Climate Change

About the Lessons

The five lessons in this unit are designed to introduce students to climate change concepts. Each lesson lasts about 45 minutes.

We recommend teaching the Climate Change Overview lesson first to provide students with background knowledge about the causes and effects of climate change. (If your students are already familiar with these concepts, you can skip this lesson.)

You can then teach one or more of the lessons on specific phenomena:

- Extreme Temperatures
- Extreme Precipitation
- Wildfires and Drought
- Rising Sea Level

Local relevance is key to student engagement with climate change concepts, so we recommend prioritizing lessons about events that affect your community most directly.

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EiE® teamed up with Pear Deck™ to create interactive versions of these lessons. Pear Deck makes it easy for educators to connect with every student by engaging them through discussion and interactive prompts.

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Climate Change Overview

Overview

Students examine data about the causes and effects of climate change. Brief videos clarify terms and concepts. Students then create models of climate change in order to predict additional effects.

A more advanced version of this lesson is available in *Climate Change*, Gr 6-8.

Guiding Question

How and why is Earth's climate changing?

Objectives

Students will be able to

- explain the relationship between weather and climate.
- analyze and interpret information about the causes and consequences of climate change.
- create a model of climate change and use it to make predictions.

Background

The use of coal-powered steam engines in the 1700s began a process known as the Industrial Revolution. As part of this process, over the past several centuries, humans have used increasing amounts of energy from burning coal, oil, and gas. These fuels are called "fossil fuels" because they form from dead organic matter over hundreds of millions of years, just as fossils re traces of organisms from long ago.

Time

- 20 minutes to explore data
- 5 minutes to watch videos
- 20 minutes to create models

Grade Level: 3–5

Vocabulary

- **Climate**
- **Climate Change**
- **Greenhouse Gas**
- **Model**
- **Weather**
- **Weather Patterns**

Standards

NGSS SEP: Analyzing and Interpreting Data. Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.

NGSS SEP: Developing and Using Models. Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.

NGSS CCC: Patterns.

CCSS.ELA-Literacy.RI.3–5.3.

CCSS.Math.Content.3.MD.B.3.

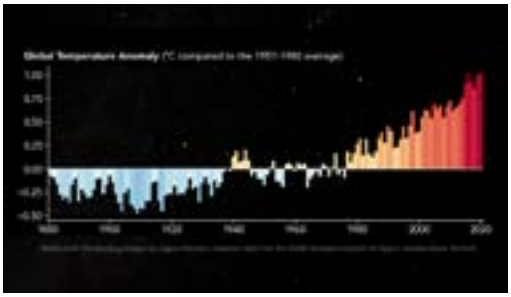
As humans burn fossil fuels to power engines, produce electricity, and engage in industrial processes such as making cement, those fuels release carbon dioxide, methane, and other gases. These gases are also emitted by other human activities, including cutting down forests, raising livestock, and using fertilizers.

Carbon dioxide, methane, and other gases such as nitrous oxide are called "greenhouse gases" because they function like the insulating panes of glass in a greenhouse, trapping heat inside Earth's atmosphere. Sunlight mostly reaches Earth as thermal energy, some of which is absorbed and some of which is radiated back into the atmosphere. Greenhouse gases in the atmosphere reduce the amount of thermal energy that escapes back into space.

An increase in the levels of greenhouse gases in the atmosphere has multiple consequences. The most direct one is an increase in the planet's average temperature, which has risen more than 1°C since the beginning of the Industrial Revolution in the 1700s. This temperature increase has led to a variety of other changes, such as an increase in extreme precipitation, more intense wildfires, and rising sea levels.

Preparation

For this activity, the educator will need the following:



- Video: Climate vs. Weather (0:28)
- Video: Greenhouse Gas (0:32)
- Video: Climate Change Definition (0:31)
- A way to show the videos to students
- Whiteboard or chart paper

For this activity, each group of students will need the following:

- 1 copy of Climate Change Data (English | Spanish)
- 1 or more copies of Climate Change Model (English | Spanish | Answer Key) (optional)
- Pens or pencils

Access the interactive version of this lesson, powered by Pear Deck™

EiE Connections

Learn more about the Engineering Design Process in the EiE Video Library.

Continue your classroom activities with these units:

Engineering and Computer Science Essentials™

- Cleaning an Oil Spill

- Analyzing Digital Images

Engineering is Elementary®

- Cleaning an Oil Spill

Museum of Science Connections

Watch the video *What Can Arctic Ice Teach Us About Climate History?* (English | Spanish) or teach the associated lesson.

Listen to the Pulsar podcast episode "Climate Change Resilience in Boston."

Family Connections

Continue the learning at home with EiE Families and STEM Events or Family STEM Activities from MOS at Home.

Credits

MOS at School programs are offered at no cost, thanks to the generosity of the Akamai Foundation, Bloomberg Philanthropies, BNY Mellon, Gordon Foundation, Hood, Lincoln and Therese Filene Foundation, Lowell Institute, Mabel Louise Riley Foundation, MathWorks, Richard K. Lubin Family Foundation, Sanofi, and TJX.

Activity Instructions

These steps offer support for implementing the *Climate vs. Weather, Greenhouse Gas, and Climate Change Definition* videos and associated activities with students.

If your students are already familiar with the basics of climate change, consider beginning with one of the lessons on Extreme Temperatures, Extreme Precipitation, Wildfires and Drought, or Rising Sea Level.

1. Explain to students that today they will be thinking about something they experience every day: weather. Ask:

> **Q: What is weather?**
>
> *A: Accept all responses. Students may identify **weather** as the short-term temperatures and conditions that we experience each day. Weather includes how sunny or cloudy it is, how warm or cold it is, whether there is precipitation such as rain, snow, or sleet, and whether there is a storm.*

Record students' ideas on a whiteboard or chart paper.

Climate	
Temperature—hot or cold Sunny or cloudy Wind Mist, fog, rain, snow, sleet, hail, snowstorms, hurricanes, tornados	

2. Tell students that, while weather changes frequently, most places have typical patterns. For example, some places are usually hot and wet, while some places are usually cold and windy. Ask:

> **Q: What are some places that are usually hot and wet?**
>
> *A: Responses will vary. Possible responses include rainforests and jungles, places near the equator, or specific regions, states, or cities.*

> **Q: What are some places that are cold and windy?**
>
> *A: Responses will vary. Possible responses include mountains and tundra, places near the Arctic or Antarctic, or specific regions, states, or cities.*

Record students' ideas on the whiteboard or chart paper. Tell students that the usual temperature and weather conditions in a place are called its climate. They have just named examples of different climates.

Climate	Climate
Temperature—hot or cold Sunny or cloudy Wind Mist, fog, rain, snow, sleet, hail, snowstorms, hurricanes, tornados	Usual temperature Usual kinds of weather Tropical, dry, temperate, or polar

3. To clarify the difference between weather and climate, you can show the video Climate vs. Weather (0:28).

watch video

4. Explain that recently, there have been more extreme weather events and changes in climate. Ask:

Q: What are some extreme weather events that you have experienced or learned about?

A: Accept all responses. Possible responses include extreme precipitation events, such as rainstorms, snowstorms, hurricanes, and floods; and extreme temperature events, such as very cold or very hot days. Students may also name wildfires as an extreme weather event.

Q: What are other changes in climate that you have experienced or learned about?

A: Responses will vary. Possible responses include higher usual temperatures, droughts, and rising sea levels.

Activity Tip

Local relevance is key to student engagement with climate change concepts, so discussing extreme weather events where you live is a powerful way to get students interested. Indeed, a single recent local extreme weather event can serve as an anchoring phenomenon for your discussion of climate change. However, students may have experienced loss in such events. Think carefully about how to guide the discussion in a way that is respectful of and sensitive to students' experiences.

Record students' ideas on a whiteboard or chart paper.

Weather	Climate
Temperature—hot or cold Sunny or cloudy Wind Mist, fog, rain, snow, sleet, hail, snowstorms, hurricanes, tornados	Usual temperature Usual kinds of weather Tropical, dry, temperate, or polar
Extreme Weather Events	**Climate Changes**
Very hot days Very cold days Big storms or floods Wildfires	Higher usual temperatures Larger storms, floods, and fires Droughts Rising sea levels

5. Tell students that today, they will be working to make a model to explain why extreme weather events and changes in climate are happening. Their model will also help them discover ways to protect people and other living things from these changes in the future.

6. Tell students that they will start by exploring different sets of data to look for patterns. Have students work in groups and provide each group with a copy of Climate Change Data (English | Spanish). Give students 10–15 minutes to discuss the data and the patterns they find.

Activity Tips

You can have each group examine one graph, several graphs, or all ten graphs. Choose the approach that is most appropriate for your students.

Note that the Sea Level Rise graph is cumulative, meaning it shows the total rise since 1900. For example, global average sea level was about 10 centimeters higher in 1970 than in 1900.

Much of the information in the graphs comes from the Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the United Nations (UN). You can use information from these organizations to create additional graphs on topics relevant to your students, such as precipitation, flooding, or drought.

Material Tips

Climate Change Data contains ten bar graphs. Each graph focuses on a particular cause or consequence of climate change. Before having students examine the graphs, you may want to review how to read a bar graph or demonstrate with an example.

For graphs of length, area, and temperature, metric units appear on the left side and imperial units on the right. Have your students focus on whichever unit type is appropriate.

7. Once students have had a chance to examine the data, discuss their findings as a class. Ask:

Q: What patterns did you notice in these graphs?

A: Responses will vary. Possible responses include decreases in forests and ice and increases in power plants, cows, cars, carbon dioxide and methane in the atmosphere, the average temperature of Earth's surface, sea level, and the area burned by wildfires.

Activity Tips

Students may wonder how we know so much about the climate long ago. One valuable type of evidence is ice cores, which are cross-sections of ice cut from a glacier. Each layer of ice corresponds to a year in the past, and scientists can study the air trapped in those layers to learn what the atmosphere was like hundreds, thousands, or even hundreds of thousands of years ago. If students want to learn more about this evidence, show the video What Can Arctic Ice Teach Us About Climate History? (2:30) (English | Spanish) or teach the associated lesson.

For this lesson, the qualitative trends in the graphs are more important than the specific numbers. However, you can use the graphs to practice grade-appropriate math skills by posing questions such as "How much higher was the sea level in 2020 than in 1920?" or "How much less forest was there in 2000 than in 1700?"

