Grades 5–8

The Potential Consequences of Climate Variability and Change

COASTAL AREAS

What Could A Hurricane Do To My Home?

AN ACTIVITY RESOURCE FOR TEACHERS

Supporting—

National Education Standards:

- ***English Language Arts***
- ***Geography***
- ***Mathematics***
- ***Science***
- ***Social Studies***

Ocean Literacy: Essential Principles and Fundamental Concepts

September 2008 Update

This learning activity was developed to examine the potential impacts of climate variability and change. Each activity is part of an overall series entitled ***The Potential Consequences of Climate Variability and Change,*** which includes grades 1–12 teacher resources. Twelve modules (10 printed and 2 online resources) comprise the set and are presented below:

OVERVIEW

- Too Many Blankets (Grades 1–4)
- Global Balance (Grades 5–12)

AGRICULTURE

- El Niño (Grades 5–8)
  This activity is provided in an online format only and is available at *http://ois.unomaha.edu/casde/casde/lessons/Nino/teacherp.htm.*
- The Great American Desert? (Grades 9–12)
  This activity is provided in an online format only and is available at *http://ois.unomaha.edu/casde/casde/lessons/grass/teacherp.htm.*

COASTAL AREAS

- What Could a Hurricane Do to My Home? (Grades 5–8)
- What Is El Niño? (Grades 5–8, 9–12)
- Coral Reefs in Hot Water (Grades 9–12)

FORESTS

- A Sticky Situation (Grades 5–8)
- Planet Watch (Grades 9–12)

HUMAN HEALTH

- Beyond the Bite: Mosquitoes and Malaria (Grades 5–8, 9–12)
- Climate and Disease: A Critical Connection (Grades 9–12)

WATER

- Here, There, Everywhere (Grades 7–8, 9–12)

The development of the activities was sponsored by the National Aeronautics and Space Administration and the Environmental Protection Agency, in support of the US Global Change Research Program. The Institute for Global Environmental Strategies implemented the effort. For more information about IGES's educational programs and resources, see *http://www.strategies.org.*

September 2008 Update

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Climate Variability & Change

COASTAL AREAS

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ACTIVITY
What Could A Hurricane Do To My Home?

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What Could A Hurricane Do To My Home?

This activity explores the potential for global climate change to increase the frequency and intensity of hurricanes and storm surges, and the impacts that could result. Designed to teach through scientific inquiry, the activity seeks to stimulate thought about the long-term impact of a warmer planet.

GRADE LEVELS

Grades 5–8

TIME REQUIRED

Four to five 45-minute class periods

OBJECTIVES

Through their participation in the following activity, students will:

- Explain the impact of hurricanes on coastal communities;
- Identify possible trends in economic and human impacts by examining hurricane records;
- Predict impacts on coastal areas if hurricane frequency increases and sea level rises;
- Determine areas that are most vulnerable to hurricane surges by using topographic maps; and
- Make and use scale drawings and maps or three-dimensional models to represent real objects, find locations, and describe relationships.

DISCIPLINES ENCOMPASSED

- Earth System Science
- Geography
- Language Arts
- Mathematics
- Meteorology
- Social Studies
- Technology

PREREQUISITE KNOWLEDGE: TEACHER

To effectively teach about the effects of climate variability and change, teachers should have a solid understanding of the following concepts:

- A hurricane is a large low-pressure weather system that has sustained winds of 74 mph or greater. These winds rotate around the calm center of the hurricane, called the eye, where air pressure is the lowest. The storm is fueled by the heat released when water evaporated from the ocean condenses. Once a hurricane starts to cross land, it usually diminishes because it loses contact with the warm ocean—its source of energy. The storm is also pulled apart by friction caused by the rough land surface as compared to the smooth ocean.
- The most dangerous impact of a hurricane is usually not from the winds but from a storm surge, a great dome of water often 50 to 100 miles wide that sweeps across the coast near where the eye of a hurricane makes landfall.
- Storm surge is caused primarily by onshore winds that push the ocean surface ahead of a storm. During a hurricane, these winds form as the storm's central pressure drops. The low pressure allows air at the center of the storm to rise. The air that rushes in from all sides to fill the void left by the rising air is turned to the right by the Coriolis force, thus producing the storm's counterclockwise winds. Other factors that affect the strength of a storm surge are coastal topography, the angle at which the storm makes landfall along the coast, and the speed of hurricane motion.

