Data Puzzles

To Reflect or Not to Reflect, That is the Question - Teacher Guide

Setting the Stage

Earth receives almost all of its energy from the Sun. When the Sun's energy reaches Earth, part of the energy is absorbed by the surface, while the rest is reflected back into space. The more energy that is absorbed, the more temperatures will increase. Whether the Sun's energy is reflected or absorbed by Earth's surface is a function of the color of the surface. Lighter colored surfaces (e.g., sea ice) have a higher reflectivity (albedo) than darker colored surfaces, which means that darker colored surfaces absorb more of the Sun's energy. Over the past four decades, Arctic sea ice has declined thereby exposing more of the darker ocean. Climate scientists are monitoring not only the sea ice but are also using satellites to measure changes in the Arctic's albedo and temperature. After two decades of nearly continuous measurements, scientists have come to the conclusion that the decline in sea ice has led to a decrease in the Arctic's albedo and is one of the reasons the Arctic is warming at a rate much faster than the rest of the world. *Photo Credit: NASA.*

Lesson Overview

In this Data Puzzle, students analyze and interpret authentic Arctic data to explain how the Arctic's albedo is affected by the decline in sea ice.

Part 1 – (10 minutes) Eliciting Students' Ideas
Access students' prior knowledge about an opening scenario.

Part 2 – (30 minutes) Identifying Important Science Ideas
Students engage with a contemporary science investigation through an interactive reading in which students are tasked with 1) making connections between the science investigation and the opening scenario, and 2) identifying an investigative question.

Part 3 – (40 minutes) Supporting Ongoing Changes in Thinking
Students test/compare their current understandings of the investigative question against authentic data.

Part 4 – (30 minutes) Constructing Evidence-Based Explanations
Students finalize new understandings as they relate to the investigative question to create an explanatory model.

Data Puzzles

Data used in this data puzzle was collected by scientists that are part of the MOSAiC research project. The materials were developed by CIRES Education and Outreach at CU Boulder with support from AGS 1554659 and OPP 1839104. Find more MOSAiC curriculum at http://mosaic.colorado.edu

Instructional Overview	
Grade Level	Middle/High School
Instructional Time	~180 minutes
Building Toward	**NGSS Disciplinary Core Idea:** ● ESS2.D: Weather and Climate **NGSS Science and Engineering Practices:** ● Analyzing and Interpreting Data ● Constructing Explanations **NGSS Crosscutting Concepts:** ● Energy and Matter ● Cause and Effect ● Stability and Change
Driving Question	● How might the Arctic's albedo be affected by the observed decline in sea ice?
What Students Will Do	● Analyze and interpret Arctic albedo (energy) data to evaluate the effect of declining (change) sea ice on the Arctic system. ● Construct a model to explain how declining sea ice is changing the Arctic's albedo (energy).
Materials	❏ Slide deck ❏ Student worksheet ❏ Answer Key
Material Preparation	❏ Print student worksheets ❏ Review presenter notes in Lesson slides ❏ Review Answer Key ❏ Gather public record materials (e.g., butcher paper and markers, Google Doc, Jamboard, etc.) ❏ Review this "Public record examples" document
Vocabulary	● Arctic sea ice extent - Area of the Arctic Ocean covered by sea ice ● Albedo - Reflectivity of a surface

Part 1 - Eliciting Students' Ideas

10 minutes

Refer to Part 1 slides included in the slide deck. See presenter notes for additional information.

1. Watch the "Surface Matters" video and facilitate a whole-class discussion focused on students' noticings and wonderings as they relate to the video. Then, ask students to consider how different surfaces (asphalt vs. grass) could be different temperatures on the same sunny day.

2. Explain to students that some surfaces are better at reflecting the Sun's energy than others (a function of color). Then, ask students to study an image in which a group of people is painting a dark-colored rooftop white and consider the prompt: *"Why might these people be painting the roof white?"*

3. Introduce students to Dr. Jen Kay, the scientist featured in this Data Puzzle, who uses satellite data to study changes in the amount of sunlight reflected off of the Earth's surface (albedo). Jen is particularly interested in understanding how declining sea ice in the Arctic might impact the Arctic's albedo.

