**RESOURCE LIBRARY**
LESSON

# Extreme Weather

Students examine the causes and effects of extreme weather events and read to contrast weather and climate. Next, they create and revise models of an extreme weather event using knowledge of weather variables. Finally, students link extreme weather events and climate change. Students use an interactive graph and long-term datasets, as well as create their own graphical representations of weather data. This lesson is part of the *Climate Change Challenge* unit.

**GRADES**

6 - 8

**SUBJECTS**

*Earth Science, Climatology, Meteorology*

**CONTENTS**

5 Activities

## ACTIVITY 1: WEATHER INTERCONNECTIONS | 1 HR 15 MINS

## DIRECTIONS

*This activity is part of the Climate Change Challenge unit.*

**1. Create a concept map of interconnections in extreme weather based on students' responses to a short video.**

- Play the *Extreme Weather: Interconnections in Extreme Weather* video (2:17) to introduce the topic of extreme weather. Begin a concept map using students' responses to the questions below. List examples of extreme weather events inside circles in a visible place, then use responses to the second question to connect events with lines, writing students' ideas nearby.

  - Ask: What *extreme weather events are discussed in this video?* (Droughts, heat waves, typhoons, powerful storms, and flooding.)

- To elicit knowledge from the *Carbon Concerns* lesson, ask students:

  - *How do you think these extreme weather events connect to Earth's climate?* (Student responses may vary, but will help give a sense of their current understanding regarding the differences between weather and climate.)

**2. Support students as they read to differentiate the terms *climate* and *weather*.**

- Distribute copies of the first two sections (*Understanding Weather* and *Understanding Climate*) of the *Weather or Climate...What's the Difference?* article to pairs of students.
- In each pair, assign one student to read and annotate the *Understanding Weather* section and the other to read and annotate the *Understanding Climate* section. Direct students to pay special attention to statements relating these two terms.
- Distribute the *Weather Interconnections Meaning Maker* handout and prompt students to define the terms *climate* and *weather* with their partners. (The key distinction from this article is that weather is a day-to-day phenomenon, whereas climate is the pattern of weather over long periods of time, usually decades.)
- Solicit definitions from volunteers to ensure that pairs are on the right track. Then assign students to complete the rest of the *Weather Interconnections Meaning Maker* handout using their understanding from their partner discussion of the readings.
- Prompt students to consider and describe in words on their chart how each term is distinct from the other.

**3. Assign students an extreme weather focus and facilitate the creation of an initial meteorological model of this event.**

- Explain to students that the next few activities will focus on an extreme weather event of their choice: droughts, hurricanes, or tornadoes.

- Form small groups of three to four students based on their preferences for each of these events, and provide each group a link to the appropriate resource(s) relevant to their weather type and its impacts:
    - Droughts: *Extreme Weather: Droughts* (3:01)
    - Hurricanes: *Hurricanes 101* (2:42)
    - Tornadoes: *Tornadoes 101* (3:00) / *Upturning Tornadoes* (5:16)
- Instruct each small group to use their assigned video to determine and record causes and effects of their extreme weather event on the T-chart in Part A of their *Extreme Weather Model Builder* handout.
- Assign each small group to use the video and their chart to draw an initial systems diagram model of their extreme weather event in Part B of their *Extreme Weather Model Builder* handout. This model should include:
    - A visual depiction of the event itself.
    - At least three causes of the extreme weather event labeled.
    - At least three effects of the extreme weather event labeled.
    - Arrows and accompanying plus and minus signs to show the relationships among causes and between causes and effects.
- Ask students who considered the same extreme weather event to mingle, forming pairs from different groups to compare and contrast their initial models. Ask students to consider:
    - *How is your work similar to, or different from, others who studied the same extreme weather event?*
- Prompt students to make brief notes on their initial model of any elements from their peer's diagram that they would like to incorporate in later revisions, and to give their peers at least one piece of positive feedback regarding their work.
- Lead a final debrief discussion to elicit students' ideas about the common themes of meteorological conditions that lead to, and result from, the extreme weather events.

# Tip

**Step 1:** The *Teacher Toolkit* has a video and article on *Concept Map* that may be helpful for concept mapping extreme weather events with students. It is important that students differentiate between extreme weather events and their consequences. For example, drought is an extreme weather event, and wildfires are a potential and destructive consequence.

# Modification

**Step 2:** The *Weather or Climate...What's the Difference?* article is leveled to accommodate readers at multiple levels. Additionally, encyclopedic entries for *weather* and *climate* provide another opportunity to make the distinction between these two terms clear to all students.

# Tip

**Step 3:** Consider having students perform additional online research to add to their list of the causes and effects of their extreme weather events.

# Tip

**Step 3:** Use the *Q Design Pack on Systems Thinking* from the Institute of Play to support students in creating and discussing their systems diagrams. See p. 33 on *Causal Maps*, specifically.

# Informal Assessment

Informally assess students' prior and developing knowledge of the factors leading to extreme weather events by examining their initial model in the *Extreme Weather Model Builder*.

## OBJECTIVES

# Subjects & Disciplines

**Earth Science**

- Climatology
- Meteorology

# Learning Objectives

Students will:

- Read to compare and contrast the terms weather and climate.

- Create an initial model of an extreme weather event.
- Link causes and effects of multiple types of extreme weather.

