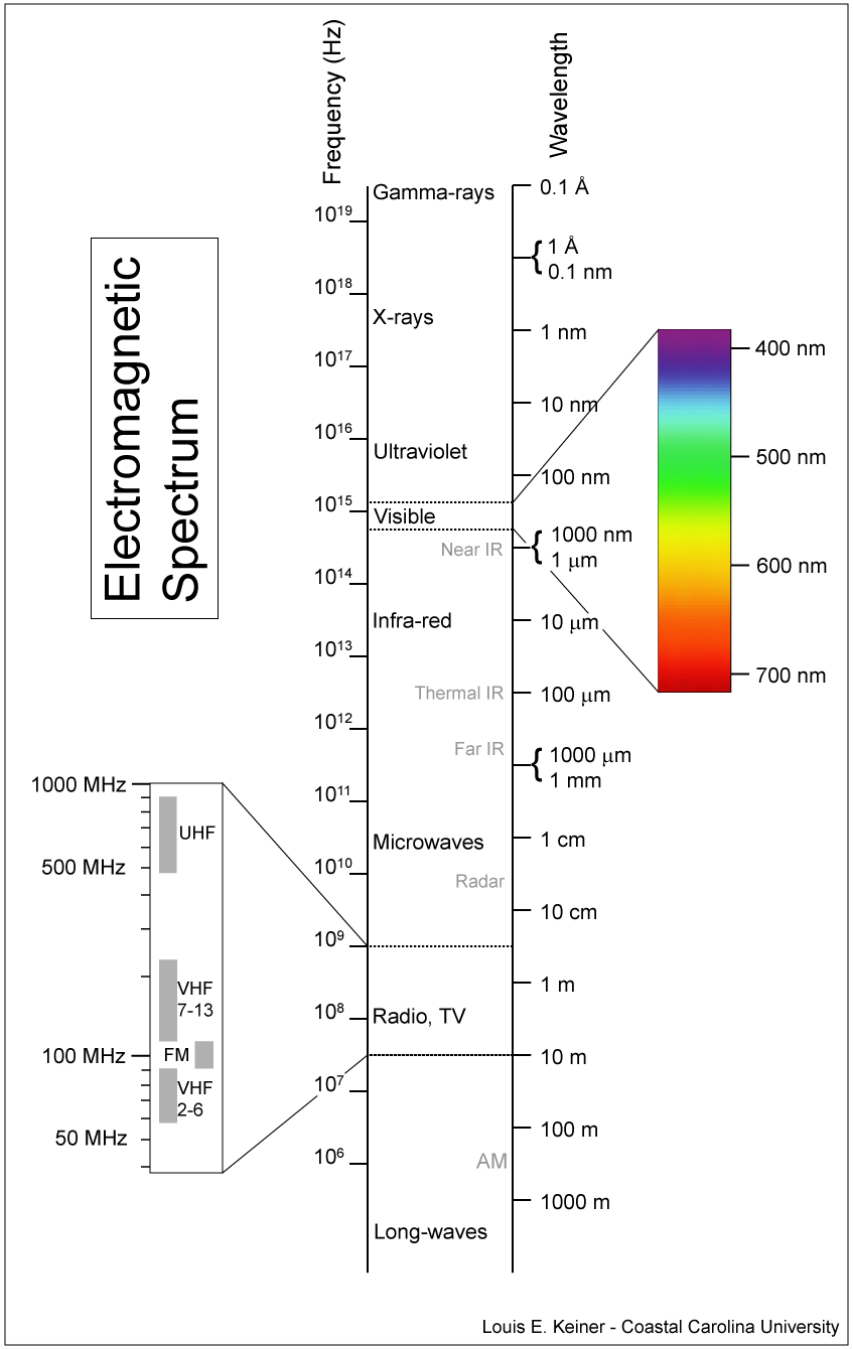
Introduction to Electromagnetic Radiation and Radiative Transfer

Temperature Dice Results



Visible light, infrared (IR), ultraviolet (UV), X-rays, γ-rays, microwaves, and radio are all forms of electromagnetic radiation.

Each type has a different wavelength (λ).

The shorter the wavelength, the greater the energy of individual photons (discrete packets of electromagnetic radiation).

