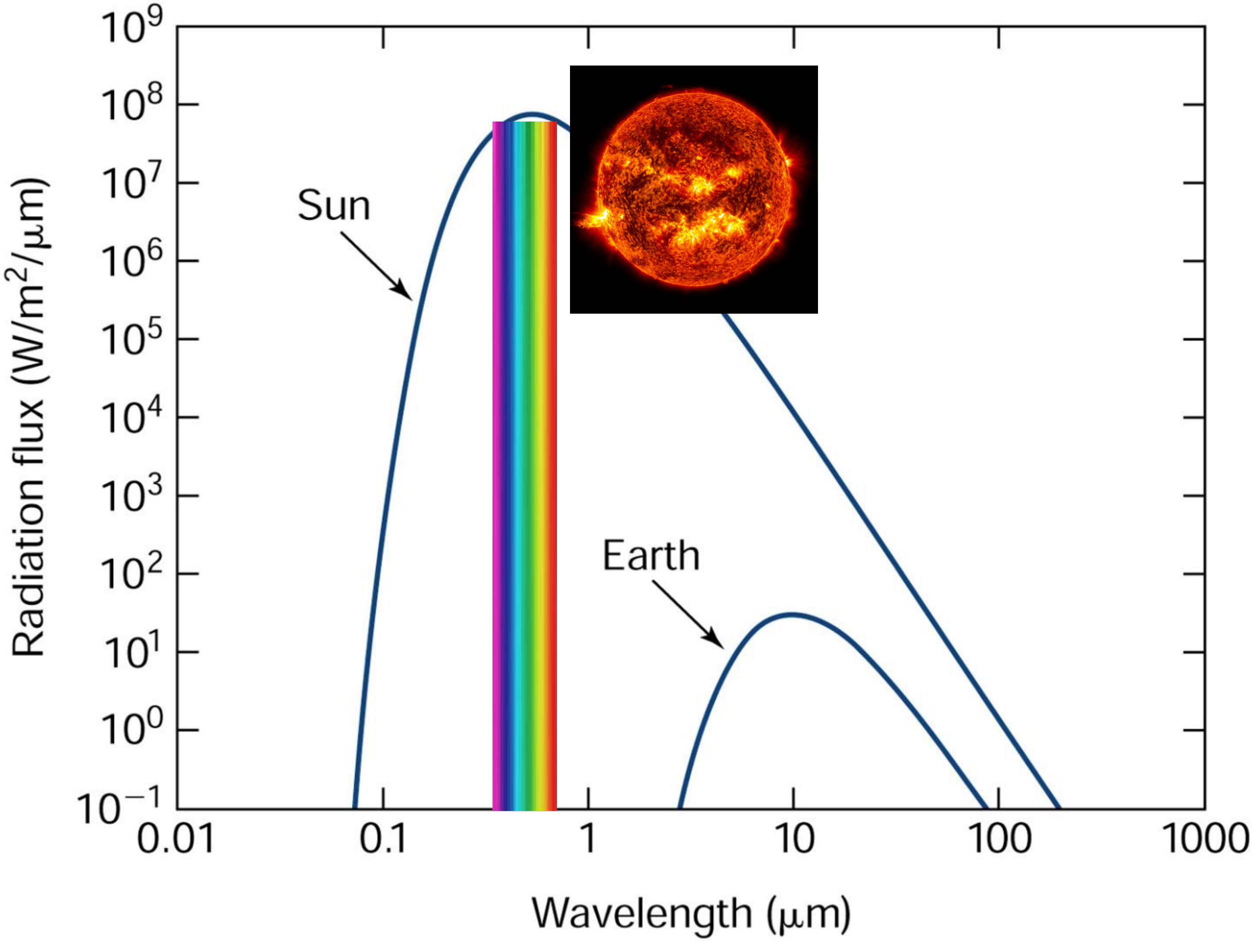
Earth and Solar Emission Spectra

The sun emits about 6.3 X 10^7 W/m^2 of radiant energy

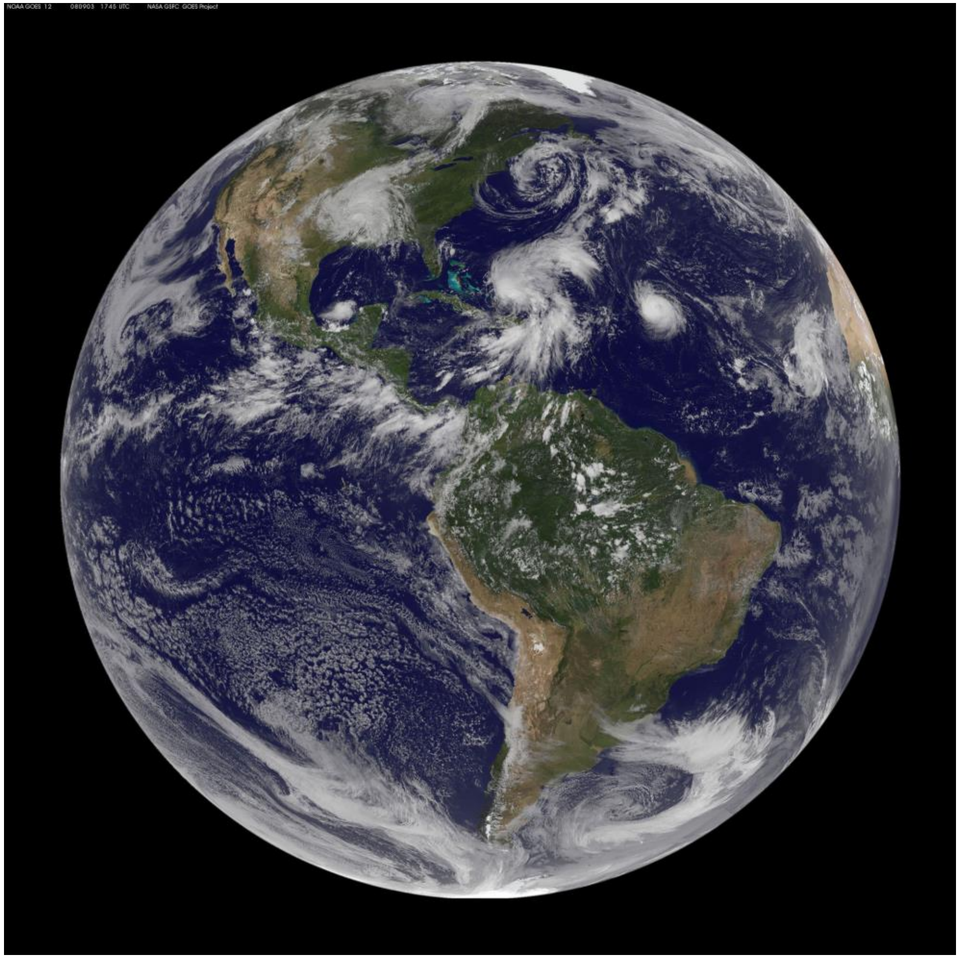