# Teaching Approach

- Project-based learning

# Teaching Methods

- Discussions
- Multimedia instruction
- Reading

# Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
  - Life and Career Skills
    - Initiative and Self-Direction
    - Social and Cross-Cultural Skills
- Critical Thinking Skills
  - Remembering
  - Understanding
- Science and Engineering Practices
  - Developing and using models

# National Standards, Principles, and Practices

### COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

- **CCSS.ELA-LITERACY.RST.6-8.4:**

Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

### NEXT GENERATION SCIENCE STANDARDS

- **Crosscutting Concept 2: Cause and Effect:**
Cause and effect relationships may be used to predict phenomena in natural or designed systems.
- **MS-ESS2-5:**
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
- **Science and Engineering Practice 2:**
Developing and using models
- **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information.

**Preparation**

## BACKGROUND & VOCABULARY

# Background Information

Weather describes the state of the atmosphere at a specific place and a short span of time. Six key variables contribute to weather: temperature, precipitation, pressure, wind, humidity, and cloudiness. Scientists and forecasters precisely measure these variables with tools such as a thermometer, barometer, and anemometer. In contrast, climate is the typical pattern of weather over the course of many years. Climate determines the frequency of particular weather events through the decades, as well as the distribution of organisms within ecosystems across Earth's surface.

Extreme weather events include hurricanes, tornadoes, and droughts. Each of these extreme weather events has the capacity to powerfully influence the lives of humans, and can sometimes even be deadly. Extreme weather can also lead to other destructive impacts. For example, droughts can increase the frequency of wildfires, and hurricanes can lead to storm surges.

# Prior Knowledge

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# Recommended Prior Activities

- Carbon All Around
- Global Trends
- Heating Up
- Local Emissions
- Our Greenhouse

# Vocabulary

| Term | Part of Speech | Definition |
|---|---|---|
| **climate** | *noun* | all weather conditions for a given location over a period of time. |
| **drought** | *noun* | period of greatly reduced precipitation. |
| **extreme weather** | *noun* | rare and severe events in the Earth's atmosphere, such as heat waves or powerful cyclones. |
| **hurricane** | *noun* | tropical storm with wind speeds of at least 119 kilometers (74 miles) per hour. Hurricanes are the same thing as typhoons, but usually located in the Atlantic Ocean region. |
| **tornado** | *noun* | a violently rotating column of air that forms at the bottom of a cloud and touches the ground. |
| **weather** | *noun* | state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness. |
| **wildfire** | *noun* | uncontrolled fire that happens in a rural or sparsely populated area. |

# ACTIVITY 2: METEOROLOGICAL MODELS | 1 HR 15 MINS

## DIRECTIONS

*This activity is part of the Climate Change Challenge unit.*

**1. Support students as they read to define key meteorological terms.**

- Go outside briefly, or open classroom windows and ask students to quickly brainstorm everything they can see, hear, smell, or feel to describe the weather at this moment in time.
- Next, challenge students to identify the six variables used by professionals to describe weather conditions. List ways that weather channels or apps describe current weather conditions in a Think-Pair-Share. Celebrate student identification of any of the six weather variables from prior knowledge:
    - *Temperature*
    - *Precipitation*
    - *Humidity*
    - *Atmospheric Pressure*
    - *Wind*
    - *Cloud Cover*
- Organize students into small groups associated with each weather variable listed above, aside from temperature (which will be used as a model variable at the end of this step). Assign each group to read and annotate the encyclopedic entry associated with their variable.
- Prompt students in their groups to begin Part C of the *Extreme Weather Model Builder* handout by defining their weather variables using knowledge from the article.
- Use temperature to model the collaborative definition process: request volunteers to share and record definitions on the board to evaluate and edit as a class. Assign all students to record accurate consensus definitions for each term to complete the table in Part C of the *Extreme Weather Model Builder*.

**2. Introduce the class weather station, and gather and graph initial weather data with students.**

- Introduce the class weather station (the *Setup* section contains guidance on creating this very simple station). This will be used to gather data on temperature and precipitation (and other variables, if desired) throughout the *Extreme Weather* lesson.
- Model how to collect initial temperature data using a thermometer. Incorporate this data point onto a class temperature point/line graph that will last for the next three days (this and the following two activities, *Weather, Meet Climate*, and *Now and Then*).
    - Prompt students to check the temperature graph for critical elements discussed in the *Global Trends* activity: title, axis labels, and key.
- Have students continue to work in the same *Weather Data Collection* groups from Step 1.

- Assign groups to collect data for additional variables. Depending on the complexity of your class weather station, you may wish to direct students on how to collect this data directly or use the *National Weather Service 3-Day Weather Observation History* to collect the data digitally. Project the National Weather Service site as you enter your zip code in the upper left corner of the page, then click on the "3 Day History" link at right-center. The graphs and chart that appear give hourly data, of which students only need the most recent (first) entry. In the table, the key weather variables appear as follows:
    - Temperature, with units in degrees Fahrenheit (F)
    - Humidity, with units in percent (%)
    - Wind; read only the first number, which refers to the constant wind speed, with units in miles per hour (mph)
    - Atmospheric pressure, with units in inches (in)
    - Precipitation, with units in inches per 24 hours (in)
    - Cloud cover (not measured here); looking at the sky through a window, students can make a rough estimate of cloud cover, in bins of 0–25%, 25–50%, 50–75%, and 75–100%.
- Orient students to this chart, and help the groups identify the most recent (first) entry for their variable.
- Assign students to incorporate this data onto the first day of a point/line graph, mirroring the one that you created for temperature.