8. Students may be unfamiliar with the heat-trapping properties of greenhouse gases. Show the video *Greenhouse Gas* (0:32) to introduce students to **greenhouse gases**, gases in the atmosphere that trap heat from the Sun and prevent it from radiating back out into space. As necessary, explain that burning fossil fuels (mentioned at 0:26) often releases carbon dioxide, while cow farts (mentioned at 0:30) release methane.

watch video

Activity Tips

Students may have misconceptions about the causes of climate change; provide information as necessary to help correct them. Below are details about three of the most common misconceptions:

1) Climate change has natural causes. While some natural processes release greenhouse gases, they are balanced by other processes that absorb the gases. For example, during the carbon cycle, carbon dioxide is released into the atmosphere as part of cellular respiration and then incorporated into sugars as part of photosynthesis. As a result, the carbon cycle was largely balanced for the past 10,000 years, resulting in a stable climate. Human activity during the past few centuries has upset this balance by releasing far more greenhouse gases than have been reabsorbed, leading to the increased retention of heat from sunlight.

2) Climate change is caused by heat from machines. Human machines that burn fossil fuels do release some heat, and, in addition, the greenhouse gases released by this burning trap additional heat over decades or centuries in the atmosphere. However, the latter effect is tens of thousands of times larger than the former, meaning that heat from the greenhouse effect is a far, far more significant cause of climate change than heat from fossil fuel combustion.

3) The hole in the ozone layer causes climate change. In the early 1900s, humans began to use chlorofluorocarbons (CFCs). These chemicals are nontoxic and inert on Earth's surface, making them seemingly ideal choices for tasks such as refrigeration and air conditioning. However, when they reach the upper atmosphere, CFCs provoke a chemical reaction that destroys ozone molecules. This destruction led to a significant thinning of the ozone layer over Antarctica, which was confirmed in 1985. Since the ozone layer minimizes the amount of harmful UV radiation that reaches Earth's surface, the thinning presented a major threat to living things. The 1987 Montreal Protocol reduced and ultimately banned the production of CFCs. In the decades since its adoption, the ozone layer has stopped thinning.

Although the depletion of the ozone layer and climate change are both caused by human activities and both result in threats to living things, the two processes are not the same. The ozone hole does not "let in" more heat from the Sun; instead, greenhouse gases in the atmosphere trap more of the heat from sunlight.

9. If students need more time, give them one or two more minutes to examine the graphs. Then ask:

Q: Using the information in the video and what you already know, how do you think the patterns in the graphs might be connected to each other?

A: Responses will vary. A possible response is that human activities such as cutting down forests, burning coal for electricity, raising cows, and driving cars release gases such as carbon dioxide and methane, increasing the amount of those gases in the atmosphere. Those gases trap heat from sunlight, increasing the temperature of Earth's surface. The warmer temperature melts ice, raises sea levels, and causes more land to be burned by fires.

10. Explain that the connected patterns students have been exploring are together a phenomenon called **climate change,** the changes from the rapid rise in global temperatures seen in the last 150 years. Show the video *Climate Change Definition* (0:31) to further define the term.

watch video

As necessary, explain that the Industrial Revolution (mentioned at 0:18) is the period when humans began burning fuels such as coal, oil, and gas to power machines. Ask:

> **Q: In the video, the narrator says that "Earth is getting hotter faster than at any point in its several-billion-year history. When you're setting records, that's not the kind you want to set." Why are high temperatures not a good thing?**
>
> *A: Accept all responses. Possible responses include that high temperatures can make it harder for people and other living things to survive in their habitats and cause dangerous events, such as sea level rise and fires.*

11. Explain to students that in order to protect people and other living things from climate change, we need to understand and be able to predict the things that cause it and the dangers it produces. One way to do this is to make a **model**, a representation of an object, system, or process.

Material Tips

If your students have experience making models, show or describe some of the work they did or phenomena they studied in order to activate their prior knowledge.

12. Have each group decide what type of model they want to make. Possible types of modelling include writing a description, drawing a diagram, or performing a physical activity. If it is useful, you can give each group one or more copies of *Climate Change Model* (English | Spanish).

13. Give groups time to develop their models. Students can incorporate data from the graphs as well as information recorded on the weather and climate chart from earlier in the lesson.

14. Discuss students' models. Ask

> **Q: What method of representation did you use for your model?**
>
> *A: Accept all responses. Students may have written a description, drawn pictures, created a diagram or flowchart, or taken some other approach.*

Q: How does your model explain the changes and extreme weather events we talked about? What other effects can it predict from climate change?

A: Responses will vary. Students may be able to predict how a warmer climate leads to changes in the water cycle, which can cause droughts, extreme precipitation, and floods.

Q: Can your model predict any other causes of climate change?

A: Responses will vary. Students may be able to predict that any activity that releases greenhouse gases is a cause of climate change. These activities include burning fuel for heat, to move vehicles, and to power other machines.

If time permits, allow students to add to or revise their models using information from the class discussion.

15. Conclude by thinking about the benefits of knowing about climate change. Ask:

Q: How can we use our models to help protect people and other living things from climate change?

A: Responses will vary. A possible response is that the models can predict changes people should make to reduce the intensity of climate change in the future (for example, burning fewer fossil fuels). Another response is that the models can predict effects of climate change that people should prepare for (for example, building structures that can withstand extreme temperatures, extreme precipitation, or sea level rise).

Activity Tips

Human action that limits the concentration of greenhouse gases in the atmosphere is known as mitigation, while human action that limits the harm caused by climate change is known as adaptation. Students can explore both concepts in detail in the Extreme Temperatures, Extreme Precipitation, Wildfires and Drought, and Rising Sea Level lessons.

Extreme Temperatures

Overview

Students examine temperature data to draw conclusions about the changes in Earth's climate since the 1960s. A video introduction discusses how greenhouse gas emissions have caused more extreme temperatures. Students then explore their local environments to suggest methods for mitigation of greenhouse gas emissions and adaptation to extreme temperatures.

A more advanced version of this lesson is available in *Climate Change*, Gr 6-8.

Guiding Question

How and why have temperatures changed since the 1960s, and how should we respond?

Objectives

Students will be able to

- analyze and interpret temperature data from the 1960s and the 2010s.
- explain how human-caused greenhouse gas emissions have caused the rise in global temperatures over the past century.
- propose local solutions for climate change mitigation and adaptation to extreme temperatures.

Background

Humans cause climate change in several ways. Some of the most significant include burning fossil fuels to power engines, generate electricity, heat buildings, and produce materials such as cement; cutting down forests; raising livestock; and using fertilizers.

All of these activities release gases such as carbon dioxide, methane, and nitrous oxide. When sunlight reaches Earth, much

Time

- 20 minutes to explore data
- 5 minutes to watch video
- 20 minutes to suggest solutions

Grade Level: 3-5

Vocabulary

- **Adaptation**
- **Climate**
- **Climate Change**
- **Greenhouse Gas**
- **Mitigation**
- **Remote Sensing**
- **Weather**
- **Weather Patterns**

Standards

NGSS SEP: **Analyzing and Interpreting Data.** Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.

NGSS MS-ESS3-5. Obtain and combine information to describe climates in different regions of the world.

NGSS CCC: Patterns.

CCSS.Math.Content.3.NBT.A.2.

CCSS.Math.Content.5.NBT.B.7.

of the energy is converted to thermal energy. Some of the energy is absorbed and some is radiated back into the atmosphere. Carbon dioxide, methane, and nitrous oxide in the atmosphere reduce the amount of thermal energy that escapes back into space. These gases are called "greenhouse gases" because they function like the insulating panes of glass in a greenhouse.

An increase in the levels of greenhouse gases in the atmosphere has multiple consequences. The most direct one is an increase in the planet's average temperature, which has risen more than 1°C since the beginning of the Industrial Revolution in the 1700s. By destabilizing climate systems such as oceanic and atmospheric currents, this overall increase can cause both high and low extreme temperatures.

Preparation

For this activity, the educator will need the following:

- Video: *Sensing Our Climate: Extreme Temperatures* (4:30) (English | Spanish)
- A way to show the video to students
- Whiteboard or chart paper

For this activity, each student will need the following:

- 1 copy of *City Temperatures* (English | Spanish | Answer Key)
- 1 copy of *Mitigation Strategies* (English | Spanish | Answer Key)
- 1 copy of *Adaptation Strategies* (English | Spanish | Answer Key)
- 1 pen or pencil

Access the interactive version of this lesson, powered by Pear Deck™

EiE Connections

Learn more about the Engineering Design Process in the EiE Video Library.

Continue your classroom activities with these units:

Engineering and Computer Science Essentials™

- Designing Solar Ovens
- Designing Computer Games

Engineering is Elementary®

- Designing Solar Ovens

Museum of Science Connections

Listen to the Pulsar podcast episode "Measuring Urban Heat Islands."

Check out the Museum's Wicked Hot Boston and Wicked Hot Mystic citizen science initiatives.

Family Connections

Continue the engineering at home with these activities:

- Building in the Heat
- PLANETS: Remote Sensing Investigation

Credits

MOS at School programs are offered at no cost, thanks to the generosity of the Akamai Foundation, Bloomberg Philanthropies, BNY Mellon, Gordon Foundation, Hood, Lincoln and Therese Filene Foundation, Lowell Institute, Mabel Louise Riley Foundation, MathWorks, Richard K. Lubin Family Foundation, Sanofi, and TJX.

Activity Instructions

These steps offer support for implementing the *Sensing Our Climate: Extreme Temperatures* video and associated activities with students.

If your students need additional background about the basics of climate change, consider teaching the Climate Change Overview lesson first.

1. Explain to students that today they will be thinking about something they experience every day: temperature. Ask:

> **Q: What is temperature?**
>
> *A: Accept all responses. Students may know that temperature is a measure of the average kinetic energy of the particles in matter. Humans experience temperature as how hot or cold something is or how hot or cold it is outside. Temperature is one part of* ***weather****, the short-term atmospheric conditions in an area, along with factors such as pressure and precipitation.*

Material Tips

If your students have already learned about temperature, show or describe some of the work they did or phenomena they studied in order to activate their prior knowledge.

Q: Why is being at the right temperature important for people, other animals, and plants?