Earth and Solar Emission Spectra

The sun emits about 6.3 X 10^7 W/m^2 of radiant energy



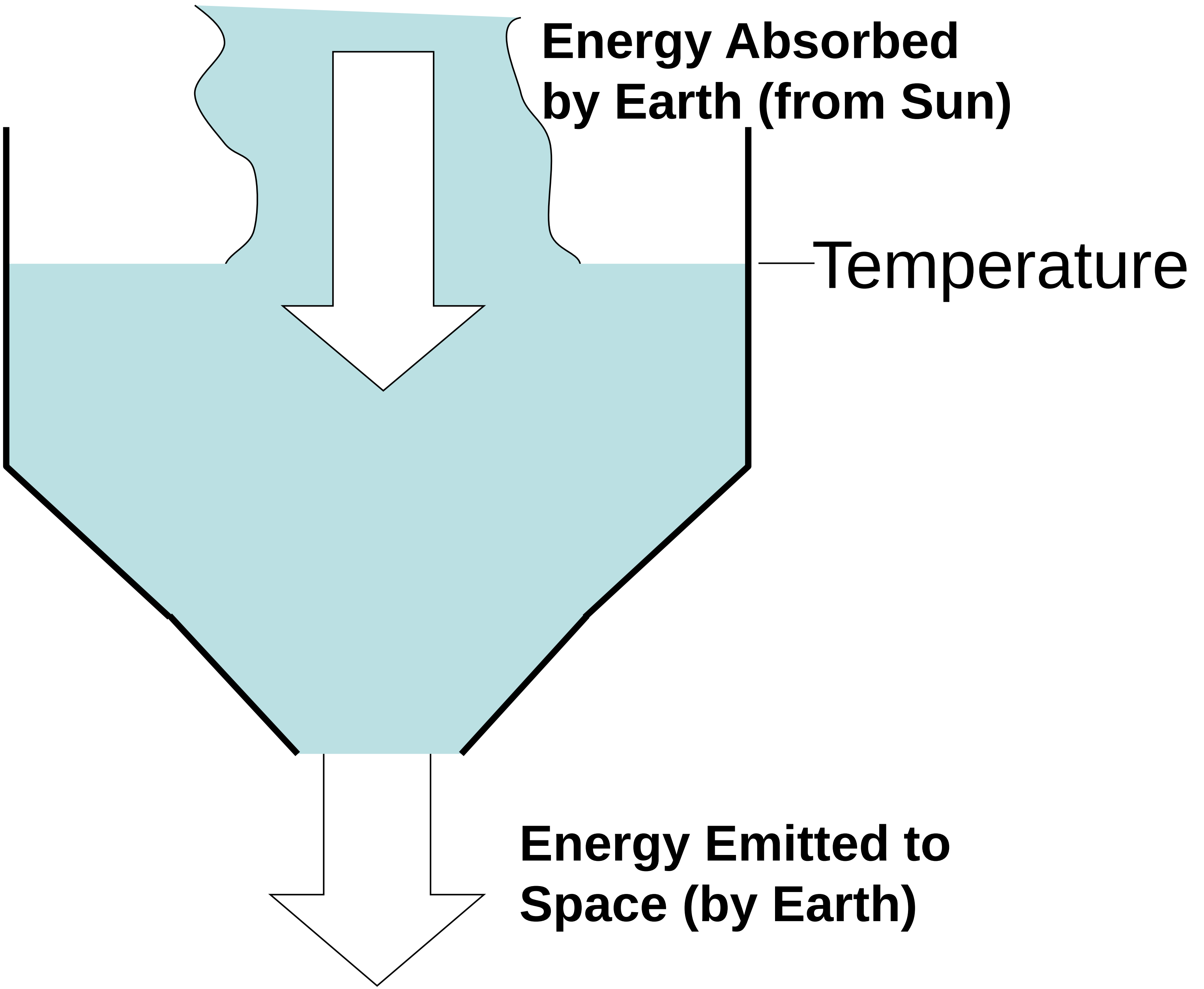
Putting Blackbody Radiation Laws to Work



