CHAPTER 11

Dealing with Extreme Weather: Hurricanes in the Caribbean

11.1 Introduction

On September 7, 2004, Hurricane Ivan slammed into the Caribbean island of Grenada. "It was absolutely terrifying," one resident said. "The winds were gusting over 145 miles per hour and just tearing off roofs." Ivan damaged just about every home on the island and destroyed almost half of them. More than 30 people lost their lives in the storm. One woman whose roof was torn off spent the storm huddled under a mattress with her family. "I stared death in the face," she said. "What could be more scary than that?"

Hurricanes like Ivan are an example of **extreme weather**. This term refers to severe or unusual weather conditions. Along with hurricanes, extreme weather includes **tornadoes,** blizzards, and even severe heat waves or cold spells. Extreme weather is often destructive. People may try to prepare for these natural events, but it isn't always possible. Extreme weather can be hard to predict or guard against. When great damage or loss of life occurs, an extreme weather event is called a **natural disaster**. Hurricanes often produce natural disasters.

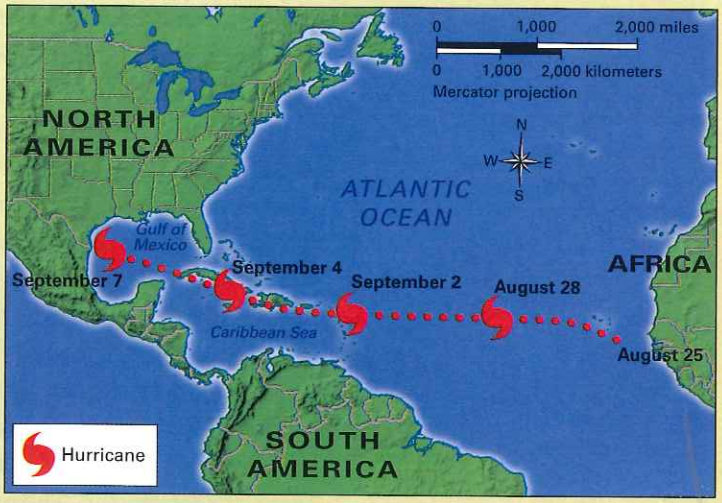
In this chapter, you will learn about hurricanes in the Caribbean **region**. You will look at their causes and effects. You will also find out how people in the region deal with this form of extreme weather.

Essential Question

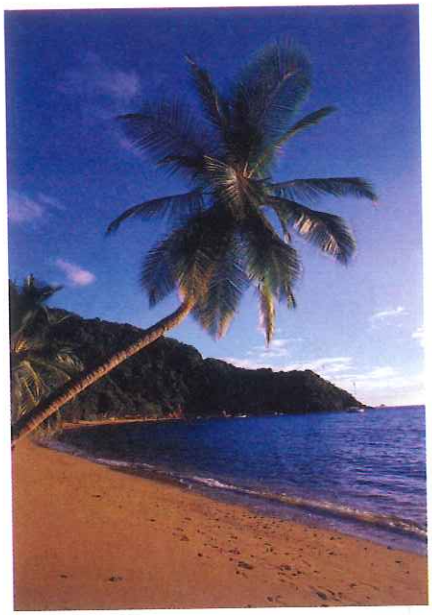
What causes extreme weather, and how do people deal with it?

This map shows the course of a hurricane from the coast of Africa to the Caribbean Sea. Notice that the storm passes through several locations in its journey. At each location, people must deal with the hurricane as a dangerous form of extreme weather. Keep this map in mind as you try to answer the Essential Question.

Graphic Organizer



◀ Hurricane Georges hit Puerto Rico in September 1998 with winds of 110 miles per hour.



A Sun-Drenched Beach on the Island of Trinidad

Tourism is a key industry in the Caribbean. Tourists are attracted to the region by sunny beaches like this one in Trinidad. Tourist areas have sprung up to meet their needs. These areas have fine hotels, restaurants, and shops. Outside these areas, however, many people still live in poverty.

11.2 The Geographic Setting

The Caribbean islands stretch in a gentle arc from the tip of Florida to the northern coast of South America. They are also known as the West Indies. They divide the Atlantic Ocean from the Caribbean Sea and the Gulf of Mexico. Thousands of islands make up this chain. Many of them are tiny, with only a few people living on them. But some, like Cuba and Hispaniola, are big islands with millions of people.

Islands in the Sun The Caribbean islands lie within one of Earth's **tropical zones**. They have a warm to hot climate year-round. Regular sea breezes cool the islands and make days pleasant.

These islands were first settled by small groups of Native Americans. The word *hurricane* comes from one of these groups, the Taino. The Taino believed that a storm god called Huracan controlled extreme weather events.

During the 1600s, European countries claimed the islands as colonies. The colonists set up **plantations,** or large farms. There they planted warm-weather crops like tobacco and sugar. The planters tried to make native peoples work on their land. But in a short time, the native peoples died out. Most were killed off by diseases brought by Europeans to the Caribbean. After that, the colonists brought large numbers of Africans to the islands to work on their farms as slaves.

During the 1800s, almost all the Caribbean islands gained their independence. Slavery was also ended. But independence brought new challenges. One was creating stable governments. Another was dealing with widespread poverty.

Today many Caribbean islands still base their economies on agriculture. Sugar remains a major **cash crop**. Bananas, coffee, and spices are also important. In recent years, **tourism** has become a key industry on many islands. Tourists flock to the Caribbean to enjoy the region's warm weather, beautiful beaches, and clear blue waters.

Extreme Weather Is a Part of Island Life Despite its pleasant climate, the Caribbean does get hit by extreme weather. Severe thunderstorms sometimes strike the islands. Heat waves and dry spells also occur.

The most extreme form of weather in the region is the **tropical cyclone**. In the Caribbean, tropical cyclones are called *hurricanes*. This is a powerful storm with winds of 74 miles per hour or more. From above, the storm looks like a giant pinwheel. It forms over warm water. As it grows, it produces heavy rain and high waves.

