Hurricane Katrina

A Problem-Based Learning Module

ESSEA

Earth System Science
Education Alliance

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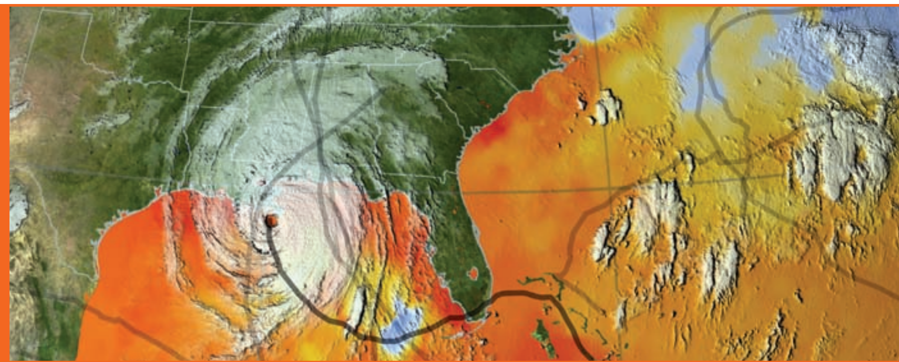


FOR THE TEACHER

KEY CONCEPTS

1. Hurricanes are tropical cyclones that contain winds in excess of 119 km/hr (74 mph) or more. They are fueled by the energy stored in warm tropical ocean waters.
2. Hurricanes impact all the Earth's spheres because of their size and energy.
3. NASA and NOAA observe hurricanes to learn more about predicting their path and behaviors.
4. Atmospheric patterns are complex and varied, making hurricane prediction and study difficult.
5. A majority of Earth's inhabitants live close enough to coastal areas to be affected by tropical cyclones.
6. Damage from hurricanes is not confined to terrestrial areas—for example, coral reefs near shore are often affected.
7. Hurricanes damage infrastructure, housing, agriculture, and threaten lives. A single storm's impact is often felt for years or decades.
8. The relationship of climate change to projected increases in hurricane numbers and intensity is the subject of much current research.

Recent assessments from the Intergovernmental Panel on Climate Change (IPCC, 2007) and the U.S. Climate Change Science Program (CCSP, June 2008) state it is likely that tropical cyclones (typhoons and hurricanes) will become more intense, with increased rainfall and wind speeds, in response to increases in tropical sea surface temperatures.

A more recent study by top climate change and hurricane scientists found that climate change is likely to result in fewer but stronger hurricanes (Knutson et al., *Nature Geoscience,* Feb. 2010).

SOURCES

Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC • http://www.ipcc.ch/ipccreports/ar4-wg1.htm

CCSP, Weather and Climate Extremes in a Changing Climate, June 2008 • http://www.climatescience.gov/Library/sap/sap3-3/final-report/default.htm

American Meteorological Society, *Climate Change Information Statement,* 2007 • http://www.ametsoc.org/POLICY/2007climatechange.html

"Tropical cyclones and climate change," *Nature Geoscience,* Feb. 2010 • http://www.nature.com/ngeo/journal/vaop/ncurrent/full/ngeo779.html

RELATED INVESTIGATIONS

MY NASA DATA: Hurricanes As Heat Engines (Grades 6–12)
http://mynasadata.larc.nasa.gov/Hurricane_Heat_Engine.html
Students examine sea surface temperature data to explore how hurricanes extract heat energy from the ocean surface.

Stronger Hurricanes? (Grades 5–12)
http://www.pbs.org/wgbh/nova/sciencenow/3302/07.html
A six-minute segment from NOVA examines the link between rising sea surface temperature and storm intensity. Links are also provided to additional resources, including a teacher's guide and transcript of the broadcast.

