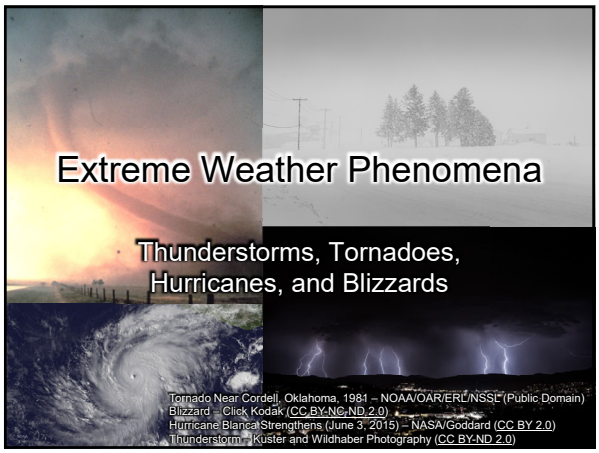


Tornado Near Cordell, Oklahoma, 1981 – NOAA/OAR/ERL/NSSL (Public Domain)
Blizzard – Click Kodak (CC BY-NC-ND 2.0)
Hurricane Blanca Strengthens (June 3, 2015) – NASA/Goddard (CC BY 2.0)
Thunderstorm – Kuster and Wildhaber Photography (CC BY-ND 2.0)

Description

- A thunderstorm is a rain shower during which you hear thunder.
- A thunderstorm is classified as “severe” when it contains one or more of the following
  - large hail (2 cm or more in diameter)
  - winds gusts 90 km/h or greater
  - heavy rain (50 mm or more per hour)

https://youtu.be/zUNEFefftt8

https://youtu.be/h-0qNl5f4BU

Requirements

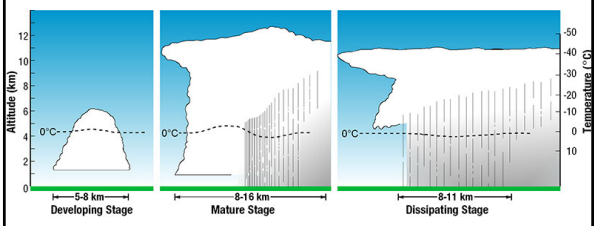
- Three basic ingredients are required for a thunderstorm to form
  - moisture
    - humidity
  - rising unstable air
    - air that keeps rising when given a nudge
  - a lifting mechanism to provide the “nudge”
    - typically a cold front

Process

- The sun heats the surface of the earth, which warms the air above it.
- If this warm surface air is forced to rise, it will continue to rise as long as it weighs less and stays warmer than the air around it.
- As the air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (convection).

- The water vapor it contains begins to cool, releases the heat, condenses and forms a cloud.
- When the water vapor condenses, it releases heat warming the air causing it to rise further.
- This process repeats until there is not enough heat energy left to warm the air.
- The cloud eventually grows upward into areas where the temperature is below freezing.

- Thunderstorms have three stages in their life cycle
  - Cumulus (Developing) stage
  - Mature stage
  - Dissipating stage

