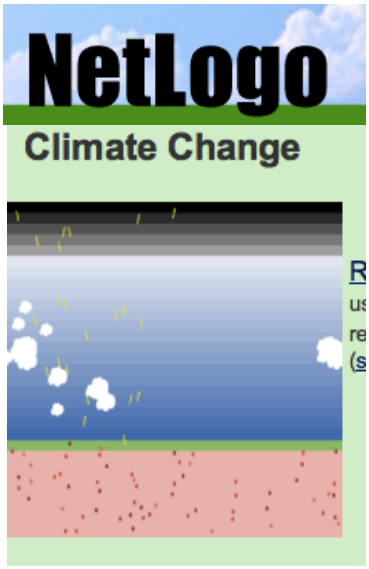
NetLogo Climate Model :

Student Worksheet

A laboratory experiment from the Little Shop of Physics at Colorado State University



Learning Objective:

The temperature of the Earth depends on the balance between energy coming in and energy leaving the atmosphere to space. If the incoming radiation in the atmosphere is increased, the planet's temperature will also increase until it emits enough outgoing radiation to balance incoming radiation. Likewise, if the incoming radiation in the atmosphere is decreased, the planet's temperature will also decrease until the outgoing radiation balances the incoming radiation.

Activity: Run a climate model using NetLogo

http://ccl.northwestern.edu/netlogo/models/ClimateChange

NetLogo's Climate Change model is an energy balance model for a planet. In the model, the Earth's subsurface is rose colored, and the Earth's surface is represented by a green strip. Above the Earth's surface is the blue atmosphere, and the top of the atmosphere is defined by the blackness of space.

When you run the model, yellow arrowheads stream downward representing sunlight energy. If sunlight is absorbed by earth, it turns into a red dot, representing heat energy. Each dot represents the energy of one yellow sunlight arrowhead, and the temperature of the earth is related to the total number of red dots.

Sometimes the red dots transform themselves into infrared (IR) energy that heads toward space, carrying away heat energy. The probability of a red dot becoming IR energy depends on the earth's temperature. The IR energy is represented by a magenta arrowhead. Each of these carries the same energy as a yellow arrowhead and as a red dot.

The model allows for different scenarios. With all models it's best to change one thing at a time after the current condition stabilizes and watch for the effects of the new scenario. Here are some parameters that can be changed within the climate model:

1. **Sun brightness**. A value of 1.0 corresponds to our sun. Higher values would allow you to see what would happen if the Earth were closer to the sun in it's orbit, or if the sun got brighter.

2. The **albedo** (**reflectivity**). If the albedo is 1.0 the earth reflects all sunlight. If the albedo is zero, the Earth absorbs all sunlight. The Earth's albedo is about 0.6.
3. **Clouds** can be added or removed.
4. **Greenhouse gases** (GHGs) represented as CO2 molecules, can be added or removed. The buttons add and subtract GHG molecules in groups of 25.
5. The **Temperature of the Earth** is represented by red dots. The more red dots the hotter the Earth's temperature is.

Run the model with these various scenarios and record your observations:

Model	What Do You Observe?
1. Start the model without any added effects (such as additional clouds or CO2). Set Sun brightness to 1.0 and albedo to 0.6. Observe the yellow arrowheads of solar energy (shortwave (SW) radiation) reaching Earth. What are some of the things that happen to SW radiation when it reaches the Earth's surface?	
2. The red dots in the subsurface indicate the temperature of the Earth. At what point do they transform into magenta arrowheads - ie. how many ticks? What type of energy does this represent? What happens to the global temperature?	
3. Run the model long enough, and the temperature begins to oscillate around a stable temperature. Why does temperature stop rising? What is the cause for the temperature to stabilize?	
4. Explore the effect of albedo holding everything else constant. Does increasing the albedo increase or decrease the earth temperature? When you experiment with this, be sure to run the model long enough for the temperature to stabilize.	
5. Add CO2 and key into a single yellow arrowhead representing or shortwave radiation. Does CO2 allow the radiation to go through (transparent) or does CO2 block the radiation (opaque) to shortwave?	

Model	What Do You Observe?
4. Do the same observations for the magenta arrowheads which represent Earth's IR radiation. Is CO_2 transparent or opaque to IR radiation? What is the highest Earth temperature you can produce?	
5. Think of another factor that you could change to influence the earth's temperature and list it here. Make your predictions and observations.	