Teek and Tom Episode 3

Weather and Climate EXTREMES!

LESSON 6

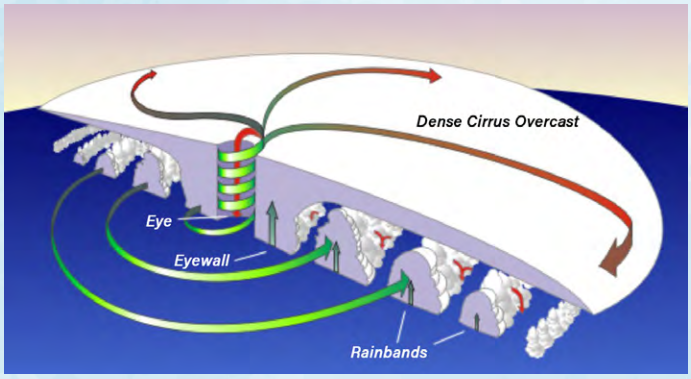
Recipes for Disasters: Tornadoes and Hurricanes

All URLs were reviewed and accurate at the time of this lesson's publication. If you should come across a non-operational link, contact NOAA Ocean Service Education at oceanserviceseducation@noaa.gov. All images are credited to NOAA unless otherwise noted.

Introduction

In the third episode of Teek and Tom, they discuss weather and climate extremes. In this lesson, we will look at two of the most severe types of weather events: the tornado and the hurricane. A tornado is a narrow, violently rotating column of air that extends from a thunderstorm to the ground. Inside the huge thundercloud, warm and humid air rises, while cool air falls, along with rain or hail. All these conditions can result in rolling, spinning air currents inside the cloud. Although this spinning column of air starts out horizontally, it can easily turn vertically and drop down out of the cloud. When it touches the ground, it's a tornado.

Hurricanes are extremely powerful weather events that form over the ocean. The heat from tropical waters provides the hurricane with energy, allowing it to turn into a violent storm. Hurricanes start as a low-pressure area that moves westward through the moisture-rich tropics. As the warm ocean air rises, more air rushes in beneath it. The rising air then cools, forming clouds and thunderstorms.



Up in the clouds, water condenses and forms droplets, releasing even more heat to power the storm. When wind speeds within such a storm reach 74 mph, it's classified as a hurricane. The terms "hurricane" and "tropical cyclone" refer to the same kind of storm: a rotating system of clouds and thunderstorms that originate over tropical or subtropical waters and have closed low-level circulation. The same type of weather event in the northwest Pacific is called a "typhoon," and "cyclones" occur in

the South Pacific and Indian Ocean. Global warming increases ocean temperatures, which increase the ferocity of hurricanes.

Weather and climate extremes are conditions, such as temperature, precipitation, drought, or flooding, that are above or below the range of historical measurements. More intense droughts, stronger hurricanes, and more intense rains are all signs of a warming climate. Extreme weather events often cause a lot of physical damage and can be very costly to the areas they impact. When weather extremes become more frequent, they may reflect a change in the climate. NOAA's National Centers for Environmental Information Climate Extremes Index (https://www.ncei.noaa.gov/access/monitoring/cei/) tracks extreme weather events by combining six indicators related to temperature, drought, precipitation events, and tropical cyclone activity. Scientists determine a percentage of the contiguous U.S. that is above or below these normal climate conditions to calculate the extremes.

Lesson Summary

Students will learn about the atmospheric conditions needed for extreme weather events like tornadoes and hurricanes. They will track the path of Hurricane Ian from 2022. Finally, students will review a climate extreme map to find whether their local area is above or below normal climate conditions and what weather extremes might impact them.

Objectives

- Students will be able to identify the basic conditions of tornado formation and where they commonly occur.
- Students will be able to identify the conditions needed for hurricane formation, as well as the impacts of landfall.
- Students will be able to identify the impacts of a warming ocean on extreme weather events.
- Students will be able to explain the difference between weather and climate extremes and give an example of each.

Estimated Time

It is estimated that one to two 45-minute class periods are needed for each lesson. This does not include the time required to view Teek and Tom Episode 3: *"Weather and Climate EXTREMES!"*, 9:53 minutes (https://oceantoday.noaa.gov/teekandtom/episode-3.html).

Education Standards

The lessons that accompany the Teek and Tom series were designed for upper elementary and middle school students. The standards addressed are abbreviated here. A full list of standards is available in Appendix A (https://oceantoday.noaa.gov/teekandtom/educators-guide/teek-and-tom-educators-guide-appendix-a.pdf).

Next Generation Science Standards

- **3-ESS2-1: Earth's Systems**. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.
- **MS-ESS2-5: Earth's Systems**. Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.
- **MS-ESS3-2: Earth and Human Activity** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Common Core English and Language Arts: Writing Standards Grades 4-5

Common Core Mathematics: Measurement and Data - Represent and interpret data.

College, Career, and Civic Life (C3) Framework for Social Studies: Geographic Representations

Materials

For a class of 30

- Students will need printouts of student record sheets, graphs, and/or maps to carry out the activities. Student record sheets are located at the end of this lesson.
- If you would like to provide the maps/graphics on a projection system, students will only need the student record sheets. Depending on the configuration of your classroom, we recommend one set per student or group.
- All maps/graphics presented in the activity are available as a slide set to project or present while teaching these activities. (https://oceantoday.noaa.gov/teekandtom/educators-guide/slide-set-6.zip)

Preparation

No special preparation is needed for this lesson.


