



Hurricanes and Climate

Investigate maps and data to learn about the connections between hurricanes and climate, places where hurricanes form and how climate change may be affecting their strength.

For Teachers:

Student Learning Objectives

- Students describe the regions where hurricanes happen.
- Students graph and interpret data to learn that different regions have varying numbers of hurricanes.
- Students will be able to explain that hurricanes happen during the warmest times of year and in regions that have warm sea surface temperatures.
- Students will graph and interpret data about how hurricanes have changed over recent decades as the Earth has warmed.

Classtime

- 2-3 class periods

Grades

- 5th - 9th grade

National Science Standards

- A: Science as Inquiry
- D: Earth Science
- F: Science in Personal & Social Perspectives

National Geography Standards

- 1: How to use maps ... to acquire, process, and report information.
- 3: How to analyze the spatial organization of people, places, and environments...

Standards for School Mathematics

- Data Analysis and Probability

What you'll need:

- Hurricanes and Climate Student Investigation Workbooks (following pages)
- Colored pencils
- Rulers
- Map of Tropical Cyclones 1985-2005 (following pages)
- Map of Sea Surface Temperatures (following pages)

Directions:

1. About hurricanes...

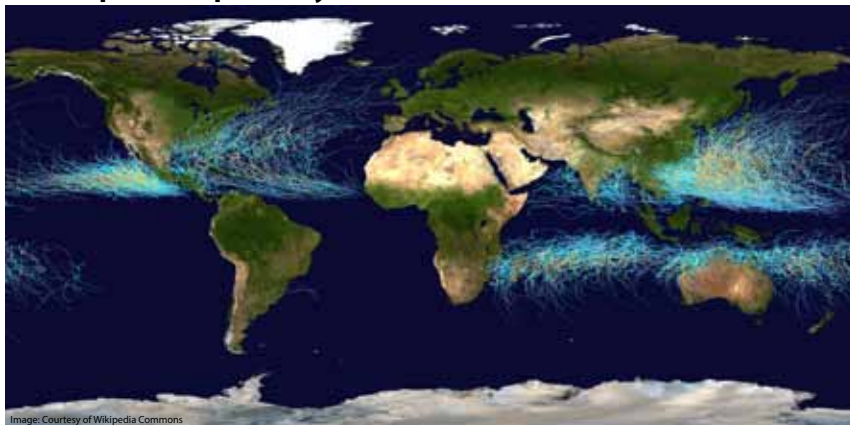
- Survey student knowledge about hurricanes through class discussion. Students may use page 1 of the workbook to collect knowledge and questions.

2. Where do hurricanes happen?

- Show the class the Map of Tropical Cyclones 1985-2005. Explain that the lines on the map show the paths of hurricanes and other tropical storms and there are six areas of the world where hurricanes occur.
- Referring to the map, ask students to color the approximate locations of these six regions on page 2 of their workbook using a different color for each region and then identifying the colors in the map key.
- As students notice where hurricanes do and do not occur, you may wish to share:
 - Hurricanes are usually over the ocean, which provides warm, moist air that fuels the storms.
 - The storms do not form at the equator where there is no rotating Coriolis force.
 - They do not form at the poles because it's too cold for tropical cyclones.

3. How many hurricanes happen?

Map of Tropical Cyclones (Hurricanes) 1985–2005



- Looking at the Map of Tropical Cyclones 1985-2005, students will likely notice that there are more hurricane paths in some regions than others. As a class, develop a hypothesis about whether the same number of hurricanes happen in each region.
- Using the table on page 3 of their workbook, ask students to create a bar graph (histogram) to explain how many hurricanes happen in each region. Ask students if their bar graph supports the idea that hurricanes are not equally distributed between regions.

4. When do hurricanes happen?

- Students investigate the seasonal timing of hurricanes on page 4 of their workbook. Have students use the same colors they used for the map to indicate the hurricane season for each region on the timeline.
- The questions at the bottom of the worksheet are intended to point out that hurricanes happen at different times of year in the Southern and Northern Hemispheres and also that hurricanes happen during the warm time of year.

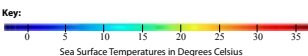
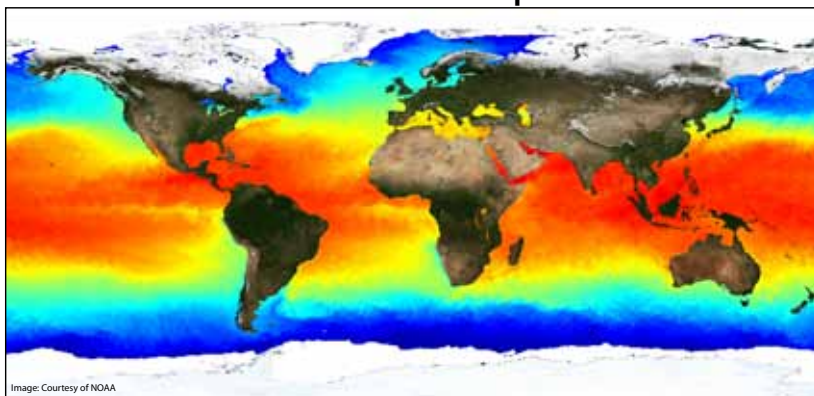
5. Where's the warm water?

- Provide student pairs or groups with either a paper or web page Map of Sea Surface Temperatures. Tell students that this map shows the temperature of the water that is at the ocean surface as measured by satellites. Review the key with students.
- Have students compare the Map of Sea Surface Temperatures and the Map of Tropical Cyclones 1985-2005 and notice that hurricanes happen in areas where the ocean water is warm. Remind students that they had also figured out that hurricanes happen at warm times of year. Ask students to predict what might happen to hurricanes as the Earth becomes warmer.

6. Is global warming affecting hurricanes?

- Introduce the data tables page 6 of the workbook. The top table shows the total number of hurricanes that happened in each region during two different time periods. The bottom table shows the number of very strong hurricanes that happened during those time periods.

Satellite Sea Surface Temperatures



The map above shows the temperature of the ocean surface (called "sea surface temperature" or SST). The data to make this map was collected by instruments on the GOES and POES satellites from June 21-24, 2005. See key to colors at left.

- Instruct students to answer the questions on the right side of the page and consider the ideas they generated about how warmer climate could affect hurricanes.

7. Are hurricanes getting stronger?

- Students represent the data from the lower table (strong hurricanes) in small bar graphs and then interpret the graphs to draw conclusions during the summary discussion. (See sample questions below)
- Does this data indicate that there are more hurricanes now?
- Does this data show that there are more stronger storms?
- Why might global warming cause changes in hurricanes?
- What other information would you like to have to know whether climate change is the cause?

Science background:

Hurricanes form in the tropics over the ocean where the sea surface is warm and so is the air. They go by different names in

different places – like tropical cyclones and typhoons. Scientists use the Saffir-Simpson scale to describe the strength of hurricanes (Category 1-5). Hurricanes form in areas of low pressure over a large area of warm water. Air is drawn into the low pressure in a spiral pattern due to the Coriolis Effect. Hurricanes draw energy from the warm water they move over.

Scientists have determined that the strength and length of storms is probably affected by global warming. There is also evidence that the number of hurricanes changes over time with a natural cycle that does not relate to global warming, so there are probably multiple factors at work. Researchers are currently trying to learn more about the connection between warming and hurricanes and whether other climate cycles play a role.

As global warming causes oceans to become warmer, and more moisture is held in the atmosphere, the intensity of hurricanes will likely increase. The warming ocean is correlated with an increase in the intensity of hurricanes. Hurricanes take heat energy from the oceans and convert it into the energy of the storm. Thus, warmer oceans offer more heat energy to hurricanes, allowing them to become stronger storms.

Webster et al. (2005)* compared hurricane data from two 15-year time periods similar to how students compare the time periods in this activity (pages 6-7 of the workbook). There is strong evidence that recent climate change caused by humans has been increasing the intensity of hurricanes, but not all scientists agree that the data we have are enough to draw a conclusion.

* Webster et al., 2005, *Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment*. *Science* 309, 1844-46.

Learn more online!

- **What on Earth Does Climate Change Impact?** <http://spark.ucar.edu/shortcontent/what-earth-does-climate-change-impact>
- **Hurricanes** <https://spark.ucar.edu/shortcontent/hurricanes>

Hurricanes and Climate

Activity by Lisa Gardiner (Spark, UCAR Science Education) copyright 2009 NESTA
www.windows2universe.org
www.spark.ucar.edu



About hurricanes...

Do you know where hurricanes happen? Do you know how they might be changing because of global warming? This investigation workbook will help you explore these questions. The first step is to collect and organize the facts about hurricanes. Use this page to help you organize the facts. First list what you know and the questions you have about hurricanes. Then explore more about hurricanes on Windows to the Universe to help you answer your questions.

