

## Does a few degrees warmer really matter that much?

High School

Earth & Space Science

Time: 3 50-min classes

### Lesson Level Performance Expectation (teacher-facing):

**Analyze and interpret data to identify patterns in weather and climate to figure out the effects of human impacts on climate change to Earth's systems.**

**Snapshot:** High school students, as scientists, investigate the current trend in Earth's temperature. Students use the cross-cutting concepts to identify the causes of the increase in global temperature and the acceleration of the cascading effects it has on Earth and its inhabitants. Students will work to answer the driving question, "Does a few degrees warmer really matter that much?" By figuring out more about global warming and climate acceleration students will learn that as the global temperature continues to increase at a constant rate the effects of that increase are becoming more frequent and more severe (accelerating). Students will investigate how climate acceleration is affecting their local ecosystem and community and look at ways to mitigate and/or reverse these conditions.

**Phenomenon:** Accelerating impacts (e.g., sea-level rise, melting ice-sheets, drought) of increasing global temperatures.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><b>Developing and Using Models</b></p> <ul style="list-style-type: none"> <li>Develop, revise, and/ or use a model based on evidence to illustrate and/ or predict the relationships between systems or between components of a system.</li> </ul> <p><b>Developing Explanations and Designing Solutions</b></p> <ul style="list-style-type: none"> <li>Apply scientific ideas, principles and/ or evidence to provide an explanation of phenomena and solve design problems,</li> </ul>	<p><b>ESS3.D Global Climate Change</b></p> <ul style="list-style-type: none"> <li>Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.</li> <li>Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact</li> </ul>	<p><b>Cause and Effect</b></p> <ul style="list-style-type: none"> <li>Changes in systems may have various causes that may not have equal effects</li> </ul> <p><b>Stability and Change</b></p> <ul style="list-style-type: none"> <li>Much of science deals with constructing explanations of how things change and how they remain stable.</li> </ul>

taking into account possible unanticipated effects.	<p>and are modified in response to human activities.</p> <p><b>ESS2.D Weather and Climate</b></p> <ul style="list-style-type: none"> <li>Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gasses added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere.</li> </ul>	
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This lesson could be one in a series of lessons building toward:

**HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** ***Clarification Statement:** Examples of Earth's systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marien population. **Assessment Boundary:** Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*

Materials		
<p><b>Student Materials</b></p> <ul style="list-style-type: none"> <li><a href="https://data.giss.nasa.gov/gistemp/new">NASA GISS</a> data tools and pre-made visualizations</li> <li>news section of the website <a href="https://data.giss.nasa.gov/gistemp/news/">https://data.giss.nasa.gov/gistemp/news/</a>,</li> </ul>	<p><b>Teacher Materials</b></p> <ul style="list-style-type: none"> <li><a href="#">Graphics for Step 1</a> - Make copies so each of the four graphics are equally distributed among the students.</li> <li><a href="#">Keeping Up With Carbon</a> video from NASA</li> <li>Research on carbon from Michigan State University—</li> </ul>	<p><b>Resources for Building Teacher Content Knowledge and/or Pedagogy.</b></p> <p><b>Student Discourse:</b></p> <ul style="list-style-type: none"> <li><a href="#">Talk Science Primer</a></li> <li><a href="#">Checklist: Goals for Productive Discussion and 9 Talk Moves</a></li> </ul>

<ul style="list-style-type: none"> <li>• <a href="https://earthobservatory.nasa.gov/images/149321/2021-continued-earths-warming-trend">https://earthobservatory.nasa.gov/images/149321/2021-continued-earths-warming-trend</a> website</li> <li>• <a href="#">Working Group 2</a> report.</li> <li>• fact sheets <a href="https://www.ipcc.ch/report/ar6/wg2/about/factsheets/">https://www.ipcc.ch/report/ar6/wg2/about/factsheets/</a>.</li> <li>• <a href="#">NASA World of Change</a></li> <li>• NOAAs At-A-Glance tool <a href="https://www.ncdc.noaa.gov/cag/">https://www.ncdc.noaa.gov/cag/</a>.</li> <li>• Tropical Storms <a href="#">NOAA Oceans Today Every Full Moon Episode 11 - Hurricane</a></li> <li>• Sea Level Rise <a href="#">NOAA Sea Level Rise Portal</a></li> <li>• <a href="#">How is Sea Level Rise Related to Climate Change</a></li> <li>• Drought <a href="#">Climate Change and Drought: What's the Connection</a></li> <li>• <a href="#">Drought Makes its Home on the Range</a></li> <li>• <a href="#">Drought Monitor</a></li> <li>• Effects on organism <a href="#">Too Hot to Handle: How Climate Change May Make Some Places too Hot to Live</a></li> <li>• <a href="#">The Ocean Foundation - Ocean and Climate Change</a></li> <li>• from Atlantic, We Created the Pandemicene (<a href="https://www.theatlantic.com/science/archive/2022/04/how-climate-change-impacts-pandemics/629699/">https://www.theatlantic.com/science/archive/2022/04/how-climate-change-impacts-pandemics/629699/</a>)</li> <li>• from NPR, <a href="#">Where Disease-Carrying Mosquitoes Will Go in the Future.</a> (<a href="https://www.npr.org/sections/goatsa">https://www.npr.org/sections/goatsa</a></li> </ul>	<p><a href="http://css.umich.edu/factsheets/carbon-footprint-factsheet">http://css.umich.edu/factsheets/carbon-footprint-factsheet</a></p>	<p><b>Cross-Cutting Concepts</b></p> <ul style="list-style-type: none"> <li>• <a href="#">Stem Teaching Tool #41</a></li> </ul>
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<p><a href="https://www.ndsoda.com/2019/03/28/707604928/chart-where-disease-carrying-mosquitoes-will-go-in-the-future">ndsoda/2019/03/28/707604928/chart-where-disease-carrying-mosquitoes-will-go-in-the-future)</a></p> <ul style="list-style-type: none"> <li>• Storm Data from Carbonbrief <a href="https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world">https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world</a></li> <li>• From CNBC, (<a href="https://www.cnbc.com/2021/05/14/what-2050-could-look-like-if-we-dont-do-anything-about-climate-change.html">https://www.cnbc.com/2021/05/14/what-2050-could-look-like-if-we-dont-do-anything-about-climate-change.html</a>)</li> </ul>		
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## Teacher Preparation

