Lesson 1: Pretest and Expressing Ideas and Questions

Overview

Students take the unit pretest, practice how and why scientists construct graphs to represent data and construct a graph of arctic sea ice extent from 1979-2015 and identify a trend in the data: arctic sea ice is declining.

Download PDF of Lesson 1 Teacher's Guide

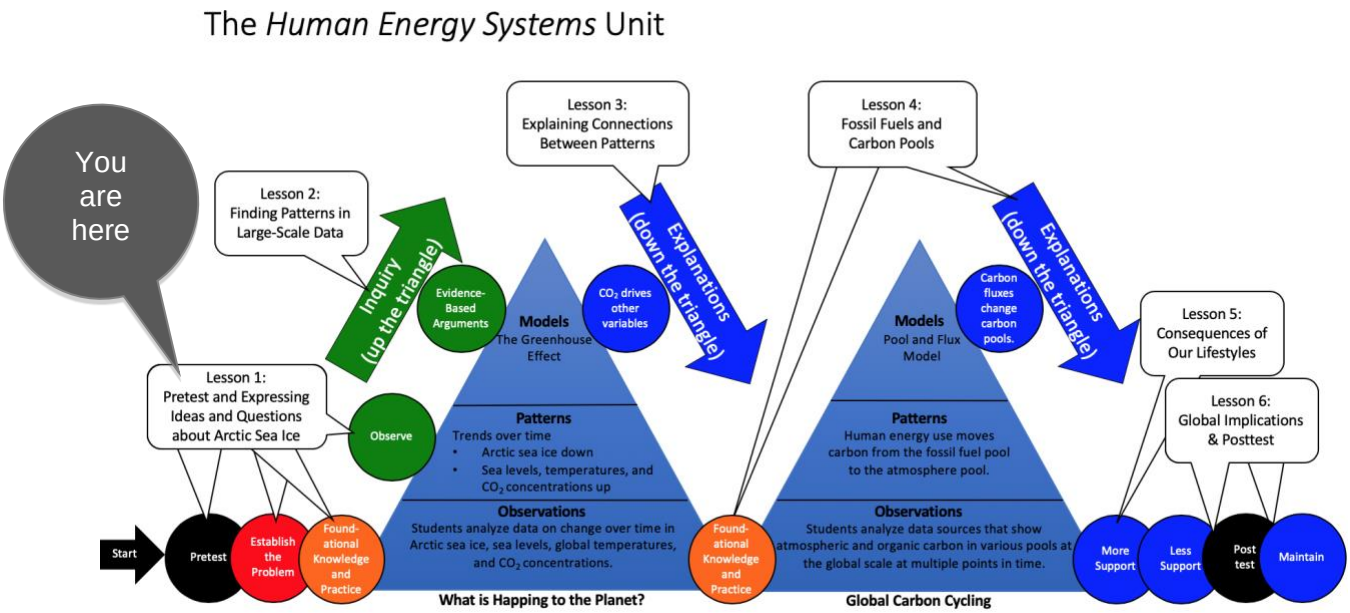
Guiding Question

What is happening to arctic sea ice?

Activities in this Lesson

- Activity 1.1: Human Energy Systems Unit Pretest (20 min)
- Activity 1.2: Expressing Ideas and Questions about Arctic Sea Ice (40 min)
- Activity 1.3: Graphing Arctic Sea Ice (45 min)
- Activity 1.4: Drawing a Trend Line (40 min)
- Activity 1.5: Finding a Trend in Arctic Sea Ice (40 min)

Unit Map



Learning Goals

Target Performances

Activity	*Target Performance*
Lesson 1 – Pretest and Expressing Ideas about Arctic Sea Ice (students as questioners and investigators)	
Activity 1.1 Human Energy Systems Unit Pretest (20 min)	Students show their initial proficiencies for the overall unit goals: 1. Questioning, investigating, and explaining how the Earth's climate is changing 2. Explaining and predicting how carbon cycles and energy flows in Earth systems.
Activity 1.2: Expressing Ideas and Questions about Arctic Sea Ice (40 min)	Students express ideas and record questions about why Arctic sea ice seems to be shrinking.
Activity 1.3: Graphing Arctic Sea Ice (45 min)	Students use data on Arctic sea ice to construct graphs showing patterns in changing coverage over time.
Activity 1.4: Drawing a Trend Line (40 min)	Students use multi-year averages to construct a trend line using data on Lake Superior ice cover.
Activity 1.5: Finding a Trend in Arctic Sea Ice Data (40 min)	Students use multi-year averages to construct a trend line using data on Arctic sea ice.

NGSS Performance Expectations

This lesson does not feature a mastery of any of the NGSS performance expectations but provides students with foundational practices and knowledge needed to master all of the performance expectations in the rest of the unit.

