



# Albedo

High School Grades

## **Lesson Summary**

Students will use either a computer interface or a thermometer and graph paper to learn about the different absorption properties of different albedos.

## **Prior Knowledge & Skills**

- Graphing skills
- Data collection skills

## **AAAS Science Benchmarks**

### **The Nature of Science**

*Scientific Inquiry*

### **The Mathematical World**

*Symbolic Relationships*

### **Habits of Mind (with extension)**

*Manipulation and Observation*

## **NSES Science Standards**

### **Unifying Concepts and Processes**

*Change, Constancy, and Measurement*

### **Physical Science**

*Chemical Reactions*

## **NCGE Geography Standards**

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

*Standard 1*

### **Physical Systems**

*Standard 7*

**Teaching Time:** ~45 - 60 minutes

## **Materials**

- Aluminum foil
- Cheesecloth
- Colored paper
- Computer, with interface (optional)
- Light source
- Metric rulers
- Ring stands
- Scissors
- Stopwatch or clock
- 3-4 thermometers or temperature probes per group

## **Advanced Planning**

**Preparation Time:** ~10 minutes

1. Review the instructions
2. Gather the necessary supplies.

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

- Background

Institute for Global Environmental Strategies: Discover Earth Program Materials

<http://www.strategies.org/index.aspx>

*Activity 2: Albedo*

**Objective:** Students will demonstrate an understanding of the effects of albedo on Earth's energy budget.

**Background:**

The amount of solar energy that is reflected from Earth back to space is called the albedo.

albedos are a ratio with a value between 0 and 1	<u>outgoing solar radiation reflected</u> incoming incident solar radiation
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Oceans and forests reflect only small amounts of solar radiation, and thus have low albedos. Deserts and clouds have high albedoes because they reflect large portions of the Sun's energy. Clouds reflect large portions of the Sun's energy before it can reach and heat the Earth's surface, thus causing the Earth to be cooler. Clouds also trap some of the long wave radiation emitted by Earth and radiate it back to Earth's surface, causing the Earth to be warmer. Generally, low, thick clouds tend to reflect radiation--meaning less radiation reaches Earth's surface, resulting in cooler temperatures. High, thin clouds will reflect less radiation and allow more to reach the surface, warming Earth. Cloud surfaces can reflect up to 50 W/m<sup>2</sup> of solar radiation.

The temperature, thickness, and types of particles making up a cloud will impact the cloud's albedo and its transmission of long wave radiation. The position of the continents, biological innovation (vegetation type and density), mountains, deforestation, and the rise and fall of sea levels also impact the albedo of Earth. If the albedo goes down, more energy is added to the system.

Albedo is influenced by dust and water in the atmosphere, and snow and ice. Albedo is also a function of the angle of incident. The larger the angle of incident the smaller the fraction of reflection.

**note:**

The balance between the cooling and warming actions of global cloud cover is very close, but overall, cloud cover produces cooling on a global basis.

**Materials for albedo studies:**

- aluminum foil
- cheesecloth
- colored paper
- computer, with interface
- light source
- metric rulers
- ring stands
- scissors
- stopwatch or clock
- 3-4 temperature probes/group

**Procedure for albedo studies:** Notes for the teacher

1. In order to help students understand the role of heat absorption in the Earth's energy balance, this exercise requires students to evaluate the absorptive abilities of different colored materials-- which are used to simulate varying heat absorbencies of differing Earth surfaces. Student instructions for this study are on page 8-11.
2. This exercise uses a constructivist approach. Following the brainstorming (engagement), you can either give the students the suggested materials for the lab, or let them generate a list of materials that will accomplish the required task. This will be the exploration phase, to be followed by explanation, elaboration, and evaluation.
3. The lab procedure for this study includes approaches for three levels of technology. The first uses computers with an interface box and temperature probes, the second uses TI-82 graphing calculators with CBL (calculator-based laboratory) temperature probes, the third uses laboratory thermometers. All three levels respond to the same goals--listed under (4.) Part A and Part B.
4. **Part A:**  
Students design a lab simulation--based upon their understanding of albedo and its affect on the Earth's energy balance--that shows the varied heating that might take place on Earth due to color variances of the Earth's surfaces. These color variances would result in different albedoes which would impact global climate conditions. The simulation will utilize technology available to your classroom. Students will obtain your approval of their proposed procedure before running a simulation and producing graphs of the results.

**Possible student-designed response to (4.) Part A:**

- a. Students use 2-3 pieces of different colored papers and one piece of aluminum foil (to enhance reflectivity) to test varied heating of Earth's surfaces.
- b. Place a light source above probes covered with the colored papers and foil.
- c. Run the exercise for five minutes or other time agreed upon by the lab group.
- d. Produce a graph of the data.

