

# Today I Learned About Climate Impacts

## Description:

We hear about climate impacts all over the world, often in global terms. But what is happening where? And what will happen in our own communities? Students play a game to understand changes to precipitation. Then, using the US Climate Resilience Toolkit, they investigate local climate concerns and solutions.

## Skills & Objectives

### SWBAT

- Explain how carbon dioxide in the atmosphere causes higher temperatures.
- Explain some relationships between higher temperatures and changes to precipitation.
- Understand key climate challenges for their area.
- Understand a few adaptation solutions for their area.

### Skills

- Understanding graphs
- Communicating scientific understanding

### Students Should Already Know That

- The water cycle moves water through evaporation, condensation, precipitation, infiltration, and surface runoff, and that all these stages can be affected by temperature.

#### Standards Alignment:

HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

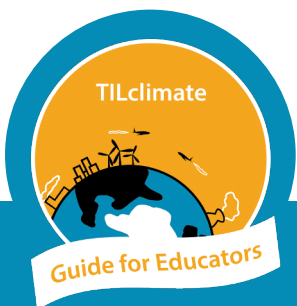
HS-ESS3-5 Analyze the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change.

#### Disciplinary Core Ideas:

ESS2.D Weather and Climate

ESS3.C Human Impacts on Earth Systems

ESS3.D Global Climate Change



# Today I Learned About Climate Impacts

## How To Use These Activities:



Pages with the circular “TILclimate Guide for Educators” logo and dark band across the top are intended for educators. Simpler pages without the dark band across the top are meant for students.

Each of the included activities is designed to be used as a standalone, in sequence, or integrated within other curriculum needs. A detailed table of contents, on the next page, explains what students will do in each activity.

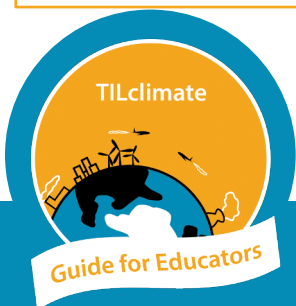
## A Note About Printing

All student pages are designed to be printable in grayscale, except for the maps on pages 1 and 3. Larger versions of these maps are provided. A few copies of this page could be printed color for students to share, or the image projected in the classroom.

The worksheets do not leave space for students to answer questions. Students may answer these questions in whatever form is the norm for your classroom – a notebook, online form, or something else. This allows you, the teacher, to define what you consider a complete answer.

**Podcasts in the Classroom:** Throughout these Guides for Educators, we invite students to think about how they would share their learning with family and friends. One way to do this is to encourage your students to create their own podcasts - they're shareable, creative, and have multiple options for embedded assessment. We would love to hear any podcasts or see any other projects you or your students create! Email us at [tilclimate@mit.edu](mailto:tilclimate@mit.edu), Tweet us @tilclimate, or tag us on Facebook @climateMIT.

We encourage you to share this Guide under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc-sa/4.0/> or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.



# Today I Learned About Climate Impacts

## Detailed Table of Contents

Page	Title	Description	Time (min)
	Podcast Episode	Students listen to TILclimate: TIL about climate impacts, either as pre-class work at home or in the classroom. <a href="https://climate.mit.edu/podcasts/e6-til-about-climate-impacts">https://climate.mit.edu/podcasts/e6-til-about-climate-impacts</a>	10-15
1-2	The Water Cycle Game	In a hands-on game, students model observed changes to precipitation patterns due to a warming world.	15-20
3	Water Cycle Game Science	Students look at maps related to the precipitation changes modeled in the Water Cycle Game.	10-20
4-5	Think Globally, Act Locally (requires single shared internet computer)	Using the US Climate Resilience Toolkit, students investigate local climate impacts.	15-25
6-8	Resilience Investigation (each team or individual requires internet)	In teams, students investigate local climate impacts and possible adaptations to those impacts. Then, they develop a communication plan to share their learning with their community.	30-45+

## The Water Cycle Game

### Materials:

- At least 20 small objects per participant/cloud, such as beads, beans, poker chips, etc. to represent water droplets.
- A small cup to hold the objects for each participant/cloud (all but two students.)

### Setup:

- This game can be played in any room that has enough space for all participants to move around, such as a large classroom, gym, multipurpose room, or outdoors (if the objects are findable in the space).
- Distribute small objects (water droplets) around the space. You can create lakes and oceans (i.e., with clumps of objects), forests (with smaller clumps), deserts (with no droplets) or whatever you'd like. You may label these features, if you like.



# Today I Learned About Climate Impacts

## Local Climate Impacts and the Water Cycle

This Educator Guide includes a game and an online investigation project. Educators may pick and choose among the pieces of the Guide, as suits their class needs.