**Driving Question: Does a few degrees really matter that much?**

### What Students Will Figure Out (Student Facing Objective)

- Analyze and interpret data to identify current trends affecting Earth's systems.
- Obtain evaluation and communication information from a variety of sources to figure out the effects of global warming are causing climate acceleration.
- Create a model to explain the cause-and-effect relationship between human impact and the effects on the climate.

### Required Student Prior Knowledge

The following science ideas are from the middle school grade band. Prior experience with these science ideas are helpful but not necessary.

### SSE3.A: Natural Resources

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)

### ESS3.B: Natural Hazards

- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)

### ESS3.C: Human Impacts on Earth Systems

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)

### ESS3.D: Global Climate Change

- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)

## Experience the Phenomenon or Experience the Problem

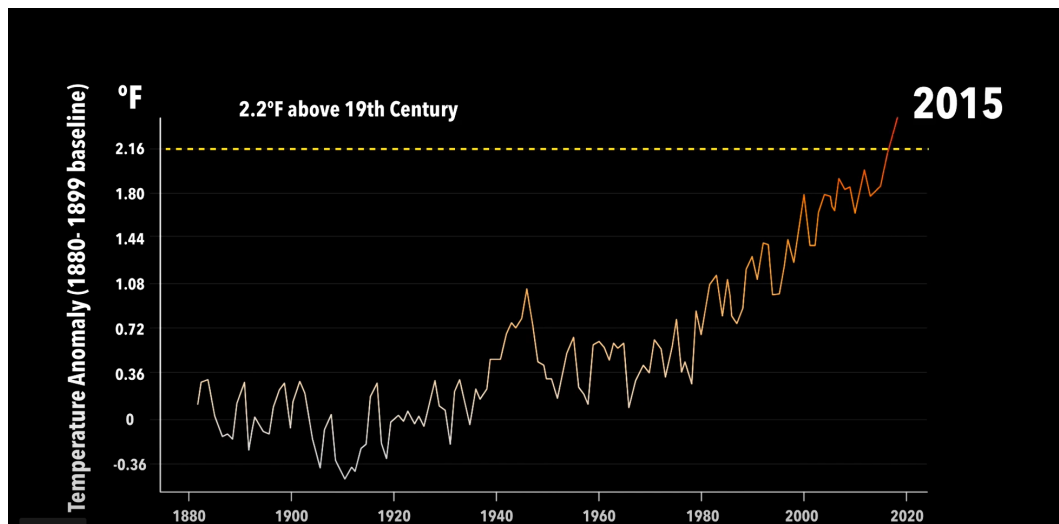
**Summary:** In this section students will analyze and interpret data to determine the average temperature of the Earth is increasing. They will brainstorm ideas about how this gradual increase in temperature could affect the Earth and its systems.

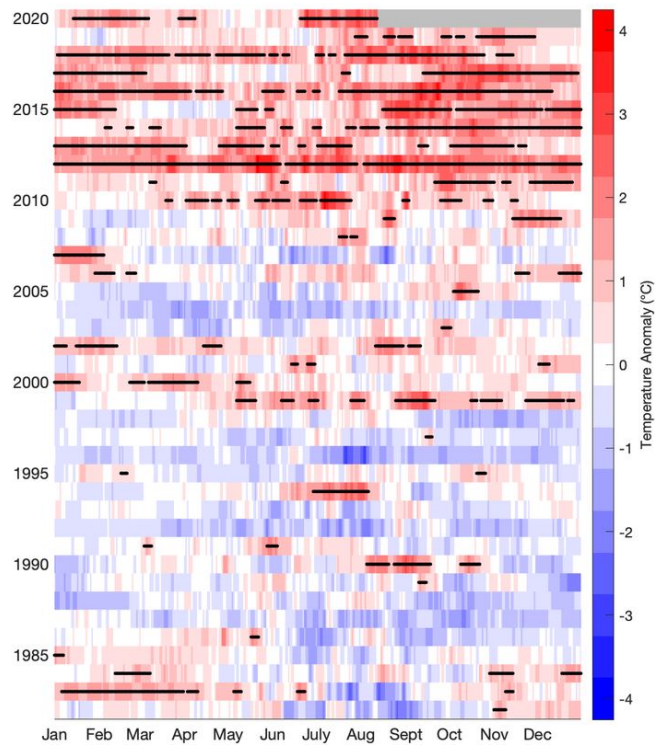
**1. Introduce the phenomena to students and allow them to make observations and ask questions.**

