Features Indicating Strong/Severe Storms

Anvil: The anvil is the elongated cloud at the top of the storm that spreads downwind with upper level steering winds. The anvil will appear solid, not wispy, and will have sharp, well defined edges.

Overshooting Top: The overshooting top is the dome of cloud directly above the main storm updraft tower and the anvil. If the overshooting top is persistent and lasts for 10 minutes or longer, it is generally a sign of a very strong thunderstorm updraft.

Shown is a severe thunderstorm in the distance with a visible thick anvil and large overshooting top. Photo by Gene Rhoden.

Main Storm Tower: The "trunk" of the storm is the visible updraft of the storm from its base near the ground to just below the anvil. This part of the storm can show:

- Vertically oriented tower, with sharp, well defined edges
- Solid, cauliflower appearance
- Visible rotation of the middle and lower levels, and possibly striations evident in the clouds

Rain-free Base: The area below the main storm tower. It is generally on the south or southwestern flank of a storm.

Wall Cloud: A wall cloud is an isolated lower cloud attached to the rain-free base and below the main storm tower. Wall clouds often are on the trailing side of a storm. For example, with a storm that is moving to the north or northeast, the wall cloud typically is on the south or southwest side of the storm. With some storms, the wall cloud area may be obscured by precipitation. Wall clouds associated with potentially severe storms:

- Usually persist for 10 minutes or more
- Often, but not always, rotate visibly
- Sometimes are accompanied by obvious rising or sinking motion of cloud piece

Wall cloud and rain free base. Photo by Brian Morganti.

Wall cloud with the rain free base and heavy rain behind the wall cloud. Photo by Roger Hill.

Flanking Line: A flanking line is a row of towering cumulus clouds stair-stepping up to the main storm tower. New storm cells can develop from the flanking line, which usually extends south or southwest of a thunderstorm.

The flanking line of a thunderstorm. Photo by Matt Ziebell.

Shelf Cloud: A shelf cloud is a low, horizontal, banded cloud attached to the base of the parent cloud, usually a thunderstorm. Rising cloud motion often can be seen in the leading, outer part of the shelf cloud, while the underside often appears turbulent and wind-torn. Generally, a shelf cloud appears on the leading edge of a storm.

Shelf cloud in Illinois. Photo by Walker Ashley.

Roll Cloud: A roll cloud is low, horizontal, tube-shaped and relatively rare. It differs from a shelf cloud by being completely detached from other cloud features.

Severe/Strong Storm Features Checklist

Upper-level storm features visible at long distances from the storm:

- A solid-looking overshooting top persisting for 10 minutes or more
- Overshooting tops that may dissipate, followed by new ones
- A solid-looking anvil with sharply defined edges

Why? An overshooting top is a signal of a strong updraft. If the top persists for at least 10 minutes, it is a sign that the storm is continuing to strengthen. If the overshooting top suddenly collapses, a burst of precipitation, hail, or damaging wind may be imminent. As the storm weakens, it will take on a wispier, fuzzy appearance.

Severe/strong thunderstorm in the distance. Note the overshooting top, sharply defined edges of the anvil, and the flanking line. Photo by Brian Morganti.

Mid-level storm features that may be seen are:

- Solid or hard-looking storm tower with a cauliflower appearance
- Flanking line, with clouds building toward the main storm tower

Looking northeast into a thunderstorm with the flanking line pointing south southwest. Photo by Tom Warner.

Why? A solid-looking storm tower indicates a strong updraft along with a favorable shear environment. A flanking line indicates the storm is drawing air from many miles away and likely will sustain itself or intensify for some time.

Low-level storm features can be seen when you are close to a storm:

- Rain-free cloud base with a large and solid-looking storm tower above
- Wall cloud persisting for 10 minutes or longer, especially if it is obviously rotating
- Rapid vertical motion (up or down) within the wall cloud or other areas of the rain-free cloud base

Why? A rain-free cloud base indicates a strong updraft, where precipitation and hail is not heavy enough to fall to the ground. When a rotating wall cloud is present, there is a much higher potential for tornado development. Wall clouds begin to rotate as the larger scale circulation, or mesocyclone, 2-10 miles in diameter, develops toward the surface. When combined with the proper atmospheric conditions, this pattern supports tornadoes.

Lower level storm features, including the updraft and downdraft area. Photo by Jim LaDue.

Supercell Variations

All supercells contain storm-scale rotation, which may give a striated or corkscrew appearance to the storm's updraft. One supercell may appear quite different visually from another, depending on the following:

- The amount of precipitation accompanying the storm
- Whether precipitation falls near or far from the updraft

How a storm moves influences the winds that it "feels," much like sticking your hand out a car window as you turn and change speeds. Winds around the storm play an important role in where precipitation exists in and around the storm's updraft.