**3. Prompt students to revise their extreme weather event models with additional research.**

- Reconvene students in their extreme weather groups from the *Weather Interconnections* activity. Prompt groups to revisit their initial weather models (Part B) and key meteorological terms (Part C) from their *Extreme Weather Model Builder*.
- Have students rewatch the appropriate extreme weather video Extreme *Weather: Drought* (3:01), *Hurricanes 101* (2:42), or *Tornadoes 101* (3:01) to practice identifying how these weather variables influence extreme weather. Complete Part D of the *Extreme Weather Model Builder* for at least four weather variables.
- Using this information, have students create a revised model of their extreme weather event in Part E of the *Extreme Weather Model Builder*. This new model should contain:
    - A visual representation of the extreme weather event.
    - Labels to identify at least four weather variables.
    - Arrows to show interactions between the variables.
    - Plus and minus signs to show relationships between the variables.

**4. Lead a discussion of the factors that are common or unique to extreme weather events.**

- Ask groups to choose one member's revised weather model (Part E) to post in a visible location in the classroom.
- Organize a gallery walk in which students visit other groups' revised weather models sequentially, preparing through small group discussion to answer two questions:
  - *What do these extreme weather events have in common?* (Listen for responses such as, 'all weather events involve temperature and moving air' or 'hurricanes and tornadoes both involve high winds and they spin.')
  - *What is unique to each extreme weather event?* (Listen for responses such as, 'each kind of event has different variables that are more important' or 'drought comes with very low precipitation, which is different from tornadoes and hurricanes.')
- Reconvene the class, soliciting volunteer contributions. Direct students to record what they think are the most meaningful similarities and differences between the different extreme weather events in Part F of the *Extreme Weather Model Builder*.

# Modification

**Step 2:** You may choose to have students create their graphs using a digital spreadsheet program.

# Tip

**Step 2:** Although the weather station need not be complex, it may be helpful to construct it prior to class (see instructions in the *Setup*).

# Modification

**Step 2:** At the end of this step, you may choose to lead students through a quick peer evaluation process of their graphs.

# Tip

**Step 2:** Students' graph construction may require more or less scaffolding, depending on prior experience. As you model creating a graph of the temperature data, explicitly designate space for two following data collection events. Label these days clearly on your x-axis, and instruct students to do the same in their graphs—additionally, note for students how you chose your range of values for the y-axis. Particular values will depend on the variable and time of year, but students can use the other days in the *National Weather Service 3-Day Weather Observation History* to get a sense of the variation in their variable over time.

# Modification

**Step 2:** The sixth weather variable, cloud-cover, is more challenging than the others to measure and find in datasets. You may consider omitting this variable from student weather data collection and/or from consideration in Lesson 2 as a whole.

# Informal Assessment

Informally assess students' understanding of the weather variables contributing to extreme weather events, as well as similarities between these events, by examining Parts B-F of their *Extreme Weather Model Builder*.

# Extending the Learning

**Step 2:** Students may wish to explore additional elements of the *National Weather Service* website, including the "Active Alerts" and "Rivers, Lakes, and Rainfall" tabs. Both tabs are relevant to extreme weather events occurring currently. You may wish to consider having students gather and graph additional information. This can be done either daily if data collection during this and the following two activities span a weekend, or by incorporating more hourly information from the three-day forecast.

# OBJECTIVES

# Subjects & Disciplines

**Earth Science**

- Climatology
- Meteorology

# Learning Objectives

Students will:

- Read to define key weather variables.
- Collect and graph current, local data on these key weather variables.
- Revise a model of an extreme weather event to incorporate the roles of, and interactions between, key weather variables.

# Teaching Approach

- Project-based learning

# Teaching Methods

- Discussions
- Lab procedures
- Reading

# Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
    - Media Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Critical Thinking and Problem Solving
  - Life and Career Skills
    - Productivity and Accountability
    - Social and Cross-Cultural Skills
- 21st Century Themes
  - Environmental Literacy
  - Global Awareness
- Critical Thinking Skills
  - Applying

    - Remembering
    - Understanding
- Science and Engineering Practices
    - Developing and using models
    - Obtaining, evaluating, and communicating information

# National Standards, Principles, and Practices

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Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

### NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 2: Cause and Effect:**
Cause and effect relationships may be used to predict phenomena in natural or designed systems.
• **MS-ESS2-5:**
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
• **Science and Engineering Practice 2:**
Developing and using models

**Preparation**

## BACKGROUND & VOCABULARY

# Background Information

Weather describes the state of the atmosphere at a specific place and a short span of time. Six key variables contribute to weather: temperature, precipitation, pressure, wind, humidity, and cloudiness. Scientists and forecasters precisely measure these variables with tools such as a thermometer, barometer, and anemometer. These variables combine to influence what we feel when we walk outside, but also determine other important aspects of our lives, such as the ability of our food to grow in a given season.

Extreme weather events include hurricanes, tornadoes, and droughts. Each of these extreme weather events has the capacity to powerfully influence the lives of humans, and can sometimes even be deadly. Extreme weather events involve the same set of variables as other types of weather. For example, hurricanes depend on temperature and humidity—they thrive on warm, moist air. Droughts occur when precipitation is very low. Although the conditions leading to the formation of tornadoes is slightly less clear, these storms seem related to differing temperatures in colliding air masses.