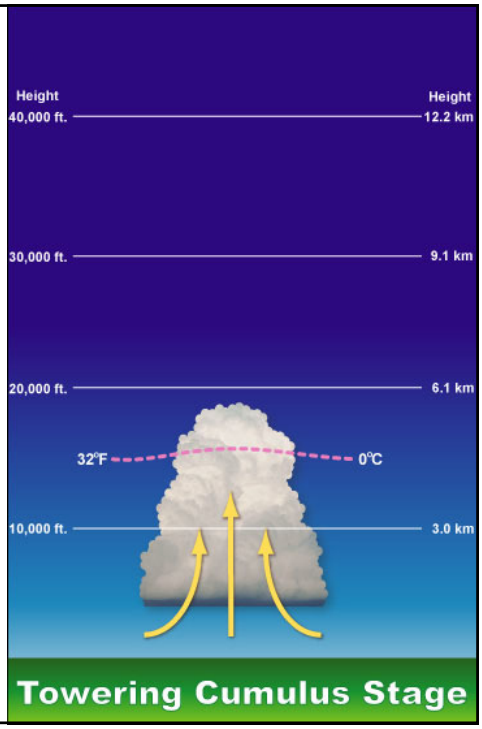


Credit: National Severe Storms Laboratory/NOAA

Cumulus (Developing) stage

- A **cumulus cloud is pushed upward** by a rising column of air (updraft).
  - The cumulus cloud soon looks like a tower.
- The updraft continues to get stronger.
- There is little to no rain during this stage but occasional lightning.

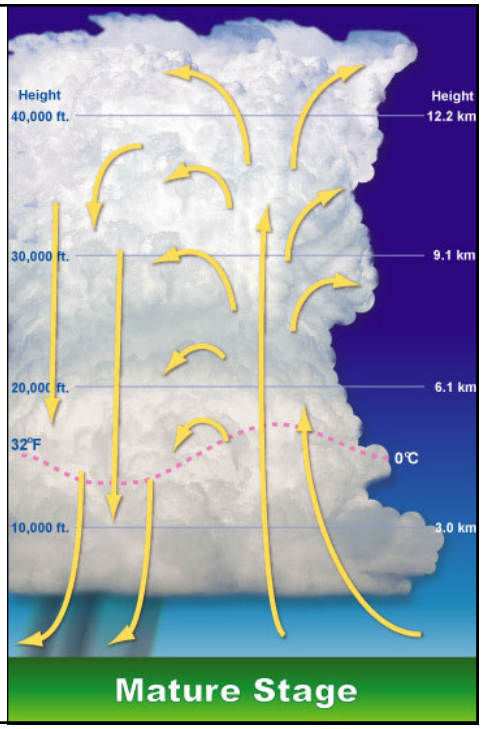
Credit: NOAA



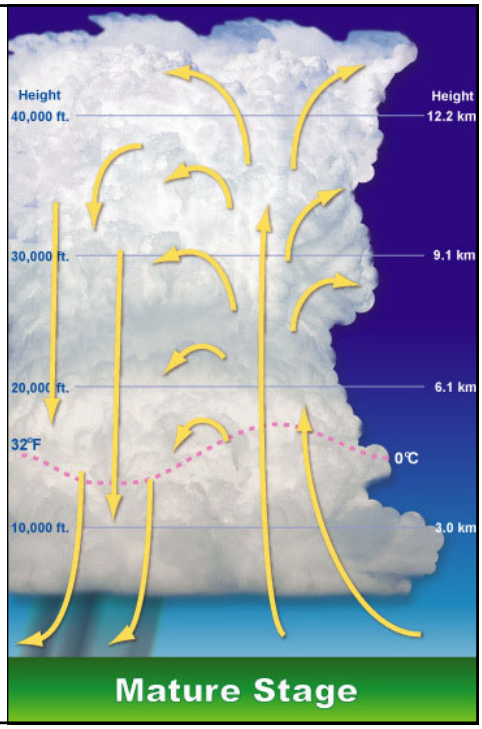
Mature stage

- The **updraft continues to feed the storm.**
- Condensing water near the top of the storm forms ice particles that grow.
  - Eventually the ice particles are too heavy and start to fall.
  - If they melt before hitting the ground it is rain, if not, it is hail.

