



My NASA Data

Hurricanes as Heat Engines Story Map

Lesson Plan

Purpose: 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.

Grade Level: 6 – 12	Lesson Objectives: <ul style="list-style-type: none">• Students will analyze NASA sea surface temperature data to use as evidence to explain a phenomenon.• Students will explore how hurricanes gain energy from the ocean surface.	Sphere(s): Atmosphere Hydrosphere
Time: 1 – 90-minute class periods or 2 – 45-minute class periods		
Phenomena NASA Connection: <p>Hurricanes are the most violent storms on Earth. They are like giant engines that use warm, moist air as fuel, which is why they form only over warm ocean waters near the equator. The warm, moist air over the ocean rises upward and as the air continues to rise the surrounding air swirls in to take its place. As the warm, moist air rises and cools off clouds form creating a system of clouds and wind that spins and grows, fed by the ocean’s heat and water evaporating from the surface. NASA satellites gather sea surface temperature data that can be used to explore changes that occur.</p>		
Essential Questions: <ol style="list-style-type: none">1. How is sea surface temperature affected by the development of a hurricane?2. How is thermal energy transferred within a hurricane system?3. How does a hurricane affect the different spheres within the Earth System?		
Grades 6-12 NGSS Performance Expectations: <ul style="list-style-type: none">• 3-ESS2-1 Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.• 4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth’s features.• 5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.• 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.• HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth’s systems.		



<p>Science and Engineering Practices:</p> <p>Analyzing and Interpreting Data: Analyze data using computational models in order to make valid and reliable scientific claims</p> <p>Developing and Using Models: Develop a model using an example to describe a scientific principle</p>	<p>Disciplinary Core Ideas:</p> <p>ESS2.D: Weather and Climate Scientists record weather across different times and areas so that they can make predictions about what kind of weather might happen next.</p> <p>ESS2.A: Earth Materials and Systems Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes.</p> <p>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</p>	<p>Crosscutting Concepts:</p> <p>Stability and Change Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.</p> <p>Patterns Patterns can be used as evidence to support an explanation</p> <p>Systems and System Models A system can be described in terms of its components and their interactions</p>
<p>NCTM Math Standards: n/a</p>		
<p>Cross-curricular Connections: National Geography Standards How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.</p>		
<p>Stem Career Connection:</p> <ul style="list-style-type: none">• Atmospheric and Space Scientists – Investigate weather and climate related phenomena to prepare weather and climate related reports and forecasts for the public• Computer and Information Scientists – Conduct research in the field of computer and information science• Applications Software Developers – Develop and modify computer applications software that are used to communicate with satellites and people using satellite data –<ul style="list-style-type: none">• Computer Programmers• Systems Engineers• Software Engineers		
<p>Multimedia Resources</p> <ul style="list-style-type: none">• Saffir-Simpson Hurricane Wind Scale, http://www.nhc.noaa.gov/aboutsshws.php• My NASA Data, https://mynasadata.larc.nasa.gov/• Hurricanes and Tropical Storms, https://www.nasa.gov/mission_pages/hurricanes/main/index.html		



<p>Materials/Resources Needed</p> <p><u>Per Student:</u></p> <ul style="list-style-type: none">• “Hurricanes as Heat Engines Story Map Datasheet” <p><u>Per Group:</u></p> <ul style="list-style-type: none">• Laptop• Internet Access	<p>Key Vocabulary</p> <ul style="list-style-type: none">• Coordinates• Latitude• Longitude• Heat• Sea Surface Temperature (SST)• Upwelling• Energy Transfer
<p>Background Information</p>	
<p>The passage of a hurricane causes a large transfer of heat between the ocean surface and the atmosphere. It also causes surface waters to diverge, bringing cooler water from below to the surface (upwelling). These effects are so large that they can be seen by a drop in sea surface temperature (SST) in satellite data observations along the path of the storm. The cooler water conditions may last for a week or longer after the storm.</p>	
<p>Prerequisite Student Knowledge</p> <ul style="list-style-type: none">• Introduction to weather or hurricanes• Familiarity with finding coordinates on a map• Basic concepts of energy transfer	



Student Name:

Date:

Period:

Hurricanes as Heat Engines

Link to Story Map:


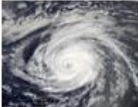
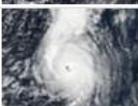

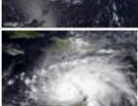
<https://nasa.maps.arcgis.com/apps/MapSeries/index.html?appid=abc5591aaa944c9ebc7b5ea6102c73c2>

Part I: Engage

1. What differences do you observe between the photograph of the Southeastern United States on Sept. 13th vs. the photograph taken on Sept. 14th?
2. What patterns do you see in the sea surface temperature data?
3. Ask a question about the patterns you observed in the sea surface temperature data.
4. Make a claim about the relationship between hurricanes and sea surface temperature.

