

# Local Gauge Correction of Radar QPE in the Multi-Radar Multi-Sensor System

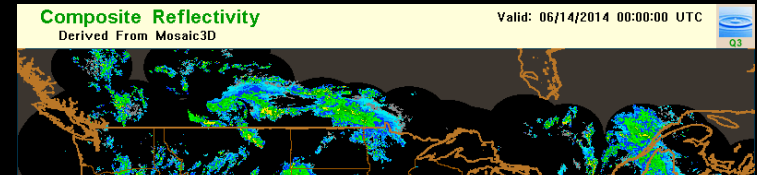
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<sup>2</sup> *Cooperative Institute for Mesoscale Studies, University of Oklahoma, Norman, OK*

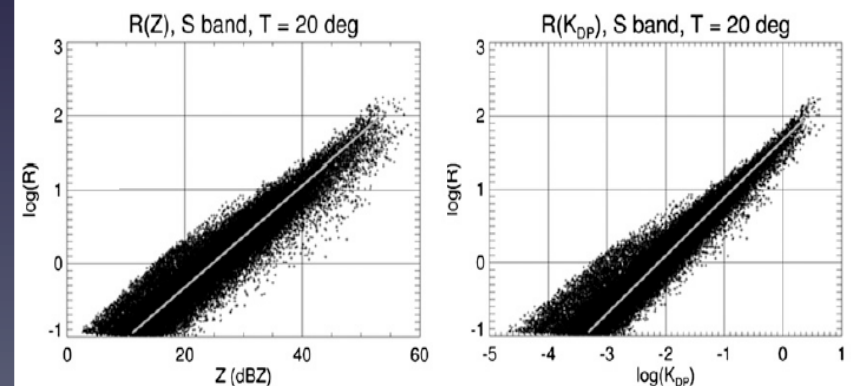
# Background: Radar QPE Pros and Cons

- Radar provide high-resolution spatially continuous measure of precipitation.
- However, radar observations are from a volume above the ground.
  - Evaporation -> overestimation
  - Warm rain growth, orographically enhanced precipitation -> underestimation
- Radar observations are an indirect measure of liquid/ice water content.
  - Calibration error
  - Attenuation (*C- and X-band radars*)
  - Clutter (*single-polarization radars*)



Courtesy: [Roger's SkyPix](http://www.stormeyes.org/tornado/SkyPix/ftsumner.htm);

<http://www.stormeyes.org/tornado/SkyPix/ftsumner.htm>



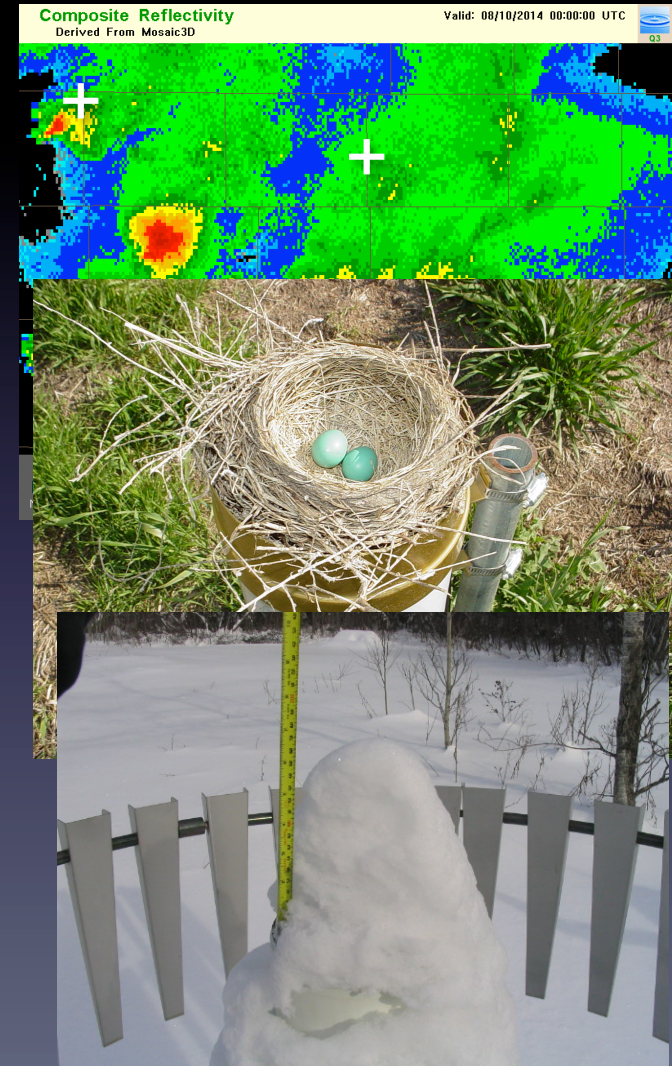
Ryzhkov et al. 2014

# Background: Gauge Pros and Cons

- Gauge is an in situ and direct measure of precipitation.
- However, gauges are often too far apart to capture important precipitation processes.
- Maintaining a high quality gauge is expensive.
- Few operational gauges can accurately measure ice water equivalent (IWC) especially on the hourly scale.

## Objective of the MRMS local gauge correction:

To reduce errors in the radar-only QPE and to obtain a higher accuracy product (but with a ~1hr latency).



# Methodology

- The main steps of the MRMS local gauge correction of radar QPE:
  1. Quality control of hourly gauge data (*Martinaitis, Tues. 11am*)
  2. Calculate hourly Radar(R) – Gauge (G) precipitation differences at gauge sites
  3. Interpolate R-G differences onto the radar QPE grid
  4. Subtract the interpolated R-G error from the hourly radar QPE.



# Methodology

- Interpolation weighting function: *inverse distance weight (IDW)*

$$w = \begin{cases} \frac{1}{r^b} & ; \quad r \leq R_0 \\ 0 & ; \quad r > R_0 \end{cases}$$

$r$ : distance.

