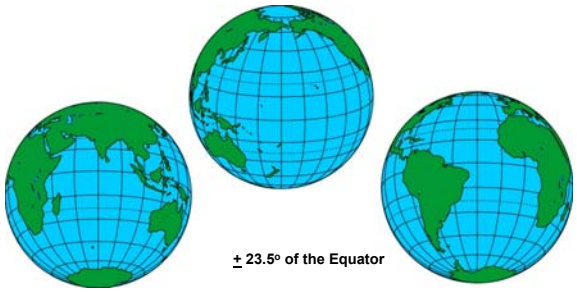
Weather in the Tropics

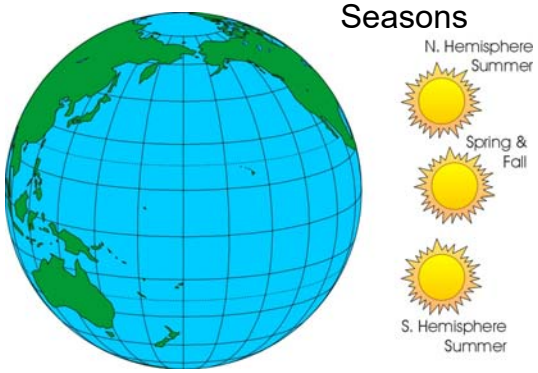
- Temperature does not change much
- Steady wind from the east
- Frequent showers
  - Over the land during the day
  - Over the sea during the night
- "In the Indies, I have always found May-like weather." –Columbus
- But with the occasional hurricane…
- Sunlight, the energy that powers life and weather, reaches the Earth abundantly in the tropics

The tropics are covered primarily by ocean



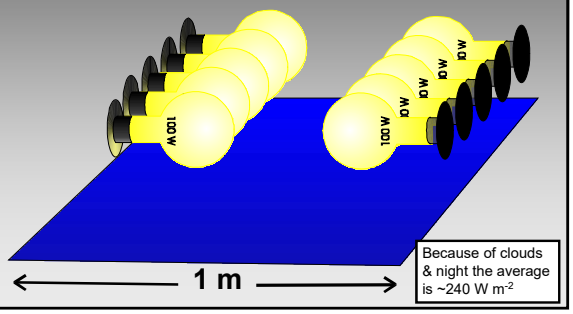
± 23.5° of the Equator

Seasons

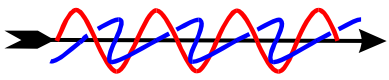


In the tropics the Sun is always nearly overhead at noon

At noon on a cloudless day with the sun directly overhead, solar heating is 1000 Watts per square meter



Electromagnetic Radiation



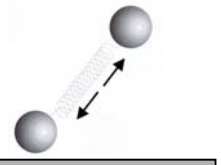
- Oscillating electric and magnetic fields
- Propagates through space at 300,000 km s^{-1} or 300 m (~ 1000 ft) per μs.
- Described by Maxwell's Equations
- Shorter wavelengths carry more energy

More About EM Radiation

- All objects, not at absolute zero, emit EM radiation (Steffan-Boltzman Law)
- Hot objects emit more radiation at shorter wavelengths than cold ones (S-B & Wein's displacement law)
- Wavelength bands
  - Microwave: $\lambda > 1$ mm
  - Infrared (IR): 1 mm > $\lambda > 0.7$ μm
  - Visible: 0.7 μm > $\lambda > 0.4$ μm
  - Ultraviolet (UV): $\lambda < 0.4$ μm
- Sun at 6000 K (5700 °C) emits in the visible band at 0.5 μm (yellow)
- Earth at 288 K (15°C) emits in the IR band at ~10 μm wavelength

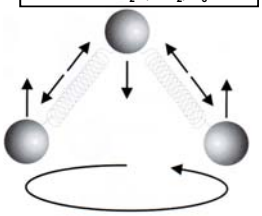
Greenhouse Gasses

Most gasses in the atmosphere have only two atoms: N_2, O_2



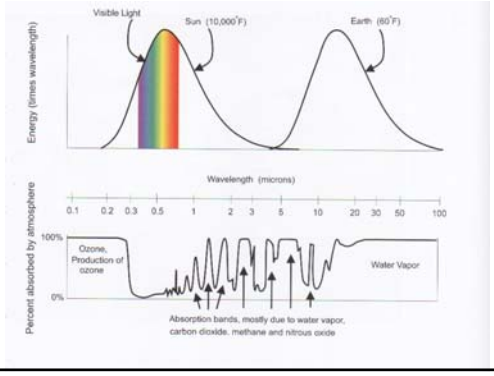
Radiate and absorb inefficiently in IR wavelengths