Our knowledge of tropical cyclones comes from **meteorology**. This is the scientific study of climate and weather. Meteorologists study weather patterns and the forces that cause them. The size and power of tropical cyclones make these storms especially challenging for meteorologists. But they have made progress in understanding these severe storms. Through their work, they hope to limit the damage and loss of life caused by these extreme weather events.

Geoterms

El Niño a warm ocean current that flows off the west coast of South America every few years. An El Niño event changes weather patterns around the world. It may also cause extreme weather in some regions.

extreme weather severe or unusual weather conditions, such as hurricanes, tornadoes, and blizzards

meteorology the scientific study of climate and weather patterns

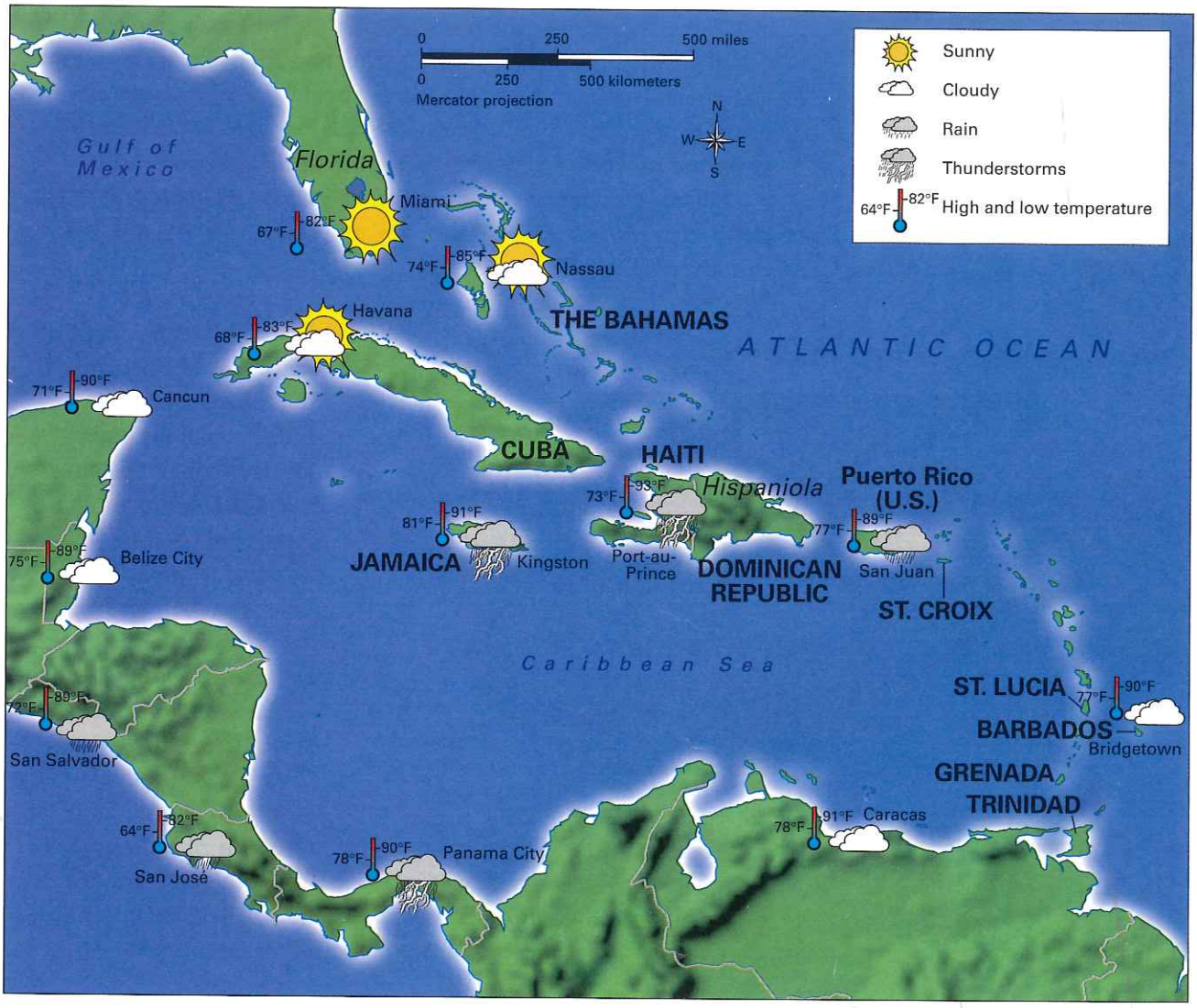
natural disaster great destruction or loss of life caused by natural forces rather than by human actions

tropical cyclone a severe storm with high winds that spiral around a calm center. Depending on where they form, tropical cyclones are called *hurricanes, typhoons,* or *cyclones.*

One Day's Weather

This map shows weather conditions in the Caribbean and surrounding areas on a specific day. Weather maps are important tools in meteorology. Scientists use them to analyze weather patterns. With this information, they can predict the weather for the next few hours or days.

Sample Weather Map



11.3 Understanding the Weather Machine

Weather doesn't just happen by itself. It is the product of natural forces working together like a machine. This "weather machine" takes energy from the sun, Earth, and the **atmosphere** and turns it into rain, wind, and other forms of weather.

Weather affects us every day, in big and small ways. Extreme weather, such as hurricanes, can have extreme effects. Storms with powerful winds can pick things up and drop them miles away. In 1997, toads rained down on the town of Villa Angel Flores in Mexico. A whirlwind had picked up the toads from a nearby body of water and then dropped them over the town!

The Sun Starts It All Weather is caused by interactions among heat, air, and water. The sun is the "engine" that drives the weather machine. As you read in Chapters 1 and 2, the sun warms Earth's surface unevenly. Its rays fall most directly between the Tropic of Cancer and the Tropic of Capricorn. Higher latitudes receive less direct sunlight. That's why temperatures are generally warmer near the equator and cooler near the poles.

