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.

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

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.

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
<th>Tropical Cyclone Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>9°N</td>
<td>108°W</td>
<td></td>
</tr>
<tr>
<td>13°N</td>
<td>108°W</td>
<td></td>
</tr>
<tr>
<td>17°N</td>
<td>108°W</td>
<td></td>
</tr>
<tr>
<td>21°N</td>
<td>108°W</td>
<td></td>
</tr>
<tr>
<td>25°N</td>
<td>108°W</td>
<td></td>
</tr>
</tbody>
</table>
16. Plot your tropical cyclone counts against their respective latitudes using the graph below. Include axis labels in your plot.

![Graph](image)

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.

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________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

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 III: Elaborate

1. What difference do you notice between the two images? What do you predict to explain this difference? (Hint: Think back to the Explain tab, where you learned about what happens to the ocean as a hurricane passes over.)

2. Based on what you have learned, and using the line plot you have created, what date did the hurricane pass? What evidence do you have to support your answer?
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.