HURRICANE RESILIENCE

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Through 20 days of instruction, students make connections between the science of hurricanes, how they affect their community and region, and how we can plan for a more resilient future. Making local connections, students develop an understanding of the risks that their local community is facing now and in the future due to hurricanes and tropical storms, how sea level rise increases the risk, and how our actions can help us be less vulnerable and more resilient.

The curriculum unit aims to empower high school students to have a voice in resilience planning and help them understand the relationship between the science of hurricanes and the local impacts of these storms on people and places.

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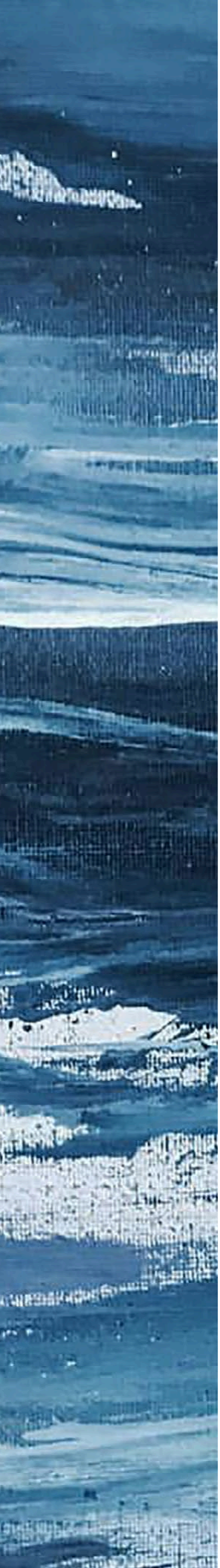

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About the Curriculum

Hurricane Resilience is a high school environmental science curriculum for use in coastal locations where hurricanes are common. Through 20 days of instruction, students make connections between the science of hurricanes, how they affect their community and region, and how we can plan for a more resilient future. Making local connections, students develop an understanding of the risks that their local community is facing now and in the future due to hurricanes and tropical storms, how sea level rise increases the risk, and how our actions can help us be less vulnerable and more resilient.

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Lesson Outline

	Lesson Number	Lesson Title	Lesson Questions	Class Periods
PART 1 HURRICANES AFFECT US	1	Hurricane Headlines	What do people do when a hurricane is approaching and how are people affected when a hurricane hits?	1
	2	Historical Hurricanes	Which hurricanes and tropical storms have affected our community?	2
	3	Storm Stories	How have people in our community experienced hurricanes?	4
PART 2 HURRICANE CHARACTERISTICS AND FUTURE PROJECTIONS	4	No Two Storms Are the Same	Which aspects of hurricanes and tropical storms are most hazardous?	2
	5	Hurricanes and Climate Change	Is warming affecting hurricanes?	1
	6	Sea Level Rise	How will sea level rise affect our coast in the future?	1
	7	Warmed-up Storms	What would past hurricanes be like if they happened in a warmer world?	1
PART 3 PLANNING FOR HURRICANE RESILIENCE	8	Modeling Hurricane Impacts	How can we modify our model communities to be less affected by storm surge flooding?	1
	9	Assessing Vulnerability & Risk	What parts of our community are most vulnerable and most at risk?	1
	10	Short and Long Term Resilience Planning	What actions can we take to decrease hurricane risk and vulnerability in the short term and in the long term?	2
	11	Communicating Resilient Actions	What do we tell other people in our community about how we can be more resilient?	4

Overview

Suggested Calendar

Monday	Tuesday	Wednesday	Thursday	Friday
Lesson 1 Hurricane Headlines	**Lesson 2** Historical Hurricanes	**Lesson 2** Historical Hurricanes	**Lesson 3** Storm Stories (planning)	**Lesson 3 *** Storm Stories (interview training)
Lesson 3 Storm Stories (data analysis)	**Lesson 3** Storm Stories (data analysis)	**Lesson 4** No Two Storms Are the Same	**Lesson 4** No Two Storms Are the Same	**Lesson 5** Hurricanes and Climate Change
Lesson 6 Sea Level Rise	**Lesson 7** Warmed-up Storms	**Lesson 8** Modeling Hurricane Impacts	**Lesson 9** Assessing Vulnerability and Risk	**Lesson 10** Short and Long Term Resilience Planning
Lesson 10 Short and Long Term Resilience Planning	**Lesson 11** Communicating Resilient Actions (introduction)	**Lesson 11** Communicating Resilient Actions (planning)	**Lesson 11** Communicating Resilient Actions (creating)	**Lesson 11** Communicating Resilient Actions (presenting)

** Students conduct a Storm Stories interview during the first weekend of the unit and then analyze the data as a class the following Monday and Tuesday.*

Skills that students utilize

Geography and Sense of Place: Throughout the curriculum, students connect with their location through research about which historical hurricanes have affected their location, interviews to document storm damage, mapped data about winds, rain, and flooding associated with hurricanes, and resilience planning for their local area. Additionally, an optional Arc-GIS component can be added to Lesson 3, which allows students to map their interview data.

Engaging in an Argument from Evidence: At several points in the curriculum, students need to make a claim and then support their claim by describing evidence and explaining their reasoning.

Interviewing: Students interview people from their community to collect qualitative data about local experiences with hurricanes (Lesson 3).

Analyzing and Interpreting Data: Students analyze qualitative data such as news headlines (Lesson 1) and interview results (Lesson 3). They analyze quantitative data about hurricane tracks (Lesson 2), storm characteristics (Lessons 4), and how hurricanes have changed over time (Lesson 5).

Developing and Using Models: Students model sea level rise in a warmer world using NOAA Digital Coast (Lesson 6) and then analyze model data showing hurricanes in a warmer world (Lesson 7). Also, students create a physical model of a hurricane making landfall and test it (Lesson 8).

Designing Solutions: Students developed a more resilient infrastructure for their coastal models that they test with a simulated hurricane (Lesson 8). Related to their local setting, they develop and describe resilience actions based on their research (Lessons 10-11).

Obtaining, Evaluating, and Communicating Information: While students are using these skills throughout the curriculum, there is a strong focus on these skills in Part 3. In Part 3, students gather information about resilience strategies (Lessons 10) and then use communication skills to share what they have learned about dangerous aspects of hurricanes and strategies that they recommend to help people be resilient (Lesson 11).

Overview

Standards Addressed

NGSS Performance Expectations

- HS-ESS3-1. Construct an explanation based on evidence for how the ~~availability of natural resources~~, occurrence of natural hazards, and changes in climate have influenced human activity.
- HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. (Lessons 6-7)
- 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. (Lesson 7)
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. (Lessons 9-11)

Common Core English Language Arts

Lesson 12 addresses:

- CCSS.ELA-LITERACY.SL.9-10.4. Present information, findings, and supporting evidence...
- CCSS.ELA-LITERACY.SL.9-10.5. Make strategic use of digital media...
- CCSS.ELA-LITERACY.SL.11-12.4. Present information, findings, and supporting evidence...
- CCSS.ELA-LITERACY.SL.11-12.5 Make strategic use of digital media...

National Geography Standards

- Standard 1: How to use maps and other geographic representations...
- Standard 4: The physical and human characteristics of places
- Standard 14: How human actions modify the physical environment
- Standard 15: How physical systems affect human systems
- Standard 18: How to apply geography to interpret the present and plan for the future

Students at South Terrebonne High School creating a model coastline to test with a simulated hurricane during Lesson 8 of the Hurricane Resilience curriculum (Lisa S. Gardiner)

Using a Driving Question Board

Throughout the Hurricane Resilience curriculum, students use a Driving Question Board to document their questions about hurricanes and tropical storms, the damage they cause, and how to stay safe.

A Driving Question Board is a tool to generate, keep track of, and revisit student questions related to the phenomena that the class is exploring, which, in this curriculum, are hurricanes and related topics that impact coastal resilience. The Driving Question Board is introduced at the beginning of the unit and then revisited periodically as students develop additional understanding of the phenomena. It is important that students understand there will be more questions on the Driving Question Board than can be answered during the unit.

The Driving Question Board is a visual representation of the questions and should be displayed in the classroom throughout the unit. A Driving Question Board can be constructed with sticky notes or sentence strips, written on whiteboards, or made with shared software applications.

To prepare the Driving Question Board for your class:

- Write a question on a sheet of poster board or chart paper. While there is a question associated with each lesson, the driving question at the center of the Driving Question Board should be more general, for example: *How and why do hurricanes affect us and how can we stay safe?*

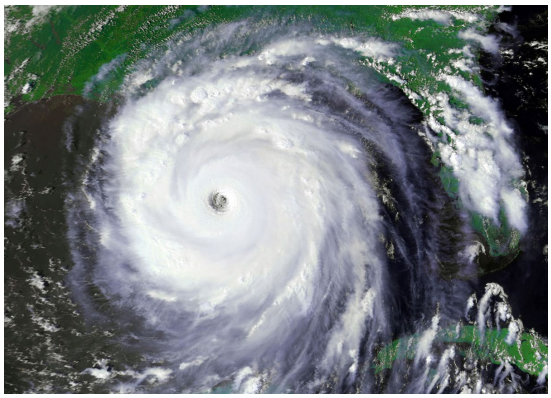
Overview

- Display the Driving Question Board so that it is easily accessible to students - either in the classroom or a virtual, online location that students can access. Students will revisit the board periodically during the unit. Depending on your class, you may wish to have students revisit the board more often than suggested in lessons.
- Provide sticky notes and markers for students to document their questions if using a classroom Driving Question Board.

Background Science

About hurricanes and tropical storms:

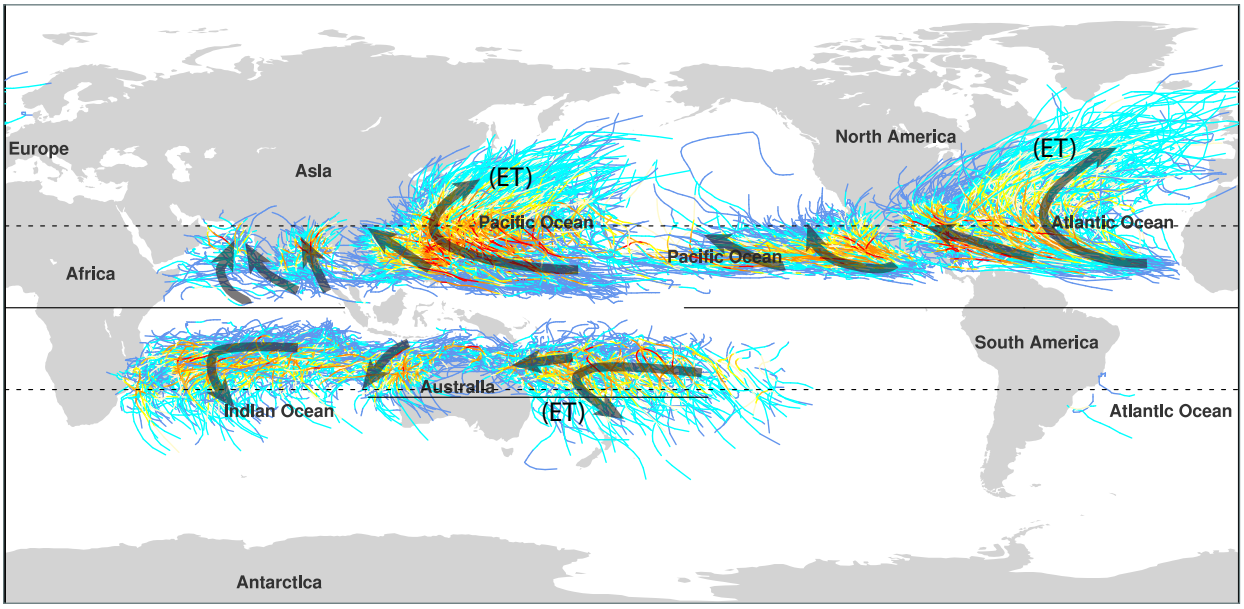
Hurricanes and tropical storms, known more generally as tropical cyclones, are weather systems that form in the tropics (typically 30° North and South of the equator) and generate winds greater than 63 km/h (39 mph) that rotate counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. When these storms have sustained winds exceeding 119 km/h (74 mph), they are known as hurricanes over the North Atlantic and Central and East Pacific oceans, and are called typhoons over the western North Pacific Ocean. Over the Indian Ocean and the South Pacific, they are called cyclones. These storms mainly occur during the summer season (which is at opposite times of the year in the Northern and Southern Hemispheres).



A satellite image of Hurricane Katrina approaching the U.S. Gulf Coast in 2005. (NOAA)

Where do hurricanes form and travel?

Similar to a stick floating down a stream, the route, or track, of a hurricane is largely controlled by the prevailing winds, which, at tropical latitudes (<30°) typically flow from East to West and are called Trade Winds. At higher latitudes, the prevailing winds flow from West to East.



Credit: Ming Ge (NCAR), published in Done and Owens (2017).

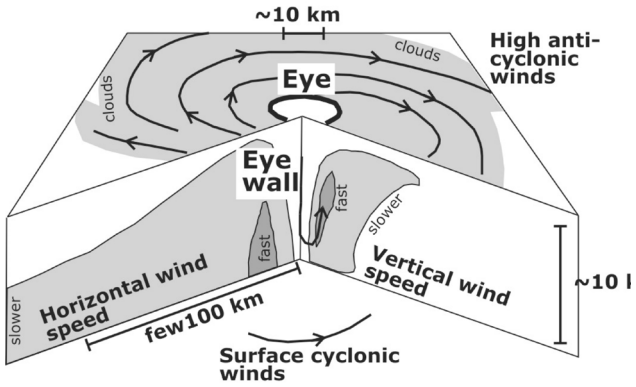
The world map above shows the tracks of hurricanes and tropical storms between 1980 and 2013 colored by the Saffir-Simpson category. Arrows indicate general tracks, and '(ET)' indicates where these storms can transition to become extratropical storms (i.e., outside the tropics). Notice on the map that they occur only rarely over the South Atlantic and the eastern South Pacific. Hurricanes and tropical storms are most prevalent from June to November in the Northern Hemisphere peaking in mid-September, and from November to April in the Southern Hemisphere peaking in mid-February.

Overview

Anatomy of a hurricane

Mature hurricanes are approximately symmetrical about a central eye. The eye is a calm area surrounded by a wall of strong winds and rain known as the eyewall.

The illustration to the right shows the basic structure of a hurricane and the terms used for its different parts. Horizontal winds spiral cyclonically inwards, and are fastest just above the ground or ocean surface and in the eye-wall where vertical winds send air high into the upper troposphere and lower stratosphere. This upward moving air fans out anti-cyclonically at the top of the storm, which means that the winds at the top of the storm are rotating opposite to the winds at the bottom of the storm. In the Northern Hemisphere, cyclonic is anticlockwise, and anticyclonic is clockwise (note the wind directions in the diagram above). Winds rotate in the reverse pattern in hurricanes and tropical storms in the Southern Hemisphere.



Credit: Done and Owens (2017) adapted from Kerry Emanuel (2003)

How do hurricanes form and grow?

Typically, hurricanes and tropical storms transfer heat energy from the tropical ocean surface, where sea surface temperatures (SSTs) are more than 26° C, into the atmosphere. This process is called cyclogenesis. Several other factors must also align for these storms to form, including:

- Warm, moist air with a tendency to rise, is essential. The rising air moves heat energy higher in the atmosphere and establishes the storm's structure.
- Humid conditions at mid-levels are needed to limit downdrafts of dry air.
- Wind shear must be low. Wind shear is the difference between winds at low and high altitudes. When strong, it can tear apart a developing tropical storm.
- Finally, a trigger is needed to start a storm. Triggers can be various types of atmospheric phenomena, including trailing cold fronts, monsoonal circulations, or pulses of energy in the atmosphere known as tropical waves.

For more information: NOAA SciJinks: How Does a Hurricane Form? (scijinks.gov/hurricane/)

How do we know which tropical cyclones are most dangerous?

The Saffir Simpson Scale is used to describe hurricanes, tropical storms, and tropical depressions based on wind speeds. Tropical storms have winds greater than 39 mph and less than 74 mph. When these storms have sustained winds of more than 74 mph, they are called hurricanes in the North Atlantic.

As hurricanes grow stronger, wind speeds increase, and so does the hurricane category. However, the most dangerous storms are not necessarily the strongest at landfall. Low category hurricanes and tropical storms have caused significant damage due to flooding. Although hurricanes are categorized into the Saffir-Simpson scale according to their wind speeds, most fatalities associated with hurricanes are caused by flood water, not wind.

Researchers at the National Center for Atmospheric Research, including Dr. James Done, are developing other types of hurricane scales to have different ways to indicate the type of storm that is heading towards a coast that better reflects the likely amount of damage. This could help coastal residents understand whether an approaching storm is likely to produce lots of rain or storm surge flooding, regardless of the wind speeds.

Saffir-Simpson Scale

Name	Wind Speed
Category 5 Hurricane	*> 155 mph*
Category 4 Hurricane	*131-155 mph*
Category 3 Hurricane	*111-130 mph*
Category 2 Hurricane	*96-110 mph*
Category 1 Hurricane	*74-95 mph*
Tropical Storm	*39-73 mph*
Tropical Depression	*< 39 mph*

Overview

Hurricanes and tropical storms can have very different characteristics.
Some storms are small in scale but bring intense rains. Others have high winds and less rain. The dangerous aspects of a hurricane or tropical storm are not always the same, which is why hurricane categories based only on wind speed may not accurately predict how the storm will affect coastal residents as it makes landfall.

While all hurricanes and tropical storms have similar morphology, they vary in terms of their geographic size, wind speeds, the amount of water vapor they carry, and the speed they move. Below are the characteristics that students analyze in Lesson 4 with definitions.

- **Forward speed:** Hurricanes vary in the speed they travel, which is called translation rate. Slow-moving storms may stall completely while fast-moving storms travel over 500 km (312 miles) in 24 hours.
- **Footprint (geographic scale):** A small storm may have hurricane force winds over an area about 150 km (about 90 mi) across, while a very large storm might have hurricane force winds that affect the coast of several states as the storm makes landfall. A storm with a large footprint has the potential to affect a larger area than a storm with a smaller footprint, but other factors (such as winds and moisture) will determine the types of impacts.
- **Wind speeds:** Historically, wind speeds are used to categorize hurricanes according to the Saffir-Simpson Scale. Once a hurricane or tropical storm makes landfall, winds drop significantly.
- **Rain:** These storms generally carry large amounts of water vapor and clouds, yet some storms carry more water than others. A hurricane or tropical storm with large amounts of water can cause intense rainfall, and the rainfall is not necessarily evenly distributed. Hurricane Harvey, for example, dropped between 30 and 60 inches of rain in the Houston, TX area in 2017. The maps of rainfall data that students explore in Lesson 4 emphasize that the amount of rain can vary with location.
- **Flooding:** The amount of flooding caused by a hurricane or tropical storm relates to factors associated with the storm as well as factors of local geography and the water table. Generally, flooding is due to both rainfall and storm surge (see below).

A note about units: It's common to describe the winds of tropical cyclones in miles per hour and the amount of flooding measured by gauges in feet, which is why units have not been converted to metric.

Madison Canal in Terrebonne Parish, Louisiana, during typical conditions and with storm surge due to Hurricane Barry in 2019. (Left: Adrianna Adams; Right: the Picou family)

How do hurricanes cause flooding?
Flooding is caused by two factors: storm surge and rainfall.

Storm surge: One of the most dangerous hurricane hazards, storm surge, is responsible for about half of all hurricane- and tropical storm-related fatalities. Storm surge happens when strong winds push ocean water towards the coast, causing the water to spill out over the land. The strength of the storm surge depends on the winds, the storm's footprint, forward speed, and the shape of the coast and shallow ocean. Surge is also driven in part by the low surface pressure at the center of the storm, which causes the surge to build up over many days and spill out over the land as the storm makes landfall. Storm surge can inundate coastal locations with many feet of fast-moving water in a matter of minutes.

Rainfall: The amount of rainfall depends on how much moisture a hurricane or tropical storm is carrying and the speed at which a storm is moving. A storm that carries a lot of moisture and is also slow moving can cause a large amount of rain to fall in one location. The rain floods rivers and impervious urban areas. The amount of flooding caused by rain depends on the topography of the land, and whether the water can permeate into the ground.

How many storms happen per year or decade?
The actual number of storms per year or per decade is typically not the same as the average number of storms. Just as your height is likely more or less than the height of an average person, the number of hurricanes and tropical storms during a year is likely more or less than the average number of storms. There is some variability around the average because of environmental changes that vary regionally from year-to-year, such as the temperature of the ocean surface, air temperature, and El Niño.

How does climate change affect hurricanes?
Scientists have determined that the strength and length of storms are probably affected by climate change. There is evidence that the number of hurricanes is increasing due to climate change and is also affected by a natural cycle.

As climate warming causes the ocean surface to warm, the intensity of hurricanes is likely to increase. Hurricanes take heat energy from the oceans and convert it into the energy of the storm. Thus, warmer oceans offer more heat energy to hurricanes, allowing them to become stronger storms with higher winds. Also, as the climate warms, hurricanes are able to transport more moisture, which can cause intense precipitation and devastating floods, like those that occurred with Hurricane Harvey in the Houston, Texas area in 2017.

In Lesson 5, students compare storm data from three time periods to explore whether there is a trend in the number of strong hurricanes. Students observe that there is evidence that storms are becoming stronger and also note that the number of storms may be increasing, but the trend isn't as clear in all regions. There is strong evidence that recent climate change caused by humans has been increasing the intensity of hurricanes.

The impact of climate change on hurricanes and tropical storms is an area of active research. We do know that a warmer climate causes these storms to carry more moisture and produce more rain. We also know that a warmer climate is causing warmer sea surface temperatures, which make a hurricane's winds stronger. There are regional variations and aspects of storms that scientists are still investigating, which are described in Lesson 7.

Sea level rise is adding to the flood risk posed by hurricanes.
To understand how hurricanes and tropical storms will affect their coastal location in the future, students take into account the impacts of sea level rise in Lesson 6.

