

THUNDERSTORMS

□ Meaning (From Oxford Dictionary)

- **THUNDER** –The loud noise that follows a flash of lightning
- **STORM** –Very bad weather, with strong winds, rain & thunder
- **THUNDER STORM**
–A storm with thunder & Lightning & usually heavy rain

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Thunderstorms

- Thunderstorms can throw one of nature's most spectacular shows, but at the same time prove to be deadly.
- Dangers associated with thunderstorms can include lightning, hail, heavy rain, flooding, strong winds associated with downbursts, microbursts and tornadoes.

Thunderstorms require four Ingredients

- **Moisture** (humidity);
- **Instability** (cold air over warm air that gives the rising warm air the buoyancy needed to continue rising on its own);
- **Wind Shear** (changing wind speed or direction with increasing altitude);
- **Lift**, in the form of an upward force.
 - The most common lifting force is “heating of air” near the ground. As the air warms it becomes lighter and begins rising.
 - Advancing masses of cool air (**Cold Front**), which force warm air upward, also trigger thunderstorms.

What Goes on in Thunderstorms



Air that's moving up, called an updraft, feeds warm, humid air into a thunderstorm.

It causes a large amount of cooled air with rain move down, called a downdraft

1 Anvil cloud

Cloud formed in rising air spreads out at storm's top to form the "anvil".

2 Air movements

Rising warm, humid air feeds the thunderstorm. Rain-cooled air falls. Falling air can reach the ground as a cooling breeze or damaging wind blast.

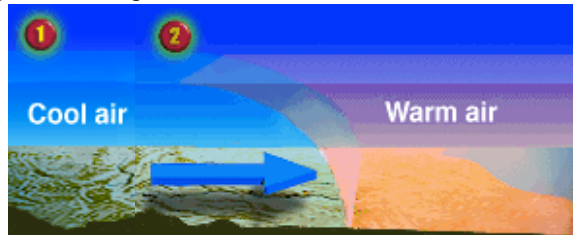
3 Lightning and rain

Electrical charges build up, causing lightning. Shock waves caused by lightning become sound waves we hear as thunder. Some storms produce heavy rain.

Cold Fronts

A cold front is a warm-cold air boundary. As a cold front moves into an area, the heavier, cool air pushes under the lighter, warm air it's replacing. The warm air cools as it rises. If the rising air is humid enough, water vapor in it will condense into clouds.

An arriving cold front can trigger thunderstorms, sometimes severe ones with large hail, dangerous winds and even tornadoes.



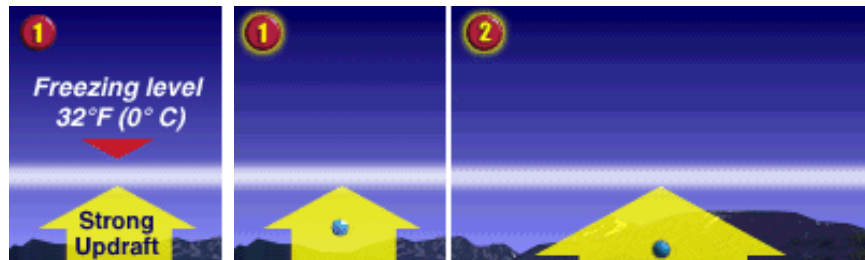
What a cold front does

1 The Cold Front
The leading edge of an advancing cold air mass.



2 Like a bulldozer
A typical cold front plows into warmer, lighter air forming towering clouds, rain and often thunderstorms.

Formation of Hail



Formation

Updraft lifts water droplets above freezing level. Ice chunks grow until hailstones are heavy enough to fall.

Large Hail

A stronger Updraft keeps hail aloft longer allowing bigger hailstones to form.

Small hailstones often melt before reaching the ground, but the larger ones reach the ground and can cause extensive damage to crops and vehicles caught in the storm.

Thunderstorms

- When certain atmospheric conditions coexist, a general thunderstorm can become severe.
- A thunderstorm is classified **severe** when **winds** reach or exceed 57.5 mph or produces **hail** (Thunderstorms sometimes drop balls of ice known as hail in addition to rain.) three-quarters of an inch in diameter or larger.
- Thunderstorms typically last less than a half an hour, but at times they form into long-lasting lines, known as [squall lines](#), or grow to become powerful [super cells](#) that can last for hours and produce killer tornadoes.

Typical Storm & Severe Storm



1

Typical storm:

Small hail usually melts before reaching ground, stiff breeze does very little or no damage.