Credit: Shutterstock

InvesTeekation Pathway

Part 1. Engage

Two images display the before and after of the 2011 tornado in Joplin, Missouri. This was a particularly destructive event, causing damage for 13 miles. At its widest point, the path of the tornado stretched a full mile. As the storm moved through Joplin, it gained strength, with winds peaking at more than 200 mph. Note: Shortly after the May 22, 2011 tornado, NOAA dispatched its King Air 350CER aircraft, equipped with specialized remote sensing equipment, to take imagery after the event. The time of day might be a factor in finding differences. The cars in the lot before the tornado may have been reflective of a work day. Since the tornado and the image taken after the event were after 5 p.m., many people may have left for the day.

Before the tornado	After the tornado
Roads are visible	*Roads are still present*
Trees dot the landscape	*Most trees are gone*
Many cars are present in parking lots	*The cars are gone*
Large building complex in the middle with many smaller houses around the streets	*The houses and building complexes are gone*

EXPLORE

Part 2. Explore

Review the recipe for a tornado with students, then ask them to review the two U.S. maps that show monthly tornado events in May and June from 1998-2022. Extension: You can see additional months at NOAA's National Weather Service (NWS) Storm Prediction Center 25-Year Average Number of Tornadoes per State by Month webpage (https://www.spc.noaa.gov/wcm/permonth_by_state/), which provides all tornados from 1997 through 2023.

Discussion questions

1. Find your state and compare the average number of tornadoes in April and May. *These answers will vary, but the overall trend would be for more tornadoes in the central part of the U.S.*

2. Compare the images for April and May. What trends do you see happening from April to May? *The trend is that as spring progresses, the high number of tornadoes moves more north and more west.*

3. Next, students are introduced to hurricanes as an extreme weather event. They look at a series of images showing a hurricane's development path and then are asked to characterize whether a storm would be a tropical depression, a tropical storm, or a hurricane based on its wind speeds. The storms are from 2022. Additional information can be found at NOAA's National Hurricane Center 2022 Atlantic Hurricane webpage (https://www.nhc.noaa.gov/data/tcr/index.php?season=2022&basin=atl).

Gaston	55	*Tropical storm*
Eleven	30	*Tropical depression*
Bonnie	95	*Hurricane*

You may find interest in these two sites if you live in an area that has been affected by hurricanes.

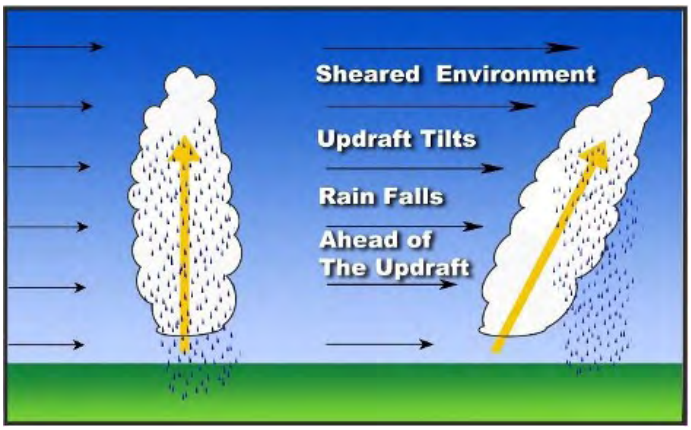
- NOAA's National Hurricane Center, Hurricanes in History (https://www.nhc.noaa.gov/outreach/history/)
- NOAA's National Hurricane Center Yearly Maps of Hurricane Tracks (https://www.nhc.noaa.gov/data/tcr/index.php)

EXPLAIN

Part 3. Explain

Students are given an infographic to develop a recipe for a hurricane. Overall, these ingredients are needed:

- A preexisting weather disturbance. A hurricane often starts as an area of low pressure in the atmosphere that moves west from Africa.
- Warm water of at least 80 degrees Fahrenheit, extending to a depth of at least 165 feet, powers the storm.
- Low wind shear. Wind shear describes how the wind changes speed and/or direction with height. The image below shows two storms, one in a very weakly sheared environment on the left and another in a strongly sheared environment on the right. The storm experiencing little or no wind shear will produce a vertical updraft. A large difference in wind speed and direction around or near the storm can weaken it.



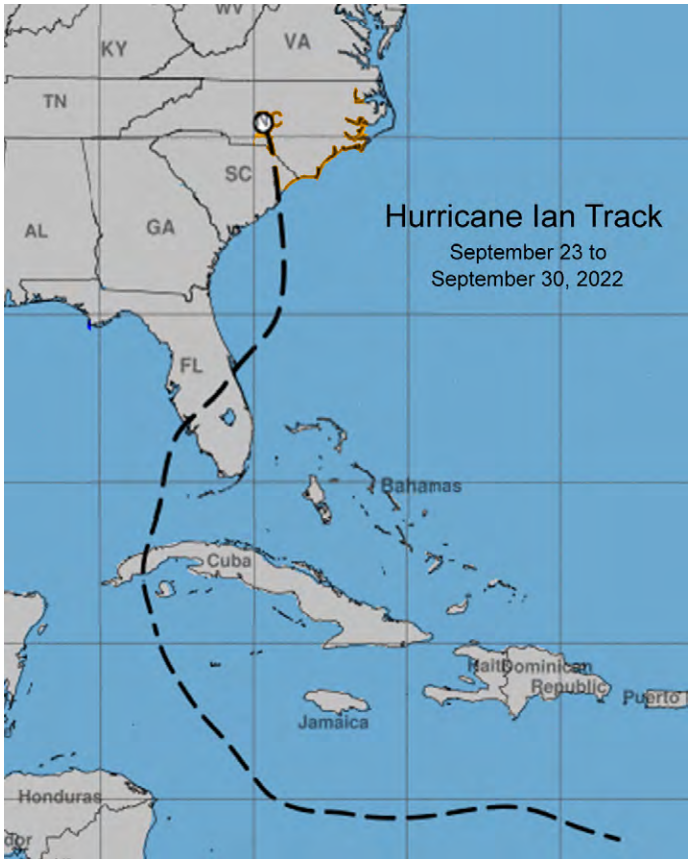
Discussion questions

1. Where do hurricanes form that impact the United States? *Disturbances over Africa in tropical regions.*
2. What water temperature is needed? *Tropical places where the water is at least 80 degrees Fahrenheit.*
3. What kind of air is needed? *Moist, warm air forms disturbances over the warm water.*
4. When is the storm considered a hurricane? *When spinning winds reach 74 miles per hour, it is considered a hurricane.*
5. How big are the storms? *Ten miles high and 1,000 miles across.*
6. How does a hurricane become less powerful? *When a hurricane hits land, when it moves over colder water, or when wind shear increases.*


