



Part A: Exploring Arctic Climate Data - Teacher Guide

Setting the Stage

Students will learn about albedo and feedback loops in the climate system. They will practice calculating albedo as a simple ratio of incoming to outgoing short-wave radiation.



Albedo Sketch Sea Ice. Photo Credit: NASA

Lesson Overview

In this lesson, students will calculate albedo and make sense of their data.

- **Lesson 1** – (30 minutes) *Understanding Albedo*
Students will calculate albedo values and answer questions about their data.

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| Instructional Overview | |
|------------------------|--|
| Grade Level | Middle/High School |
| Instructional Time | 50 minutes (<i>total time needed</i>) |
| Activity 3 Goals | <ul style="list-style-type: none">• Calculate albedo from incoming and outgoing radiation data• Use known values to make sense of the calculated data• How to plot data and make sense of graphs<ul style="list-style-type: none">• Apply knowledge about albedo and the climate system to |



| | |
|--------------------------------|--|
| | understanding Arctic change |
| Lesson Driving Question | <ul style="list-style-type: none">• How do you calculate albedo?• How do you evaluate the data that you calculated? |
| Building Toward | NGSS: ESS2D , LS2C |
| NGSS Dimensions | <p>Science and Engineering Practices:</p> <ul style="list-style-type: none">• Analyzing and Interpreting Data• Using Mathematics and Computational Thinking <p>Disciplinary Core Ideas:</p> <ul style="list-style-type: none">• Earth's Systems |
| Materials | <ul style="list-style-type: none"><input type="checkbox"/> Powerpoint Slides<input type="checkbox"/> Student Worksheet |
| Material Preparation | <ul style="list-style-type: none"><input type="checkbox"/> Print copy of Student Worksheet for each student |
| Vocabulary | <p><u>Albedo</u> is a measure of how much light a surface reflects, with 0 representing no reflection (black) and 1 representing total reflection (white), and it refers to the fraction of sunlight or radiation that is diffusely reflected by a surface.</p> |

Lesson 1: Understanding Albedo (50 minutes)

How does surface material affect albedo and solar radiation reflection?

Albedo is the ratio of incoming solar radiation that is reflected back into space. Albedo is expressed as a value from 0 to 1, with 1 meaning that 100% of the incoming solar radiation is bounced off the surface, and 0 meaning that all of the incoming radiation is absorbed by the surface of the Earth.

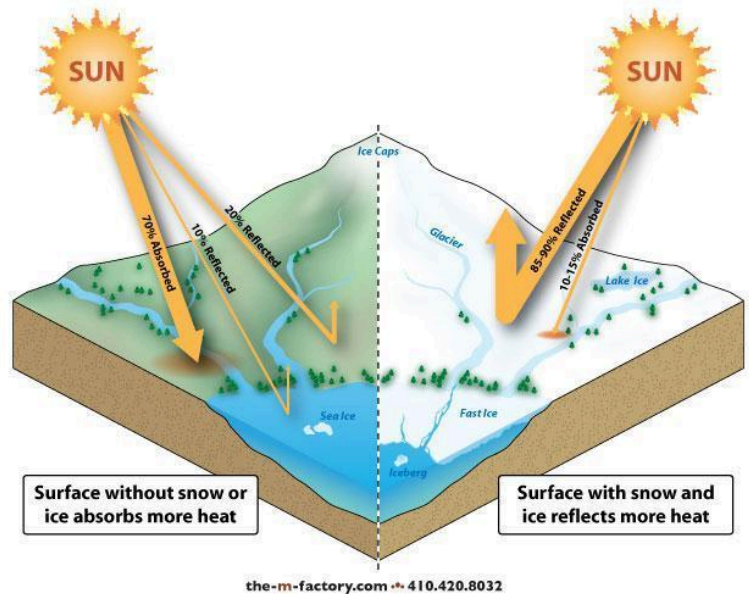
Note that albedo can be expressed either as a ratio or as a percentage. While reading about albedo, you are likely to find values expressed either way, for example, 30% or 0.30.

A surface that reflects most of the radiation it receives has *high albedo*.

1. Give an example of a surface that has high albedo.
2. Explain your reasoning. Why do you think this surface has high albedo?

A surface that absorbs most of the radiation it receives has *low albedo*.

3. Give an example of a surface that has low albedo.
4. Why do you think this is true?



Albedo Schematic. Photo Credit: Smithsonian Institution.

The mathematical definition of albedo is the ratio of incoming to outgoing shortwave radiation.

$$\frac{\text{incoming shortwave radiation (w/m}^2\text{)}}{\text{outgoing shortwave radiation (w/m}^2\text{)}} = \text{albedo (unitless)}$$

Incoming shortwave radiation is energy that comes from the Sun. It is expressed in units of watts per square meter. In other words, the value tells us how many watts of energy are received per square meter of land area.

5. On the graph of incoming short-wave radiation, why is the value zero in November–February?



Calculate some practice albedo values. Use the graphs of incoming shortwave radiation and outgoing shortwave radiation to calculate albedo.

| On May 1 | On July 1 |
|-----------------------|-----------------------|
| Incoming (downward) = | Incoming (downward) = |
| Outgoing (upward) = | Outgoing (upward) = |
| Albedo = | Albedo = |

6. Confirm your answers with the data on the albedo graph. Do they agree?

Compare your calculated albedo values with known averages for the following surfaces:

- Asphalt 0.05 - 0.10
- Forest 0.05 - 0.20
- Tundra 0.18 - 0.25
- Open ocean 0.06
- Sea ice 0.50 - 0.70
- Snow 0.40 - 0.95 (*Fresh snow is up to .95 reflective, meaning it reflects back 95% of the incoming sunlight. Very dirty snow is in the 0.4 range. Recent work in Greenland found ice with albedo as low as 0.3.*)
- Earth and atmosphere average 0.30

7. Explain your two values with respect to these average values. Do they make sense?

Find more curriculum here:

<https://ceee.colorado.edu/resources/arctic-climate-connections>