Shortest to longest wavelength: γ-rays, X-rays, UV, visible, IR, microwave, radio

When a photon hits a molecule (gas, liquid, or solid), one of the following events will occur:

- The photon continues in the same direction (transmission)
- The photon goes in a new direction (scattering/reflection)
- The photon is destroyed, and its energy goes to the molecule (absorption)

The individual probabilities for transmission, scattering, or absorption depend on the molecule and the wavelength of the photon

A UV photon hitting a nitrogen molecule will probably be…

A UV photon hitting an ozone molecule will probably be…

A visible photon hitting a nitrogen molecule will probably be…

A visible photon hitting a water molecule will probably be…

An IR photon hitting a nitrogen molecule will probably be…

An IR photon hitting a water molecule will probably be…

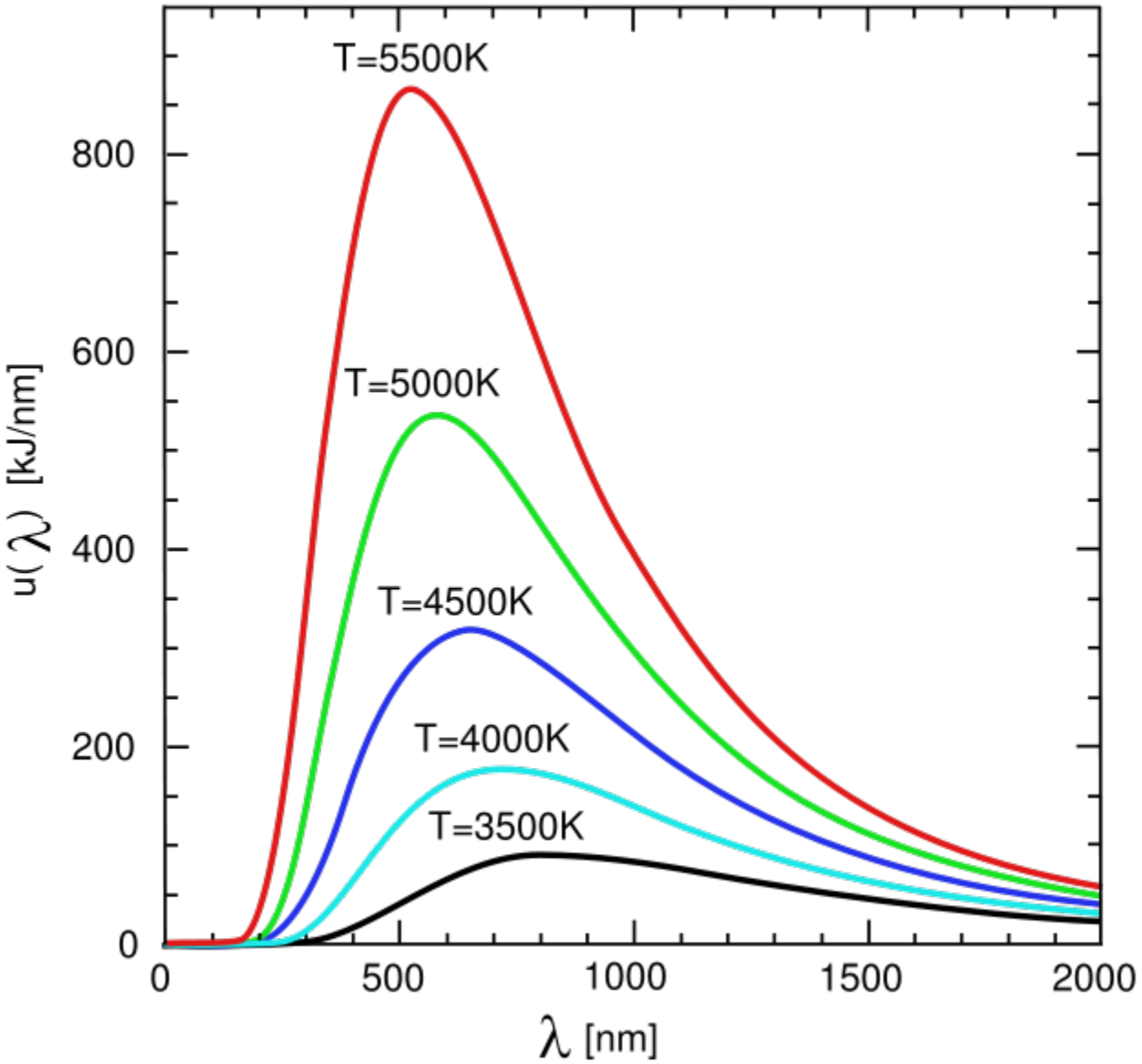
- transmitted?
- scattered?
- absorbed?