Background Information

Three-dimensional Learning Progression

Understanding data representations. Lessons 1 and 2 focus on helping students make sense of representations of data about Earth systems. This is difficult and challenging for many students. We see four interconnected issues:

1. Representation: Students see many different representations of data about Earth systems. For example, in Lesson 1 students see (a) animations of satellite data showing maps that change over time, (b) tables with numerical representations of sea ice extent, and (c) graphs showing patterns and trends. Students need to recognize that even though they look different, these are all representations of the same phenomena. They also need to recognize that the same variables (e.g., time, extent of sea ice) are represented in different ways, and that there are different choices about which data to represent from a larger data set.
2. Generalizability: Data about Earth systems are usually selected to be representative of patterns in systems, but the relationship between the patterns in the representation and the patterns in the Earth systems can be difficult and confusing. For example, students

make graphs after choosing one month (September) and recording data for September of each year. What patterns in these data extend to other months? How are patterns in these data connected to data from other places, such as the Antarctic or lakes that freeze over in North America? Students need to consider and answer questions such as these.

3. Short-term variability: Like many data sets about Earth systems, Arctic sea ice data show random variation from one year to the next; there is no good way to predict whether the extent of ice will go up or down in the next year, or how much. Most humans are very good at finding patterns, even when they don't really exist (this is why games of chance are so popular). So students need to recognize randomness and understand how it limits our ability to make claims about short-term patterns or predictions of how sea ice will change in the next year.
4. Long-term trends: Arctic sea ice is also like other Earth systems in that even when data are noisy in the short term, there can also be clear trends over longer periods of time. Students need to develop strategies for identifying and representing long term trends, such as the averaging strategy that they practice in Activity 1.5.

Explaining patterns in Earth systems data. Students need to recognize that random patterns in short-term variability are very difficult or impossible to explain, but that good explanations for long-term trends are often possible.

Some students will probably suggest that the decreasing trend in Arctic sea ice is due to "climate change" or "global warming." They need to recognize that this kind of explanation—recognizing relationships between variables—is useful, but doesn't go very far. Scientists look to understand *mechanisms:* How is climate change affecting Arctic sea ice, and what is causing climate change. We hope that Lesson 1 will end with these unanswered questions, to be addressed in later lessons.

Key Ideas and Practices for Each Activity

Activity 1.1 includes the pretest for this unit. The discussion in this activity (a) helps students to anticipate and begin thinking about the questions that they will answer in this lesson and (b) helps you as a teacher see how your students reason about patterns in Earth systems, including climate change and global carbon cycling.

Activity 1.2 establishes an important question: why is Arctic sea ice melting? Although students do not gather the evidence, they need to answer that question in this lesson, in this activity they are given an opportunity to share their initial ideas about why this phenomenon might be happening.

Activity 1.3 gives students an opportunity to practice interpreting data in the Arctic sea ice graph, which is one of many data sets they will use throughout the *Human Energy Systems* Unit. Students retrieve data from a publicly available data set about Arctic sea ice. They use the data to construct a graph. When they first construct the graph, it is difficult to see a trend due to the noisy nature of the data. They also discuss how different representations of data allow for different interpretation and knowledge.

In Activity 1.4, students use samples of messy data sets (similar to Arctic sea ice) to find a "signal in the noise." The students develop different strategies for finding a trend line in noisy data. Finding a trend is a key practice in analysis of scientific data sets. Finding global trends in merged data sets, for example, is how scientists have learned that climate change is taking place as a result of human activity. This activity helps students develop a critical eye when analyzing data that ideally will help them distinguish a pattern in noisy data.

In Activity 1.5, students then return to their graphs of Arctic sea ice and use the same strategies from the previous activity to find a trend in their arctic sea ice data. They discover that arctic sea ice extent is decreasing over time. However, at the end of this lesson they only have evidence to show that the ice is decreasing, but not why. These questions will be answered later in the unit when the students discuss the greenhouse effect and CO_2 emissions.

Content Boundaries and Extensions

Lesson 1 is intended to help students develop facility is working with Earth systems data and to encourage them in their roles as Questioners—generating questions about how and why the Earth is changing. The answers to those questions will come in later lessons.

Activity 1.1: Human Energy Systems Pretest (20 min)

Overview and Preparation

Target Student Performance

Students show their initial proficiencies for the overall unit goals:

1) Questioning, investigating, and explaining how the Earth's climate is changing
2) Explaining and predicting how carbon cycles and energy flows in Earth systems.

Resources You Provide

- pencils (1 per student, for paper version)

Resources Provided

- 1.1 Human Energy Systems Unit Pretest (1 per student)
- 1.1 Assessing the Human Energy Systems Unit Pretest

Setup

Print one copy of the 1.1 Human Energy Systems Unit Pretest for each student.

Directions

1. Describe the unit pretest.

Explain the purpose of the unit pretest to students:

- It will help you as a teacher understand how students think about global-scale carbon and energy.
- It will help them think about what they know and what questions they have.

2. Have students take the unit pretest.

Distribute copies of 1.1 Human Energy Systems Unit Pretest to be completed with paper and pencil.

Assessment

Use the 1.1 Human Energy Systems Unit Pretest to assess students' understanding of global carbon and energy cycling in terms of learning progression levels. You should not give your students grades on the pretest or expect your students to know the correct answers. The document 1.1 Assessing the Human Energy Systems Unit Pretest has assessment guidelines and identifies correct responses and explaining how students' responses reveal their learning progression levels.

