

3/23/16

ROC TAC Meeting  
Norman, OK



# Multi-Radar Multi-Sensor (MRMS) System – What is...?

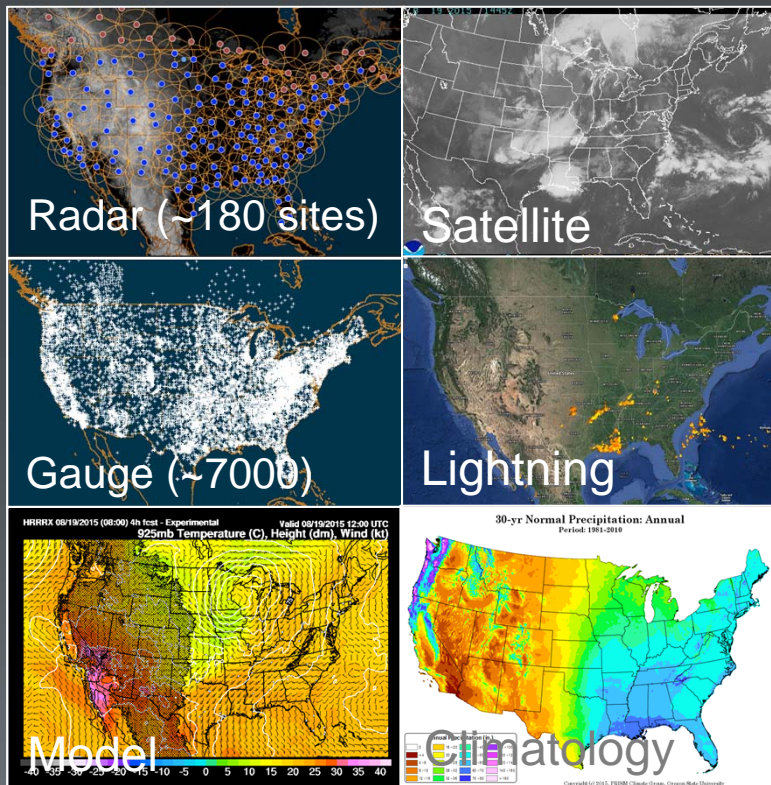
“....a cast of thousands...”

NSSL  
CIMMS  
ROC  
NCO  
NWS  
FAA  
DoD  
CWB

# What is MRMS?

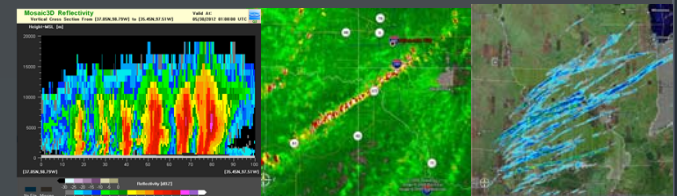
An NWS operational system for the integration of multi-sensor data and creation of high-resolution (**1km, 2min**) severe weather, aviation, model data assimilation and precipitation products over CONUS and southern Canada.

## INPUT DATA

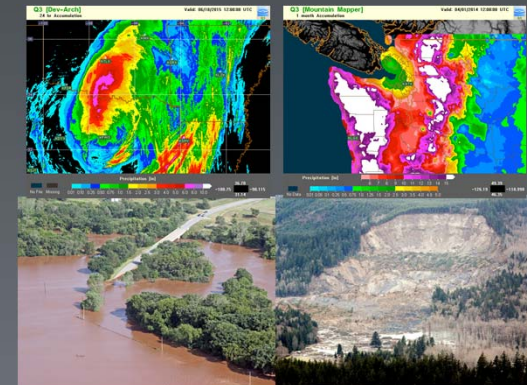


## PRODUCTS

Severe Weather

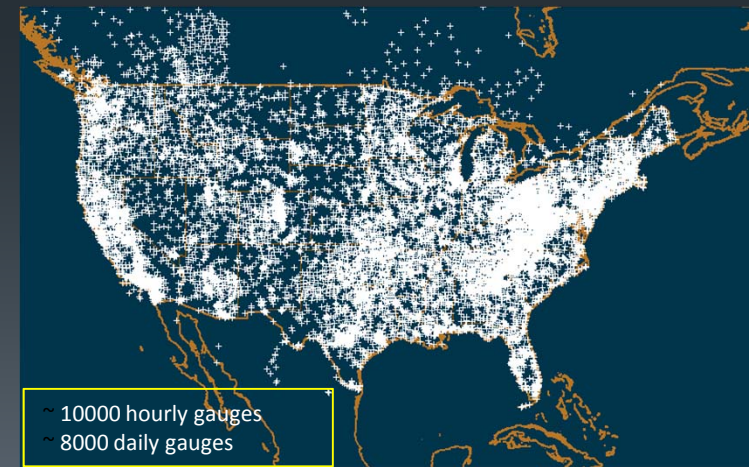
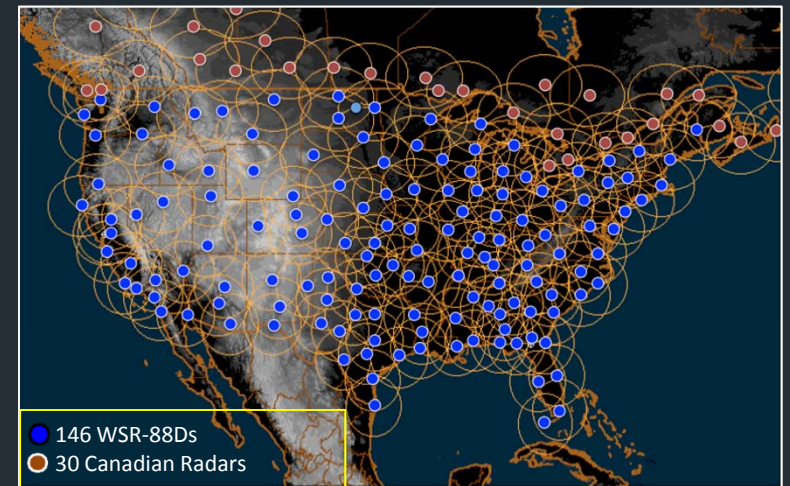