Molecules can also emit photons

- Molecules that are good absorbers at a particular wavelength are also good emitters (potentially) at that wavelength
- The probability of emission also depends on the temperature of the molecules

Characteristics of a blackbody:

- A blackbody is a substance with 100% absorption at every wavelength (no transmission or scattering)
- A blackbody emits the maximum amount of radiation possible
- Warm blackbodies emit more radiation than cold blackbodies
- The wavelength with the most emission is shorter for warmer blackbodies



Author: 4C

$F = \sigma T^4$

F = radiation energy flux summed over all wavelengths (units are W m^{-2})

T = temperature (units are K)

σ = 5.67×10^{-8} W m^{-2} K^{-4}

$\lambda_{max} = b / T$

b = 2898 μm K

Approximate the Sun as a blackbody:

- Temperature at surface is about 5800 K
- Using $F = \sigma T^4$, flux at surface is about 6.4×10^7 W m^{-2}

  (This is equivalent to more than 1 million 60W light bulbs every square meter)
- Using $\lambda_{max} = b / T$, what is the wavelength of most emission?

  (b is about 3000 μm K)

Approximate the Sun as a blackbody:

- Temperature at surface is about 5800 K
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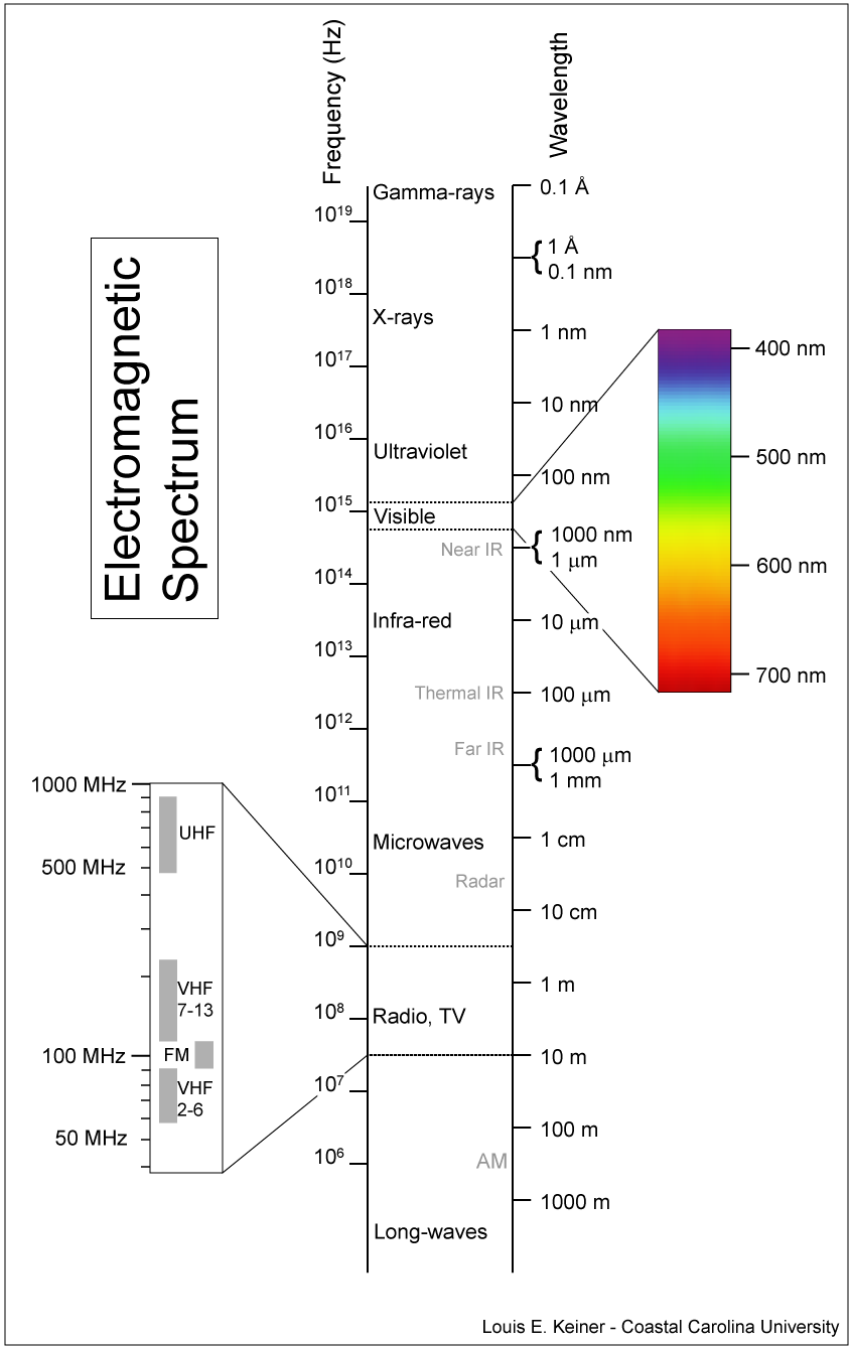
- Using $\lambda_{max} = b / T$, wavelength of most emission is about 0.50 μm

