Classic Anvil Shaped Thunderstorm

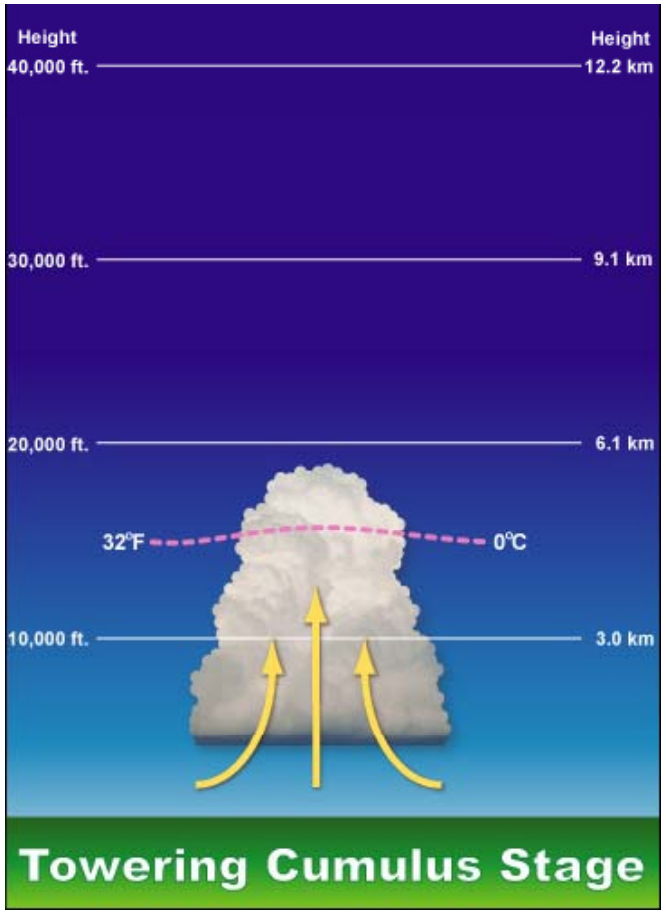
Many of the illustrations and explanations in this power point came from http://www.srh.weather.gov/jetstream/index.htm

Overshooting Top Indicates Strong Updrafts

Life Cycle of a Thunderstorm

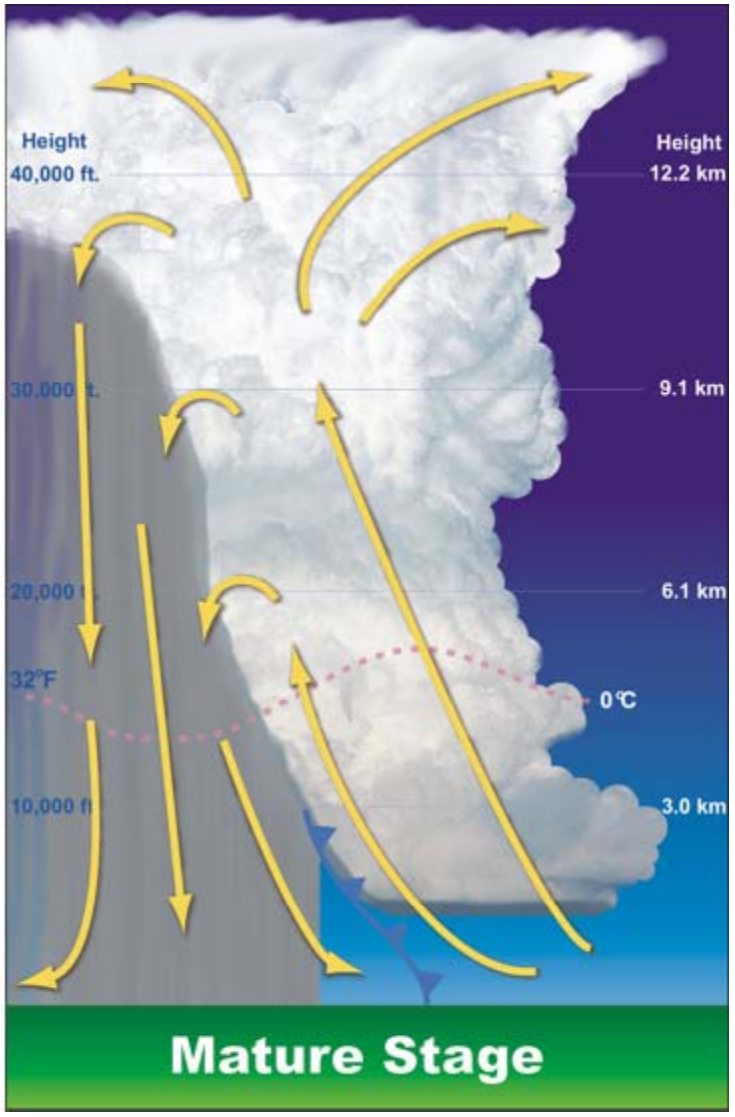
The Towering Cumulus Stage

A cumulus cloud begins to grow vertically, perhaps to a height of 20,000 feet (6 km). Air within the cloud is dominated by updraft with some turbulent eddies around the edges.