Tell students you have a few data sets you would like them to view. Give each student one data set to analyze in their alone zone using the I<sup>2</sup> strategy (what I see and what I think it means). Have them record any questions they have about the data in their science notebooks or scratch paper.

Organize students into small groups of like data sets and provide each group with a whiteboard or larger sheet of paper. Have students discuss what they saw in the data and what they think it means and record their noticings. Each group should decide on a spokesperson to share what they noticed with the class.

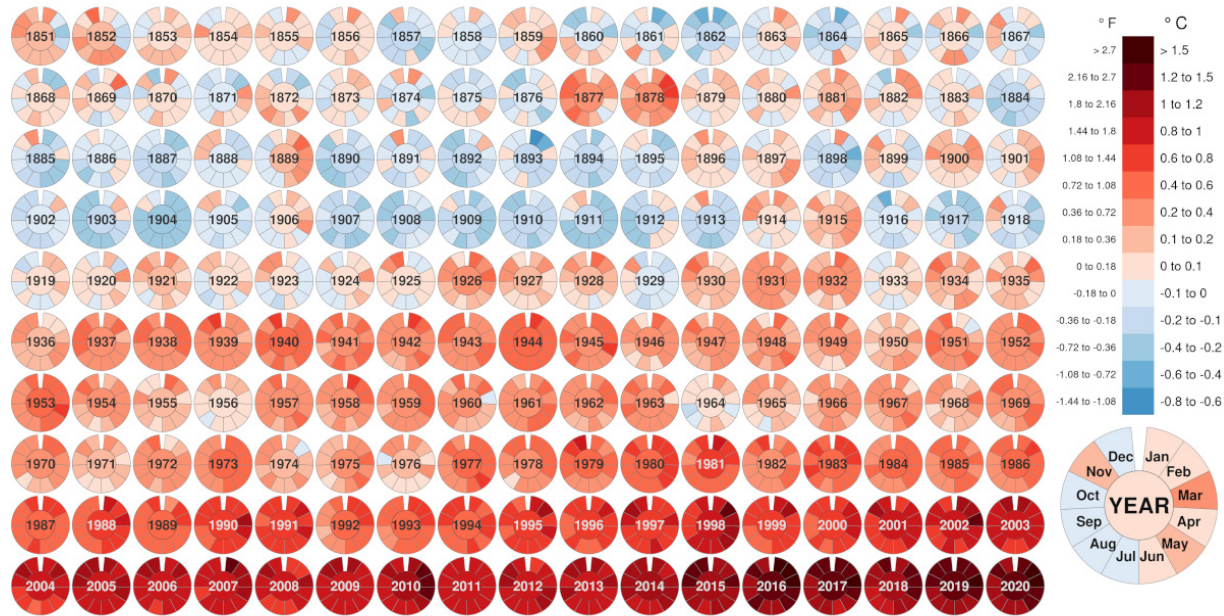
Project a data check and have that group share what they noticed. As each group shares, the other groups should record any questions they have about this new data.





A look at recent marine heatwaves. Black dots indicate heatwaves. Each row is a year, and the color indicates whether the day is above (red) or below (blue) the average. (Gulf of Maine Research Institute). Ask students to notice the trend: if they had to draw a line graph with the x-axis as year and the y-axis as the number of marine heatwaves in the Gulf of Main, what would it look like? (Here, students should come up with a graph that shows the heatwaves increasing at an increasing rate.)

