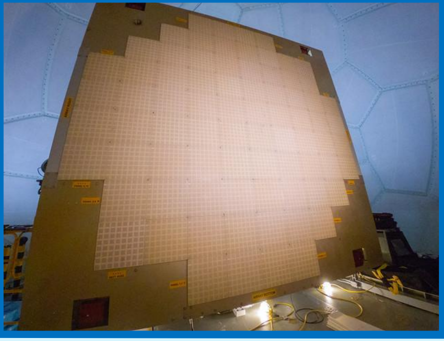
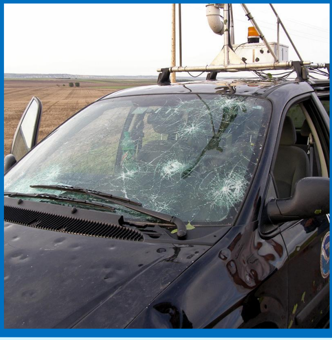
Better forecast/warning tools and techniques

Multi-Radar Multi-Sensor

Kenneth Howard, MRMS Program Manager, WRDD

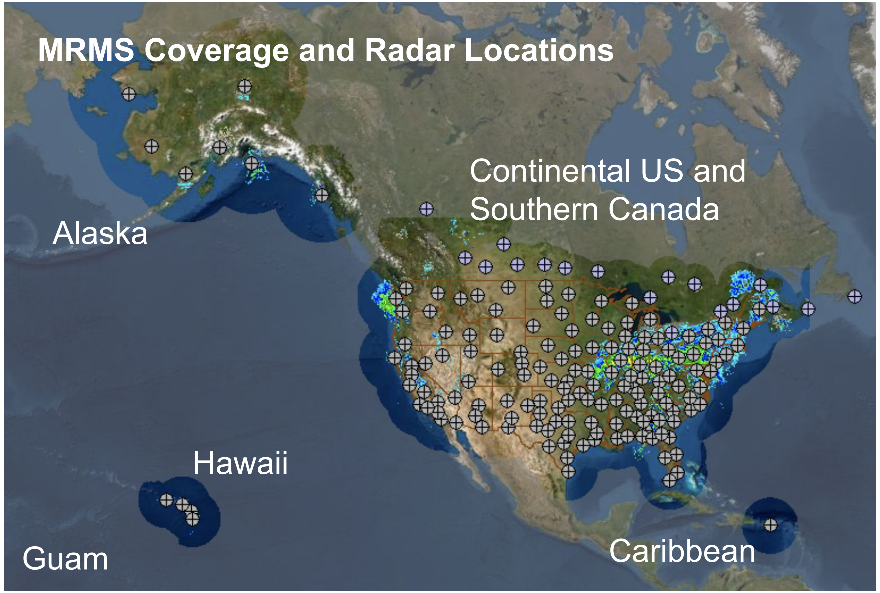




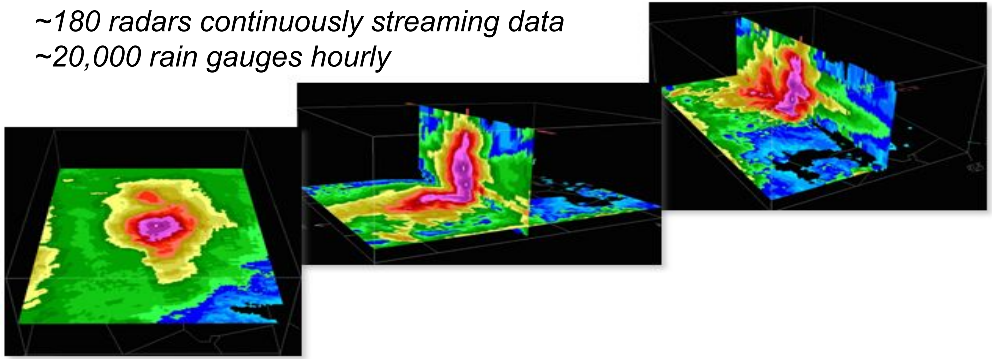
Multi-Radar Multi-Sensor (MRMS)

is an science processing architecture that:

- Integrates radar, surface observations, satellite, lightning, and numerical weather prediction data into common reference grid
- Automatically generates complete seamless national 3D radar mosaic, storm attributes and multi-sensor quantitative precipitation estimates at high temporal and spatial resolution
- Serves as framework for advanced applications research and development for operations



