

**Lesson Title:** Haywire Hurricanes!

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**Topic:** Students will discover relationships between human activity, climate change, sea surface temperatures, and hurricanes.

**Targeted Grade Level:** High School Environmental Science (9th-12th grade)

**Time Needed:** two-three, 80-minute class periods

**Subject Integration:** Environmental Science and Literacy

**NGSS Standards:**

**HS-ESS3-6.** Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]

#### **SEPs**

- **Asking questions (for science)** - See, Think, Wonder activity in Engage
- **Analyzing and interpreting data** - Learning Station Activity in Explain
- **Constructing explanations (for science)** - Elaborate and Evaluate activities
- **Obtaining, evaluating, and communicating information** - Elaborate and Evaluate activities

#### **CCs**

- **Cause and effect: Mechanism and explanation** - throughout the lesson, students will discover relationships between human activity, climate change, sea surface temperatures, and hurricanes

#### **DCIs**

- **ESS2.D: Weather and Climate**
- **ESS3.D: Global Climate Change**

### **Common Core State Standards Connections:**

**RST.11-12.1** - Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

**RST.11-12.2** - Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

### **Measurable Student Learning Intentions:**

- **Learning Intention 1:** Students will be able to describe what changes the speed, size, and direction of travel of hurricanes in their own words.
- **Learning Intention 2:** Students will be able to describe how climate change could increase the severity or frequency of hurricanes impacts on different spheres of Earth.

<b>Engage</b>	<p><b>Procedures:</b></p> <ul style="list-style-type: none"><li>● The teacher should have the two, three-dimensional hurricane models found at this <a href="#">link</a> ready for use in class. Each model should be accompanied by the corresponding images and text found at this <a href="#">link</a> which is a portion from this <a href="#">original resource</a> (NASA GPM, n.d.).</li><li>● Students will engage in a <a href="#">“See, Think, Wonder” activity</a> about the three-dimensional hurricane models. This activity sheet can be printed or assigned virtually for students to complete.<ul style="list-style-type: none"><li>○ The teacher will guide students to focus on the structure of hurricanes and the accompanying information.</li><li>○ Students should be guided to make observations and ask questions about the models.</li></ul></li><li>● Students will watch this <a href="#">NASA video</a> about hurricanes (NASA GPM, n.d.).<ul style="list-style-type: none"><li>○ Based on the video, students will answer the questions on <a href="#">this slip</a>: How has NASA satellite data improved the study of hurricanes? How has this impacted people?</li><li>○ Students will write their names on the back of the slip.</li><li>○ The teacher will quickly read through and select responses to share with the class that share specific examples of how NASA data is used to improve the study of earthquakes.</li></ul></li></ul> <p><b>Resources:</b></p> <ul style="list-style-type: none"><li>● <a href="#">3D Hurricanes models</a></li><li>● <a href="#">Accompanying materials for 3D models</a></li><li>● <a href="#">“See, Think, Wonder” activity</a></li></ul>
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- [NASA video](#)
- [NASA Video slip](#)

**Citations:**

NASA GPM. (n.d.). *Looking at Storms in 3D*. Precipitation Education. <https://gpm.nasa.gov/education/interactive/looking-storms-3d>

NASA. (n.d.). *How NASA Earth Satellites Track Hurricanes*. Youtube. <https://www.youtube.com/watch?v=2WHXOi2orxA>

**Explore**

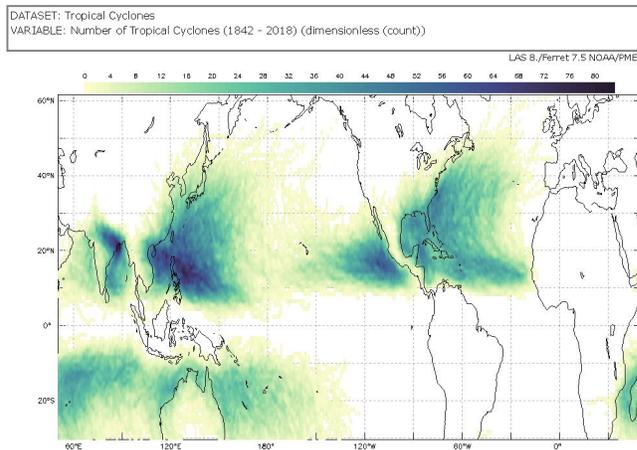
**Procedures:**

- Students will complete a station lab activity in order to explore several different aspects of hurricanes. Students should work with a partner and may go in any order.

