All About Hurricanes: The Science Behind Hurricanes

As hurricane Sandy made its way to the Eastern coast of the United States in October 2012, meteorologists called the storm unprecedented in terms of its potential for damage and fatalities. Few events on Earth rival the sheer power of a hurricane. Also known as tropical cyclones and typhoons, these fierce storms can churn the seas into a violent topography of 50-foot (15-meter) peaks and valleys, redefine coastlines and reduce whole cities to watery ruin. Some researchers even theorize that the dinosaurs were wiped out by prehistoric hypercanes, a kind of super-hurricane stirred to life by the heat of an asteroid strike.

Every year, the world experiences hurricane season. During this period, hundreds of storm systems spiral out from the tropical regions surrounding the equa-tor, and between 40 and 50 of these storms intensify to hurricane levels. In the Northern Hemisphere, the season runs from June 1 to Nov. 30, while the Southern Hemisphere generally experiences hurricane activity from January to March. So 75 percent of the year, it's safe to say that someone somewhere is probably worrying about an impending hurricane.

A hurricane builds energy as it moves across the ocean, sucking up warm, moist tro-pical air from the surface and dispensing cooler air aloft. Think of this as the storm breathing in and out. The hurricane escalates until this "breathing" is disrupted, like when the storm makes landfall. At this point, the storm quickly loses its momentum and power, but not without unleashing wind speeds as high as 185 mph (300 kph) on coastal areas.

Defining a Hurricane

To understand how a hurricane works, you have to understand the basic principles of atmospheric pressure. The gases that make up Earth's atmosphere are subject to the planet's gravity. In fact, the atmosphere weighs in at a combined 5.5 quadrillion tons (4.99 quadrillion metric tons). The gas molecules at the bottom, or those closest to the Earth's surface where we all live, are compressed by the weight of the air above them.

The air closest to us is also the warmest, as the atmosphere is mostly heated by the land and the sea, not by the sun. To understand this principle, think of a person frying an egg on the sidewalk on a hot, sunny day. The heat absorbed by the pavement actually fries the egg, not the heat coming down from the sun. When air heats up, its molecules move farther apart, making it less dense. This air then rises to higher altitudes where air molecules are less compressed by gravity. When warm, low-pressure air rises, cool, high-pressure air seizes the opportunity to move in underneath it. This movement is called a pressure gradient force.

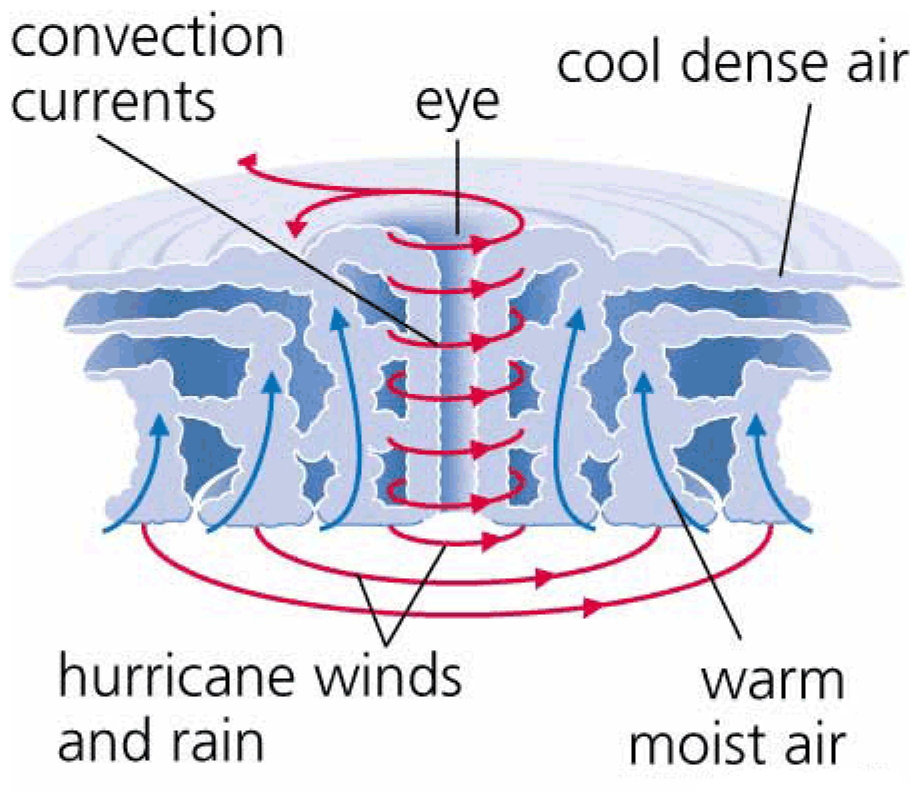
These are some of the basic forces at work when a low-pressure center forms in the atmosphere -- a center that may turn into what people in the North Atlantic, North Pacific and Caribbean regions call a hurricane. What else is happening? Well, as we know, warm, moist air from the ocean's surface begins to rise rapidly. As it rises, its -water vap-or condenses to form storm clouds and droplets of rain. The condensation releases heat called latent heat of condensation. This latent heat warms the cool air, causing it to rise. This rising air is replaced by more warm, humid air from the ocean below. And the cycle continues, drawing more warm, moist air into the developing storm and moving heat from the surface to the atmosphere. This exchange of heat creates a pattern of win-d that circulates around a center, like water going down a drain.

