Lab 2
GEO 302C
Week of _____

Bring a printed copy of this lab to your lab section. We will answer the lettered questions in class.

Goal for today: Be able to understand the greenhouse effect sufficiently well to provide a scientifically based explanation of the greenhouse effect to a layperson.

What are waves and radiation?

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?

Your fearless TA will use a rope to demonstrate the difference between higher-energy and lower-energy waves.

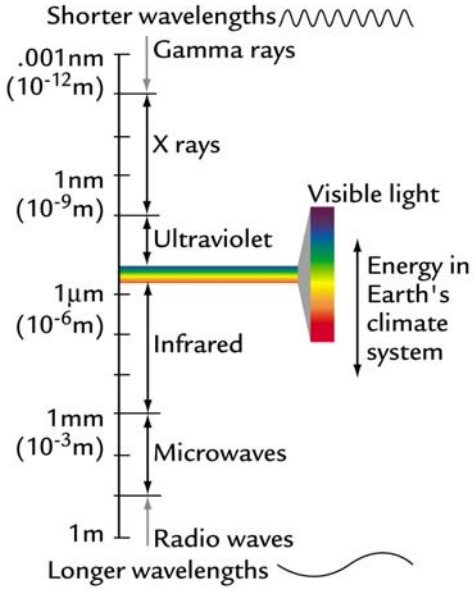
C. How much energy does it take your [fearless] TA to maintain a wave with a long wavelength compared to the energy it takes your TA to maintain a wave with a very short wavelength?

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?*

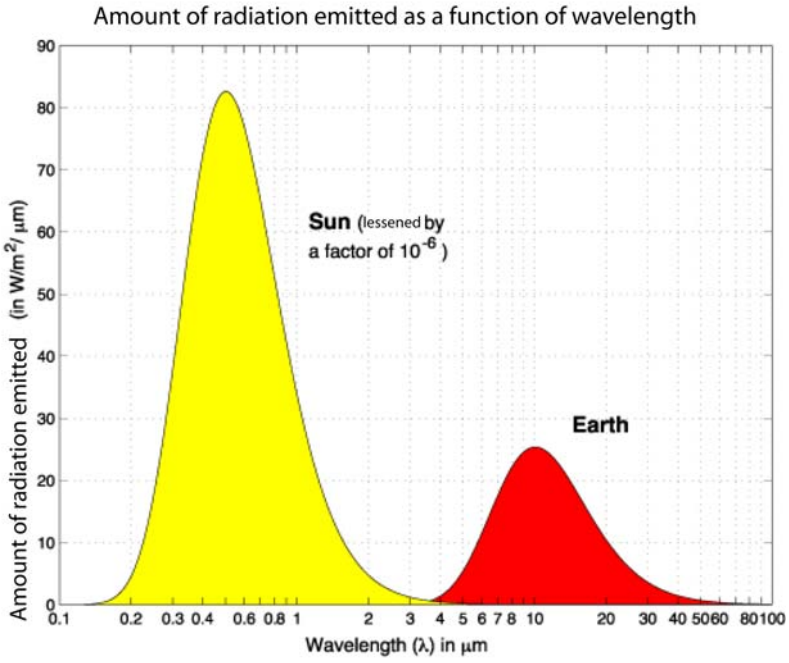
Here is a diagram of the electromagnetic spectrum (from Ruddiman)



G. Do all objects emit all types of radiation?

H. Why do some objects emit more radiation than others?

Here's a diagram of the amount of radiation emitted by the sun and the Earth as a function of wavelength.



I.1 Label the above diagram with the approximate surface temperature of the Earth.

I.2 Label the above diagram with the approximate surface temperature of the Sun.

J.1 What is the approximate peak intensity of radiation emitted by the Earth?

J.2 What is the approximate peak intensity of radiation emitted by the Sun?

K. As the temperature of an object increases, how does the peak intensity of radiation that it emits change?

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?

All matter both emits and absorbs radiation. Because we're looking at the absorption properties of Earths' atmosphere, we're interested in what sort of radiation that different gases absorb. Because different gases have different molecular structure, each type of gas absorbs a different wavelength of radiation. Knowing that different gases absorb different wavelengths of radiation is key to understanding why the presence of greenhouse gases in the atmosphere increases the surface of the Earth.

Your TA will show a video to demonstrate the effects of colored filters.