~180 radars continuously streaming data
~20,000 rain gauges hourly

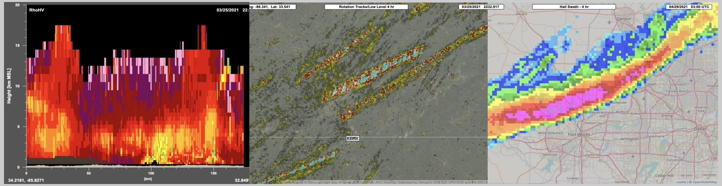


Running operationally at NOAA/NCEP since 2014

Operational Product Viewer:
https://mrms.nssl.noaa.gov/qvs/product_viewer/

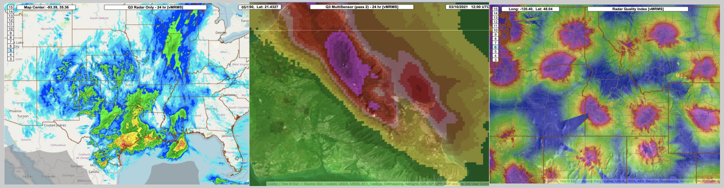
MRMS Product Categories

Severe



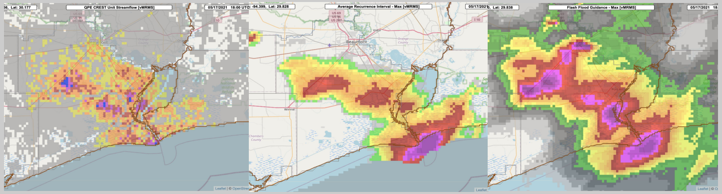
- Hail Size/Accumulated Tracks
- Rotation Tracks
- Lightning Probabilities
- 3D Mosaics of Dual Pol Radar Variables

Precipitation



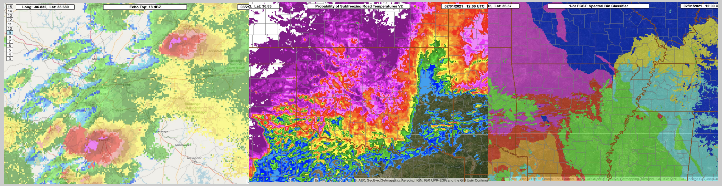
- Rain and Snow Rates
- Short and Long Term Accumulations
- Multi-Sensor Precipitation
- Radar Coverage Quality

FLASH



- Normalized Runoff/Streamflow
- Climatological Rainfall Severity
- Precip Comparisons to NWS Flash Flood Guidance

Transportation

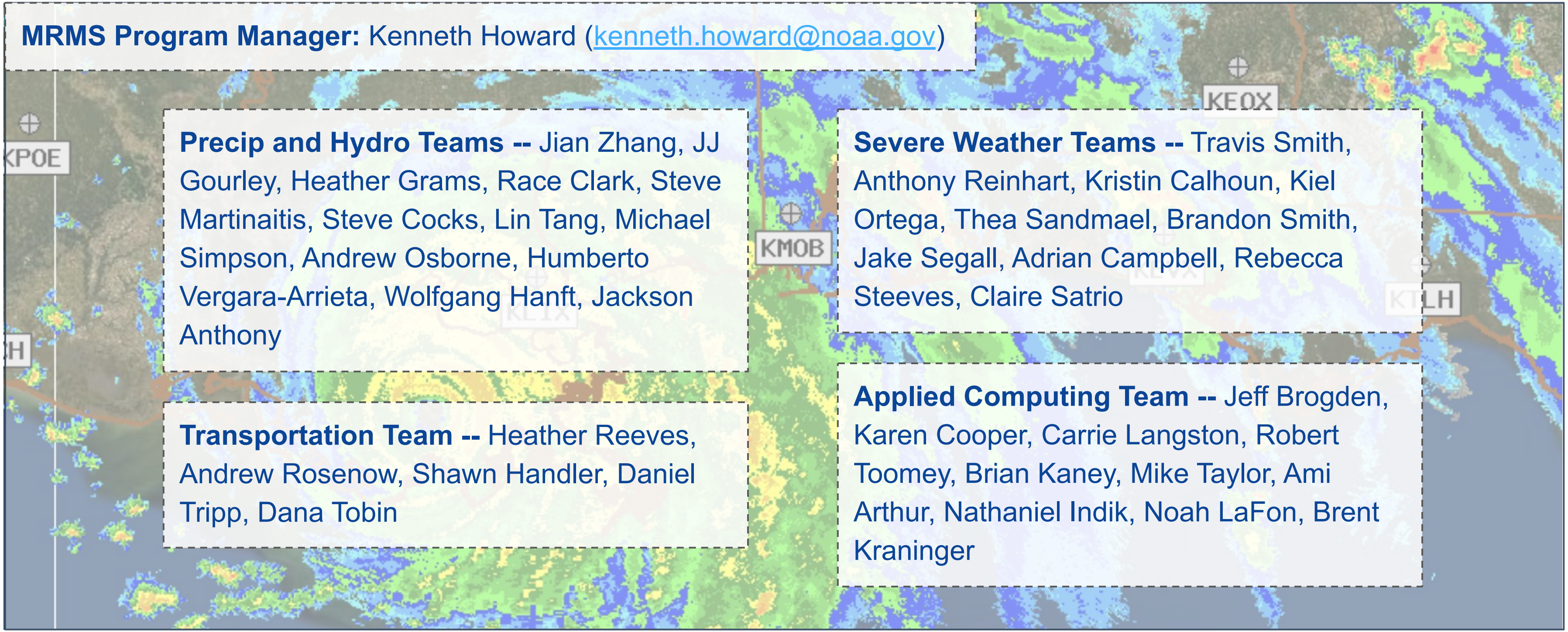


- Aviation Hazards (i.e. hail, icing, convection)
- Surface Transportation (i.e. rapidly accumulating snow, freezing rain, low visibility)

The MRMS Development and R2O Teams at NSSL

For MRMS questions: mrms@noaa.gov

For More Information: https://mrms.nssl.noaa.gov/



MRMS Program Manager: Kenneth Howard (kenneth.howard@noaa.gov)

Precip and Hydro Teams -- Jian Zhang, JJ Gourley, Heather Grams, Race Clark, Steve Martinaitis, Steve Cocks, Lin Tang, Michael Simpson, Andrew Osborne, Humberto Vergara-Arrieta, Wolfgang Hanft, Jackson Anthony

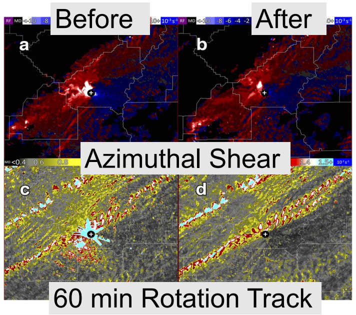
Transportation Team -- Heather Reeves, Andrew Rosenow, Shawn Handler, Daniel Tripp, Dana Tobin

Severe Weather Teams -- Travis Smith, Anthony Reinhart, Kristin Calhoun, Kiel Ortega, Thea Sandmael, Brandon Smith, Jake Segall, Adrian Campbell, Rebecca Steeves, Claire Satrio

Applied Computing Team -- Jeff Brogden, Karen Cooper, Carrie Langston, Robert Toomey, Brian Kaney, Mike Taylor, Ami Arthur, Nathaniel Indik, Noah LaFon, Brent Kraninger

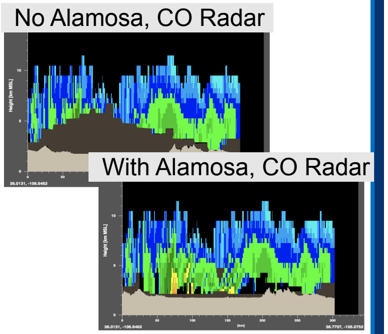
MRMS Research and Development Priorities

Operational Product Improvements



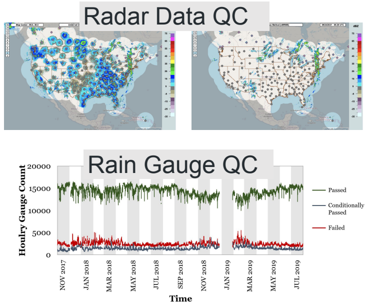
- Integration of new scientific advancements
- Modernization of software for improved efficiency/latency
- Updates based on user feedback on product performance

Integration of New Data Sources



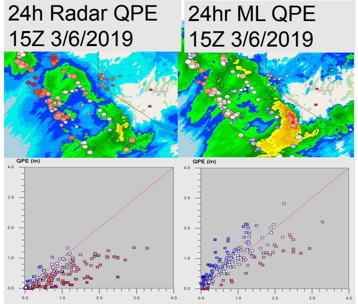
- New supplemental radar networks
- Satellite observations
- Emerging technologies