But what about those signature ferocious winds? Converging winds at the surface are colliding and pushing warm, moist air upward. This rising air reinforces the air that's already ascending from the surface, so the circulation and wind speeds of the storm increase. In the meantime, strong winds blowing the same speed at higher altitudes (up to 30,000 feet or 9,000 meters) help to remove the rising hot air from the storm's center, maintaining a continual movement of warm air from the surface and keeping the storm organized. If the high-altitude winds don't blow at the same speed at all levels -- if wind shears are present -- the storm becomes disorganized and weakens.

Even higher in the atmosphere (above 30,000 feet or 9,000 meters) high-pressure air over the storm's center also removes heat from the rising air, further driving the air cycle and the hurricane's growth. As high-pressure air is sucked into the low-pressure center of the storm, wind speeds increase. Then you have a hurricane to contend with.

How a Hurricane Forms

You never hear about hurricanes hitting Alaska. That's because hurricanes develop in warm, tropical regions where the water is at least 80 degrees Fahrenheit (27 degrees Celsius). The storms also require moist air and converging equatorial winds. Most Atlantic hurricanes begin off the west coast of Africa, starting as thunderstorms that move out over the warm, tropical ocean waters.-



A hurricane's low-pressure center of relative calm is called the eye. The area surrounding the eye is called the eye wall, where the storm's most violent winds occur. The bands of thunderstorms that circulate outward from the eye are called rain bands. These storms play a key role in the evaporation/condensation cycle that feeds the hurricane.

The rotation of a hurricane is a product of the Coriolis force, a natural phenomenon that causes fluids and free-moving objects to veer to the right of their destination in the Northern Hemisphere and to the left in the Southern Hemisphere. Imagine flying a small plane directly south. While you're moving southward, the planet is rotating. If you plotted a flight from the North Pole to the equator on a map, the path will appear to curve to the right.

So in the Northern Hemisphere, winds deflect to the right. In the Southern Hemisphere, they deflect to the left. This wind deflection gets storms spinning. As a result, hurricanes in the Northern Hemisphere rotate counterclockwise and clockwise in the Southern Hemisphere. The force also affects the actual path of the hurricane, bending them to the right (clockwise) in the Northern Hemisphere and to the left (counterclockwise) if you're south of the equator. If you can't remember, just move within five degrees of the equator; the Coriolis force is too weak there to help form hurricanes.

Hurricanes often begin their lives as clusters of clouds and thunderstorms called tropical disturbances. These low-pressure areas feature weak pressure gradients and little or no rotation. Most of these disturbances die out, but a few persevere down the path to hurricane status. In these cases, the thunderstorms in the disturbance release latent heat, which warms areas in the disturbance. This causes the air density inside the disturbance to lower, dropping the surface pressure. Wind speeds increase as cooler air rushes underneath the rising warm air. As this wind is subject to the Coriolis force, the disturbance begins to rotate. The incoming winds bring in more moisture, which condenses to form more cloud activity and releases latent heat in the process.

Lifecycle of a Hurricane

Given the destruction the storm unleashes, it's easy to think of a hurricane as a kind of monster. It may not be a living organism, but it does require sustenance in the form of warm, moist air. And if a tropical disturbance continues to find enough of this "food" and to encounter optimal wind and pressure conditions, it will just keep growing.