Climate change is causing global sea level to rise in two ways.

- First, when climate warms, glaciers and ice sheets melt and the meltwater makes its way down rivers to the ocean. This moves water that had been on land into the ocean. With more water in the ocean, sea level rises.
- Second, as seawater warms, the water molecules move further apart. This causes the water to expand. About half of the sea level rise that is happening today is due to the expansion of water as it warms.

Sea level along a coast is also affected by sinking and uplifting of the land. This effect is regional. For example, coastal Louisiana is sinking lower each year, a process called subsidence. Because the land is sinking, the sea level appears to be rising much faster than if the land was stable and the only impact was from global sea level rise caused by climate change. The opposite occurs as well if the land is uplifting. For example, in areas of coastal Alaska, sea level appears to be falling because the land is uplifting rapidly due to plate tectonics.

Overview

What is resilience?
Resilience is the ability to bounce back or recover from difficulties. There are multiple ways to plan for resilience. For example, one could reduce vulnerability to flood water by raising a house on stilts. Another way to plan for resilience is to design for "graceful failure," which is to ensure that negative consequences are not dire when adversely affected by a hazard. For example, by designing a house with a ground floor made from materials that can be flooded without harm, negative consequences of flooding are prevented.

In order to plan for resilience, it's important to first understand what is at risk. In Part 3 of the curriculum, students determine what aspects of their community are **vulnerable** and then calculate the relative **risk** based on the vulnerability. Below are definitions of these terms and examples.

- **Vulnerability** is a combination of several factors, including whether something is exposed to a hazard, whether it is sensitive to the hazard, and whether it is adaptable. For example, a home located on an exposed, hurricane-prone coast is in harm's way. If that house is a small wooden structure built on sand, then it is very sensitive to the winds and flooding associated with a hurricane. However, if it has the capacity to be adapted - for example, by being moved to a more stable location and on a raised foundation - then this can decrease its vulnerability.
- **Risk** is based on the vulnerability combined with the consequences if the item or place were destroyed. For example, if our very vulnerable house was an unoccupied shack, then no one would become homeless if it were destroyed by a landfalling hurricane. But if the house was home to people, and if it was one of 40 similar houses that made up a small coastal community, then the consequences would be larger. Forty households of people could become homeless if the houses were destroyed by a landfalling hurricane, thus the risk would be higher.

The U.S. Climate Resilience Toolkit outlines five steps to being more resilient (toolkit.climate.gov/#steps). While the toolkit is used to make steps towards resilience at large scales - such as an entire state or city - the same strategies are helpful at a smaller scale, too - such as for an individual household.

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

The table to the right outlines which steps of the *Climate Resilience Toolkit* align with the lessons in Part 3 of the *Hurricane Resilience* curriculum. The Toolkit website (toolkit.climate.gov) includes information and helpful videos that explain each step, which you may wish to add to these lessons to further support student learning.

	Correlating Parts of The Resilience Toolkit
Lesson 9	**Step 1: Explore Hazards** • List the things you value that could be damaged. **Step 2: Assess Vulnerability & Risks** • Determine which of your assets are exposed to harm. • Assess each asset's vulnerability. • Estimate the risk to each asset.
Lesson 10	**Step 3: Investigate Options** • Consider possible solutions for the highest risks. • Check how others have responded to similar issues. • Reduce your list to feasible actions. **Step 4: Prioritize & Plan** • Rank the expected value of each action.
Lesson 11	**Step 4: Prioritize & Plan** • Evaluate costs, benefits, and challenges. **Step 5: Take Action** • In this case, students' actions are to develop communications materials to help others understand what they can do to improve resilience.

Case study: Louisiana resilience planning

LA SAFE stands for Louisiana's Strategic Adaptations for Future Environments. In the Lesson 11 case study, students assess information from the LA SAFE Terrebonne Parish adaptation plan developed in 2018. The goals of the LA SAFE planning process are to:

- To generate parish-wide community-driven adaptation plans focused on opportunities for residents and stakeholders to proactively adapt and prepare for anticipated environmental changes over the next 10, 25, and 50 years.
- To implement a catalytic project in each of the six parishes that demonstrates adaptive development practices that conform to current and future flood risks. Furthermore, LA SAFE is intended to identify and support the development of resilience-building projects and practices that can serve as models for the entire region.
- To create a statewide adaptation model that enhances long-term sustainability and resiliency for all Louisiana parishes.

Natural wetlands in south Louisiana help buffer the coast as hurricanes approach. (Lisa S. Gardiner)

Because natural wetlands are disappearing as sea level rises, engineered wetlands are being developed in coastal Louisiana to help buffer the coast. (Lisa S. Gardiner)

Planning for living with hurricanes in the short- and long-term

In the *Hurricane Resilience* curriculum, students consider two types of resilience strategies: (1) short-term planning for safety when a hurricane is heading for the coast, and (2) long-term planning that can help decrease vulnerability and risk overall, making people better able to weather storms. These categories have some overlap so students may identify actions that fit into both (for example, planning evacuation routes could be for a particular storm or could be a part of long-term planning to consider how to reduce traffic congestion during evacuations in a region).

In addition, students also divide resilience actions into those that can be accomplished by an individual or household and those that need the support of an entire community or region. For example, for long-term planning, raising a home above the level of extreme flooding is something a household can do while adding a levee around an area of the coast would be a project for a community or several communities in a larger area.

Actions for hurricane resilience in the short-term

Once the hazards posed by hurricanes and tropical storms are known and understood, people can decrease their risk with actions such as:

- Creating household and school/workplace emergency plans that address people's needs and include how to support people with disabilities.
- Developing a hurricane disaster supply kit that includes essentials. (See *ready.gov/kit* for items to include.)
- Making an evacuation plan. Plan your route and where you'll stay.
- Paying attention to hurricane forecasts and warnings.
- Securing homes, businesses, yards, and vehicles
- Procuring supplies
- Evacuating

Long-term resilience planning for hurricanes and sea level rise

Making plans and taking actions for resilience at a coastal, hurricane-prone location can help individuals, households, and communities decrease the risk and vulnerability they face now and in the future. Examples of actions that promote resilience in the long-term include:

- Buying flood insurance
- Raising homes on stilts
- Moving wiring higher on walls to be above flood level
- Replacing roofing with wind-proof materials
- Moving to higher ground
- Replacing impervious surfaces like asphalt with pervious pavement, which allows water to drain
- Building a levee to protect a community or region
- Creating a buyout program to help residents in the most vulnerable locations move to safer areas
- Restoring wetlands, which buffer the coast during a hurricane

References:

Done, J. M. and B. Owens Chapter 7.3 Tropical Cyclones. In Mitchell-Wallace, K., Jones, M., Hillier, J. and Foote, M. (Eds) 2017. Natural catastrophe risk management and modeling: A practitioner's guide. John Wiley & Sons.

Emanuel, K., 2003. Tropical cyclones. Annual review of earth and planetary sciences, 31(1), pp.75-104.

Teacher Guide

Lesson 1: Hurricane Headlines

SKILLS:

Lesson question: What do people do when a hurricane is approaching and how are people affected when a hurricane hits?

Learning objectives:

- Students learn how people prepared for and then dealt during a hurricane by analyzing news headlines about Hurricane Florence (2018).
- Students analyze data about the amount of damage that different categories of hurricanes cause, learning that even low category storms are able to cause damage.

Timing: One class period

Materials:

- Student pages: *Hurricane Headlines* (pages 14-17)
- Projector and computer with Internet access for the classroom
- Lesson 1 Slides (download from scied.ucar.edu/HurricaneResilience)
- Colored Pencils

Preparation:

- Review the Lesson 1 Slides and the Headline Timeline on the student pages.
- Copy student pages for each student.

Directions

Consider hurricane impacts.

- Have students recall a hurricane or tropical storm that affected their local area. Discuss what students remember about the storm from their own experience.
- Tell students that in this activity, they will assess how a hurricane affected the people and places in another coastal location. They will explore what news headlines can tell us about the storm and its impacts on people and places.

Assess Hurricane Florence from the headlines.

- Handout the *Hurricane Headlines* student pages (pages 14-17) to each student.
- Show **Slide 1**, the map of Hurricane Florence's path. Tell students that in this activity, they will find out from news headlines what happened when Hurricane Florence hit the North Carolina coast in 2018. (Leave the map projected while students complete the activity.)
- Tell students that in order to answer the question at the top of *Hurricane Headlines* student page 14 (What do news stories tell us about Hurricane Florence?) they will answer the questions on the first page while analyzing the headlines from the Washington Post that are in the Headline Timeline (student pages 15-17).
- Have students work in pairs to describe Hurricane Florence through a timeline of news headlines following the instructions on the second page of the first Student Activity Sheet, focusing on (1) forecasts, (2) preparation, and (3) storm impacts and responses.
- Bring the class back together and discuss what students now know about Hurricane Florence after reading the headlines with the following questions:
  - What were people dealing with before and during the storm?
  - What can stories help us understand about a hurricane?

Explore data about types of hurricanes and how much damage they cause.

- Show **Slide 2** (the map of hurricane tracks worldwide) and ask students to answer the questions:
  - Where do hurricanes happen?
  - Where do hurricanes make landfall?
- Explain that not all hurricanes make landfall at the same intensity and show **Slide 3** (the Saffir Simpson Scale). Explain that the scale describes hurricane intensity based on how strong the winds are of a hurricane or tropical storm. Ask students, based on the Saffir-Simpson Scale, what they think is the most dangerous type of hurricane?
  - *(Students will likely indicate Category 5 based on what they just learned.)*
- Show **Slide 4** (graph of most damaging hurricanes and tropical storms) and explain to students that it shows the cost of damage (y-axis) due to the 30 most destructive hurricanes and tropical storms to hit the US coast between 1983 and 2019. Ask students: Are all of the most destructive storms high on the Saffir Simpson scale?
  - *(Students should notice that there are tropical storms and Category 1 and 2 storms that are among the most destructive. They should also notice that the most destructive storms are Category 3 and 4.)*
- Tell students that Hurricane Florence was a Category 1 storm and it is among the 30 most damaging storms. Ask students, based on the headlines they analyzed, what aspect of Hurricane Florence caused the most damage?
  - *(Students should recognize that flooding was a major problem during Hurricane Florence. Students may recognize that the Saffir Simpson categories are based on winds, not flooding. Students will explore which characteristics of hurricanes are the most damaging in Lessons 3 and 4.)*
- Have students brainstorm what else, besides wind speed, could make a hurricane damaging.
  - *(For example, the amount of rain, the amount of storm surge, how fast the storm moves, the size of the storm, etc. Note that students may not know all these factors at this point, which is okay).*
- Show **Slide 5** (overall and insured losses due to hurricanes). This graph shows how the cost of hurricane damage has changed over time in the United States. Orient students to the graph:
  - The x-axis shows years since 1980.
  - The y-axis is the cost of damage.
  - Blue is insured losses.
  - Green is uninsured losses.
  - Provide students with a tangible example: if a roof is damaged by a hurricane's winds, the cost of the roof repair is represented on the graph.
- Ask students how the cost of damage has changed over time.
  - *(Students should notice that the cost of damage has increased.)*
- Ask students: What do you think has changed that could increase the cost of damage?
  - *(Students may wonder if there are more hurricanes today than there were in the past, which is something that they explore in Lesson 5. Students may also wonder if there are more houses and other buildings near coasts now, which could add up to more damage. This is something that students consider during Lesson 9.)*

Introduce the Hurricane Resilience unit.

- Working in pairs, have students brainstorm the types of impacts that a hurricane can have (drawing on both prior knowledge and what they have learned in this lesson), considering both:
  - **impacts on places and things** (such as flooded homes, wind damage, wetlands loss, destroyed roads, etc.)
  - **impacts on people** (physical and mental health problems, loss of jobs, having to move, etc.)
- Bring the class together to compile a list of types of hurricane impacts on the board and then ask students what actions people can take to stay as safe as possible (drawing on both prior knowledge and the headlines).

  - *(Students may mention individual actions such as getting to higher ground or boarding up windows and may also mention larger-scale actions such as closing an airport and calling in the military to help.)*
- Introduce students to the Hurricane Resilience unit: Explain that, during the unit, they will:
  - Gather stories from people in their local area about how hurricanes have affected people and places,
  - Figure out what hurricane characteristics are the most hazardous,
  - Discover how hurricanes could affect us in the future,
  - And make plans for how people in this community can stay safe, now and in the future.

Opportunities for Assessment:

- Sharing experiences with hurricanes and tropical storms at the start of class can be helpful for formative assessment. It will indicate what types of prior experiences students bring to this unit.
- Student answers to the questions about Hurricane Florence on the *Hurricane Headlines* student page (page 14) should also be used for formative assessment, indicating whether students can identify weather forecasts (predictions) and storm impacts. It can also indicate whether students are able to identify actions that people took to prepare and steps that people took to respond to the storm impacts. These are elements that students will explore in depth during Parts 1 and 2 of the curriculum.

A flooded area of South Carolina due to Hurricane Florence in 2018. (South Carolina Air National Guard)

Name:

What do news stories tell us about Hurricane Florence?

Lesson 1 Student Pages: Hurricane Headlines

Step 1: Interpret the headlines.

Color-code the headlines on pages 15-17 into the three categories listed below. Add the colors to the key.

- ◯ Forecasts and warnings
- ◯ Preparing: what people are doing to prepare
- ◯ During the hurricane: impacts and how people are dealing with them

Step 2: Answer the questions below about Hurricane Florence based on the headlines.

What do these headlines tell you about Hurricane Florence?

Describe the warnings that you can find in the news headlines.

What did people do to prepare?

What were the storm impacts?

What actions did people take in the past that were successful in reducing impacts?

Where else do you think people were getting information about the storm besides newspapers and news websites?

What do news stories tell us about Hurricane Florence?

Lesson 1 Student Pages

Headline Timeline: Hurricane Florence

9/7/2018 - 9/13/2018

DATE	HEADLINE	CATEGORY
9/7	**Tracking Florence:** *Florence is expected to strengthen and may threaten the east coast*	◯
9/9	**'We're in the bull's eye': Evacuation orders multiply as Hurricane Florence churns toward East Coast** *The governors of North Carolina, South Carolina, Virginia and Maryland have declared states of emergency. The hurricane is expected to make landfall later in the week.*	◯
9/9	**Hurricane watches posted as 'extremely dangerous' Florence churns toward Carolinas** *The storm could slow or stall over the Mid-Atlantic and produce disastrous amounts of rain.*	◯
9/10	**Trains canceled, airports reduce operations as East Coast braces for Hurricane Florence** *Charleston International Airport said it anticipates its runways to close by midnight Wednesday. But some airlines were already announcing plans to cease operations.*	◯
9/11	**Hurricane Florence in Washington region: The worst is likely to stay south** *The most extreme rainfall is likely to focus in Southern Virginia and areas farther south, but small shifts could bring substantial rain and flooding to the Washington area.*	◯
9/11	**D.C. declares state of emergency ahead of Hurricane Florence, braces for 'torrential rain'** *Officials laid out how they are preparing for the Category 4 storm.*	◯
9/11	**'Multiple threats, multiple hazards.' Aside from powerful wind, Florence could inundate the Carolinas, Virginia** *Hurricane Florence is expected to stall and could soak an already oversaturated region.*	◯
9/11	**Moving chickens, harvesting tobacco, managing hog manure: N.C. farmers prepare for Florence** *The nation's eighth-largest agricultural producer prepares to weather the hurricane.*	◯
9/11	**Hurricane warnings issued as 'life-threatening' Florence strengthens** *Catastrophic flooding and destructive winds are likely in the eastern Carolinas.*	◯
9/12	**Disaster-preparedness apps are flourishing ahead of Hurricane Florence** *The impending storm recently made a digital walkie-talkie the App Store's No. 1 app. People have learned the value of smartphones in emergencies, experts say.*	◯
9/12	**Hurricane Florence looks like a nightmarish monstrosity — 'even from space'** *"Get prepared on the East Coast, this is a no-kidding nightmare coming for you."*	◯
9/12	**These cats and dogs were moved to safety as Hurricane Florence bears down on the East Coast** *A District shelter is calling on people to adopt, which helps to make room for more animals in need of shelter.*	◯

What do news stories tell us about Hurricane Florence?

Lesson 1 Student Pages

DATE	HEADLINE	CATEGORY
9/12	**Nursing homes rush to move elderly and ill from path of Hurricane Florence** *Officials in the Carolinas want to avoid repeating mistakes in Florida, where older residents died in the aftermath of Hurricane Irma last year.*	◯
9/12	**Hurricane Florence grows larger as it bears down on Carolinas with 'life-threatening' fury** *The Category 2 storm is likely to produce "catastrophic" flooding in the eastern Carolinas as well as damaging winds.*	◯
9/13	**Forecasts for cities affected by Hurricane Florence** *How Florence will affect populations centers in Southeast Virginia, the Carolinas, and Georgia.*	◯
9/13	**A hurricane is coming. Now we wait:** *The slow, anxious hours before the storm.*	◯
9/13	**'It's looking a little grim': As hurricane bears down on Carolinas, the waiting is over:** *Powerful first surges of Hurricane Florence hit the beaches on Thursday as residents in a large area await potentially catastrophic rains.*	◯
9/13	**D.C. Mayor Bowser mayor rescinds state of emergency orders as hurricane heads south** *As Hurricane Florence lands in the Carolinas, District officials expect diminished threat to Washington.*	◯
9/13	**Hurricane Florence's assault begins as wind gusts top 105 mph on Outer Banks, waters rise 10 feet** *The damaging winds, rise in the ocean and unforgiving rains will bring devastating effects to the Carolinas.*	◯
9/14	**Cajun Navy races to the Carolinas; citizen rescuers pull people from rising waters** *An armada of various boats streamed toward Hurricane Florence this week, trying to emulate the effort during Hurricane Harvey in Texas.*	◯
9/14	**Will Hurricane Florence's remnants curl back and drench Washington early next week?** *Areas west and north of Washington have the best chance of seeing some heavy rain Monday into Tuesday.*	◯
9/14	**Tropical Storm Florence forecast: 'Catastrophic flash flooding' becomes primary threat** *Florence's winds are weakening, but some of its most devastating effects probably are yet to come.*	◯
9/14	**Hurricane evacuees face long journeys, lengthy stays in search for safety** *By the time Florence bore down on the Carolinas on Friday, about 20,000 people had sought refuge at one of 200 Red Cross shelters across the region.*	◯
9/14	**Record flooding projected as Florence rolls slowly across the Carolinas** *Officials warn that this is a slow-motion natural disaster that could last for weeks.*	◯
9/14	**At least 4 deaths linked to 'powerful, slow and relentless' storm pummeling North Carolina** *Hurricane Florence is lashing parts of North Carolina and South Carolina. Water rescues are underway in New Bern, N.C., as the storm is about to make landfall.*	◯

What do news stories tell us about Hurricane Florence?

Lesson 1 Student Pages

DATE	HEADLINE	CATEGORY
9/15	**'We face walls of water': Communities in North Carolina band together to face Florence** *Florence was downgraded to a tropical storm Saturday. But its slow forward movement means that coastal and southeastern areas will still get the brunt of its deluge.*	◯
9/15	**North Carolina braces for Florence's devastating deluge** *As Florence stalls out on its march westward, record rainfalls threaten to flood bodies of water across a large region.*	◯
9/16	**Carolinas turn into an archipelago of island communities as Florence's rain causes widespread flooding** *With rivers still rising and roads inundated, officials warn evacuees it's not safe to go home.*	◯
9/16	**Florence forecast: Dangerous flooding expands into western North Carolina and southwest Virginia** *The devastating rain event will only slowly relent in southeast North Carolina as it pushes toward the Appalachians and eventually the Northeast.*	◯
9/16	**Florence has made Wilmington, N.C., an island cut off from the rest of the world** *There are no roadways open to the city, the airports and port are closed.*	◯
9/17	**Florence remnants spawn deadly tornadoes in Richmond area** *Storms killed at least one person in the Richmond area Monday as the remnants of Hurricane Florence swept through the Mid-Atlantic.*	◯
9/17	**With Florence's flooding expected to worsen, the military could respond for days** *Helicopters on ships nearby are still on call if needed, said a general overseeing relief efforts.*	◯
9/17	**Rivers, death toll and environmental hazards still rising in Carolinas as flooding sets records** *Experts warn that rivers will crest and remain at high level for as many as 10 days before dropping, part of "catastrophic flooding" across the region following the hurricane.*	◯
9/18	**More headaches as Florence's waters overtake toxic pits and hog lagoons** *Environmental casualties: Soaked hog farms, flooded coal ash pits and threatened sewage systems.*	◯

All of the headlines in this timeline are from news stories published in *The Washington Post* between September 7 and 18, 2018.

This satellite image shows Hurricane Florence on Sept. 14, 2018, approaching the coast of North Carolina and South Carolina. (NOAA)

Teacher Guide

Lesson 2: Historical Hurricanes

SKILLS:

Lesson question: Which hurricanes and tropical storms have affected our community?

Learning objectives:

- Students use the NOAA Historical Hurricane Tracks tool to create a hurricane timeline for their local area, learning how often hurricanes and tropical storms have made landfall in their location.

Timing:

- Two class periods
  - Day 1: Find data using the Historical Hurricane Tracks tool
  - Day 2: Creating a hurricane timeline

Materials:

- Computers (one for each student pair) and Internet access
- Computer, projector, and Internet access (teacher)
- Student pages: *Our Historical Hurricanes* (pages 21-22)
- Paper, rulers, and colored pencils (for making timelines, if not made digitally)

Preparation:

- Bookmark the URL for NOAA Historical Hurricane Tracks on student computers (coast.noaa.gov/hurricanes).
- Copy the *Our Historical Hurricanes* student pages for each student.
- Test out the Historical Hurricane Tracks tool and search your local hurricanes following the instructions.

Directions

DAY 1

Introduce NOAA Historical Hurricane Tracks.