2

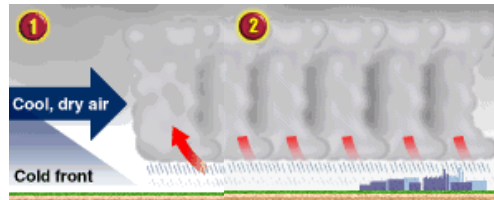
Severe storm:

Hail 3/4 of an inch in diameter or larger and winds 57.5 mph or greater can do extensive damage.

Squall Lines

- When many individual thunderstorms organize into a nearly continuous line, a squall line is born.
- They can be more than 100 miles long and often form 50 to 150 miles ahead of advancing [cold fronts](#).

Squall lines often destructive



Storms in a row

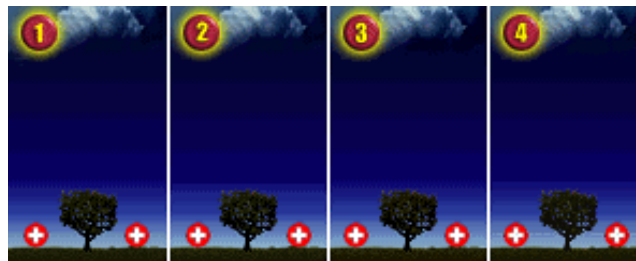
Advancing cold air plows humid air upward, forming numerous thunderstorms in a long, narrow line.

Damaging winds

Falling rain, snow evaporate, cooling the air. Cool, heavy air plunges, blasting the ground with high winds.

Anatomy of Lightning Stroke

- **Lightning** is the key ingredient that defines a thunderstorms since lightning is needed to create thunder.



1

Stepped leader
Electrons, which have negative charge, begin zigzagging downward.

2

Attraction
As the stepped leader nears the ground, it draws a streamer of positive charge upward.

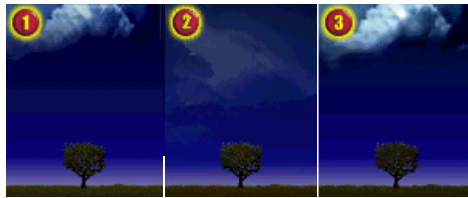
3

Flowing charge
As the leader and the streamer come together, powerful electric current begins flowing.

4

Contact!
Intense wave of positive charge, a "return stroke," travels upward at 60,000 miles per second.

Different forms of Lightning Flashes



Forked lightning

Crooked lightning bolts discharge from cloud-to-ground or cloud-to-air.

Sheet lightning

Clouds, rain block forked lightning bolt, but flash illuminates clouds.

Ball lightning

On rare occasions, small glowing balls leap from clouds, but quickly vanish.

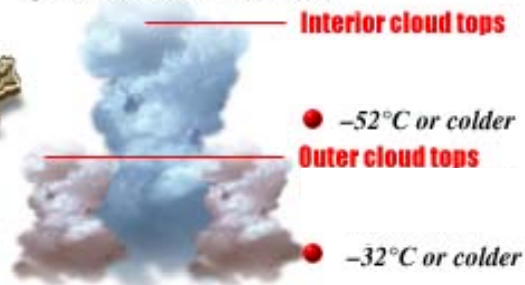
- peak current of a average lightning stroke = 30,000 amps.
- Extreme lightning discharges can reach 300,000 amps & 200 million volts.
- Ball lightning seems to be the one exception. Extremely rare, which is usually described as a floating sphere, often about the size of a basketball.
- Ball lightning is not known to have ever killed or injured anyone, but has caused minor damage. The origins of ball lightning continue to elude scientists.

Mesoscale convective complexes

Scattered afternoon thunderstorms merge into larger storm area.



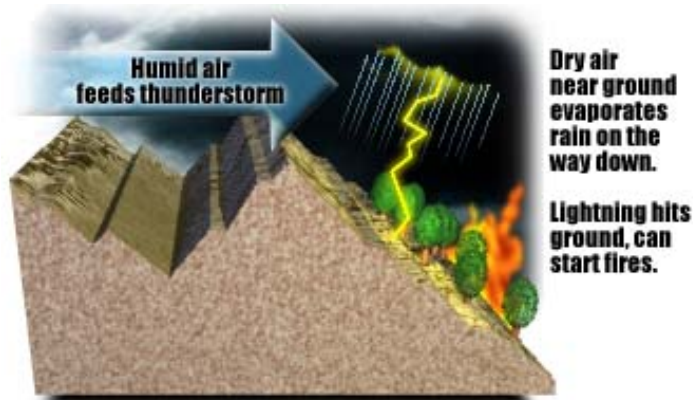
Cross section of storm area



- If conditions are favorable, the isolated thunderstorms merge and form large clusters of thunderstorms, known as “**Mesoscale convective complexes**”.

Dry thunderstorms bring lightning, spark wildfires

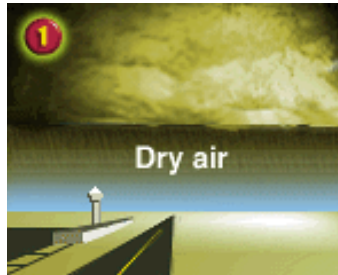
- [Dry thunderstorms](#) form high above the ground with a large layer of very dry air, between the base of the cloud and the ground. As rain falls from the cloud into the dry air, the rain drops [evaporate](#) before they reach the ground.



Downdrafts or Downbursts

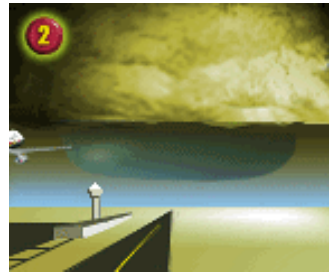
- *Downdrafts* in severe thunderstorms can create gusty winds with speeds that have been recorded as high as 160 mph.
- Downburst winds can smash buildings and easily uproot trees and are often mistaken for *tornadoes*.
- If the downburst is concentrated in an area **less than 2.5 miles** in diameter, it is called a *microburst*.
- In addition to damaging buildings and blowing down trees, microbursts blasting down to the ground are a major *aviation hazard* and have caused several crashes.
- Today, pilots are trained in how to avoid microbursts and special [Doppler radars](#) to detect them are being installed at airports.

Microbursts can cause plane crashes



Air cools rapidly

Dry air enters thunderstorm and is cooled by rain, forming a chunk of very cool air.



Microburst forms

Cool air plunges downward and has caused planes to crash.

Thunderstorm Flight Dangers



Tornadoes



- Tornado defines as "a violently rotating column of air in contact with the ground and pendant from a thunderstorm."
- In other words, a thunderstorm is the first step in the creation of a tornado. Then, if other conditions are right, the thunderstorm might spin out one or more tornado
- Tornadoes are the most violent storms on Earth. Winds spiraling into them usually exceed 100 mph and can reach speeds of 300 mph
- Tornadoes form in within a thunderstorm's updraft.
- A tornado's strength is rated after it hits, unlike a hurricane whose intensity is rated before it strikes land. A team of meteorologists and engineers survey the damage path, measuring track length and width, and study the most severe damage to estimate tornado winds. These factors will determine its ranking on the ***Fujita tornado intensity scale***.

A close-up view of Tornadoes



1 Rapid air movement

Tornado acts like a giant vacuum cleaner, sucking in air near the ground.

2 Spiraling winds

Storm's rotation twists tornado's winds. Dust and debris darken the base of funnel.

3 An ominous sign

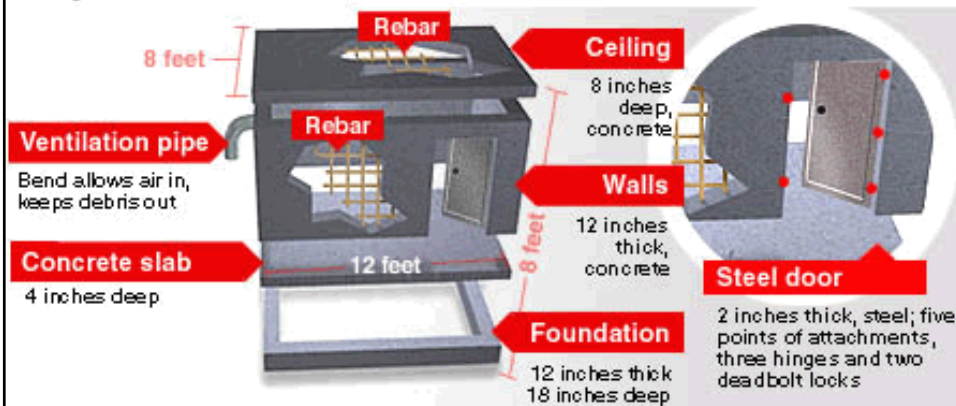
Large hail often falls near tornadoes.

Tornadoes - Fujita Scale

- Forecasters and researchers use a wind damage scale created by **T. Theodore Fujita** to classify tornadoes.
- In this six-tiered Scale Tornadoes are ranked by the damage they do.
- **F0** and **F1** tornadoes on the scale are considered "weak" and cause minimal to moderate damage with winds from 40-112 mph.
- **F2** and **F3** tornadoes are considered strong, packing winds of 113-206 mph that can cause major to severe damage.
- Violent tornadoes are those classified **F4** and **F5** with winds exceeding 206 mph. Damage is extreme to catastrophic.

Shelter in a storm

These tornado shelters have survived F5 tornadoes and are built in accordance with government standards.



Supercells are the ultimate in storms

The largest, strongest and longest-lasting thunderstorms have named as "supercells."

They are capable of producing tornadoes, large hail, dangerous bursts of wind or flash floods as well as lightning, which is a danger in all thunderstorms.

How Supercell storms bring hazards



1 Mesocyclones

Rotating winds inside the storm add strength.



2 Tornadoes

Most killer tornadoes come from supercells.



3 Hail

Large hailstones can break windows, destroy crops.



4 Wind

Downbursts of wind can exceed 100 mph.

What makes a Storm a Hurricane

- ❖ The seven main characteristics that define a tropical cyclone, including a hurricane, are:
 - Hurricanes have no fronts.
 - Hurricane winds weaken with height
 - The centers of hurricanes are warmer than their surroundings
 - Hurricanes and tropical systems form under weak high-altitude winds.
 - Air sinks at the center of a hurricane
 - Hurricanes' main energy source is the latent heat of condensation
 - Hurricanes weaken rapidly over land

Evolution of a hurricane

☐Hurricanes

➤ Hurricanes are tropical cyclones in the Atlantic Basin (Atlantic, Caribbean Sea and Gulf of Mexico) and in the *Pacific east of the International Date Line*.

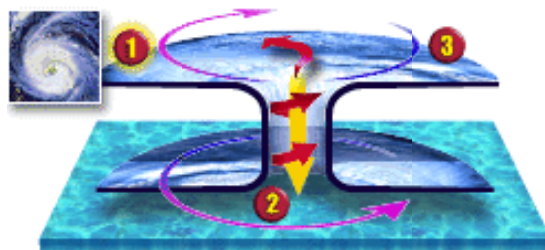
☐Typhoons

➤ Typhoons are tropical cyclones over the *northern Pacific west of the date line*.

☐ Tropical cyclones

➤ Tropical cyclones in the *South Pacific and over the Indian Ocean* are just called cyclones.

A typical Northern Hemisphere hurricane



1 Sinking Air

Air sinking inside eye inhibits clouds and rain.

2 Wind at wall surface

Maximum wind found in eye wall at surface.

3 Wind direction

Winds weaken with height and air spirals outward clockwise at high altitudes.

Hurricane Hunters

- People flying in to the Hurricane are known as “*Hurricane Hunters*”.
- The purpose of flying into the storm is to collect data that helps forecasters, and scientists.
- Hunters Fly into a storm from the outer edge all of the way to the eye at the storm's center and out the other side.
- Today, U.S. Air Force 53rd Weather Reconnaissance Squadron uses WC-130 turboprops for this purpose.

Hurricane Hunter - C130 HURCULES



**Photographs within Hurricanes taken
by Hurricane Hunters**



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by Hurricane Hunters**



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Hurricane "LILI" in 2002.



Satellite photograph

How and why storms are named

- Forecasters give names to tropical cyclones, including hurricanes, to avoid confusion when more than one storm is being followed at the same time.
- One can think that a forecaster will tag a storm with his ex-wife's name, or the name of a neighbor he dislikes.
- But the naming system is much more formal. (Organized naming began in 1950).
- A storm is named when it reaches tropical storm strength with winds of **39mph**, and becomes a hurricane or typhoon when its wind speed reaches **74 mph**.

How today's names are selected

- The World Meteorological Organization's (WMO) Regional Association IV Hurricane Committee selects the names for Atlantic Basin and central and eastern Pacific storms.
- For the Atlantic Basin and the eastern Pacific, six lists of names are used, with each list used again - minus any retired names - six years after it was last used.
- The WMO's regional committee selects the names to replaces those that are retired.
- Similar WMO regional committees are involved in selecting names for other parts of the world.

