MRMS Version v12 Update

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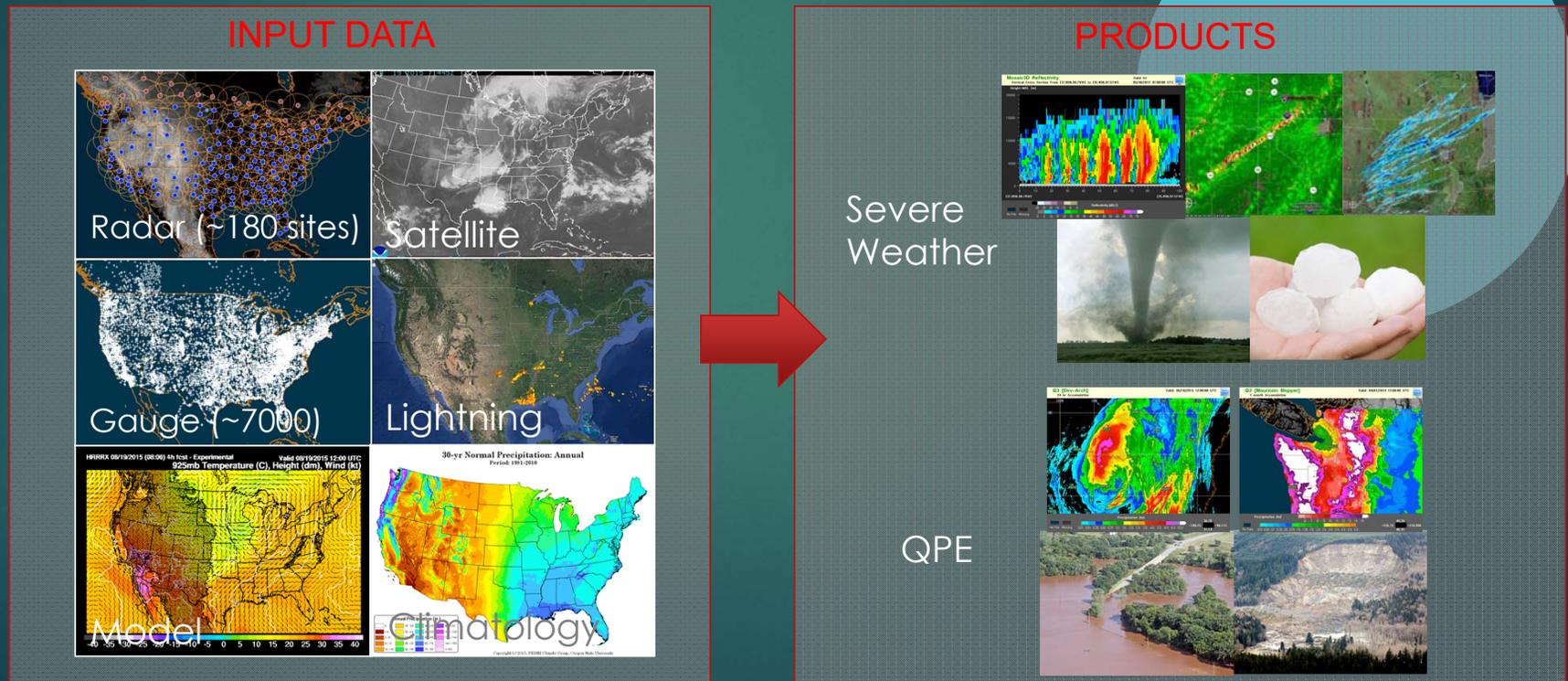[2]*CIMMS, University of Oklahoma*

Norman, OK

Outline

- ▶ Background
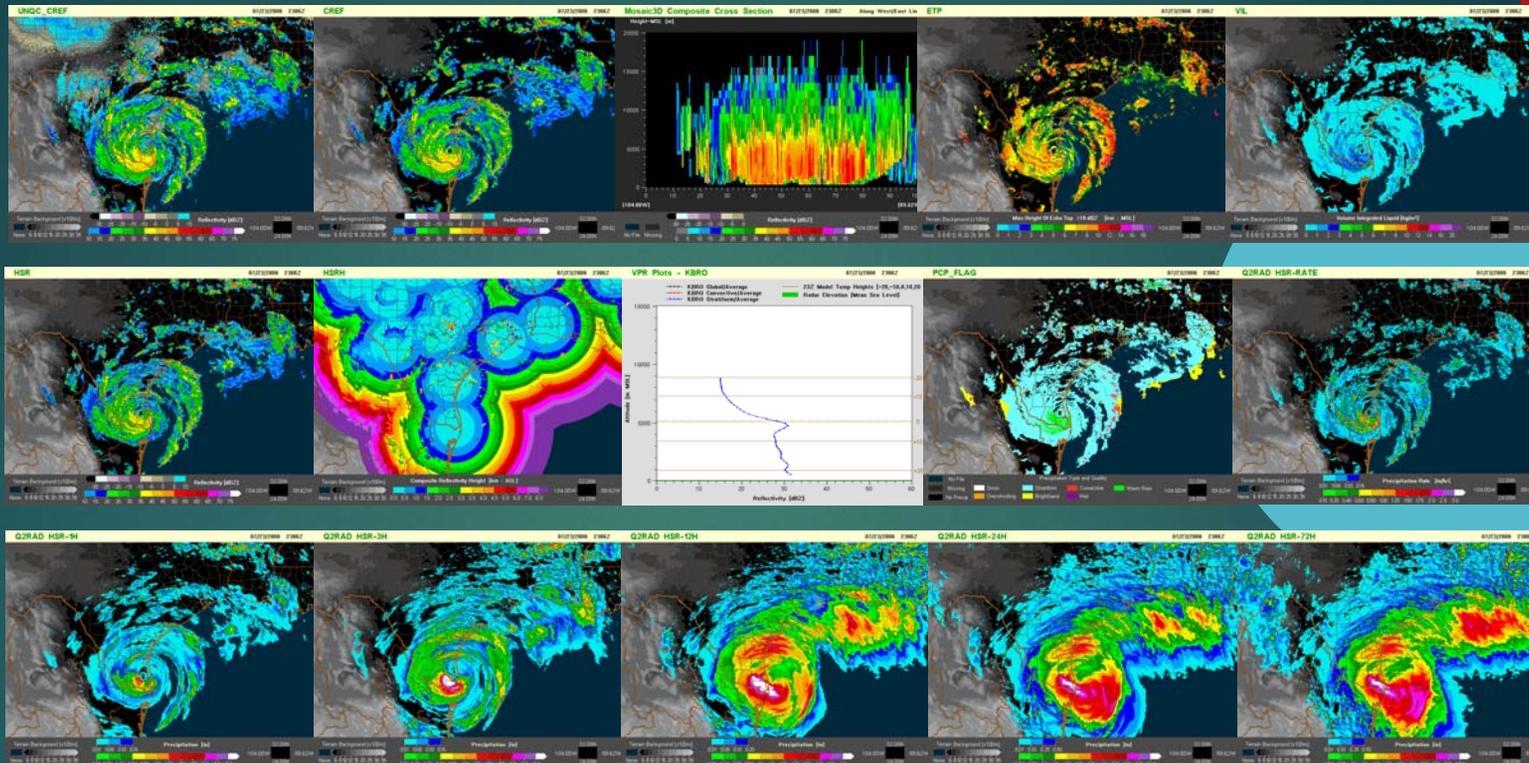
- ▶ MRMS version 12 QPE updates