Many greenhouse gasses have three atoms: H_2O, CO_2, O_3

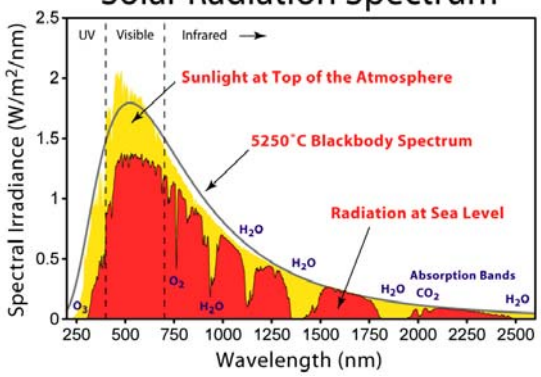


Radiate and absorb efficiently in IR wavelengths

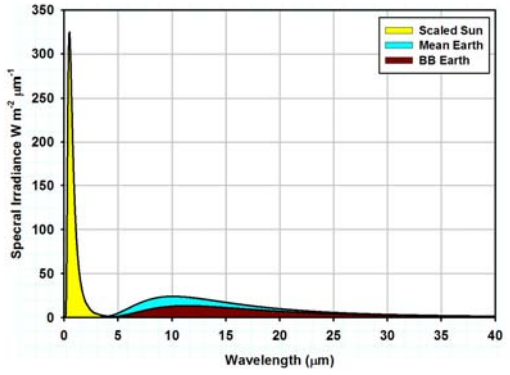
Electromagnetic Spectrum



Solar Radiation Spectrum



How visible & IR distribution really looks

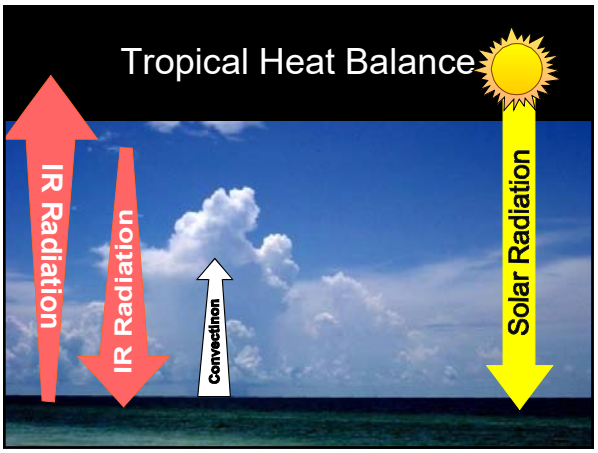


Greenhouse Effect

- A radiative balance between Solar heating and IR cooling *with no atmosphere* predicts an average surface temperature of −18°C
- Actual average temperature is 15°C
- A radiative balance with realistic IR absorption and emission by the atmosphere predicts ~57°C
- Need convection to get the extra heat from the surface into the atmosphere

Surface Heat Balance

- Oceans and vegetated land absorb nearly all of the sunlight that falls on them
- Ice, clouds, and light colored sand reflect sunlight
- Nearly all objects emit or absorb IR radiation with almost 100% efficiency
- Apart from clouds, the atmosphere is nearly transparent to visible EM radiation
- The (tropical) atmosphere is nearly opaque to IR radiation
- Atmosphere radiates back to the surface and to space
- Balance between solar heating and IR cooling determines Earth's temperature



Summary

- Tropical weather
  - Temperatures don't change much
  - Steady winds, mostly from east
  - Frequent showers
- Tropics covered by water, sun nearly overhead
- Solar heating: Max = 1000 W m^{-2},
  - Average = 240 W m^{-2}
- Incoming solar radiation: Visibile 0.4 to 0.7 μm
- Outgoing solar radiation: Infrared 10 μm
- Atmosphere traps IR---Greenhouse effect
- Incoming and outgoing balance wordwide, but
- Excess in tropics
- **MONDAY is Labor Day NO CLASS**
- For next time: Read **Emanuel 34-35, Convection**