

Lesson 5: Hurricanes and Climate Change

SKILLS:



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.

Lesson 5: Hurricanes and Climate Change

- 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.

Lesson 5: Hurricanes and Climate Change

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.

Lesson 5: Hurricanes and Climate Change

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.

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

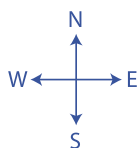
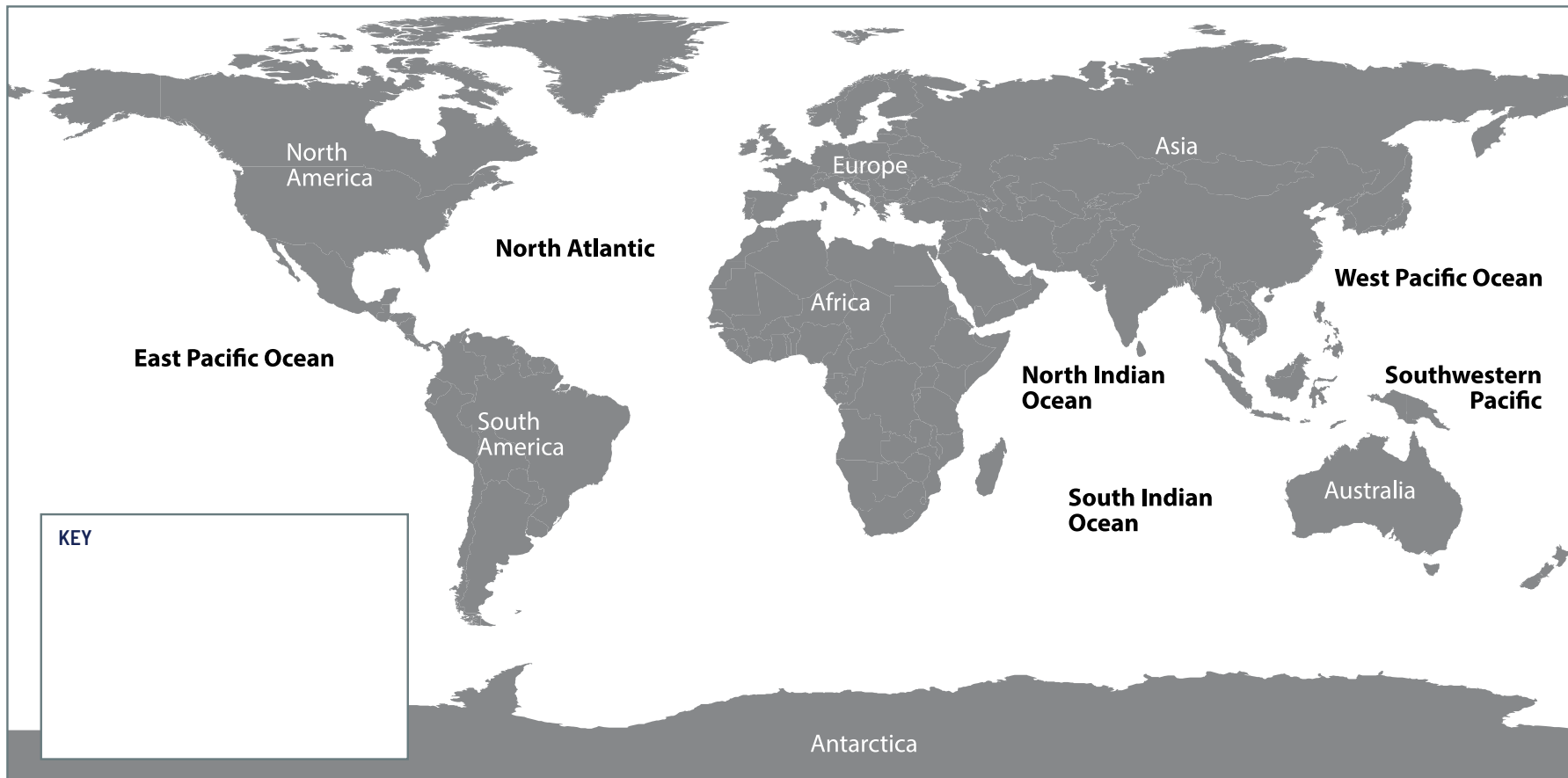
Data from NOAA National Centers for Environmental Information IBTrACS v.3 retrieved by Ming Ge (NCAR)

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		

