What is a feedback?

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

Overview

The earth's climate is a complex system that is determined by a variety of forces and *feedbacks*. The concept of feedback is central to an understanding of the science and the everyday experience of the climate.

Necessary materials:

Feedback Activity

- 4 small cups: 2 attached at the base, 2 attached at the mouth
- 1 track

The parts for this activity can be purchased at any grocery store (2 oz cups) or hardware store (angle iron or L channel).

Theory

Here's an example of feedback at work: in areas that receive lasting snow in the winter, the season change from fall to winter is much less sudden than the change from winter to spring. A warmer fall will gradually fade into the lasting snow of winter, as opposed to the rapid change from winter to spring. This rapid change is due to a *positive feedback*. Snow reflects most of the light that hits it; bare ground absorbs it. Warming a snow-covered landscape melts snow, meaning more sunlight is absorbed, meaning higher temperatures, meaning more warming, meaning more snow melts, meaning more ground is exposed... and so on. The positive feedback means a quick switch from a snowy cold winter to the bare ground and balmy temperatures of spring. The positive feedback takes a small swing in temperature and amplifies it.

On the other hand, a *negative feedback* will work to damp out a change. Here's an example: as incoming solar radiation warms the ocean, water evaporates and rises. As the vapor rises it cools and condenses to form clouds. These low clouds reflect incoming radiation. Less radiation means less warming—meaning less evaporation and fewer clouds.... The negative feedback is a stabilizing force.

The two-cup devices and track

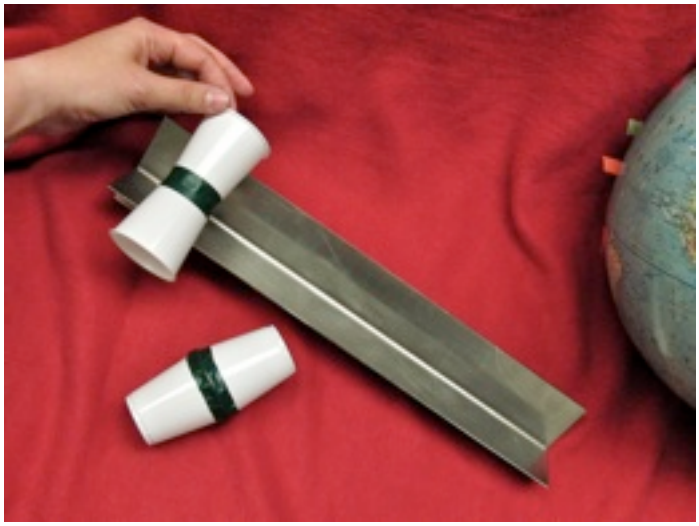
Doing the Experiment

Begin the lesson with an explanation of feedback. You might ask your students for examples of positive and negative feedback they have experienced in the earth system and elsewhere.

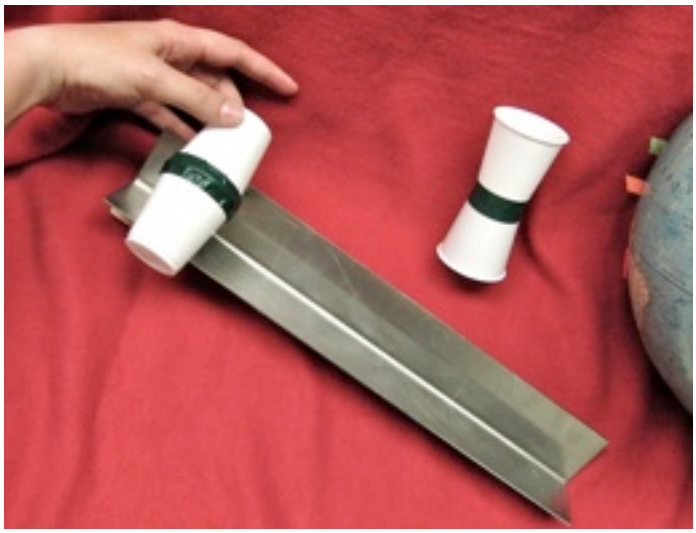
Explain to the class that this exercise will model

positive and negative feedbacks. Set up the track on a flat surface and avoid vibrations. Show the two-cup devices to the class and ask them to explain the difference between them—in particular the size of the cup where it touches the track. The diameter of one cup device starts out at a maximum and gets smaller as you move from the center outward along the long axis. The other device is quite the opposite.

Ask students to observe as you (or a volunteer student from your class) rolls the base-to-base cup device down the ramp. The cup should be placed, centered, at the very top of the ramp and allowed to roll freely by the force of gravity alone without any additional pushing. Notice that this device falls off the ramp before reaching the bottom. This is a positive feedback. It works to amplify any small deviation from straight rolling: a small turn to one side rapidly increases in magnitude. Now repeat this with the mouth-to-mouth cup device. This one stays firmly on the ramp. If it starts to roll to the side, the motion will correct itself so that the cup stays put. This is a negative feedback; any deviation from straight rolling damps out as the cups swivels in the opposite direction, and the cup quickly turns enough to roll right off the ramp.



A positive feedback



A negative feedback

Summing Up

Positive and negative feedbacks often have a different meaning to the general public, with positive viewed as a good thing, and negative, not so. As mentioned above, positive feedbacks in the climate system can amplify fluctuations in the climate system and are often viewed with apprehension.

For More Information

CMMAP, the Center for Multi-Scale Modeling of Atmospheric Processes: http://cmmap.colostate.edu

Little Shop of Physics: http://littleshop.physics.colostate.edu