NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
ACTIVITY : 45 MINS

Feedbacks of Ice and Clouds

Students use interactive computational models to explore how light-colored surfaces such as snow, ice, and some clouds have a cooling effect on Earth. Then they interpret real-world data to examine the positive feedback loop between ice coverage and temperature.

GRADES

7 - 12+

SUBJECTS

Earth Science

CONTENTS

2 Images, 2 Links

OVERVIEW

Students use interactive computational models to explore how light-colored surfaces such as snow, ice, and some clouds have a cooling effect on Earth. Then they interpret real-world data to examine the positive feedback loop between ice coverage and temperature.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/feedbacks-ice-and-clouds/

Content Created by

The Concord Consortium

DIRECTIONS

1. Activate students' prior knowledge about reflection and absorption.

Show the **photos of the Bear Glacier in Alaska (1909 and 2005)**. Tell students that some surfaces reflect light more than others and that more reflective surfaces have a higher albedo. Ask:

- *Which photo shows surfaces with higher albedo?* (The 1909 photo shows surfaces with a higher albedo. There is more snow and ice in that photo than in the 2005 photo.)
- *Which photo shows surfaces that would absorb the most solar radiation?* (The 2005 photo shows surfaces that would absorb the most solar radiation. The ice and snow in the 1909 photo would reflect most of the solar radiation.)
- *Why does a dark-colored surface feel much hotter than a light-colored surface in the sunshine?* (The dark-colored surface absorbs more radiation than the light-colored surface. The absorbed radiation becomes heat energy in the surface.)

2. Discuss the role of uncertainty in the scientific process.

Tell students that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. Let students know they can see examples of scientists' uncertainty in climate forecasting.

Show the **Global Temperature Change Graph** from the 1995 IPCC (Intergovernmental Panel on Climate Change) report and tell them that this graph shows several different models of forecast temperature changes. Ask: *Why is there more variation (a wider spread) between the models at later dates than at closer dates?* (There is more variation between the models at later dates than at closer dates because there is more variability in predicting the far future than in predicting the near future.)

Tell students that the ability to better predict near-term events occurs in hurricane and tropical storm forecasting as well. Project **The Definition of the National Hurricane Center Track Forecast Cone** and show students the “cone of uncertainty” around the track of the storm. The cone shows the scientists' uncertainty in the track of the storm, just as the climate models show the scientists' uncertainty in how much Earth's temperature will change in the future.

Ask: *When are scientists most confident in their predictions?* (Scientists are most confident in their predictions when they have a lot of data. This is why the forecast for near-term events is better than forecasts of longer-term events, both in storm forecasting and in climate forecasting.)

Tell students that they will be asked questions about the certainty of their predictions and that they will need to think about what scientific data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Discuss the role of systems in climate science.

Tell students that forecasting what will happen in Earth's climate system is a complicated process because there are many different interacting parts. Scientists think about how one part of the system can affect other parts of the system. Give students a simple example of a system, as described in the scenario below.

On an island, there is a population of foxes and a population of rabbits. The foxes prey on the rabbits. Ask:

- *When there are a lot of rabbits, what will happen to the fox population?* (It will increase because there is an ample food supply.)
- *What happens to the fox population when they've eaten most of the rabbits?* (The foxes will die of starvation as their food supply decreases.)
- *What happens to the amount of grass when the fox population is high?* (The amount of grass will increase because there are fewer rabbits to eat the grass.)
- *If there is a drought and the grass doesn't grow well, what will happen to the populations of foxes and rabbits?* (The rabbit population will decrease because they have a lesser food supply. The fox population should also decrease as their food supply decreases.)

Humans introduce dogs to the island. The dogs compete with the foxes over the rabbit food supply. Ask: *What will happen to the populations of foxes, rabbits, and grass after the dogs are introduced?* (The foxes will decrease because they are sharing their food supply, the rabbits will decrease because they have more predators, and the grass will do well because of the lowered impact of the smaller rabbit population.)

Tell students that they will be exploring cause-effect and system feedback relationships between carbon dioxide and water vapor in this activity. Ask students to think about how each piece of the system affects other pieces of the system.

4. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. Project the NOAA **Weather Forecast Model**, which provides a good example of a computational model. Tell students that:

- scientists use information about the past to build their climate models.
- scientists test their climate models by using them to forecast past climates.
- when scientists can accurately forecast past climates, they can be more confident about using their models to predict future climates.