Differentiation & Extending the Learning

Differentiation

- If classroom in includes English Language Learners or have other special needs and considerations, you may want to read questions aloud and discuss meaning of questions.

Modifications

Extending the Learning

Activity 1.2: Expressing Ideas and Questions About Arctic Sea Ice (40 min)

Overview and Preparation

Target Student Performance

Students express ideas and record questions about why Arctic sea ice seems to be shrinking.

Resources You Provide

- sticky notes (1 per student)
- (Optional) Powers of Ten video (http://www.youtube.com/watch?v=0fKBhvDjuy0)

Resources Provided

- 1.2 Expressing Ideas and Questions about Arctic Sea Ice PPT
- 1.2 Expressing Ideas and Questions Tool for Arctic Sea Ice (1 per student)
- 1.2 Assessing the Expressing Ideas and Questions Tool for Arctic Sea Ice
- 1.2 Human Energy Systems Storyline Reading: Learning from the Work of an Atmospheric Chemist (1 per student)

Recurring Resources

- Questions, Connections, Questions Student Reading Strategy
- (Optional) Big Idea Probe: What Would Happen if We Cut Fossil Fuel Use in Half? (1 per student)
- (Optional) Assessing Big Idea Probe: What Would Happen if We Cut Fossil Fuel Use in Half?
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Setup

Prepare a computer with a projector to display the 1.2 Expressing Ideas and Questions about Arctic Sea Ice PPT. If you are planning on using the poster to record student ideas, print the poster ahead of class and prepare sticky notes for each student. Print one copy for each student of 1.2 Expressing Ideas Tool for Arctic Sea Ice and 1.2 Human Energy Systems Storyline Reading: Learning from the Work of an Atmospheric Chemist.

Directions

1. Use the instructional model to show students where they are in the course of the unit. Show slide 2 of the 1.2 Expressing Ideas and Questions about Arctic Sea Ice PPT.
2. Have students discuss the pretest. Ask students to share questions they have after taking the pretest. Explain that we will try to answer most of those during the *Human Energy Systems* unit.
3. Introduce students to the goal of the unit. Tell students that in this unit, the main goal is to understand what happens to the planet when humans use energy (e.g., when they use electricity, drive cars, or eat food). In this first lesson, they will be exploring a specific phenomenon: changes in arctic sea ice. Tell them that scientists and citizens are very interesting in what is happening to arctic sea ice, and it will be

their job in this lesson to figure out what is happening and how we know that. This lesson has three main goals:

a) to record their "initial ideas" about why arctic sea ice is melting,
b) to create a graphic representation of arctic sea ice data and find a trend in the data, and
c) to discuss why and how scientists make and use graphs to represent data.

4. Introduce the new spatial scale of the unit.

Tell the students that in previous units, the "scale" was different for a few reasons (with the exception of the *Ecosystems* unit). First, explain that scale is different in terms of *space* (spatial scale).

- Open 1.2 Expressing Ideas about and Questions Arctic Sea Ice PPT and display Slide 3.
- Ask students to identify which spatial scale the previous units were (e.g., *Systems & Scale, Animals, Plants, Decomposers*).
- Tell students that this unit studies systems that are at a very large scale.
- Display Slide 4 to provide examples of which systems fall within the "large scale" row of the table on the slide. Point to the image of the Earth and tell them we will be studying systems that tell us what is happening on the entire planet, not just one organism.
- Optional: Re-watch the Powers of Ten Video from the Systems and Scale Unit and have students identify when in the video they read the "large scale" that this unit will study.

5. Introduce the new temporal scale of the unit.

Next, explain that scale is different in terms of *time* (temporal scale). In previous units, they studied changes that happened in a very short amount of time. In this unit they will study systems that span decades, hundreds, and even millions of years.

6. Show the students images of arctic sea ice.

Display Slide 5 of the PPT. Ask students to share anything they've heard about what is happening to the ice that covers the arctic ocean on the Earth's north pole.

7. Have students complete the Expressing Ideas Tool on their own.

Tell students that now they will take a few minutes to think and record their ideas about what happens to arctic sea ice over time.

- Give each student one copy of 1.2 Expressing Ideas and Questions Tool for Arctic Sea Ice.
- Display Slide 6 of the PPT, which matches the information they see on their Expressing Ideas Tool. Point out that the images represent sea ice from the same month 36 years apart.
- Give students about 10 minutes to complete the tool as individuals.
- Remind students that this is just the "Expressing Ideas" section. They should treat this like brainstorming and write down any ideas they can think of. Later in the unit they will return to these ideas to see how they've changed.

8. Students compare their own ideas with the ideas of their classmates.

Tell students that now that they have had a chance to record their ideas on their own, it is important to compare their ideas to their classmates' to see how they are similar and different, and also so we know how many different ideas there are in the class. Eventually we will want to reach consensus about these ideas, but at this point there may be a variety of different ideas and we want to talk about them.

- Divide students into pairs and have students compare their ideas on the 1.2 Expressing Ideas and Questions Tool for Arctic Sea Ice with each other.

