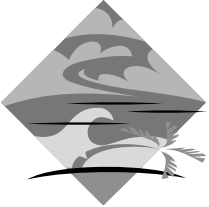




Hurricanes


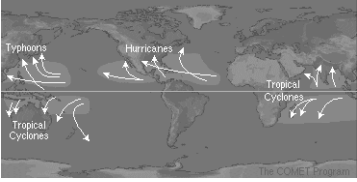
What is a Hurricane?

An intense tropical weather system with a well defined circulation and maximum sustained winds of 74 mph (64 knots) or higher. (NOAA)




Hurricanes occur throughout the Atlantic and Pacific Oceans and go by several different names, depending on the region in which they occur.

In the Atlantic and Eastern Pacific, they are simply "**hurricanes**". In the South Pacific, Australians refer to them as "**cyclones**", and in other Pacific regions, they are known as "typhoons."



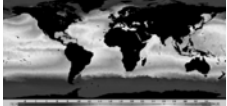
For simplified purposes, all storms of this nature, which spin around a center or an eye, are often referred to generically as "**tropical cyclones**"



As powerful as hurricanes are, they are very delicate weather systems. It takes an almost exact set of weather conditions to create and sustain a hurricane.

Ingredients for a Hurricane

- WARM OCEAN WATER (Sea surface temperatures must be 26.5°C (81°F))

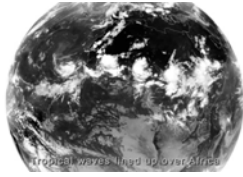


This is a sea surface temperature map for the northern hemisphere summer. The yellow, orange, and red colors show water temperatures warm enough to sustain hurricanes (> 26.5°C).

[http://ww2010.atmos.uiuc.edu/\(GJI\)/wwhlpr/hurricane_ocean.rxml](http://ww2010.atmos.uiuc.edu/(GJI)/wwhlpr/hurricane_ocean.rxml)

Ingredients for a Hurricane (cont.)

- A PRE-EXISTING AREA OF DISTURBED WEATHER (Tropical Wave)



Ingredients for a Hurricane (cont.)

- LIGHT WINDS IN THE UPPER ATMOSPHERE (LOW VERTICAL WIND SHEAR)



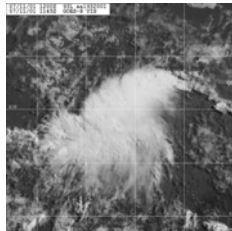
1 No shear:
Easterly winds at all levels allow storms to grow and strengthen hurricane.



2 Shear:
Strong westerly winds at high altitudes blow hurricanes apart and weaken hurricane.

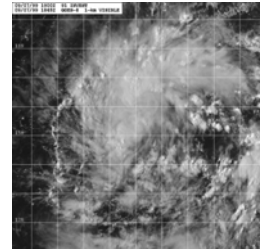
USA TODAY

All hurricanes form from a cluster of thunderstorms called a tropical wave. In the Atlantic, most tropical waves originate off the coast of Africa or in the Gulf of Mexico.



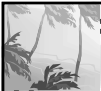
http://ksks.essortment.com/hurricaneformat_rmem.htm

When these waves begin to organize themselves into a swirl, they become tropical depressions. These depressions carry top sustained winds, wind lasting more than one minute, of 35 miles per hour. Less than 10 % of tropical weather disturbances grow into tropical storms because it is relatively rare for several factors to be just right for their development.



http://ksks.essortment.com/hurricaneformat_rmem.htm

In the Pacific, these waves originate off the coast of Central America and Mexico. However, these waves can develop in all the oceans of the tropics.



http://ksks.essortment.com/hurricaneformat_rmem.htm

Tropical depressions can grow into tropical storms in a matter of hours or even days, depending on the atmospheric conditions surrounding the depression.

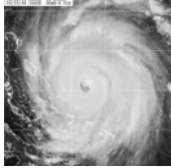
The tropical depression is deemed a tropical storm when its maximum sustained winds exceed 40 mph.

With many tropical storms, we begin to see an eye wall in development as well as a near-definite center of circulation, the eye. When the tropical cyclone reaches tropical storm status, it is given a name.