Part II: Explore

1. What colors do you see in the sea surface temperature data?
2. What do these colors mean?
3. Where are the highest values? The lowest?
4. Using the hurricane simulator, fill in the chart with the minimum sea surface temperature needed to form each hurricane.

Hurricane	Satellite Image	Category Wind Speeds	Sea Surface Temperatures
Hurricane Isaac September 10, 2018		Category 1 Winds 74-95 mph (119-153 km/hr)	
Hurricane Helene September 10, 2018		Category 2 Winds 96-110 mph (154-177 km/hr)	
Hurricane Ophelia October 14, 2017		Category 3 Winds 111-130 mph (178-209 km/hr)	
Hurricane Florence September 10, 2018		Category 4 Winds 131-155 mph (210-249 km/hr)	
Hurricane Matthew October 1, 2016		Category 5 Winds greater than 155 mph (249km/hr)	

5. What is the minimum sea surface temperature required for a hurricane to form?



6. How does this support the claim you made about the relationship between hurricane formation and sea surface temperature?

7. What do you see on the graph displaying Power Dissipation Index and Sea Surface Temperature? Identify any trends or differences you see in the graph.

8. What do these trends or differences mean?

9. Write a complete paragraph caption for this graph. Start with a topic sentence that describes the whole graph. In the body of the paragraph include the trends and differences you saw and their meanings from questions 7 and 8.

10. What is something you would like to know about this graph? Come up with a research question you would like to ask.

11. How does this graph support your claim about the relationship between hurricanes and sea surface temperature?

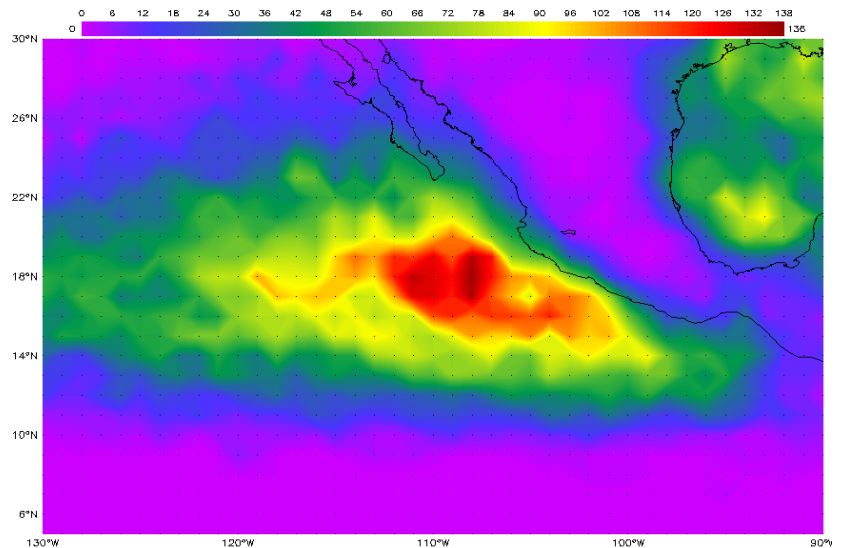
12. In the tropical cyclone count image, where in the world do you find the highest values of data?