Quality Control of Observations



- Data Quality is critical step for all downstream products and uses
- Every new data source has unique QC challenges
- QC development is continuous

Leveraging Machine Learning

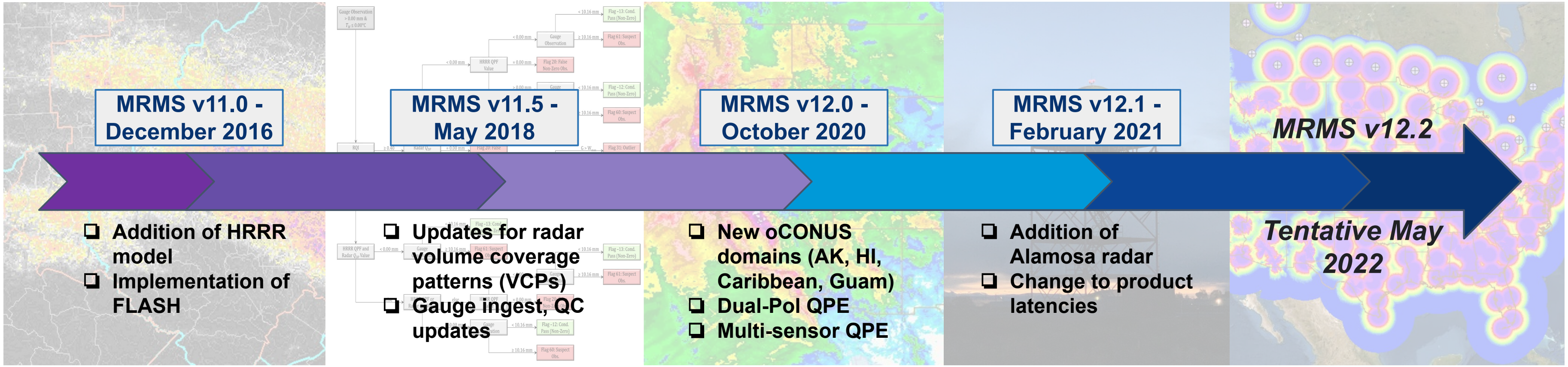


- Rapidly advancing capabilities and tools available
- Opportunities for new solutions in all the other categories listed here

MRMS Operational Success

- NSSL team works directly with the NWS National Centers for Environmental Prediction (NCEP) Central Operations staff on the operational implementation for the NWS, including on-site training and interactions
- NSSL built and maintains a real time MRMS system processing environment nearly identical to the NCEP system, in addition to a second real-time system in the Cloud

Notable MRMS Builds over the Past Five Years



MRMS Core Research Impacts

Cited over **125** times since 2016
1387 Full Text Views/Downloads this year (AMS)

MULTI-RADAR MULTI-SENSOR (MRMS) SEVERE WEATHER AND AVIATION PRODUCTS
Initial Operating Capabilities

BY TRAVIS M. SMITH, VALLIAPPA LAKSHMANAN, GREGORY J. STUMPF, KIEL L. ORTEGA, KURT HONDL, KAREN COOPER, KRISTIN M. CALHOUN, DARREL M. KINGFIELD, KEVIN L. MANROSS, ROBERT TOOMEY, AND JEFF BROGDEN

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

Cited over **350** times since 2016
2508 Full Text Views/Downloads this year (AMS)

MULTI-RADAR MULTI-SENSOR (MRMS) QUANTITATIVE PRECIPITATION ESTIMATION
Initial Operating Capabilities

BY JIAN ZHANG, KENNETH HOWARD, CARRIE LANGSTON, BRIAN KANEY, YOUCUN QI, LIN TANG, HEATHER GRAMS, YADONG WANG, STEPHEN COCKS, STEVEN MARTINAITIS, AMI ARTHUR, KAREN COOPER, JEFF BROGDEN, AND DAVID KITZMILLER

The initial operating capabilities of the Multi-Radar Multi-Sensor quantitative precipitation system 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 a 2-min update cycle over the conterminous United States.