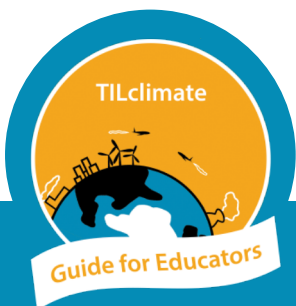
Parts of this Guide may align with the following topics:

- Physical science: Evaporation and heat trapping gases.
- Life/environmental science: The water cycle, changes to evaporation.
- History/social science: Effects of precipitation changes on policy, migration, etc.
- ELA/nonfiction: Communicating scientific understanding to the general public.

## MIT Resources

We recommend the following as resources for your own better understanding of climate change or as depth for student investigations. Specific sections are listed below:

- Climate Science, Risk & Solutions, an interactive introduction to the basics of climate change. <https://climateprimer.mit.edu/>
  - Chapter 02 The greenhouse effect and us
  - Chapter 03 Measuring past temperatures
  - Chapter 04 Predicting climate
  - Chapter 07 What are the risks?
  - Chapter 10 What can we do?
- MIT Climate Portal Explainers are one-page articles describing a variety of climate topics. <https://climate.mit.edu/explainers>
  - Climate-Resilient Infrastructure
  - Sea Level Rise
  - Urban Heat Islands
  - Cities and Climate Change
  - Climate Models
  - Greenhouse Gases





# Today I Learned About Climate Impacts

## Wrap-Up Discussion Questions

- How accurately did the game model these two precipitation changes?
- What other precipitation changes might you expect with a warmer Earth?
- How would the climate concern you studied affect people in your community?
- How could a solution you chose work in your community?
- According to data compiled by the Yale Program on Climate Change Communication, 61% of Americans believe that climate change will harm Americans, while only 43% believe that they will be personally harmed. Why do you think so many people in the U.S. believe that they will not personally be affected much by climate change? How could you help those people understand the potential climate impacts in their communities?

## Climate Solutions

Climate solutions can be thought of as falling into four categories outlined below. Across all categories, solutions at the community, state or federal level are generally more impactful than individual actions. For example, policies that increase the nuclear, solar and wind mix in the electric grid are generally more effective at reducing climate pollution than asking homeowners to install solar panels. For more on talking about climate change in the classroom, see “How to Use This Guide”.

### •Energy Shift

How do decision-makers make the switch from carbon-producing energy to carbon-neutral and carbon-negative energy?

### •Energy Efficiency

What products and technologies exist to increase energy efficiency, especially in heating and cooling buildings?

### •Adaptation

How can cities and towns adapt to the impacts of climate change?

### •Talk About It

Talking about climate change with friends and family can feel overwhelming. What is one thing you have learned that you could share to start a conversation?

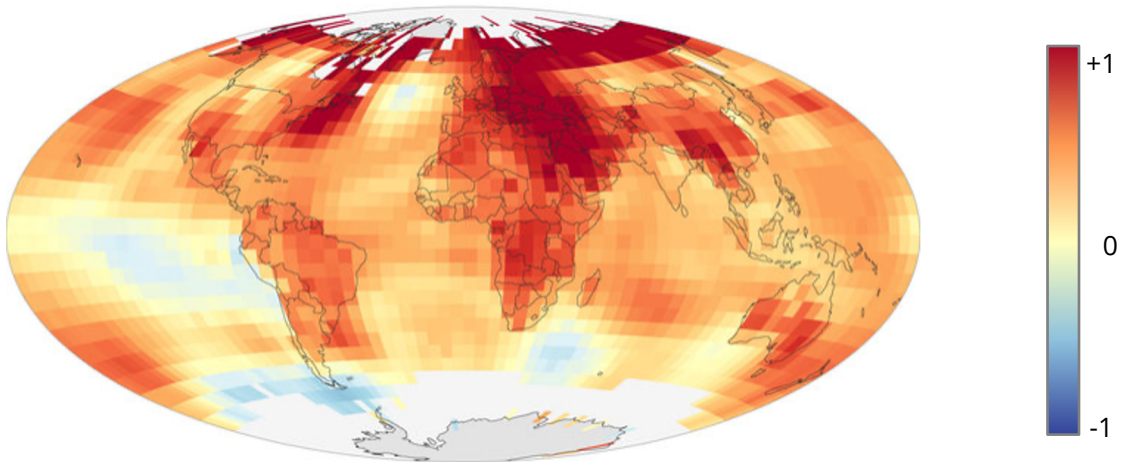
What solutions are the most exciting in your classes? We would love to hear from you or your students! Images, video, or audio of student projects or questions are always welcome. Email us at [tilclimate@mit.edu](mailto:tilclimate@mit.edu), Tweet us @tilclimate, or tag us on Facebook @climateMIT.