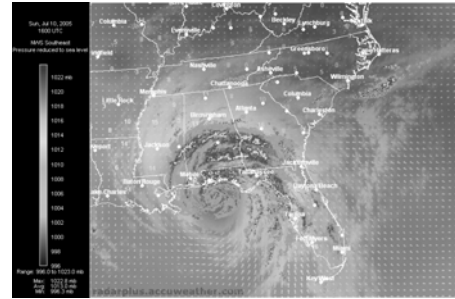


http://ksks.essortment.com/hurricaneformat_rmem.htm

With favorable conditions: warm water, open sky and away from land, the tropical storm will grow into a hurricane. It gains this status when its maximum sustained winds exceed 74 mph. At this wind velocity, it is also deemed a category one hurricane, a minimal hurricane. At this stage, the eye will become a bit more defined and an eye wall, a wall of thunderstorms on the westward side of the eye, begins to develop.



http://ksks.essortment.com/hurricaneformat_mmem.htm



Air spirals inward – from high pressure to low pressure

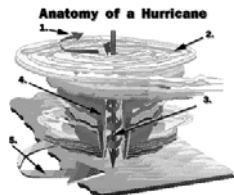
How Hurricanes Form

- <http://us.cnn.com/SPECIALS/2004/hurricanes/interactive/forms/frame1set.exclude.html>

Parts of the storm

A storm's elements

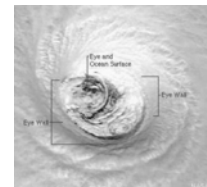
- 1. Exhaust**
Hot air drawn into the atmosphere.
- 2. Storm clouds**
Spiral in upper atmosphere.
- 3. Eye**
Cool air descends into the 20-mile wide eye, creating a small center of calm weather.
- 4. Eye wall**
Storm's fiercest winds.
- 5. Spiraling winds**
In the hurricane's lower realms, air flows in towards the center and whirls upward. These counterclockwise winds gain speed as they approach the eye, like a whirlpool. The narrower the eye, the stronger the wind.



Palm Beach Post

Eye Wall

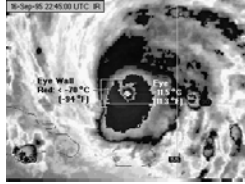
Immediately outside of the eye is the eye wall region, an area of vigorous tall/deep clouds, heavy rainfall, and the strongest observed winds.



<http://www.comet.ucar.edu>

Eye

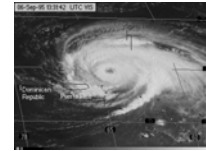
The center of a hurricane is known as the eye. It is a 20-65 km (12-40 mile) wide region of relatively clear and calm conditions brought about by descending air.



<http://www.comet.ucar.edu>

Spiral Bands

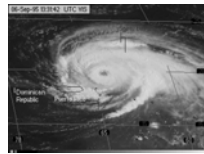
Localized areas of tall/deep clouds, heavy rain, and high winds, known as spiral bands, may extend a few hundred kilometers outward from the center of a hurricane.



<http://www.comet.ucar.edu>

Winds: Low-level Inflow and High-level Outflow

At the surface, the air spirals inward in a counterclockwise (cyclonic) circulation. The circulation becomes weaker with height, eventually turning into clockwise (anticyclonic) outflow near the top of the storm.



<http://www.comet.ucar.edu>

Hurricane intensity is ranked according to the Saffir-Simpson Scale.

Category	Wind Speed		Storm Surge		Damage
	km/hr	mi/hr	m	ft	
1	119-154	74-95	1-2	4-5	Minimal
2	155-178	96-110	2-3	6-8	Moderate
3	179-210	111-130	3-4	9-12	Extensive
4	211-250	131-155	4-6	13-18	Extreme
5	>250	>155	>6	>18	Catastrophic

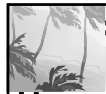
The Atlantic hurricane season is from June 1 to November 30. The Eastern Pacific hurricane season is from May 15 to November 30.