**Part B:**

- a. Simulate a cloud covering that cuts reflectivity approximately in half.
- b. Run the experiment as before.
- c. Have the students generate a paragraph that compares and discusses how the simulated albedos would impact the energy balance of the Earth. Students should use their Part A & Part B graphs to illustrate their comments.

**Possible student-designed response for (4.) Part B:**

- a. Run the experiment again, this time incorporating partial cloud cover into your lab set-up. Decide as a group how to best accomplish this.
- b. After running this second set-up, produce a graph of your data.
- c. Compare and interpret the graphs from Part A & B--how do they illustrate possible albedos of the Earth's surface?

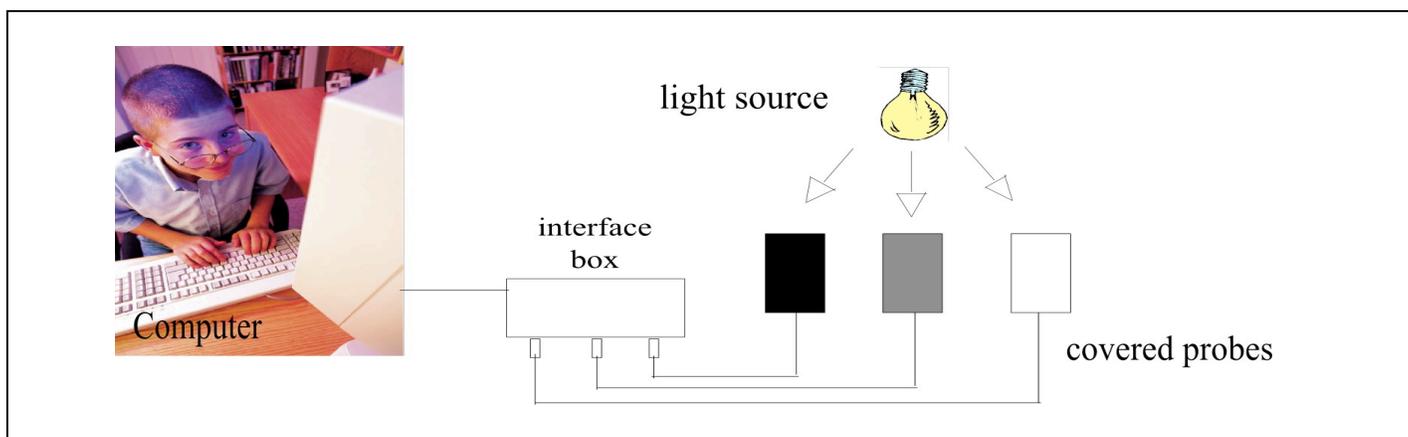
**5. Procedure using computers with an interface box and temperature probes for Part A:**

- a. Connect 3-4 temperature probes to an interface box which has been connected to a computer. The temperature probes should be lying horizontally on a counter top.
- b. Cut pieces of colored construction paper to cover the temperature probes. Students should have 2-3 different colored pieces of paper and one aluminum foil cover (to enhance reflectivity).
- c. Place a light source above the covered probes.
- d. Run the exercise for five minutes or other time agreed upon by the lab group.
- e. Produce a graph of the captured data using the computer program.

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**for Part B:**

- a. Simulate a cloud by suspending cheesecloth between two ring stands over part (approximately 50%) of the covered temperature probes
- b. Run the experiment as before
- c. Have the students generate a paragraph that compares and discusses how the simulated albedos would impact the energy balance of the Earth. Students should use their Part A & Part B graphs to illustrate their comments.



5. using computers with an interface box and probes

## 6. Procedure using TI-82 graphing calculators

TI-82 graphing calculators with Computer Based Lab (CBL) temperature probes can be used instead of computer-based equipment. Print the TI-82 graph on a computer if possible. If not, have students manually generate graphs on graph paper.

## 7. Procedure using laboratory thermometers

Use laboratory thermometers and graph paper.

8. Conduct a class discussion about the results of the lab exercise. Have students answer the following questions individually. Use the rubric on page 8 - 9 if desired.
  - (1.) From Part A, which color of paper absorbed heat faster? Why?
  - (2.) From Part A, did the colored paper absorb heat faster than the aluminum foil?
  - (3.) From Part B, what effect did the “cloud” of cheesecloth have upon the colored paper surfaces and the aluminum foil? Relate this to the Earth’s cloud cover and albedo.
  - (4.) What do you think would have happened if the colored papers and aluminum foil had been crumpled? Explain your answer relative to the Earth colors and surfaces.
9. Instead of or in addition to the above questions, a collective question might be asked, again using the rubric if desired.

## Extension of this exercise:

To observe the differences in temperature resulting from albedo, students with access to weather satellite imagery can:

1. capture infrared weather images, and take temperature reading of different colored surfaces, and,  
**note:** In infrared images, cloud surfaces will be much colder than land surfaces; light surfaces on both land and water will be colder than dark surfaces.
2. map temperatures for the area in which they live and compare their findings to infrared satellite images.