- Ask students how many hurricanes and tropical storms they think made landfall in their local area over the last 100 years.
- Tell students that in this activity, they will make a timeline of all the hurricanes and tropical storms that made landfall in their location.
- Orient students to Historical Hurricane Tracks on NOAA Digital Coast.
  - Assign students or pairs of students to computers.
  - Have students launch Historical Hurricane Tracks and then guide them through the following features:
    - **Search by location, year, or storm name.** Have students test this by searching a location (enter the name of your city, for example). This will pull up the full inference, which shows a map of storm tracks that have hit your location, as well as a list of the hurricanes and tropical storms.
    - **Orient students to the interface.** Point out the map of storm tracks that passed directly over their location and the list of storm names that appear next to the map. Note the location of the Legend (which shows the categories and color codes) and the options for filtering the data (category, pressure, year, and distance).

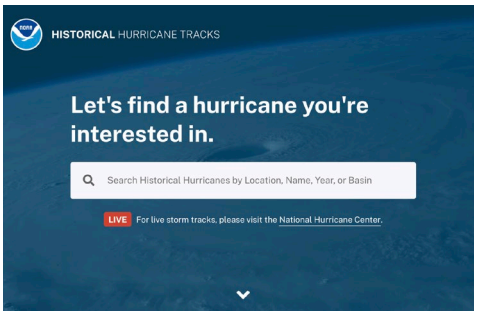
Have students research local hurricanes using the Historical Hurricane Tracks tool.

- Pose the lesson question: *Which hurricanes and tropical storms affected our community?*
- Hand out the *Our Historical Hurricanes* student pages.
- Have students follow the instructions to find all storms that struck in your coastal area within a 50 miles radius and then omit storms that happened over 100 years ago. (Narrowing the search allows students to focus on storms that occurred when current residents were living in the area.)

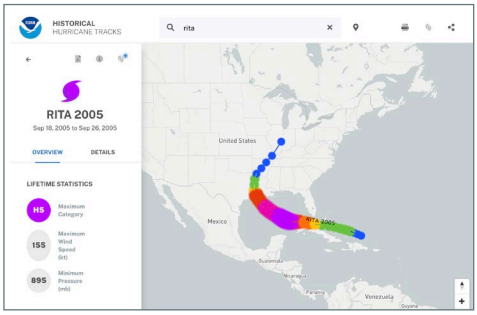
Analyze the data.

Have students use the directions on the student activity sheet to sort the list by year and ask what they notice. (Students may notice many things, including that some storms have names and others don't, which is because storms weren't named until 1953.)

- Have students describe the data following the questions on the student pages, including:
  - How many storms happened in each decade? *(Answers will vary by location.)*
  - Do storms always come from the same direction? *(Students should notice that they do all come from the ocean towards the land, but the specific track will vary.)*
  - What is the range in Saffir Simpson categories for the storms that made landfall here? *(Students will likely notice a variation in the storm categories for any location. Make sure students look at the category of the storm when it made landfall; note that strength changes over time.)*
- As students analyze the data, they may wonder why sometimes there are several storms in a row and, at other times, there weren't any storms. See the Science Background section (pages 4-8) for an explanation of variability in hurricane frequency to prepare to answer student questions.
- Have students zoom in to figure out which storms struck closest to where they live.
- If the Historical Hurricanes tool does not include data from the current year, students will need to add recent storms to their list. Students may be able to do this from memory. To ensure their additions are accurate, check the National Hurricane Center's list of recent storms (nhc.noaa.gov/data/tcr).



Intro screen of the Historical Hurricane Tracks tool. (NOAA Digital Coast)

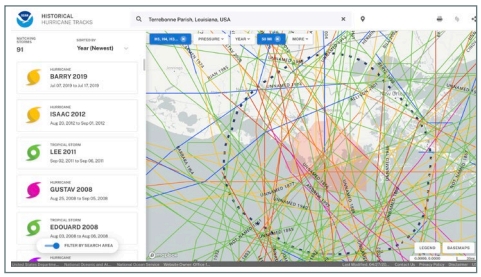


Historical Hurricane Tracks includes a database about hurricane characteristics, including the storm tracks, category, timeline, wind speed, and pressure.

DAY 2

Make hurricane timelines.

- Have students each construct a timeline of all the hurricanes, tropical storms, and tropical depressions that they think could have affected their community following these guidelines:
  - Include all the hurricanes and tropical storms in the past 100 years that made landfall in a particular part of the coast.
  - Place the events in the correct order and location along the timeline.
  - Include the correct year for each storm.
  - Use symbols, colors, or both to indicate the strength of the storm.
- You may wish students to work in pairs instead of individually. Students can create their timeline digitally or on paper using colored pencils and a ruler.



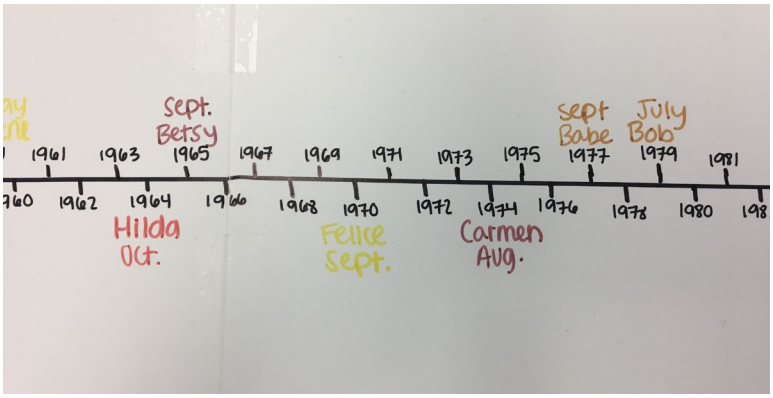
Searching for a location brings up all hurricanes and tropical storms that have affected that location. In this lesson, students will search for their location in order to identify storms to include in their timeline.

Introduce the Driving Question Board.

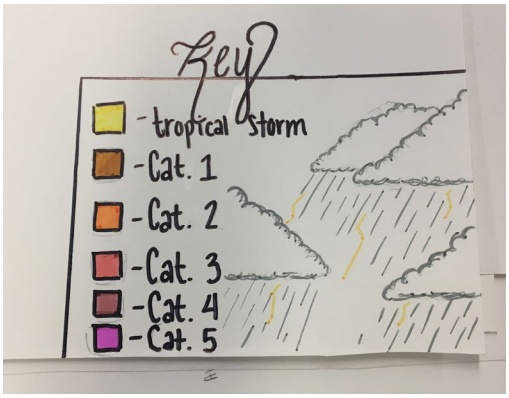
- Share the Driving Question Board with students. Explain that the Board is a place where we can collect our questions about hurricanes, the risks they pose, and how we can stay safe. The Board will be displayed in the classroom throughout the unit, and the class will update it each week.
- Introduce the central question in the Driving Question Board (such as *How and why do hurricanes affect us and how can we stay safe?*). Write this question on the Board if you have not already.
- Once students have analyzed data about their local hurricanes and tropical storms, they may have questions about why some years have more storms than others, why the category varies, or what some storms were like. Pass out sticky notes and have each student write a question that they have about hurricanes.
- Have students add their questions to the Driving Question Board and work together to organize them into categories.

Opportunities for Assessment:

- The timelines that students create can be used as an assessment. Timelines should extend 100 years and include all hurricanes and tropical storms that occurred in the local area over that time, according to the NOAA Historical Hurricane Tracks tool. Timelines should note the storm year, name, and strength.
- The questions on the student pages can be used to assess student understanding about hurricane characteristics and data analysis skills.



Sample timeline created by students at South Terrebonne High School. (LSG)



Students should create a key for the colors and symbols that they use in their timeline. (LSG)

Extension:

- If you have additional time, you may wish to allow students to compare the storm data from different locations or different times, based on a question that they have about hurricanes (such as "Does our community get more hurricanes than Miami?" or "Have there been more hurricanes in the past decade than a hundred years ago?")

Name:

Which hurricanes and tropical storms have affected your community?

Lesson 2 Student Pages: Historical Hurricanes

Tropical cyclones include hurricanes, tropical storms, and tropical depressions. In this project, you'll find out which storms made landfall in your location. Follow the steps below.

On a computer or tablet, go to the Historical Hurricane Tracks tool on NOAA Digital Coast: coast.noaa.gov/hurricanes/

Search to find all the storms that struck in your location.

- Enter your location into the search.
- Hover over the storm names on the left to highlight tracks on the map.
- Click on "Legend" in the lower right to find out how the colors of the storm tracks relate to categories on the Saffir-Simpson scale.

Broaden the list to include other storms that affected your location.

- The map shows storm tracks, which shows how the center of the storm traveled, but a hurricane is so big that it affects a broad area on either side of the track.
- Click "search distance" at the top of the map and enter 50 miles to see the tracks of storms that likely affected your location even if the track didn't go right over.

Narrow the list to find the storms that people in your community have experienced.

- In the next part of this project, you'll find out from older people in the community what the damage was like for past hurricanes and tropical storms, so you'll want to identify which hurricanes and tropical storms happened during their lifetimes.
- Sort the storms by year so that the most recent are at the top of the list. On paper or in a document, list all the storms that occurred in the past 100 years. You will create a timeline of these storms.

Analyze the data by answering the questions below and on page 22.

1. What do you notice in the list of storms?

2. How many storms have happened in each decade?

Which hurricanes and tropical storms have affected your community?

Lesson 2 Student Pages

3. What directions do the storms come from as they approach your coastal location?

4. How many storms are in each Category? (Refer to the Legend for Saffir-Simpson Categories.)

5. Which storms struck closest to where you live? (Use the zoom tool to find your location on the map.)

Teacher Guide

Lesson 3: Storm Stories

SKILLS:

Lesson question: How have people in our community experienced hurricanes?

Learning objectives:

- Students learn about local people's experiences with hurricanes and tropical storms by conducting interviews.
- Students analyze their interview data to identify the actions people took to stay safe during, and bounce back after, a hurricane or tropical storm.
- Students identify characteristics of storms that affected the local area based on their interview data and online research about the physical characteristics of the storms themselves.

Timing:

- Four class periods
  - Day 1: Introduce the Storm Stories project and plan for interviews
  - Day 2: Practice interviewing and collecting data
  - Homework: Students interview a community member about two storms
  - Day 3: Analyze interview data about actions people took to stay safe
  - Day 4: Analyze interview data about storm impacts and online storm research

A note about the paper-based and digital versions of this lesson:
This lesson can be done with students either collecting and analyzing data on paper questionnaires or with students entering the data into a spreadsheet via a Google Form. If you have two or more classes that are doing this lesson or are doing the lesson as distance learning, it's recommended that you have students use the Google Form to upload their data. This will allow all students to compile the interview data into one spreadsheet. The Google Form can be accessed via phone, tablet, or computer. Throughout the lesson, directions marked **[Digital Option]** indicate the instructions for digital data analysis.

Materials:

- Hurricane Timelines (created in Lesson 2)
- Hurricane Resilience Driving Question Board
- Classroom projector and computer with Internet access
- Computers or tablets with Internet access for each pair of students
- Student pages:
  - *Storm Stories Interview Protocol (page 30)*
  - *Storm Story Questionnaire (pages 31-32)*
  - *Accounts of a Storm (pages 33-34)*
- Student notebooks or paper, pens/pencils
- Chart paper
- Markers (one for each student)
- Long paper strips for writing headlines (one for each student)
- A list of potential interviewees for students who need suggestions
- Optional: Storm Story interview data collected by previous/other classes (to add to what students collect)
- **[Digital Option]** Google Form for student data entry and access to Google Sheets (see preparation below)

Preparation:

- Create a list of school employees who are willing to be interviewed by students.
- Make three or four copies of the *Storm Story Questionnaire* for each student (Day 1-2).
- Make one copy of the *Storm Stories Interview Protocol* for each student (Day 1-2).
- Make one copy of the *Accounts of a Storm* student page for each student (Day 4).
- **[Digital Option]** Copy of the Google Form (Find the link to the Google Form at scied.ucar.edu/HurricaneResilience) to your Google Classroom if you would like students to enter data through the form and analyze it via a spreadsheet. Provide students with the link to the form on Day 2.

Directions

Day 1

Introduce the lesson.

- Have students look at the Hurricane Timelines they created during Lesson 2.
- Remind students that not all hurricanes cause the same amount of damage. And not all places feel the same effects. Ask students to speculate about which of the storms on their timeline probably caused the most damage. *(Some students may indicate that the storms that made the most direct pass over the location would cause the most damage. Others might think that the strongest category storms caused the most damage. The case study about Hurricane Florence might lead them to suggest that slow-moving hurricanes cause the most damage.)*
- Record the ideas on the board or chart paper as hypotheses (educated guesses). Students will return to these on Day 4 of the lesson.
- Explain that we can find out how past hurricanes impacted the community by asking people who lived through them. Tell students that in this project, they will interview people they know about their experiences during hurricanes to find out how places and people were affected.

Prepare for interviews.

- Introduce students to the *Storm Stories Interview Protocol*. Review the protocol as a class. Explain that they are at Step 1, and will do Step 2 as homework.
- Orient students to the *Storm Stories Questionnaire*. This is where they will take notes during each interview. Explain that they will fill out the *Storm Stories Questionnaire* during each interview.
- **[Digital Option]** Orient students to the Google Form for data entry to prepare students to upload data.

Have students make interview plans.

- Have students list two people they want to interview (a first choice and a backup). Encourage students to choose people who are older than them so that they can gather data about storms that are throughout their Hurricane Timeline.
  - Storm stories can be collected from family members, teachers and other school employees, neighbors, or others in the community. Ensure that student plans for Storm Story interviews include people with whom students feel safe.
  - Have a list of potential interviewees available for students who may not have anyone in mind to interview (for example, if they are new to the community). This list might include teachers or other adults at school that students know.
- Have students compare their lists to make sure there are no repeat names.

Homework:

- Students should set up an interview for the following afternoon or evening (or over the weekend - see note below). If their first interviewee is not available, instruct students to contact the second. Interviews need to be conducted between Day 2 and Day 3 of the lesson.

- If you started the Hurricane Resilience curriculum on a Monday and have five classes per week, then interviews will occur over a weekend, which should add some flexibility for both students and their interviewees.
- Have students interview a person about two storms, or interview two people if each person only has one storm to share.
- If you are teaching this lesson with multiple classes, you can pool all their data for analysis and allow each student to collect data about one storm. If you are teaching this lessom for multiple school years, save the data from interviews to increase the size of the dataset that students analyze.

Day 2

Review the homework.

- Ensure that all students were successful in setting up an interview time with one person for after school. There is a chance that some students were not successful through no fault of their own if the people are not available. In that case, have students select a name from your list of additional potential interviewees.

Have students practice interviewing each other.

- Have students work in pairs to practice interviewing each other. Students will trade rolls as the interviewer. Have each student ask all of the questions and fill out the questionnaire before trading rolls. Note that if students have not experienced any hurricanes or tropical storms, they can make up a Storm Story. Ensure that any questionnaire about a fictional story is labeled so that it doesn't become part of the class data set. If students have experienced a hurricane, their interviews can become part of the data that the class will analyze.
- **[Digital Option]** If you have students upload their data via the Google form, have them try to do this directly on a computer or mobile device during the interview and compare that to the process of filling out the paper questionnaire. You may wish to let students decide which strategy they'd prefer. (Using the paper questionnaire makes it easier to change answers and collect answers out of order, but it means that there is a data entry step at the end. Collecting data directly into the form eliminates a step, but if technology fails, then the data could be lost.)
- After all students have had the experience of interviewing another student, have the class discuss their experiences as the interviewer. Ask what they might do differently during their actual interviews.
- Explain that, because the whole class will analyze all the data as a group, it's important that all students use the same methods when collecting the data. Ask if students have questions about how to fill in parts of the questionnaire. If there are questions, decide as a class what to do in that situation so that everyone is collecting data with the same methods.

Have students prepare for interviews.

- Instruct students to use the Hurricane Timeline they developed to identify which storms their interviewee might remember.
- Handout two copies of the *Storm Stories Questionnaire.*
- **[Digital Option]** Provide students with the link to the Google Form.
- Remind students that the focus of this project is to learn how people in our community have experienced hurricanes. However, if they discover that their interviewee moved into the area from another hurricane-prone location, Storm Stories about another place are okay. Stories that are from other locations will still help us learn about the challenges presented by hurricanes and what people do to stay safe. (Since students are asking where interviewees lived at the time, the non-local data can be excluded during the second part of the data analysis.)

Homework

- Students conduct their interviews and fill out the questionnaire about two storms that the interviewee remembers (using one copy of the questionnaire for each storm). This should take between 20 minutes and an hour depending on the interviewee.
- **[Digital Option]** Students upload their interview data via the Google Form.

Day 3

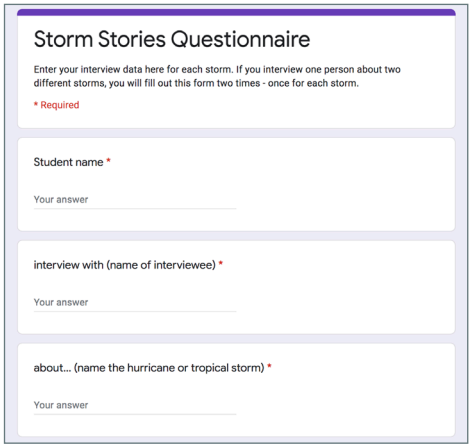
Introduce the data analysis activity.

- Tell students that, now that we have the Storm Stories, it's time to make sense of the information. While every person who was interviewed had their own individual experiences with hurricanes, we can analyze all the data together to figure out whether there are patterns in terms of what people experienced and what they did during hurricanes and tropical storms.
- Introduce the day's data analysis question: *What actions did people take to stay safe and keep their homes and belongings safe?*

Analyze the data about resilient actions.

[Digital Option] If students have entered the data via the Google Form:

- Project the Google Form, click responses, and then click the green icon to create a spreadsheet of data that students entered. Orient students to the spreadsheet.
  - Rows are for each storm that each interviewee described. (For example, if one person was interviewed about Hurricane Betsy and Hurricane Ivan, that would be in two rows of the spreadsheet).
  - Columns indicate the types of data. (For example, one column includes the data about whether people answered no, yes, or don't remember when asked if there was flooding.)
- Organize students into five groups and provide each group with a computer or tablet to access the spreadsheet of data.
- Have each group make a copy of the spreadsheet that they will use for analysis (File > Make a Copy).
- Assign groups to focus their analysis on one of the following questions:
  - How did you learn that the storm was coming?
  - Before the storm, what did you do?
  - During the storm, what did you do?
  - After the storm, what did you do?
  - What decisions have you made to stay safe from hurricanes in the long term?
- Help students focus their data analysis by providing the following questions on the board:
  - How many interviews chose each answer?
  - Which answer was most frequently selected? Which was least frequently selected?
  - How many interviews added something extra to the "other" field and what did they add?



An example of the Google Form that students will fill out if you are using the digital option.

Answers	number of responses
Stocked up on food/water	4
Created an emergency kit	4
Installed window protections	1
Secured home exterior and items in the ya	2
Secured or relocated vehicles	2
Turned off electricity/gas	0
Planned for evacuation	1
Evacuated prior to the storm	1
Took care of other people or pets	1

Example of student collected data in the spreadsheet. Questions that allow multiple answers to be selected will include the selected answers separated by commas. It's helpful to increase the column width to see all the answers.

- Visit each group to ensure that they focus on the correct columns of data to answer their assigned question. To help students focus on the data that they need to analyze, they may wish to hide columns in the spreadsheet that show other data types and make the column that they are focusing on wider so that they can see all the answers.
- If students are familiar with spreadsheets, instruct them to create a bar graph of their data. If they are less proficient, you may have them count the number of different answers and make a bar graph by hand. When there are multiple answers to each question, students will need to break apart the answers to count how many there are total.

If students have the data in paper copies of the *Storm Stories Questionnaire*:

- Organize five sheets of chart paper around the classroom, each with one of the following questions. Include the checkboxes from the questionnaire and space for other answers:
  - How did you learn that the storm was coming?
  - Before the storm, what did you do?
  - During the storm, what did you do?
  - After the storm, what did you do?
  - What decisions have you made to stay safe from hurricanes in the long term?
- Model for students how they will add checkmarks to specific answers on the chart paper. This will allow the class to summarize all of their data together. Note how they should fill in the "other" category if that is their answer.
- Have students add checkmarks to each sheet of paper with a marker to indicate how their interviewee answered each question. Since students collected two Storm Stories, they should add two checkmarks, one for each storm, to each question.
- Divide the class into five groups and assign each group to summarize the data for a piece of chart paper. Instruct groups to create bar graphs of the data. Provide an example of a bar graph and guidance if needed.

Communicate results.

- Review the data analysis question *(What actions did people take to stay safe and keep their homes and belongings safe?)* and note that each group analyzed a piece of the dataset that allows us to answer that question. Have each group present their bar graph to the rest of the class and explain what it indicates.
- Discuss how people's actions change before, during, and after a storm and when planning for the long term.
- Save the data analysis (whether in spreadsheets or on paper) for use during Lesson 10.

Exit ticket: Construct explanations for how hurricanes affect people in the community.

- Share the question: *What actions did people take to stay safe and keep their homes and belongings safe?*
- Pass out long strips of paper and markers, one per student. Instruct students to write a headline that addresses the question. Remind students that a good headline is catchy but, more importantly, it gets at the heart of the issue.
- Hang the headlines on the wall and, if possible, leave them displayed for the rest of the unit.

Notes about data analysis:

When students are analyzing the most frequently mentioned storms on Day 4, you may find that some groups have more data points than others. This shouldn't matter if students are analyzing data via a spreadsheet, but might make the activity too long if student groups are working with the Storm Stories Questionnaires. You may choose to have two groups divide up one storm and then see whether they had the same description of it in the end.

Hurricanes and tropical storms only described in one story are interesting, but will not be helpful in the Day 4 analysis activity. Choose the storms that were most often described in stories and assign each group one of those storms. It's not necessary for students to analyze all storms. The idea is to illustrate the diversity of storms and their impacts.