- When a storm surge is added to both the normal height of a high tide and the effects of driving winds, it can create a massive storm tide that pushes water well inland. Nine out of ten hurricane fatalities are caused by storm surges.
- Hurricane season in the western Atlantic is from June through November. The greatest frequency of hurricanes occurs in September, which coincides with when ocean water temperatures are at their warmest.
- The Gulf Stream is a large current of warm ocean water in the Atlantic. Driven by wind patterns and other forces acting on the ocean, the Gulf Stream flows north from the Gulf of Mexico, along the eastern coast of North America, and then east toward Europe. The warm water warms the air above it, which causes temperatures over western Europe to be milder than would be expected at that latitude. The heat energy provided by the Gulf Stream can intensify hurricanes that pass over it.
- More and more people are moving toward the coast. Nearly 35 million people are estimated to be living along the coast from North Carolina to Texas, the area of the United States most threatened by hurricanes, with more people moving closer to the coast all the time. (U.S. Census Bureau News, 2008)
- Hurricanes seem to occur in natural cycles of above-normal and below-normal activity that last 20 to 30 years and are unrelated to global climate change. The years 1972 to 1994, for example, marked an active period for hurricane activity, with an average of 9.1 named storms per year. Since 1995, however, hurricane activity has increased dramatically, averaging 14.8 named storms per year. One factor correlated with periods of increased hurricane activity is warmer sea surface temperatures, which are also associated with more intense storms. Scientists are concerned about how warmer ocean waters and rising sea levels, both expected as a result of global climate change, may impact both the properties and lives of the growing numbers of people moving to the coast.
- The Saffir-Simpson Hurricane Scale is a 1–5 rating based on a hurricane's intensity. For more detailed information link to: *http://www.nhc.noaa.gov/aboutsshs.shtml*

PREREQUISITE KNOWLEDGE: STUDENTS

Students must have the following skills and knowledge to complete this activity:

- Ability to read and interpret topographic maps and data tables.
- Ability to make and use maps and models to develop arguments and draw conclusions.
- Ability to read tide tables.
- Ability to use Internet browsers to do research for problem-solving.
- Ability to work collaboratively in groups.
- Ability to distinguish between high and low pressure systems and describe how they form.

KEY TERMS AND CONCEPTS

The following terms and concepts will be presented in the following text and activities:

Climate
Condensation
Friction
Gulf Stream
Hurricane
Pressure systems (high and low)
Sea level
Storm surge
Tides
Tropical storm
Weather system

SUGGESTED READING/RESOURCES

CLIMATE SCIENCE RESOURCES

The connection between global climate change and hurricanes is an evolving area of research. Teachers and students are encouraged to keep abreast of the latest news on this topic. Following are Web sites that provide the latest research on climate science:

NASA's Earth Observatory
http://earthobservatory.nasa.gov

NASA Science
http://nasascience.nasa.gov

National Oceanic and Atmospheric Administration (NOAA)
http://www.noaa.gov

U.S. Environmental Protection Agency
http://www.epa.gov/climatechange

FOR STUDENTS

Hurricane History from the *Florida Sun-Sentinel*
http://www.sun-sentinel.com/storm/history

National Hurricane Center Tropical Prediction Center
http://www.nhc.noaa.gov

The Saffir-Simpson Hurricane Scale
http://www.nhc.noaa.gov/aboutsshs.shtml

FAQ: Hurricanes, Typhoons, and Tropical Cyclones
http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html

Hurricanes with Dr. Jeff Halverson: Understanding the 21st Century's New Threat
http://www.nasa.gov/mission_pages/hurricanes/multimedia/AtlanticHurricanesWithJeff.html

Learn about hurricanes from NASA expert Dr. Jeffrey Halverson. This Web page contains 35 separate, 1–4 minute long, video segments that look at hurricanes using scientific animations or "visualizations" made from NASA satellite imagery. Each segment is viewable in your browser and is also available for download as a QuickTime movie.

