Measuring Albedo

Setting the Stage

When solar radiation (short wave radiation) reaches Earth, part of the energy is absorbed by the surface, while the rest is reflected back into space. The more energy (heat) that is absorbed, the more temperatures will increase. In this lesson, students will measure the reflectance (albedo) of different surfaces and come up with a rule to describe the relationship between the color of a surface and its albedo.

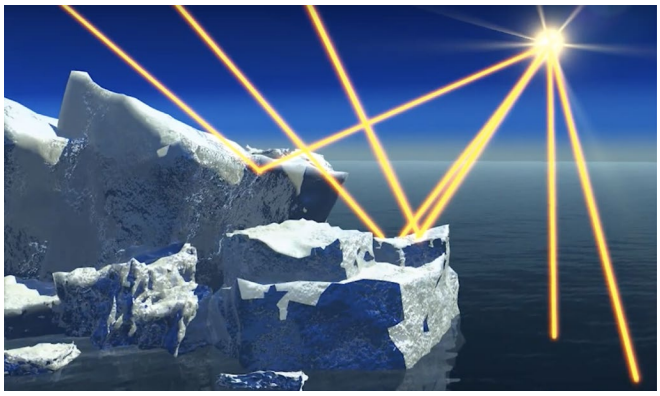

Image Credit: NASA

Lesson Overview

- *Part 1 – (30 minutes) Measuring Albedo*
  Students will measure the albedo of different colored surfaces using an Albedo app.
- *Part 2 – (20 minutes) Albedo and Ice Demonstration*
  Students will identify and describe the relationship between albedo and temperature in this demonstration. Demonstration can be implemented by the teacher or completed by students.
- *Part 3 – (10 minutes) Update Earth's energy budget model worksheet*
  Students update their "Earth's energy budget model worksheet" to include concepts related to albedo and sea ice loss.
- *Part 4 – (10 minutes) Summary Table*
  Students reflect on their learning and how it helps them understand the unit driving question.

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Instructional Overview	
Grade Level	Middle/High School
Instructional Time	70 minutes
Standards Alignment	**NGSS Disciplinary Core Ideas:** ● ESS2.A: Earth Materials and Systems **NGSS Science and Engineering Practices:** ● Constructing Explanations **NGSS Crosscutting Concepts:** ● Energy and Matter ● Structure and Function
Unit Driving Question	● Why might the Arctic be warming twice as fast as the rest of the world?
Driving Question(s) For This Lesson	● What is the relationship between the color of a surface and its albedo? ● What happens to energy that is not reflected by a surface? ● How could a decline in sea ice affect the Arctic's albedo and temperature?
Learning Goals	● Describe the relationship between the color and albedo ● Describe the relationship between albedo and temperature
Materials	❑ Measuring Albedo PPT ❑ Measuring Albedo student worksheet (1 per student) ❑ Answer Key ❑ "Earth's energy budget model" worksheet (Students should have a copy of this worksheet as it was distributed and modified in the previous lesson) ❑ Blank worksheet ❑ Summary Table ❑ Initial Ideas Public Record Part 1 Materials: ❑ Technology (iphone, ipads) with the Albedo app downloaded ❑ Note: Must download the Albedo app to devices prior to lesson! ❑ Photographers gray card or gray paper printout (1 per student) Part 2 Materials ❑ White poster board, to represent ice ❑ Dark poster board, to represent ocean ❑ A dark, water resistant surface such as a plastic plate, and a comparable light-colored surface

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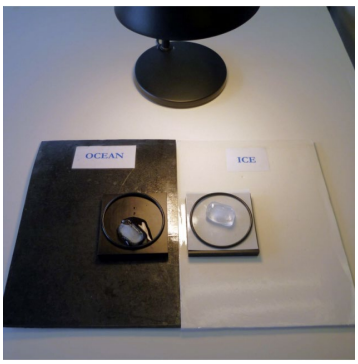
	❑ Ice cubes ❑ Timer/stopwatch ❑ Desk lamp (or can be done outside on a sunny day) Optional: ❑ Homework/Exit Ticket ❑ Video: Annual Arctic sea ice minimum 1979-2019 with area graph ❑ Arctic sea ice growing younger, thinner 
Material Preparation	❑ Print student worksheets ❑ Cue and test web links ❑ Review presenter notes from the Measuring Albedo PPT ❑ Review Answer Key ❑ Display summary table and initial ideas public record. Part 1: ❑ **Download** the Albedo app to all devices (ipads, iphones). Test the app using a photographers gray card/gray paper, and two different color sheets of papers (black and white). Part 2: Note: Demonstration can be implemented by the teacher or completed by students. ❑ Gather materials and arrange lab station(s) **Set Up: Albedo and Ice Demonstration** 1. Place dark and light surfaces (e.g., poster boards, paper, etc.) evenly under the lamp 2. Place dark plate and light plate on similarly colored surface (e.g., dark plate goes on dark surface -- poster board or paper) 3. Place one ice cube on each plate 4. Turn on the light and start the time 5. Students observe and record the results on student worksheet