## Procedure for albedo studies

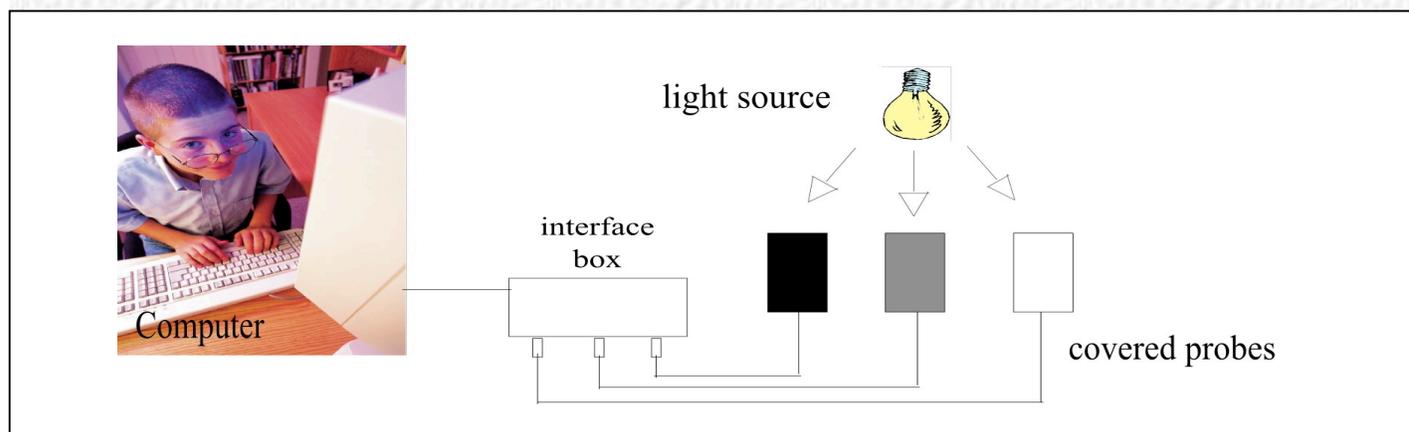
### Student Instructions

#### Part A:

Based upon your understanding of albedo and its affect on the Earth's energy balance, design a lab simulation that will show the varied heating that might take place on Earth due to color variances of the Earth's surfaces. These color variances would result in differing albedoes, which would impact global climate conditions. Your simulation should utilize a computer, interface box, and associated temperature probes. When your procedure is approved by your teacher, run the simulation, and produce a graph of your data.

#### Part B:

Run the experiment again, this time incorporating partial cloud cover into your lab set-up. Decide as a group how to best accomplish this. After running this second set-up, produce a graph of your data. Compare and interpret the graphs from Part A & B--how do they illustrate possible albedos of the Earth's surface?



5. using computers with an interface box and probes

### Questions:

Answer the following questions by yourself, following a group discussion about the results of the lab exercise.

1. From Part A, which color of paper absorbed heat faster? Why?
2. From Part A, did the colored paper absorb heat faster than the aluminum foil? Why/why not?
3. From Part B, what effect did the "cloud" of cheesecloth have upon the colored paper surfaces and the aluminum foil? Relate this to the Earth's cloud cover and albedo.
4. What do you think would have happened if the colored papers and aluminum foil had been crumpled? Explain your answer relative to Earth colors and surfaces.

## Informative Rubric

	Proficient		Non-proficient	
	4	3	2	1
Development	Accurate, specific, and purposeful information is extended to fully explain the topic.	Accurate, specific, and purposeful information explains the topic with some extension of ideas.	Information is somewhat accurate but may be general or extraneous in the attempt to explain the topic.	Information is inadequate to explain the topic and is often inaccurate, general, or irrelevant.
Organization	The plan is logical, purposefully ordered, and uniquely enhances the understanding of the information.	The plan is usually logical, purposefully orders, and facilitates the understanding of the information.	The plan is somewhat logical, but the order sometimes interferes with the understanding of the information.	The plan is illogical and confusing.
Audience:	The intended audience is consistently addressed.	The intended audience is usually addressed.	The intended audience is sometimes addressed.	The intended audience is not addressed.
Language	Word choice is appropriate, extensive, and creative.	Word choice is appropriate and varied. Minor errors in usage, grammar, and mechanics may be present but do not interfere with meaning. Spelling follows known patterns.	Word choice is adequate but errors in usage, grammar, mechanics, and spelling interfere with meaning.	Word choice is limited. Many errors in usage, grammar, mechanics, and spelling are present and interfere with meaning.
Oral Presentation	There are very few, if any, errors in usage, grammar, and mechanics.	Presentation skills are usually applied to adequately convey content.	The partial application of presentation skills may detract from the content.	The lack of presentation skills thoroughly detract from the content.