Lesson 4: Local Climate Impacts

Phenomenon:

Climate change is contributing to the increased frequency and severity of many extreme weather events. Your specific phenomenon will depend on where you are. You may focus on hurricanes, flooding, drought, wildfires, or local agriculture or public health issues.

Introduction:

Extreme weather events seem to be occurring with greater frequency and intensity. Before we attribute these trends to climate change, however, we need data that shows this connection, and testable hypotheses about how climate change is impacting these events. The connection between climate change and the increasing frequency and severity of extreme weather events is not direct. The impact lies in the connection of climate change to the conditions that underlie the events, not in the occurrence of the event itself. Warmer oceans produce more intense hurricanes. Drought increases the risk of wildfires. Changing temperatures can lead to less snow in mountainous areas, increased range of pest and invasive species, and increased frequency of heat waves and extended rainfall events, just to list a few of the possible outcomes of the influence of climate change. Farmers are also needing to change how they plan for the future, as are urban planners and public health officials.

This lesson will connect climate to weather and climate change to changing weather patterns and conditions. It also connects students to local data. This lesson is designed to help you find and utilize data where you are teaching. You will identify a local issue or need to respond to climate change and focus on the data for your area. That's what makes this a place-based lesson.

This lesson plan will provide the outline of how to find your own data and construct activities around it. Examples from NCSE Ambassador Teachers will be provided, though your local issue may not be covered directly by this lesson plan. The Supplemental Folder will include other examples and resources to help you adapt this lesson to your specific needs.

Lesson Outline:

Age Level	Grade 5-12 (three options will be developed for 5th, middle, and high school applications. High school accommodations will also be developed for 9th grade bio, AP Bio, and Envi Sci applications)
Time Needed	1-2 50 minute periods.
Vocabulary	• **Extreme weather:** Unusually severe weather at the extremes of the

	range of weather seen in the past. Often, extreme events are defined as lying in the most unusual ten percent. • **Event Records:** Local records are kept for many weather parameters including rainfall, flooding, drought, fire, etc. Benchmarks are often defined for events related to these parameters such as 100 year floods. These benchmarks are meant to help communities prepare for the eventualities of these events and plan the allocation of resources needed to respond to them. • **Frequency:** Related to event records is the expected frequency of the event. We are currently seeing that many of these benchmarks need to be updated due to the impact of climate change.
Student Learning Outcomes	• Students will learn of the various ways that a heat build-up in the climate system affects weather systems. • Students will examine misinformation about extreme weather
Disciplinary core ideas	• HS-ESS2.D3: Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. • HS-PS3.A1: Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • HS-PS3.B1: Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • HS-PS3.B4: The availability of energy limits what can occur in any system. • HS-PS3.D1: Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
Performance expectations	• HS-ESS3-5: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
Educator Prep	• Difference between weather and climate - https://cleanet.org/resources/43434.html • Extreme weather and climate change - https://cleanet.org/resources/46148.html • Climate reanalyzer - https://cleanet.org/resources/45145.html • Your Warming World - http://paldhous.github.io/climate-change/ • FLICC: Five characteristics of science denial • Blue and red dice (ideally one for each student, or at least half a

	dozen of each color) • Local databases
Fact	Risk from extreme weather is increasing, albeit some forms of extreme weather are more confidently linked to global warming than others.
Myth	Extreme weather always happens, so warming isn't making extreme weather worse.
Fallacy	**Jumping to conclusions:** Just because extreme weather happened in the past doesn't mean climate change isn't having an influence now.

Engage

No matter where we live, we are impacted by climate change. This is true for rural, urban and suburban areas, coastal and mountainous regions, north, south, east, west, and everywhere in between. Identifying a local issue connected to climate change allows this lesson to become personal for your students, so some sensitivity may be needed in cases where a student's family is directly impacted by the issue. Due to this, this lesson should start with engagement with data, just as the others, so that students don't feel threatened or judged. It is also suggested that you wait until the end of this lesson to introduce the misconception. The goal is for the students to connect the evidence to the event so that they can see that climate change is contributing to a need to address the issue. The next lesson will focus on solutions, so this lesson should also guide the students to the understanding that they can do something to help.