9. Post ideas for class discussion.

Tell students that now that they have had a chance to write their ideas as individuals and as pairs, it is important to look at the range of ideas in the class. Again, at this point, do not correct any wrong ideas. Treat this as brainstorming: all ideas are on the table.

- Show slide 7 of the 1.2 Expressing Ideas and Questions about Arctic Sea Ice PPT.
- Give each pair 2 sticky notes.
- Tell students to write their most important idea from their Expressing Ideas Tools on a sticky note and put it on the board under the "Your Ideas" column.

Tell students to write their most important question from their Expressing Ideas Tools on a sticky note and put it on the board under the "Your Questions" column.

10. Class discussion

Lead a whole class discussion to examine the variety of student ideas and questions on the poster. Use the talk and writing moves at the beginning of this lesson to help with facilitating the class discussion – see the Notes part of the slide.

- Show slide 8 of the 1.2 Expressing Ideas and Questions about Arctic Sea Ice PPT. Note that this slide is a duplicate of the previous one but with a new heading. Take this time to discuss students' ideas, organize them according to patterns, etc.
- Later, you can use this duplicate slide as a record of class ideas for the future, either by saving the post-it notes or by taking a picture of them.

11. Students read the Human Energy Systems Storyline Reading

Show slide 9 of the 1.2 Expressing Ideas and Questions about Arctic Sea Ice PPT. Have students read 1.2 Human Energy Systems Storyline Reading using the Questions, Connections, Questions Student Reading Strategy. See the Questions, Connections, Questions Reading Strategy Educator Resource document for information about how to engage students with this strategy.

- After pairs are finished reading, have students share with the class what they found interesting and any questions they have.

12. Save the Expressing Ideas Tool for later.

Show slide 10 of the 1.2 Expressing Ideas and Questions about Arctic Sea Ice PPT.

- Tell students that they will revisit these ideas later in the unit to see how their thinking changes.
- The class can also return to shared ideas on Slide 8.

13. (Optional) Have students complete the Big Idea Probe: What Would Happen if We Cut Fossil Fuel Use in Half?

If you decide to use the Big Idea Probe: What Would Happen if We Cut Fossil Fuel Use in Half?, have students complete it and share their ideas. See the Assessing the Big Idea Probe: What Would Happen if We Cut Fossil Fuel Use in Half? And the educator resource Using Big Idea Probes for suggestions about how to use the Big Idea Probe.

Assessment

Use the student responses to the class discussions and also their ideas on the 1.2 Expressing Ideas and Questions Tool for Arctic Sea Ice, as well as the 1.2 Assessing the Expressing Ideas and Questions Tool for Arctic Sea Ice to assess their thinking at the beginning of the unit. By the end of the unit, students should be able to explain that arctic sea ice melt is a result of increased temperatures, which is a result of increases greenhouse gases, which is a result of human combustion of fossil fuels. For now, listen to students' ideas, with attention to how they describe cause and effect. Some students may not use a cause and effect model to describe why the ice is melting. Others may suggest that it is due to "pollution," "global warming," or humans doing generally "bad" things to the environment without being able to explain the mechanism that causes the ice to melt.

Tips

- Remember that this is the Expressing Ideas section of the unit. The goal is to get as many student ideas on the table as possible so they can compare their ideas with others and revisit their ideas later to see how they have changed. If students share incomplete or vague answers, ask them to elaborate and share as many details in their thinking as possible. This will make it easier to see how their ideas change over the course of the unit.

Differentiation & Extending the Learning

Differentiation

- Refer back to Expressing Ideas and Questions Tools from past units as a model.
- Strategic grouping with strong speakers
- Provide sentence stems to aid individual writing and for discussion
- Insist on ideas and questions from **all** students
- Emphasize that there are no incorrect answers and check for alternative ideas that may be cultural in nature

Modifications

Use Slide 7 of the PPT to record student ideas instead of using sticky notes. Or, transcribe the ideas on their sticky notes into the text on the slide so their ideas will be easier to return to later.

Extending the Learning

Activity 1.3: Graphing Arctic Sea Ice (45 min)

Overview and Preparation

Target Student Performance

Students use data on Arctic sea ice to construct graphs showing patterns in changing coverage over time.

Resources You Provide

- pencil (1 per student)

Resources Provided

- 1.3 Graphing Arctic Sea Ice PPT
- 1.3 Graphing Arctic Sea Ice Worksheet
- 1.3 Grading the Graphing Arctic Sea Ice Worksheet
- Website to retrieve data: http://nsidc.org/data/seaice_index/archives/image_select

Setup

Print one copy of the 1.3 Graphing Arctic Sea Ice Worksheet for each student. Prepare a computer and projector to display the PPT. If you plan on having students retrieve data themselves, prepare a computer with an Internet connection for each student or pair of students.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 1.3 Graphing Arctic Sea Ice PPT.

2. Discuss the problem with data.

Remind students that in this unit we will be examining systems at larger spatial and temporal scales than in previous units. This presents a problem: How do we know when we've looked at ENOUGH data to see a difference that is important? How do we know which data to pay attention to? In this lesson, we will explore these ideas.