A: Accept all responses. Possible responses include that living things can survive only at certain temperatures, and that at other temperatures they can be too cold or too hot. Animals and plants also need their habitats to be at certain temperatures to have the right conditions, such as snow on the ground or water in a river.

2. Explain to students that while the temperature changes depending on the time of day and time of year, most places have a usual temperature: some places are usually warm, some are usually cold, and some are in the middle. Ask:

Q: What are some places that are usually warm?

A: Responses will vary. Possible responses include tropical places, places near the equator, or specific regions, states, or cities.

Q: What are some places that are usually cold?

A: Responses will vary. Possible responses include places in the Arctic and Antarctic, places far north or south, high-elevation places, or specific regions, states, or cities.

Activity Tips

If your students are familiar with the idea of means/averages, you can explain that taking the average temperature for an area is one way of measuring its climate. Scientists can measure average temperatures during the daytime, during the nighttime, at different times of year, and from one year to the next.

Tell students that the usual temperature and weather conditions in a place are called its climate. They have just named places with warm and cold climates.

3. Tell students that they are going to do something that scientists who study climate do: analyze how the average temperatures in different places have changed over time. Distribute *City Temperatures* (English | Spanish) to students. Explain that they will be calculating the average temperature for different cities in the 1960s and 2010s. They will then look for changes in the average temperature between the two decades. The information they find could be important for protecting people and other living things.

Activity Tips

The temperature data set comes in both Fahrenheit and Celsius, with and without decimals. Use the temperature scale and level of precision that is appropriate for your students.

Local relevance is key to student engagement with climate change concepts. Before the lesson, look up the average temperatures in the 1960s and 2010s for one to three local areas. (For the United States, easy-to-access data is available from the National Oceanic and Atmospheric Administration Regional Climate Centers.) Add those areas and temperatures to the bottom of City Temperatures and have students calculate temperature changes for them as well. Students may also share their prior knowledge about climate and weather in those areas.

Students may have experienced loss in extreme weather events. Think carefully about how to guide the discussion in a way that is respectful of and sensitive to students' experiences.

This lesson uses data from the 1960s because students may know people (such as family members or teachers) who were alive at that time, making the comparison to the present more engaging. Although this range does not capture the entirety of human greenhouse gas emissions, it includes most of them: approximately three-quarters of all human greenhouse gas emissions before 2020 occurred in the period after 1960.

4. Give students time to calculate temperature averages and changes. You can allow them to work individually, in groups, or in some combination of the two. (For example, you can have students calculate changes on their own and then discuss their results in groups.)

5. Have students interpret their findings. Ask:

Q: What do you notice about the temperature changes?

A: Responses will vary. A possible response is that all the temperature changes are positive.

Material Tips

Displaying data in various formats can help scientists interpret it. Consider having students graph some of the data by hand or digitally in order to discover patterns.

Q: What do the temperature changes tell us about temperature change in these cities?

A: The fact that the temperature changes are positive means that the cities listed got warmer between the 1960s and the 2010s.

6. Explain to students that the change was not just in these cities. The entire planet got warmer between 1960 and 2020, part of a process called **climate change**. Ask:

Q: Do you have any ideas about why Earth might have higher temperatures now than it did in the 1960s?

A: Responses will vary. Students may know that the atmosphere now contains more greenhouse gases, gases that trap heat from the Sun and prevent it from radiating back out into space. They may have heard of different kinds of greenhouse gases, especially carbon dioxide. between the 1960s and the 2010s.

Q: What are some ways these higher temperatures might be affecting people, animals, or plants?

A: Responses will vary. Possible responses include that people can get sick if it is too hot, and that other living things might no longer have the right habitats to live in.

7. Tell students that although greenhouse gases increase Earth's overall average temperature, they can cause other changes to temperatures at specific places and times. Play the video Sensing Our Climate: Extreme Temperatures (4:30).

watch video

Activity Tips

Although the temperature data used in this unit were collected at Earth's surface, the video mentions using remote sensing for data collection. If students are interested, you can consider possible benefits and drawbacks of collecting data from the ground, from the atmosphere, or from space. For example, temperature measurements on the ground are easy and cheap to make and can capture small differences between nearby locations. Remote sensing measurements require expensive equipment, can be blocked by clouds, and do not always have high resolution, but they can cover large areas and observe places difficult or impossible to reach on the ground.

Aqua, the NASA satellite mentioned in the video, was launched in 2002. Its name (Latin for water) comes from its primary mission to learn more about the water cycle, but it also collects data on other elements of climate such as temperature.

Discuss the video. Ask:

> **Q: What else did you learn about temperature changes from the video?**
>
> *A: Responses will vary. Possible responses include that climate change can also cause extreme cold temperatures and that scientists can use **remote sensing**, the science of scanning Earth from a distance using technology like satellites and high-flying airplanes, to gather information about climate change.*

> **Q: What does the video say about how humans can respond to climate change?**
>
> *A: Humans can use satellites to predict future changes, and they can invent new technologies, such as electric cars, that do not release greenhouse gases.*

8. Explain that electric cars and remote sensing are examples of strategies for responding to climate change. Mitigation is human action that limits the concentration of greenhouse gases in the atmosphere, such as using electric cars instead of cars that burn gas. Adaptation is human action that limits the harm caused by climate change, such as predicting what areas will get hotter or colder and putting in air conditioning or heaters so people can stay safe.

On a whiteboard or chart paper, make a table with the headings "Mitigation" and "Adaptation." Have students brainstorm other examples of each strategy and add them to the chart.

Mitigation *human action that limits the concentration of greenhouse gases in the atmosphere*	**Adaptation** *human action that limits the harm caused by climate change*
• Using electric cars that do not burn fossil fuels	• Putting in air conditioning or heaters

9. Tell students that while it can be hard to protect other parts of the country or the world from climate change, there's a lot they can do to protect the people, animals, plants, and environment around them. Today, they will suggest ideas for mitigation and adaptation in their community. Distribute *Mitigation Strategies* (English | Spanish) and explain that they will use it to record sources of greenhouse gas emissions at their school. Distribute *Adaptation Strategies* (English | Spanish) and explain that they will use it to record ways that their school might be affected by extreme temperatures.

10. Travel around the school and school grounds; possible places to visit include a cafeteria, heating or cooling equipment, dumpsters or other waste disposal, a garden or other green space, and vehicles or parking. Have students work individually or in small groups to record sources of greenhouse gases on the left side of *Mitigation Strategies* and vulnerabilities to extreme temperatures on the left side of *Adaptation Strategies*. Draw student attention to relevant features of the school environment as necessary.

Activity Tips

Although mitigation is often discussed in terms of reducing the sources that emit greenhouse gases into the atmosphere, enhancing the sinks that absorb greenhouse gases from the atmosphere is also a mitigation strategy. Examples of important sinks include the ocean and plants. It may be appropriate to discuss the idea of greenhouse gas sinks with students (or they may bring it up themselves), especially if your school grounds contain plants.

As you travel around the school, it may also be appropriate for students to ask individuals (other students, teachers, workers, and administrators) about their knowledge of the school's greenhouse gas emissions and vulnerability to extreme temperatures. Make sure to arrange any interviews ahead of time. You could also have individuals come to visit your classroom.

11. Return to the classroom. In small groups or as a class, have students share the greenhouse gas sources they recorded on *Mitigation Strategies.* Ask:

> **Q: What sources of greenhouse gases did you notice?**
>
> *A: Responses will vary. Possible responses include vehicles, such as school buses or garbage trucks; devices that use electricity, such as lights or air conditioners; objects whose manufacture releases greenhouse gases, such as paper or cement; food whose production releases greenhouse gases, such as beef and milk; heating devices, such as furnaces; and the removal of plants or green space.*

12. Explain that students can use their knowledge about climate change to plan ways to reduce the school's greenhouse gas emissions. Ask:

> **Q: What changes can we make here to mitigate climate change?**
>
> *A: Responses will vary. Possible responses include reducing activities that produce greenhouse gases (such as idling cars outside the school), making activities more efficient (such as using efficient light bulbs), and doing them in ways that do not require fossil fuels (such as using cars and school buses powered by electricity from a non-carbon source).*

Have students fill in the right column of *Mitigation Strategies* with the ideas they discuss.

13. Explain that although mitigation is extremely important for reducing the future effects of climate change, some effects, such as extreme temperatures, are already happening. In small groups or as a class, have students share the ways that the school might be affected by extreme temperatures that they recorded on *Adaptation Strategies.* Ask:

> **Q: How might our school be affected by extreme temperatures?**
>
> *A: Responses will vary. Possible responses include being too hot or cold inside, having pipes freeze and burst, losing electricity because wires are affected by extreme heat or cold, and having plants or animals die.*

14. Explain that students can use their knowledge about climate change to plan ways to adapt the school for extreme temperatures. Ask:

> **Q: How could our school adapt to extreme temperatures?**
>
> *A: Responses will vary. Possible responses include planting trees and other plants around the school (or on its roof), making sure the school is well-insulated, reducing the amount of dark pavement around the school, ensuring the school has appropriate heaters or air conditioning, ensuring the school has a backup source of electricity (ideally not from burning fossil fuels), getting a weather forecast each day, checking on school animals in extreme temperatures, and setting up cooling stations with water on hot days.*

Have students fill in the right column of *Adaptation Strategies* with the ideas they discuss.

15. Discuss how to put these ideas into action. Ask:

> **Q: Now that we have brainstormed ideas for mitigation and adaptation at our school, how can we put these ideas into action?**
>
> *A: Responses will vary. Some actions, such as reducing paper and electricity use, can be implemented in your classroom (and encouraged in other classrooms). Other ideas may need to be implemented by the school administration.*

> **Q: Where else could you use these strategies to mitigate and adapt to climate change?**
>
> *A: Responses will vary. Possible responses include at home and at local community organizations. Encourage students to investigate the specific circumstances in those places and share their knowledge about ways to mitigate and adapt to climate change.*

16. Wrap up by returning to the Guiding Question:

> **Q: How and why have temperatures changed since the 1960s, and how should we respond?**
>
> *A: Temperatures have changed because humans have put more greenhouse gases into the atmosphere. These gases trap heat, increasing the temperature of the planet. We can respond by reducing how many greenhouse gases are emitted and by adapting to protect ourselves, animals, plants, and the environment from more extreme temperatures.*

Extension Activity

Use the following activity after the lesson to extend student mastery of this Grades 3–5 Science and Engineering Practice.