- ▶ Summary and Future Work

What is MRMS?

An *operational* system for the integration of Multi-Radar Multi-Sensor data and creation of high-resolution (*1km, 2min*) severe weather and Quantitative Precipitation Estimation products over CONUS and southern Canada.
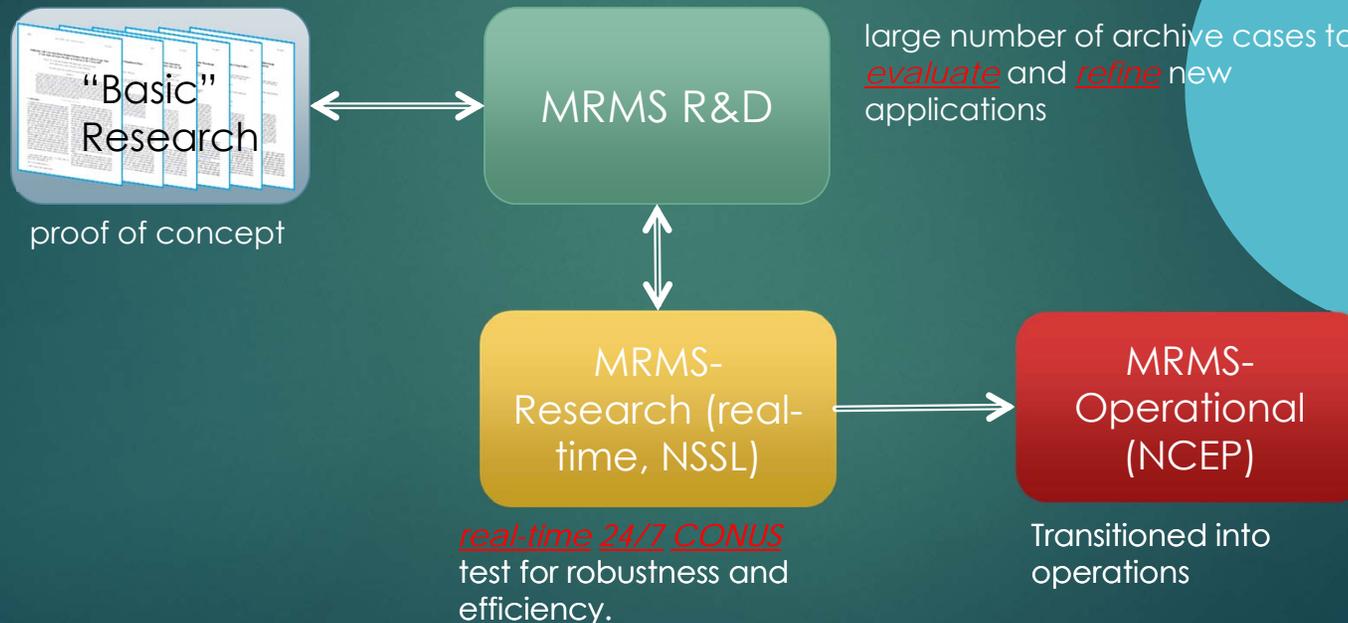
What is MRMS?

MRMS produces and disseminates (via SBN and LDM) a suite of **100+** high resolution product grids over North America **(1-km, 2 to 15 minutes)** for use in model data assimilation, severe weather, aviation and hydrometeorology (flooding and water resource management).

What is MRMS?

A *research* platform for evaluations and refinements of *new severe weather and hydrological applications* and to facilitate their *transition into operations*.

"Basic" Research

proof of concept

MRMS R&D

large number of archive cases to *evaluate* and *refine* new applications

MRMS-Research (real-time, NSSL)

real-time 24/7 CONUS test for robustness and efficiency.

MRMS-Operational (NCEP)