If you have students analyze the data digitally, you may want to spend some time orienting students to the data, depending on your students' proficiency with spreadsheets. Remind student groups to make a copy of the spreadsheet before they start their work so that groups can be analyzing different parts of the data and not make changes (such as sorting rows, hiding columns) that will affect other groups.

Depending on prior experience, students may need additional support to create bar graphs of data during Day 3 and 4.

Day 4

Introduce the data analysis activity.

- Have students review what hazards people face during hurricanes and tropical storms, according to their Storm Story interviews. *(Students will likely mention wind, flooding, and rain.)*
- Ask students: Do all storms have the same amount of damage from wind or flooding? How are these storms the same? How are they different? These are the day's data analysis questions. *(Answers will vary, but students may note that the person they interviewed had different experiences during the two storms they described.)*
- Tell students that in this data analysis activity, each group will analyze one storm to define what the storm was like, given people's descriptions of it. Then, they will look up their storm in NOAA Historical Hurricane Tracks and learn about the physical characteristics of the storm.
- Have students return to their groups from the previous day.

Organize the data by storm.

[Digital Option] If students have entered the data via the Google Form:

- Project the spreadsheet for the class, sort the data by the storm names, and have students identify the most commonly described storms from the list. Note that because students entered this data manually, there may be spelling errors.
- Provide each student group with a computer or tablet and have each group make a copy of the spreadsheet that they will use for analysis.
- Assign each group a different storm, using the most commonly described storms, and instruct students to hide data rows that are from other storms so that they can focus on their assigned storm.

If students have the data in paper copies of the *Storm Stories Questionnaire*:

- Identify the storms that were most commonly described by having students record how many interviews they have about each storm. Tally the results on the board.
- Assign each group a different storm, using the storms that are most commonly described in the interview data, and provide the *Storm Stories Questionnaire* pages that the class collected about that storm.

Have students compare the accounts about a storm to the physical science data about the storm.

- Hand out a copy of the *Accounts of a Storm* student page to each student and a computer or tablet to each group.
- Following the instructions on Part 1 of the student page, students will define what the storm was like given interview descriptions of wind, flooding, road closures, and the length of the storm. Before they begin, orient students to the bar graph templates.
  - Students who are unfamiliar with graphing may benefit from an example of how to create percentages of the data and how to create bars that show the percentages.
  - Note: if there are only a small number of Storm Stories that describe each storm, creating bar graphs of the data isn't going to be meaningful. You may instead have students summarize the data without graphing.
- Following the instructions for Part 2 of the student page, students should look up their storm in NOAA Historical Hurricane Tracks (coast.noaa.gov/hurricanes/) and zoom into the part of the map where the storm track affected their community. Students will note the characteristics of the storm (such as category, wind speed, and how fast the storm was moving) at that location on the map.

Students share their storm.

- Give each group time to develop a slide to present to the class that describes their storm, including:
  - their analysis of the Storm Stories data about the storm
  - the characteristics of the storm they researched in NOAA Historical Hurricane Tracks
- Have student groups present about their storm to the rest of the class (1- 2 minutes for each presentation) so that all students

- get an overview of each storm. As other groups present, have students in the audience take notes about each storm and its characteristics.
- Hold a brief discussion after all the groups have presented, focusing on the data analysis questions: Do all storms have the same amount of damage from wind or flooding? How are these storms the same? How are they different? *(Students will likely discover that there are differences between the storms, which is something they will learn more about in the next lesson.)*
- Have students review the hypotheses they generated at the beginning of the lesson and discuss whether their data supports any of the hypotheses.

Update the Driving Question Board.

- Have students return to the Driving Question Board to see whether there are questions that can now be answered or questions that should be changed based on what we know now. Have students consider whether they have new questions to add to the Board.

Opportunities for Assessment

- The content of the data that students collect during interviews will depend on the person they are interviewing, so focus on the quality of the data that students collect, including the completeness of the data when assessing student work. Since the interview data will be needed before analysis, it's recommended that you include timeliness of interviews as a part of students' grades to add incentive for students to complete interviews on time.
- Answers to the exit ticket question should communicate students' conclusions after analyzing data about how people in their community were affected by hurricanes. This is directly tied to the lesson question and should indicate the understanding that students have developed.
- Answers on the *Accounts of a Storm* student page should indicate how students are making sense of the storm data.
- Once groups present about the different storms (Day 4), listen to student ideas comparing storm characteristics (e.g., how some storms have higher winds than others, some stay in the area for longer, some cause more flooding). Students will investigate hurricane characteristics in depth in the next lesson.
- Give students the Hurricane Resilience Quiz 1 to assess learning through the end of Lesson 3 (Part 1). Assessments can be downloaded from the Hurricane Resilience Assessments google folder.

Storm Stories Interview Protocol

Lesson 3 Student Pages: Storm Stories

Step 1: Prepare

- Think of two local people you are interested in interviewing. When thinking of who to interview, keep in mind:
  - Older people have experienced more hurricanes and tropical storms.
  - People who have lived in the area for many years will likely have experienced more storms in this area.
- Based on your Hurricane Timeline and how long these people have lived in the area, identify which hurricanes and tropical storms you want to ask them about.

Step 2: Set up your interview.

- Contact one of the two people and ask if you can interview them. Let them know that this is for a class project to explore how hurricanes and tropical storms have affected the local area. Tell them that you'd like to interview them about two hurricanes or tropical storms that they remember.
- If they agree to an interview, set up a time. (Your teacher will tell you when this assignment should be completed.)
- Not everyone wants to be interviewed. That's okay. If someone doesn't want to be interviewed, move on to the other person on your list.

Step 3: Conduct the interview.

- You'll need:
  - Two copies of the *Storm Stories Questionnaire* (one for each storm you're asking about)
  - A pencil or pen
  - The URL for the Storm Stories Google Form on a phone, tablet, or computer (if your class is entering the data into a spreadsheet).
- Remind the person that you'd like to ask them about two hurricanes or tropical storms that they experienced. Have them choose the storms. To help stay organized, interview them about one storm at a time.
- An interview is often more like a conversation. It's okay if there are pauses in the conversation.
- Ask questions from the *Storm Stories Questionnaire* to guide your interview. Listen carefully to the answers to the questions and note them in the *Storm Stories Questionnaire*.
- If the person doesn't remember something, note that in the *Storm Stories Questionnaire*. (There are options for "don't remember" for each question.)

Step 4: Upload your data.

- If your class is entering the data into a spreadsheet with the Storm Stories Google Form, enter your data using the form. Each questionnaire (Storm Story) should be added to the form separately, so you will fill out the form twice - once for each hurricane or tropical storm the person described.
- If your class is not using the Google Form, then bring your *Storm Stories Questionnaires* to the next class. Your class will analyze the data then.

Student name:

Storm Stories Questionnaire

Lesson 3 Student Pages: Storm Stories

My interview with _____ about _____ in the year _____.

(Fill in person's name.) (Fill in hurricane or tropical storm name.) (Fill in year.)

Before the storm

Where did you live at the time of the storm? (Name a town or city and state)_____

How did you learn that the storm was coming? (select all that apply)

- ○ TV
- ○ Radio
- ○ Internet
- ○ Friends or family
- ○ Other _____

How did you feel when you learned that the storm was coming? _____

_____

What did you do? (select all that apply)

- ○ Stocked up on food/water
- ○ Created an emergency supply kit
- ○ Installed window protections
- ○ Secured home exterior and items in the yard
- ○ Secured or relocated vehicles (car/boat)
- ○ Turned off electricity/gas
- ○ Planned for evacuation
- ○ Evacuated prior to the storm
- ○ Took care of other people or pets
- ○ Other _____

During the storm

What did you do during the storm? (select all that apply)

- ○ I evacuated nearby (less than 20 miles).
- ○ I evacuated far away (more than 20 miles).
- ○ Other people came to my house.
- ○ I stayed in a part of the house until the storm passed.
  Which part of the house? _____
- ○ I stayed inside.
- ○ I went outside.
- ○ Other _____

Was there flooding at your location?

- ○ Yes
- ○ No
- ○ Don't remember
- ○ Don't know because evacuated

Storm Stories Questionnaire

Lesson 3 Student Pages

Was there wind damage?

- ○ Yes
- ○ No
- ○ Don't remember
- ○ Don't know because evacuated

Were roads closed?

- ○ Yes
- ○ No
- ○ Don't remember
- ○ Don't know because evacuated

How long did the storm last?

- ○ Less than 1 day
- ○ 1-2 days
- ○ 3 days or longer
- ○ Don't remember
- ○ Don't know because evacuated

After the storm

I found that these items were damaged:

- ○ House
- ○ Cars/trucks
- ○ Boat
- ○ Trees
- ○ Belongings
- ○ Other _____
- ○ Nothing was damaged.

What did you do?

- ○ Fixed my home.
- ○ Fixed a car/boat.
- ○ Repaired other damaged items.
- ○ Cleaned up debris.
- ○ Checked on other people.
- ○ Cleaned up the yard.
- ○ Other _____

How long did it take for life to get back to normal? _____ (fill in the blank)

What decisions have you made to stay safe from hurricanes in the long term?

- ○ Bought flood insurance
- ○ Moved to higher ground
- ○ Modified home (such as raising it up to avoid flooding)
- ○ Developed an evacuation plan
- ○ Created an emergency kit
- ○ Bought a generator
- ○ Raised appliances
- ○ Other _____

Name:

Accounts of a Storm

Lesson 3 Student Pages: Storm Stories

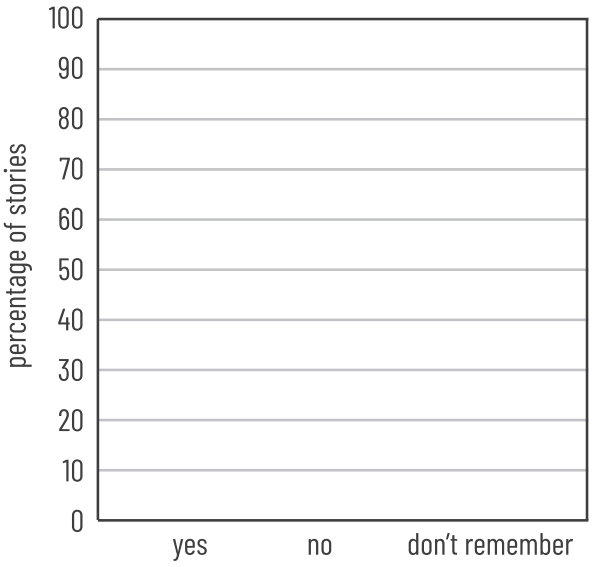
Storm Name: Year:

Total number of stories we collected about this storm:

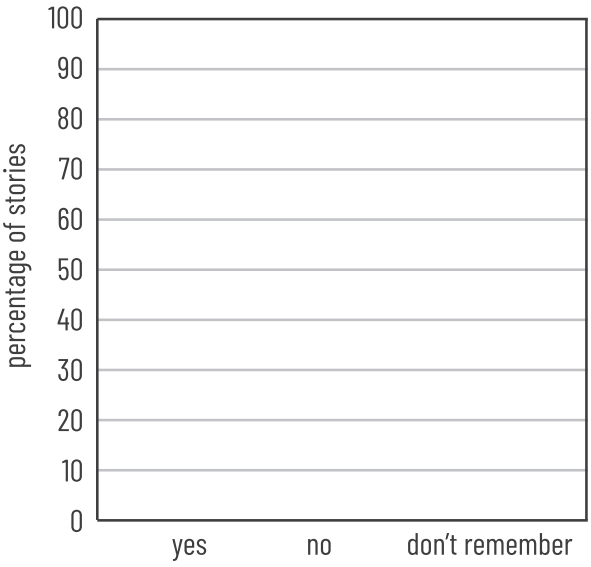
Part 1: What was the storm like according to the Storm Stories data?

Instructions: Make bar graphs to describe the percentage of stories that reported wind damage, flooding, and whether roads were closed. To calculate percentages of answers, you will need to divide the number of stories that had each answer by the total number of stories and multiply by 100. For example, if 4 out of 10 stories noted that there was wind damage that is 4/10 x 100 = 40%

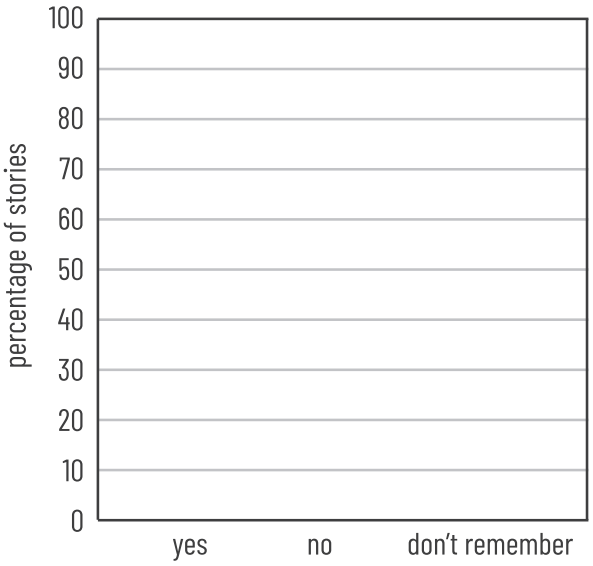
Was there wind damage?



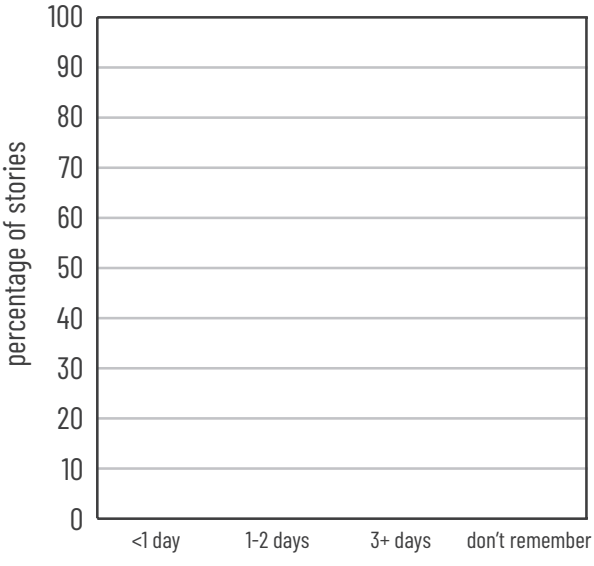
Was there flooding?



Were roads closed?



How long did the storm last?



Part 2: What was the storm like according to the storm's physical characteristics?

Instructions: Go to NOAA Historical Hurricane Tracks (coast.noaa.gov/hurricanes) and search for the storm. Since multiple hurricanes can have the same name, make sure to check that the storm has the correct year. Zoom into the map of the storm's track to find the data about the storm when it hit your location. Record the data below.

Storm category:	
Wind speed:	
How long was it over your location?	
From what direction did it approach the coast?	

What else do you notice about the storm?

Teacher Guide

Lesson 4: No Two Storms Are the Same

SKILLS:

Lesson question: Which aspects of hurricanes and tropical storms are most hazardous?

Learning objectives:

- Students analyze and interpret data from hurricanes that have impacted their area to understand that each storm has unique characteristics.
- Students identify storm characteristics that have the greatest effect on their community using geoscience data about the storms and data from storm stories.

Timing: Two class periods

Materials:

- Classroom computer, projector, and Internet access
- Lesson 4 slides: Hurricane Characteristics (download from scied.ucar.edu/HurricaneResilience)
- Student page: *Which aspects of hurricanes and tropical storms are most hazardous? (page 39)*
- One set of Storm Data Cards for wind, rain, and water level (download from scied.ucar.edu/HurricaneResilience).
- Table tents with the names of each hurricane or tropical storm in the data
- Chart paper
- Markers
- Timer
- Stray Prompts for Argumentation Session (page 40)
- List of respectful argumentation norms (page 41)
- Student notebooks

Preparation:

- Review the slides.
- Print copies of the student page, one for each student.
- Storm Data Cards are available for ten locations along the U.S. Gulf Coast and East Coast. Locate the collection of Storm Data Cards for storms that occurred in or near your region using the Hurricane Resilience website (scied.ucar.edu/HurricaneResilience). Print the data cards and cut them apart. Familiarize yourself with the data cards to be able to support student learning.

Directions

Day 1

Introduce the lesson.

- Reminds students that, as they learned in Lesson 3, multiple hurricanes and tropical storms have affected their region. Those storms are not all the same, so in this activity, students are going to explore what makes some hurricanes more hazardous than others by analyzing data about a variety of storms.

Orient students to the data.

- Hand out the student page: "*Which aspects of hurricanes and tropical storms are most hazardous?*"
- Introduce the storms. These storms represent a wide variety of tropical cyclones that have affected the region. Some are small tropical storms, and others are Category 3 or 4.

- Introduce the data types (the column headings in the table) and define each type of data using the information in Lesson 2's Slides. (Note that information about the data types categories are on the student page.)
  - **Slide 2:** describes forward speed and footprint
  - **Slide 3:** describes max wind speed and local winds
  - **Slide 4:** describes max rain and local rain
  - **Slide 5:** describes water level
- Model the process that students will use to collect information about each storm using data from Hurricane Issac. Start by writing the storm name and year in a row on their student sheet.
  - Show students the Hurricane Issac wind map (**Slide 6**).
    - The max wind is noted as 81 mph. According to the category scale on the student page, this is in the medium category. Instruct students to add "medium" into their table under max wind.
    - Forward speed is listed as 6 mph. This is in the slow category. Instruct students to add "slow" into their table under forward speed.
    - The footprint is listed as 418 miles, which is in the large category. Instruct students to add "large" into their table under footprint.
    - Local winds require looking at the colors indicating wind speed for a particular area (in this case, Terrebonne Parish, LA). Using the key, students should notice that most winds are in the 40-50 mph color, which would put the local winds in the medium category.
  - Show students the Hurricane Isaac rain map (**Slide 7**).
    - The max rain is listed as 27 inches. This is in the high category. Instruct students to add "high" into their table under max rain.
    - Looking at the map, and its key, students can identify the amount of local rain (i.e., the rain in Terrebonne Parish, LA). Students should notice that there are no areas that got over 10" of rain, which means it's not in the "high" category. Medium (areas with 5-10 inches of rain), is the correct category. Have students note this in their table under local rain.
- Show students the Hurricane Isaac water level graph (**Slide 8**)
    - This graph shows the water level measurements from a number of gauges in the area during Hurricane Isaac. The dark blue line indicates water level measurements in Houma, LA. Comparing the measured water levels with the light blue median levels (which is the average water level over many years for each day), students can figure out that the water level was higher than the median during the storm.

Students collect and categorize tropical cyclone data.

- Make a station for each storm in the classroom that includes the wind, rain, and water level data cards. (Note that water level data is not available for all storms.)
- Instruct students to fill in the parts of the table that correspond with the data for each storm using the same process that the class used for Hurricane Issac.

Students use the data to compare and contrast tropical cyclones.

- Show the Saffir Simpson scale (Slide 9). Explain that hurricane categories are based on max wind speed only. However, students have collected data about a number of other factors that can cause them to be hazardous.
- Have students refer to their data tables to compare two storms that have the same category.
  - Ask how they were similar. *(Their winds were similar.)*
  - Ask how they were different. (Have students compare other hurricane characteristics by asking: Are the storms moving at the same speed? Do they have the same rainfall? Are they the same size?)

- Have students refer to their tables to compare two storms that have very different characteristics.
  - Have students compare the two storms with a partner, looking at the data they collected in their student page.
  - Bring the class back together and ask what characteristics made each storm hazardous. *(Answers will vary depending on the storms, but should be consistent with the data students collected in their data tables.)*

Day 2

Claim-Evidence-Reasoning (CER): Which storm characteristic is most dangerous?

- Write the guiding question on the board: Which storm characteristic is most dangerous?
- Tell students that they will work in groups to construct an argument to answer this question. Then they will share their argument with the class and revise based on the class feedback and questions.
- Give each group a piece of chart paper and markers to record their argument using this basic format:

The Guiding Question:	
Our Claim:	
Our Evidence:	Our Reasoning:

- Familiarize students with the expectations for writing a CER argument:
  - ***Guiding Question:*** Which storm characteristic is the most dangerous?
  - ***Claim:*** an answer to the question. For example, "Our claim is … because …" It should be written as a sentence.
  - ***Evidence:*** data to support the claim. Students should cite evidence from the storm characteristics data they explored and also include at least one piece of evidence from the Storm Stories data supporting their claim. This could be a bulleted list or written in sentences.
  - ***Reasoning:*** the connection between the claim and the evidence. This is an explanation of why the evidence supports their claim. Students can relate their claim to vulnerability and the impact of hurricanes on their community. This is often written in sentences.
- Have each group construct their CER argument and write it on their chart paper.
  - Emphasize that this is complex and there is no one right answer. The task is to construct an argument that makes the most sense to the group based on the evidence available.
  - *(Note: Diligent students may want to dig deeper to come up with additional evidence. To help keep this exercise brief, have students only use evidence from the hurricane data that they analyzed and the storm stories they remember.)*

Mini-Argumentation Session: Sharing Our Thinking

- Have students post their CER argument chart paper posters around the room.
- Explain the purpose of an argumentation session.
  - Stress to students that the goal of argumentation is to learn from each other and bring back information that can be used to strengthen their own argument. It is NOT about proving someone right or wrong.

