UNIT STORYLINE

Unit Question: How do changes in Earth’s system impact our communities and what can we do about it?

<table>
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<tr>
<th>Lesson Question</th>
<th>Phenomena or Design Problem</th>
<th>What we do and figure out</th>
<th>How we represent it</th>
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<tr>
<td>LESSON 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 days</td>
<td>Why are floods and droughts happening more often?</td>
<td>We observe two news clips of extreme flood and drought events and share our own water stories. We examine headlines that show a “new normal” of increased floods and droughts and notice a pattern of rising temperatures. We develop an initial model explaining what could be causing warmer temperatures and how warmer temperatures could lead to both droughts and floods. We develop a Driving Question Board (DQB) and brainstorm investigations and sources of data that could help us figure out answers to our questions. We figure out: Floods and droughts are increasing. Floods and droughts are linked to a change in precipitation. Heat waves and warmer temperatures are linked to the increase in floods and droughts.</td>
<td></td>
</tr>
<tr>
<td>Anchoring Phenomenon</td>
<td>Floods and droughts are increasing across the US and there is a pattern of rising temperatures associated with both.</td>
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<tr>
<td>LESSON 2</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3 days</td>
<td>What would we normally expect for these places and how do we know it’s really changing?</td>
<td>We develop a systems model to describe Earth’s water system. We analyze data to determine what is normal and not normal about temperature and precipitation as it relates to floods and droughts. We do this with our community and six case sites in the United States. We figure out: Earth’s freshwater is distributed in the air, at the ground, and below the ground and moves in between these spaces. Year-to-year variability in precipitation and temperature is a normal pattern. Data averaged over long periods of time can give us the trends for an area. Precipitation or heavy storm events show increasing trends in flood areas. Precipitation, groundwater, and snowpack show decreasing trends in drought areas. Temperatures are increasing for all of the places we investigated.</td>
<td></td>
</tr>
<tr>
<td>Investigation</td>
<td>Long-term measurements show that changes in temperature and precipitation are not normal for these places.</td>
<td></td>
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</tbody>
</table>

Navigation to Next Lesson: We figured out that increased temperatures seem to be linked to increases in floods and droughts, but we have a lot of questions about what is causing this and where all of the water is coming from or going to. We want to look at more places than just the two places in the videos to help figure out what is happening.

Navigation to Next Lesson: We are wondering if the rise in temperature is related to some places being drier and some places being wetter.
**LESSON 3**

2 days

**How would increased temperatures affect evaporation?**

**Investigation**

*When we warm wet and dry soil at the surface we observe an increase in evaporation. This increases the overall water vapor in the air which does not move around the atmosphere evenly.*

We create bottle setups to test how increased temperatures affect evaporation rates. We also view visualizations of water vapor movement across the US and ocean temperatures in an open system. We figure out:

- Increased temperatures lead to increased evaporation rates and more water vapor in the atmosphere.
- Evaporation happened in all cases, but more moist conditions had higher evaporation rates than drier conditions.
- The amount of water vapor is not the same for every location and winds move the water vapor to different locations.
- Drought areas may be getting drier when water vapor moves away from the location, while flood areas may be getting wetter when more water vapor moves toward the location.
- Cooler ocean water and landforms may affect how much water vapor gets to a location.

**LESSON 4**

1 day

**Are rising temperatures affecting anything else in Earth's water system?**

**Investigation**

*Snow, ice, glaciers, and groundwater are decreasing in many areas, while sea level is rising. Earth's water system is changing.*

We obtain additional scientific and technical information about other components of Earth's water system and how those components are changing as temperatures increase. We conclude that all components and processes in the system have been affected by a temperature rise. We update our model and add an entry to our Progress Tracker. We figure out:

- Changes to sources of water affect communities in different ways.
- A small change in temperature in the atmosphere can have big changes in Earth's water system.

**Navigation to Next Lesson:** We observe that increased temperatures cause an increase in evaporation and water vapor in the air. Winds and ocean temperatures affect the movement of water vapor in the atmosphere explaining more about the location of droughts and floods. We wonder how increased temperatures may be affecting other parts of Earth's water system.

**Navigation to Next Lesson:** We figure out that a small increase in temperature is having big impacts on all parts of the water system creating different problems for communities. We think we can explain how rising temperatures have led to droughts and floods in our communities.
Lesson 5
2 days
How are rising temperatures changing water stories in these communities?
Putting Pieces Together, Problematizing

**Phenomena or Design Problem**

Changes in community water sources can be explained through data and evidence.

