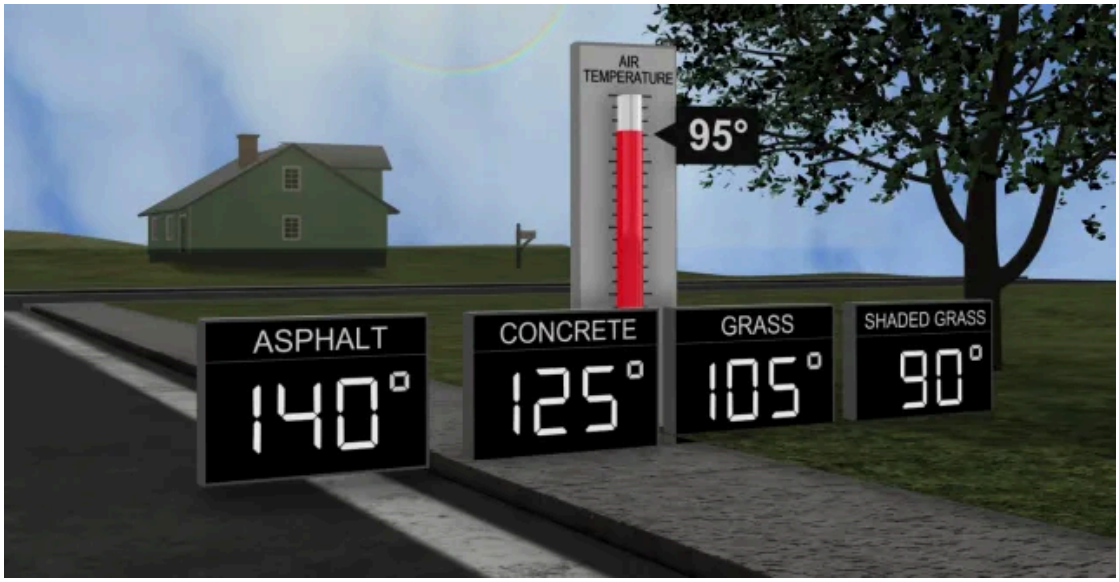
WARM UP



1. What do you notice or wonder?

2. How can different surfaces be at different temperatures on the same sunny day?

OBJECTIVE

SWBAT analyze and interpret Arctic albedo (energy) data to evaluate the effect of declining (change) sea ice on the Arctic system (HS-ESS2-2).
SWBAT develop conceptual models to explain how declining sea ice is changing the Arctic's albedo (energy) (HS-ESS2-4).

Criteria For Success (CFS)

Students will receive a minimum score of an 80% on the exit ticket

To reflect, or not to reflect, that is the question

Directions:

- Circle the investigative question the scientists are investigating.
- Highlight similarities between the reading and the warm-up scenario.

Puzzle Plot

Since 1978, satellites have monitored changes in the extent (area covered) of Arctic sea ice. Records show that Arctic sea ice reaches its minimum extent (smallest size) at the end of summer every September. Scientists compare each September's sea ice extent to data from years past and have discovered an alarming pattern - sea ice is declining...rapidly (Figure 1).