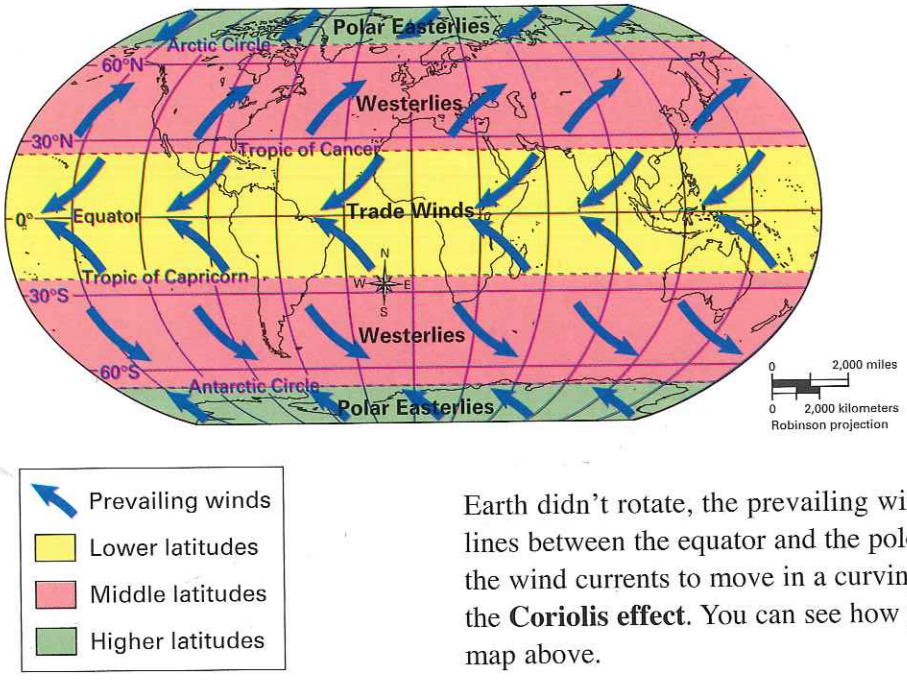
The sun's heat is distributed around Earth through a process called **convection,** or heat transfer. This transfer occurs in both gases and liquids, like air and water. Warm air and warm water are less dense than cooler air and water. As a result, warm air tends to rise in the atmosphere. And warm water rises in the oceans.

When warm air or water rises out of an area, cool air or water flows in to take its place. The steady movement of air or water due to convection is called a **current**.

Winds and Trade

This map shows the main prevailing winds around the globe. Notice the winds blowing toward the equator from higher latitudes to the north and south. They are known as *trade winds*. These winds were named for their ability to move trade goods across the seas in the days when sailing ships were powered by wind.

Prevailing Winds Around the World

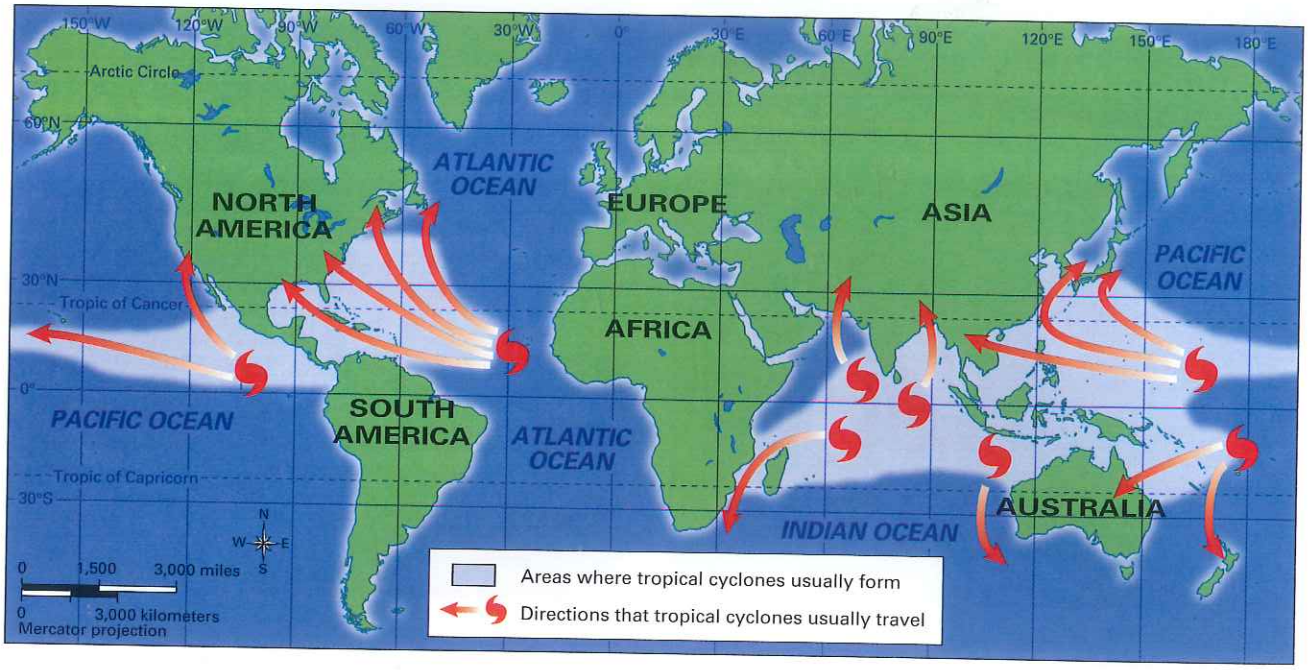


Air and Water Move in Predictable Patterns

The movement of air and water around the globe occurs in regular patterns. In general, warm air and water currents flow from the equator toward the poles. At the same time, cool air and water currents flow from the poles toward the equator.

This predictable pattern creates **prevailing winds**. These are winds that usually blow in one direction. If Earth didn't rotate, the prevailing winds would move in straight lines between the equator and the poles. But Earth's rotation causes the wind currents to move in a curving pattern. This pattern is called the **Coriolis effect**. You can see how prevailing winds curve on the map above.

Cyclones Around the World



Small Changes Can Cause Extreme Weather Wind and ocean currents have an important influence on weather. That's because they distribute heat and cold around the world. Even minor changes in prevailing winds or ocean currents can cause major changes in weather.