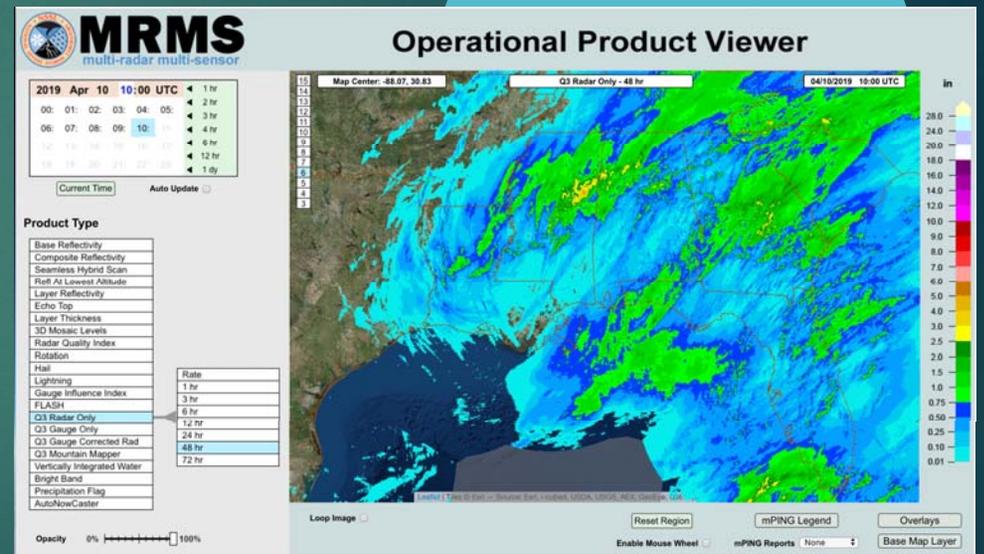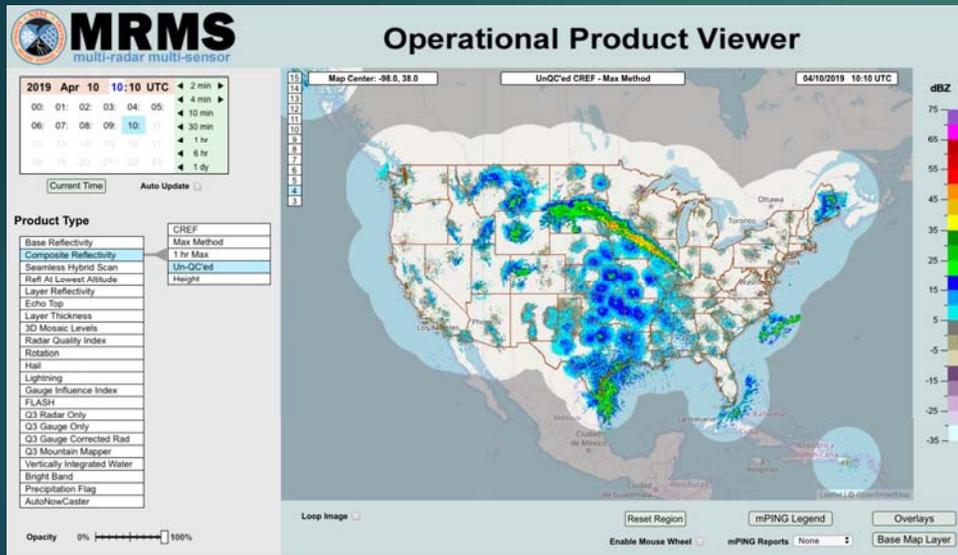Transitioned into operations

Current MRMS Oper. QPEs (v11.6)

- Radar-Based QPE [Q3RAD]
  - Precipitation rate, type, quality index, 1hr accumulation (*2 min update cycle*)
  - 3, 6, 12, 24, 48, 72hr accumulations (*1 hr*)
  - *~ 2 min* latency, a forcing for FLASH
  - *an input to RFCs' MPE and a situational awareness product for WFOs.*

- Automated gauge QC (QC approx. 15,000 gauge observations per hour)
- Local Gauge Bias Corrected Radar QPE [Q3GC]
  - 1, 3, 6, 12, 24, 48, 72hr accumulations, and gauge influence index (*1 hr update cycle*)
  - *~ 1 hr* latency, an input to RFCs' *MPE*

- Gauge and Climatology merged QPE – Mountain Mapper [Q3MM]
  - 1, 3, 6, 12, 24, 48, 72hr accumulations (*1 hr update cycle*)
  - *~ 1 hr* latency

- CONUS domain, 1km resolution

MRMS Operational Products

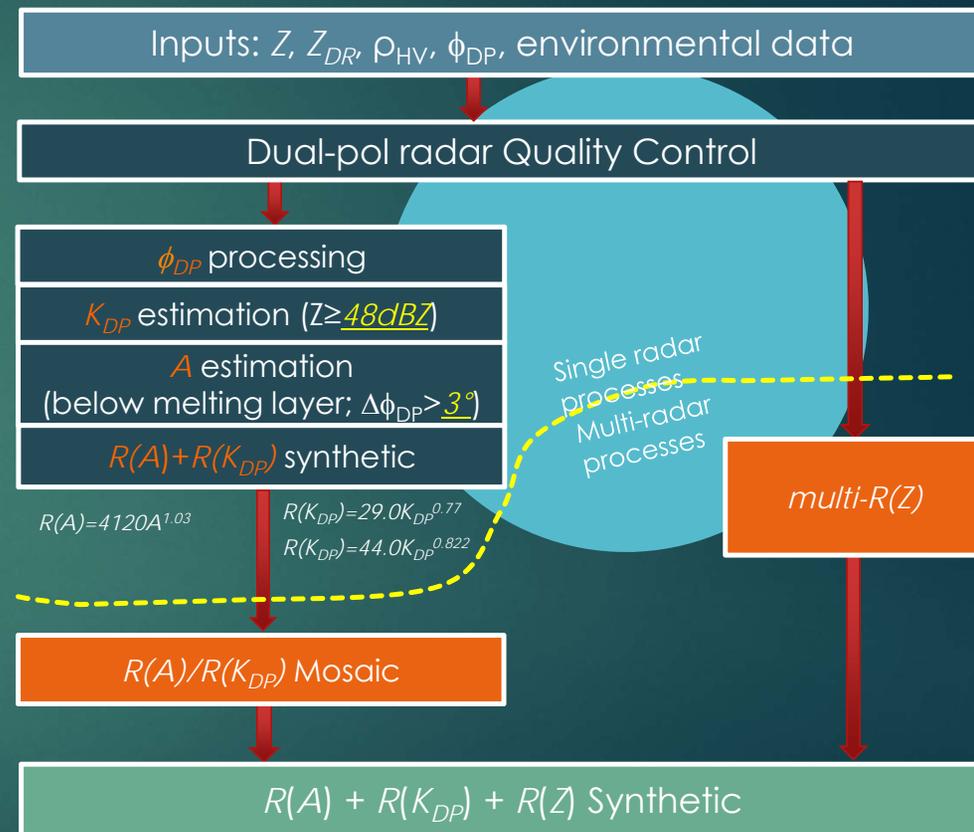https://mrms.nssl.noaa.gov/qvs/product_viewer.php