Map Showing Hurricane Activity In The Conterminous United States



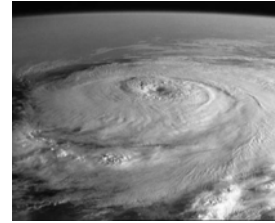
Hurricane risk for the United States



Storms are given names so that it is easier to talk about them and refer to them. The old system was based on using coordinates, which was very confusing because it is not unusual for there to be two or even three hurricanes developing in an ocean.

2002	2003	2004	2005	2006	2007
Arthur	Ana	Alex	Arlene	Alberto	Andrea
Bertha	Bill	Bonnie	Bret	Beryl	Barry
Cristobal	Claudette	Charley	Charley	Chris	Charist
Dolly	Danny	Danielle	Dennis	Debby	Dean
Eduard	Erika	Earl	Emily	Ernesto	Erin
Fay	Fabian	Frances	Franklin	Florence	Felix
Gustav	Grace	Gaston	Gert	Gordon	Gabrielle
Hanna	Henri	Hermine	Harvey	Helene	Humberto
Isidore	Isabel	Ivan	Irene	Isaac	Ingrid
Josephine	Juan	Jeanne	José	Joyce	Jerry
Kyle	Kate	Karl	Katrina	Kirk	Karen
Lili	Larry	Lisa	Lee	Leslie	Lorenzo
Marco	Mindy	Matthew	María	Michael	Melissa
Nana	Nicholas	Nicole	Nate	Nadine	Noel
Omar	Odette	Otto	Ophelia	Oscar	Oiga
Paloma	Peter	Paula	Philippe	Patty	Patric
Rene	Rose	Richard	Rita	Rafael	Rebekah
Sally	Sam	Shary	Stan	Sandy	Sebastian
Teddy	Teresa	Tomas	Tammy	Tony	Tanya
Vicky	Victor	Virginie	Vince	Valerie	Van
Wilfred	Wanda	Walter	Wilma	William	Wen

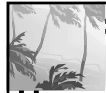
If the Category 1 hurricane is in open water and other conditions are favorable, it will develop within a matter of short days into full-blown hurricane with winds exceeding 100 mph.



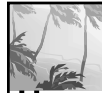
Major hurricanes with winds above 130 mph are rare. They have strong eye walls, which are intense and violent cloud bands that contain the highest winds of the storm.




Hurricanes produce damaging surface winds, heavy rains, and storm surges.



Damage-Causing Winds
While high winds cause significant structural and environmental damage, storm surges are frequently the most devastating element of a hurricane.




Rainfall
Rainfall is difficult to predict at times because while a hurricane may spend nearly a week developing out in the ocean, it may make landfall and not dump much rain at all.




Storm Surges

A storm surge is a rise in sea level along a coastline caused by the combination of a hurricane's surface winds and the physical geography of a coastline. Surface winds above the ocean's surface push water toward the hurricane's eye, creating a mound of water. The mound of water is then influenced by the slope of the coastline as the hurricane approaches land.




<http://www.comet.ucar.edu>




Shallow-water Coastline

If the coastline is shallow, water cannot flow away from the mound and the mound grows. If the coastline is deep, water can disperse and the mound may grow slowly or disperse depending on hurricane strength. An example of a shallow-water coastline is the Gulf Coast while an example of a deep-water coastline is found in New England.




Deep-water Coastline



Each of the animations above depicts surge dynamics in action. As you watch the storm-surge animations, notice the effect that the physical geography of each coastline has on storm surge. Also note the waves on top of the ocean's surface. Wind, waves, and sea-level rise all contribute to storm-surge damage.


<http://www.comet.ucar.edu>





Predicting Worst Storm-surge Damage

The greatest storm-surge damage is to the right of a hurricane's eye (as you face the shoreline) in the Northern Hemisphere. It occurs to the right of the eye because winds, ocean waves, and sea-level rise are all moving in an onshore direction. In contrast, to the left of the eye, ocean waves and sea-level rise are moving in an onshore direction, but the winds are blowing in an offshore direction. The offshore direction of the winds moderates the effect of the storm surge.

<http://www.comet.ucar.edu>




Tropical cyclones throughout the world, in general, travel from East to West.





