Lab 2: Earth’s Radiative Balance
Most of the environmental processes acting near the surface of the Earth derive their energy from exchanges of heat between the Earth and the atmosphere above. Much of this heat comes from radiant energy initially provided by the absorption of solar radiation. The absorbed energy is used to warm the atmosphere, evaporate water, warm the subsurface along with a host of other processes.

Understanding the Earth’s radiative balance is key to studying climate and climate change.

The radiation balance of the Earth system is an accounting of the incoming and outgoing components of radiation. These components are balanced over long time periods and over the Earth as whole. If they weren't, the Earth would be continually cooling or warming.
1. What are waves and radiation?

- A wave is a disturbance that propagates through a transmission medium, usually with transference of energy.
- Radiation is the transmission of energy by means of:
  - Waves
  - Particles

In physics, radiation describes any process in which energy emitted by one body travels through a medium or through space, ultimately to be absorbed by another body.
A. What is the primary source of energy for the climate system?

B. By what heat transfer process does energy get from the sun to Earth?
Major heat transfer processes

- **Radiation**: 

- **Conduction**: is the spontaneous transfer of thermal energy through matter, from a region of higher temperature to a region of lower temperature, and acts to equalize temperature differences.

- **Convection**: refers to the movement of molecules within fluids.

- **Sensible Heat**: is potential energy in the form of thermal energy or heat. The thermal body must have a temperature higher than its surroundings.

- **Latent Heat**: is simply heat released or absorbed by a substance (in this case, water vapor) as it changes its state.
2. Rope Experiment

- **Higher Frequency**
  - Shorter wavelength
- **Lower Frequency**
  - Longer wavelength
on_conceptual_waves.gif

Depicts white light being separated into
different frequency waves.
C. How much energy does it take to maintain a wave with a long wavelength compared to the energy it takes your TA to maintain a wave with a very short wavelength?

D. As wavelength gets smaller, does the energy carried by the wave increase or decrease?

E. As wavelength gets larger, does the energy carried by the wave increase or decrease?

F. IMPORTANT! Why is the rope not really a good representation of energy transfer by radiation?
3. Electromagnetic Spectrum

Electromagnetic radiation is classified into types according to the frequency of the wave, these types include (in order of increasing frequency): radio waves, microwaves, terahertz radiation, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays. Of these, radio waves have the longest wavelengths and Gamma rays have the shortest. A small window of frequencies, called visible spectrum or light, is sensed by the eye of various organisms, with variations of the limits of this narrow spectrum.
Solar Radiation

- **Solar radiation** describes the visible and near-visible (ultraviolet and near-infrared) radiation emitted from the sun. The different regions are described by their wavelength range within the broad band range of 0.20 to 4.0 μm (microns).

- **Terrestrial radiation** is a term used to describe infrared radiation emitted from the atmosphere.
  - **Ultraviolet**: 0.20 - 0.39 μm
  - **Visible**: 0.39 - 0.78 μm
  - **Near-Infrared**: 0.78 - 4.00 μm
  - **Infrared**: 4.00 - 100.00 μm
Light, or visible light, is electromagnetic radiation of a wavelength that is visible to the human eye (about 400–700 nm).
G. Do all objects emit all types of radiation?

H. Why do some objects emit more radiation than others?
4. Amount of radiation emitted by the sun and the Earth

![Graph showing the amount of radiation emitted as a function of wavelength.]

- **Sun**: ~6000K
- **Earth**: ~300K
L. The vast majority of objects emit at least SOME radiation. What is the defining characteristic of an object that does NOT emit ANY radiation?

M. Do you think this sort of object exists in our climate system? Why or why not?
At absolute zero all molecular motion does not cease but does not have enough energy for transference to other systems.
5. Colored Filters

- Color Filter---colored glass, dyed gelatin, etc., used to produce certain color or light effects

http://www.geo.utexas.edu/courses/302c/Labs.html
O. Why are the filters analogous to greenhouse gases?

P. How are the filters unlike greenhouse gases?
Absorption

Nitrous oxide

Methane

Oxygen & Ozone

Water vapor

Carbon dioxide

Total atmosphere

wavelength
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The Greenhouse Effect

Some solar radiation is reflected by the Earth and the atmosphere.

Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.

Solar radiation passes through the clear atmosphere

Most radiation is absorbed by the Earth's surface and warms it.

Infrared radiation is emitted from the Earth's surface.
Global Warming