HURRICANE PHOTOGRAPHS



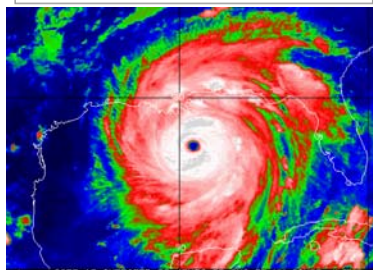
Hurricane Katrina

Duration:	Aug. 23 - 31, 2005
Highest winds:	175 mph (280 km/h)
Total damages (in USD):	\$25-120 billion (Likely to be the costliest Atlantic hurricane of all time)
Total fatalities:	1,014 direct, 577 indirect (with estimates of up to 10,000)
Areas affected:	Bahamas, South Florida, Louisiana (especially Greater New Orleans), Mississippi, Alabama, Florida Panhandle, most of eastern North America

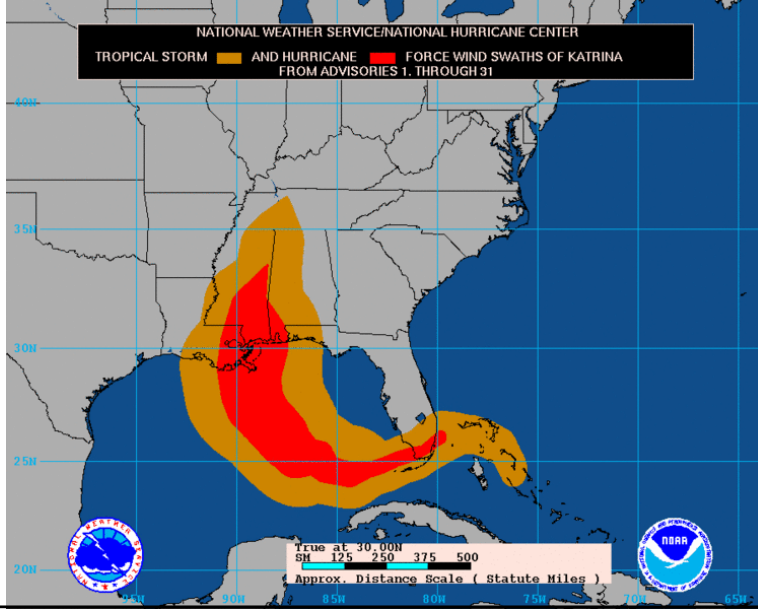
Eye of Hurricane Katrina seen from a NOAA Hurricane Hunter aircraft.

Image taken on [August 28, 2005](#), before the storm made landfall.

Hurricane Katrina with winds of 160 mph (255 km/h)



The path & size change of Hurricane Katrina





Hurricane Katrina

Aziz



Hurricane Katrina

Aziz



Hurricane Katrina

Aziz



Hurricane Katrina

Aziz



Hurricane Katrina

Asia

AP



Hurricane Katrina

Asia









Hurricane Katrina
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Hurricane Katrina

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Hurricane Katrina

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Hurricane Katrina
Aziz



Hurricane Katrina
Aziz

How To Minimize the Hazard from Thunderstorms

- If you can hear thunder, you are close enough to the storm to be struck by lightning. Go to safe shelter immediately. Find shelter in a building or car. Keep car windows closed.
- Unplug electrical appliances, avoid using the telephone or any electrical appliances. (Leaving electrical lights on, however, does not increase the chances of your home being struck by lightning.)
- Don't take a bath or shower.
- Turn off the air conditioner. Power surges from lightning can overload the compressor and damage the air conditioner!
- Draw blinds and shades over windows. If windows break due to objects being blown by the wind of a storm, then the shades will prevent glass from shattering into your home.

How To Minimize the Hazard from Thunderstorms

- If you are caught outside during a thunderstorm, you must act immediately:
 - If you are in the woods, take shelter under the shorter trees.
 - If you are boating or swimming, get to land and find shelter right away!
 - If you can go to a low-lying, open place away from trees, poles or metal objects. Make sure the place you pick is not subject to flooding.
 - Become a very small target! Squat low to the ground. Place your hands on your knees with your head between them. Make yourself the smallest target possible.
 - Do not lie flat on the ground - this will make you a larger target!

References

<http://www.usatoday.com/weather/stormcenter>

<http://www.answers.com/topic/hail>

<http://www.nhc.noaa.gov/refresh>

THANK YOU