



NATIONAL WEATHER SERVICE

Building a Weather-Ready Nation

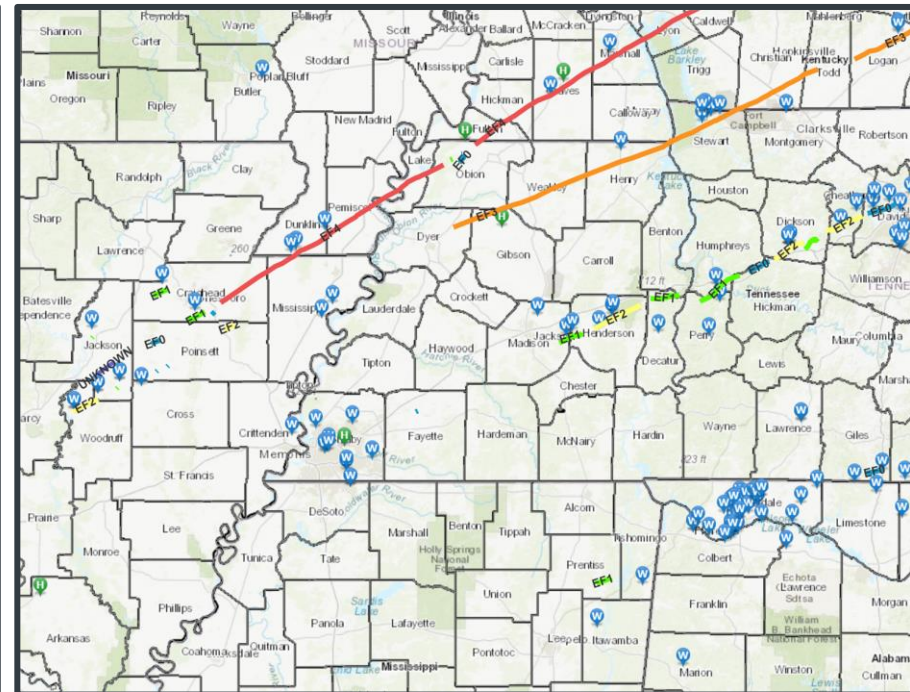
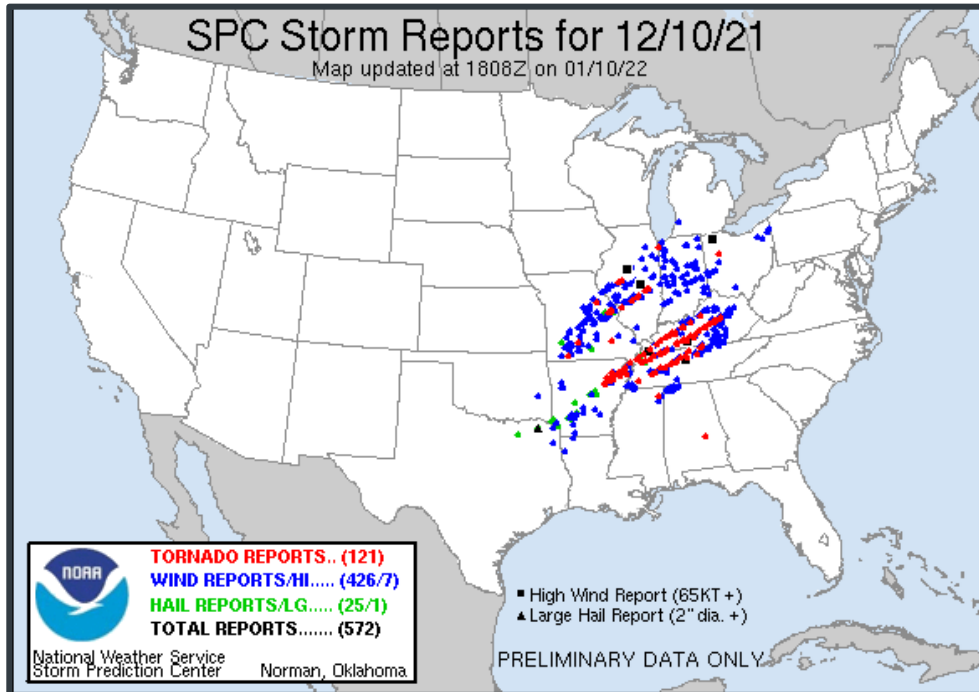
The Devastating Tornadoes of 10-11 December 2021: Datasets and IDSS Before, During, and After The Storm

JANUARY 23, 2024

Presenter: Mike Johnson, NWS Memphis

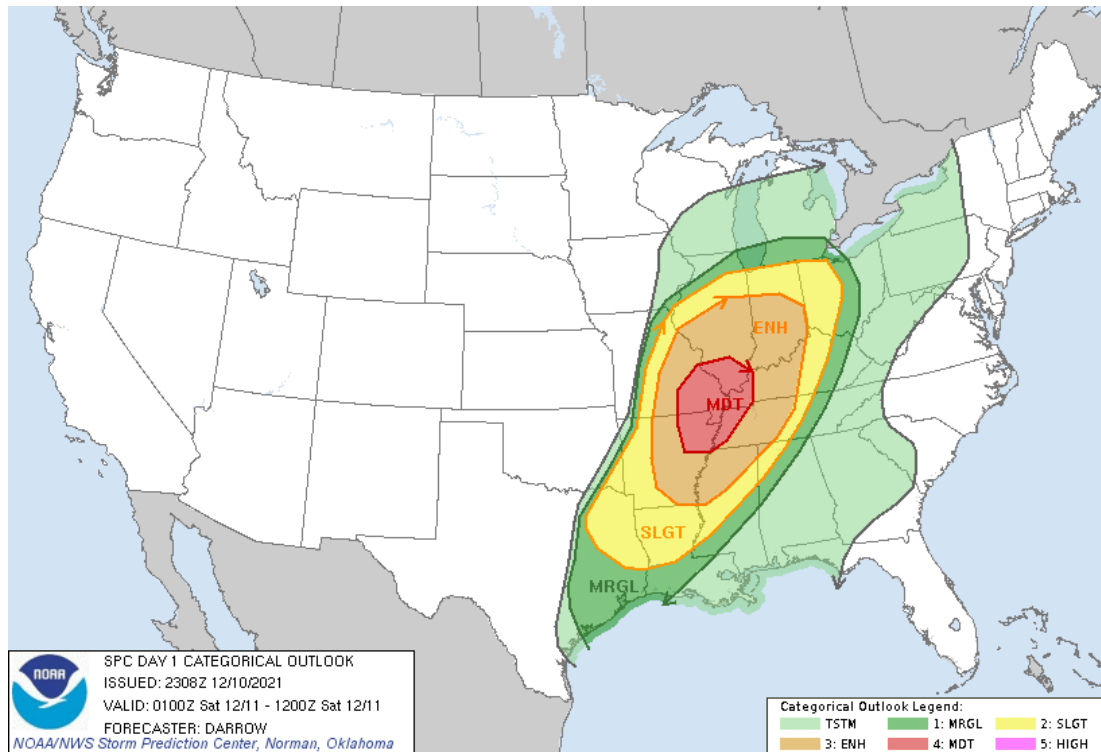
Collaborators: Scott McNeil, NWS Memphis
Sheana Walsh, NWS Honolulu