  - In this case, the word "argument" means a reason and evidence that supports a claim. An argument is communicated to help others understand. (It's not a fight between people who disagree, which is a definition that might be more familiar to students!)
  - Respectful discussion protocols should be adhered to. Disagreeing with ideas and respectful argumentation is encouraged; disagreeing with people's opinions and name calling is not allowed. See the list of *respectful argumentation norms* as a resource.
- Describe the argumentation format. (which is sometimes called "Stay-Stray").
  - Each group will choose one person to stay at their poster and explain it to their classmates in 1-2 minutes, and then answer questions in 2-3 minutes.
  - The rest of the group members will visit other posters to hear from different presenters and ask questions. Group members should split up and go to as many other groups as possible.
  - You will indicate that it's time to switch every five minutes. The presenters stay put, and the other students move to another poster, ideally one that their other group members have not yet visited.
  - Repeat rounds as time allows. Two to three rounds are ideal for allowing students to receive and give feedback.
  - You may want to have students take notes and refer to the list of question prompts during the Q&A portion.
- After the argumentation rounds, students should return to their original groups to debrief and discuss what they learned from their classmates. Provide the following things to consider on the board to help guide group discussions:
  - If other groups made the same claim as they did, what evidence did they use to support their claim?
  - Which arguments did they feel were stronger than others? What made one argument stronger than another?
  - What feedback did your group receive about your own argument? Were there areas that could be clarified or expanded? Are there new ideas that could be added to strengthen your argument?
- In their groups, students should suggest revisions to their argument to strengthen and clarify. They should discuss and reach consensus, if possible, about their final argument. The final version should be written and turned in.
  - You may wish for students to work individually to revise and turn in their own final argument. (This could be completed as out of classwork.) This would provide an individual grade and would document how each student chose to make revisions.

Wrap up the activity.

- Bring the class together and review students' arguments about answers to the question *(Which storm characteristic is most dangerous?)*. Note that there is not one particular characteristic that is a correct answer to this question because a variety of storm characteristics contribute to making a storm dangerous. Thus all arguments can be correct depending on the situation.

Opportunities for Assessment:

- Student work during Day 1 should reflect their ability to analyze and interpret data, including mapped data. Collect the student page and check whether the information that students add to their tables is correct.
- On Day 2, students complete a CER activity, supporting their claim about what aspect of hurricanes is the most dangerous with evidence and reasoning. There is no one correct claim. All characteristics can be hazardous, which should lead students to come up with different claims. Ensure that their evidence is accurate and reasoning is sound.
- During the argumentation rounds on Day 2, visit each group and note whether students are following the respectful argumentation norms and whether the information discussed is helpful for strengthening arguments.
- Consider having the final arguments be written up by each student individually to allow assessment of individual understanding of the claim, evidence, and reasoning.

Name:

Which aspects of hurricanes and tropical storms are most hazardous?

Lesson 4 Student Page

To learn more about hurricanes and tropical storms that affected a region, you will analyze and interpret data about the size, forward speed, winds, rain, and water level during past storms.

For each type of data, assign each storm a category (using the ones on the right) based on the maps, graphs, or measurements. (For example, if a hurricane had a forward speed of 21 mph, it would be in the "fast" category.)

Write the name of the storm and the categories into the table below.

Storm name and year	Data Type: Forward speed	Data Type: Footprint	Data Type: Max wind speed	Data Type: Max rain	Data Type: Max flooding

Categories for each data type:

FORWARD SPEED
Fast = above 15 mph
Medium = 10-15 mph
Slow = less than 10 mph

FOOTPRINT (geographic size)
Large = more than 300 miles across
Medium = 200-300 miles across
Small = less than 200 miles across

MAX WIND SPEED
High = more than 100 mph
Medium = 75-100 mph
Low= less than 75 mph

MAX RAIN
High = More than 20" of rain
Medium = 10-20" of rain
Low= less than 10" of rain

MAX FLOODING (based on water level)
High = more than 6 feet
Medium = 3-6 feet
Low = less than 3 feet

How to estimate footprint:

Use the wind map to estimate a storm's footprint, which reflects the geographic size of the storm.

Put a piece of paper or a ruler perpendicular to the storm track (black line) and measure the maximum distance where winds were at least 40 mph.

Compare the distance you measure to the scale on the map to find the footprint in miles.

Stray Prompts for Argumentation Session

GENERAL QUESTIONS

1. I'm still not quite clear about what you are saying. Can you tell me more about that?
2. Why do you think that?
3. What is your evidence for that idea?
4. Thinking about where you got blocked, how could we help you or your group?
5. Did you consider .....?
6. I agree with your group about ..... but I'm not sure that I agree with .....

EXPERIMENTAL DESIGN QUESTIONS

1. What did your group do to collect that data?
2. Why did you think that way was the best to do it?
3. What did your group do to make sure that your measurements were correct?
4. What did your group do to make sure that your calculations were correct?
5. What did your group do to be systematic? (try one thing at a time)

CLAIM QUESTIONS

1. How do you know that your claim is valid (right?)
2. What other claims did your group discuss before you decided on that one?
3. Why did your group abandon the other claims?

EVIDENCE QUESTIONS

1. Can you explain how you analyzed the data to find patterns and trends?
2. Why did your group use that approach to analyze the data?
3. Was there any evidence or data that did not fit your claim?

REASONING QUESTIONS

1. What other interpretations of the data did your group consider?
2. "But how does that evidence support that claim?" (Reasoning)
3. What else could you do to be more certain?

JUSTIFICATION QUESTIONS

1. How does your claim fit with scientific theories or laws that you have studied?
2. What could you do next to be more certain that your claim is completely correct?
3. How certain are you that your group's claim is accurate? What are you still uncertain about?

Respectful Argumentation

1. Respect for the other person is more important than your ideas.

2. Don't interrupt.

3. Don't dominate. Allow others to ask questions (even invite them).

4. Challenge ideas, not people or groups.

5. Remember that the goal is "improving your argument," not "winning."

6. Remember that your goal is to learn from the other person to help them and your group.

7. Evaluate the evidence, not the person.

8. Ask "open-ended" (not yes/no) questions that require the person to explain, and not defend.

Adapted from resources developed at the Denver Museum of Nature and Science.

Name:

Is climate warming affecting hurricanes and tropical storms?

Lesson 5 Student Pages: Hurricanes and Climate Change

Hurricanes have different names in other parts of the world. The storms referred to as **hurricanes** in the North Atlantic and East Pacific are called **typhoons** when they happen in the West Pacific and **tropical cyclones** when they happen in the Southwestern Pacific and Indian Ocean. In this activity, you'll investigate whether climate change is affecting these storms.

We know that hurricanes form above warm ocean water and that warmer water makes them stronger. The planet is warming, which has caused sea surface temperatures to climb. Has the warming climate affected hurricanes? This is an area of active research. One way that scientists are trying to answer this question is by looking at the history of these storms to see whether they have changed.

The table below on the left side shows the total number of hurricanes that happened in each region during three time periods. The table below on the right side shows the number of very strong hurricanes that happened during the same time periods. Answer the questions based on the data and label the map on the following page (page 47).

Total Number of Hurricanes:

Region	1971-1985	1986-2000	2001-2016
East Pacific Ocean	148	150	143
West Pacific Ocean	137	228	228
North Atlantic	78	92	116
Southwest Pacific	76	101	76
North Indian Ocean	0	17	17
South Indian Ocean	91	123	129

Number of Strong Hurricanes (Category 4 and 5 storms)

Region	1971-1985	1986-2000	2001-2016
East Pacific Ocean	35	50	42
West Pacific Ocean	24	22	37
North Atlantic	13	21	31
Southwest Pacific	7	9	23
North Indian Ocean	0	4	6
South Indian Ocean	16	22	34

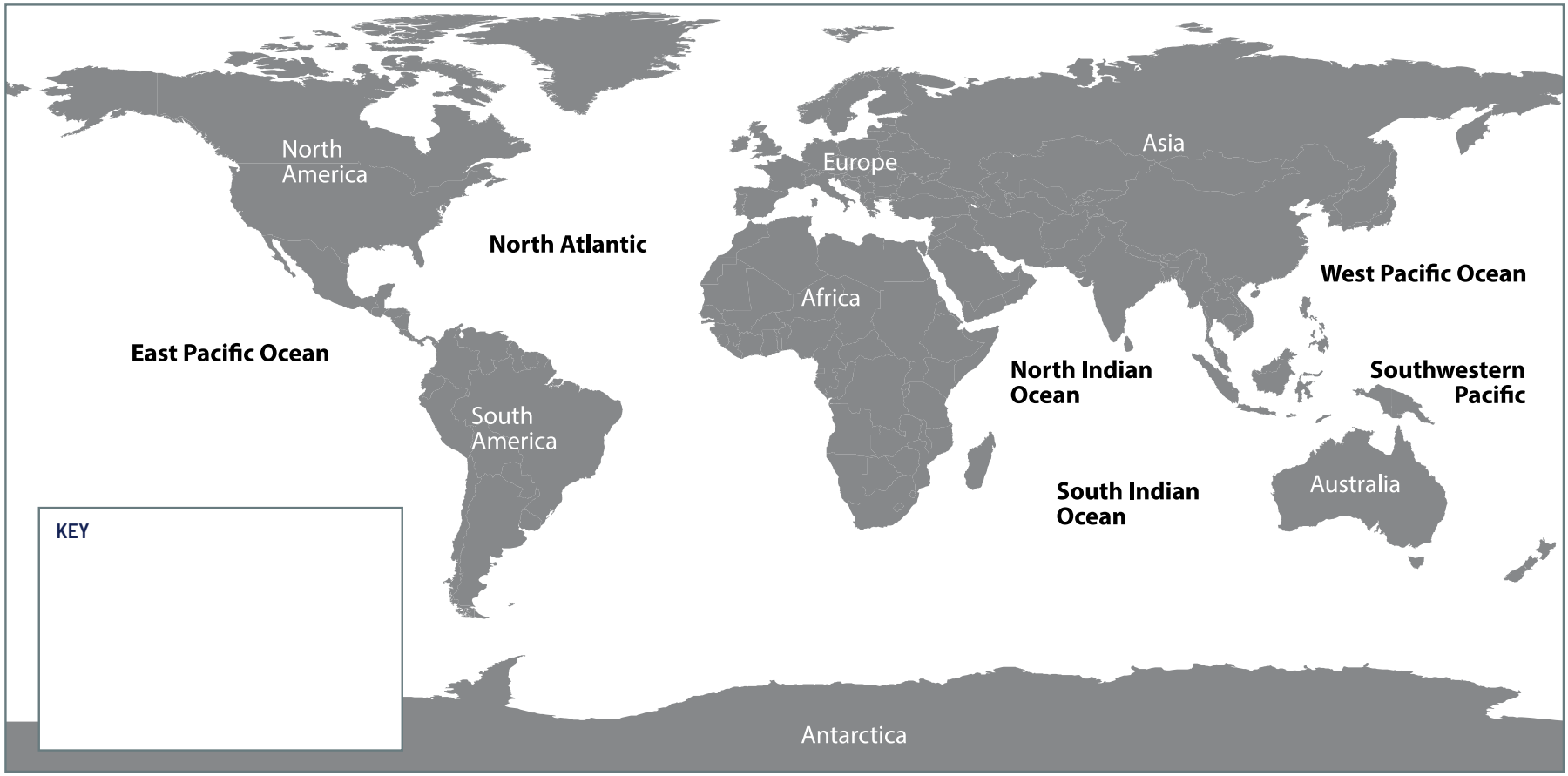
Data from NOAA National Centers for Environmental Information IBTrACS v.3 retrieved by Ming Ge (NCAR)

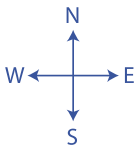
Questions:

1. Has the total number of hurricanes increased, decreased, or stayed about the same? Is the trend the same for all regions?
2. Has the number of strong (Category 4 and 5) storms increased, decreased or stayed about the same? Is the trend the same for all regions?

Is climate warming affecting hurricanes and tropical storms?

Lesson 5 Student Pages





Create a color or symbol code to label your map using the data tables on the previous page (page 46).

- Show where the number of hurricanes has increased or decreased over time.
- Show where the number of strong hurricanes has increased or decreased over time.
- Make a key on your map to explain your colors/symbols.

In the space below, write an explanation for the patterns you see in the data.

Name:

Comparing Three Locations

Lesson 5 Student Pages: Part B Extension

Use NOAA Historical Hurricane Tracks to compare hurricane frequency and intensity in three coastal locations between 1986-2000 and 2001-2016. Make sure that you use the same radius for all three locations in the tool.

LOCATION 1:

Time Period	Number of Tropical Cyclones (tropical storms and hurricanes)	Number of Strong Hurricanes (Category 4 and 5)
1986-2000		
2001-2016		

LOCATION 2:

Time Period	Number of Tropical Cyclones (tropical storms and hurricanes)	Number of Strong Hurricanes (Category 4 and 5)
1986-2000		
2001-2016		

LOCATION 3:

Time Period	Number of Tropical Cyclones (tropical storms and hurricanes)	Number of Strong Hurricanes (Category 4 and 5)
1986-2000		
2001-2016		

Comparing Three Locations

Lesson 5 Student Pages: Part B Extension

Claim-Evidence-Reasoning

After you have collected the data, state a claim about similarities or differences between hurricanes and tropical storms in the three locations, provide evidence from the data, and explain their reasoning about why the evidence supports the claim.

1. Your claim:

2. What evidence supports your claim:

3. Explain why the evidence supports your claim:

Teacher Guide

Lesson 5: Hurricanes and Climate Change

Lesson question: Is warming affecting hurricanes?

Learning objectives:

- Students analyze data to understand how the frequency and strength of hurricanes and tropical storms are changing over time.

Timing: One class period

Materials:

- Classroom computer, projector, and Internet access
- Lesson 5 slides; Hurricanes and Climate Change (download from scied.ucar.edu/HurricaneResilience)
- Student pages: *Is climate warming affecting hurricanes and tropical storms?* (pages 46-47)
- *How Hurricanes Form* article (scied.ucar.edu/learning-zone/storms/how-hurricanes-form)
- Colored pencils or markers
- Hurricane Timelines (created in Lesson 2)
- **Materials for optional extension:**
  - Student page: *Comparing Three Locations* (pages 48-49)
  - Computers with Internet access and the *NOAA Historical Hurricane Tracks*

Preparation:

- Check the slides and make sure the video in **Slide 2** plays. (Use the URL in the slide notes if it will not play from the slide.)
- Print copies of the *How Hurricanes Form* article for each student or provide the URL and computers so that students can read the article online.
- Make copies of the *Is climate warming affecting hurricanes and tropical storms?* student pages. It will be easiest if this is not printed double-sided so that students can look at both pages at the same time.

Directions

Introduction

- Have students review which aspects of hurricanes and tropical storms make their community most vulnerable. *(Students should refer to their findings from the previous day's CER assignment and refer to storm characteristics such as winds, flooding, precipitation, or the rate of forward movement.)*
- Tell students, since we now know what aspects of these storms are dangerous, we'll consider how they become dangerous - how they grow larger and stronger.

What does a hurricane need to grow?

- Have students read the *How Hurricanes Form* article online (or from printed copies). (Note: this can be done as homework before class.)
- Direct students to the *What a Hurricane Needs to Form and Grow* section. Ask students: Why do hurricanes lose strength when they move out of the tropics?
  - From the reading, students should understand that warm ocean water is the source of energy for hurricanes. Also, warm ocean water creates warm and moist air, which leads to a hurricane's clouds and rain.

- Play the NASA Animation of Surface Sea Temperatures (**Slide 2**) for the class and ask: *Where are the oceans the warmest?*
  - The ocean temperatures are warmest in the tropics (between 30°N and 30°S latitude). When the storms move beyond the tropics, where ocean temperatures are lower, they lose strength.
- Review the concept that ocean temperatures are highest in the tropics because these locations receive more direct thermal energy in the form of sunlight, which heats the water.

The ocean is getting warmer as the climate warms.

- Project the slide of the Graph of Change in Average Global Temperature (**Slide 3**) and describe that the data indicate that Earth is warming. Ask students how they think this change in the Earth's average temperature has affected the ocean (i.e., has climate warming caused the ocean to warm?). Explain that data about ocean temperature can help us answer that question.
- Project the slide of the Graph of Average Global Sea Surface Temperatures 1880-2015 (**Slide 4**). Ask students to make observations and ask questions about what the graph is showing.
- Write the following prompts on the board and have students discuss with a partner:
  - What do you see? What do you wonder about?
  - What trends or patterns do you notice?
- Instruct each pair of students to write a caption that includes the trends or patterns that they notice in the graph and an explanation of what they think it means. Student pairs share out their captions with the class.
  - *Students should notice an overall warming of surface sea temperatures. They may also notice that temperatures cooled from 1880 to 1910, warmed from 1910 to 1945, were stable from 1945-1970, and then warmed again from 1970-2015. Students may also notice seasonal changes in temperature each year. It is worthwhile to point out that temperatures vary regionally, and that this is an average of sea surface temperatures.*

How does a warmer ocean affect hurricanes and tropical storms?

- Ask students to make a prediction about how the increasing sea surface temperatures are affecting hurricanes. Tell students that they will investigate this prediction with data about hurricanes and tropical storms around the world.
- Pass out *Is climate warming affecting hurricanes and tropical storms?* student pages (data table, questions, and map). Have students look at the world map with labeled regions. Explain that hurricanes occur in all the regions indicated on the map. They are called hurricanes in the Atlantic and Gulf of Mexico and are called tropical cyclones in other regions.
- Have students answer the first two questions based on the data table:
  - According to the data, are hurricanes becoming more frequent? *(In some regions)*
  - According to the data, are hurricanes getting stronger? *(Yes, in all regions)*
- Have students use the data to annotate their map following the instructions at the top of the map page. Students should write an explanation below their map for the patterns.
- Hold a class discussion to share student explanations of the patterns.
  - Note that there is some ambiguity in the data about the total number of storms. Not all areas show the same trend in the number of storms. It's okay if students disagree about the trend in the number of storms.
- Show **Slide 5**, Losses Due to Hurricanes and Tropical Storms in the US. Explain that losses refer to the amount of damage.
  - Ask students what they notice about the amount of losses over time. *(Students should notice that there has been an increase in damage from hurricanes and tropical storms over time.)*
  - Ask students to consider what might happen in the future as these storms continue to change due to climate warming. *(Students will likely speculate that coastal communities will be more vulnerable if hurricanes continue to get stronger.)* Tell students that they will be exploring storm impacts and damage later in the unit.

Are hurricanes changing in our area?

- Have students answer this question by looking at their Hurricane Timeline and counting the total number of storms between 1986-2000, the total number of storms between 2001-2016, and the number of strong hurricanes (Category 4 and 5) in those same time frames. (If time is short, have students count the storms on one student's Hurricane Timeline and then explore the data as a class.) The table below may help students organize this information.

FROM MY HURRICANE TIMELINE:

Time Period	Total Number of Hurricanes and Tropical Storms	Number of Strong Hurricanes (Category 4 or 5)
1986-2000		
2001-2016		

- While answers will vary depending on location and the radius that students used to search for hurricanes and tropical storms using Historical Hurricane Tracks, the following questions can help students connect their local data to the global data they explored earlier:
  - Is the local pattern the same as the global pattern, showing an increase in strong hurricanes? *(Students will likely note that the sample size of strong hurricanes is very small. It would be hard to detect a trend given a low number from a small area.)*
  - Is the total number of hurricanes and tropical storms, more, less, or about the same in the two time periods? *(Depending on the location along the Atlantic or Gulf coasts, this number may show an increase, a decrease, or be about the same. Remind students of what they found in the global data about the total number of storms - in some areas the number has increased, and in others, it's about the same or has decreased.)*

Wrap-up

- Refer to the driving question (*Is warming affecting hurricanes?*) and note that knowing how environmental changes are affecting community vulnerability will help us make good plans for hurricane resilience in the future.
- Bridge to the next activity: Tell students that, by looking at how these storms have been changing, we can project how they might change in the future. During the next two lessons, the class will consider the future of hurricanes, rather than the past, to understand how climate warming will likely affect them in the future.

Optional Extension

(This builds upon "Are hurricanes changing in our area?" and will take about 30 minutes.)

- To further explore how hurricanes have changed, students use the *Comparing Three Locations* student page (pages 48-49) and NOAA Historical Hurricane Tracks to compare hurricane frequency and intensity in three coastal locations between 1986-2000 and 2001-2016.
- Provide guidance if students need suggestions about choosing locations. You might suggest that students choose to compare a location along the Gulf Coast with two locations along the U.S. East Coast.
- Students should ensure that the same radius is selected for all three locations (for example, 100 nautical miles) in the tool. Have students refer to the directions that they followed during Lesson 2 if they need support using the tool.
- Claim-Evidence-Reasoning: After students have collected the data, they should state a claim about similarities or differences between hurricanes and tropical storms in the three locations, provide evidence from the data, and explain their reasoning about why the evidence supports the claim.

Opportunities for Assessment:

- The presentation at the start of the lesson provides a number of opportunities for students to interpret graphs and maps of data.
- The student pages provide additional opportunities to assess student abilities to analyze and interpret data. In this case, students analyze and interpret summary data about the number of hurricanes in different regions and at different times.
- The extension activity provides an opportunity for students to gather and analyze hurricane data based on their own interests in terms of locations, make a claim, cite evidence from the data, and explain their reasoning.

Teacher Notes:

- The article *Hurricanes & Climate Change* (c2es.org/content/hurricanes-and-climate-change) is a useful source for learning about what we know about the impacts of a warmer climate on hurricanes.
- Note that climate change is also causing sea level rise, which makes the potential impacts of landfalling hurricanes and tropical storms more damaging. In the next lesson, students use the *NOAA Sea Level Rise Viewer* to explore what areas of the local area are most vulnerable to rising sea levels.
- Supporting student understanding of climate change: If students need support understanding how greenhouse gas emissions cause climate change, consider assigning students to read the short article *Why Earth Is Warming* (scied.ucar.edu/learning-zone/how-climate-works/why-earth-warming) before or after this lesson.

Teacher Guide

Lesson 6: Sea Level Rise

SKILLS:

Lesson question: How will sea level rise affect our coast in the future?

Learning objectives:

- Students learn from a video how global sea sea level rise is caused by climate warming.
- Students analyze a map to learn that sea level rise is not the same along every coast because of changes in the level of the land along the coast.
- Students use an interactive map as a model to learn how their local coastline will likely be affected by sea level rise over the next hundred years.