Credit: Shutterstock

ELABORATE

Part 4. Elaborate



Hurricane Ian was a major hurricane of the 2022 North Atlantic hurricane season. Students will track part of the path of Hurricane Ian over eight days. They will use the information provided to answer the following questions.

1. When was Ian classified as a tropical storm? *September 24*
2. When was Ian upgraded to a hurricane? *September 27*
3. How long was Ian classified as a hurricane? *Four days*
4. What state felt the greatest impact of the hurricane? *Florida*

EVALUATE

Part 5. Evaluate

1. Show students the NOAA Ocean Today video, "Fuel for the Storm: How warming oceans lead to bigger hurricanes in the future." (https://oceantoday.noaa.gov/every-full-moon/episode11-hurricane/).

2. If time permits, this NOAA Ocean Today video shows a snapshot of the formation of Hurricane Sandy in 2012. The Making of a Super Storm (https://oceantoday.noaa.gov/fullmoon-makingofasuperstorm/).

3. Have students work in small groups or pairs and ask them to highlight the impacts of a warmer ocean on hurricanes, atmospheric rivers, and inland storms. Potential impacts include:
   - More moisture in atmospheric rivers
   - Longer and more intense heat waves
   - More moisture in hurricanes
   - More moisture moving inland for storms
   - Increased rainfall
   - More flooding with storms
   - Increased storm surge on coasts
   - Stronger hurricanes

4. Finally, have students look carefully at the climate extremes map and identify the index percentages for each region. Encourage discussion about what they have learned so far about atmospheric rivers and weather on the coasts and inland that can bring heavy rain and flooding. Remind them how increased moisture in the atmosphere powers storms like snow storms, tornadoes, and hurricanes. The provided list will help remind them about potential weather extremes.
   - More heat waves
   - Heavy rain from atmospheric rivers
   - More flooding from increased rainfall
   - Severe snow storms from atmospheric rivers
   - Tornadoes
   - Hurricanes bring more rainfall and flooding

   Have students work in small groups or discuss the Climate Extremes Index map as a class and complete the chart provided to them. (answer key on next page)

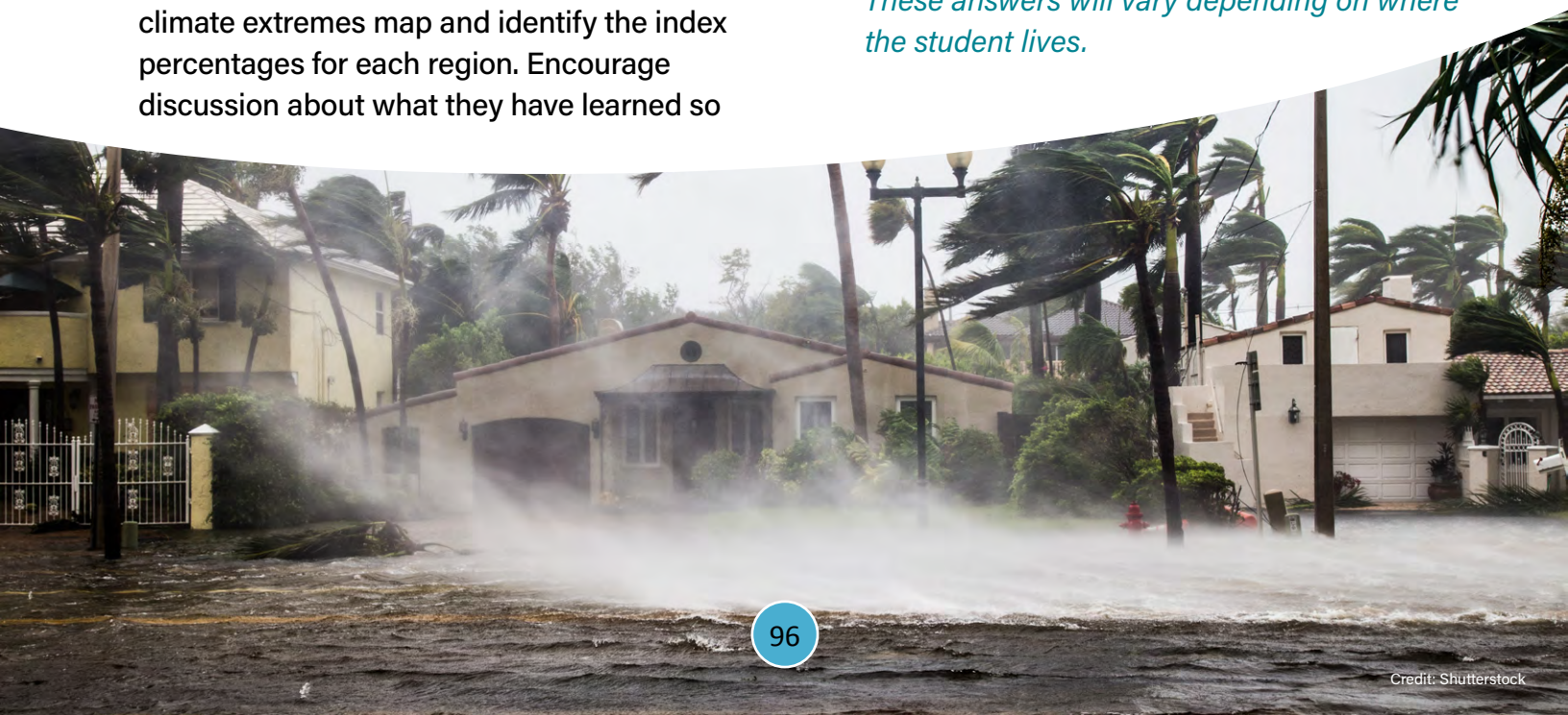
Discussion questions

1. Why do you think the Ohio Valley and the Upper Midwest have such low percentages?

   These regions get some moisture from passing storms and have some tornadoes, but they have less severe heat waves and little impact from hurricanes.

