Mary L. Urquhart September 1, 2005

# The Energy Balance Game

**Purpose**: Demonstrate the concept of energy balance with sunlight and how thermal inertia relates to temperatures throughout the year.

**Materials:** About 50 gram cubes, pennies, or other small objects that can be counted per group of two students; 3 cups per pair of students.

One cup represents the sun, another a part of the earth, and the third cup represents space. Each object represents a packet of energy. We will simulate the movement of energy into and out of a location on the earth by moving "energy blocks" from to different cups. We will start our energy balance exercise in March, the month of vernal (spring) equinox in the northern hemisphere. Let's begin by considering the changing amount of solar energy absorbed by the earth at our location each month, and assume that the net energy emitted to space as infrared light is constant.

Energy IN should be moved from the sun cup to the earth cup.
Energy OUT should be moved from the earth cup to the space cup.
Energy Remaining is the energy left in the earth cup for each month.

| Month | Not Temperature Dependent | | |
|---|---|---|---|
| | Energy IN | Energy OUT | Energy Remaining |
| March | 4 | 4 | |
| April | 5 | 4 | |
| May | 6 | 4 | |
| June | 7 | 4 | |
| July | 6 | 4 | |
| August | 5 | 4 | |
| September | 4 | 4 | |
| October | 3 | 4 | |
| November | 2 | 4 | |
| December | 1 | 4 | |
| January | 2 | 4 | |
| February | 3 | 4 | |

How does the remaining energy change throughout the year?

Based on your table, which months would you expect to be the hottest?

Which months would you expect to be the coldest?

The amount of energy emitted as light by an object is actually very temperature dependent! Hotter objects emit more light, as well as more energetic light. Let's try our activity again, this time sending more energy into space when there is more energy stored in the ground (higher temperature).

| Month | Temperature Dependent | | |
|---|---|---|---|
| | Energy IN | Energy OUT | Energy Remaining |
| March | 4 | 3 | |
| April | 5 | 4 | |
| May | 6 | 4 | |
| June | 7 | 5 | |
| July | 6 | 5 | |
| August | 5 | 5 | |
| September | 4 | 5 | |
| October | 3 | 4 | |
| November | 2 | 4 | |
| December | 1 | 3 | |
| January | 2 | 3 | |
| February | 3 | 3 | |

*Note to the teacher: This model is for illustrative purposes only, and does not represent actual values of energy absorption and emission.*

How does the remaining energy change throughout the year?

Based on your table, which months would you expect to be the hottest?

Which months would you expect to be the coldest?

How does the remaining energy per month vary between your two models? (Hint, you can fill out the table on the next page for an easy comparison between the two models.)

| Month | Not Temperature Dependent | | | Temperature Dependent | | |
|---|---|---|---|---|---|---|
| | Energy IN | Energy OUT | Energy Remaining | Energy IN | Energy OUT | Energy Remaining |
| | | | | | | |
| March | 4 | 4 | | 4 | 3 | |
| April | 5 | 4 | | 5 | 4 | |
| May | 6 | 4 | | 6 | 4 | |
| June | 7 | 4 | | 7 | 5 | |
| July | 6 | 4 | | 6 | 5 | |
| August | 5 | 4 | | 5 | 5 | |
| September | 4 | 4 | | 4 | 5 | |
| October | 3 | 4 | | 3 | 4 | |
| November | 2 | 4 | | 2 | 4 | |
| December | 1 | 4 | | 1 | 3 | |
| January | 2 | 4 | | 2 | 3 | |
| February | 3 | 4 | | 3 | 3 | |

## Going Further

Why is temperature at a specific location on the Earth different from what would be predicted by a simple energy balance (energy in = energy out) over the course of a year?

How could you adjust the model for where you live?

How would the model be different in China?

How would the model be different for people who live in Equador?

How would the model be different for people who live in Australia?

In both models we made the assumption that all of the energy absorbed over the course of a year was emitted back to space sometime within that time frame. Is this a reasonable assumption? Why or why not?

What would happen if one energy unit is retained at the end of every year?

What would happen if one energy unit is lost at the end of every year?

What are some real physical processes that could prevent an energy balance (energy in= energy out) over the course of a year?