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

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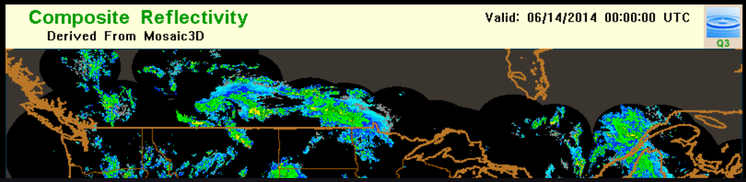
Background: Radar QPE Pros and Cons

- Radar provide ***high-resolution spatially continuous*** measure of precipitation.

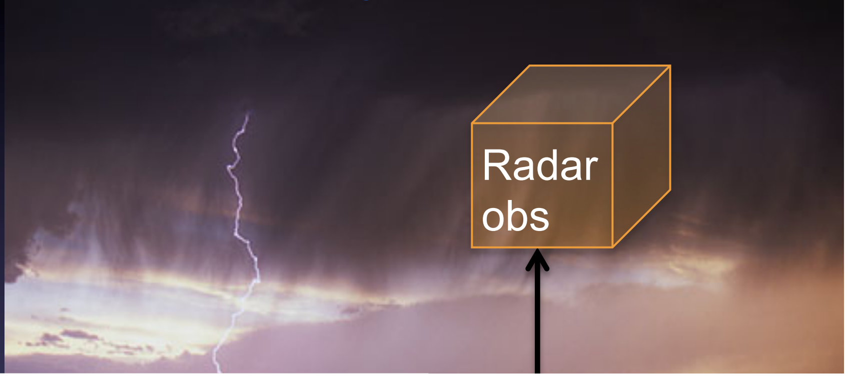
- However, radar observations are from a ***volume above*** the ground.
  - Evaporation -> *overestimation*
  - Warm rain growth, orographically enhanced precipitation -> *underestimation*

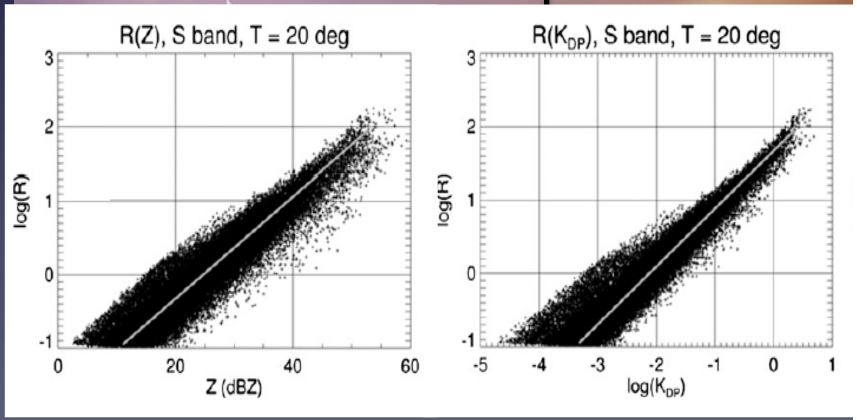
- Radar observations are an ***indirect*** measure of liquid/ice water content.

  - Calibration error
  - Attenuation (*C- and X-band radars*)
  - Clutter (*single-polarization radars*)



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

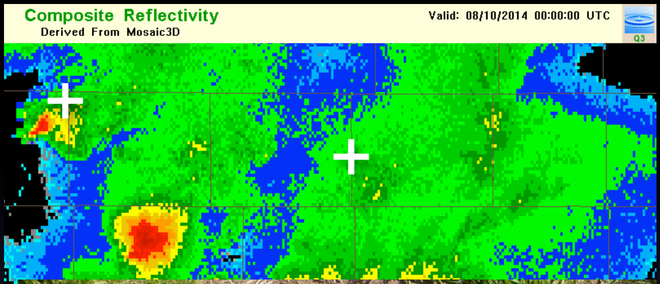




Ryzhkov et al. 2014

Background: Gauge Pros and Cons

- Gauge is an ***<u>in situ</u>*** and ***<u>direct</u>*** 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.



<u>Objective of the MRMS local gauge correction</u>:

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)*

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

r: distance.

b: exponent; values between 1 ~ 2.5.