  (This is in the middle of the visible spectrum)


Electromagnetic Spectrum
Frequency (Hz)
Wavelength
Gamma-rays
X-rays
Ultraviolet
Visible
Near IR
Infra-red
Thermal IR
Far IR
Microwaves
Radar
Radio, TV
AM
Long-waves
0.1 Å
1 Å
0.1 nm
1 nm
10 nm
100 nm
1000 nm
1 μm
10 μm
100 μm
1000 μm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1000 m
400 nm
500 nm
600 nm
700 nm
1000 MHz
500 MHz
100 MHz
50 MHz
UHF
VHF 7-13
FM
VHF 2-6
Louis E. Keiner - Coastal Carolina University

1000 nm = 1 μm

Approximate the Earth as a blackbody:

- Temperature at surface is about 288 K
- Using $F = \sigma T^4$, flux at surface is about 390 W m^{-2}

  (This is equivalent to more than four and a half 60W light bulbs every square meter)
- Using $\lambda_{max} = b / T$, what is the wavelength of most emission?

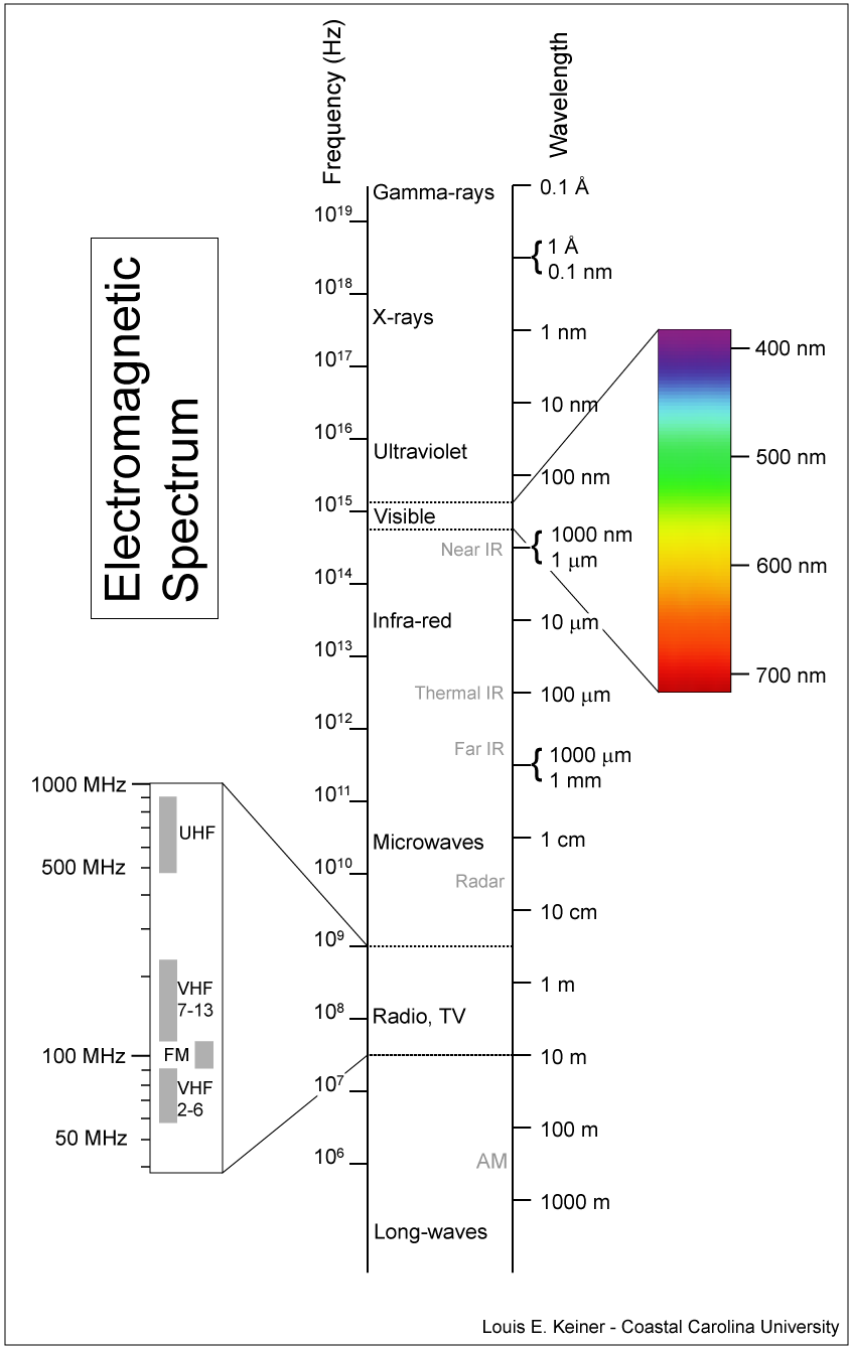
  (b is about 3000 μm K)