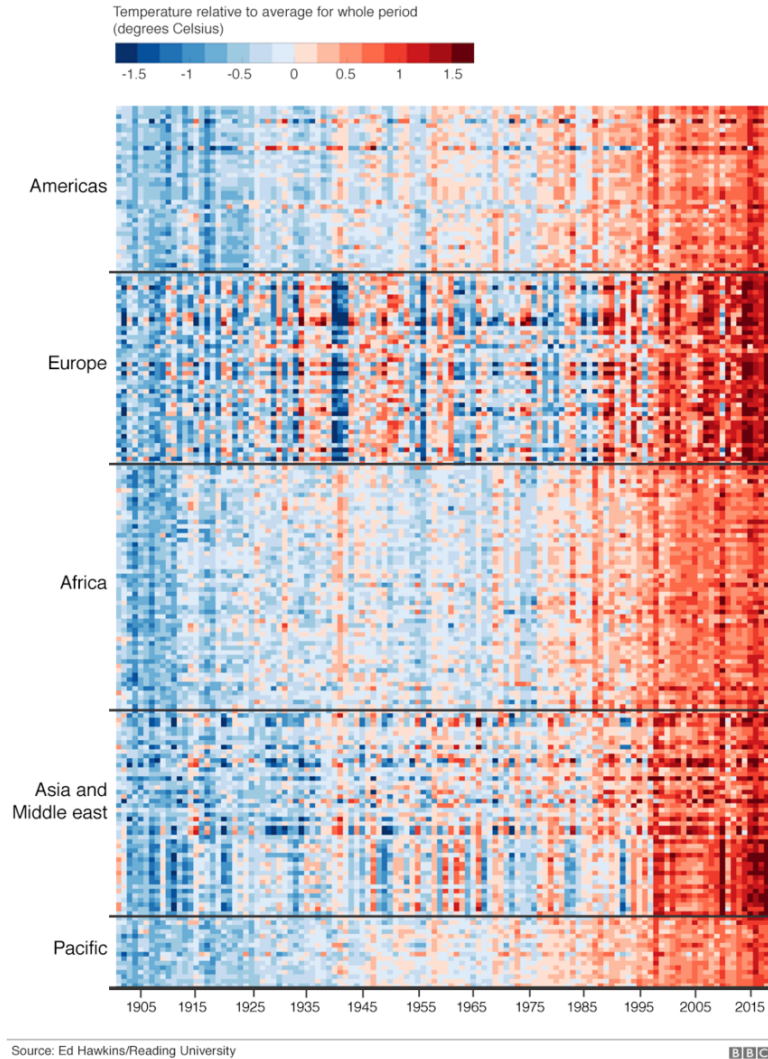
Monthly global mean temperature 1851 to 2020 (compared to 1850-1900 averages)



Data: HadCRUT5 - Created by: @neilrkaye



## Temperature changes around the world (1901-2018)



After all groups have shared, ask students what similarities and differences they noticed in the data sets. There will be many similarities, however, the big takeaway here is that the Earth's temperature is rising at an accelerated rate -- the warmest temperatures on record all recently. Students will also notice many differences, but the big difference is that each data has a different time frame.

Last, have students share questions they have about the data. Common questions include:

- Why is the temperature rising?
- Will the temperature keep going up?
- How can this affect me or where I live?
- It looks like that there have been spikes in temperature through the years so is this just something that happens?
- Will the temperature eventually start to decrease?
- Because the increase is gradual does it really matter? Don't things just adapt?
- And, most importantly, why does it seem that the temperature is increasing steadily but the impacts are increasing at an increasing rate?

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**Additional Guidance:**

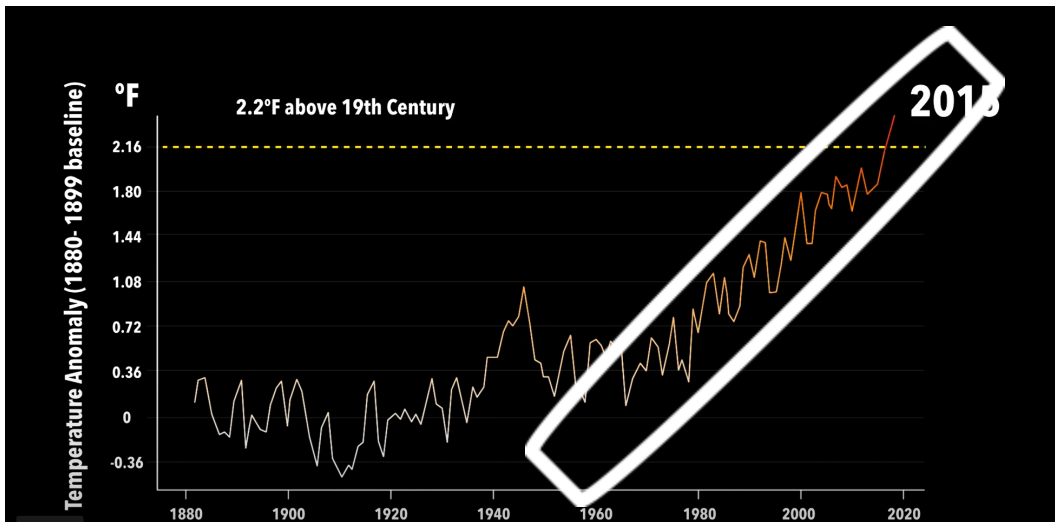
- Allowing students to analyze the datasets provides a common shared experience and anchors student learning, allowing opportunities for them to share and discuss. This introduction is vital to three-dimensional teaching and learning and should not be skipped.
- Allowing students to share in small groups first before making their ideas public allows them time to formulate their ideas and practice speaking them before going public. This allows reluctant speakers to get more comfortable sharing ideas, allowing them more access to participate in class.
- Acknowledging student ideas and questions (free of judgment, at this point) allow for all students to have a voice. It is important that all students participate in the class discussion to share one observation and one question. Recording what students say brings validation to their ideas and questions and also allows for other students to see that they share similar ideas.