N. Define "filter."

O. Why are the filters analogous to greenhouse gases?

P. How are the filters unlike *greenhouse gases?*

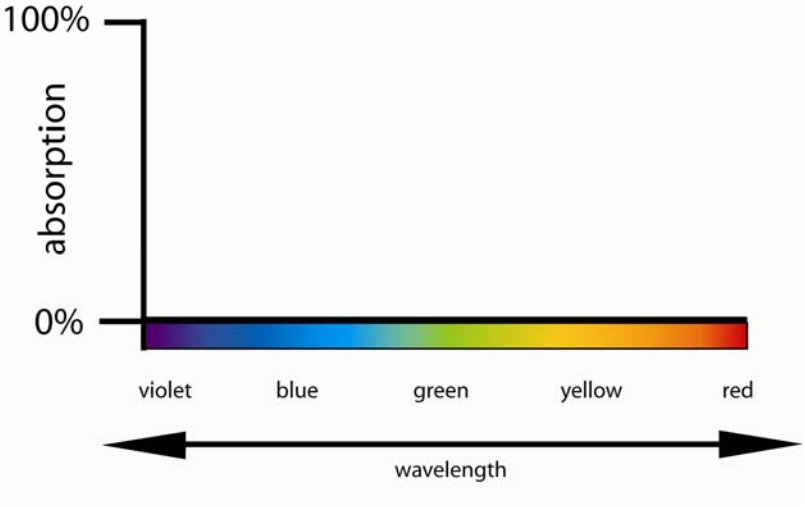
Several lines below are two partial absorption spectrums.

Q. What type of radiation is shown on the horizontal axis?

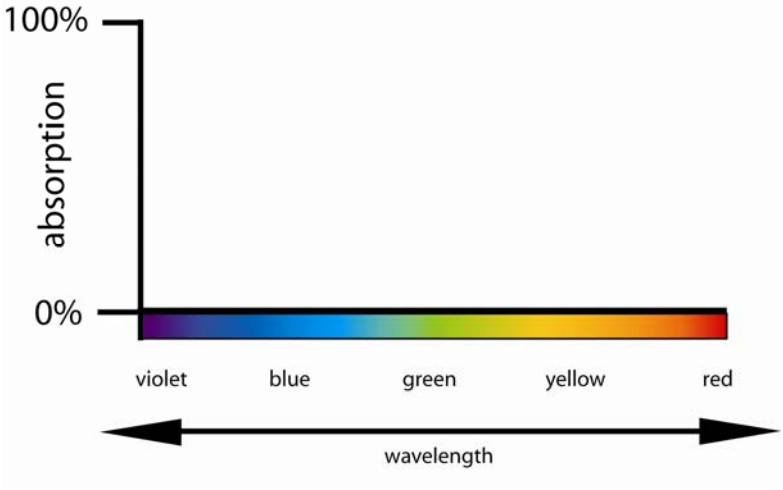
R. Is the radiation shown on the horizontal axis generally considered shortwave or longwave radiation?

S. For both spectrums, label one end of the wavelength axis "increasing" and the other "decreasing"

T. Sketch the absorption spectrum for the blue filter.



U. Sketch the absorption spectrum for the red filter:



V. IMPORTANT!! *Why are the two absorption spectrums that we just sketched incomplete? (What's missing?)*

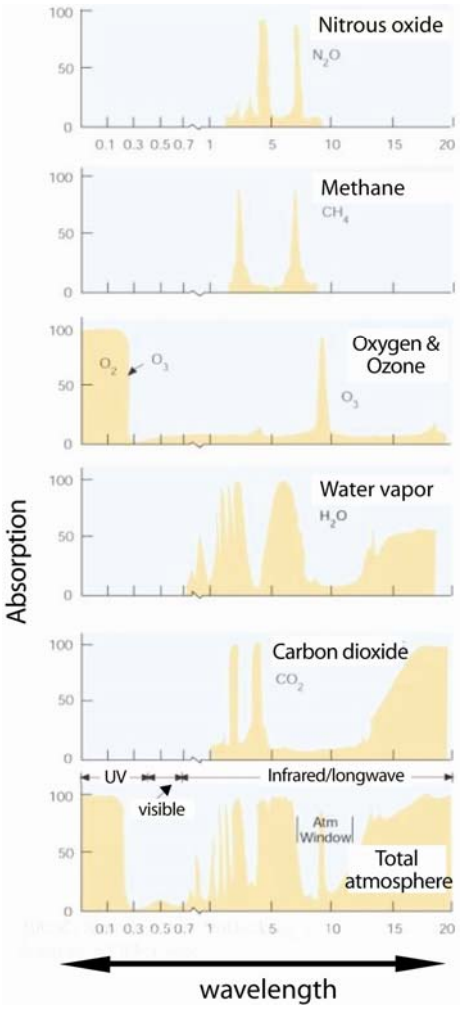
W. If you shine red light through the blue filter, what do you see? Why?

