MRMS Severe Research and Efforts for Forecast Improvements

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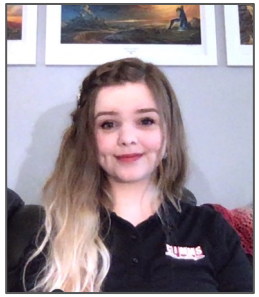

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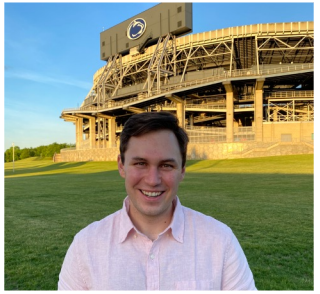

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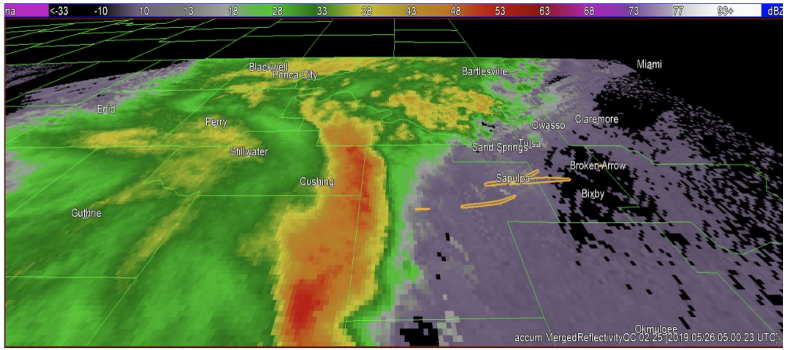
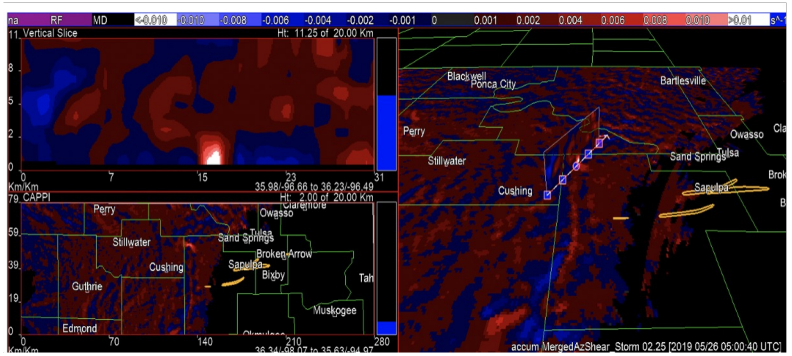




What we do?

- Research and development of the Multi-Radar Multi-Sensor (MRMS) Severe products
  - R2O for MRMS
  - Supplemental radar integration testing
  - Model DA and verification/validation
  - New products using dual-pol and velocity
- Research, develop, and transition new products for the WSR-88D
  - Continued development of the WDSS-II system
  - ROC Technology Transfer MOU
- Develop and conduct science on large datasets using machine learning and other traditional methods
- Conduct research and develop tools that improve warnings and warning decision making
- Leverage emerging technologies
- Science related to TWIEP and VORTEX-USA

Multi-Radar Multi-Sensor

MRMS is an advanced remote sensing processing system developed by CIWRO/NSSL researchers and is used in the WX enterprise.

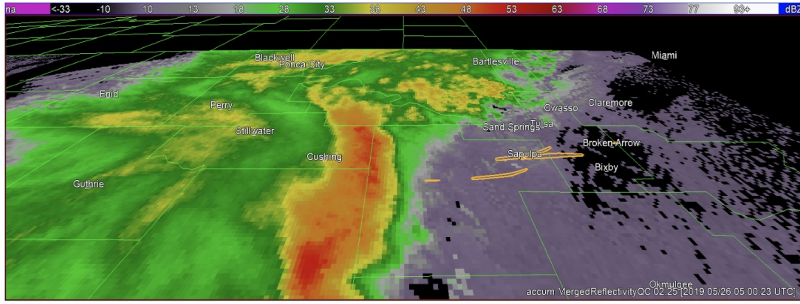
- Built upon several programs (including WDSS-II and HMET)
- Updating and supporting the research community
- Development platform for new applications
- kiel.orgtea@noaa.gov for a license and build of WDSS-II and jian.zhang@noaa.gov for HMET

