

THINKING AND ACTING
LIKE A
SCIENTIST

TEACHER'S GUIDE

Glacial Ice Timeline

How does global temperature affect glacial ice volume over time?

GRADES 9–12

Earth & Space





Glacial Ice Timeline

Grade Level/Content	9–12/Earth and Space Science
Lesson Summary	In this lesson, students construct an evidence-based timeline and forecast of the relationship between global temperature and glacial ice volume.
Estimated Time	5, 45-minute class periods
Materials	computer with Internet access, scissors, glue, markers, additional art supplies for posters, 3-panel poster board, Investigation Plan , journal
Secondary Resources	Alaska Satellite Facility: How do glaciers move? AntarcticGlaciers.org: Mapping the World's Glaciers National Snow and Ice Data Center: Where are glaciers located?
NGSS Connection	HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
Learning Objectives	<ul style="list-style-type: none">• Students explain characteristics of the glacial life cycle.• Students collect and display historical glacial ice volume on an evidence-based timeline.• Students write an explanation that describes the effect of temperature on glacial ice volume.

How does global temperature affect glacial ice volume over time?

In July 2017, a block of ice the size of Delaware broke off the Larsen C Ice Shelf in Antarctica. This was the end result of the crack scientists observed in 1960 when they first photographed the thousand-foot-thick shelf of ice floating on the sea. A new trillion-ton iceberg named A-68 broke off and began floating in the Weddell Sea. Scientists observed more cracks in the iceberg and predict it will break into smaller bergs as it moves farther out to sea.

Glaciers all over the world accumulate new ice and shed old ice as seasons change. Calving, the process of an ice chunk breaking off a glacier, occurs in glaciers of all sizes, so the action itself wasn't surprising. The timing was the concern. In 2014, the crack on Larsen C began to grow rapidly, alarming scientists. On May 31, 2017, the crack's leading edge was 8 miles from the edge. By July 12, 2017, the crack's 25-mile journey was complete. Was this rapid change due to rising temperatures or just a normal part of a glacier's lifecycle? In this investigation, students construct an evidence-based timeline and forecast the relationship between temperature and glacial ice volume over time. They share their findings in a classroom gallery walk.

Investigation is based on the Van Andel Education Institute (VAEI) Instructional Model for Inquiry-Based Science.
In all investigations:



Students don't know the "answer" they are supposed to get.



Students play a driving role in determining the process for learning.



Teachers and students construct meaning together by journaling.



Students are working as hard as the teacher.

Part 1

INVESTIGATION SETUP

Students will need the following:

- Computer with Internet access
- Scissors
- Glue
- Markers
- Additional art supplies as needed
- 3-panel poster board
- [Investigation Plan](#)
- Journal

Part 2

INVESTIGATION FACILITATION



Question

Introduce the investigation question.

How does temperature affect glacial ice volume over time for _____?

- Have students work in groups of three for this lesson.
- Assign each small group a different region to study using this enlarged [Mapping the World's Glaciers](#) figure or the National Snow and Ice Data Center's [Where are glaciers located](#) chart.

CURIOSITY

To promote curiosity, show students images of glaciers and glacial features from various websites. Have students begin to ask questions about what they see. Encourage them to write these questions in their journals.



Personal Knowledge

Students capture what they already know about glaciers and how temperature affects glaciers over time.

- Before students start their research, set aside time for them to share and discuss within their small groups what they already know about glaciers and the effect of temperature on glaciers. Have students discuss where glaciers exist on Earth and how they form and change over time.
- Remind students to write down what they know in their journals.

COLLABORATION

Have students engage in a *Round Robin* group brainstorming activity to ensure all students participate. Each student is given an index card and personally reflects on the prompt. After the initial independent brainstorm, the group compiles a list from the individual cards and records additional ideas. Each group shares their list with the class.

Investigation Plan

Students gather information from secondary sources to determine how temperature affects glacial ice volume over time.