**EXPLORE STATION 1:**

Students will engage in a “Cyclone counts” data cubes activity from [My NASA Data](#)(My NASA Data, n.d.).

. Students will observe the following [map](#), then complete 5 rolls of the dice by rolling the [dice](#), then answering the corresponding question on the [question sheet](#) provided at the lab station.



**EXPLORE STATION 2:**

Students will engage in a “Sea Surface temperature” exploration by watching the [video](#), then answering these [data analysis questions](#). This activity is from [MyNASADData](#)(My NASA Data, n.d.).

### **EXPLORE STATION 3:**

Students will explore the Merge Cube HoloCube app. Each student may create their own [paper merge cube](#) or can use a Merge cube from a class set. Students will look specifically at the sea surface temperature and precipitation representations and discuss the following questions with a partner and write their responses on a sticky note to leave at the station:

- What do you notice about the data? Where is the sea surface temperature the greatest? The least?
- Could this contribute to the intensity of hurricanes?

This activity is based on an activity found on [MyNASAData](#) (My NASA Data, n.d.).

### **EXPLORE STATION 4:**

Students will sort the [cards](#) into categories -- they should be guided to sort/divide the cards as they see fit. The teacher should then “check” the students cards and, if necessary, ask the students to sort by the spheres of Earth (Scienceclass.net, n.d.). The teacher may need to clarify what each sphere contains.

### **EXPLORE STATION 5:**

Students will use a device (phone, tablet, etc.) to complete a paired reading activity about the virtual [article](#) (National Geographic, n.d.).

- Student A will read a paragraph.
- Student B will state the main points of the paragraph.
- Students will switch roles.

### **Resources:**

- Cyclone Counts [map](#),
- Map analysis [dice](#),
- Map analysis [question sheet](#)
- Sea surface temperature [video](#)
- [data analysis questions](#)
- [paper merge cube](#)
- Device with Merge Cube HoloCube app downloaded
- Sphere of Earth [cards](#)
- Device with access to internet

	<ul style="list-style-type: none"> <li>● National Geographic <a href="#">article</a>.</li> </ul> <p><b>Citations:</b></p> <p>My NASA Data. (n.d.). Tropical cyclone Counts Model. My NASA Data. <a href="https://mynasadata.larc.nasa.gov/mini-lesson/tropical-cyclone-counts-model">https://mynasadata.larc.nasa.gov/mini-lesson/tropical-cyclone-counts-model</a></p> <p>My NASA Data. (n.d.). Energy and Matter: Sea Surface Temperature. My NASA Data. <a href="https://mynasadata.larc.nasa.gov/mini-lesson/energy-and-matter-sea-surface-temperature">https://mynasadata.larc.nasa.gov/mini-lesson/energy-and-matter-sea-surface-temperature</a></p> <p>My NASA Data. (n.d.). HoloGLOBE with MERGE Cube. My NASA Data. <a href="https://mynasadata.larc.nasa.gov/lesson-plans/hologlobe-merge-cube">https://mynasadata.larc.nasa.gov/lesson-plans/hologlobe-merge-cube</a></p> <p>Scienceclass.net. (n.d.). <i>Manipulative/Card Sort</i>. Scienceclass.net. <a href="http://science-class.net/Earth_systems/earth_systems.htm">http://science-class.net/Earth_systems/earth_systems.htm</a></p> <p>National Geographic. (n.d.). <i>Hurricanes, Cyclones, and Typhoons Explained</i>. National Geographic Resource Library. <a href="https://www.nationalgeographic.org/article/hurricanes-cyclones-and-typhoons-explained/">https://www.nationalgeographic.org/article/hurricanes-cyclones-and-typhoons-explained/</a></p>
<b>Explain</b>	<p><b>Procedures:</b></p> <ul style="list-style-type: none"> <li>● On a chromebook, phone, or other device, students will begin by exploring the <a href="#">Hurricane Applet</a> (Whittaker &amp; Ackerman, n.d.).       <ul style="list-style-type: none"> <li>○ The teacher should guide the students to click and move the high pressure system, to move the hurricane to warmer and cooler areas, to change the season.</li> </ul> </li> <li>● The teacher will guide the students in a hurricane discussion and lead the students through certain aspects of the simulator to explain key parts of hurricanes (This portion of the activity is based on this <a href="#">teacher's guide</a>) (Whittaker &amp; Ackerman, n.d.):       <ul style="list-style-type: none"> <li>○ The teacher should lead students to reset the simulator and ask them where hurricanes originate.           <ul style="list-style-type: none"> <li>■ Students should have come to the conclusion that they began off the coast of Africa.</li> </ul> </li> <li>○ The teacher should elaborate that hurricanes begin as tropical waves of low pressure from Africa and explain that there are many tropical waves every year, but only a few will become hurricanes.</li> <li>○ The teacher should then lead students to reset the simulator ask students what they think the “L” represents. Give students the hint that they may have heard of or seen this symbol on the weather on television.           <ul style="list-style-type: none"> <li>■ Students may suggest “Low pressure”</li> </ul> </li> </ul> </li> </ul>