$b$ : exponent; values between 1 ~ 2.5.

$R_0$ : radius of influence; values between 50 ~ 250km

- $b$  and  $R_0$  are “*optimized*” *hourly* through a cross-validation that minimizes the interpolation error of R-G differences:

$$J = \sum_{n=1}^N (\varepsilon_n - \tilde{\varepsilon}_n)^2$$

$$\varepsilon_n = R_n - G_n$$

$$\tilde{\varepsilon}_n = \frac{\sum_{\substack{k=1,N \\ k \neq n}} w_k \varepsilon_k}{\sum_{\substack{k=1,N \\ k \neq n}} w_k}$$

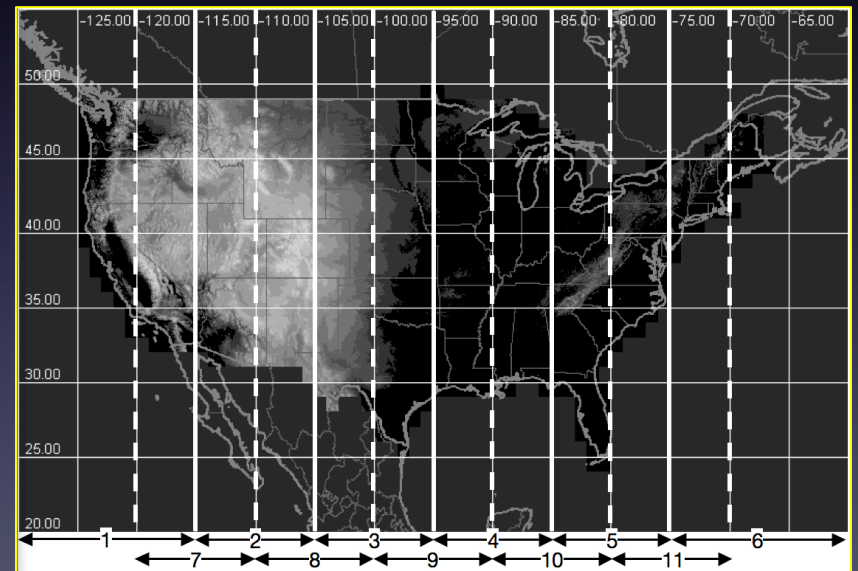
$N$ : number of gauges

$R_n$ : hourly radar QPE at the  $n^{\text{th}}$  gauge

$G_n$ : hourly gauge QPE at the  $n^{\text{th}}$  gauge

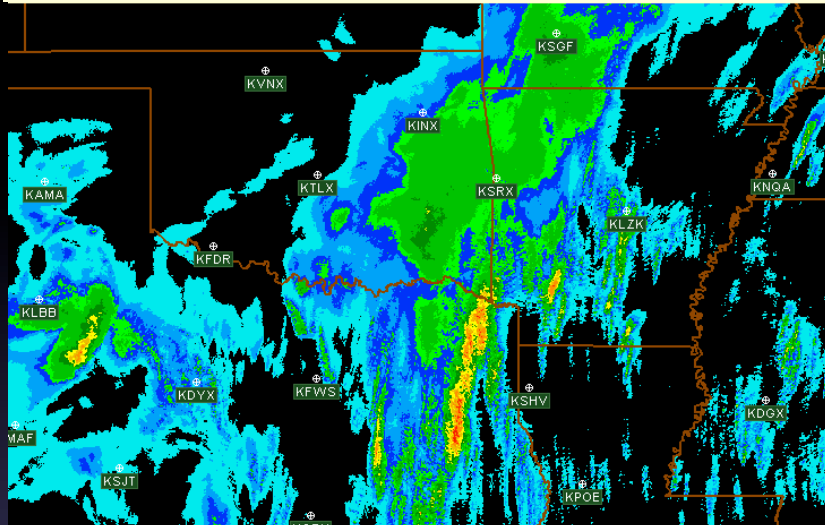
# Methodology

- The LGC parameters are also adjusted for different areas to account for spatial variations of precipitation:
  - IDW parameters are optimized and LGC applied for each of eleven longitude zones (tiles)
  - LGC QPEs from individual tiles are merged to produce the CONUS product.

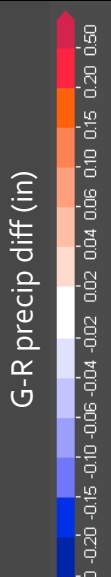
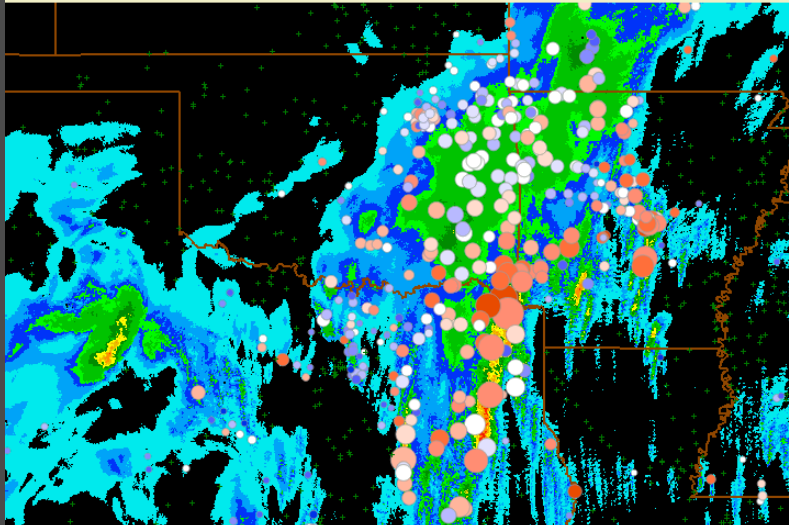