2. What is the climate index for your state? What weather extremes impact your area?

   These answers will vary depending on where the student lives.



Credit: Shutterstock

Region	Index percentage	Weather extremes that impact the region
West	*45.36%*	*Heavy rain from atmospheric rivers* *More flooding from increased rainfall* *Severe snow storms from atmospheric rivers* *More heat waves*
Northeast	*22.16%*	*More flooding from increased rainfall* *Hurricanes bring more rainfall and flooding* *More heat waves*
Upper Midwest and Ohio Valley	*8.78%* *7.10%*	*More heat waves* *Tornadoes* *More flooding from increased rainfall*
Southwest	*16.80%*	*More heat waves* *Hurricanes bring more rainfall and flooding*
South	*24.10%*	*Hurricanes bring more rainfall and flooding* *More heat waves* *Tornadoes* *More flooding from increased rainfall*
Southeast	*18.84%*	*Hurricanes bring more rainfall and flooding* *More heat waves* *More flooding from increased rainfall*
Northwest	*19.48%*	*More flooding from increased rainfall* *Severe snow storms from atmospheric rivers* *More heat waves*
Northern Rockies and Plains	*18.32%*	*More heat waves* *Severe snow storms from atmospheric rivers* *More flooding from increased rainfall*

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Credit: NASA

Extensions

The University Center for Atmospheric Research's Center for Science Education has a series of lessons on worldwide hurricane incidence and the effects of increasing sea surface temperatures (https://scied.ucar.edu/activity/hurricanes-and-climate).

These NOAA Ocean Today Videos will be helpful for student understanding during discussions about hurricanes.

- Hurricane Storm Surge (https://oceantoday.noaa.gov/hurricanestormsurge/)
- Hurricane Survival (https://oceantoday.noaa.gov/hurricanesurvival/)

Student Record Sheets

PART 1. A Bad Night in Joplin

A tornado began in Joplin, Missouri, at 5:41 p.m. local time on May 22, 2011, and lasted for 32 minutes. It caused damage for 13 miles. At its widest point, the path of the tornado stretched a full mile. As the storm moved through Joplin, it gained strength, with winds peaking at more than 200 mph. Look at the two images below and identify four features that changed after the storm.

Before

After

Before the Tornado	After the Tornado

"Before-and-after" images like this are important in helping federal and local officials and emergency responders understand a tornado's damage and what hazards still exist. This tornado caused 161 fatalities and more than 1,000 injuries, making it one of the deadliest single tornadoes on record in the U.S. since official records began in 1950. Over 3,000 residences were heavily damaged or completely destroyed, and 15,000 vehicles, including heavy buses and tractor trailers, were picked up and carried by the winds — some for hundreds of yards. A team from NOAA's National Weather Service (NWS) found vehicles that had been rolled into balls of bent metal and broken glass by the storm's force.

Credit: Shutterstock

Earth Curiosities

Amazing Precipitation Records

Type of Precipitation	Date	Place	Record Amount
Rain in 24 hours	January 7, 1968	Réunion Island (in the Indian Ocean, off the coast of Madagascar)	71.9 inches
Rain in 1 hour	July 3, 1975	Inner Mongolia, China	15.8 inches
Hailstone	July 23, 2010	Vivian, South Dakota	8 inches & 1.9 pounds
Snow total in 24 hours	April 15, 1921	Silver Lake, Colorado	75.6 inches

8-inch hailstone, Vivan, South Dakota (NWS)

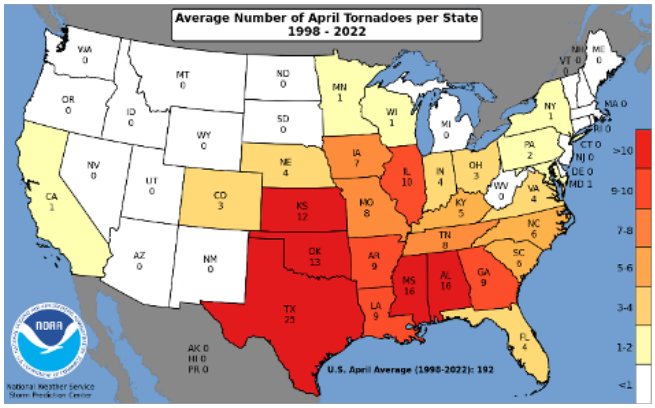
PART 2.

