An Overview of Hail Detection Techniques Using SHAVE Hail Reports

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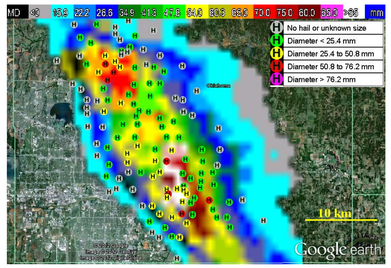
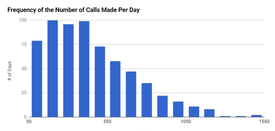
The Severe Hazards Analysis and Verification Experiment

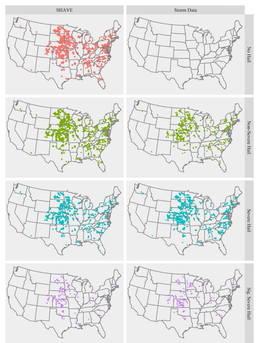


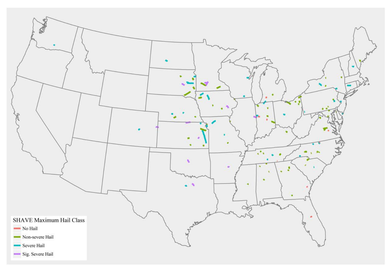


(top) Daily phone call totals during SHAVE
(left) MRMS MESH swath and SHAVE reports for 16 July 2009 in Oklahoma City, OK. Hail up to baseballs was reported.

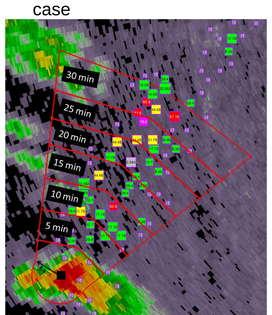
- 2006-2015 effort to collect hail reports at high spatial resolution by cold-calling the public
- Confirmed null and non-severe hail reports (not available in *Storm Data*)
- 259,096 calls were made collecting 54,299 hail reports (17,618 other report types were also collected)
- Spans 88D regimes: super-res introduction, dual-pol upgrade, implementation of new VCPs including SAILS, meso-SAILS, and AVSET

Data and Methods



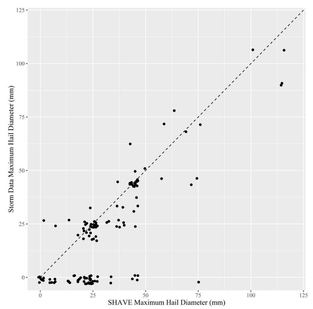


- SHAVE cases illustrating good spatial resolution were selected for analysis
- 389 storms over 229 days were selected from 2006 through 2012 SHAVE operations (*top left*)
- 21,545 SHAVE hail reports came from all the cases
  - 9,912 were no hail; 7,120 were non-severe (< 25.4 mm diameter); 3,648 were severe; 486 were significant-severe (≥ 50.8 mm diameter)
  - 3,335 *Storm Data* hail reports resulted form the 389 storms
- Single-radar (WSR-88D), data from NCEI's Severe Weather Data Inventory (SWDI) and Multi-Radar, Multi-Sensor (MRMS) data were processed for each case

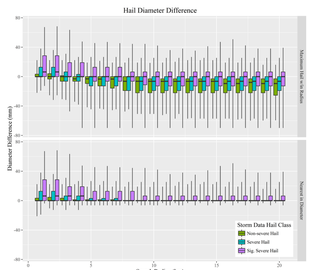


- Reports were compared to accumulated swaths of MRMS products
- For cases illustrating the best coverage (131 storms over 91 days), manual tracking and analyses of the storms were completed *(top right)*
  - 1,417 individual WSR-88D volumes total
- Reports were related to the storms in space and time using a search polygon built along the storm motion out to 30 minutes using the current storm motion (*left*)
- Reports were clustered in 5-minute bins with the maximum size used for comparison

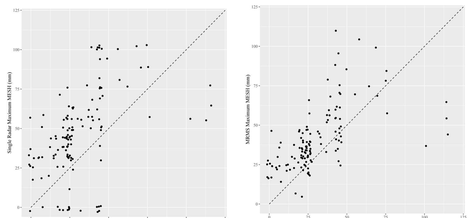
General Results



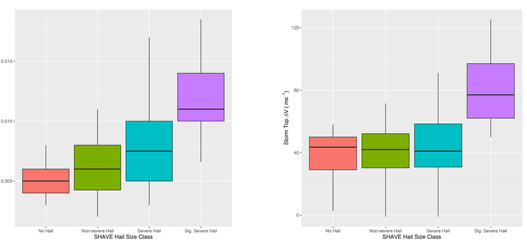
For the 130 tracked storms, many had no *Storm Data* reports along the storm path segment sampled by SHAVE (no *Storm Data* cases marked with -1; some jitter added for point separation)



Using all reports to compare *Storm Data* reports and neighboring SHAVE reports, revealed different size difference distributions dependent on searched area. SHAVE reports were found to have a median spacing of 1.72 km, which did not differ significantly when considering reports of larger sizes (e.g., fairly even sampling along the storm's path).



