



## Where Are We in the Storyline?

Activity 1	What are people saying about climate change and what do I already know about it?
Activity 2	What happens to a fuel when it burns?
<b>Activity 3</b>	<b>What is causing global warming?</b>
Activity 4	How is global warming affecting Earth's systems?
Summative	Assessing student learning



## Activity 3 Summary

<b>Activity Overview</b>	Students are presented with graphs showing that Earth's average temperature has increased over the past century. They use a simulation to explain the change in Earth's temperature in terms of changes to Earth's energy balance. They develop a model that explains how human activities that increase greenhouse gases have caused global warming.
<b>What Students Uncover</b>	Global warming is a well-documented phenomenon in which Earth's average temperature has risen by about 1°C at approximately double the rate from the last 50 years. Over the past century, the leading cause of global warming has been the enhancement of the greenhouse effect caused by human activities (especially burning fossil fuels as an energy source for our devices). Increased greenhouse gases (mainly CO <sub>2</sub> ) alter Earth's energy balance, causing more energy to be trapped in the atmosphere. This extra energy warms Earth's surface temperature.
<b>How Does this Connect?</b>	The headlines students analyzed in Activity 1 referred to carbon dioxide, fossil fuels, global warming, and climate change. Students likely already had a vague idea that these topics "go together," but they likely did not explain these connections in terms of changes to Earth's energy balance. This activity is critical to helping students achieve the performance expectation: HS-ESS2-4: <i>Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.</i>



## Resolving Misconceptions

**MISCONCEPTION:** There is no scientific consensus or agreement on anthropogenic climate change.

According to NASA, “the vast majority of actively publishing climate scientists – 97 percent – agree that humans are causing global warming and climate change.” Human activities that increase the amount of greenhouse gases in the atmosphere (especially burning fossil fuels) have been the main driver of global warming over the last 100 years.



## Activity Instructions

**Activity 3 question: What is causing global warming?**

### Materials Needed:

- Activity 3 Slide Deck
- Activity 3 Student Handout (1 per student)
- Device with internet connection

### Teacher Prep

- Review the Activity 2 Slide Deck
- Print Student Handouts
- Review the [Greenhouse Effect PhET simulation](#)

### Key Vocabulary

Greenhouse effect | Energy balance | Global warming | Visible light | Infrared radiation | Absorb | Reflect

**Time period:** 1 one-hour class period



## Teacher Tool Kit

Tool	How the tool applies to this activity
<a href="#">Resolving Misconceptions</a>	This activity begins with the assertion that global warming is happening, using data from NASA and NOAA, which show that Earth’s average temperature has increased over the past century. The rest of the activity engages students in explaining how human activities are the leading cause of global warming. If students do not trust the data, you may need to do more work to convince them before moving on to the simulation. The <a href="#">Understanding Climate Modeling Story Short</a> goes into much more detail about how we know global warming is occurring.
<a href="#">BRAVE Conversations</a>	In this activity, students will work in small groups and share ideas with the whole class. BRAVE conversations set the tone for respectful classroom discourse.
<a href="#">Driving Question Boards</a>	When reviewing the DQB, students may notice that some of their original ideas were incorrect. Remind students that the classroom is a judgment-free zone where everyone is learning and that learning involves making mistakes.



### Introduction

Open the Activity 3 slide deck. Use the “Driving Question Board” slide and/or the driving question board in your classroom to remind students what they have learned. Today, we will build on what we have learned to answer the question, “What is causing global warming.” Students have likely heard that carbon dioxide is connected to global warming, but they may not have considered it in terms of Earth’s energy balance.

Use the “What is Global Warming?” slide to lead a short notice and wonder think-pair-share routine. Tell students that they have one minute to silently look at the graph, think about what they notice, and wonder about it. After one minute of silent thinking, ask students to turn to a partner and share what they noticed and wondered. You may decide to have a student share out or summarize what you heard. Make sure that students recognize that Earth’s global average temperature has been increasing over the last century.

Use the “Earth is Setting Records” slide to show the data in a different way. You may choose to repeat the think-pair-share routine or ask students to consider how this infographic shows the same data differently than the previous graph. The important thing for students to recognize is that while some areas of the Earth were colder than the 1991-2020 average in 2023, overall, the average global temperature was the highest on record. Also, 2023 was not just an outlier; there is a very clear trend toward warmer-than-average global temperatures. We refer to this trend as global warming. Our goal today is to clearly explain the leading cause of Earth’s increasing temperatures.

### Activity

Pass out a copy of the Activity 3 Student Handout to each student. Read the background information (first three paragraphs) aloud as a class. Tell students they will use a simulation to investigate Earth’s atmosphere and how it regulates Earth’s energy balance.

Show the “Greenhouse Effect Simulation” slide and explain to students that the slider on the right allows them to change the concentration of greenhouse gases. Give students a few minutes to open the simulation, explore a bit, and answer questions #1 & 2. Lead a short discussion to ensure students understand how visible light and infrared radiation are represented in the simulation. Then, instruct students to complete Part A of the handout. Give students about five minutes to complete this short investigation. Then, lead a quick discussion to make sure that students noticed that the “out” arrow on the energy balance meter decreases as the greenhouse gas concentration increases. Students must recognize that greenhouse gases interact with the infrared radiation leaving the Earth, thus trapping excess energy in the atmosphere. Use the link on the “The Greenhouse Effect” slide to show a short video summarizing how Earth’s atmosphere regulates its energy balance.

Show the “Greenhouse Effect Over Time” slide and explain that the calendar icon allows them to simulate the greenhouse gas concentration at different points in time. Instruct students to follow the directions on the handout to complete Part B. Check in with students or lead a short discussion to ensure that students realize that the leading cause of increasing carbon dioxide in the atmosphere is human activities (especially burning fossil fuels, as shown by the increasing number of factories and buildings depicted in the simulation). Help them make the connection to Activity 2, where they learned that burning organic molecules produces carbon dioxide. Press students to discuss the connection between carbon dioxide and Earth’s temperature in terms of Earth’s energy balance (rather than simpler explanations like “carbon dioxide makes the temperature go up). Focusing on Earth’s energy balance helps students to focus on explaining the cause-and-effect relationship between greenhouse gases and Earth’s temperature.

Show the “Developing a Model” slide. Explain to students that they now have the opportunity to practice meeting the performance expectation; HS-ESS2-4: *Use a model to describe how variations in the flow of energy into and out of*



*Earth's systems result in changes in climate.* Activity 6 is a summative assessment for this performance expectation (that you may choose to grade) that will require students to make and explain similar models about energy flow for a slightly different phenomenon. The modeling task on the student handout is their opportunity to work with their peers and get feedback on their models before the summative assessment.

### Closing

You may want to collect students' work and give them written feedback or choose another strategy, such as peer review.

### Sources

PhET Interactive Simulations (2024). Greenhouse Effect. [https://phet.colorado.edu/sims/html/greenhouse-effect/latest/greenhouse-effect\\_all.html](https://phet.colorado.edu/sims/html/greenhouse-effect/latest/greenhouse-effect_all.html)