3. Discuss different ways of representing data.

Explain that scientists use many different representations of data to help them understand and communicate what is happening to artic sea ice. In this activity, they will use data that scientists have collected to make a graph. But why do scientists do things like this? Ask students to share any examples they know about ways scientists and other people represent information:

- Open 1.3 Graphing Arctic Sea Ice PPT. Use slide 3 to elicit student ideas about different *ways* scientists and other people represent data. The pie chart is one example. Ask them for other ideas and record their ideas on the slide.
- Use slide 4 to then ask them *why* scientists do this. For example, why would scientists want to use a pie chart instead of numbers to represent data? Ask students to explain why each of the forms they suggest might be useful. Help students think about **Representation**: what different information (time period, data, etc.) can be displayed using different representations?

- Finally, use slide 5 to ask students why we might be using a graph to represent changes in arctic sea ice. Listen to their ideas and add (if necessary) that the graph will help us identify patterns in the data that we might not be able to see so easily in the images and numbers. Ask: *What will a graph allow us to see that these images don't?*

4. (Optional) Overview the basic components of a graph.

Some students may benefit from a brief refresher on the components of a graph.

- Use slide 6 to overview the primary components that they will use to represent the arctic sea ice data: the title, vertical axis, horizontal axis, units, and axis labels.
- Using the prompts on slide 7, assess your students' graph-reading practices: *What does the horizontal axis in this graph tell us? What does the vertical axis tell us? What do these graphs tell us about rainfall?*
- Use the Turn-and-Talk strategy to have students construct a 3-5 sentence description of the information in the graph.

Use the results of this turn-and-talk to assess if your students are able to proceed with the graph construction.

5. Demonstrate how to access the data and enter the data on the worksheet.

Tell students that it is their job to use data that scientists have collected about arctic sea ice to construct a graph. Go to the link above and demonstrate how to use the website to find different data points from different years.

- Demonstrate how to find data by entering Hemisphere→ Northern, Start Year → 1979, Start Month→ September, and Image→ Sea Ice Extent, Check the "Fixed Month Animations" Box. You should see the data point at the bottom of the image: Total Extent = 7.2 million sq. km. Advance the viewer one year at a time by clicking the "1>" button.
- Distribute one copy of 1.3 Graphing Arctic Sea Ice Graph Worksheet to each student.
- Tell students to input this first data point into the **table** (not graph) on Page 1 of their worksheet. Wait to see if there are any questions about this.

6. Have students complete the table on Page 1 of the worksheet.

There are two options for this step:

- Option 1: Instruct students to go to the website themselves and collect the data to complete Table 1. If you choose this option, demonstrate for students how to find the data for 1979 as an example.
- Option 2: Use the images in the presentation (Slides 10-45) to have students complete the table.
- Use slides 8-9 of the PPT to overview their options and to show them where to find the data on the images.

7. Discuss any patterns visible in the images and numbers alone.

After the table is completed but before constructing the graph, ask students for their ideas about the data as represented by numbers (in the table) and pictures (in the presentation or online).

- Ask students: *What patterns do you see in the numbers? What patterns do you see in the pictures?*

- Scroll through the images in the presentation again if necessary. Listen to the students' ideas at this point. Do they notice any patterns? Do the different representations allow them to notice anything different in the data? If so, which ones? If not, why not?

8. Have students construct a graph of the data.

Tell students it is their job to plot the data points from their data table onto the graph on Page 2 of their worksheet.

- Divide students into pairs.
- Instruct one student to read the data points, and the other to plot the graph.
- Give students about 10 minutes to construct their graphs.
- Remind students that the graphs need labels for title and axes, too.

9. Have students share reflections on the graph-making process.

Have students share with the class what they chose for their axis labels and their titles. Ask students to look at the graphs and ask them: *What does this graph let you see that the numbers and the pictures did not? Why do you think graphs like this are helpful tools for scientists?* Tell students that in the next activity they will look for a trend in the graphs.

- Help students compare the three different representations in this activity: the images, the table, and the graph. Lead a short discussion about how different representations allow us to look at data differently.

10. Have students complete an exit ticket.

- Show Slide 50 of the 1.3 Graphing Arctic Sea Ice PPT.
- Conclusions: How does the amount of Arctic sea ice change from one year to the next?
- Predictions: How has the amount of Arctic sea ice changed over the last 20 years?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead into the next activity.

Assessment

Look at students' arctic sea ice graphs before the next activity. Note the axis titles chosen by the students and use this to gauge how well they understand the information in the graph. Use the 1.3 Grading the Graphing Arctic Sea Ice Worksheet for a model version of the graph. If students had trouble constructing the graph you may need to revisit this activity before moving on.

Tips

Have students practice inputting one data point into the graph as a group and let them ask clarifying questions before completing the entire graph.

Differentiation & Extending the Learning

Differentiation

- Have students work independently on plotting data points on individual graphs.
- Have the x-axis and y-axis already pre-labeled for students.
- Provide a handout of the data from the website.
- Provide sample pre-plotted data points on the graph to help get students started.

Modifications

Extending the Learning

- Assign students an independent or group research project to research patterns in arctic or Antarctic ice prior to 1979.
- Have students use the same website to graph the data from Antarctica.

