Ridin’ out the Storm

Teachers, please note the new SEM format. Suggested answers are in red. Instructional notes for teachers are in blue and preceded by the icon. The format of the Student Version has not changed.

Materials needed

• Copies of the Atlantic Hurricane Tracking Chart for each student or group of students (www.nhc.noaa.gov/AT_Track_chart.pdf)

• Two different colored pencils for each student or group of students

Be sensitive to students’ experiences before using this activity. If students have lived through a hurricane or have close relatives or friends who have experienced a hurricane, an alternative activity might be more appropriate.

You might begin this exploration by having students watch the video at http://www.youtube.com/watch?v=HJydFJORWf4. The video was sponsored by the United States Geological Survey with the contribution of the Carnegie Mellon University Informedia Project. The video describes how and why hurricanes occur.

Alternatively, show your students the video at http://animoto.com/play/0fTzb1fbeHieLmWnPgP7CQ?autostart=true. It can also be used to capture student interest and introduce the topic.
Determining a Hurricane’s Category

The category of a hurricane is based on its minimum sustained (lasting at least one minute) wind speed. But even before it becomes a hurricane, a tropical system is categorized by its wind speeds. Scientists put these data into a table to make them easier to remember. They can also transfer the data to a graph to visualize them more easily.

1. Hurricane wind speed can be measured in kilometers per hour. Using table 1, convert the wind speed from mph to km/hr (1 mi ≈ 1.61 km). Fill in the corresponding column in the chart (col. 3, the one for kilometers per hour).

<table>
<thead>
<tr>
<th>Description</th>
<th>Miles per hour</th>
<th>Kilometers per hour (km/hr)</th>
<th>Knots per hour (kt/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical Storm</td>
<td>40 mph</td>
<td>≈ 64.4 km/hr</td>
<td>≈ 34.8 kt/hr</td>
</tr>
<tr>
<td>Category 1 Hurricane</td>
<td>74 mph</td>
<td>≈ 119.14 km/hr</td>
<td>≈ 64.4 kt/hr</td>
</tr>
<tr>
<td>Category 2 Hurricane</td>
<td>96 mph</td>
<td>≈ 154.56 km/hr</td>
<td>≈ 83.5 kt/hr</td>
</tr>
<tr>
<td>Category 3 Hurricane</td>
<td>111 mph</td>
<td>≈ 178.71 km/hr</td>
<td>≈ 96.6 kt/hr</td>
</tr>
<tr>
<td>Category 4 Hurricane</td>
<td>131 mph</td>
<td>≈ 210.91 km/hr</td>
<td>≈ 114.01 kt/hr</td>
</tr>
<tr>
<td>Category 5 Hurricane</td>
<td>155 mph</td>
<td>≈ 249.55 km/hr</td>
<td>≈ 134.89 kt/hr</td>
</tr>
</tbody>
</table>

2. Hurricane wind speed is also measured in knots per hour (nautical miles per hour, or kt/hr), which is a measure of speed used in air and water navigation. Using table 1, convert the wind speed from km/hr to kt/hr (1 knot ≈ 1.85 km). Fill in the corresponding column in the chart (col. 4).

3. On the number lines, graph the minimum sustained wind speed (mph) for category 2, 3, 4, and 5 hurricanes. Then write an inequality to represent each hurricane category.

Most people do not have any real understanding of a hurricane’s wind speed. For example, the speed of a car riding past the school as students are being dropped off in the morning and picked up in the afternoon may be about 35 mph; a good water skier may be pulled at a speed of 35 mph; the speed of the fastball of a pitcher who wins the Cy Young Award in Major League Baseball might be approximately 96 mph; and a car may race down the straightaway at the Indianapolis (Indy) 500 at 155 mph.
5. Using the graph, what is the approximate correlating temperature in degrees Fahrenheit to 26° C?

Answers will vary. The temperature is close to 80° F.

6. The average human body temperature is 98.6 degrees Fahrenheit. Using the graph, determine the approximate temperature in degrees Celsius.

Answers will vary. The temperature is close to 37° C.

7. A formula for finding the ratio of Fahrenheit degrees to Celsius degrees is

$$\frac{\text{boiling point °F} - \text{freezing point °F}}{\text{boiling point °C} - \text{freezing point °C}}.$$ 

Use the information in Table 2 to find the ratio.