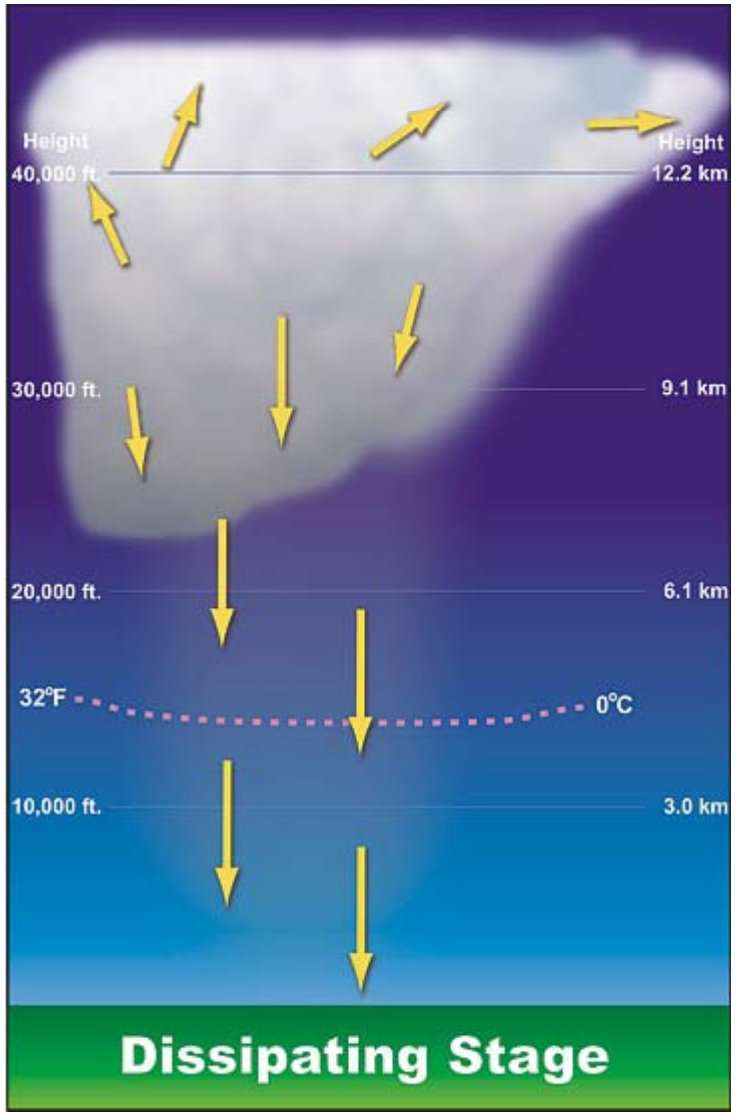
The Mature Cumulus Stage

The storm has considerable depth, often reaching 40,000 to 60,000 feet (12 to 18 km). Strong updrafts and downdrafts coexist. This is the most dangerous stage when large hail, damaging winds, and flash flooding may occur.