A good example of this effect is the impact of an **El Niño**. An El Niño is a warm ocean current that sometimes flows along the west coast of South America. This warm current doesn't appear every year. But when it does, it usually shows up during the Christmas season. That's why it's called El Niño, which is a nickname for "the Christ child" in Spanish.

In an El Niño year, the weather on the Pacific coast of North and South America gets warmer. Rainfall increases, and flooding is common. At the same time, weather on the other side of the Pacific gets drier. Severe forest fires sometimes occur in Southeast Asia and Australia during these dry spells. The effects of an El Niño's appearance can be felt as far away as India and Africa.

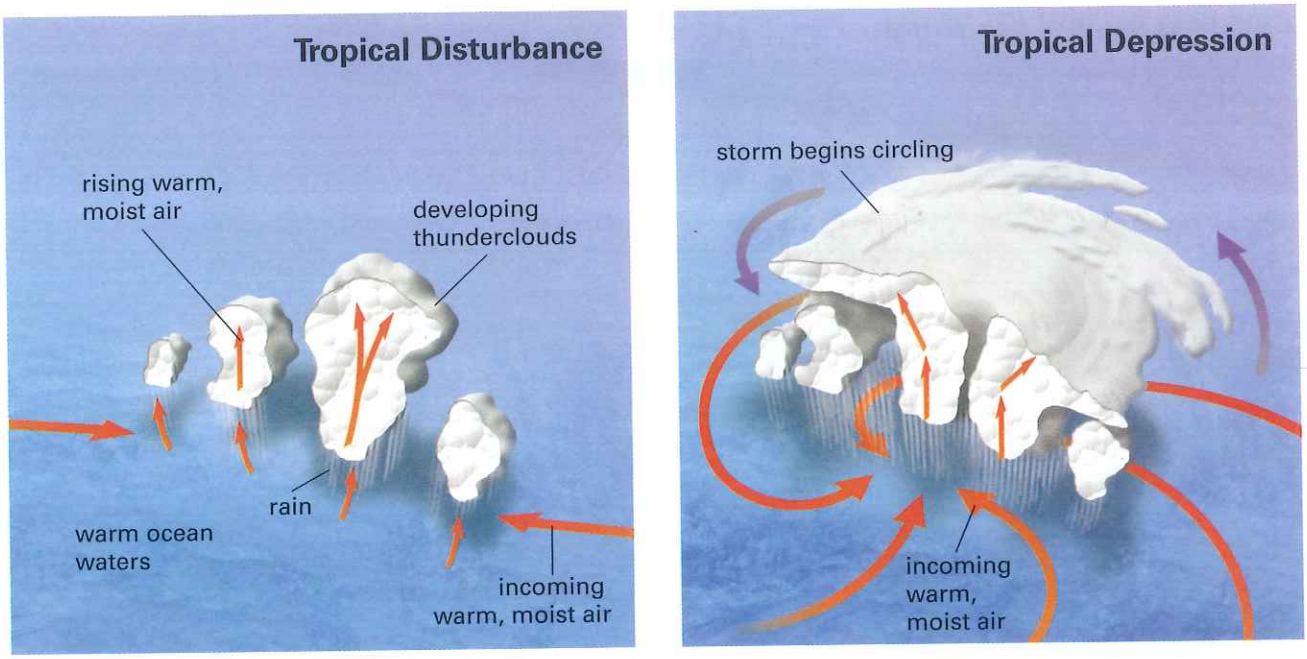
Tropical Cyclones: The Most Violent Weather Events In the tropics, the weather machine can be very powerful. That's because there's more energy from the sun to warm the air and water. This energy produces tropical cyclones, the most violent storms on Earth.

Tropical cyclones occur only where ocean temperatures reach at least 80°F. Lots of warm, moist air is needed to start these storms. That's why they usually occur in the warmer months of the year.

Tropical cyclones form in three oceans. In the Atlantic Ocean and the eastern Pacific, they are called *hurricanes*. In the western Pacific, they are usually called *typhoons*. In the Indian Ocean, these storms are called *cyclones*.

Tropical Cyclones

The word *cyclone* comes from a Greek word that means "moving in a circle." Tropical cyclones form over three oceans at different times of the year. In the Atlantic Ocean and the eastern Pacific, the season runs from June through November. In the western Pacific, the season lasts from April to December. In the Indian Ocean, the season is from December to April.



Birth of a Hurricane
A hurricane develops in four main stages. First, various storms come together to form a tropical disturbance. Second, the disturbance grows into a tropical depression. Third, the depression becomes a tropical storm. Finally, the storm becomes a tropical cyclone, or hurricane. In each stage, wind speeds increase as the storm sucks in more air and moisture.

11.4 Extreme Weather: A Hurricane Is Born

Have you ever seen a thunderstorm approaching? The wind picks up and the temperature drops. Clouds roll in and the sky grows dark. A bolt of lightning pierces the sky, followed by a crack of thunder. Suddenly it's pouring rain. In some parts of the world, such a storm might be the first stage of a hurricane.

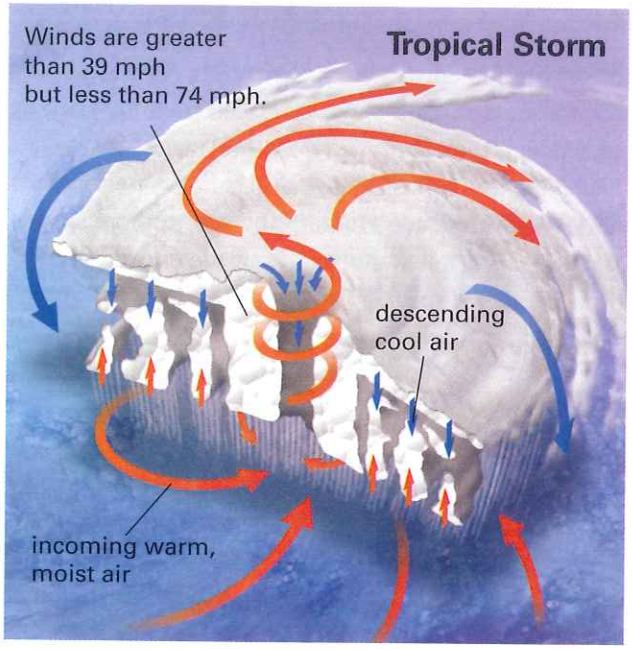
Tropical Thunderstorms Begin the Process Hurricanes in the Atlantic Ocean usually start out off the coast of Africa. In the summer, water temperatures in that part of the ocean rise to 80°F or more. The ocean releases warm, moist air into the atmosphere. As the warm air rises, the moisture **condenses** to form clouds and rain. The result is a tropical thunderstorm.

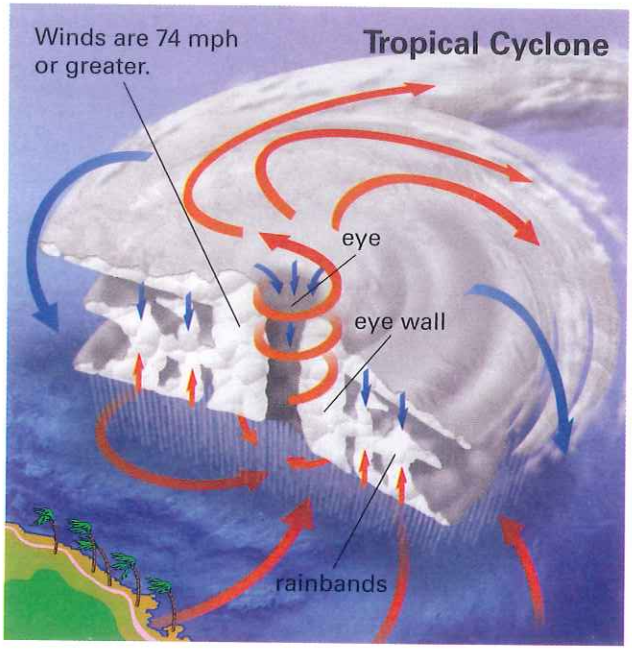
Sometimes several thunderstorms come together to create a **tropical disturbance**. This is a cluster of thunderstorms that move together with the prevailing winds.

From a Tropical Disturbance to a Hurricane As a tropical disturbance grows, more warm, moist air rises from the ocean. In the Northern Hemisphere, this rising air begins to circle in a counterclockwise direction. This is due to the Coriolis effect, which you read about earlier. When wind starts circling inside a tropical disturbance, the storm becomes a **tropical depression**.

When conditions are right, a tropical depression will suck up still more warm air and moisture. Once wind speeds inside the storm reach 39 miles per hour, a tropical depression is called a **tropical storm**.

Most tropical storms die out in time. But a few continue to grow in size and wind speed. When wind speeds reach 74 miles per hour, the storm becomes a tropical cyclone. A hurricane is born!





11.5 Inside a Monster Storm

A hurricane is a huge, whirling storm. And it packs a powerful punch. In just one day, a hurricane releases more energy than 500,000 atomic bombs. If you could turn that energy into electricity, it would be enough to satisfy the electrical needs of the United States for six months!

The Parts of a Hurricane A hurricane is made up of three key parts. The first part is the **eye**. This is a calm spot at the center of the storm. The eye of a hurricane might be 20 to 40 miles across. The winds of a hurricane swirl around the calm eye.

The second part is the **eye wall**. The eye wall is made up of thunderstorms that surround the eye. From the center of the storm, the eye wall looks like a great curtain of clouds. This wall of storms can be anywhere from 5 to 30 miles thick.

Rainbands are the third key part. These are bands of dense clouds that swirl around the eye wall. The rainbands spiral toward the center of the hurricane as it moves across the ocean. They drop large amounts of rain as the storm travels.

The Path of Hurricanes As you read, Atlantic hurricanes are born off the coast of Africa. Once a monster storm develops, trade winds blow it from east to west across the Atlantic. The hurricane spins rapidly as it moves, like a giant top.

The exact track, or path, of a hurricane is unpredictable. A hurricane may change course with a shift in wind direction. It also may speed up, slow down, or even stop for a while and build up strength. As long as a hurricane stays over warm water, it can continue to grow in both size and power. Severe storms can swell to 1,000 miles across in size and pack wind speeds of up to 200 miles per hour.

11.6 Tracking and Preparing for a Hurricane

"Hold on," the pilot says to his crew. "We're going in!" The plane shakes violently as it enters the storm's eye wall. But then the shaking stops. The plane has reached the calm eye of the hurricane.

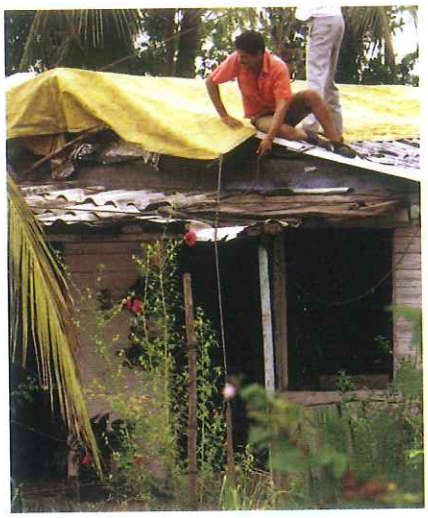
This plane and its crew are part of a special Air Force unit called the Hurricane Hunters. The Hurricane Hunters fly into tropical storms to record weather data. The work is dangerous, but the crews believe that what they learn is worth the risks. "The bottom line for all of us," says a pilot, "is that we do save lives."

Meteorologists Track and Name Hurricanes The Hurricane Hunters work with meteorologists to track the paths of tropical storms. The meteorologists use satellite images and data from the flight crews to decide when a storm has become a hurricane. At that point, they give the hurricane a name.

Meteorologists have alphabetical lists of male and female names to use in naming hurricanes. The name of the year's first hurricane always begins with the letter A. When a very destructive hurricane hits land, its name is retired and never used again. Since 1954, at least 40 hurricane names have been retired.

Preparing for a Hurricane Once meteorologists know the track of a storm, they warn people in its path. When a storm might hit land within 24 to 36 hours, they issue a *hurricane watch*. When the storm is less than 24 hours away, they issue a *hurricane warning*. These predictions are not always perfect, but they do give people a chance to prepare for the storm.

Meteorologists use the Saffir-Simpson scale to rate a hurricane's strength. This scale rates hurricanes from 1 to 5. The higher the number, the more damage the storm can cause. This information helps people decide whether to board up their windows and stay home or to seek a safer shelter away from the coast. Storms often change ratings as they travel. In 2003, Hurricane Isabel stayed at level 5 for over 30 hours. This made it one of the longest-lasting Category 5 storms on record.



Getting Ready for a Hurricane

This Cuban is tying a tarp over his roof in preparation for a hurricane. People in this region know how to prepare for big storms. Hurricane survival kits typically include these things:

- Water: 1 gallon a day per person for 3 to 7 days
- Food: enough to feed people and pets for 3 to 7 days
- First aid kit and medicines
- Blankets and clothes
- Flashlight and batteries
- Battery-powered radio
- Tools for repairing storm damage

The Saffir-Simpson Scale

Scientists rate hurricanes using the Saffir-Simpson scale. Category 5 storms are the most dangerous. But less powerful storms can also be deadly.

Category 1 hurricane

Category 2 hurricane

11.7 Landfall: A Natural Disaster Begins

When a hurricane hits land, its power is truly awesome. "The wind is at a ferocious roar and coming in powerful bursts," wrote a reporter who witnessed Hurricane Ivan's landfall in Jamaica in 2004. "Even stepping outside for a minute would mean serious injury or worse. Hurricane Ivan has arrived in all its fury and it's terrible indeed."

The Power of Wind and Rain When a hurricane strikes, it lashes everything in its path with wind and rain. The most powerful hurricanes carry winds of up to 200 miles per hour. Such fierce winds can uproot trees or snap them in half. They can shatter windows, blow off roofs, flip over cars, and hurl boats through the air.

Heavy hurricane rains often cause terrible flooding. They can also loosen rocks and soil on hillsides. The result may be deadly mudslides that crush everything in their path. In 1998, a Category 5 hurricane called Mitch dropped more than 75 inches of rain on Honduras, a small Central American country bordering the Caribbean Sea. The rain caused floods and mudslides that killed about 11,000 people.

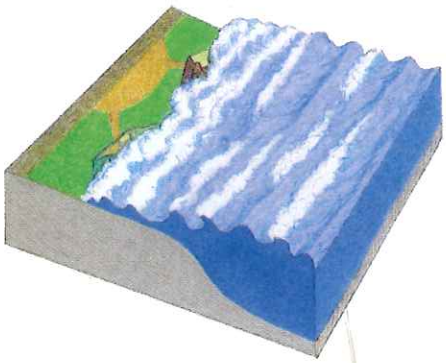
Storm Surge: The Most Dangerous Force of All The most destructive feature of a hurricane is the **storm surge**. A storm surge is a wall of water pushed ashore by a storm. A storm surge can rise as much as 33 feet above sea level. That's as high as a three-story building. When this wall of water hits land, it can destroy everything in its path. Storm surges cause about 9 out of every 10 deaths from hurricanes.

The more powerful the hurricane, the higher the storm surge is likely to be. In 1999, a Category 4 storm named Lenny hit several Caribbean islands. In St. Croix, Lenny's 15-foot storm surge knocked over power poles, threw boats up on shore, and destroyed a ballpark. In St. Lucia, dozens of people were left homeless when their homes were washed away. A Category 5 storm named Katrina tore through the region in 2005. Katrina's storm surge flattened levees that protected the U.S. city of New Orleans from flooding. When the storm ended, much of New Orleans was under water. Damage was so widespread that Katrina became the costliest Atlantic hurricane of all time.

Storm Surge from Hurricane Ivan
A storm surge is a hurricane's most deadly feature. When this wall of water hits land, it causes massive floods. In 2004, a storm surge from Hurricane Ivan flooded this beach home in Cuba. This monster storm killed about 70 people across the Caribbean.

Category 3 hurricane

Category 4 hurricane



Category 5 hurricane

Rescuing Survivors of Jeanne
These people are being rescued from a flooded house in Puerto Rico after Hurricane Jeanne in 2004. The worst damage from this storm occurred in Haiti. About 3,000 Haitians died as a result of flooding and mudslides. Many Haitians may never fully recover from this disaster.

11.8 Cleaning Up After a Natural Disaster

A hurricane can have a very powerful impact. But the problems don't end when the storm moves on. Although the hurricane may be over, the effects of the natural disaster continue.

Hurricanes Lose Strength over Land Luckily, hurricanes don't last forever. Hurricane John, the world's longest-running storm, lasted nearly a month and crossed 5,000 miles of ocean. But most hurricanes die out sooner than that. The main reason is that they hit land.

Hurricanes die when they lose their main source of energy. Remember that these storms need warm ocean water to keep them going. Once they hit land or cross cool water, they begin to weaken. In the Caribbean, storms can cross an island and then pick up force on the other side. But they lose steam when they hit a large **landmass** like the United States or Mexico. At that point, they usually die out in a few days.

Rebuilding After a Natural Disaster Once a hurricane has passed, people in its path face the task of rebuilding. This is often a huge challenge. A hurricane may destroy many of the homes on a hard-hit island. It may damage schools, hospitals, roads, bridges, and power lines. Many people may be left homeless. Hunger and disease may be serious problems.

The first task after a storm passes is to rescue people caught in the wreckage. Relief agencies are set up to find and treat the injured. Relief workers also work to supply food, water, shelter, and clothing to those in need.

The next task is cleaning up. Floodwaters have to be drained from low-lying areas. Water and **sewage** lines have to be repaired to provide clean water and **sanitation**. Roads need to be cleared. Electrical power has to be restored. Damaged buildings must be knocked down. This work requires time and money. It can take months or even years for a Caribbean island to fully recover from a severe hurricane.

11.9 Beginning to Think Globally

In this chapter, you have learned about extreme weather in the Caribbean. You learned how tropical cyclones get started and how they develop into deadly storms. You read about the methods that meteorologists use to analyze and track these storms. You also learned how natural disasters caused by these storms affect people and communities in the Caribbean.