**What we do and figure out**

- We use our key model ideas from previous lessons to construct explanations, using evidence, about how changes in temperature are having impacts on the water stories in our case site communities. We peer review our explanations and revise them using the feedback from our peers. We figure out:
  - Small changes in one part of Earth’s system can have big impacts on another part.
  - An increase in temperatures can be used to explain the cause for multiple climate-related phenomena.

**How we represent it**

![Image of data and evidence for community water sources]

Navigation to Next Lesson: Now that we understand what is causing droughts and floods, we are wondering if we can apply these ideas to another headline we read about in Lesson 1.

Lesson 6
2 days
How are rising temperatures connected to two seemingly different phenomena?
Putting Pieces Together, Problematizing

**Phenomena or Design Problem**

Changes reported by headlines and by an Alaskan whaler can be explained through the increasing temperatures in Alaska.

**What we do and figure out**

- We revisit our Alaskan headlines about wildfires and also learn about another community in Alaska that is experiencing multi-year sea ice loss. We apply our key model ideas in a transfer task to explain how an increase in temperatures is causing both phenomena to occur. We figure out:
  - An increase in temperatures can cause an increase in both wildfires and a decrease in multi-year sea ice.

**How we represent it**

![Image of data and evidence for Alaskan phenomena]

Navigation to Next Lesson: We figured out that the Alaskan claims are caused by rising temperatures. We also believe that the temperatures may continue to rise in the future. After visiting the class model and the Driving Question Board, we realized we still have questions about why the temperatures are increasing, along with what is causing that increase.
### Lesson Question

**LESSON 7**

1 day

Are there any changes in the air that could be related to rising temperatures?

Investigation

![Graph showing concentration of some atmospheric gases](image)

**Phenomena or Design Problem**

The concentration of some atmospheric gases have stayed relatively stable over time, while other gases have increased at an unusual rate.

**What we do and figure out**

We wonder if changes in the air are related to the rise in temperatures. By looking at data, we build our understanding of the meaning of parts per million and figure out how to find the percent change in the quantity of these gases over time. We notice that, while some gases have not changed at all, some have changed very little, and other gases show an unusual increase over the 100-year period. We figure out:

- The atmosphere is made from different concentrations of gases.
- Some gases have not really changed over time, but some show an unusual increase.
- Carbon dioxide and methane are a small percent of the atmosphere but are increasing at a high rate.

**How we represent it**

- **Model Ideas List**
  - Some gases have not really changed over time, but some show an unusual increase.
  - Carbon dioxide and methane are a small percent of the atmosphere but are increasing at a high rate.

**Navigation to Next Lesson:** We figure out that carbon dioxide and methane, which make up a small percent of the atmosphere, are increasing at a high rate. Based on these new findings, we wonder if the gases that are rising are related to or causing the temperatures going up.

### Lesson Question

**LESSON 8**

2 days

Are changes in carbon dioxide and methane related to or causing temperatures to increase?

Investigation

![Molecular model of greenhouse gases](image)

**Phenomena or Design Problem**

Greenhouse gases absorb and release energy in the atmosphere regulating Earth's temperature.

**What we do and figure out**

We use molecular models to investigate the way molecules move in response to energy transfer. We investigate this idea further using an interactive showing how molecules move when energy is absorbed. Using these ideas and the ideas from a reading, we figure out that because greenhouse gases absorb, vibrate, and release energy, they keep our atmosphere warm. We apply these ideas to what we learned about GHGs increasing in our atmosphere to figure out that increasing GHGs are why temperatures are currently increasing. We figure out:

- GHGs are gas molecules in the atmosphere that absorb, vibrate, and release energy back into the atmosphere. This keeps Earth at a livable temperature.
- As the amount of GHGs increases in our atmosphere, they cause the atmosphere to get warmer.

**How we represent it**

**Model Ideas List**

**Navigation to Next Lesson:** We figure out that increasing GHGs are causing the temperatures to rise, and we wonder if this rise in GHGs is normal.
### Lesson Question

**Phenomena or Design Problem**

- What we do and figure out
- How we represent it

#### LESSON 9

1 day

Are the changes in the amount of CO$_2$ in the atmosphere part of normal cycles that Earth goes through?