Based on their visual appearance, supercells are often labeled as:

- Low precipitation
- Classic
- High precipitation

Classic Supercell thunderstorm. Photo by Roger Hill.

Low Precipitation Supercell (LP)

- Barber pole or corkscrew appearance is possible.
- Precipitation is sparse or well removed from the updraft below cloud base, which often is transparent.
- Large hail is often difficult to discern visually. Although precipitation may not be apparent below the storm, sometimes very large hail is falling that can not be seen at a distance.

Low Precipitation Supercell. Photo by Roger Edwards.

Artist rendition of a Low Precipitation Supercell.

Classic (CL) Supercell

- Majority of supercells in this category
- Large, flat rain-free base
- Can have wall cloud
- Barber pole or corkscrew appearance of updraft possible, as in LP supercell
- Heavy precipitation falls adjacent to the updraft
- Large hail possible
- Potential for strong, long-track tornadoes

Classic Supercell. Photo by Bill Martin.

Artist rendition of a Classic Supercell.

High Precipitation (HP) Supercell

- Precipitation often surrounds updraft, and may hide it
- Can have a wall cloud, but it may be obscured by the heavy precipitation
- RFD filled with precipitation
- May have an associated shelf cloud

High Precipitation Supercell. Photo by Al Moller.

Artist rendition of High Precipitation Supercell.

- Tornadoes potentially obscured by heavy precipitation (rain-wrapped)
- Extremely heavy precipitation with flash flooding

Visual Clues of Supercells

- Rotating wall cloud suggests the presence of a rotating updraft
- Striations on the sides of the storm, streaks of cloud or bands of cloud that give the storm a corkscrew or barber pole appearance, indicate the storm's updraft is rotating, generally seen with Low Precipitation or Classic Supercells
- Inflow cloud bands, such as a "beaver's tail," feed into the storm. The beaver's tail is a smooth, nearly flat cloud band extending out from the eastern edge of the rain-free base toward the east.

Inflow band. The smooth, flat cloud on the lower right side is often referred to as a beaver's tail. Photo by Roger Edwards.

Estimating Wind Speed: It's often difficult to estimate wind speed, especially in the plains where there are few physical indicators to observe damage. Below is the Beaufort Wind Force Scale for estimating wind speeds. This is only a rough guide. Actual damage may occur at weaker or stronger speeds.

Wind Speed (mph)	Effects
25-31	Large branches in motion
32-38	Whole trees in motion
39-54	Twigs break off trees, wind impedes walking
55-72	Damage to TV antennas, large branches break off trees
73-112	Surfaces off roofs peeled off, windows broken, trailer homes overturned
113+	Roofs blown from houses, weak buildings and trailer homes destroyed, large trees uprooted, train cars blown off tracks

Town near Desoto, MO, hit by thunderstorms that produced 20 to 30 minutes of severe winds estimated to be between 80 and 100 mph, May 6, 2003. Photo from NOAA.

Spotting Downbursts

There are several visual signs that a downburst is either underway or about to occur.

Virga: Precipitation streaks from the cloud, but does not reach the ground. The atmosphere below the clouds tends to be very dry and rainfall evaporates before it touches the ground. Gusty winds occur in the area of the virga.

Virga with a dry microburst. Photo by Brian Morganti.

Rain foot: The rain foot is a pronounced outward bend of the precipitation area near the ground, marking an area of strong outflow winds.

Wet downburst with rain foot on the left of rain shaft area. Photo by Brian Morganti.

A wet microburst. Photo by Jim LaDue.

Dust foot: A plume of dust/dirt that is raised as the downburst reaches the ground and moves away from the impact point.

Dust foot/microburst. Photo by Brian Morganti.

Tornado Formation

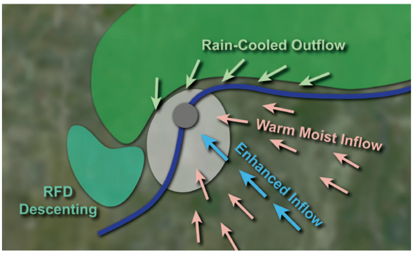
Tornadoes are one of nature's most fearsome creations. Each year they constitute a major hazard around the United States. Storm spotters can help to increase warning lead time by recognizing and reporting clues associated with tornado development and the various stages of the tornado life cycle. This section describes the typically observed features before tornado formation, during the life of the tornado, and as the tornado dissipates.

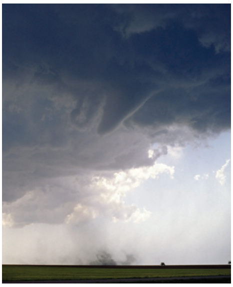
Visual Clues of Tornado Formation

- Large, rounded rain-free base. This can indicate the presence of a mesocyclone.
- Increasing spin in wall cloud and cloud base around wall cloud. This can suggest that the low level rotation is increasing.
- Clearing skies working into the rain-free base, which suggests a part of the rear-flank downdraft is wrapping around the mesocyclone. This often precedes or accompanies tornado formation in supercell thunderstorms.
- Rapid vertical motions, scud (see p. 49), rising into wall cloud, sinking motion around wall cloud from rear-flank downdraft.
- Local burst of heavy rain/hail just west or southwest of wall cloud. Occasionally, this is a precursor to a tornado.

A tornado may form within a few minutes of these clues appearing! In other cases, outflow behind the gust front can spread out from storm and cut off the formation process. Not all of the signs listed above are required for tornado development; however, storms exhibiting most or all of these features have better odds of producing a tornado.

Developing Stage

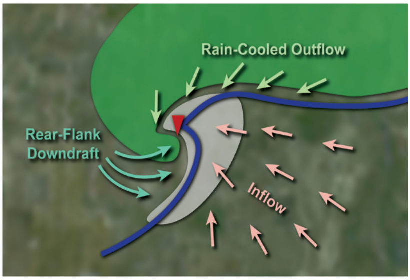




Incipient and early-stage tornadoes. Views to the west or northwest. Note visual clues of rotation, clear slots around edges of wall clouds, and developing condensation funnels. Photos by Joel Genung, Scott Blair, Roger Edwards.

- Tornado circulations can develop from either the ground upward or from the middle and low levels downward.
- Rear-flank downdraft and precipitation southwest of a wall cloud may signal processes that help establish a tornado.
- Some circulations start in low levels, near the cloud base, with rapid accelerations of cloud material into an area of tightening rotation.
- Watch closely! The first sign of tornado development may be a dust whirl at the ground. If seen, closely examine this whirl to see if it is connected to the cloud base.

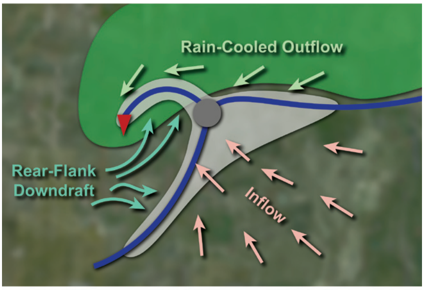
Mature Stage



Mature tornadoes. Views to north and northwest. Note near-vertical orientation of condensation funnels and clear slots advancing around wall clouds. Photos by Scott Blair, Roger Edwards, Robert Prentice.

- Potentially the strongest and most dangerous stage of the tornado’s lifetime.
- Funnel often has a near-vertical orientation.
- Visible funnel may not extend all the way to the ground, or may become hidden inside the wrapping precipitation!
- Often, rear-flank downdraft wraps around south and east side of the wall cloud gradually cutting off original inflow air.
- Rain-free base may take on a horseshoe-shaped appearance. The tornado and wall cloud may be found at the north end of this structure.

Dissipating Stage



Dissipating or rope stage tornadoes. Note surface debris clouds or condensation on the ground, indicating continuation of damaging winds. Note also the tilted, contorted appearance of the condensation funnels. Photos by Chuck Doswell and Roger Edwards.

- Rear-flank downdraft wraps around tornado.
- The tornado is separating from the warm buoyant air that it needs for its survival.
- Tornado shrinks, tilts, and takes on a contorted snakelike appearance before finally dissipating. Sometimes this is referred to as the rope stage.
- Although the tornado is not as large as it was in the mature stage, it can still be dangerous.

Cyclic Supercells

Cyclic supercell, view to northeast toward Stockton, KS, June 9, 2005. Note old tornado and clear slot in left foreground and new tornado in right background. Photo by Scott Blair.

Simultaneous tornadoes from two different mesocyclones, looking west: left, fully condensed, late-stage tornado from older mesocyclone; right, tornado without condensation into the debris cloud becoming better organized in newer mesocyclone, Zurich, KS, June 9, 2005 . Photo by Chuck Doswell.

- With some supercells, inflow may be refocused a few miles east of the dissipating tornado.
- If the environment is favorable, a new mesocyclone and wall cloud will form.
- The new mesocyclone and wall cloud will become the dominant part of the storm, and a new tornado may form.
- For safety, check overhead often when near the inflow region of a supercell.