Dec 10-11 Storm Reports



Pre-Event Mesoanalysis and Messaging

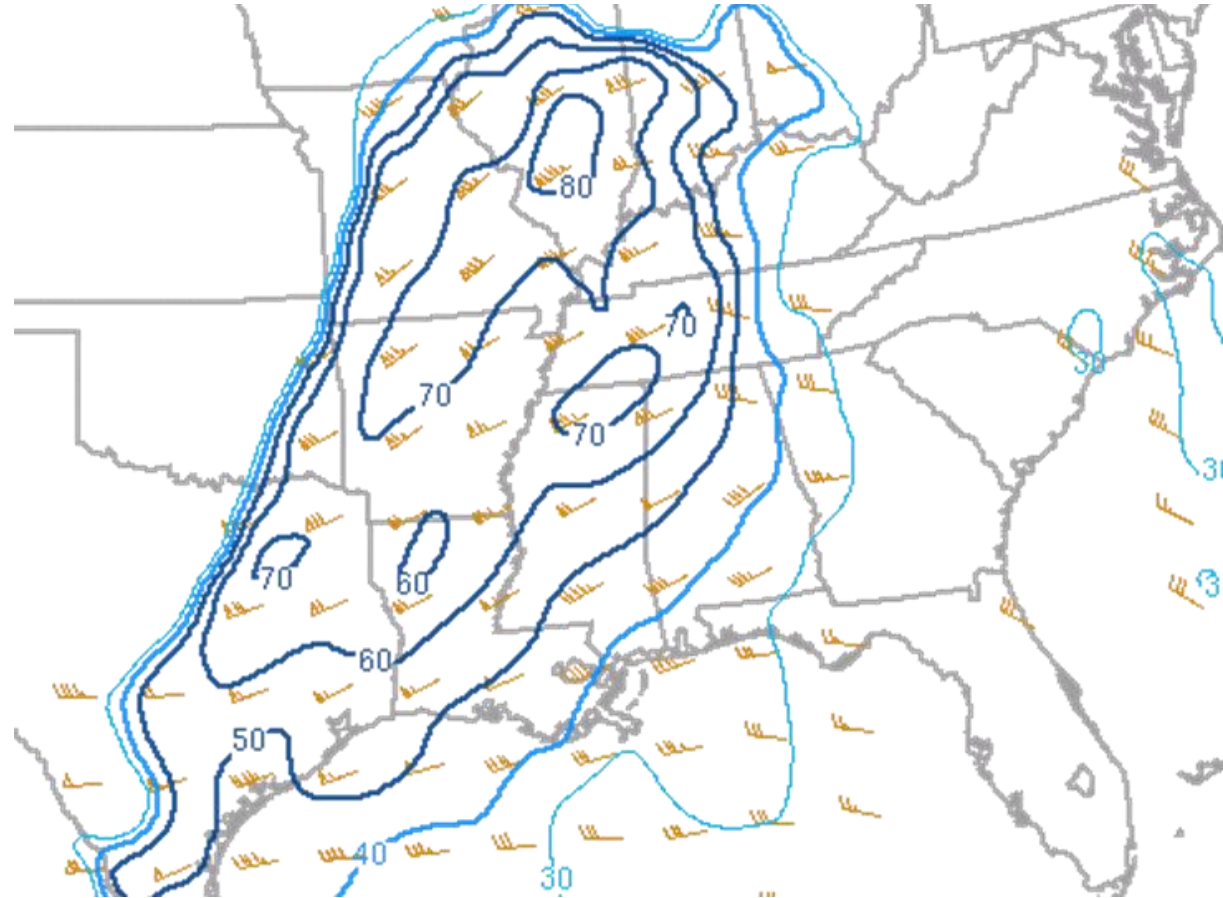
- Record breaking warmth across Mid-South on Dec 10
- Strong forcing and impressive parameter space
 - Relatively high confidence in overnight Quasi-Linear Convective System (QLCS)
 - Medium confidence in discrete supercells in warm sector
- Included mention of nocturnal tornadoes for several days



Effective Layer Bulk Wind Difference

12/11/21 at 02 UTC - Effective Layer Bulk Wind Shear (kts)

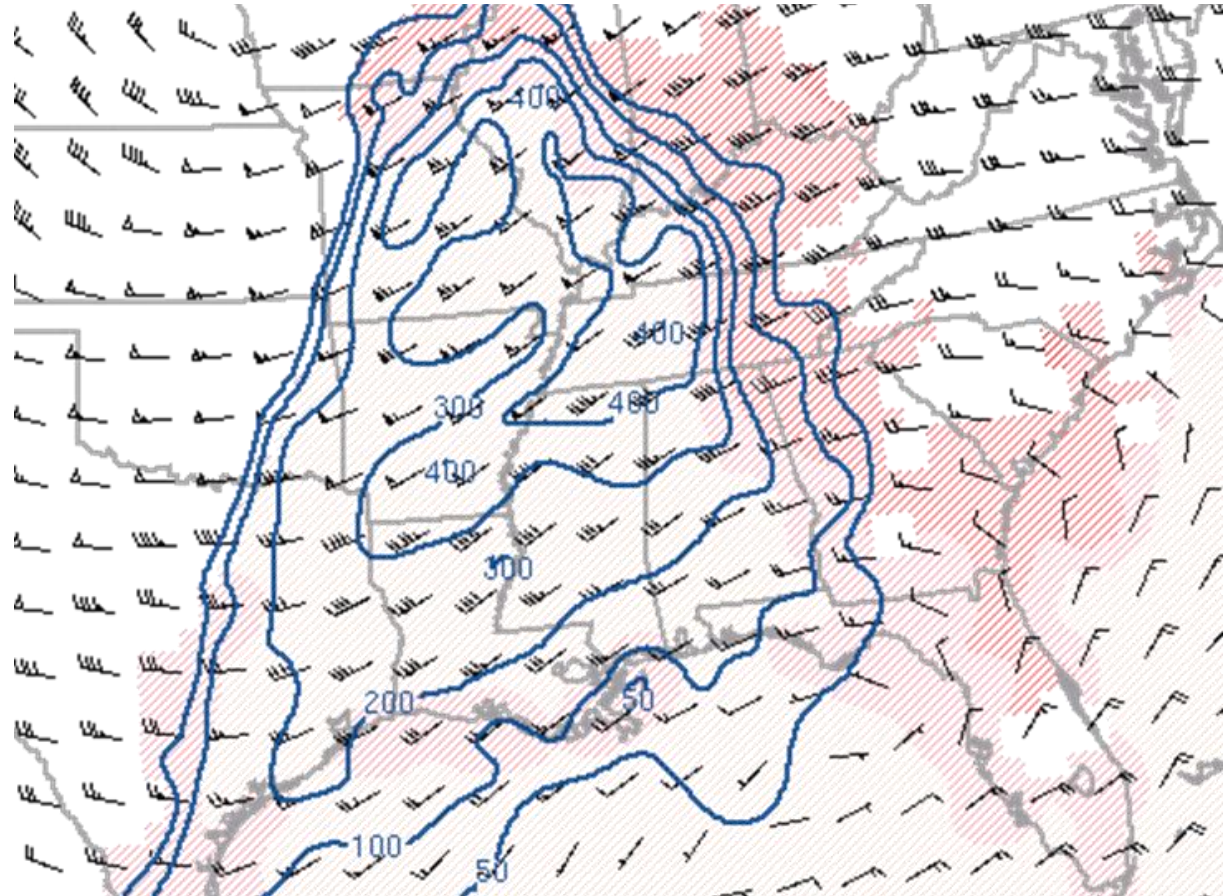
- Effective layer bulk shear exceeding 65-70 kts across all of the Mid-South and Lower Ohio Valley



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Effective Layer Storm - Relative Helicity (SRH)

12/11/21 at 02 UTC - Effective Layer Storm Relative Helicity (m^2/s^2)