Activity 1.4: Drawing a Trend Line (40 min)

Tab 1: Overview and Preparation

Target Student Performance

Students use multi-year averages to construct a trend line using data on Lake Superior ice cover.

Resources You Provide

- 1.3 Graphing Arctic Sea Ice Worksheet (completed worksheets from previous activity)

Resources Provided

- 1.4 Drawing a Trend Line PPT
- 1.4 Drawing a Trend Line Worksheet
- 1.4 Grading the Drawing a Trend Line Worksheet

Setup

Print one copy of the 1.4 Drawing a Trend Line Worksheet for each student. Prepare a computer and projector to display the presentation. Retrieve students' completed worksheets from the previous activity with their graphs of arctic sea ice data.

Tab 2: Directions (accordion for individual steps in directions)

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 1.4 Drawing a Trend Line PPT.

2. Revisit the students' arctic sea ice graphs from the previous activity.

Return the graphs of arctic sea ice from Activity 1.3 to each pair of students. Ask them to look at their graph for two minutes and describe what information the graph conveys in words to each other. Tell them that "overall" is the key word here: instead of looking at each individual point on the graph, they should look for the general "trend" that is emerging when all of the data points are put together.

- Pass out one copy of 1.4 Drawing a Trend Line Worksheet to each student. Have them write a short description of the trend that they see in their arctic sea ice graph on the first part of the worksheet.
- Ask students to share their initial descriptions of the overall trend of the arctic ice graph. At this point, listen to their ideas, but do not correct their ideas.
- Ask questions that will help reveal how the students came to their conclusions like: *Can you tell me more about how you decided that?* Or *Who can add to that?* Or *Who had a similar or different description?* Or *How is your description similar or different?*

3. Practice identifying a global pattern.

Open 1.4 Drawing a Trend Line PPT. Use slides 3-4 to show students the graph of land and ocean temperatures during the winter of 2013-2014. Point out that during this winter, the Great Lakes region of North America had temperatures that were below average. However, if we relied only on the data from this region, we might have missed the overall global pattern in temperature for that winter.

- Use slide 5 to have students discuss with each other what the global temperature trend was during the winter of 2013-2014. First, have them turn and talk and describe the global pattern. Then, have a few pairs share their description with the class.
- Use slide 6 to construct a class explanation of the global pattern. Write their ideas on slide 6. At this point, it is ok to evaluate and correct student thinking. If they are having trouble identifying that 2013-2014 winter was warmer than average, ask them for more details about their reasoning. Help them move towards a class description that identifies the global trend of higher temperatures, despite the lower temperatures in a few regions.
- Lead a short discussion about **Generalizability**. How well does this image of temperature represent *global* patterns? What about their arctic sea ice graph? Does that tell us anything about what is happening globally, or just in one region? Pose these questions to the class, but do not expect the students to have developed ideas at this point. They will discuss this further in Lesson 2.

4. Discuss why we look for trends (patterns of change over time).

Tell students that this first example represented temperature data using colors and a map, and that in the next example we will practice finding a trend (a pattern of change over time) in a line graph (or scatter plot). When trying to identify trends on a scatter plot, we are looking for three options: a negative trend (where the data go downward from left to right), and positive trend (where the data go upward from left to right) and no change (where the data generally move in a flat line from left to right).

- Use slide 7 to demonstrate what a negative and positive trend look like on a scatter plot.
- Use slide 8 to show that there are different ways of calculating a trend line. The graph on the top has a straight line because it was calculated using a mathematical formula that considers all data points in the graph. The bottom graph has a curvy line because it was calculated using 5-year averages, which only considers data points in 5-year periods.
- Tell students that sometimes data sets on a scatter plot are messy, and that it's not always possible to see the trend with the naked eye. This is why drawing a line (like the lines on slide 7) are helpful for identifying trends that are difficult to see.

5. Discuss why and how we make trend lines.

Use slide 9 of the presentation to introduce students to a line graph of maximum ice cover on Lake Superior. This graph shows the maximum ice cover from 1973-2013 for each year. Have students look at the graph without a trend line and ask them: *Do you see any trend here?* Point out that it is difficult to identify trends in messy data sets like this one without drawing a trend line.

- Ask students why a scientist might want to make a trend line. Listen to their ideas. If they do not make the suggestion, add that scientists make graphs because it can help them see the data in ways that they can't see from looking at just the pictures or just the numbers. It helps them look past **short-term variability** and to see **long term trends**. Point out that trend lines help see what is happening when the data points are messy and noisy due to short-term variability.
- Ask students about the short-term variability they see in this graph. Is it predictable?
- Ask students to predict, based on the graph, what the arctic sea ice extent might be in a year from the time the graph ends. They should have difficulty making this prediction! It is difficult to make a prediction due to the stochastic variation in the graph (meaning that the extent of the sea ice changes from year to year based on many random factors, and there is no clear short-term pattern).

6. Practice making a trend line with Lake Superior ice cover graph.

Ask: *If you wanted to make a trend line, how would you do it? How would you "smooth" out the data?* Listen to ideas from the students about how they might look for a trend in the data. Ideas may include:

a. Draw a straight line that goes in the general direction of the trend.

b. Draw a straight line that touches as many data points as possible.

c. Draw an oval around all the points and then draw a line through the oval.

d. Find averages for every few years and make a data point and then connect those points.