# Prior Knowledge

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# Recommended Prior Activities

- Carbon All Around
- Global Trends
- Heating Up
- Local Emissions
- Our Greenhouse
- Weather Interconnections

# Vocabulary

| Term | Part of Speech | Definition |
|---|---|---|
| **atmospheric pressure** | *noun* | force per unit area exerted by the mass of the atmosphere as gravity pulls it to Earth. |
| **climate** | *noun* | all weather conditions for a given location over a period of time. |
| **cloud cover** | *noun* | amount of sky covered with clouds. |
| **drought** | *noun* | period of greatly reduced precipitation. |
| **humidity** | *noun* | amount of water vapor in the air. |

| Term | Part of Speech | Definition |
|---|---|---|
| **hurricane** | *noun* | tropical storm with wind speeds of at least 119 kilometers (74 miles) per hour. Hurricanes are the same thing as typhoons, but usually located in the Atlantic Ocean region. |
| **precipitation** | *noun* | all forms in which water falls to Earth from the atmosphere. |
| **temperature** | *noun* | degree of hotness or coldness measured by a thermometer with a numerical scale. |
| **tornado** | *noun* | a violently rotating column of air that forms at the bottom of a cloud and touches the ground. |
| **weather** | *noun* | state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness. |
| **wind** | *noun* | movement of air (from a high pressure zone to a low pressure zone) caused by the uneven heating of the Earth by the sun. |

# ACTIVITY 3: WEATHER, MEET CLIMATE | 50 MINS

## DIRECTIONS

*This activity is part of the Climate Change Challenge unit.*

**1. Prompt students to gather and graph weather station data.**

- In the same weather data collection groups as in the previous activities in the *Extreme Weather* lesson, ask students to reflect on today's weather. Ask them to make predictions regarding how their variable will have changed when they examine today's data.
- Assign students to collect data for their variables. They can either physically use the class weather station, or digitally with the *National Weather Service Weather Observation History for the Past Three Days*, as during the *Meteorological Models* activity.
    - Students may need a reminder to enter their zip code in the upper left corner of the page, and then click on the "3 Day History" link at right-center, but should collect data today in small groups, rather than as a class, and with limited teacher assistance.
- Assign students to incorporate this data onto the second day of their point/line graph.

**2. Clarify the distinctions and connections between weather and climate by viewing and discussing an interactive graph with students.**

- Project the interactive *Billion-Dollar Weather and Climate Disasters: Time Series Graph*. Ask for volunteers to point out the following elements:
  - Title
  - Key
  - X-axis label
  - Y-axis labels (**Note:** There are two y-axes. The one on the left that corresponds to the number of billion-dollar disasters is most important here.)
- Help students familiarize themselves with the graph answering the following questions in a Think-Pair-Share:
  - *How many billion-dollar weather events occurred in 1980?* (Three)
  - *How many billion-dollar weather events occurred in 2018?* (Fourteen)
  - *What types of billion-dollar weather events are increasing over time?* (Most types appear to be increasing. Increases in severe storms and flooding are particularly apparent.)
  - *What types of billion-dollar weather events are decreasing over time?* (It's not clear that any are; perhaps winter storms.)
- Prompt students to recall the distinctions between weather and climate (using their *Weather Interconnections Meaning Builder* from the *Weather Interconnections* activity, if necessary), asking:
  - *Does this graph contain information about weather, climate, or both?* (Both. Individual events on the graph are weather. However, long term patterns, such as the increase in severe, billion-dollar storms since 1980 that students likely identified above, represent information on climate.)

**3. Support students as they read to address hypotheses regarding the future frequency of extreme weather events.**

- Reconvene students in their extreme weather groups from the *Weather Interconnections* activity.

- Challenge students to hypothesize how the frequency of their weather event will change in the future, given their understanding of carbon dioxide concentrations, global warming, and climate change.
    - Direct students to record their hypotheses in Part G of the *Extreme Weather Model Builder*, with supporting evidence to justify their claims. (Students' hypotheses should articulate both their prediction and justification. For example, 'I think tornadoes will increase in the future as the planet warms because they form from warm air.' Hypotheses may incorporate prior information from the *Extreme Weather Model Builder* or more recent knowledge from the *Billion-Dollar Weather and Climate Disasters: Time Series Graph*.)
- Invite students to read and annotate an article to evaluate their hypothesis within their extreme weather groups, as follows:
    - Droughts: *Drought and Climate Change*
    - Hurricanes: "Hurricanes and climate" section of *Hurricanes, Cyclones, and Typhoons Explained*
    - Tornadoes: *Tornadoes and Climate Change*
- As they read, students should determine whether the article agrees with their hypothesis. They should also note the evidence presented for any of the weather variables in Part H of the *Extreme Weather Model Builder* handout with their group.

**4. Direct students to create a final extreme weather model incorporating the effects of global warming and climate change.**

- With evidence from the article, direct students to revisit their revised extreme weather model (Part E) again, noting what information (text and/or visual) would be necessary to incorporate the role of global warming and climate change in this weather event (Part H).
- On a large piece of chart paper, ask each group to draw a final model incorporating:
    - Text and visuals to accurately depict the extreme weather event's formation (from Part E).
    - At least four of the six weather variables (from Part E).
    - A depiction of how global warming and climate change is predicted to affect the weather variables, which will, in turn, increase or decrease the frequency of this extreme weather event (using the information recorded in Part H).

