Evaluating the Three-Ingredients Method for Nowcasting QLCS Tornadoes

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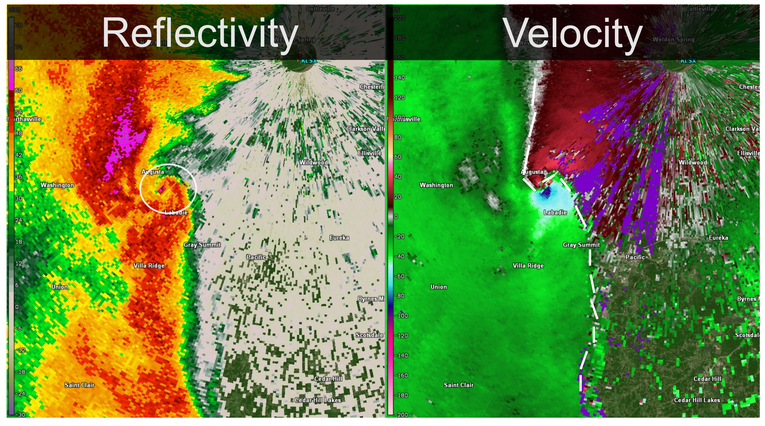
Project Overview

- This project seeks to evaluate the 3IM and environmental conditions favorable for QLCS tornadoes to improve nowcasting.
- Six years of RUC/RAP data, 0-hour environmental data, and Doppler radar data were evaluated
- Created database of over 1000 Quasi-Linear Convective Systems (QLCS) cases
- Partitioned into differing climatic regions across the United States
- Creating an improved nowcasting method for each distinct climatic region

3IM Explanation

- NWS forecasters use the “Three Ingredients Method” (3IM) to anticipate QLCS mesovortex and tornadogenesis.
- Includes finding balanced or slightly shear dominant regimes
- Finding 0-3 km line normal bulk shear ≥ 30 kts, and surges or bowing segments in the QLCS.
- Locations that meet all are often favored locations for severe storm reports

Augusta, Missouri 2019 QLCS Tornado Example



- A squall line exhibits a surging section seen in reflectivity and velocity
- Balanced UDCZ can be seen denoted by the white markers on velocity
- >30 kts of LNBS according to RAP model
- Tornadic circulation can be seen at the inflection point in the surge denoted by white circle on reflectivity

3IM Evaluation

Table 2: 3IM statistics for the traditional 3IM criteria separated by distinct regions.

Regions	Southern (512 Cases)		Central (462 Cases)		Eastern (123 Cases)	
Cases that met 3IM	149	29%	108	23%	28	23%
Tornado cases where 3IM did NOT verify	117	51%	52	44%	9	39%
Tornado cases where 3IM verified (POD)	112	49%	67	56%	14	61%
3IM false positive cases (FAR)	37	25%	41	38%	14	50%

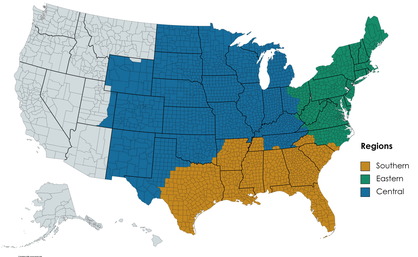
- Southern region captures less than half of QLCS tornadoes under current criteria
- Central and Eastern regions perform better under current criteria
- Eastern region have a small sample size of tornadic QLCS cases

Table 2: 3IM statistics across distinct regions by designated environmental parameters

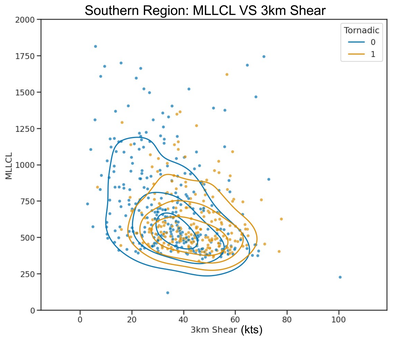
Regions	Southern (512 Cases)		Central (462 Cases)		Eastern (123 Cases)	
Environmental Parameters	- 3km Wind Shear ≥ 20kts - LCL heights ≤ 1100m - 3km Lapse Rate from 4-7 C° / km - 0-3km SRH ≥ 100 m^2/s^2 - Balanced and Surging		- 3km Wind Shear ≥ 25kts - LCL heights ≤ 1400m - 3km Lapse Rate from 5-8 C° / km - 0-3km SRH ≥ 100 m^2/s^2 - Balanced and Surging		- 3km Wind Shear ≥ 20kts - LCL heights ≤ 1100m - 3km Lapse Rate from 4-7 C° / km - Balanced and Surging	
Cases that met stats	240	47%	131	28%	30	24%
Tornado cases where stats did NOT verify	72	31%	46	39%	9	39%
Tornado cases where stats verified (POD)	157	69%	73	61%	14	61%
False positive cases (FAR)	83	35%	58	44%	16	53%

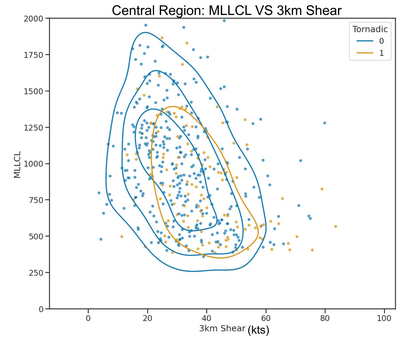
- Southern region has largest increase of 20% in POD using new parameters
- Central region POD increases slightly
- Eastern region remains unchanged due to small sample size
- FAR is larger in all regions with Southern region having the largest increase
- NWS officials will have an easier time nowcasting without the need to calculate LNBS

- A map of the distinct regions designated by CWA boundaries
- Western region is unincluded due to a lack of QLCS cases

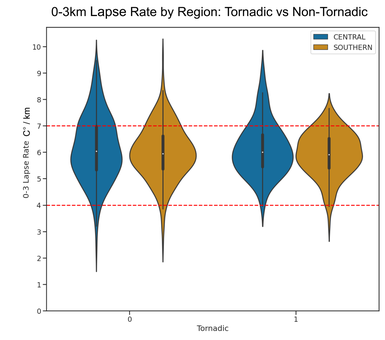


Environmental Parameter Evaluation

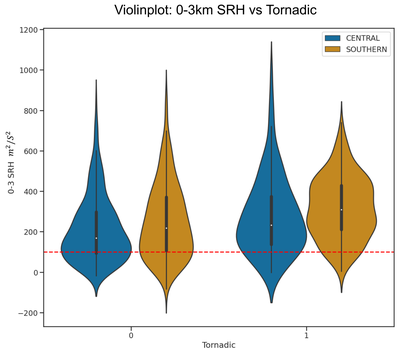




- Comparison of the Central and Southern regions based on MLLCL heights and 3km Shear
- Majority of Southern region’s tornadic cases occur when MLLCL heights are < 1km
- Central region’s tornadic cases are more diffuse and occur more frequently at higher MLLCL heights
- Southern region has more tornadic cases compared to any other region



- Very sharp cutoff in lapse rates for tornadic cases
- Lapse Rates < 4 likely imply a stable Boundary Layer
- Lapse Rates > 7 approach the dry adiabatic lapse rate implying efficient mixing and thus higher cloud bases
- Overlap is present between Central and Southern regions, need multiple parameters to get complete picture



- Central region QLCS tornadoes mostly occur at around 200 m^2/s^2 SRH
- Southern region exhibits 2 peaks with QLCS tornadoes generally occurring at around 250 m^2/s^2 and 400 m^2/s^2 of SRH
- Majority of non-tornadic cases generally have less than 100 m^2/s^2 SRH

Conclusions

- The 3IM is generally ineffective in the Southern region
- Using parameter evaluation yields better POD in the Southern and Central Regions
- FAR increase was noted in all, however this will have to be weighed with increase in POD