# Today I Learned About Climate Impacts

"We were very much interested in what climate change is going to do to the availability of water. Would the region experience have more water in the future or less water?"

*Professor Elfatih Eltahir, MIT Department of Civil and Environmental Engineering*  
*TILclimate podcast: Today I Learned About Climate Impacts*



**Recent Temperature Trends (1990-2020)**  
(Degrees Fahrenheit per Decade)

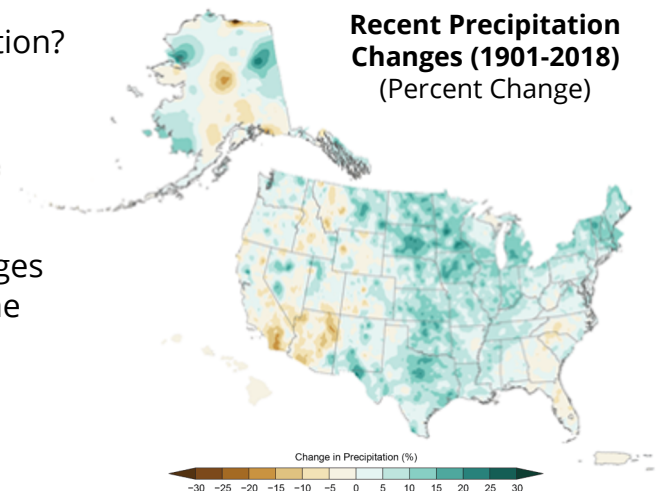
## Climate Change and Precipitation

As we burn fossil fuels like coal, oil, and natural gas and cut down forests, we release carbon dioxide (CO<sub>2</sub>) into the atmosphere. This CO<sub>2</sub> acts like a blanket around Earth, trapping heat. Trapped heat is warming Earth, the ocean, and the air. Overall, the world is getting warmer. We can explain and model observed temperature changes around the world with this understanding.

But how does a warmer Earth affect precipitation?

The effects are complex, since global weather patterns are complex. Today, you will play a simplified game to explore some changes to precipitation.

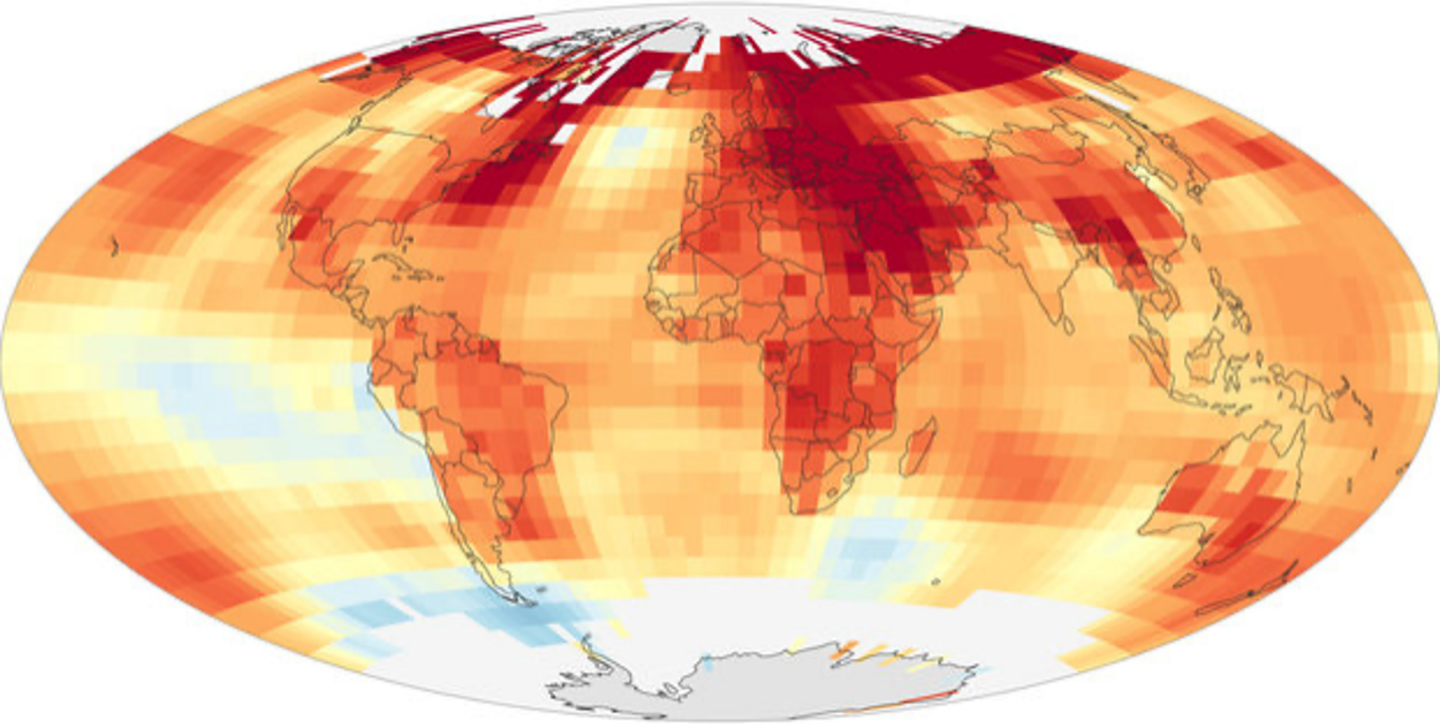
As you can see in the map, precipitation changes do not affect all regions in the same way. Some areas have gotten wetter, while others have become drier.