Cited over **110** times since 2017
1551 Full Text Views/Downloads this year (AMS)

THE FLASH PROJECT
Improving the Tools for Flash Flood Monitoring and Prediction across the United States

JONATHAN J. GOURLEY, ZACHARY L. FLAMIG, HUMBERTO VERGARA, PIERRE-EMMANUEL KIRSTETTER, ROBERT A. CLARK III, ELIZABETH ARGYLE, AMI ARTHUR, STEVEN MARTINAITIS, GALATEIA TERTI, JESSICA M. ERLINGIS, YANG HONG, AND KENNETH W. HOWARD

FLASH advances the state of the science in operational flash flood monitoring and prediction in the U.S. National Weather Service.

Peer-Reviewed Publications from MRMS Team (2015-2021):
- 57 Lead Authored, 103 Co-Authored

Google Scholar Mentions (peer-reviewed journals, conference presentations):
- "Multi-Radar Multi-Sensor" returns 1,070 papers


Kenneth Howard


Heather Grams


Steven Martinaitis


Jian Zhang


Anthony Reinhart


Heather Reeves


Travis Smith

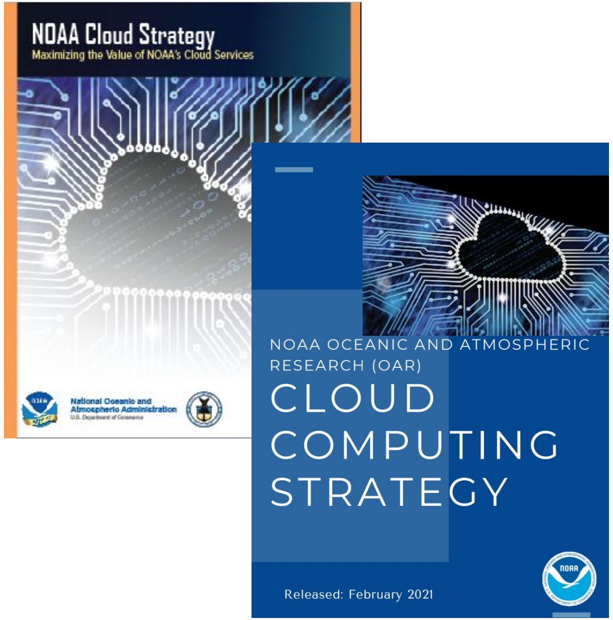

Jeffrey Brogden


Kristin Calhoun

Questions for the MRMS panel?

MRMS - Cloud Computing

- NOAA/OAR priority to leverage cloud computing
- Successful implementation of MRMS on AWS
- Used in the testing and transition of MRMS updates to NWS since 2020
- Developmental version of MRMS running 24/7
  - 99% uptime since January 2021
  - Costs competitive with on-prem hardware
- Web display and research tools migrated
- Innovating how NSSL does research
- Support from NOAA partners



2015

2016 — Demonstration of MRMS historical runs

2017 — Real-time radar processing feasibility study

2018

2019 — NSSL Cloud Contract approved

2020 — 30-day initial operational test and V12 transitioned to NWS from AWS

2021 — Running full test system on AWS

Alignment with NOAA and OAR Goals

NOAA R&D Vision Areas 2020-2026

OAR Strategic Goals		**Vision Area 1:** Reducing societal impacts from hazardous weather and other phenomena	**Vision Area 2:** Sustainable use and stewardship of ocean/coastal resources	**Vision Area 3:** Robust and effective research, development, and transition enterprise
Goal 3: Make Forecasts Better	**3.1** Develop interdisciplinary Earth system models			
	3.2 Tools and Processes to forecast high-impact weather and water events	✓		✓
	3.3 Transition science that meets users' current and future needs	✓		✓
Goal 4: Drive Innovative Science	**4.1** Reinforce a culture of innovation and adaptability	✓		✓
	4.2 Invest in high-risk, high-reward science			
	4.3 Accelerate the delivery of mission-ready, next-gen science	✓		✓

MRMS serves as a key data assimilation input and a verification resource for development of atmospheric and hydrologic forecast systems

MRMS is a platform for rapid integration of new observations with a proven track record of successful transitions of new science into operational environments

MRMS Research-to-Operations Strategy

Objective: Accelerate delivery of latest science and high quality software into operational environments

Deliver the Latest Science

- Integrate and fully leverage all existing and emerging observing systems, datasets, and technology to optimize MRMS performance

Deliver High-Quality Software

- Work with NWS to plan and schedule R2O release cycles
- Embrace proven industry best practices for software development
- Long-term planning and coordination with operational partners
- Remaining flexible to capitalize on new remote sensing opportunities and new science