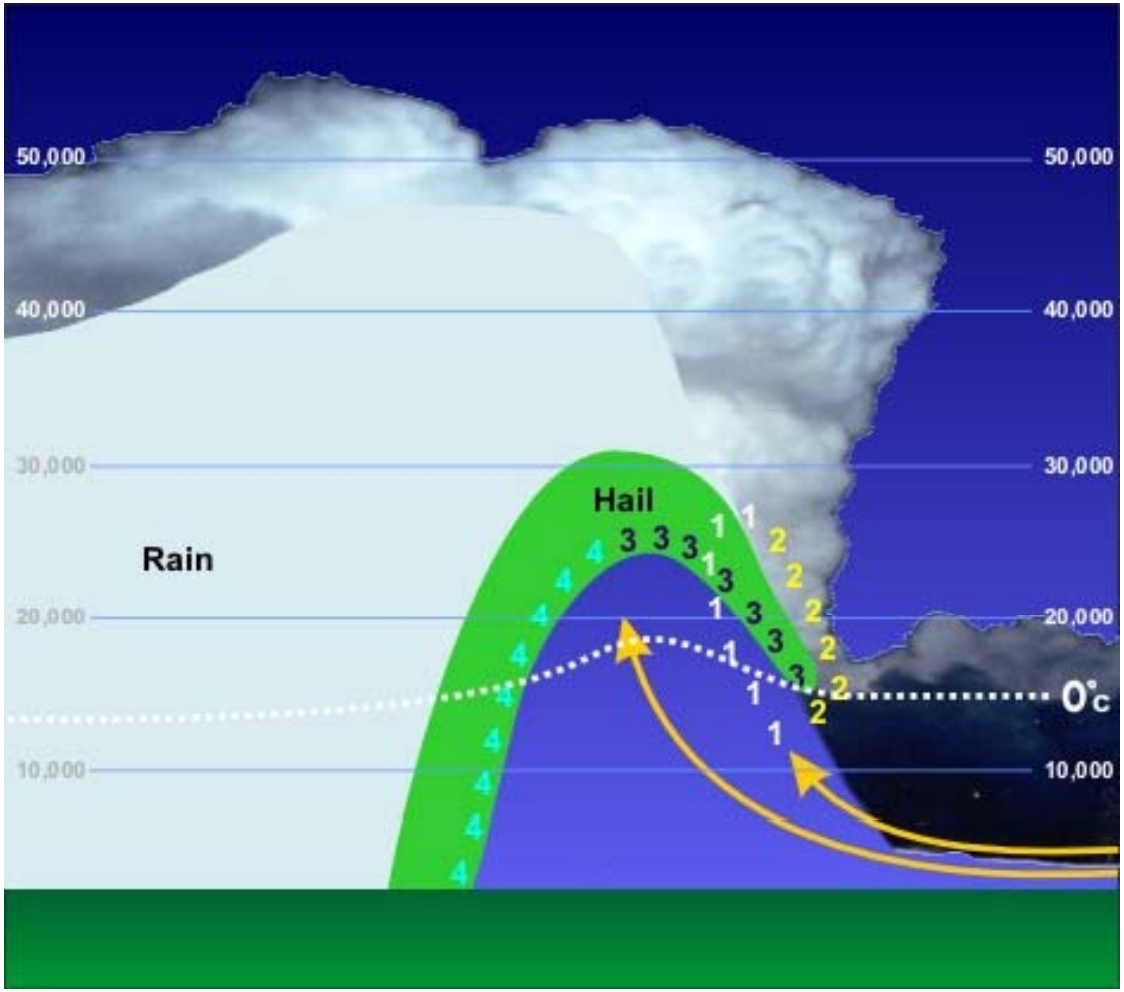
The Dissipating Stage

The downdraft cuts off the updraft. The storm no longer has a supply of warm moist air to maintain itself and therefore it dissipates. Light rain and weak outflow winds may remain for a while during this stage, before leaving behind just a remnant anvil top.



Strong updrafts create a rain-free area in supercell thunderstorms (above right). We call this area a WER which stands for "weak echo region".

This term, WER, comes from an apparently rain free region of a thunderstorm which is bounded on one side AND above by very intense precipitation indicted by a strong echo on radar.

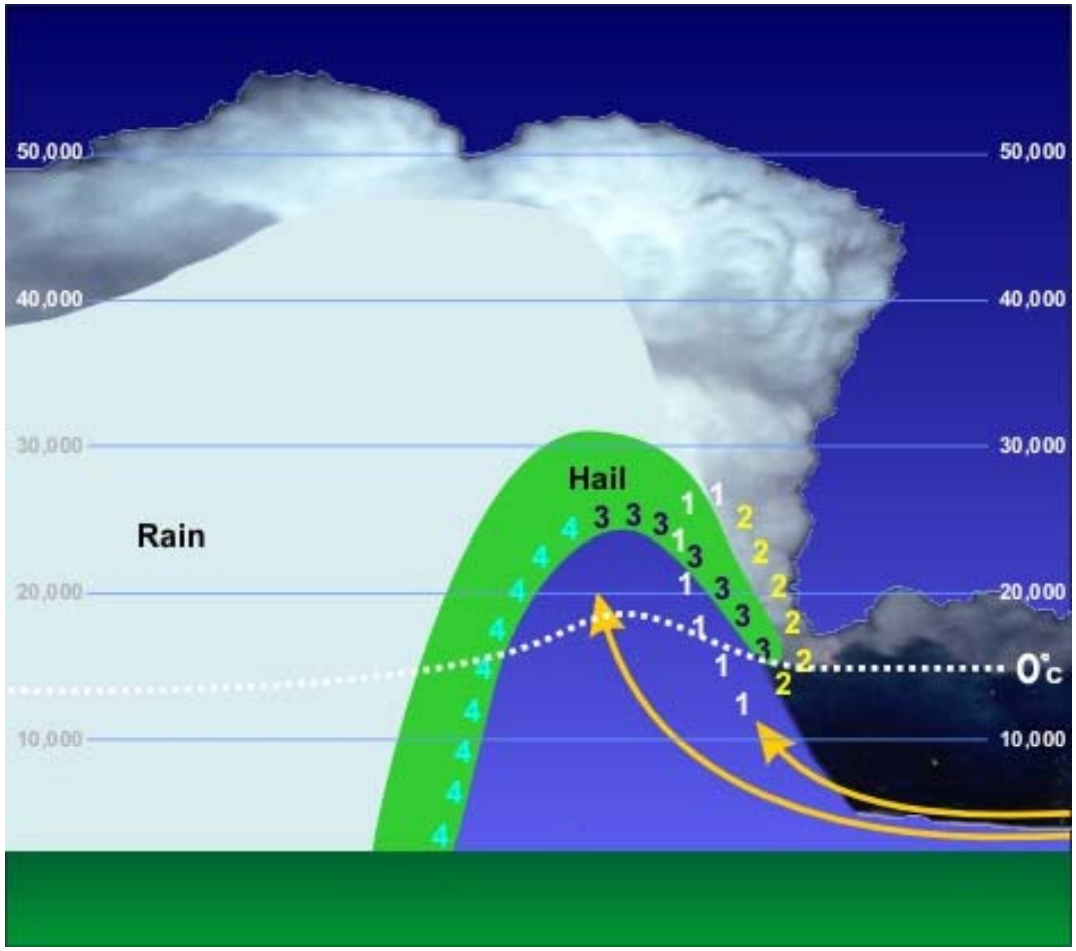


This rain-free region is produced by the updraft and is what suspends rain and hail aloft producing the strong radar echo. (right)
The hail nucleus, buoyed by the updraft is carried aloft by the updraft and begins to grow in size as it collides with supercooled raindrops and other small pieces of hail.