7. Have students draw trend lines.

Turn students' attention to #2 of their worksheets. Overview the five steps involved in drawing a trend line for Lake Superior Ice:

- Step 1: Connect the dots (this is already done on the Lake Superior ice graph).
- Step 2: Divide the picture into sections by drawing vertical lines on the graph every five years.
- Step 3: Calculate the average of the data points within those five-year time periods.
- Step 4: Place one star in each section that shows the average for that time period.
- Step 5: Draw a line to connect the new stars.

Have students complete #3 on their worksheet, which asks them to write a description of their trend and to label it positive, negative, or no change.

8. Have students compare their trend lines for Lake Superior with others.

Divide students into pairs to compare trend lines for Lake Superior ice cover. In what ways are they the same and/or different? Have students work out any discrepancies they may see. When students feel comfortable with the process, move on to the next activity.

Tab 3: Assessment

This activity contains numerous opportunities for formative assessment. First, see how students describe the global trend of temperature anomalies in step two. Next, see what explanations they provide when you ask them to predict how much arctic sea ice will be on Lake Superior in five years. Do they confidently make a prediction, or do they suggest that they cannot predict due to the variation in the graph? Finally, monitor how easily they are able to construct the trend line on the Lake Superior graph in step four. If they have trouble with either of these, you may want to revisit these steps before moving to the next Activity.

Tips

- The method included in this activity represents just one of many ways to quickly find a trend in noisy data. If you have a preferred method you are more comfortable with, you might want to experiment with multiple methods in this activity.
- If students are having trouble identifying a trend in the data, have them calculate an average of the stars on the left side of the graph and the stars on the right side, and then draw a line going through the two new averages. This should make the negative trend very clear.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

- Complete step #7, steps 1-5 for drawing trend lines together as a class.
- Have students discuss questions in pairs or groups first before sharing responses with the rest of the class.

Modifications (Accordion)

For more advanced math students, consider having them constructing the trend line from the scatter plot using point-slope form. This video includes a short tutorial: https://learnzillion.com/lessons/250-write-a-trend-line-from-a-scatter-plot and https://learnzillion.com/resources/51255

Extending the Learning (Accordion)

Have students find data sets online that they can transform into scatter plots and then calculate the trend.

Activity 1.5: Finding a Trend in Arctic Sea Ice (40 min)

Tab 1: Overview and Preparation

Target Student Performance

Students use multi-year averages to construct a trend line using data on Arctic sea ice.

Resources You Provide

- Activity 1.3 Graphing Arctic Sea Ice Worksheet (completed worksheets from Activity 1.3)

Resources Provided

- 1.5 Finding a Trend in Arctic Sea Ice PPT
- 1.5 Finding a Trend in Arctic Sea Ice Worksheet
- 1.5 Grading the Finding a Trend in Arctic Sea Ice Worksheet
- Arctic Sea Ice Video: https://www.youtube.com/watch?v=FDRnH48LvhQ

Recurring Resources

- Learning Tracking Tool for Human Energy Systems (1 per student)
- Assessing the Learning Tracking Tool for Human Energy Systems

Setup

Print one copy of the 1.5 Finding a Trend in Arctic Sea Ice Worksheet for each student. Prepare a computer and projector to display the presentation. Retrieve students' completed 1.3 Graphing Arctic Sea Ice Worksheets with their graphs of arctic sea ice data.

Tab 2: Directions (accordion for individual steps in directions)

11. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 1.5 Finding a Trend in Arctic Sea Ice PPT.

12. Have students draw a trend line for Arctic ice.

Return students' copies of 1.3 Graphing Arctic Sea Ice Worksheets. Have students use the same procedure to draw a trend line on the arctic sea ice graph on their graphs. Give them about 15-20 minutes to draw the trend line. After they are done, have the students pair with others and compare/contrast their trend lines.

13. Have students describe the arctic sea ice trend in words.

Give each student a copy of 1.5 Finding a Trend in Arctic Sea Ice Worksheet. Tell them to complete the worksheet, which requires them to hand sketch their arctic sea ice table and explain the trend line in their own words. Give students about 10 minutes to complete the worksheet.

14. Have students compare trend lines and develop a class description.

When students have finished their worksheets, discuss these ideas as a class. Use slide 5 to instruct students to Turn and Talk with a partner.

- Ask the pairs to compare their *descriptions* of their trend lines (number 3 from their 1.5 Finding a Trend in Arctic Sea Ice Worksheet). Listen to their ideas: do the pairs all share an agreement that they see a negative, downward trend?

- Use slide 6 to have students share descriptions of the trend they see. Do they see a positive trend, a negative trend, or no change? Have them explain how they know that (i.e., their evidence), and develop a class description of the trend. Record the class description on the slide.
- At this point, see how easily the students arrive at a class consensus that there is a downward trend in the data. If some students' ideas are different, discuss the differences and see if (as a class) you can reach consensus for the reasons for the differences.