Few Places Escape Extreme Weather Tropical cyclones are tremendously destructive. But they are not the only example of extreme weather. Tornadoes, blizzards, and heavy rains can all do great harm as well.

Most parts of the world experience some form of extreme weather. In the United States, tornadoes rip through towns and destroy property every spring. In the winter months, blizzards block roads, knock out power lines, and stop air travel. The story is much the same on other continents. In South Asia, heavy rains often cause flooding. In parts of Africa, sandstorms destroy crops.

El Niño's Impact on Weather El Niño plays a key role in extreme weather. As you have learned, El Niño is a warm ocean current that flows from time to time along the Pacific coast of South America. When an El Niño occurs, it can trigger extreme weather in the Pacific region and in other parts of the world.

A major El Niño appeared off the coast of South America in 1997 and 1998. This warming of the ocean caused heavy rains and flooding in South America. It also produced tornadoes in Florida. At the same time, it caused dry spells that led to wildfires in Southeast Asia, Australia, and Central America.

Scientists are still trying to understand the role El Niño plays in extreme weather. But the effects are clear. You will look at El Niño's impact around the world in the next section.

Counting the Costs

This table shows effects of five recent hurricanes in the Caribbean. These estimates are rough. It is difficult to gather accurate information about the loss of lives and property caused by extreme weather events.

Five Destructive Hurricanes in the Caribbean, 1998–2004

Hurricane	Year	Major Areas Affected	Estimated Deaths	Estimated Damage
Jeanne	2004	U.S. Virgin Islands, Puerto Rico, Dominican Republic, Haiti, Bahamas, Florida	3,005	$6.9 billion
Ivan	2004	Grenada, Jamaica, Grand Cayman, Cuba, Alabama, Florida, Texas, Louisiana	92	$18 billion
Michelle	2001	Cuba, Honduras, Nicaragua, Jamaica, Cayman Islands	17	$28 million
Mitch	1998	Honduras, Nicaragua, El Salvador, Guatemala	11,000	$5 billion
Georges	1998	Puerto Rico, Dominican Republic, Haiti, Florida, Mississippi	602	$5.9 billion

Source: National Hurricane Center.

11.10 Global Connections

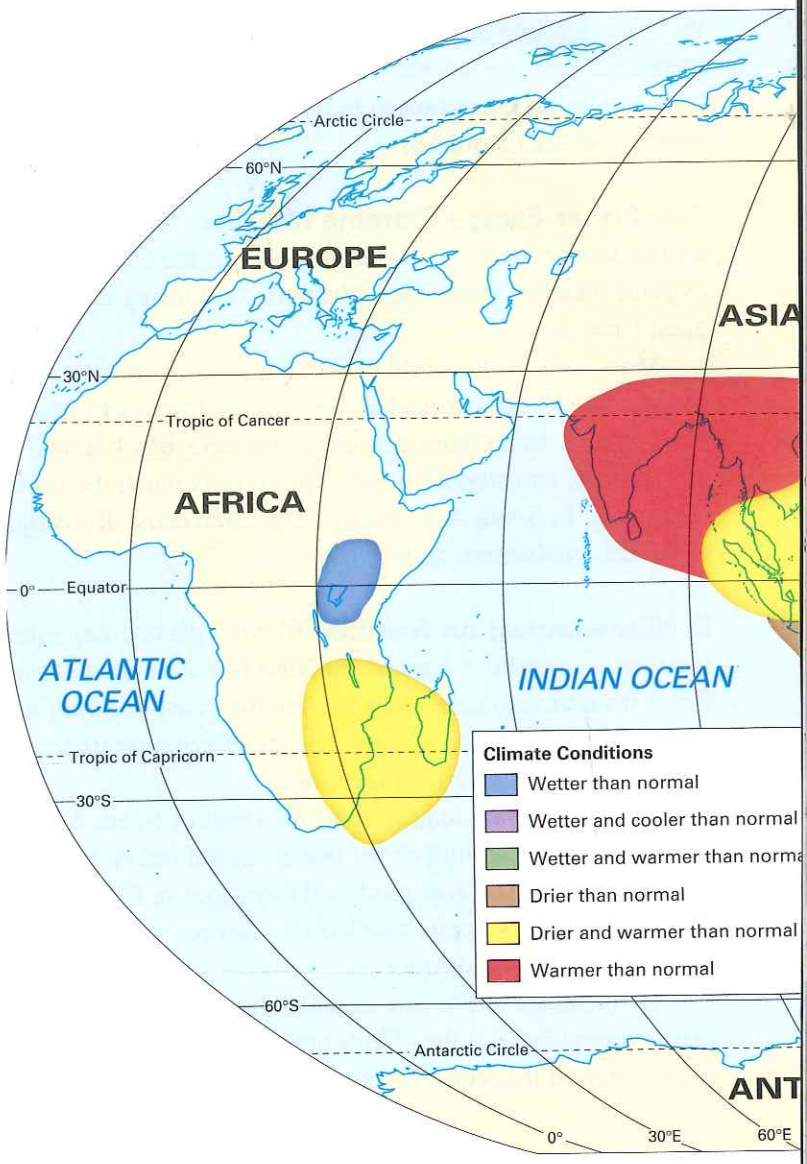
The small map shows warmer than usual ocean currents during an El Niño year. Notice that the warmest ocean area is off the west coast of South America. The large map shows how different areas of the world are affected during a major El Niño year. The table shows some extreme weather events in the United States between 1990 and 2000.

What parts of the world are most affected by an El Niño? As you might expect, lands bordering the Pacific Ocean show the greatest effects from an El Niño. The west coasts of North and South America experience weather that is wetter than usual. Areas on the other side of the Pacific suffer from very dry weather.