Next Update(v12)

- Radar-Based QPE [Q3DP]

  - Precipitation rate, type, quality index, 1hr accumulation (*2 min update cycle*)
  - 3, 6, 12, 24, 48, 72hr accumulations (*1 hr*)
  - A new dual-pol synthetic QPE based on specific attenuation (A), specific differential phase (K_{DP}), and reflectivity (Z) with vertical profile correction.
  - Evaporation correction
  - Accumulation Quality Index
  - Azimuth Rotary Joint check and mitigation protocal

- Multi-Sensor QPE [Q3MS]

  - 1, 3, 6, 12, 24, 48, 72hr accumulations (*1 hr update cycle*)
  - A combination of dual-pol radar, gauge, precip climatology, and model QPF (HRRR forecast 01h)
  - Two passes: #1 with 1hr latency and #2 with 2hr latency

- CONUS, Alaska, Caribbean: 1km resolution
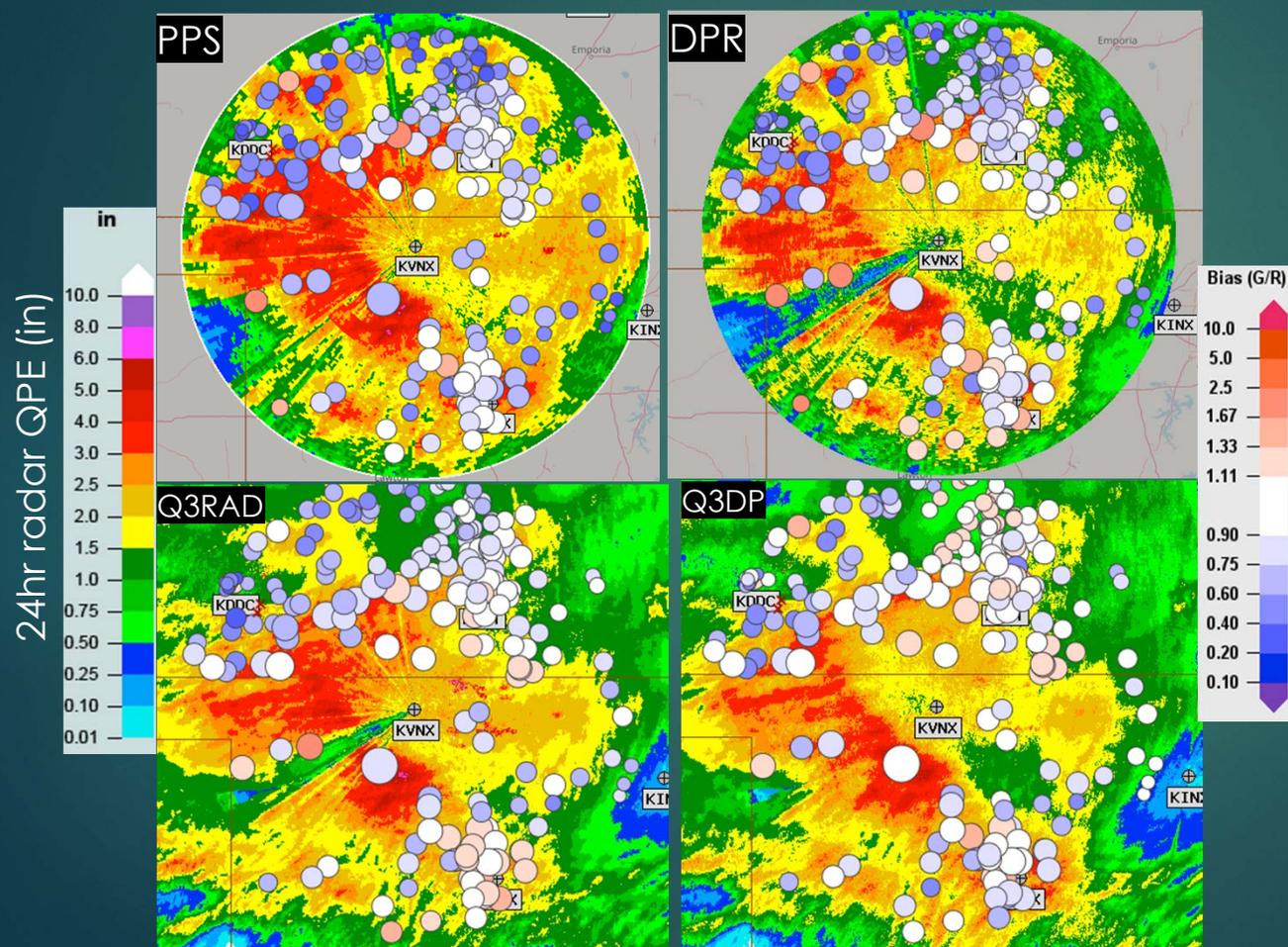
- Hawaii and Guam: 500 m resolution

Q3DP

A new dual-pol radar synthetic QPE combining R(A), R(K_{DP}), and R(Z) was developed

- *R(A) is applied in areas where radar beam is below the melting layer and sampling rain only*

- *R(K_{DP}) is applied in areas of hail*

- *R(Z) with a vertical profile of reflectivity correction is applied elsewhere*

- ❖ Evaluations for one year across CONUS showed significant improvements over current operational radar QPEs, especially in the warm season heavy to extreme rainfall

- ❖ Less sensitivity to partial beam blockages and to calibration errors in Z and Z_{DR} than current operational radar QPEs

Inputs: Z, Z_{DR}, ρ_{HV}, ϕ_{DP}, environmental data

Dual-pol radar Quality Control

ϕ_{DP} processing

K_{DP} estimation (Z≥*48dBZ*)

A estimation
(below melting layer; $\Delta\phi_{DP}$>*3°*)

R(A)+R(K_{DP}) synthetic

$R(A)=4120A^{1.03}$

$R(K_{DP})=29.0K_{DP}^{0.77}$
$R(K_{DP})=44.0K_{DP}^{0.822}$

Single radar processes
Multi-radar processes

multi-R(Z)

R(A)/R(K_{DP}) Mosaic

R(A) + *R(K_{DP})* + *R(Z)* Synthetic

12Z 6/24 - 12Z 6/25/2018
KVNX, 210 km range
Number of gauges: 229
Gauge mean: 1.59 in
Gauge max: 5.68 in

| Prod	Bias (Q/G)	MAE (in)	CC
PPS	1.48	0.78	0.70
DPR	1.31	0.59	0.72
Q3RAD	1.14	0.37	0.81
Q3DP	1.11	0.31	0.87

Calibration:
- Z bias: ~ (+ 0.82dBZ)
- Z_{DR} bias: ~ (+ 0.13dB)

Q3DP did not exhibit the blockage artifacts to the SW of KVNX

MRMS Multi-Sensor QPE Product (MSQPE)

- Seamlessly blends multiple precipitation platforms using physically-based methodology for optimal precipitation coverage and accuracy

  - MRMS Locally Gauge-Corrected Radar QPE (LGC QPE) usingMRMS dual-pol synthetic radar QPE w/ evaporation correction

  - MRMS Mountain Mapper QPE

  - HRRRv2 1-hr QPF

- Precipitations weighted using updated MRMS RQI product, atmospheric and surface conditions, terrain, and precipitation properties
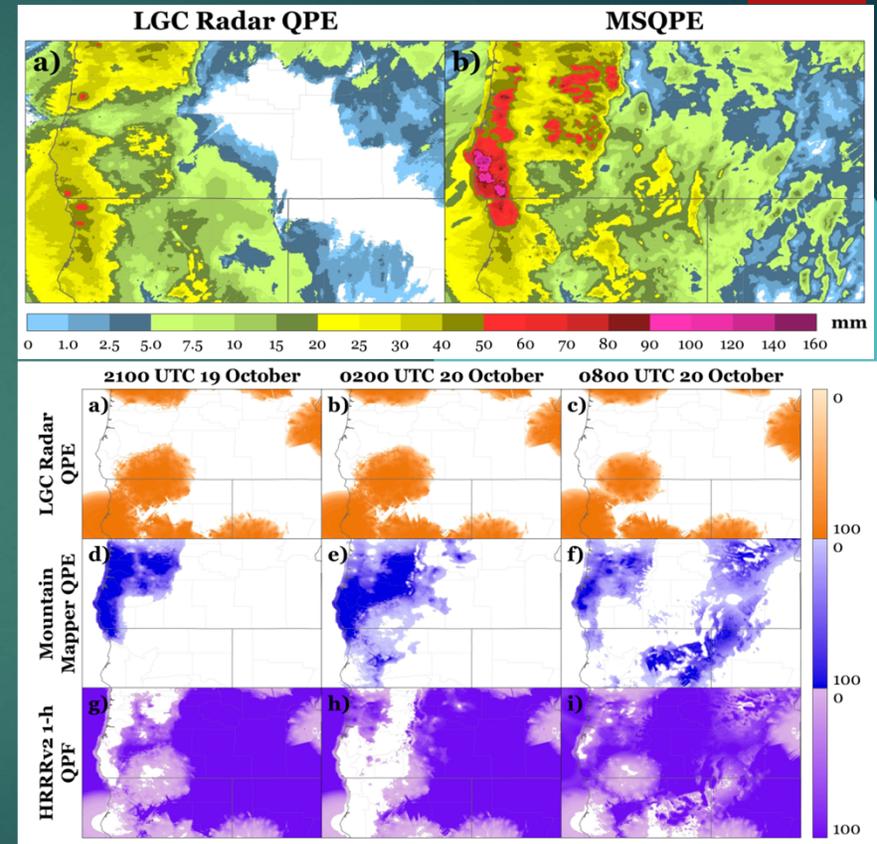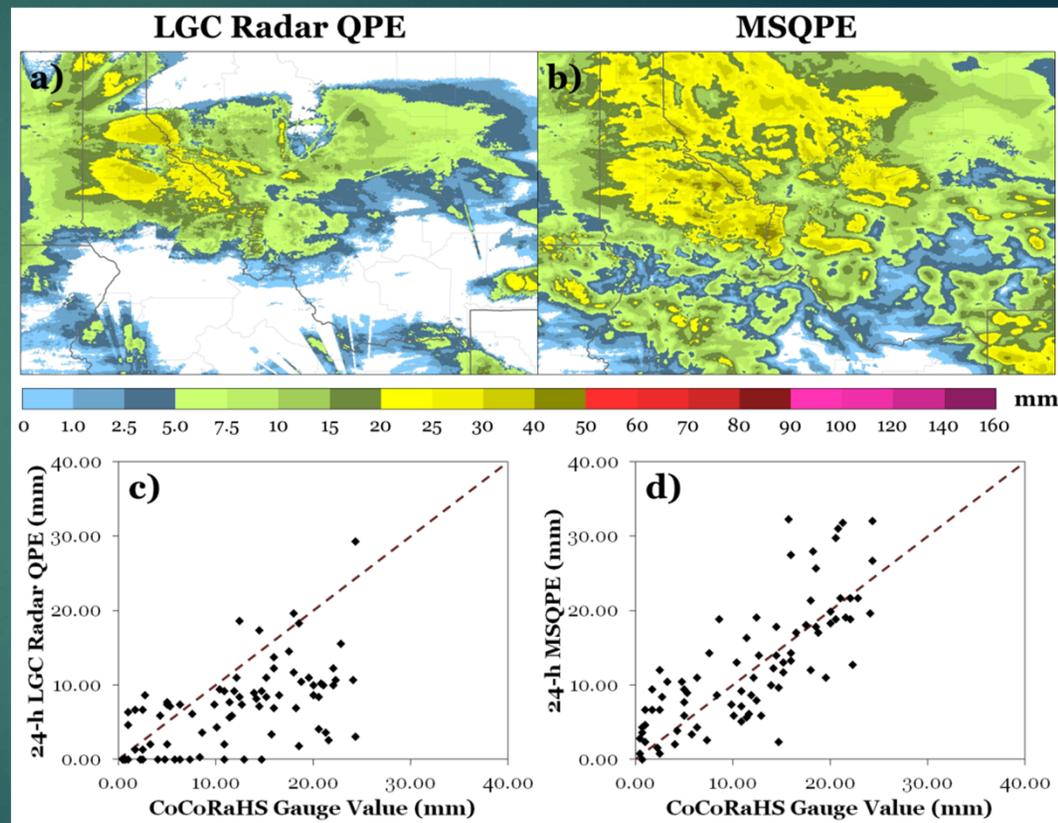

24-h accumulation of MRMS LGC radar QPE and MSQPE QPE along with example hourly percent contribution of each product for the 24-h period ending 1500 UTC 20 October 2017.