X. When you shine red light through the blue filter, what happens to the red light (where does it go?)

Y. Why can we not see gases in the atmosphere? (Answer in terms of how atmospheric gases interact with visible light.)

Now let's take a look at the absorption spectrums that were presented in lecture.

Z. Label the ends of the wavelength axis at the bottom with "increasing" and "decreasing". Also label the wavelength axis with "higher energy radiation" and "lower energy radiation"



AA. Which of the gases above absorbs ultraviolet (UV) light?

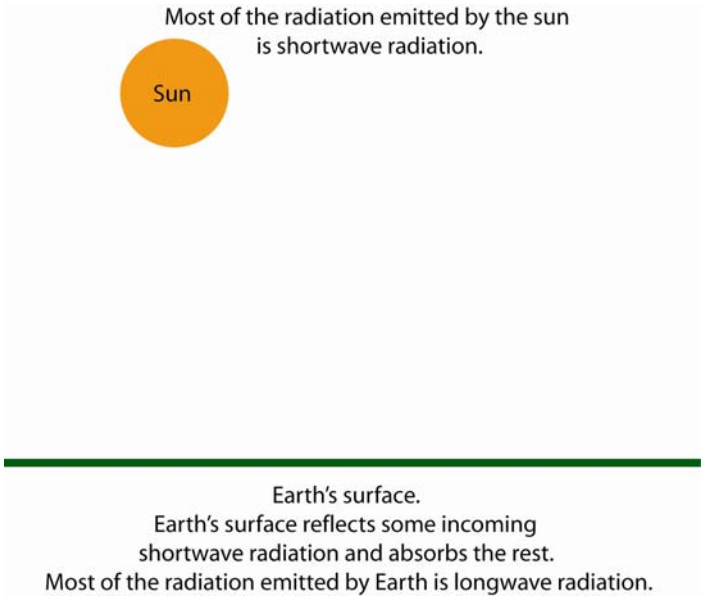
BB. What gas(es) absorb(s) radiation that has a wavelength of 5 micrometers?

CC. On the above graph, label the wavelength range of the emission of radiation from the sun. Do the same for the Earth.

DD. Why can we not see gases in the atmosphere? (Answer in terms of how atmospheric gases absorb/don't absorb visible light.)

Now let's synthesize what we've learned about radiation, temperature, and absorption properties of gases.

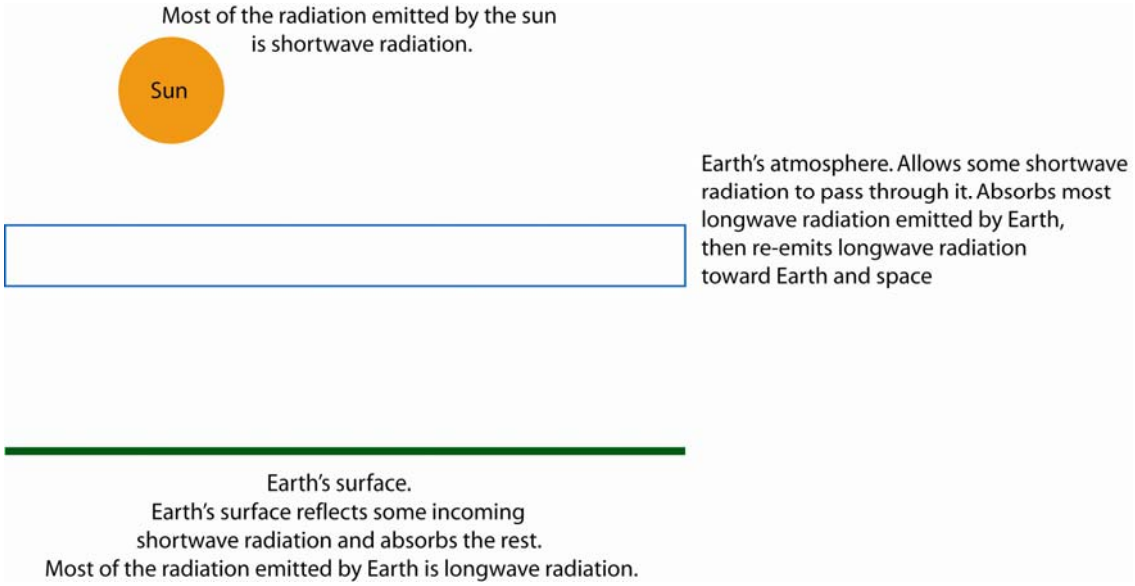
First let's look at a hypothetical Earth with no atmosphere. Here's a diagram.