Sometimes the hailstone is blown out of the main updraft and begins to falls to the earth.

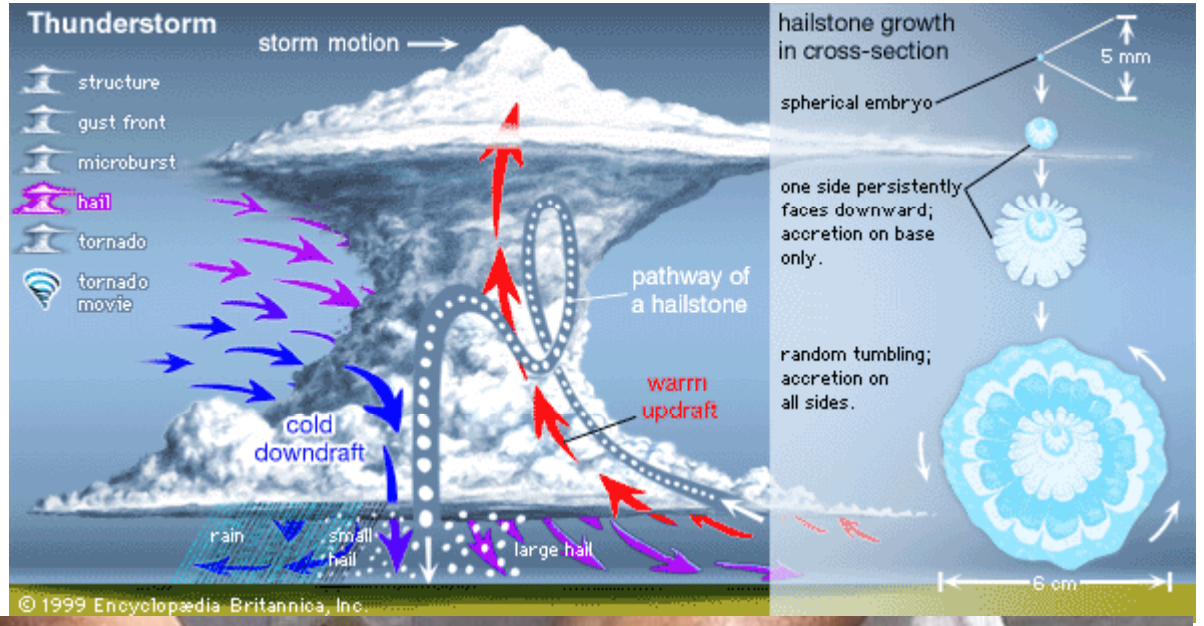
If the updraft is strong enough it will move the hailstone back into the cloud where it once again collides with water and hail and grows. This process may be repeated several times.

In all cases, when the hailstone can no longer be supported by the updraft it falls to the earth. The stronger the updraft, the larger the hailstones that can be produced by the thunderstorm.



Hail

One of the people killed during the March 28, 2000 tornado in Fort Worth was killed when struck by grapefruit-size hail.