Tornado Variations in Appearance

Tornadoes can come in various shapes and sizes. Below are some pictures of the various types that may be encountered.

Pencil-shaped tornado about the time of F5 damage near Union City, OK, May 24,1973. Photo by Chuck Doswell.

Cone-shaped tornado with debris fan south of Hill City, KS, looking west, June 9, 2005. Photo by Elke Edwards.

"Wedge" tornado, where the visible funnel is wider than the distance from ground to surrounding cloud base, looking northwest near Argonia, KS, May 29, 2004. Photo by Robert Prentice.

Scorpion tail shape to roping tornado near Lake McClellan TX, May 20, 1999. Photo by Roger Edwards.

Deadly nighttime tornado near Westminster, TX, May 9, 2006. Photo by Eric Nguyen.

Bowl-shaped condensation funnel above well-developed tornado debris cloud near Aurora, NE, June 17, 2009. Photo by Roger Edwards.

Multi-Vortex tornadoes have two or more circulations or vortices orbiting about each other or around a common center.

Multi-vortex tornado near Glen Elder, KS, May 29, 2008. Photo by Scott Blair.

Rope tornadoes often signify a tornado that is weakening or dissipating. Still, such tornadoes can contain deadly and damaging ground circulations, whether visible or not.

Rope tornado near Saint Peter, KS, May 22, 2007, looking northeast. Photo by Roger Edwards.

Non-supercell tornadoes developing on leading part of a squall line, where an updraft base has not been undercut yet by outflow, taken near Fort Dodge, IA, June 11, 2004. Photo by Roger Edwards.

Non-Supercell Landspout tornadoes do not arise from organized storm-scale rotation, and therefore usually are not associated with a visible wall cloud or a radar-indicated mesocyclone. Typically, these tornadoes are observed beneath cumulus and towering cumulus clouds, often as no more than a dust whirl, and are the land-based equivalents of non-supercell waterspouts.

Non-supercell tornado or landspout from a single high-based thunderstorm in Colorado in 1988. Photo by David O. Blanchard.

Non-supercell tornado from a high-based thunderstorm near Venango, KS, in 1997. Photo by David O. Blanchard.

Non-supercell tornado from the base of a line of towering cumulus clouds near Kit Carson, CO, June 19, 2008. Photo by Roger Edwards.

A **waterspout** is a tornado over water. There are two types of waterspouts. The Type A waterspout forms in a supercell thunderstorm and is a violent and potentially destructive vortex that often moves quickly and is capable of significant structural damage if it moves over land.

The Type B waterspout is usually less violent, slower moving, and less destructive. Type B develops quickly beneath a rapidly building line of cumulus clouds. The winds near the base of a Type B waterspout can reach and exceed gale force (34 knots), which is strong enough to swamp or capsize a small watercraft. All waterspouts pose a threat to boater safety and should be avoided.

Tornado/Funnel Cloud Look-a-Likes: Several atmospheric and man-made features may be mistaken for tornadoes. Some of the most common are:

- Scud Clouds
- Rain Shafts
- Gustnadoes
- Tail clouds
- Smoke
- Communication Towers
- Grain Elevators
- Dust Devils

To distinguish between a real tornado or funnel and one of the above look-a-likes, study the feature and be able to answer the following questions:

1. Can I see it clearly?
2. Is the feature attached to a thunderstorm base?
3. Is the feature in the section of the storm where tornadoes/funnels typically develop, i.e., near the updraft?
4. Is there organized rotation present within the feature?
5. If it appears to be a tornado, is there debris?

If your answer to any of these questions is "no," then the feature likely is not a tornado. If you have doubts, continue to observe the feature. **Important: report only what you see, not what you think you see.**

Scud clouds near Julesburg, CO, June 1, 2008. Photo by Chuck Doswell.

Scud clouds are low cloud fragments that may attach to a storm's base and can strongly mimic the appearance of a ragged funnel. Some scud can rise from or near the ground leaving the impression of a tornado. Watch for persistent rotation of the suspicious feature to rule out scud.

Precipitation shaft from a high-based supercell near Wray, CO, July 1, 2005. Photo by Chuck Doswell.

Smoke being ingested into a wall cloud near Gotebo, OK, 1984. Photo by David O. Blanchard.

A **Dust Devil** is usually a small, rapidly rotating wind that is made visible by the dust, dirt or debris it picks up. Also called a whirlwind, it develops best on clear, dry, hot afternoons.

Examples of dust devils over the western United States in 1985 and 1986. Photos by David O. Blanchard.