Approximate the Earth as a blackbody:

- Temperature at surface is about 288 K
- Using $F = \sigma T^4$, flux at surface is about 390 W m^{-2}

  (This is equivalent to more than four and a half 60W light bulbs every square meter)
- Using $\lambda_{max} = b / T$, wavelength of most emission is about 10 μm

  (This is in the middle of the thermal IR spectrum)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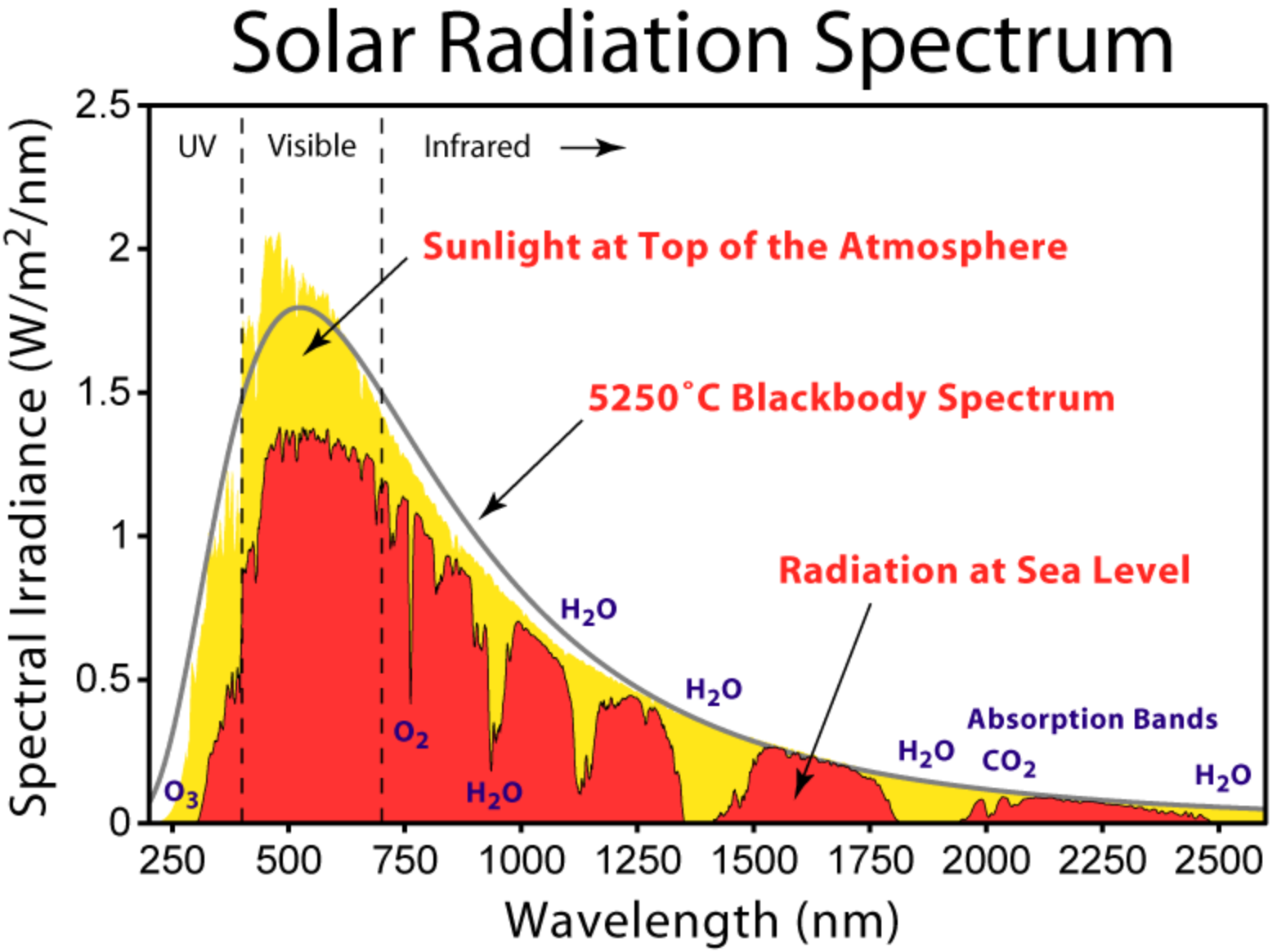
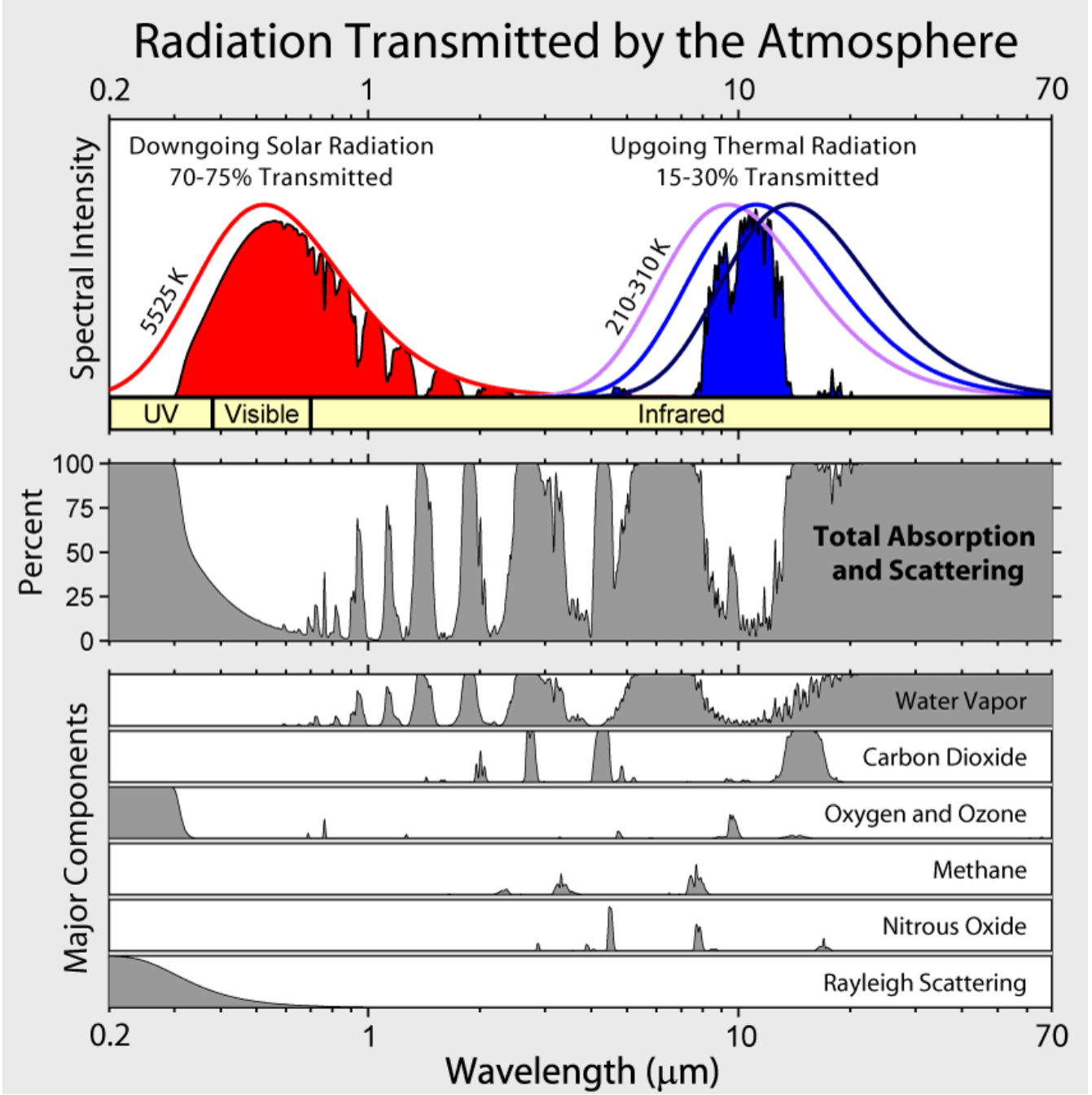