Once a hurricane makes landfall on a continent or large island, its development usually stops and the storm weakens. When they strike a large land mass, the hurricane will fizzle into a cluster of thunderstorms or rain showers.

http://kaks.essortment.com/hurricaneformat_rmern.htm



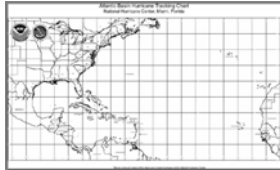
However, if it makes landfall on a small island or small cluster of islands, the opposite could occur. Because of the warmer and shallower water surrounding most small islands, the hurricane may intensify greatly. This is often the case with Atlantic hurricanes that strike the Bahamas. These hurricanes often intensify slightly when they are over the warm water of the Bahama islands, which are very close to South Florida.



http://kaks.essortment.com/hurricaneformat_rmern.htm

How To Track A Hurricane

The National Hurricane Center, which is part of the National Weather Service and the National Oceanic and Atmospheric Administration, tracks tropical storms and hurricanes. Hurricane watches and warnings are issued when the storms get close to the U.S. You can track the progress of storms by listening to the coordinates given by your television meteorologists. Or you can regularly check on <http://www.nhc.noaa.gov/> for the latest longitude and latitude locations issued by the National Hurricane Center.

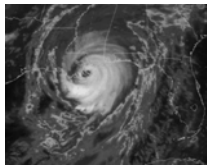


Tracking Hurricanes Using Satellite Imagery

Why Hurricane Tracking is Vital: Satellite imagery is very important for tracking and determining intensity trends of hurricanes and other tropical storms. When a hurricane is well offshore and out of effective radar range (more than 270 km/150 miles), satellite imagery is the best way to continuously track the storm. Weather reconnaissance planes flying into hurricanes provide valuable but not continuous data.



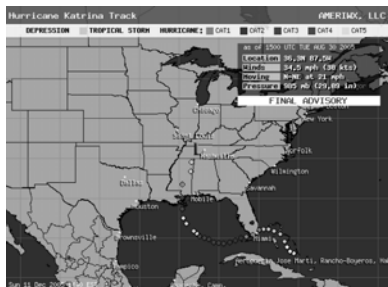
Hurricane Katrina



Hurricane Katrina formed in the Atlantic Ocean on near the Bahamas on August 24th. Hurricane Katrina hit SE Florida late on August 25th as a Category 1 Hurricane. Katrina moves SW across southern Florida and emerged into the SE Gulf of Mexico where Katrina Strengthened and became a Category 5 Hurricane in the Gulf of Mexico on August 28th. Katrina headed toward the Northern Gulf Coast and Katrina hit Louisiana as a Major Hurricane on August 29th. Katrina was the Costliest Hurricane in U.S. history and the damage was spread from the Florida Panhandle to Louisiana with the City of New Orleans suffering major Flooding as the some of the Dikes that protected the city gave way. Major Damage occurred along the Mississippi Gulf coast with the cities of Gulfport and Biloxi among the cities suffering major damage.

<http://www.hurricaneadvisories.com/katrina.html>

Federal officials consider Katrina the most destructive hurricane to ever strike the United States.



<http://www.hurricaneadvisories.com/katrina.html>

KATRINA Graphics Archive from the National Hurricane Center

http://www.nhc.noaa.gov/archive/2005/KATRINA_graphics.shtml

Hurricane Katrina is responsible for more than 1,100 deaths in Louisiana. The storm also killed more than 200 people in Mississippi and 15 across Florida, Alabama and Georgia.

(CNN Monday, March 20, 2006)



<http://hurricanekatrinainformation.com>

Prelude to Katrina: FEMA Hurricane Simulation Pam (video)

http://www.infowars.com/video/clips/news/091205_no_pam_sim.htm

Additional resources

- <http://school.discovery.com/lessonplans/programs/ragingplanet-hurricane/>
- <http://www.palmbeachpost.com/storm/content/storm/about/anatomy.html>
- <http://www.fema.gov/kids/hurr.htm>
- <http://www.fema.gov/hazards/hurricanes/>
- <http://www.nhc.noaa.gov/>
- <http://www.gritsonline.org/alert.htm>
- http://www.pbs.org/wgbh/nova/teachers/viewing/3302_07_nsn.html
- http://www.pbs.org/wgbh/nova/teachers/activities/3204_02_nsn.html
- <http://www3.essdack.org/socialstudies/katrina.htm>

What is a hurricane?