As a teacher, you will:

- Identify a local issue
- Locate data relevant to this issue
- Engage the students with the data through a hands-on activity
- Guide the students through the experience using inquiry
- Connect the lesson to the misconception that climate change is not impacting the event
- Foster resilience in your students as they begin to think about solutions

Explore

Warm-Up

Explain that weather is chaotic. This is actually a scientific way of saying that predictions of weather events depend on complicated relationships between many variables which makes it necessary to assign probability to predictions. So when a weather forecast says there is a 90% chance of rain, that means it is likely to rain, but some areas within the forecast area might not

see any rain at all. This does not make the prediction wrong, though we all get frustrated when we expect one outcome and experience another.

It is even more confusing when an extreme event is not predicted. Extreme events are always possible, but the probability of extreme events is increasing as climate change impacts the conditions that generate the extreme event.

You can use dice to demonstrate how probability impacts extreme weather events. You may be able to find blank dice that you can customize using a marker (like these), or you can alter normal dice by adding dots. It is also useful to have two colors of dice to keep them separate. We'll arbitrarily use blue and red. Blue dice are normal, red ones have two sixes.

Distribute dice to students. Explain that the dice are like weather, where a six is an extreme event. Have students roll dice, ask all sixes to raise their hands. Point out that the red die has two sixes, increasing odds of extreme weather. The extra dot represents the impact of increased CO_2 in the atmosphere from human activity. Explain that the red dice is like a climate with global warming, while the blue dice is like climate without global warming, and that global warming increases the odds of extreme weather. There should be more sixes among red dice.

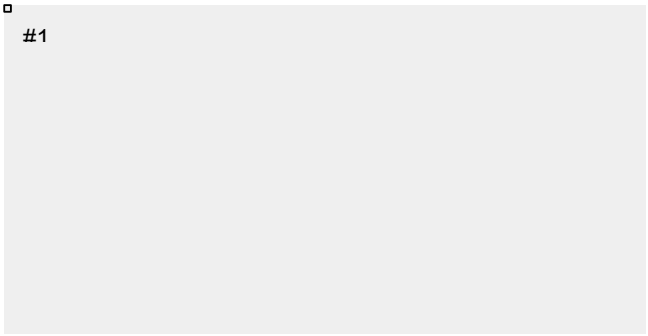
Next, ask a student who rolled a six from a red dice whether it was due to the red dice having an extra six or would they have rolled a six anyway. Ask them to consider how the extra six changes the odds of this outcome. The purpose of this exercise is to demonstrate that it's difficult to say global warming caused a single event, but that it increases the likeliness of extreme events.

Reinforce this activity with this 2-minute video showing how climate change's influence on weather is like steroid use influencing a baseball batter.

Another way to do this warm-up is to repeat the activity and have the students report outcomes in a Google Form. Emphasize that with global warming taking place, energy is being added to the ocean and the atmosphere. A focus on energy can help students see how this additional energy can lead to more frequent and severe storms.

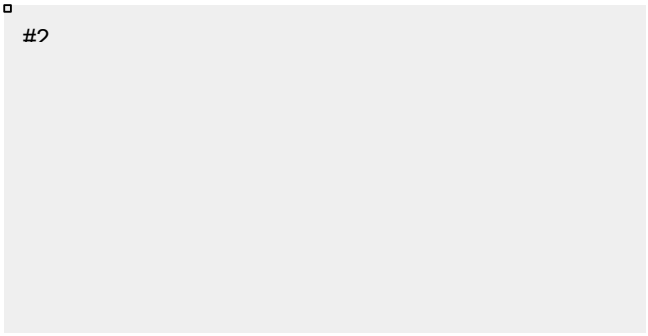
As groups plug in results, a histogram can be created representing the number of times a specific number shows up. Use this as a reference to model how often extreme events can happen. Tell the students that any sum of 10 or over represents an extreme event. Over time, substitute dice with two sixes in your groups to represent increasing available energy.

- Have students roll a normal pair of dice. In the #1 box below, sketch in the histogram produced from this FIRST set of data:



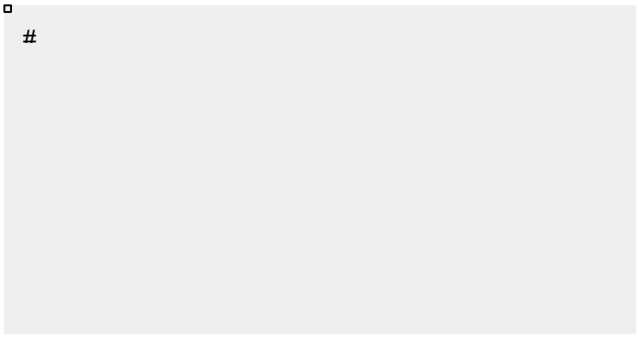
How many EXTREME events occured?_____

- Now exchange one die in each pair with one with double sixes. In the #2 box below, sketch in the histogram produced from the SECOND set of data:



How many EXTREME events occured?
_____

- Substitute both dies with double sixes. In the #3 box below, sketch in the histogram produced from the THIRD set of data:



How many **EXTREME** events occured? _____

How did the increase in **"ENERGY"** impact the number of extreme events?