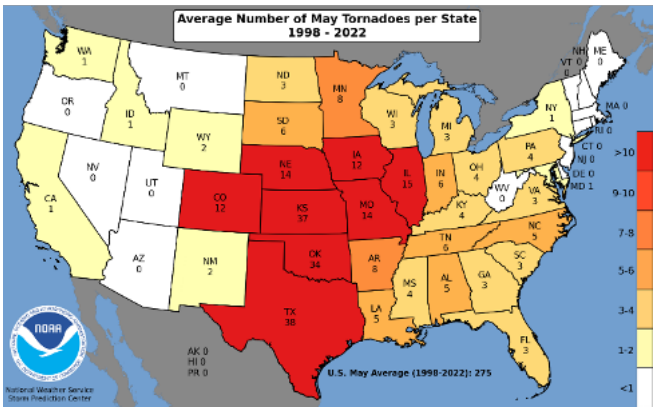
Tornadoes

Recipe for a Tornado

- Warm, moist air near the ground
- Cooler dry air above in the atmosphere
- Wind shear – a change in wind speed or direction the higher you go in the atmosphere

Tornadoes can be among the most violent phenomena of all atmospheric storms we experience. Because wind is invisible, it is hard to see a tornado unless it forms a condensation funnel made up of water droplets, dust, and debris. About 1,200 tornadoes hit the U.S. each year, and 15,000 severe storm and tornado watches and warnings are issued by NOAA NWS each year.



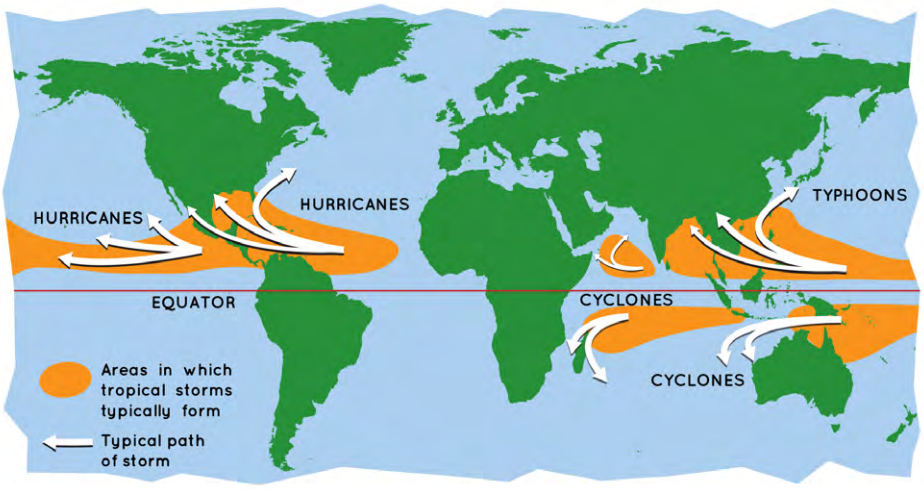


1. These maps show the average number of tornadoes in April and May for each state from 1998 to 2022. Notice that the left map is April, and the right map is May. Since 1950, there have only been four tornadoes in Alaska. From 1950 to 2018, only 42 tornadoes were reported in the state of Hawaii. That is an average of 0.05 each month. Find your state and compare the average number of tornadoes in April and May.

2. Compare the images for April and May. What trends do you see happening from April to May?

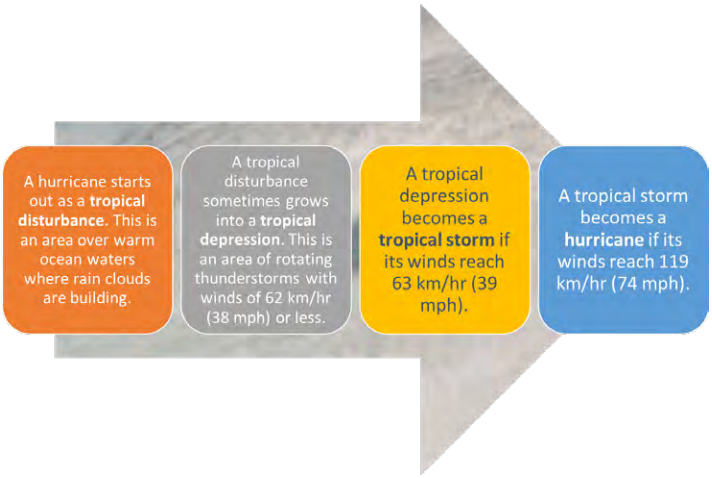
Hurricanes

Hurricanes are severe tropical storms that form in the southern Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and the eastern Pacific Ocean. They collect heat and energy through contact with warm ocean waters and then move toward land. Evaporation from the ocean water increases their power. Hurricanes rotate in a counterclockwise direction around an "eye," which is the center of the hurricane. Hurricanes are called "typhoons" in the northwest Pacific and "cyclones" in the South Pacific and Indian Ocean.



Credit: https://mynasadata.larc.nasa.gov/

Many hurricanes start out as tropical disturbances and then become tropical depressions off the west coast of Africa. As the disturbance moves west due to prevailing winds, it becomes a tropical storm with winds between 39 and 73 mph. It is called a hurricane when the winds reach at least 74 mph. When this storm comes onto land, the heavy rain, strong winds, and large waves can damage buildings, trees, and cars. Hurricanes are most common between June and November. The Atlantic and Gulf coasts can get hit, and the effects can be felt more than 100 miles inland. People who live on the coast may experience extreme winds and flooding from rain and storm surge. People who live inland are at risk for wind, thunderstorms, and flooding.



3. Determine whether the following storms from 2022 would be considered a tropical depression, a tropical storm, or a hurricane.

Storm name	Wind speed	Tropical depression, tropical storm, or hurricane
Gaston	55	
Eleven	30	
Bonnie	95	

PART 3.

Recipe for a Hurricane

Whipping up a hurricane calls for a number of ingredients readily available in tropical areas.

Look at the informational poster and find the key ingredients needed for a hurricane to develop.

Put your findings in the recipe form below.