A first attempt at a global climate model

→Relate Earth's T to incoming and outgoing radiation

An Energy Balance Model of Earth's T



Energy Balance Model: Halfway Done

Energy Flux In = Energy Flux Out

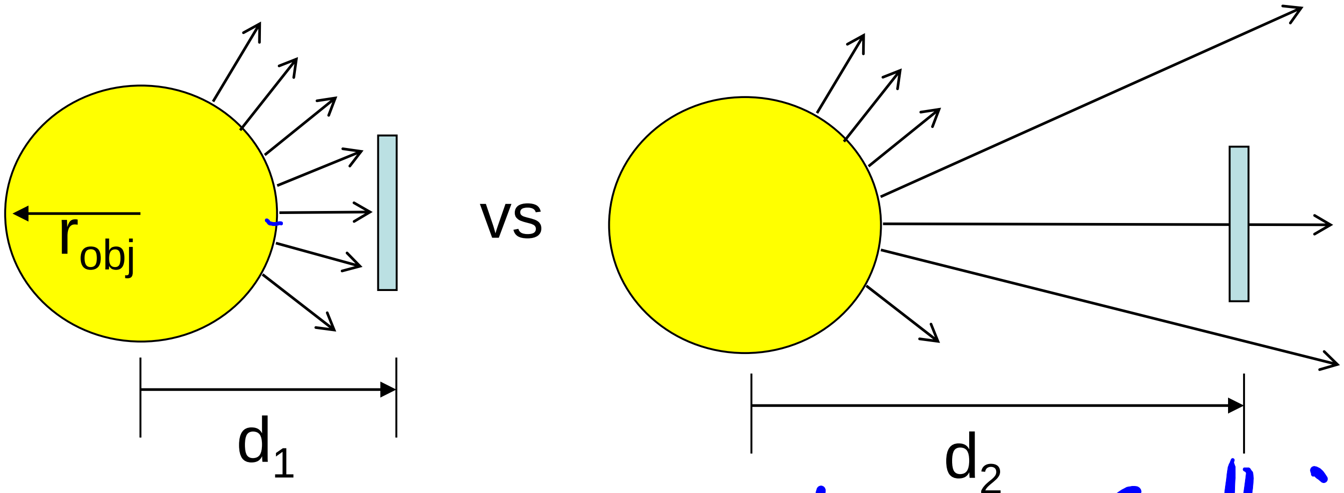
$$F_{in} = F_{out}$$

Assume Earth radiates like a blackbody

Stefan-Boltzmann Law

$$F_{in} = F_{out} = \sigma T^4_{Earth}$$

Radiant Energy Flux Far From Source



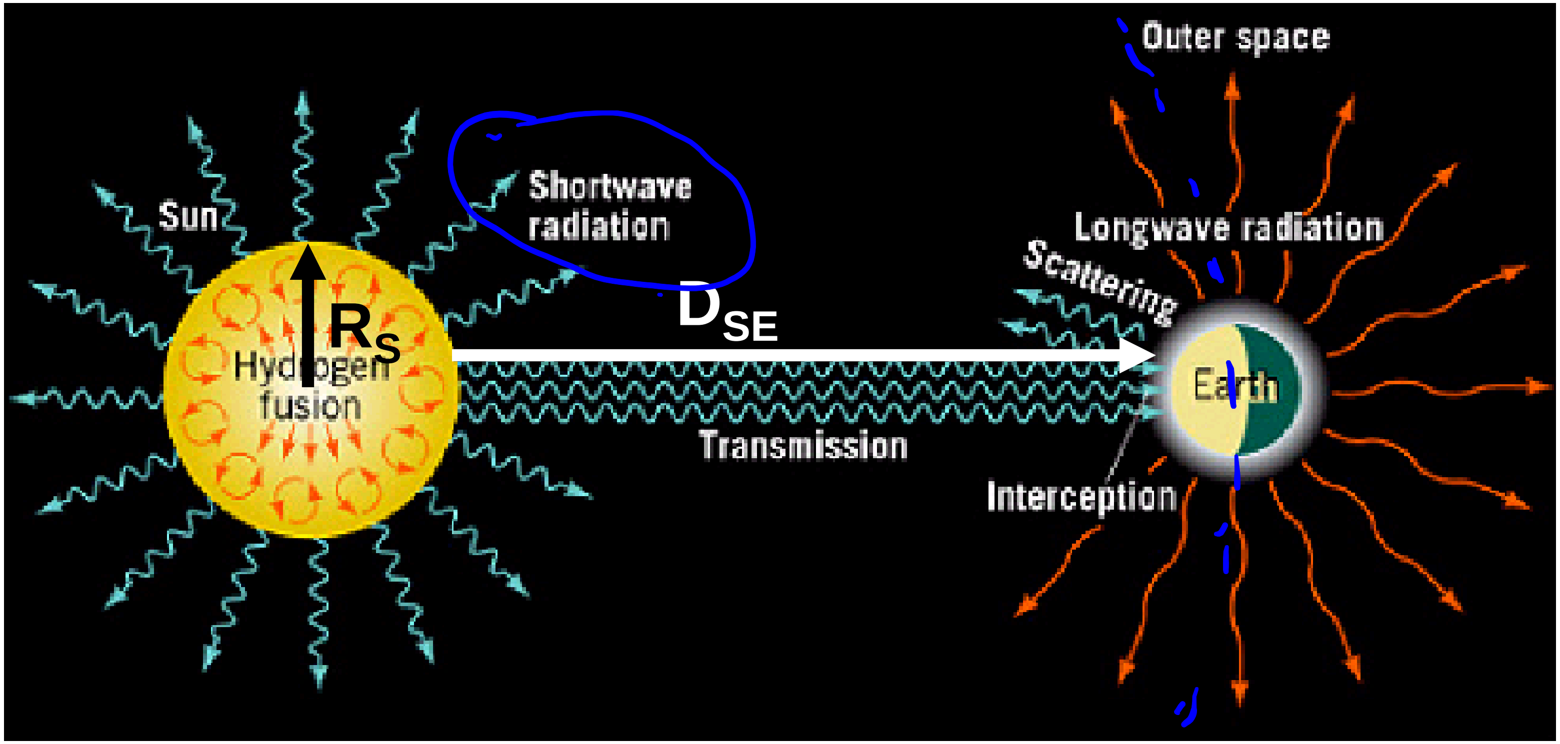
distance Earth is from sun

Radiation flux decreases as *inverse square* of distance from source

$$F_{d_2} = F_{d_1} * \left(\frac{d_1}{d_2} \right)^2$$

Inverse Square Law: Painting Spheres

Earth's Energy Balance: Towards F_{IN}



Need to account for

a) Earth-Sun distance (D_{SE}),
b) Earth intercepts fraction of total solar flux at D_{SE}
c) Earth "reflects" some of the intercepted radiation

↳ Albedo

Both the disc and the sphere have the s radius. Which one will intercept the mo radiation

Visual settings

Activate

Show results

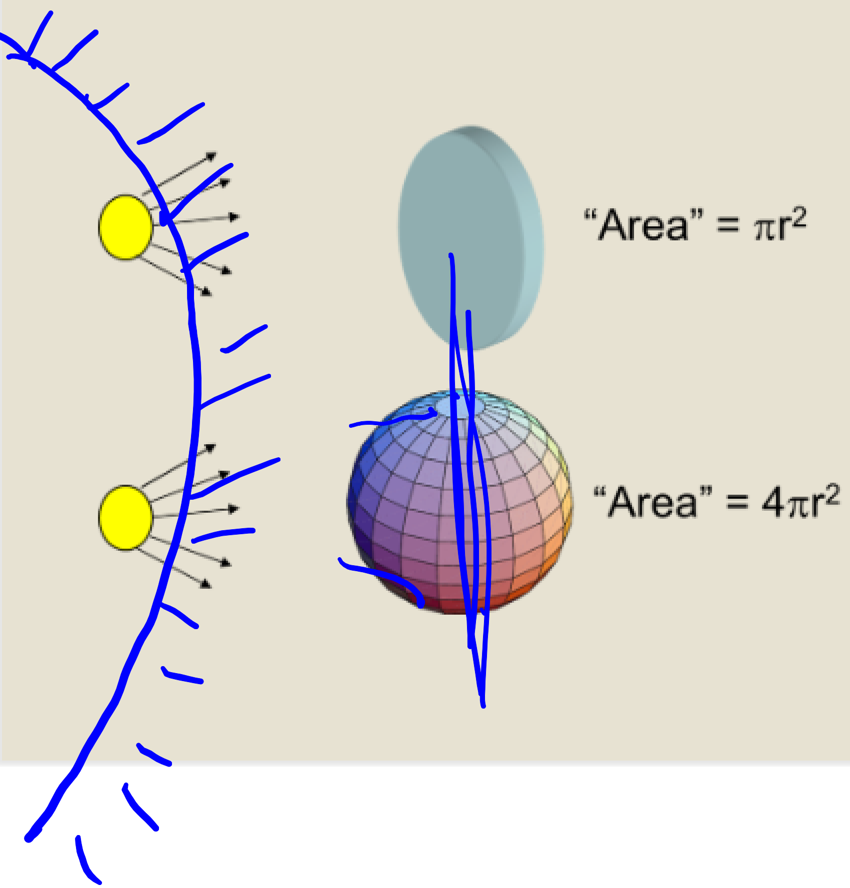
Show correct

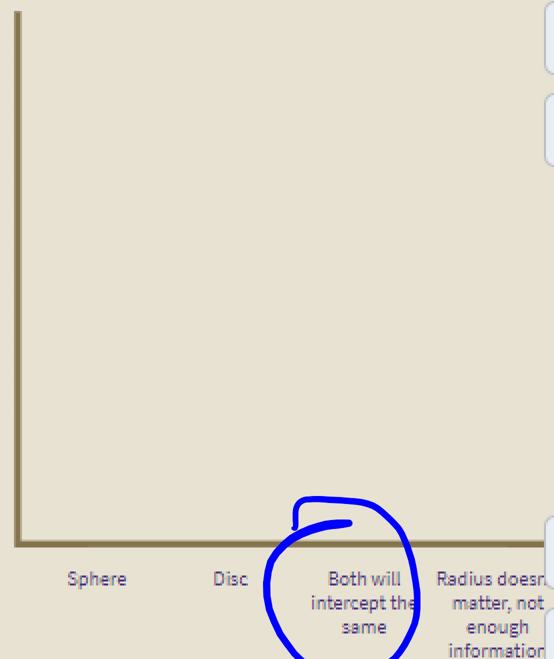
Lock

Clear results

Fullscreen

Poll locked. Responses not accepted.





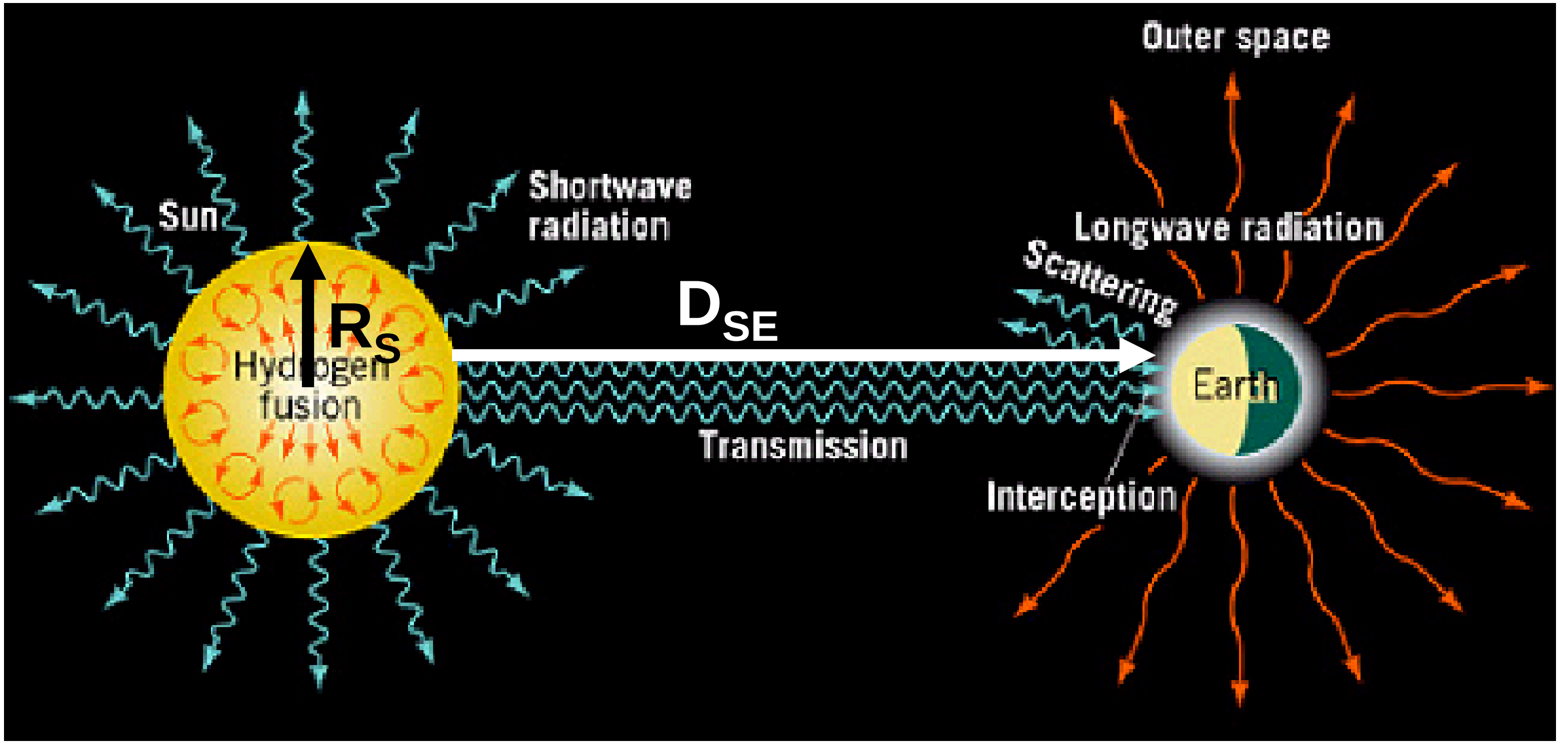
Next

Previous

Total Results: 0

Our own little test

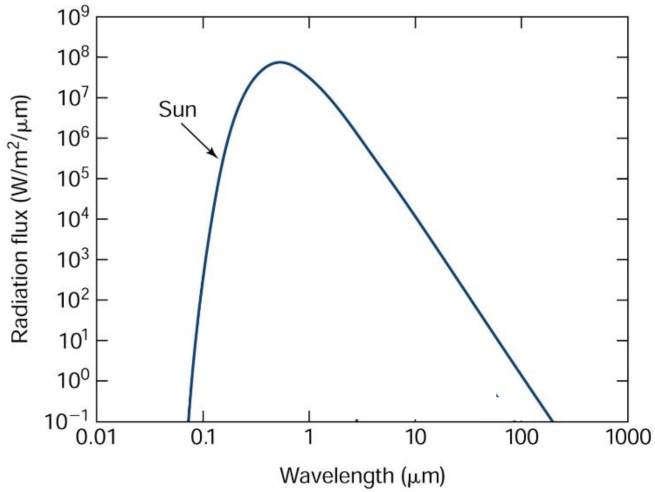
Earth's Energy Balance: Towards F_{IN}



Need to account for

a) Earth-Sun distance (D_{SE}), ***inverse square law***
b) Earth intercepts fraction of total solar flux at D_{SE}
c) Earth "reflects" some solar radiation, **Albedo ("A")**

Solar Constant (not really a constant)



Energy emitted by sun at different wavelengths

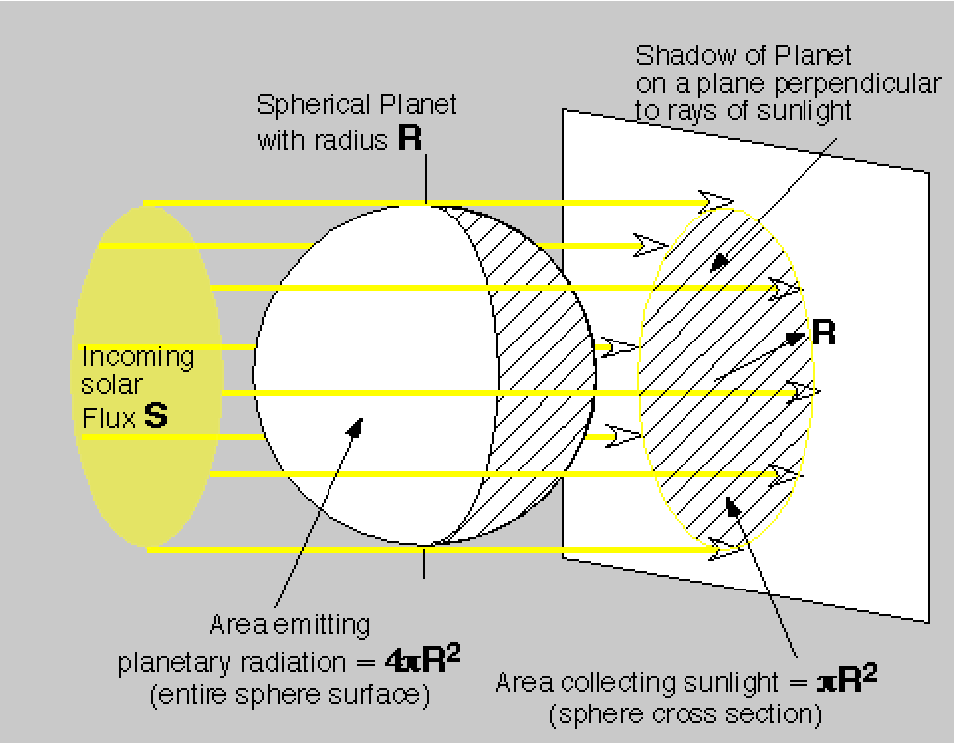
Energy flux from sun at Earth's location (inverse square law)

$$F_s = \sigma T_s^4$$

$$F_s^{0E} = \frac{\sigma T_s^4 \cdot 4\pi R_s^2}{4\pi D_{SE}^2} = \text{solar constant} \Rightarrow S_0 \sim 1370 \frac{W}{m^2}$$