**2. Students zoom in on the increasing trend to brainstorm ideas about what this could mean for the Earth's climate.**

Project the graph from the video and have students think about what this trend means. Give students a few minutes to discuss the following in small groups:

- How do you think this increase affects the Earth's climates?
- As the temperature rises, do you think each increase has the same steady effect on the Earth?

- Predict what we might see happen to the Earth's climate if the temperature continues to rise.



Facilitate a class discussion about the trend in the data. As students share their ideas, use Talk Moves to get them to explain their ideas. Using Talk Moves to facilitate discussion allows students to dig deeper into the reasons for their statements. This also allows other students to build on others ideas or surface disagreements.

### Possible Student Responses

- We think since the changes in temperature are gradual that the change in the Earth is also gradual.
- We think that as the Earth gets warmer changes happen faster and become more dangerous.
- We think everything will eventually even out and things will be fine, just maybe a little warmer.
- Climate change is fake.

Acknowledge all students' ideas at this point, even ones that may be inaccurate. Allow students the opportunity to agree or respectfully disagree with ideas presented by their classmates and remind students that this is one reason why scientists work together to figure out phenomena or solve a problem.

Ask students what they could investigate to figure out what is happening with the Earth's climate; what investigations could they do or what data could they look at. Look for students to say they want data sets on weather patterns, ocean temperatures, population trends and that they could investigate through simulations or collecting data from their local environment.

**(Optional Extension)** Depending on the background knowledge and prior experience with this topic, it may benefit students to build a working definition of global warming and climate change. Students should be allowed to come up with these definitions in their own words but ensure that the information is accurate.

- Global warming - the warming of the Earth mainly due to the increase of greenhouse gasses in the atmosphere.
- Climate Change - the increase in the change in measures of climate such as changes in precipitation patterns over a long time period.

In general, when climate change is talked about it is in terms of human action that causes the change in climate and not the natural and mostly more gradual change in climate we have seen across time.

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**Additional Guidance:**

- Building vocabulary in the moment, when it is needed, adds context to meaning and gives the word use purpose. This is an important vocabulary strategy and helps build lasting use for all students, especially students who struggle with memorization and those who are multi-language learners.
- Use this discussion as a formative assessment opportunity, as many students have misconceptions and/or incomplete ideas when it comes to the topic of global warming and climate change. At this point it is not important to fix misconceptions by telling students why they are wrong. Instead, allow students to change their own minds by providing them opportunities throughout the lesson to investigate and use evidence to shift their thinking.
- If the idea that climate change isn't real does surface explain that in this class they will gather and evaluate data that can be used as evidence to support (or refute) a claim (the global temperature is increasing). Science ideas are based on evidence and decisions are made and revised based on the scientific evidence that is available at any given point in time and as more evidence is provided science ideas may also change.

## Investigate the Phenomenon

**Summary:** In this section students investigate trends in temperature changes over time and trends in climate change. By researching changes that have occurred over time, students can make conclusions about climate change and its accelerating impacts. Students can use this information to make predictions about what will happen in the future if warming trends continue on their current path, especially related to the impacts of climate change such as heatwaves, increasing/decreasing intensity of precipitation etc.

### **3. Students investigate weather and climate data to look for trends using a variety of resources.**

To allow students to see that climate change is happening in their local region as well as globally, have them explore some of the data at the following websites. Pair students up and assign them to explore one or two of the following websites and be prepared to share what they find that will help them answer their questions about global warming and its effects on climate change.

When groups are finished, have pairs of students assigned to different resources team up to share and compare the information they pulled from their sites. Tell students that while they are sharing they should record similarities and differences between the different data and information. Switch pairs at least one more time so each pair of students talks to at least 2 other groups before discussing as a class.

- [NASA GISS](https://data.giss.nasa.gov/gistemp/news/) This page has various data tools and pre-made visualizations students can explore. They will also want to read the information from the news section of the website <https://data.giss.nasa.gov/gistemp/news/>, especially the most recent articles. This article along with the video is very informational.  
<https://earthobservatory.nasa.gov/images/149321/2021-continued-earths-warming-trend>
- [Working Group 2](https://www.ipcc.ch/report/ar6/wg2/about/factsheets/) report. Have students read the home page and watch the video. Although they can explore all the information on the site, direct them to focus on the information found on the fact sheets <https://www.ipcc.ch/report/ar6/wg2/about/factsheets/>. Students should look at the fact sheet for North America first and then explore others.
- [NASA World of Change](https://climate.nasa.gov/evidence/) Have students click through some of the images and read the information about how the shifts in Earth's temperature are affecting different regions around the world.

- You may also want students to look at data from their local area in regards to temperature using NOAA's At-A-Glance tool <https://www.ncdc.noaa.gov/cag/>. Explain that they can use this tool to look at temperature and precipitation for cities/counties across the United States. Tell them they can also click on some of the tools located on the right hand side of the site to better identify different trends in the data. Give students time to explore the site and tell them to record any information they find interesting. Students will also need to explore the information in the data access tab located at the top of the page.

Revisit the ideas they had from section 2 (below) and ask them to share any evidence that may have led them to change their thinking around the current trends in global warming and climate change.