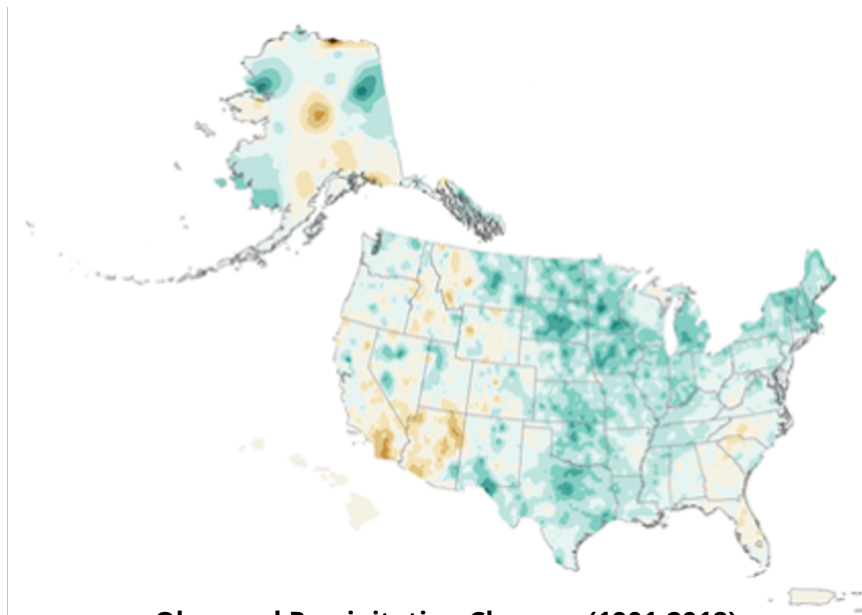
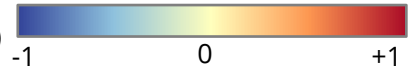
**Recent Precipitation Changes (1901-2018)**  
(Percent Change)

Temperature image: NOAA Climate.gov <https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature>  
Precipitation image: 4<sup>th</sup> National Climate Assessment, Chapter 2 <https://nca2018.globalchange.gov/chapter/2/>

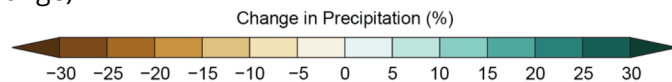
# Today I Learned About Climate Impacts



**Observed Temperature Trends (1990-2020)**  
(Degrees Fahrenheit per Decade)



**Observed Precipitation Changes (1901-2018)**  
(Percent Change)



Temperature image: NOAA Climate.gov <https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature>  
Precipitation image: 4<sup>th</sup> National Climate Assessment, Chapter 2 <https://nca2018.globalchange.gov/chapter/2/>

# Today I Learned About Climate Impacts

## Water Cycle Game

Each participant (other than the leader and timekeeper) is a cloud. The objects are water droplets. Each cloud should choose a pattern to walk around the space, which they will repeat throughout the activity. A leader reads the text in the boxes, and the clouds follow the directions. A timekeeper sets the clock for each stage.

Look at the distribution of water droplets around the space. What are the patterns?

### Water Cycle Without Climate Change (4 minutes)

Human civilization as we know it has developed over the past 10,000 years, since the end of the last ice age. This time period has had a very stable climate.

You are a cloud. As you move around, if you see a body of water, pick up one water droplet. This is evaporation.