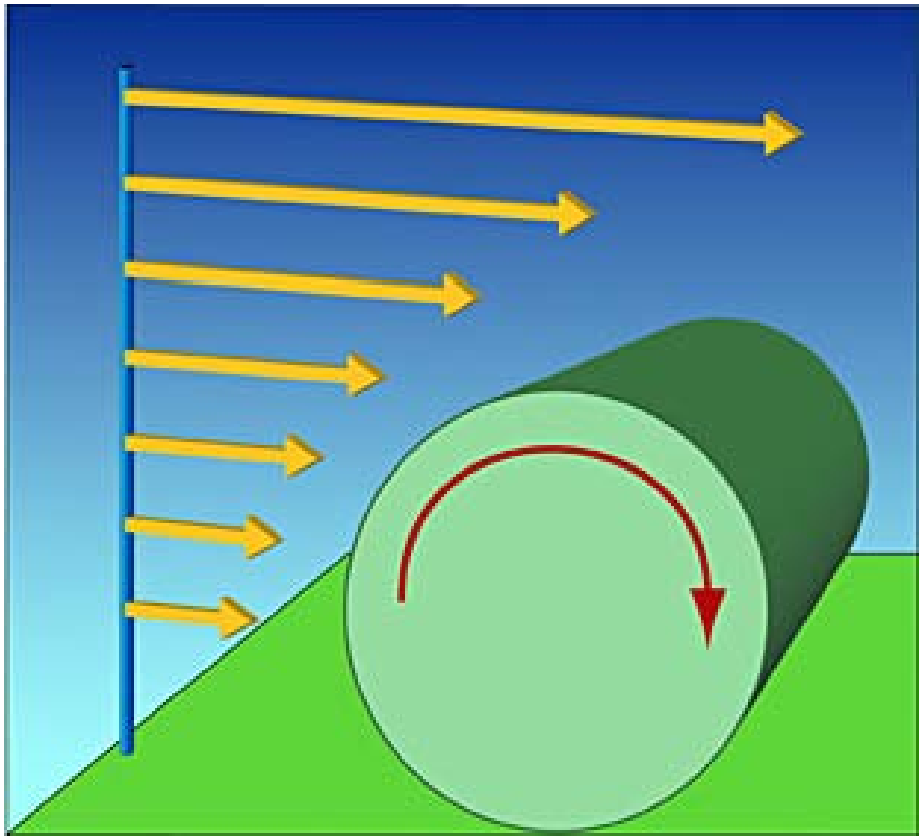
Hailstone size

	Measurement		Updraft Speed	
	in.	cm.	Mph	km/h
bb	< ¼	< 0.64	< 24	< 39
pea	1/4	0.64	24	39
marble	1/2	1.3	35	56
dime	7/10	1.8	38	61
penny	3/4	1.9	40	64
Nickel	7/8	2.2	46	74
quarter	1	2.5	49	79
half dollar	1 ¼	3.2	54	87
walnut	1 1/2	3.8	60	97
golf ball	1 3/4	4.4	64	103
hen egg	2	5.1	69	111
tennis ball	2 1/2	6.4	77	124
baseball	2 3/4	7.0	81	130
tea cup	3	7.6	84	135
grapefruit	4	10.1	98	158
softball	4 ½	11.4	103	166

Directional wind shear is the change in wind direction with height. The wind near the surface is blowing from the southeast to the northwest. As the elevation increases the direction veers (changes direction in a clock-wise motion) becoming south, then southwest, and finally, west.

Speed shear is the change in wind speed with height. In the illustration on the left, the wind is increasing with height. This tends to create a rolling affect to the atmosphere and is believed to be a key component in the formation of mesocyclones which can lead to tornadoes.

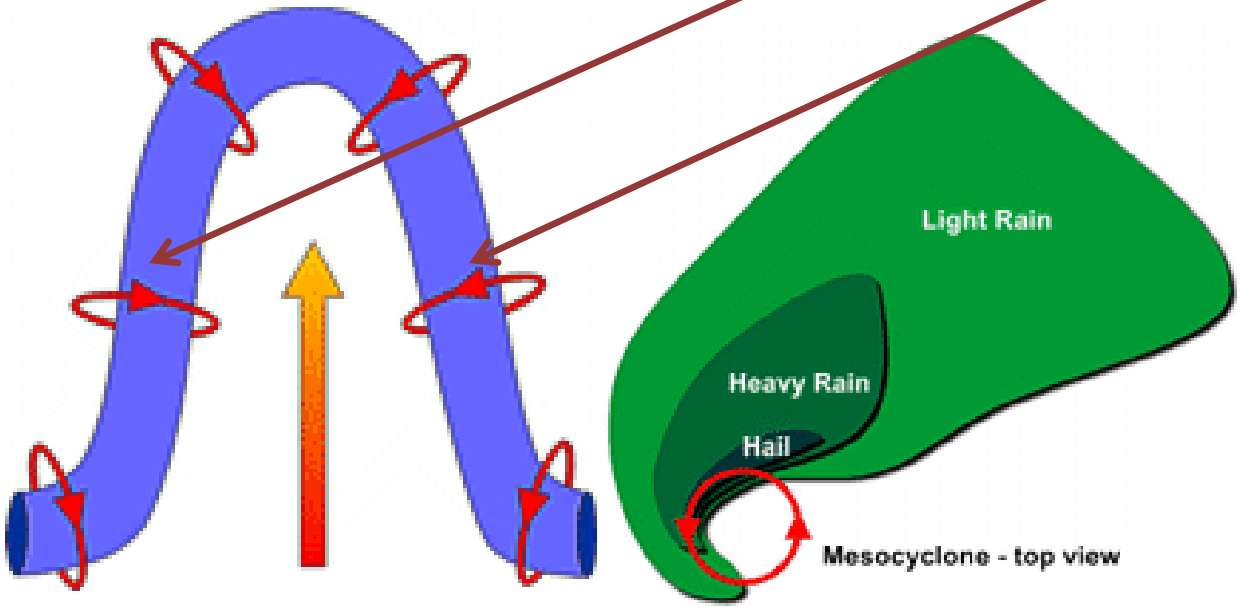
Strong vertical shear is the combination of a veering directional shear and strong speed shear and is the condition that is most supportive of supercells.