amount of energy reaching location of Earth

Earth's Energy Balance: Earth-Sun Geometry



Sun's energy **collected** by Earth

$S_o \pi R_E^2$

Sun's energy **collected** by Earth, spread over entire Earth area

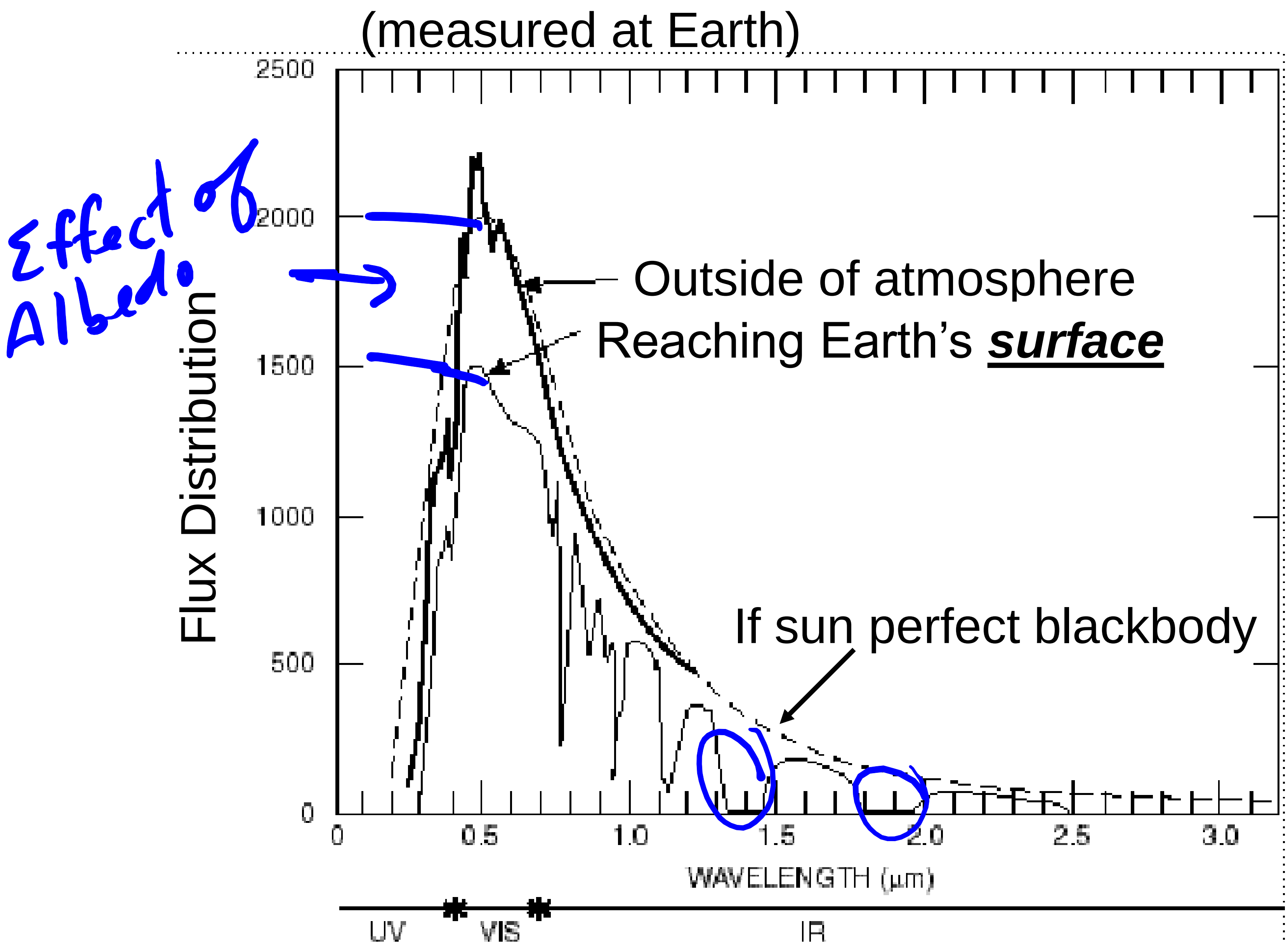
$$\frac{S_o \pi R_E^2}{4\pi R_E^2} = \frac{S_o}{4}$$

Sun's energy **collected and absorbed** by Earth, spread over entire Earth area

Albedo

$$F_{in} = \frac{S_o}{4}(1-A)$$

Solar Radiation Flux at Earth



Earth's Energy Balance—No Atmosphere

$$F_{in} = F_{out}$$

$$\frac{S_o(1-A)}{4} = \sigma T_E^4$$

0.28

$$T_E = \left(\frac{S_o(1-A)}{4\sigma}\right)^{\frac{1}{4}}$$

$\sqrt{}$

$1370 \frac{W}{m^2}$

$5.67 \times 10^{-8} \frac{W}{m^2 K^4}$

Earth's Energy Balance—No Atmosphere

$$F_{in} = F_{out}$$

$$\frac{S_o(1-A)}{4} = \sigma T_E^4$$

Earth's Energy Balance—No Atmosphere

$F_{in} = F_{out}$

$$\frac{S_o(1-A)}{4} = \sigma T_E^4$$

$$T_E = \left[\frac{S_o(1-A)}{4\sigma}\right]^{\frac{1}{4}} = 256\,K$$

$\underline{\text{Earth}}$

Same approach for ANY planet!