



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

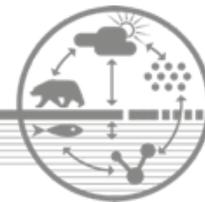
Lesson Overview

- *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) Exit Ticket/Update Summary Table*
Students reflect on their learning by completing an exit ticket and updating the whole class summary table.



Instructional Overview	
Grade Level	Middle/High School
Instructional Time	60 minutes
Standards Alignment	<p>NGSS Scientific Knowledge is based on Empirical Evidence:</p> <ul style="list-style-type: none"> Science knowledge is based upon logical and conceptual connections between evidence and explanations. <p>NGSS Disciplinary Core Ideas:</p> <ul style="list-style-type: none"> PS4.B: Electromagnetic Radiation <p>NGSS Science and Engineering Practices:</p> <ul style="list-style-type: none"> Planning and Carrying Out Investigations Constructing Explanations <p>NGSS Crosscutting Concepts:</p> <ul style="list-style-type: none"> Energy and Matter
Unit Driving Question	<ul style="list-style-type: none"> How have scientific questions, methods, technologies, and our knowledge of the Arctic changed over time?
Driving Question(s) For This Lesson	<ul style="list-style-type: none"> What is the relationship between the color of a surface and its albedo? How does light affect the temperature of surfaces with different colors? How could a decline in sea ice affect the Arctic's albedo and temperature?
Learning Goals	<ul style="list-style-type: none"> Describe the relationship between the color and albedo Describe the relationship between albedo and temperature
Materials	<ul style="list-style-type: none"> <input type="checkbox"/> Measuring Albedo PPT <input type="checkbox"/> Measuring Albedo student worksheet (1 per student) <input type="checkbox"/> Exit Ticket Rubric <input type="checkbox"/> Answer Key <input type="checkbox"/> Technology (iphone, ipads) with the Albedo: A Reflectance App downloaded <ul style="list-style-type: none"> <input type="checkbox"/> Note: Must download the "Albedo: A Reflectance App" to devices prior to lesson! <input type="checkbox"/> Photographers gray card or gray paper printout (1 per student) <input type="checkbox"/> Summary Table - <i>if using entire unit</i> (large butcher paper or digital copy, 1 per class) <p><u>Part 2 Materials</u></p> <ul style="list-style-type: none"> <input type="checkbox"/> White poster board, to represent ice <input type="checkbox"/> Dark poster board, to represent ocean <input type="checkbox"/> A dark, water resistant surface such as a plastic plate, and a comparable light-colored surface <input type="checkbox"/> Ice cubes





	<ul style="list-style-type: none"> <input type="checkbox"/> Timer/stopwatch <input type="checkbox"/> Desk lamp (or can be done outside on a sunny day) <p>Optional:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Video: Annual Arctic sea ice minimum 1979-2019 with area graph <input type="checkbox"/> Video: Arctic sea ice growing younger, thinner <input type="checkbox"/> MOSAiC Distributed Network virtual reality Google Expedition
<p>Material Preparation</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Print student worksheets <input type="checkbox"/> Cue and test web links <input type="checkbox"/> Review presenter notes from the Measuring Albedo PPT <input type="checkbox"/> Display summary table- <i>if using entire unit</i> <p>Part 1:</p> <ul style="list-style-type: none"> <input type="checkbox"/> 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). <p>Part 2:</p> <p>Note: Demonstration can be implemented by the teacher or completed by students.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Gather materials and arrange lab station(s) <p>Set Up: Albedo and Ice Demonstration</p> <ol style="list-style-type: none"> 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
<p>Vocabulary</p>	<p><u>Albedo</u>: Reflectivity of a surface</p>



Part 1 - Measuring Albedo (30 minutes)

Driving Question: What is the relationship between color and albedo?

Refer to Part 1 slides included in the [Measuring Albedo PPT](#). See PPT presenter notes for additional information.

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



Albedo: A Reflectance App

Thomas Leeuw Tools

Everyone

▲ You don't have any devices.

🔖 Add to Wishlist

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)

Driving Question: How does light affect the temperature of surfaces with different colors?

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.

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 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 dark/light 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 - Exit Ticket/Update Summary Table (10 minutes)

Refer to Part 3 slides included in the [Measuring Albedo PPT](#). See PPT presenter notes for additional information.

1. Exit Ticket - Students create an explanation and annotated sketch to answer the question, "If sea ice continues to decline in thickness and extent, how will it affect the Arctic's reflectance (albedo) and temperature? Why?"
 - a. Project and describe the [Exit Ticket Rubric](#) to the class before they begin the assessment as this is what you will use to grade their exit tickets.
2. Update Summary Table (**if using entire unit**) - Gather student ideas to update the MOSAiC Motivation box in the summary table (see [Answer Key](#)).

Optional: [MOSAiC Distributed Network virtual reality Google Expedition](#)

Have students engage with MOSAiC science and Arctic fieldwork in this [virtual reality Google Expedition](#) focused on the research stations deployed as part of MOSAiC's Distributed Network. Consider having students create a list of instruments/science being conducted as part of the MOSAiC expedition. Add MOSAiC instruments/science identified by students to the MOSAiC "Investigation" box in the whole class summary table.