Hurricane Dynamics Implementation Sequence

Phenomenon: Hurricane Dynamics **Grade Level:** 6-8	**Guiding Question:** How can we forecast hurricanes given climate change projections and our knowledge of what fuels them?	**Contact:** Reach out to the My NASA Data Team if you have questions.
Further Investigation: My NASA Data Hurricane Dynamics main website and the My NASA Data main website		
Revision Date: 2-16-2024		
Note to Teachers: The Hurricane Dynamics Implementation Sequence provides a series of lessons and activities for students to learn how hurricanes affect the different spheres within the Earth System by using maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.		

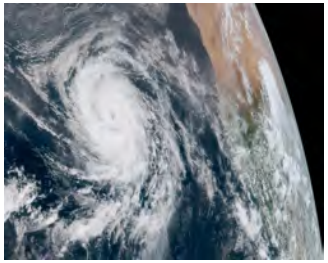
Standards - These standards are supported by the activities in this guide but not completely covered.

Performance Expectations:

- MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
- MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
- MS-PS1-4 The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.

Science and Engineering Practices:	**Crosscutting Concepts:**	**Disciplinary Core Ideas:**
● Analyzing and Interpreting Data ● Constructing Explanations and Designing Solutions	● Patterns ● Cause and Effect ● Energy and Matter ● Stability and Change	● *DCIs are aligned to each activity below. Please note that the aligned activity may not fully address all components of the DCI.*

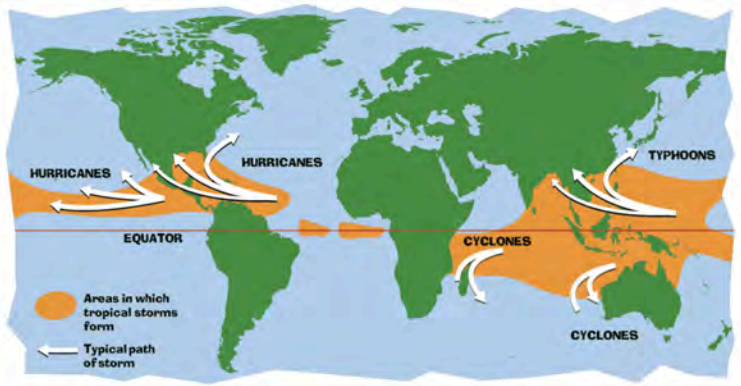
Background Information and NASA Connection



Hurricanes are large, swirling storms with winds of 119 kilometers per hour (74 mph) or higher. That's quicker than a cheetah can run, which is the fastest animal on land. They are said to be the most violent storms on Earth. These storms are also called by other names, such as typhoons or cyclones, depending on where they occur. The scientific term for these storms is “tropical cyclone.” Only tropical cyclones that form over the Atlantic Ocean or the eastern Pacific Ocean are called "hurricanes”. Whatever they are called, tropical cyclones all form the same way.

When Do They Occur?

Warm ocean waters provide the energy needed for a storm to become a hurricane. Usually, the surface water temperature must be 26 degrees Celsius (79 degrees Fahrenheit) or higher for a hurricane to form. The rate at which wind speed or direction changes with height is called vertical wind shear. Low vertical wind shear - winds that change very little going up through the atmosphere - is needed for hurricane development. High vertical wind shear - winds that are changing significantly with height - tends to rip storms apart.



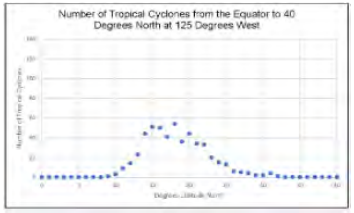
Credit: NASA SpacePlace

Why does NASA study hurricanes?

Hurricanes are the most powerful weather event on Earth. NASA’s expertise in space and scientific exploration contributes to essential services provided to the American people by other federal agencies, such as hurricane weather forecasting.

The National Oceanic and Atmospheric Administration and the National Hurricane Center (NHC) uses a variety of tools to predict these storms’ paths. These scientists need a wealth of data to accurately forecast hurricanes. NASA satellites, computer modeling, instruments, aircraft and field missions contribute to this mix of information to give scientists a better understanding of these storms.

Source: My NASA Data|Hurricane Dynamics

Day 1			
Time	**NGSS Disciplinary Core Ideas**	**Learning Objective**	**Activity / Assessment**
50 min	**ESS3.B: Natural Hazards** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	I can analyze how a phenomenon changes with location. 	**Lesson Plan**: [Tropical Cyclone Counts - Compare Data Displays] Students will be able to compare data displays to determine which best answers the driving question.
Day 2			
Time	**NGSS Disciplinary Core Idea**	**Learning Objective**	**Activity / Assessment**
50 min	**ESS3.B: Natural Hazards** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	I can evaluate the usefulness of a model that shows the reach of a hypothetical hurricane. 	**Lesson Plan: Hurricane Sandy to Scale** Students will be able to use mathematics to form a basic model of the area covered by a hurricane. Students use their knowledge of natural hazards to determine the limitations of the model.