Identifying a Local Issue

Now, identify a local issue related to climate change. Issues may include changes in weather patterns and subsequent increased frequency of flood, fire, drought, or other phenomenon; changes in agricultural yields/planning; changes in other resources related to climate such as impacts on fisheries, hunting, sporting activities, and or other recreational activities; and/or changes in traditional observations and activities including local ecology, invasive species, seasonal patterns, etc.

Students can research local climate impacts in their area using the National Climate Assessment: https://nca2014.globalchange.gov/. A good example of how to do this is provided by **NCSE Ambassador Teacher David Amidon** in the **Extend** portion of this lesson.

Have your students work in groups to research the issue. Provide the groups with different sets of data related to the issue (graphs, text, images, maps) that will help them learn more about changes that have occurred. Students should sort the materials into 3-4 categories that make sense to their group. Categories could include labels such as “drought frequency”, “fire impacts”, “flood risks”, “rainfall”, etc., but it is best for the students to find the trends and assign the labels themselves.

On a large piece of paper (11x17 or larger), students create a table with the categories across the top and space below in which to summarize what they have found by examining the data. Students can share with other groups to compare which categories and what data they found significant.

A good example of this activity concerning wildfires from **NCSE Ambassador Teacher Kim Parfitt** is provided in the **Supplemental Document**.

Students then create either a concept map (lines that link concepts must be linking verbs or phrases) or a connections circle with a paragraph explanation for each anchor of the circle.

Display the concept maps/connection circles so students can view the work of their peers. Review the overarching question: **Is climate change influencing your local issue?**

Then using three different colored sticky notes, have each individual student create a claim and evidence statement based upon the data they found most convincing related to the overarching question. These could include statements such as “increased energy stored in ocean water produced stronger and larger hurricanes”, “tree death from beetles has increased the occurrence and intensity of forest fires”, or “decreased snow melt has impacted the availability of water for irrigation and forced farmers to plant different crops”. The goal of this activity is for students to connect the results of climate change to real impacts in their communities that require action.

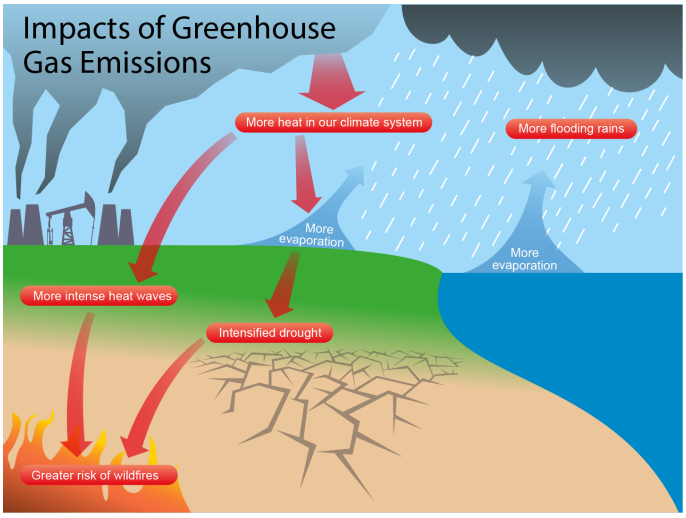
Again, to see an example of concept maps and stickies, see **Kim’s** lesson the **Supplementary Document.**

Explain

Natural disasters are caused by a number of factors - and all of the events you may explore are linked to weather and climate in some way. With global warming taking place, energy is being added to the ocean and the atmosphere. This lesson investigates how this increase in energy in impacts extreme weather events.

All of the issues are generally related to the greenhouse effect.

Reflect on how greenhouse gases are trapping heat and that this has flow-on effects throughout our climate system. Explain how global warming is affecting all weather - from the heat build-up making heat waves worse to more moisture in the atmosphere affecting precipitation. However, the effect is more direct and clear for extreme weather like heat waves, and less direct and clear for other effects like wildfires.



Introduce the myth that since extreme weather has occurred in the past, climate change has nothing to do with extreme weather events today.

