Significant Hail In The Ohio Valley: An Event-Driven MRMS Perspective

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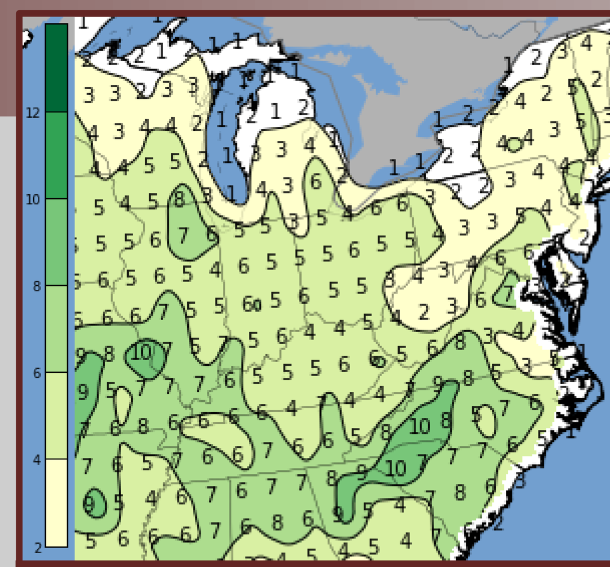
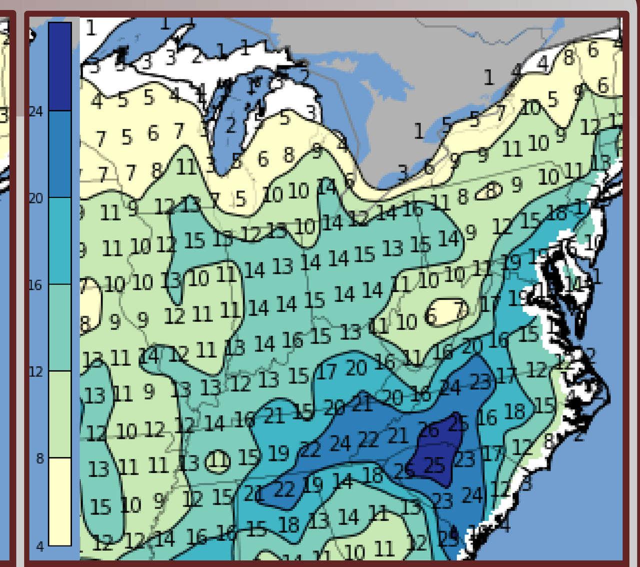
Introduction To Study

- Although a somewhat uncommon occurrence in the Ohio Valley in comparison to damaging straight-line winds, severe and significant hail (diameter >=2") does cause extensive crop and property damage throughout the region.
- With the operational installation of Multi-Radar Multi-Sensor (MRMS) in 2016, new algorithm-based datasets are now available to assist with hail detection in real-time warning operations.
- Because often times the degree of damage is likely dependent on the maximum hail size (Smith and Waldvogel, 1989), identification of key MRMS-derived signatures in conjunction with traditional radar interrogation techniques can provide increased lead time for NWS forecasters for detecting, and warning for, large and significant hail.



SPC Severe Hail Days Per Year (2003-2012)



SPC Severe Thunderstorm Wind Days Per Year (2003-2012)

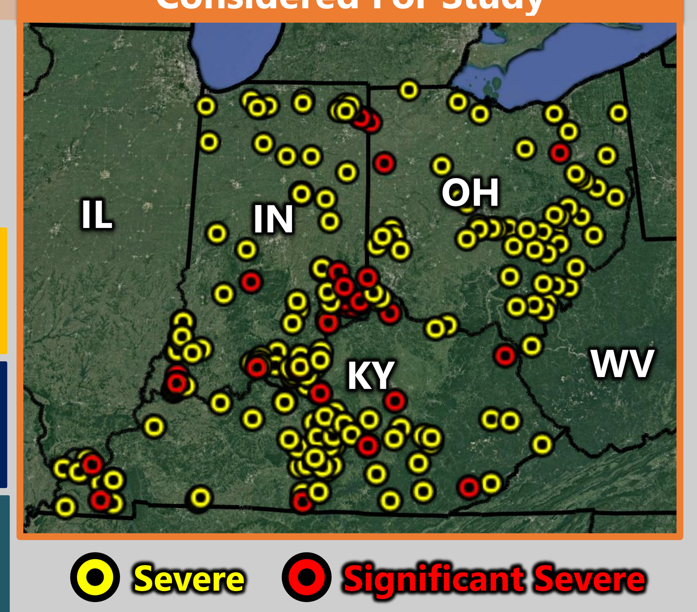
Methodology of Data Collection

- Severe and significant hail reports from the NOAA/NCEI Storm Events Database were catalogued for the states of Ohio, Kentucky, and Indiana, yielding 203 severe hail (2018) and 37 significant hail (2016-2018) reports.
- MRMS-derived large hail indicators considered:

Severe Hail Index (SHI) (A weighting function dependent on MRMS reflectivity and RAP environmental parameters that is limited to the hail growth zone)	**Reflectivity (Z) at the -20°C Isotherm**
Max 30-minute Hail Swaths (derived from MESH)	**Maximum Expected Size of Hail (MESH)** $MESH = 2.54(SHI)^{0.5}$
Probability of Severe Hail (POSH) $POSH = 29 \ln(SHI/WT) + 50$ (where WT is the warning threshold, which is a function of the height of the above radial level of the RAP environmental melting level)	**Depth of 50+ dBZ echoes above the -20°C Isotherm**

- Time trends for each large hail indicator were categorized by size of the observed report and compared with actual NWS warning hail sizes.
- Nearly 29,000 individual data points were analyzed to determine the degree of value of each MRMS dataset in assessing real-time warning operation severe/significant hail potential.

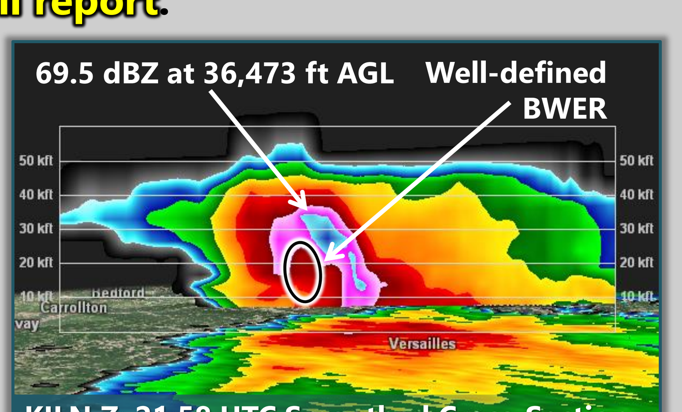
Severe and Significant Hail Reports Considered For Study