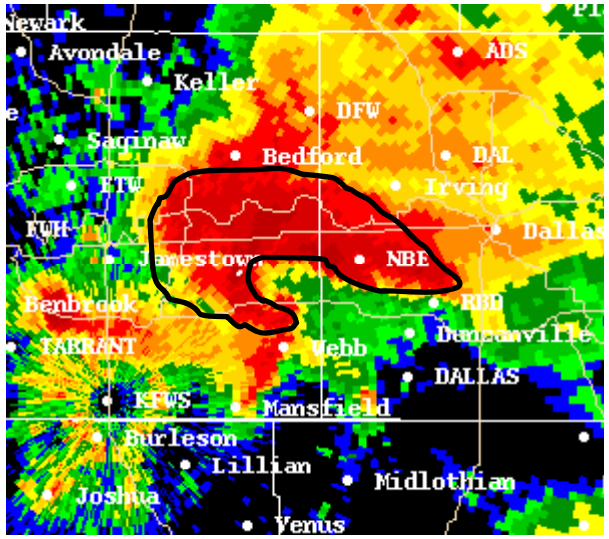


Most tornadoes are spawned from supercell thunderstorms. Supercell thunderstorms are characterized by a persistent rotating updraft and form in environments of strong vertical wind shear.

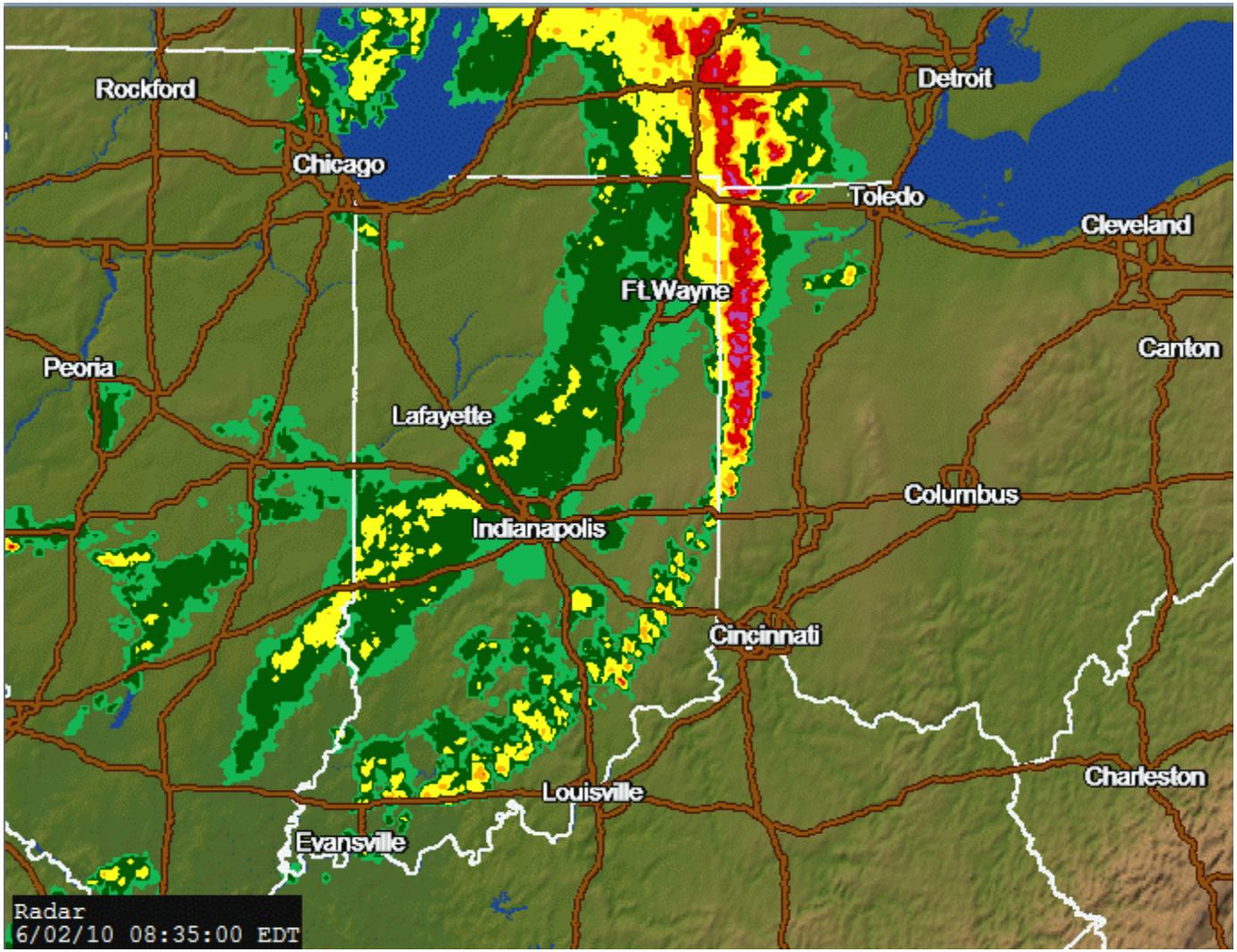
The updraft lifts the rotating column of air created by the speed shear. This provides two different rotations to the supercell; cyclonic or counter clockwise rotation and an anti-cyclonic of clockwise rotation.

The directional shear amplifies the cyclonic rotation and diminishes the anti-cyclonic rotation (the rotation on the right side of the of the updraft in the illustration at left). All that remains is the cyclonic rotation called a mesocyclone. By definition a supercell is a rotating thunderstorm. Strong rotation is indicated by a hook echo.