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Vocabulary	Albedo: Reflectivity of a surface

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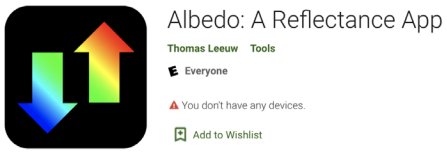
Part 1 - Measuring Albedo (30 minutes)

Refer to Part 1 slides included in the Measuring Albedo PPT. See PPT presenter notes for additional information.

- Note: Download “Albedo: A Reflectance App” to all devices prior to the start of class.

1. Introduce the term albedo to students (see PPT)
    a. Read through the background information (see student worksheet) as a whole class referencing the albedo image in slides.
    b. Model the “Albedo: A Reflectance App” procedure for students (see PPT)



2. Students use the Albedo app to complete their data table and answer Part 1 questions.
    a. Review Part 1 questions as a whole class

Teacher Tip:

- Use the class discussion surrounding question 3, “What do you think happens to the energy (sunlight) that is not reflected off of the surface?” to segue into Part 2 - the Albedo and Ice Demonstration.

Part 2 - Albedo and Ice Demonstration (20 minutes)

Refer to Part 2 slides included in the Measuring Albedo PPT. See PPT presenter notes for additional information.

***Note: The “Albedo and Ice Demonstration” can be implemented as a teacher demonstration or completed by students. Depending on the strength of the light, it may take up to 10 minutes for the ice to melt away. Consider using this time to show a few data visualizations of Arctic sea ice loss.

1. Procedure:
    a. Place dark and light surfaces (e.g., poster boards, paper, etc.) evenly under the lamp
    b. Place dark plate and light plate on similarly colored surface (e.g., dark plate goes on dark surface -- poster board or paper)
    c. Place one ice cube on each plate
    d. Turn on the light and start the time
    e. Observe and record the results on student worksheet

Optional:
While students wait for their ice to melt, watch and discuss the Arctic sea ice data

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visualizations below:

- Video: Annual Arctic sea ice minimum 1979-2019 with area graph
- Arctic sea ice growing younger, thinner

2. Discuss as a class:
    a. What happened? Why do you think the ice cube on the light/dark colored surface melted faster?
    b. Which colored surface (dark or light) do you think absorbed more energy from the lamp/sun?
    c. Which colored surface (dark or light) do you think reflected more energy from the lamp/sun?
    d. How does light affect the temperature of surfaces with different colors?

Part 3 - Update Earth's energy budget model worksheet (10 minutes)

Refer to Part 3 slides included in the Measuring Albedo PPT. See PPT presenter notes for additional information.

1. Teacher guides students through updating their "Earth's energy budget model worksheet" to include information about changes to the amount of shortwave and longwave energy coming and going from the Arctic over the past ~2 decades (2000-2018).The teacher should update the class model under a document camera (see Answer Key for example). Students may want to use colored pencils to copy the whole class model onto their worksheet.

Teacher Note: Remind students that they will refer to and update the "Earth's energy budget model worksheet" with new information/concepts at the end of each class.

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Part 4 - Summary Table (10 minutes)

Refer to Part 4 slides included in the Measuring Albedo PPT. See PPT presenter notes for additional information.

1. Students work in groups to reflect on their learning and how it relates back to the unit driving question, “Why might the Arctic be warming twice as fast as the rest of the world?”

2. Facilitate a discussion in which students come to a consensus about what they learned and how it helps them understand the unit driving question. Ideas/concepts agreed upon by the class should be included in the summary table (see Answer Key).
    a. Students record new summary table entries onto their own summary tables.

Optional Extension: Homework/Exit Ticket

- Students provide a short explanation and create a sketch to describe how a decline in sea ice will affect the Arctic’s albedo and temperature.

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