5. Have students launch the Feedbacks of Ice and Clouds interactive.

Provide students with the link to the Feedbacks of Ice and Clouds interactive. Divide students into groups of two or three, with two being the ideal grouping to enable sharing computer workstations. Tell students they will be working through a series of pages of models with questions related to the models. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students this is Activity 5 of the lesson **What is the Future of Earth's Climate?**

6. Have students discuss what they learned in the activity.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *What is the relationship between ice cover and temperature?* (When there is a lot of ice cover, the temperature is low. This is because the solar radiation is reflected into space rather than absorbed.)
- *In the* ***model of the Earth system with clouds (Model 7)****, how did clouds affect the temperature?* (In the model, clouds have a cooling effect.)
- *Is this model (Model 7) realistic?* (The model is realistic, but it is not complete. Clouds can have cooling effects or warming effects depending on the location and makeup of the clouds. This model only shows high clouds that reflect sunlight back into space.)
- *What would happen to ice cover if greenhouse gas concentrations increase?* (Ice cover would decrease. This is because greenhouse gases trap heat energy in the atmosphere, causing the ice to melt because of the increased temperature. As the ice melts, more radiation is absorbed because there are fewer light-colored surfaces to reflect the radiation, leading to further warming.)
- *What type of feedback is the relationship between clouds and temperature?* (This is a negative feedback relationship. The cloud cover increases with increasing water vapor, but the cloud cover serves to reduce incoming solar radiation which leads to cooling. The stimulus is counteracted by the response.)
- *What type of feedback is the relationship between ice and temperature?* (This is a positive feedback relationship. The melting ice leaves a darker surface that absorbs more solar radiation, leading to more heating, leading to more melting. The stimulus is reinforced and accelerated by the response. Similarly, when the temperature is cold, more ice forms, which reflects more solar radiation, which leads to less heat absorption, which leads to further ice formation.)

TipTeacher Tip

This activity is part of a sequence of activities in the What Is the Future of Earth's Climate? lesson. The activities work best if used **in sequence**.

TipTeacher Tip

To save your students' data for grading online, register your class for free at the High-Adventure Science portal page.

Modification

This activity may be used individually or in groups of two or three students, or as a whole class activity. If using as a whole class activity, use an LCD projector or interactive whiteboard to project the activity.

Informal Assessment

1. Check students' comprehension by asking them the following questions:

- How do ice, snow, and clouds affect temperature?
- Why is it colder on clear nights than on cloudy nights?
- If the sea ice melts, how might that affect global temperature and the atmospheric concentrations of carbon dioxide and water vapor?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science

Learning Objectives

Students will:

- explain why light-colored surfaces have a cooling effect on Earths' temperature

- describe the positive feedback loop between temperature and ice cover
- describe the negative feedback loop between cloud cover and temperature
- describe the uncertainty about the feedbacks of temperature, water vapor, and cloud cover that complicate scientists' ability to predict future climate conditions

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

- **(5-8) Standard A-1:**

Abilities necessary to do scientific inquiry

- **(5-8) Standard A-2**:

Understandings about scientific inquiry

- **(5-8) Standard B-1**:

Properties and changes of properties in matter

- **(5-8) Standard B-3**:

Transfer of energy

- **(5-8) Standard D-1**:

Structure of the earth system

- **(5-8) Standard E-1**:

Abilities of technological design

- **(5-8) Standard E-2**:

Understandings about science and technology

- **(5-8) Standard F-5**:

Science and technology in society

- **(5-8) Standard G-1**:

Science as a human endeavor

- **(9-12) Standard A-1**:

Abilities necessary to do scientific inquiry

- **(9-12) Standard A-2**:

Understandings about scientific inquiry

- **(9-12) Standard B-5**:

Conservation of energy and increase in disorder

- **(9-12) Standard D-1**:

Energy in the earth system

- **(9-12) Standard E-1**:

Abilities of technological design

- **(9-12) Standard E-2**:

Understandings about science and technology

- **(9-12) Standard G-1**:

Science as a human endeavor

- **(9-12) Standard G-2**:

Nature of scientific knowledge

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

- **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.6-8.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.9-10.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.11-12.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.1

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

- **Standard 3**:
Research and Information Fluency
- **Standard 4**:
Critical Thinking, Problem Solving, and Decision Making