Arlene to Zeta: 27 Hurricanes of the 2005 Season
http://learners.gsfc.nasa.gov/mediaviewer/27Storms

This 5-minute data visualization from NASA shows all 27 named storms of the 2005 Atlantic hurricane season and examines some of the conditions that made hurricane formation so favorable.

The Exploratorium: Overview of Climate Change Research—Atmosphere
http://www.exploratorium.edu/climate/primer/atmos-p.html

FOR TEACHERS

Hurricane Activity
Gulf of Maine Aquarium Web site:
http://octopus.gma.org/surfing/weather/index.html

Hurricanes: The Greatest Storms on Earth
http://earthobservatory.nasa.gov/Library/Hurricanes

This November 2006 reference article on NASA's Earth Observatory Web site provides background information on hurricanes and how they form, as well as a discussion of hurricanes and climate change. The information is written at a level more appropriate for upper level high school students/undergraduates. It provides excellent information for teachers to improve their understanding of hurricanes. Middle school teachers may consider using portions of this resource with more advanced students.

RELATED CLASSROOM ACTIVITIES AND RESOURCES

Hurricanes as Heat Engines
http://mynasadata.larc.nasa.gov/Hurricane_Heat_Engine.html
Students examine authentic sea surface temperature data from NASA satellites to explore how hurricanes extract heat energy from the ocean surface. Grade Level: 4–12.

Hurricanes and Sea Surface Temperature
Explore how the sea surface temperature affects the change of intensity of hurricanes using this interactive Java Applet developed by the University of Wisconsin (note—Java needs to be enabled in your Web browser).

Additional NASA hurricane education resources can be found at:
http://www.nasa.gov/vision/earth/lookingat earth/hurricane_educ_links.html

What Do Maps Show?
http://egsc.usgs.gov/isb/pubs/teachers-packets/mapshow/index.html
Educators guide for grades 4–8 produced by the U.S. Geological Survey. Lesson 4 is "How to Read a Topographic Map."

GULF STREAM: RESOURCES AND IMAGES

Flowing Ocean Classroom
http://seacoos.org/Community%20and%20 Classroom/currents-classroom
Bring the Gulf Stream into your classroom and learn about the wonders of ocean currents and circulation. This Web site from SEACOOS (SouthEast U.S. Atlantic Coastal Ocean Observing System) includes the "Flowing Oceans: Understanding the Gulf Stream" poster, as well as ocean circulation facts and activities, a circulation glossary, and links to helpful Web sites.

The Surge of the Storm
http://seacoos.org/Community%20and%20 Classroom/hurricane-classroom/surge-online
This classroom activity for grades 5–12 demonstrates the effect of a hurricane's surge on low-lying coastal areas. Includes Web references and related materials.

NASA Satellite Images and Animations
"MODIS Sea Surface Temperature Highlighting the Gulf Stream (2002 to 2006)"
http://svs.gsfc.nasa.gov/goto?3389
This animation shows a 32-day moving average of sea surface temperature data from July 4, 2002 to October 23, 2006. The animation starts over Europe, pans across the Atlantic, and settles in over the Gulf Stream. The temperature data in this visualization comes from the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard NASA's Terra and Aqua spacecraft.

Visible Earth
http://visibleearth.nasa.gov
Visible Earth is an online catalog of NASA images and animations of our home planet. Search the catalog for "Gulf Stream."

ACTIVITY

What Could A Hurricane Do To My Home?

This activity will attempt to answer the question: ***Will global climate change intensify the effects of hurricanes on coastal areas?***

MATERIALS

- Map of the U.S. Atlantic and Gulf coasts that includes the Gulf Stream:
  See the "Suggested Reading/Resources" section on page 5 for sources of Gulf Stream images/resources. Particularly good is the "Flowing Ocean: Understanding the Gulf Stream" poster, available at: *http://seacoos.org/Community%20and%20 Classroom/currents-classroom.*
- Class map: a topographic map of the fictional coastal community, Seaside (page 12)
- Tide chart for Seaside: *http://tidesonline.nos.noaa.gov*
  Use chart for Portland, Maine.
- Construction paper
- Pencils
- Computers with Internet connection
- Student activity sheets

PROCEDURE

Step 1
Ask students to give their definition of a hurricane. What does a hurricane need to "feed" it? Students can look up answers from the list of Web sites in the "Suggested Reading" section. Students can also use the Hurricane Activity listed in the "Suggested Reading" section as an introduction to this lesson. Guide the students into developing an accurate definition.