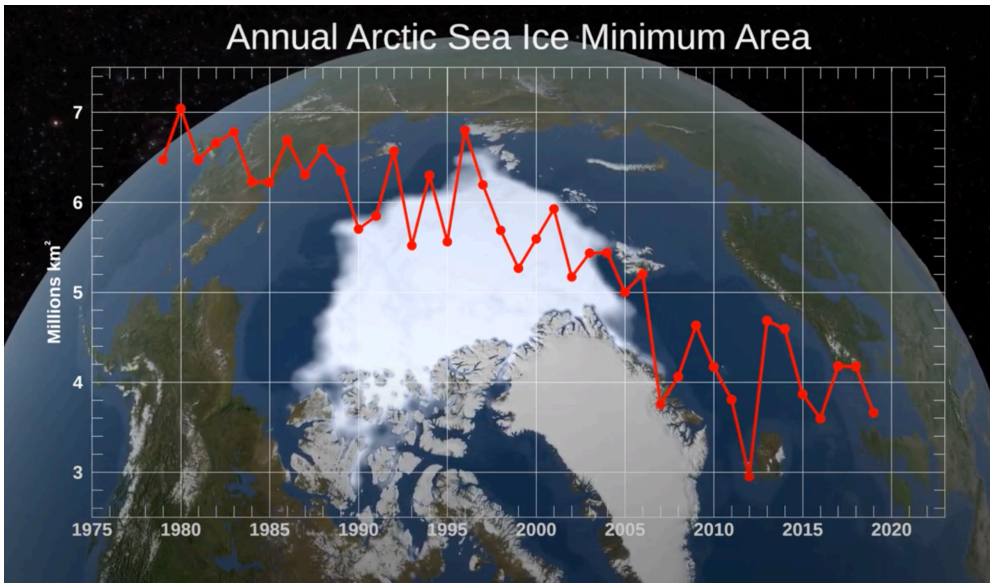


Figure 1. Arctic sea ice minimum extent for each year from 1979 through 2022. Watch NASA's Arctic sea ice data visualization here.

Why does this matter? Well, it turns out that Arctic sea ice plays a major role in the Arctic climate system! When solar energy (energy from the Sun) reaches Earth, part of the energy is absorbed by the surface (leading to an increase in temperature), while the rest is reflected back into space. This reflectivity is called albedo and is described using the following equation:

$$albedo = \frac{\text{solar energy reflected}}{\text{total amount of solar energy}}$$

The higher the albedo value, the more energy is reflected off a surface. Complete reflection is 1 and complete absorption is 0 (Figure 2). Sea ice reflects about 60% of solar energy striking its surface, so its albedo measurement is 0.60 (Figure 3). This means that 40% (40%=100%-60%) of the solar energy that reaches the sea ice is absorbed. In contrast, the ocean reflects only about 6% of the solar energy striking its surface, so its albedo measurement is 0.06. This means that 94% (94%=100%-6%) of the solar energy that reaches the ocean is absorbed.

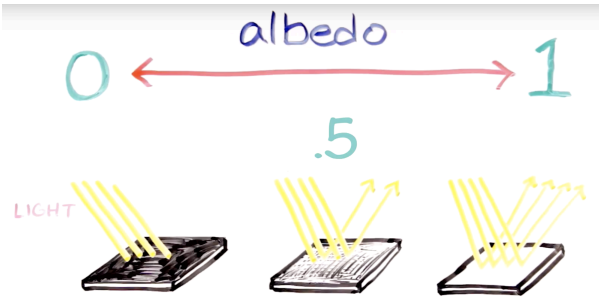


Figure 2. Albedo (reflectivity) is measured on a scale from 0 to 1. Darker colors reflect less **insolation** (light energy) than lighter colors. Image: Univ. of Arizona/WGBH Ed. Found.

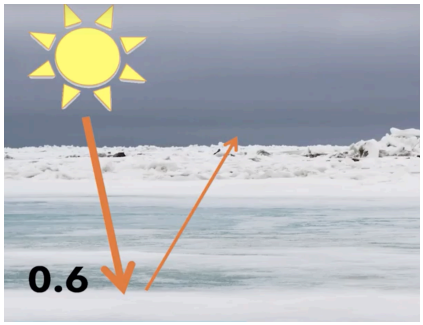


Figure 3. Arctic sea ice has an approximate albedo of 0.6 which means that it reflects ~60% of the Sun's energy striking its surface. Image: CIRES

Scientist Jen Kay is part of a team of researchers working to understand how Earth's energy budget changes over time and space. Earth's energy budget describes the balance between the energy that is reaching Earth from the Sun and the energy that is flowing back out into space from the Earth. Jen is particularly interested in the Arctic's energy budget, and is investigating the following question, "how might the Arctic's albedo be affected by the observed decline in sea ice?" Jen knows that lighter-colored surfaces (e.g., white) have a higher albedo than darker-colored surfaces (e.g., black) and predicts that the decline in the light-colored sea ice will cause the albedo of the Arctic to decrease as well. Scientists like Jen worry that if the albedo of the Arctic declines, the energy that used to be reflected will be absorbed and lead to increased warming in the Arctic.

