Section 8 – Severe Thunderstorms

Hazard Profile

Thunderstorms are created when heat and moisture near the Earth's surface is transported to the upper levels of the atmosphere. By-products of this process are the clouds, precipitation, and wind that become the thunderstorm.

All thunderstorms, regardless of severity, must have three conditions present in order to form. The first necessary condition is moisture in the lower to mid levels of the atmosphere. As air rises in a thunderstorm updraft, moisture condenses into small water drops which form clouds (and eventually precipitation). When the moisture condenses, heat is released into the air, making it warmer and less dense than its surroundings. The added heat allows the air in the updraft to continue rising.

The second necessary condition is instability. If the airmass is unstable, air which is pushed upward by some force will continue upward. An unstable airmass usually contains relatively warm (usually moist) air near the earth's surface and relatively cold (usually dry) air in the mid and upper levels of the atmosphere. As the low-level air rises in an updraft, it becomes less dense than surrounding air and continues to rise. This process is often augmented by added heat due to condensation as discussed above. The air will continue to move upward until it becomes colder and denser than its surroundings.

The third necessary condition is a source of lift. Lift is the mechanism used for starting an updraft in a moist, unstable airmass. The lifting source can take on several forms. The most common source is called differential heating. As the sun heats the earth's surface, portions of the surface (and the air just above the surface) will warm more readily than nearby areas. These "warm pockets" are less dense than the surrounding air and will rise. If unstable air has sufficient moisture, a thunderstorm may form.

According to the National Weather Service (NWS), a thunderstorm occurs when thunder accompanies rainfall. Radar observers use the intensity of radar echos to distinguish between rain showers and thunderstorms. Along with rolling thunder, lightning detection networks routinely track cloud-to-ground flashes to help track thunderstorms.

There are four different types of thunderstorms: Single Cell, Multicell Cluster, Multicell Line, and Super Cell. All are discussed below.

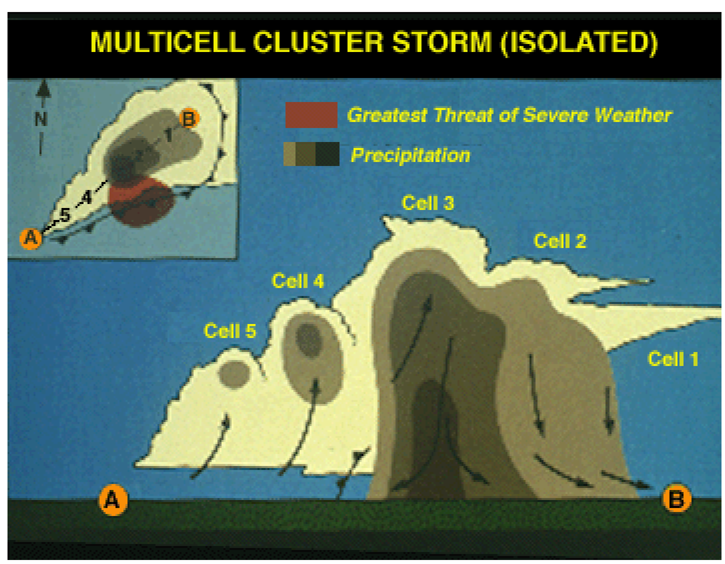
Single Cell Storm

Single cell thunderstorms have lifetimes of 20-30 minutes. Typically, they are not strong enough to produce severe weather. A true single cell storm is rare. Even with separate appearing storms in weak vertical wind shear, the gust front of one cell often triggers the growth of another cell some distance away.

Although most single cell storms are non-severe, some single cell storms may produce brief severe weather events. These storms, known as pulse severe storms, tend to form in more unstable environments than the non-severe single cell storm. Brief heavy rainfall and occasional weak tornadoes can also be expected. Because single cell storms are poorly organized and seem to occur at random times and locations, it is difficult to forecast exactly when and where this type of severe weather will occur.

Multicell Cluster Storm

The multicell cluster is the most common type of thunderstorm. The multicell cluster consists of a group of cells moving along as one unit with each cell in a different phase of the thunderstorm life cycle. As the cluster moves, each cell takes its turn as the dominant cell in the cluster. New cells tend to form at the upwind (usually western or southwestern) edge of the cluster. Mature cells are usually found at the center of the cluster with dissipating cells at the downwind (usually eastern or northeastern) edge of the cluster.



Although each cell in a multicell cluster lasts only about 20 minutes (as with a single cell storm), the multicell cluster itself may persist for several hours. Multicell clusters are usually more intense than single cell storms but weaker than supercell storms. Multicell cluster storms can produce heavy rainfall, downbursts (wind speeds up to about 80 miles an hour), moderate-sized hail (developing up to golfball size), and occasional weak tornadoes. Severe weather will tend to occur where updrafts and downdrafts are close to each other (i.e., near the updraft- downdraft interface (UDI) associated with mature cells).

