

SURFACE ALBEDO AND GLOBAL CHANGE

Overview

Energy from the sun can be reflected back to space or absorbed by the earth. Albedo (pronounced al-bee-doh) is the amount of light reflected from a surface compared to the amount of light that strikes the surface. Light that is not reflected is absorbed by a surface is absorbed and can be observed as heat. In this interactive demonstration, students will learn about the relationship between reflectivity and temperature.

Target audience: K+; works well in a small group / STEM fair setting

Learning objectives

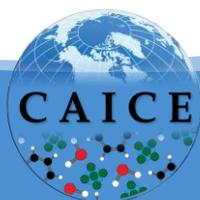
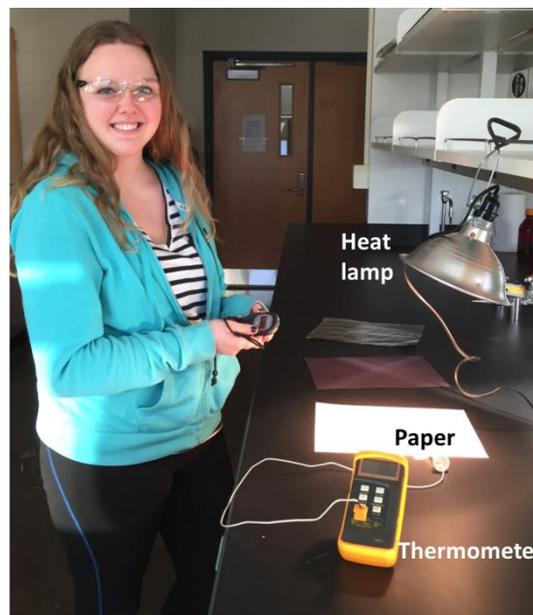
- Detect the temperature of a surface using your senses and a thermometer
- Detect the reflectivity of a surface using your senses.
- Compare temperature and reflectivity results of black and white surfaces.
- Make predictions about how global change will alter the earth's albedo and temperature.

Materials and supplies

- 2 heat lamps (with stands)
- Black and white papers
- Black and white plastic sheets and ice cubes
- Dual-channel thermometer (or two single-channel thermometers)

Set-up

1. Position the heat lamp above a flat surface (as shown in the picture to the right).
2. Underneath one lamp, place the black and white plastic sheets, each with an ice cube on top. To ensure comparable measurements, place the ice cubes so that they receive the same amount of light from the lamp.
3. Underneath the second lamp, place black or white paper, each with the temperature probe positioned underneath. To ensure comparable measurements, place the probes so that they receive the same amount of light from the lamp.



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Instructions

1. Start by asking your audience to make a prediction – *Will a black t-shirt or a white t-shirt keep you cooler on a hot summer day? Regardless of their prediction, let's find out!*
2. Explain that the heat lamp represents the sun, and the paper the different t-shirts.
 - a. Instruct the students to look at each piece of paper. *Which one is brighter? Which one is darker?*
 - b. After ensuring that the paper is a safe temperature (see safety notes below), encourage students to using their senses (hands), to examine which paper is warmer.
 - c. Then instruct the student to check the temperature of each paper using the thermometer.
 - d. Agree upon which colored paper is warmer.
3. Then ask “*Will an ice cube melt faster on a white or black surface?*” Examine the plastic and ice cubes and agree upon an answer.
4. Explain how the phenomenon works.