Results of MSQPE Study in Western CONUS

▶ Overall results showed significant improvement in precipitation coverage and accuracy over the western CONUS

Average (43 Events)	LGC Radar QPE	MSQPE
Mean Bias Ratio	0.747	0.987
ME (mm)	−1.526	−0.218
MAE (mm)	2.780	2.480
Correlation	0.752	0.827

➢ Gauge vs. QPE comparisons noted significant reductions of missing precipitation while minimizing introduction of false precipitation coverage

Example Case Study Event: 24-h precipitation accumulation of MRMS LGC radar QPE and MSQPE QPE across eastern Washington, northern Idaho, and western Montana for the 24-h period ending 1400 UTC 18 February 2018.
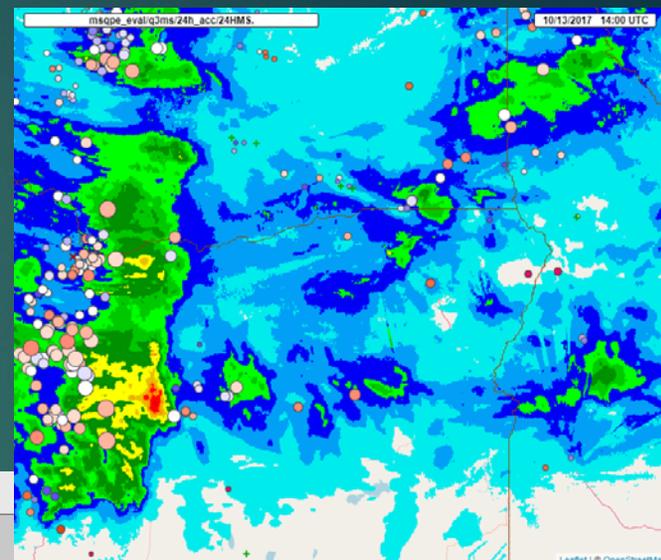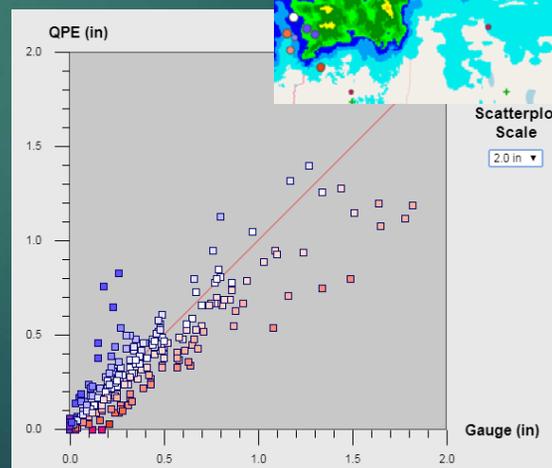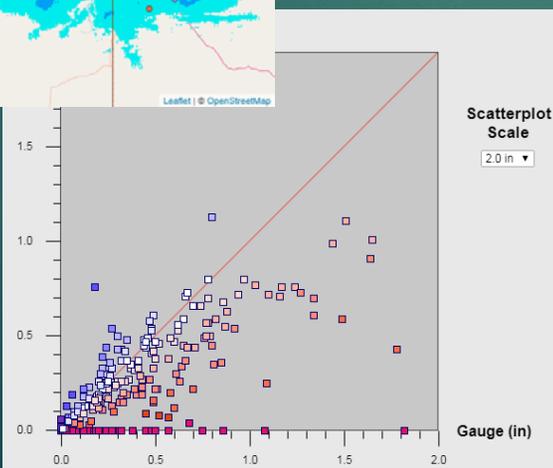
Q3MS Performance: 14Z 10/13/2017
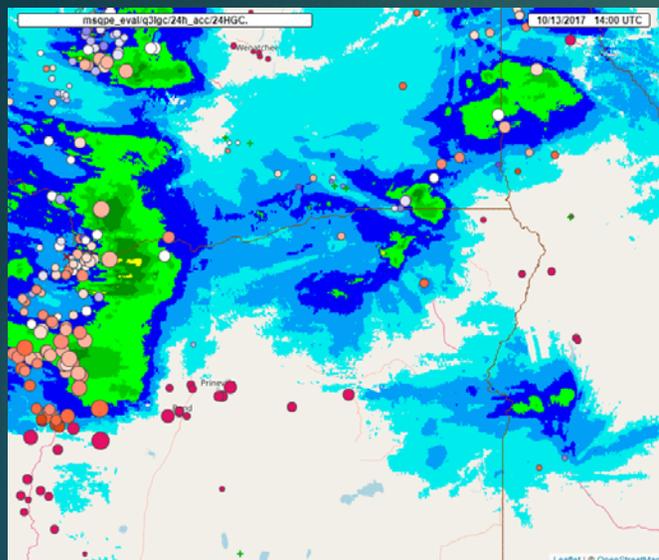
Vs. CoCoRaHS gauges

	LGC QPE	MSQPE
MAE (mm)	4.623	2.769
ME (mm)	−3.683	−0.965
Bias Ratio	0.649	0.907
Correlation	0.707	0.899

LGC Radar QPE

Multi-Sensor QPE

Radar QPE Accumulation Quality

24hr RAQI 11Z 9/14/18

24hr RAQI 11Z 9/15/18

KLTX outage: 10-20%?