Constructing Explanations and Designing Solutions.

- Use evidence (e.g., measurements, observations, patterns) to design a solution to a problem.

In the days, weeks, or months following this lesson, you can extend student understanding and engagement by working to implement one or more of the mitigation or adaptation ideas generated by the class.

Many of the changes needed to mitigate and adapt to climate change cannot be effectively implemented by individuals working alone. Rather, they require collective action at the local, state, national, and international levels. Likewise, there may be some changes that students in your class cannot implement without the support of school administration. Have students consider how they can advocate for those changes. For example, students may write letters, meet with school officials, or organize an event.

Consider collecting data both before and after a change is implemented to understand its effects and whether it should be replicated elsewhere. For example, you could collect data about the number and types of vehicles idling outside the school both before and after the implementation of a no-idling policy, then calculate the approximate reduction in greenhouse gas emissions as a result of the change.

Extreme Precipitation

Overview

Students examine precipitation data to draw conclusions about the changes in Earth's climate since the 1960s. A video introduction discusses how increased temperatures have caused more extreme precipitation. Students then explore their local environments to suggest methods for mitigation of greenhouse gas emissions and adaptation to extreme precipitation.

A more advanced version of this lesson is available in *Climate Change,* Gr 6-8.

Guiding Question

How and why have precipitation patterns changed since the 1960s, and how should we respond?

Objectives

Students will be able to

- analyze and interpret precipitation data from the 1960s and the 2010s.
- explain how human-caused greenhouse gas emissions have caused an increase in global precipitation over the past century.
- propose local solutions for climate change mitigation and adaptation to extreme precipitation.

Background

Humans cause climate change in several ways. Some of the most significant include burning fossil fuels to power engines, generate electricity, heat buildings, and produce materials such as cement; cutting down forests; raising livestock; and using fertilizers.

All of these activities release gases such as carbon dioxide,

Time

- 20 minutes to explore data
- 5 minutes to watch video
- 20 minutes to suggest solutions

Grade Level: 3–5

Vocabulary

- **Adaptation**
- **Climate**
- **Climate Change**
- **Greenhouse Gas**
- **Mitigation**
- **Precipitation**
- **Remote Sensing**
- **Weather**
- **Weather Patterns**

Standards

NGSS SEP: **Analyzing and Interpreting Data.** Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.

NGSS MS-ESS3-5. Obtain and combine information to describe climates in different regions of the world.

NGSS CCC: Patterns.

CCSS.Math.Content.3.NBT.A.2.

CCSS.Math.Content.5.NBT.B.7.

methane, and nitrous oxide. When sunlight reaches Earth, much of the energy is converted to thermal energy. Some of the energy is absorbed and some is radiated back into the atmosphere. Carbon dioxide, methane, and nitrous oxide in the atmosphere reduce the amount of thermal energy that escapes back into space. These gases are called "greenhouse gases" because they function like the insulating panes of glass in a greenhouse.

An increase in the levels of greenhouse gases in the atmosphere has multiple consequences. The most direct one is an increase in the planet's average temperature, which has risen more than 1°C since the beginning of the Industrial Revolution in the 1700s. As the ocean warms, more moisture evaporates, leading to larger and more energetic storms such as hurricanes and blizzards. Many of the world's regions have experienced an increase in heavy precipitation since the 1960s as a result of this phenomenon.

Preparation

For this activity, the educator will need the following:

- Video: *Sensing Our Climate: Extreme Precipitation* (3:52) (English | Spanish)
- A way to show the video to students
- Whiteboard or chart paper

For this activity, each student will need the following:

- 1 copy of *City Precipitation* (English | Spanish | Answer Key)
- 1 copy of *Mitigation Strategies* (English | Spanish | Answer Key)
- 1 copy of *Adaptation Strategies* (English | Spanish | Answer Key)
- 1 pen or pencil

Access the interactive version of this lesson, powered by Pear Deck™

EiE Connections

Learn more about the Engineering Design Process in the EiE Video Library.

Continue your classroom activities with these units:

Engineering Everywhere®

- Designing Water Filters
- Evaluating a Landscape

Engineering Adventures®

- Engineering Aid Drop Packages
- Engineering an Avalanche Protection System

Museum of Science Connections

Listen to the Pulsar podcast episode "Climate Change Resilience in Boston."

Family Connections

Continue the engineering at home with these activities:

- Engineer a Floating House
-
- PLANETS: Remote Sensing Investigation

Credits

MOS at School programs are offered at no cost, thanks to the generosity of the Akamai Foundation, Bloomberg Philanthropies, BNY Mellon, Gordon Foundation, Hood, Lincoln and Therese Filene Foundation, Lowell Institute, Mabel Louise Riley Foundation, MathWorks, Richard K. Lubin Family Foundation, Sanofi, and TJX.

Activity Instructions

These steps offer support for implementing the Sensing Our Climate: Extreme Precipitation video and associated activities with students.

If your students need additional background about the basics of climate change, consider teaching the Climate Change Overview lesson first.

1. Explain to students that today they will be thinking about something they have probably experienced before: precipitation. Ask:

> **Q: What is precipitation?**
>
> *A: Accept all responses. Students may know that* **precipitation** *is rain and snow (as well as less-common phenomena such as sleet or hail). As necessary, explain that precipitation is one part of* **weather**, *the short-term temperatures and conditions that we experience each day.*

Material Tips

If your students have already learned about precipitation, show or describe some of the work they did or phenomena they studied in order to activate their prior knowledge.

Q: Why is getting the right amount of precipitation important for people, other animals, and plants?

A: Accept all responses. Possible responses include that living things need water in their habitats to survive, but too much water can drown them or wash them away. Some animals need precipitation for their habitats to have the right features, such as snow on the ground or water in a river.

Activity Tips

Consider providing your students with examples of local organisms that require an amount of precipitation within a specific range. Have them share observations they have made about those organisms when they get too much or too little precipitation. (For example, what happens to trees when there is lots of rain or no rain at all?)

2. Explain to students that while the amount of precipitation changes from day to day and month to month, most places have a usual amount of precipitation: some places usually get a lot of precipitation, some places usually get little precipitation, and some are in the middle. Ask:

Q: What are some places that usually get a lot of precipitation?

A: Responses will vary. Possible responses include tropical places, places near the equator, or specific regions, states, or cities.

Q: What are some places that usually get little precipitation?

A: Responses will vary. Possible responses include deserts, tundra, high-elevation places, or specific regions, states, or cities.

Activity Tips

If your students are familiar with the idea of means/averages, you can explain that taking the average precipitation for an area is one way of measuring its climate. Scientists can measure average precipitation per day, at different times of year, and from one year to the next.

Tell students that the usual temperature and weather conditions in a place are called its **climate**. They have just named places with wet and dry climates.

3. Tell students that they are going to do something that scientists who study climate do: analyze how the usual precipitation in different places has changed over time. Distribute *City Precipitation* (English | Spanish) to students. Explain that they will be calculating how the usual annual precipitation has changed for different cities between a long time ago (the 1960s) and more recently (the 2010s). They will do this by subtracting the old annual precipitation amount from the new one. The information they find could be important for protecting people, animals, and plants.

Activity Tips

The precipitation data set comes in both centimeters and inches, with and without decimals. Use the units and level of precision appropriate for your students.

Local relevance is key to student engagement with climate change concepts. Before the lesson, look up the average annual precipitation in the 1960s and 2010s for one to three local areas. (For the United States, easy-to-access data is available from the National Oceanic and Atmospheric Administration Regional Climate Centers.) Add those areas and precipitation amounts to the bottom of City Precipitation and have students calculate precipitation changes for them as well. Students may also share their prior knowledge about climate and weather in those areas.

Students may have experienced loss in extreme weather events. Think carefully about how to guide the discussion in a way that is respectful of and sensitive to students' experiences.

This lesson uses data from the 1960s because students may know people (such as family members or teachers) who were alive at that time, making the comparison to the present more engaging. Although this range does not capture the entirety of human greenhouse gas emissions, it includes most of them: approximately three-quarters of all human greenhouse gas emissions before 2020 occurred in the period after 1960.

4. Give students time to calculate precipitation changes. You can allow them to work individually, in groups, or in some combination of the two. (For example, you can have students calculate changes on their own and then discuss their results in groups.)

5. Have students interpret their findings. Ask:

Q: What do you notice about the precipitation changes?

A: Responses will vary. A possible response is most of the precipitation changes are positive, although a few are negative.

Q: What do the precipitation changes tell us about the change in precipitation in these cities?

A: The fact that the precipitation changes are mostly positive means that most of the cities listed received more precipitation in the 2010s than in the 1960s. Only two of the cities, Jacksonville and Los Angeles, received less precipitation.

Activity Tips

Displaying information in various formats can help scientists interpret it. Consider having students graph some of the data by hand or digitally in order to discover patterns.

Activity Tips

Displaying information in various formats can help scientists interpret it. Consider having students graph some of the data by hand or digitally in order to discover patterns.

6. Explain to students that the change was not just in these cities. Precipitation amounts changed in many places around the planet between 1960 and 2020, part of a process called **climate change.** Ask:

Q: Do you have any ideas about why Earth might have different precipitation patterns now than it did fifty years ago?

A: Responses will vary. Students may know that the atmosphere now contains more ***greenhouse gases,*** *gases that trap heat from the Sun and prevent it from radiating back out into space. They may have heard of different kinds of greenhouse gases, especially carbon dioxide. These gases increase the planet's average surface temperature, causing more water to evaporate and storms to become more intense.*

Q: What are some ways changes in precipitation might be affecting people, animals, or plants?

A: Responses will vary. A possible response is that big storms can drown living things or wash away their habitats. If living things don't get enough precipitation, they can be thirsty or run out of food to eat.

Activity Tips

More information on the sources and effects of greenhouse gases is available in the Climate Change Overview and Extreme Temperatures lessons. More information about other consequences of the increase in global average temperature is available in the Wildfires and Drought and Rising Sea Level lessons.

Students may need help to understand the connection between increased temperatures and extreme precipitation. It may be useful to remind them about previous work they have done with the water cycle and to discuss how increased temperatures affect the different phases of the cycle.