**Investigation**

Ice core samples contain trapped bubbles of gases.

We carry out an investigation to determine if gas can be trapped in ice. When we figure out it can, we find out more about how scientists use ice core samples from locations on Earth that have very old ice to determine the amounts of carbon dioxide in the air over time. We focus on carbon dioxide because we know that recently it has been rising the most. We figure out:

- Levels of CO$_2$ are increasing at a faster rate than the normal cycles, which means the new levels are out of the normal range.
- CO$_2$ levels over the last 100 years have been rising consistently.
- We look back at data from hundreds of thousands of years through analyzing ice core data and find there are cycles, but the last 100 years are not following the normal cycle.

#### LESSON 10

2 days

What is happening in the world to cause the sharp rise in CO$_2$?

**Investigation**

Data shows a rapid increase in fossil fuel use, CO$_2$ emissions, and human population in the last two centuries.

We zoom into the last 200 years of Earth's history to understand what led to a rapid increase in CO$_2$ emissions. We watch a visualization and read about key innovations in human history that transformed the types of energy used to power our communities. We figure out:

- Large deposits of mineral resources (such as "fossil fuels") are used to power our communities and transportation networks, and this use has increased over time.
- Population growth increases consumption of resources (per-capita consumption).
- A growing population that consumes large amounts of mineral resources is correlated with the rapid increases in CO$_2$ in Earth's atmosphere.

**Model Ideas List**

- Some gases have not really changed over time, but some show an unusual increase.
- Carbon dioxide and methane are a small percent of the atmosphere but are increasing at a high rate.
- GHGs absorb, vibrate, and release energy back into the atmosphere.
- As the amount of GHGs increase in our atmosphere, they cause the atmosphere to get warmer.
- CO$_2$ levels are higher than any time in the past and seem to be increasing really fast outside the normal range.
- ↓ population + ↓ mineral resource use = ↑ CO$_2$ in atmosphere
- CO$_2$ and H$_2$O (greenhouse gases) are products of the combustion of fossil fuels.

**Navigation to Next Lesson:**

- We figured out that CO$_2$ levels are increasing at a faster rate than normal cycles. Now we want to know what is different today than in the past that is causing more CO$_2$ to be in the air?
- We are wondering what fossil fuels, which provide us with energy, are made of?
### LESSON 11

**1 day**

**Why could burning fossil fuels create a problem for CO2 in the atmosphere?**

**Investigation**

#### Atmosphere

<table>
<thead>
<tr>
<th>Number</th>
<th>What to do</th>
<th>How we represent it</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Step 1: The atmosphere. Carbon dioxide stays in the atmosphere for about 30 years or up to thousands of years.</td>
<td>Earth's Carbon System model</td>
</tr>
<tr>
<td>2</td>
<td>Step 2: The atmosphere. Carbon dioxide stays in the atmosphere for about 30 years or up to thousands of years.</td>
<td>Earth's Carbon System model</td>
</tr>
<tr>
<td>3</td>
<td>Step 3: The atmosphere. Carbon dioxide stays in the atmosphere for about 30 years or up to thousands of years.</td>
<td>Earth's Carbon System model</td>
</tr>
<tr>
<td>4</td>
<td>Step 4: The atmosphere. Carbon dioxide stays in the atmosphere for about 30 years or up to thousands of years.</td>
<td>Earth's Carbon System model</td>
</tr>
<tr>
<td>5</td>
<td>Do the plant and animal experiment. We can use a place in your classroom and study a plant or animal.</td>
<td>Earth's Carbon System model</td>
</tr>
</tbody>
</table>

*Burning fossil fuels adds CO2 to the atmosphere at a faster rate than is taken out by photosynthesis.*

We modify an Earth's Carbon System model to represent the locations of carbon and processes that move carbon around. We simulate these processes using a kinesthetic activity. We figure out that photosynthesis cannot take up CO2 at the same rate that burning fuels puts CO2 in the atmosphere and that this is creating a buildup of CO2 in the atmosphere. We figure out:

- Photosynthesis is a way to get CO2 out of the atmosphere, but the rate of photosynthesis is not enough to take up CO2 from combustion of fossil fuels and cellular respiration combined.
- Combustion of fossil fuels is creating a carbon imbalance in the atmosphere.