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

- *b* and R_o are "***optimized" hourly*** through a cross-validation that minimizes the interpolation error of R-G differences:

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

$$\varepsilon_n = R_n - G_n$$

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

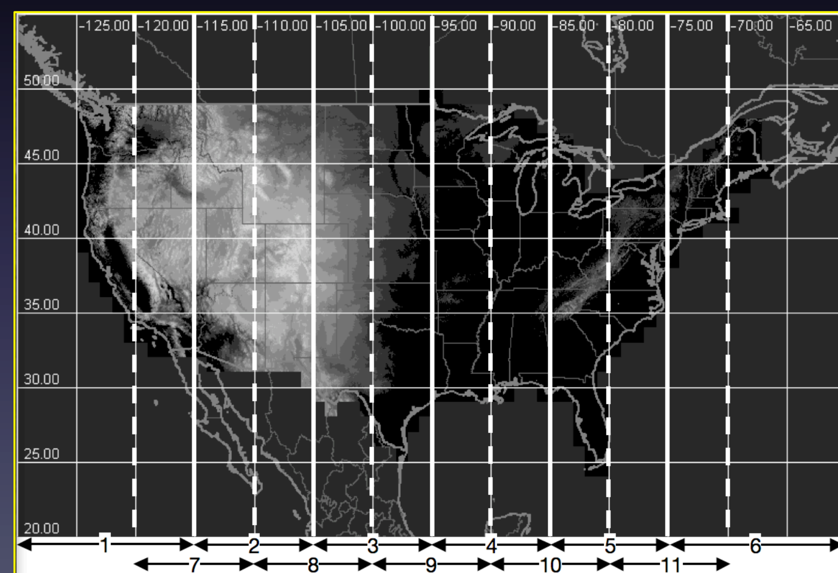
N: number of gauges

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

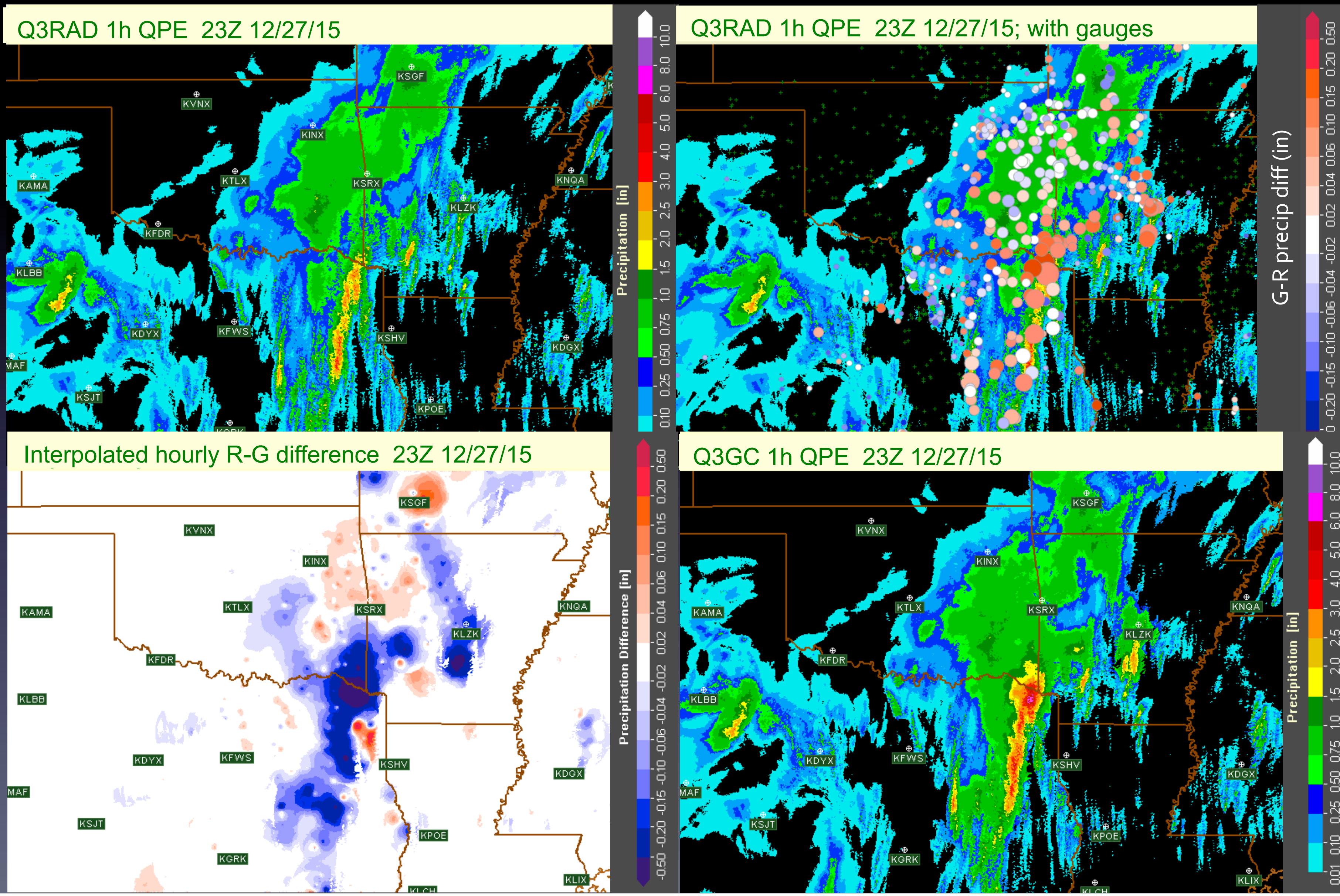
G_n: hourly gauge QPE at the n^{th} gauge