# LGC example: 23Z 12/27/15

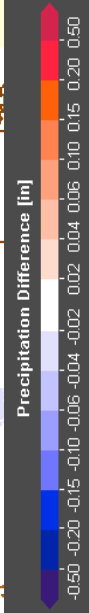
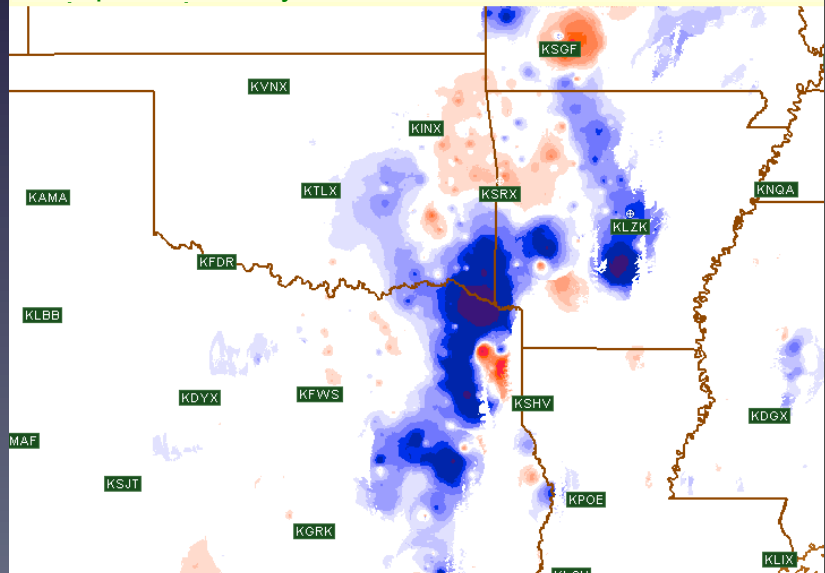
Q3RAD 1h QPE 23Z 12/27/15



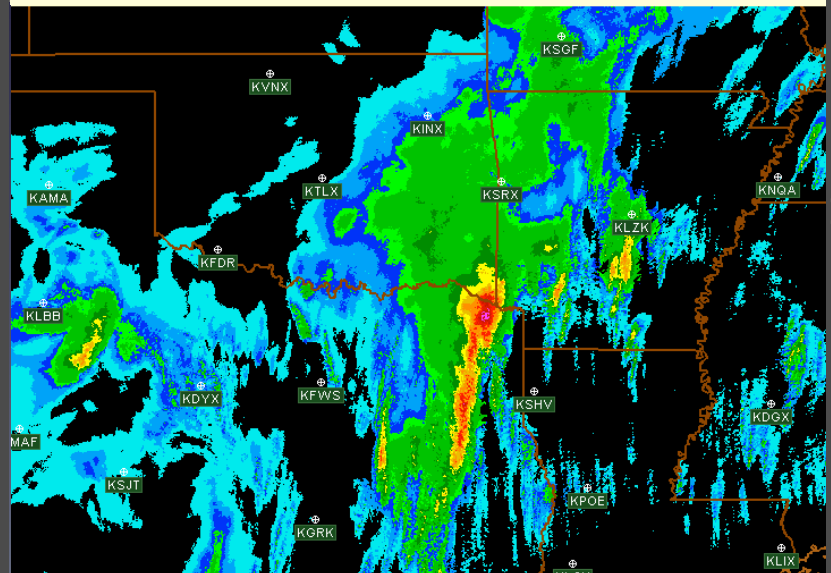
Q3RAD 1h QPE 23Z 12/27/15; with gauges



Interpolated hourly R-G difference 23Z 12/27/15

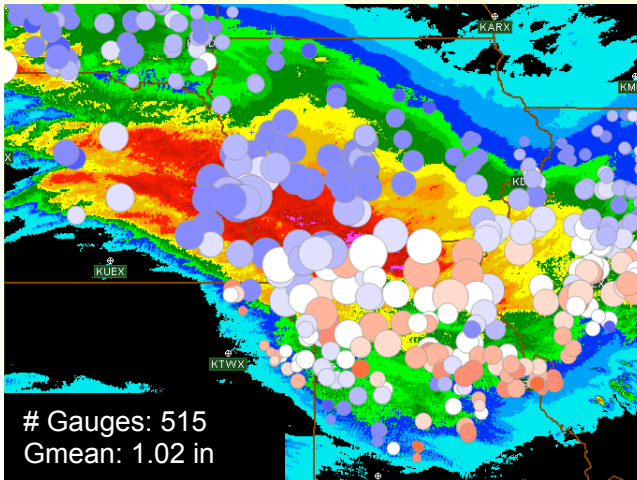


Q3GC 1h QPE 23Z 12/27/15

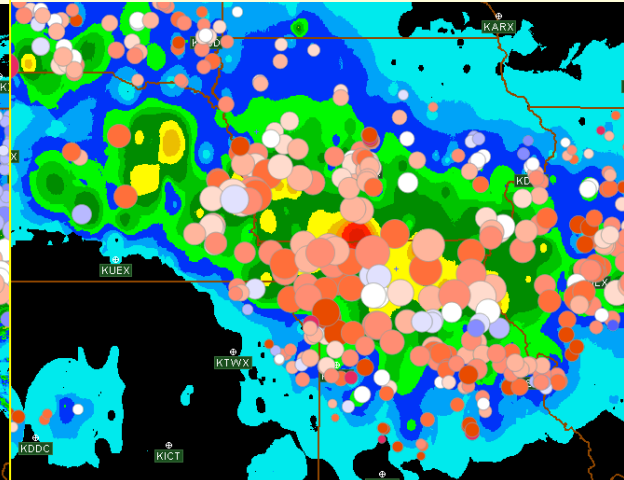


# Performance: N. Plains 6/4/14

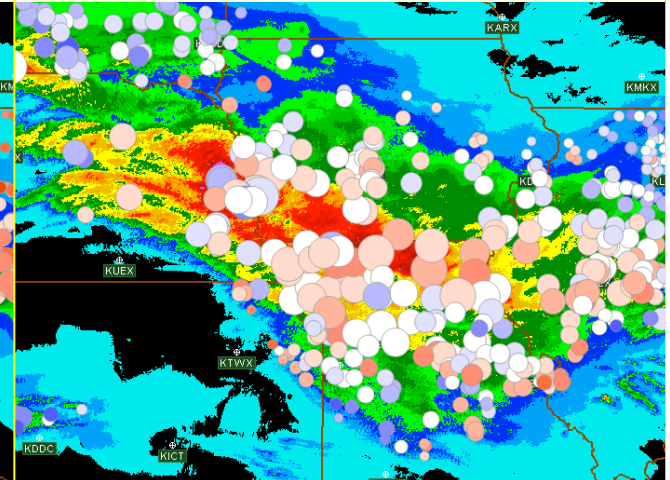
Q3RAD 24h QPE 12Z 6/4/14



Q3GAUGE 24h QPE 12Z 6/4/14



Q3GC 24h QPE 12Z 6/4/14



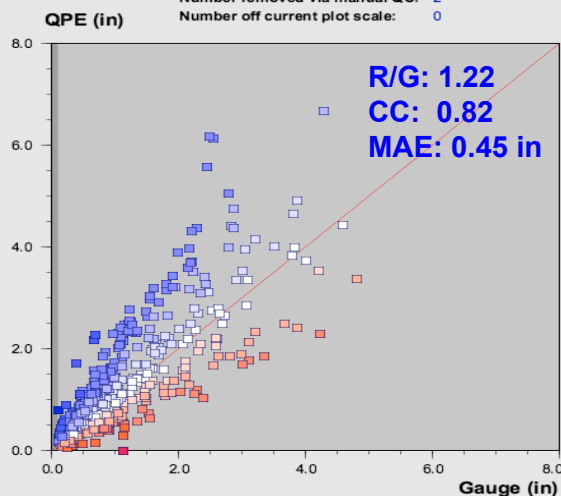
QPE: Q3 [Rad- Only - Dev]

Valid: 06/04/2014 12:00:00 UTC

Gauges: 515

24 hr Accum

Number removed via manual QC: 2  
Number off current plot scale: 0



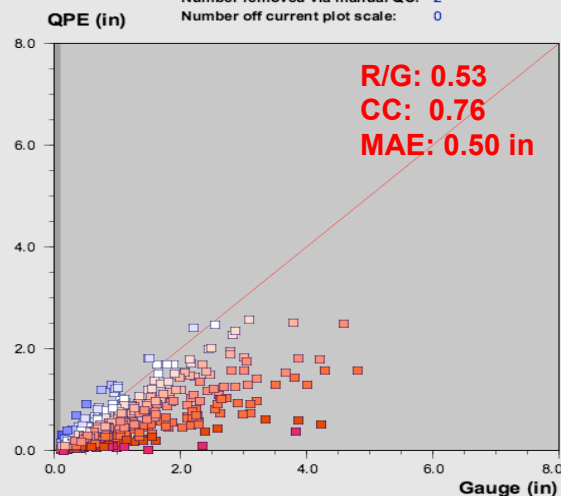
QPE: Q3 [QC Gauge]

Valid: 06/04/2014 12:00:00 UTC

Gauges: 515

24 hr Accum

Number removed via manual QC: 2  
Number off current plot scale: 0



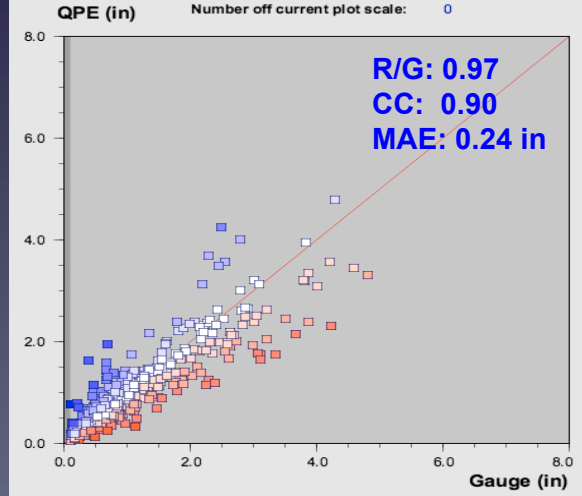
QPE: Q3 [GC Rad- Dev]