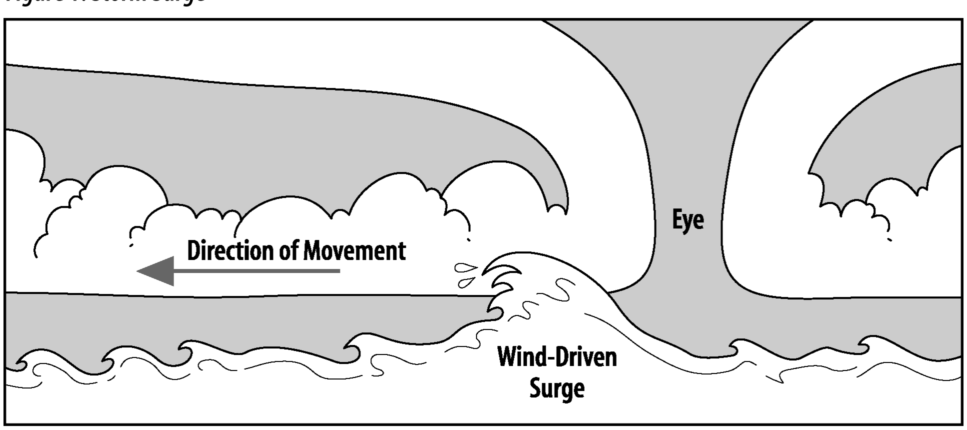
Step 2
Show students a map of the East Coast of the United States that includes the Gulf Stream. Using the information in the "Prerequisite Knowledge: Teacher" section, explain hurricanes, the hurricane season, and how storms are affected by the Gulf Stream.

Step 3
Explain how a storm surge forms and the damage it can cause (see Figure 1). To further understand the extent of damage caused by a storm surge, use the Hurricane Andrew storm surge activity at: *http://octopus.gma.org/surfing/weather/index.html.*

For the purposes of this activity, imagine that the storm surge from a hurricane is 15 feet above a normal high tide.

Step 4
Using historical data from the National Hurricane Center*, http://www.nhc.noaa.gov,* have students compare the 10 deadliest and the 10 most expensive hurricanes to strike the U.S. mainland. Students fill in the answers to Questions 1 through 3 on the **Student Activity Sheets.**

Figure 1. Storm Surge



Step 5
Scientists have not yet definitively linked an increase in hurricanes to global climate change. However, sea level rise has been proven to be occurring in many places due to global climate change. Explain how this can affect coastal communities during hurricanes.

Step 6
Assume that all members of the class are moving to the coastal community of Seaside (or you may substitute an actual community and obtain a USGS topographic map and tide tables, which are available from the Web or local marine supply stores). Ask students to choose a place for their homes in any part of the community. (Some may want oceanfront property; others may decide to put their homes on the highest part of town.)

Ask each student to mark the location of his or her home on the topographic map. Number each house and make a key, such as: #1, Kevin Smith, 15 feet above sea level. Students answer Question 4 on the **Student Activity Sheets.**

Step 7
Tell the students that a hurricane will hit the coastal community of Seaside. Assuming the storm surge causes sea level to rise 15 feet, what would happen to the community at low tide? At high tide? Were any homes hit? Students answer Question 5 on the **Student Activity Sheets.**

Step 8
Discuss the impact an increase in hurricane activity might have on your real-life community. Have students determine how to prepare themselves and the community for such an occurrence. Students answer Questions 6 and 7 on the **Student Activity Sheets.**

Step 9
Scientists know that warm waters "fuel" tropical storms, which may become hurricanes. As yet, there is no definitive evidence that hurricanes are increasing as a result of global climate change. However, some studies have shown that global climate change may be contributing to more intense hurricanes. Discuss how global climate change might impact hurricane frequency and intensity. Students answer Question 8 on the **Student Activity Sheets.**

CONCLUSION

- Discuss similarities and differences between student predictions.
- Ask students to explain how their study of the Seaside community relates to the real world.
- Discuss how the effects of climate variability and change combined with hurricane activity can affect coastal populations.
- Ask the students to explain how this information could affect coastal migration.