This is because the relationship is linear.

8. What does this ratio mean in terms of temperature change (Celsius to Fahrenheit)?

When converting from Celsius to Fahrenheit, for every increase of 5 degrees in Celsius temperature, the Fahrenheit temperature increases 9 degrees.

9. To convert a Celsius temperature into Fahrenheit, we can use the following formula: $F = \frac{9}{5} C + 32$.

What does 32 represent in the formula?

When the Celsius temperature is 0 degrees, the Fahrenheit temperature is 32 degrees.

For question 9, depending on the grade level of the students with whom you are working, you might also have them determine the formula for converting Celsius temperature to Fahrenheit using values from the table.
10. Where in the graph do we see the 32 from the formula?

The 32 is the y-intercept of the graph of the line segment, where the line segment intersects the y-axis.

11. Use the formula in question 9 to find the temperature in degrees Fahrenheit for a temperature of 26 degrees Celsius. What temperature must the water temperature be (in degrees Fahrenheit) before a hurricane can form? How does this compare with the value you got from the graph?

\[ F = \frac{9}{5} C + 32 \]

\[ F = \frac{9}{5} (26) + 32 \]

\[ F = 78.8^\circ \]

Answers for comparison will vary.

12. Use the information in the formula to find the equation to convert a Fahrenheit temperature into Celsius:

\[ F = \frac{9}{5} C + 32 \]

\[ C = \frac{5}{9} (F - 32) \]

13. What does this formula (Fahrenheit to Celsius) mean in terms of temperature change?

Answers will vary. One possible answer is to first subtract 32 from the Fahrenheit temperature and then multiply that answer by 5/9 to find the Celsius temperature. Another is that Celsius temperatures are smaller numerically than Fahrenheit temperatures.

Tracking Hurricanes

Meteorologists track the movement of a hurricane using latitude and longitude, which are the coordinates used to identify any point on the earth’s surface. According to the American Heritage Science Dictionary, longitude is defined as a measure of relative position east or west on the earth’s surface, given in degrees from a certain meridian, usually the prime meridian at Greenwich, England, which has a longitude of 0 degrees. The distance of a degree of longitude is about 69 statute miles or 60 nautical miles (111 km) at the equator, decreasing to zero at the poles.

Latitude is defined as a measure of relative position north or south on the earth’s surface, measured in degrees from the equator, which has a latitude of 0 degrees, with the poles having a latitude of 90 degrees north and south, respectively. The distance of a degree of latitude is about 69 statute miles or 60 nautical miles (111 km). Latitude and longitude are the coordinates that together identify all positions on the earth’s surface.

Each light horizontal line on the tracking map represents a different line of latitude. These lines are labeled along the right and left edges of the chart. Each light vertical line represents a line of longitude. These lines are labeled along the top and bottom edges. Sometimes latitude and longitude numbers are given without the “N” or “W” annotations; in this case, positive latitudes are the same as north latitudes (north of the equator), and negative longitudes are west longitudes.
14. Using the map, what is the approximate location of your state or province in latitude and longitude?

Answers will vary.

At the following Web site, you might be able to find the exact location of your school, city, or closest landmark: http://www.infoplease.com/atlas/latitude-longitude.html.

Table 3 tells the location of two hurricanes—Hurricane Humberto and Hurricane Ingrid. The positions mark the location of the hurricanes at the start of a day.

<table>
<thead>
<tr>
<th>Table 3 Hurricanes Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
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<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
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<td>11</td>
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<tr>
<td>12</td>
</tr>
<tr>
<td>13</td>
</tr>
</tbody>
</table>

15. Print a full-sized copy of the Atlantic Hurricane Tracking Chart from http://www.nhc.noaa.gov/AT_Track_chart2.pdf. Plot the position points for Hurricane Humberto and Hurricane Ingrid from the information in Table 3. Use a different colored pencil for each hurricane. Be sure to indicate the direction that each hurricane is traveling.

Students may print a copy of the chart directly from the Web site, or you may provide copies for the class.

16. Which countries do Hurricane Humberto and Hurricane Ingrid appear to be traveling toward?

Answers may vary. Humberto directly affects Haiti and Cuba as well as many other countries near the path, including Puerto Rico, the Dominican Republic, Jamaica, the Bahamas, and the United States. Ingrid makes landfall in the United States but could also affect Mexico. Eventually they both travel into the North Atlantic.