24hr RAQI 11Z 9/16/18

KMHX outage: ~80-90%
KLTX /KCAE outage: 10-20%

24hr RAQI 11Z 9/17/18

KMHX outage: 100%
KCAE outage: 0-10%
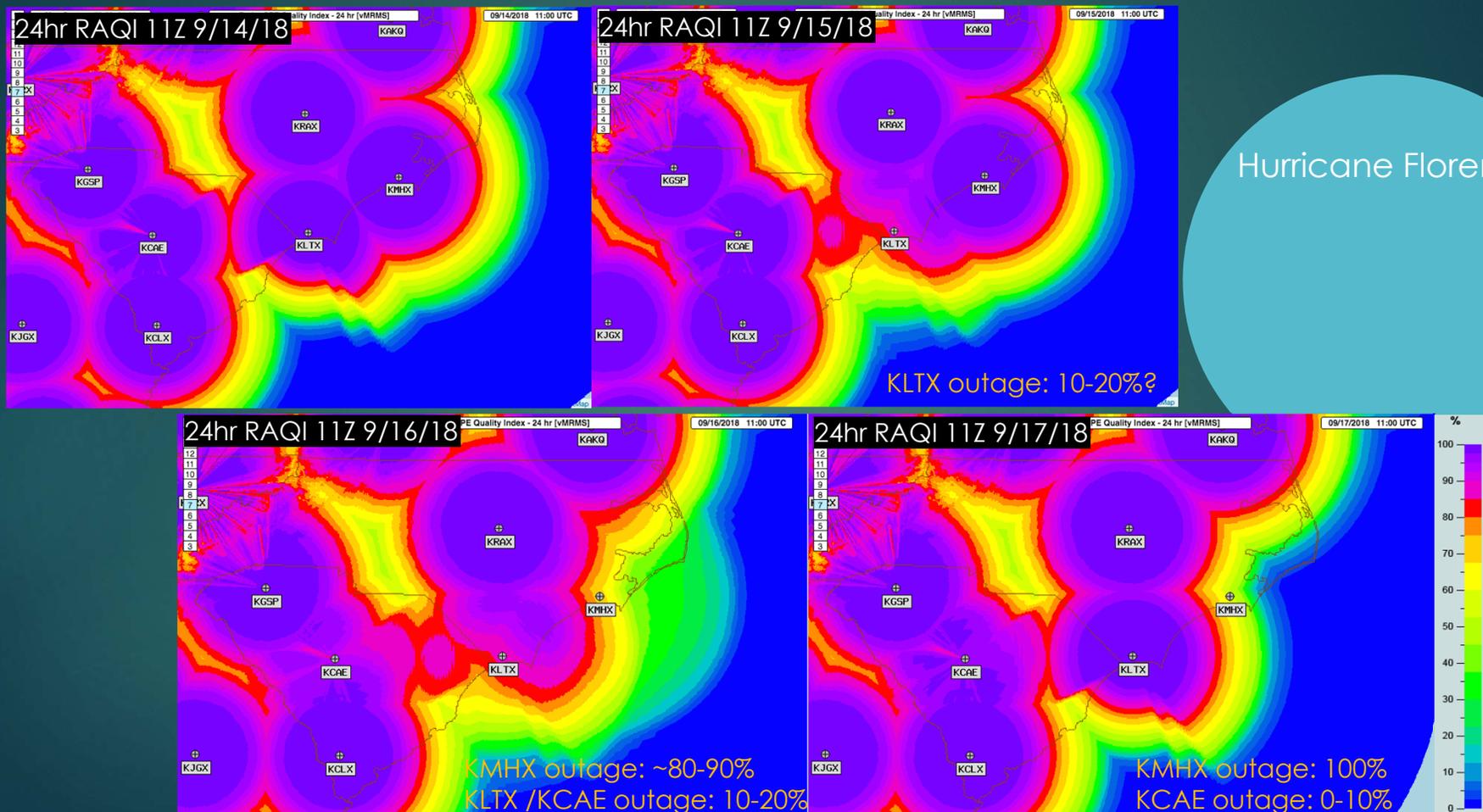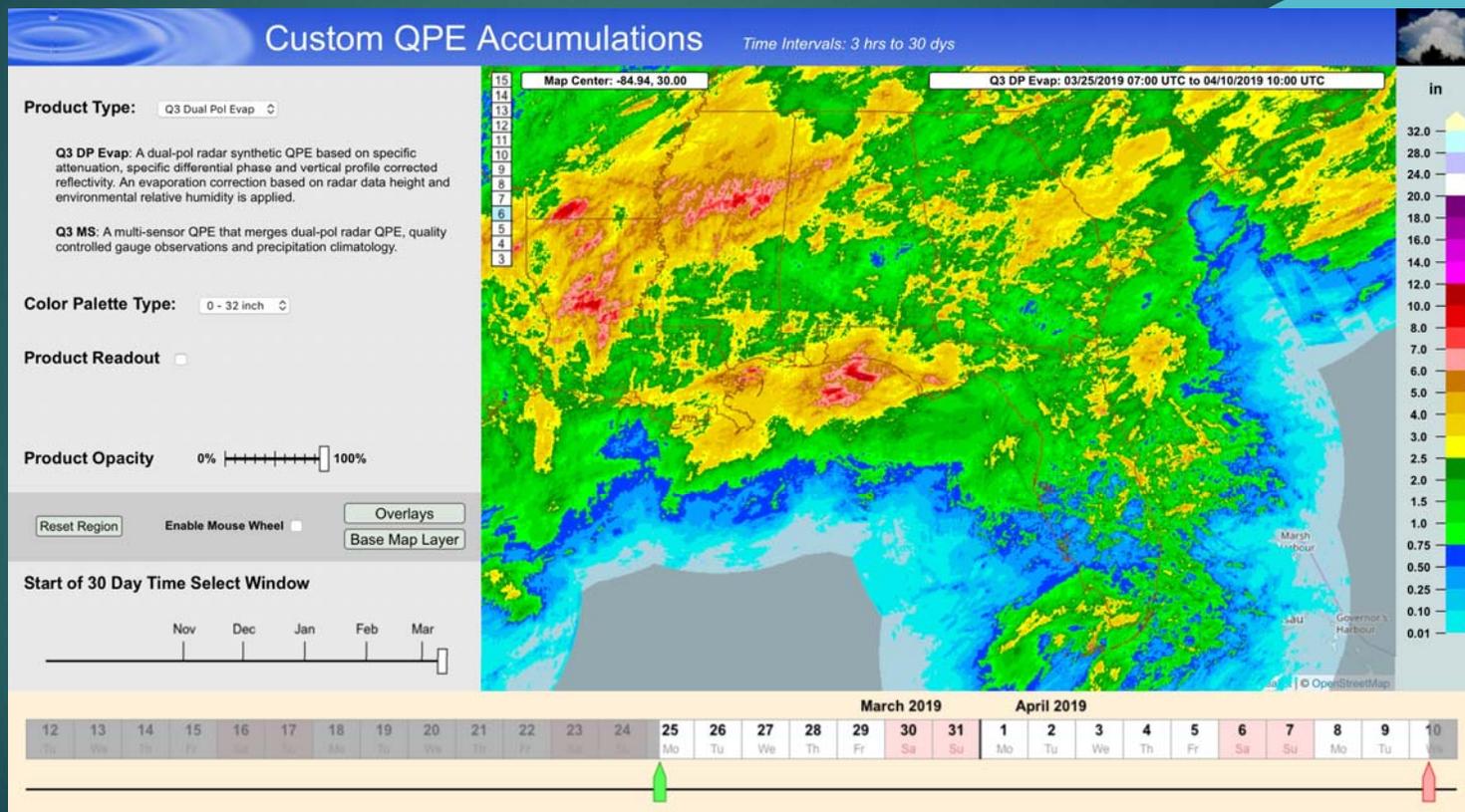
Hurricane Florence