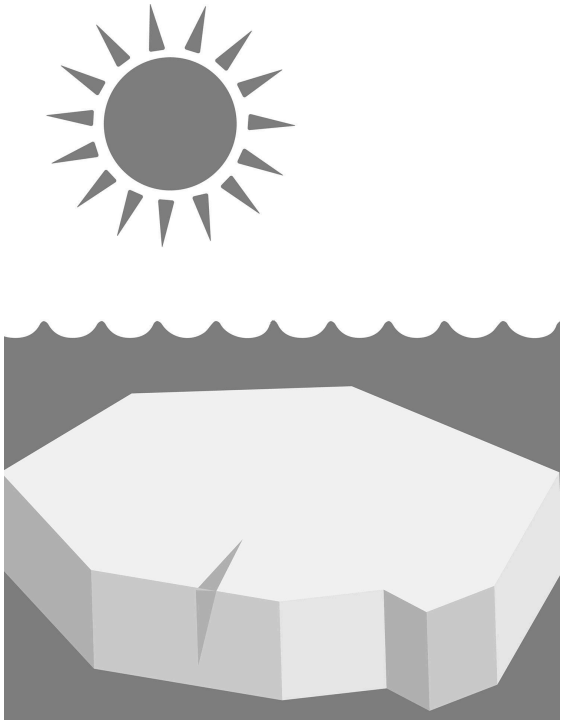
Jen uses incoming and reflected solar radiation data collected from satellites as part of the Clouds and Earth's Radiant Energy System (CERES) project to determine the changes in the Arctic's albedo. Jen compares these albedo data to changes in the extent of sea ice to test her prediction.

Video

Do you think there are similarities between the video, reading, and warm-up? Why or why not?

Identifying Important Science Ideas

1. **Draw and describe** how the sunlight shining on sea ice differs from sunlight shining on ocean water.

Annotate the image below	2-3 sentence explanation
	How does sunlight shining on sea ice differ from sunlight shining on ocean water?

2. **Investigative question**: What question is Jen investigating?

3. **Make a prediction about the investigative question**:

I predict that the Arctic's albedo will increase, decrease, or stay the same (circle one) as the extent of Arctic sea ice declines because…

Supporting Ongoing Changes in Thinking

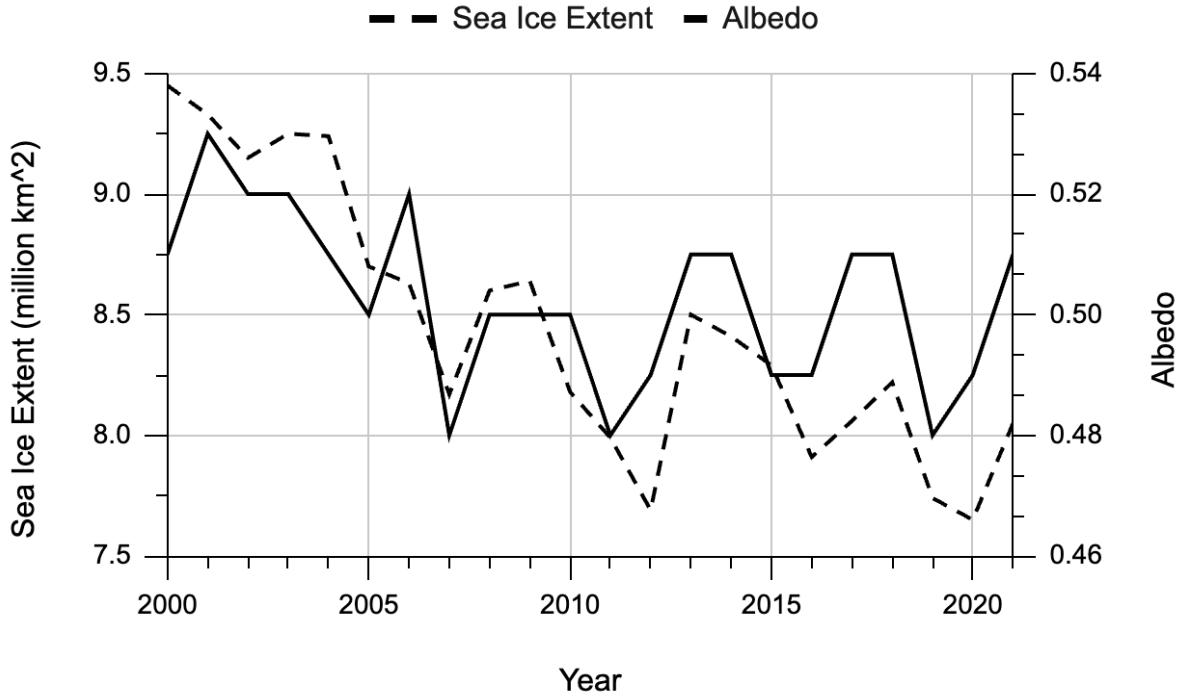
The datasets were collected from Defense Meteorological Satellite Program (DMSP) satellites and from CERES instruments that were attached to different NASA satellites. Aque CERES Tracking Earth's Heat Balance (watch from 0-1:54 minutes).