Credit: NOAA



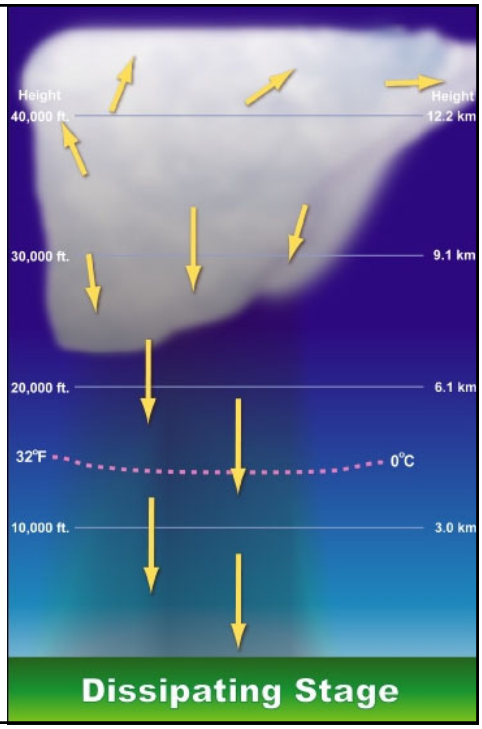
- **Precipitation begins to fall out of the storm**, creating a **downdraft** (a column of air pushing downward).
- The downdraft and rain-cooled air spreads out along the ground and forms a line of gusty winds.
- This stage is the most likely time for hail, heavy rain, frequent lightning, strong winds, and tornadoes.



Credit: NOAA

Dissipating stage

- The **updraft is overcome by the downdraft**.
- The cooler wind cuts off the warm moist air that was feeding the thunderstorm.
- Rainfall decreases in intensity, but lightning remains a danger.

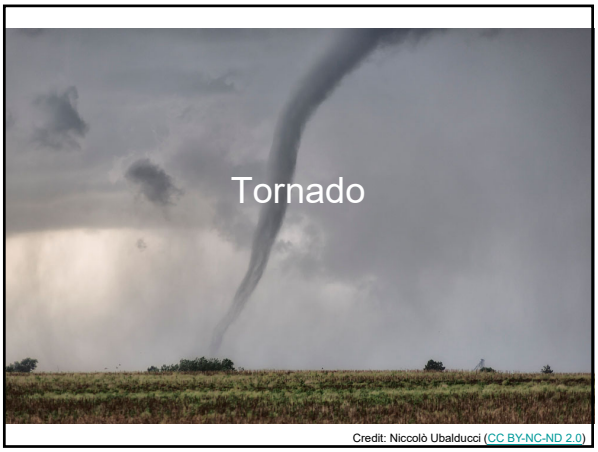


Credit: NOAA

Safety

- At Your House
  - Go to a secure location away from windows.
    - Take your pets with you if time allows.
- At Your Workplace or School
  - Stay away from windows.
  - Do not go to large open rooms such as cafeterias, gymnasiums or auditoriums.

- Outside
  - Go inside a sturdy building immediately.
    - Sheds and storage facilities are not safe.
  - Taking shelter under a tree can be deadly.
    - The tree may fall on you.
    - Standing under a tree also put you at a greater risk of getting struck by lightning.
- In a Vehicle
  - Being in a vehicle is safer than being outside; however, drive to closest secure shelter if there is sufficient time.



Description

- A tornado is a narrow, violently rotating column of air that extends from a thunderstorm to the ground.
- Winds spiraling into a tornado can vary from 60 km/h to as high as 500 km/h.
- Tornadoes are the most violent storms on Earth.

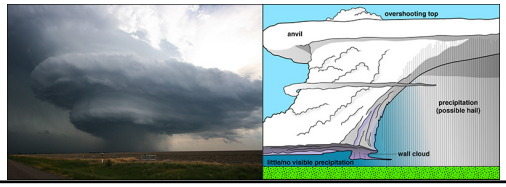
https://youtu.be/MJJG3-MVz1U

How do tornadoes form?

- The truth is that we don't fully understand.
- The most destructive tornadoes occur from supercells, which are rotating thunderstorms with a well-defined radar circulation called a mesocyclone.

What is a supercell?

- A supercell is an often-dangerous thunderstorm with a very organized internal structure including a rotating updraft that allows it to keep going for up to several hours.

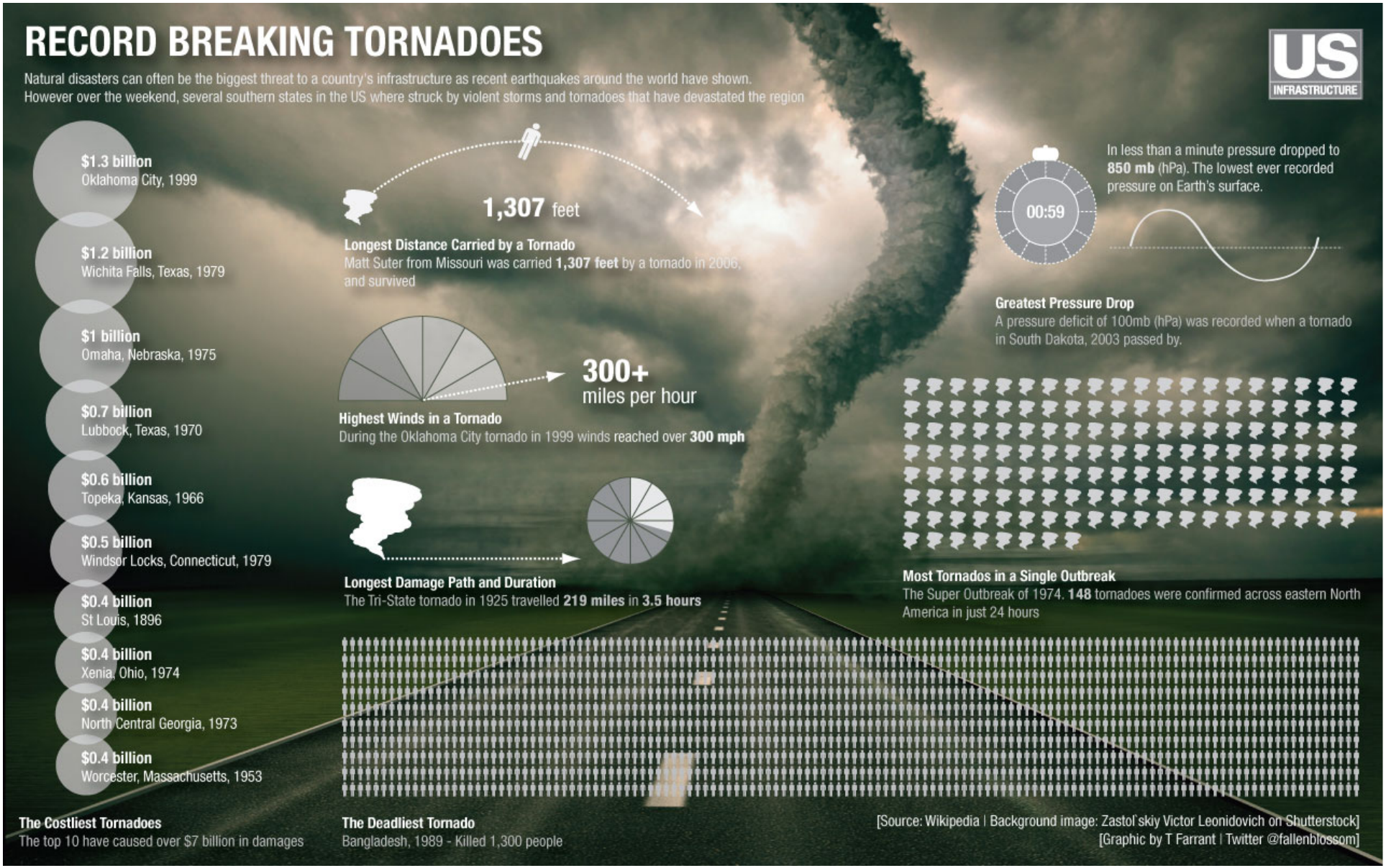


Credit: NOAA

Intensity of Tornadoes

- The Enhanced Fujita Scale is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure.
- Wind speeds are estimated from damage to structures based on the degree of damage to 28 damage indicators.