EXTENSIONS

1. Instead of using a topographic map, have students do this activity by creating a three-dimensional model of Seaside with modeling clay.
2. Have students contact the local historical society, library, or newspaper archives to try to find historical information about the impact of past hurricanes in their community. Students may want to create a timeline, like the "Hurricane History" from the ***Florida Sun-Sentinel:*** *http://www.sun-sentinel.com/storm/history.*
3. Ask students how they would design their homes to have the best chance of withstanding hurricane force winds and storm surges. They should consider how they might design the roof and footings, for instance. What materials would they use? Research building codes of coastal areas, such as barrier islands, to identify strategies that are already in place.
4. Have students design an escape plan in the event a hurricane warning is issued for their area. Look at a road map of the region. Plot an escape route to higher ground. Instruct them to try to avoid bridges and low-lying wetland areas, as these could be washed out or flooded during a hurricane.
5. Have students research the importance of satellites in studying hurricanes.

Student Activity Sheet: WHAT COULD A HURRICANE DO TO MY HOME?

Name

Answer the following questions in complete sentences, using your own words:

1. Using historical data obtained from the National Hurricane Center, *http://www.nhc.noaa.gov,* list the 10 deadliest and the 10 most expensive hurricanes to strike the U.S. mainland since 1900.

Ten Deadliest Hurricanes to Strike the U.S. Mainland Since 1900

RANK	HURRICANE	YEAR	CATEGORY	DEATHS
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Ten Most Expensive Hurricanes to Strike the U.S. Mainland Since 1900

Identify the most expensive storms using data from the National Hurricane Center (NHC) that has been adjusted for rising construction costs. This information is usually labeled as "Adjusted" or "Ranked Using a Deflator."

For example, in the 2007 NHC report, *The Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2006,* this information is labeled "Ranked Hurricane Damage Using 2006 Deflator." A deflator is a tool that adjusts estimates so that you can compare costs over time.

RANK	HURRICANE	YEAR	CATEGORY	DAMAGE $$$$
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

2. What conclusions can you draw from this data? Include factors that may have affected this data (for example, as more people now live near the coast, there is more extensive property damage; however, weather forecasts have improved, which has given people more time to escape).

3. Can you see a trend in the number (increasing or decreasing) or severity of hurricanes? Do you need more data? If so, what?

4. Using longitude and latitude readings, give the location of your home. Be sure to mark it on the class map of Seaside. What is the elevation of your home? Why did you choose this location?

N

W E

S

5. Assume a hurricane were to hit your coastal community of Seaside, with a storm surge 15 feet above the current sea level at low and high tide (use your tide charts).

a) Will your home be hit at low tide? How many homes in the Seaside community were hit?

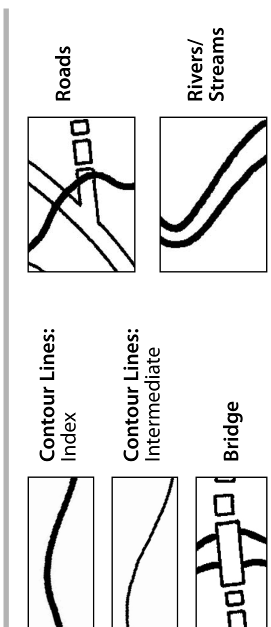
b) Will your home be hit at high tide? How many homes in the Seaside community were hit?

6. What impact would an increase in hurricane activity have on your real homes? How much of your community would be threatened by storm surges?

7. How would you prepare if hurricane activity and storm surges increased in your real community?

8. Using the knowledge you have gained from this activity, discuss how you think global climate change might impact hurricane intensity and frequency.