Recipe for a Hurricane

1. Where do hurricanes form that impact the United States?

2. What water temperature is needed?

3. What kind of air is needed?

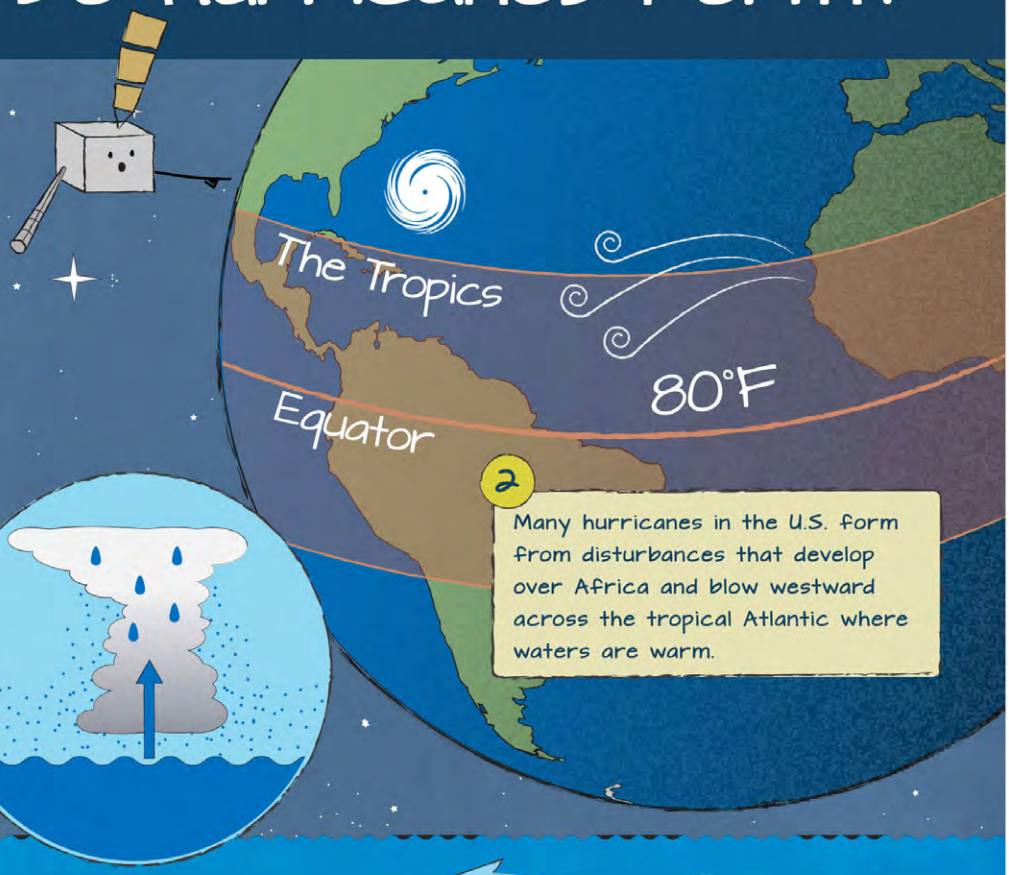
4. When is the storm considered a hurricane?

5. How big are the storms?

6. How does a hurricane become less powerful?

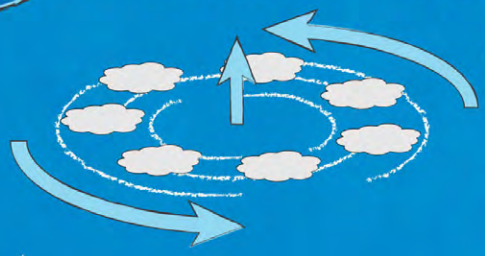
How Do Hurricanes Form?

1. Hurricanes form in tropical regions where the ocean is at least 80 degrees Fahrenheit. These waters evaporate, creating warm, moist air—which acts as fuel for the storm.

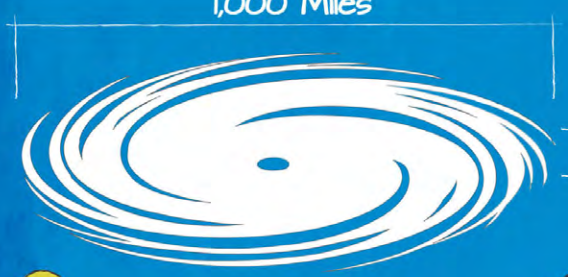


2. Many hurricanes in the U.S. form from disturbances that develop over Africa and blow westward across the tropical Atlantic where waters are warm.

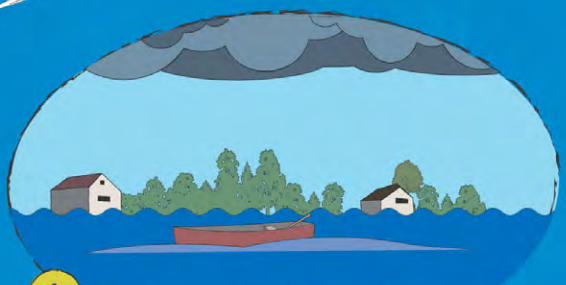
3. The warm, moist air rises high into the atmosphere where it begins to cool. Water vapor condenses back into liquid droplets and forms big, stormy anvil-shaped clouds.



4. As warm air rises, the winds begin blowing in a circle. The spiraling winds gather a cluster of clouds.

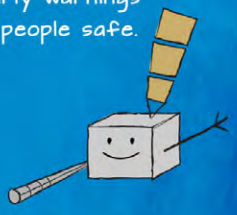


5. Once the spinning winds reach 74 miles per hour, the storm has officially become a hurricane. These storms can be 10 miles high and over 1000 miles across!



6. If a hurricane hits land, it runs out of warm, moist air and its winds decrease, but it can still cause lots of damage (especially from flooding).

Thankfully, the GOES-R series of weather sateillites take a scan of the U.S. every five minutes, keeping an eye on conditions that might cause a hurricane. This helps meteorologists deliver early warnings and keep people safe.



SciJinks

Find out more about Earth's weather at scijinks.gov

PART 4.