- Remind students to read the entire [Investigation Plan](#) before they begin working.
- Have each small group conduct preliminary research to select one or more glaciers in their assigned region that will provide them with enough data to write an explanation and construct a timeline for their classroom gallery poster board presentation.
- Have each student in the small group choose a topic (glacial ice volume, glacial life cycle, or temperature) that they will research about their chosen glacier(s) and present to their own group and eventually to the class.
- Have students research and collect enough data (information and images) to be able to explain their chosen topic and answer the investigation question.
- Remind students to cite their sources as they are gathering information. Discuss with students how to evaluate sources to ensure that information is valid and reliable.
- After the initial research phase is completed, ask students to meet with members of the other class groups in their topic category (glacial life cycle, ice volume, or temperature) to compare notes and share ideas.
- Inform students to complete their research and compile the data (information and images) and share within their small group. This combined information will be used in their data analysis.

INVESTIGATION PLAN GLACIAL ICE TIMELINE

1. Select a glacier in your assigned region. Make sure it will provide enough information and images to write an explanation to your investigation question and construct a poster board panel for a gallery walk.
2. Within your groups, decide who will be researching the following categories regarding your chosen glacier(s):
 - GLACIAL LIFE CYCLE:** Explain the characteristics of the glacial life cycle.
 - GLACIAL ICE VOLUME:** Collect and compare historical glacial ice volume on an evidence-based timeline.
 - TEMPERATURE:** Collect and compare historical temperatures (weather data) on an evidence-based timeline.
3. Begin the research for your assigned category. Collect enough data (information and images) to explain your topic on one poster board panel. Be sure to use credible sources and cite the sources you use. Record the data you collect and its sources in your journal.
4. After the initial research phase is completed, meet with members of the other class groups in your category (glacial life cycle, ice volume, or temperature) to compare notes and share ideas.
5. Complete your research and compile the data (information and images) to share with your small group.

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Investigation Plan

CRITICAL THINKING

Use the [Fair Test](#) checklist to help students think critically about the investigation plan. Help them understand that a good investigation plan must include a test that is repeatable, generates quality data, and minimizes error. The more critically students think about their investigation plan, the more confident they can be in their results.



Observation

Students record information about glacial life cycle, temperature, and glacial ice volume over time.

Have students record their findings in their journals. Encourage them to organize their data in a way that allows them to analyze their data. This analyzed data will be used in their explanation.

SELF-DIRECTION

As students work in small groups to investigate the glacier(s) in their assigned region, they will encounter diagrams, photographs, and satellite images during their research. Some show changes over centuries while others show changes over decades. Each group will decide which images best show their glacier(s) over time.

PERSEVERANCE

The students in each group researching the temperature category will need to compare data by years, not by the date an image was taken, as temperatures during the accumulation and the ablation seasons both affect the size of a glacier. Historical weather data is recorded as monthly averages for an entire year. The lack of weather data for an older image may require replacing that image or using temperature data that may or may not accurately reflect the weather at the glacier site.

Part 3

INVESTIGATION ANALYSIS AND DEVELOPMENT OF CLAIM



Data Analysis

Students make sense of their data by organizing it and representing it visually.

- Have students analyze their data. They may wish to use the [Data Analysis](#) prompt as a guide.
- Have students **evaluate** their data for trustworthiness. Ask: *Are you confident in the data you collected? How confident are you in the sources you used?*
- Then, have them analyze their data to find patterns and trends. They may **re-organize** the data and/or **represent** it visually to construct meaning.
- Have students **interpret** what the identified patterns or trends mean.
- Remind students to consider the natural life cycle of a glacier. The type of weather data used (on site, regional, or global) also needs to be taken into consideration.
- Ensure they have enough data that it can be used as evidence to support a claim.

COLLABORATION

To interpret patterns in their data, students must work together to share and analyze the data they collected individually. Students will meet with members of their assigned region group to determine how temperature affects glacial ice volume over time. The students in each small group must work together and review all of their data to analyze for evidence to make a claim.



Secondary Knowledge

Students use secondary sources to understand how temperature affects glacial ice volume over time.

Introduce these secondary sources to provide a deeper understanding of the science of glaciers:

Alaska Satellite Facility: [How do glaciers move?](#)

AntarcticGlaciers.org: [Mapping the World's Glaciers](#)

National Snow and Ice Data Center: [Where are glaciers located?](#)

After reviewing these glacier websites, students should understand how temperature affects glacial ice volume over time. Students use this information in the reasoning portion of their explanation.