Multicell Line Storm

The multicell line storm consists of a long line of storms with a continuous, well-developed gust front at the leading edge of the line. The string of storms can be solid or there can be breaks in the line. As the gust front moves forward, the cold outflow forces warm unstable air into the updraft usually at the leading (eastern) edge of the storm, with the heaviest rain and largest hail just behind (to the west of) the updraft. Lighter rain, associated with older cells, often covers a large area behind the active leading edge of the squall line.

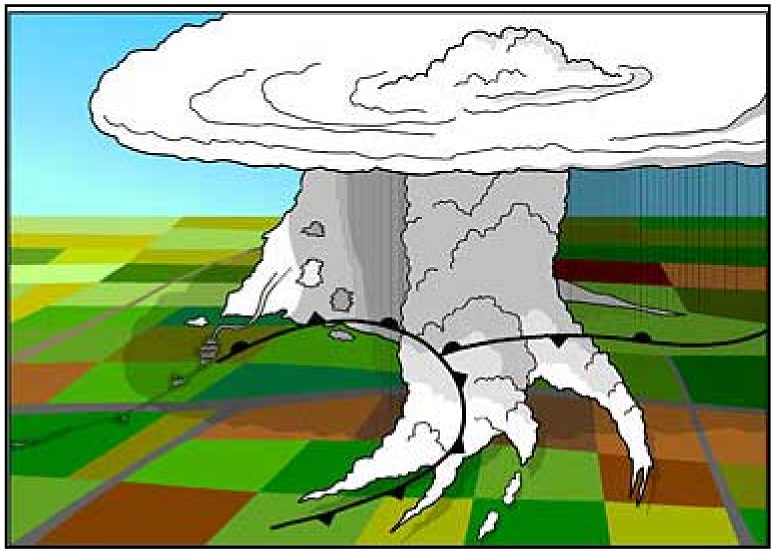
Thunderstorm Clouds on Lake Travis
Source: LCRA

Squall lines can produce hail up to about golf ball size, heavy rainfall and weak tornadoes, but they are best known as prolific downburst producers. Occasionally, an extremely strong downburst will accelerate a portion of the squall line ahead of the rest of the line. This produces what is called a bow echo. Bow echoes are easily detected on radar but are difficult (or impossible) to observe visually.

As with multicell cluster storms, squall lines usually produce severe weather near the UDI. Recall that this is near the leading (eastern) edge of the storm. If tornadoes are associated with a squall line, they will usually develop in cells that are just north of a break in the line or in the line's southemmost cell (sometimes called the "anchor cell"). Cells in these locations tend to behave more like supercells than typical squall line cells.

Supercell Storm

The supercell is a highly organized thunderstorm. Although supercells are rare, they pose an inordinately high threat to life and property. Like the single cell storm, the supercell consists of one main updraft. However, the updraft in a supercell is extremely strong, reaching estimated speeds of 150-175 miles an hour. The main characteristic which sets the supercell apart from the other thunderstorms already discussed is the element of rotation. The rotating updraft of a supercell, called a mesocyclone helps the supercell produce extreme severe weather events, such as giant hail (more than 2 inches in diameter), strong downbursts of 80 miles an hour or more, and strong to violent tornadoes.



Supercell Storm – View from Above
Source: NOAA

The supercell environment is characterized by high instability, strong winds in the mid and upper atmosphere, and veering of winds with height in the lowest mile or so. This environment is a contributing factor to the supercell's organization. As precipitation is produced in the updraft, the strong upper level winds literally blow the precipitation downwind. Relatively little precipitation falls back down through the updraft, so the storm can survive for long periods of time with only minor variations in strength. The leading edge of a supercell's precipitation area is characterized by light rain. Heavier rain falls closer to the updraft with torrential rain and/ or large hail immediately north and east of the main updraft. The area near the main updraft (typically towards the rear of the storm) is the central area of severe weather formation.

Location

Thunderstorms are generally localized events. The severity of impact of thunderstorms is considered to be limited as they generally result in injuries treatable with first aid, shut down of critical facilities and services for 24 hours or less, and less than ten percent of affected properties are destroyed or suffer major damage. Because it cannot be predicted where a thunderstorm may occur, all buildings and facilities are considered to be exposed to this hazard and could potentially be impacted.

Historical Occurrences

Historical evidence shows that most of the TCRFC area is susceptible to thunderstorm activity; however, past reported property damages indicate that, while thunderstorm events do occur, their economic impacts are typically not severe. It is important to note that only thunderstorm events that have been reported have been factored into this risk assessment, and in most cases NCDC data is limited to severe thunderstorm events that are noteworthy for specific reasons (high winds, deaths, injuries, property or crop damages, lightning strikes, etc.). It is likely that a high number of occurrences have gone unreported over the past 50+ years. Table 8-1 shows aggregated historical information by jurisdiction.