Valid: 06/04/2014 12:00:00 UTC

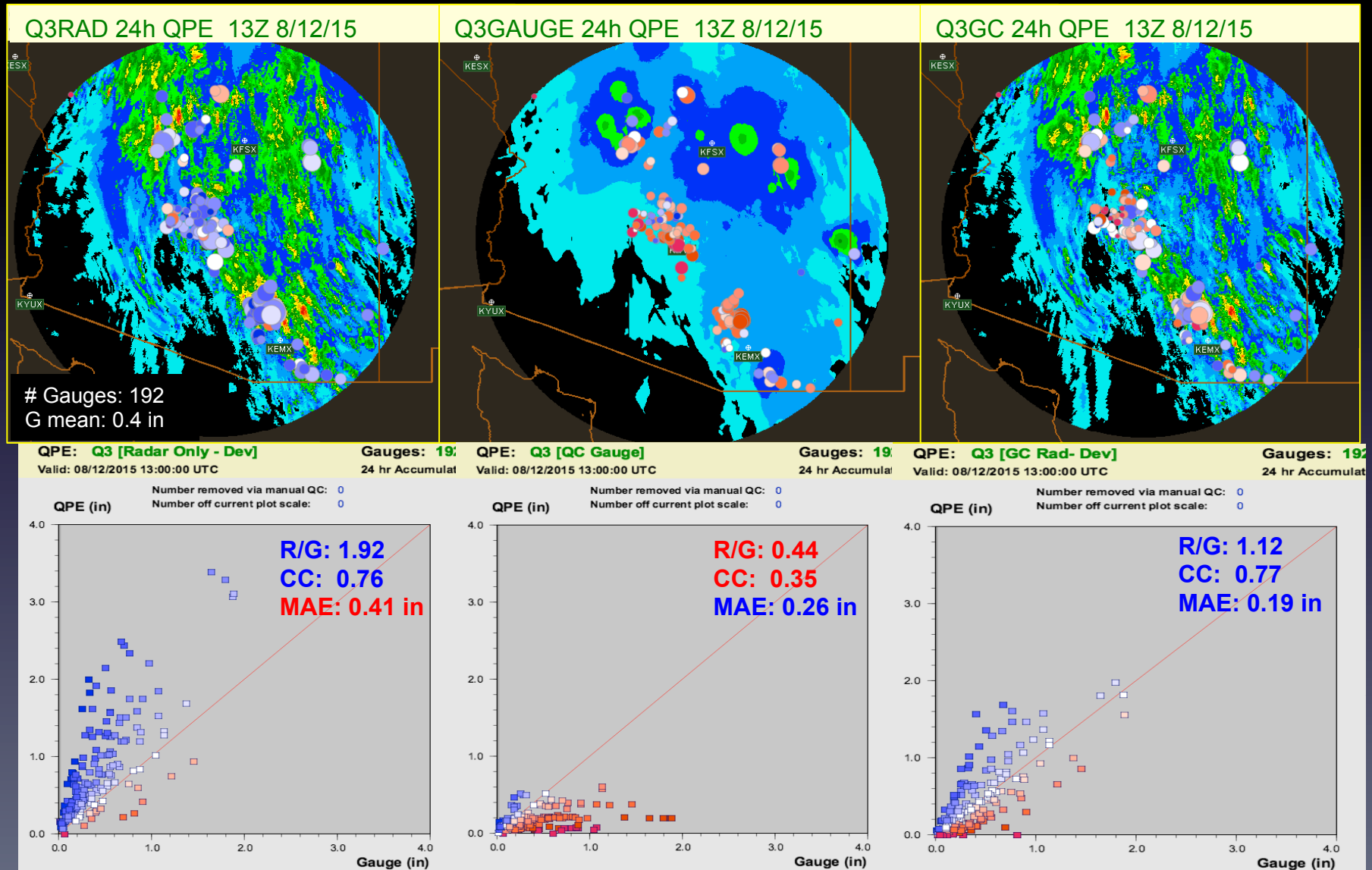
Gauges: 515

24 hr Accum

Number removed via manual QC: 2  
Number off current plot scale: 0



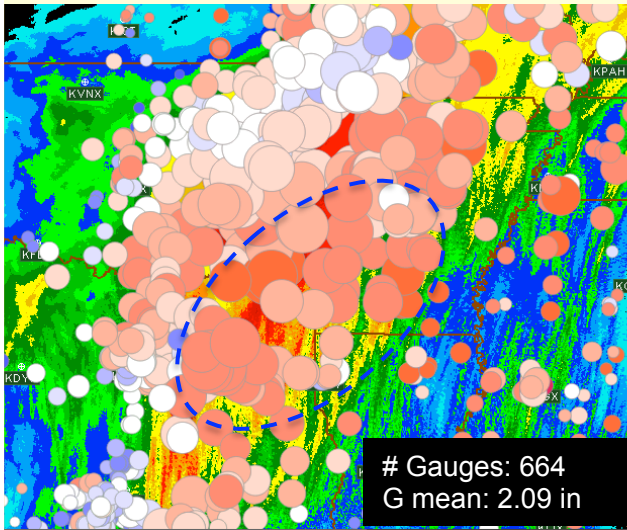
# Performance: AZ 8/12/15



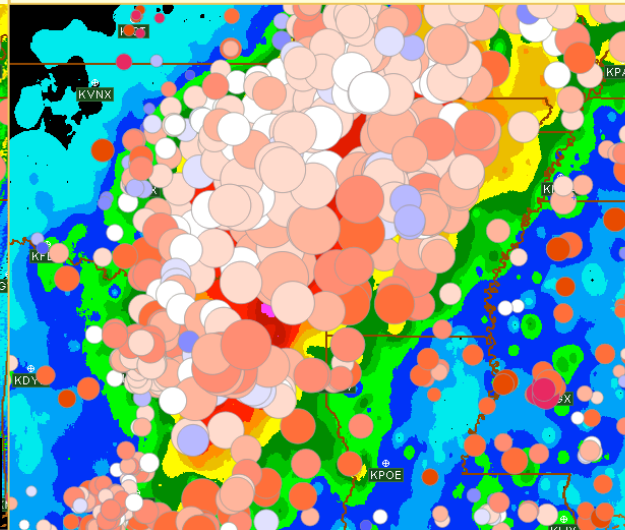


# Performance: S. Plains 12/28/15

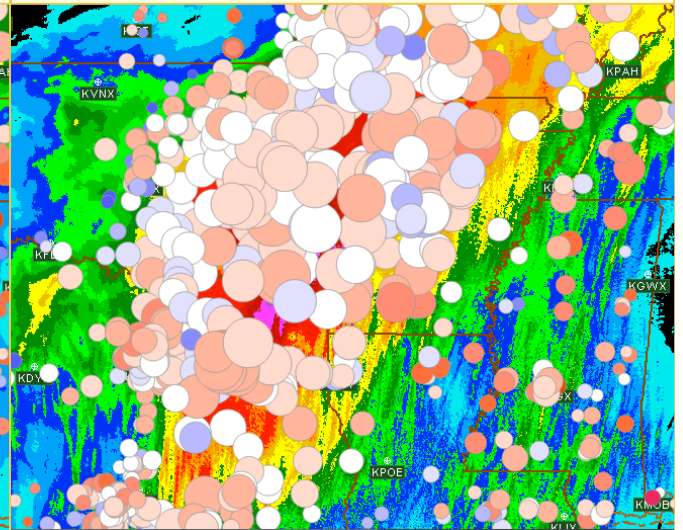
Q3RAD 24h QPE 13Z 12/28/15



Q3GAUGE 24h QPE 13Z 12/28/15



Q3GC 24h QPE 13Z 12/28/15



QPE: Q3 [Radar Only] IDP OPS

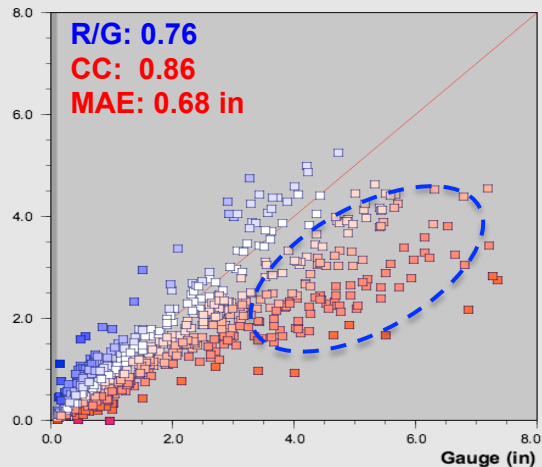
Valid: 12/28/2015 13:00:00 UTC

Gauges: 664

24 hr Accumulat

Number removed via manual QC: 3  
Number off current plot scale: 1

QPE (in)



QPE: Q3 [QC Gauge]

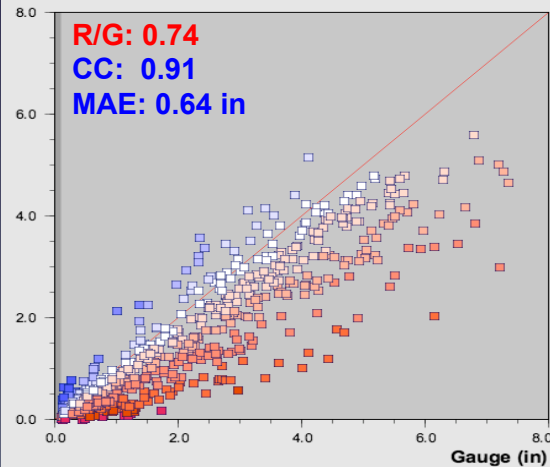
Valid: 12/28/2015 13:00:00 UTC

Gauges: 664

24 hr Accumulat

Number removed via manual QC: 3  
Number off current plot scale: 1

QPE (in)



QPE: Q3 [Gauge Adj Rad] IDP OPS

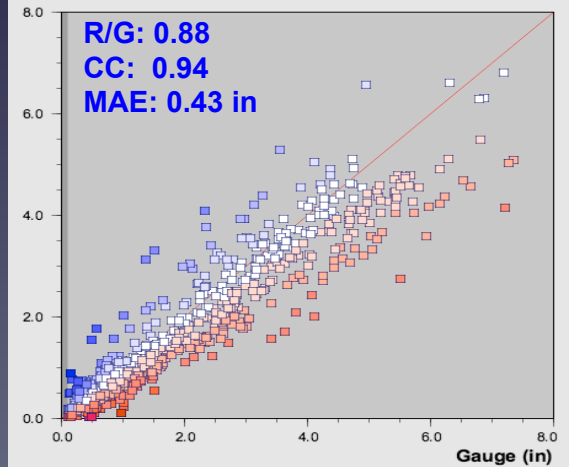
Valid: 12/28/2015 13:00:00 UTC

Gauges: 664

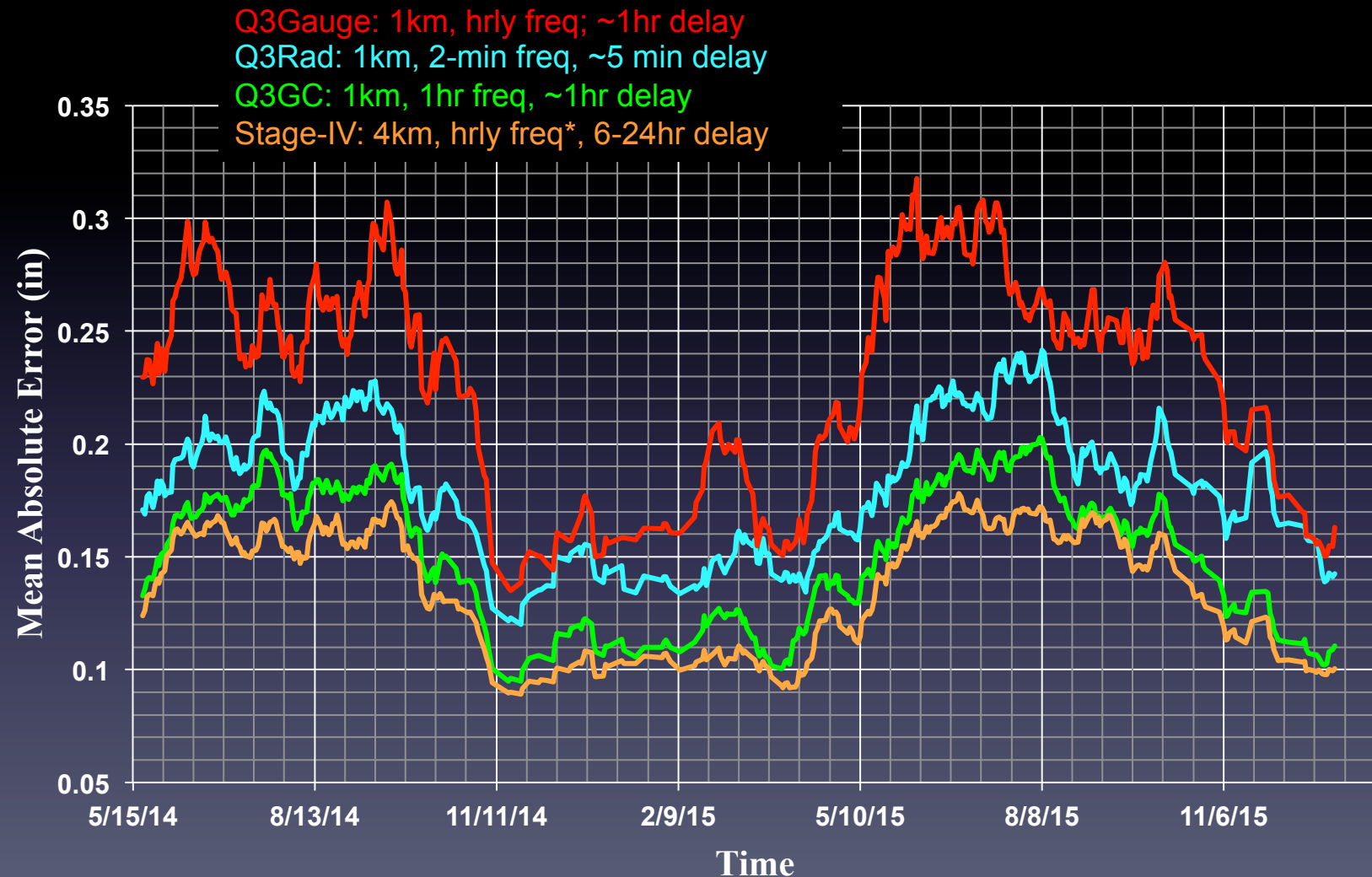
24 hr Accumulat

Number removed via manual QC: 3  
Number off current plot scale: 1

QPE (in)



# Performance: CONUS, 2014 – 15




Comparison with 12Z CoCoRaHS gauges across the CONUS



# Summary

- A real-time local gauge bias correction of radar QPE in the MRMS system was introduced
- The correction process has two unique aspects:
  - Automated hourly gauge QC
  - Spatially and temporally adjusted interpolation weighting function to minimize the interpolation error in different precipitation distributions
- Future work:
  - Ingest more gauge data (MADIS)
  - LGC and Mountain Mapper merged QPE ([Martinaitis et al., poster 553](#))
