AWOC 2015-16 Severe WES-2 Simulation Notes

May 23, 2015 Event Highlights:

This event features multiple, low-topped, discrete supercell storms which develop south of a slow-moving, west-to-east-oriented quasi-stationary frontal boundary. The storm environment is characterized by strong, effective inflow layer shear and very low LCLs. There were ten reported tornadoes (depicted in the graphic below as inverted red triangles) rated either EF0 or EF1 damage. These tornadoes developed in south central Oklahoma between 2100 UTC 23 May 2015 and 0100 UTC 24 May 2015. Many storms that developed exhibited low-level rotation signatures on radar but the ones that produced tornadoes were the ones possessing the most persistent and deepest mesocyclones. All tornadic storms developed south of a quasi-stationary frontal boundary.

Due to the warm core nature of the convection, and marginal CAPE in the hail growth zone, hail reports were scarce with only one instance of 1.5” diameter-sized hail reported at approximately 2300 UTC in Canadian County. Due to the relatively slow movement of the discrete storms ahead of the boundary, smaller warning polygons were most effective. Numerous flash flooding reports also occurred throughout the evening and overnight hours due to training movement nature of the storms along and north of the frontal boundary. Figure 1 is a map of locations of all local storm reports during the case data time period with details of the tornado/hail reports listed in figure 2. (Note: Details of the flash flood reports are available upon request.)

To help with the feedback and learning process, decision point evaluation criteria is provided to help the facilitator/trainee evaluate acceptable trainee responses based on the simulation learning objectives. The selected warning decision points (questions) are described in the simulation notes guide and answer form. These decision points can form the basis of student assessment but other storms that also produced tornadoes during the simulation could be opportunities for evaluating learning objectives as well. However, only brief evaluation criteria is provided for these decision points (See appendix)

Use the trainee responses from the AWOC Severe WES-2 Simulation Google Docs Answer Form to help with a simulation review/debrief process.

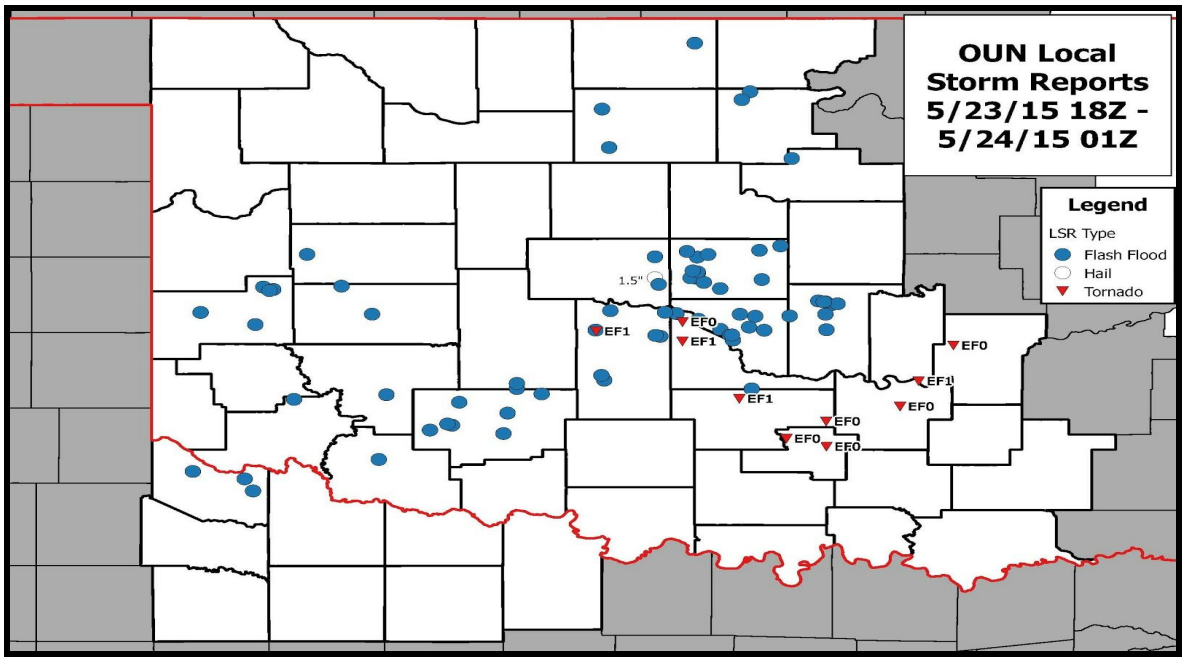

Figure 1. Location of local storm reports.

Event Type	Beg Date/Time	End Date/Time	County Name	Event Source	Beg. Location	Mag	Length (miles)	Width (yds)	End Location
Tornado	5/23/2015 16:12	5/23/2015 16:32	GRADY	Emergency Manager	3.0 W POCASSET	EF1	6	500	4.0 NNE POCASSET
Tornado	5/23/2015 16:59	5/23/2015 17:07	MURRAY	Emergency Manager	1.0 N SULPHUR	EF0	3	40	4.0 N SULPHUR
Tornado	5/23/2015 17:05	5/23/2015 17:05	PONTOTOC	Emergency Manager	2.5 ESE ADA	EF0	0.2	20	NULL
Tornado	5/23/2015 17:10	5/23/2015 17:11	MURRAY	Emergency Manager	1.5 SSW JOY	EF0	0.5	50	NULL
Tornado	5/23/2015 17:11	5/23/2015 17:17	MCCLAIN	Emergency Manager	2.5 ESE BLANCHARD	EF1	2	50	2.8 ENE BLANCHARD
Tornado	5/23/2015 17:16	5/23/2015 17:16	GARVIN	Storm Chaser	9.0 S STRATFORD	EF0	0.2	50	NULL
Tornado	5/23/2015 17:30	5/23/2015 17:32	MCCLAIN	Storm Chaser	1.0 WSW NEWCASTLE	EF0	0.5	50	NULL
Tornado	5/23/2015 18:05	5/23/2015 18:05	GARVIN	NWS Employee	3.1 ESE MAYSVILLE	EF1	0.5	50	NULL
Tornado	5/23/2015 18:13	5/23/2015 18:13	HUGHES	Trained Spotter	2.0 N HOLDENVILLE	EF0	0.2	50	NULL
Tornado	5/23/2015 17:26	5/23/2015 17:33	SEMINOLE	Emergency Manager	3.6 SSW SASAKWA	EF1	2.75	100	1.0 S SASAKWA
Hail	5/23/2015 17:03	5/23/2015 17:03	CANADIAN	NWS Employee	Yukon	1.25 in	Null	Null	Null

Figure 2. Tornado and hail local storm report metadata for the simulation. All Times CST.

Decision Point Evaluation Summary

Questions	Evaluation Criteria
Phase 1: Threat assessment in CWA (2100 - 0000 UTC)	Student should recognize strong (30-35 kts) 0-1 km shear, and sufficient (> 40 kts) 0-6 km shear, moderate (2000-3000 J/kg) SBCAPE, and very low (<500 m) LCLs conducive to tornado development along and south of the thunderstorm outflow boundary which pushes southeast from the quasi-stationary front. They should also note limiting factors such as low-level lapse rates, STP, excessive MLCIN, and high PWs which are parameters that negate likelihood for large, persistent tornadoes, wind and hail. Use of LAPS data and RUC13 are preferred over the HRRR for effective short-term forecast of convective trends in this analysis as the HRRR was consistently off in correct placement of boundaries, wind shifts, and precipitation.
Phase 2 Warning Decision Points #1, #2: (2156 - 2219 UTC)	Interrogation of all-tilts base data (esp. Z/V/CC) from KTLX reveals increasing improvement for tornadic development by 2200 UTC (Figure 3) for a cluster of storms that develop initially southwest of Pocasset and north of Amber in NW Grady Co. Rotation begins at 2156 UTC for three storms in close proximity then the middle one becomes stronger by 2200 UTC as it exhibits an inflow notch and absorbs the eastern storm. Note that the western-most storm also has a very small area of rotation. So, by 2203 UTC, based on trends of storm structure, trainee should recognize that this storm is certainly worthy of a tornado warning. An example of a warning polygon for decision point #1 is shown in figure 4. A live broadcast report of a tornado is received by 2212 UTC (see WESSL report) which should trigger a follow-up to the initial TOR issued or, a new TOR issued for northern Grady County with updated basis. Movement of strengthening parent storm and threat track would extend a reasonable warning polygon into southwest Canadian Co. as shown in figure 5. From 2214-2219 UTC, trainee should note the increasingly favorable low-level circulation, reflectivity structure (hook echo), and low CC as the tornadic storm moves just northwest of Pocasset (figure 6).

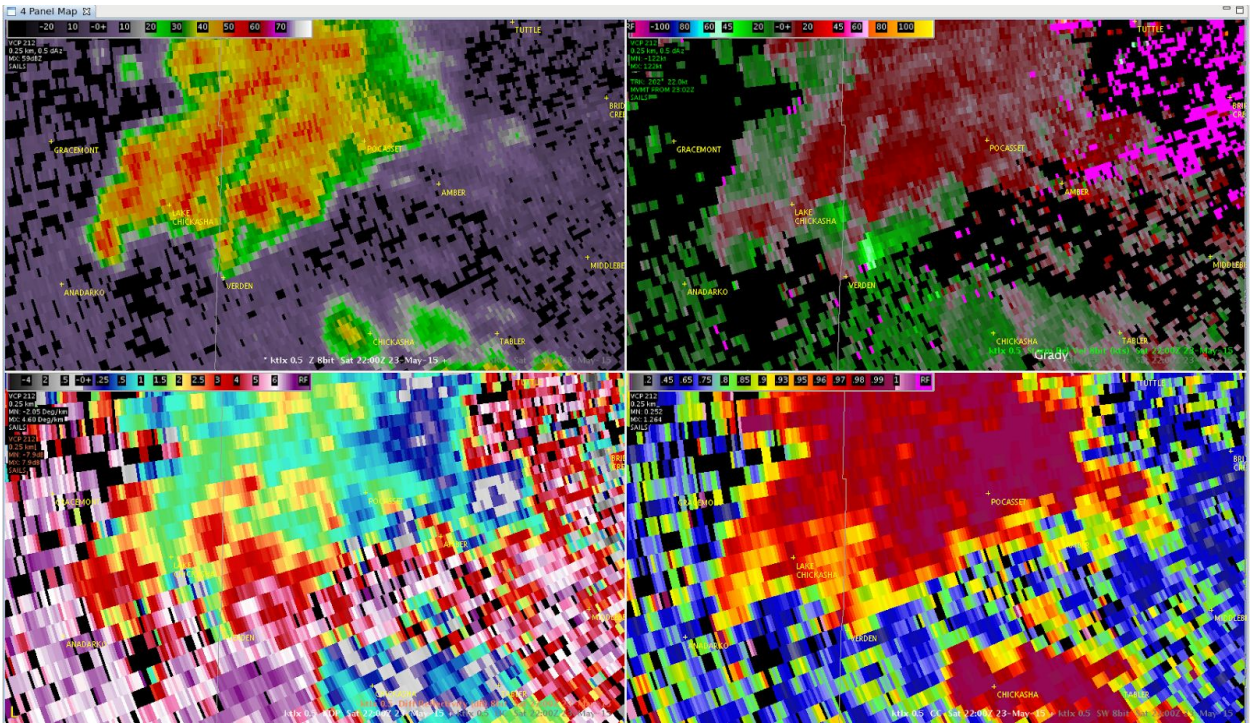

Figure 3: 4-panel KTLX 0.5 deg of (clockwise) Z/SRM/CC/KDP at 2200 UTC.

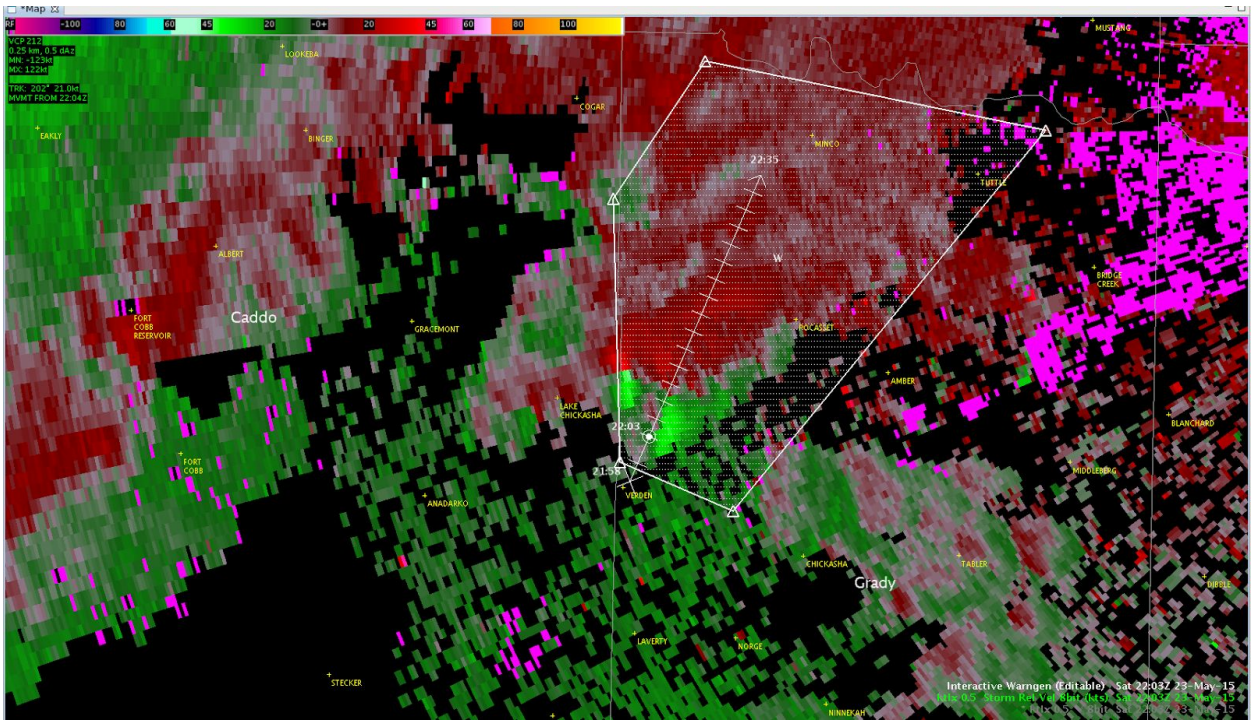

Figure 4. Example tornado warning polygon issued at 2203 UTC for decision point #1.

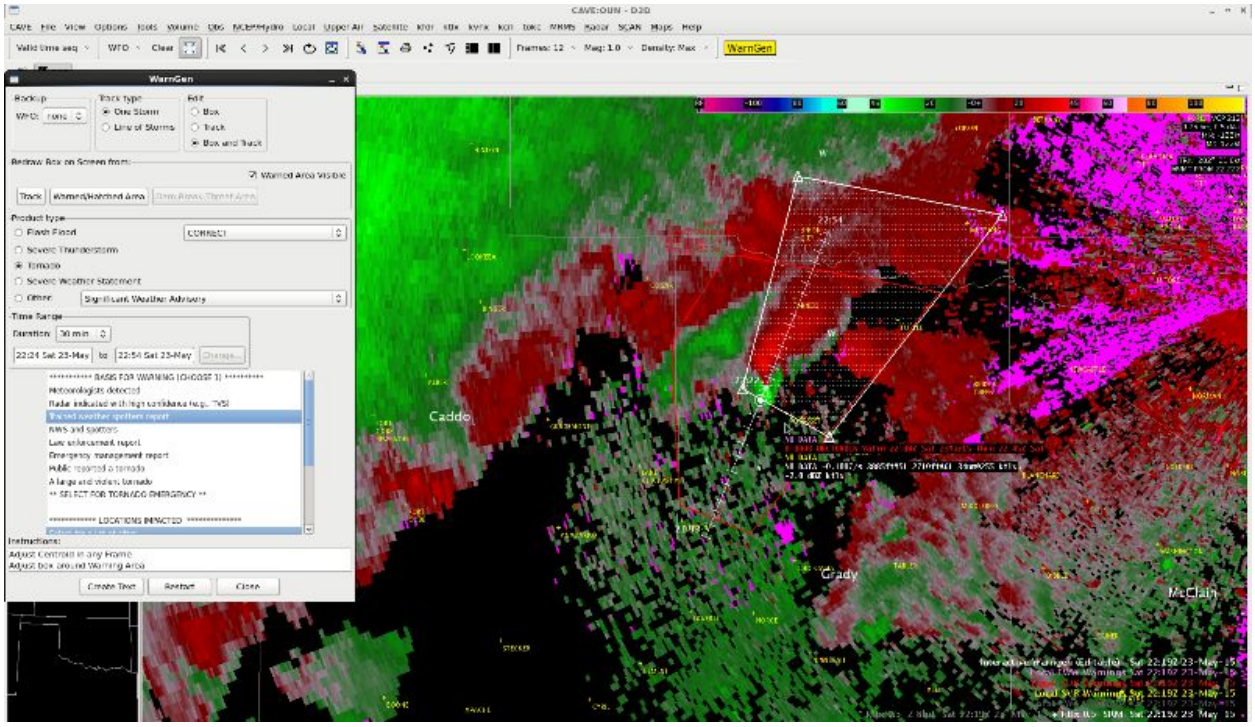

Figure 5. Example of new TOR re-issued at 2219 UTC for strengthening rotation and spotter report of tornadic storm near Pocasset in Grady County.

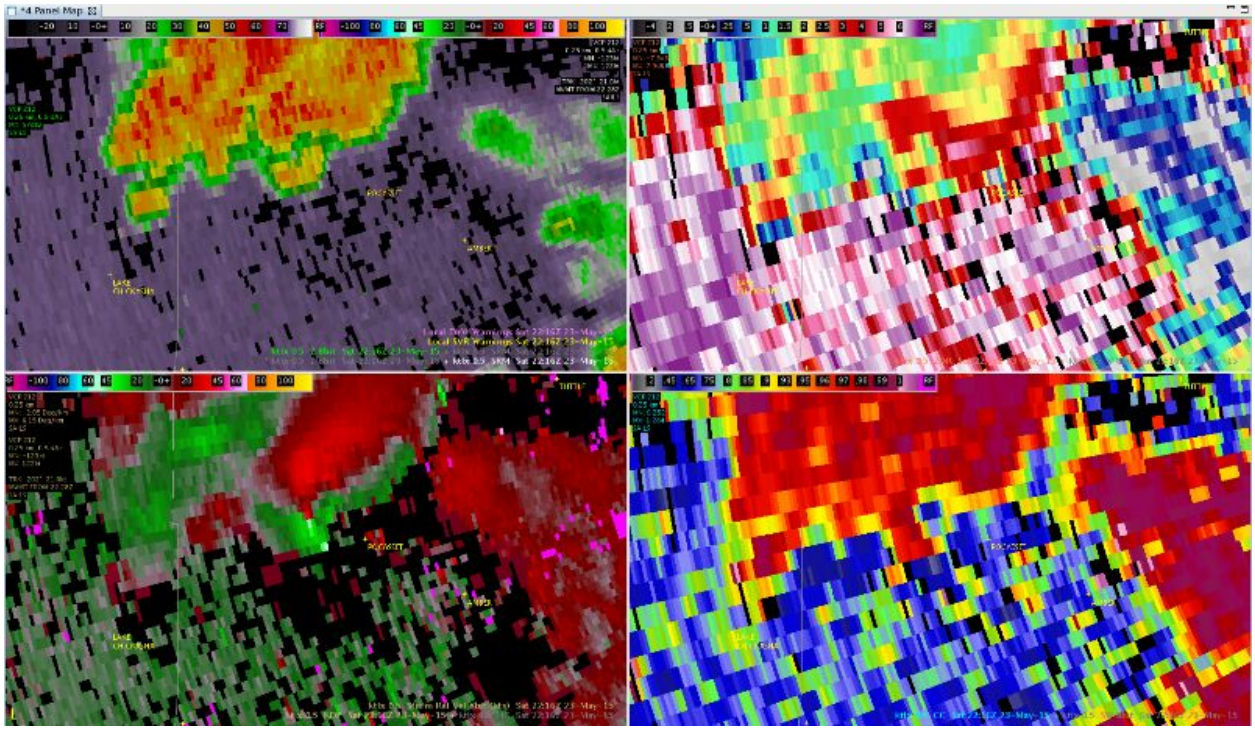

Figure 6. KTLX 4-panel 0.5 deg of (clockwise) Z/ZDR/CC/SRM at 2216 UTC from KTLX.

Questions	Evaluation Criteria
Phase 2 Warning Decision Point #3: (2316 UTC)	This is a difficult warning decision as storm characteristics are weak and ill-defined due to proximity with adjacent storms and interaction with advancing outflow boundary which undercuts inflow to the storm. In addition, structure is obscured by range folded radar data.
	In the 3 volume scans prior to 2316 UTC, the storm in northern McClain County moves north northeastward but remains disorganized. However, by 2312 UTC it develops an inflow notch and trailing appendage in 0.5 deg reflectivity. Weak convergent rotation and 35 kts of delta V @ 0.5 deg is noted in velocity data.
	By 2315 UTC, there is a report of tornado damage near Blanchard so trainee should include that information in their warning. In addition, trainee should anticipate interaction of storm's projected path of movement with an advancing gust to the north which could cut off storm's inflow.(figure 7) Thus, an example polygon suggestion for a 30 min.TOR based on the 2312 UTC radar image is shown in figure 8 (note: the warned area is confined to McClain County). By 2317 UTC (figure 9), it is becoming more apparent that the storm is weakening as it interacts with the thunderstorm cold pool outflow boundary to the north, so likely not necessary to extend new warning into Cleveland County, which might prompt officials to sound sirens for Moore and Norman.

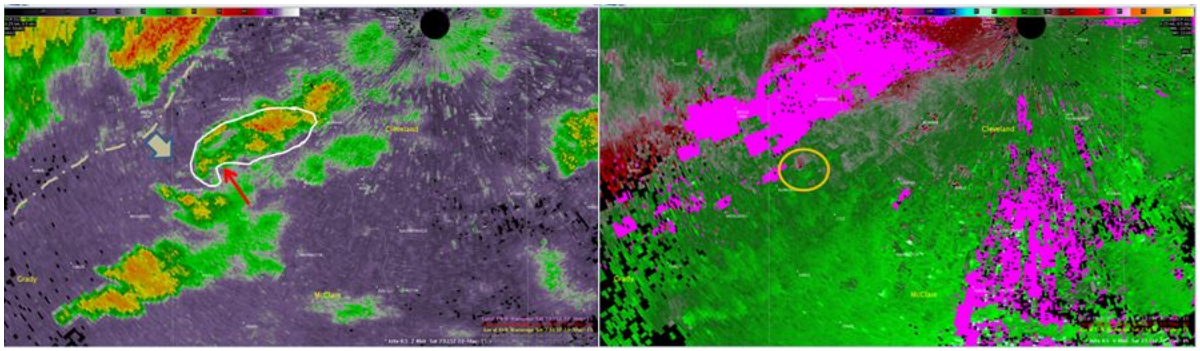

Figure 7. KTLX 0.5 deg Z/V at 2315 UTC with annotations of features as described in the text.

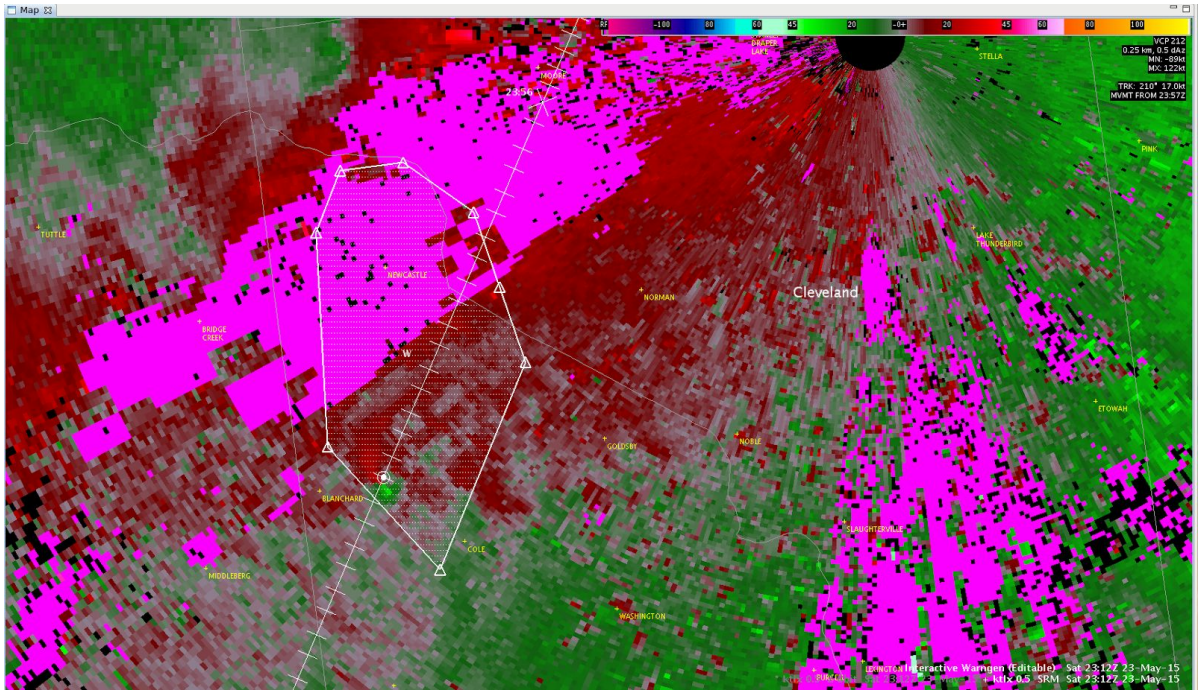

Figure 8. KTLX 0.5 deg SRM at 2312 UTC with suggested TOR warning polygon.

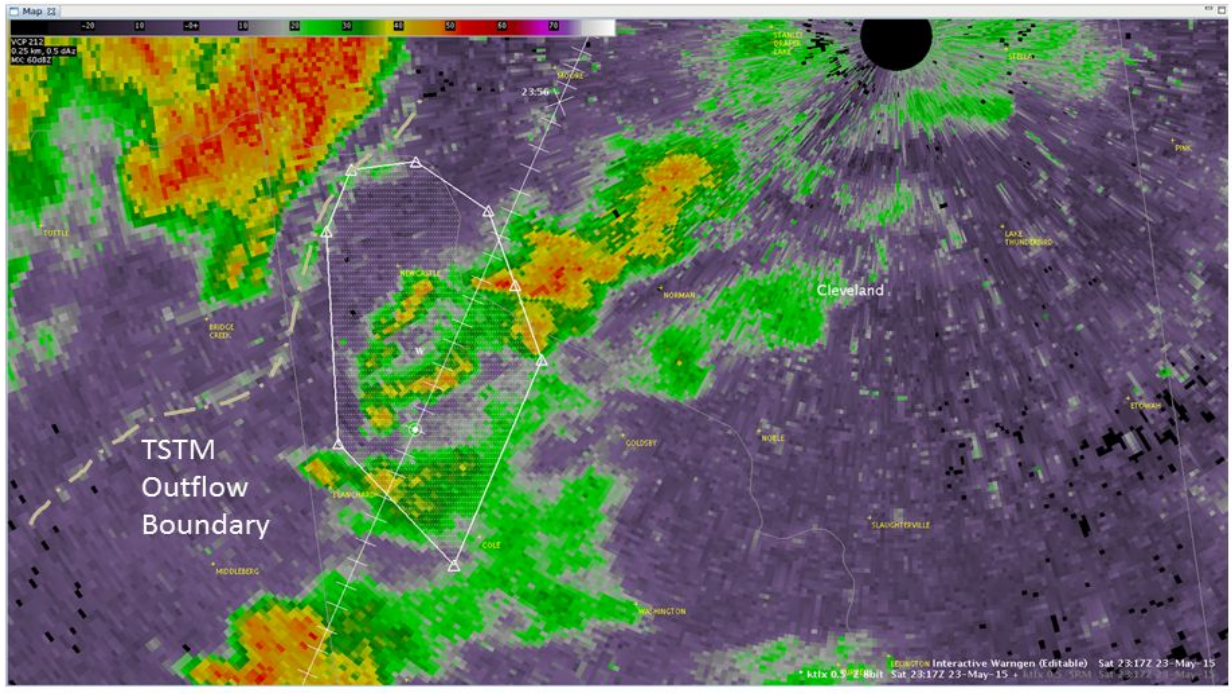

Figure 9. KTLX 0.5 deg base reflectivity (Z) at 2317 UTC showing pending interaction of warned storm with thunderstorm induced cold pool/outflow boundary to the north.

Questions	Evaluation Criteria (2330-0030 UTC)
Phase 2 Warning Decision Point #4: (0000 UTC)	With intense monitoring beginning at 2330 UTC, trainee should be able to pick out three rotating storms clustered in close proximity moving north-northeastward and intensifying across northern Garvin County (figure 10). Storm #1 (furthest south) is about to move out of Stephens County into southwestern Garvin County. Interrogation of Storm #1 from 2333-2338 UTC shows a hook echo, pronounced three-body scatter spike at 3.1 deg and 4.0 degrees, 56 kts of delta V, 65 dBZ to 22.4 kft, and a 20 kft deep mesocyclone. Storm top is 44 kft. By 2338 UTC, storm #1 is worthy of a tornado warning (figure 11). Storm # 1 produces an unverified report of a tornado 7 miles E of Velma at 2337 UTC. Storm #2 (just northeast of Antioch) also has developed an inflow notch, is highly tilted, and has weak rotation at 0.5 deg (31 kts GTG shear at 1.3 deg) but only 13 kft deep rotation. By 2348 UTC , trainee should recognize increasing tornado potential for this storm and be monitoring very closely for a tornado warning (figure 12). By 2354 UTC (figure 13) , Storm #2 has 60 kts GTG shear at 1.8 deg, showing increasing acceleration into the updraft, and a deepening mesocyclone to 20 kft. This would be a good time to issue a TOR for Storm #2 but with Storm #3 also showing signs of persistent low-level rotation, you should consider drawing a polygon that captures both threats (figure 14).
	By 2359 UTC, with the tornado warning hopefully already out, you should be able to issue a SVS indicating a possible tornado debris signature (TDS) for basis (figure 15). By 0005 UTC, you'll receive the Joe Carter

	spotter report for tornado east of Maysville, and subsequently Storm #2 occludes/weakens, but Storm #3 NW of Maysville stays strong. By 0005-0010 UTC, you will likely need to re-issue your TOR on the basis of reports and the two circulations still ongoing (figure 16). By 0018 UTC, Storm #2 and #3 have merged and circulations have weakened, but note there is now a new tornadic storm with a well-defined appendage in southern Pottawatomie County (figure 17).

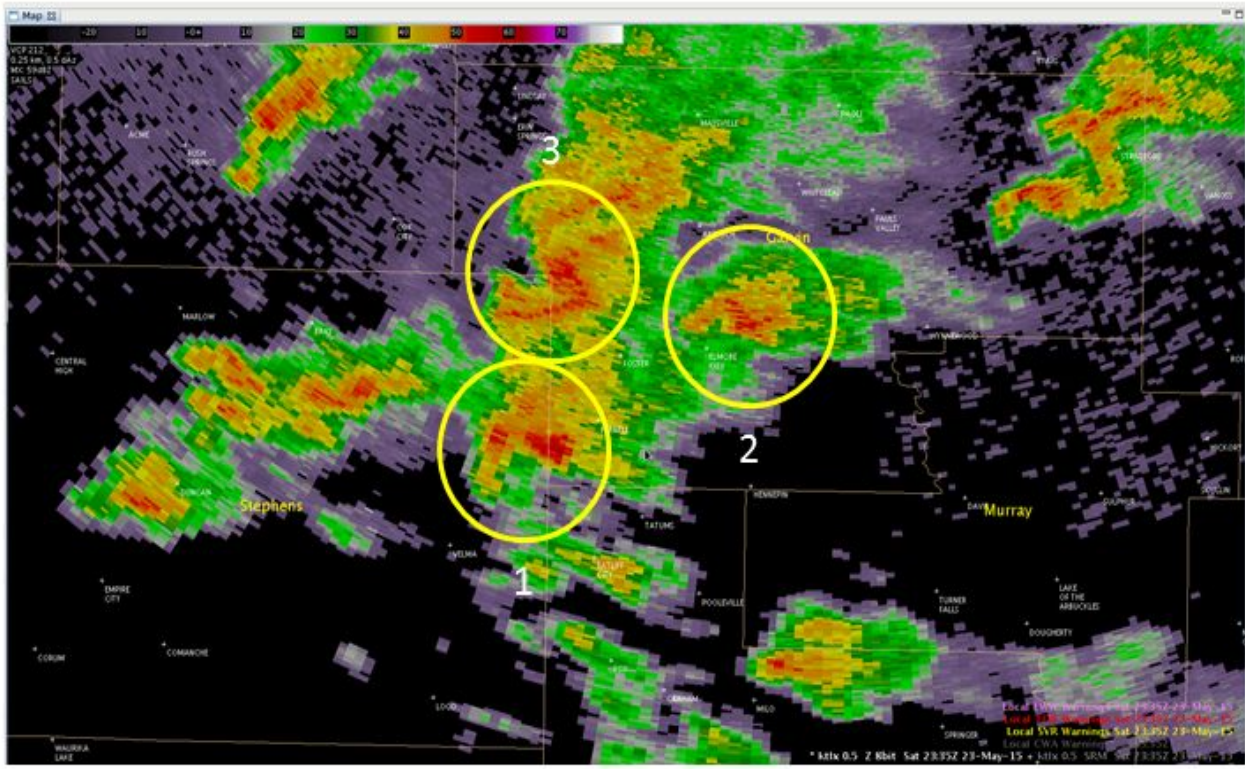

Figure 10. Storm #1, Storm #2, and Storm #3 at 2335 UTC.

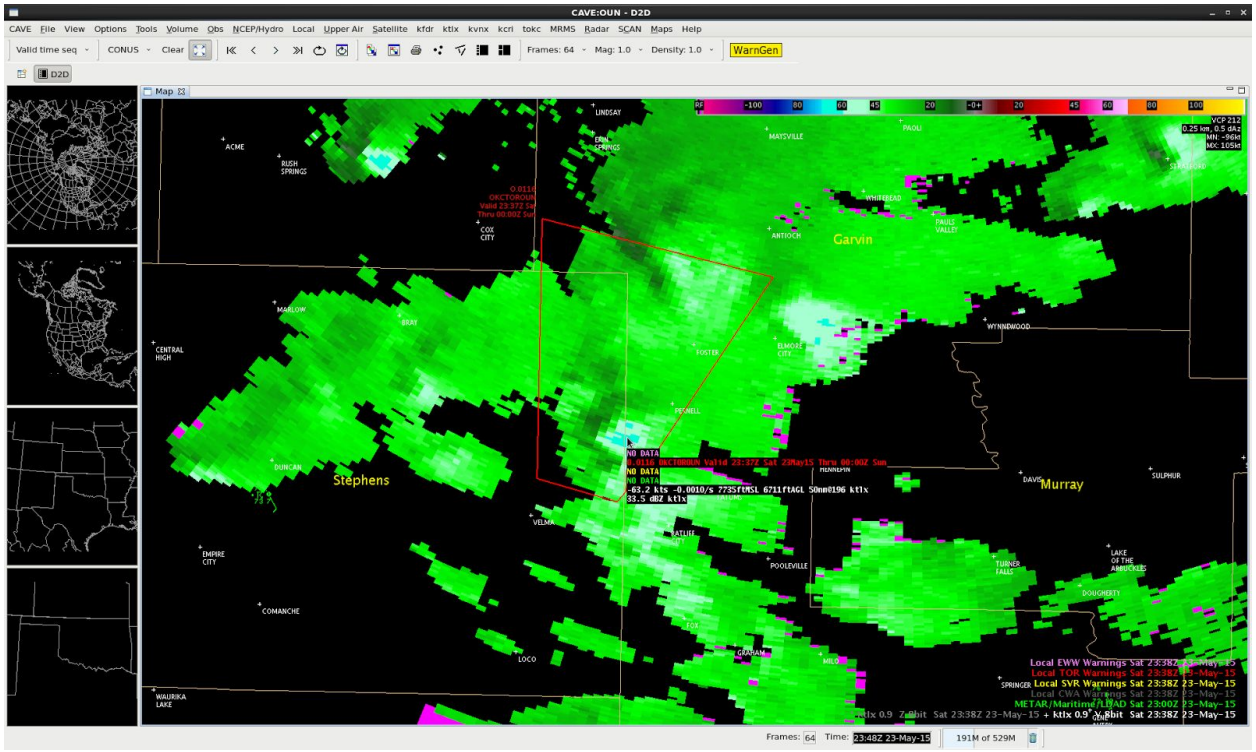

Figure 11. KTLX 0.9 deg V at 2338 UTC.

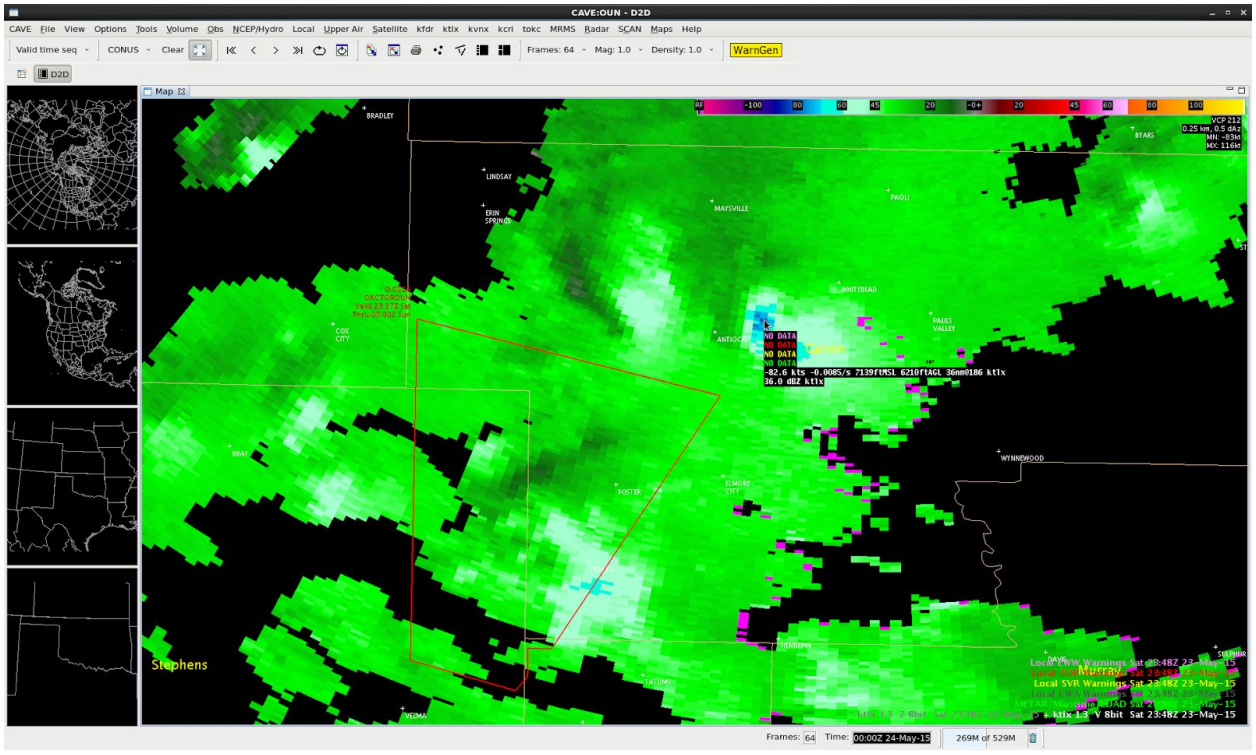

Figure 12. KTLX 1.3 deg V at 2348 UTC. Cursor sampling readout indicates developing tornadic storm northeast of Antioch.

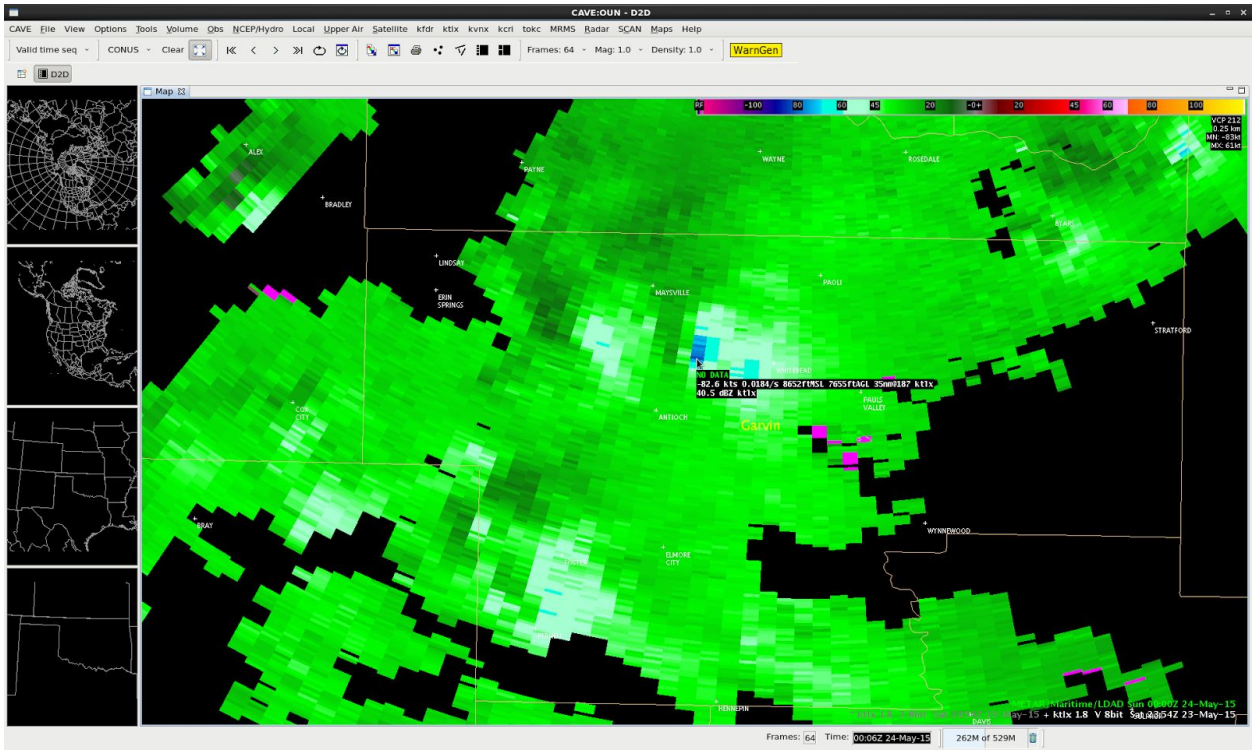

Figure 13. KTLX 1.8 deg V at 2354 UTC. Cursor sampling readout indicates developing tornadic storm northeast of Antioch.

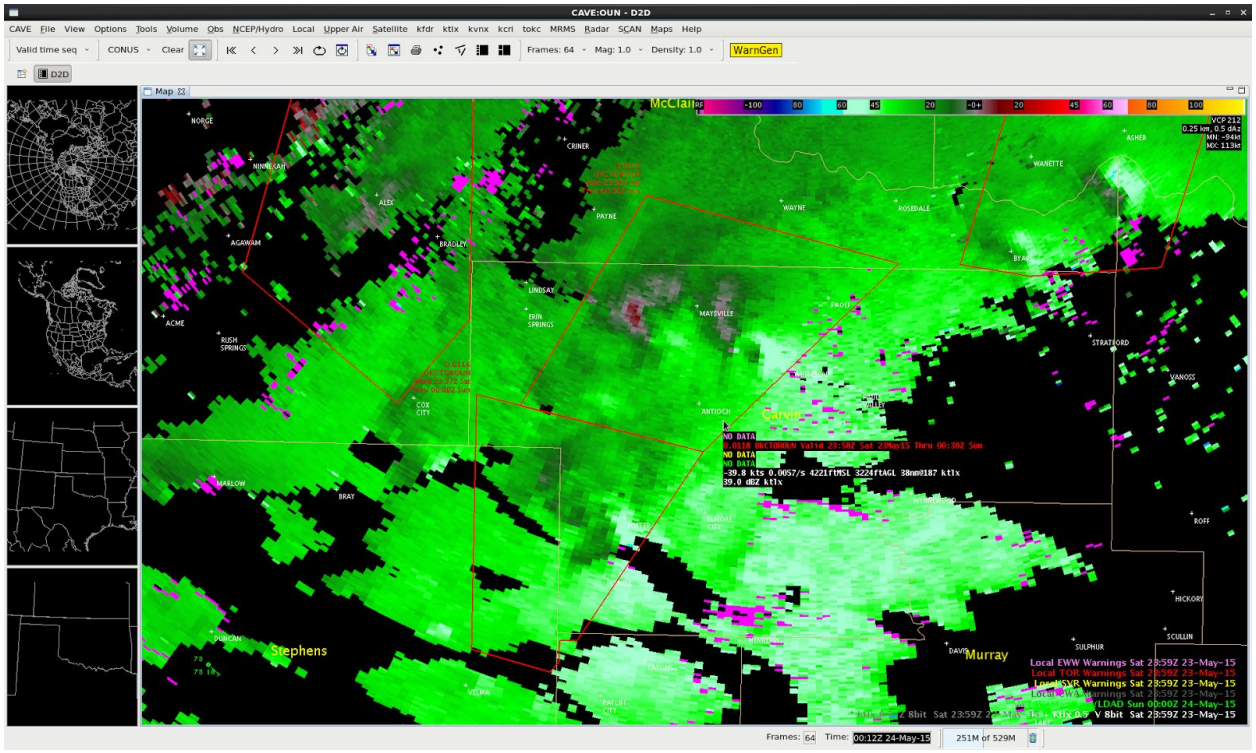

Figure 14. KTLX 1.8 deg V at 2359 UTC showing polygon capturing two threats in close proximity southwest and southeast of Maysville in northern Garvin County.

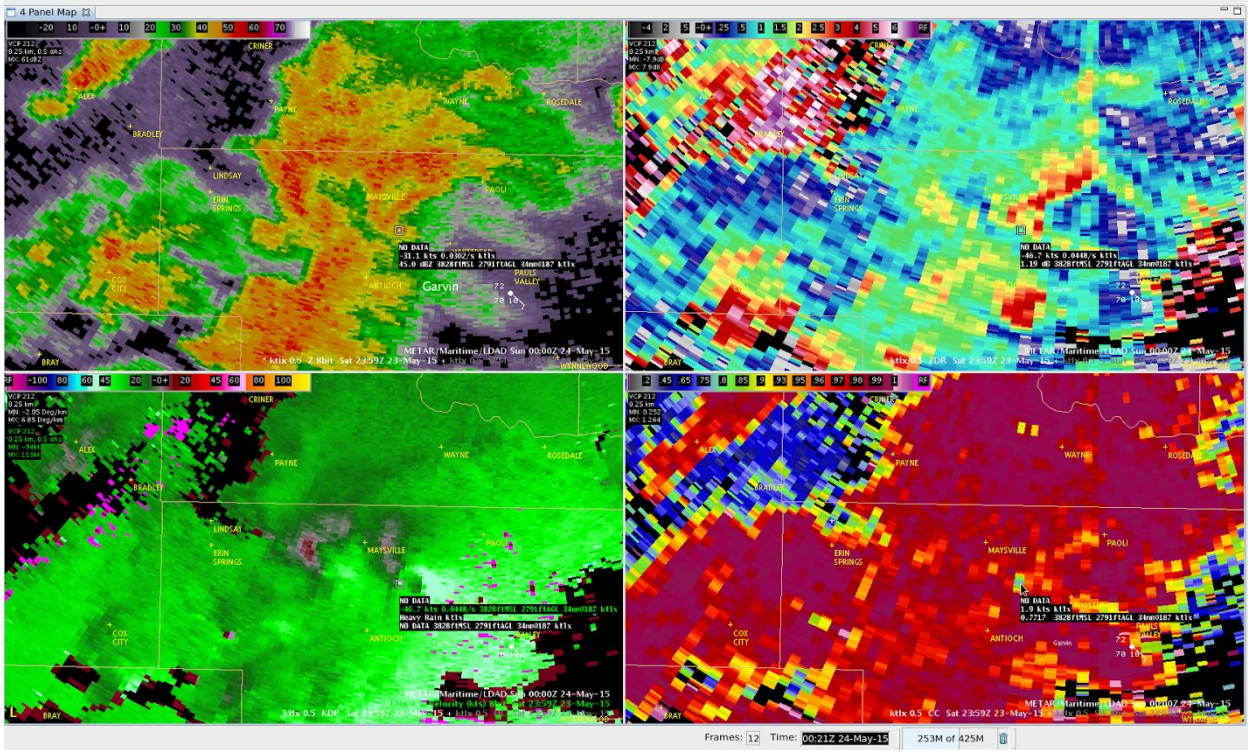

Figure 15. KTLX 0.5 deg 4-panel of (clockwise) Z, ZDR, CC, and V at 2359 UTC.

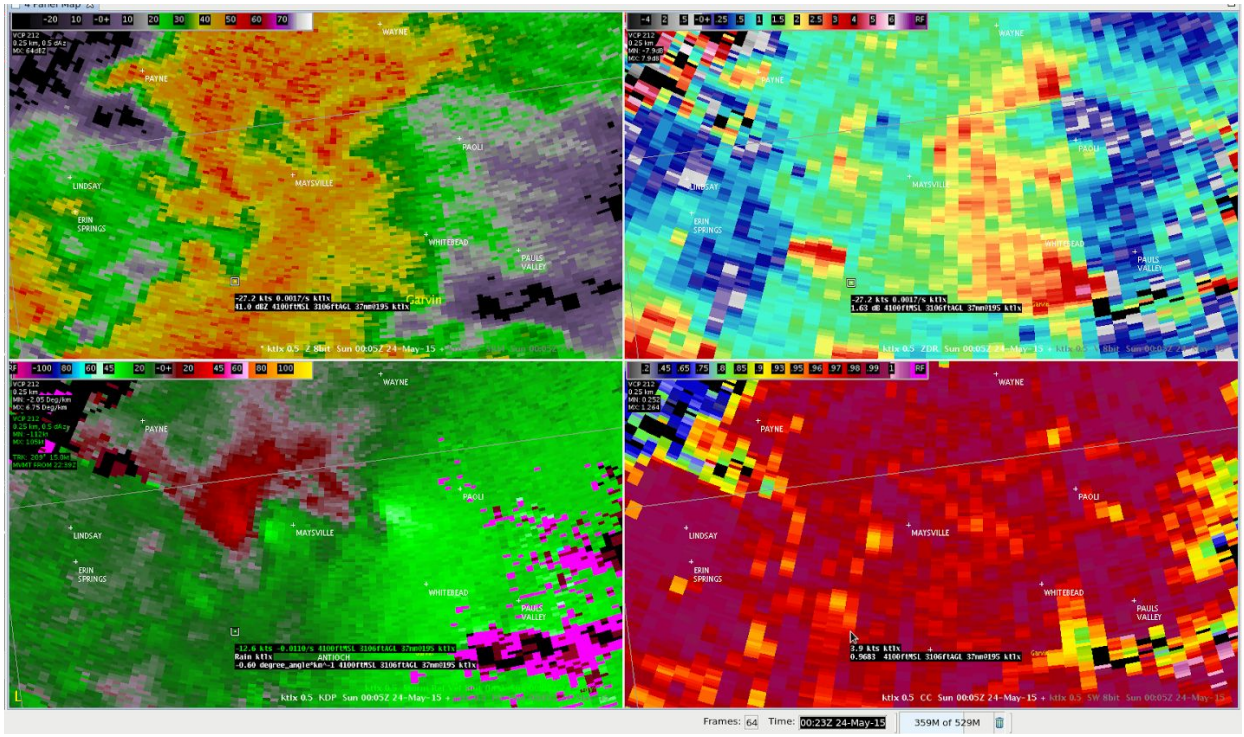

Figure 16. KTLX 0.5 deg 4-panel of Z, ZDR, CC, and SRM at 0005 UTC.

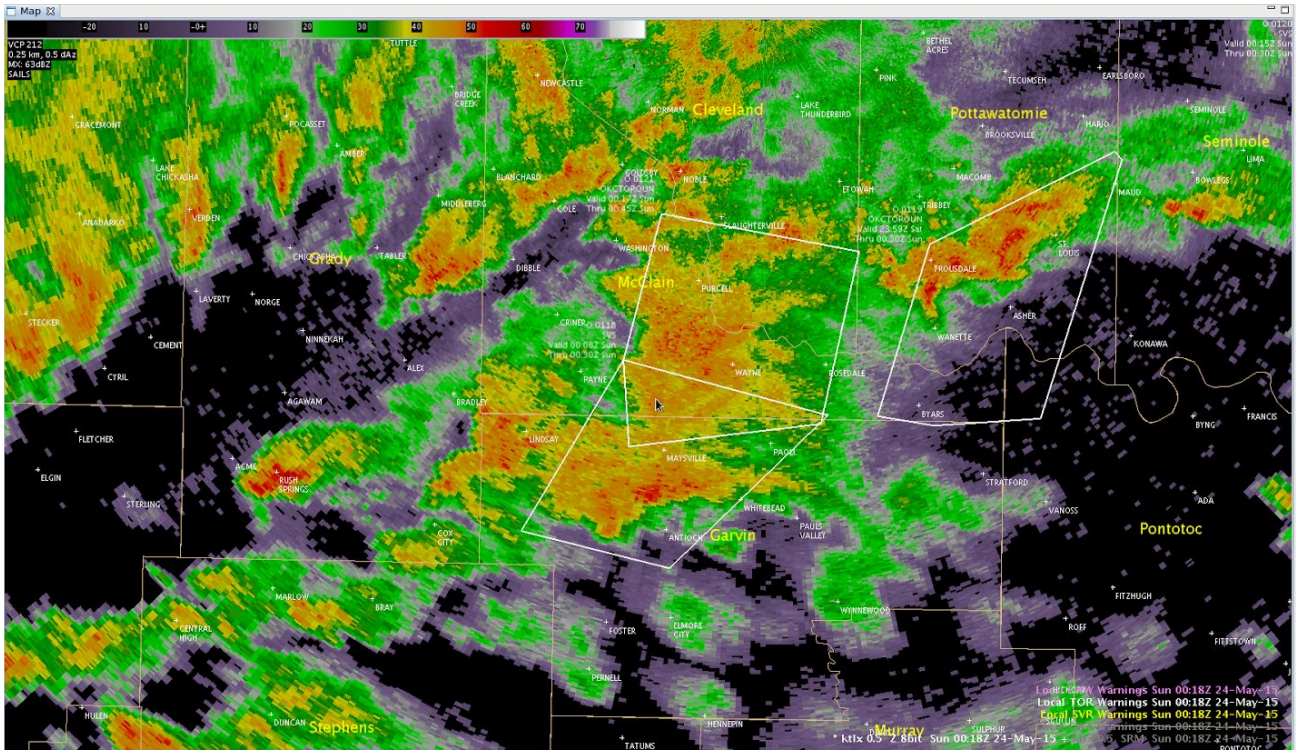

Figure 17. KTLX 0.5 deg Z at 0018 UTC with OUN tornado warnings overlaid.

Questions	Evaluation Criteria
Phase 3 Decision Support Question #1 (0039 UTC)	A measured response requires inspection of the storm in Pottawatomie County which has been severe (TOR issued) from 0021-0037 UTC (figure 18) and it showed signs of weak rotation SE of Brooksville at the time of report. However, the report said the person was at Earlsboro where according to the current radar data, nothing is going on. So, it could be that the person is not actually in Earlsboro but situated further southeast looking toward Earlsboro. Or, since there is a storm over Seminole (3 miles E of Earlsboro), they could be seeing some low clouds associated with that storm. In either case, since the LCLs are extremely low (~ 500 m AGL), the picture report of a low cloud they are calling tornado is unverified and needs to be investigated. Note that there likely should be a tornado warning out for the storm near Brooksville. Proper response via Twitter is to ask the person where they are located and if the cloud is rotating. Finally, thank them for the tweet and ask them if they can keep tweeting.

Phase 3 Decision Support Question #2 (0055 UTC)	The first step in addressing this support is to geolocate the source. The cursor shown in figure 19 is the intersection of Highway 177 and Little River. The location is just southeast of Brooksville, where a storm had some persistent trailing appendage consistent with low-level rotation previously from 0034-0047 UTC (see figures 20, 21). By 0050 UTC, the rotation has persisted but broadened as the updraft portion of the storm crossed highway 177 (figure 22), which should be part of the guidance. By 0055 UTC (figure 23), the storm has merged with adjacent storms and rotation has weakened (figure 24). Any warning associated with this storm should be allowed to expire by 0100 UTC due to the weakening trend and due to the fact that the outflow boundary and leading edge of cooler air is approaching as per the archived WFO OUN TOR #0123 overlaid. Guidance to EM should relay the specificity of this weakening trend.
Phase 3 Decision Support #3 (overnight forecast for OKC metro)	By 0100 UTC the leading edge of the line of showers and thunderstorms with very heavy rain extends from southwest Oklahoma through central Oklahoma and northward into central Kansas (see figure 25). Severe storms (occasionally producing brief tornadoes) are still occurring in TSA's CWA east of the line in Okfuskee County and Latimer County. There is one SVR still in effect for a line of stronger storms across the extreme northern parts of OUN's CWA in eastern Osage/western Washington counties. Over the past 30 minutes, there has been a slight decrease/weakening trend for severe activity as discrete storms have become engulfed by the advancing outflow boundary in central OK. The OKC metro area is experiencing periods of intense rainfall with One Hour Precipitation (OHP) amounts estimated by KTLX radar showing pockets of 2.0 - 2.5 in/hr over central OK in strongest convection which are starting to move back over the metro especially across southern Oklahoma County, Cleveland County and Pottawatomie County (figure 26). Storm Total Precipitation (STP) product at 0058 UTC (figure 27) shows portions of Oklahoma/Northern Cleveland County have already received 1.5 to 2.0 inches since 1800 UTC, so with 1 hr Flash Flood Guidance (FFG) at <1.0 in over the metro, expect additional rain from the

	storms moving back northward into Norman and the OKC metro to cause extensive flash flooding. The GFS model was already forecasting a large 4 inch closed contour maxima of accumulated rainfall by 1200 UTC 24 May over Cleveland/McClain Counties (figure 29). But, due to the observed training of storms over Norman/OKC metro and very high rainfall rates, one should predict even higher amounts than the model QPF. In fact, during the next hour, rainfall rates would increase to 2.5 in to 3.0 inches per hour over Cleveland County producing flooding of 6-7 inches in Norman and vicinity (figure 30). Intensification of storms training over the same area with resultant very heavy rates dramatically increased **after 0100 UTC** in Norman as storms moved back into the area from the southwest. This is a key predictive trend. So, main hazard message for the OKC metro should be extensive (potentially life threatening) flash flooding due to the already saturated conditions, but no more tornadoes.

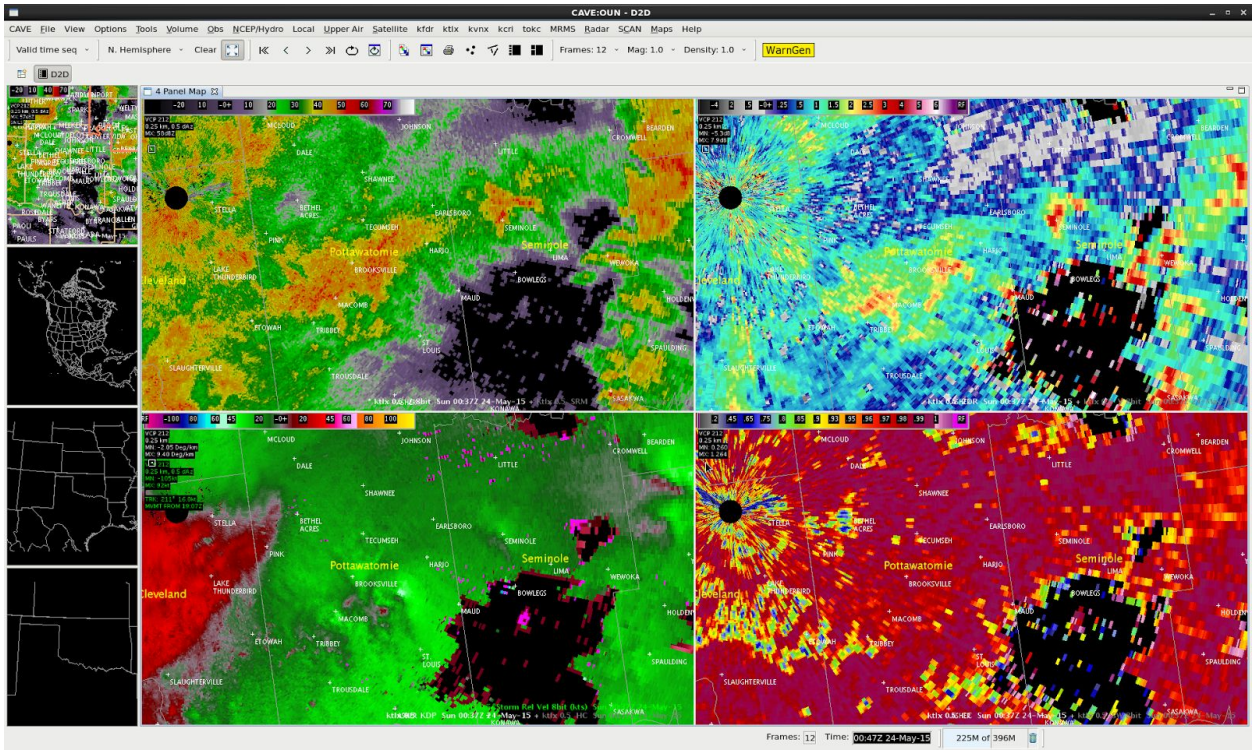

Figure 18. KTLX 0.5 deg 4-panel of Z, ZDR, CC, and SRM at 0037 UTC.

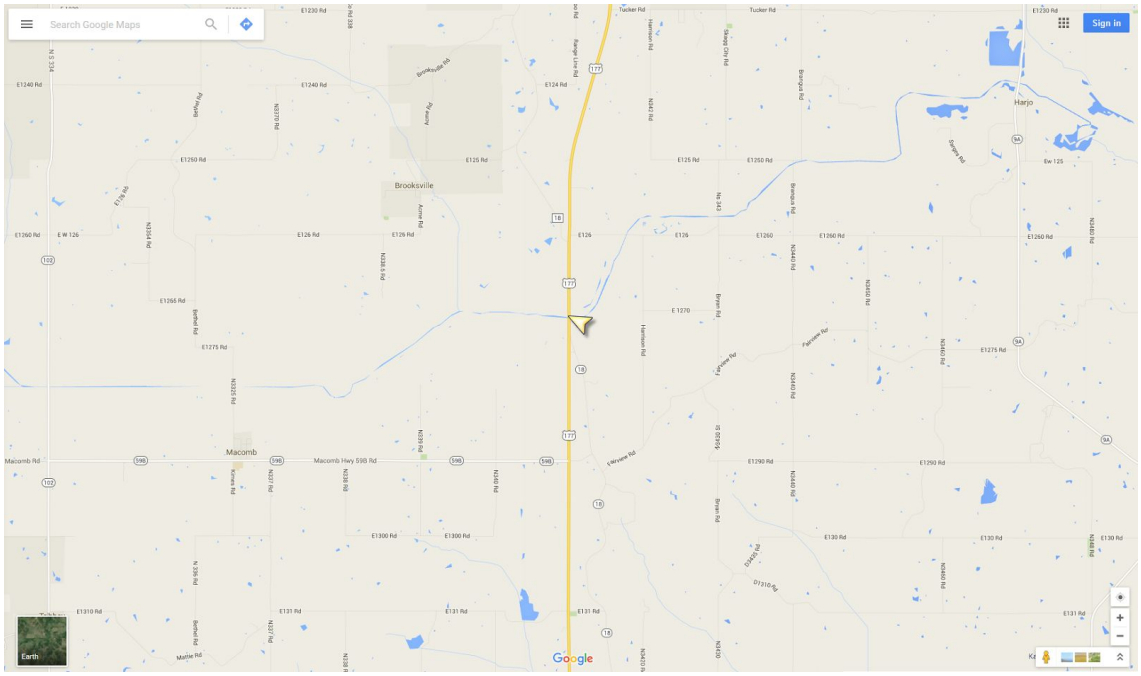

Figure 19. Google map location referenced in Decision Support question #2.

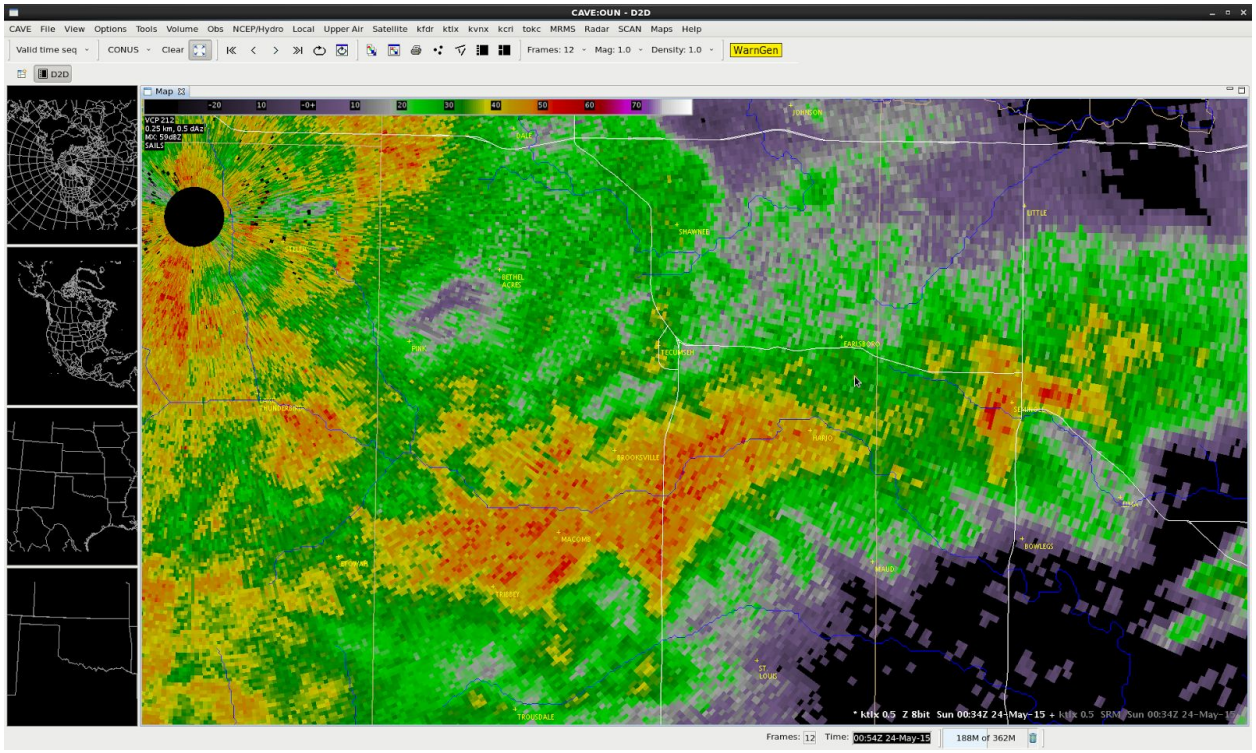

Figure 20. KTLX 0.5 deg Z at 0034 UTC.

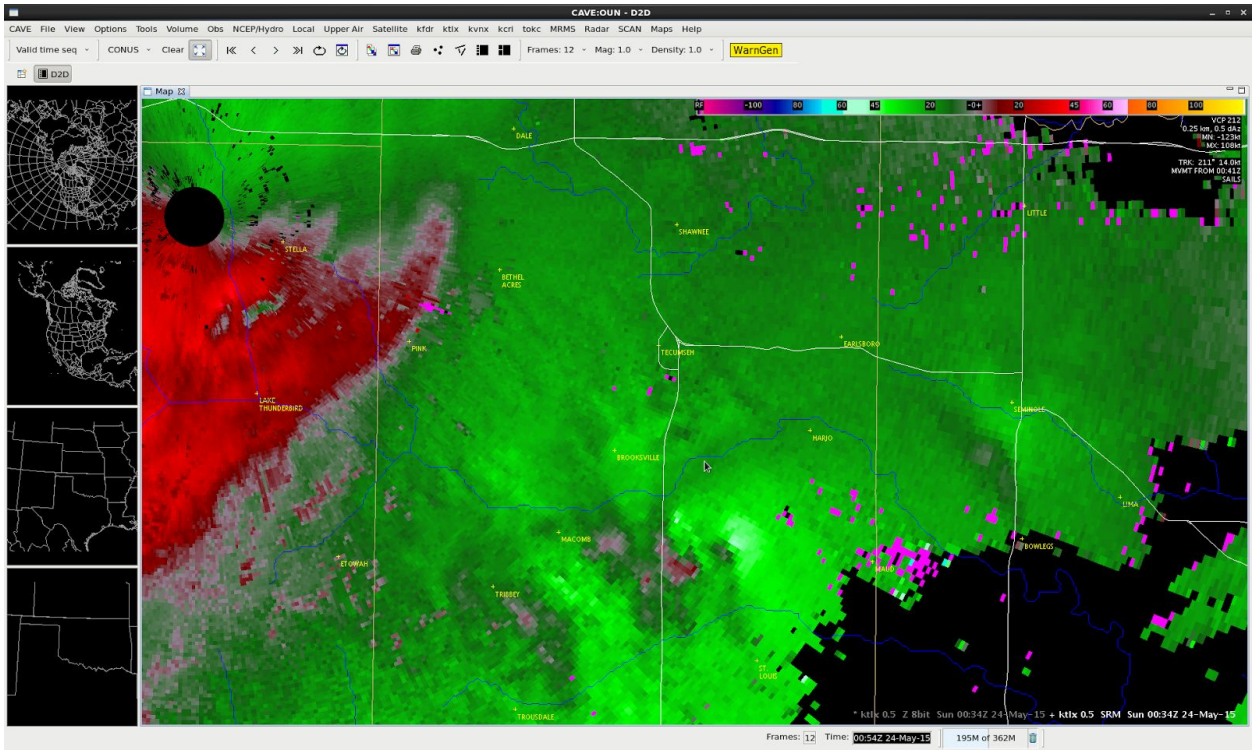

Figure 21. KTLX 0.5 deg SRM at 0034 UTC.

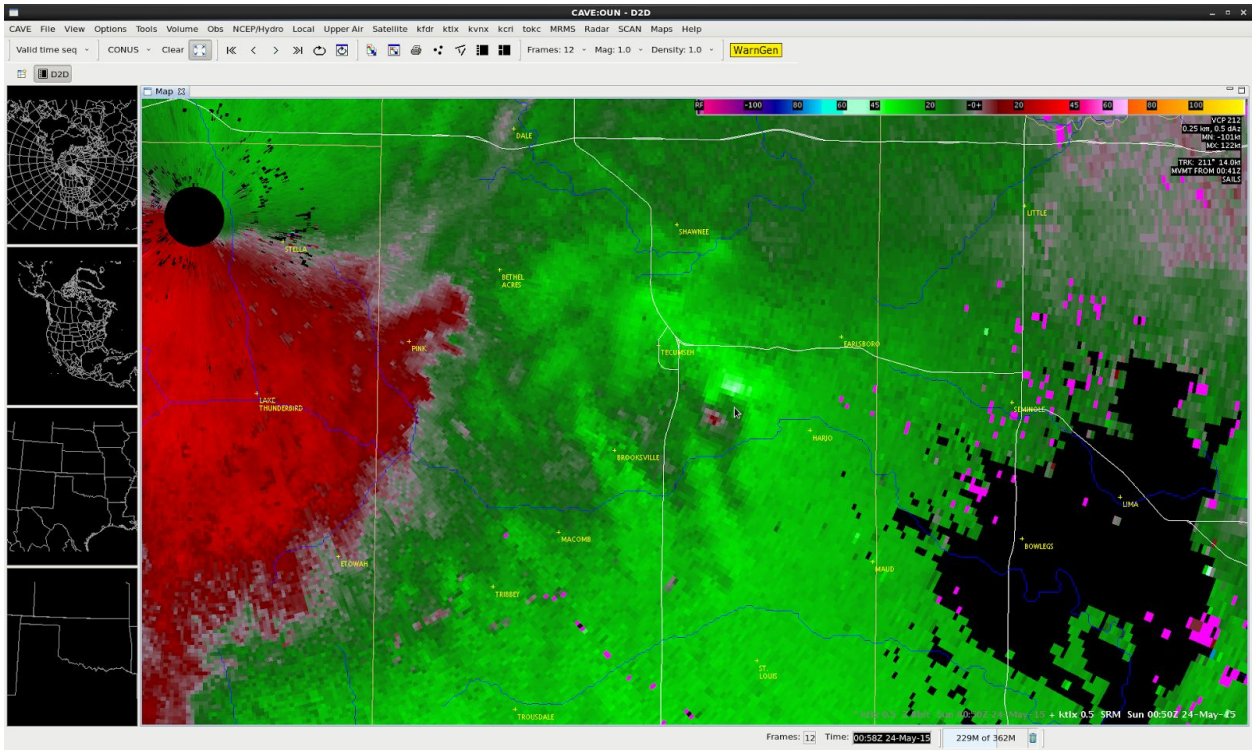

Figure 22. KTLX 0.5 deg SRM at 0050 UTC.

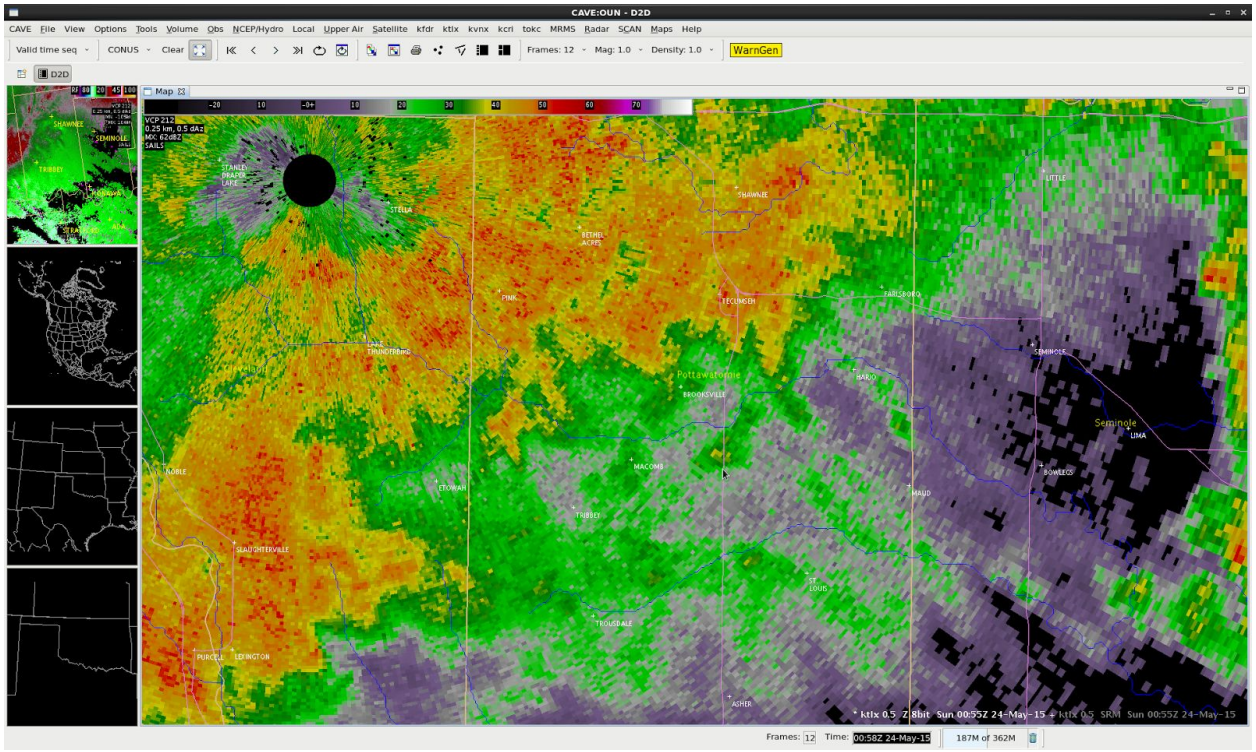

Figure 23. KTLX 0.5 deg Z at 0055 UTC.

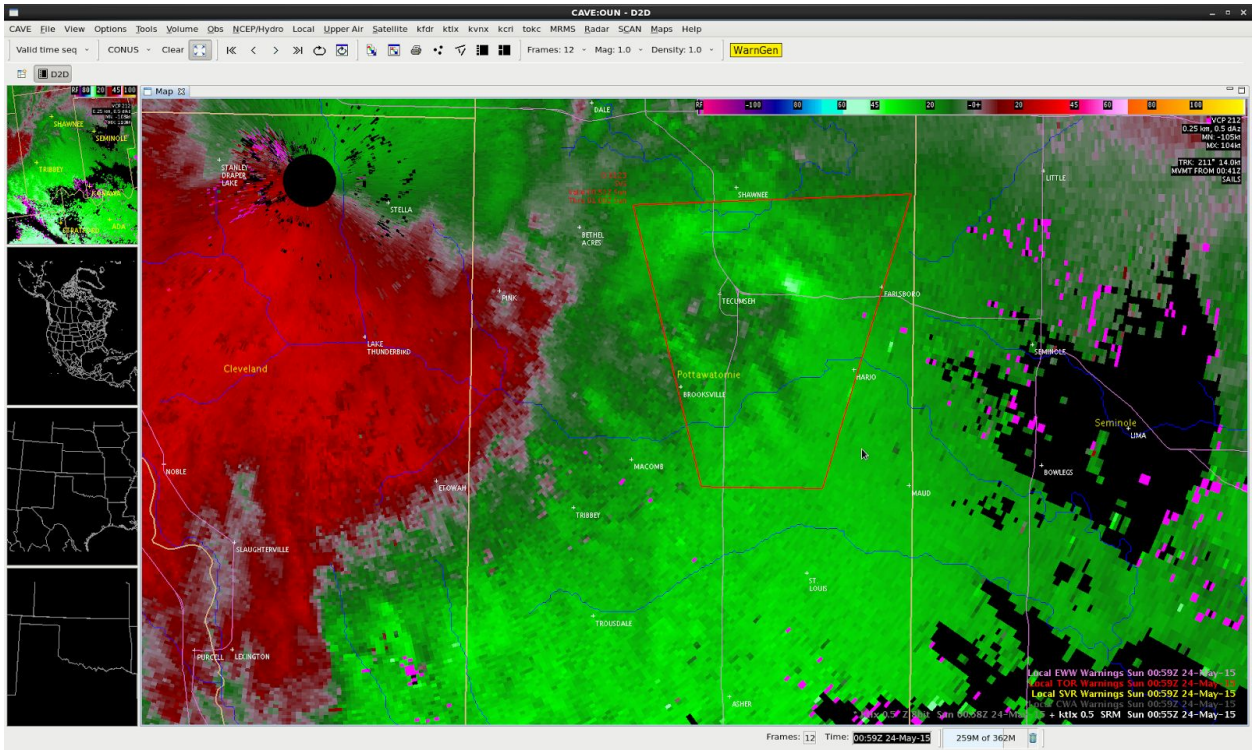

Figure 24. KTLX 0.5 deg SRM at 0055 UTC with OUN warning overlaid.

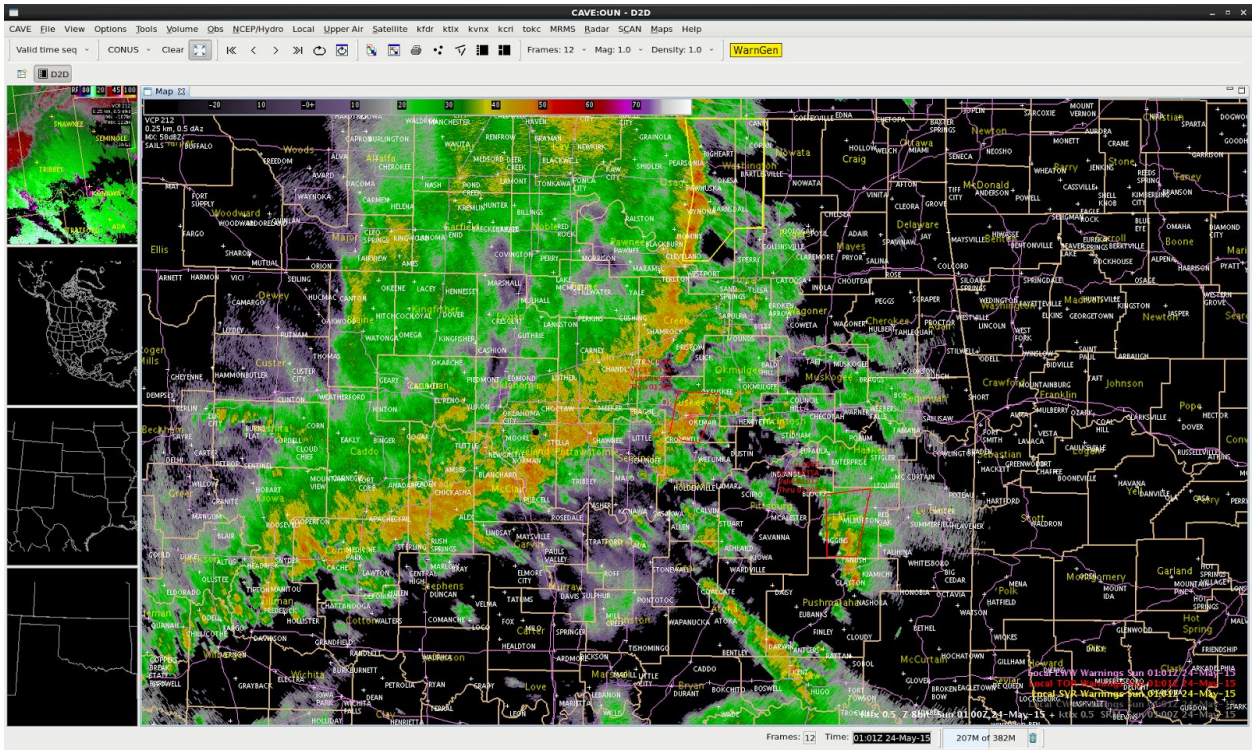

Figure 25. KTLX 0.5 deg Z at 0100 UTC with OUN/TSA warnings overlaid.

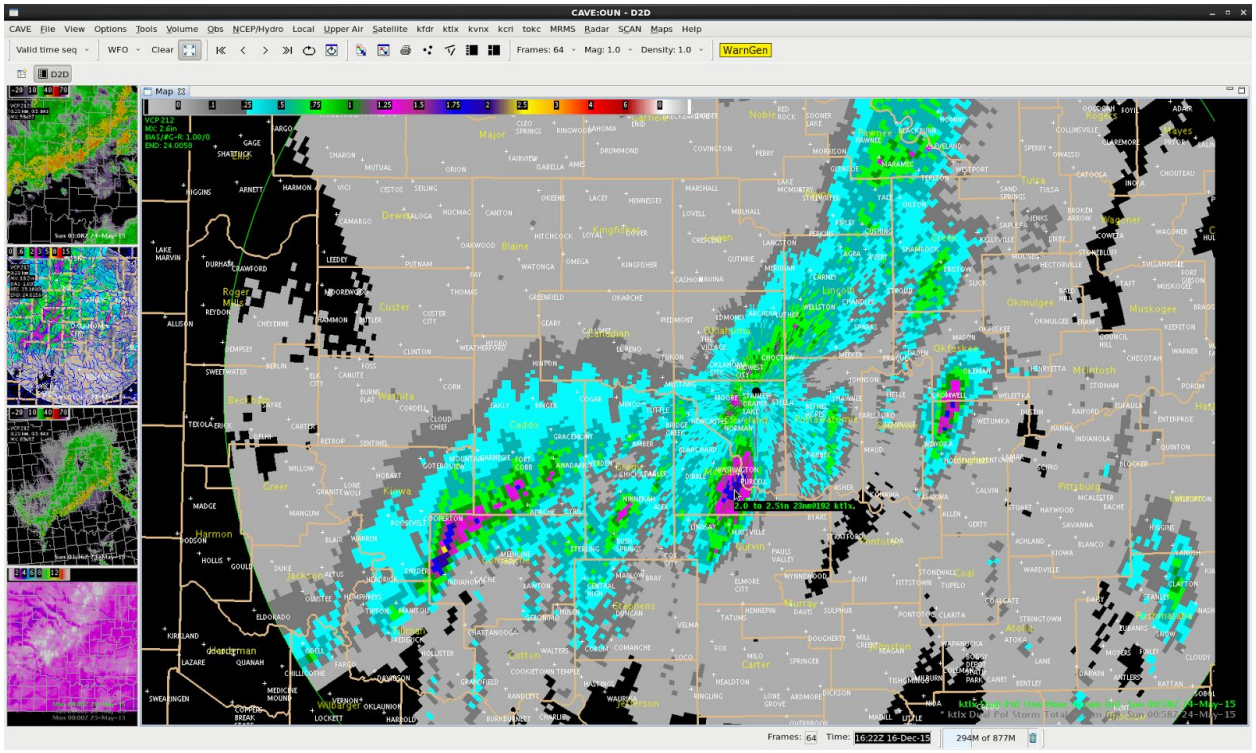

Figure 26. KTLX Dual Pol One Hour Precip (OHP) Accumulation (in) at 0058 UTC with cursor readout just south of Purcell in McClain County (12 miles south of Norman).

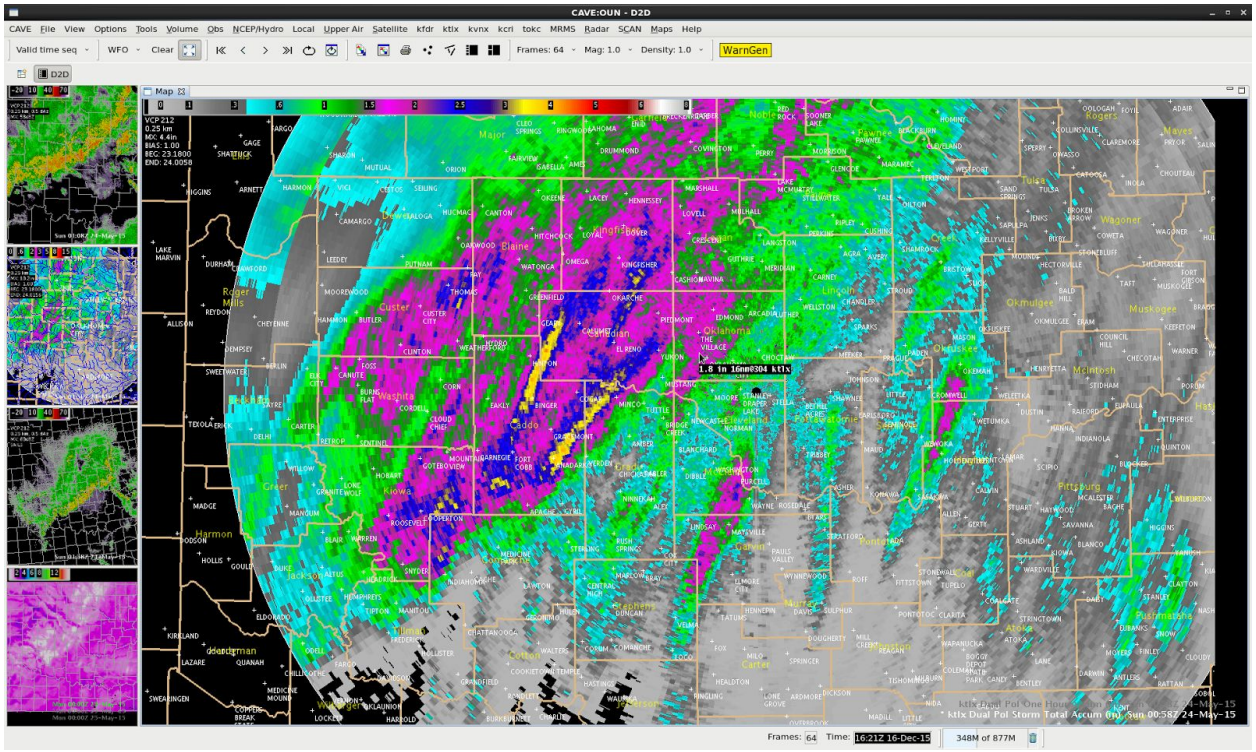

Figure 27. KTLX Dual Pol Storm Total Precip (STP) accumulation (in) from 1800 to 0058 UTC with cursor readout over southern Oklahoma County (Oklahoma City).

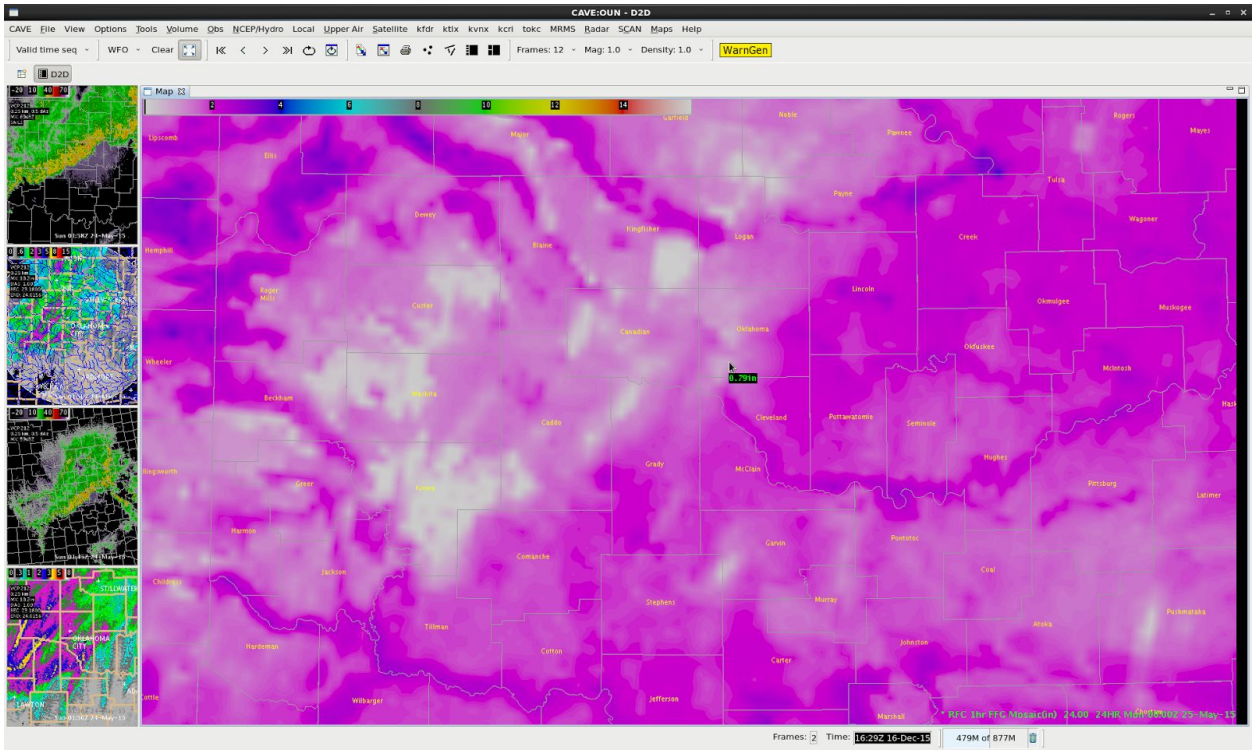

Figure 28. One-Hour Flash Flood Guidance (FFG) with cursor readout over southern Oklahoma County.

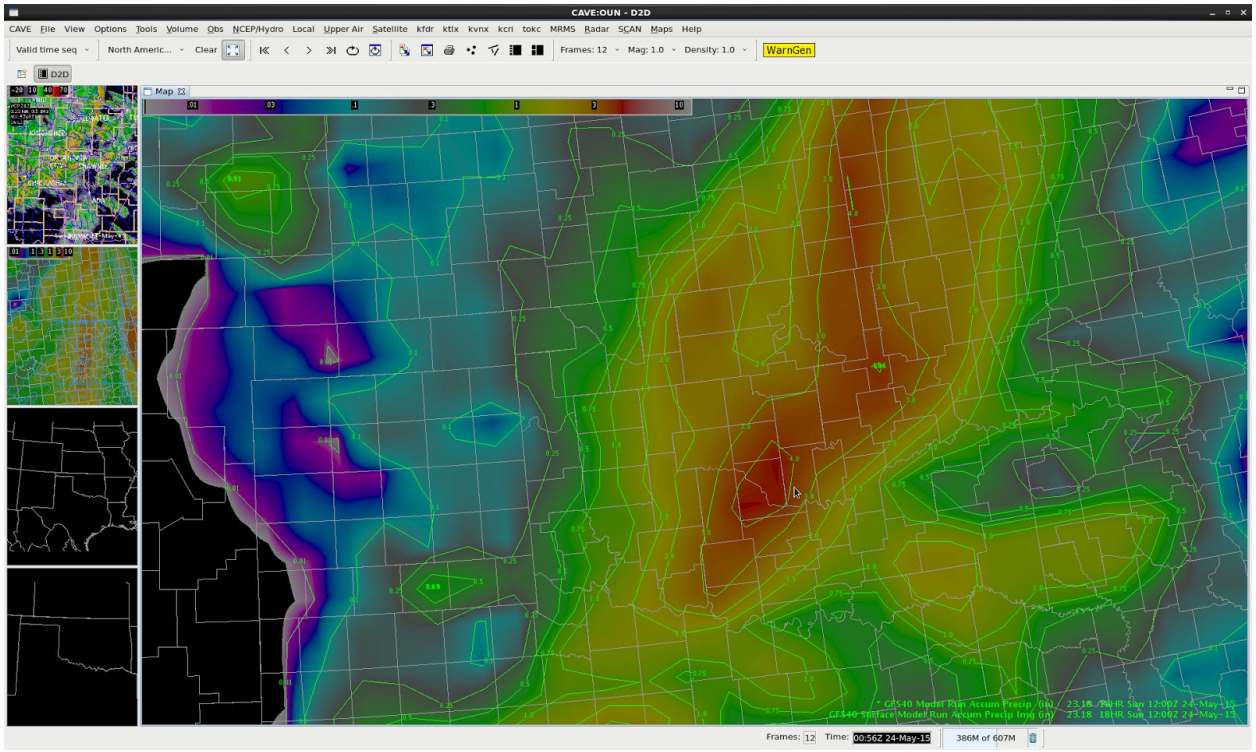

Figure 29. GFS40 Model Run Accumulation Precipitation 18hr Forecast ending at 1200 UTC 24 May 2015.

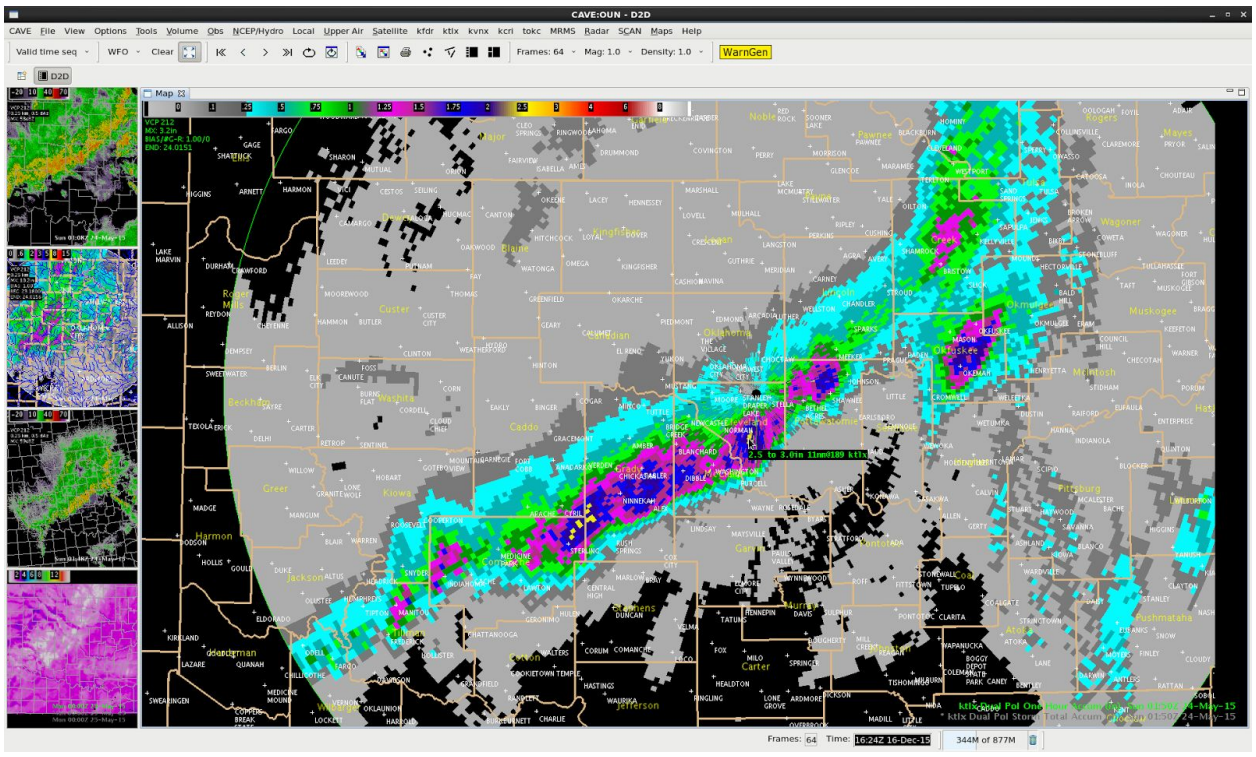

Figure 30. KTLX Dual Pol One Hour Precip (OHP) Accumulation (in) at 0150 UTC with cursor readout over Norman (Cleveland County).

Appendix

Additional storms of interest in the simulation (not with prescribed warning decision points):

Time / Location	Radar/Verification
2249-2254 UTC near Sulphur in Murray County	Pre-warning signatures are velocity couplet increasing to 38 kts of Vr at 0.5 degree with possible BWER at 2254 UTC. Produces an EF0 tornado 1.0 mi N of Sulphur from 2259 UTC to 2307 UTC.
2315-2330 UTC south of Sasakwa in extreme southern Seminole County	Well-defined couplet increasing to 40 kts delta-v at 0.5 deg with a BWER at 2325 UTC (figures 31,32). Produces an EF1 tornado from 2326-2333 UTC..
0000-0012 UTC north of Holdenville in western Hughes County.	Produced a brief EF0 tornado 2.0 m N of Holdenville at 0013 UTC (figure 33).

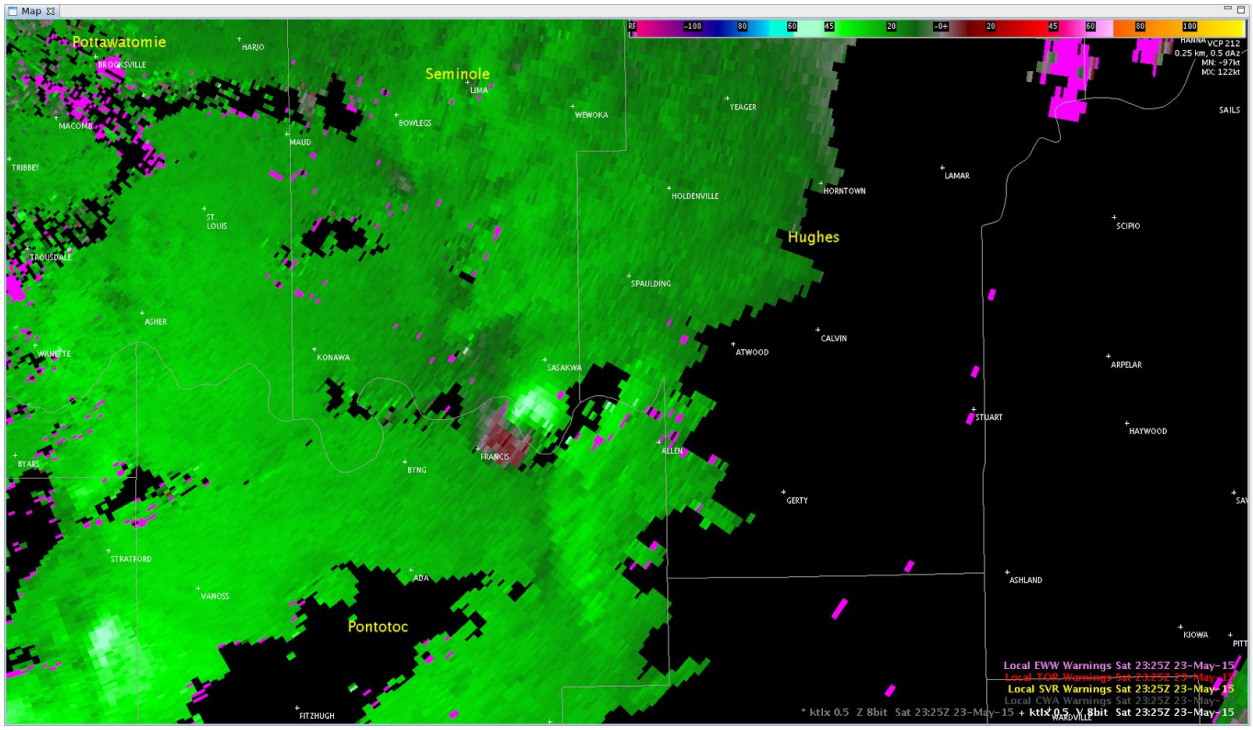

Figure 31. KTLX 0.5 deg V at 2325 UTC.

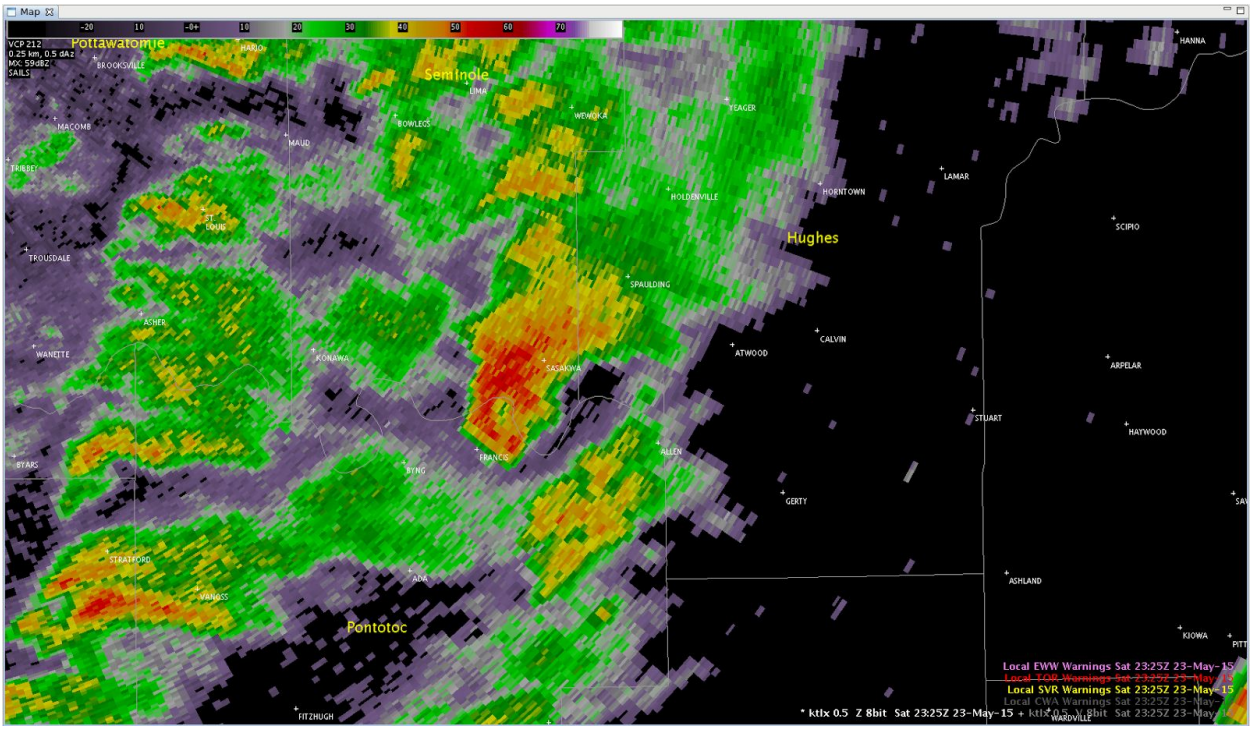

Figure 32. KTLX 0.5 deg Z at 2325 UTC.

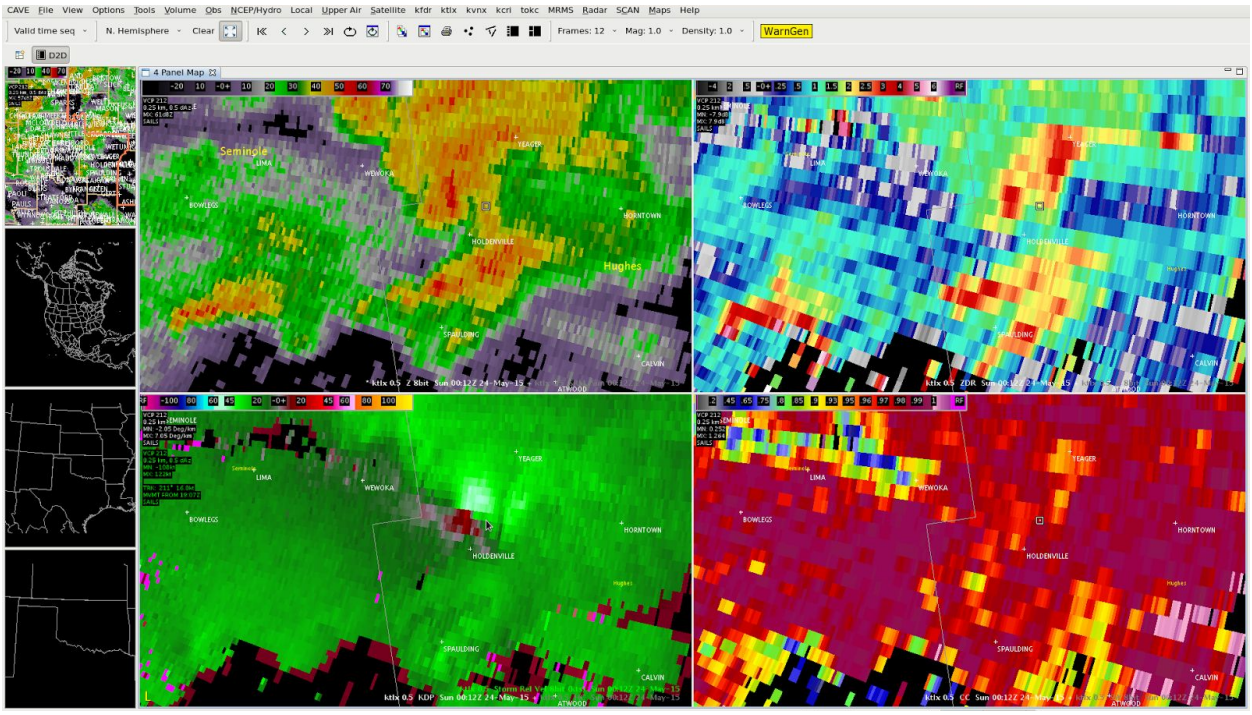

Figure 33. KTLX 0.5 deg 4-panel of Z/ZDR/CC/SRM at 0012 UTC.

Selected May 23, 2015 Storm Images/Damage Photos (courtesy of Chris Spannagle, Jim Ladue, Joshua Leach, and NWS Norman.)

Tornado damage near Pocasset (Grady County.

Tornado near Maysville (Garvin County).

Tornado 3.4 E of Maysville.

Tornado near Maysville.

Flash flooding in Norman.

Flash flooding in Oklahoma City at Penn Square Mall.