Part 2 - Identifying Important Science Ideas

30 minutes

Refer to Part 2 slides included in the slide deck. See presenter notes for additional information.

1. Students read the puzzle plot text included in the student worksheet either individually, in small groups, or as a whole class. While reading, students are asked to do the following tasks:
    a. Circle the investigative question the scientists are investigating.
    b. Underline similarities between the reading and the opening scenario.

2. Show the following videos (*the links are also embedded in the puzzle plot text*) to help students visualize concepts presented in the text..
    a. Annual Arctic Sea Ice Minimum 1979-2022 (0:45 minutes)

3. Facilitate a whole-class discussion to help make connections between the reading and the opening scenario by utilizing the following prompts:
    a. Do you think there are similarities between the reading and the opening scenario? Why or why not?

4. Students summarize important science ideas presented in the puzzle plot by drawing and describing how sunlight shining on sea ice differs from sunlight shining on ocean water.

5. Students make a prediction for the investigative question that they will test in Part 3 by analyzing real data.

Part 3 - Supporting Ongoing Changes in Thinking

40 minutes

Refer to Part 3 slides included in the slide deck. See presenter notes for additional information.

1. The datasets students will analyze were collected from Defense Meteorological Satellite Program (DMSP) satellites and from CERES instruments that were attached to different NASA satellites. Introduce students to the datasets through discussion and watching a video about how scientists are monitoring Earth's albedo.
    a. Aque CERES Tracking Earth's Heat Balance (watch from 0-1:54 minutes)

2. Model for students or give students time to visit the NASA satellites (Aqua, Terra, and Suomi NPP) upon which CERES instruments were attached.

3. Use the prompts embedded in the slide deck to help orient students to the datasets by giving them an opportunity to study and discuss the graphs both individually and with a partner.

4. Students work in pairs to identify patterns in the datasets.

5. Based on the patterns identified, students create a rule (if present) to describe the relationship between the factors represented in the graph.

6. Students cite evidence from the graph to evaluate whether or not the data supported or refuted their initial prediction for the investigative question.

Part 4 - Constructing Evidence-Based Explanations

30 minutes

Refer to Part 4 slides included in the slide deck. See presenter notes for additional information.

1. Utilize the slide deck to describe what should be included in a scientific model and analyze an example of an explanatory model.

2. Students work in pairs to construct their explanatory models for the investigative question.

Note: If there is disagreement amongst students about what should be included in their explanatory models, consider creating a "Gotta Have Checklist", a whole-class public record in which students collaboratively identify the parts and conventions (signs/symbols connecting parts) that you just gotta have in your model.

3. Students share their explanatory models.
    a. Model sharing can be facilitated as a gallery walk, in small groups, or as a whole class.

4. Digging Deeper - Students consider how declining sea ice might affect Arctic temperatures?

Additional Teacher Resources
Videos • "What is Albedo?" https://www.youtube.com/watch?v=uWZEvZ118DM&feature=emb_logo • Learn more about the Clouds and Earth's Radiant Energy System (CERES) project in this video produced by NASA: https://www.youtube.com/watch?v=uVkfh89iyeU&feature=emb_logo • "Arctic Feedbacks" https://www.youtube.com/watch?v=3qyT43pbUus • "Ice Albedo - Global view" video developed by NASA https://www.youtube.com/watch?v=qdgMAFFcF_8&feature=emb_logo • "Earth's Delicate Energy Balance" video produced by the California Academy of Sciences

https://www.youtube.com/watch?v=U2CPwWgY_G4

Data visualizations

- "The Arctic is absorbing more sunlight" from NASA earth observatory https://earthobservatory.nasa.gov/images/84930/the-arctic-is-absorbing-more-sunlight#:~:text=No%20other%20region%20on%20Earth,Ocean%20for%20the%20entire%20summer.
- NASA visualization: "Annual Arctic Sea Ice Minimum 1979-2019 with Area Graph" https://www.youtube.com/watch?v=Ymph_i6VWbM&feature=emb_logo
- "Visualizing the 2012 Sea Ice Minimum" from NASA earth observatory https://earthobservatory.nasa.gov/images/79256/visualizing-the-2012-sea-ice-minimum