- Next, distribute copies of the *Extreme Weather Model Rubric* and have students self-assess their final extreme weather models. Allow time for groups to make revisions to their model, if necessary.
- Collect the final extreme weather models for assessment.
- Revisit the class *Know and Need to Know* chart. Encourage students to articulate any recent insights or remaining questions regarding the connections between weather and broader patterns of global warming and climate change. Emphasize that the extreme weather events they have been exploring are related to climate change.

# Rubric

Use the *Extreme Weather Model Rubric* to formally assess students' progress towards NGSS PE *MS-ESS2-5*: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.

# Extending the Learning

**Step 2:** You may wish to download data from the interactive *Billion-Dollar Weather and Climate Disasters: Time Series Graph* to practice additional analyses with students. Or you may choose to assign additional research into specific extreme weather events, such as Hurricane Katrina of 2005, the El Reno tornado of 2013, or the Camp Fire of 2018. You may also wish to add discussion of the human and economic dimensions of such events, possibly in conjunction with students' social studies educators.

## OBJECTIVES

# Subjects & Disciplines

**Earth Science**

- Climatology
- Meteorology

# Learning Objectives

Students will:

- Revise a model of an extreme weather event to incorporate the role of global warming and climate change.

- Relate global warming and climate change to extreme weather.

# Teaching Approach

- Project-based learning

# Teaching Methods

- Cooperative learning
- Multimedia instruction
- Reading

# Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
    - Media Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Critical Thinking and Problem Solving
  - Life and Career Skills
    - Productivity and Accountability
    - Social and Cross-Cultural Skills
- 21st Century Themes
  - Environmental Literacy
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Applying
  - Understanding
- Science and Engineering Practices
  - Constructing explanations (for science) and designing solutions (for engineering)

- Developing and using models

# National Standards, Principles, and Practices

### COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **CCSS.ELA-LITERACY.RST.6-8.7:**
Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

### NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 2: Cause and Effect:**
Cause and effect relationships may be used to predict phenomena in natural or designed systems.
• **MS-ESS2-5:**
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
• **Science and Engineering Practice 2:**
Developing and using models

**Preparation**

## BACKGROUND & VOCABULARY

# Background Information

Extreme weather events include hurricanes, tornadoes, and droughts. Each of these extreme weather events has the capacity to powerfully influence the lives of humans, and can sometimes even be deadly. The frequency and intensity of many extreme weather events have been on the rise in recent years.

Depending on the type of extreme weather event, shifts in frequency and intensity may or may not be related to global warming and climate change. For example, the destructive potential of hurricanes is increasing as sea levels rise, leading to greater storm surges. Warmer temperatures can increase the severity of drought by evaporating more water from soils. Finally, the relationship between tornadoes and climate change is currently not clear, but the subject of ongoing scientific research.

# Prior Knowledge

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# Recommended Prior Activities

- Carbon All Around
- Global Trends
- Heating Up
- Local Emissions
- Meteorological Models
- Our Greenhouse
- Weather Interconnections

# Vocabulary

| Term | Part of Speech | Definition |
|---|---|---|
| **atmospheric pressure** | *noun* | force per unit area exerted by the mass of the atmosphere as gravity pulls it to Earth. |
| **climate** | *noun* | all weather conditions for a given location over a period of time. |
| **climate change** | *noun* | gradual changes in all the interconnected weather elements on our planet. |
| **drought** | *noun* | period of greatly reduced precipitation. |
| **global warming** | *noun* | increase in the average temperature of the Earth's air and oceans. |
| **humidity** | *noun* | amount of water vapor in the air. |
| **hurricane** | *noun* | tropical storm with wind speeds of at least 119 kilometers (74 miles) per hour. Hurricanes are the same thing as typhoons, but usually located in the Atlantic Ocean region. |
| **precipitation** | *noun* | all forms in which water falls to Earth from the atmosphere. |
| **temperature** | *noun* | degree of hotness or coldness measured by a thermometer with a numerical scale. |

| Term | Part of Speech | Definition |
|---|---|---|
| **tornado** | *noun* | a violently rotating column of air that forms at the bottom of a cloud and touches the ground. |
| **weather** | *noun* | state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness. |
| **wildfire** | *noun* | uncontrolled fire that happens in a rural or sparsely populated area. |
| **wind** | *noun* | movement of air (from a high pressure zone to a low pressure zone) caused by the uneven heating of the Earth by the sun. |

# ACTIVITY 4: NOW AND THEN | 50 MINS

## DIRECTIONS

*This activity is part of the Climate Change Challenge unit.*

**1. Prompt students to gather and graph weather station data.**

- In the same weather data collection groups from previous activities in the *Extreme Weather* lesson, ask students to share stories of their experiences with extremes of each of their weather variables. For example, a time they can remember when it was so humid the air felt heavy, or when it was cloudy for a month without sight of the sun.
- Assign students to collect data for their variable again in data collection groups. Students should either physically use the class weather station, or digitally with the *National Weather Service Weather Observation History for the Past Three Days*, as during the *Meteorological Models* and *Weather, Meet Climate* activities, and incorporate this data onto the third day of their point/line graph.
- Calculate summary statistics (mean, median, range) for temperature from your graph in a visible place. Remind students to return to their previous notes for definitions and example calculations, if needed. Then, direct groups to calculate mean, median, and range for their own weather variable.
- Prompt students to Think-Pair-Share in response to the following questions:
    - *Do you think the summary statistics from weather data you have gathered is an accurate representation of the state's yearly average? Why or why not?*
    - *If you wanted to represent the state yearly average more accurately, how often and what times of year would you collect data?*

- *How do you think the state's yearly average temperature, in particular, has changed in your state over the past 30 years?*

**2. Compare student data to long-term temperature data for your state.**

- Project the *NOAA: Climate at a Glance: Statewide Time Series* for temperature in your state from 1895 (or the starting year) to the current year onto a writable surface.
    - Change the "Time Scale" drop-down menu to 12-month to capture yearly temperature means.
    - Select your state from the drop-down menu.
    - Leave all other parameters at their default settings.
- Request a student volunteer to add the three class temperature readings to this chart by finding the x (current year) and y (temperature) coordinates on the graph, while others note and report on the graph title, axes, and key. (It is particularly important that students use the key to identify the constant gray line as the average of the data up until the year 2000.)
- In their weather data collection groups, ask students to consider the following questions, guiding them towards an understanding of variation in the data:
    - *Why do the points for temperature not all fall right along the gray line? (There is variation from year to year in the temperature; for example, some years are cooler, while others are warmer. It may be helpful to point students to the range as a way of conceptualizing this variation. Data with a larger range of values typically have more variation overall.)*
    - *Even though the temperature varies from year to year, can you see any long-term patterns?* (For most, if not all states, it is evident that, despite variation in data, temperatures in the years since 2000 are rising well above the mean for the period before that time.)

**3. Support students as they calculate summary statistics with a digital spreadsheet program.**

- Have students reconvene in their extreme weather groups.
- Prompt each group to choose a focal state (not your own) that routinely experiences their extreme weather event:

- Hurricane groups should choose a state in the Southeastern U.S. (for example, Florida, Alabama, Georgia, Louisiana, or Mississippi).
- Tornado groups should choose a state in the Midwestern U.S. (for example, Nebraska, Kansas, Oklahoma, Missouri, or Iowa).
- Drought groups should choose a state in the Western or Southwestern United States. (for example, Colorado, New Mexico, Arizona, Utah, Montana, Idaho, or California).

- Model for students how to copy and calculate summary statistics digitally for this state:
    - As students watch, transfer the data for your own state's *NOAA: Climate at a Glance: Statewide Time Series* graph for temperature into a digital spreadsheet software. Assign extreme weather groups to copy the same data for their focal state. (Note that not all states have data from the earliest years. This is okay because students will simply focus on the first and last complete decades.)
    - Calculate the mean, median, and range of temperature for the first and last complete decades available for your state. Then prompt students to do the same with their extreme weather focal state for the first and last complete decades.
    - Demonstrate how to organize the summary statistics you have calculated for your state in a chart, and assign students to do the same with their extreme weather focal state data, with a row for each of the two decades (1900-1909 and 2010-2019) the following columns:
        - Mean Temperature (F)
        - Median Temperature (F)
        - Range in Temperature (F)
        - Student data will vary depending on their state of choice.

- Ensure that this chart is saved and available for students in the *Plot It!* activity.
- Demonstrate creating an evidence-based comparison using the first and most recent decades. (For example: The decade between 1900 and 1909 had lower mean and median temperatures in September than the decade between 2010 and 2019. Although the ranges show there is some variation in the data, it appears to be getting warmer in our state over time.)
- Record these evidence-based comparisons below the chart as text in the digital spreadsheet program for use in the *Plot It!* activity.
- Prompt groups to do the same by creating and recording an evidence-based comparison of the first and last complete decades for their focal state. Have students share their statements for evaluation by other groups.

**4. Guide student' comparisons of temperature and carbon dioxide's long-term data.**

- End the activity by reflecting on the differences between the temperature data used in this activity and the carbon dioxide data used in the *Carbon Concerns* lesson (revisit the *Scripps Interactive Keeling Curve*, if necessary), asking students:
  - *Are temperatures for your state increasing, decreasing, or staying the same?* (All states should show an increase in mean temperature between the first and last decades of data available.)
  - *How do state trends in temperature compare to the global trends in carbon dioxide concentrations from the Keeling Curve?* (Both should show an overall increase, though the slope of the Keeling Curve is likely steeper.)

# Tip

**Step 3:** It may be helpful to prepare a copy of your state's digital climate information to share with students prior to conducting this activity. See the *Setup* for more information. Additionally, the Teaching Channel also has a helpful video and article on how to use the *I do, we do, you do*. The video and article model completion of a novel task (such as using presentation software). Finally, if multiple extreme weather groups are focusing on the same weather type, help them to differentiate their analyses and conclusions by asking each group to choose a different focal state.

# Informal Assessment

Informally assess students' understanding of variation through their responses to questions in Step 2, and their ability to organize and analyze digital data by examining the digital charts and evidence-based statements they create in Step 3.

# Extending the Learning

**Steps 2-3:** It may be interesting for students to compare, chart, and analyze long-term climate trends from other states and other variables, as well as your own state's temperature information, using the *NOAA: Climate at a Glance: Statewide Time Series*. Using this information, they can make more complex and varied evidence-based comparisons.