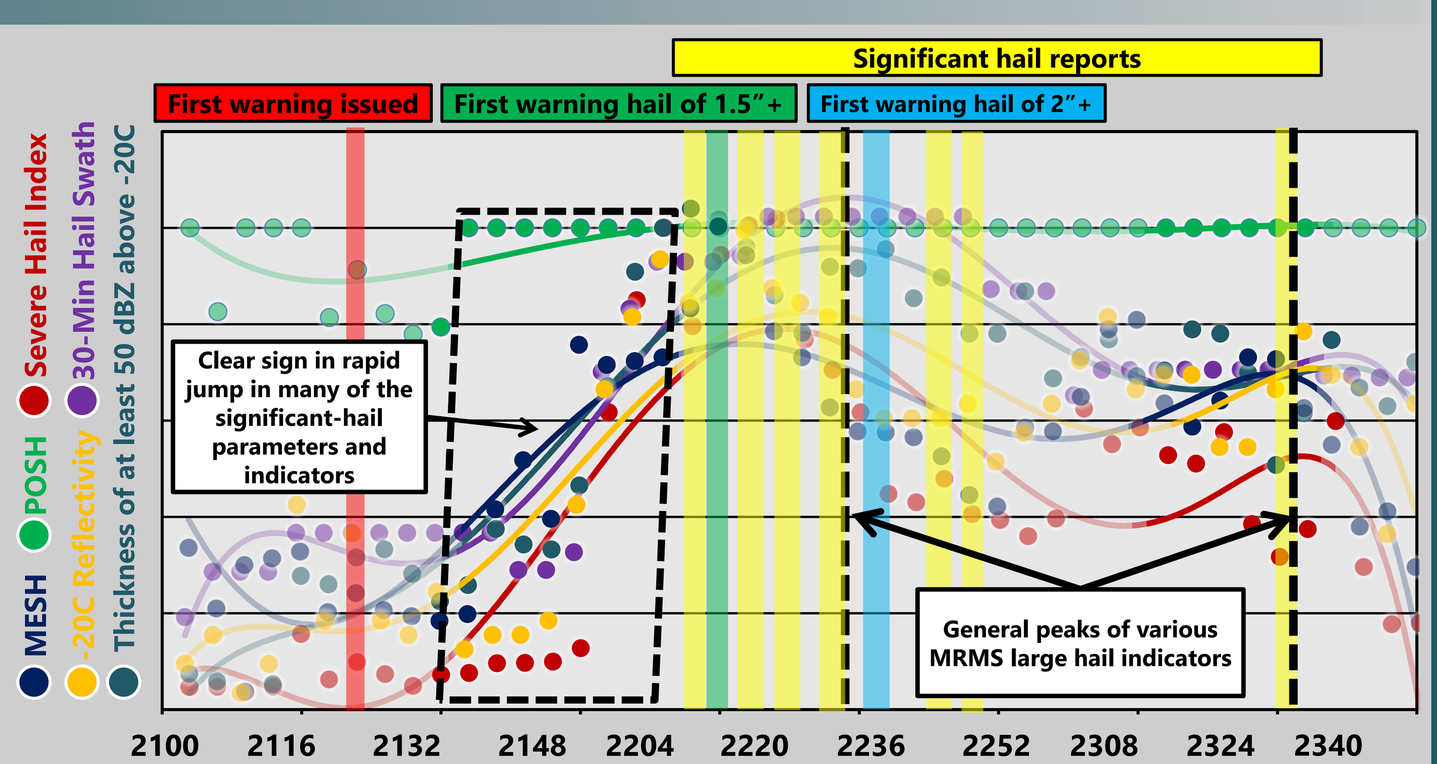


DATA COLLECTION TIMELINE

Case Study: October 19, 2016

- A quick glance at some of the MRMS dataset parameters can often increase confidence and potentially increase lead time by getting a warning out sooner.
- In this case, there were numerous MRMS indicators of significant hail becoming increasingly likely right at or shortly before the first significant hail report.





Maximum MRMS-Derived Pixel Value Within Storm of Interest Through Time

Warning Threshold Considerations — First Significant Hail Report: 2212 UTC

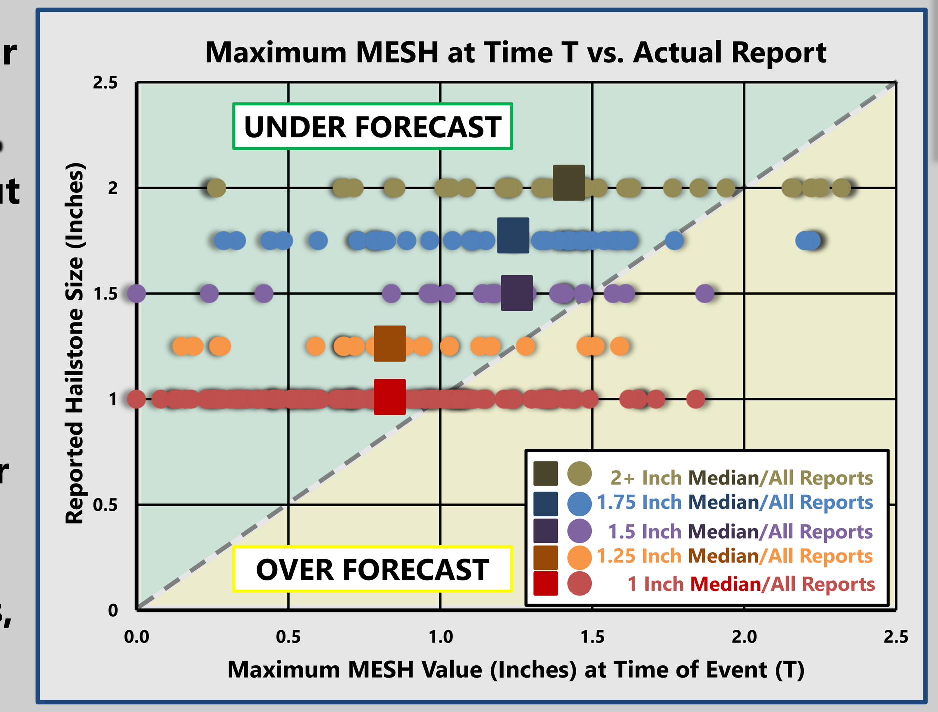
If your significant hail warning threshold was...	Lead Time (minutes)	Actual Significant Hail Warning Lead Time (minutes)	Difference (+/- minutes)
MESH >= 2"	13 minutes	25 minutes after first significant hail report	+ 38 minutes
65+ dBZ at -20C Isotherm	0 minutes		+ 25 minutes
Thickness of 50 dBZ above -20C level of at least 6,000ft.	4 minutes		+ 29 minutes
Severe hail index of at least 400	4 minutes		+ 29 minutes

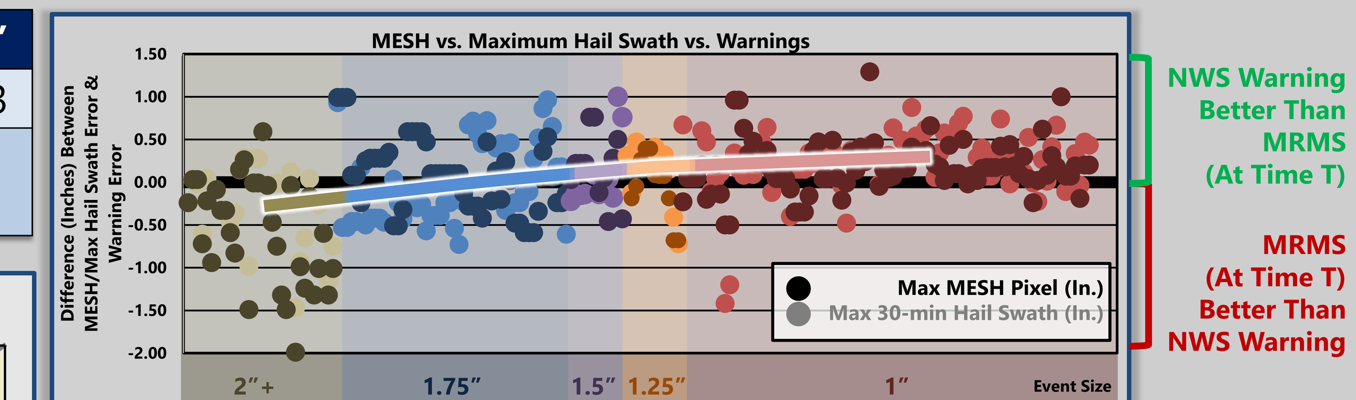
MRMS Large Hail Indicators & NWS Warnings Vs. Observations Comparison

- For unwarned events, MRMS indicators were generally very low compared to averages for warned events.

Unwarned Events	2"	1.75"	1.5"	1.25"	1"
Number of Unwarned Events	0	2	3	8	23
Number of Maximum MESH Values At/Above 1.00" at T	0	1	1	2	1

- Max MESH values under-forecast observations, but correlation was closer to 1:1 for 1-inch events opposed to larger or significant events.
- This may be partially skewed by a tendency for reports to relate to the standard 1-inch NWS warning threshold values, even if actually slightly smaller or larger.





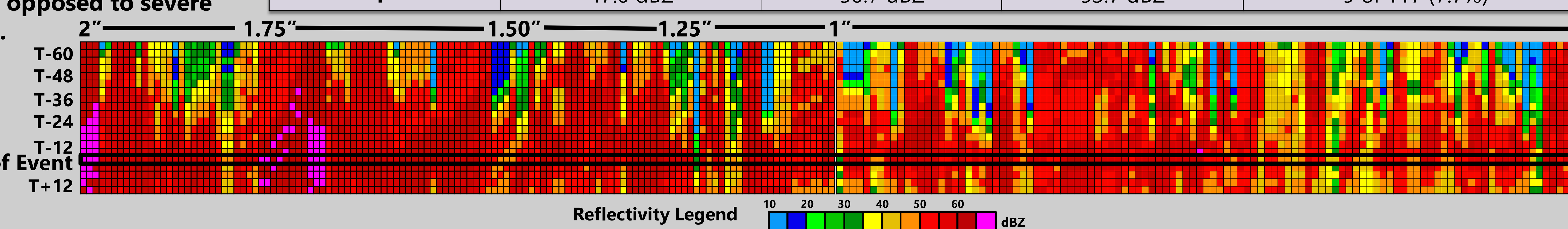
- A comparison of differences between maximum MESH and 30-minute Hail Swath values to observed reports at time T to NWS warning hail size showed that MRMS large hail indicators offered greater value with larger hail events whereas warning performance was better than MRMS for severe (opposed to significant) hail events.

Mean Absolute Error (MAE)	2"	1.75"	1.5"	1.25"	1"
Max MESH MAE	0.780	0.584	0.406	0.391	0.347
Max 30-min Hail Swath MAE	0.609	0.682	0.482	0.271	0.291
NWS Warning MAE	1.188	0.620	0.313	0.240	0.116

Max MRMS Reflectivity (dBZ) at -20°C Isotherm: Hail Size Comparison

- The rate of increase of isothermal reflectivity from T-12 to T was, on average, nearly double for significant events opposed to severe events.

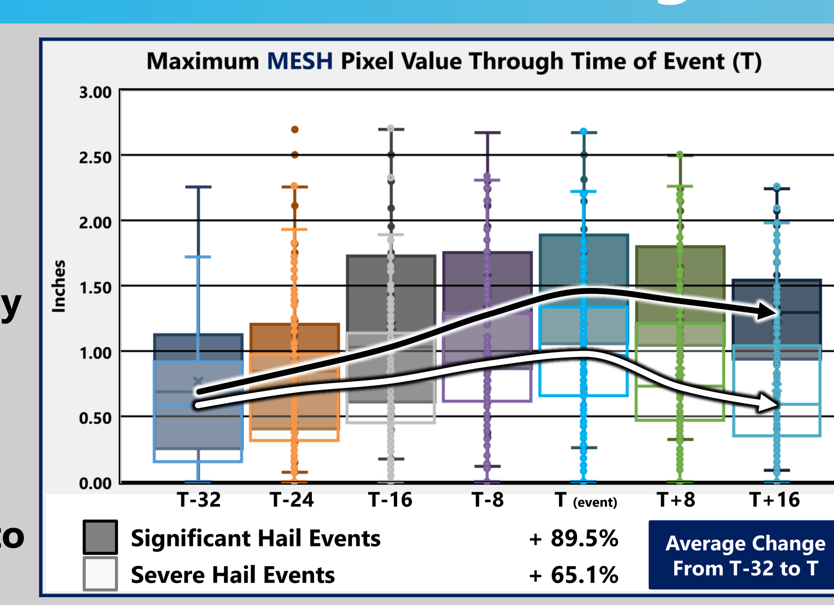
Observed Hail Size	-20°C Avg. Ref. T-60 to T+16	-20°C Avg. Ref. T-32 to T	-20°C Avg. Ref. at Time T	# Max Ref. At/Above 60 dBZ at Time T
1.75" – 2"	52.8 dBZ	56.5 dBZ	58.6 dBZ	41 of 89 (46.0%)
1.25 – 1.5"	47.8 dBZ	51.6 dBZ	54.9 dBZ	7 of 34 (20.5%)
1"	47.0 dBZ	50.7 dBZ	53.7 dBZ	9 of 117 (7.7%)



MRMS Large Hail Indicators Through Time: Severe vs. Significant

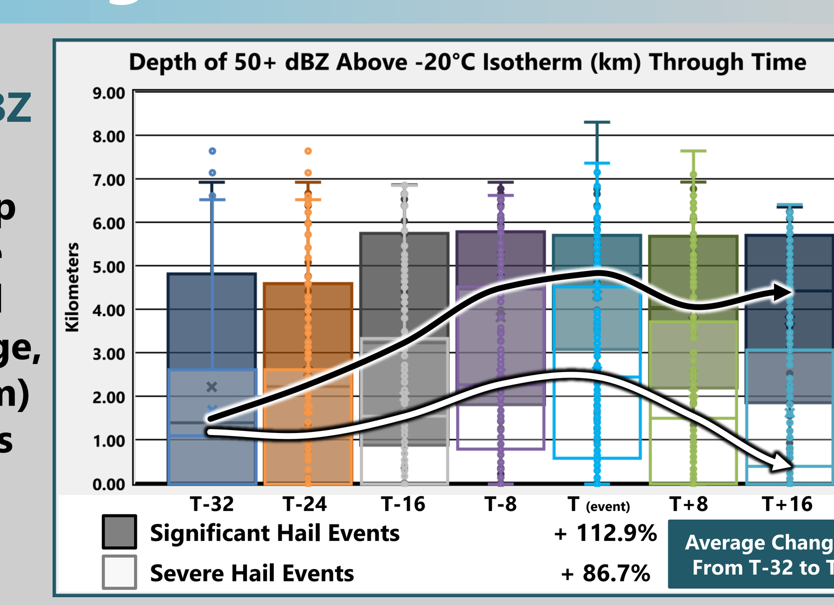
MESH:

- MESH values for all events (severe and significant) generally increased leading up to the time of the event (T) before decreasing slightly after time T.
- From T-32 to T, average MESH values increased by nearly 50% more for significant events opposed to severe events.



