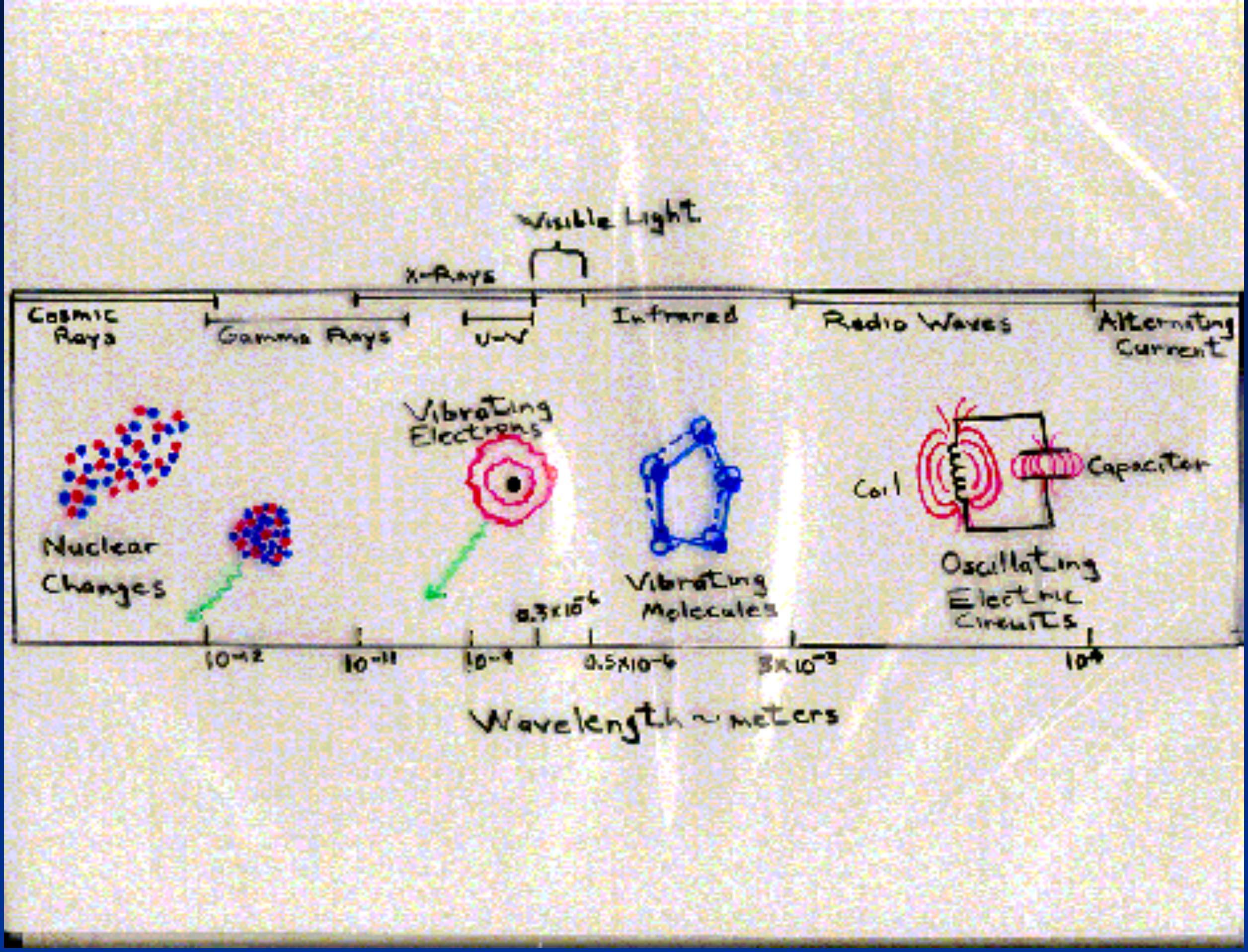
Equilibrium Temperature of the Earth



Electromagnetic Spectrum

Spectrum

Graph of intensity versus wavelength or frequency

Intensity

Energy per unit area per unit time

Unit of intensity is $\frac{J}{m^2 \cdot s}$

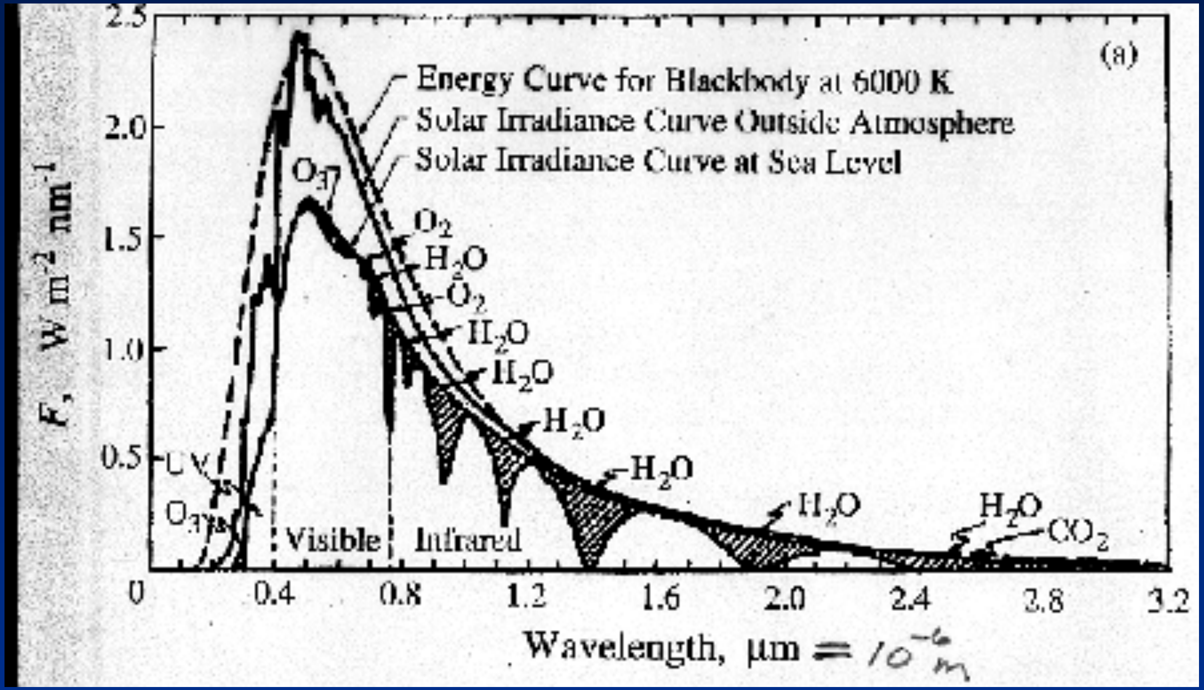
Wave

λ - wavelength

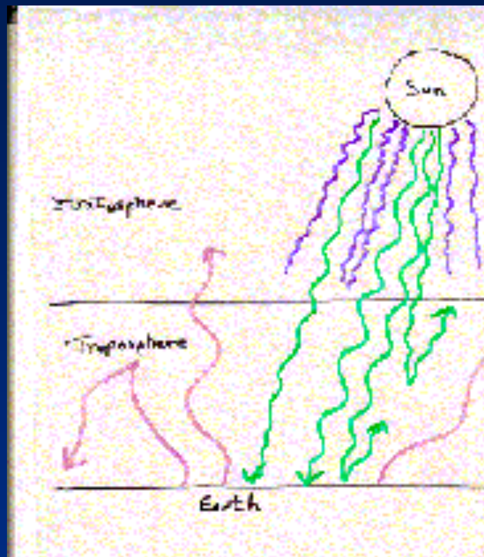
f - cycles/sec

1400 KHz - radio station

1400 KHz = 1,400,000 cycles/sec.



Spectrum of sunlight striking the atmosphere and surface of the Earth



The fraction of light reflected from the surface of the Earth is called the *albedo* of the Earth

Simple Calculation to Determine the Equilibrium Temperature of the Earth

- The intensity from the sun that reaches the outer atmosphere of the earth is called *the solar constant.*
- The solar constant is equal to 1.37 kW/m^2.
- The albedo, a, of the earth is usually taken to be 0.3 which means that 30% of the sunlight is reflected.
- Thus the intensity, Iabs, absorbed by the earth is