## OBJECTIVES

# Subjects & Disciplines

**Earth Science**

- Climatology
- Meteorology

# Learning Objectives

Students will:

- Collect and graph current local data on key weather variables.
- Discuss the concept of statistical variation, using examples from local weather and climate data.
- Chart data and calculate summary statistics digitally.

# Teaching Approach

- Project-based learning

# Teaching Methods

- Discussions
- Lab procedures
- Modeling

# Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration
  - Life and Career Skills

    - Leadership and Responsibility
    - Productivity and Accountability
    - Social and Cross-Cultural Skills
- 21st Century Themes
  - Environmental Literacy
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Applying
- Science and Engineering Practices
  - Analyzing and interpreting data
  - Engaging in argument from evidence
  - Using mathematics and computational thinking

# National Standards, Principles, and Practices

### COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **CCSS.ELA-LITERACY.RST.6-8.7:**
Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

### NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 1:**
Patterns
• **MS-ESS3-2:**
Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
• **Science and Engineering Practice 4:**
Analyzing and interpreting data

**Preparation**

## BACKGROUND & VOCABULARY

# Background Information

Climate change is a broad term for the many ways that Earth's long-term weather patterns shift. Earth's climate is always changing, for example, with periods of warmer or colder temperatures, and these periods often last thousands or millions of years. Recently, however, Earth's climate has begun to warm at a rapid pace, relative to previous changes. This is called global warming, and it has led to many other changes, such as the melting of glaciers and rising sea levels.

In the 48 contiguous United States, temperatures have risen more than one 1ºF over the last century. However, warming isn't constant across the country. For example, the North and West have experienced higher temperature increases than the South. Regardless, the most rapid warming that has occurred in the United States has been very recent, since 1970.

# Prior Knowledge

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# Recommended Prior Activities

- Carbon All Around
- Global Trends
- Heating Up
- Local Emissions
- Meteorological Models
- Our Greenhouse
- Weather Interconnections
- Weather, Meet Climate

# Vocabulary

| Term | Part of Speech | Definition |
|---|---|---|
| **atmospheric pressure** | *noun* | force per unit area exerted by the mass of the atmosphere as gravity pulls it to Earth. |
| **climate** | *noun* | all weather conditions for a given location over a period of time. |

| Term | Part of Speech | Definition |
|---|---|---|
| **climate change** | *noun* | gradual changes in all the interconnected weather elements on our planet. |
| **cloud cover** | *noun* | amount of sky covered with clouds. |
| **drought** | *noun* | period of greatly reduced precipitation. |
| **global warming** | *noun* | increase in the average temperature of the Earth's air and oceans. |
| **humidity** | *noun* | amount of water vapor in the air. |
| **hurricane** | *noun* | tropical storm with wind speeds of at least 119 kilometers (74 miles) per hour. Hurricanes are the same thing as typhoons, but usually located in the Atlantic Ocean region. |
| **precipitation** | *noun* | all forms in which water falls to Earth from the atmosphere. |
| **temperature** | *noun* | degree of hotness or coldness measured by a thermometer with a numerical scale. |
| **tornado** | *noun* | a violently rotating column of air that forms at the bottom of a cloud and touches the ground. |
| **weather** | *noun* | state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness. |
| **wildfire** | *noun* | uncontrolled fire that happens in a rural or sparsely populated area. |

# ACTIVITY 5: PLOT IT! | 50 MINS

## DIRECTIONS

*This activity is part of the Climate Change Challenge unit.*

**1. Model and support students as they digitally chart and graph weather station data.**

- Model the transfer of weather station data from the past three days into a digital spreadsheet, arranging days as rows, and the temperature in a single column.
- Prompt weather data collection groups to do the same with their weather variable.
- In an I Do, We Do, You Do format, model how to create digital line graphs using their weather variable data:
    - Using the temperature data, encourage students to observe as you create a digital point/line graph of data for each day of data collection. Ask volunteers to name the axes and title of the graph.

- Share an electronic copy of the temperature data with your students in their weather data collection groups. With each group working together on a single copy of the file, ask them to recreate a digital graph of the same data alongside you.

- Then assign weather collection groups to create a digital line graph of their weather variable. It should match the graph they have been creating by hand during the *Meteorological Models, Weather, Meet Climate,* and *Now and Then* activities.
- Prompt students to compare their hand-drawn and digital graphs, and take a moment to celebrate the professional look of their digital creations.

**2. Model and support students as they digitally graph mean decadal temperature data.**

- Return to the evidence-based comparison and digital chart of the summary statistics from the *Now and Then* activity in which you recorded mean, median, and range of temperatures for your state over the earliest and most recent full decades available.
- Using only the "Decade" and "Mean Temp. (F)" columns of your chart, model once more how to create a digital point/line graph with decade on the x-axis and temperature on the y-axis, comparing the earliest and most recent decadal data. Explain how the graph supports the evidence-based comparison of these decades that students constructed in the previous activity.
- Prompt weather data collection groups to create similar point/line graphs. The graphs should compare the first and last decades of data for their focal state using their chart from the *Now and Then* activity.
- Briefly discuss the value of representing data in graphical form by asking:

    - *How does your graph support the evidence-based comparison you made in the previous activity?*

- Look for students' responses linking their evidence-based statement to its visual representation in the graph.