Evaluate – FLICC

We are moving the **Evaluate** section above the **Extend** section in this lesson since it flows more naturally to this section. This activity will help students see how the misconception stated above is invalid.

Spot the fallacy exercise

Introduce the students to examples of misinformation arguing that extreme weather has happened in the past, without human-caused global warming, so any extreme events we see today must be natural, just like they've always been. Clarify that the chief argument is that global warming has no influence on weather.

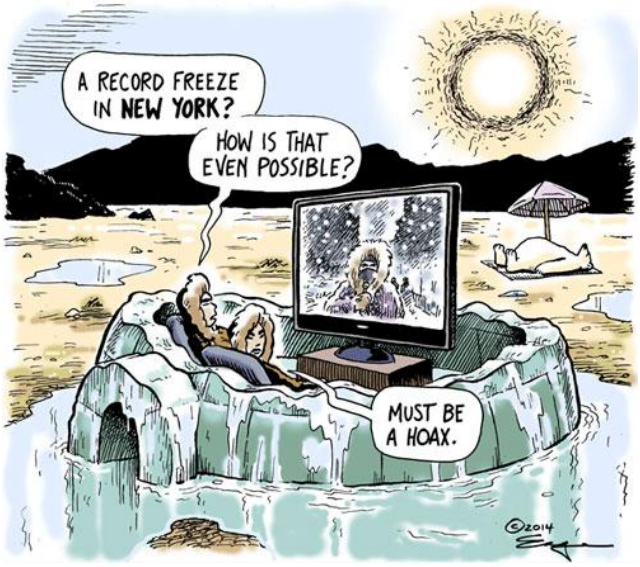
President Trump's tweet about cold weather in New York on New Year's Eve provides a good example:

> *"In the East, it could be the COLDEST New Year's Eve on record. Perhaps we could use a little bit of that good old Global Warming that our Country, but not other countries, was going to pay TRILLIONS OF DOLLARS to protect against. Bundle up!"*

Try to find examples similar from local figures, or about local impacts.

Split the students into groups and assign them the task of explaining the fallacy using the dice analogy.

This approach is similar to using cartoons and comics to expose misconceptions. Rather than focusing on political figures, you could show the students a cartoon like the one below and ask them to explain what makes the cartoon funny. The humor of cartoons often involves misrepresenting something in a way that it is ridiculous. It is not always obvious what truth is being misrepresented, however, especially when the cartoon involves understanding of science content. If the students can tell you why the cartoon is funny, then they are able to see what is "right" and how it is misrepresented.



Extend

The **Extend** section provides a link and an activity that can help you show ways climate change can impact our lives in many different ways. Specific examples of lessons from NCSE Ambassador Teachers are included in the **Supplemental Documents Folder**.

An easy way to extend this lesson is to have your students watch the Nova documentary: **Decoding The Weather Machine**:

http://www.pbs.org/wgbh/nova/earth/decoding-weather-machine.html

Another way would be to engage the students in an activity that shows how changing weather patterns can impact our lives in ways other than causing extreme events.

The activity below comes from **NCSE Ambassador Teacher, Jennifer Broo**.

Use the U.S. Climate Residence Took Kit Activity to show students how changes in weather patterns in general will impact their communities.

Go to https://toolkit.climate.gov/#climate-explorer (US Climate Resilience Took Kit) and launch the climate explorer.

Select search by location and type in your zip code.

Define the following terms:

Mean Daily Maximum Temperature
Mean Daily Minimum Temperature
Days with Maximum Above 95°F
Days with Minimum Below 32°F

Notice there are two lines on the graph. One blue and one red. What does each line represent?

Fill in the chart for your zip code:

	2020		2080	
	Red Median	Blue Median	Red Median	Blue Median
Mean Daily Maximum Temperature:				
Mean Daily Minimum Temperature:				
Days with Maximum Above 95°F:				
Days with Minimum Below 32°F:				

How will climate change affect your daily life?

What's your favorite place to vacation (or place you would like to visit) in the continental United States (not Hawaii or Alaska)? _____

Fill in the chart for your favorite vacation spot:

	2020		2080	
	Red Median	Blue Median	Red Median	Blue Median
Mean Daily Maximum Temperature:				
Mean Daily Minimum Temperature:				
Days with Maximum Above 95°F:				
Days with Minimum Below 32°F:				
Mean Dailey Precipitation				

How will climate change affect your future vacations to this spot?