	Estimated Wind Speed	Typical Observations
EF-0	65-85 mph	Light damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF-1	86-110 mph	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF-2	111-135 mph	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF-3	136-165 mph	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF-4	166-200 mph	Devastating damage. Whole frame houses Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF-5	Over 200 mph	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m; high-rise buildings have significant structural deformation; incredible phenomena will occur.



Record Breaking Tornadoes
Credit: Tiffany Farrant/GDS Infographics (CC BY 2.0)

Greatest Storms on Earth

https://youtu.be/uH9A-7Y3lL0

Safety

- At Your House
  - Go to your basement, safe room, or an interior room away from windows.
    - Don't forget pets if time allows.
- At Your Workplace or School
  - Proceed to your tornado shelter location quickly and calmly.
  - Stay away from windows and do not go to large open rooms such as cafeterias, gymnasiums, or auditoriums.

- Outside
  - Seek shelter inside a sturdy building immediately if a tornado is approaching.
    - Sheds and storage facilities are not safe.
    - Neither is a mobile home or tent.
  - If you have time, get to a safe building.
- In a vehicle
  - Being in a vehicle during a tornado is not safe. The best course of action is to drive to the closest shelter.
    - If you are unable to make it to a safe shelter, either get down in your car and cover your head, or abandon your car and seek shelter in a low lying area such as a ditch or ravine.

Hurricane Matthew Hits Haiti (October 4, 2016)
Credit: NASA Goddard Space Flight Center (CC BY 2.0)

Description

- A hurricane is a type of storm called a tropical cyclone, which forms over tropical or subtropical waters.
- A tropical cyclone is a rotating low-pressure weather system that has organized thunderstorms but no fronts (a boundary separating two air masses of different densities).

Credit: NOAA

Classification

- Tropical disturbance, tropical wave
  - Unorganized mass of thunderstorms, very little, if any, organized wind circulation.
- Tropical depression
  - Has evidence of closed wind circulation around a center with sustained winds from 20-34 knots (23-39 mph).
- Tropical storm
  - Maximum sustained winds are from 35-64 knots (40-74 mph)
- Hurricane
  - Maximum sustained winds exceed 64 knots (74 mph).

Hurricane Katrina Day by Day – National Geographic

https://youtu.be/HbJaMWw4-2Q

Blizzard

Blizzard Beauty
Credit: marcel lemieux (CC BY-NC 2.0)

Blizzard

- Usually formed when the jet stream dips far to the south, allowing cold air from the north to clash with warm air from the south.
- It's a blizzard if…
  - heavy falling or blowing snow
  - winds 40 km/h or more
  - visibility reduced to less than 400 m
  - for at least 4 hours

Safety

- Stay indoors and wait until it ends
- If you must go outside, dress properly to stay warm. Tie one end of a long rope to your door and hold onto the other end to avoid getting lost in the blinding snow.
- If you must travel during a winter storm, do so during the day and let someone know your route and arrival time.

- If your car gets stuck in a blizzard or snowstorm, stay in your car.
  - Allow fresh air in your car by opening the window slightly on the sheltered side – away from the wind.
  - You can run the car engine about 10 minutes every half-hour if the exhaust system is not blocked with snow.
    - Check the exhaust pipe periodically to make sure it is not blocked. Remember: you can't smell potentially fatal carbon monoxide fumes.

- To keep your hands and feet warm, exercise them periodically.
- In general, it is a good idea to keep moving to avoid falling asleep.
- If you do try to shovel the snow from around your car, avoid overexerting yourself.
  - Overexertion in the bitter cold can cause death as a result of hypothermia from sweating or a heart attack.