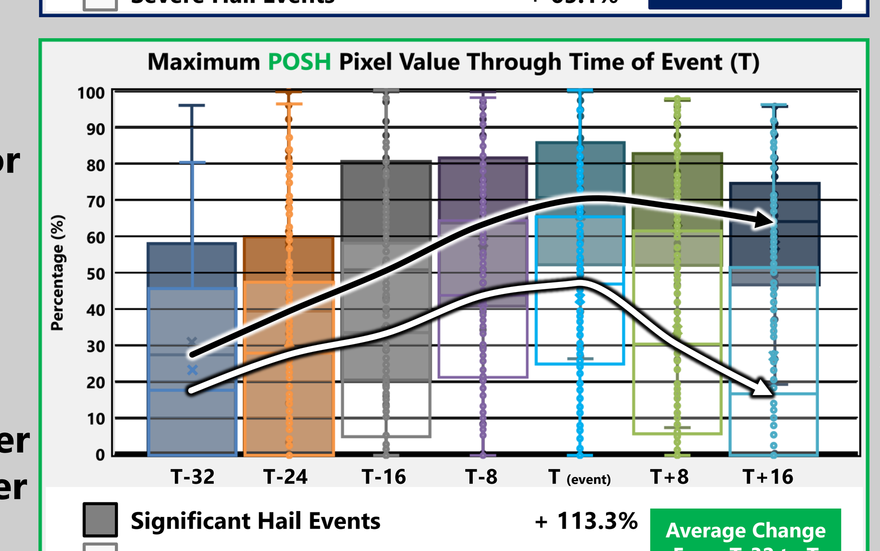
Depth of Top 50+ dBZ Echo Above -20°C

- The height of the top 50+ dBZ echo above the -20°C isothermal plane was, on average, nearly double (4.6km) for significant events opposed to severe events (2.6km).



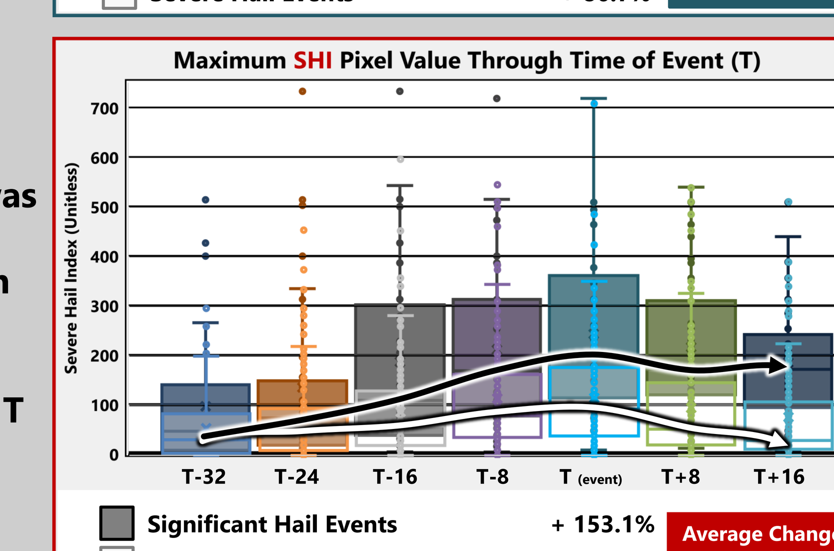
POSH:

- POSH values generally maximized around time T for all events, and was, on average, about 20% higher for significant events opposed to severe events at time T.
- There was generally a sharper drop-off in POSH values after severe events opposed to significant events.



SHI:

- On average, the SHI was nearly double for significant events than for severe events.
- The SHI more than doubled from T-32 to T for both severe and significant events.



Acknowledgements

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