MRMS Long Accumulations

https://mrms.nssl.noaa.gov/qvs/long_qpe_accum/

v12 MRMS QPE for oCONUS

- Processes of adding an MRMS domain
    - Identify data sources:
        - Model
        - Gauge
        - *Satellite*
    - Develop ingest, QC and remapping software
    - Implement existing algorithms and evaluate performance
        - Not perfect but provide a baseline and benchmark
    - Identify deficiencies and develop refinements/new algorithms
- *RFC/WFO inputs are very important.*
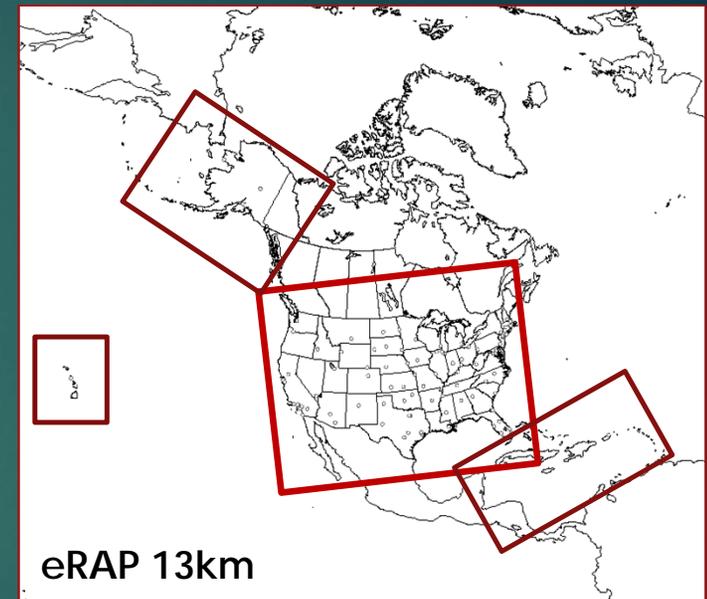
eRAP 13km

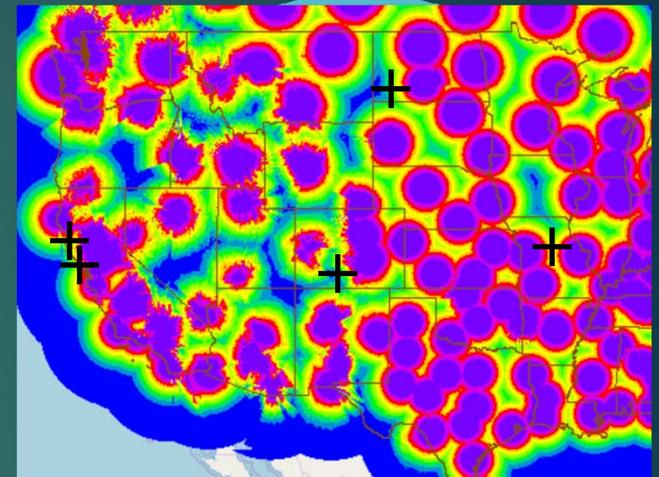| CONUS	Hawaii	Alaska	Caribbean	Guam
HRRR+eRAP 13km	eRAP 13km	HRRR_AK + eRAP 13km	eRAP13km	GFS

Summary

MRMS v12 will include a number of major updates to QPE:

- A new dual-pol radar synthetic QPE using R(A), R(K$_{DP}$) and R(Z)
  - Provide better estimates for heavy to extreme rain
  - Mitigate underestimation in heavy rain mixed with hail
  - Immune to partial beam blockages (up to 90-95%) and calibration biases.
- An evaporation correction to reduce wet bias in dry environment.
- An automated hardware problem mitigation
  - to avoid removal of precipitation echoes due to corrupted dual-pol data
- New radar accumulation quality index (RAQI) to show radar outage & range degradation
- A new multi-sensor QPE merging radar, gauge, precipitation climatology, model QPF, and satellite QPE, which will provide improved estimates in radar gaps
- Initial MRMS product suites for oCONUS domains: Hawaii, Alaska, Caribbean and Guam
- ❖ *To be transitioned into operations Q2 FY2020*

Ongoing and Future Work

- To address issues identified by RFCs/WFOS
- Refinements of the dual-pol synthetic QPE
  - For light/moderate stratiform rain
  - For oCONUS domains
- Enhancements of the multi-sensor QPE
  - For oCONUS domains
- Gauge wind correction
- Gauge meta data consolidation (w/ MADIS group)
- Software development for the Canadian radar dual-pol upgrade
- Snow water equivalent QPE using dual-pol radar data
- Integrating gap-filling radars
- Satellite QPE enhancements (w/ NESDIS)

Gap-filling radars