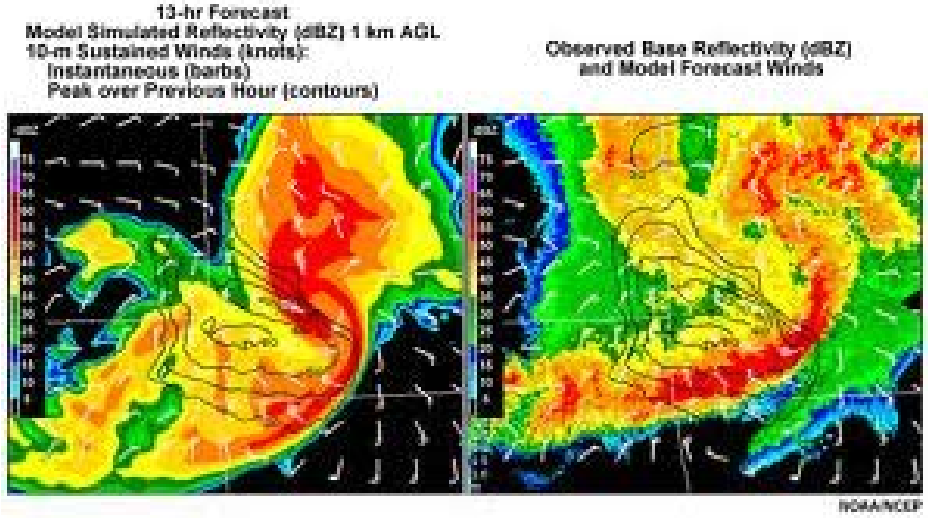
Line of Thunderstorms from Indianapolis to Ft. Wayne. The Gust Fronts from these Storms Created Outflow Boundary (Bow Echo) out Ahead.

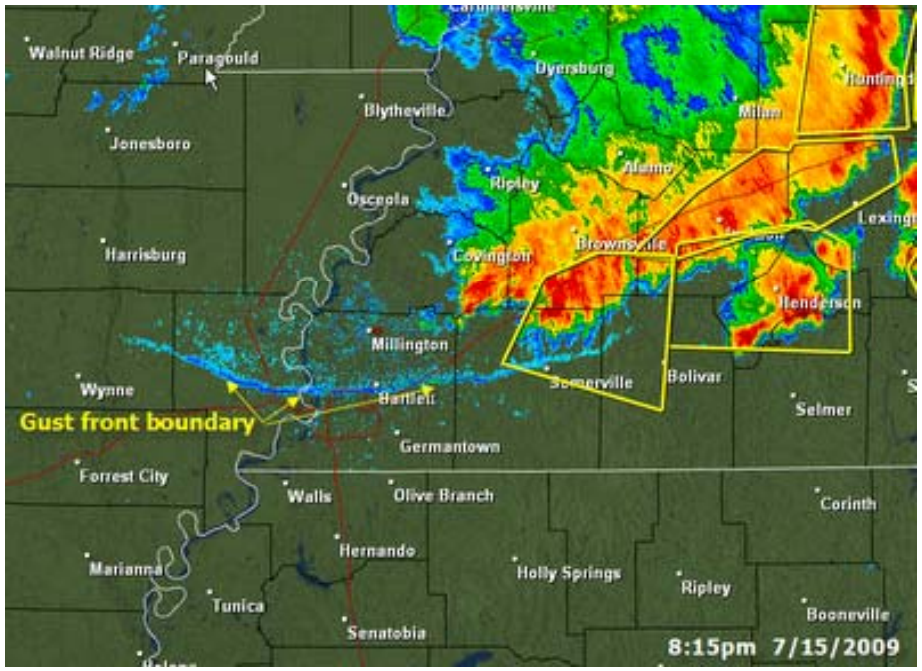


Roll Cloud with Outflow Boundary

Forecast and Observed

from the Comet Web Site.



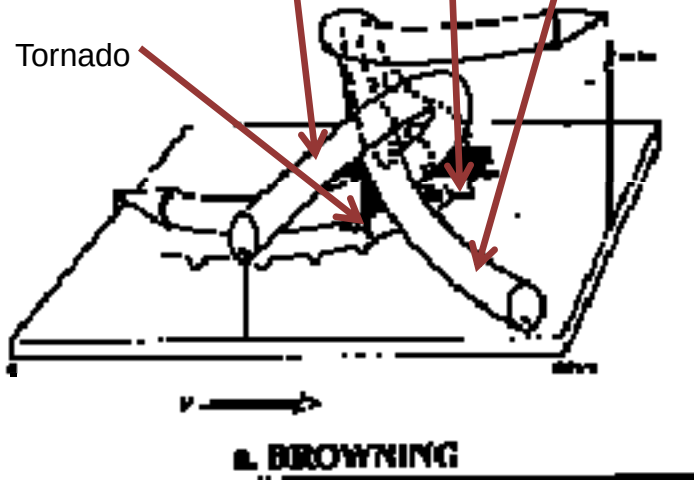


Dead Man Walking

Multiple Suction Vortices (also called Suction Spots) Often Occur within the Tornado Wall.