Explore the datasets - https://eyes.nasa.gov/apps/earth/#/

Dataset	Observations

Instructions: Refer to the graph below to answer questions #4-8.

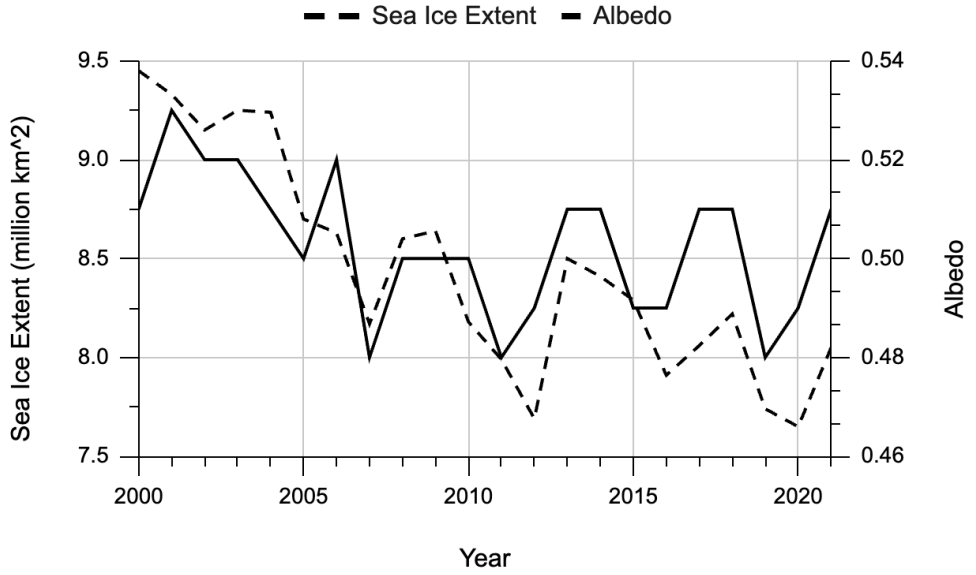
Title: Average albedo and sea ice extent during Arctic summers from 2000-2021.



4. Find the data for 2001. Based on the graph, what was happening to the sea ice and to the albedo in 2001?

5. Now find the data for 2012. Based on the graph, what was happening to the sea ice and to the albedo in 2012?

Title: Average albedo and sea ice extent during Arctic summers from 2000-2021.



6. What patterns do you observe in the data?

- _____
- _____
- _____
- _____
- _____

7. Based on the patterns you identified, create a rule to describe the relationship between sea ice extent and albedo. *Example: As x increases, y decreases.*

_____

_____

_____

8. **Revisit your prediction:** Did the data support your prediction for the investigative question (*see question 3*)? Explain.