Methodology

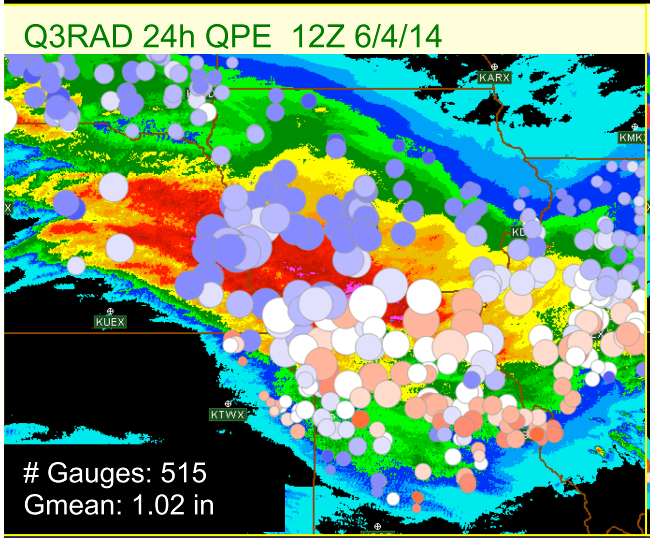
- The LGC parameters are also adjusted for different areas to account for spatial variations of precipitation:
  - IDW parameters are optimized and LGC applied for each of eleven longitude zones (tiles)
  - LGC QPEs from individual tiles are merged to produce the CONUS product.