Explanation

Students write a claim and provide evidence and reasoning to support it.

- Have students use what they've discovered from their analyzed data to write an explanation that answers their investigation question. Students may wish to use the [Explanation](#) prompt as a guide. Have them write their explanation in their journal.
- Have students develop a **Claim** to answer the question: How does temperature affect glacial ice volume over time for _____?
- Then, have them add **Evidence** (the analyzed data) to support their claim.
- Finally, have them add **Reasoning** to their claim. Reasoning should include the information obtained from this investigation as well as science principles they have learned.

Continued

Claim

Temperature affects glacial ice volume over time by influencing the amount of snow that accumulates and turns into glacial ice during the cooler accumulation season. It also influences the amount of ice that melts, evaporates, or breaks off during the warmer ablation season.

Evidence

Evidence gathered for our timeline shows that more ice builds up when the temperature is below freezing for prolonged periods and more ice melts when the temperature is above freezing for prolonged periods.

Reasoning

Investigation: We followed the investigation plan and used credible resources. We combined data from multiple sources to strengthen our claim.

Science: Glaciers are rivers of snow that have turned into ice over time. The glacier-forming process takes years. Snow falls and is covered by more snow to become a dense snowpack. Snow that does not melt after a year is called firn or névé. As the firn becomes denser and loses contact with the atmosphere, it gradually turns into glacial ice, a solid mass that flows in response to gravity.

Glaciers have two main zones: the accumulation zone at the top where snow compacts and turns to ice and the ablation zone at the bottom where the glacier loses ice due to melting, evaporation, or calving (breaking into chunks). The size of a glacier changes due to the temperature and the amount of precipitation over time. If more ice and snow remain due to the temperature, the glacier will grow larger. If more ice and snow are lost due to the temperature, the glacier will shrink. If the accumulation and the ablation in a year are the same, the size of the glacier will remain the same.

Earth experiences cycles of warming and cooling periods. In recent years, the dramatic rise in temperature exceeds levels predicted by historical patterns. Glacial ice core samples provide data that links temperature changes to glacial volume.

Note: Evidence gathered for the claim will vary by source and the period studied.



Evaluation

Students reflect on the investigation.

- Ask students to suggest alternative explanations for their results. Have them provide evidence to support their ideas.
- Have students think back to the things they learned in their research. Then, have them name one thing they found surprising.

Part 4

INVESTIGATION ASSESSMENT AND EXTENSION

Students demonstrate an understanding of how temperature affects glacial ice volume over time by explaining the characteristics of the glacial life cycle and constructing an evidence-based timeline.



Application

- Have students create a 3-panel poster presentation of their findings to share in their classroom gallery walk.
- Have each small group conduct a [Present and Defend](#) to the class during the gallery walk.

DISCOURSE

Have students conduct a [Present and Defend](#) to develop presentation skills as well as audience participation. Research partners present a summary of their investigation to the class. The class analyzes the information presented and asks clarifying questions, challenges and/or supports the arguments made, and even presents alternative explanations as appropriate. Research teams defend their explanation with evidence and reasoning.

Assessment

- For a **formative assessment**, after the initial research is completed, conduct a cross-group “experts” meeting for students who researched the same category (glacial life cycle, ice volume, or temperature) to compare notes and share ideas. Monitor the expert groups and meet with individual students one-on-one as needed.
- For a **summative assessment**, evaluate each small group’s [Present and Defend](#) during the classroom gallery walk. Evaluate the students investigations on how well they:
 - explain the characteristics of the glacial life cycle.
 - collect and compare historical glacial ice volume on an evidence-based timeline.
 - collect and compare historical temperatures on an evidence-based timeline.
 - write explanations describing the relationship between temperature and glacial ice volume.

Extension

- For further study, students can investigate another type of glacier found in the region they studied or in another region of the world. Types of glaciers they might study are mountain glaciers, valley glaciers, tidewater glaciers, piedmont glaciers, hanging glaciers, cirque glaciers, ice aprons, rock glaciers, ice shelves, icefields, ice caps, ice streams, and ice sheets.

For additional lessons or to customize this lesson, go to www.nexgeninquiry.org.

INVESTIGATION PLAN

GLACIAL ICE TIMELINE

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