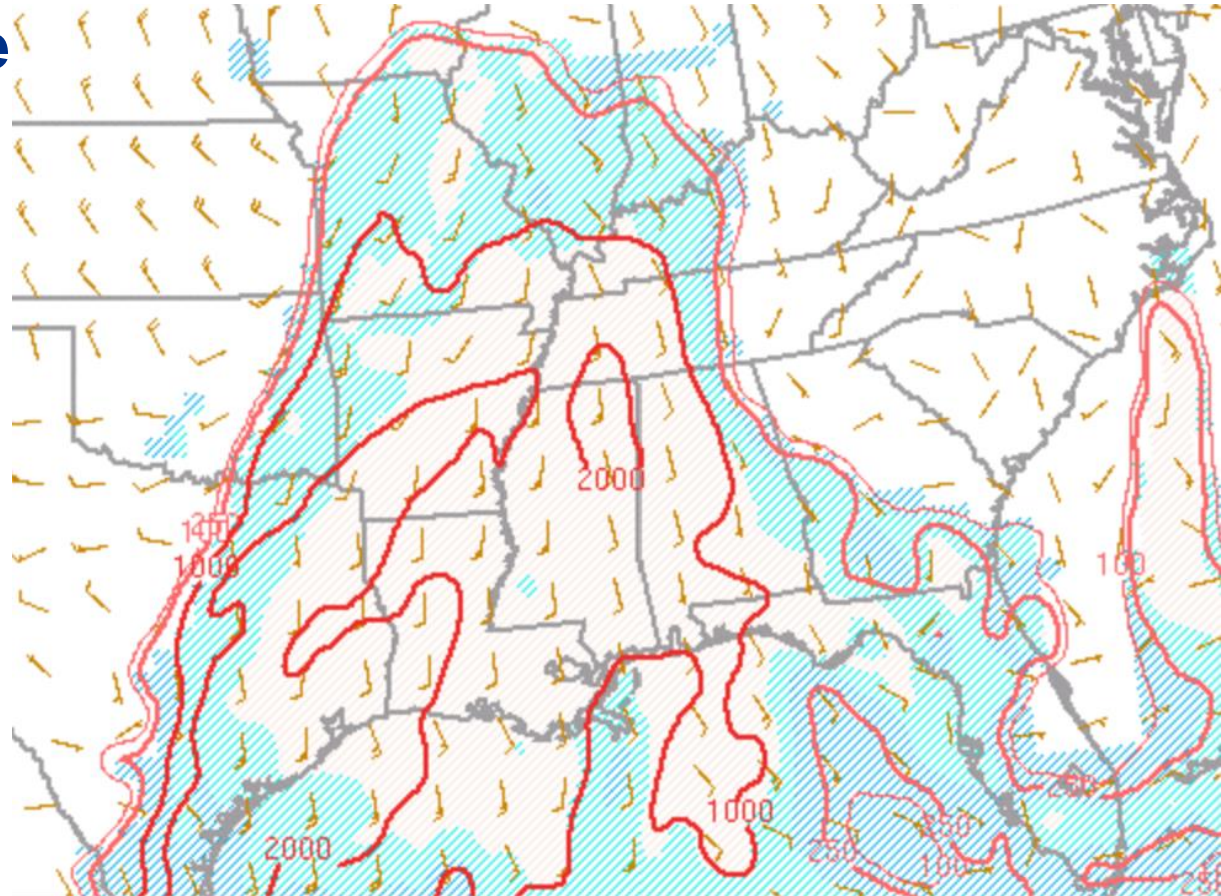
- Effective SRH values of 300-400 m^2/s^2 in the warm sector



100-mb Mean Layer Convective Available Potential Energy (MLCAPE)

12/11/21 at 02 UTC - 100-mb mean layer CAPE (J/kg)

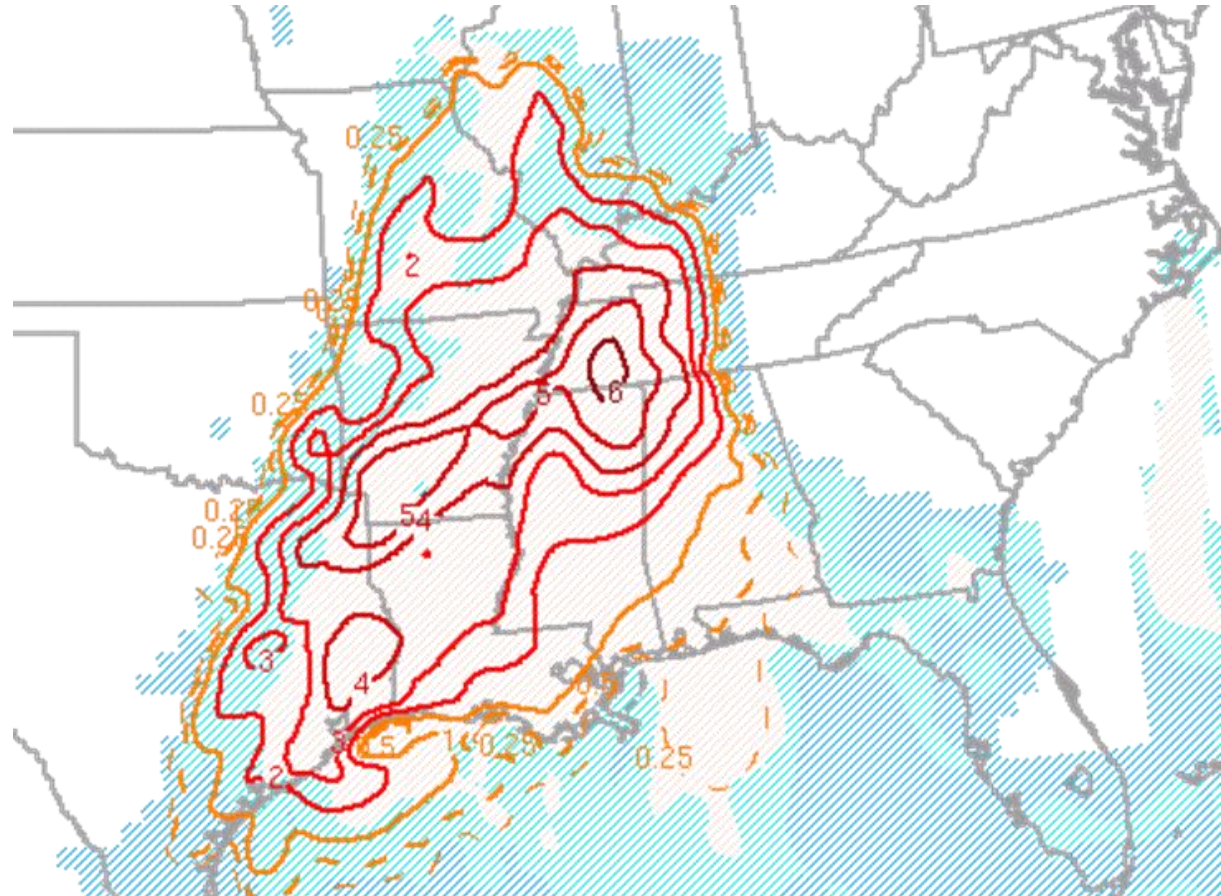
- Upwards of 2000 J/kg of MLCAPE within the open warm sector
- Minimal Mean Layer Convective Inhibition

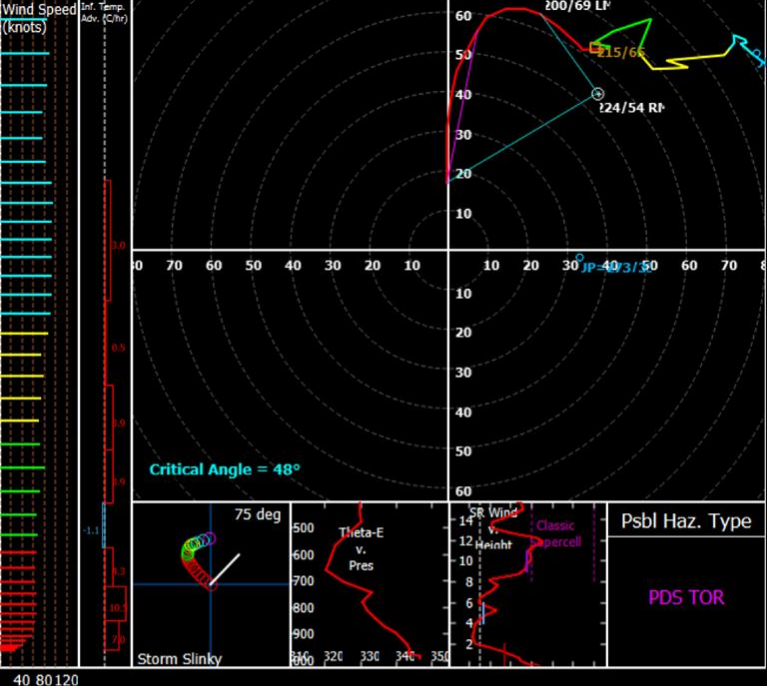
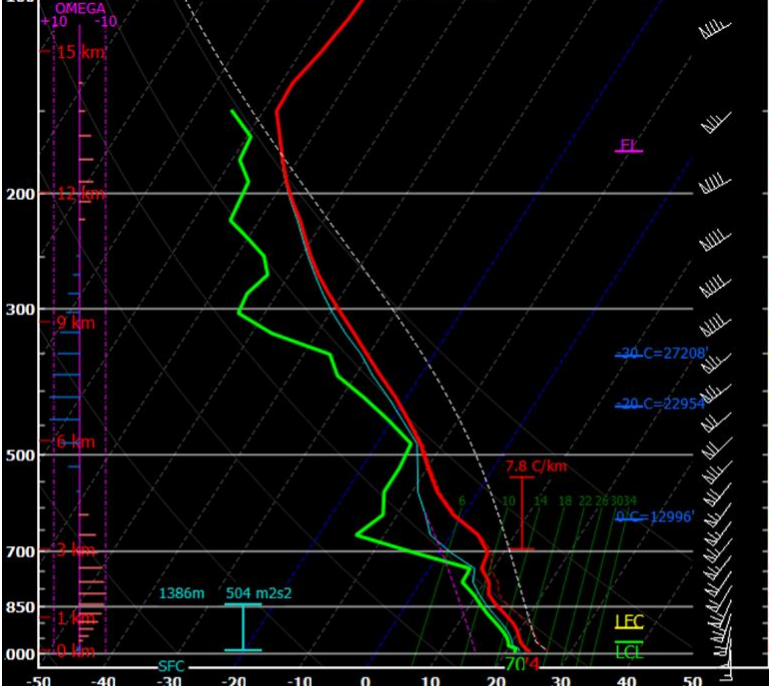