If you have ten water droplets, walk three steps and then rain your water back down on the Earth. You may choose whether you rain all your water into one waterbody or spread it on the land between waterbodies.

### Change in Precipitation Intensity (4 minutes)

As the lower atmosphere becomes warmer due to heat-trapping gases in the upper atmosphere, evaporation rates go up.

If you see a body of water, pick up two water droplets at a time.

If you have ten water droplets, walk three steps and then rain your water back down on the Earth. You may choose whether you rain all your water into one waterbody or spread it on the land between waterbodies.

### Change in Drought Severity (4 minutes)

Warmer temperatures also dry out the land, increasing drought.

If you see water that is not in a body of water, pick up one or two water droplets.

If you have ten water droplets, walk three steps and then rain your water back down on the Earth. You may choose whether you rain all your water into one waterbody or spread it on the land between waterbodies.

Note where the water droplets ended up at the end of the game.

Are there any major changes in patterns of distribution?

How many clouds ended the game with water droplets in their cups?

How many had just rained?

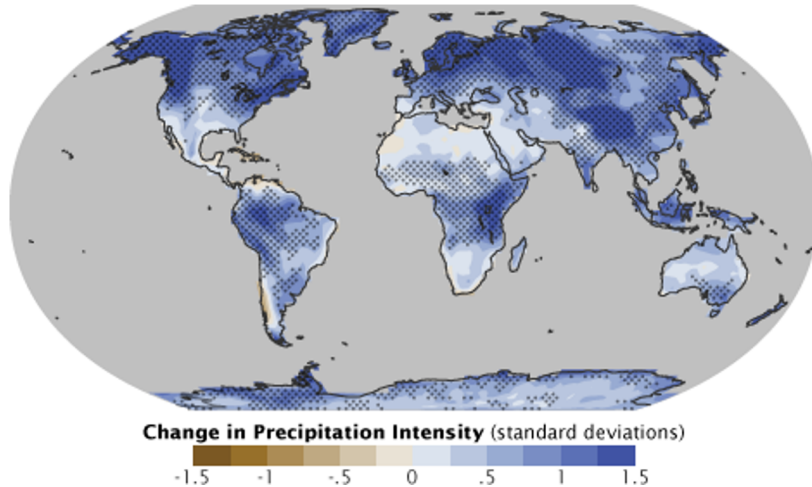
Images from NASA Earth Observatory <https://earthobservatory.nasa.gov/features/Water>



# Today I Learned About Climate Impacts

## Water Cycle Game: The Science

Each of the changes modeled in the game are based on actual observed and modeled changes in global precipitation patterns.



### Change in Precipitation Intensity

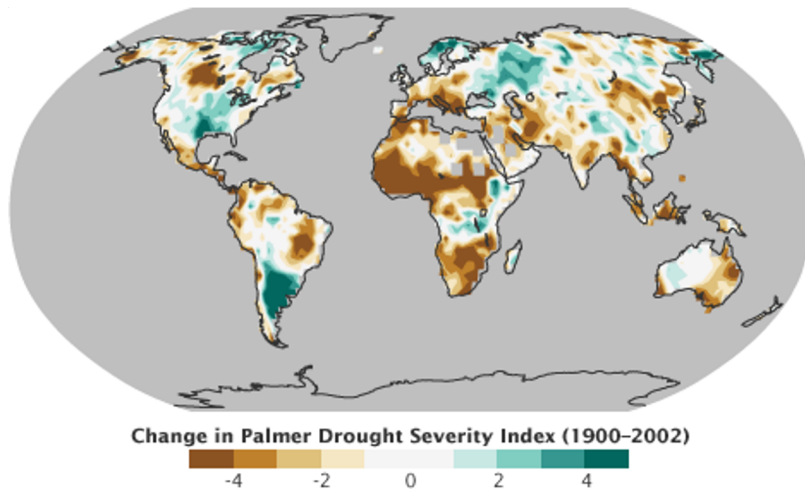
More rain falls in short amounts of time today than in the past. In other words, there are longer periods with little precipitation, followed by large single storm events.

How does this change in pattern affect how water is used and handled around the world?

### Change in Drought Severity

Through the 1900s, droughts increased in some areas (Sub-Saharan and Southern Africa, eastern Brazil, Iran) while they have decreased in others (western Russia, south-eastern South America, Scandinavia, southern United States).

How do shifts in drought patterns affect farming and water use?