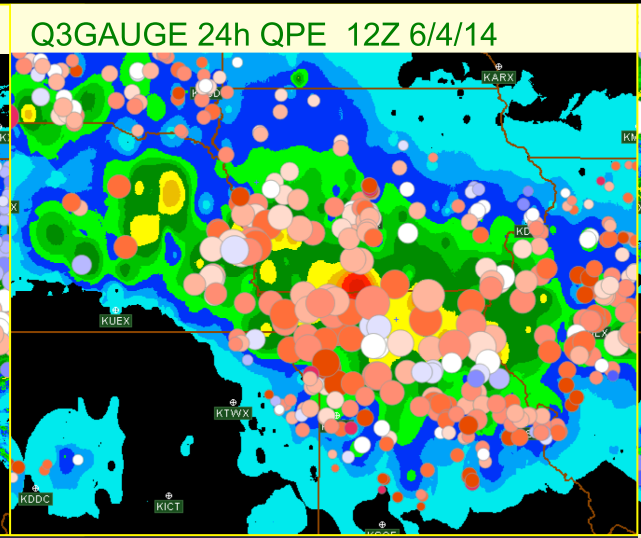


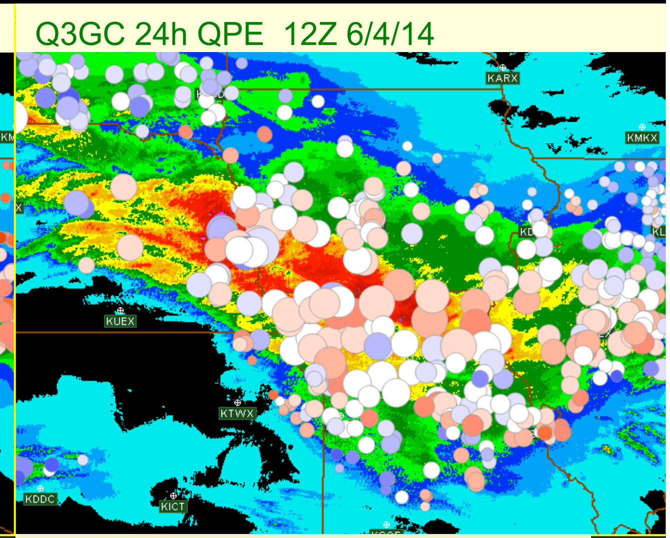
LGC example: 23Z 12/27/15

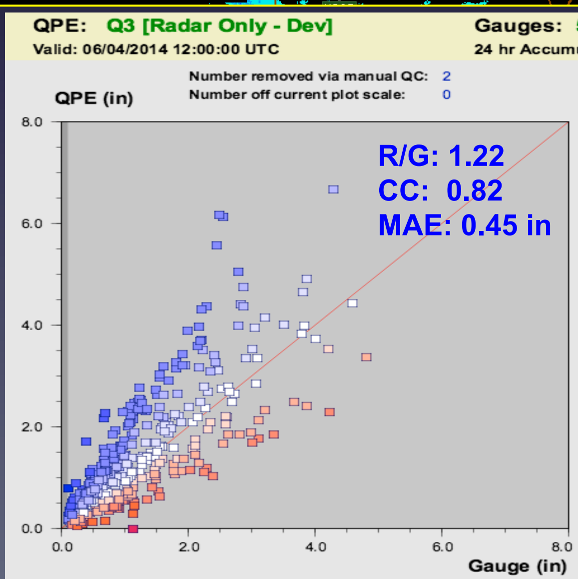


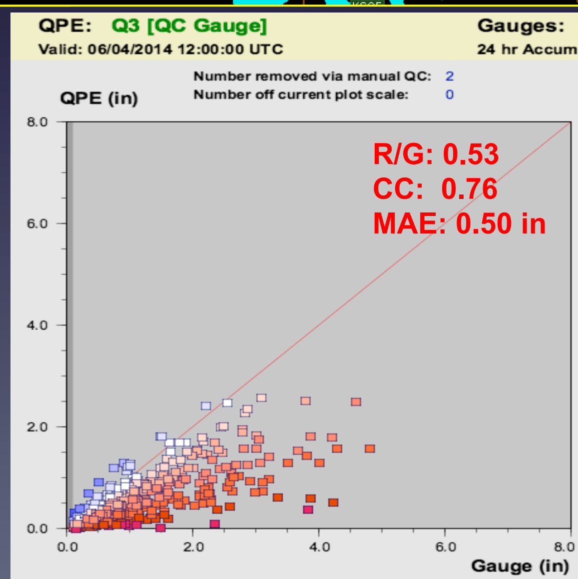
Performance: N. Plains 6/4/14