What I know about hurricanes:

What I learned about hurricanes:

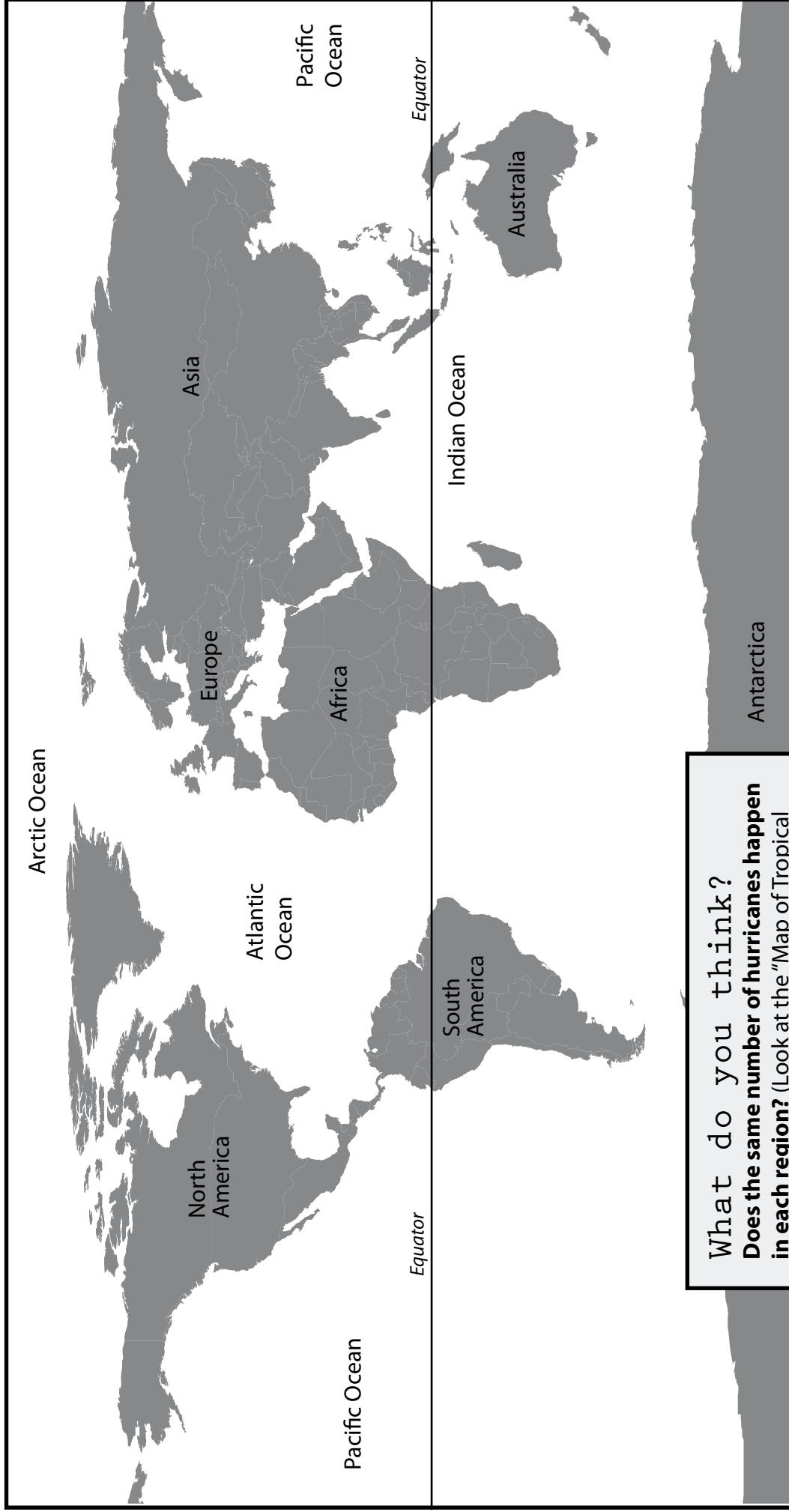
Go to: www.windows.ucar.edu/earth/Atmosphere/hurricane.html
As you explore online, fill in what you learn here.

Questions I have about hurricanes:

Where do hurricanes happen?

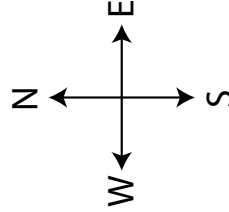
2

There are six regions of the world where hurricanes (tropical cyclones) are likely to occur. Label these on the map below after you look at the "Map of Tropical Cyclones 1985–2005". Choose a different color for each region and color the part of the ocean where hurricanes are likely to occur. Fill the colors into the key below.



What do you think?
Does the same number of hurricanes happen in each region? (Look at the "Map of Tropical Cyclones" to help you answer this question.)

..... YES NO
.....



- East Pacific Ocean
- West Pacific Ocean
- North Atlantic
- Southwestern Pacific
- North Indian Ocean
- South Indian Ocean

How many hurricanes happen?

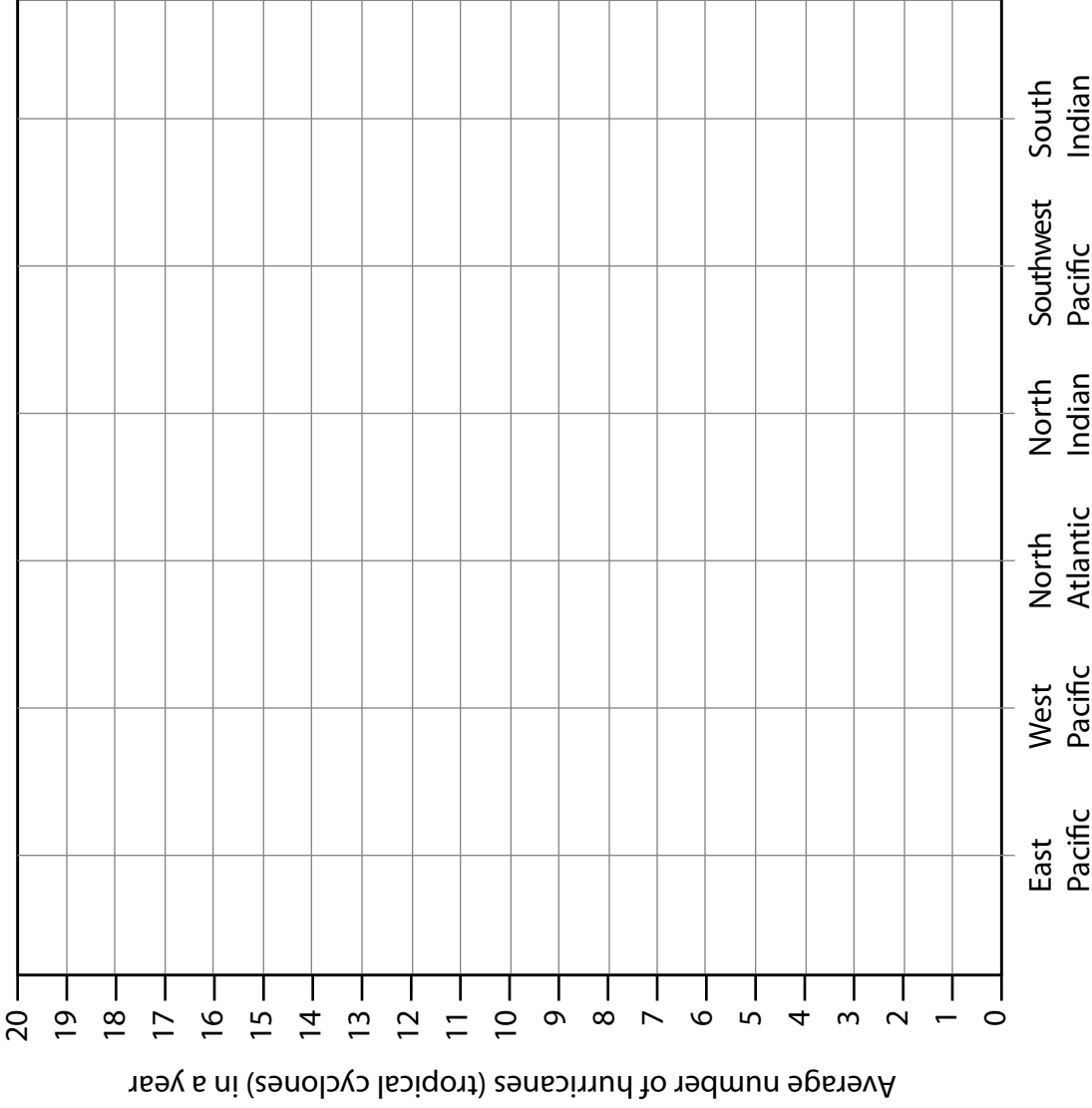
3

The number of hurricanes (tropical cyclones) that happen varies a bit from year to year. But the average number can tell you how many are likely. Take a look at the data table below. This shows the time of hurricane season and the average number of hurricanes in each region. What do you think? Do regions get the same number of hurricanes?

Hurricane Region	Hurricane Season	Number of hurricanes per year (average)
East Pacific Ocean	May - November	9
West Pacific Ocean	April - January	17
North Atlantic	June - November	6
Southwestern Pacific	October - May	5
North Indian Ocean	April - December	2
South Indian Ocean	October - May	10

Average hurricanes data from NOAA based on data from 1968-1989 and rounded to closest whole number.

Make a bar graph! A bar graph is a great way to show relative differences in number. Each bar is the amount of hurricanes for each region. Draw each bar using the same colors that you used for the map on the previous page.



Now what do you think?
Does the same number of hurricanes happen in each region? (Look at your bar graph to help you answer this question.)

YES NO

When do hurricanes happen?

Hurricane season is the time of year when hurricanes will most likely happen. But hurricane season is not at the same time in all places. Use the same colors from your key on page 2 to indicate the hurricane season for each region on the timeline below.

	January	February	March	April	May	June	July	August	September	October	November	December
East Pacific Ocean												
West Pacific Ocean												
North Atlantic												
North Indian Ocean												
Southwest Pacific												
South Indian Ocean												

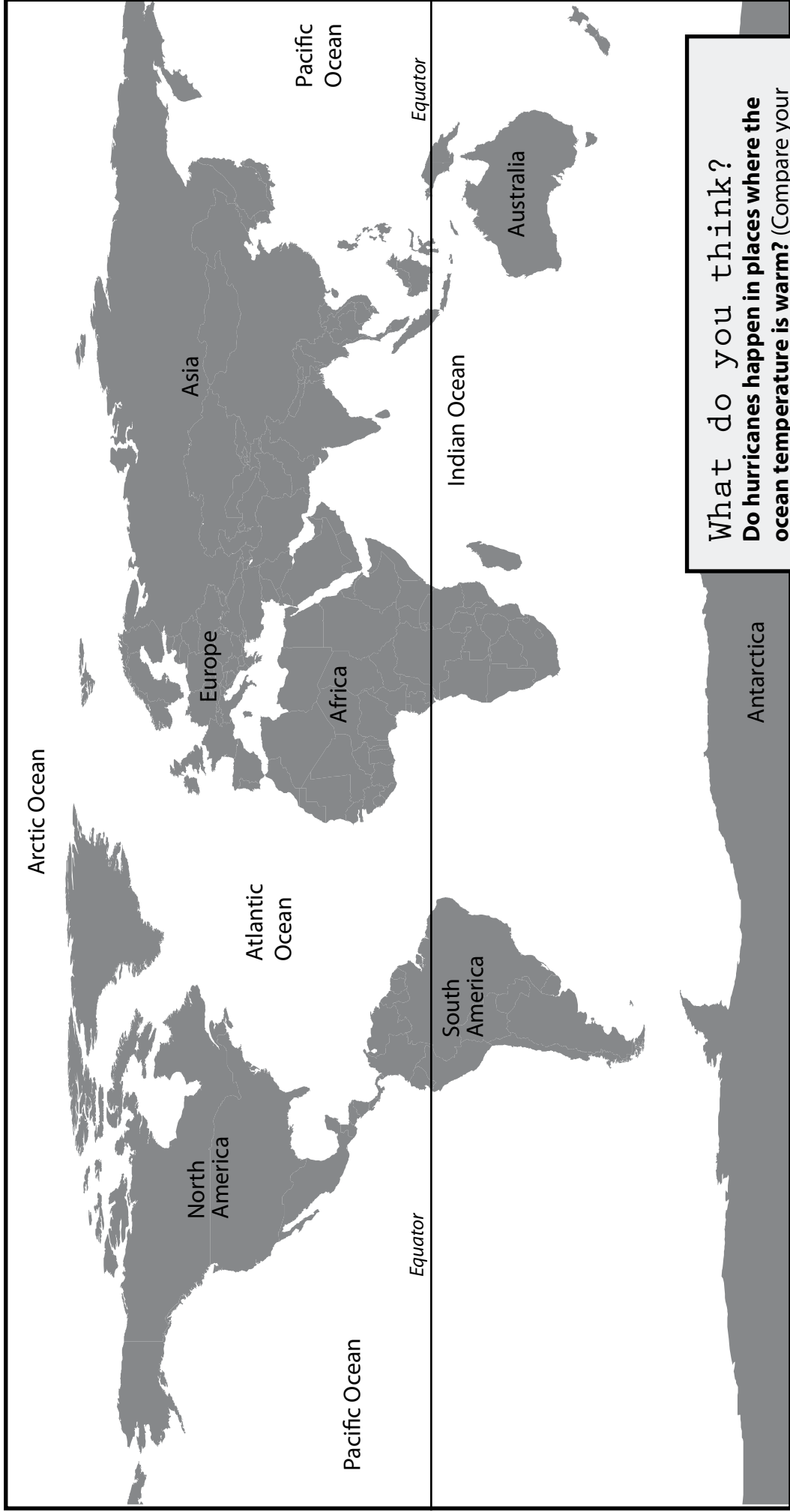
Questions:

1. Which regions have hurricane season at about the same time of year? Can you see how regions fall into two groups based on the timing of hurricane season? Which regions have similar timing?
2. Look at where these regions are located on your map. In terms of their location, what do regions with similar hurricane seasons have in common? (Hint: look for the Equator!)
3. In which seasons are hurricanes most common? (Remember, seasons are opposite in the Northern and Southern Hemispheres.)

Where's the warm water?

5

The temperature of the ocean surface is not the same everywhere and it has an impact on hurricanes. Use a red or orange pencil to color the parts of the ocean where the water is the warmest based on what you see in the "Sea Surface Temperatures" map.



What do you think?
Do hurricanes happen in places where the ocean temperature is warm? (Compare your map of warm water to your map of the six hurricane regions to answer this.)

YES NO

Is global warming affecting hurricanes?

6

We know that hurricanes form above warm ocean water. And it's thought that warmer water can lead to stronger hurricanes. The Earth warmed one degree Fahrenheit over the 20th Century. Warming is causing sea surface temperatures to climb. Has global warming has an impact on hurricanes? This is an area of active research. One way that scientists are trying to answer this question is by looking at the history of hurricanes.

The top table shows the total number of hurricanes that happened in each region during two time periods. The lower table shows the number of very strong hurricanes that happened over the same two time periods. Researchers at Georgia Tech and the National Center for Atmospheric Research examined this data to learn more about whether hurricanes have changed in recent decades because of global warming. Take a look at the numbers and answer the questions below.

Total Number of Hurricanes:

Hurricane Region	1975-1989	1990-2004
East Pacific Ocean	144	140
West Pacific Ocean	340	283
North Atlantic	80	100
Southwestern Pacific	83	79
North Indian Ocean	13	28
South Indian Ocean	128	147

Questions:

1. Has the total number of hurricanes increased, decreased, or stayed about the same? Is the trend the same for all regions?
2. Has the number of strong (category 4 and 5) storms increased, decreased, or stayed about the same? Is the trend the same for all regions.

Number of Strong Hurricanes:

(Category 4 and 5 storms)

Hurricane Region	1975-1989	1990-2004
East Pacific Ocean	36	49
West Pacific Ocean	85	116
North Atlantic	16	25
Southwestern Pacific	10	22
North Indian Ocean	1	7
South Indian Ocean	23	50

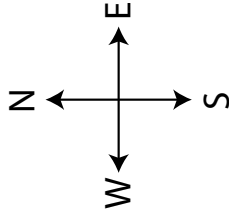
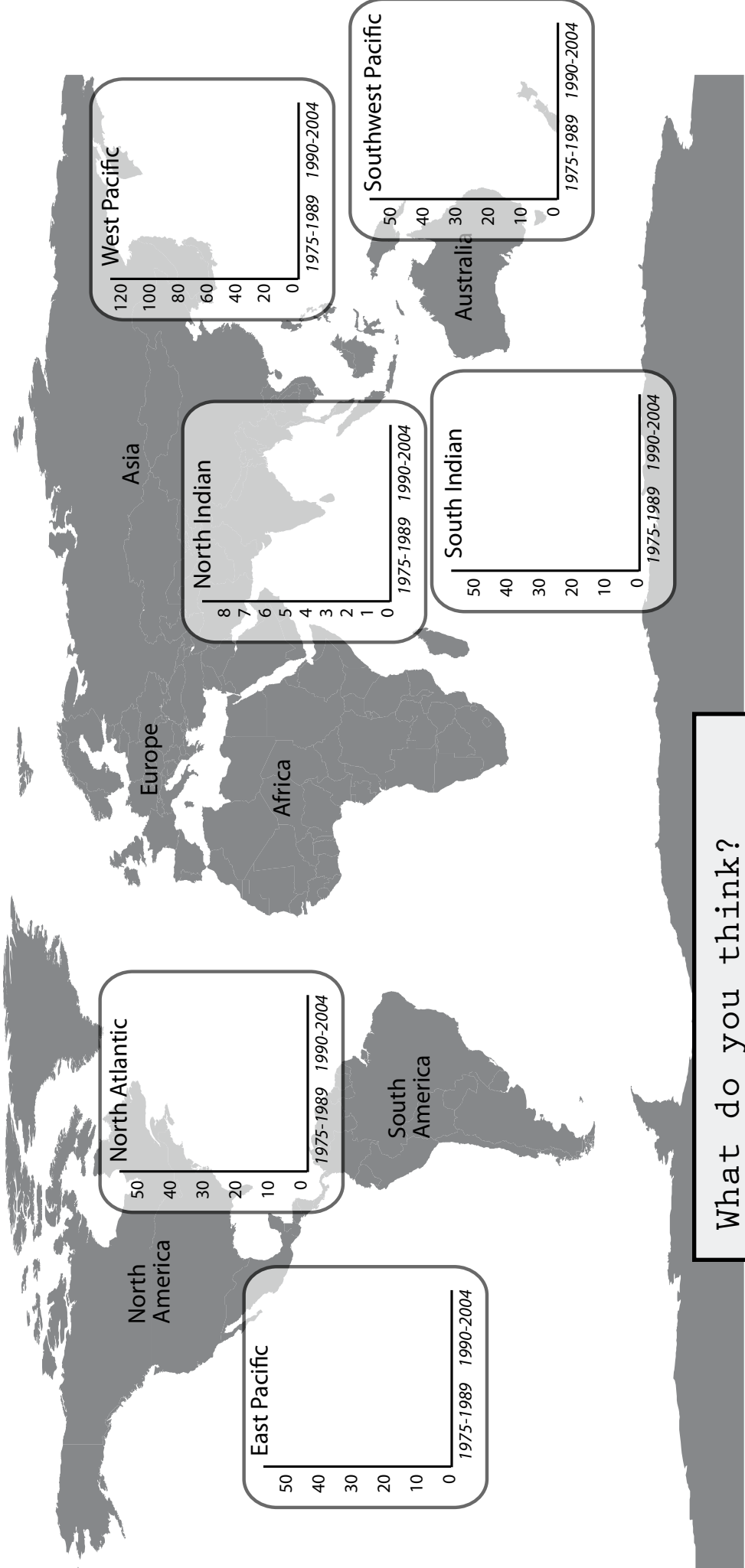
Data from Webster, et al. (2005) *Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. Science* 309, 1844-46.