What causes a hurricane to form?

From what is its great power derived?

What causes a hurricane to increase in intensity?

What stages does a hurricane go through?

How are hurricanes rated?

What are the main parts of a Hurricane?

What causes the greatest loss of life and property when a hurricane reaches land?

Do hurricanes ever hit the USA's West Coast? If not, why not?

No hurricane is on record as having ever hit the U.S. Pacific Coast. A [USA TODAY graphic](#) has more on why hurricanes stay away from California and places farther north. Hurricanes, however, do hit Mexico's West Coast. [Click here](#) for information on these storms. And, the remnants of tropical storms and hurricanes have affected California. [Click here](#) for more information.

<http://www.usatoday.com>

How can I find out when the last hurricane hit a particular part of the U.S. Coast or how many hurricanes have hit and when they hit?

The best starting point is to go to the [USATODAY.com Hurricane history](#) page and scroll down to the ribbon that reads, "Hurricane climatology, averages." The second link, to the NCDC, will help you get started finding how many storms have hit particular parts of the coast. .

<http://www.usatoday.com>

Do Hurricanes cross the equator?

Observations show that no hurricanes form within 5 degrees latitude of the equator. People argue that the Coriolis force is too weak there to get air to rotate around a low pressure rather than flow from high to low pressure, which it does initially. If you can't get the air to rotate you can't get a storm. This is a reason why genesis does not occur at low latitudes but it does not explain why a developed hurricane does not cross the equator..

Could a hurricane cross ? Yes, because a well developed storm has plenty of spin that would dominate the weak Coriolis force near there. If it crossed the Coriolis force would be working against the initial direction of the spin, but it would be dominated by what we call the relative vorticity of the storm.

Review coriolis force with your students.

<http://www.soest.hawaii.edu/GG/ASK/hurricanes.html>

Why don't they destroy or weaken hurricanes when they threaten land?

The basic problem is the size and intensity of hurricanes. They cover tens of thousands of square miles even when they are just beginning. They draw their energy from air over hundreds of thousands of square miles of ocean.

Cooling the water over this large area or finding a way to prevent evaporation of water would reduce hurricanes' strength. But, all of the dry ice in the world would be quickly absorbed in a small part of the ocean near a hurricane. Also, the hurricane would quickly move away from the cooled water or water covered with something to prevent evaporation.

The National Hurricane Center notes that a hurricane releases heat energy at a rate of 50 trillion to 200 trillion watts. (trillion here is used in the U.S. and French sense: a number followed by 12 zeros) This is the equivalent of a 10-megaton nuclear bomb exploding about every 20 minutes.

<http://www.usatoday.com>

How are hurricanes affected by global warming?

There are some different opinions among scientists who study hurricanes about the influence of historical emissions of greenhouse gases on the behavior of tropical cyclones, or as they are called in the Atlantic, hurricanes. Some think that the effect is not discernible, while others believe that they have seen a large effect.

To help students better understand this debate, review the following concepts:

Global warming
Greenhouse effect

Possible causes and effects of global warming:
Sources of greenhouse gases

http://sciencepolicy.colorado.edu/outreach/media_resources/hurricanes_globalwarming/

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<http://www.usatoday.com>

S What gave rise to the Katrina? What determined her path? How was Katrina categorized, and what did she look like as she struck the Gulf Coast? Could the devastation have been avoided?

Have a group discussion with your students.

S What would you do in the case of a disaster? Does your family or school have an emergency evacuation plan?

Have students create a personal emergency plan.



S Imagine that you are residents in a city that is several meters below sea level, such as New Orleans and a hurricane is heading toward your area. Would you stay or leave? What are the reasons behind your decision?

Have a group discussion with your students.