Effective-Layer Significant Tornado Parameter (STP)

12/11/21 at 02 UTC - Effective-Layer Significant Tornado Parameter

- Widespread values of 3-5 from southern Arkansas into southwest Kentucky





PCL	CAPE	CINH	LCL	LI	LFC	EL
SFC	2750	-2	270	-8	692	12883
ML	2086	-9	627	-6	1010	12401
FCST	3182	0	1143	-8	1143	13207
MU	2751	-2	270	-8	692	12883

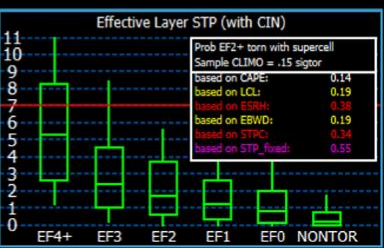
SRH (m2/s2)	Shear (kt)	MnWind	SRW
SFC-1km	476	47	188/51
SFC-3km	547	53	201/56
Eff Inflow Layer	504	49	191/54
SFC-6km	58	208/60	144/17
SFC-8km	65	210/61	152/15
LCL-EL (Cloud Layer)	61	215/65	178/14
Eff Shear (EBWD)	59	208/60	146/16

BRN Shear =	4-6km SR Wind =
101 m2/s2	192/15 kt

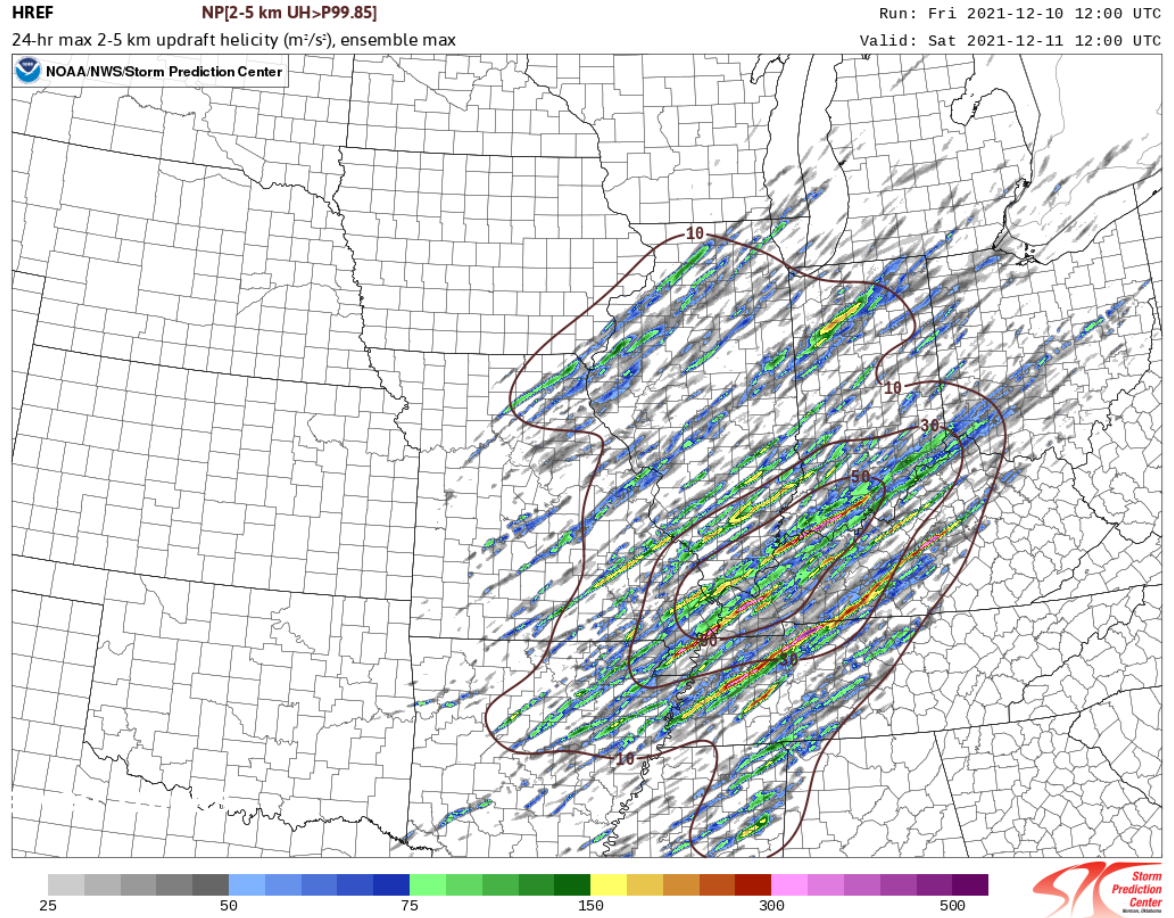
Storm Motion Vectors...	Bunkers Right =	Bunkers Left =	Corfidi Downshear =
...	224/55 kt	200/69 kt	237/92 kt

SARS - Sounding Analogue System	
SUPERCELL	SGFNT HAIL
05 May 03 00Z (UMN) SIG	No Quality Matches
04 May 03 21Z (MKC) SIG	
05 May 03 01Z (LZK) SIG	
24 Apr 03 00Z (SEP) NON	

Effective Layer STP (with CIN)	
EF4+	EF3
EF2	EF1
EF0	NONTOR



Mesoanalysis

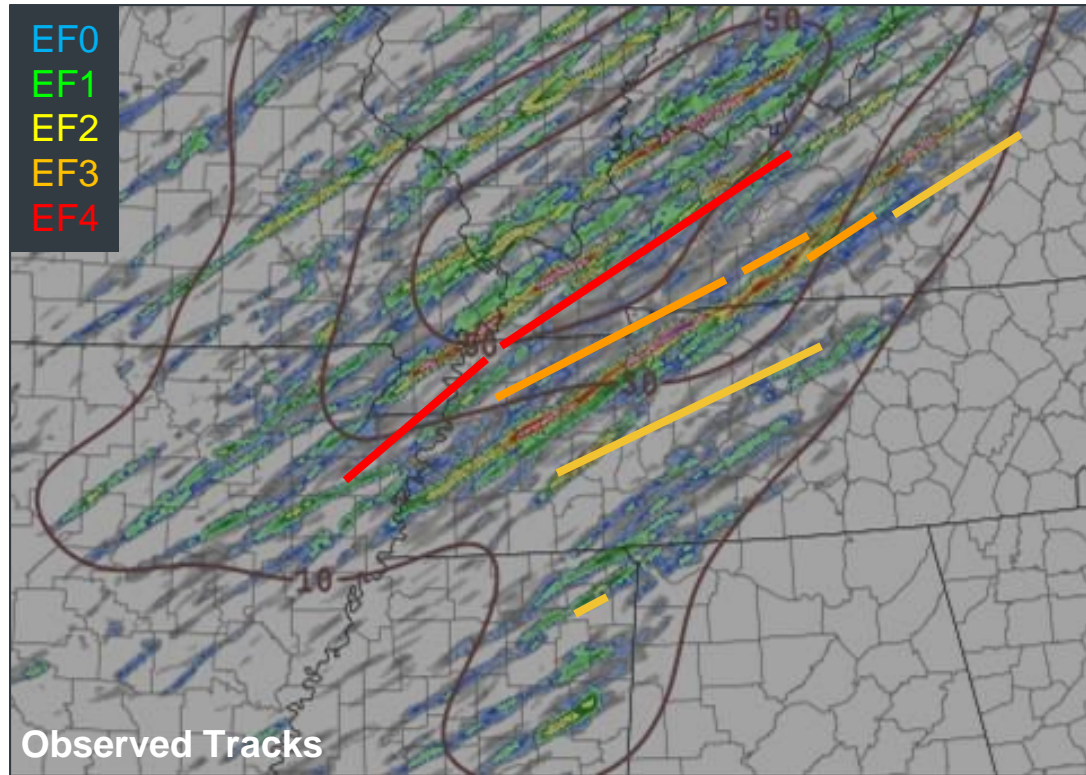


- High-Resolution Ensemble Forecast (HREF v3) 24-hr max updraft helicity progs indicated a strong signal for long-lived supercells
- Increased confidence in the potential for long-track tornadoes
- This type of guidance corroborated the high-end messaging prior to the event



Mesoanalysis

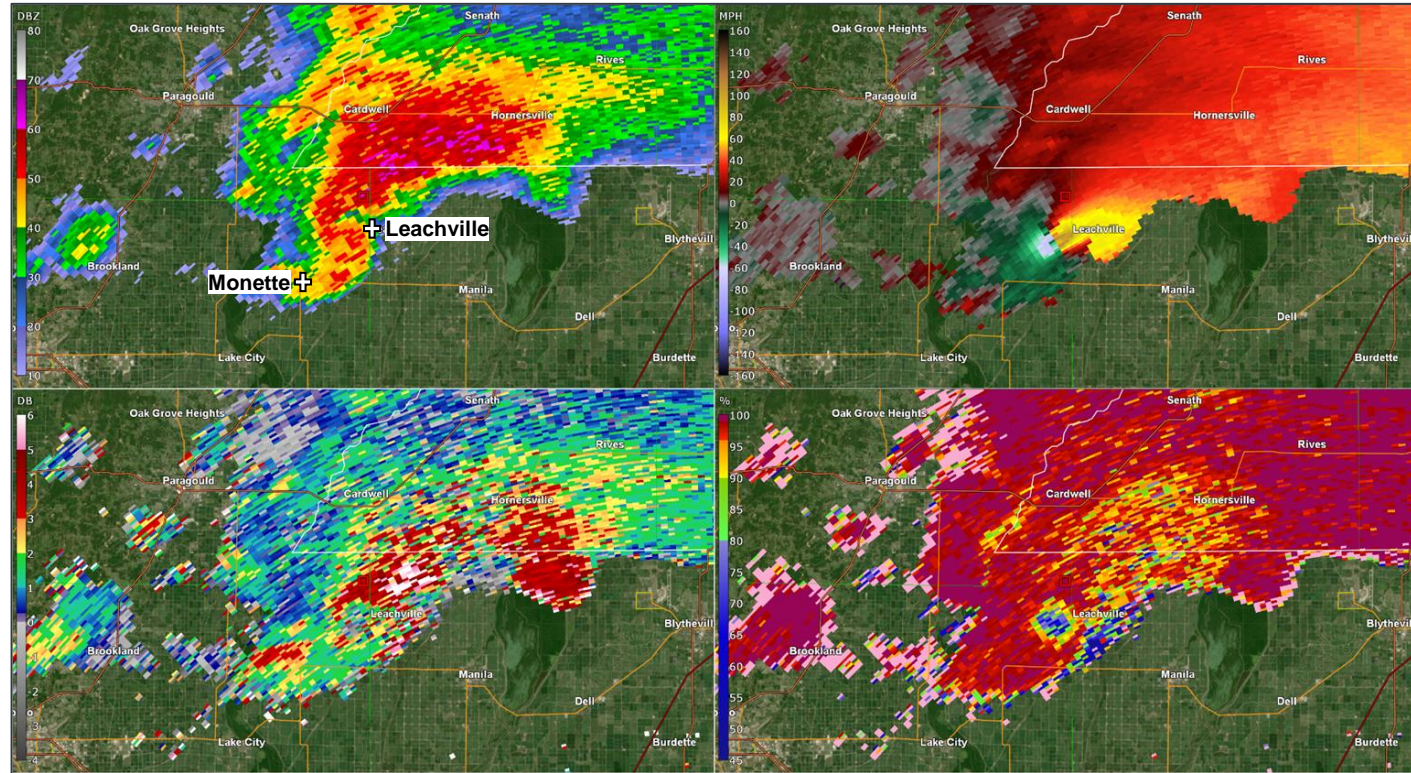
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Leachville, AR

7:26 PM CST

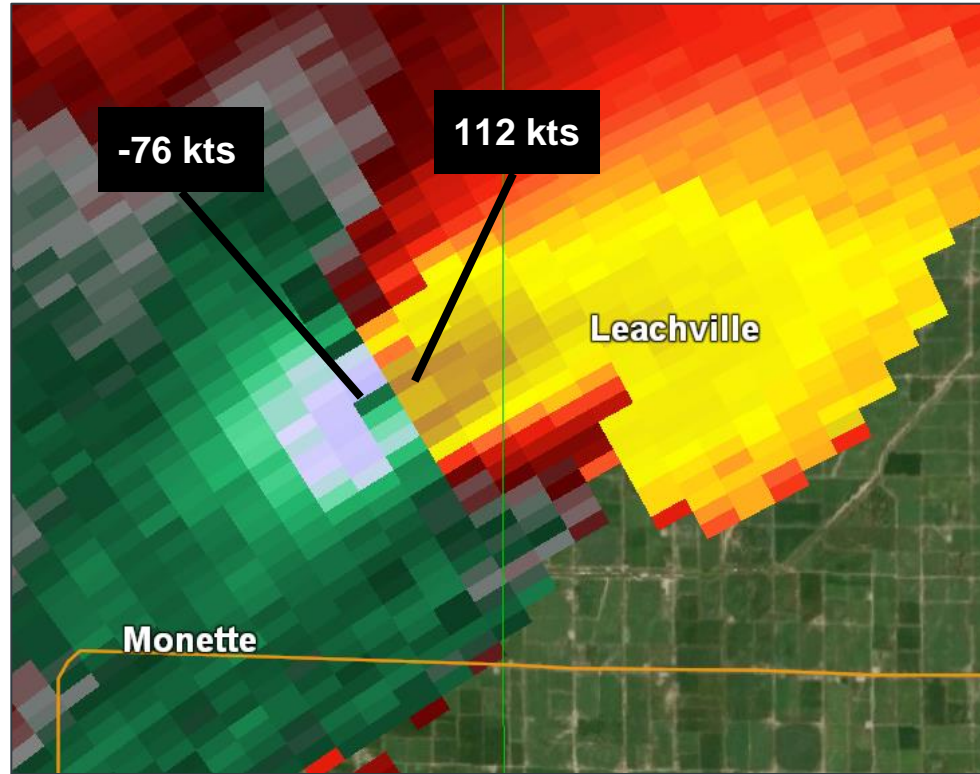
- Mesocyclone is extremely intense with a rotational velocity of 94 kts (~3,400 ft AGL)
- Well defined Tornadic Debris Signature
- 1 fatality in Monette, AR and 1 fatality in Leachville, AR
- EF3 damage surveyed in both communities



Leachville, AR

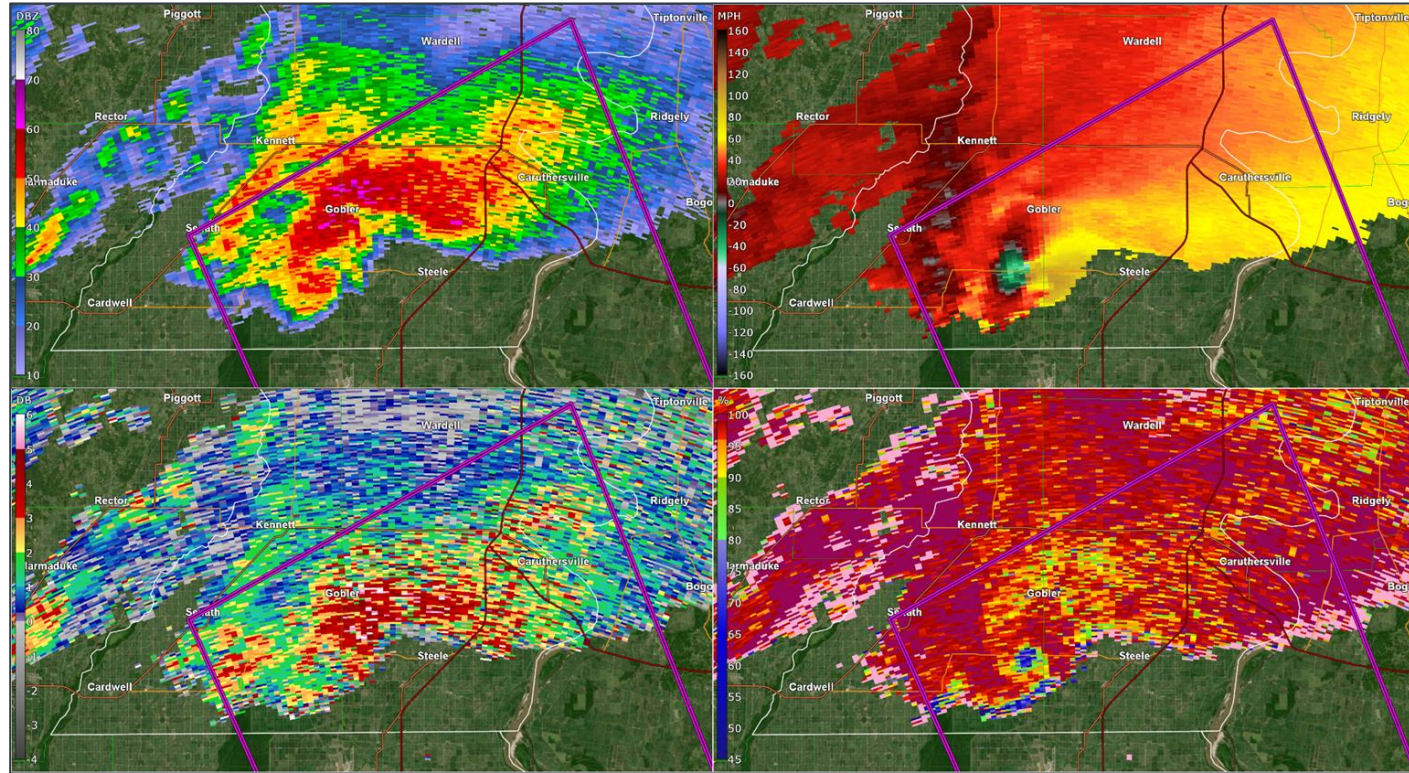
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Initial Tornado Emergency 7:53 PM CST

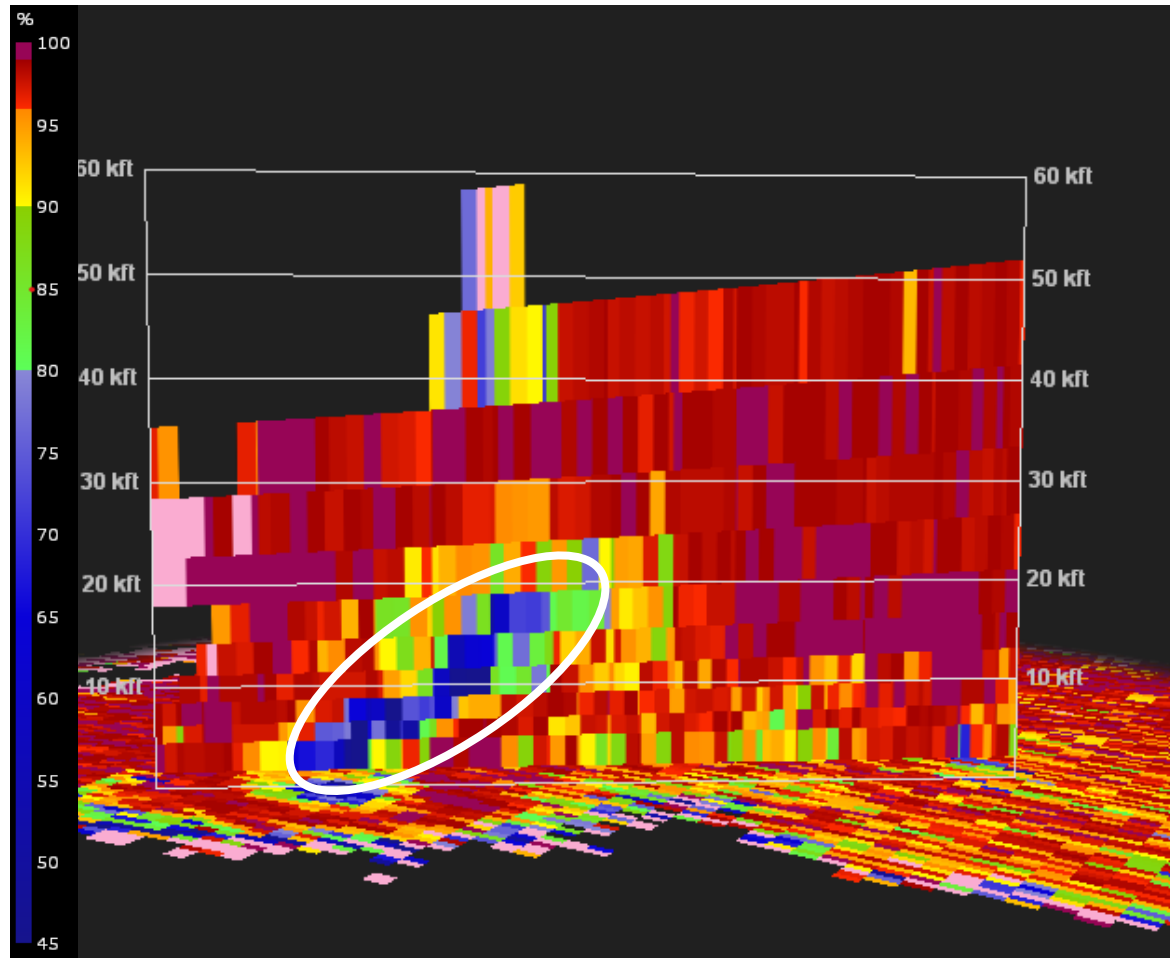
- Mesocyclone remains very intense with a rotational velocity near 70 kts (~4,200 ft AGL)
- Tornadic Debris Signature (TDS) evident in correlation coefficient to a depth near 20,000 ft AGL
- Tornado approaching Interstate 55 and more populated areas (2 fatalities in Pemiscot County, MO)



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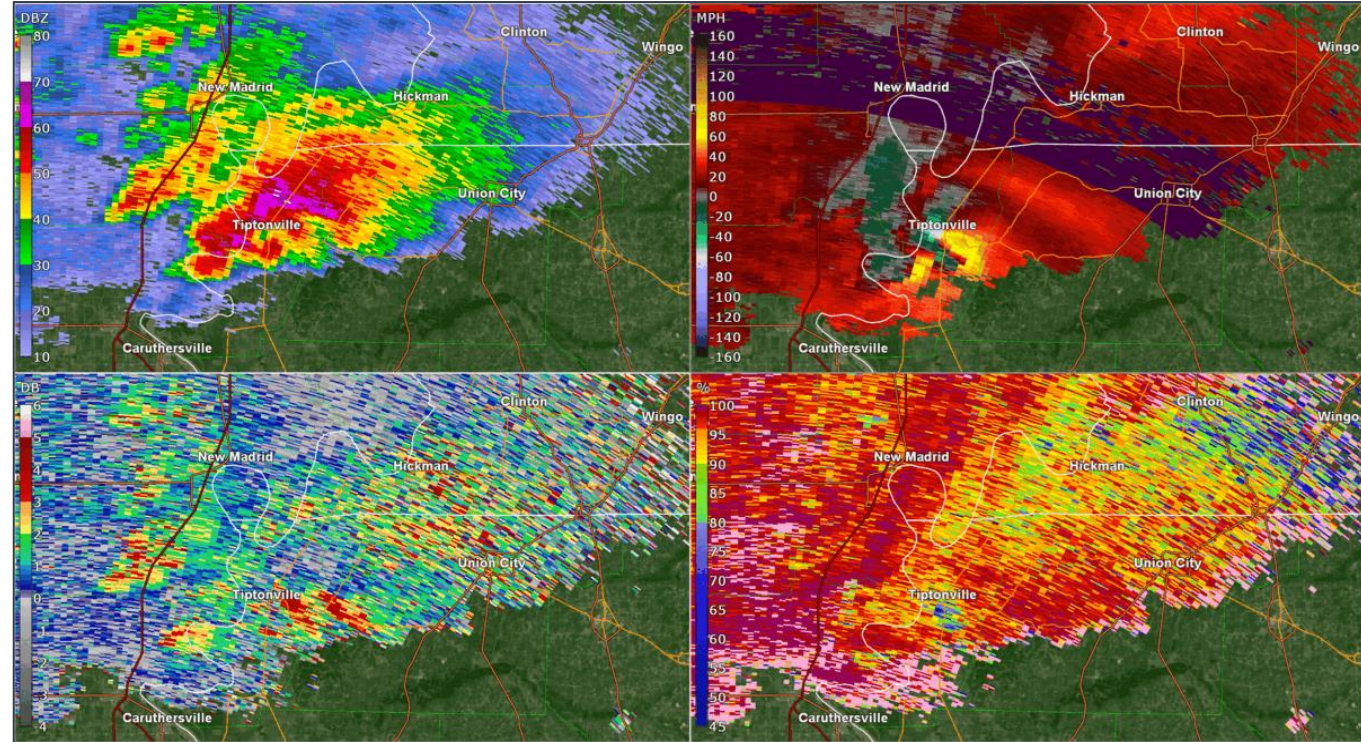
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Reelfoot Lake

8:30-9:03 PM CST

- The violent tornado persisted as the storm reached the southern shore of Reelfoot Lake in Lake/Obion County, TN (~7,000 ft AGL)
- EF3 damage was observed at Reelfoot Lake, TN (4 fatalities)
- Supercell began to cycle at this point and the tornado dissipated



A Few Damage Photos

Debarked and stubbed trees SW of Hornersville,
MO just across Arkansas state line
(EF3 - 140 mph)

A



Single family home destroyed west of Steele, MO
(EF3 - 145 mph)

B



A Few Damage Photos

Single family home destroyed in Braggadocio, MO (EF4 - 170 mph)

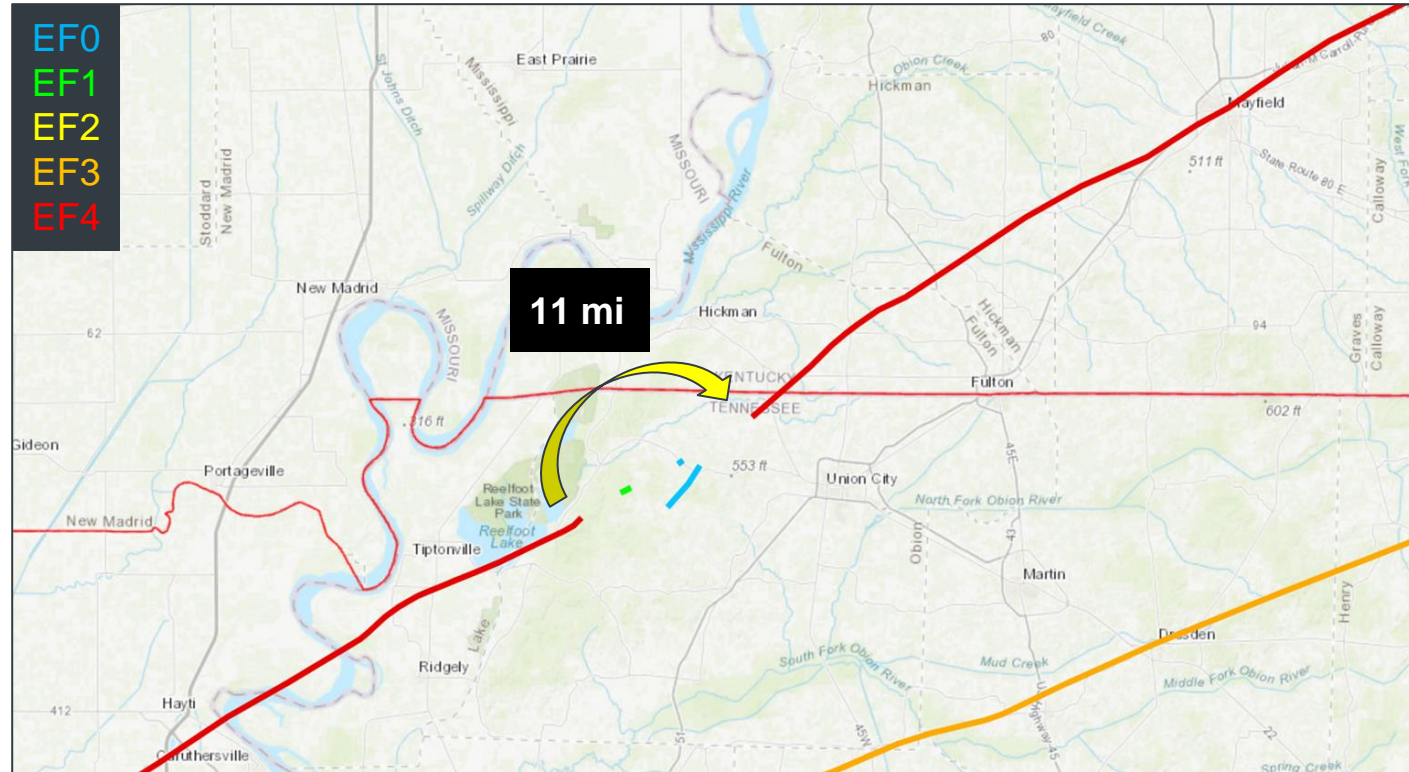


Small retail building swept off foundation near Reelfoot Lake, TN (EF4 - 167 mph)



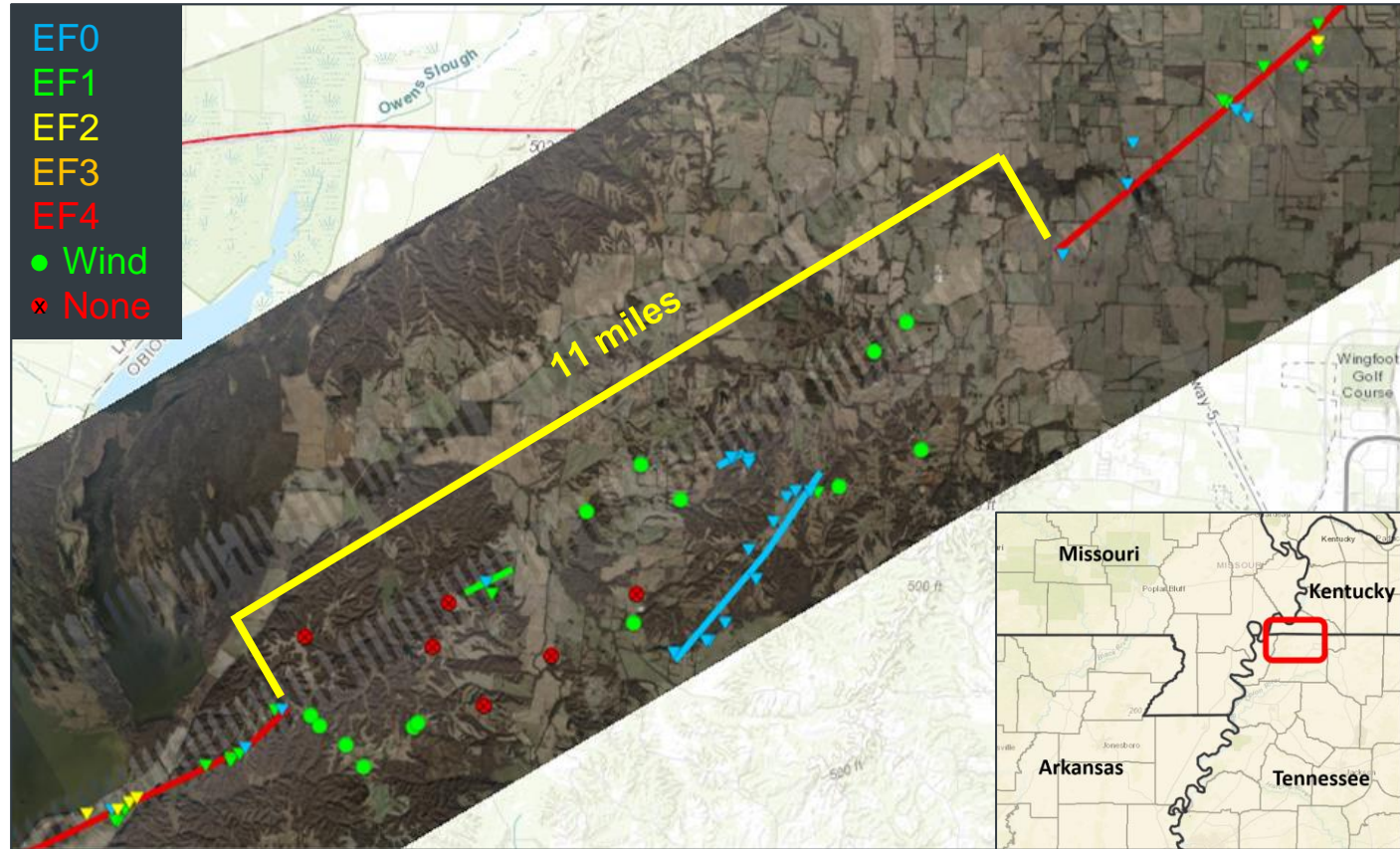
Initial Damage Survey Results

- NWS teams spent many hours surveying in the days following the event to determine if this was a continuous track
- NWS surveys found an 11-mile gap between the two long-track tornadoes



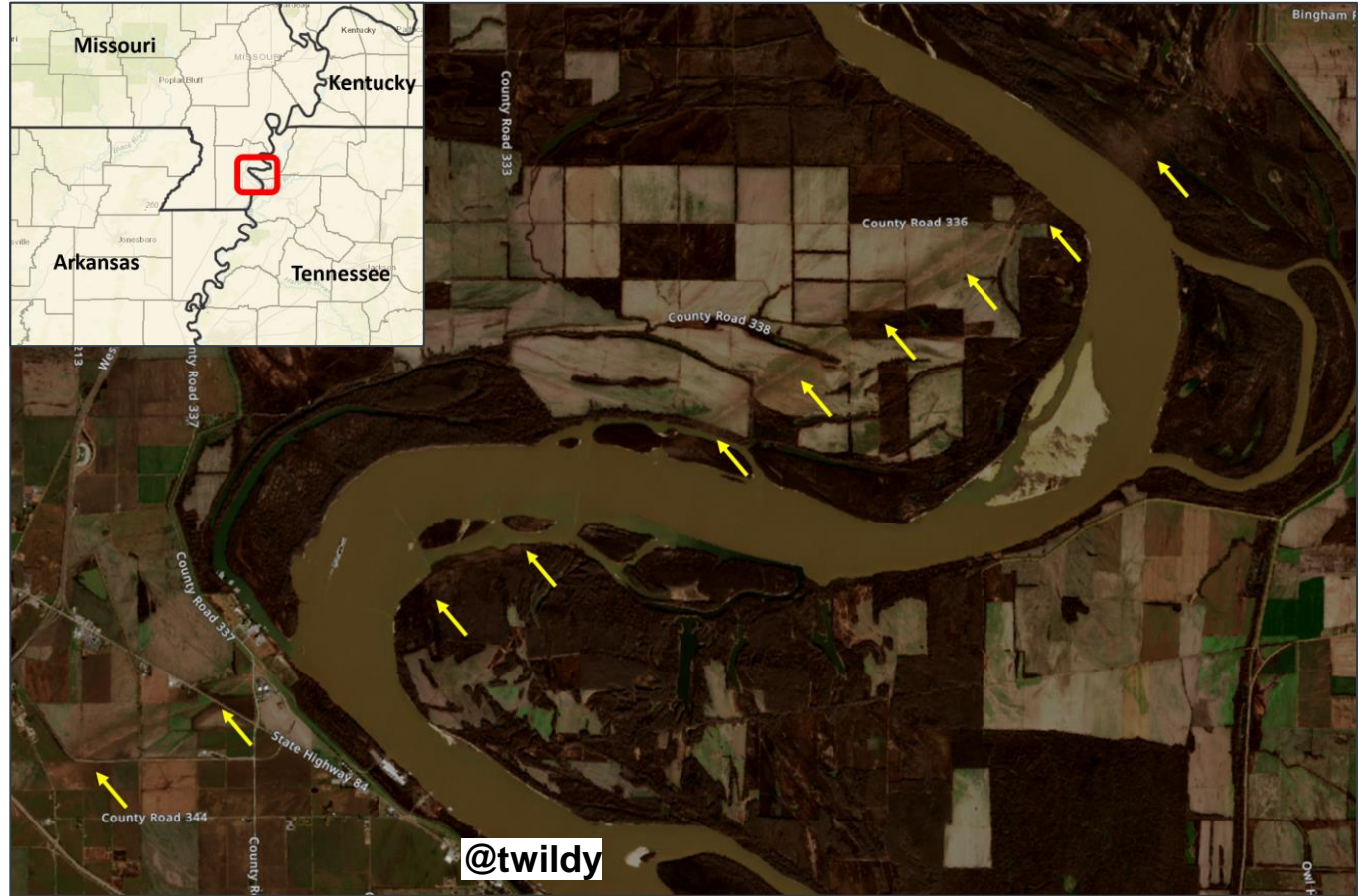
A Closer Look

- After the initial long-track tornado lifted, three brief, weak tornadoes were confirmed over northwest Obion County, TN
- The survey was aided by aerial/drone imagery
- The availability of the very high resolution Gray Sky imagery was vital to the success of this survey



Satellite Observations

- High spatial resolution aerial and ground survey data were augmented with satellite observations
- Sentinel-2 imagery shows well-defined scarring or deposition of debris across the Mississippi Delta
- Assisted in aligning the tornado track in the Damage Assessment Toolkit in more data sparse areas near the Mississippi River



Satellite Observations

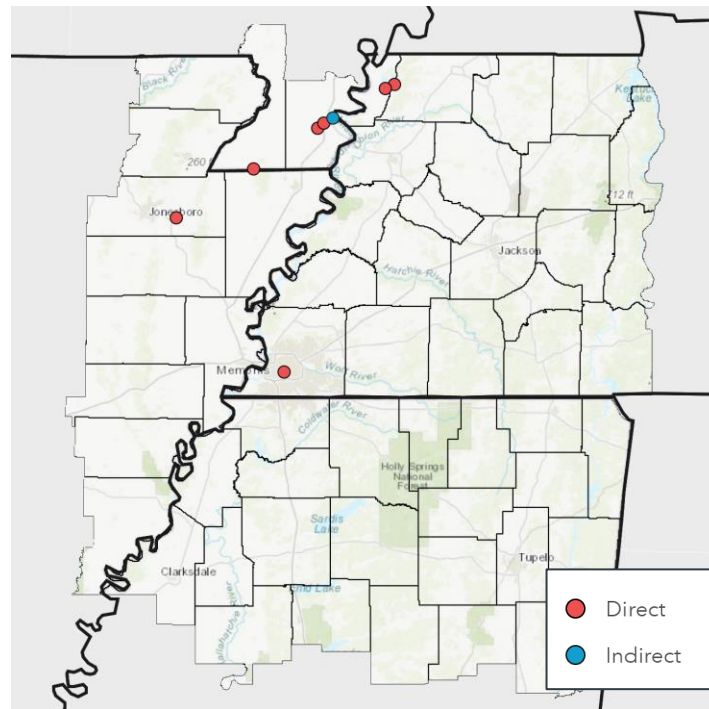
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Mid-South Impacts

- 18 tornadoes were confirmed within the Memphis County Warning Area
- A total of 9 direct fatalities and dozens of injuries
- 25 Tornado Warnings issued (3 using catastrophic tag)
- Probability of detection was 99% with a false alarm rate of only 32%
- Average lead time was 22 minutes

Dec 10-11, 2021 Fatalities



Summary

- Mesoanalysis of observational and high resolution guidance enhanced confidence that significant tornadoes were the primary concern.
- NWS Memphis issued “Tornado Emergency” prior to the impacts in Pemiscot (MO), Lake (TN), and Obion (TN) Counties where 6 of the fatalities occurred.
- NWS survey teams were very meticulous and concluded that there were two separate, long-track EF4s (81.2 and 165.6 miles) with a break of 11 miles.
 - There was no “Quad-State Tornado” and was not the longest tornado track in recorded history
- Efficient, proactive messaging before and during the event undoubtedly saved lives



Thank you!

NWS Memphis Event StoryMap

Contact:

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