The student pages of this activity (pgs. 2–4) can be viewed online or downloaded at: **http://www.strategies.org/Katrina_StudentActivityPBL.pdf**

The full version, with teacher notes, can be downloaded at: **http://www.strategies.org/Teacher2010Pages/KatrinaAll.pdf**

National Science Education Standards

Grades 5-8	Grades 9-12
Science as Inquiry	
Abilities necessary to do scientific inquiry; Understandings about scientific inquiry	
Life Science	
Populations and ecosystems	Interdependence of organisms; Matter, energy and organization in living things
Earth and Space Science	
Structure of the Earth system—oceans hold a large amount of heat and have a major effect on climate	Energy in the Earth system; Geochemical cycles
Science in Personal and Social Perspectives	
Populations, resources and environments; Natural resources; Risks and benefits	Natural and human-induced hazards; Science and technology in local, national and global challenges

NASA · National Science Foundation · NOAA · Institute for Global Environmental Strategies

FOR THE STUDENT

SCENARIO

Summer 2005 was winding down when a monster storm was just beginning to brew. Hurricane Katrina started as a tropical storm in the Bahamas on Aug. 24. It began moving slowly to the northwest, then west, gaining strength as it moved through the warm Atlantic waters. Just a few hours before hitting the Florida coast on Aug. 25, Katrina became a Category 1 hurricane—wind speeds over 119 km/hr (74 miles per hour) or more. The storm's winds slowed only slightly as it moved across the tip of the Florida peninsula in seven hours.

Then the storm hit the warm waters of the Gulf of Mexico and quickly picked up speed. It moved across the Gulf where conditions in the atmosphere and sea surface were perfect for fueling the storm. Katrina exploded into a Category 5 hurricane on Aug. 28, with winds peaking at 282 km/hr (175 mph). Before making landfall on Aug. 29, the storm was at the top end of Category 3 intensity, with estimated sustained winds of 110 knots (127 mph).

NASA—*http://disc.gsfc.nasa.gov/hurricane/HurricaneKatrina2005.shtml*

Katrina was one of the deadliest and costliest hurricanes to hit the United States. It killed over 1,500 and caused an estimated $80–$100 billion in damages. The storm's destruction spread along the U.S. central Gulf Coast, from central Florida to Texas. Coastal cities such as New Orleans, Louisiana, Mobile, Alabama, and Gulfport, Mississippi were hardest hit. Much of the damage was caused by the storm surge and levee breaks between New Orleans and Lake Pontchartrain.

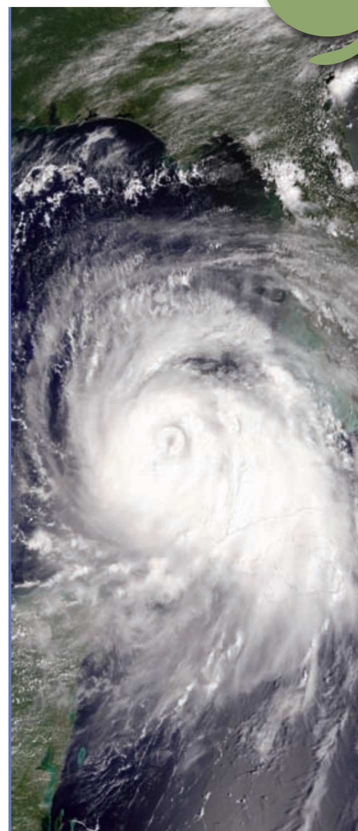
1995 was the start of a more active period for hurricanes. In 2005 alone there were a record 27 named storms, of which 15 became hurricanes. The previous record (21) was in 1933. 2005 also had the largest number (4) of Category 5 storms.

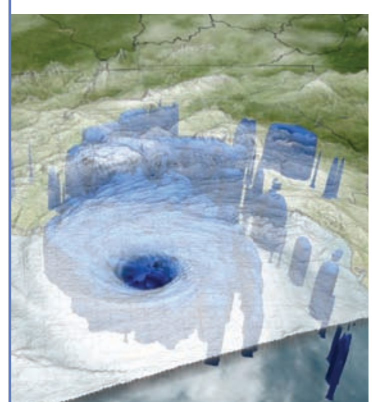
National Climatic Data Center, Climate of 2005: Atlantic Hurricane Season—*http://www.ncdc.noaa.gov/oa/climate/research/2005/hurricanes05.html*

Over the past 35 years the number of Category 4 and 5 hurricanes worldwide has nearly doubled. Global sea-surface temperatures have also increased over the same period.

National Science Foundation—*http://www.nsf.gov/news/news_summ.jsp?cntn_id=104428*

Are recent increases in the number and strength of hurricanes a result of an increased greenhouse effect and a warmer climate? Or are they the result of a natural cycle? Scientists continue to research what is causing this trend. However, there is no doubt that these storms have a huge impact on coastal communities.

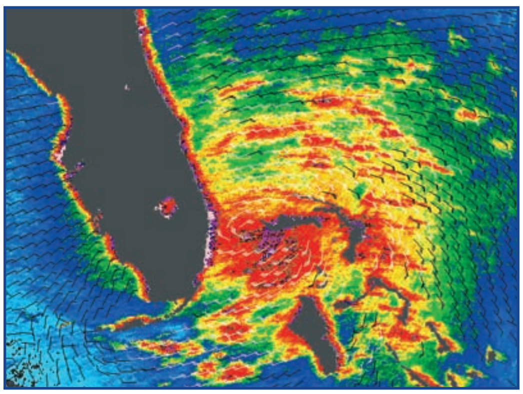




YOUR TASK

U.S. coastal areas are critically important to the nation's economy. For that reason, NASA and the National Ocean Service have formed a joint task force that is studying the trends and impacts of hurricanes on coastal regions. They have invited your group to participate.

You are tasked with conducting an Earth system science analysis of Hurricane Katrina. Your report should also examine the question: **"How could future climate change impact the frequency and intensity of hurricanes?"**



RESOURCES

Here are some resources to get you started. You will need to find additional, high-quality resources to complete your task.

Arlene to Zeta: 27 Storms of the 2005 Season
http://svs.gsfc.nasa.gov/goto?3354

Hurricane-Biosphere Connection
http://www.nasa.gov/centers/goddard/news/topstory/2004/0602hurricanebloom.html

NASA Hurricane Resource Page
http://www.nasa.gov/mission_pages/hurricanes/main/index.html

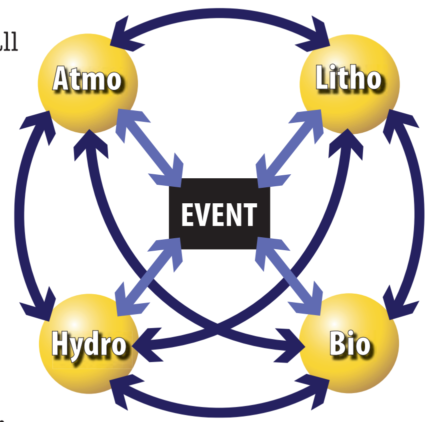
National Hurricane Center
http://www.nhc.noaa.gov

Stronger Hurricanes: Is Global Warming Making Hurricanes More Intense?
http://www.pbs.org/wgbh/nova/sciencenow/3302/07.html

What Is an Earth System Science Analysis?

Earth is a system. The system can be divided into four major parts called "spheres." These are the atmosphere (air), biosphere (all living things, including people), lithosphere (land) and hydrosphere (water in all forms, including liquid, frozen and vapor).

Earth's spheres interact. An event—such as a hurricane—can cause changes or impacts to one or more of Earth's four spheres; it can also be the result of such changes.



The two-way, cause-and-effect relationship between an event and a sphere is called an interaction. Interactions also occur between the spheres; for example, a change in the atmosphere can cause a change or impact in the hydrosphere, and vice versa.

Your Earth system science analysis (ESS) should include a description of the impacts and interactions between and among Hurricane Katrina and the Earth's spheres.

An ESS analysis is done in three steps, which include looking at:

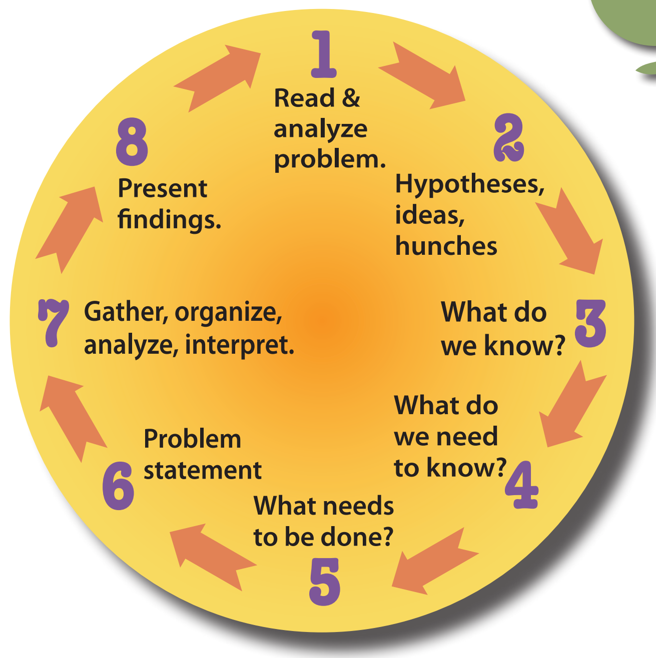
- How the event affects each of the spheres (E>S);
- How the spheres affect the event (S>E); and
- How the spheres affect each other (S>S).

A very simple example: L>E = impact of the lithosphere (L) on the hurricane (E). As the hurricane passes over land, the energy source (warm ocean water) is removed and the hurricane starts to weaken.

Causal Chains: In a system, nothing occurs in isolation. The interactions that occur within Earth's system actually occur as a series of chain reactions and complex interactions. Make sure that your analysis includes the systemic relationships, called causal chains, where multiple spheres and/or the event are involved in complex and interrelated changes. Each causal chain should include at least three interactions (e.g., E>S>S or S>S>S).

ASSIGNMENT

Working with your group, use the following problem solving model to do your project.



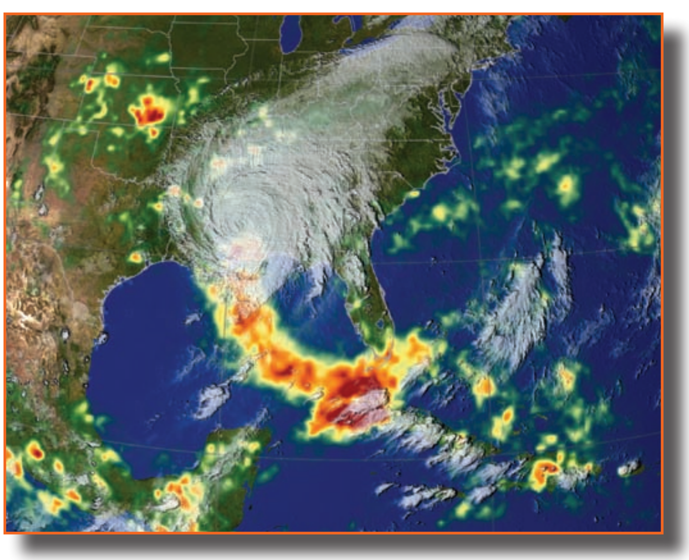
1. Read and analyze the scenario and task on pages 1–2:
- Discuss the scenario with your team.
- Don't be tempted to start thinking about potential solutions or to start looking for information.

2. List initial hypotheses, ideas, or hunches:
- Based on what you have read, what do you think?
- List your ideas, hunches, or hypotheses.

3. List what you already know:
- Begin your list with the information contained in the scenario.
- Add knowledge shared by other group members.
- Record this information under the heading: "What do we know?"

4. List what is unknown:
- Prepare a list of questions your group thinks need to be answered to do your analysis.
- Record them under the heading: "What do we need to know?"

5. List what needs to be done:
- Develop a plan. List actions such as questioning an expert, getting online data, or visiting a library to find answers to the questions developed in Step 4.
- Prioritize the questions you are trying to answer, then divide up the questions among your team.



All satellite images courtesy of NASA and NOAA.

6. Develop a problem statement:
- A problem statement is a one- or two-sentence idea that clearly identifies what your team is trying to solve, produce, respond to, test, or find out.
- Record your statement.

7. Gather information:
- Record your information and resources.
- You and your team will gather, organize, analyze, and interpret information from multiple sources.
- Exchange ideas; think about solutions; weigh alternatives; and consider the pros and cons of potential courses of action.

8. Present findings:
- Prepare a report or presentation in which you and your group make recommendations, predictions, inferences, or other appropriate resolutions of the problem.
- Be prepared to support your positions. If appropriate, consider a multimedia presentation using images, graphics, and/or sound.

The steps in this model may need to be completed several times. Steps 2 through 6 may be conducted at the same time, as new information becomes available. As more information is gathered, the problem statement may be refined or altered.