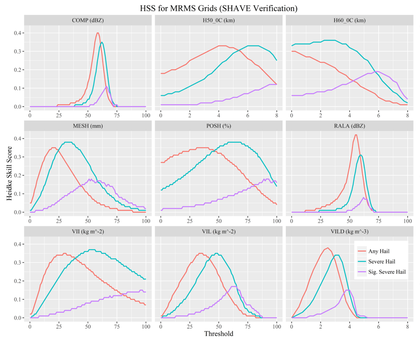
Both maximum single-radar (*far left*) and MRMS (*left*) MESH along the tracked path did not correspond well to the maximum hail observed along the path.



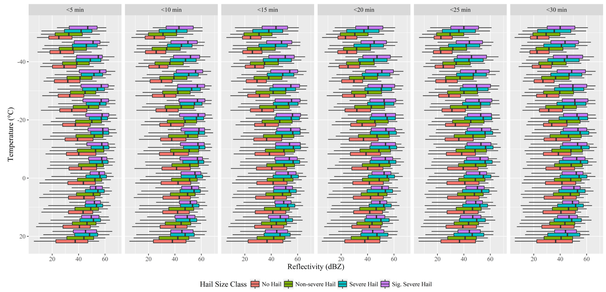
Mid-level rotation (*left*) and storm top ΔV values (*right*) were most helpful discriminating storms that produced significant-severe sized hail somewhere along the sampled path.

- A weak echo region (bounded or not) and TBSS was present in all sig. severe cases
- 91.4% of cases exhibiting a weak echo region were at least severe; only 8.6% had non-severe hail and none were associated with no hail at all
- 5.7% of cases with a three-body scatter spike did not have any hail; 24% were associated with non-severe hail
- Of storms manually identified as rotating, 78.4% were at least severe and only 1 was associated with no hail being reported

MRMS Results

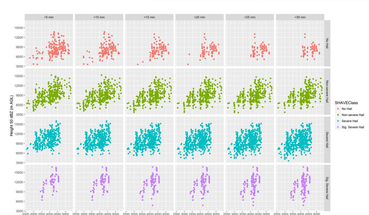


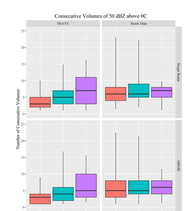
- Accumulations of reflectivity at lowest altitude (RALA; threshold of 55 dBZ) was found to have the best skill in discriminating where hail of any size fell
- Accumulations of MESH (threshold of 30 mm) was found to have best skill in discriminating where severe hail fell
- No products were skilled in discriminating where sig. severe hail fell



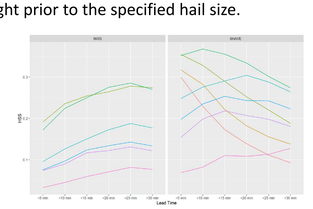
(above) MRMS vertical reflectivity profiles (95th percentile boxplots) at the point of highest SHI compared to general hail size categories for 6 lead time categories. Overall, reflectivity-only based products will be limited in discriminating different hail size categories for any lead time.

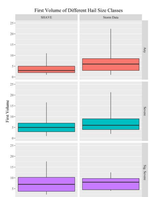
Volume-by-volume Analysis





(*left*) Height of 50 dBZ compared to 0°C height per the technique in Donavon and Jungbluth. (*right*) 95th percentiles of number of consecutive volumes of 50 dBZ above the 0°C height prior to the specified hail size.





(*left*) Heidke Skill Score for TBSS for different lead times using SHAVE and *Storm Data* reports. (*right*) 95th percentiles of number of volumes prior to first report of different hail size categories. Later peaks in HSS in *Storm Data* may be from later appearing reports.

Polarimetric Cases

- A small set of polarimetric cases were used to develop the Hail Size Discrimination Algorithm (HSDA)
  - For Hydrometeor Classification Algorithm identified pixels of 'Rain/Hail', the HSDA provides an estimate for non-severe, severe, and significant-severe hail
- HSDA outperformed single-radar MESH from SWDI (CSI of 0.543 vs. 0.324, respectively)
- All polarimetric SHAVE cases with good spatial density from the years 2010 through 2015.
- Total polarimetric cases (at least 1 polarimetric WSR-88D within 150 km of SHAVE reports) total 442
  - With 302 single-polarization cases, SHAVE has 744 total cases available for MRMS evaluation and future applied research

Map (*top left*) of the 3,257 reports used for HSDA development. Vertical profiles using 4 matching techniques for reflectivity (*top right*), differential reflectivity (*bottom left*), and correlation coefficient (*bottom right*).

Future Work

- Finish single- and multi-radar analysis
- Finish compiling dual-pol cases
  - Add *Storm Data* reports, combine with SWDI
- Continue development of NHDA (combination of single- and dual-pol algorithms)
- Manual polarimetric analysis for volume-by-volume analysis
- Investigate dual-pol MRMS fields
- SHAVE database will be used to assist development of new probabilistic warning guidance
- Apply MRMS findings to multi-year reanalysis of MRMS data

Acknowledgements

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