Timing: One class period

Materials:

- Classroom computer, projector, and Internet access
- Sea Level Rise video from the NOAA National Ocean Service (access at scied.ucar.edu/HurricaneResilience)
- NOAA map of Sea Level Trends (tidesandcurrents.noaa.gov/sltrends/sltrends.html)
- NOAA Digital Coast Sea Level Rise Viewer (coast.noaa.gov/slr)
- Paper and pencil for exit ticket question

Preparation:

- Preview the video, the Sea Level Trends map, and the NOAA Digital Coast Sea Level Rise Viewer.

Directions

Introduction

- Remind students that in the last lesson, they learned that climate warming is causing hurricanes to change and stronger storms to become more common. In this lesson, students are going to take a look at another effect of climate change that is making our coast more vulnerable: sea level rise.
- Tell students that today we will be looking at why sea level rise is happening, look at data about the amount of sea level rise that's occurring, and then investigate how this will likely affect our coast in the future.
- Remind students that they learned how hurricanes and tropical storms cause storm surge, which is a temporary increase in sea level. In this investigation, they will be focusing on sea level rise that is long-term, not just during a storm.

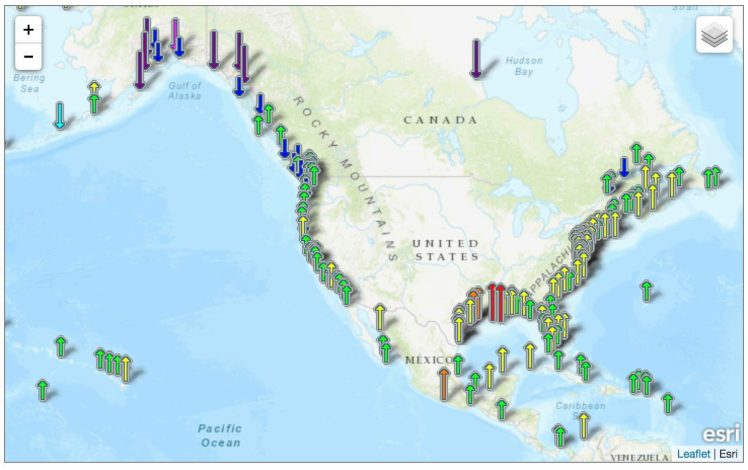
Explain how climate warming causes global sea level rise.

- Watch from minute 7:43 to 18:36 of the Sea Level Rise video from the NOAA National Ocean Service. Before you play the video, provide students with the following guiding questions to consider as they watch.
  - How much of the sea level has risen in the past century? *(On average over the past century, rise has been 1.5 mm/yr, but the rate of rise is increasing. It was 1.1 mm/yr early in the century and 2.79 mm/yr rise recently.)*
  - How do we know? *(measurements from tide gauges and satellites)*
  - What are the two reasons for the increase in global sea level? *(melting of glaciers and other ice on land, and thermal expansion of seawater)*
  - How do increases in air temperature (global warming) cause sea level to rise? *(The ocean is absorbing most of the extra heat, expanding water, and is causing ice on land to melt and add water to the ocean.)*

  - Why is the air temperature warming? *(Because there are extra greenhouse gases in the atmosphere from fossil fuel emissions.)*
- Note: Pauses for discussion are embedded within the video, which you can use to review the guiding questions.
- Ensure that students understand the two reasons for sea level rise that they learned about in the video: (1) seawater expands with heat, and (2) water is added to the ocean as land-ice melts.
- Ask students why these two processes are happening now. (*Because of climate warming*)

Explain how changes in the land along a coast contribute to change in sea level, too.

- Project the NOAA map of Sea Level Trends for the class and explain that this map shows how water levels are changing along coasts according to tide gauge data.
- Have students focus on coastal sea level measurements over large areas, such as the U.S. east and Gulf coasts. Students should notice that the amount of sea level rise is not the same everywhere.
- Explain that these variations in the rate of sea level rise are due to differences in the *subsidence and uplift* of coastal land in different locations. Provide the following examples:
  - Navigate the map to coastal Louisiana. Students will notice that the arrows indicate that sea level is rising at a much faster rate than in other places. Explain that this is because the land is sinking lower, a process called *subsidence*, which compounds the amount of sea level rise.
  - Navigate the map to the coast of southern Alaska. Students will notice that the arrows indicate that sea level is decreasing. Explain that this is happening because the land is rising, a process called *uplift*. (If students are familiar with plate tectonics and isostatic rebound, mention that these are the reasons that land is rising up.) The rate of land rising is greater than the rate of global sea level rise due to climate change, which makes sea level decrease along the coast in this location.
  - Navigate the map to the U.S. East Coast. In this region, land is not sinking or rising much. Students should notice that the arrows indicate a modest level of sea level rise. This is the effect of global sea level rise without any other change to the elevation of the land surface.
- Post the question: How has sea level in our local area been changing?
  - As a class, zoom into the map to find the arrow closest to your local area.
  - Note the color of the arrow and look at the key to see how much sea level rise the arrow represents. The sea level trends in the key are described in mm/year, which the tide gauges measure, and also in feet/century, which is extrapolated based on the data.)
  - Locate the number of feet/century that corresponds with the arrow closest to your coast. You will need this number for the next part of the lesson.

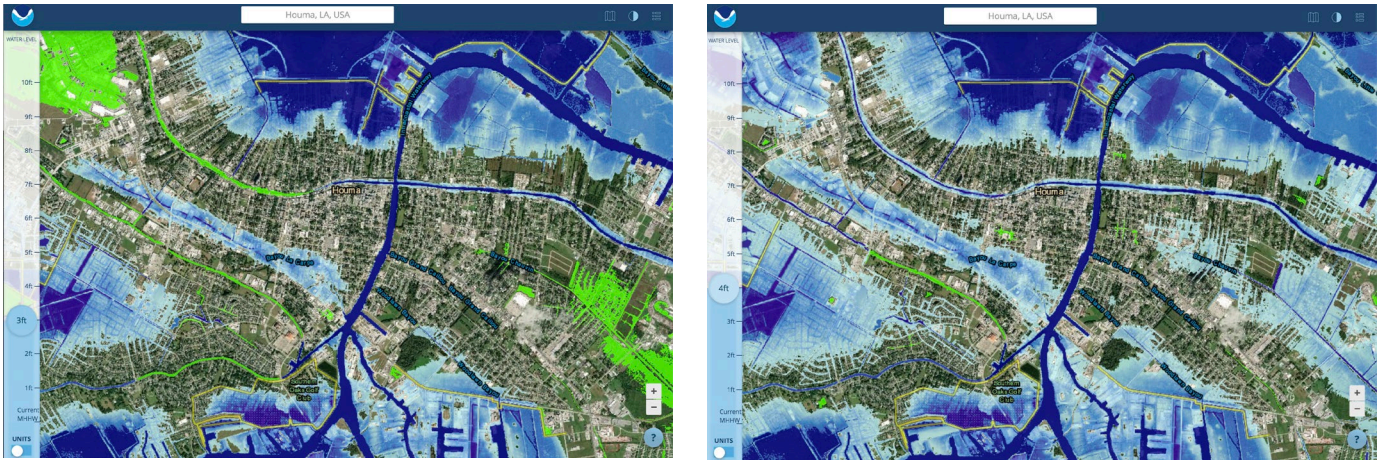


NOAA map of relative sea level change in North American coastal locations

Investigate a map that shows the future of sea level rise.

- Project the Sea Level Rise Viewer from NOAA Digital Coast for the class and explain:
  - While the previous map showed recent changes in sea level, this map will let us see what sea level may look like along our coast in the future.
  - We'll be using the map as a model. Models are used in earth and environmental science to simulate real conditions so that we can predict how environments will be affected when there is a change.

- Enter your location into the search. (You may need to zoom the map in or out so that the class can see the entire coastline.)
- Orient students to the map.
  - The map legend, which is visible when you click the button in the upper right. Green indicates low-lying areas, blue indicates water, and levees are shown as yellow lines.
  - On the left side of the map is the water level indicator. The blue circle indicates the water level compared to today. (MHHW means "Mean Higher High Water," which is the average height of the highest tide recorded each day during the recording period).
- Raise the water level indicator to the number of feet per century that you found as the rate of sea level rise using the NOAA map of Sea Level Trends. Have students observe what areas of their local coastline become flooded (changing to light or dark blue on the map).
  - If the number of feet/century for your area is listed as a range (such as 1 to 2 feet) in the Sea Level Trends map, move the water level indicator to the minimum value of the range and have students make observations. Then move the water level to the higher end of the range and have students again make observations.
  - If your location has the highest rate of sea level rise (above 3 feet/century), no upper limit is given on the map of sea level trends. In coastal Louisiana, the only U.S. location in that category, local measurements have found sea level rise of 4.2 feet over the next century, which can be used as the upper limit.
- With the Sea Level Rise Viewer map of your local area projected, have students note what locations look vulnerable to flooding in the future and which locations look like they will stay dry. Ask students to describe why certain locations are more or less vulnerable to flooding. List the areas on the board.
- Discuss the Sea Level Rise Viewer as a model. How does it accurately simulate real conditions? How is it simplified? Students may mention the following:
  - The model includes information about the elevation of the land surface, which is what allows it to identify what areas might flood in the future.
  - The model does not include predictions of areas where sediments may accumulate in the future or how floodgates and human-built levees could change the outcome.



The Sea Level Rise viewer showing Houma, Louisiana, with a 3 foot (left) and 4 foot (right) rise in sea level.

Connecting Future Sea Level and Hurricanes

- Help students consider prior knowledge about coastal flooding during hurricanes.
  - Remind students that through Storm Stories (Lesson 3), they heard about the hazards of flooding during hurricanes.
  - Remind students that when they analyzed data about hurricane characteristics (Lesson 4), they learned about how much flooding occurred during different tropical storms and hurricanes.
- As an exit ticket, have students answer the question: How will sea level rise affect the way that hurricanes impact our coast in the future?

Opportunities for Assessment

- Ensure that students can name the two reasons that a warmer climate causes sea level rise: (1) melting glaciers and ice sheets and (2) expansion of sea water as it warms.
- During the sensemaking discussion, listen to the reasons why students think certain locations will be vulnerable to flooding in the future and why other regions might be more protected. As students move into Part 3 of the curriculum, they will gain more experience with the idea that vulnerability and risk are not evenly distributed.
- With the exit ticket, note whether students are combining what they have learned about the impacts of hurricanes with the impacts of sea level, particularly whether they recognize that the chances of flooding compound when sea level rise is combined with storm surge. Additionally, students may recognize that sea level rise will change the shape of the coast or flood wetlands, which serve as a buffer (depending on the location). These types of changes would cause a landfalling hurricane to affect different locations and to have more severe impacts.

Teacher Notes:

- For more information and educational resources related to the NOAA Sea Level Rise Video, visit oceanservice.noaa.gov/education/sea-level-rise
- The Sea Level Rise Viewer does not account for future engineering adaptations developed to help prevent flooding. Raising this point with students can start a productive conversation about how engineering can help improve resilience, which they will be moving towards in the third part of the curriculum. Note that some coastal engineering can cause benefits in one area while causing problems in another area. For example, jetties along a coast can cause beaches to widen on one side of the jetty, protecting the community, while sand erodes from the other side of the jetty.
- There is some uncertainty in future sea level rise projections. Over this century, global sea level will rise an average of 1.7-4.0 feet (0.5-1.2 m) due to climate warming. If large parts of ice sheets slip into the ocean, that number will be higher. This is an area of active research. See the background content at the beginning of this curriculum for more information about sea level rise.
- In places where land is subsiding, like coastal Louisiana, there will be more sea level rise because land subsidence adds to the sea level rise caused by climate warming. In places where land is uplifting, like southern Alaska, sea level rise will have less impact over this century along the coast.

Teacher Guide

Lesson 7: Warmed-up Storms

SKILLS:

Lesson question: What would past hurricanes be like if they happened in a warmer world?

Learning objectives:

- Students compare data from actual hurricanes and tropical storms with model data that represents what the same storms would be like in a world with a warmer climate, learning that storms will likely become windier and can cause more rainfall.

Timing: One class period

Materials:

- Classroom computer, projector, and Internet access
- Lesson 7 Slides: Warmed-up Storms (download from scied.ucar.edu/HurricaneResilience)
- *Storm Data Cards* for your region (also used in Lesson 4, download from scied.ucar.edu/HurricaneResilience)
- *Warmed-up Storm Data Cards* for the same region as the *Storm Data Cards* (download from scied.ucar.edu/HurricaneResilience)
- Table tents with storm names
- Student page: *What would hurricanes and tropical storms be like in a warmer world?* (page 57)
- Markers (one for each student)
- Long paper strips for writing headlines (one for each student)
- Driving Question Board (used in previous lessons)

Preparation:

- At the Hurricane Resilience website (scied.ucar.edu/HurricaneResilience), locate the collection of *Warmed-up Storm Data Cards* from the same region as the *Storm Data Cards* you used for Lesson 4. Data Card collections are available for seven locations along the U.S. Gulf, Caribbean, and Atlantic coasts. Choose the one that is closest to your location to help students focus on their region.
- Print the data cards and set up stations around the room with the cards and table tents that note each storm name. Alternatively, have the PDFs of *Warmed-up Storm Data Cards* and *Storm Data Cards* available on computers for students to access and compare.
- Make copies of the student page - one for each student.
- Review the slides.

Directions

Introduction

- Have students review what they have learned in Lessons 4-6:
  - The most hazardous aspects of hurricanes (such as wind, rain, and flooding) (Lesson 4)
  - Hurricanes worldwide are getting stronger as climate warms (Lesson 5)
  - Climate change is causing sea level rise, which is making our coast more vulnerable (Lesson 6)
- Show the climate stripes (**Slide 2**) to remind students that climate has been warming, which is why hurricanes are getting stronger and the reason that global sea level is rising. Note that climate is predicted to continue warming in this century. While estimates vary, sometime later this century, global climate will be 2°C warmer.

- Ask students: What do you think those storms would be like if they happened in a world that was 2°C warmer? (**Slide 3**) Explain that we can answer this question by comparing the characteristics of the actual storms with storms modeled as if they happened in the same location but in a warmer world. Modeling can allow us to get an idea of what future hurricanes might be like. This is one way that climate scientists figure out how warmer temperatures will affect hurricanes.
- Computer models that take into account lots of different parts of the Earth system (**Slide 4**) are used to predict how climate is likely to change in the future, and they can also be used to predict how climate warming will affect hurricanes.
- These simulations model the atmosphere, land, ocean, and ice around the world. This takes a lot of computing speed, so it's done with supercomputers (**Slide 5**).
- Show students an image of a simulated hurricane (**Slide 6**) and explain that this is not an actual hurricane; it was generated with a computer model.

Compare actual and warmed-up storms.

- Show **Slide 7** to remind students of the question that they will explore with data analysis (What if historical storms happened again in a world that is warmer by 2°C?) If possible, leave the slide projected while students complete the data analysis.
- Introduce the data stations to students. (Stations around the room for each hurricane and tropical storm in the set.)
- Give each student a copy of the *What would hurricanes and tropical storms be like in a warmer world?* student page and introduce the instructions. Describe that students should compare the actual storm to the warmed-up version. Go over an example at one of the stations together as a class before sending students to the stations to explore the data.
  - **Wind:** Introduce the warmed-up wind map, which was generated with a computer model. students should compare the max wind of the warmed-up storm and actual storm.
  - **Footprint:** Remind students how to measure the footprint using the wind map. They'll measure and compare the footprint of the actual and warmed-up storms.
  - **Rain:** Tell students that we know that rainfall increase by 7% per degree Celsius of warming, so in a 2°C warmer world, there would be 14% more rain. Multiply the storm's max rain by 1.14 to estimate the max rain of the warmed-up storm.
  - **Flooding:** Remind students that sea level rise is affecting the water level. If you are using hurricane data from your region, students can add the estimate of sea level rise for their region that they found in Lesson 6 to the max water level.
- Provide at least 10 minutes for students to visit stations around the classroom. Students may not have time to visit every station, but they should be able to discern the pattern if they visit three or more stations.

Draw conclusions from the data analysis.

- Pass out long strips of paper and markers, one per student.
- Have each student write a headline to sum up what happens to hurricanes in a warmer world. Remind students that a good headline is catchy but, more importantly, it gets at the heart of the issue.
- Have students hang their headlines on the wall. Show **Slide 8** and have students discuss what they found. (*No matter which hurricane or tropical storm they analyzed, students will find that rainfall, winds, storm footprint, and flooding increase in a warmer world.*)

Review what we know and what we don't yet know about how hurricanes are changing.

- Describe what scientists know.
  - **Slide 9**: The amount of rainfall is increasing as climate warms.
  - **Slide 10**: Hurricane winds are getting stronger as climate warms.
  - **Slide 11**: Storms surge is increasing both because sea level is rising and because stronger winds push more water onto land during hurricanes.
- Describe what scientists are still investigating.
  - **Slide 12**: Are the numbers of hurricanes and tropical storms changing?
  - **Slide 13**: What if hurricanes slowed down?

Update the Driving Question Board.

- Have students return to the Driving Question Board to see whether there are questions that can now be answered or questions that should be changed based on what we know now. Have students consider whether they have new questions to add to the board now that they have investigated the impacts of climate change on how hurricanes and sea level will likely affect the coast in the future.

Opportunities for Assessment

- Student work on the student page will reflect their ability to compare and contrast the actual storm data and the data from "warmed up" storms.
- Headlines that students write after their data analysis should reflect understandings built during data analysis: that in a warmer climate, storms have higher winds, more rainfall, and cause more flooding.
- Give students the Hurricane Resilience Quiz 2 to assess learning through the end of Lesson 7 (Part 2). Assessments can be downloaded from the Hurricane Resilience Assessments google folder.

Teacher Notes

- Science tells us that rainfall rates increase by 7% per degree Celsius of warming. To a good approximation the total storm rainfall increases by 14% under 2°C of warming. Note that this change in rainfall ignores any other potential changes to hurricanes in a warmer world. For example, if hurricanes slow down their approach to the coast then this can also increase total rainfall. In fact, a hurricane that halves its forward speed will double its rainfall totals, all other things being equal.
- Sea level rise will contribute to increasing hurricane surge heights in the future. In fact, seas have already risen along our hurricane-prone coastlines. This means that peak water levels for recent historical storms are higher than they otherwise would be without recent sea level rise. Note that adding sea level rise to water levels during actual storms does not account for the possibility that stronger storms in the future, would cause more storm surge. They also don't account for other potentially important factors for peak water height such as erosion, subsidence, and future construction.
- Hurricanes obtain their energy from the warm oceans. A warmer ocean therefore contains more fuel for hurricanes. Scientists agree that wind speeds increase by approximately 5% per degree Celsius of warming, so about 10% for 2°C of warming. Damage typically increases three times as fast as the rising wind speeds, so a 10% increase in wind speed increases damage by 30%. Scientists are currently working to understand if eye width and forward speed of hurricanes are affected by climate warming.

Students at South Terrebonne High School, Houma, LA, compare maps of data from hurricanes and tropical storms with model data from the same storms in a warmer climate.

Name:

What would hurricanes and tropical storms be like in a warmer world?

Lesson 7 Student Page: Warmed-up Storms

To learn how hurricanes and tropical storms are affected by climate change, compare:

- data from actual storms that affected your region, and
- data calculated from model storms that simulate what would happen if the same storms happened in a 2°C warmer world.

Compare the actual and model storms' footprint, wind, rain, and flooding data and record your findings in the table at the right.

Instructions:
Write the name of the storm at your station into a row of the table.

Measure the **footprint** on the actual wind map and the warmed-up storm wind map. Write the two numbers in the footprint column and note which is larger.

Compare the **max wind** from the actual and the warmed-up storm maps. Put the speeds in the wind column and note which is larger.

Find the **max rain** of the actual storm. Rainfall increase by 7% per degree Celsius of warming, so in a 2°C warmer world, rain would be 14% more. Multiply the storm's max rain by 1.14 to estimate the max rain of the warmed-up storm. Write the two numbers in the rain column and note which is larger.

Water levels will be higher in the future because of sea level rise. If you know how much sea level rise is expected in the region over this century (from Lesson 6), add it to the highest water level and write both in the column. Or provide an estimate, adding 1-3 feet to the water level for the warmed-up storm.

Move to another station and repeat.

Name of the hurricane or tropical storm	**Footprint** (compare maps)	**Max wind** (compare maps)	**Max rain** (calculate - see instructions)	**Flooding** (calculate - see instructions)

Teacher Guide

Lesson 8: Modeling Hurricane Impacts

SKILLS:

Lesson question: How can we modify our model communities to be less affected by storm surge flooding?

Learning objectives:

- Students create a model to simulate how a hurricane creates storm surge along a coast.
- Students revise their model coast to add adaptations that help prevent flooding with a simulated hurricane.

Timing: One class period

Materials:

- Classroom computer, projector, and Internet access
- Lesson 8 Slides: Being Resilient (download from scied.ucar.edu/HurricaneResilience)
- For each group of three to five students:
  - Baking tray with raised rim, approximately 12 x 18"
  - Modeling clay (6-8 ounces)
  - Hairdryer
  - About one liter of water
  - Ten or more plastic Monopoly houses and hotels or building bricks of similar size
  - Extension cord (if needed to reach outlet)
  - Paper towels (in case water spills)
  - Scissors
- Resilience adaptation materials for the class
  - Sponges
  - Tongue depressors, popsicle sticks, or nail files
  - Toothpicks (one to two boxes)
  - Other materials that students can use to engineer their coast to be more resilient to storm surge (such as pieces of cardboard, small pieces of wood or plastic, plastic building bricks)

Preparation:

- Make a sample model coastline to share with students.
  - Create a coastline along the short end of the pan using 6-8 ounces of modeling clay. Cover about a third of the pan.
  - Add at least ten Monopoly houses/hotels or building bricks to your coast to simulate a community.
  - If you are in an area that has wetlands along the coast, add pieces of sponge to the coast to simulate the wetlands.
  - Add water to the open two-thirds of the pan to simulate the ocean.
  - Practice using the hairdryer to simulate how winds push water onto land during a hurricane or tropical storm. (See the Hurricane Resilience website for a video of the demonstration.)
- Review the Being Resilient slides.