We figured out that CO2 entering the atmosphere is not balanced by CO2 taken out of the atmosphere. We think we can explain what is causing the temperatures to rise.

### LESSON 12

**2 days**

**How are changes to Earth’s carbon system impacting Earth’s water system?**

**Putting Pieces Together**

*Some social media posts need additional clarification to reflect accurate science ideas.*

We model the causal relationship between fossil fuel use and changing water resources. We review a tweet regarding climate change and its impacts, break the tweet down into claims, and clarify the information as a class. We take an assessment identifying claims made in another tweet and refute any inaccurate claims by providing an explanation of the causal relationships between human activities and climate change. We figure out:

- Changes in the carbon system have an effect on Earth’s water system.
- We can use our scientific understanding to clarify claims about the connection between the carbon system and Earth’s water system.

While we now understand the connection between the changing carbon system and our changing water system, we still have questions about what we can do to help fix the problem of our changing climate.
**Lesson 13**

1 day

Why is solving the climate change problem so challenging?

**Problematizing**

As CO₂ emissions increase, so do global temperatures. To reach equilibrium, emissions need to be cut by 9 gigatons per year.

We determine that the problem of increasing temperatures is due to the CO₂ imbalance in the atmosphere caused by human combustion. We use a simulation to determine what cuts are needed to emissions rates to reach equilibrium. We figure out:

- Our carbon imbalance in our atmosphere is due to human combustion.
- We release an estimated 10.5 gigatons of CO₂ from human combustion.
- Simply cutting emissions in half will not halve temperature increases.
- To reach CO₂ emissions equilibrium, emissions would need to be cut by 9 gigatons.
- Any reduction in emissions helps to slow the global temperature increase.

Lessons of temperature and CO₂ between now and 2050

<table>
<thead>
<tr>
<th>Change to eliminate emissions</th>
<th>Gigatons of CO₂ per year</th>
<th>Predictions of the effects on temperature and CO₂ concentration</th>
<th>Observations of temperature and CO₂ between now and 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eliminate all carbon emissions</td>
<td>0</td>
<td>Temperatures would drop slowly.</td>
<td>Both would drop, but not that much since it is just 1 gigaton emissions.</td>
</tr>
<tr>
<td>Cut emissions in half</td>
<td>5.5</td>
<td>Temperatures and CO₂ will drop but not as fast.</td>
<td>Temperatures and CO₂ will drop faster than CO₂ emissions.</td>
</tr>
<tr>
<td>Cut it to 1/3</td>
<td>3.5</td>
<td>Temperatures and CO₂ will drop after giving up for a while.</td>
<td>Temperatures and CO₂ will drop faster than CO₂ emissions.</td>
</tr>
<tr>
<td>Cut it to 1/4</td>
<td>2</td>
<td>Temperatures and CO₂ will drop after giving up for a while.</td>
<td>Temperatures and CO₂ will drop faster than CO₂ emissions.</td>
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<tr>
<td>Cut it to 1/5</td>
<td>1.5</td>
<td>Temperatures and CO₂ will drop after giving up for a while.</td>
<td>Temperatures and CO₂ will drop faster than CO₂ emissions.</td>
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</table>

Navigation to Next Lesson: We think we’ve heard of things we can do to solve this, like turning off lights, changing out bulbs, driving less, eating less meat. But how much do our daily actions impact the CO₂ levels in the atmosphere?

**Lesson 14**

1 day

What things can people do to reduce carbon dioxide going into the atmosphere?

**Investigation**

Everyday actions and behaviors emit CO₂, and changes to those behaviors can reduce emissions.

We calculate our daily carbon footprint and create a class Carbon Scoreboard. We calculate the average carbon footprint for someone in our class and compare it to the average American’s footprint. We revisit our footprint and choose carbon reduction activities and behaviors we are willing to make that would reduce our carbon emissions and would benefit our family in other ways. We compound the effects of these changes if everyone in our classroom, school, and community are willing to make changes.

- Changes to daily activities and behaviors can reduce atmospheric CO₂.
- If more people do these things, we will have further reduction in CO₂.
- Changes to behaviors are limited by other constraints, so each person may have different options available to them.

Navigation to Next Lesson: We are wondering not only how to engage more people in these kinds of behaviors, but also what other solutions could we consider on a larger scale?
**LESSON 15**

3 days

**How can large-scale solutions work to reduce carbon in the atmosphere?**

**Investigation**

<table>
<thead>
<tr>
<th>Phenomena or Design Problem</th>
<th>What we do and figure out</th>
<th>How we represent it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluating solutions against our criteria and constraints</td>
<td>We use a Design Matrix to organize the different solutions for reducing CO$_2$ in the atmosphere that we evaluated last class. From our evaluations we determine our constraints for the solutions in trying to meet the criteria of reducing the imbalance of carbon in the air. We reevaluate each solution using our constraints and decide that multiple solutions would need to be implemented to meet our criteria. We figure out:</td>
<td><img src="image" alt="Graph showing different solutions and their impact on CO$_2$ emissions." /></td>
</tr>
<tr>
<td>Plant Rich Diets</td>
<td></td>
<td></td>
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<tr>
<td>Reducing Food Waste</td>
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<tr>
<td>Wind Turbines</td>
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<tr>
<td>LED Lighting</td>
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<tr>
<td>Xeriscape</td>
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<tr>
<td>Reducing Plastic</td>
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<tr>
<td>Reforestation</td>
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</tbody>
</table>

Solutions have differing effects towards the reduction of atmospheric CO$_2$. Implementing multiple solutions can compound the reduction in CO$_2$ emissions.

In this lesson, we obtain information from community plans to determine how the solutions are being used in the communities and how they rebalance carbon and/or help the community to become more resilient to changes already occurring in the community. We use these plans as examples to help motivate the need to evaluate and/or develop a plan for their own community. We figure out:

- Communities develop plans to rebalance CO$_2$ levels in the atmosphere while also building a more resilient community adapting to changes already occurring within the community.
- Plans include many solutions across different parts of the community and at different scales, from individual and family options to large-scale community solutions.

**LESSON 16**

1 day

**How are these solutions working in our communities?**

**Investigation**

Community plans include ways to mitigate carbon or adapt to changes.

In this lesson, we are wondering if our community has a plan or if we should develop a plan for our community.
## LESSON 17

### What solutions work best for our school or community?

Investigation, Putting Pieces Together

We create a checklist for what a resilience plan for our school and local community should include. We work in groups to design resilience plans that contribute to the long-term rebalancing of carbon and also prepare the community for change. We provide feedback to other groups and evaluate the plans by asking questions. We brainstorm how to communicate our plans to other audiences. We argue for the one best for our community. We figure out:

- Communities can design plans to help rebalance carbon dioxide which will take awhile, but they can also do things to make the community resilient to changes happening now.
- Communities design plans based on community member needs and characteristics of the community itself.
- Some places and people may be more at risk for impacts in the community.
- Solutions adopted at home and school can make the whole community more resilient.

### Schools, communities, and businesses adopt new behaviors or technologies to contribute to rebalancing carbon and to build resilience to changes happening now.

<table>
<thead>
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<th>What we do and figure out</th>
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<tr>
<td>Communities can design plans to help rebalance carbon dioxide which will take awhile, but they can also do things to make the community resilient to changes happening now.</td>
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<td>Communities design plans based on community member needs and characteristics of the community itself.</td>
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<td>Some places and people may be more at risk for impacts in the community.</td>
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<tr>
<td>Solutions adopted at home and school can make the whole community more resilient.</td>
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</table>

### How we represent it

<table>
<thead>
<tr>
<th>What we do and figure out</th>
<th>What we should include</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify and describe the problem.</td>
<td>What do people about the problem?</td>
</tr>
<tr>
<td>Determine the cause of the problem.</td>
<td>Some areas will become drier or wetter than before.</td>
</tr>
<tr>
<td>Brainstorm how to communicate our plans to other audiences.</td>
<td>Some areas or some people in our community will be at more risk or more impacted.</td>
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### Navigation to Next Lesson:

We will celebrate learning by answering questions from the DQB.

## LESSON 18

### What can we explain now, and what questions do we still have?

Putting Pieces Together

We identify the questions from our DQB that we can now answer. We celebrate all that we have learned in this unit and across the school year. We spend time identifying the questions that we did not answer and build a new DQB of these questions. We create a plan to answer some of them on our own and in school next year and beyond. We figure out:

- Science learning is about asking questions and gathering evidence to answer those questions.
- As some questions get answered, new questions come up.

### Navigation to Next Lesson:

This is the last lesson in the unit.

## LESSONS 1-18

33 days total