13. Do you notice any patterns in the data? What patterns do you notice?

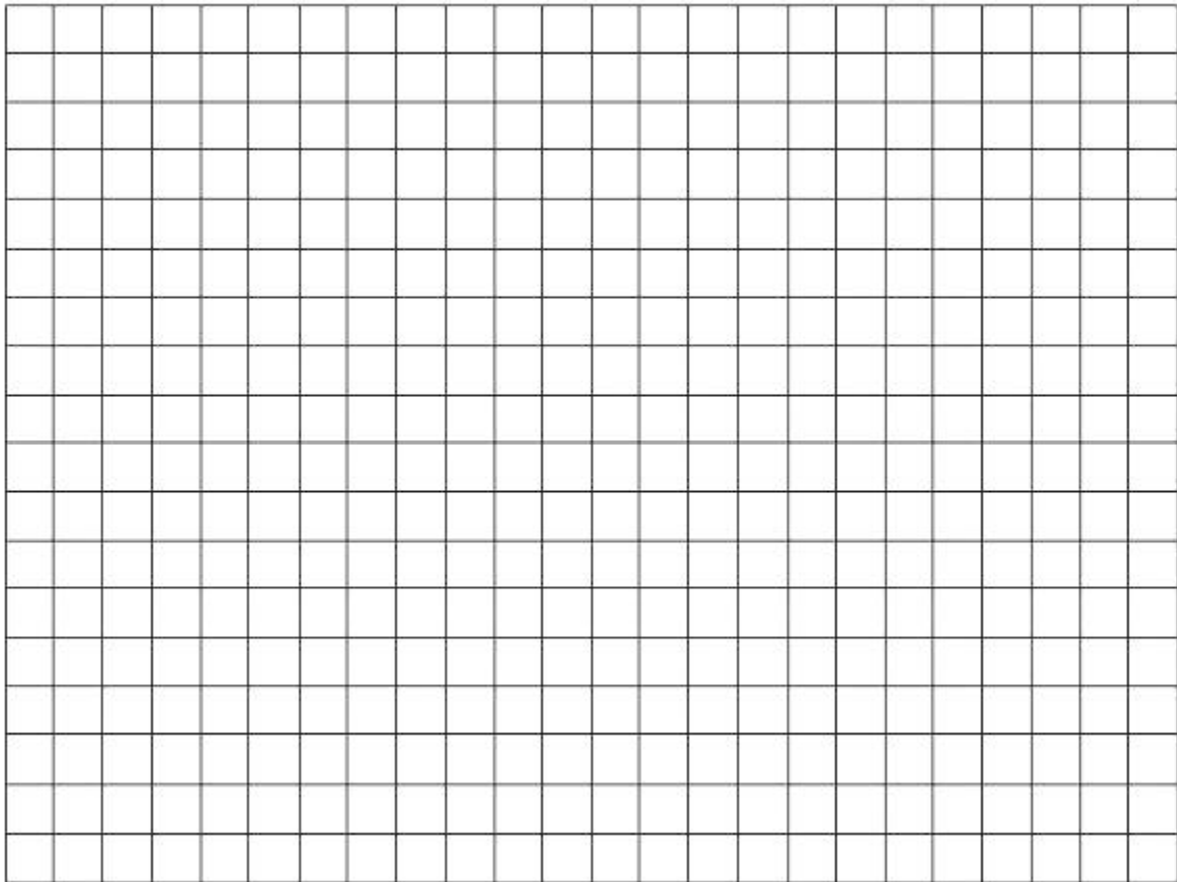
14. How does the tropical cyclone count data relate to the claim you made about the relationship between sea surface temperature and hurricanes? What evidence do you have to support your reasoning?

15. Using the tropical cyclone count image, determine tropical cyclone count at the coordinates listed below.

Latitude	Longitude	Tropical Cyclone Count
9°N	108°W	
13°N	108°W	
17°N	108°W	
21°N	108°W	
25°N	108°W	



16. Plot your tropical cyclone counts against their respective latitudes using the graph below. Include axis labels in your plot.



17. Describe what your line plot represents?

18. At what latitudes are tropical cyclones most likely to occur?

19. Predict the relationship between sea surface temperature and the distribution of tropical cyclones. Use evidence from earlier activities to support your prediction.



20. After revisiting the hurricane simulator, in which season does your hurricane get the strongest?

21. What differences in sea surface temperature do you notice between the seasons?

22. Where do you find the greatest color (temperature) difference between seasons?

23. Which season has the warmest sea surface temperatures? What about the coldest?

24. What factors strengthen hurricanes?

25. What factors weaken hurricanes?

26. Using what you have learned about hurricanes as heat engines, write a paragraph explaining why hurricanes occur in this season. Use evidence from previous parts of this lesson to support your claim.

27. After observing the path of Hurricane Florence, why do you think it strengthens as it approaches North America?

28. How does this support your claim?



Part III: Explain

1. What effect do oceans have on hurricanes?
2. What effect do hurricanes have on oceans?
3. Which absorbs more heat? Land or water?
4. What is the difference between a tropical cyclone and a hurricane?
5. If the storm surge from a hurricane is 7ft., what category hurricane is this?
6. At what hurricane wind speed can windows break?



Part V: Evaluate

1. Observe the sea surface temperature surrounding the tropical storm and its path. Will this new tropical storm strengthen or weaken? What evidence do you have to support your claim? Incorporate reasoning from what you've learned about the science of hurricane formation.

2. Observe the sea surface temperature surrounding the hurricane and its path. Will this hurricane strengthen or weaken? What evidence do you have to support your claim? Incorporate reasoning from what you've learned about the science of hurricane formation.

3. What do you observe? What happened to the Hurricane?

4. Based on what you've learned about hurricane formation, what you think happened to this hurricane during July 3rd- 7th? Use evidence and reasoning to support your conclusion.