EE. Add (and label) arrows to the following diagram that represent

- *Incoming solar radiation*
- *Reflected solar radiation*
- *Emitted radiation from Earth.*

Now let's consider a more realistic model of Earth. Here's a diagram that includes the atmosphere:



FF. To the diagram of Earth with an atmosphere, add and label arrows that represent the following list of items. For the sake of simplicity, assume that the atmosphere is COMPLETELY transparent to solar radiation (do you think this is a reasonable assumption?)

- *Incoming solar radiation*
- *Reflected solar radiation*
- *Emitted radiation from the Earth*
- *Emitted radiation from the atmosphere.*

GG. Assuming that the amount of incoming solar radiation (the input to the system) is equal in both diagrams above, what can you say about the amount of radiation hitting the Earth in the system without an atmosphere compared to the amount of radiation hitting Earth in the system with an atmosphere?

HH. Why does the atmosphere absorb longwave radiation?

II. Why do you think that the vast majority of the scientific community believes that increasing the amount of greenhouse gases in the atmosphere will increase the surface temperature of the Earth?

Lab 2 Homework
GEO 302C
Week of Feb, 2, 2009

This lab homework is due to your TA in your section, at the start of your section, the week of February, 9, 2009. Lab homework turned in after the due time will be considered late.

Your name:
Your EID:

Warm up True and False questions (You can check out Lecture 3 slides or http://en.wikipedia.org)

1. (2 points) An object's temperature controls the amount of radiation that it emits (True or False)

2. (2 points) The sun emits exclusively shortwave radiation (True or False)

3. (2 points) The most common gas in the atmosphere is nitrogen (True or False)

4. (2 points) Nitrogen is a greenhouse gas (True or False)

5. (2 points) The atmosphere emits longwave radiation toward Earth and toward space (True or False)

Greenhouse gases

6. Imagine that a new, man-made gas is released to the atmosphere in large quantities. The imaginary gas absorbs only ultraviolet radiation. (It absorbs no visible radiation, and it does not absorb longwave radiation.)

6a. (5 points) Will the new gas function like a greenhouse gas (yes/no)?

6b. (10 points) Why or why not?

7. (10 points) What are trace gases? Give four examples.

The Greenhouse Effect

8. (15 points) In one or two sentences, describe the difference between the "greenhouse effect" and "global warming" ("global warming" is another term for the "enhanced greenhouse effect"). Note that there *is* a difference.

9 (50 points): Explain the greenhouse effect. Your explanation of the greenhouse effect must do the following (not necessarily in order):

a. (5 points) Explain the relationship between radiation and energy.
b. (5 points) Describe what happens to the temperature of an object when it absorbs radiation.
c. (5 points) Detail how the peak intensity of radiation that an object emits changes when the object's temperature changes. (Hint: check out slide 7 of the lecture 3 PowerPoint slides.)
d. (5 points) Explain HOW the radiation emitted by the sun is different than the radiation emitted by Earth.
e. (5 points) Explain WHY radiation emitted by the sun is different from radiation emitted by Earth.
f. (5 points) Define a greenhouse gas in terms of the type of radiation that it absorbs and emits.
g. (5 points) Provide at least two examples of gases that are NOT greenhouse gases
h. (5 points) Provide at least two examples of gases that are greenhouse gases.
i. (5 points) Identify where radiation emitted by the atmosphere goes (hint – it goes in two directions)
j. (10) (5 points) Include a very simple diagram to illustrate your points.

To help you with this task, check out he lecture powerpoint slides (lecture 3), and the answers that you wrote above during lab class. Also check out http://www.manicore.com/anglais/documentation_a/greenhouse/physical.html. (Direct quotes from the lecture slides or the website listed will be given no credit.

Bonus 1. (5 points; partial [extra] credit given for trying but getting it wrong). Diagram an example of a positive feedback loop that in some way relates to global warming (alternatively termed the "enhanced greenhouse effect"). Your diagram must include labels for the initial change and each forcing/response. Explain why it is a positive feedback loop.

Bonus 2. (15 points) Draw an absorption spectrum for a new man-made gas (we'll call it "SuperGreenhouse Gas") that would be a new, very potent gas. In order to get full [extra] credit, you should also explain WHY SuperGreenhouse Gas's absorption spectrum makes it a potent greenhouse gas. As a starting point, here is the absorption spectrum of the total atmosphere: