Oak Lawn Tornado 1967

An analysis of the Northern Illinois Tornado Outbreak of April 21st, 1967
Oak Lawn History

- First Established in the 1840s and 1850s
- School house first built in 1860
- Immigrants came after the civil war
- Post office first established in 1882
- Innovative development plan began in 1927
- Population exponentially grew up to the year of 1967
Path of the Storm

• The damage path spanned from Palos, Illinois (about 2-3 miles west/southwest of Oak Lawn) to Lake Michigan. With the worst damage occurring in the Oak Lawn area. Specifically, the corner of 95th street and Southwest Highway.

• Other places that received significant damage includes:
  89th and Kedzie Avenue
  88th and California Avenue
  Near the Dan Ryan at 83rd Street
Timing (All times below are in CST on April 21st, 1967)

• 8 AM – Thunderstorms develop around the borders of Iowa, Nebraska, Kansas, and Missouri
• 4:45 PM – Cell is first indicated on radar (18 miles west/northwest of Joliet)
• 5:15 PM – rotating clouds reported 10 miles north of Joliet
• 5:18 PM – Restaurant at the corner of McCarthy Road and 127th Street had their windows blown out
• 5:24 PM – Funnel Cloud reported (Touchdown confirmed)
• 5:26 PM – Storm continues Northeast and crosses Roberts Road between 101st and 102nd streets
• 5:32 PM - Tornado cause worst damage at 95th street and Southwest highway
• 5:33 PM – Tornado causes damage to Hometown City Hall
• 5:34 PM – Tornado passes grounds of Beverly Hills Country Club
• 5:35 PM – Tornado crosses Dan Ryan Expressway and flips over a semi
• 5:39 PM – Tornado passes Filtration plant at 78th and Lake Michigan and Dissipates
Notable Areas Destroyed

- Fairway Supermarket
- Sherwood Restaurant
- Shoot’s Lynwood Tavern
- Suburban Bus Terminal
- Airway Trailer Park
- Oak Lawn Roller Rink
- Plenty More!

Pictures to the right were taken BEFORE the twister
52 Total Tornadoes in 6 states (5 EF4’s including the Oak Lawn, Belvidere, and Lake Zurich Tornadoes)
Next several slides summary

• The next several slides, I will be going through different parameters. With each parameter I will explain:

• 1. What the parameter is and how to analyze it.

• 2. Show charts of the parameters at the 00 Z time on April 22\textsuperscript{nd}, this results to 6pm CST on April 21, 1967, roughly the time of the tornado occurrence.

• 3. Explain what the charts are showing
850mb Analysis

• The 850 MB level is one of the mandatory levels, which means that radiosonde instruments record winds, temperature and humidity at that specific level.

• 850 mb is also good for assessing low level warm air and cold air advection.

• When thermodynamic, kinematic, and lift conditions in the atmosphere are favorable, the 850 mb jet provides a good proxy as to where violent tornadoes are most likely to develop.

• Midwest and Northeastern tornadoes in the U.S. are mostly concentrated just ahead of the 850 mb jet center.

• References: https://www.spc.noaa.gov/publications/broyles/viol850j.pdf
  https://www.weather.gov/source/zhu/ZHU_Training_Page/Miscellaneous/chart_comparison/chart_comparison.htm
850mb Analysis (Pictures)
Explanation of previous slides pictures
(All values are at the 850 mb level)

• Picture #1 shows the 850 mb Isotach (kt) – Low Contour map, showing where the strongest area of occurrence is as well as the location of the storms relative to the map. As you can see, most of the tornados occurred on the northern side of the maximum values.

• Picture #2 shows the moisture values as well as the station plots showing wind direction. There is a lot of available moisture around the Texas area, but with the wind values coming from the south/southwest, there is a lot of moisture advection occurring.