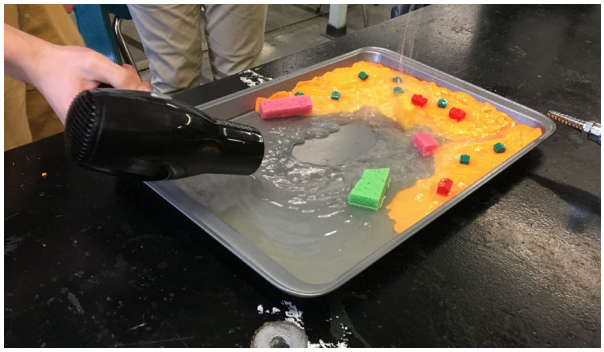
Directions

Survey prior knowledge about hurricane flooding.

- Ask students what they know about flooding due to hurricanes and tropical storms. List what they know and where they learned the information on the board. *(At this point in the curriculum, students have likely heard stories of flooding as they collected interviews, they have seen data about water level and flooding, and they have learned that as the climate warms, the amount of storm surge flooding and rainfall is increasing. Additionally, they may have personal experiences with local flooding during hurricanes and tropical storms.)*

Introduce the physical model that students will use.

- Tell students that they will make a physical model of a hurricane hitting the coast to see the impacts of water level and coastal flooding. Then they will engineer ways for a community to avoid flood damage when a hurricane makes landfall.
- Remind students that they looked at data generated by a computer model in the previous lesson. A physical model represents a system with physical objects, while a computer represents a system with math equations.
- Orient students to the sample model coastline. Review the objects in the model and what each represents.
  - The water simulates the ocean.
  - The modeling clay simulates the coast.
  - Monopoly houses/or bricks simulate houses or other buildings.
  - If you are in an area with wetlands along your coast, use pieces of sponge to simulate the wetlands.
- Introduce the hairdryer, which simulates the winds of a hurricane.
  - Demonstrate by holding the dryer so that water is pushed towards the coast.
  - Show students how the hair dryer can be used to model forward speed, footprint, wind speed, and storm track.
    - Wind speed: change the dryer speed from low to high
    - Forward speed: move the dryer faster or slower towards the coast
    - Footprint: spreads dryer winds wider
    - Storm track: change the angle of the dryer
  - Discuss safety. *(It is essential that the hairdryer not be dropped into, or held in, the water. To reduce the safety concerns, you may wish to have only one hairdryer for the class and be the one to use it to simulate hurricanes for each group.)*
- Discuss how this model does a good job representing the actual coast and a hurricane and where it falls short. *(Students may note that the modeling clay is impervious so water can't sink into it, there are no wetlands or beaches in this model, and that the hurricane winds are going in one direction instead of a spiral.)*



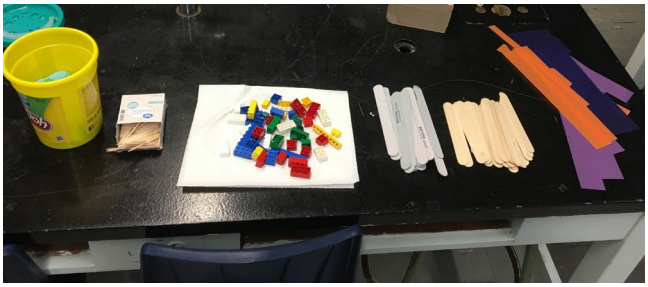
Students modeling storm surge using a hair dryer to push water towards the coast of their models.

Students make models and test.

- Have students work in groups of three to five to create their model coastlines and make their community.
- Once students have made their coasts, have each group add water into the ocean part of their baking tray. (Note that the trays will need to be on a level surface (table or floor) for the "ocean" to fill the area evenly.)
- If you are having each student group use their own hairdryer, they can simulate the hurricane themselves. If you are demonstrating this for students, visit each group and simulate a hurricane with the dryer.
  - Encourage students to take photos or videos to document what happens when the wind of the simulated hurricane pushes the water onto the coast. (Slow motion video works particularly well when documenting how the winds move water onto land.)
- Have students drain out the ocean water and leave their models set-up to use for the next part of the activity.

To decrease hurricane damage, we can make changes that help keep coasts safe.

- Have students return to their seats so that they can see the screen. Project the Being Resilient slides (**Slide 1**).
- Acknowledge that there was flooding in the model coasts. Have students estimate what percentage of the buildings were flooded by storm surge.
- Tell students that there are strategies that make buildings and communities less vulnerable to hurricane damage, including flooding. This helps us be more resilient, or more able to recover from a storm.
- Define vulnerability with students using the flow chart on **Slide 2**. (See the slide notes for details.)
- Share an example of how design can help a person be more resilient in the case of a breakable glass versus a non-breakable plastic cup (**Slide 3 and 4**). This is the concept of "graceful failure." Relate the concept to hurricanes: there are things that we can do to make sure that a hurricane hitting our coast is more of a graceful failure than a catastrophic disaster.
- Ask students to name coping strategies that they heard about in the Storm Stories interviews. Then share the examples on **Slide 5** in case there are any that students haven't mentioned.
- Tell students that now we are going to look at some examples of how a community can become more resilient.
  - › Share examples of community adaptation (**Slides 6-7**), including improving evacuation routes, restoring wetlands, enforcing building codes, and building levees.
  - › Share examples of floodproofing (**Slide 8**) such as designing floating buildings, raising electrical outlets higher on walls, raising homes, and using sandbags
  - › Share examples of windproofing (**Slide 9**) such as storm shutters, stormproof roofing, and tying down belongings in the yard
  - › Share examples of stormwater control, such as rain gardens and permeable pavement (**Slide 10**).



To develop resilience adaptations for their models, students can use a variety of supplies, including clay, toothpicks, plastic blocks, nail files, popsicle sticks, and pieces of file folders.

Students make resilience adaptations to their models.

- Tell students that a hurricane is going to hit their coast. Their goal is to make adaptations to their coastal environment that will help their community survive without flooding during the storm.
- Introduce the additional supplies available for students to plan for resilience. (Don't explain how they might use the supplies. That's up to the students.)
- After students have had about 8 minutes to make resilience changes, have them simulate a hurricane using the dryer and take photos/videos to show how their adaptations worked.
- If time allows, have students explain their adaptations to another group.

Students adapt their model to try and prevent flooding due to storm surge by adding sponges to simulate wetlands and popsicle sticks to simulate levees or seawalls.

Clean up

- Instruct students to remove reusable components from the models (houses, sponges, and plastic, wood or metal resilience materials) and then drain the water into a sink or bucket. Dispose of the clay if it has become too saturated to use again.

Wrap up and transition to the next lesson.

- Discuss as a class what resilience strategies were helpful in the model.
- Optional: Assign the homework (see Assessment below).
- Tell students that in the next lessons, they will make plans for how their community and the places they care about can be less vulnerable to hurricanes and more resilient.

Opportunities for Assessment

- Homework: Help students reflect on this lesson by having them label two of their photos to document their coast before and after resilience adaptations as homework. Labels should note what areas were vulnerable to flooding and which areas were less vulnerable and what resilience strategies were implemented.
- This lesson introduces the resilience portion of the curriculum (Part 3), so opportunities for formative assessment are embedded. Surveying prior knowledge at the start of class provides one formative assessment opportunity. Also, note whether student groups are drawing from the strategies presented in slides or prior knowledge as they design adaptations for their coast.

Teacher Guide

Lesson 9: Assessing Vulnerability and Risk

SKILLS:



Lesson question: What parts of our community are most vulnerable and most at risk?

Learning objectives:

- Students identify places that they value in their local area and assess their vulnerability to hurricanes and tropical storms.
- Students determine what risk each place faces now and in the future.

Timing: One class period

Materials:

- Classroom computer, projector, and Internet access
- Slide 2 from Lesson 8 slide deck (download from scied.ucar.edu/HurricaneResilience)
- Student pages:
  - *What's Vulnerable?* (pages 65-66)
  - *What's the Risk?* (page 67)

Preparation:

- Make one copy of each student page for each student.

Directions

Define resilience.

1. Remind students that resilience (introduced in Lesson 8) is the ability to bounce back from a shock or stress, acquire new capabilities, or handle changing conditions.
   - Have students think of a time in their life when they have been resilient and share with a partner.
   - Shift from personal resilience to hurricane resilience:
     - Ask students to name actions that they heard about in Storm Stories interviews that helped people be resilient when facing a hurricane.
     - Ask students what resilience strategies they remember from the previous lesson.
2. Provide a more detailed definition of resilience.
   - Resilience is the capacity of individuals, communities, and systems to survive, adapt, and grow despite ongoing stresses and unexpected shocks. Adaptation is a piece of resilience and is defined as modifying how we live in a place to survive despite changing environmental conditions (according to LA SAFE, Louisiana's resilience planning effort).
   - Note that resilience planning takes into account many different ways that people or communities are vulnerable (because of sinking land, changing economics, demographics, disease, etc.). In this project, we are looking at resilience to hurricanes specifically.

Assess vulnerability.

3. Tell students that now they will identify places that they think are valuable in their community and then identify their vulnerability. Remind students that **vulnerability** means that something, some place, or someone is exposed or sensitive to harm.

4. Project for the class the graphic entitled *What is vulnerable?* (**Slide 2**) from the Lesson 8 slide deck. Remind students that they saw this during the previous class period.
5. Hand out the *What's Vulnerable?* student page. Orient students to the table on the student page by relating the column headings to the sections of the *What is vulnerable?* graphic from Slide 2.
   - Column B (Is the place in harm's way?) is exposure in the graphic.
   - Column C (Could the place physically withstand a hurricane?) is sensitivity.
   - Column D (Are people in the place able to handle a hurricane?) is the adaptive capacity.
6. Have students complete the *What's Vulnerable?* student page to consider what places in their community that they value are most vulnerable. Explain that to assess the vulnerability, they will estimate how exposed certain places are and how sensitive the places and the people in those places are to hurricanes.
   - Filling in information will require that students make their best estimates.
   - For column D, students should estimate whether the people are likely to be negatively affected by a hurricane. Provide examples for students of how some people may be more vulnerable than others (e.g., those who lack the financial resources or a car that would allow them to evacuate, those who have a disability that would make hurricane preparations difficult). This is called social vulnerability.
   - Students will then calculate the vulnerability in column E.
   - After calculating for five places, students should identify the most vulnerable place they found. On the second page of the *What's Vulnerable* student page, have students cite evidence and explain their reasoning for why it is the most vulnerable.
7. Have students share which places they claim to be most vulnerable and why.
   - As students share, ask them to describe their evidence and reasoning to support their claim. (If short on time, have students work in groups of three to five to share their most vulnerable location, evidence, and reasoning.)
   - To add a geography component, mark each vulnerable location on a map as students share their evidence and reasoning.

Determine risk.

8. Tell students that **vulnerability** to an event, like a hurricane, combined with the **consequences** if the event occurred, and the probability of the event, adds up to **risk**.
9. Have students use the *What's the Risk?* student page to assess the consequences if the places they value were destroyed and calculate the **risk** of hurricanes now and in the future, when the probability of harm will be higher.
   - When orienting students to the student page, facilitate a discussion to help students decide what they feel distinguishes between high/med/low consequences: the number of people impacted, the importance of the service provided (for example a hospital being destroyed versus a home), the monetary value, the uniqueness, etc.
   - Remind students that, in this exercise, they are comparing the relative risk of different places. (The numbers used in the student page calculations are only meaningful in comparison with the numbers for other locations.)
   - Explain why the risk now might be different than the risk in 2050. Students should recall from Lessons 5-7 that climate warming is causing hurricanes to become stronger and sea level to rise. Sea level is also rising due to land subsidence in many areas. This all contributes to a higher probability of a strong hurricane and more extensive flooding in the future.

Sensemaking

- Facilitate a class discussion of the following questions.
  - What trends do you notice when comparing the risk now to future risk (columns C & D)?
  - What is different between the places with the highest risk values and the lowest?
  - Can you accept the risks of hurricanes and sea level rise now? How about future risks?
    - Tell students that there isn't a correct level of risk, that everyone is different in the way they perceive risk, so no two people will have exactly the same idea about how much risk is too much. What's most important is to know how much risk you feel comfortable with.

- Which places are most in need of help in order to reduce risk (now and in the future)?
  - Note that to reduce risk, we can take actions that make us and the places that we value less vulnerable. Tell students that during the next lesson, they will focus on actions that people in the community can take to reduce risk and be more resilient.

Opportunities for Assessment

- On the *What's Vulnerable?* student page, the evidence and reasoning related to the most vulnerable place on their list serve as a brief CER assignment and will allow students to demonstrate that they understand the factors that are a part of vulnerability.
- Answers on the *What's at Risk?* student page should demonstrate that students understand that risk is greater in the future than it is today.
- Answers to the question *Can you accept the risk?* during the sensemaking discussion can serve as a formative assessment for the following lessons. Be aware of students' moods. At this point, some students might be concerned, angry, or feeling vulnerable to disaster. Provide a safe space for students to discuss how this exercise made them feel.

Name:

What's Vulnerable?

Lesson 9 Student Pages: Assessing Vulnerability and Risk

1. List an important place in your community in each row of **column A** below (you will have a total of five places). The places could be specifically important to you (like your home) or could be important to the community (like a hospital, community center, or shop).
2. If a hurricane is heading towards the coast in your area, are the places exposed, or in harm's way? Decide whether each place is very exposed, somewhat exposed, or not exposed to hurricanes and circle an answer in **column B** for each location.
3. Can the places, and people in them, withstand hurricanes? Estimate whether each place could physically withstand a hurricane (**column C**) and whether the people in that place are able to handle a hurricane (**column D**).
4. To estimate vulnerability, add the numbers from columns B, C, and D together and put the totals for each row into **column E**. The places that are most vulnerable will have the highest numbers. The places that are least vulnerable will have the lowest numbers.

A **Places in your community that you value**	B **Is the place in harm's way?** (circle one)	C **Could the place physically withstand a hurricane?** (circle one)	D **Are people in the place able to handle a hurricane?** (circle one)	E **Vulnerability** (Add the numbers from B+C+D together.)
	Very exposed (3) Somewhat exposed (2) Not exposed (1)	Yes, very well (1) Some damage (2) Probably not (3)	Yes, very well (1) It may be difficult (2) Probably not (3)	
	Very exposed (3) Somewhat exposed (2) Not exposed (1)	Yes, very well (1) Some damage (2) Probably not (3)	Yes, very well (1) It may be difficult (2) Probably not (3)	
	Very exposed (3) Somewhat exposed (2) Not exposed (1)	Yes, very well (1) Some damage (2) Probably not (3)	Yes, very well (1) It may be difficult (2) Probably not (3)	
	Very exposed (3) Somewhat exposed (2) Not exposed (1)	Yes, very well (1) Some damage (2) Probably not (3)	Yes, very well (1) It may be difficult (2) Probably not (3)	
	Very exposed (3) Somewhat exposed (2) Not exposed (1)	Yes, very well (1) Some damage (2) Probably not (3)	Yes, very well (1) It may be difficult (2) Probably not (3)	

Name:

What's Vulnerable?

Lesson 9 Student Pages

In the spaces below, make a claim about which of the five places you assessed on the previous page (page 65) is most vulnerable, and then support your claim with evidence and reasoning that describes why it's vulnerable.

Make a claim.
Which place (from the five on the previous page) is most vulnerable to hurricanes and tropical storms?

Cite evidence.
What's your evidence that it is vulnerable to these storms?

Share your reasoning.
Why does the evidence suggest that it is vulnerable?

Name:

What's At Risk?

Lesson 9 Student Pages: Assessing Vulnerability and Risk

1. What would be the consequences if each place is destroyed? List the **same places (column A)** and **vulnerabilities (column E)** that you included in your *What's Vulnerable?* table.
2. **Estimate the consequences** if the place were destroyed in **column F.**
3. Calculating risk takes into account the vulnerability to an event, the consequences if destroyed, and the probability that the event will happen. In this case, we are exploring the risk associated with hurricanes. The probability of a strong hurricane hitting a place along the coast are increasing as climate warms and sea level rises.
   - To calculate the **risk now (column G)**, add vulnerability and consequences (E and F) and then multiply by two.
   - To calculate the **risk in 2050 (column H)**, add vulnerability and consequences (E and F) and then multiply by three (because there will be a high probability of a damaging hurricane in the future.)

A **Places in your community that you value**	E **Vulnerability**	F **Estimate of consequences if destroyed** (circle one)	G **Risk now** based on medium probability (E+F)*2	H **Risk 2050** based on high probability (E+F)*3
		Low (1) Medium (2) High (3)		
		Low (1) Medium (2) High (3)		
		Low (1) Medium (2) High (3)		
		Low (1) Medium (2) High (3)		
		Low (1) Medium (2) High (3)		

Teacher Guide

Lesson 10: Short and Long Term Resilience Planning

SKILLS:

Lesson question: What actions can we take to decrease hurricane risk and vulnerability in the short term and in the long term?

Learning objectives:

- Students identify actions that can be taken to decrease risk and vulnerability, increasing resilience, when a hurricane or tropical storm is approaching a coast.
- Students identify actions that can be taken to decrease risk and vulnerability due to hurricanes and sea level rise along their coast over the long term.
- Students gather information from multiple sources about the actions that can be taken and then assess which are most feasible.
- Students analyze and interpret a community resilience plan to consider the risks and benefits of various actions in terms of long term hurricane resilience.

Timing: Two class periods

Materials:

- Small dot stickers (eight per student)
- Small sticky notes in two colors
- Pens or pencils
- Paper
- One computer or tablet for each student or pair of students with Internet access
- **Day 1** Information sources for student research:
  - The results of student analysis of Storm Stories from Lesson 3, Day 3 (which explored what people did to stay safe)
  - *Ready.com/hurricanes*
  - *Louisiana Homeowners Handbook to Prepare for Natural Hazards* (PDF*)
- **Day 2** Information sources for student research:
  - Storm Stories data for the last interview question
  - *Ready.com* hurricane recommendations (Ready.gov/hurricanes)
  - Case studies in the NOAA Resilience Toolkit (toolkit.climate.gov/#case-studies)
  - *Louisiana Homeowners Handbook to Prepare for Natural Hazards* (PDF*)
  - *Rising Above: Climate Change Adaptation Manual for Communities in Louisiana:* pages 14-22 (PDF*)
- Chart paper, marker
- *Six Resilience Projects for Terrebonne Parish, Louisiana* (PDF*)
- Driving Question Board (used in previous lessons)

*download this resource from scied.ucar.edu/HurricaneResilience

Preparation:

- Review all information sources before class to prepare to facilitate student research.
- Bookmark links to information sources for students, or prepare printed copies if computers/internet are not available.
- Make printed copies of the *Six Resilience Projects for Terrebonne Parish, Louisiana*, or prepare to have students access the one-page PDF on computers or tablets.

Directions

Day 1

Introduce the activity.

- Introduce the lesson question: *What actions can we take to decrease hurricane risk and vulnerability in the short term and in the long term?*
- Tell students that in the first part of this activity, they will focus on short-term actions (e.g., what actions to take when a hurricane is heading towards the coast) that reduce risk and help us be more resilient. And during the next class, they will focus on long-term risks (actions that reduce hurricane risk decades into the future).

Compile a list of actions for short-term resilience.

- Split students into five groups and provide each group sticky notes (one color).
- Assign each group one of the questions from the Storm Stories analysis (Lesson 3, Day 3):
    i. How did you learn that the storm was coming?
    ii. Before the storm, what did you do?
    iii. During the storm, what did you do?
    iv. After the storm, what did you do?
    v. What decisions have you made to stay safe from hurricanes in the long term?
- Tell students that their goal is to find and list actions for short-term resilience on sticky notes. Instruct students to consider both actions that individuals/families can take as well as actions that the whole community can take. Instruct students to gather actions from the following two sources for their group's question:
    - Their Storm Stories analysis, which will reflect what people they interviewed did.
    - Recommended actions from the *Ready.com/hurricanes* webpage.
- Create a space on a wall or on the board with two headings:
    - Actions to Reduce Risks to Individuals.
    - Actions to Reduce Risks to the Community.
- Have students hang all sticky notes under the appropriate heading on the wall. *(Note that actions to reduce risk to the whole community often need many people and community support to implement.)*
- Have each group take turns sharing out their resilience actions. As students present, have them group similar actions.
    - Note: If there are differences between the actions that people took based on Storm Stories interviews and the actions recommended by the Ready website, discuss this as a class. Note that there might be many reasons that people don't take the advice of experts, some practical and some not.

Assess which resilience actions are most feasible.

- Tell students that some actions might be more feasible than others. *(For example, expensive actions won't work for people who don't have the money.)* Bring up the idea of feasibility as a way to determine which solutions could actually be implemented. Brainstorm together what factors would make a solution more feasible than another *(ex: implementation cost, time to implement, the scale of the solution, the consequences of not implementing, etc.).* Record these ideas in a new list, if desired.
- Give each student four dot stickers. Have students vote for two solutions from the Actions of Reduce Risk to Individuals list and two solutions from the Actions of Reduce Risk to the Community list that they feel are most feasible by placing a sticker next to them.
- Ask students what they notice about the resilient actions that got the most votes with stickers. Why did they vote for a particular action? *(Answers will vary depending on what actions are listed, but student answers will likely include mentions of cost, effort, impact, and time.)*

Think-Puzzle-Explore with another source of information about resilient actions.

