

## Lab Handout

# Lab 20. Predicting Hurricane Strength: How Can Someone Predict Changes in Hurricane Wind Speed Over Time?

## Introduction

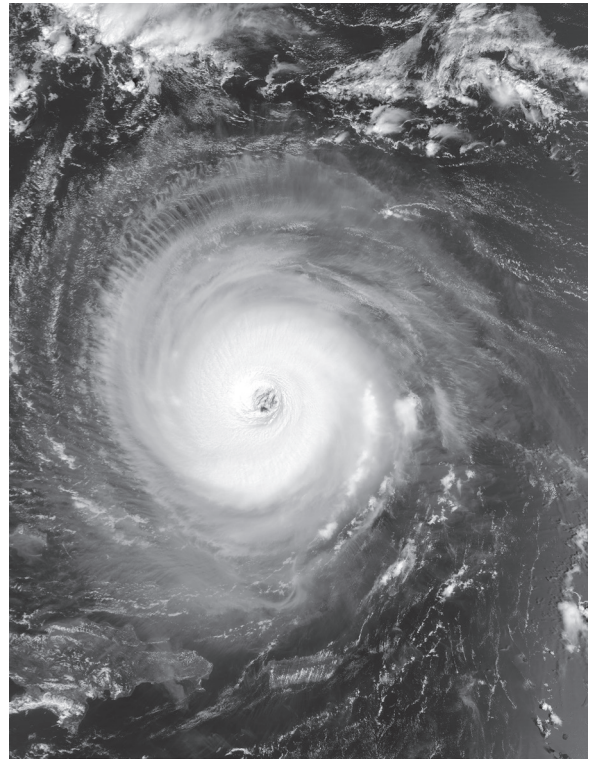
The strongest tropical storms are called hurricanes, typhoons, or cyclones. The different names all mean the same thing but are used to describe tropical storms that originate in different parts of the world. If a huge storm starts off the west coast of Africa in the Atlantic, it is called a hurricane. Hurricanes have strong winds, a spiral shape, and a low-pressure center called an eye. Unlike other natural hazards, such as earthquakes or even tornadoes, we can observe the development of a hurricane over time and track how it moves across the ocean.

A hurricane begins as a tropical disturbance in the ocean off the west coast of Africa. A tropical disturbance forms in an area where the ocean surface temperature is at least 27°C (80°F). The warm humid air at that location rises and creates an area of low atmospheric pressure near the ocean surface. Cooler air in the region then rushes into the area of low pressure. This air picks up evaporated water from the surface, increases in temperature, and moves upward into the atmosphere. This process produces large water-filled thunderclouds around the area of low pressure. The trade winds (which blow from east to west) slowly push the disturbance to the west.

Over the next few days, more warm air will rise and the winds will begin to circulate around the center of the disturbance in counterclockwise (when viewed from above) direction. A layer of clouds called an outflow will also begin to form at the top of the storm. Winds inside the storm will increase in speed over time. When the winds within the storm are between 25 and 38 miles per hour (mph), the storm is called a tropical depression. When the wind speeds reach 39 mph, the storm is classified as a tropical storm rather than as a tropical depression. This is also the point in time when the storm gets a name. In a couple of days, as the system moves across the ocean, the clouds expand and the winds continue to speed up. When the wind speeds inside the storm reach 74 mph, it is classified as a hurricane (see Figure L20.1).

## FIGURE L20.1

Image of Hurricane Isabel about 400 miles north of Puerto Rico on September 14, 2003, captured by the NASA Terra satellite; the sustained wind speed inside Hurricane Isabel at that time was 155 mph



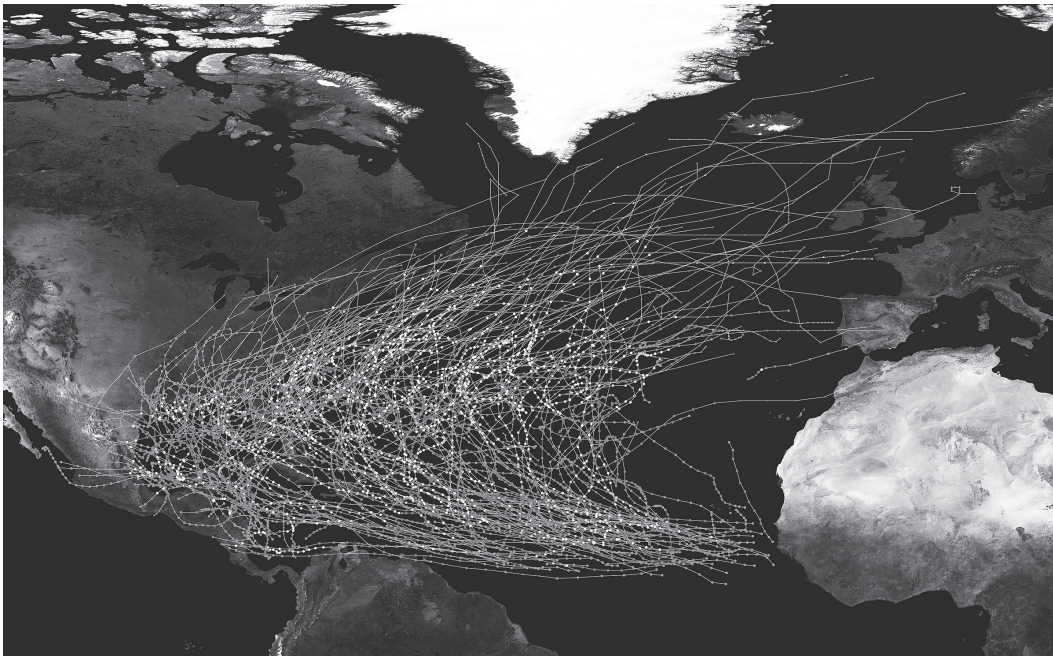
Note: A full-color version of this figure is available on the book's Extras page at [www.nsta.org/ladi-ess](http://www.nsta.org/ladi-ess).

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In an average year, several different hurricanes will form over the Atlantic Ocean and head westward toward the Caribbean, the east coast of Central America, or the southeastern United States. Figure L20.2 shows the tracks of all North Atlantic Ocean hurricanes that developed between 1980 and 2005. The points on each track represent the location of that storm at six-hour intervals. Hurricanes will often last several weeks before they break down because they tend to move very slowly across the ocean. In fact, hurricanes usually travel across the ocean at only about 24 kilometers per hour (or 15 mph).

## FIGURE L20.2

**Map showing the tracks of all hurricanes in the North Atlantic Ocean from 1980 to 2005; the points show the locations of the storms at six-hour intervals**



*Note: A full-color version of this figure is available on the book's Extras page at [www.nsta.org/adi-ess](http://www.nsta.org/adi-ess).*

Scientists use the sustained wind speed inside a hurricane to classify it. The sustained wind speed inside a hurricane, however, can increase or decrease over time. It is therefore important for scientists to understand why the winds inside a hurricane change over time. This type of information is important because scientists are responsible for issuing evacuation warnings, and they need to know if the wind within a hurricane is likely to increase or decrease before it reaches landfall. It is also important to understand the factors that affect the wind speed of a hurricane over time as it moves over water or land; this information helps city planners to establish building codes for cities to ensure that new buildings will be able to withstand the winds of a typical hurricane for that area.

In this investigation, you will have an opportunity to learn more about the factors that affect wind speed within hurricanes. Your goal is to develop a conceptual model that you can use to not only explain why the wind speed within a hurricane changes over time as it moves over water or land but also predict how the strength of a hurricane will increase or decrease over time based on the path that it follows.

### Your Task

Develop a conceptual model that can be used to explain why wind speed inside a hurricane changes over time as it moves over water or land. Your conceptual model must be based on what we know about natural hazards; weather; the importance of tracking how energy flows into, within, and out of a system; and cause-and-effect relationships. Once you have developed your model, you will need to test it to see if you can use it to make accurate predictions about how the strength of several hurricanes changed over time in the past.

The guiding question of this investigation is, *How can someone predict changes in hurricane wind speed over time?*

### Materials

You may use any of the following materials during your investigation:

#### Equipment

- Computer or tablet with internet access

#### Other Resources

- Some Major Hurricanes handout
- Hurricane Track A—Black and White handout (use to test your model)
- Hurricane Track A—Color handout (use to check your predictions)
- Hurricane Track B—Black and White handout (use to test your model)
- Hurricane Track B—Color handout (use to check your predictions)

### Safety Precautions

Follow all normal lab safety rules.

**Investigation Proposal Required?**    Yes    No

### Getting Started

The first step in this investigation is to determine how the strength of a hurricane changes over time as it travels over water and land. To accomplish this goal, you will need to examine several different historical hurricane tracks and look for patterns that you can use to explain and predict changes in wind speed. You can access historical hurricane track maps from the National Oceanic and Atmospheric Administration (NOAA) at <https://coast.noaa.gov/hurricanes>. The tracks on the maps are color-coded using the Saffir-Simpson Hurricane Scale (see Table L20.1, p. 484) so you can keep track of how the strength of a storm changed over time.

**TABLE 20.1**

**Types of tropical storms classified by wind speed according to the Saffir-Simpson Hurricane Scale and by colors used on historical hurricane track maps from the National Oceanic and Atmospheric Administration**

Classification	Wind speed			Color used on historical hurricane track maps
	mph	kn	km/h	
Category 5 hurricane	≥ 157	≥ 137	≥ 252	Purple
Category 4 hurricane	130–156	113–136	209–251	Pink
Category 3 hurricane	111–129	96–112	178–208	Red
Category 2 hurricane	96–110	83–95	154–177	Orange
Category 1 hurricane	74–95	64–82	119–153	Yellow
Tropical storm	39–73	34–63	63–118	Green
Tropical depression	25–38	22–33	40–62	Blue

You can then examine how hurricane wind speed is related to the surface temperature of the ocean (also called sea surface temperature, or SST). Information about current SSTs in the North Atlantic can be found at [www.ospo.noaa.gov/Products/ocean/sst/contour/index.html](http://www.ospo.noaa.gov/Products/ocean/sst/contour/index.html). You can also find information about monthly SSTs for 1984–1998 at [www.ospo.noaa.gov/Products/ocean/sst/monthly\\_mean.html](http://www.ospo.noaa.gov/Products/ocean/sst/monthly_mean.html). Finally, you may want to compare land surface temperature to SSTs. Information about land surface temperature during the daytime by month can be found at <http://earthobservatory.nasa.gov/GlobalMaps>.

Once you finished analyzing these data, you can develop your conceptual model. A conceptual model is an idea or set of ideas that explains what causes a particular phenomenon in nature. People often use words, images, and arrows to describe a conceptual model. Your conceptual model needs to be able to explain why hurricanes wind speed changes over time. The model also needs to be consistent with what we know about natural hazards, weather, and how energy flows into, within, and out of systems.

The last step in this investigation is to test your model. To accomplish this goal, you can use your model to make predictions about how the wind speed of past hurricanes changed over time using the Hurricane Track A and Hurricane Track B handouts. The black-and-white track maps include letters that mark specific locations along these tracks. Your goal is to predict the category of these hurricanes at these locations. Your teacher will then give you color versions of these hurricane track maps. The color versions include information about the strength of these hurricanes at each location. You can use these maps to determine if your predictions were accurate. If you are able to make accurate predictions about how the wind speed within these two hurricanes changed over time, then you will be able to generate the evidence you need to convince others that the conceptual model you developed is valid or acceptable.

### Connections to the Nature of Scientific Knowledge and Scientific Inquiry

As you work through your investigation, be sure to think about

- the use of models as tools for reasoning about natural phenomena, and
- the types of questions that scientists can investigate.

### Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a claim, evidence to support your claim, and a justification of the evidence. The *claim* is your group’s answer to the guiding question. The *evidence* is an analysis and interpretation of your data. Finally, the *justification* of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L20.3.

### Argumentation Session

The argumentation session allows all of the groups to share their arguments. One or two members of each group will stay at the lab station to share that group’s argument, while the other members of the group go to the other lab stations to listen to and critique the other arguments. This is similar to what scientists do when they propose, support, evaluate, and refine new ideas during a poster session at a conference. If you are presenting your group’s argument, your goal is to share your ideas and answer questions. You should also keep a record of the critiques and suggestions made by your classmates so you can use this feedback to make your initial argument stronger. You can keep track of specific critiques and suggestions for improvement that your classmates mention in the space below.

*Critiques of our initial argument and suggestions for improvement:*

**FIGURE L20.3**

**Argument presentation on a whiteboard**

The Guiding Question:	
Our Claim:	
Our Evidence:	Our Justification of the Evidence:

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If you are critiquing your classmates' arguments, your goal is to look for mistakes in their arguments and offer suggestions for improvement so these mistakes can be fixed. You should look for ways to make your initial argument stronger by looking for things that the other groups did well. You can keep track of interesting ideas that you see and hear during the argumentation in the space below. You can also use this space to keep track of any questions that you will need to discuss with your team.

*Interesting ideas from other groups or questions to take back to my group:*

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the best argument possible.

## **Report**

Once you have completed your research, you will need to prepare an investigation report that consists of three sections. Each section should provide an answer for the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. You should write your report using a word processing application (such as Word, Pages, or Google Docs), if possible, to make it easier for you to edit and revise it later. You should embed any diagrams, figures, or tables into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid.