

Multiple-Radar / Multiple-Sensor (MRMS) severe weather applications

Greg Stumpf

CIMMS / NWS-MDL, Norman, OK

Kurt D. Hondl

NSSL, Norman, OK



Background



Storm Cell Identification and Tracking (SCIT) algorithm

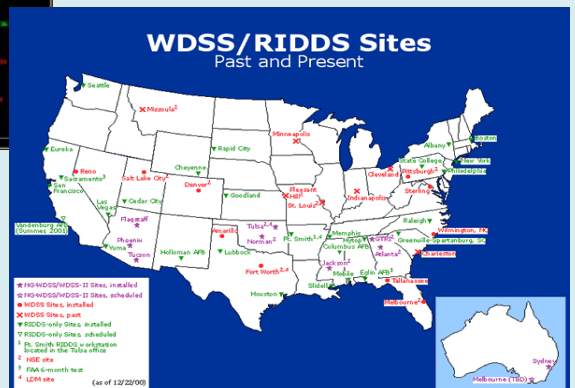
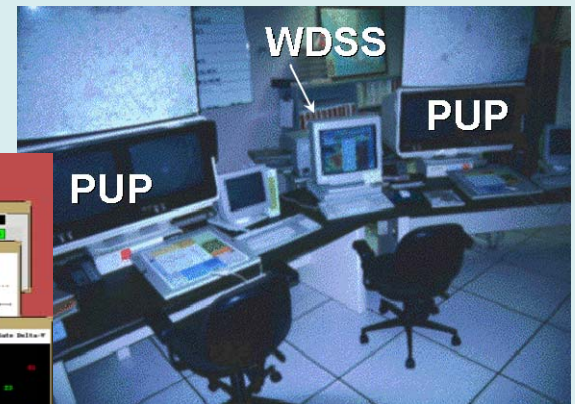
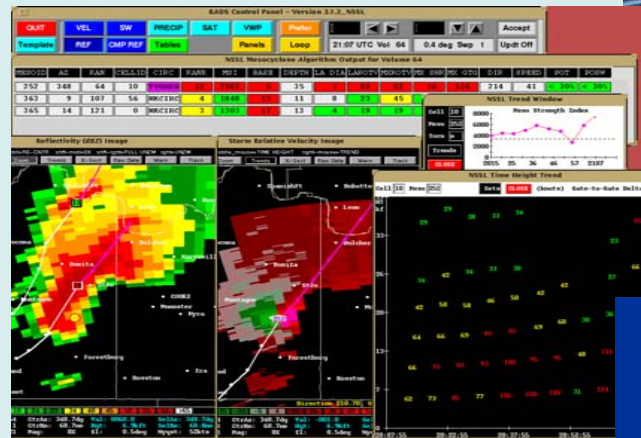
Hail Detection Algorithm (HDA)

Mesocyclone Detection Algorithm (MDA)

Tornado Detection Algorithm (TDA)

Damaging Downburst Prediction and Detection Algorithm (DDPDA)

Warning Decision Support System (WDSS)



Developers gain understanding of operational requirements

NWS users exposed to latest R&D Feedback

Limitations of early algorithms

Only one data source – a single WSR-88D:

Cone-of-Silence

Range Degradation

Terrain blockage

Clutter and AP

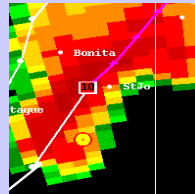
Volume product latency



Storm hazards treated as centroid points:

Extent of 2D threat area not depicted

Bad vertical and time association



Garbage in = garbage out

Need improvements in data quality

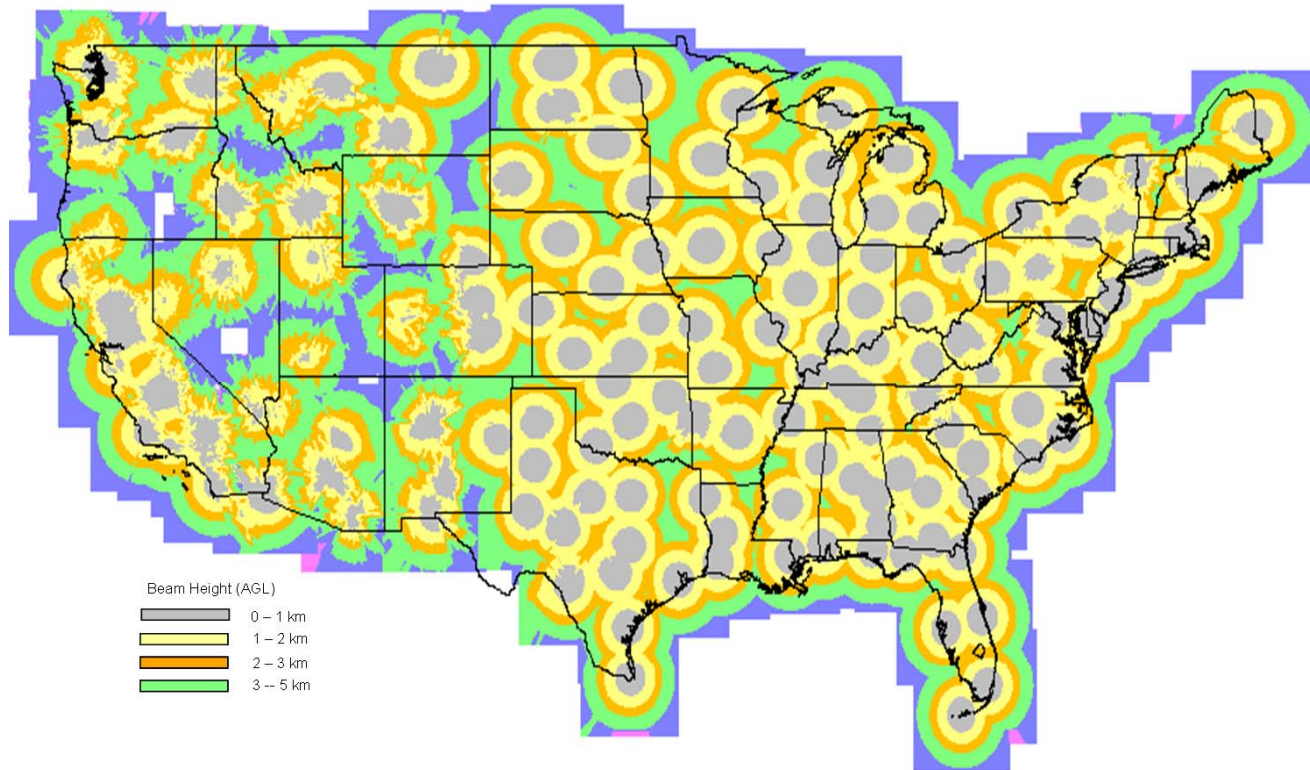


algorithms



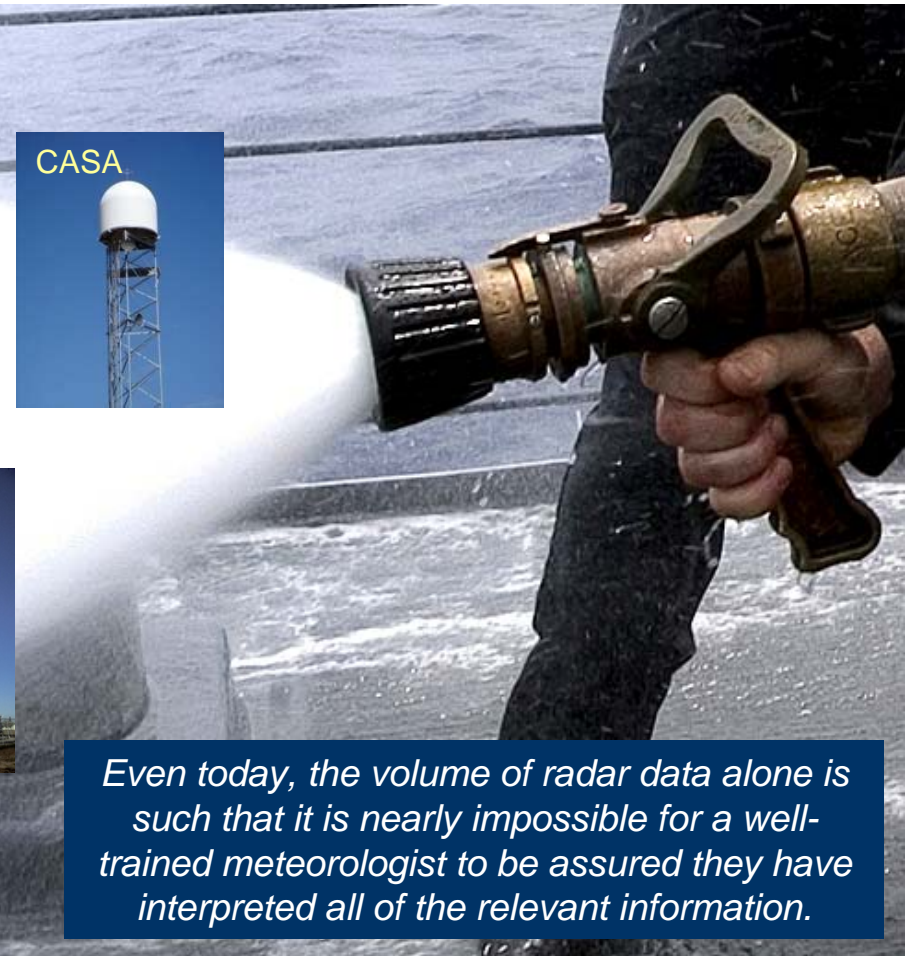
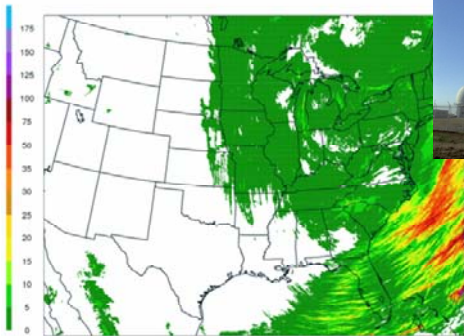
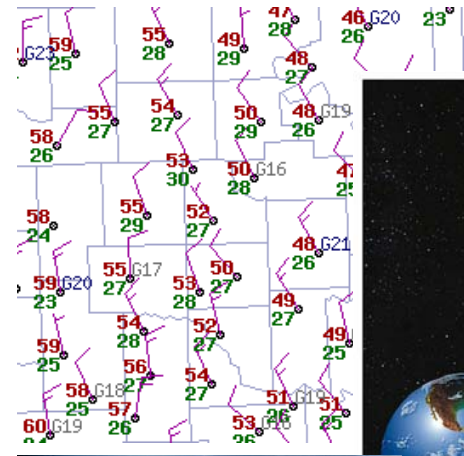
Base Radar Data Analysis

Opportunities For Improvement



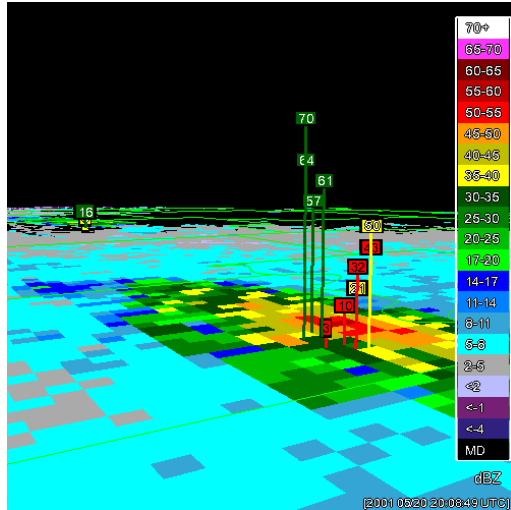
Exploit multiple-radar coverage to mitigate the limitations

Multiple sensors



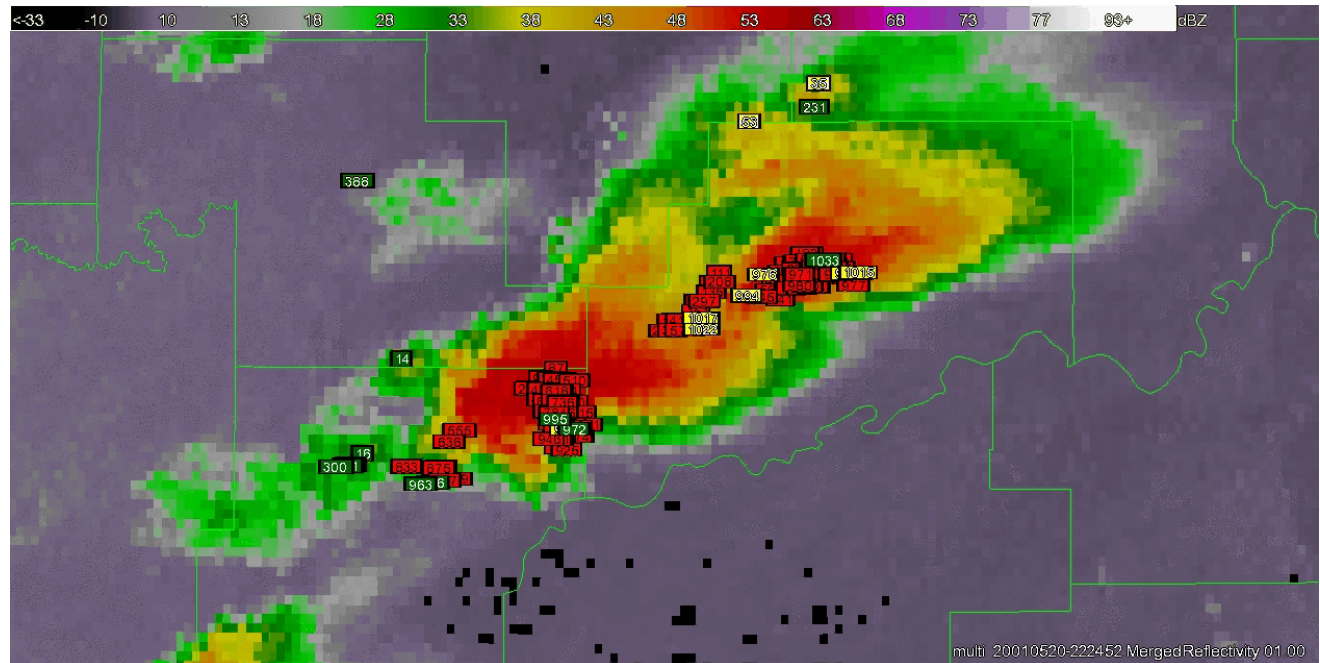
Even today, the volume of radar data alone is such that it is nearly impossible for a well-trained meteorologist to be assured they have interpreted all of the relevant information.

Multi-Radar / Multi-Sensor (MRMS) Algorithms



Warning Decision Support System – Interactive Information:

- ✦ MRMS framework
- ✦ Developed in the early 2000s
- ✦ Tested at several WFOs (JAN, ICT, LSX, OUN)
 - ✦ Veteran's Day 2002 Service Assessment recommended WDSSII implementation





Advantages of MRMS

Integrate multiple-radar and multiple-sensor information

- ✧ No longer single-radar specific.
- ✧ **More accuracy** in detection and diagnosis (better sampling - more “eyes” looking at storms).

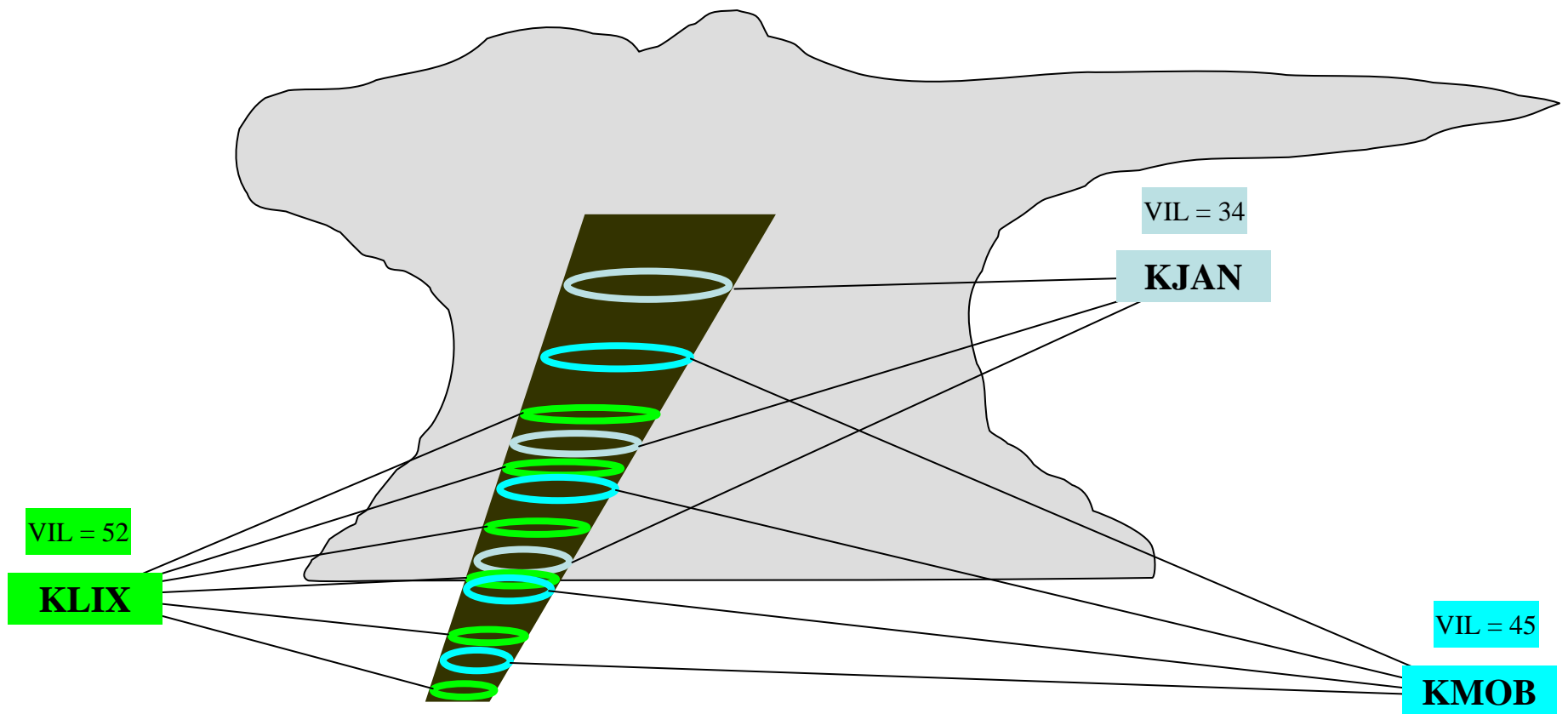
Rapid-update capability

- ✧ Uses virtual volume scan concept.
- ✧ **Better lead time** (no more waiting until end of volume scan for guidance).

Automatically fill in outage gaps by other sensors

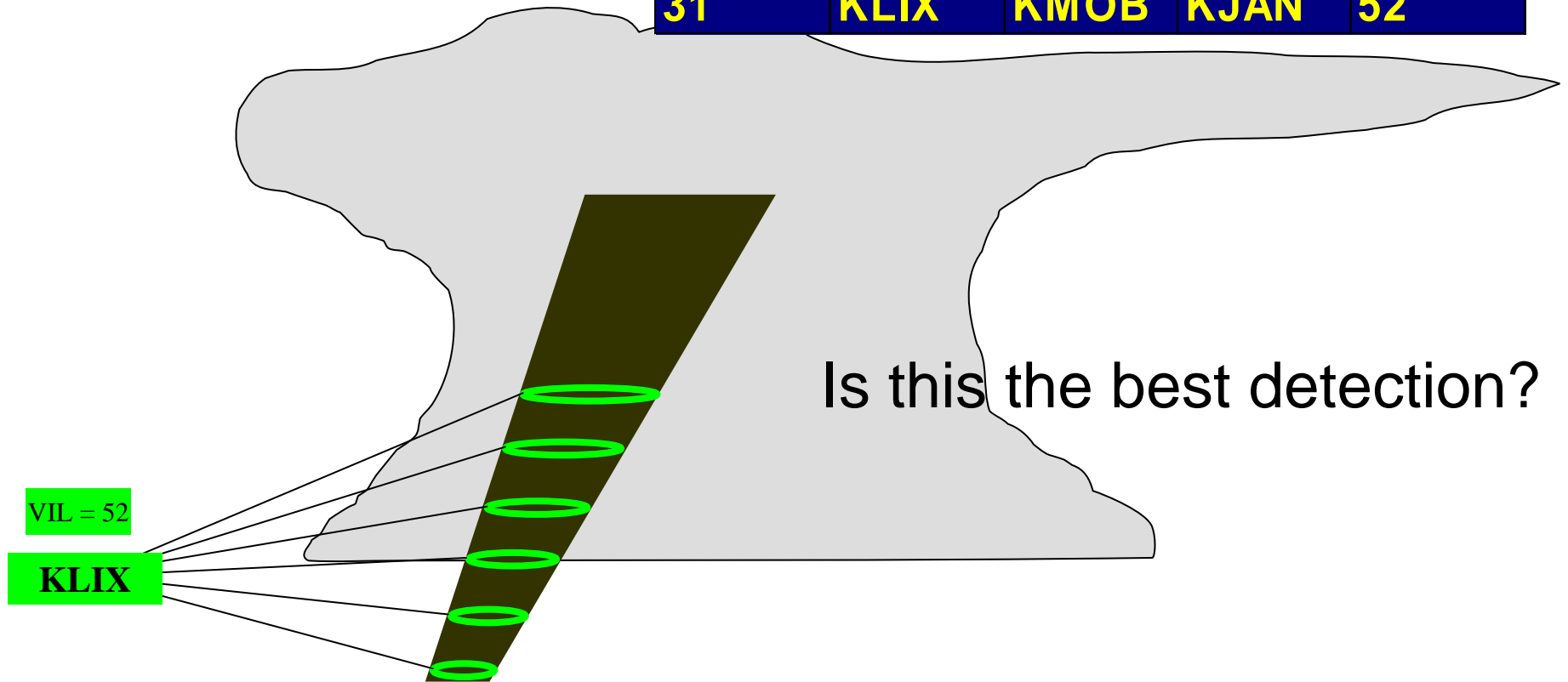
- ✧ Provides **better continuity of operations.**

Many single radars provide many different answers



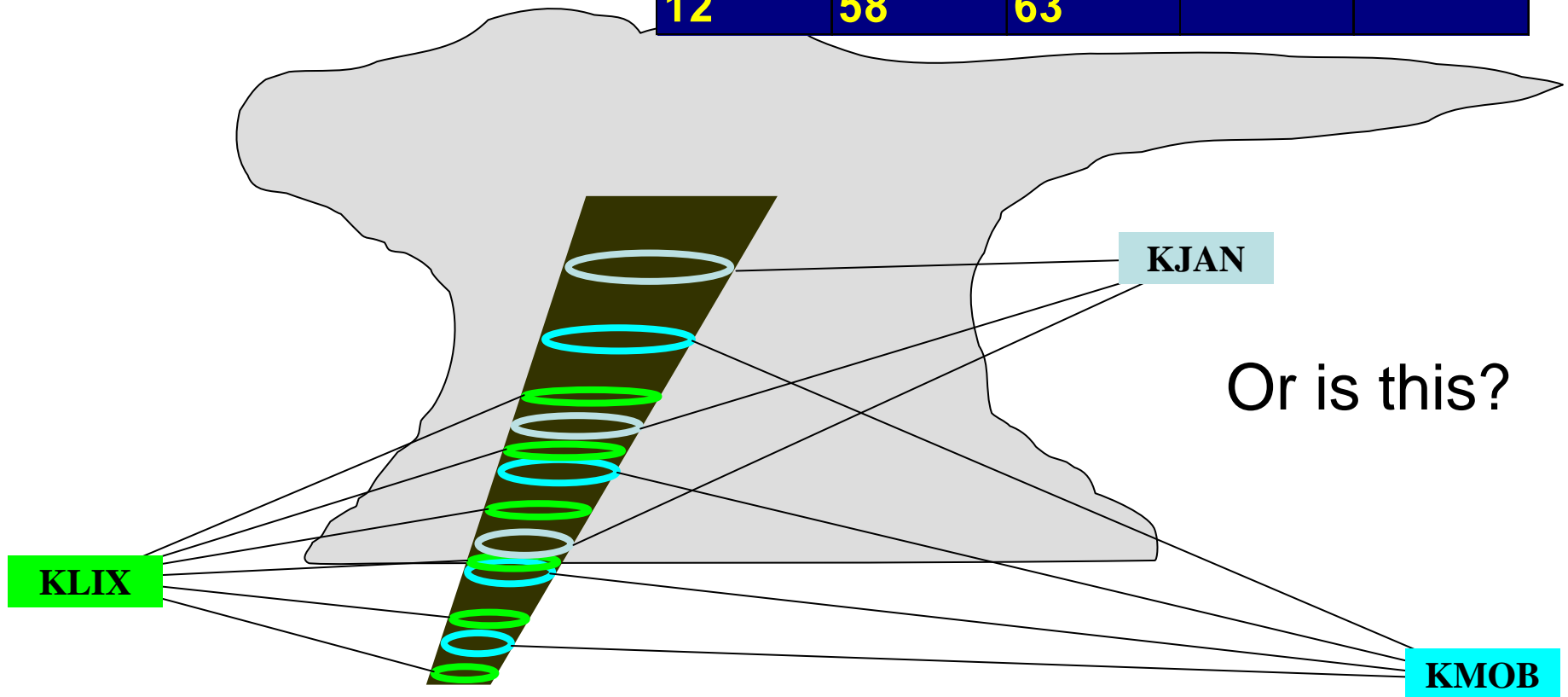
Many single radars provide many different answers

CELL ID	RADAR	RADAR	RADAR	VIL
31	KLIX	KMOB	KJAN	52

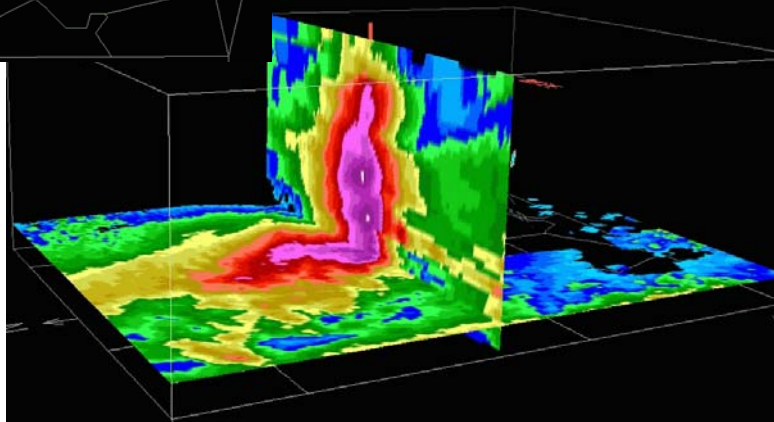
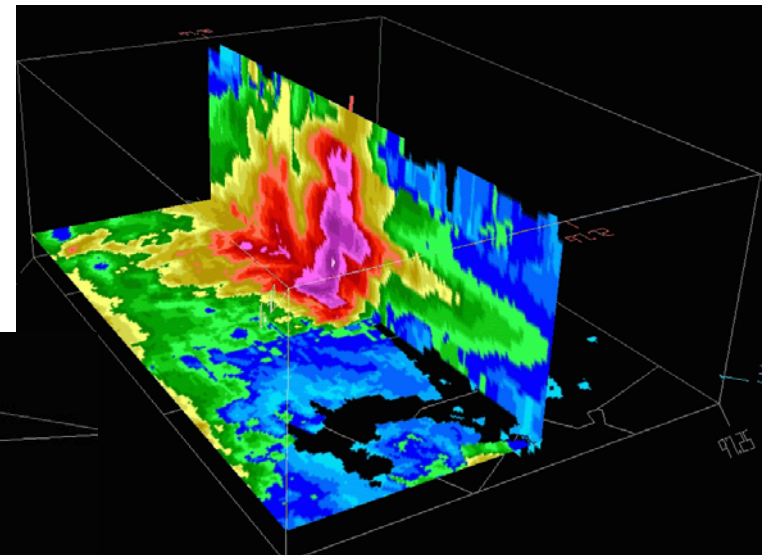
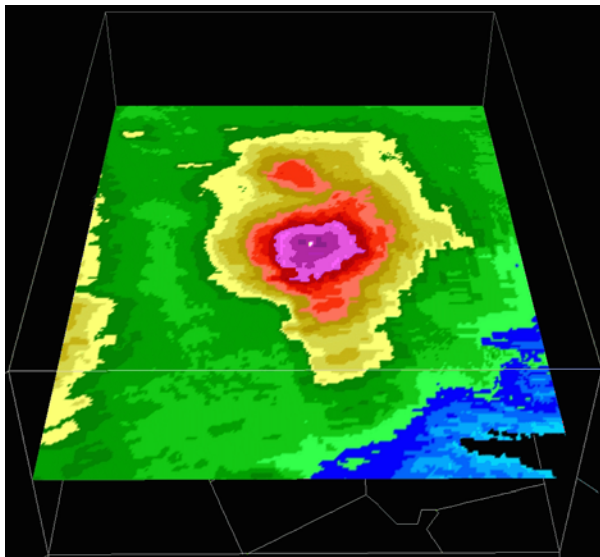


Multiple radars provide one answer

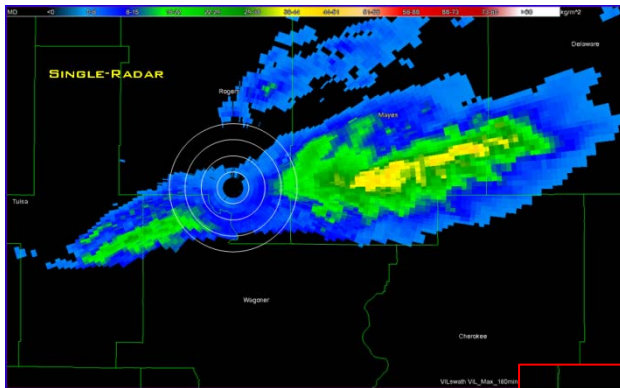
CELL ID	VIL	Max Dbz	etc.	etc.
12	58	63		



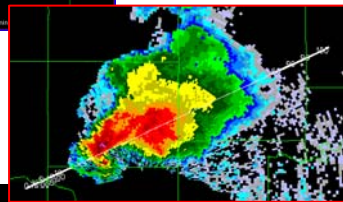
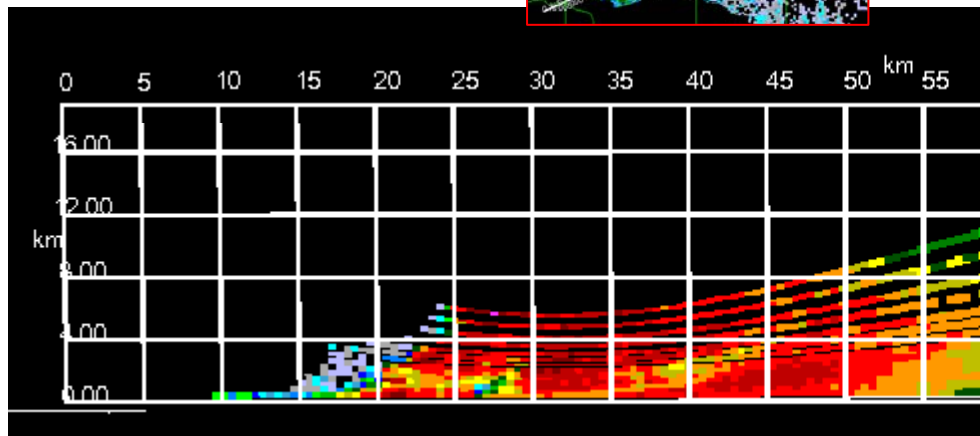
Multiple-Radar 3D Reflectivity Mosaic



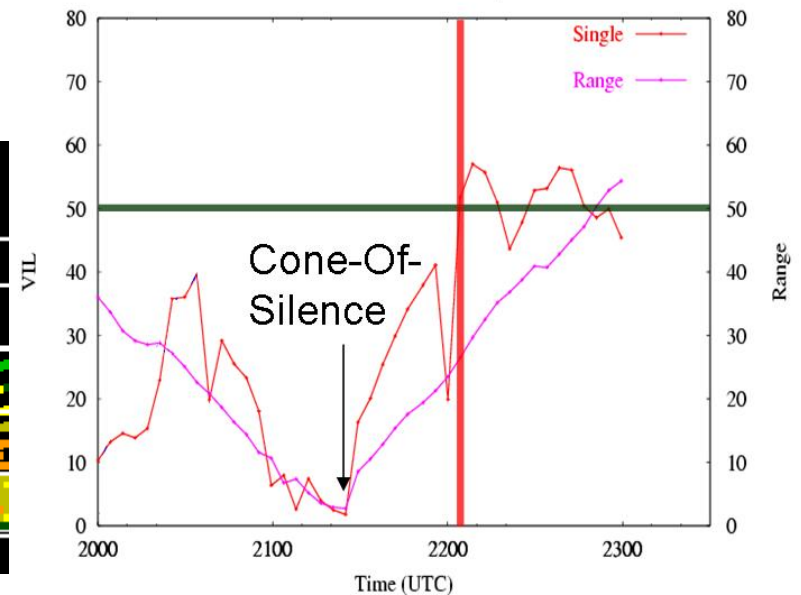
Single radar data



Single Radar



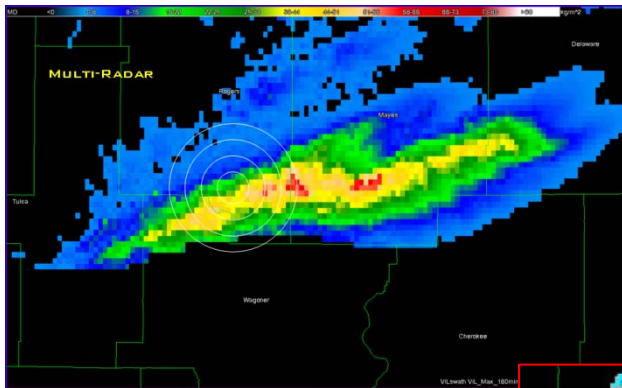
2004/04/22: Multi-radar VIL vs. Single-radar VIL



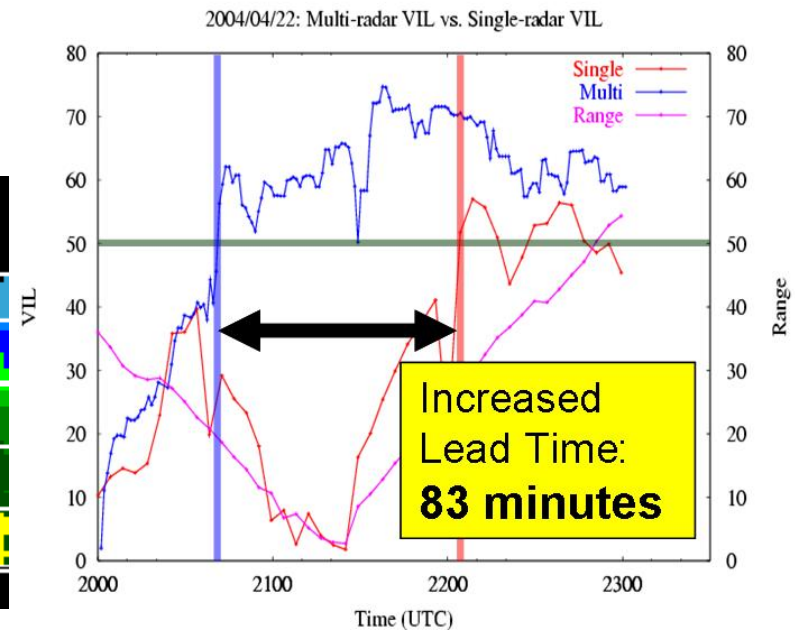
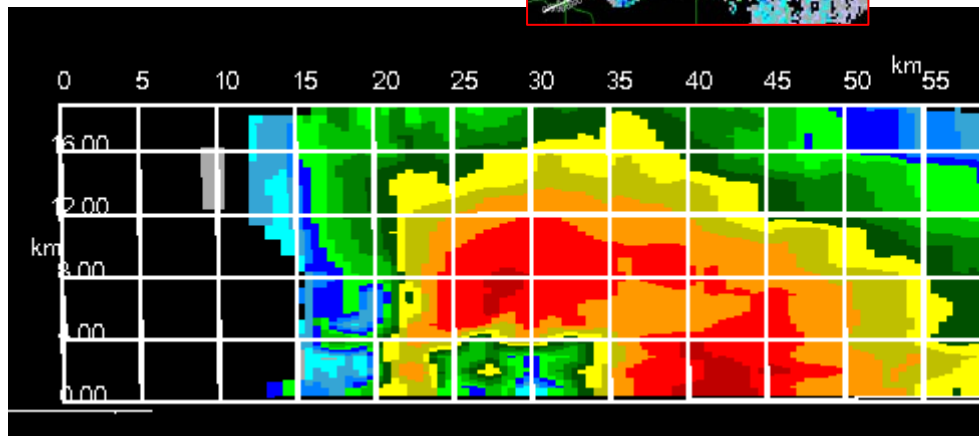
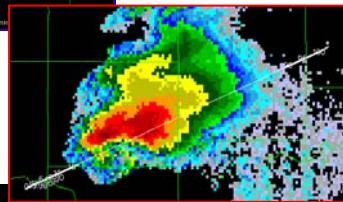
Blended 3D multi-radar data

Radars in network supplement each other:

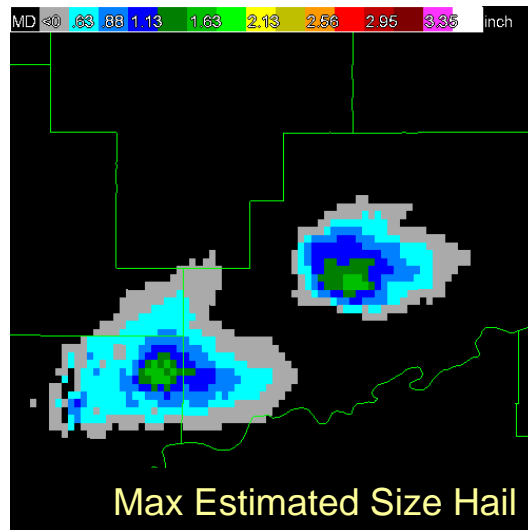
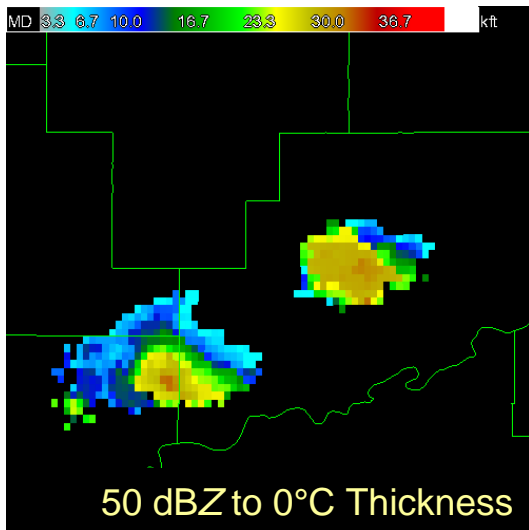
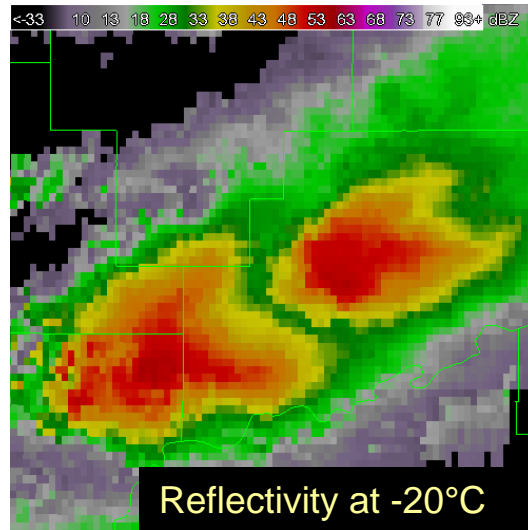
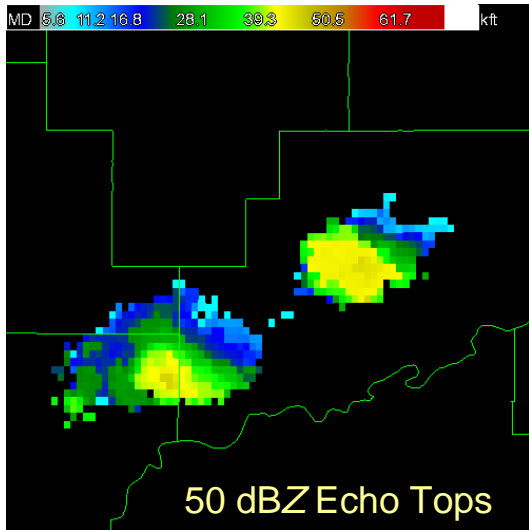
- Overlapping coverage
- Fills in gaps from terrain blockage
- Increased sampling frequency



Multiple Radars



Multi-sensor reflectivity products



- Reflectivity At Lowest Altitude
- Maximum Vertical Reflectivity (CR)
- Echo Tops (18, 30, 50 dBZ)
- Isothermal Reflectivity (0°C, -10°C, -20°C)
- Isothermal Reflectivity Thickness
- Layer Reflectivity (Average, Maximum, Integrated)
- VIL, VIL Density
- POSH, MESH

MRMS Hail Swaths

"Is there a business I can call to verify my warning?"

"Where was the greatest likelihood of the largest hail?"



March 12-13 2006
Outbreak

Kansas
Missouri
Illinois
Indiana

MRMS
Hail Swaths

Note "Six-State
Supercell"!

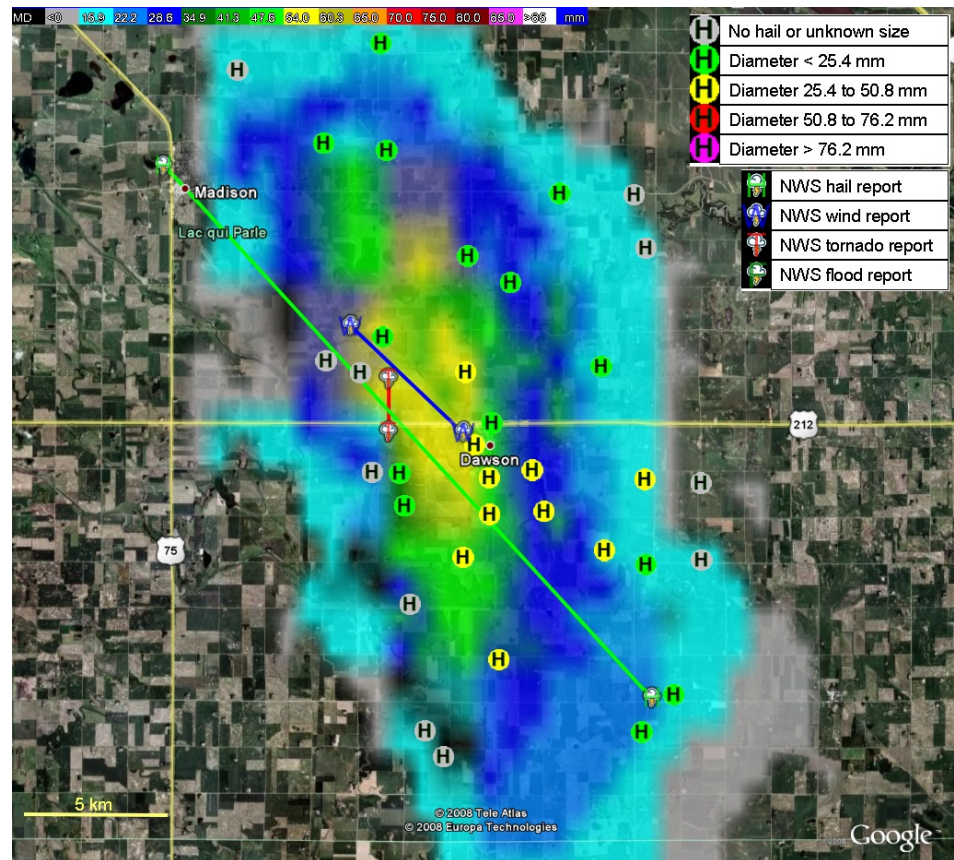
Tuning MRMS Hail Estimation

Severe Hazards AnalYSIS & Verification Experiment

Goal: Collect high temporal and spatial resolution data that describe the distribution of hail sizes in hail swaths to tune MRMS hail algorithms.

“Bias-corrected” MESH (MESHb)

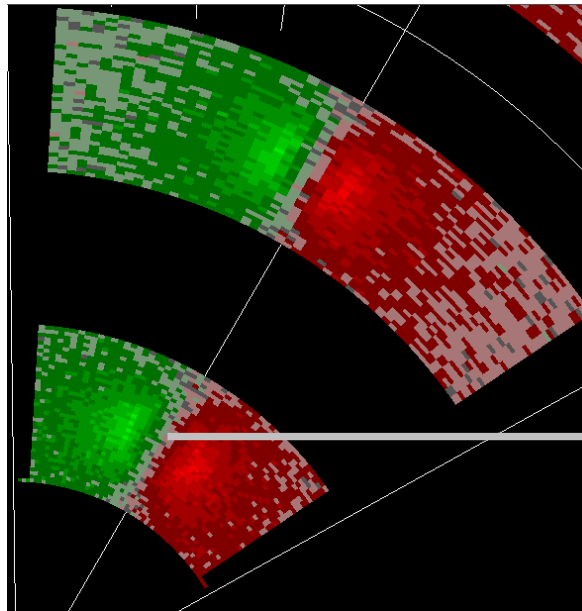
- Adjusted MESH based on recent comparison with high-density reports from the SHAVE project



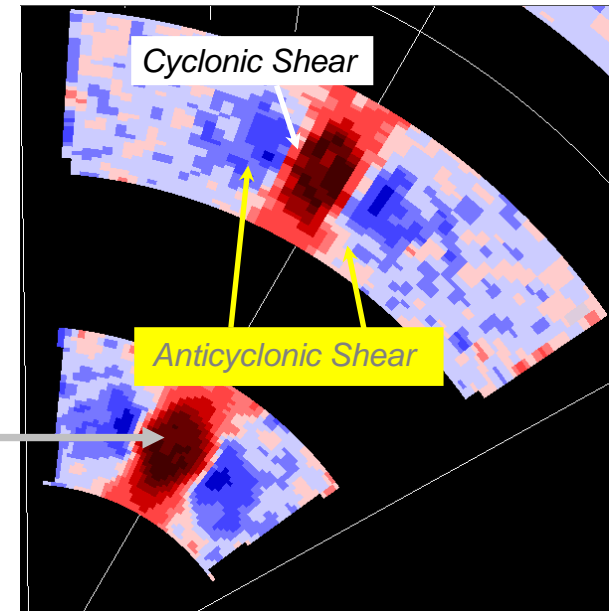
Vortex Detection and Diagnosis

- Removes radar viewing angle dependence and range dependence
- Enables multi-radar blending
- Smoother, easier to track features

Radial Velocity

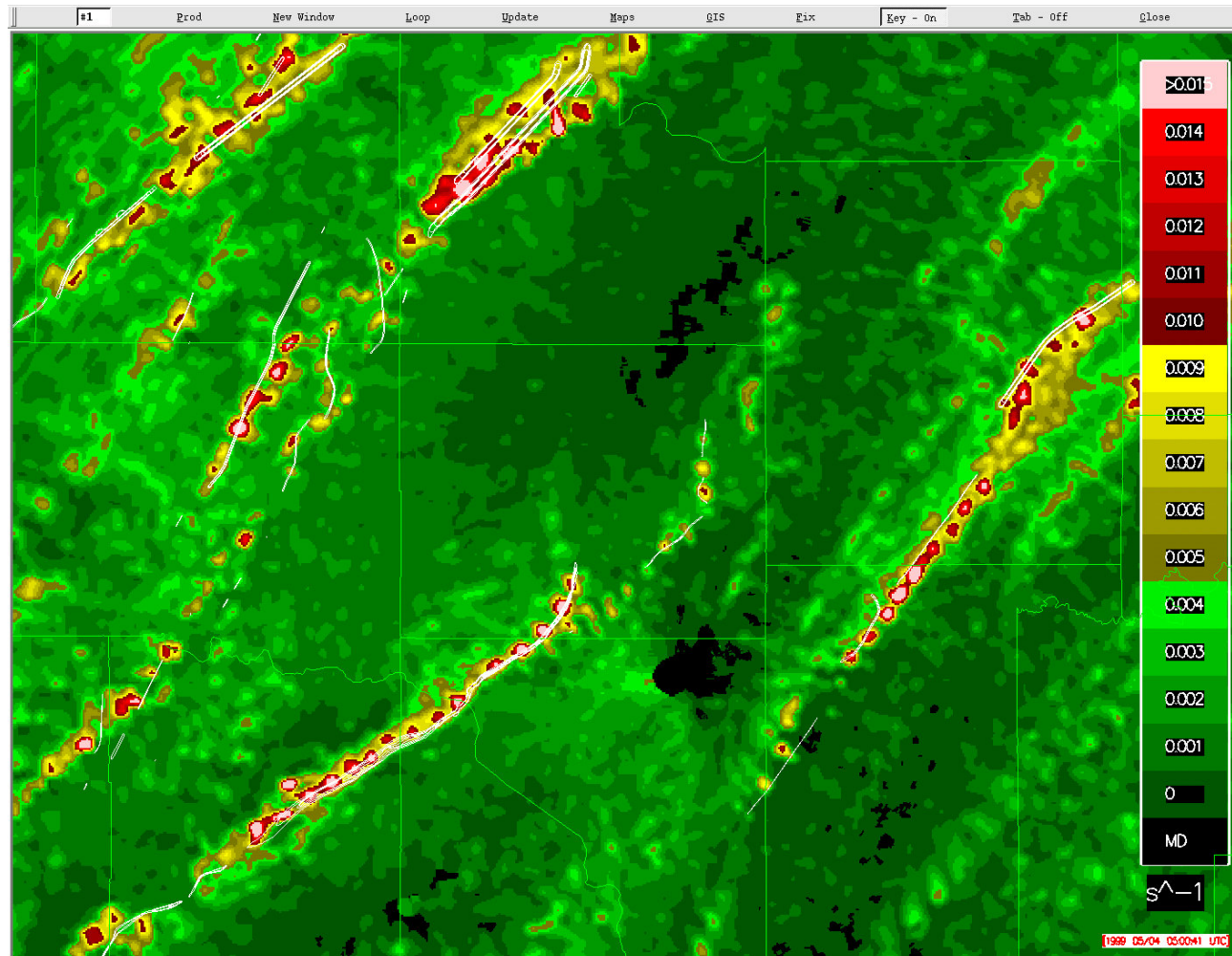


Azimuthal Shear



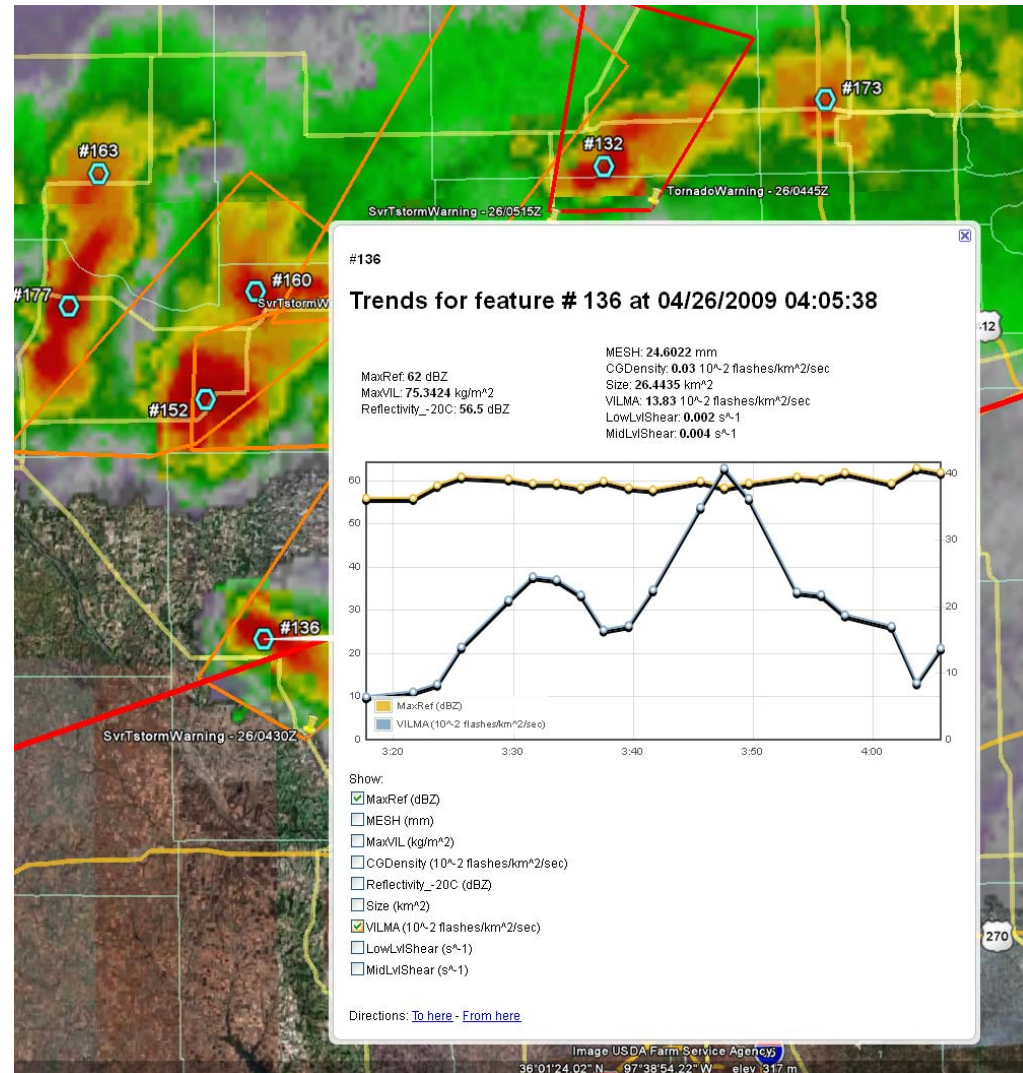
Linear Least Squares Derivative (LLSD) kernel
passed over velocity field

Multiple-Radar “Rotation Tracks”



Cluster tracking and trends

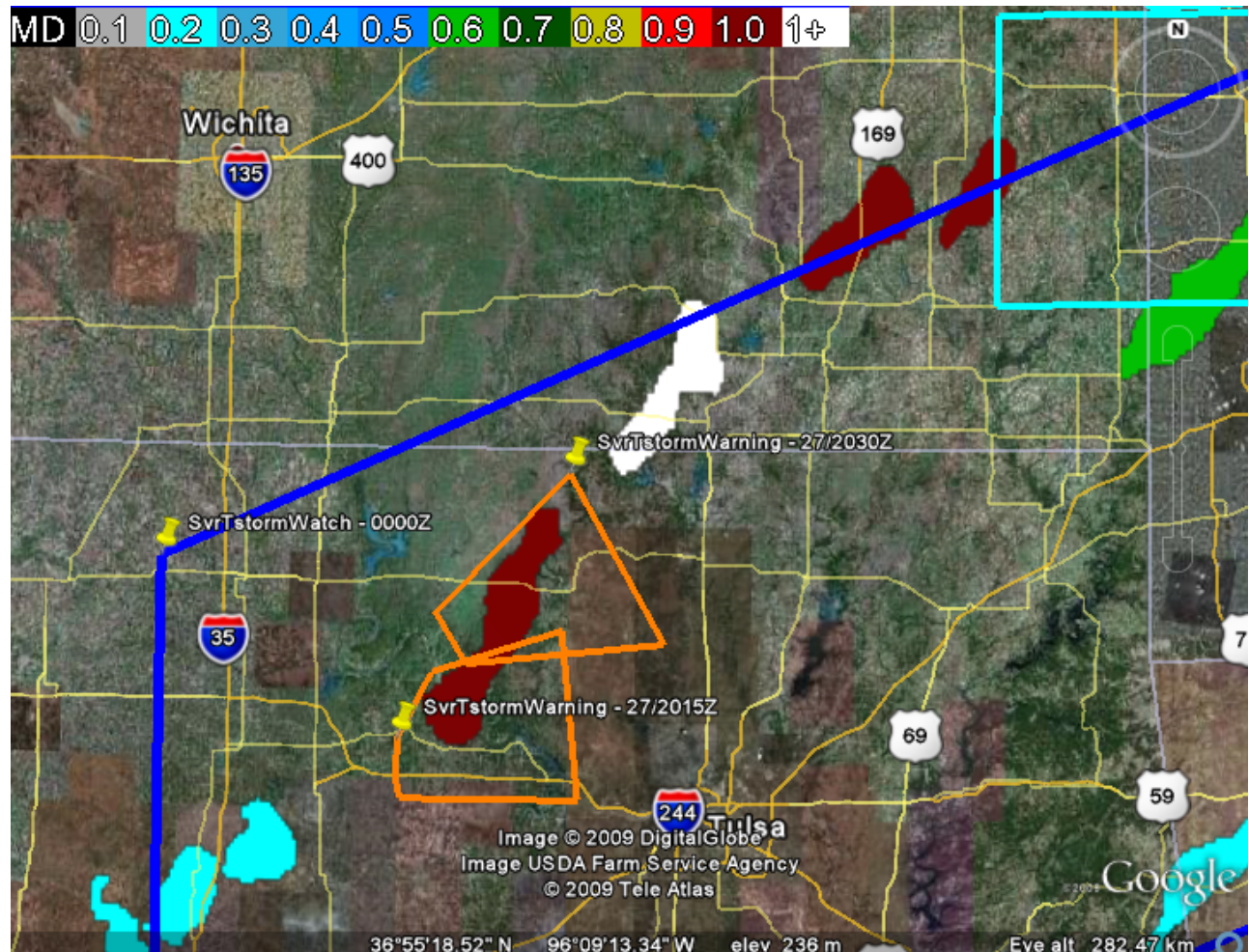
- Based on “K-Means” image processing technique
- Identifies areas of interested based on any MRMS field (e.g., Isothermal Reflectivity at -10°C , Satellite IR temperatures)
- Multi-parameter trends available in Google Earth



Lightning Strike Probability

Probability that CG strike occur in the next 30 minutes.

“Neural Network”
trained on CG
strike data and
MRMS fields



Current MRMS Users

- NSSL produces about 100 different data fields in real-time

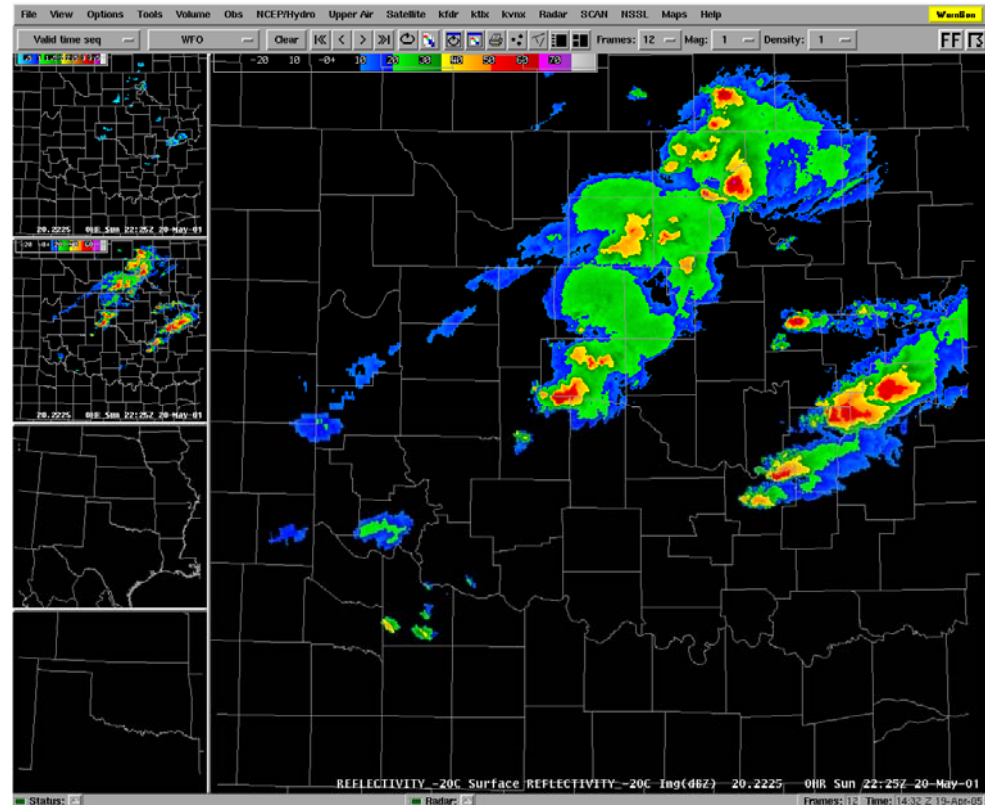
- 4 WFOs – direct feeds into AWIPS



- Storm Prediction Center operations



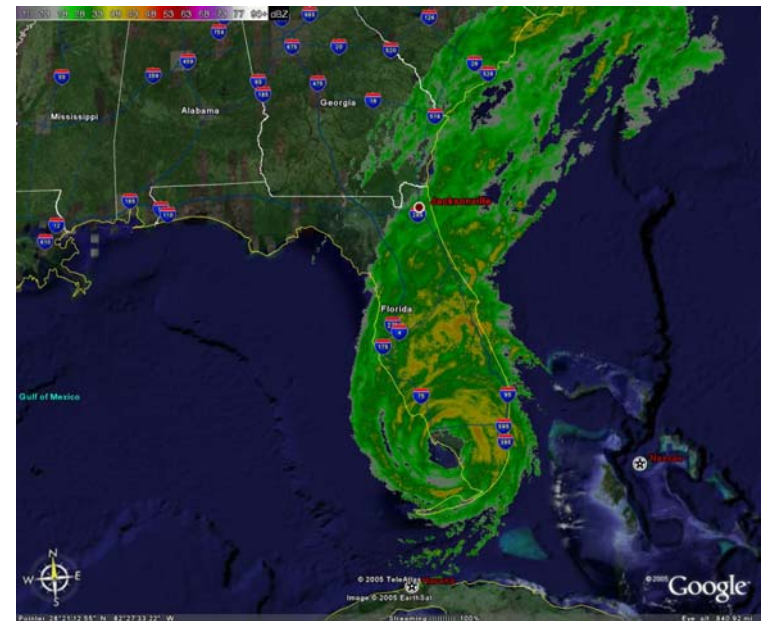
- Licensed to private industry: 46% of US TV stations



KML Products (Google Earth)

<http://wdssii.nssl.noaa.gov/>

- ✦ Live MRMS products for the CONUS.
- ✦ Severe storm analysis products derived from 3D reflectivity fields and environmental data
- ✦ Multi-radar reflectivity products (1 km, 5-minute updates)
- ✦ Multi-radar Doppler velocity products (0.5 km, 2-minute update)
- ✦ 12,000 unique users (including NWS), 3.5M hits per month





NSSL “On Demand” Verification System

Make high resolution hail swath and rotation tracks products more accessible and customizable (in space and time) for a variety of users:

- ⚡ NWS
- ⚡ Emergency Management
- ⚡ First-Responders
- ⚡ Scientific Research

Make the products more rapidly available (after 1 hour) for quick-response verification.

Provide multiple formats for use in a variety of applications.

Provide a long-term archive at NCDC for climatological research.

http://ondemand.nssl.noaa.gov

Interactive Selection...

nssl :: ondemand

Selection | About the Data | Example - Selection | Example - Results

Related Link Category

- WDSSII
- National Severe Storms Laboratory
- National Weather Service
- NEXRAD Radar Operations Center
- NOAA

Headlines

Archive begins August 2007.

Disclaimer

Data are experimental and not intended for protection of life and property.

Data are restricted to non-commercial use without permission.

While we make every attempt to collect and preserve continuous data, gaps in the data may occur in rare instances.

Selection

Mouse Coordinates
Lat/Lon
24.30 / -93.40

Start Date/Time
Year/Month/Day
2007 / 10 / 18
Hour [UTC]
22

End Date/Time
Year/Month/Day
2007 / 10 / 19
Hour [UTC]
22

SE Lat/Lon
35.50 / -84.50

Submit Query | Reset

Please select data (eg. RotationTracks, MESH Swath):

- ☒ MESH
- ☒ Rotation Tracks

Output Format (Ctrl-click to select multiple)

- ☐ AWIPS netCDF
- ☐ WDDSSII netCDF
- ☐ KMZ

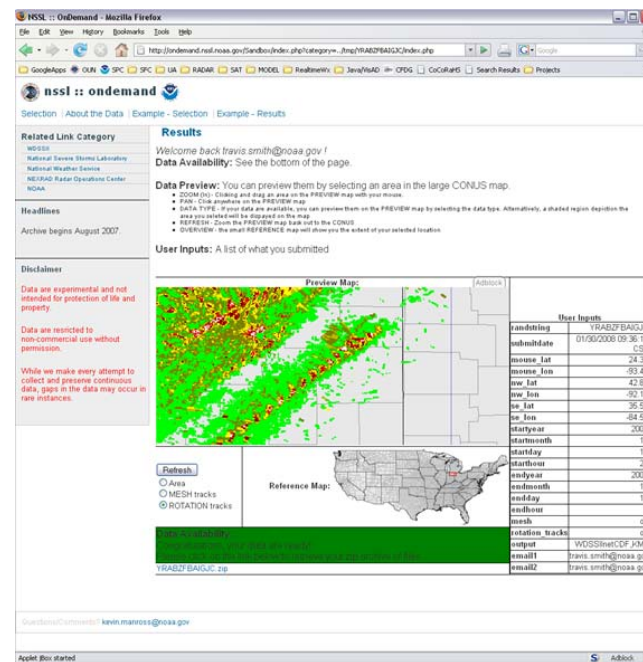
Email Address:
travis.smith@noaa.gov

Re-enter Email Address:
travis.smith@noaa.gov

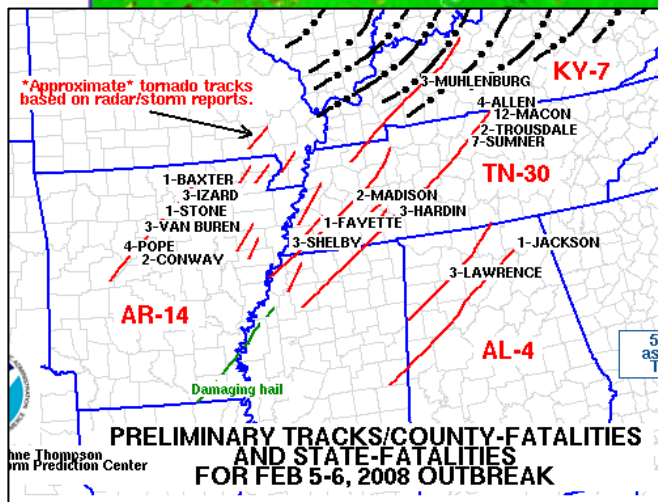
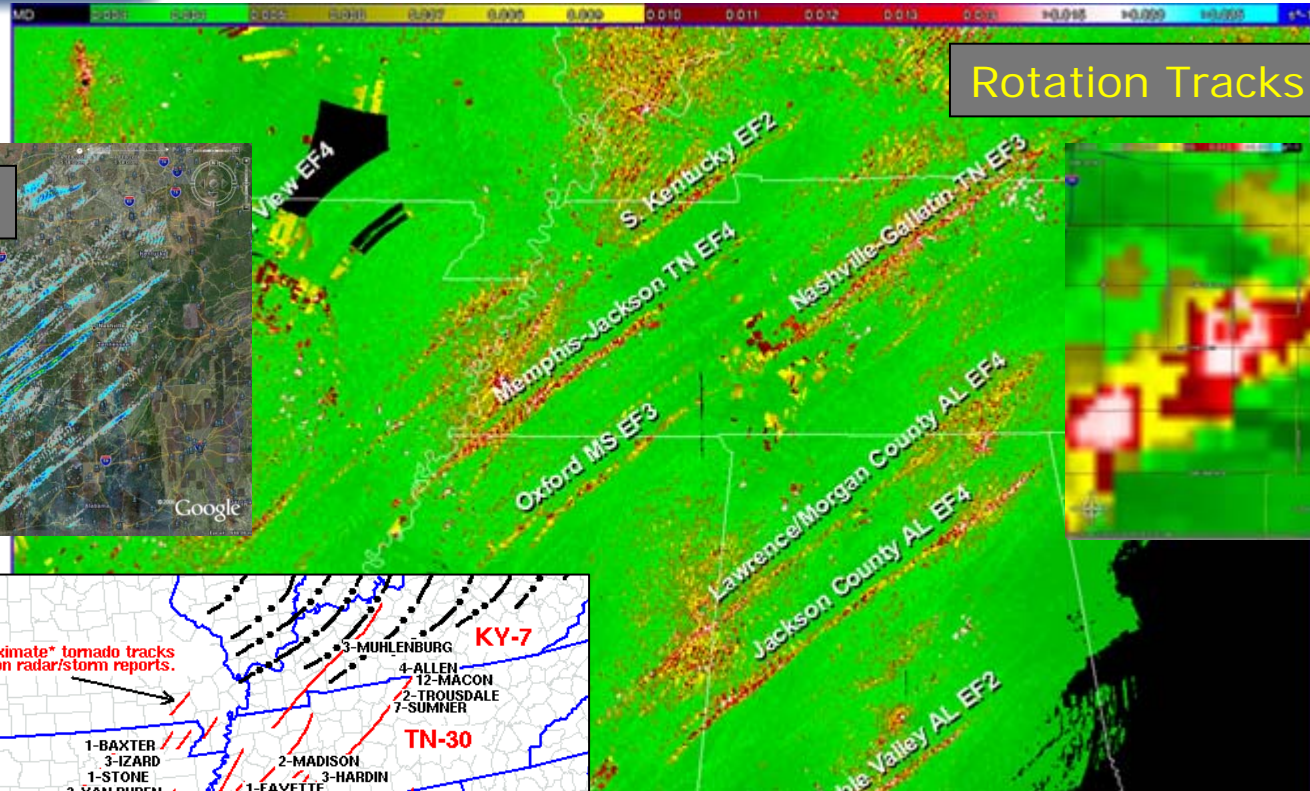
Questions/Comments? kevin.manross@noaa.gov

http://ondemand.nssl.noaa.gov/Sandbox/index.php?category=selection.php#

...Interactive Results



On-Demand: Super Tuesday Outbreak Feb 5, 2008



"Where should we send damage survey teams?"

"Where do the first responders need to focus on?"

2009 Hazardous Weather Testbed Experiment

Evaluated the accuracy and the operational utility of the **WDSSII multiple-radar/multiple-sensor severe weather applications** in supporting NWS hazardous convective weather warning decision making.



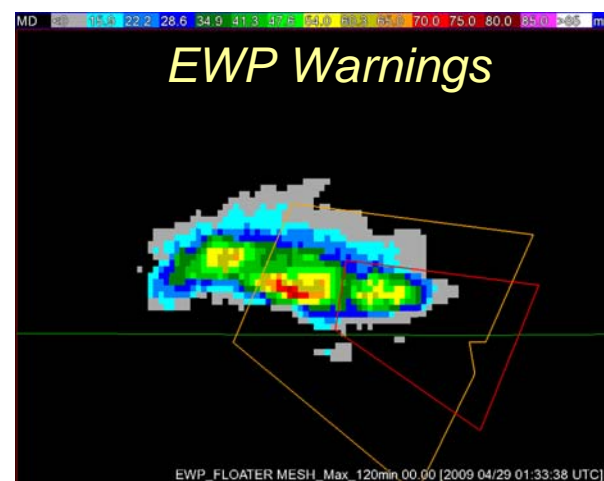
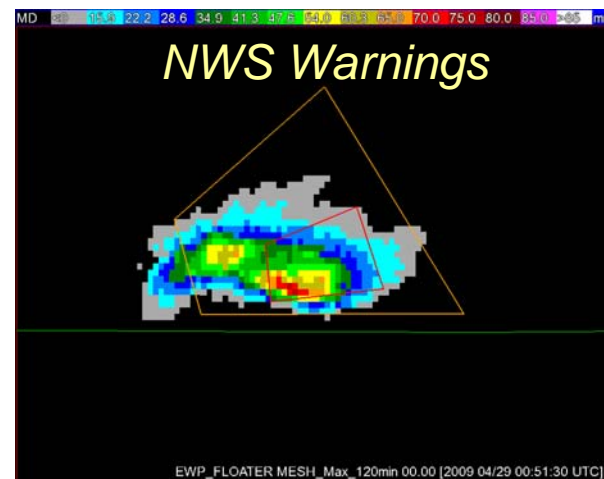
- ⚡ How do they enhance “base data analysis”?
- ⚡ How can they be improved?
- ⚡ What new products should be developed?
- ⚡ Provide an intro to the online products (Google Earth KML, On-Demand).



2009 HWT Outcomes

The MRMS algorithms:

- Greatly augmented and raised the confidence of warning decisions
- Rapidly-perform certain tasks automatically, permitting forecaster to focus on more-challenging warning decisions
- Aided in the positioning of storm-based warning polygons





Current Status

Current Interim Access for all WFOs:

- Google Earth (CONUS images)

- On-Demand Verification System (hail, rotation tracks)

Possible Additional Access in near-future:

- RIDGE2

- IEMCOW (On-Demand output)

- Dual-Polarization upgrade backup coverage (into AWIPS)

NCEP deployment of 3D radar mosaic system:

- NMQ

- RUC/HRRR initialization

- 4D Wx Cube “System of Systems”



AWIPS2 Transition

MDL/NSSL Whitepaper awaiting OS&T approval.

OSIP to follow.

Provide to AWIPS2 standard severe weather products for CONUS.

ADVISOR:

AWIPS Data Visualization and monitoring System for Operational Records.

“Recommender” for Next Generation Warning Tool

“Create your own” local MRMS products.

Proven and vetted local products can be added to national suite.