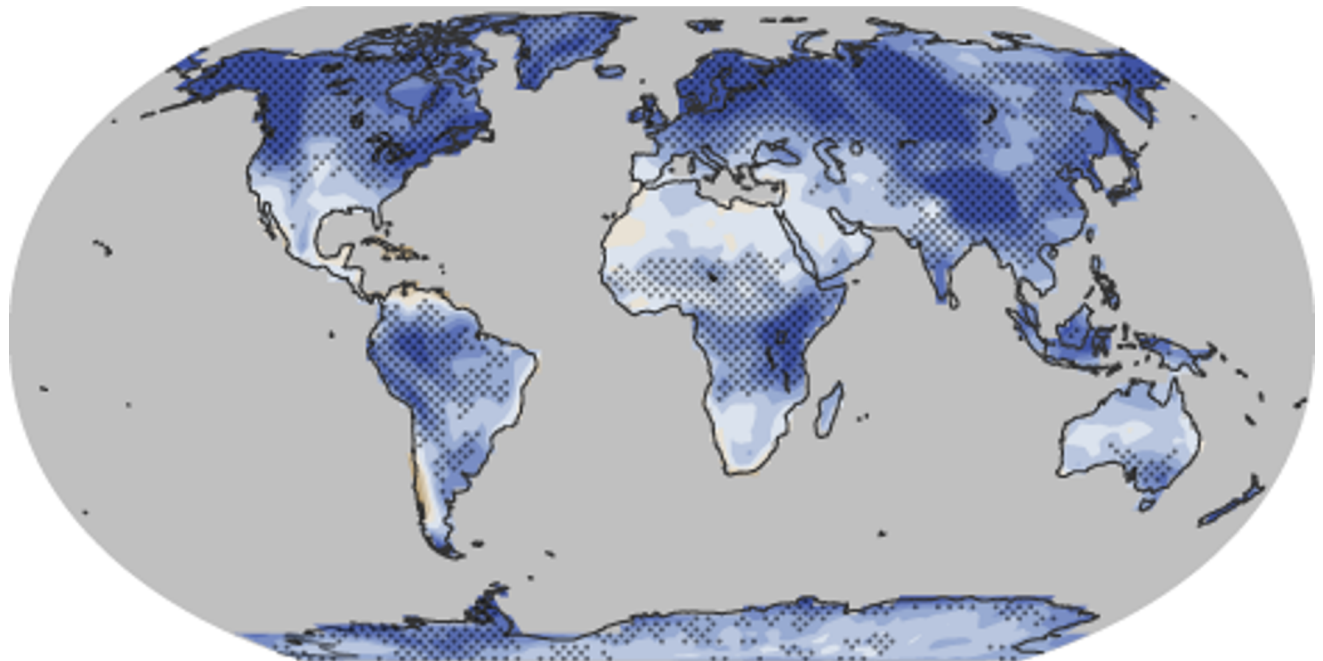


## Discussion Questions

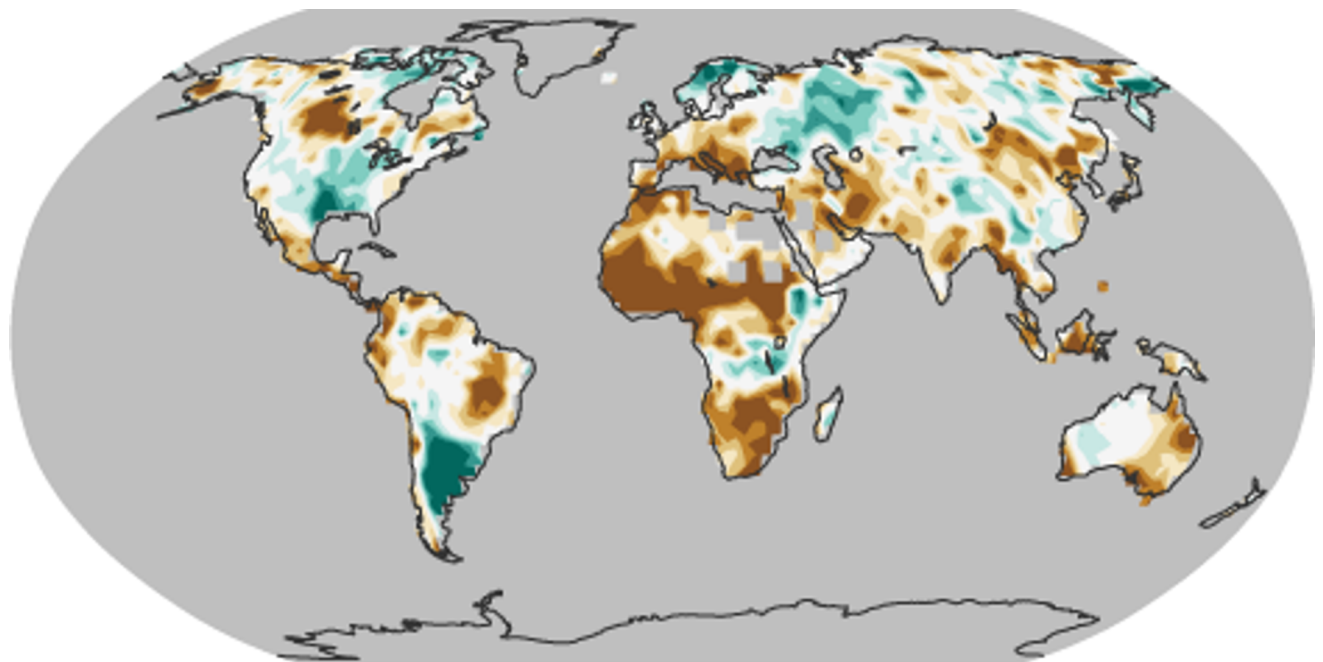
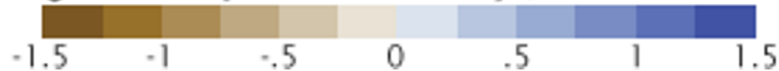
- How accurately did the game model these two precipitation changes?
- What other precipitation changes might you expect with a warmer Earth? (Consider seasonal ice-melt, for example.)
- In your own words, describe how higher concentrations of carbon dioxide in the atmosphere lead to larger rainstorms.
- In your own words, describe how higher concentrations of carbon dioxide in the atmosphere lead to droughts.