A 2022 Disaster

Hurricane Ian was a major hurricane of the 2022 North Atlantic hurricane season. Warm ocean sea surface temperatures across the region aided the hurricane's formation. As Ian approached the central Florida coast, it continued to strengthen with winds of 155 mph. The combination of Ian's excessive rainfall, severe winds, and storm surge contributed to widespread damage and loss of property. More than 2.6 million people lost electricity. Many coastal communities were washed away by the winds and storm surge.

Satellite image of Hurricane Ian on September 28, 2022 (NOAA)

You will track the path of Hurricane Ian as it traveled up from the Caribbean to impact Florida and other states. The map shows an area of the Atlantic Ocean and Caribbean Sea off the east coast of North America. Use the map to track the path of Hurricane Ian from the positions given in the accompanying table.

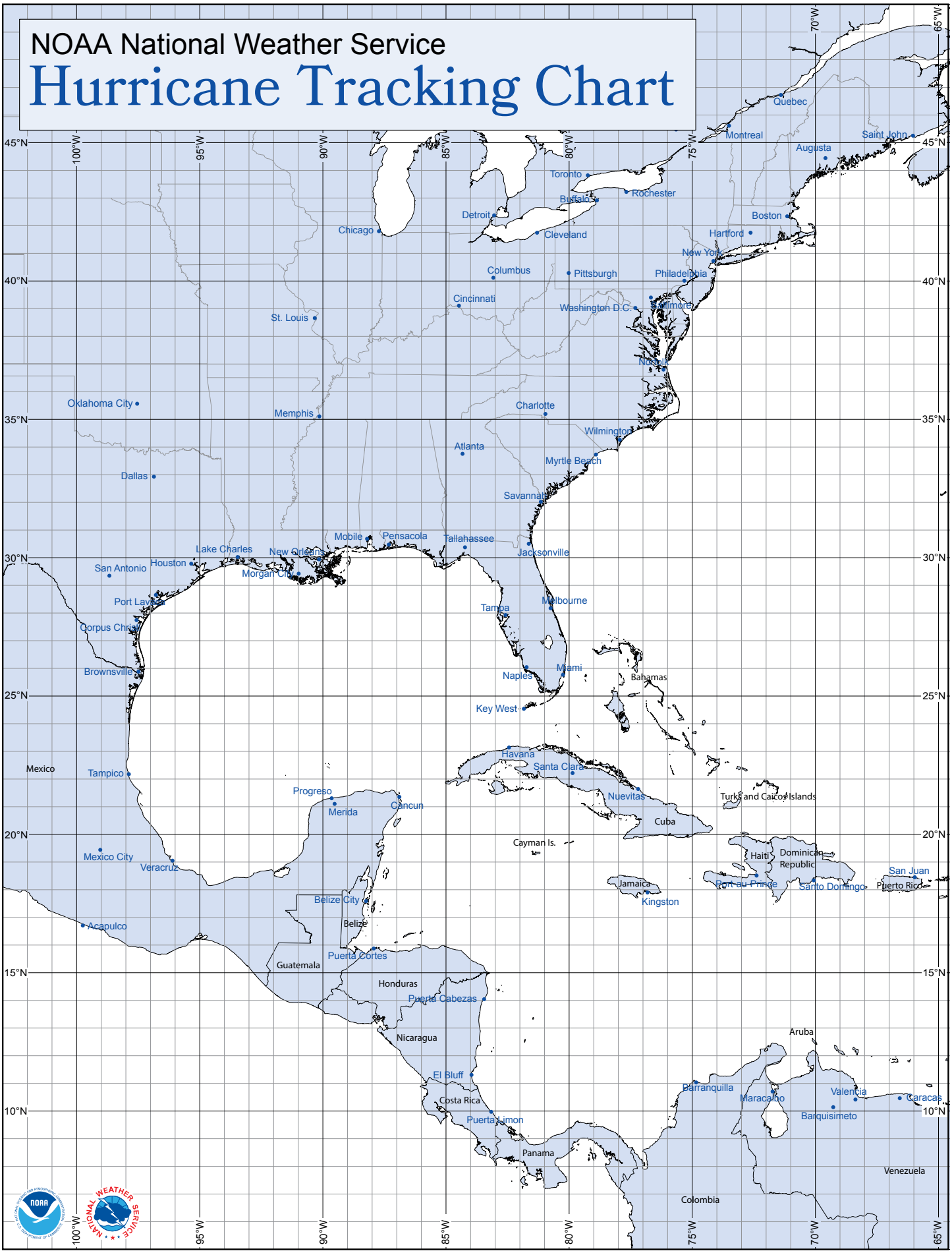
Each position shows the storm's center for the time indicated in the table. These positions are given as latitude and longitude. Longitude increases toward the left (west), and latitude increases upward (north).

Plot each of the eight positions from the table and mark them on the map with corresponding numbers to compare the map with the numbered positions to the information on the data table. Connect your plotted points with line segments and answer the follow-up questions.

Credit: Shutterstock

NOAA National Weather Service

Hurricane Tracking Chart



NATIONAL WEATHER SERVICE: Building a Weather-Ready Nation www.weather.gov

To learn more about tropical cyclones, and how to protect yourself, visit JetStream - an Online School for Weather at www.weather.gov/jetstream

Track for Hurricane Ian, September 2022

Position	Date	West Longitude	North Latitude	Winds in miles per hour
1	September 24	72	15	40
2	September 25	79	15	50
3	September 26	83	20	100
4	September 27	84	23	125
5	September 28	83	26	155
6	September 29	80	30	80
7	September 30	79	34	70
8	October 1	79	35	50

1. When was Ian classified as a tropical storm?

2. When was Ian upgraded to a hurricane?

3. How long was Ian classified as a hurricane?

4. What state felt the greatest impact of the hurricane?

Credit: Shutterstock

PART 5.