QPE



# MRMS Dataflow

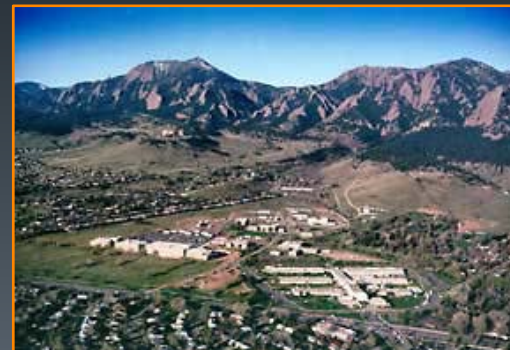
- CONUS Domain: 20-55°N, 130-60°W
- Resolution
  - 0.01°latitude x 0.01°longitude
  - 2 min update cycle
- Data Sources
  - ~180 radars every 4-5min
    - WSR-88Ds L3, L2
    - Canadian L2
    - TDWR 'base'
    - Gap filling
  - ~10000 gauges every hour
    - HADS
    - MADIS
  - RAP/HRRR hourly analyses
  - Lightning and satellite





# MRMS in Operations

- MRMS completed transition to operations (Initial Operational Capability-V10.0) on Sep. 29, 2014
- Runs on Integrated Dissemination Program (IDP) Processing Infrastructure in College Park, MD and Boulder, CO.
  - Consists of ~55 virtual machines
  - C++ Code Environment
  - 6-month code release cycle
  - Backup IDP System located in Boulder, CO
- Most recent version implemented is V10.5
  - Operational December 2015
  - Includes RIDGE II requirements and additional oCONUS domains
  - Current onboarding MRMS v11.0 (5-km CREF and NCAR ANC)
- Generates over 155 unique product files every two minutes
  - Up to 200 GB/day



# MRMS Product Description

Welcome to the **NEW AMS Journals site!**



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Multi-radar Multi-sensor (MRMS) Severe Weather and Aviation Products: Initial Op ....

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## Multi-radar Multi-sensor (MRMS) Severe Weather and Aviation Products: Initial Operating Capabilities

Travis M. Smith<sup>1,2</sup>, Vallappa Lakshmanan<sup>1,2</sup>, Gregory J. Stumpf<sup>1,3</sup>, Kiel L. Ortega<sup>1,2</sup>, Kurt Hondl<sup>2</sup>, Karen Cooper<sup>1,2</sup>, Kristin M. Calhoun<sup>1,2</sup>, Darrel M. Kingfield<sup>1,2</sup>, Kevin L. Manross<sup>4,5</sup>, Robert Toomey<sup>1,2</sup>, and Jeff Brogden<sup>1,2</sup>

<sup>1</sup> CIMMS/University of Oklahoma, Norman, Oklahoma

<sup>2</sup> NOAA/OAR/NSSL, Norman, Oklahoma

<sup>3</sup> NOAA/NWS/MDL, Silver Spring, Maryland

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DOI: <http://dx.doi.org/10.1175/BAMS-D-14-00173.1>

Published Online: 27 January, 2016



Abstract

PDF

### Abstract

The MRMS system's initial operating capabilities for severe weather and aviation include quality-controlled, multi-radar fields of three-dimensional reflectivity, near-storm environment, and radial velocity derivatives to produce severe weather guidance information.

The Multi-Radar Multi-Sensor (MRMS) system, which was developed at the National Severe Storms Laboratory and University of Oklahoma, was made operational in 2014 at the National Centers for Environmental Prediction. The MRMS system consists of the Warning Decision Support System—Integrated Information suite of severe weather and aviation products, and the quantitative precipitation estimation products created by the National Mosaic and Multi-sensor Quantitative Precipitation Estimation system. Products created by the MRMS system are at a spatial resolution of approximately 1 km, with 33 vertical levels, updating every 2 minutes over the Conterminous United States and southern Canada. This paper describes initial operating capabilities for the severe weather and aviation products that include a three dimensional mosaic of reflectivity, guidance for hail, tornado, and lightning hazards, and nowcasts of storm location, height and intensity.

Corresponding Author Address: Travis Smith, NSSL/WRDD, National Weather Center, 120 David L. Boren Blvd., Norman, OK, 73072, Email: [Travis.Smith@noaa.gov](mailto:Travis.Smith@noaa.gov)

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Multi-Radar Multi-Sensor (MRMS) Quantitative Precipitation Estimation: Initial O ....

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## Multi-Radar Multi-Sensor (MRMS) Quantitative Precipitation Estimation: Initial Operating Capabilities

Jian Zhang<sup>1</sup>, Kenneth Howard<sup>1</sup>, Carrie Langston<sup>1,2</sup>, Brian Kaney<sup>1,2</sup>, Youcun Qi<sup>1,2</sup>, Lin Tang<sup>1,2</sup>, Heather Grams<sup>1,2</sup>, Yadong Wang<sup>1,2</sup>, Stephen Cocks<sup>1,2</sup>, Steven Martinaitis<sup>1,2</sup>, Ami Arthur<sup>1,2</sup>, Karen Cooper<sup>1,2</sup>, Jeff Brogden<sup>1,2</sup>, and David Kitzmiller<sup>3</sup>

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<sup>3</sup> NOAA/NWS/OHD, Silver Spring, Maryland

DOI: <http://dx.doi.org/10.1175/BAMS-D-14-00174.1>

Published Online: 4 August, 2015



Abstract

PDF

### Abstract

The MRMS QPE initial operating capabilities include an ensemble of quantitative precipitation estimations and associated diagnostic products based on radar, gauge and atmospheric environmental and climatological data at 1-km resolution and 2-min update cycle over CONUS.

Rapid advancements of computer technologies in recent years made the real-time transferring and integration of high-volume, multi-source data at a centralized location a possibility. The Multi-Radar Multi-Sensor (MRMS) system recently implemented at the National Center for Environmental Prediction demonstrates such capabilities by integrating ~180 operational weather radars from conterminous United States and Canada into a seamless national 3-D radar mosaic with very high spatial (1 km) and temporal (2 min) resolution. The radar data can be integrated with high-resolution numerical weather prediction model data, satellite data, lightning and rain gauge observations to generate a suite of severe weather and quantitative precipitation estimation (QPE) products.

This paper provides an overview of the initial operating capabilities of MRMS QPE products.

Corresponding author address: Jian Zhang, NSSL, National Weather Center, 120 David L. Boren Blvd., Norman, OK, 73072. E-mail: [jian.zhang@noaa.gov](mailto:jian.zhang@noaa.gov)

# MRMS Product Dissemination

6

## NOAAPORT Dissemination:

- YAUC01 Composite Reflectivity
- YAUC02 Composite Reflectivity Height
- YAUC03 Composite Reflectivity [0-4 km]
- YAUD01 Radar Quality Index
- YAUD02 Seamless Hybrid Scan Reflectivity
- YAUL01 Cloud-to-Ground Lightning Density (1, 5, 15, & 30 min.)
- YAUL02 Cloud-to-Ground Lightning Probability (0-30 min.)
- YAUM03 Probability of Warm Rain (POWR)
- YAUP01 Surface Precipitation Type
- YAUP02 Instantaneous Radar Precipitation Rate
- YAUP03 Radar 1H, 3H, 6H, 12H, 24H, 48H, 72H QPE
- YAUP04 Local Gauge Bias Corrected 1H, 3H, 6H, 12H, 24H QPE
- YAUP06 Mountain Mapper 1H, 3H, 6H, 12H, 24H, 48H, 72H QPE
- YAUQ01 Base Reflectivity
- YAUS04 Low-Level Rotation Tracks (60 & 1440 min. accum.)
- YAUS06 Mid-Level Rotation Tracks (60 & 1440 min. accum.)
- YAUS10 Maximum Estimated Size of Hail (MESH)
- YAUS11 MESH Tracks (60 & 1440 min. accum.)
- YAUS13 Vertically Integrated Liquid (VIL)
- YAUS15 Vertically Integrated Ice (VII)
- YAUS16 18, 30, 50, & 60 dBZ Echo Top (ET)
- YAUS17 Height of 50dBZ Echo Above -20°C
- YAUS18 Height of 50dBZ Echo Above 0°C
- YAUS20 Height of 60dBZ Echo Above 0°C
- YAUS21 Reflectivity at 0°C, -10°C, -20°C
- YAUS22 Reflectivity At Lowest Altitude (RALA)