Are hurricanes getting stronger?

7

How many strong hurricanes were there a few decades ago? How many are there today?

Make small bar graphs on the map below using the data on the previous page to show whether there has been a change in the number of strong hurricanes in the six regions of the world where tropical cyclones occur.



What do you think?
Are there more strong hurricanes now? (Take a look at the bar graphs of strong hurricanes you made above. Do they show a trend?)

YES NO

Map of Tropical Cyclones (Hurricanes) 1985–2005

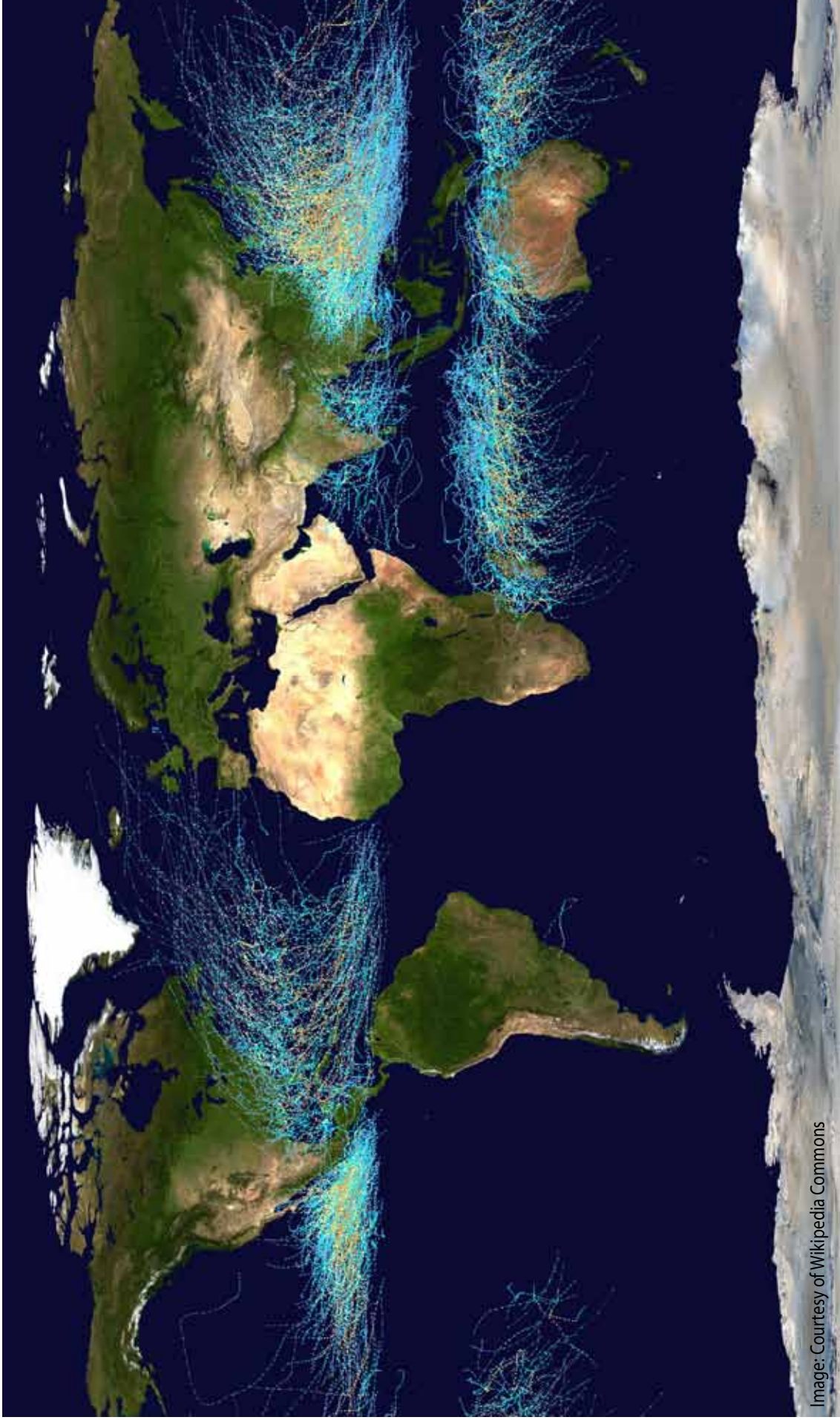


Image: Courtesy of Wikipedia Commons

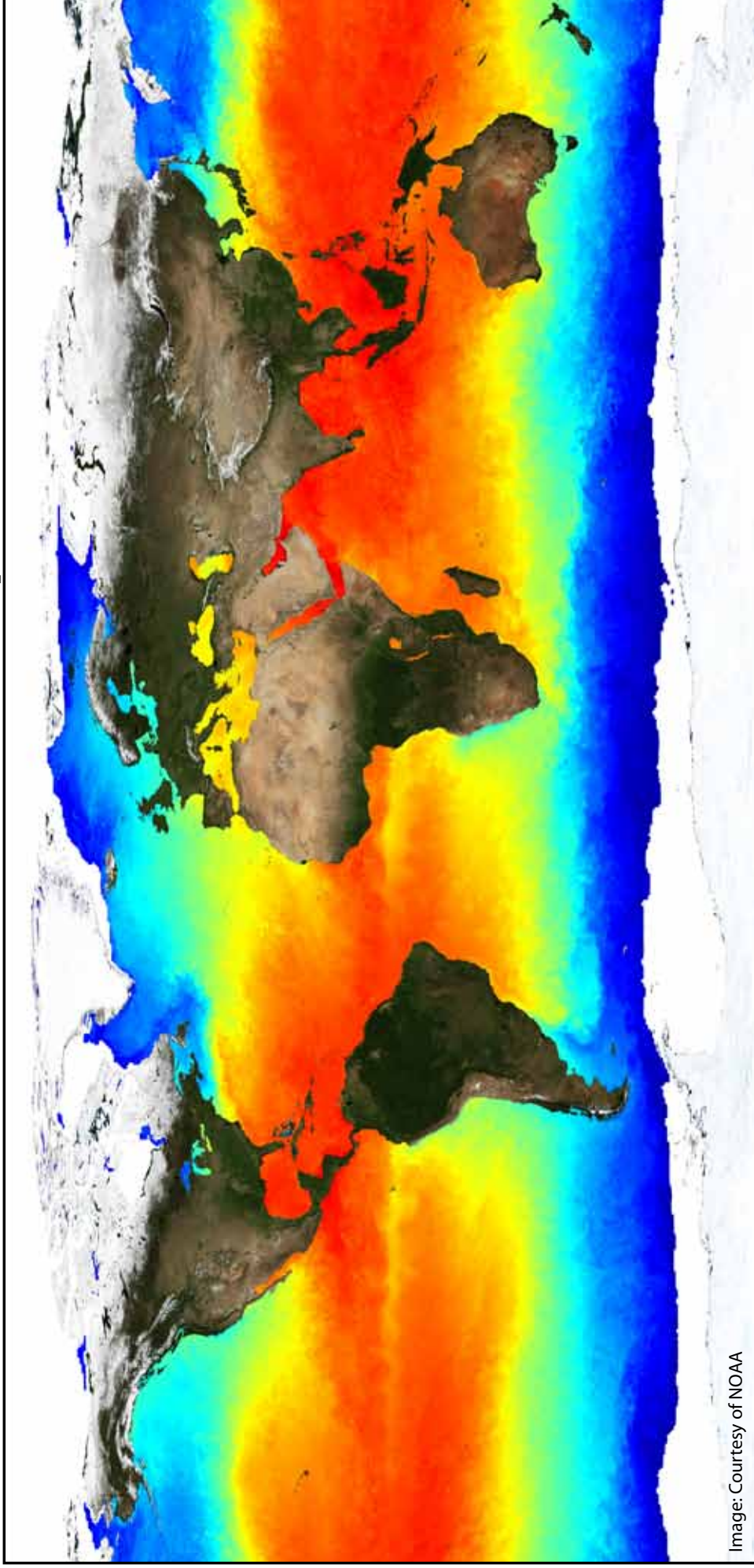
Key: Saffir-Simpson Hurricane Scale

- Tropical Depression
- Tropical Storm

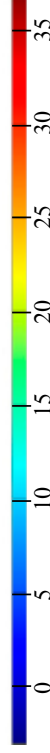
Category: 1 2 3 4 5

The map above shows the paths of all tropical cyclones that occurred between 1985 and 2005. Tropical cyclones are also known as hurricanes. The color of each path indicates the strength of the storm (according to the Saffir-Simpson Hurricane Scale). See key at left.

Satellite Sea Surface Temperatures



Key:



Sea Surface Temperatures in Degrees Celsius

The map above shows the temperature of the ocean surface (called "sea surface temperature" or SST). The data to make this map was collected by instruments on the GOES and POES satellites from June 21-24, 2005. See key to colors at left.