    - *How is looking at data represented in a table or chart different from examining that same data in a graph?*

- Look for students' responses comparing the ease or persuasiveness of examining data in these two forms.

**3. Prompt students to examine strategies for responding to natural disasters influenced by global warming.**

- Reminding students of their revised extreme weather models from the *Weather, Meet Climate* activity, ask students the following in a Think-Pair-Share:
  - *Given the graphs you made of temperature in your focal state, how do you expect the frequency of your extreme weather event to be changing there?* (Look for students' responses linking their extreme weather models to changes in temperature, specifically.)
  - *How might people respond to these changes to stay safe and protect their communities?* (Students' answers will depend on prior knowledge.)
- In their extreme weather groups, assign each student to read and annotate one of two articles about the response to their extreme weather event (such that, at least one student in each group reads each relevant article). Prompt students to underline each strategy that could help to keep people safe:
  - Hurricanes:
    - *Can Technology Hack Hurricane Relief?*
    - *Hurricane Safety Tips Explained*
  - Tornadoes:
    - *How to Stay Safe from Tornadoes*
    - *Taking Cover: A Guide to Tornado Shelters*
  - Droughts:
    - *5 Dramatic Ways California Is Tackling Drought*
    - *Understanding Droughts* (Preparing for Droughts section)
- When students have finished reading, direct them to work with their group to create a list of all of the strategies they discovered in their two articles, specifically, strategies involving the use of technology in response to extreme weather. Clarify for students that examples of technology from the above articles can be as complicated as a drone with scientific equipment used for weather monitoring, and as simple as a basement storm shelter.
- Prompt student groups to choose at least three of these technologies and record them below their temperature graph.

- Distribute the *Weather Meets Climate Rubric* to each extreme weather group and assign groups to use the tool to self-assess their portfolio product, showing temperature trends in a state prone to extreme weather (data chart, evidence-based comparison, graph, and response technologies).
- Allow students time to incorporate their findings from the rubric, and ensure that each student saves a copy of their group's product with their name, for assessment and incorporation into their final project portfolio.
- Finally, lead a debrief discussion to revisit the class *Know and Need to Know* chart, prompting students to share any new insights related to their data analysis and visualization of changing temperatures in relation to extreme weather and climate.

# Tip

**Step 1:** The Teaching Channel also has a helpful video and article on how to use the *I Do, We Do, You Do*. The video and article model completion of a novel task (such as using presentation software).

# Rubric

Use the *Weather Meets Climate Rubric* to formally assess students progress towards NGSS PE *MS-ESS3-2*: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

# Extending the Learning

**Step 3:** Students may perform additional research to understand extreme weather response technologies in greater detail by creating a poster highlighting the history, benefits, and mechanism of a particular technology.

## OBJECTIVES

# Subjects & Disciplines

**Earth Science**

- Climatology
- Meteorology

# Learning Objectives

Students will:

- Digitally graph climatic trends.
- Identify technological strategies to respond to the effects of extreme weather events.

# Teaching Approach

- Project-based learning

# Teaching Methods

- Lab procedures
- Modeling
- Reading

# Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration
  - Life and Career Skills
    - Leadership and Responsibility
    - Productivity and Accountability
    - Social and Cross-Cultural Skills
- Critical Thinking Skills
  - Analyzing
  - Applying
  - Evaluating
- Science and Engineering Practices
  - Analyzing and interpreting data
  - Using mathematics and computational thinking

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### NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 1:**
Patterns
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Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
• **Science and Engineering Practice 4:**
Analyzing and interpreting data

**Preparation**

## BACKGROUND & VOCABULARY

# Background Information

Although some extreme weather events are expected to increase in frequency and intensity, there are many steps that people can take to keep themselves safe. For example, in areas prone to flooding during hurricanes, seawalls can help hold back water. In parts of the country where drought occurs frequently, new irrigation techniques can reduce water use as it becomes scarce. Finally, in the case of tornadoes, advanced radar systems can help people get more accurate warnings of a storm's path.

Graphical representations help communicate the messages of data in visual form. Different types of graphical representations, such as bar and line graphs, are suited for use with different types of data. Labels help an audience interpret graphs. Typically, a graph should have a title, and each axis (x and y) should have a brief text description of the variable being measured.

# Prior Knowledge

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# Recommended Prior Activities

- None

# Vocabulary

| Term | Part of Speech | Definition |
|---|---|---|
| **atmospheric pressure** | *noun* | force per unit area exerted by the mass of the atmosphere as gravity pulls it to Earth. |
| **climate** | *noun* | all weather conditions for a given location over a period of time. |
| **climate change** | *noun* | gradual changes in all the interconnected weather elements on our planet. |
| **cloud cover** | *noun* | amount of sky covered with clouds. |
| **humidity** | *noun* | amount of water vapor in the air. |
| **mean** | *noun* | mathematical value between the two extremes of a set of numbers. Also called the average. |
| **median** | *adjective* | situated in the middle. |
| **precipitation** | *noun* | all forms in which water falls to Earth from the atmosphere. |
| **range** | *noun* | difference between the smallest and largest value in a set of numbers. |
| **temperature** | *noun* | degree of hotness or coldness measured by a thermometer with a numerical scale. |
| **weather** | *noun* | state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness. |
| **wind** | *noun* | movement of air (from a high pressure zone to a low pressure zone) caused by the uneven heating of the Earth by the sun. |