Modeling the Earth's Atmosphere

Description:

This lesson illustrates the characteristics of the greenhouse effect, a concept that is crucial to a comprehensive understanding of climate change. The human-side of the greenhouse effect and climate change more broadly are discussed in later lessons within this module.

Objectives:

- Understand the basic principles of the Earth's atmospheric system
- Comprehend the role of greenhouse gases in regulating the Earth's temperature
- Identify the key properties of greenhouse gases and non-greenhouse gases

Vocabulary:

Atmosphere, impervious, greenhouse effect, greenhouse gas

Materials:

- Small boxes (opportunity for students to recycle shoe boxes or other small boxes from home and discuss environmental benefits of reusing materials)
- Thermometers (affordable set of thermometers can be found here)
- Soil
- Materials to cover boxes (plastic wrap, tin foil, cardboard, wax paper, Plexiglas, etc.)
- Tape
- Optional: different materials to cover the bottom of the box (soil, sand, asphalt, pebbles, grass, plants, etc.)

Background Information:

The National Aeronautics and Space Administration (NASA) provides an explanation of atmospheric gases and the greenhouse effect: "A greenhouse stays warm inside, even during winter. Sunlight shines in and warms the plants and air inside. But the heat is trapped by the glass and can't escape. So during the daylight hours, it gets warmer and warmer inside a greenhouse…Gases in the atmosphere such as carbon dioxide do what the roof of a greenhouse does. During the day, the sun shines through the atmosphere. Earth's surface warms up in the sunlight. At night, Earth's surface cools, releasing the heat back into the air. But some of the heat is trapped by the greenhouse gases in the atmosphere. That's what keeps our Earth a warm and cozy 59 degrees Fahrenheit, on average."[1]

Watch the International Climate Initiative's informational video to learn more about the greenhouse effect.

Land cover also influences how heat is stored in the atmosphere. Some surfaces absorb more heat than others, like the Catskill and Delaware Watersheds as compared to NYC. Much of the land in these watersheds is covered by a large vegetative layer which stores NYC's water, while creating shade that dissipates heat and causes lower rates of evapotranspiration. Through evapotranspiration, plants release water into the surrounding air that decreases the local temperature. Contrarily, urban environments like NYC are mostly made up of buildings, pavement, and glass, which are impervious. The

[1] NASA Climate Kids Greenhouse Effect

EPA describes this phenomenon; "As cities develop, more vegetation is lost, and more surfaces are paved or covered with buildings. The change in ground cover results in less shade and moisture to keep urban areas cool. Built up areas evaporate less water, which contributes to elevated surface and air temperatures."[2] This is one element of the urban heat island effect, which is discussed in greater detail in the Contextualizing the Urban Heat Island Effect lesson. To explore this with students, follow the steps for the optional experiment that uses the bottom layer of the box (land cover) as the changing variable.

Method:

- After discussing the greenhouse effect, split students into five groups.
- Give each group a shoe box and approximately two cups of soil.
- Tell the students they will be modeling the greenhouse effect with their shoeboxes. Each shoebox will have a different cover (sample options listed in materials section) and one box must be left without a cover.
- As a class, hypothesize how the various covers might affect the temperature inside the box. Explain that the covers represent the atmospheric layer covering Earth.
- Have each group choose their cover and fill their boxes with soil.
- Now students should stick their thermometer in the middle of the box within the soil so the temperature of the soil can be recorded.
- Cover each box, taping the edges if necessary.
- Then, place them outside or on the windowsill where they can receive direct sunlight.
- Monitor and record the temperature of the boxes two times a day over a set period of time, ideally one week.
- Discuss the results as a class. Students may find that thinner covers lead to less heat being trapped in the shoe box. Therefore, a thin layer like plastic wrap might represent pre-industrial atmospheric greenhouse gas levels, when the effects of climate change were less intense. A thicker layer, like cardboard or tin foil, will trap more heat similar to a thicker layer of greenhouse gases surrounding the Earth. The thicker layers might represent present or future atmospheric greenhouse gas levels.
- Optional: As an alternative or follow up experiment, have students use one consistent cover and different materials layered on the bottom of the shoebox, such as sand, asphalt, pebbles, grass or plants. This would simulate different land cover surfaces and their effect on the atmosphere.

Discussion:

- Why did different covers or soil types yield different results?
- How did the results compare to your hypothesis?
- Considering your model, what would each cover or soil type represent in our Earth's system?
- How would concentrations of the various greenhouse gases vary based on results from the different boxes?

[2] EPA Reducing Urban Heat Islands: Compendium of Strategies Urban Heat Island Basics

- Which human activities add more greenhouse gases to our atmosphere? What industries are the biggest emitters of greenhouse gases and why? Find more information on the breakdown of greenhouse gas emissions in DEP's Climate Change Introduction slides.
- What are the different layers of the Earth's atmosphere and what exists in each layer?
- What are the different layers of the Earth's surface and how might they also impact temperatures? How can land use practices impact surface temperature?

Extension:

- Graph the data collected from each cover or soil type and compare the results. What is the best type of graph for this data?
- What is the function of each layer and which key gases exist within them? Explore using more information from NASA.
- What is the ozone layer's role in protecting humans from harmful radiation? Is the ozone layer changing? How? Find more information from the EPA.
- Why can't other planets support life? Explore temperature and other factors on other planets to explain why life only exists on Earth.

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