It can take anywhere from hours to days for a tropical disturbance to develop into a hurricane. But if the cycle of cyclonic activity continues and wind speeds increase, the tropical disturbance advances through three stages:

1.) Tropical depression: wind speeds of less than 38 mph

2.) Tropical storm: wind speeds of 39 to 73 mph

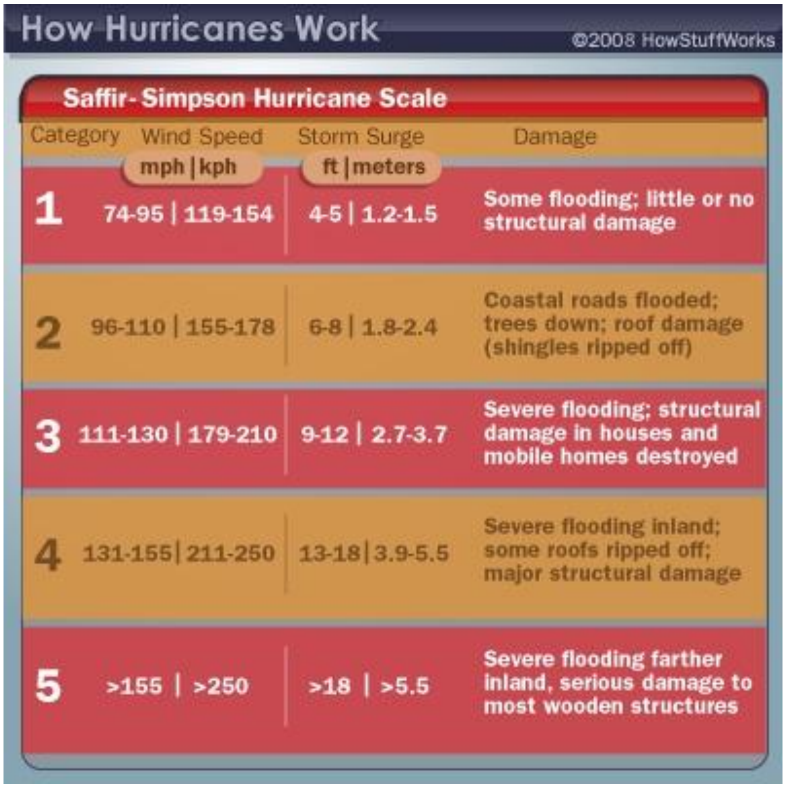
3.) Hurricane: wind speeds greater than 74 mph

Between 80 and 100 tropical storms develop each year around the world. Many of them die out before they can grow too strong, but around half of them eventually achieve hurricane status.

Hurricanes vary widely in physical size. Some storms are compact, with only a few bands of wind and rain trailing behind them. Other storms are looser -- the bands of wind and rain spread out over hundreds or thousands of miles. Hurricane Floyd, which hit the eastern United States in September 1999, was felt from the Caribbean islands to New England.

Once a hurricane has formed and intensified, the only remaining path for the atmospheric juggernaut is dissipation. Eventually, the storm will encounter conditions that deny it the warm, moist air it requires. When a hurricane moves onto cooler waters at a higher latitude, gradient pressure decreases, winds slow, and the entire storm is tamed, from a tropical cyclone to a weaker extratropical cyclone that peters out in days.

That important supply of warm, moist air also vanishes when the hurricane makes landfall. Condensation and the release of latent heat diminishes, and the friction of an uneven landscape decreases wind speeds. This causes winds to move more directly into the eye of the storm, eliminating the large pressure difference that fuels the storm's awesome power.


How Hurricanes Work ©2008 HowStuffWorks

Saffir-Simpson Hurricane Scale

Category	Wind Speed mph | kph	Storm Surge ft | meters	Damage
1	74-95 | 119-154	4-5 | 1.2-1.5	Some flooding; little or no structural damage
2	96-110 | 155-178	6-8 | 1.8-2.4	Coastal roads flooded; trees down; roof damage (shingles ripped off)
3	111-130 | 179-210	9-12 | 2.7-3.7	Severe flooding; structural damage in houses and mobile homes destroyed
4	131-155 | 211-250	13-18 | 3.9-5.5	Severe flooding inland; some roofs ripped off; major structural damage
5	>155 | >250	>18 | >5.5	Severe flooding farther inland, serious damage to most wooden structures

Hurricane Categories

Hurricanes can unleash incredible damage when they hit. With enough advance warning though, cities and coastal areas can give residents the time they need to fortify the area and even evacuate. To better classify each hurricane and prepare those affected for the intensity of the storm, meteorologists rely on rating systems.