- The teacher should explain that hurricanes begin as low pressure systems and when it reaches a category one it begins to spin like a hurricane. Since it is a low pressure system the winds will spiral inwards, converge, and rise. This rising motion is the trigger for thunderstorms and severe weather. Even if they are a good distance away they can bring severe weather.
  - The teacher should guide students to reset the applet to Fall and then watch the hurricane intensify to a category 5.
    - Students should be guided to use the mouse to drag the hurricane into the warm pool of water in the Gulf of Mexico.
    - The teacher should ask the students what happened to the hurricane when they entered warm water, indicating a higher sea surface temperature..
      - Students should suggest that the storm intensified.
    - The teacher should guide students to drag the hurricane to the colder waters of the North Atlantic (You can even drag the high pressure east and give the hurricane a gentle nudge with your mouse so it recurves north) and make observations.
    - The teacher should clarify that if the storm has winds of 39 mph they become a tropical storm and get a name. If the winds reach 74 mph they become a category 1 hurricane. If the winds reach 96 mph they become a category 2 hurricane.
    - The teacher should ask the students what the picture when they think of a hurricane and hurricane damage.
      - Students should suggest severe weather in the form of high winds, torrential rains (which lead to flooding), and tornadoes.
  - The teacher should guide students to “push” the hurricane over land with the High pressure system and make observations.
    - Students should notice the hurricane lose intensity.
    - The teacher should explain that when hurricanes pass over land, they weaken because they cannot draw their principal energy source, water vapor, from the oceans.
      - The teacher can clarify that when the water vapor condenses into clouds in the hurricane this latent heat is released. The latent heat warms the atmosphere and gives energy to the hurricane.
- ASSESSMENT: When students complete the activity, they should independently complete the [claim-evidence-reasoning response](#).