- We think that since the changes in temperature are gradual that the change in the Earth is also gradual.
- We think that as the Earth gets warmer changes happen faster and become more dangerous.
- We think everything will eventually even out and things will be fine, just maybe a little warmer.
- Climate change is fake.

From the data presented in the resources students should conclude that not only is the Earth's climate changing but it seems to be changing faster and the effects are becoming more severe. Confirm that the amount of global heating is happening faster and faster even though the temperature has recently been rising at a more or less constant rate.

#### **4. Students watch a short film on climate acceleration and make observations about the effect it is having on the planet.**

Tell students that you have a short film that you would like them to watch about climate change. Have students watch the video, they do not need to take any notes as they watch. Some students may benefit from using a transcript to revisit ideas from the film. Show the film, Climate Acceleration from UCLA

- [UCLA IoES GreenSparks Education Video – Climate Acceleration \(English\)](#)
- [UCLA IOES GreenSparks Educational Video - Climate Acceleration \(Español\)](#)

Have students think about how the claims in this film help support their ideas about global warming, climate change, and climate acceleration. Allow students to share any connections they have made between the data they investigated in the previous section and the film.

### **5. Students work in groups to develop a model to explain some of the direct effects of global warming.**

This activity can be used to allow students to develop a model of how an increase in global temperature affects different natural phenomena. In this activity students will research effects of global warming to create a model that helps explain the interactions between the components in Earth's systems. Students can then use what they figured out at the microscale to better explain their observations at the macroscale.

#### **Students work in groups to develop a model to explain some of the direct effects of global warming.**

Supply each group with a large whiteboard or sheet of chart paper. Explain that each group should develop an explanation for how global warming relates to their topic. Tell students that their explanation should include a model (picture, words and symbols) that demonstrates the process of HOW increasing temperatures affect the Earth's systems and its populations.

Resources for:

- Tropical Storms
  - [NOAA Oceans Today Every Full Moon Episode 11 - Hurricane](#)
- Sea Level Rise
  - [NOAA Sea Level Rise Portal](#) - there are many things students can investigate on this site. The sea level rise viewer should be assigned to at least one group.
  - [How is Sea Level Rise Related to Climate Change](#)
- Drought
  - [Climate Change and Drought: What's the Connection](#)
  - [Drought Makes its Home on the Range](#)

- [Drought Monitor](#)
- Effects on organism
  - [Too Hot to Handle: How Climate Change May Make Some Places too Hot to Live](#)
  - [The Ocean Foundation - Ocean and Climate Change](#) - There is a lot of good information here that could be split this up and have students focus on just a few.

### Sharing out our models

When students are finished with their models, tell them they will be doing a gallery walk. Explain that next to each model there is a 2-column table, one column for something you noticed in the model and the other for a question you have about the model. Say, “As you travel in your groups to look at each model, share one noticing and one question for each group. Your notice and question must be new, in that you can not write the same noticing or question that has already been asked by another group.”

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### Additional Guidance:

- Scientific models are used to explain and predict phenomena. As some students may be new to models, remind them that scientific models are fluid and can be revised as more information is gathered. These models can also be used to make predictions and solve problems. In this step of the lesson, scientific models are used as a thinking tool to allow students time to engage with and think through and organize the data they have collected from the reading. They will also use this model to help them think through ideas about stability and change as well as begin to surface possible mitigation efforts.

## 6. Facilitate a class discussion to build consensus around our models to determine some of the effects of global warming, climate change, and climate acceleration.

Allow some time for each of the groups to go back to their model and review the comments and questions. Then give each group time to explain to the class what they figured out about the cascading effect of global warming and its relationship to



climate change acceleration. As the groups are presenting, encourage them to address any of the class comments or questions.

Questions that can not be answered at this time could be put aside for an extension opportunity or later assignment.

When all the groups have finished, summarize what students have shared. Key point should include:

- Greenhouse gas emissions from pollution are the biggest factor causing the rise in global temperatures. Emissions can be controlled and global warming and climate change can be halted, at least at the present time, as far as we know. But so far, global greenhouse gas emissions have continued to increase--so we are not yet on a path toward halting climate change.
- Sea levels are rising due to the warming of the oceans. This is caused by water expansion (warmer water takes up more space) and glacier melt. Sea level rise causes flooding of coastal lands, shoreline weathering and erosion, and increased flooding. Sea level rise also caused displacement of people and other living things.
- Heavy downpours are becoming more frequent and more severe because rising temperatures increase the water vapor holding capacity of the atmosphere--raising the ceiling on how intense precipitation can become. More intense downpours can lead to increased risk of flooding and erosion, with impacts both to cities and ecosystems.
- The intensity of droughts is also increasing in many areas, but not always due to lack of rain. As temperature increases so does the "thirstiness" of the atmosphere (i.e., its propensity to evaporate water from soils and bodies of water). Warmer weather also means less snowfall, and shorter snow seasons, in most places that used to see lots of snow. Lack of snow in some areas means the ground will not have the moisture it needs for spring crops or enough water to moisten soils that support natural vegetation and ecosystems. As droughts intensify, they can have increasing effects on the plant and animal life. When droughts coincide with hotter temperatures, larger and more intense wildfires can result. Increased wildfires also leads to more CO<sub>2</sub> emissions and less carbon sequestration from plants.
- Increasing temperatures can also lead to some areas, especially urban areas, becoming so hot it is difficult for people to live there. Death due to the combination of high heat and high humidity has increased across the midwest and southeast because it sometimes becomes too hot for the body to cool itself. The increased heat also has an effect on plants and animals, especially those living in the ocean. As the ocean temperature increases and "marine heat waves" occur, some of the animal life can no longer survive so they either move or die. This shift in population also affects the economy as people who depend on these animals for their livelihood have to travel further to find their catch.