15. Have students discuss what the trend means.

Use slide 7 to instruct students to Turn and Talk again, but this time with a different purpose. Now that the class has reached the consensus that the data show a downward trend, what does that mean?

- As partners to share their ideas from number 4 on their 1.5 Finding a Trend in Arctic Sea Ice Worksheet.
- After the students talk with their partners, use slide 6 to construct and revise a class explanation for what is happening to arctic ice. Write down their class explanation. Continually ask students if they have additions or suggestions for changes that will make the explanation clearer, or more strongly supported with evidence from the graph.
- Have students complete #3 on their worksheet, which asks them to write a description of their trend and to label it positive, negative, or no change.

16. Compare student graphs with NOAA graph.

After students have shared their own graphs, display slide 8 of the presentation that shows NOAA's version of the graph's trend line. Have the students compare their own trend lines to NOAA's.

- Ask students to note any differences between NOAA's graph and their graph. They might notice, for example, that this graph shows data for the month of October, not September. They may notice other details that are different as well.
- Remind them that they are comparing **trend lines**. How is their trend line similar or different to NOAA's? Students should notice that both graphs show a negative trend, even though the months are different.
- Point out that because this is data from a different month, the **short-term variation** will be different, but the **long-term trend** will be the same: it will be negative.
- Use slide 9 to compare the short-term variability of the October and September graphs. Use this to point out the similar long-term trends, but different short-term variability.

17. Watch a one-minute video on arctic sea ice.

Have students watch the one-minute video from NOAA that shows arctic sea ice extent from 1987-2014.

- Watch the video once through, and then watch the video again. The second time through, pause the video in various places to help the students look for specific elements of the video that helps them interpret what they are seeing. During the discussion, help them connect the pieces of the video to their explanations for what is happening.
- Pause the video at 17 seconds. Have them identify where in the video they see old ice, and where in the video they see seasonal ice. Point them to the color legend as a reference and ask a student to explain what the legend tells them.
- Pause the video at 20 seconds when it is winter on the Northern Hemisphere. Have them identify the moving dial that shows it is winter.

- Pause the video again when it is summer in the northern hemisphere. Have them discuss the difference between what they see in the winter and in the summer. See if they notice that there is more change in the seasonal ice (dark blue) than in the old ice (white).
- Pause the video again right before the end (around 1:00). Ask the students to describe the difference in the amount of old ice in 2014 as compared to 1987.

18. Have a discussion to introduce the Learning Tracking Tool for this activity.

Show Slide 10 of the 1.5 Finding a Trend in Arctic Sea Ice Worksheet.

- Pass out a Learning Tracking Tool for Human Energy Systems to each student.
- Explain that students will add to the tool after activities to keep track of what they have figured out that will help them to answer the unit driving question.
- Discuss goals for this lesson.
- Have students write the activity name in the first column, "Questions for this Lesson."
- Have a class discussion about what students figured out during the activity that will help them in answering the lesson driving questions:
  - What causes the annual cycle: CO_2 concentrations in Hawaii to go down every summer and up every winter?
  - What causes the long-term trend: CO_2 concentrations to go up every year?
  - How can we predict what will happen to CO_2 concentrations in the future?
- When you come to consensus as a class, have students record the answer in the second column of the tool.
- Have a class discussion about what students are wondering now that will help them move towards answering the unit driving question. Have students record the questions in the third column of the tool.
- Have students keep their Learning Tracking Tool for future activities.
- Example Learning Tracking Tool

Activity	What We Figured Out	What We are Asking Now
Activity 1.5 Finding a Trend in Arctic Sea Ice Worksheet	*Although the amount of Arctic sea ice varies from year to year, it is declining in the long term.* *We have some ideas about why this might be happening, as well as lots of questions.*	*What is happening to global temperature, atmospheric CO_2, and sea level?*

Tab 3: Assessment

The most important ideas to listen to in this lesson are how students describe the long-term trend. Do they see that the trend shows that artic sea ice is declining? Use their ideas on 1.5 Finding a Trend in Arctic Sea Ice Worksheet to determine where they are in their thinking at this stage. Look to see if they feel comfortable using the trend as evidence to make a prediction about what will happen in the future. At this point in the lesson, students should be able to explain that all data representations represent the same system, but in different ways. Listen to their ideas in the final discussion using Slide 8 to determine if they are comfortable explaining why and how scientists simplify large data sets to identify trends, or if they need to revisit the activity before moving on.

Tips

When watching the video, students may need help identifying the difference between (a) seasonal variation of ice extent between winter and summer, and (b) the overall declining trend.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

- Draw the trend line together as a class.
- Have a full class discussion about the trend line instead of in groups.
- Allow students to watch the video on individual devices, if available, to allow for personal interaction.

Modifications (Accordion)

Extending the Learning (Accordion)

- Have students research any other forms of representations of data related to arctic sea ice extent. They might be surprised to discover how many different ways there are to represent the same data.
- Have students visit this interactive feature about ice melt in Greenland:

  http://www.nytimes.com/interactive/2015/10/27/world/greenland-is-melting-away.html?emc=edit_tnt_20151027&nlid=146126&tntemail0=y&_r=1