17. In which directions are Hurricane Humberto and Hurricane Ingrid traveling? How are the hurricanes the same? How do they differ?

Answers may vary. One possible answer: Humberto moves northwest, turns north, and then travels to the northeast. Ingrid moves northwest, turns south, makes a loop, and then continues to the northeast.

18. How many degrees latitude did Humberto change between day 3 and day 4?

Humberto’s latitude changed 1 degree (17° N to 18° N).

19. Between which two days did Ingrid have the largest change in longitude?

A nine-degree change takes place between days 12 and 13, from 81° W to 72° W.

20. Between which two days did Ingrid have no change in latitude?

Between days 3 and 4, days 5 and 6, and days 8 and 9, there was no change in latitude. This may be seen on the map as a horizontal line or in the table as no change in degrees north.
21. Find the distance in degrees that each hurricane traveled over the first three days.

Hurricane Humberto: \( d = 6.32^\circ \);
Hurricane Ingrid: \( d = 4.47^\circ \).

If you use the distance formula
\[
d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2},
\]
the ordered pairs \((x_1, y_1)\) and \((x_2, y_2)\) correspond to \((\text{latitude}, \text{longitude})\) for the hurricane's position on two consecutive days.

For Humberto:
\[
d = \sqrt{(16 - 15)^2 + (68 - 65)^2} + \sqrt{(17 - 16)^2 + (71 - 68)^2}
\]
\[
= 1 + 9 + \sqrt{1 + 9} + 9
\]

For Ingrid:
\[
d = \sqrt{(25 - 24)^2 + (89 - 87)^2} + \sqrt{(26 - 25)^2 + (91 - 89)^2}
\]
\[
= 1 + 4 + \sqrt{1 + 4} + 4
\]

Depending on grade level, have students find the distances by (1) using a ruler, (2) using the Pythagorean theorem, or (3) using the distance formula.

22. Decide when Ingrid traveled farther: between days 2 and 3 or between days 3 and 4. Justify your answer.

Ingrid traveled farther between days 2 and 3 than between days 3 and 4. Explanations could include direct measurement; the map grid \((1 + 2 > 0 + 2)\); using the distance formula; or a notion related to the lengths of the legs of a right triangle and the Pythagorean theorem.

23. Based on the graph, between which two days did Humberto travel the farthest? Justify your answer.

Humberto traveled the farthest between days 11 and 12, which have the greatest distance between consecutive days.

24. How many degrees did Humberto travel between those two days?

Answers will vary. Using the distance formula or Pythagorean theorem results in an answer of 8.54 degrees \( d = \sqrt{(35 - 32)^2 + (63 - 71)^2} \).

25. Find the distance (in degrees) between the starting and ending point for each hurricane.

Hurricane Humberto: \( d = 20.1^\circ \)
Hurricane Ingrid: \( d = 19.9^\circ \)

26. Refer to your tracking chart in question 15. Is your answer to question 25 the same as the total distance traveled? Why, or why not?

Hurricanes do not generally move in a straight path. Using the distance formula only gives you the distance between two points. Because hurricanes turn and change direction, the actual distance traveled is greater than the distance between the beginning and end points.

Can you …

- use the Beaufort scale, which gives a range of air speeds, to examine how wind speed affects trees, flags, or other things?
- convert the wind speed you calculated to km/hr from mph using dimensional analysis?
- use parametric equations to model the motion of the two hurricanes?

Did you know that …

- a Northern Hemisphere hurricane twists counterclockwise? A Southern Hemisphere Hurricane twists clockwise and upward.
- the Saffir-Simpson Scale is a 1–5 rating based on a hurricane’s present intensity? The scale is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane’s landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the coastline in the landfall region.
- since 1944, the 53rd Weather Reconnaissance Squadron, known as the Hurricane Hunters of the Air Force Reserve, is the only Department of Defense organization still flying into tropical storms and hurricanes? The ten Lockheed-Martin WC-130J aircraft and crews are part of the 403rd Wing, based at Keesler Air Force Base in Biloxi, Mississippi.
Mathematical Content

Graphs and their relationships to tables and formulas; interpreting graphs; interpreting data; conversion between units of measure

Resources