Images from NASA Earth Observatory <https://earthobservatory.nasa.gov/features/Water>  
The Palmer Drought Severity Index has a range from -10 (extreme drought) to +10 (extremely wet.)

# Today I Learned About Climate Impacts



**Change in Precipitation Intensity (standard deviations)**



**Change in Palmer Drought Severity Index (1900-2002)**



Images from NASA Earth Observatory <https://earthobservatory.nasa.gov/features/Water>

# Today I Learned About Climate Impacts

"A lot of what motivates my research is to inform people at the local level about things that they care about, so that they participate in the formulation of the policy based on science rather than based on misinformation."

*Professor Elfatih Eltahir, MIT Department of Civil and Environmental Engineering  
TILclimate podcast: Today I Learned About Climate Impacts*

## Think Globally, Act Locally

As we burn fossil fuels like coal, oil, and natural gas, we release carbon dioxide (CO<sub>2</sub>) into the atmosphere. This CO<sub>2</sub> acts like a blanket around Earth, trapping heat. Trapped heat is warming Earth, the ocean, and the air. Overall, the world is getting warmer. But Earth's climate system is complex, which means that the exact impacts of this warming vary by location – some areas getting drier while others flood more often, some places getting hotter while others have more variable and unpredictable temperatures.

Action on climate is also a split between the global and the local. The heat-trapping gases released in any one place affect the whole world. To protect people and places around the world from harm, changes must happen at the local and regional level. Leaders and communities in towns, cities, counties, states, and countries are all contributing to action on climate change.

## Local Climate Hazards and Solutions

According to the National Oceanic and Atmospheric Administration, there are five steps to Climate Resilience. Today, you will participate in steps 1, 2, and 3 of this process. Depending on your class and time, you may move into steps 4 and 5, using the guidelines at <https://toolkit.climate.gov/>



1. Explore Hazards
2. Assess Vulnerability and Risk
3. Investigate Options
4. Prioritize and Plan
5. Take Action

# Today I Learned About Climate Impacts

## Step 1: Explore Hazards

The list of climate impacts around the world is long and can seem overwhelming. Not every impact is happening in the same way (or at all) in every place. For each region, there are a smaller number of more likely impacts. As a whole class, investigate the most pressing impacts in your community.

1. Visit <https://crt-climate-explorer.nemac.org/> and type in the name of your nearest city or your county.
2. Click the box **Ready to plan for resilience?**
3. Under **Top Climate Concerns**, click the toggle for “Show full range of projections.”

### Describe

What are the top climate concerns for your area? Note the range of projections for each, as well as the time scale for the projection.

4. Form teams: Each climate concern should have one Science team and one Action team. (For example, if your region has three top climate concerns, there would be three pairs of teams, or six teams altogether.)
5. In your teams, begin by brainstorming questions that you have about your climate concern. Consider:
  - Can you explain the connection between heat-trapping gases in the atmosphere and this impact? If not, use one of the resources listed below.
  - Have members of your team or their families already experienced this impact? Be aware of how discussing climate change may feel different for each member of your team.
  - What would you want your friends and family to know about this impact?
6. Science teams, move to Step 2. Action teams, move to Step 3.