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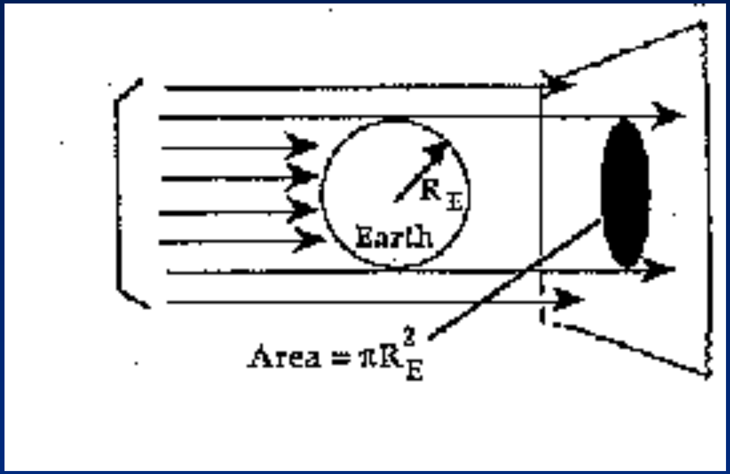
- $I_{abs} = (1-a)1.37 = 0.7 \times 1.37 = 0.959\ kW/m^2$.



The sunlight strikes the earth on just one side as shown.

Thus the total power being absorbed, Pabs, on the earth is Iabs times the area of a circle whose radius is the radius of the earth,

$$Pabs = Iabs(\pi R^2),$$

where R is the radius of the earth.

The amount of power being radiated away, P_{rad}, is

$$P_{rad} = I_{rad} (4\pi R^2),$$

where I_{rad} is the intensity being emitted in units of kW/m^2.

Since there is thermal equilibrium,

$$P_{abs} = P_{rad}$$

or

$$I_{abs} (\pi R^2) = I_{rad} (4\pi R^2).$$

Dividing through by πR^2 yields

$$I_{rad} = I_{abs}/4.$$

The Stefan-Boltzmann law for a blackbody says

$$I_{rad} = \sigma T^4,$$

where T is the temperature of the blackbody and σ is the Stefan-Boltzmann constant ($\sigma = 5.67\times10^{-8}$ $W/m^2 \cdot K^4$).

Substituting yields

$$\sigma T^4 = I_{abs}/4 = 959 \text{ W/m}^2/4 = 240 \text{ W/m}^2$$

Or

$$T = 255 \text{ K} = -18^{o}\text{C}$$