Although an increase in extreme precipitation events is one reason cities became more liable to flood between the 1960s and the 2010s, there are other reasons as well. One is an increase in impermeable pavement, which, unlike soil, cannot absorb water and so leads to increased flood levels during rainfall. Sea level rise also increases the likelihood of flooding during storms. This lesson does not include discussion of these phenomena, but you may want to discuss them if students bring them up.

7. Tell students that scientists are interested in the ways that extreme precipitation events are occurring. Play the video Sensing *Our Climate: Extreme Precipitation* (3:52).

watch video

Discuss the video. Ask:

> **Q: What else did you learn about extreme precipitation from the video?**
>
> *A: Responses will vary. Possible responses include that extreme precipitation can take the form of both hurricanes and blizzards and that scientists can use **remote sensing**, the science of scanning Earth from a distance using technology like satellites and high-flying airplanes, to gather information about climate change.*

> **Q: What does the video say about how humans can respond to climate change?**
>
> *A: Humans can use airplanes and satellites to observe when storms form, see where they go, and predict how people should prepare for them.*

Activity Tips

Although the precipitation data used in this unit were collected at Earth's surface, the video mentions using remote sensing for data collection. If students are interested, you can consider possible benefits and drawbacks of collecting data from the ground, from the atmosphere, or from space. For example, weather measurements on the ground are easy and cheap to make and can capture small differences between nearby locations. Remote sensing measurements require expensive equipment, can be blocked by clouds, and do not always have high resolution, but they can cover large areas and observe places difficult or impossible to reach on the ground.

If students are interested in how higher temperatures can cause more snowstorms, you can play the video Snowstorms (0:28) to provide further information.

8. Call students' attention to the line at the end of the video that "Humans are incredibly innovative and resilient, and our development and utilization of new technology will allow us to be prepared." Explain that there are different ways to use technology in response to climate change. **Mitigation** is human action that limits the concentration of greenhouse gases in the atmosphere, such as using electric cars instead of cars that burn gas. **Adaptation** is human action that limits the harm caused by climate change, such as using satellites to observe where storms will hit.

On a whiteboard or chart paper, make a table with the headings "Mitigation" and "Adaptation." Have students brainstorm other examples of each strategy and add them to the chart.

Mitigation *human action that limits the concentration of greenhouse gases in the atmosphere*	Adaptation *human action that limits the harm caused by climate change*
• Using electric cars that do not burn fossil fuels	• Predicting where storms will hit and evacuating people

Activity Tips

To avoid confusion, you can explain to students that mitigation and adaptation have different definitions outside the context of climate change. Students may be familiar with other uses of the terms; for example, in biology, adaptation means "a characteristic that allows a living thing to survive in its environment."

9. Tell students that while it can be hard to protect other parts of the country or the world from climate change, there's a lot they can do to protect the people, animals, plants, and environment around them. Today, they will suggest ideas for mitigation and adaptation in their community. Distribute *Mitigation Strategies* (English | Spanish) and explain that they will use it to record sources of greenhouse gas emissions at or caused by their school. Distribute *Adaptation Strategies* (English | Spanish) and explain that they will use it to record ways that their school might be affected by extreme precipitation.

Activity Tips

Depending on time, your school environment, and other lessons you have already completed, you may choose to focus only on mitigation or adaptation. (The mitigation activity in this lesson also appears in the Extreme Temperatures, Wildfires and Drought, and Rising Sea Level lessons.) Distribute only the appropriate sheet to students and use only the relevant discussion questions later in the activity.

If your in-class time is limited, students can complete the investigation and brainstorming of mitigation and adaptation strategies without leaving the classroom, or they can do so outside of class time.

10. Travel around the school and school grounds; possible places to visit include a cafeteria, heating or cooling equipment, dumpsters or other waste disposal, a garden or other green space, a blacktop or playground, drainage canals and grates, and vehicles or parking. Have students work individually or in small groups to record sources of greenhouse gases on the left side of *Mitigation Strategies* and vulnerabilities to extreme precipitation on the left side of *Adaptation Strategies*. Draw student attention to relevant features of the school environment as necessary.

Activity Tips

Although mitigation is often discussed in terms of reducing the sources that emit greenhouse gases into the atmosphere, enhancing the sinks that absorb greenhouse gases from the atmosphere is also a mitigation strategy. Examples of important sinks include the ocean and plants. It may be appropriate to discuss the idea of greenhouse gas sinks with students (or they may bring it up themselves), especially if your school grounds contain plants.

As you travel around the school, it may also be appropriate for students to ask individuals (other students, teachers, workers, and administrators) about their knowledge of the school's greenhouse gas emissions and vulnerability to extreme precipitation. Make sure to arrange any interviews ahead of time. You could also have individuals come to visit your classroom.

11. Return to the classroom. In small groups or as a class, have students share the greenhouse gas sources they recorded on *Mitigation Strategies*. Ask:

> **Q: What sources of greenhouse gases did you notice?**
>
> *A: Responses will vary. Possible responses include vehicles, such as school buses or garbage trucks; devices that use electricity, such as lights or air conditioners; objects whose manufacture releases greenhouse gases, such as paper or cement; food whose production releases greenhouse gases, such as beef and milk; heating devices, such as furnaces; and the removal of plants or green space.*

12. Explain that students can use their knowledge about climate change to plan ways to reduce the school's greenhouse gas emissions. Ask:

> **Q: What changes can we make here to mitigate climate change?**
>
> *A: Responses will vary. Possible responses include reducing activities that produce greenhouse gases (such as idling cars outside the school), making activities more efficient (such as using efficient light bulbs), and doing them in ways that do not require fossil fuels (such as using cars and school buses powered by electricity from a non-carbon source).*

Have students fill in the right column of Mitigation Strategies with the ideas they discuss.

13. Explain that although mitigation is extremely important for reducing the future effects of climate change, some effects, such as extreme precipitation, are already happening. In small groups or as a class, have students share the ways that the school might be affected by extreme precipitation that they recorded on Adaptation Strategies. Ask:

Q: How might our school be affected by extreme precipitation?

A: Responses will vary. Possible responses include getting wet or snowy, having pavement flood, having mudslides or avalanches on hills, or having roofs leak or break.

Have students fill in the right column of Mitigation Strategies with the ideas they discuss.

14. Explain that students can use their knowledge about climate change to plan ways to adapt the school for extreme precipitation. Ask:

Q: How could our school adapt to extreme precipitation?

A: Responses will vary. Possible responses include monitoring weather forecasts and warning people of impending extreme precipitation, having extra umbrellas and shovels available, replacing pavement with plants to improve drainage, adding plants or barriers on hillsides to prevent erosion, having sloped roofs, and cleaning gutters regularly.

Have students fill in the right column of Mitigation Strategies with the ideas they discuss.

15. Discuss how to put these ideas into action. Ask:

Q: Now that we have brainstormed ideas for mitigation and adaptation at our school, how can we put these ideas into action?

A: Responses will vary. Some actions, such as reducing paper and electricity use, can be implemented in your classroom (and encouraged in other classrooms). Other ideas may need to be implemented by the school administration.

Q: Where else could you use these strategies to mitigate and adapt to climate change?

A: Responses will vary. Possible responses include at home and at local community organizations. Encourage students to investigate the specific circumstances in those places and share their knowledge about ways to mitigate and adapt to climate change.

16. Wrap up by returning to the Guiding Question:

> **Q: How and why have precipitation patterns changed since the 1960s, and how should we respond?**
>
> *A: Temperatures have changed because humans have put more greenhouse gases into the atmosphere. These gases trap heat, increasing the temperature of the planet. This increased temperature warms water, causing more evaporation and more energetic storms. We can respond by reducing how many greenhouse gases are emitted and by adapting to protect ourselves, animals, plants, and the environment from more extreme precipitation.*

Extension Activity

Use the following activity after the lesson to extend student mastery of this Grades 3–5 Science and Engineering Practice.

Constructing Explanations and Designing Solutions.

- Use evidence (e.g., measurements, observations, patterns) to design a solution to a problem.

In the days, weeks, or months following this lesson, you can extend student understanding and engagement by working to implement one or more of the mitigation or adaptation ideas generated by the class.

Many of the changes needed to mitigate and adapt to climate change cannot be effectively implemented by individuals working alone. Rather, they require collective action at the local, state, national, and international levels. Likewise, there may be some changes that students in your class cannot implement without the support of school administration. Have students consider how they can advocate for those changes. For example, students may write letters, meet with school officials, or organize an event.

Consider collecting data both before and after a change is implemented to understand its effects and whether it should be replicated elsewhere. For example, you could collect data about the number and types of vehicles idling outside the school both before and after the implementation of a no-idling policy, then calculate the approximate reduction in greenhouse gas emissions as a result of the change.

Wildfires and Drought

Overview

Students examine data on the area burned by wildfire to draw conclusions about the changes in Earth's climate since 2000. A video introduction discusses how increased temperatures have caused more extensive wildfires. Students then explore their local environments to suggest methods for mitigation of greenhouse gas emissions and adaptation to wildfires.

A more advanced version of this lesson is available in *Climate Change,* Gr 6-8.

Guiding Question

How and why have wildfires changed since the 2000s, and how should we respond?

Objectives

Students will be able to

- analyze and interpret wildfire data from the 2000s and the 2010s.
- explain how human-caused greenhouse gas emissions have caused an increase in the total area burned by wildfire.
- propose local solutions for climate change mitigation and adaptation to wildfires.

Background

Humans cause climate change in several ways. Some of the most significant include burning fossil fuels to power engines, generate electricity, heat buildings, and produce materials such as cement; cutting down forests; raising livestock; and using fertilizers.

All of these activities release gases such as carbon dioxide, methane, and nitrous oxide. When sunlight reaches Earth, much of the energy is converted to thermal energy. Some of the energy

Time

- 20 minutes to explore data
- 5 minutes to watch video
- 20 minutes to suggest solutions

Grade Level: 3–5

Vocabulary

- **Adaptation**
- **Climate**
- **Climate Change**
- **Drought**
- **Greenhouse Gas**
- **Mitigation**
- **Remote Sensing**
- **Weather**
- **Weather Patterns**
- **Wildfire**

Standards

NGSS SEP: **Analyzing and Interpreting Data.** Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.