### Resources

- Ask MIT: How is climate change affecting the weather today? <https://climate.mit.edu/ask-mit/how-climate-change-affecting-weather-today>
- MIT Explainer: Sea Level Rise <https://climate.mit.edu/explainers/sea-level-rise>
- MIT Explainer: Urban Heat Islands <https://climate.mit.edu/explainers/urban-heat-islands>
- MIT Explainer: Hurricanes <https://climate.mit.edu/explainers/hurricanes>



# Today I Learned About Climate Impacts

## Step 2: Assess Vulnerabilities and Risks

Science teams will use graphs and data from The Climate Explorer to investigate your climate concern.

1. Visit <https://crt-climate-explorer.nemac.org/> and type in the name of your nearest city or your county.
2. For climate concerns related to weather, rain, drought, stormwater flooding, and heat, click the box **Climate Graphs**. For climate concerns related to sea level rise and high-tide flooding, click the box **High-Tide Flooding** and skip ahead to 4.
3. Click the drop-down menu to see which data topics are available in this view. They are organized under **Temperature**, **Precipitation**, and **Other**.

### Decide

Which of these datasets is related to your climate concern? Choose 2-3.

4. For **High-Tide Flooding**, choose a tidal location on the map to view data.

### Observe

How would you describe the pattern in the following for your chosen dataset(s)?

- Historical (gray)
- Lower emissions (blue)
- Higher emissions (red)

5. Choose either the lower emissions (blue) or higher emissions (red) prediction line for one dataset.

### Analyze

How would this pattern affect people in your community? Consider how the changes shown in this dataset would affect people's ability to get around, go to school and work, play outside, access food and water, and other aspects of daily life.

### Extend

What other questions could you answer with this tool?

### Share

Partner up with the Action team that was working on the same climate concern. Work together to decide how to share your learning with your community. See page 8.

# Today I Learned About Climate Impacts

## Step 3: Investigate Options

Action teams will use case studies from the US Climate Resilience Toolkit to explore options for adaptation to their local climate concern.

1. Visit <https://toolkit.climate.gov/case-studies>.
2. In the **Filter by climate threat/stressor** dropdown menu, read the list of stressors.

### Decide

Which of these stressors is related to your climate concern? Choose and click 1-2.

3. In the **Filter by steps to resilience** dropdown menu, choose **Take Action**.
4. Each team member (or pairs of team members) should choose one case study to read.

### Analyze

As you read your case study, consider:

- What challenge is this community facing? How is it related to the climate concern you are focused on for your region?
- What solution(s) are they using – are they changes to infrastructure (roads, sidewalks, dams, etc.) community supports (emergency preparedness, shelters, etc.) or technology?
- How could a solution like this work in your community?

### Report & Select

As each team member reports on their case study, the team should choose 1-2 to focus on for sharing with the Science team.

### Reduce Emissions

The case studies all focus on adaptation – protecting people and places from harm due to climate impacts. These climate impacts are caused by warming from heat-trapping gas emissions. If you have time, consider: what technologies or processes have you seen in your community that are reducing carbon dioxide from burning fossil fuels?

### Extend

What other questions could you answer with this tool?

### Share

Partner up with the Science team that was working on the same climate concern. Work together to decide how to share your learning with your community. See page 8.

# Today I Learned About Climate Impacts

## Sharing Your Learning

1. Pair up with the other team working on the same climate concern.
2. Each team should briefly teach the other what they have learned about the science of their impact and the possible adaptations to it.

## Discuss

How do the actions relate to the science? Do the proposed adaptations solve some of the problems with the impact?

3. Decide on one impact and one related adaptation to present.
4. Develop a plan for how to communicate this story to your community.

## Consider

As you develop your communication plan:

- Talking about climate impacts can be overwhelming or scary. How can you balance the hope of the adaptation idea with the worry of the climate prediction?
- Are there any projects already happening in your area that are addressing the issue you chose? Are there organizations working on this topic in your area?
- When talking to the general public, graphs and charts are not always the best way to communicate. How can you turn your impact and adaptation into a story?
- Who needs to hear your story? Is it the general public, students at your school, community leaders? Defining your audience can help define the best method for communication.
- Choose your medium. Depending on your goals, consider a podcast, video, website, social media campaign, posters, pamphlets, a speech, or something else.
- Look for 'co-benefits.' Many climate adaptations for one challenge also help with another. For example, increased parks and greenspace helps reduce heat but also gives a community more places for celebrations, gatherings, and enjoyment of nature.

## Extend

Are there other connections between teams that you could make? How are all the climate impacts and adaptations investigated by your class related?