**Assessment:**

	<p><b>*** Learning Intention 1 addressed here***</b></p> <p>Students write a CER response answering the question, "What changes the speed, size, and direction of travel of hurricanes?"</p> <p><b>Resources:</b></p> <ul style="list-style-type: none"> <li>• <a href="#">Hurricane simulator</a></li> <li>• <a href="#">Claim-evidence-reasoning response sheet</a></li> </ul> <p><b>Citations:</b></p> <p>Whittaker, T., &amp; Ackerman, S. (n.d.). <i>Hurricane Applet Teachers Guide</i>. Weather Wise.  <a href="http://profhorn.aos.wisc.edu/wxwise/guidesandworksheets/hurricane_applet_secondary.pdf">http://profhorn.aos.wisc.edu/wxwise/guidesandworksheets/hurricane_applet_secondary.pdf</a></p> <p>Whittaker, T., &amp; Ackerman, S. (n.d.). <i>The Hurricane Applet - Atlantic</i>.</p>
<p><b>Elaborate</b></p>	<p><b>Procedures:</b></p> <ul style="list-style-type: none"> <li>• The teacher should introduce the project (Loosely based on this <a href="#">project</a>) to the students by explaining that hurricanes can have many negative effects on Earth's spheres including (Orange County Water, n.d.):       <ul style="list-style-type: none"> <li>○ a. Human safety</li> <li>○ b. Infrastructure (homes, businesses, transportation, utilities, etc.)</li> <li>○ c. Agriculture (farming, forestry, horticulture, aquaculture)</li> <li>○ d. Commerce (tourism, real estate/development,</li> <li>○ e. Ecosystems and wildlife</li> <li>○ f. Natural resource consumption (energy, water, food)</li> <li>○ g. Some other area of impact identified by the students</li> </ul> </li> <li>• The teacher should lead students through the <a href="#">checklist/rubric</a> and explain the expectations of the project.</li> <li>• The teacher should make sure all topics are represented in the class.</li> <li>• Assessment: Students will write a <a href="#">CER</a> over a topic different than their own answering the question, "How could climate change increase the severity or frequency of (select hurricanes impact) on (choose sphere of Earth)?"</li> </ul> <p><b>Assessment:</b></p> <p><b>*** Learning Intention 2 addressed here***</b></p> <p>Students will write a <a href="#">CER</a> over a topic different than their own answering the question, "How could climate change increase the severity or frequency of (select hurricanes impact) on (choose sphere of Earth)?"</p> <p><b>Resources:</b></p>

	<p><a href="#">FlipGrid Project Expectations</a></p> <p><a href="#">Assessment CER Worksheet</a></p> <p><b>Citations:</b></p> <p>Orange County Water. (n.d.). <i>Climate Change &amp; Extreme Weather Lesson Plan</i>. Orange County Water Atlas Learning Kit.  <a href="http://www.orange.wateratlas.usf.edu/education/curriculum/orange/lessons/WA35_ClimateChange_Weather-T.pdf">http://www.orange.wateratlas.usf.edu/education/curriculum/orange/lessons/WA35_ClimateChange_Weather-T.pdf</a></p>
<b>Evaluate</b>	<p><b>Procedures:</b></p> <ul style="list-style-type: none"> <li>● Students will tri-fold presentation board focused on the following goals outlined on the <a href="#">activity sheet</a>: <ul style="list-style-type: none"> <li>○ Educate the public on how future climate change could impact the frequency and intensity of hurricanes. <ul style="list-style-type: none"> <li>■ Support your claim with specific scientific evidence and reasoning that has been described in a way that makes sense to the public.</li> <li>■ Showcase data that supports your claim.</li> </ul> </li> <li>○ Educate your viewers on the interactions between each of Earth’s spheres during and after a hurricane.</li> <li>○ Educate the public on 3 possible negative impacts of hurricanes and propose a solution to each of these impacts.</li> </ul> </li> <li>● Students will use their understanding developed throughout the other activities in addition to their own research.</li> <li>● Students will be assessed based on a provided rubric.</li> <li>● This project is loosely based on this <a href="#">activity</a> (Earth System Science Education Alliance, 2010).</li> </ul> <p><b>Assessment:</b></p> <p>This project addresses both learning intentions and will be assessed based on the provided rubric.</p> <p><b>Resources:</b></p> <p><a href="#">Project Outline Worksheet</a></p> <p><b>Citations:</b></p> <p>Earth System Science Education Alliance. (2010, March). <i>Hurricane Katrina A Problem-Based Learning Module</i>.  <a href="http://www.agiweb.org/education/NASA/tr/invest/activities/Hurricane-Katrina.pdf">http://www.agiweb.org/education/NASA/tr/invest/activities/Hurricane-Katrina.pdf</a></p>

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