Topographic Map
SEASIDE



Suggested Reading and Resources for Students

CLIMATE SCIENCE RESOURCES

The connection between global climate change and hurricanes is an evolving area of research. Teachers and students are encouraged to keep abreast of the latest news on this topic. Following are Web sites that provide the latest research on climate science:

NASA's Earth Observatory
http://earthobservatory.nasa.gov

NASA Science
http://nasascience.nasa.gov

National Oceanic and Atmospheric Administration (NOAA)
http://www.noaa.gov

U.S. Environmental Protection Agency
http://www.epa.gov/climatechange

HURRICANE SOURCES

Hurricane History from the *Florida Sun-Sentinel*
http://www.sun-sentinel.com/storm/history

National Hurricane Center Tropical Prediction Center
http://www.nhc.noaa.gov

The Saffir-Simpson Hurricane Scale
http://www.nhc.noaa.gov/aboutsshs.shtml

FAQ: Hurricanes, Typhoons, and Tropical Cyclones
http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html

Hurricanes with Dr. Jeff Halverson: Understanding the 21st Century's New Threat
http://www.nasa.gov/mission_pages/hurricanes/multimedia/AtlanticHurricanesWithJeff.html

Learn about hurricanes from NASA expert Dr. Jeffrey Halverson. This Web page contains 35 separate, 1–4 minute long, video segments that look at hurricanes using scientific animations or "visualizations" made from NASA satellite imagery. Each segment is viewable in your browser and is also available for download as a QuickTime movie.

Arlene to Zeta: 27 Hurricanes of the 2005 Season
http://learners.gsfc.nasa.gov/mediaviewer/27Storms

This 5-minute data visualization from NASA shows all 27 named storms of the 2005 Atlantic hurricane season and examines some of the conditions that made hurricane formation so favorable.

The Exploratorium: Overview of Climate Change Research—Atmosphere
http://www.exploratorium.edu/climate/primer/atmos-p.html

Appendix A
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"NOAA Attributes Recent Increase in Hurricane Activity to Naturally Occurring Multi-Decadal Climate Variability," ***NOAA Magazine Online,*** Nov. 25, 2005. *http://www.magazine.noaa.gov/stories/mag184.htm*

NOAA Hurricane Research Division, "Frequently Asked Questions." *http://www.aoml.noaa.gov/hrd/tcfaq/E11.html*

U.S. Census Bureau News, "Facts for Features, Special Edition: 2008 Hurricane Season Begins," May 28, 2008. *http://www.census.gov/Press-Release/www/releases/archives/facts_for_features_special_editions/012006.html*

USA Today, "Hurricane Questions Answered." *http://www.usatoday.com/weather/resources/askjack/2004-08-20-hurricane-answers_x.htm*

Appendix B
Assessment Rubric & Answer Key

Assessment Rubric

SKILL	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Demonstrates ability to access relevant information at appropriate Internet sites.	Able to access relevant information from appropriate Internet sites.	Accesses some relevant information from appropriate Internet sites.	Accesses very little relevant information at a few appropriate Internet sites.	Is not able to access relevant information at appropriate Internet sites.
Collects and organizes data.	Able to collect a lot of data that is well organized.	Able to collect some data with good organization.	Able to collect some data with poor organization.	Not able to collect and organize data.
Able to accurately interpret and use a topographic map.	Able to accurately interpret and use a topographic map.	Able to accurately interpret, but needs help using a topographic map.	Needs help interpreting and using a topographic map.	Not able to interpret or use a topographic map.
Represents findings clearly on map/graph or model (such as a map key).	Findings are clearly represented.	Findings are represented somewhat clearly.	Findings are not represented clearly.	Not able to represent findings.
Participates in class discussions/ presentations.	All answers are logical.	Provides many answers, most are logical.	Provides few or illogical answers.	Not able to provide answers.
Provides logical answers to questions.	Always participates.	Participates frequently.	Rarely participates.	Does not participate.
Infers links between coastal development and global climate change.	Able to infer many links.	Able to infer some links.	Able to infer links with guidance.	Not able to infer any links.

ANSWER KEY Student Activity Sheets: WHAT COULD A HURRICANE DO TO MY HOME?

Answer the following questions:

1. Ten Deadliest Hurricanes to Strike the U.S. Mainland Since 1900

RANK	HURRICANE	YEAR	CATEGORY	DEATHS	NOTES
1	TX (Galveston)	1900	4	8000+	a
2	FL (SE/Lake Okeechobee)	1928	4	2500	b
3	KATRINA (SE LA/MS)	2005	3	1500	
4	AUDREY (SW LA/N TX)	1957	4	416	h
5	FL (Keys)	1935	5	408	
6	FL (Miami)/MS/AL/Pensacola	1926	4	372	
7	LA (Grand Isle)	1909	3	350	
8	FL (Keys)/S TX	1919	4	287	j
9	LA (New Orleans)	1915	4	275	e
10	TX (Galveston)	1915	4	275	

Notes:
a. Could be as high as 12,000
b. Could be as high as 3,000
e. Total including offshore losses is 600
h. At least
j. Could include some offshore losses

Source:
National Weather Service, NOAA Technical Memorandum NWS TPC-5, "The Deadliest, Costliest, and Most Intense United States Tropical Cyclones From 1851 To 2006 (And Other Frequently Requested Hurricane Facts)," April 2007.
http://www.nhc.noaa.gov/Deadliest_Costliest.shtml

1. (cont.) **Ten Most Expensive Hurricanes to Strike the U.S. Mainland Since 1900**
(Adjusted for Inflation)

RANK	HURRICANE	YEAR	CATEGORY	DAMAGE
1	KATRINA (LA/MS/FL)	2005	3	$84,645,000,000
2	ANDREW (SE FL/SE LA)	1992	5	$48,058,000,000
3	WILMA (SW/SE FL)	2005	3	$21,527,000,000
4	CHARLEY (SW FL)	2004	4	$16,322,000,000
5	IVAN (NW FL/AL)	2004	3	$15,451,000,000
6	HUGO (SC)	1989	4	$13,480,000,000
7	AGNES (FL/NE U.S.)	1972	1	$12,424,000,000
8	BETSY (SE FL/SE LA)	1965	3	$11,883,000,000
9	RITA (LA/TX/FL)	2005	3	$11,808,000,000
10	CAMILLE (MS/SE LA/VA)	1969	5	$ 9,781,000,000

Note:
Ranked using 2006 deflator; $ based on U.S. Department of Commerce Implicit Price Deflator for Construction.

Source:
National Weather Service, NOAA Technical Memorandum NWS TPC-5, "The Deadliest, Costliest, and Most Intense United States Tropical Cyclones From 1851 To 2006 (And Other Frequently Requested Hurricane Facts)," April 2007.
http://www.nhc.noaa.gov/Deadliest_Costliest.shtml

Special Note: This guide was last updated in September 2008 when Hurricane Ike struck the Texas coast. Preliminary estimates were $7 to $12 billion* for insured damages; after total costs are finalized (and adjusted for inflation), Hurricane Ike will likely replace one of these storms as ten most expensive.
Source: Risk Management Solutions, Sept. 17, 2008
http://www.rms.com/NewsPress/PR_091708_Ike_Industry_Loss.asp

2. Deaths—Nine of the ten listed all occurred before 1960. Possible factors could include:

- Technological advances;
- Meteorologists' ability to predict and track storms gave people advanced warning and time to evacuate;
- Improved and increased communication ability allowed warnings to reach more people;
- Better road systems provided more people means to evacuate;
- Deaths could have been prevented by improvements in building design;
- Better rescue efforts and technology allowed rescue workers to save more lives.

Damage—Overall, the damage caused by hurricanes has been increasing since the 1960s. Possible factors could include:

- More people live in coastal communities, causing an increase in property damage;
- More expensive homes are being built at the coasts;
- Storms occurring more often or with more force.

3. Although general observances can be made, more data is needed. Students would have to review a listing of all hurricanes on record by year and category to make an accurate hypothesis.

4.–6. All answers will be different. The teacher will have to check each student's responses for accuracy.

7. Answers may be general or specific, and could include:

- Move to a different location;
- Build stronger structures;
- Develop an evacuation plan for your family or community;
- Put together an emergency supply kit.

8. Although global climate change does not affect hurricanes directly, it could increase their intensity and frequency. If global temperatures increase and sea levels rise, this could intensify the effect of storm surges. Also, frequency and strength of hurricanes has also been on the rise recently, which may be an indicator of a changing climate.