NGSS MS-ESS3-5. Obtain and combine information to describe climates in different regions of the world.

NGSS CCC: Patterns.

CCSS.Math.Content.3.MD.C.6.

is absorbed and some is radiated back into the atmosphere. Carbon dioxide, methane, and nitrous oxide in the atmosphere reduce the amount of thermal energy that escapes back into space. These gases are called "greenhouse gases" because they function like the insulating panes of glass in a greenhouse.

An increase in the levels of greenhouse gases in the atmosphere has multiple consequences. The most direct one is an increase in the planet's average temperature, which has risen more than 1°C since the beginning of the Industrial Revolution in the 1700s. Increased temperatures can increase evaporation from bodies of water such as lakes and reservoirs, as well as faster melting of spring snowpack, leading to longer and more intense droughts in some areas. Increased temperatures and droughts together lead to more extensive wildfires.

Preparation

For this activity, the educator will need the following:

- Video: *Sensing Our Climate: Wildfires and Drought* (3:37) (English | Spanish)
- A way to show the video to students
- Whiteboard or chart paper

For this activity, each student will need the following:

- 1 copy of Area Burned (English | Spanish | Answer Key)
- 1 copy of Mitigation Strategies (English | Spanish | Answer Key)
- 1 copy of Adaptation Strategies (English | Spanish | Answer Key)
- 1 pen or pencil

Access the interactive version of this lesson, powered by Pear Deck™

EiE Connections

Learn more about the Engineering Design Process in the EiE Video Library.

Museum of Science Connections

Listen to the Pulsar podcast episode "Staying Safe in a Lightning Storm."

Family Connections

Continue the engineering at home with these activities:

- Keep It Watered!
- PLANETS: Remote Sensing Investigation

Credits

MOS at School programs are offered at no cost, thanks to the generosity of the Akamai Foundation, Bloomberg Philanthropies, BNY Mellon, Gordon Foundation, Hood, Lincoln and Therese Filene Foundation, Lowell Institute, Mabel Louise Riley Foundation, MathWorks, Richard K. Lubin Family Foundation, Sanofi, and TJX.

Activity Instructions

These steps offer support for implementing the *Sensing Our Climate: Wildfires and Drought* video and associated activities with students.

If your students need additional background about the basics of climate change, consider teaching the Climate Change Overview lesson first.

1. Explain to students that today they will be thinking about something they likely know about: fire. Ask:

> **Q: What is fire?**
>
> *A: Accept all responses. Students may describe fire as what happens when something burns. They may list features of fire, such as heat, light, and danger. They may also give examples of how they use fire, such as to cook, heat water, or stay warm.*

> **Q: What is a wildfire?**
>
> *A: Accept all responses. Students may know that a wildfire is an uncontrolled fire in an outdoor area. They may give examples of wildfires they have heard about or experienced.*

Material Tips

If your students have already learned about fire, show or describe some of the work they did or phenomena they studied in order to activate their prior knowledge.

Activity Tips

Students may have experienced loss in wildfires. Think carefully about how to guide the discussion in a way that is respectful of and sensitive to students' experiences.

Consider providing your students with examples of local organisms that are affected by wildfires. Discuss the ways in which these organisms have been affected.

Q: Why are wildfires useful for animals and plants?

A: Accept all responses. Students may know that wildfires can help nutrients cycle through an ecosystem. Wildfires can also prevent the buildup of dry plant matter, preventing much larger fires in the future. Some living things rely on fire for their life cycle. For example, certain trees sprout only after being exposed to fire.

2. Explain to students that wildfires often happen in places that are hot and dry. Ask:

Q: What are some places that are usually hot?

A: Responses will vary. Possible responses include tropical places, places near the equator, deserts, or specific regions, states, or cities.

Q: What are some places that are usually dry?

A: Responses will vary. Possible responses include deserts or specific regions, states, or cities.

Activity Tips

You can explain to students that one way of measuring climate is by an area's fire season, the period in the year during which wildfires are most likely to start and to spread. Some ways to measure the intensity of a fire season are the number of days, number of fires, or total area burned.

Tell students that the usual temperature and weather conditions in a place are called its climate. They have just named places with hot and dry climates. If a place becomes hotter and drier, it will often have more wildfires.

3. Tell students that they are going to do something that scientists who study climate do: analyze how fire seasons have changed over time. Distribute *Area Burned* (English | Spanish) to students. Explain that they will be calculating the area burned in the 2000s and the 2010s, then subtracting to see how the fire seasons changed from one decade to the next. The information they find could be important for protecting people, animals, and plants.

Activity Tips

The wildfire data set comes in both square kilometers and square miles. Use the unit that is appropriate for your students.

Local relevance is key to student engagement with climate change concepts. Before the lesson, if you live in a wildfire-prone area, you can look up wildfire statistics for where you live and have students perform calculations with them as well. (For the United States, yearly state-by-state data is available from the National Interagency Fire Center.) If you live in an area not as prone to wildfires, you can create local relevance by having students determine how the size of burned areas compares to that of local regions. For example, about 28,500 square km burned in California in the 2010s, an area slightly larger than the entire state of Massachusetts.

This lesson uses data from the 2000s because that is the earliest period for which many precise wildfire statistics are reported. This fact is partly due to the availability of remote sensing technologies. For example, NASA's Terra and Aqua—the satellites mentioned in the video—launched in 1999 and 2002, respectively. These satellites provide detailed images of fires around the world.

4. Give students time to calculate areas burned and the changes between decades. You can allow them to work individually, in groups, or in some combination of the two. (For example, you can have students calculate changes on their own and then discuss their results in groups.)

5. Have students interpret their findings. Ask:

Q: What do you notice about the changes in area burned?

A: Responses will vary. A possible response is that all the changes are positive.

Q: What do the changes in area burned tell us about the change in fire in these states and provinces?

A: The fact that the changes are all positive means that more area burned in each of these states and provinces in the 2010s than in the 2000s.

Material Tips

Displaying information in various formats can help scientists interpret it. Consider having students graph some of the data by hand or digitally in order to discover patterns.

Activity Tips

The area burned alone does not capture all the changes in wildfire patterns. For example, in the 2010s, many wildfires also spread more quickly, making it more difficult for people to respond by evacuating or firefighting.

6. Explain to students that the change was not just in these states and provinces. Wildfires have burned increasingly large areas in many places around the planet since 2000, part of a process called **climate change.** Ask:

Q: Do you have any ideas about why wildfires might be burning more area now than in the 2000s?

*A: Responses will vary. Students may know that the atmosphere now contains more **greenhouse gases**, gases that trap heat from the Sun and prevent it from radiating back out into space. They may have heard of different kinds of greenhouse gases, especially carbon dioxide. These gases increase the planet's average surface temperature, causing **drought**, or an extended period of abnormally dry weather. The resulting dry, hot conditions make it easier for wildfires to start and to spread.*

Q: What are some ways changes in wildfires might be affecting people, animals, or plants?

A: Responses will vary. A possible response is that frequent, large, intense wildfires can destroy people's homes and the habitats of other living things. They can also kill people and other living things or hurt them through pollution such as smoke.

7. Tell students that scientists are interested in the ways that extreme wildfires are occurring. Play the video *Sensing Our Climate: Wildfires and Drought* (3:37).

watch video

Activity Tips

The video mentions using remote sensing for data collection. If students are interested, you can consider possible benefits and drawbacks of collecting data from the ground, from the atmosphere, or from space. For example, wildfires can often be spotted remotely before they are observed on the ground. However, remote sensing measurements require expensive equipment, can be blocked by clouds, and do not always have high resolution.

Discuss the video. Ask:

Q: What else did you learn about wildfires from the video?

*A: Responses will vary. Possible responses include that drought contributes to wildfires and that scientists can use **remote sensing,** the science of scanning Earth from a distance using technology like satellites and high-flying airplanes, to gather information about climate change.*

Q: What does the video say about how humans can respond to climate change?

A: Humans can use airplanes and satellites to observe when wildfires start, to see where they go and the path of their smoke, and to predict how people should prepare for them.

8. Call students' attention to the line at the end of the video that says "Humans are incredibly innovative and resilient, and our development and utilization of new technology will allow us to be prepared." Explain that there are different ways to use technology in response to climate change. **Mitigation** is human action that limits the concentration of greenhouse gases in the atmosphere, such as using electric cars instead of cars that burn gas. **Adaptation** is human action that limits the harm caused by climate change, such as using satellites to observe the location of wildfires and smoke.

On a whiteboard or chart paper, make a table with the headings "**Mitigation**" and "**Adaptation**." Have students brainstorm other examples of each strategy and add them to the chart.

Mitigation *human action that limits the concentration of greenhouse gases in the atmosphere*	Adaptation *human action that limits the harm caused by climate change*
• Using electric cars that do not burn fossil fuels	• Predicting where wildfires and smoke will go and warning people

Activity Tips

To avoid confusion, you can explain to students that mitigation and adaptation have different definitions outside the context of climate change. Students may be familiar with other uses of the terms; for example, in biology, adaptation means "a characteristic that allows a living thing to survive in its environment."

9. Tell students that while it can be hard to protect other parts of the country or the world from climate change, there's a lot they can do to protect the people, animals, plants, and environment around them. Today, they will suggest ideas for mitigation and adaptation in their community. Distribute *Mitigation Strategies* (English | Spanish) and explain that they will use it to record sources of greenhouse gas emissions at their school. Distribute *Adaptation Strategies* (English | Spanish) and explain that they will use it to record ways that their school might be affected by wildfires.

Activity Tips

Depending on time, your school environment, and other lessons you have already completed, you may choose to focus only on mitigation or adaptation. (The mitigation activity in this lesson also appears in the Extreme Temperatures, Extreme Precipitation, and Rising Sea Level lessons.) Distribute only the appropriate sheet to students and use only the relevant discussion questions later in the activity.

If your in-class time is limited, students can complete the investigation and brainstorming of mitigation and adaptation strategies without leaving the classroom, or they can do so outside of class time.

10. Travel around the school and school grounds; possible places to visit include a cafeteria, heating/cooling or air-filtration equipment, dumpsters or other waste disposal, a garden or other green space, a blacktop or playground, and vehicles or parking. Have students work individually or in small groups to record sources of greenhouse gases on the left side of *Mitigation Strategies* and vulnerabilities to wildfires on the left side of *Adaptation Strategies*. Draw student attention to relevant features of the school environment as necessary.