From http://www.globalwarmingart.com



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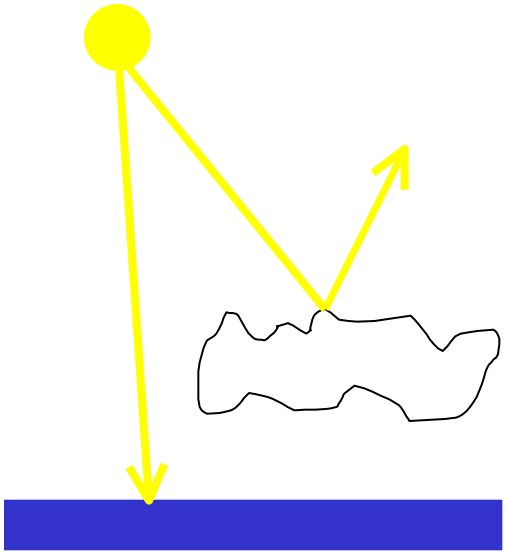
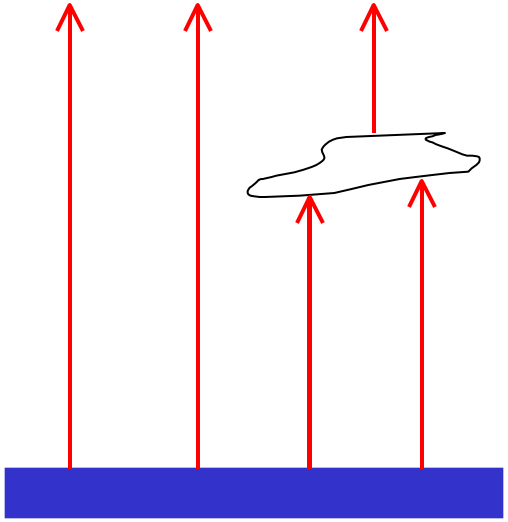
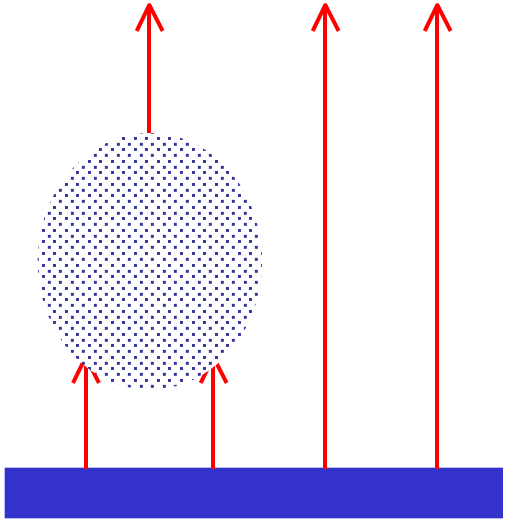


visible



infrared (water vapor window)



infrared (water vapor)

Satellite Images

- Visible (VIS): white indicates large radiation flux, dark indicates small radiation flux
- IR water vapor window (IR): white indicates small radiation flux, dark indicates large radiation flux
- IR Water vapor (WV): white indicates small radiation flux, dark indicates large radiation flux