- Introduce students to the *Louisiana Homeowners Handbook to Prepare for Natural Hazards*. Explain that every state has its own suite of natural hazards and its own needs for preparing. Louisiana is one of many states in the U.S. that needs to prepare for hurricanes and tropical storms, so that hazard is in this handbook.
- Instruct students to look at the handbook with a partner to research ways that individuals/families can protect their homes/property from hurricanes. Focus on the "Eight Things You Can Do to Prepare" on page five as a place to start.
  - Have students jot down notes in three columns as they are going through using Think-Puzzle-Explore to frame their thinking. Instruct students to record ideas about how you could find the answers to your puzzlings and anything you think you'd like to learn more about. (Note: items recorded in the puzzle & explore columns might be useful for students during Lesson 11.)
    i. Title the first column "Think" and record here anything you find interesting.
    ii. The second column is titled "Puzzle" and is where you write down any questions that are coming up as you are reading.
    iii. The third column should be titled "Explore." Share out from the information gathering with the whole class, and discuss.
- Transition to the next day's lesson by telling students tomorrow they will explore long term risks as they consider how to stay safe in the future.

Day 2

Introduce long-term resilience planning.

- Help students shift their thinking to consider risks in the future by having them calculate how old they will be in 2050 and ask them to think about what their life might be like then.
- Remind students of the top choice solutions for short-term hurricane resilience (i.e., when a storm is approaching) that they developed the day before. Ask students: What might be different when considering the risk of hurricanes in the future?
  - *Students should recall what they learned about the combined impacts of stronger hurricanes and sea level rise in the future (Lessons 5-7), which will increase risk.*
- Tell students that in this lesson, they will look towards the future to plan for resilience in a world with stronger hurricanes and rising sea levels.

Compile a list of actions for long-term resilience.

- Have students return to the groups that they worked with for the short-term resilience activity. Assign each group to one of the information sources below.
  - Storm Stories; last question (about long-term changes made to stay safe)
  - Recommended actions from *Ready.com/hurricanes* (webpage)
  - Recommended actions from the *Louisiana Homeowners Handbook to Prepare for Natural Hazards* (PDF)
  - Examples profiled in case studies from the NOAA Resilience Toolkit (website)
  - *Rising Above: Climate Change Adaptation Manual for Communities in Louisiana:* pages 14-22 (PDF)
- Students should spend about 10 minutes recording actions for long-term resilience on sticky notes (the second color) gathered from their assigned information source. Instruct students to consider actions at a variety of scales, including actions that individuals/families can take as well as actions that the community or region can take.
- Have students put all sticky notes from their group on a wall near the sticky notes gathered from the short-term resilience actions on Day 1. Instruct students to organize the long-term actions to reduce risks into categories by scale: (1) individual/household actions and (2) community/regional actions.
- Have each group take turns sharing out the resilient actions that they found in their source. As students present, have them group similar actions. Record the grouped actions on chart paper (or in a Google doc). (This list of short term/long term individual and community scaled actions will be used for Lesson 11.)

- Allow students to vote (using dot stickers as they did earlier in Lesson 10) for solutions they feel are the most feasible. Give each student four stickers and allow them to vote for the top two in each category (individual/family, community/region).
- Ask students why they voted for particular actions. *(Answers will vary depending on what actions are listed, but student answers will likely include mentions of cost, effort, impact, and time.)*

Case study: Will plans for Terrebonne Parish, Louisiana help decrease hurricane risk?

- Orient students to the resilience plan for Terrebonne Parish, Louisiana.
  - The plan was developed with input from community meetings with Parish residents. (This was part of a larger process creating plans with six coastal Louisiana parishes coordinated by LA SAFE.)
  - The community used data about expected changes to environmental conditions (flooding and land loss, as well as other conditions) over the next 50 years to inform their discussions.
  - The plan was developed to address many different obstacles to resilience, not just sea level rise and storms, so it reflects all sorts of resilience challenges - economic and social as well as environmental.
  - Based on the community input, the project created plans for six projects.
- Provide each group with the handout, *Six Resilience Projects for Terrebonne Parish, Louisiana*, and instruct students to look at the project boards online (lasafe.la.gov/project-boards/) for a more detailed description of each.
- Working in their groups, have students assess how the six projects will affect community risks of damage due to hurricanes and sea level rise in the future.
- Have them use the claim-pass strategy to consider whether the planned changes will help and if they think those changes will be enough.
  - **About the claim-pass strategy**: In groups, students develop a written "discussion" through this strategy, contributing their ideas to a group document following the steps below:
    - One student writes a claim such as "Yes, I think the planned changes will be enough because ____." or "No, I don't think the planned changes will be enough because ____."
    - They pass it to a second student who continues writing, adding to the initial claim or countering it. For example, "I agree because ____" or "On the other hand ____"
    - They pass it to a third student. After the paper has passed through everyone in the group, the first student reads it aloud to the group.
- Wrap up by taking a survey of how many students agree/disagree that planned changes would be enough to keep the community safe from hurricanes in the future. Ask students what else they would recommend for this community.

Update the Driving Question Board.

- Have students return to the Driving Question Board to see whether there are questions that can now be answered or questions that should be changed based on what we know now. Have students consider whether they have new questions to add to the board now that they have considered short and long term actions to increase hurricane resilience.

Opportunities for Assessment

- **Day 1**
  - As groups share their resilient actions with the class, ensure that they have identified the major strategies from both the Ready website and Storm Stories.
  - After students vote for the resilient actions and are discussing the outcome, pay attention to the reasons that students provide for why certain actions are more feasible than others to ensure that students understand what makes certain actions feasible (such as cost, effort, impact, and time). If time allows, add an exit ticket describing whether a particular action is feasible and why if you would like more detail about individual student learning.
  - The tables that students create during the final part of the lesson (Think-Puzzle-Explore) will illuminate how students are processing new information about strategies for resilience. This can inform how you support student learning during the next lesson as students will be focusing on processing information from multiple sources about long-term resilience.

- **Day 2**
  - As groups share their actions for long term resilience, ensure that they have identified the main ideas presented in their information source.
  - After students vote for the resilient actions and are discussing the outcome, pay attention to the reasons that students provide for why certain actions are more feasible than others to ensure that students understand what makes certain actions feasible (such as cost, effort, impact, and time).
  - If you'd like to assess student answers in the claim-pass activity (which is part of the case study), have students include their names with their individual answers and then collect the written "discussion" at the end of class. Their answers should document their thinking about whether a given set of actions will address hurricane risk.

Teacher notes

- The Ready.com website, which is where the reference material is from, is a U.S. public service campaign to educate and empower people to prepare for, respond to, and mitigate emergencies, such as hurricanes.
- *The Louisiana Homeowners Handbook to Prepare for Natural Hazards* was developed by the Gulf of Mexico Alliance and published by Louisiana Sea Grant with support from NOAA, Sea Grant, EPA, FEMA, the State of Louisiana, and many other organizations. The goal of the handbook is to help residents prepare for natural hazards (including tornadoes, hurricanes, and floods) to help reduce risks to people and property.
- Note that Storm Stories might not include as much detail about long-term actions because they were geared towards describing a short-term situation (a particular hurricane). The final question in the questionnaire is the only one related to long-term changes. Recommendations from expert sources are included so that students generate a range of ideas.
- You may wish to substitute resources in the list that students use to generate ideas for long-term resilience, depending on your local area. Resources specific to your region would be good to include if they are available.
- For the case study, you may wish to substitute the long-term resilience plan for your local area if one exists. This will help students make a place-based connection. If your community doesn't have a long-term resilience plan, the case study will allow students to think about what long-term planning for coastal communities can look like.

Teacher Guide

Lesson 11: Communicating Resilient Actions

SKILLS:

Lesson question: What do we tell other people in our community about how we can be more resilient?

Learning objectives:

- To wrap up the Hurricane Resilience unit, students develop and present posters to communicate how specific actions can increase resilience and decrease the harm caused as hurricanes and tropical storms make landfall in their location.

Timing: Four class periods

Materials:

- Classroom computer, projector, and Internet access
  - Sample poster: *Put a Freeze on Winter Holiday Fires* (download from scied.ucar.edu/HurricaneResilience)
  - Link to the Visual.ly Infographics Gallery (visual.ly/view)
- Google Slide Template for posters (linked from scied.ucar.edu/HurricaneResilience)
- Lists of resilient actions that students voted for during Lessons 10
- One computer or tablet for each pair of students
- Student pages:
  - *Evaluating a Resilience Action (page 77)*
  - *Making a Resilience Poster Plan (pages 78-79)*
  - *Communicating Resilience Visually (pages 80-81)*
  - *Resilience Poster Rubric (page 82)*
  - *Poster Plan Feedback Notes (page 83)*

Preparation:

- Copy student pages. (The two-page ones, *Making a Resilience Poster Plan and Communicating Resilience Visually*, can be printed double sided.)
- Review the student pages and rubric to support students as they develop posters.
- Find examples of infographics from the Visual.ly Environment Gallery that you'd like to share with students. (Focus on infographics that include science topics and include data or statistics as those will provide a good model for students.)
- Compile a list of the resilient actions that got the most votes during Lesson 10. Organize the actions into the four categories that students used over the previous lessons. (Ensure there are at least enough actions for each pair of students to have one action for their project.)
  - Short term, individual/household actions
  - Short term, community/regional actions
  - Long term, individual/household actions
  - Long term, community/regional actions

Directions

Day 1

Introduce the resilience communication project.

- Tell students that they are going to create posters to inform their community about actions they can take for short-term and long-term hurricane resilience. Show students the list of resilient actions that they voted for in the previous lesson. Tell students that the posters are going to draw on what they have learned throughout the unit about the storms, how they affect people, and what we can do to be resilient.
- Project the sample poster: *Put a Freeze on Winter Holiday Fires* (which is from the National Fire Protection Association). Explain that, while the topic is very different from the hurricane resilience actions (the focus of student posters), this is a good example of how a poster can be used to communicate about a hazard and help people learn what they can do to stay safe.
  - What sections of the poster describe the problem? *(Mainly the top row of information)*
  - What sections explain what to do to stay safe? *(Most of the lower two rows of information)*
  - How did they use graphics to communicate about data and facts? *(The central graphic has one out of 45 little trees highlighted to illustrate one out of 45 fires. The graphic to support the sentence about one in four winter fires highlights one tree out of four.)*
- Explain that each pair of students will develop a poster about a different resilience action. Have student pairs choose which resilient action they will communicate about with a poster from the list. (Alternatively, assign an action to each pair or have students select one out of a hat.)

Students evaluate their resilient actions.

- Handout the *Evaluate a Resilience Action* page to each student and provide each pair with a computer or tablet.
- Tell students that the first step is to explore the resilient action, describe its benefits and challenges, and decide how much it would cost relative to other resilient actions.
- Following the student page and through online research, students assess the costs, benefits, and challenges for their action and explain their reasoning.
  - Note about costs: Categories are listed on the student page (i.e., low cost, medium, high cost) so that students don't need to find actual costs of an action. Students can probably easily determine the relative cost of many of the actions and solutions, and others will be more challenging. Visit student pairs and ask about what cost they selected. If students are unsure, remind them of the total list of actions and ask whether they think the cost would be more or less than the other actions.

Students plan their resilience posters.

- Handout the *Making a Resilience Poster Plan* student pages (two pages) and orient students to the student pages. Explain that this is where they will organize the information that they will include on posters. Their student page includes sections for the content that they will need in their poster, including:
  i. A title that describes the action
  ii. A description of the problem that the action solves
  iii. Some information from the Storm Stories data
  iv. An explanation of how the action reduces vulnerability
  v. An explanation of what people would need in order to do this
  vi. An infographic
  vii. Photos, maps, or other types of visuals
  - Remind students that their aim is to help other people, who haven't been studying Hurricane Resilience, learn what they can do to stay safe and decrease risk.

- Handout the *Resilience Poster Rubric*, which defines the expectations for the posters. Note that the *Resilience Poster Rubric* describes what a successful poster includes.
- Student pairs should plan their posters using the *Making a Resilience Poster Plan* student pages and referring to the Resilience Poster Rubric to make sure they have everything. (Tell students that they will focus on the infographic during the following class. A general idea of what they want to communicate is all they need at this point.)

Day 2

Introduce how infographics are used to communicate.

- Tell students that they will create an infographic for their posters. Introduce infographics and how they can be used to communicate data and facts visually. Visually presenting data and facts can help people see patterns and trends that they might not notice when reading text about the same information.
  - Show students examples of science infographics from the Visual.ly Environment Gallery. (Search the word "data" to find good examples of visual representation of data.)
  - Introduce the *Communicating Resilience Visually* student pages, which helps students plan their infographic. Tell students that after they draft their graphic, they will get feedback from their fellow students and teacher before they create the final version.

Students plan their infographics.

- Student pairs should use the *Communicating Resilience Visually* student pages to plan their infographic. Students will need computers or tablets for the "finding facts and data" step.
  - **Main idea:** Students will include their notes about what they would like to communicate.
  - **Finding facts and data:** Students search online for information to include in their graphics and keep track of what they find.
  - **Planning the infographic:** Students will create a title, choose data and facts to include, and decide how they want to represent the data.
  - **Make a draft:** Students will sketch out the graphic so they can get feedback from other students and their teacher.

Peers and the teacher provide feedback about poster plans.

- Provide each student group with a copy of the *Poster Plan Feedback Notes* page. Explain that this is for them to record ideas and suggestions from their classmates and teacher.
- Have each student pair share the information from their *Making a Resilience Poster Plan* student pages and their draft infographic with another pair of students to collect feedback.
- After collecting feedback from their peers, have students hand in their *Poster Plan Feedback*, *Making a Resilience Poster Plan*, and *Communicating Resilience Visually* student pages. After class, review the poster plans and provide guidance/revisions as needed to help students as they create their polished posters.

Day 3

Creating Posters

- Student pairs should revise their plans based on feedback, polish text, create infographics, and find photos and other images.
- Provide each pair with a computer or tablet with access to the Poster Template. Explain that the poster template is a Google Slide that is the size of a poster (2 x 3 feet). If students are not familiar with Google Slides, orient them to the tools for adding text, images, and shapes. Point out how students can decide what colors to use and fonts.

(If students need more time, either have them finish posters as homework or add an extra day for students to work on posters.)

Day 4

Sharing posters

- Once posters are complete, have each pair of students present their poster to the rest of the class (2 minutes per presentation should be sufficient).
- Discuss how students feel the messages from their posters could be used by the community.
- *(If you'd like to extend this project, have students create a website to share the posters with others. Provide the URL to the community, including all people interviewed for the Storm Stories assignment. Alternatively, if there is funding for printing posters, you may have students organize a local exhibit.)*

Revisit the Driving Question Board one last time.

- Have students turn their attention to the Driving Question Board and invite students to look for questions that can be answered based on what they have learned about resilience and staying safe from hurricanes in Part 3 of the curriculum. If there are remaining questions, consider having students take responsibility for researching the answers and reporting what they learned to the class.

Wrap up the Hurricane Resilience unit.

- Have students discuss the following scenario: They meet a family that is moving to this area. The family has never lived on a hurricane-prone coast before. The people ask you how they can live in this place and stay safe from hurricanes and tropical storms. Based on what you've learned, what would you recommend to them?

Opportunities for Assessment

- Answers on the *Evaluate a Resilience Action* student page will provide a sense of what students know about the resilient action that they will be profiling in a poster (based on prior knowledge and a quick internet search). This can help you determine which pairs of students may need more direction and support as they develop their poster plans and graphics.
- Posters can be assessed using the *Resilience Poster Rubric*, which includes sections for evaluating the various poster components as well as the overall effectiveness.
- During the unit wrap-up, students are likely to share broad ideas about what they are taking away from the Hurricane Resilience unit instead of specifics that they focused on in their posters. If you'd like to assess these broad student ideas individually, you may wish to have students write their answer before discussing as a class.
- Give students the Hurricane Resilience Final Test to assess learning through the end of Lesson 11 (Part 3). Assessments can be downloaded from the Hurricane Resilience Assessments google folder.

Teacher notes

- Portions of the poster project can be completed either in-class or as homework as long as students are adept at working collaboratively outside of the classroom.
- About Infographics:
  - Students are encouraged to include data within their infographic, which may be a graph or chart. Depending on student abilities, and the types of data that they wish to use, you may need to hold an introduction to working with data and graph creation.
  - To support students as they develop infographics for their posters, you may wish to download information pages from the STEM Literacy Through Infographic website (science-infographics.org), which are also linked from the *Hurricane Resilience* resources page (scied.ucar.edu/HurricaneResilience).

Evaluating a Resilience Action

Name and briefly describe a resilience action.

This action is:

- ◯ short term
- ◯ long term

It's something that can be done by:

- ◯ an individual or household
- ◯ a community or region

	Describe what you know (or what you think you know.)	Explain your reasoning (and provide evidence if possible.)
Cost estimate Circle one.	Low Medium High	
Benefits Which problem(s) do/does the action address, and what would be improved?		
Challenges List anything that affects implementation.		

Group Names:

Making a Resilience Poster Plan

Use the spaces below to create an outline of your resilience action poster.

Your poster title
Your title should include the name of the resilient action, clearly stating what the action is.

Our action plan is for: ◯ Individuals/households ◯ Communities

Describe the problem that this action solves.
The problem should be associated with hurricanes and tropical storms.

Include information from Storm Stories related to the problem or action.
Add information from the data that your class collected and analyzed (for example, the percentage of people surveyed who experienced the problem or took this action).

Group Names:

Making a Resilience Poster Plan *(continued)*

Use the spaces below to create an outline of your resilience action poster.

Explain how the action reduces vulnerability.

What's needed for this action?
List information about the time, money, people's help, or other things that would be needed for this action.

Summarize an idea that you want to communicate visually.
You will make an infographic that includes data or facts related to your topic.

Photos, maps, and/or other types of visual aids.
You should include at least one photo, map, or visual component in addition to your infographic.

Group Names:

Communicating Resilience Visually

For your resilience poster, you will create an infographic that communicates a part of your poster topic. An infographic is used to represent data and facts visually. Visually presenting data and facts can help people see patterns and trends that they might not notice when reading text about the same information.

The main idea

What's the main idea you wish to communicate with your infographic? Write it as one sentence. Try to make the sentence simple.

How does your main idea connect to your poster topic?

How can this information be conveyed visually? (List your ideas!)

Finding data and facts

What data and facts can help you communicate your main idea? List the specific data and facts on the left that you'd like to include. Search online for each item and add notes about what you find in the column on the right.

Data or fact searched	What we found online (and where we found it)

Group Names:

Communicating Resilience Visually *(continued)*

Planning the infographic

1. What is the title of your graphic? (should be similar to the main idea)

2. What data/facts will your graphic contain? (choose 2-4 things)

3. How will you represent the data? (line graph, pie chart, icons, numbers, etc.)

Make a draft of your graphic and get feedback from others.
Sketch the layout of your infographic on paper once you have collected all the facts and data that you want to put on your graphic and have a basic idea of how you would like it to look.

You will present your sketch and your answers to the three questions above to other students and your teacher. Use their feedback to make sure your infographic communicates the main idea.

Create your graphic!

- For visual representations of data (such as a graph or chart), use Google Sheets or Excel to create visuals that you will add to your poster.
- For visual representations of facts, try the tools in Google Slides to create shapes, lines, and format text. Add your own artwork, photos, or clipart to help communicate the facts.

Group Names:

Resilience Poster Rubric

	0	1	2	3
The poster contains a title that describes the action.	No title is provided.	The title is too vague to understand what the action is.	The title is provided and related to an action but is somewhat unclear.	The title clearly states what the action is.
The poster includes which scale of plan is addressed by the action.	The poster doesn't indicate which scale.	The plan is mentioned but incorrectly identified.	The plan is mentioned, but it is not clear which one the action relates to.	The plan addressed is clearly and correctly stated.
The problem addressed by the action is described on the poster.	No problem is mentioned.	The problem is described incorrectly and/or incompletely.	The problem is described clearly, but it does not relate to hurricanes.	The problem is described clearly and accurately.
The poster connects to storm story data.	No connection to a storm story is evident.	A quote/summary is present, but it does not relate to the action or problem.	A quote/summary is present but weakly links to the action or problem.	At least one quote/ summary from a story with a strong link to the action is provided.
The poster explains how the action reduces vulnerability.	No explanation of how the action reduces vulnerability.	Vulnerabilities are mentioned but not explained.	Vulnerabilities are mentioned but not clearly explained as they relate to the action.	A clear explanation of how action reduces vulnerability is provided.
The poster describes the benefit(s) of the action.	No mention of the benefits is evident.	The benefits of the action are mentioned but incomplete.	The benefits of the action are clearly mentioned but supporting research not mentioned.	The benefits of the action are clearly mentioned and supported by research.
The steps of implement-ing the action, including costs, are presented.	The poster does not mention the steps, materials, or costs.	Steps, materials, and costs are mentioned but do not provide a clear picture of what is needed.	Steps, materials, and costs are mostly complete with some gaps in what's needed to implement the action.	Steps, materials, and costs are complete and realistic and provide a clear picture of what is needed to implement the
The poster contains an infographic.	No infographic is present.	Infographic is present but is somewhat inaccurate or is poorly organized.	Infographic is accurate but distracts from our understanding of the action or problem.	Infographic is present, accurate, and clearly organized. It adds to the understanding of the action or problem.
The poster contains a visual aid (photo, etc).	No visual is present.	Visual aid is present, but it is unclear how it relates to the action or problem.	Visual aid is present and clearly relates to the topic but does not add any new information.	Visual aid is present, clearly relates to the topic, and furthers our understanding of the action or problem.
The overall effectiveness of the poster.	The poster is unorganized, unclear, or inaccurate.	Poster is lacking in accuracy, neatness, or organization and demonstrates some understanding of the action and problem.	The poster is accurate, neat, and mostly organized. It demonstrates an average understanding of the action and problem.	The poster is organized, neat, accurate, and demonstrates an in-depth understanding of the action and problem.

Group giving feedback: names

Group getting feedback: names

Poster Plan Feedback Notes

Take notes in the spaces below about feedback on your poster plan from your classmates and teacher.

Poster Plan	Comments from classmates:	Comments from teacher:
Poster title		
Description of the problem that this action solves		
Information from the Storm Stories data that's related to the problem or action		
Explanation of how the action reduces vulnerability		
Description of what's needed for this action		
The draft infographic		
Photos, maps, and/or other types of visual aids		
Other suggestions		