_____

_____

_____

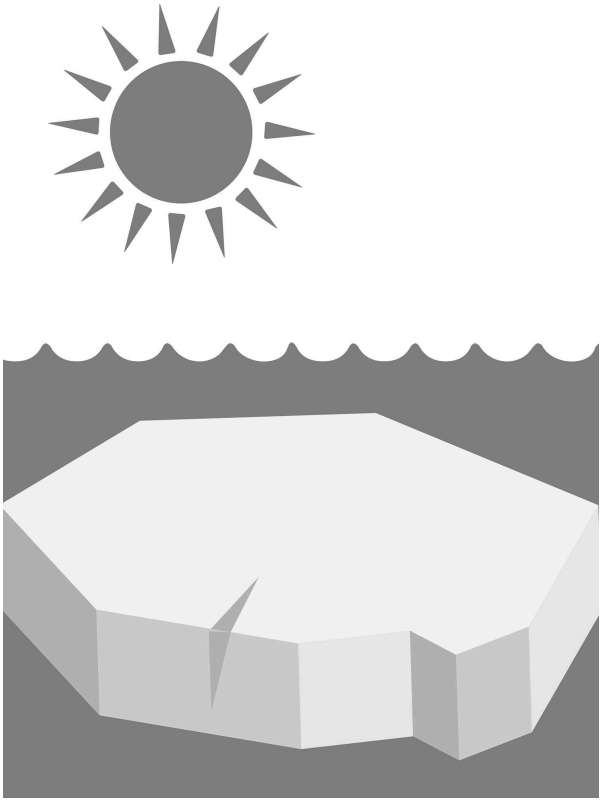
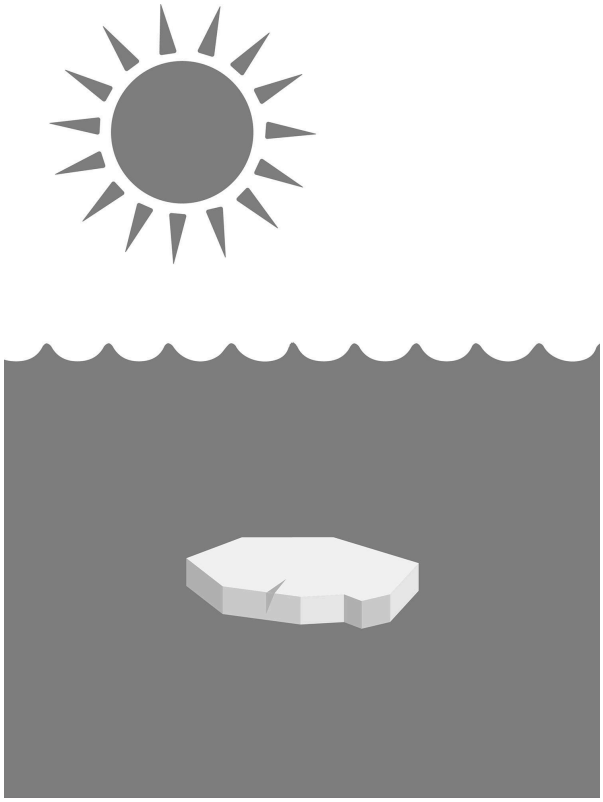
Constructing Evidence-Based Explanations

Scientists use models (e.g., annotated sketches, 3D replicas) to visualize explanations to questions they are investigating!

9. Gotta-Have-Checklist: A gotta-have checklist is a list of ideas and evidence that are needed to fully explain a question. Use the table below to create your own gotta-have checklist.

What ideas do we need to have to answer the question "How much the Arctic's albedo be affected by the observed decline in sea ice?"	What evidence do you have to support these ideas (*e.g., a number from the graph*)?
• •	• •

10. **Develop a model** (annotated sketch) to explain the investigative question, "How might the Arctic's albedo be affected by the observed decline in sea ice?"

More sea ice	Less sea ice
	

Claim A: Declining sea ice causes warming due to albedo changes.
Claim B: Declining sea ice is just a result of warming, not a cause.

11. **Argue from Evidence:** Use evidence from the dataset to argue which claim is better supported.

12. **Digging deeper**: How might the decline in sea ice affect temperatures in the Arctic?

Exit Ticket Grade

_____/_____

Name: _____

Date: _____

Class: _____

OBJECTIVE

SWBAT analyze and interpret Arctic albedo (energy) data to evaluate the effect of declining (change) sea ice on the Arctic system.

(NOVICE) 1 2 3 4 5 (MASTERY)

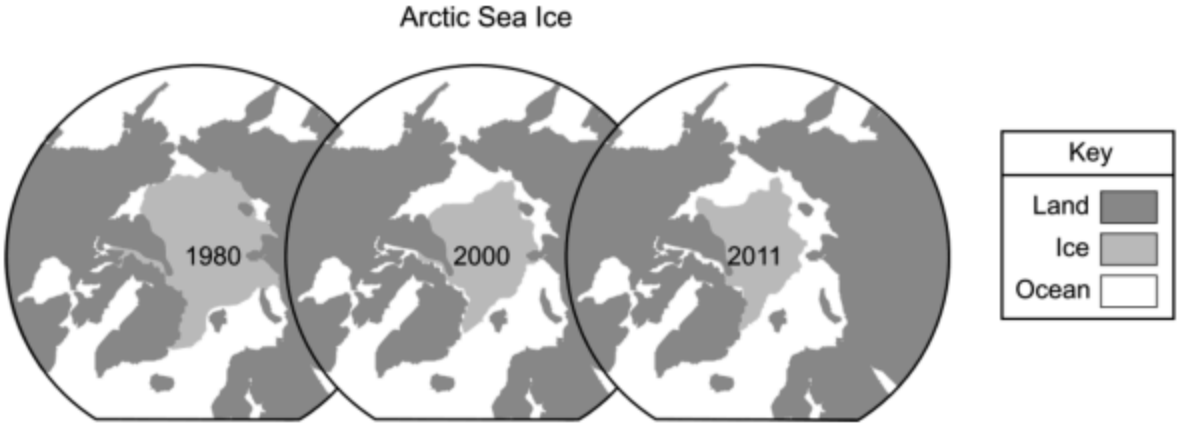
SWBAT develop conceptual models to explain how declining sea ice is changing the Arctic's albedo (energy).