Table 8-1. Historical Thunderstorm Impact by Jurisdiction (NCDC, 1950-2008)

JURISDICTION	NUMBER OF REPORTED EVENTS	MAXIMUM WIND SPEED RECORDED (KNOTS)	DEATHS	INJURIES	PROPERTY DAMAGE (2008 DOLLARS)
Bastrop County	**36**	**100**	**0**	**0**	**644,180**
Bastrop	10	70	0	0	366,483
Elgin	5	60	0	0	280,430
Smithville	5	60	0	0	70,722
Blanco County	**17**	**70**	**0**	**0**	**425,790**
Johnson City	2	60	0	0	57,964
Brown County	**Not Participating**				
Brownwood	46	70	1	2	2,733,646
Burnet County	**44**	**73**	**0**	**0**	**413,739**
Bertram	0	N/A	0	0	0
Burnet	11	65	0	0	688,503
Cottonwood Shores	0	N/A	0	0	0
Granite Shoals	2	N/A	0	0	75,437
Highland Haven	0	N/A	0	0	0
Marble Falls	12	70	0	0	278,324
Meadowlakes	0	N/A	0	0	0
Colorado County	**22**	**65**	**0**	**0**	**371,394**

JURISDICTION	NUMBER OF REPORTED EVENTS	MAXIMUM WIND SPEED RECORDED (KNOTS)	DEATHS	INJURIES	PROPERTY DAMAGE (2008 DOLLARS)
Columbus	14	80	0	4	362,246
Eagle Lake	7	65	0	0	457,667
Weimar	12	55	0	0	238,953
Fayette County	**25**	**70**	**0**	**0**	**481,209**
Carmine	0	N/A	0	0	0
Flatonia	2	N/A	0	0	33,402
La Grange	7	70	0	0	158,058
Lampasas County	**26**	**65**	**0**	**2**	**359,758**
Kempner	5	52	0	0	80,773
Lampasas	15	61	0	0	167,894
Lometa	5	56	0	6	7,351,867
Lee County	**30**	**86**	**0**	**6**	**577,843**
Lexington	7	70	0	0	338,488
Giddings	10	70	0	0	745,076
Llano County	**31**	**87**	**0**	**0**	**1,354,003**
Llano	11	61	0	0	416,651
Horseshoe Bay	2	N/A	0	0	69,402
Sunrise Beach Village	0	N/A	0	0	0
Mason County	**7**	**86**	**0**	**0**	**4,008**
Mason	10	61	0	0	724,295
Matagorda County	**54**	**95**	**3**	**2**	**89,781**
Bay City	10	60	0	0	222,975
Palacios	3	52	0	1	191,049
McCulloch County	**Not Participating**				

JURISDICTION	NUMBER OF REPORTED EVENTS	MAXIMUM WIND SPEED RECORDED (KNOTS)	DEATHS	INJURIES	PROPERTY DAMAGE (2008 DOLLARS)
Brady	22	61	0	0	604,526
Mills County	**24**	**61**	**0**	**0**	**42,855**
Goldthwaite	12	61	0	0	41,118
San Saba County	**17**	**70**	**0**	**0**	**1,079,165**
San Saba	13	70	0	1	211,884
Travis County	**Not Participating**				
Briarcliff	0	N/A	0	0	0
Jonestown	0	N/A	0	0	0
Lago Vista	0	N/A	0	0	0
Lakeway	1	N/A	0	0	0
Mustang Ridge	0	N/A	0	0	0
Point Venture	0	N/A	0	0	0
San Leanna	0	N/A	0	0	0
Volente	0	N/A	0	0	0
West Lake Hills	1	68	0	0	142,949
Wharton County	**52**	**70**	**0**	**1**	**598,036**
East Bernard	4	51	0	0	209,964
El Campo	12	65	0	4	79,642
Wharton	19	65	0	0	353,836
Williamson County	**113**	**80**	**0**	**2**	**4,255,096**
Cedar Park	5	69	0	0	182,629
Florence	2	65	0	0	131,425
Hutto	1	N/A	0	0	1,429,488
TOTALS FOR STUDY AREA	**803**	**2,921**	**4**	**31**	**30,194,623**

Source: NCDC

Probability of Future Events

Most thunderstorms occur during the spring (March, April and May) and fall, during the month of September. The frequency of occurrence for a thunderstorm event is highly likely. Warning time for thunderstorms is generally minimal or non-existant.

Vulnerability Assessment

To estimate thunderstorm losses, NOAA historical thunderstorm loss data was used to develop a thunderstorm stochastic model. In this model, losses were scaled to account for inflation and expected annualized losses were calculated through a non-linear regression of historical data. Table 8-2 shows potential annualized losses by county. "Negligible" indicates that the annualized expected property losses are less than $5,000.

