



# Earth's Energy Cycle: Albedo

High School Grades

## **Lesson Summary**

Students use a photo of the Bhutan glaciers in order to investigate the different effects albedo has on solar absorption.

## **Prior Knowledge & Skills**

- Graphing skills
- Data collection skills

## **AAAS Science Benchmarks**

### **The Nature of Science**

*Scientific Inquiry*

### **The Physical Setting**

*The Earth*

### **The Mathematical World**

*Symbolic Relationships*

### **Common Themes**

*Constancy and Change*

### **Habits of Mind**

*Communication Skills*

## **NSES Science Standards**

### **Physical Science**

*Interactions of Matter and Energy*

### **Earth and Space Science**

*Energy in the earth System*

## **NCGE Geography Standards**

### **The World in Spatial Terms**

*Standard 1*

### **Physical Systems**

*Standard 7*

**Teaching Time:** 20 – 40 minutes

## **Materials**

- Two thermometers
- One copy of the Bhutan glacier photo (attached)
- Tape
- Watch or stopwatch
- Outdoor sunshine or a small desk lamp with a 150 watt bulb
- Student page
- Pen or pencil

## **Advanced Planning**

**Preparation Time:** ~10 minutes

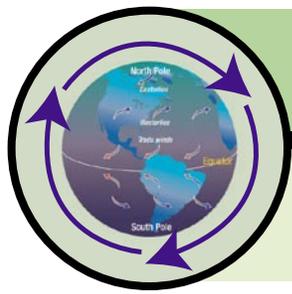
1. Review the instructions
2. Gather the necessary supplies.
3. Make color copies of the Bhutan glacier image
4. Copy *Student Page* for all students

## **Recommended Reading:** (attached)

- Background information: What is Albedo?

National Center for Atmospheric Research: Climate Discovery Teacher's Guide

<http://www.eo.ucar.edu/educators/ClimateDiscovery/>



## Unit: Cycles Lesson: 4

### Materials & Preparation

#### Time:

- Preparation: 10 min
- Teaching: 20-40 min

#### Materials for Student Teams:

- 2 Thermometers
- One copy of the Bhutan glacier photo (p.4)
- Tape
- Watch or stopwatch
- Outdoor sunshine or a small desk lamp with a 150 watt bulb

#### Materials for Students:

- *Student Page*
- Pen or pencil

### National Science Standards

- Physical Science: Content Standard B (Transfer of Energy)
- Earth and Space: Content Standard D (Structure of the Earth System)

### Learning Goals

#### *Students will*

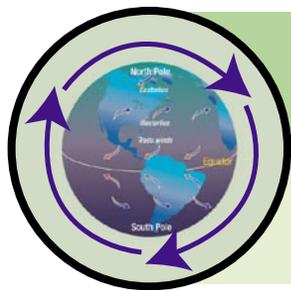
- Explore how the color of materials at the Earth's surface effect the amount of warming.
- Develop a hypothesis, collect data, and make interpretations.
- Be able to explain why dark colored materials become hotter.

### What Students Do in this Lesson

Students experiment and observe how the color of materials that cover the Earth affects the amounts of sunlight our planet absorbs.

### Key Concepts

- The amount of energy retained by the Earth is strongly dependant on the albedo of Earth surfaces.
- Sunlight falling on a white glacier surface strongly reflects back into space, resulting in minimal heating of the surface and lower atmosphere.
- Sunlight falling on a dark soil or rock is strongly absorbed, and contributes to significant heating of the Earth's surface and lower atmosphere.



## Earth's Energy Cycle: Albedo

### Advanced Preparation

- Copy *Student Page* for all students.
- Make color copies of the Bhutan glacier image (p.4). Laminate these photos for use with multiple classes.

### Introducing the Lesson

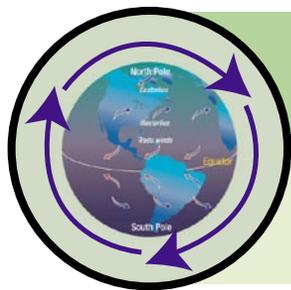
- Ask students if they have ever noticed that wearing a black shirt on a warm sunny day will make you hotter. Ask them if they have noticed that they are hotter when standing on blacktop pavement/asphalt. Why is that the case? Discuss how light is absorbed and transformed into heat energy.
- Ask students what they think might happen if the Earth was wearing a white or black tee-shirt. Of course, the Earth can not wear a tee-shirt, but the color of the Earth's surface is not the same everywhere. Show students a picture of the Earth from space (See *Windows to the Universe* [www.windows.ucar.edu](http://www.windows.ucar.edu) for images). What colors do they see? Which are the lightest colors? Which are the darkest? Where do they expect that most sunlight will be absorbed? Where do they expect that the least sunlight will be absorbed?.

### Facilitating the Lesson

1. Divide students into groups of 2-4. Provide each student a *Student Page* and each group a set of materials.
2. Have groups look at the photo of the Bhutan glaciers. Explain that this picture was taken from a satellite high above the Earth. Ask students what they see in the picture. The dark reddish parts of the picture are land (rocks). The white sections are ice and snow. This ice and snow is in glaciers. Define glacier. Parts of the glaciers are light blue in color. These are made of blue ice, sand and gravel. The very dark patches are lakes that form from the glacier melt water.
3. Ask students to make a hypothesis about which areas of the photograph they think would absorb the most solar energy and which would absorb the least. Write the hypothesis on the *Student Page*.
4. Instruct students to fix their thermometers to the back of the picture using tape. One thermometer bulb should be under a section of light colored ice and the other thermometer bulb under a section of dark red land. Remember to place the thermometers so that when you lay the picture down on a table, the thermometers are right side up and can be read.
5. Place the light (not turned on) directly above the picture, about a foot above. Do not turn it on yet!
6. Ask students to decide who in their group is going to record the data, who is going to read the ice thermometer, who is going to read the land thermometer and who is going to be the time keeper.
7. The two students read their thermometers before the light is turned on and give the numbers to the data collector. The thermometer readings should be approximately the same.
8. Once they have the initial readings, groups should turn on their light and the time keeper begins timing. Temperature readings will be taken every two minute (for 6 or 8 minutes total). Advise students to read the thermometers without shading the light if possible.