## NCO LDM Dissemination: (all MRMS products)

Discipline	Category	Parameter	Name	Frequency	Unit	Missing	Range Folded	No Coverage	Description
209	2	0	LightningDensityNLDN1min	1-min	flashes/km <sup>2</sup> /min	-1	n/a	-3	CG Lightning Density 1-min - NLDN
209	2	1	LightningDensityNLDN5min	1-min	flashes/km <sup>2</sup> /min	-1	n/a	-3	CG Lightning Density 5-min - NLDN
209	2	2	LightningDensityNLDN15min	1-min	flashes/km <sup>2</sup> /min	-1	n/a	-3	CG Lightning Density 15-min - NLDN
209	2	3	LightningDensityNLDN30min	1-min	flashes/km <sup>2</sup> /min	-1	n/a	-3	CG Lightning Density 30-min - NLDN
209	2	4	LightningProbabilityNext30min	15-min	%	0	n/a	0	Lightning Probability 0-30 minutes - NLDN
209	3	0	MergedAzShear0to2kmAGL	2-min	0.001/s	0	0	0	Azimuth Shear 0-2km AGL
209	3	1	MergedAzShear3to6kmAGL	2-min	0.001/s	0	0	0	Azimuth Shear 3-6km AGL
209	3	2	RotationTrack30min	2-min	0.001/s	0	n/a	0	Rotation Track 0-2km AGL 30-min
209	3	3	RotationTrack60min	2-min	0.001/s	0	n/a	0	Rotation Track 0-2km AGL 60-min
209	3	4	RotationTrack120min	30-min	0.001/s	0	n/a	0	Rotation Track 0-2km AGL 120-min
209	3	5	RotationTrack240min	30-min	0.001/s	0	n/a	0	Rotation Track 0-2km AGL 240-min
209	3	6	RotationTrack360min	30-min	0.001/s	0	n/a	0	Rotation Track 0-2km AGL 360-min
209	3	7	RotationTrack1440min	30-min	0.001/s	0	n/a	0	Rotation Track 0-2km AGL 1440-min
209	3	14	RotationTrackML30min	2-min	0.001/s	0	n/a	0	Rotation Track 0-3km AGL 30-min
209	3	15	RotationTrackML60min	2-min	0.001/s	0	n/a	0	Rotation Track 0-3km AGL 60-min
209	3	16	RotationTrackML120min	30-min	0.001/s	0	n/a	0	Rotation Track 0-3km AGL 120-min

# MRMS Transparency

**NSSL** The National Severe Storms Laboratory

ABOUT NSSL WEATHER RESEARCH RESEARCH TOOLS PROJECTS PEOPLE NEWS & MEDIA EDUCATION

NSSL Home > Projects > Multi-Radar/Multi-Sensor System (MRMS)

## MULTI-RADAR/MULTI-SENSOR SYSTEM (MRMS)

### MRMS Transition to Operations

[GRIB2 IDs for MRMS data →](#)

The MRMS system was developed to produce severe weather and precipitation products for improved decision-making capability to improve severe weather forecasts and warnings, hydrology, aviation, and numerical weather prediction.

MRMS is a system with automated algorithms that quickly and intelligently integrate data streams from multiple radars, surface and upper air observations, lightning detection systems, and satellite and forecast models. Numerous two-dimensional multiple-sensor products offer assistance for hail, wind, tornado, quantitative precipitation estimation forecasts, convection, icing, and turbulence diagnosis.

- MRMS Fact Sheet (PDF)
- MRMS Application Suite

### CURRENT WORK:

- Advanced CONUS 4D reflectivity mosaic and products
- Severe weather and aviation related products per FAA NextGen requirements
- Resolution of 1-km x 2-min update cycle with 3D reflectivity mosaic at 31 levels

### MRMS TRANSITION TO OPERATIONS

- GRIB2 IDs for MRMS data

### RELATED LINKS

- MRMS Fact Sheet (PDF)
- MRMS Application Suite
- GRIB2 IDs for MRMS Data
- MRMS Virtual Lab (user account required)
- MRMS News
- WDSS-II
- NSSL On-Demand

**NATIONAL WEATHER SERVICE**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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## NOAA Virtual Lab

Weather.gov > Meteorological Development Laboratory > NOAA Virtual Lab

Meteorological Development Laboratory  
National Program, MDL

Statistical Postprocessing Digital Forecasts Verification Storm Surge Decision Support Tools Web Services NOAA VLab About MDL

### Overview

The Virtual Laboratory (VLab) is a service and IT framework, being built out by OSTI and lead by MDL/DSB, which enables NOAA employees and their partners to share ideas, collaborate, engage in software development, and conduct applied research. The VLab will enable NOAA to:

- Reduce the time and cost of transitions of NWS field innovations to enterprise operations,
- Minimize redundancy and leverage complementary, yet physically separated, skillsets,
- Forge scientific and technical solutions based on a broad, diverse consensus, and
- Promote an NWS culture based on collaboration and trust

### Implementation

The VLab is comprised of two main components:

- Virtual Lab Collaboration Services (VLCS)
- Virtual Lab Development Services (VLDS)

### Principles

The VLab operates under the following set of guiding principles:

- Transparency - The VLab and its staff are open and transparent in all communications and decision-making
- Teamwork - The VLab and its staff facilitate and support collaborative teamwork
- Flexibility - The VLab and its staff adapt to different and/or changing user needs
- Responsiveness - The VLab and its staff respond quickly to user needs
- Accountability - The VLab and its staff are accountable to its users through meaningful metrics

### Capabilities

Metadata or 'the documentation of data', serves the purpose of making data discoverable, usable and understandable. A variety of metadata standards and formats have been developed over time to support data discovery and data documentation.

NOAA's directives for metadata, as part of its data documentation plan, include NOAA Administrative Order 212-15 and NOAA's Environmental Data Management Committee's (EDMC) Data Documentation Planning Directive. The Data Documentation directive "establishes ISO 19115 Parts 1 and 2 and a recommended representation standard (ISO 19139) for documenting NOAA's environmental data and information."

In the future the VLCS will include portals that will allow users to "Share their projects" and "Share their expertise". This sharing will increase visibility and transparency of projects and users' expertise promoting collaboration.

Figure 1




# MRMS Evaluation and Validation

Web-based evaluation tool: [CONUS, 24/7](#)


[mrms.ou.edu](http://mrms.ou.edu):

- 2-D product images
- Cross sections of 3D refl grid
- QPE/gauge scatterplots and stats
- Time series of any MRMS variables at any point in CONUS
- Monitoring of radar calibrations
- etc.



**MRMS - NSSL DEV**  
Multi-Radar Multi-Sensor System

Application Suite  
Launcher



Single Product Maps <small>-Image Viewer-</small>	3D Product Tools <small>-Image Viewer-</small>	Data Plot Tools <small>-Plot Utility-</small>	Gauge/QPE Compare <small>-Comparison Utility-</small>	Two Product Maps <small>-Comparison Utility-</small>	VPR Plots <small>-Plot Utility-</small>
MRMS vs mPING <small>-Data Analysis-</small>	Level 3 Metadata <small>-Data Analysis-</small>	Level 3 Scatterplots <small>-Data Analysis-</small>	Simple Product Kiosk <small>-Image Viewer-</small>		Polar Products <small>-Legacy-</small>

The MRMS project is a joint initiative between the National Severe Storms Laboratory, Federal Aviation Administration, National Weather Service/Office of Hydrologic Development, the Office of Climate, Water and Weather Services and the University of Oklahoma Cooperative Institute in Mesoscale Meteorological Studies.

MRMS is an automated system that rapidly and intelligently integrates data from multiple radars and radar networks, surface and upper air observations, and numerical weather prediction (NWP) models. It serves as an international testbed for research, development, evaluation and science to operations infusion of high resolution 3D radar mosaic for NWP model data assimilation and aviation applications. It also generates a suite of quantitative precipitation estimation ("QPE") products for the monitoring and warnings of floods and flash floods and in support of comprehensive hydrologic and ecosystem modeling.





[2005 Legacy QVS](#)  
[2012 Legacy QVS](#)





[NOAA Privacy Policy](#)  
[NSSL Disclaimer](#)

**Welcome to the Web Application Launcher for Investigating the MRMS/Q3 System**

Near the top of this page there is a horizontal row of tabs or buttons

- Hover over each button for a brief explanation of that item
- Click on the button to open that web application in a new browser window

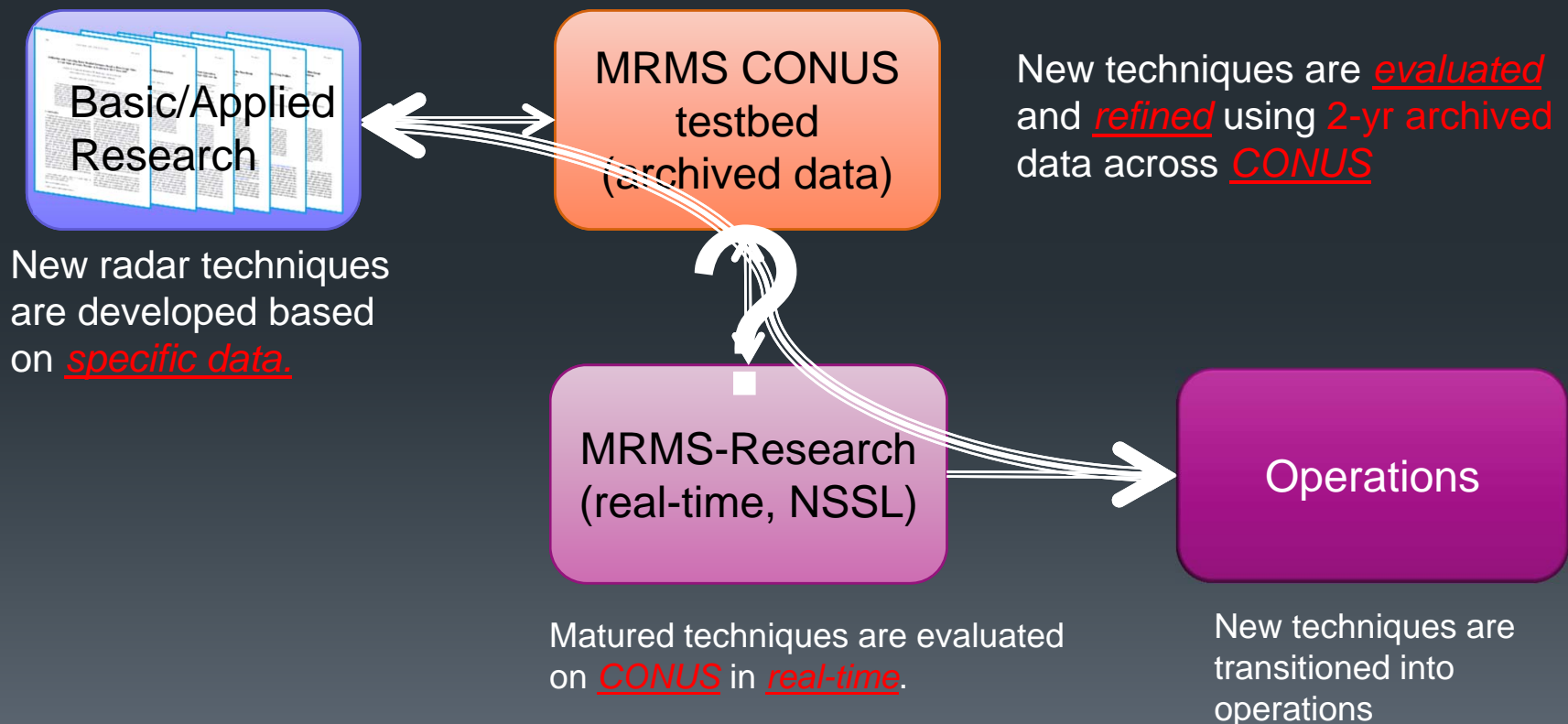





*NWS users have provided invaluable feedback that guided MRMS development to what it is today (Operations-2-Research).*



# MRMS R&D Platform

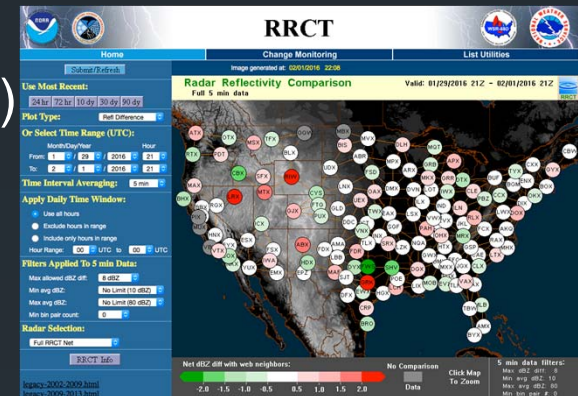
A research platform for evaluations of new radar techniques for severe weather, aviation, and hydrological applications and to facilitate their rapid transition into operations.



# MRMS as a Real-Time National Radar Network Evaluation Tool

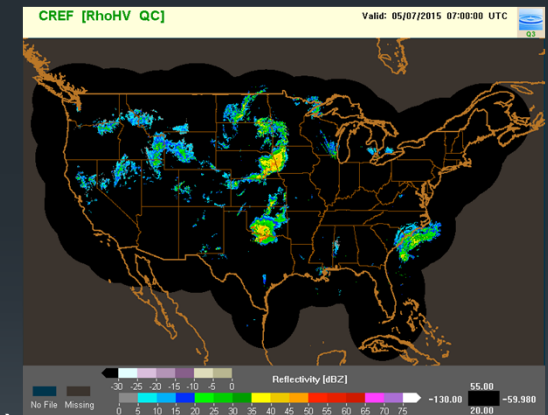
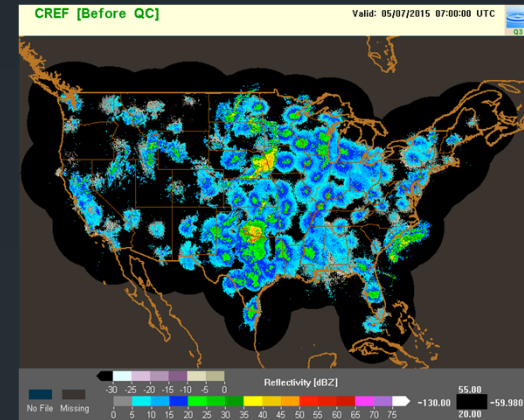
- Z calibration monitoring (completed ~2011)
- Real-time PPS and DPR radar QPE parameters monitoring (2014)
- Z<sub>DR</sub> calibration monitoring (2015 – 2016)

- Rain method
- Snow method
- Bragg scatter method



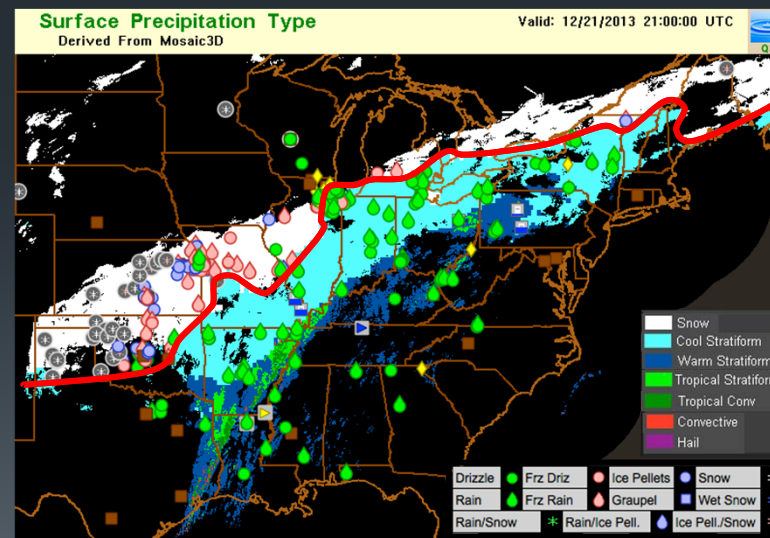
# MRMS as a National Product System

- MRMS Dual-Pol radar QPE (2016-2018)
  - R(A), R(Kdp), R(Z) synthetic
- 3-D national  $Z_{DR}$ ,  $K_{DP}$ ,  $\rho_{hV}$  mosaic (2016-2018)
- National Quasi Vertical Profile (2016-2018)
- All season surface precipitation type (2017-2019)
- Multi-Sensor Merged QPE (2017-2020)
  - Radar, satellite, gauge, model
- Turbulence (with NCAR, 2017-2020)
- 3-D national hydromet type and content (2018-2021)
- Icing (with NCAR, 2018-2021)



# MRMS to Support Operational ORPG Product Generation

- Real-time MetSignal evaluation (2014-2015)
- Real-time DPR snow QPE coefficient estimator (2016)
- Real-time continental/tropical rain classification for  $R(Z-Z_{DR})$  relationship selection guidance (2016)





# MRMS as a National Testbed for Potential ORPG Products

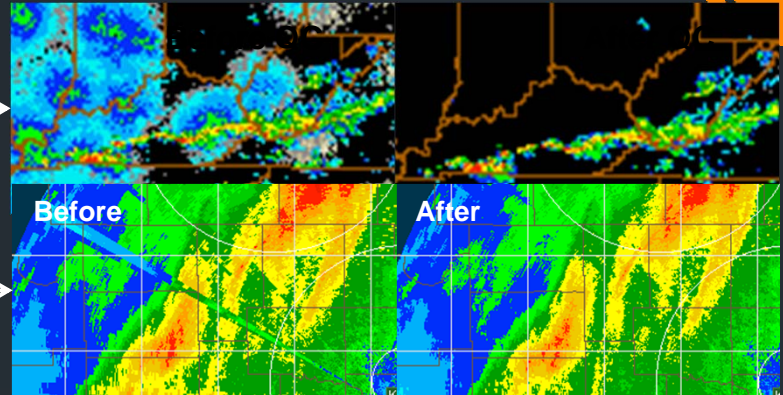
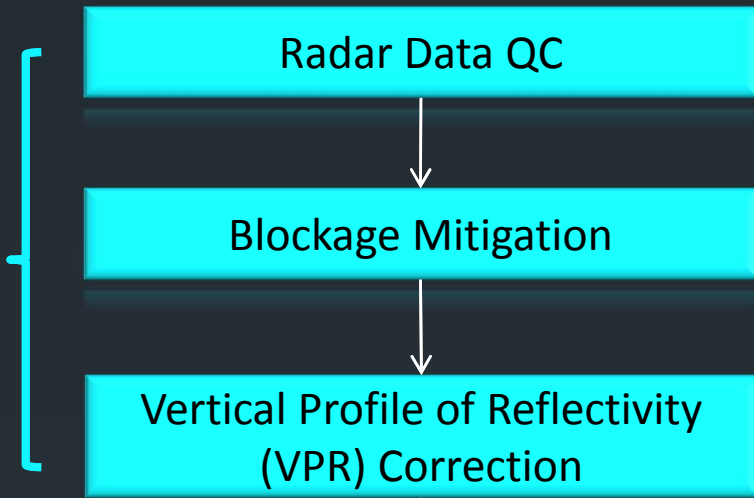
- Specific attenuation based radar QPE [R(A)] (2015-2017)
- HCA2 (all season surface precipitation type) (2017-2019)
- Cloud detection (2018-2020)
- $Z_{DR}$  column (2018-2020)

# MRMS Full Operating Capability (FOC)

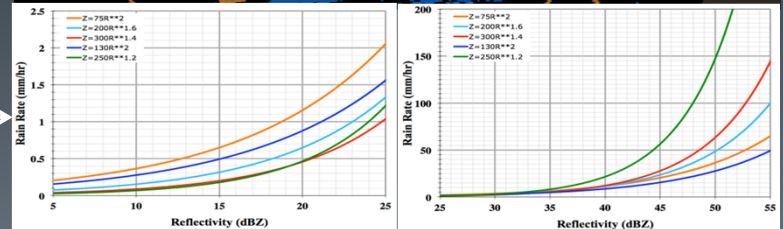
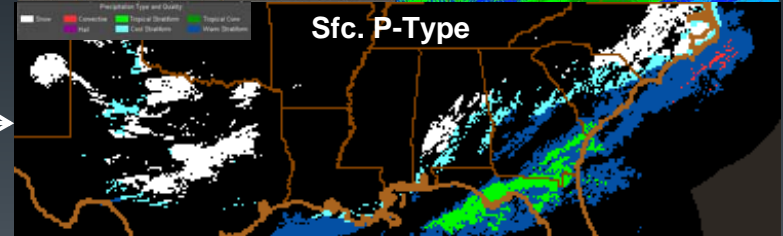
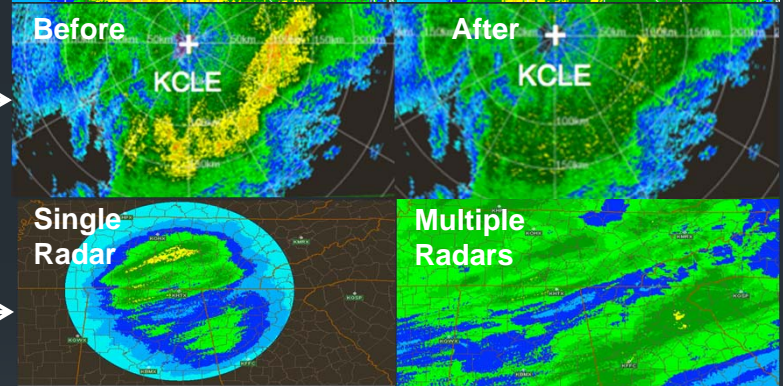
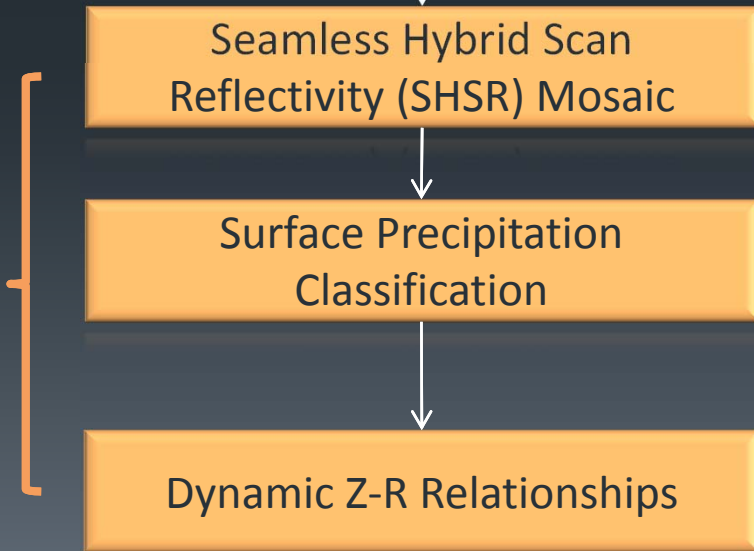
- Full Operating Capability (FOC) will occur in Q2FY17- V12.0
  - Expansion to full suite of MRMS products including
    - Convective forecasts
    - Advanced hydro products for FFMP
    - Additional severe and aviation weather products
- Fully redundant backup system in Boulder, CO
- Full Optimization across all components of MRMS system
- Upgrade the oCONUS RIDGE domains to run all V11.0 MRMS products

# MRMS Radar QPE Processes

Single radar,  
multi-sensor



Multi-radar,  
multi-sensor




# Summary

- The Multi-Radar Multi-Sensor system provides high-resolution (*1km, 2min*) *operational* products for the CONUS and southern Canada.
- MRMS is a *research platform* for evaluations of new radar techniques and facilitates *research-to-operations* transfer of the new techniques.




# Thank You!



## MRMS - NSSL DEV

Multi-Radar Multi-Sensor System

Application Suite  
Launcher



Single Product Maps -Image Viewer-	3D Product Tools -Image Viewer-	Data Plot Tools -Plot Utility-	Gauge/QPE Compare -Comparison Utility-	Two Product Maps -Comparison Utility-	VPR Plots -Plot Utility-
MRMS vs mPING -Data Analysis-	Level 3 Metadata -Data Analysis-	Level 3 Scatterplots -Data Analysis-	Simple Product Kiosk -Image Viewer-		Polar Products -Legacy-

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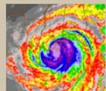
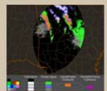
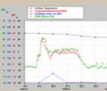
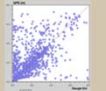
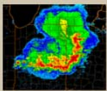
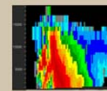
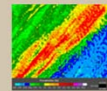

MRMS is an automated system that rapidly and intelligently integrates data from multiple radars and radar networks, surface and upper air observations, and numerical weather prediction (NWP) models. It serves as an international testbed for research, development, evaluation and science to operations infusion of high resolution 3D radar mosaic for NWP model data assimilation and aviation applications. It also generates a suite of quantitative precipitation estimation ("QPE") products for the monitoring and warnings of floods and flash floods and in support of comprehensive hydrologic and ecosystem modeling.

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[2012 Legacy QVS](#)  
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### Welcome to the Web Application Launcher for Investigating the MRMS/Q3 System

Near the top of this page there is a horizontal row of tabs or buttons

- Hover over each button for a brief explanation of that item
- Click on the button to open that web application in a new browser window

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