Table 8-2. Potential Annualized Losses by County (Thunderstorm)

JURISDICTION	TOTAL EXPOSURE	ANNUALIZED EXPECTED PROPERTY LOSSES ($)	ANNUALIZED PERCENT LOSS RATIO
Bastrop County	**1,898,937,000**	**11,800**	**0.00%**
Bastrop	576,435,000	6,323	0.00%
Elgin	344,327,000	Negligible	0.00%
Smithville	271,908,000	Negligible	0.00%
Blanco County	**448,775,000**	7,525	**0.00%**
Johnson City	78,214,000	Negligible	0.00%
Brown County	**Not Participating**		
Brownwood	1,160,816,000	45,850	0.00%
Burnet County	**1,142,430,000**	**7,093**	**0.00%**

JURISDICTION	TOTAL EXPOSURE	ANNUALIZED EXPECTED PROPERTY LOSSES ($)	ANNUALIZED PERCENT LOSS RATIO
Bertram	55,114,000	Negligible	0.00%
Burnet	255,342,000	12,608	0.00%
Cottonwood Shores	41,613,000	Negligible	0.00%
Granite Shoals	124,784,000	Negligible	0.00%
Highland Haven	33,235,000	Negligible	0.00%
Marble Falls	376,568,000	5,079	0.00%
Meadowlakes	94,973,000	Negligible	0.00%
Colorado County	**652,241,000**	**6,537**	**0.00%**
Columbus	259,875,000	6,186	0.00%
Eagle Lake	168,646,000	8,462	0.01%
Weimar	171,576,000	Negligible	0.00%
Fayette County	**1,143,993,000**	**8,673**	**0.00%**
Carmine	16,978,000	Negligible	0.00%
Flatonia	73,581,000	Negligible	0.00%
La Grange	308,041,000	Negligible	0.00%
Lampasas County	**451,748,000**	**6,457**	**0.00%**
Kempner	47,851,000	Negligible	0.00%
Lampasas	429,672,000	Negligible	0.00%
Lometa	41,863,000	122,531	0.29%
Lee County	**491,147,000**	**10,601**	**0.00%**
Lexington	68,009,000	6,232	0.01%
Giddings	309,504,000	13,210	0.00%

JURISDICTION	TOTAL EXPOSURE	ANNUALIZED EXPECTED PROPERTY LOSSES ($)	ANNUALIZED PERCENT LOSS RATIO
Llano County	**762,494,000**	**24,920**	**0.00%**
Llano	217,712,000	7,226	0.00%
Horseshoe Bay	401,845,000	Negligible	0.00%
Sunrise Beach Village	108,772,000	Negligible	0.00%
Mason County	**152,814,000**	**Negligible**	**0.00%**
Mason	114,666,000	12,103	0.01%
Matagorda County	**937,051,000**	**Negligible**	**0.00%**
Bay City	1,011,160,000	Negligible	0.00%
Palacios	236,596,000	Negligible	0.00%
McCulloch County	**Not Participating**		
Brady	296,230,000	10,214	0.00%
Mills County	**200,103,000**	**Negligible**	**0.00%**
Goldthwaite	120,497,000	Negligible	0.00%
San Saba County	**195,326,000**	**19,971**	**0.01%**
San Saba	157,499,000	Negligible	0.00%
Travis County	**Not Participating**		
Briarcliff	78,826,000	Negligible	0.00%
Jonestown	115,523,000	Negligible	0.00%
Lago Vista	382,670,000	Negligible	0.00%
Lakeway	1,058,045,000	Negligible	0.00%
Mustang Ridge	38,236,000	Negligible	0.00%
Point Venture	49,272,000	Negligible	0.00%
San Leanna	27,719,000	Negligible	0.00%

JURISDICTION	TOTAL EXPOSURE	ANNUALIZED EXPECTED PROPERTY LOSSES ($)	ANNUALIZED PERCENT LOSS RATIO
Volente	34,753,000	Negligible	0.00%
West Lake Hills	546,896,000	14,295	0.00%
Wharton County	**1,056,683,000**	**10,845**	**0.00%**
East Bernard	92,899,000	Negligible	0.00%
El Campo	641,235,000	118,163	0.02%
Wharton	499,567,000	6,267	0.00%
Williamson County	**6,478,980,000**	**75,287**	**0.00%**
Cedar Park	1,872,480,000	Negligible	0.00%
Florence	59,444,000	Negligible	0.00%
Hutto	91,087,000	23,825	0.03%
TOTALS FOR STUDY AREA	**29,575,276,000**	**608,283**	**N/A**

Source: HAZUS-MH MR3 (exposure values) and NCDC (property losses)