Australian meteorologists use a slightly different scale to classify hurricanes. While the Australian scale of cyclone intensity also ranks storms by wind speed and damage on a scale of 1 to 5, it covers both hurricanes and tropical storms.

On the next page, we'll look at the tremendous damage hurricanes can inflict when they collide with coastal areas.

Hurricane Damages

Over the course of millennia, hurricanes have cemented their reputation as destroyers. Many people even frame them as the embodiment of nature's power or acts of divine wrath. The word "hurricane" itself actually derives from "Hurakan," a destructive Mayan god. No matter how you choose to sum up or personify these powerful acts of nature, the damage they inflict stems from several different aspects of the storm.

Hurricanes deliver massive downpours of rain. A particularly large storm can dump dozens of inches of rain in just a day or two, much of it inland. That amount of rain can create flooding, potentially devastating large areas in the path of the hurricane's fierce center.

In addition, high sustained winds within the storm can cause widespread structural damage to both man-made and natural structures. These winds can roll over vehicles, collapse walls and blow over trees. The prevailing winds of a hurricane push a wall of water, called a storm surge, in front of it. If the storm surge happens to coincide with high tide, it causes beach erosion and significant inland flooding.

The hurricane itself is often just the beginning. The storm's winds often spawn tornadoes, which are smaller, more intense cyclonic storms that cause additional damage. You can read more about them in How Tornadoes Work.

The extent of hurricane damage doesn't just depend on the strength of the storm, but also the way it makes contact with the land. In many cases, the storm merely grazes the coastline, sparing the shores its full power. Hurricane damage also greatly depends on whether the left or right side of a hurricane strikes a given area. The right side of a hurricane packs more punch because the wind speed and the hurricane's speed of motion complement one another there. On the left side, the hurricane's speed of motion subtracts from the wind speed.

This combination of winds, rain and flooding can level a coastal town and cause significant damage to cities far from the coast. In 1996, Hurricane Fran swept 150 miles (241 km) inland to hit Raleigh, N.C. Tens of thousands of homes were damaged or destroyed, millions of trees fell, power was out for weeks in some areas and the total damage was measured in the billions of dollars.

Tracking a Hurricane

To monitor and track the development and movement of a hurricane, meteorologists rely on remote sensing by satellites, as well as data gathered by specially equipped aircraft. On the ground, Regional Specialized Meteorological Centers, a network of global centers designated by the World Meteorological Organization, are charged with tracking and notifying the public about extreme weather.

Weather satellites use different sensors to gather different types of information about hurricanes. They track visible clouds and air circulation patterns, while radar measures rain, wind speeds and precipitation. Infrared sensors also detect vital temperature differences within the storm, as well as cloud heights.

The Hurricane Hunters are members of the 53rd Weather Reconnaissance Squadron/403rd Wing, based at Keesler Air Force Base in Biloxi, Miss. Since 1965, the Hurricane Hunters team has used the C-130 Hercules, a very sturdy turboprop plane to fly into tropical storms and hurricanes. The only difference between this plane and the cargo version is the specialized, highly sensitive weather equipment installed on the WC-130. The team can cover up to five storm missions per day, anywhere from the mid-Atlantic to Hawaii.

The Hurricane Hunters gather information about wind speeds, rainfall and barometric pressures within the storm. They then relay this information back to the National Hurricane Center in Miami, Fla. If you're curious about these foolhardy pilots, read Why would someone fly an airplane into a hurricane?

Meteorologists take all the storm data they receive and use it to create computer forecast models. Based on a great deal of current and past statistical data, these virtual storms allow scientists to forecast a hurricane's path and changes in intensity well in advance of landfall. With this data, governments and news agencies ideally can warn residents of coastal areas and greatly reduce the loss of life during a hurricane.

Long-term forecasting now allows meteorologists to predict how many hurricanes will take place in an upcoming season and to study trends and patterns in global climate.

All About Hurricanes: Utah Hurricanes

**There is no know hurricane that has hit the coast of the U.S. and made it all the way up to Utah’s boarders.