• Picture #3 shows the temperature values, and the one thing to point out here is that there is a strong temperature change as you move to the northeast, and combining picture #4, which is the height contours map and shows that the center of lower pressure is occurring around Minnesota, it is likely that this temperature change coincides with a cold front, which might be the strong lifting mechanism for thunderstorm development
700 mb analysis

- Considered the top of the lower atmosphere, the 700 mb chart looks for both moisture and vertical motion to forecast precipitation. Height of 700mb typically ranges from 7,700 to 10,500 feet
- The 700 mb chart is considered the last of the low-level charts
- The trough/ridge pattern becomes more defined at the 700 mb level
- The 700 mb chart uses the symbol Omega (in microbars per second) to represent vertical motion relative to the earth’s surface. Rising air is given by a minus sign and sinking air is given by a positive sign

Reference:
https://www.weather.gov/jetstream/700mb#:~:text=700%20mb%20considered%20by%20many,top%20of%20the%20lower%20atmosphere.&text=This%20is%20also%20getting%20into,will%20indicate%20the%20relative%20humidity.
700 mb Pictures

#1

#2

#3

#4
700 mb analysis from previous pictures

• Picture #1 is showing the Omega values (rising/sinking air) with negative values indicating rising air and positive values indicating sinking air. As you can see, the strongest amount of rising air is occurring right around the northeastern part of Illinois.

• Picture #2 shows moisture values. Similar to the 850 mb chart, the moisture values peek in the Texas and Louisiana area. The difference is that the air is blowing more westerly compared to southwesterly in Northern Illinois. So, there is less moisture advection at the 700 mb level. However, with the change in wind direction, we can see that there is shear occurring in the area of focus.

• Picture #3 shows the temperature distribution at the 700 mb level. Similarly, to the 850 mb chart, there is a temperature decrease as you immediately move northwest from Northern Illinois. However, the temperature change is a lot less dramatic at this level than it is at the 850 mb level.

• Picture #4 shows the height levels. Once again, we can see that the center of lower pressure is occurring in the northern part of Minnesota. If we compare the locations of the center of low pressure from the 700 mb chart to the 850 mb chart, we can see that the system at these two points are stacked. However, we cannot completely confirm a vertically stacked system without looking at the upper levels first.
500 mb analysis

• Similar to the 700 and 850 mb charts respectively, the 500 mb chart is measured at a constant pressure of 500 mb.

• The 500 mb chart can measure height increases/decreases. Heights increase when air is warmer (less dense) and they decrease when the air is colder (more dense). Can also be referred to as height rise/fall.

• 500 mb charts can also measure vorticity, which is a clockwise or counterclockwise spin in the troposphere. Can also be termed vertical vorticity.

• Horizontal Vorticity is caused by a change in wind direction or speed with height. Streamwise vorticity is the amount of horizontal vorticity that is parallel to storm inflow.

• Wind speed increasing when moving away from the center point of the trough is positive shear vorticity, and negative shear vorticity is when wind speed is decreasing when moving away from the center of the trough.

• Reference:
500 mb analysis from previous slide

• Picture #1 shows the temperatures at 500 mb, and similar to the previous charts, we see a strong temperature change as you move northwest from our target location of Northern Illinois.

• Picture #2 is the heigh maps at 500 mb, and the one thing to mention in this picture is that lines are relative straight around Northern Illinois, but the center of low pressure is now completely up in Canada, and almost off screen of what we have. This proves that the system is not vertically stacked and does not show signs of decreasing.

• Picture #3 is a vorticity measurement, and there is a vorticity maximum right around our center of low pressure. The Positive Cyclonic Vorticity that we see is a sign of air continuing to rise (height increase).
Vorticity Continued

• When looking at Vorticity, we must look back a few hours to even a full day. This is because when there are regions of Positive Vorticity advection, that results in rising air, and rising air also results in Low pressure systems. So, it is important for us to look back a couple of hours and see if there are any locations of Positive Vorticity Advection that would support the growing, strengthening, or sustainability of a low.
Explanation of Previous Slide

• The two photos shown on the previous slides are 500 mb vorticity shown 3 hours and 6 hours before the Oak Lawn tornado hit. As you can see, there are places of maximum Positive Vorticity Advection for both times. This shows that the low-pressure system is continuing to grow from this point onward.