Ask students to think about the effects of global warming and climate change that affect them or their local community. This discussion will vary depending on location. Facilitate this discussion to focus on the idea of climate acceleration. Ask students, "Now

that you know more about the impacts of climate change, what predictions can you make about what will happen to the Earth if the average global temperature continues to rise?” Students will have a variety of answers, acknowledge all students' ideas but focus on the ideas that the Earth's systems will continue to change and that change will happen faster and faster the warmer the Earth gets.

## **7. (Optional Activity) Students investigation more about carbon's role in Earth's systems**

If students need more information on the carbon cycle and the role carbon plays in Earth's systems, consider having students engage in this optional step of the lesson before transition into mitigation efforts.

Students need more information about different roles carbon plays in the Earth's systems. Throughout the lesson students have surfaced ideas about carbon emissions, pollution, fossil fuels and greenhouse gasses however, you will want to ensure students have a clear picture about what these things are before we can evaluate and/or create a mitigation plan.

Point out to students that the carbon cycle (or part of the carbon cycle) is represented in the class consensus model. The carbon cycle is a very complex and crucial system that drives life on our planet. To help students understand the importance of the carbon cycle to life on Earth, play the [Keeping Up With Carbon](#) video from NASA. When the video is over, ask students to summarize what they have learned and how the information will allow them to connect their actions to mitigation efforts.

If time permits, allow students to read through some of the research on carbon from Michigan State University—<http://css.umich.edu/factsheets/carbon-footprint-factsheet> (or other site)—have students develop a mathematical model to explain how different human actions affect the climate and ideas of how humans might change their actions to help reduce emissions.

**8. Students engage in additional research to figure out the trajectory of the effects of global warming and climate change if global efforts are not put in place to change it.**

In the previous step, students have figured out what is currently happening with climate change. Now ask students what they predict might happen if these global trends continue on the same trajectory. Although some students may suggest that the climate will eventually level off or 'return to normal,' most will say that the effects of climate change will continue to accelerate as the average temperature continues to increase.

Ask students for explicit examples that demonstrate that students understand both the cause-and-effect relationships of global warming and climate change and how it affects weather patterns (specifically, climate acceleration) through the lens of energy and matter. Asking for explicit examples will force students to state both the underlying cause (human impact) and the effect. For example, students may say, "If we continue to burn fossil fuels more carbon emission will go into the atmosphere, this will cause temperature to rise which tells us there is more energy in the atmosphere that causes more violent storms" Other examples to look for are:

- Warming temperatures cause harm to ecosystems as some organisms can only survive within a certain temperature range.
- The warmer temperatures are causing the glaciers to melt and this also causes sea level to rise.
- When the ocean water is warmer, it takes up more space, which also causes the sea level to rise.
- As the oceans get warmer, some of the aquatic life has to move or they will die because the water is too hot for them to live.
- Warmer air temperature means there is also more energy in the atmosphere, and this causes more severe storms which causes more damage to shorelines and developed coastal areas.

Tell students there are also other things to consider when predicting what the future might look like. Assign students to groups of 4 and give each member a different resource to read/look through.

As students examine their resources, have them record any important information and questions. When students have finished, give each student 2 minutes to share what they have learned with their group members using the talking stick protocol. Present these resources:

- from Atlantic, We Created the Pandemicene  
(<https://www.theatlantic.com/science/archive/2022/04/how-climate-change-impacts-pandemics/629699/>)
- from NPR, [Where Disease-Carrying Mosquitoes Will Go in the Future](https://www.npr.org/sections/goatsandsoda/2019/03/28/707604928/chart-where-disease-carrying-mosquitoes-will-go-in-the-future).  
(<https://www.npr.org/sections/goatsandsoda/2019/03/28/707604928/chart-where-disease-carrying-mosquitoes-will-go-in-the-future>)
- Storm Data from Carbonbrief  
<https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world>
- From CNBC,  
(<https://www.cnbc.com/2021/05/14/what-2050-could-look-like-if-we-dont-do-anything-about-climate-change.html>)

When students have finished, project these questions and have a class discussion.