The Downdrafts within a Severe Thunderstorm

Most models listed above contain two downdrafts. The Forward Flank Downdraft (FFD) is downstream (east to north) of the Thermal Updraft. The second is the Rear Flank Downdraft (RFD) upwind (west to south) of the Thermal Updraft.



Details on Temperature of RFD

Recent theories suggest that once a mesocyclone is underway, tornado development is related to the temperature differences across the edge of downdraft air wrapping around the mesocyclone. However, mathematical modeling studies of tornado formation also indicate that it can happen without such temperature patterns; and in fact, very little temperature variation was observed near some of the most destructive tornadoes in history on May 3, 1999 in Oklahoma.

All of the models above agree that the FFD originates with mid-level, outside air circulating around the storm along the right-flank and south of the updraft and mesocyclone. The counter-clockwise (cyclonic) circulation associated with the mesocyclone pulls this outside air into the thunderstorm. With precipitation falling downstream into this relatively drier outside air, the air becomes cooler and denser (due to evaporative cooling) than the air inside the thunderstorm and sinks toward the ground with the falling precipitation. Once the FFD reaches the ground, it spreads outward, creating the forward gust front, associated self-cloud, and a thermal gradient field (TGF) with the warmer air south and east of the FFD.

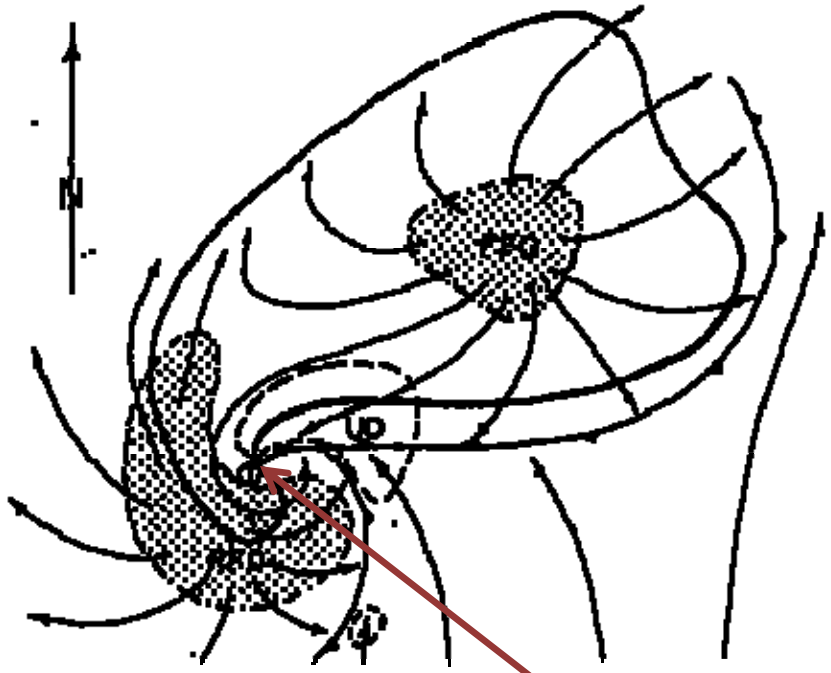
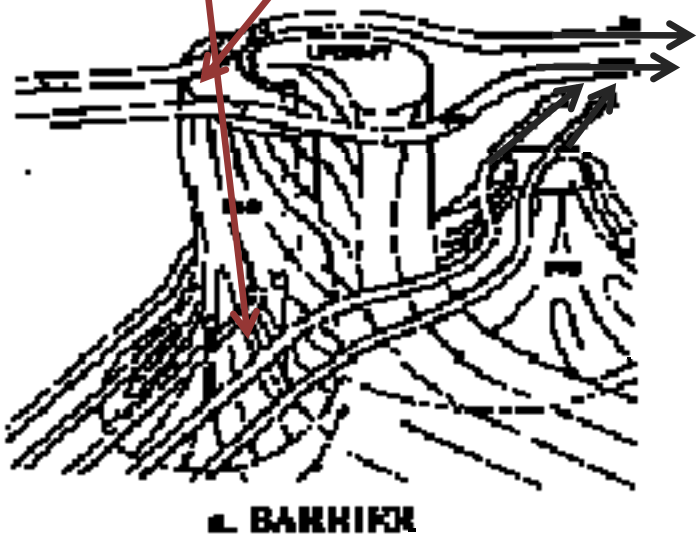


Diagram showing how the Jet Stream splits and goes around both sides to the thunderstorm at upper level and how the lower winds from the southwest also split and go around the storm. Both flows contribute to the rotation of the mesocyclone and mesoanticyclone in the storm.



Clouds that Look Like Things

Microburst Leading to Aircraft Crash

The downburst or microburst (smaller scale) is an intense, penetrative downdraft, which spreads outward in all directions upon reaching the surface. The lateral scale of the downburst is approximately 2-3 miles with the microburst one half to one mile. The life cycle of a downburst, as it descends within the rain shaft, can be as long as 10-15 minutes with the maximum surface winds lasting 2-4 minutes. The vertical speed of the downdraft can be as strong as 6000 feet per minute (approx. 60 knots) with surface winds reaching 45 knots for stationary storms or F-3 strength for travelling microbursts.