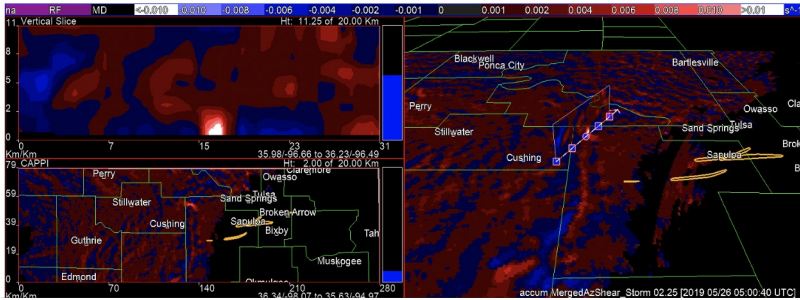
Verification and assimilation into NWP models

Supplemental radar integration testing

New products to detect rotation and shear

Pioneering NSSL cloud computing



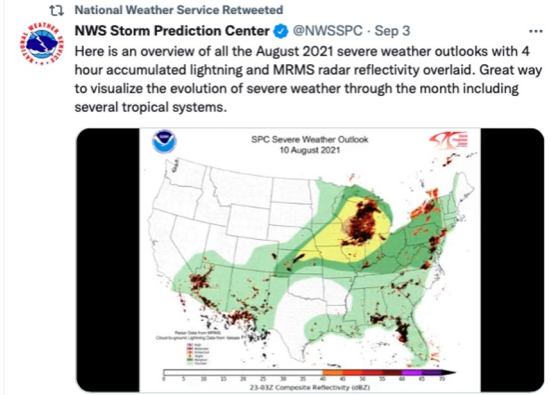


MRMS and the NWS

Warning Decision Support and Public Messaging

- MRMS reflectivity, hail, precipitation, FLASH, and ProbSevere products used routinely in NWS severe weather operations and public messaging
- MRMS rotation tracks used for post-event emergency response and for tornado damage surveys
- NWS-wide field survey completed in August 2022 by AFS11 to poll operational users on current MRMS usage and capability gaps (**204** responses)
  - **88%** support additional radars
  - **86%** want public data archive
  - **67%** want reduced latency from SBN

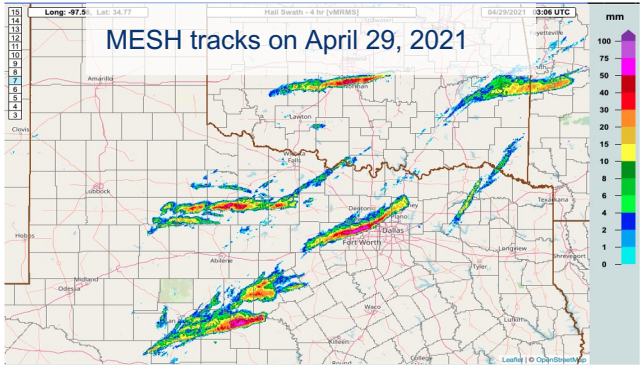
NWS Houston Office Social Media Messaging for Tropical Storm Imelda (2019)

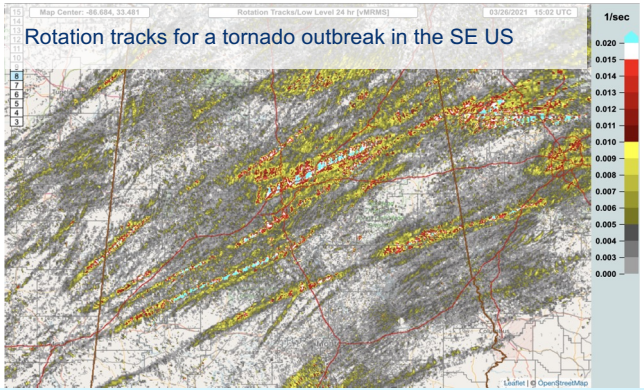


Northeast US Flash Flooding from Remnants of Hurricane Ida (2021)

MRMS Severe Weather Products

- **Maximum Estimated Size of Hail (MESH)** provides hail size estimation that can be expected
- **Rotation Tracks** indicate where rotation in storms are occurring; Strong values indicate high tornadic likelihood
- **Vertically Integrated Liquid and Ice** indicate the amount of liquid or ice in a storm vertically at each point and relates to rainfall/hail potential
- **Lightning Probability** is a machine learning algorithm that determines the likelihood of cloud-to-ground lightning that could occur over a given area in the next 30-60 minutes

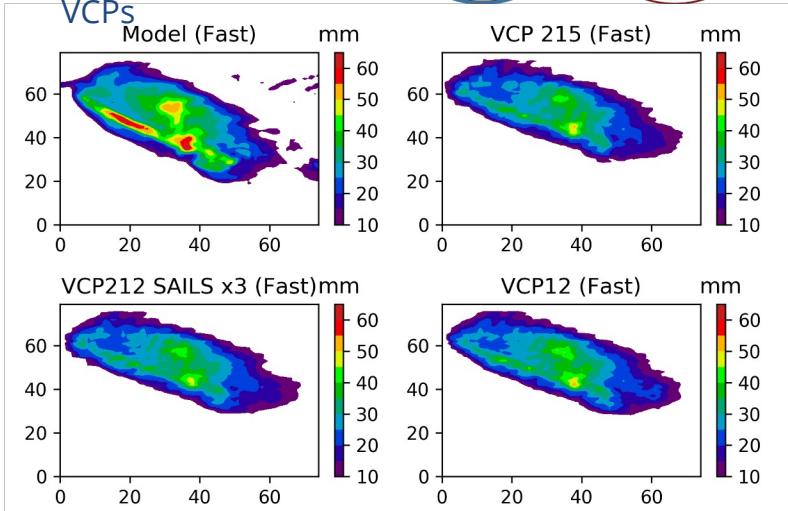




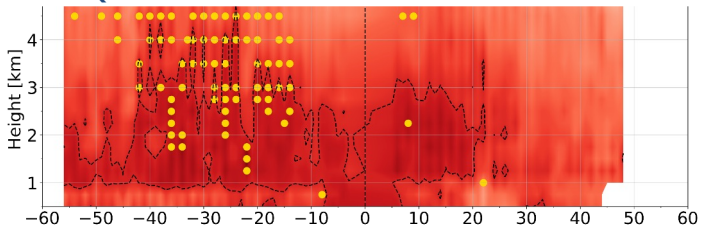
MRMS Severe Research

- AzShear/Divergence Shear for tornadic circulation detection
- Effects of scanning strategy on MRMS products
- Filling gaps in the WSR-88D network

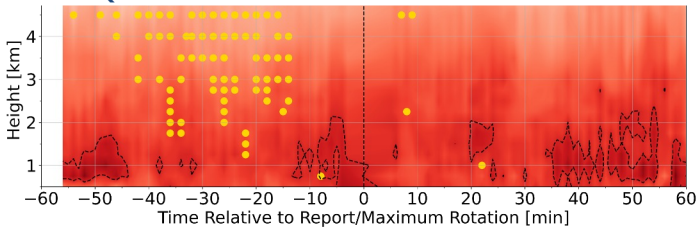
Simulated MRMS MESH from varying VCPs



QCLS Tornadic MRMS AzShear



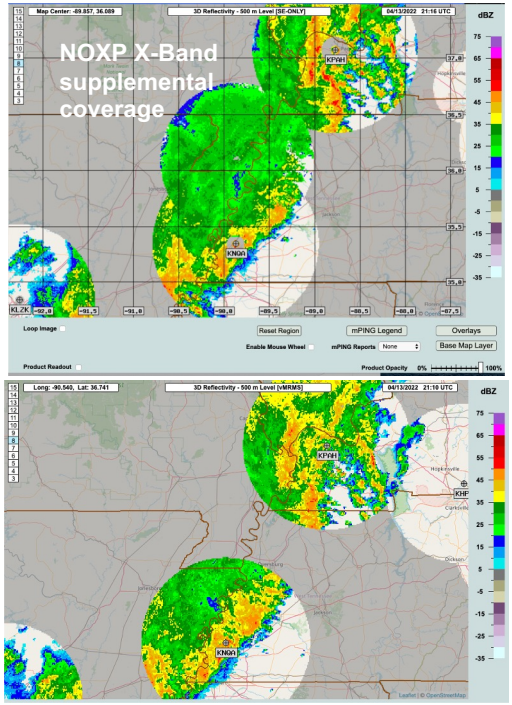
QCLS non-Tornadic MRMS AzShear

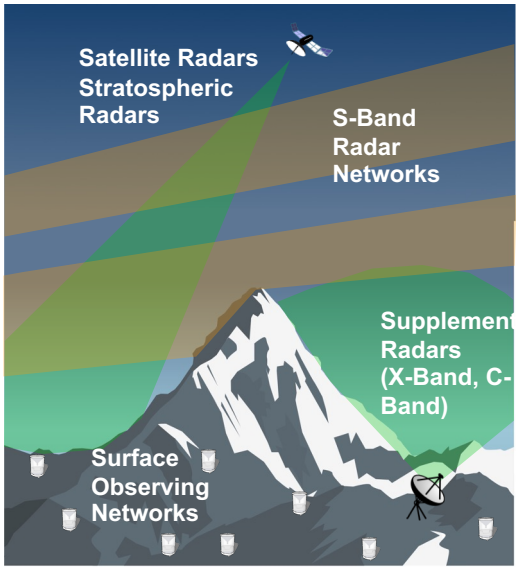


MRMS's Future: R2O Platform for new Observations

MRMS is ideally positioned to serve as the R2O gateway for new and emerging observing systems.

- Initial successes demonstrated with Canadian radar networks and supplemental radars (e.g., Alamosa)
- Established processes for ingest, quality control, and optimized merging of widely varying data sources
- Established pathway to model data assimilation and operational agencies
- Conduct science to utilize upcoming PAR and other dish and non-dish radars

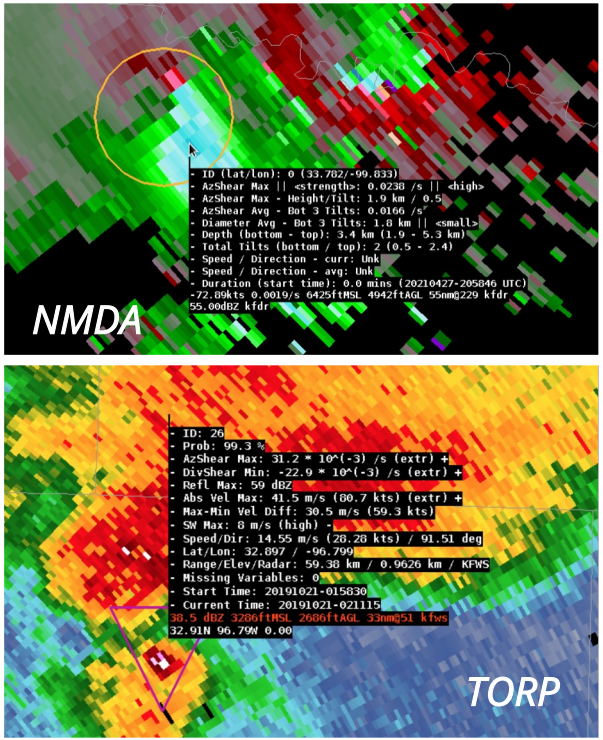




ROC Tech Transfer MOU

Work with the ROC to help develop and transition new products for the WSR-88D. Tested in the HWT.

- New Mesocyclone Detection Algorithm (NMDA)
  - Uses azimuthal shear to detect and track mesocyclones to replace current MDA
  - Calculates and trends mesocyclone attributes
- Tornado Probability Algorithm (TORP)
  - Modernizing the Tornado Detection Algorithm (TDA/TVS) using machine learning
  - Publication in revision

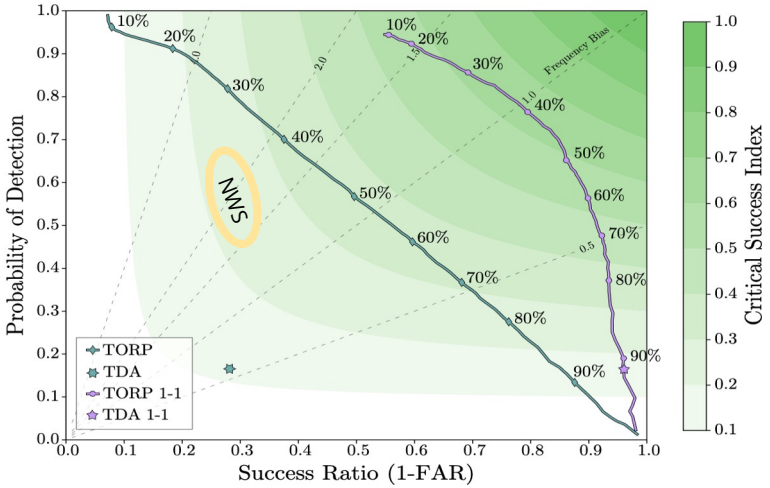


> *"Both algorithms gave good detections, which when combined with velocity and reflectivity signatures, and prior reports from other storms, likely would have been enough to nudge me to a warning faster than it otherwise would have been."* - Forecaster participant in the HWT

TORP

- TORP provides tornado probability guidance using single-radar data, and calculates tornado probabilities with a random forest (RF) machine-learning model on high-rotation objects, as defined by LLSD azimuthal shear of radial velocity (AzShear)

- Runs in real-time internally and viewable on the severe weather research map service (SWRM)

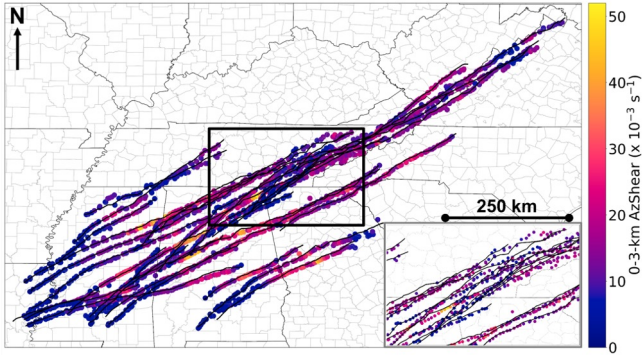


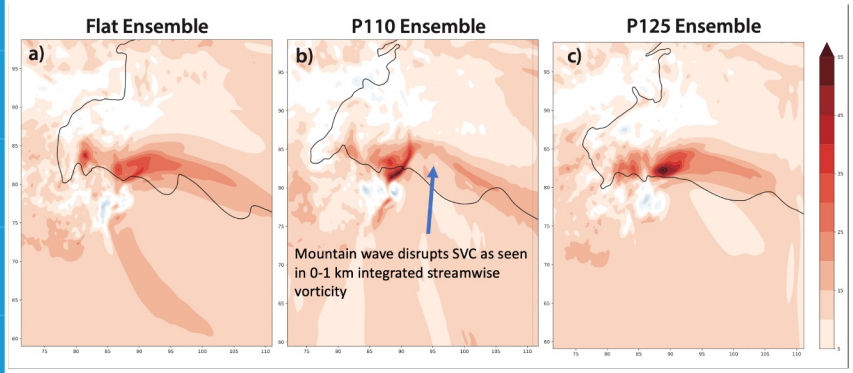
Purple - storm reports only when TDA was available

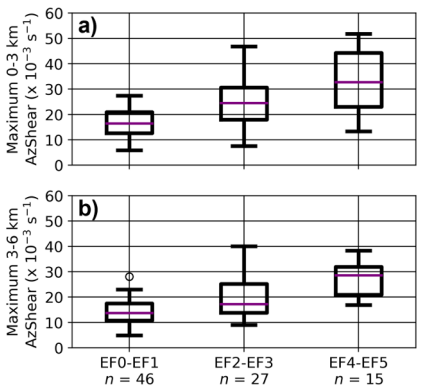
Teal - TORP evaluated with 150,000+ reports, detections, and manually identified non-tornadic storms in tornadic environments

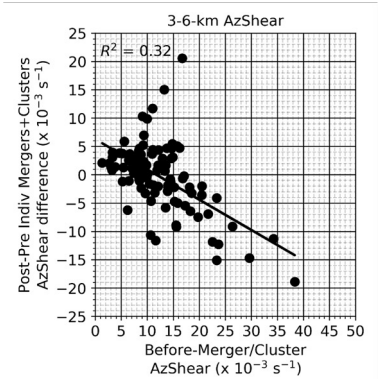
Applications to Supercells

- Storm mode and object detection
- Identification of rotation and other potential hazards
- Synthetic radar observations
- Detailed analysis of significant past events
- Applying severe storm indicators in Dual-Pol fields



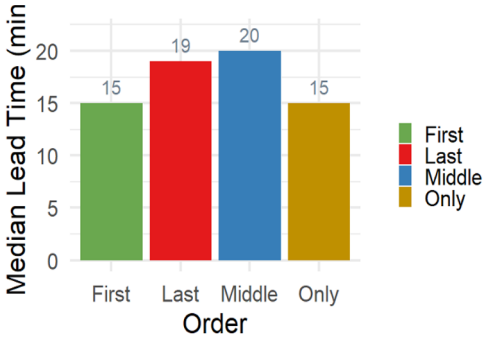


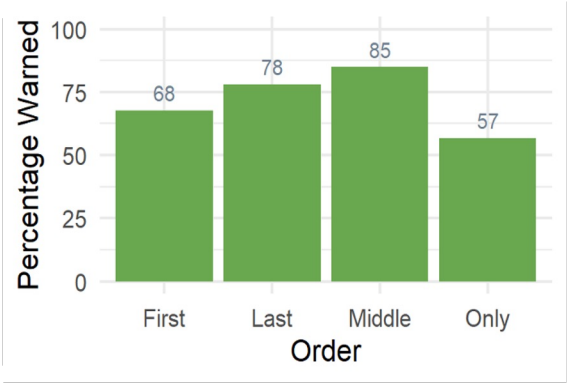




Applications to Warning decisions

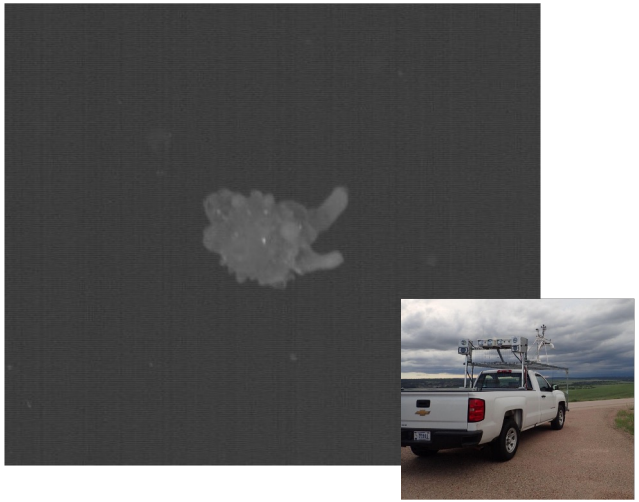
Investigating intra-storm tornado warning performance





- The first tornadoes *of each storm* are **less-often warned** and (when they are) have **less lead time**.
- Subsequent tornadoes for cyclic storms are **more likely to be warned** and have **greater lead times**.

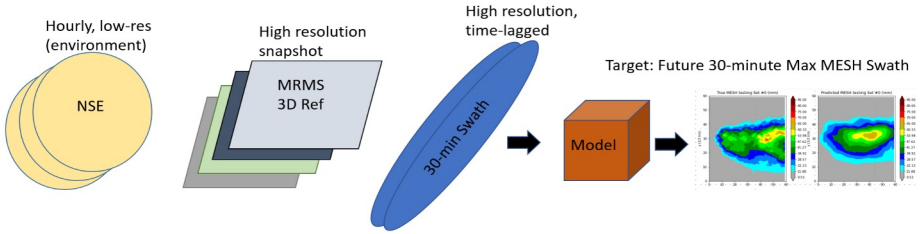
Hail algorithms and science

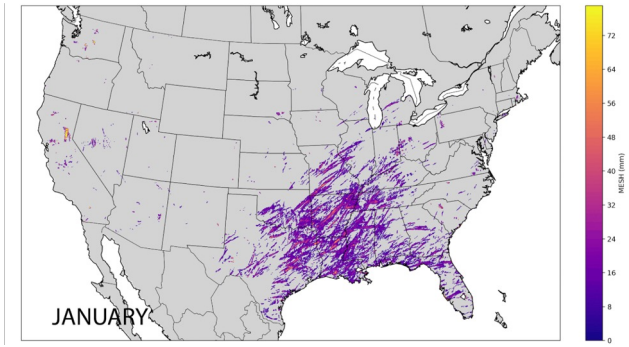


Harnessing Big Data

Multi-Year Reanalysis of Remotely Sensed Storms (MYRORSS)

- CONUS-wide coverage of ~MRMS data at 5-min temporal resolution for 1998 through 2011
- Use case: MESH climatology using monthly swaths (i.e., very basic hail climatology)
- Use case: U-nets for MESH swath prediction





- Derived data: MESH swaths with statistics from other MRMS and NSE fields; 2 storm-cluster databases with statistics from other MRMS and NSE fields (~1100 total variables, ~40M objects)

Collaborative Interests

- Taking advantage of large datasets
- Using observations in new ways
  - Model verification/validation
  - AzShear and Updraft Helicity comparison
  - Model and observational studies
- New radars and radar technology
- Improving our understanding of Severe Convection
- Developing tools and algorithms for use with radars
- Machine learning tools and algorithms
- Climatologies using radar data
- Field work using mobile radar

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Datasets for collaboration

- MYRORSS (https://osf.io/8f4v2/ and soon also located at https://noaa-oar-myrorss-pds.s3.amazonaws.com/index.html)
  - MRMS data covering CONUS, 1998 - 2011, 3D reflectivity + derivatives, two azshear layers
  - Storm cluster database (~40M objects, ~1100 attributes)
  - Future database-style derivatives based on MESH and echo top swaths
- SHAVE (*coming soon*)
  - High-resolution hail reports (~2 km spacing), including < 1" dia. and "no hail" reports
  - Manually tracked storms for 213 cases
    - Attributes from manual interrogation and radar data, paired to reports downstream
- Tornado-related data sets (2011-2018)
  - Single-radar data for every storm report + max/min/mean/percentiles within 2.5 km of report
    - LLSD gradients of every variable, including dual-pol
  - Student datasets
    - Pre-tornadic, non-tornadic storms in tornadic environments, QCd tornado reports
  - 1-min interpolated tornado report dataset with segmentation info (like Onetor), DAT data wi
    speeds/magnitudes/DIs, and population density at different resolutions (2011-2021)
    - Even includes damage survey pictures!
- Mesocyclone/rotation dataset
  - 8000+ location points of rotation manually derived from WSR-88D single-radar data
  - Wide variety of storm/case types and geographic locations
- MRMS v12.2 reanalysis ongoing.