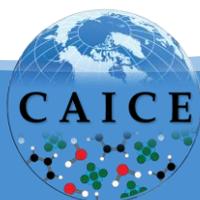
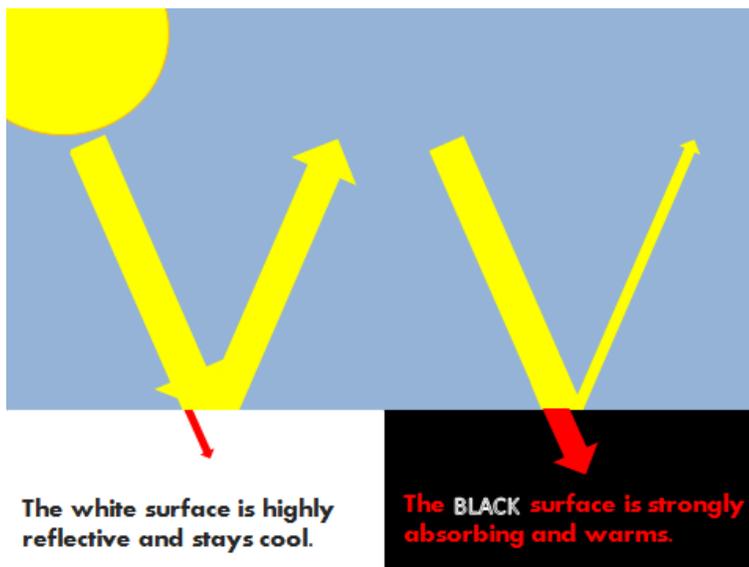
Safety

The heat lamp may become very hot if left on for extended periods of time. Use heat-resistant gloves or mitts when handling a hot lamp.

Use the thermometer to check the temperature of the paper. If it is less than 110 °F (or 43 °C), then it is safe for the students to touch the paper. If the temperature exceeds 110 °F omit step 2b and do not allow students to touch the paper. Turn off the heat lamp or increase the distance between the lamp and the paper until a safe temperature is reached.

Explanation

When light hits a surface, it can be reflected or absorbed as heat. The white surface is highly reflective (and appears bright) and scatters sunlight back where it came from. The black surface absorbs most of the light that encounters it, and gets warmer.



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On a global scale

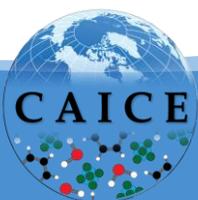
The earth's temperature is also affected by how its surface reflects and absorbs solar energy. On average, 30% of the sunlight reaching the earth's atmosphere is reflected, mostly by clouds. Clouds have a significant impact on the temperature of the earth and keep Earth cooler by reflecting the sun's energy back into space.



(NASA.gov)

Discussion Questions

1. Surface albedo in a single location can vary seasonally. Discuss how the surfaces where you live can be different in winter, spring, summer, and fall.
2. *Consider this...* Soot particles emitted into the atmosphere by burning biomass and fossil fuels can travel long distances to the Arctic circle and deposit on polar ice.
 - a) How would soot deposition change the albedo of polar ice?
 - b) If this change occurs, how would it affect polar ice?
 - c) How would this change in polar ice further affect albedo?
3. *Consider this...* An architect designing a residential development in Las Vegas, Nevada wishes to use building and landscaping materials that are naturally cooling. What materials would you suggest that the architect use and why?



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ANSWER KEY

Discussion Questions

1. Surface albedo in a single location can vary seasonally. Discuss how the surfaces where you live can be different in winter, spring, summer, and fall.
For example, corn fields in Iowa are snow and ice covered in the wintertime, making them highly reflective. After spring melting, dark topsoil is exposed, decreasing albedo. By summer, green crops cover the surface. In the autumn, corn dries and becomes golden in color.
2. *Consider this...* Soot particles emitted into the atmosphere by burning biomass and fossil fuels can travel long distances to the Arctic circle and deposit on polar ice.
 - a) How would soot deposition change the albedo of polar ice? It would darken the surface, decreasing its reflectivity.
 - b) If this change occurs, how would it affect polar ice? The Earth's surface would be less reflective and would become warmer. This could cause the ice to melt.
 - c) How would this change in polar affect albedo? As polar ice melts, the poles turn from white in color to blue ocean. The ocean is less reflective (and more light-absorbing) so it heats up even further.
3. *Consider this...* An architect designing a residential development in Las Vegas, Nevada wishes to use building and landscaping materials that are naturally cooling. What materials would you suggest that the architect use and why?
Reflective surfaces (like aluminum) and light colors (like white) will reflect more light and keep buildings cooler.