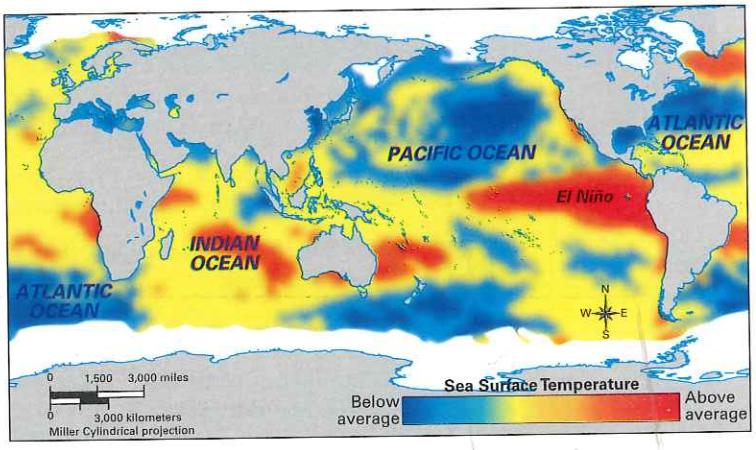
What relationship do you see between an El Niño and extreme weather? An El Niño can affect weather in ways you might not expect. The years 1991, 1993, 1994, and 1997 were considered El Niño years. As the table shows, there were fewer hurricanes in the Atlantic in those years. There were also fewer extreme temperature events in the United States than in an average year.

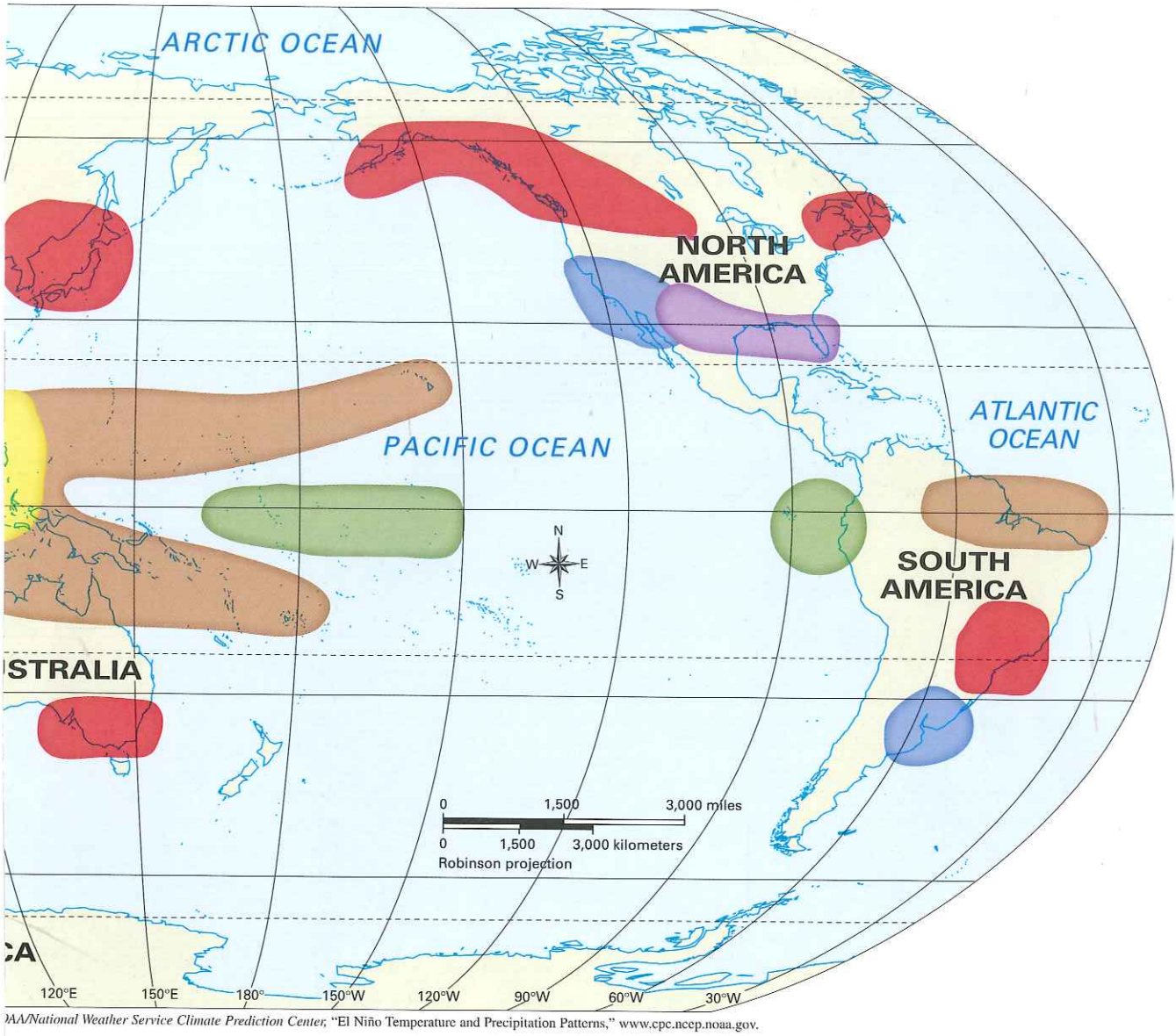
How can understanding an El Niño's effects help meteorologists to predict extreme weather? Just how an El Niño shapes climate is not yet fully understood. But the more meteorologists learn about the factors that shape our climate, the better they will be at predicting extreme weather. This, in turn, could help people prepare for natural disasters caused by weather.

El Niño's Effects Around the World



Sea Surface Temperatures in an El Niño Year





)AA/National Weather Service Climate Prediction Center, "El Niño Temperature and Precipitation Patterns," www.cpc.ncep.noaa.gov.

Extreme Weather Events in the United States, 1990–2000

El Niño year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Atlantic Hurricanes	8	3	4	4	3	11	9	3	10	8	8
Violent Tornadoes	50	12	32	5	6	14	4	10	14	18	3
Extreme Hail Events	56	84	134	38	48	110	99	65	100	73	71
Extreme Temperature Events	(no information available)			33	65	229	272	238	344	395	418

Sources: *National Oceanic and Atmospheric Administration,* www.noaa.gov. Jan Null, "El Niño and La Niña Years: A Consensus List," Oct. 2004, *Golden Gate Weather Services,* ggweather.com. *Weather Underground,* "Hurricane Archive," www.wunderground.com.