Day 3			
Time	**NGSS Disciplinary Core Idea**	**Learning Objective**	**Activity / Assessment**
30 min	**ESS3.C: Human Impacts on Earth Systems** Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)	I can analyze soil moisture quantities associated with Hurricane Harvey around Houston, Texas. 	**Mini Lesson:** Hurricane Harvey's Effect on Soil Moisture Students will be able to analyze and interpret a box plot and evaluate the spread of the data.
Days 4 and 5			
Time	**NGSS Disciplinary Core Idea**	**Learning Target**	**Activity / Assessment**
90 min	**PS3.A: Definitions of Energy** The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (MS-PS1-4)	I can analyze NASA sea surface temperature data to use as evidence to explain a phenomenon. 	**Lesson Plan:** Hurricanes as Heat Engines-Lesson Plan Students will be able to analyze maps, graphs, and data tables for use with the Data Literacy Cubes.

Additional Resources (Page 1 of 5)			
Time	**NGSS Disciplinary Core Idea**	**Learning Target**	**Activity / Assessment**
30 min	**ESS3.B: Natural Hazards** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	I can explain the location and frequency of tropical cyclones by analyzing a histogram.	**Mini Lesson:** **Tropical Cyclone Counts Histogram** Compare a histogram and map to determine the differences in the information conveyed in each data display.
30 min	**ESS2.D: Weather and Climate** Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6)	I can interpret a double bar chart comparing the number of tropical cyclones in different locations.	**Mini Lesson: Tropical Cyclone Counts Bar/Column Chart** Students will be able to interpret a double bar/column chart comparing the number of tropical cyclones in different locations.

Additional Resources (Page 2 of 5)			
Time	**NGSS Disciplinary Core Idea**	**Learning Target**	**Activity / Assessment**
30 min	**ESS3.B: Natural Hazards** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	I can explain the number of cyclones by analyzing and interpreting a box plot.	**Mini Lesson:** **Tropical Cyclone Counts Box Plot** Analyze and interpret a box plot and evaluate the spread of the data. Compare it with a different visualization of the data to see how the two compare, discuss the limitations of the two types of data displays and formulate questions.
30 min	**ESS3.B: Natural Hazards** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	I can analyze a scatter plot and a map to identify the number of tropical cyclones at specific locations.	**Mini Lesson:** **Tropical Cyclone Counts Scatter Plot** Interpret a scatter plot to find patterns in the number of tropical cyclones from 1842 to 2018.

Additional Resources (Page3 of 5)			
Time	**NGSS Disciplinary Core Idea**	**Learning Target**	**Activity / Assessment**
>90min	**ESS3.B: Natural Hazards** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	I can explore how hurricanes gain energy from the ocean surface.	**Story Map:** **Hurricanes as Heat Engines Story Map** Using various visualizations (i.e., images, charts, and graphs), students will explore the energy exchange that occurs when hurricanes extract heat energy from the ocean. This story map is intended to be used with students who have access to a computing device in a 1:1 or 1:2 setting.
15 min	**PS4.C: Information Technologies and Instrumentation** Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)	I can create a false color image by using a color key and a data table.	**Interactive: Creating Images from Numbers** Scientific data are often represented by assigning ranges of numbers to specific colors. The colors are then used to make false color images which allow us to see patterns more easily. Students will make a false-color image using a set of numbers.

Additional Resources (Page 4 of 5)			
Time	**NGSS Disciplinary Core Idea**	**Learning Target**	**Activity / Assessment**
30 min	**PS4.C: Information Technologies and Instrumentation** Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)	I can create an array table and determine the color of a pixel in a grid.	**Interactive:** **Creating and Interpreting Images as Models** Information from satellites is often used to display information about objects. This information can include how things appear, as well as their contents. Explore how pixel data sequences can be used to create an image and interpret it.
>90 min	**ESS3.D: Global Climate Change** Human activities, such as the release of greenhouse gasses from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)	I can conduct an investigation on whether global warming is causing an increase in hurricane frequency and intensity.	**Lesson Plan:** **Hurricane Katrina A Problem-Based Learning Module** Because it recognizes the importance of U.S. coastal areas to the nation's economy, the U.S. National Ocean Service has formed a task force that is studying the trends and impacts of hurricanes on coastal regions. They have invited your students to participate. In this activity, students are tasked with conducting an Earth systems analysis of Hurricane Katrina that will help answer the question "Is global warming causing an increase in hurricane frequency and intensity?"

Additional Resources (Page 5 of 5)			
Time	**NGSS Disciplinary Core Idea**	**Learning Target**	**Activity / Assessment**
50 min	**ESS2.C: The Roles of Water in Earth's Surface Processes** Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4)	I can analyze maps, graphs and data on hurricanes and the associated precipitation and cloud cover.	**Lesson Plan:** Hurricane Dynamics: Maps, Graphs, and Data This lesson plan provides some generic maps, graphs, and data tables for use with the Data Literacy Cubes. Because it is a differentiated resource, this lesson plan is appropriate for multiple grade bands.
30 min	**ESS3.C: Human Impacts on Earth Systems** Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4)	I can analyze an online tool that displays different satellites in 3D and how each one is specifically-used to study air quality.	**Lesson Plan:** Satellites at Work Students visit a NASA Website called "Eyes on the Earth" to view satellite missions in 3D circling the Earth and learn to navigate to specific satellites to learn about their capability of analyzing our changing planet and air quality.