(NOVICE) 1 2 3 4 5 (MASTERY)

Exit Ticket

1. Snow on the ground prevents polar climates from gaining heat by what mechanism?
   a. heating by greenhouse gases
   b. heat spread from the equator
   c. reflection of solar radiation
   d. release of heat from Earth's core

The north polar view maps below show the average area covered by Arctic Sea ice in September of 1980, 2000, and 2011.



2. The maps best support the inference that Earth's climate is
   a. cooling, because the average area covered by Arctic Sea ice is decreasing
   b. cooling, because the average area covered by Arctic Sea ice is increasing
   c. warming, because the average area covered by Arctic Sea ice is decreasing
   d. warming, because the average area covered by Arctic Sea ice is increasing

Base your answer to the following questions on the data table and your knowledge of Earth and Space science. The data table shows the average percentage of insolation from 2006 to 2012 that was reflected during the summer months by the ice sheet that covers a large portion of Greenland.

Data Table

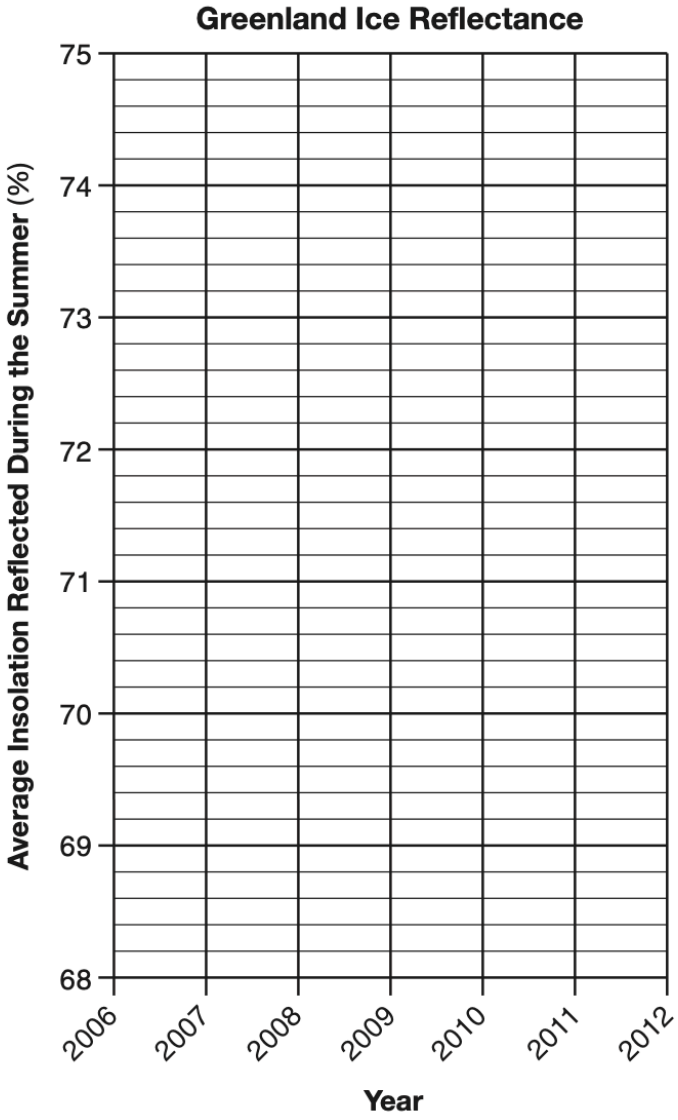
Year	Average Insolation Reflected During the Summer (%)
2006	74.3
2007	72.8
2008	72.9
2009	71.8
2010	70.3
2011	70.1
2012	68.3

3. On the grid, construct a line graph by plotting the average insolation reflected during the summer by the Greenland ice sheet from 2006 to 2012. Connect *all seven* plots with a line.

4. Describe one characteristic of the ice sheet that makes it a good reflector of insolation.

_____

_____



5. Describe the general trend for the average insolation reflected by the Greenland ice sheet from 2006 to 2012 and state what can be inferred about the change in size of the Greenland ice sheet during this time period.

Insolation-reflected trend: _____

Inferred change in size: _____