### Summarizing and Reflecting

- Discuss results. Point out how this model is different than the real world (For example, would either ice or the land surface ever get to those temperatures?) This model shows relative differences based on the color of the surface but does not take into account the type of material or its reflective abilities. Explain that ice is melting. How would less ice affect the system?



## Earth's Energy Cycle: Albedo

- Once each group has collected their data, compile all data on computer, blackboard, or overhead transparency so that all groups can see it. Ask students to make a graph of the data that shows ice shelf and ocean with different colors. Ask students if there a difference in the amount of heat they absorbed.

### Background Information

#### *What Is Albedo?*

While the Earth's temperature is dependent upon the greenhouse-like action of the atmosphere, the amount of energy retained by the Earth is strongly dependant on the albedo of Earth surfaces. Just as some clouds reflect solar energy into space, so do light-colored land surfaces. Scientists use the term albedo to define the percentage of solar energy reflected back by a surface. This surface albedo effect strongly influences the absorption of sunlight. Forests, grasslands, ocean surfaces, ice caps, deserts, and cities all absorb, reflect, and radiate solar energy differently. Sunlight falling on a white glacier surface strongly reflects back into space, resulting in minimal heating of the surface and lower atmosphere. Sunlight falling on a dark soil or rock is strongly absorbed, and contributes to significant heating of the Earth's surface and lower atmosphere.

Understanding local, regional, and global albedo effects is critical to predicting global climate change. Light colored ice and snow are very weakly absorptive, reflecting 80-90% of incoming solar energy. Dark-colored land surfaces, are strongly absorptive and contribute to warming, reflecting only 10-20% of the incoming solar energy. If global temperatures increase, snow and ice cover may shrink. The exposed darker surfaces underneath may absorb more solar radiation, causing further warming. The magnitude of the effect is currently a matter of serious scientific study and debate.

#### *How Much Are Glaciers Melting?*

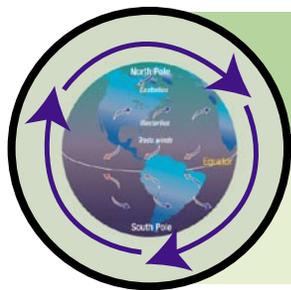
Currently glaciers cover about 10% of the Earth's land surface. In most areas of the world, mountain glaciers are melting. Between 1961 and 1998 small glaciers lost an average of 7 meters of ice thickness. Glaciers in mountainous areas near the equator have been particularly hard-hit. According to global climate models, all of the glaciers in Glacier National Park in Montana will be gone by the year 2030. Snow and ice cover near the north pole is currently decreasing at approximately 0.4% per year. Arctic sea ice has been decreasing at about 2.9% per decade. Since 1974, seven ice shelves, most in Antarctica have retreated by a total of approximately 13,500 square kilometers.

#### *About the Image..*

The image used in this activity is of retreating mountain glaciers in Bhutan. It is a satellite image taken by the ASTER instrument aboard NASA's Terra satellite. Visible in the image are several glaciers in the Himalayan mountains of Bhutan. The glaciers have been melting over the past few decades, and lakes have formed on the surfaces and near the termini of many of the glaciers. Some of the glaciers are white as the ice is covered with snow pack. Other parts are rocky and have the same color as the surrounding land.

### Additional Resources

- NCAR Kids' Crossing: Living in the Greenhouse  
<http://eo.ucar.edu/kids/green>



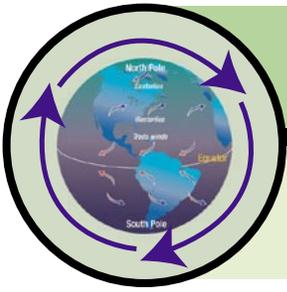
## Earth's Energy Cycle: Albedo

### Land and Glaciers

This picture shows glaciers in the Himalayan mountains of Bhutan. The glaciers have been melting over the past few decades. This makes lakes form nearby.



This picture was taken by an instrument aboard NASA's Terra satellite. You can find more pictures like this at NASA's Earth Observatory and the National Snow and Ice Data Center ([nsidc.org](http://nsidc.org))



# CLIMATE DISCOVERY STUDENT PAGES

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

## Earth's Energy Cycle: Albedo

Name \_\_\_\_\_

Date \_\_\_\_\_ Class \_\_\_\_\_

Take a look at the photograph that says Land and Glaciers at the top. Place the bulb of one thermometer under the light colored snow and ice part of the photo. Place the bulb of the other thermometer under the dark colored land part of the photo. (Make sure both thermometers are facing so that you can read them easily.)

What is your hypothesis?  
 (What do you think will happen to the thermometers under the ice colored parts of the photo and the land colored parts of the paper?)

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Collect the data!  
 Use the table below to help you collect the temperature data.

Time	Temperature under ice picture	Temperature under land picture
0 minutes		
2 minutes		
4 minutes		
6 minutes		
8 minutes		

What do YOU think?  
 How is this different than the real world?

What does the data mean?  
 Graph your data by plotting the points and connecting them into two lines:  
 One line for the ice photo temperature  
 One line for the land photo temperature  
 (Remember to fill in the temperature axis and the key.)

Key:

Ice

Land

Explain what you think it shows in the space below.

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