• The Vort. Max at 18 Z (6 hours prior) are a little higher than the Vort. Max at 21 Z. This means that, although the Low is likely still strengthening at 21 Z, it is strengthening at a faster rate at the 18 Z timesframe.
300 mb chart

- The 300 mb chart shows conditions in the upper troposphere. This chart is also known as the jet stream level, that is because this level is the best for identifying the jet stream. The jet stream is easier to locate at the 300 mb chart in the winter and the 200 mb chart in the summer.

- Jet streaks can also be identified using the 300 mb chart. If a jet streak exists on the left side of a trough and winds are stronger to the left of the trough, the trough will become more amplified with time and will dig in a southerly direction. If a jet streak exists on the right side of a trough and winds are stronger to the right of the trough, the trough will become less amplified with time and "lift out" in a northeasterly direction.

- The 300 mb chart also shows divergence. Upper-level divergence occurs when a stronger wind moves away from a weaker wind. When divergence occurs in the upper levels, it leads to rising air.

- Reference:
300 MB Pictures

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#2

#3

#4
300 mb analysis of previous slide

- Picture #1 shows the heights at the 300mb level. The wind flows roughly parallel to the height lines, and the closer the lines together are, the faster the wind speed is approximately. This picture shows the height differential very tight, which results in high wind speed (jet stream). The Jet stream in Northern Illinois has a Southwest direction, but if you follow the jet stream, it extends almost all the way towards the Pacific Ocean. This long jet stream allows for a lot of moisture advection.

- Picture #2 shows the temperatures at this level. This chart doesn’t really show too much, but it does show a temperature minimum around the southeast part of South Dakota.

- Picture #3 shows the 300 mb Divergence x 10^{-5} (1/s). We can see from this graph that there is a strong divergence maximum right over our target area of Northern Illinois. Remember that divergence at this level results in rising air. With the maximum over our area, we can definitely see all of the rising air associated with this system.

- Picture #4 shows the 300 mb Isotach – Low Contour. (Isotach being lines of equal wind speed). The strongest wind speeds are occurring in the northern part of Michigan and the southwest corner of the united states. These two locations are locations of the jet streaks within this system.
Instability parameters

- SBCAPE stands for Surface-Based Convective Available Potential Energy. It measures the instability in the troposphere, where the value represents the total amount of potential energy available to a parcel of air originating at the surface and being lifted to its level of free convection. MUCAPE stands for Most Unstable Convective Available Potential Energy.
- Higher values mean the atmosphere is more unstable and would produce a stronger updraft.
- Lifted Index is calculated as the difference between the observed temperature at 500 mb and the temperature of an air parcel lifted to 500 mb from near the surface.
- SBCIN stands for surface based convective inhibition. It measures the amount of energy that will prevent an air parcel from rising from the surface to the level of free convection. Almost the opposite of SBCAPE.
Instability Pictures

#1

#2

#3

#4
Review of Previous Slides

- Picture #1 shows the SBCAPE values. As you can see, there are very high values occurring over our target area. This means the atmosphere is more unstable and would produce a stronger updraft. Which favors strong thunderstorms. The interesting thing about the values are that they are located further to the south, not to mention that the Oak Lawn Tornado was one of the southern most tornadoes, it is interesting that most of the tornadoes occurred just north of the Maximum CAPE values.

- Picture #2 shows the SBCIN values. Not surprising, the values are low around our target area. This is because CIN is close to the opposite of CAPE, so this observation is not surprising.

- Picture #3 shows the MUCAPE values. The values are almost identical to the SBCAPE values. This shows that the CAPE values are very similar as you go up in the atmosphere.

- Picture #4 shows the lifted index values. The maximum values are shown in Southern Missouri and Northern Arkansas. This is interesting considering this is not near the area where the tornadoes occurred. In our target area, there is only a small lifted index value.
Wind Shear Analysis

• Wind shear is the difference in wind speed and/or direction over a distance in the atmosphere. It can be described as horizontal or vertical wind shear. While wind shear destroys hurricanes, strong vertical wind shear is important for the development of severe convective storms. This causes updraft and downdraft to occur within separate regions of the thunderstorm and helps maintain the thunderstorms lifespan.

• Vertical wind shear is defined as the change of horizontal wind direction or speed with height. Horizontal wind shear is defined as change of horizontal wind direction or with horizontal distance.

• SRH stands for Storm Relative Helicity and is a measure of the potential for cyclonic updraft rotation in right-moving supercells. It is calculated at the lowest 1–3-kilometer layer above the ground.
Wind Shear Analysis

#1

#2
Analysis of previous slide

• Picture #1 shows the wind shear values at the lower 1–3-kilometer level. Similar to the CAPE values, the highest values of wind shear are occurring just south of our target area. However, there is still a high wind shear value over the area of Oak Lawn. This strong wind shear will definitely allow for strong development of thunderstorms.

• Picture #2 shows the Storm Relative Helicity (SRH) at the 1-3 km level, and unlike the wind shear values, the SRH does not max out at our target area. So, the basic conclusion of this map is. Although other values such as wind shear and SBCAPE show numbers that suggest strong thunderstorm development, the SRH map does not show the same support.
Moisture

• Dewpoint is the atmospheric temperature below which water droplets begin to condense and dew can form. Dewpoint is the temperature the air needs to be cooled at a constant pressure in order to achieve a relative humidity of 100%. The higher the dew point rises, the greater the amount of moisture in the air.

• Precipitable water is the total atmospheric water vapor contained in a vertical column of unit cross-sectional area extending between any two specified levels.

• LCL stands for lifting condensation level, and it is the height at which the relative humidity of an air parcel will reach 100% with respect to liquid water when it is cooled by dry adiabatic lifting.
Moisture Pictures

#1

#2

#3
Analysis of previous slide

- Picture #1 shows the dewpoint values. Similar to other parameters, the highest values are just to the south of our target area. Not surprising is that the moisture flow (or atmospheric river) extends from the Gulf of Mexico. If we take the location of the maximum dewpoint and combine it with the wind direction from earlier, we see that there is strong evidence of a lot of moisture advection taking place.

- Picture #2 shows the precipitable water. This map is very similar to the dewpoint map, where most of the maximum values are occurring to the south of the target area as well as a flow of it coming from the Gulf. The only strong difference being the location of the maximum values. The precipitable water maximum is in Northern Mississippi.

- Picture #3 shows the LCL values. Low LCL values favor thunderstorms and there are lows values over our target area. An interesting thing with the LCL map, is that the low values extend to the west. Which so happens to be the location where the storms initially came from.
Surface Plots

• MSLP stands for mean surface level pressure, and it is the pressure reduced to sea level. These are good for identifying low pressure and high-pressure systems.

• Moisture convergence is a very important tool in forecasting the development of thunderstorms in the short-term scale. Surface moisture convergence generally precedes the development of thunderstorms by a few hours.
Surface Maps
Analysis of previous slide

• Picture #1 shows the moisture convergence. Clearly based on the picture, there is a strong moisture convergence occurring right around our target area of Northern Illinois. This map shows strong evidence of the development of thunderstorms happening over the next several hours.

• Picture #2 shows the mean surface level pressure. We can clearly see a strong low-pressure system with a low of 997 mb. Based on this map and comparing the lower-level/upper-level maps, we see that the low-pressure system is negatively tilted. Which means it shows no sign of slowing down at this point. If the low was vertically stacked, then we would see a sign of it slowing down. Another interesting thing about the location of the low, is that it is occurring to the north of our target area. Now, with most low-pressure systems, there exists a cold front to the south. When considering that, and the fact that most of the strongest storms in a low-pressure system occur along the cold front, this map once again shows strong evidence of thunderstorm development over our target area of Northern Illinois.
Surface map Continued

The Picture to the right shows the surface map of the system. Similar to before, we see the low-pressure system making its path to the northeast. Located to the west/northwest/north of Northern Illinois. The difference with this picture is that we can visibly see the fronts associated with this system. We actually see that a stationary front exists in northern Illinois, which is different from the thought that the storms were driven from a cold front.
Summary of Scientific Setup

• Strong southwest upper-level jet stream of over 100 knots.
• Upper-level low that was negatively tilted along with a short and defined short wave trough
• Stationary Boundary from Central Plains to Great Lakes
• Moist air in place along with southwest moisture advection
• High wind shear, CAPE, moisture convergence, and helicity