  - Integration of *satellite QPE* (SCaMPR, GOES-R).

# Thank You!



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-

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.

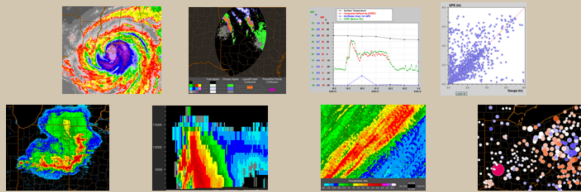
MRMS is an automated system that rapidly and intelligently integrates data from multiple radars and radar networks, surface and upper air observations, and numerical weather prediction (NWP) models. It serves as an international testbed for research, development, evaluation and science to operations 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.

[2009 Legacy QVS](#)  
[2012 Legacy QVS](#)  
[NOAA Privacy Policy](#)  
[NSSL Disclaimer](#)

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

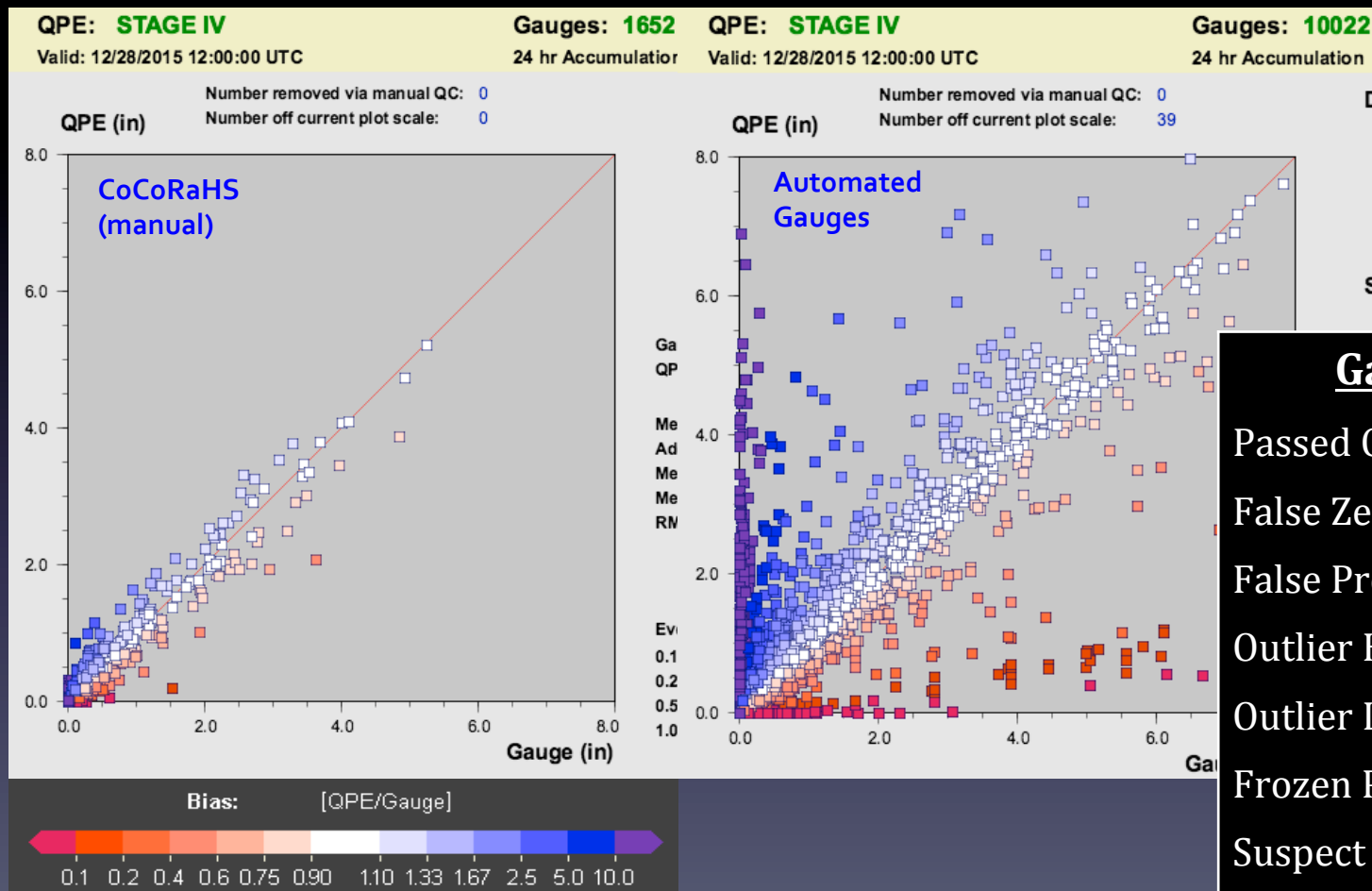
Near the top of this page there is a horizontal row of tabs or buttons