- What other effects of climate change will we see that we might have previously considered?
- What health precautions might you have to consider in your lifetime as the climate change continues to change the Earth?
- What do these articles predict about water resources?
- What do you predict the climate in your local region will look like in 10, 20 or 30 years from now based on current trends?
- **Does a few degrees warmer really matter that much?**

Allow students some individual think time and then facilitate a discussion to surface ideas. Depending on the region, students will have different predictions and ideas. However, students should surface the idea that we and the Earth are trending in the wrong direction. Students should predict that many changes to the Earth will happen within their lifetime if nothing changes.

During this discussion highlight any references to mitigation efforts by recording them in a public space, but wait to talk about these until after the prediction discussion. After students have shared all their ideas and predictions, circle back to any ideas about slowing, stopping, or reversing climate change.

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#### **Additional Guidance:**

- The talking stick protocol allows all student voices to be heard while adhering to a time limit.  
**Small Group Talking Stick Round 1: (1-2-minutes per person)**

Take your notes and meet with the small group you are assigned to. When given the start signal, pass around a pencil as a talking stick to take turns having each person use their note to explain what they have learned from their resource. As each person shares, think about how this compares to what you have learned from your resource.

**Small Group Talking Stick Round 2: (1 minute per person)**

Pass the talking stick around again to have each person share at least one similarity and one difference they noted between the models and explanations that were shared.

## Designing Solutions

**Summary:** In this section, students will research current mitigation efforts and develop an action plan.

### 9. Students research ideas for mitigation and create an action plan.

Now that students have a better idea of how an increasing temperature can affect them and their communities, ask students to consider what could be done to combat global warming and climate change. Students will have many ideas and some may already be involved with school or community projects around making these changes. As students share their ideas, record them in a public space. Students will have a variety of ideas from changes they can make as individuals to volunteering for local and national climate change initiatives. Remind students that their voices also have power and encourage them to share what they have figured out about climate change to friends and family members.

To prompt students to learn more about actions they can take, have students research climate initiatives going on at their local or state level to encourage involvement and action. Students can look for these initiatives on:

- Their local and state government sites including the EPA and DNR
- Other local sites including park districts, nature preserves and other community groups

- You can also suggest that students reach out to their representatives. Local and State representatives' contact information can be found on your state's government websites.
- Look for other ways to advocate by researching what other youth are doing. An example is Sunrise Movement: <https://www.sunrisemovement.org/take-action/>

On a more global level, many companies as well as some countries are also making a push to be carbon neutral in the future. As this may be an unfamiliar term, ask students to consider what carbon neutral means and have them do a quick turn and talk with a shoulder partner. Have a few students share what they think. Some students may think that carbon neutral means they will no longer emit carbon as waste, however, that is a misconception. Through facilitation, lead students to determine that carbon neutral means that they will have no net loss or gain of carbon emissions; this means that even though we may still be emitting some greenhouse gasses, we will also be doing carbon offsets (growing trees) and carbon removal (sucking CO2 from the air through direct air capture).

There are several companies that have advertisements out that they plan to be carbon neutral by a certain year. For example

- Amazon wants to be carbon neutral by 2040 (<https://sustainability.aboutamazon.com/>)
- Toyota by 2035 (<https://pressroom.toyota.com/the-road-to-carbon-neutrality-toyota-releases-2021-north-american-environmental-report/>)

Students may have also heard of other initiatives to combat climate change like the [Million Trees Project](#) and [Wind Energy Initiative](#). Students can also investigate how using solar power has decreased the need for the burning of fossil fuels to provide “cleaner” electricity.

Last, have students make an action plan, this can be done individually and/or in groups. These can be small changes an individual can make such as talking about what they've learned to friends and family or a bigger project that includes the school, community etc.. Guide students towards ideas that focus on big, systemic changes. For school and community based ideas, consider using these sites:

- [The Climate Initiative](#) ([https://www.theclimateinitiative.org/?gclid=Cj0KCQjwpcOTBhCZARIsAEAYLuX8aynNshIkZAF0trHA6IkbnQFcAuaVXAFj2S7JV\\_aIR2WUmqvRZlgaAof8EALw\\_wcB](https://www.theclimateinitiative.org/?gclid=Cj0KCQjwpcOTBhCZARIsAEAYLuX8aynNshIkZAF0trHA6IkbnQFcAuaVXAFj2S7JV_aIR2WUmqvRZlgaAof8EALw_wcB))
- [Youth Environmental Summit](#) (<https://www.youthenvironmentalsummit.org/>)
- [Audubon](#) (<https://www.audubon.org/>)

**Additional Guidance:**

- While many carbon mitigation campaigns focus on individual actions such as eating less meat or driving less or “reducing your carbon footprint,” that framing of personal responsibility for greenhouse gas emissions was disinformation funded by BP <https://mashable.com/feature/carbon-footprint-pr-campaign-sham> to encourage individuals to take responsibility for emissions instead of the companies producing the emissions, essentially, it is a way to deflect the blame and distract.
- We have learned from the pandemic that even if individual carbon footprints decrease substantially (less driving, flying etc.), the overall impact on greenhouse gas emissions is negligible. Without fundamental changes to our systems—energy, transportation, housing, agriculture etc., we will not reduce emissions sufficiently to avoid the worst of the impacts of climate change.
- A focus on systemic changes that have a hope of moving the needle on climate change are critical.