Activity Tips

Although mitigation is often discussed in terms of reducing the sources that emit greenhouse gases into the atmosphere, enhancing the sinks that absorb greenhouse gases from the atmosphere is also a mitigation strategy. Examples of important sinks include the ocean and plants. It may be appropriate to discuss the idea of greenhouse gas sinks with students (or they may bring it up themselves), especially if your school grounds contain plants.

As you travel around the school, it may also be appropriate for students to ask individuals (other students, teachers, workers, and administrators) about their knowledge of the school's greenhouse gas emissions and vulnerability to wildfire. Make sure to arrange any interviews ahead of time. You could also have individuals come to visit your classroom.

11. Return to the classroom. Have students work in small groups or as a class to share the greenhouse gas sources they recorded on *Mitigation Strategies.* Ask:

> **Q: What sources of greenhouse gases did you notice?**
>
> *A: Responses will vary. Possible responses include vehicles, such as school buses or garbage trucks; devices that use electricity, such as lights or air conditioners; objects whose manufacture releases greenhouse gases, such as paper or cement; food whose production releases greenhouse gases, such as beef and milk; heating devices, such as furnaces; and the removal of plants or green space.*

12. Explain that students can use their knowledge about climate change to plan ways to reduce the school's greenhouse gas emissions. Ask:

> **Q: What changes can we make here to mitigate climate change?**
>
> *A: Responses will vary. Possible responses include reducing activities that produce greenhouse gases (such as idling cars outside the school), making activities more efficient (such as using efficient light bulbs), and doing them in ways that do not require fossil fuels (such as using cars and school buses powered by electricity from a non-carbon source).*

Have students fill in the right column of *Mitigation Strategies* with the ideas they discuss.

13. Explain that although mitigation is extremely important for reducing the future effects of climate change, some effects, such as larger and more intense wildfires, are already happening. Have students work in small groups or as a class to share the ways that the school might be affected by wildfires that they recorded on *Adaptation Strategies.* Ask:

Q: How might our school be affected by wildfires?

A: Responses will vary. Possible responses include having people or animals exposed to smoke, having plants near the school catch fire, or having parts of the school itself catch fire.

14. Explain that students can use their knowledge about climate change to plan ways to adapt the school for wildfires. Ask:

Q: How could our school adapt to wildfires?

A: Responses will vary. Possible responses include monitoring remote sensing data and warning people of nearby smoke or fire, having effective air filtration systems for when it is smoky, keeping plants well-watered and spaced away from the school, using fire-resistant materials in the school, and having evacuation plans.

Have students fill in the right column of *Adaptation Strategies* with the ideas they discuss.

15. Discuss how to put these ideas into action. Ask:

Q: Now that we have brainstormed ideas for mitigation and adaptation at our school, how can we put these ideas into action?

A: Responses will vary. Some actions, such as reducing paper and electricity use, can be implemented in your classroom (and encouraged in other classrooms). Other ideas may need to be implemented by the school administration.

Q: Where else could you use these strategies to mitigate and adapt to climate change?

A: Responses will vary. Possible responses include at home and at local community organizations. Encourage students to investigate the specific circumstances in those places and share their knowledge about ways to mitigate and adapt to climate change.

16. Wrap up by returning to the Guiding Question:

> **Q: How and why have wildfires changed since the 2000s, and how should we respond?**
>
> *A: Temperatures have changed because humans have put more greenhouse gases into the atmosphere. These gases trap heat, increasing the temperature of the planet. This increased temperature warms water, causing more evaporation and faster snowmelt. Together, increased temperatures and drought contribute to faster-spreading, larger, and more intense wildfires. We can respond by reducing how many greenhouse gases are emitted and by adapting to protect ourselves, animals, plants, and the environment from wildfires.*

Extension Activity

Use the following activity after the lesson to extend student mastery of this Grades 3–5 Science and Engineering Practice.

Constructing Explanations and Designing Solutions.

- Use evidence (e.g., measurements, observations, patterns) to design a solution to a problem.

In the days, weeks, or months following this lesson, you can extend student understanding and engagement by working to implement one or more of the mitigation or adaptation ideas generated by the class.

Many of the changes needed to mitigate and adapt to climate change cannot be effectively implemented by individuals working alone. Rather, they require collective action at the local, state, national, and international levels. Likewise, there may be some changes that students in your class cannot implement without the support of school administration. Have students consider how they can advocate for those changes. For example, students may write letters, meet with school officials, or organize an event.

Consider collecting data both before and after a change is implemented to understand its effects and whether it should be replicated elsewhere. For example, you could collect data about the number and types of vehicles idling outside the school both before and after the implementation of a no-idling policy, then calculate the approximate reduction in greenhouse gas emissions as a result of the change.

Rising Sea Level

Overview

Students examine sea level data to draw conclusions about the changes in Earth's climate since 1920. A video introduction discusses how increased temperatures have caused sea level rise. Students then explore their local environments to suggest methods for mitigation of greenhouse gas emissions and adaptation to sea level rise.

A more advanced version of this lesson is available in *Climate Change,* Gr 6-8.

Guiding Question

How and why have sea levels changed since the 1920s, and how should we respond?

Objectives

Students will be able to

- analyze and interpret sea level data from 1920 to 2020.
- explain how human-caused greenhouse gas emissions have caused a rise in sea levels over the past century.
- propose local solutions for climate change mitigation and adaptation to sea level rise.

Background

Humans cause climate change in several ways. Some of the most significant include burning fossil fuels to power engines, generate electricity, heat buildings, and produce materials such as cement; cutting down forests; raising livestock; and using fertilizers.

All of these activities release gases such as carbon dioxide, methane, and nitrous oxide. When sunlight reaches Earth, much of the energy is converted to thermal energy. Some of the energy is absorbed and some is radiated back into the atmosphere. Carbon dioxide, methane, and nitrous oxide in the atmosphere

Time

- 20 minutes to explore data
- 5 minutes to watch video
- 20 minutes to suggest solutions

Grade Level: 3–5

Vocabulary

- **Adaptation**
- **Climate**
- **Climate Change**
- **Greenhouse Gas**
- **Mitigation**
- **Remote Sensing**
- **Weather**
- **Weather Patterns**

Standards

NGSS SEP: **Analyzing and Interpreting Data.** Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.

NGSS 3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.

NGSS CCC: Patterns.

CCSS.Math.Content.3.MD.B.3.

reduce the amount of thermal energy that escapes back into space. These gases are called "greenhouse gases" because they function like the insulating panes of glass in a greenhouse.

An increase in the levels of greenhouse gases in the atmosphere has multiple consequences. The most direct one is an increase in the planet's average temperature, which has risen more than 1°C since the beginning of the Industrial Revolution in the 1700s. This increased temperature melts glaciers and ice sheets in places such as Greenland and Antarctica. It also causes ocean water to warm and expand. Both phenomena cause sea levels to rise.

Preparation

For this activity, the educator will need the following:

- Video: *Sensing Our Climate: Rising Sea Level* (3:32) (English | Spanish)
- A way to show the video to students
- Whiteboard or chart paper

For this activity, each student will need the following:

- 1 copy of *City Sea Level Change* (English | Spanish | Answer Key)
- 1 copy of *Mitigation Strategies* (English | Spanish | Answer Key)
- 1 copy of *Adaptation Strategies* (English | Spanish | Answer Key)
- 1 pen or pencil

Access the interactive version of this lesson, powered by Pear Deck™

Access the interactive version of this lesson, powered by Pear Deck™

EiE Connections

Learn more about the Engineering Design Process in the EiE Video Library.

Continue your classroom activities with these units:

Engineering Everywhere®

- Designing Bridges
- Designing Submersibles
- Designing Water Filters

Museum of Science Connections

Listen to the Pulsar podcast episodes "Climate Change Resilience in Boston," "Glaciers: Tortoise or Hare?", and "Preserving Our Heritage with Technology."

Watch the video *Places in Peril: Cities Facing the Climate Crisis.*

Check out the Museum's Wicked High Tides citizen science initiative.

Family Connections

Continue the engineering at home with these activities:

Engineer a Floating House

PLANETS: Remote Sensing Investigation

Credits

MOS at School programs are offered at no cost, thanks to the generosity of the Akamai Foundation, Bloomberg Philanthropies, BNY Mellon, Gordon Foundation, Hood, Lincoln and Therese Filene Foundation, Lowell Institute, Mabel Louise Riley Foundation, MathWorks, Richard K. Lubin Family Foundation, Sanofi, and TJX.

Activity Instructions

These steps offer support for implementing the Sensing Our Climate: Rising Sea Level video and associated activities with students.

If your students need additional background about the basics of climate change, consider teaching the Climate Change Overview lesson first.

1. Explain to students that today they will be thinking about the sea. Ask:

> **Q: What is the sea?**
>
> *A: Accept all responses. Students may know that the sea or ocean is the location of most water on Earth. Although most seas are part of a single body of water, people use different names to refer to different parts, such as the Atlantic Ocean, Pacific Ocean, Indian Ocean, and Caribbean Sea.*

Q: Why is the sea important for people, animals, and other living things?

A: Accept all responses. Possible responses include that many living things live in or near the sea or depend on it for food. People use the sea in different ways, such as for food and transportation.

Activity Tips

If you live near the sea, consider providing your students with examples of local organisms that live in or near it. Have them share observations about those organisms when the sea level is higher or lower. (For example, what do organisms on the beach do at high tide? At low tide?) If you don't live near the sea, students can share any experiences they have had if they have visited it.

Material Tips

If your students have already learned about the sea, show or describe some of the work they did or phenomena they studied in order to activate their prior knowledge.

2. Have students consider sea level. Ask:

Q: What affects the level of the sea?

*A: Accept all responses. Students may know that the level of the sea is affected by gravity from the Moon and the Sun. The **weather**, short-term temperatures and conditions such as wind and storms, also affects sea level.*

Explain to students that while the sea level changes depending on the time of day and time of the month, each place has a usual sea level between high tide and low tide.

3. Tell students that they are going to do something that scientists who study the sea do: represent how the usual sea level in different places has changed over time. Distribute *City Sea Level Change* (English | Spanish) to students. Explain that they will be making a bar graph to show how the usual sea level has changed for different cities between 1920 and 2020. This information could be important for protecting people, animals, and plants.