- 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



[mrms.ou.edu](http://mrms.ou.edu)  
[jian.zhang@noaa.gov](mailto:jian.zhang@noaa.gov)

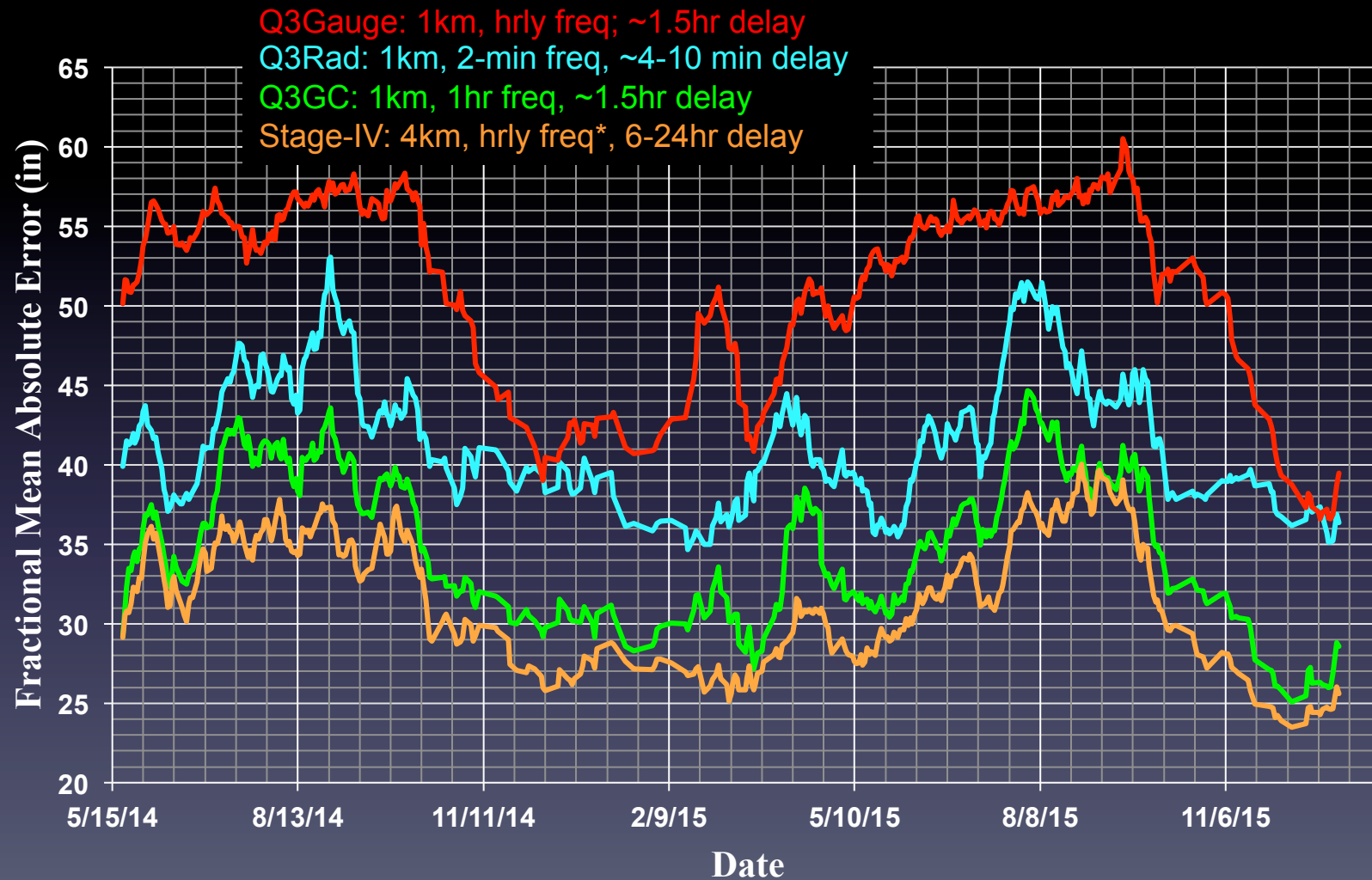
# Gauge QC



## Gauge QC Flags

Passed QC	0
False Zero	1
False Precipitation	2
Outlier High	3
Outlier Low	4
Frozen Precipitation	5
Suspect Value	6
Outside Time Window	-2
Unchecked (no QC)	-1

# Performance: CONUS 2014-15



Comparison with 12Z CoCoRaHS gauges across the CONUS

# CONUS CoCoRAHS Gauge Statistics

Domain mean daily precipitation amount (in)  
# of non-zero gauges (CoCoRaHS)