NEXT GENERATION SCIENCE STANDARDS

- **Crosscutting Concept 2**:
Cause and effect: Mechanism and prediction
- **Crosscutting Concept 3**:
Scale, proportion, and quantity
- **Crosscutting Concept 4**:
Systems and system models
- **Crosscutting Concept 5**:
Energy and matter: Flows, cycles, and conservation
- **Crosscutting Concept 7**:
Stability and change

- **HS. Earth and Human Activity:**
HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
- **HS. Earth and Human Activity:**
HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
- **HS. Earth's Systems:**
HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
- **HS. Earth's Systems:**
HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- **HS. Earth's Systems:**
HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
- **MS. Earth and Human Activity:**
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
- **Science and Engineering Practice 1:**
Asking questions and defining problems
- **Science and Engineering Practice 2:**
Developing and using models
- **Science and Engineering Practice 4:**
Analyzing and interpreting data
- **Science and Engineering Practice 6:**
Constructing explanations and designing solutions
- **Science and Engineering Practice 7:**
Engaging in argument from evidence
- **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information.

Preparation

What You'll Need

REQUIRED TECHNOLOGY

- Internet Access: Required
- Tech Setup: 1 computer per classroom, 1 computer per learner, 1 computer per small group, Projector

PHYSICAL SPACE

- Classroom
- Computer lab
- Media Center/Library

GROUPING

- Heterogeneous grouping
- Homogeneous grouping
- Large-group instruction
- Small-group instruction

BACKGROUND & VOCABULARY

Background Information

Solar radiation consists of visible light, infrared radiation (heat), and ultraviolet radiation. When solar radiation encounters Earth's atmosphere and surface, it can be reflected (sent back into space) or absorbed. Energy that is absorbed becomes heat in Earth's surface. This heat can be re-radiated into space. Light-colored surfaces reflect more solar energy than dark-colored surfaces.

Infrared radiation is emitted by Earth's surface. Instead of the infrared radiation being allowed to exit Earth's atmosphere into space, greenhouse gases absorb it and re-emit it, keeping more heat in the atmosphere. Greenhouse gases include carbon dioxide, methane, and water.

Clouds can have a cooling effect or a warming effect, depending on their makeup and position in the atmosphere. High-level clouds have a net cooling effect as they reflect incoming solar radiation. Low-level clouds have a net warming effect as they prevent infrared radiation from escaping into space.

Prior Knowledge

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Recommended Prior Activities

- Sources, Sinks, and Feedbacks

Vocabulary

Term	Part of Speech	Definition
absorb	*verb*	to soak up.
albedo	*noun*	scientific measurement of the amount of sunlight that is reflected by a surface.
atmosphere	*noun*	layers of gases surrounding a planet or other celestial body.
carbon dioxide	*noun*	greenhouse gas produced by animals during respiration and used by plants during photosynthesis. Carbon dioxide is also the byproduct of burning fossil fuels.
climate	*noun*	all weather conditions for a given location over a period of time.
emit	*verb*	to give off or send out.
greenhouse effect	*noun*	phenomenon where gases allow sunlight to enter Earth's atmosphere but make it difficult for heat to escape.
greenhouse gas	*noun*	gas in the atmosphere, such as carbon dioxide, methane, water vapor, and ozone, that absorbs solar heat reflected by the surface of the Earth, warming the atmosphere.
ice core	*noun*	sample of ice taken to demonstrate changes in climate over many years.
infrared radiation	*noun*	part of the electromagnetic spectrum with wavelengths longer than visible light but shorter than microwaves.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
parts per million (ppm)	*plural noun*	A unit of measure of the amount of dissolved solids in a solution in terms of a ratio between the number of parts of solids to a million parts of total volume.
radiation	*noun*	energy, emitted as waves or particles, radiating outward from a source.

Term	Part of Speech	Definition
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.
temperature	*noun*	degree of hotness or coldness measured by a thermometer with a numerical scale.

For Further Exploration

Articles & Profiles

- National Geographic: Daily News: Climate Predictions: Worst-Case May Be Most Accurate
- National Geographic Education: Encyclopedia—Climate Change
- National Geographic Education: Encyclopedia—Global Warming
- National Geographic: All About Climate
- National Geographic News: Mysterious Clouds More Common Due to Climate Change?

Images

- National Geographic: Daily News: Pictures: 7 Emergency Climate Fixes: 1. Artificial Volcanoes

Reference

- National Geographic Encyclopedic Entry: Cloud

FUNDER

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