Activity Tips

Activity Tips
The sea level data comes in both centimeters and inches. Use the units that are appropriate for your students.

Local relevance is key to student engagement with climate change concepts. If you live near the sea, before the lesson, look up sea level change for one or more local areas between 1920 and 2020. (Easy-to-access data is available from the National Oceanic and Atmospheric Administration.) Consider having students graph changes in sea level for those areas as well. Students may also share their prior knowledge about sea level and weather in those areas.

Students may have experienced loss due to sea level rise or extreme weather events. Think carefully about how to guide the discussion in a way that is respectful of and sensitive to students' experiences.

4. Give students time to graph sea level changes. You can allow them to work individually, in groups, or in some combination of the two. (For example, you can have students graph changes on their own and then discuss their results in groups.)

5. Have students interpret their findings. Ask:

> **Q: What does your graph show about the sea level changes?**
>
> *A: Responses will vary. A possible response is that all the sea level changes are positive, meaning sea level increased in all the cities listed between 1920 and 2020. The changes range from 13 cm (5") to 37 cm (15").*

6. Explain to students that the change was not just in these cities. Sea level rose in many places around the world between 1920 and 2020, part of a process called **climate change**. Ask:

> **Q: Do you have any ideas about why Earth might have higher sea levels now than it did in the early 1900s?**
>
> *A: Responses will vary. Students may know that the atmosphere now contains more greenhouse gases, gases that trap heat from the Sun and prevent it from radiating back out into space. They may have heard of different kinds of greenhouse gases, especially carbon dioxide. These gases increase the planet's average surface temperature, causing ice to melt in places such as Greenland and Antarctica.*

> **Q: What are some ways these higher sea levels might be affecting people, animals, or plants?**
>
> *A: Responses will vary. Possible responses include that people's homes can flood if the sea level is too high and that other living things might no longer have the right habitats to live in.*

7. Tell students that an increase in Earth's average temperature increases sea level in several ways. Play the video *Sensing Our Climate: Rising Sea Level* (3:32).

watch video

Discuss the video. Ask:

> **Q: What else did you learn about sea level rise from the video?**
>
> *A: Responses will vary. A possible response is that increased temperature causes sea level rise both by melting ice and by causing the thermal expansion of water. Students may also discuss*

how scientists can use remote sensing, the science of scanning Earth from a distance using technology like satellites and high-flying airplanes, to gather information about climate change.

Q: What does the video say about how humans can respond to climate change?

A: Humans can use satellites to monitor changes, and they can use technologies such as coastal barriers to limit the impacts of sea level rise.

8. Explain to students that there are different ways to use technology in response to climate change. Mitigation is human action that limits the concentration of greenhouse gases in the atmosphere, such as using electric cars instead of cars that burn gas. Adaptation is human action that limits the harm caused by climate change, such as building barriers to prevent flooding.

On a whiteboard or chart paper, make a table with the headings "Mitigation" and "Adaptation." Have students brainstorm other examples of each strategy and add them to the chart.

Mitigation *human action that limits the concentration of greenhouse gases in the atmosphere*	**Adaptation** *human action that limits the harm caused by climate change*
• Using electric cars that do not burn fossil fuels	• Building barriers to prevent flooding

Activity Tips

To avoid confusion, you can explain to students that mitigation and adaptation have different definitions outside the context of climate change. Students may be familiar with other uses of the terms; for example, in biology, adaptation means "a characteristic that allows a living thing to survive in its environment."

9. Tell students that while it can be hard to protect other parts of the country or the world from climate change, there's a lot they can do to protect the people, animals, plants, and environment around them. Today, they will suggest ideas for mitigation and adaptation in their community. Distribute *Mitigation Strategies* (English | Spanish) and explain that they will use it to record sources of greenhouse gas emissions at their school. Distribute *Adaptation Strategies* (English | Spanish) and explain that they will use it to record ways that their school might be affected by sea level rise.

Activity Tips

Depending on time, your school environment, and other lessons you have already completed, you may choose to focus only on mitigation or adaptation. (The mitigation activity in this lesson also appears in the Extreme Temperatures, Extreme Precipitation, and Wildfires and Drought lessons.) Distribute only the appropriate sheet to students and use only the relevant discussion questions later in the activity.

If your in-class time is limited, students can complete the investigation and brainstorming of mitigation and adaptation strategies without leaving the classroom, or they can do so outside of class time.

10. Travel around the school and school grounds; possible places to visit include a cafeteria, heating or cooling equipment, dumpsters or other waste disposal, a garden or other green space, and vehicles or parking. Have students work individually or in small groups to record sources of greenhouse gases on the left side of Mitigation Strategies and vulnerabilities to sea level rise on the left side of Adaptation Strategies. Draw student attention to relevant features of the school environment as necessary.

Activity Tips

Although mitigation is often discussed in terms of reducing the sources that emit greenhouse gases into the atmosphere, enhancing the sinks that absorb greenhouse gases from the atmosphere is also a mitigation strategy. Examples of important sinks include the ocean and plants. It may be appropriate to discuss the idea of greenhouse gas sinks with students (or they may bring it up themselves), especially if your school grounds contain plants.

As you travel around the school, it may also be appropriate for students to ask individuals (other students, teachers, workers, and administrators) about their knowledge of the school's greenhouse gas emissions and vulnerability to sea level rise. Make sure to arrange any interviews ahead of time. You could also have individuals come to visit your classroom.

The National Oceanic and Atmospheric Administration has tools for visualizing future sea level rise in a variety of climate scenarios. Consider sharing projected rise amounts for given years or scenarios. Your state or community may also have an amount of sea level rise that it uses for infrastructure planning.

11. Return to the classroom. In small groups or as a class, have students share the greenhouse gas sources they recorded on *Mitigation Strategies.* Ask:

Q: What sources of greenhouse gases did you notice?

A: Responses will vary. Possible responses include vehicles, such as school buses or garbage trucks; devices that use electricity, such as lights or air conditioners; objects whose manufacture releases greenhouse gases, such as paper or cement; food whose production releases greenhouse gases, such as beef and milk; heating devices, such as furnaces; and the removal of plants or green space.

12. Explain that students can use their knowledge about climate change to plan ways to reduce the school's greenhouse gas emissions. Ask:

Q: What changes can we make here to mitigate climate change?

A: Responses will vary. Possible responses include reducing activities that produce greenhouse gases (such as idling cars outside the school), making activities more efficient (such as using efficient light bulbs), and doing them in ways that do not require fossil fuels (such as using cars and school buses powered by electricity from a non-carbon source).

Have students fill in the right column of Mitigation Strategies with the ideas they discuss.

13. Explain that although mitigation is extremely important for reducing the future effects of climate change, some effects, such as sea level rise, are already happening. In small groups or as a class, have students share the ways that the school might be affected by sea level rise that they recorded on *Adaptation Strategies.* Ask:

Q: How might our school be affected by sea level rise?

A: Responses will vary. Possible responses include buildings flooding, having water become polluted and unsuitable for drinking or other uses, and having people and animals get wet.

14. Explain that students can use their knowledge about climate change to plan ways to adapt the school for sea level rise. Ask:

Q: How could our school adapt to sea level rise?

A: Responses will vary. Possible responses include elevating buildings or vulnerable objects within buildings, constructing hard barriers such as levees or soft barriers such as plants, checking groundwater quality, monitoring floods and storms, and having evacuation plans in place.

Have students fill in the right column of Adaptation Strategies with the ideas they discuss.

15. Discuss how to put these ideas into action. Ask:

> **Q: Now that we have brainstormed ideas for mitigation and adaptation at our school, how can we put these ideas into action?**
>
> *A: Responses will vary. Some actions, such as reducing paper and electricity use, can be implemented in your classroom (and encouraged in other classrooms). Other ideas may need to be implemented by the school administration.*

> **Q: Where else could you use these strategies to mitigate and adapt to climate change?**
>
> *A: Responses will vary. Possible responses include at home and at local community organizations. Encourage students to investigate the specific circumstances in those places and share their knowledge about ways to mitigate and adapt to climate change.*

16. Wrap up by returning to the Guiding Question:

> **Q: How and why have sea levels changed since the 1920s, and how should we respond?**
>
> *A: Temperatures have changed because humans have put more greenhouse gases into the atmosphere. These gases trap heat, increasing the temperature of the planet. This increased temperature melts ice and causes the thermal expansion of water, raising sea levels. We can respond by reducing how many greenhouse gases are emitted and by adapting to protect ourselves, animals, plants, and the environment from sea level rise.*

Extension Activity

Use the following activity after the lesson to extend student mastery of this Grades 3–5 Science and Engineering Practice.

- Constructing Explanations and Designing Solutions.

Use evidence (e.g., measurements, observations, patterns) to design a solution to a problem.

In the days, weeks, or months following this lesson, you can extend student understanding and engagement by working to implement one or more of the mitigation or adaptation ideas generated by the class.

Many of the changes needed to mitigate and adapt to climate change cannot be effectively implemented by individuals working alone. Rather, they require collective action at the local, state, national, and international levels. Likewise, there may be some changes that students in your class cannot implement without the support of school administration. Have students consider how they can advocate for those changes. For example, students may write letters, meet with school officials, or organize an event.

Consider collecting data both before and after a change is implemented to understand its effects and whether it should be replicated elsewhere. For example, you could collect data about the number and types of vehicles idling outside the school both before and after the implementation of a no-idling policy, then calculate the approximate reduction in greenhouse gas emissions as a result of the change.

Glossary

Adaptation
human action that limits the harm caused by climate change

Climate
trends in temperatures and conditions over long time scales

Climate Change
a long-term change in weather patterns for a given area, especially changes from the rapid rise in global temperatures seen in the last 150 years

Drought
an extended period of abnormally dry weather

Greenhouse Gas
a gas in the atmosphere that traps heat from the Sun and prevents it from radiating back out into space

Mitigation
human action that limits the concentration of greenhouse gases in the atmosphere

Model
a representation of an object, system, or process

Precipitation
rain or snow

Remote Sensing
the science of scanning Earth from a distance using technology like satellites and high-flying airplanes

Weather
short-term temperatures and conditions

Weather Patterns
typical temperatures and conditions

Wildfire
an uncontrolled fire in an outdoor area