Appendix C
National Education Standards

This activity responds to the following National Education Standards:

STANDARDS FOR THE ENGLISH LANGUAGE ARTS

Standard 3: Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics).

Standard 4: Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

Standard 5: Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.

Standard 6: Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss different print and nonprint texts.

Standard 7: Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

Standard 8: Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

Standard 12: Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

National Council of Teachers of English and International Reading Association. 1996. ***Standards for the English Language Arts*** *p. 24–46. Urbana, Illinois and Newark, Delaware: National Council of Teachers of English and International Reading Association.*

NATIONAL GEOGRAPHY STANDARDS GEOGRAPHY FOR LIFE (5–8)

Geography Standard 1: *The World in Spatial Terms.* How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

Geography Standard 4: *Places and Regions.* The physical and human characteristics of places.

Geography Standard 7: *Physical Systems.* The physical processes that shape the patterns of Earth's surface.

Geography Standard 15: *Environment and Society.* How physical systems affect human systems.

American Geographical Society, Association of American Geographers, National Council for Geographic Education, and National Geographic Society. 1994. ***Geography for Life: National Geography Standards*** *p. 143–182. Washington, DC: National Geographic Research and Exploration.*

CURRICULUM AND EVALUATION STANDARDS FOR SCHOOL MATHEMATICS (5–8)

Standard 1: Mathematics as problem solving.

Standard 2: Mathematics as communication.

Standard 3: Mathematics as reasoning.

Standard 4: Mathematical connections.

National Council of Teachers of Mathematics. 1989. ***Curriculum and Evaluation Standards for School Mathematics*** *p. 65–119. Reston, VA: The National Council of Teachers of Mathematics, Inc.*

NATIONAL SCIENCE EDUCATION STANDARDS (5–8)

CONTENT STANDARD: K–12

Unifying Concepts and Processes

Standard: As a result of activities in grades K–12, all students should develop understanding and abilities aligned with the following concepts and processes:

- Systems, orders, and organization
- Evidence, models, and explanation
- Constancy, change, and measurement

National Research Council. 1996. ***National Science Education Standards*** *p. 115–119. Washington, DC: National Academy Press.*

CONTENT STANDARDS: 5–8

Science as Inquiry

Content Standard A: As a result of activities in grades 5–8, all students should develop:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science

Content Standard B: As a result of activities in grades 5–8, all students should develop an understanding of:

- Motion and forces
- Transfer of energy

Earth and Space Science

Content Standard D: As a result of activities in grades 5–8, all students should develop an understanding of:

- Structure of the Earth system

Science and Technology

Content Standard E: As a result of activities in grades 5–8, all students should develop:

- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspectives

Content Standard F: As a result of activities in grades 5–8, all students should develop an understanding of:

- Natural hazards
- Risks and benefits
- Science and technology in society

National Research Council. 1996. ***National Science Education Standards*** *p. 143–171. Washington, DC: National Academy Press.*

CURRICULUM STANDARDS FOR SOCIAL STUDIES

Strand 3: *People, Places, & Environments.* Social studies programs should include experiences that provide for the study of people, places, and environments.

Strand 8: *Science, Technology, & Society.* Social studies programs should include experiences that provide for the study of relationships among science, technology, and society.

Strand 9: *Global Connections.* Social studies programs should include experiences that provide for the study of global connections and interdependence.

National Council for the Social Studies. 1994. ***Expectations of Excellence: Curriculum Standards for the Social Studies*** *p. 21–30. Washington, DC: National Council for the Social Studies.*

OCEAN LITERACY: THE ESSENTIAL PRINCIPLES & FUNDAMENTAL CONCEPTS OF OCEAN SCIENCES

Principle 3: The ocean is a major influence on weather and climate.

Fundamental Concept: The ocean absorbs much of the solar radiation reaching Earth. The ocean loses heat by evaporation. This heat loss drives atmospheric circulation when, after it is released into the atmosphere as water vapor, it condenses and forms rain. Condensation of water evaporated from warm seas provides the energy for hurricanes and cyclones.

Ocean Literacy: The Essential Principles and Fundamental Concepts of Ocean Sciences, 2006. *http://www.coexploration.org/ocean literacy*