After you view the video "Fuel for the Storm," (https://oceantoday.noaa.gov/every-full-moon/episode11-hurricane/welcome.html) work in small groups or pairs to summarize the impacts of a warmer ocean on hurricanes, atmospheric rivers, and inland storms. Share your findings with the class.

Climate Extremes

We have seen many examples of weather extremes, from snowstorms to tornadoes and hurricanes. When the number of these events increases or decreases, it may reflect a changing climate. Scientists track extreme weather events by collecting data related to temperature, drought, flooding, precipitation events, and tropical cyclone activity. They use this to determine what parts of the U.S. are above or below normal climate conditions to calculate the extremes.

Look at the map below and identify the index percentages for each region. Choose from the following list of weather extremes that might impact the climate for each region.

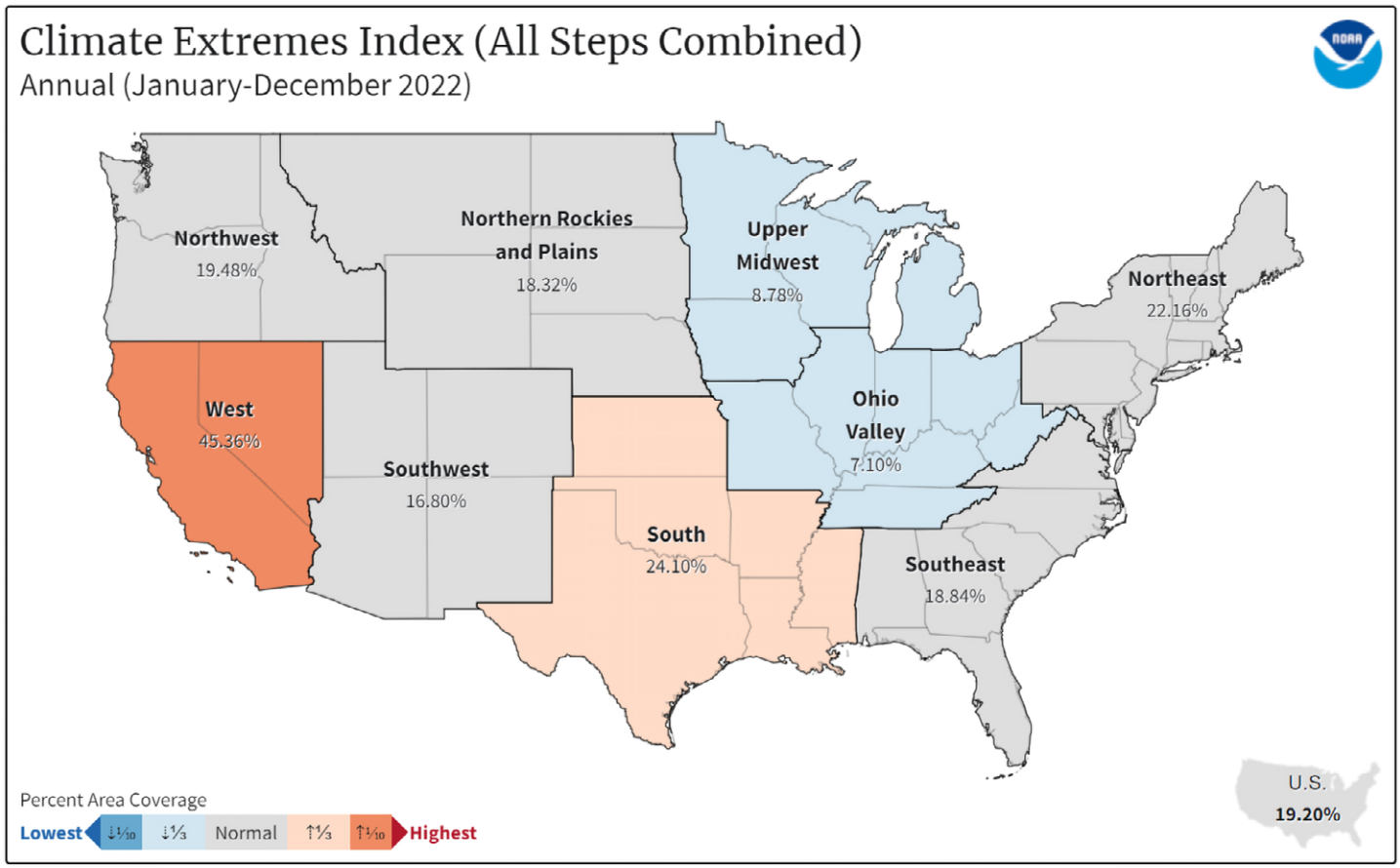
- More heat waves
- Heavy rain from atmospheric rivers
- More flooding from increased rainfall
- Severe snow storms from atmospheric rivers
- Tornadoes
- Hurricanes bring more rainfall and flooding

Region	Index percentage	Weather extremes that impact the region
West		
Northeast		
Upper Midwest and Ohio Valley		

Region	Index percentage	Weather extremes that impact the region
Southwest		
South		
Southeast		
Northwest		
Northern Rockies and Plains		

1. Why do you think the Ohio Valley and the Upper Midwest have such low percentages?

2. What is the climate index for your state? What weather extremes impact your area?


Climate Extremes Index (All Steps Combined)
Annual (January-December 2022)
Northwest
19.48%
Northern Rockies
and Plains
18.32%
Upper
Midwest
8.78%
Northeast
22.16%
West
45.36%
Ohio
Valley
7.10%
Southwest
16.80%
South
24.10%
Southeast
18.84%
U.S.
19.20%
Percent Area Coverage
Lowest
↓1/10
↓1/3
Normal
↑1/3
↑1/10
Highest