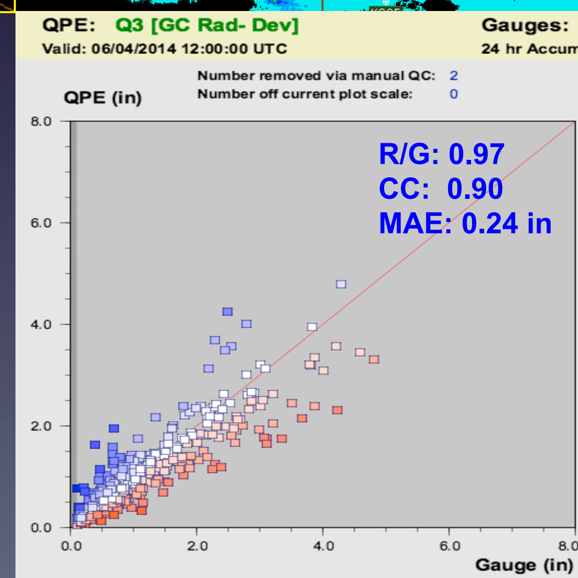




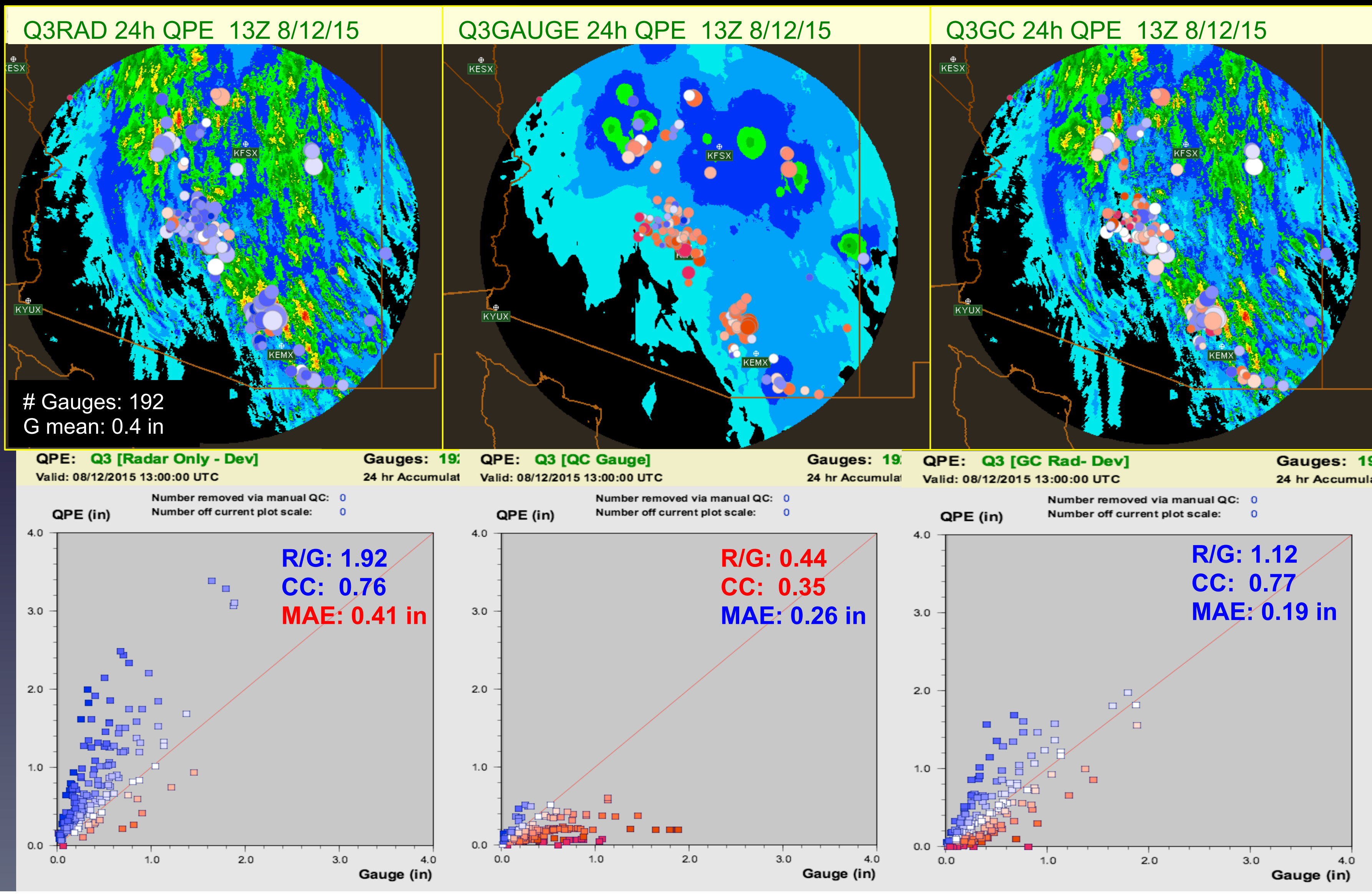




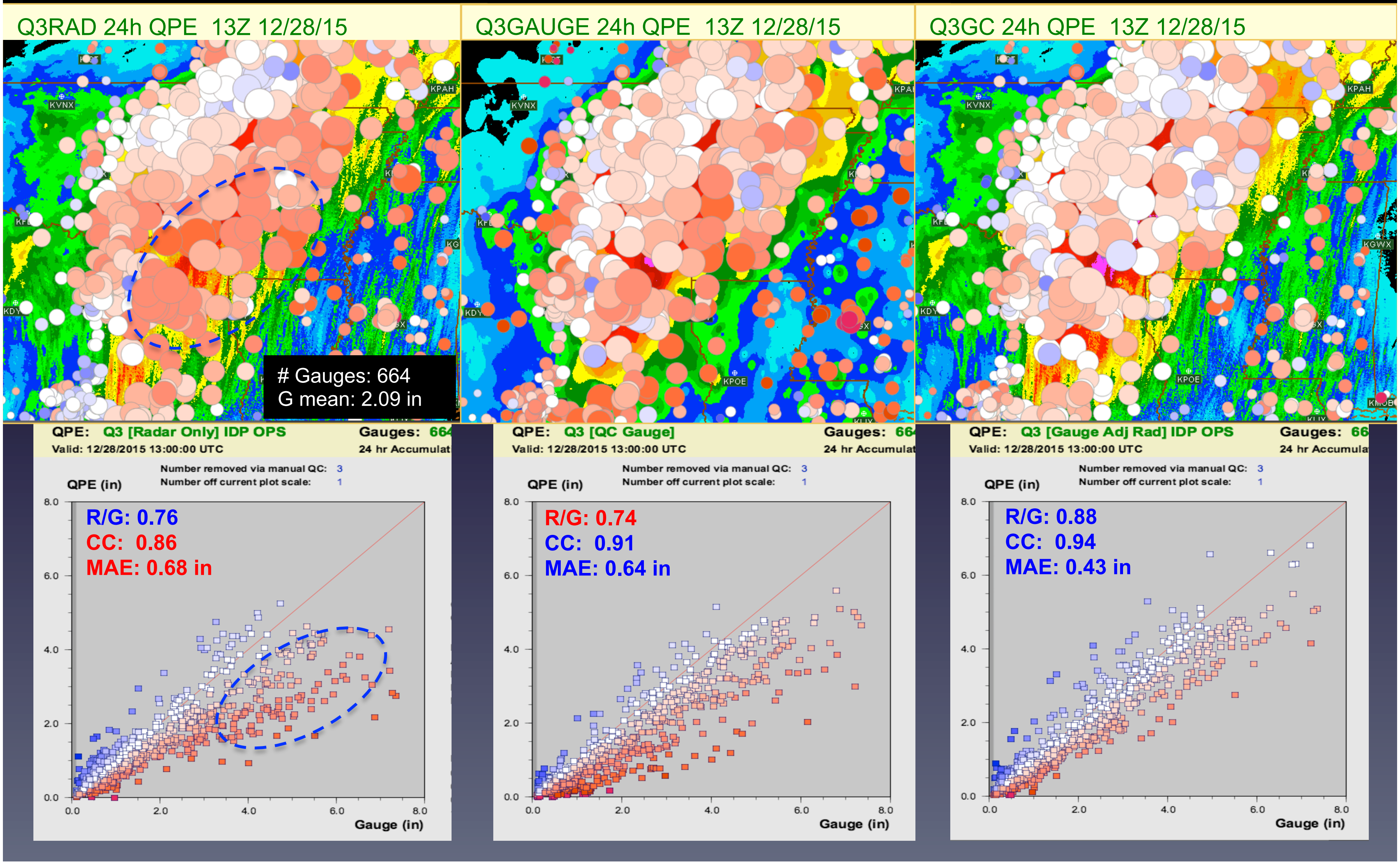




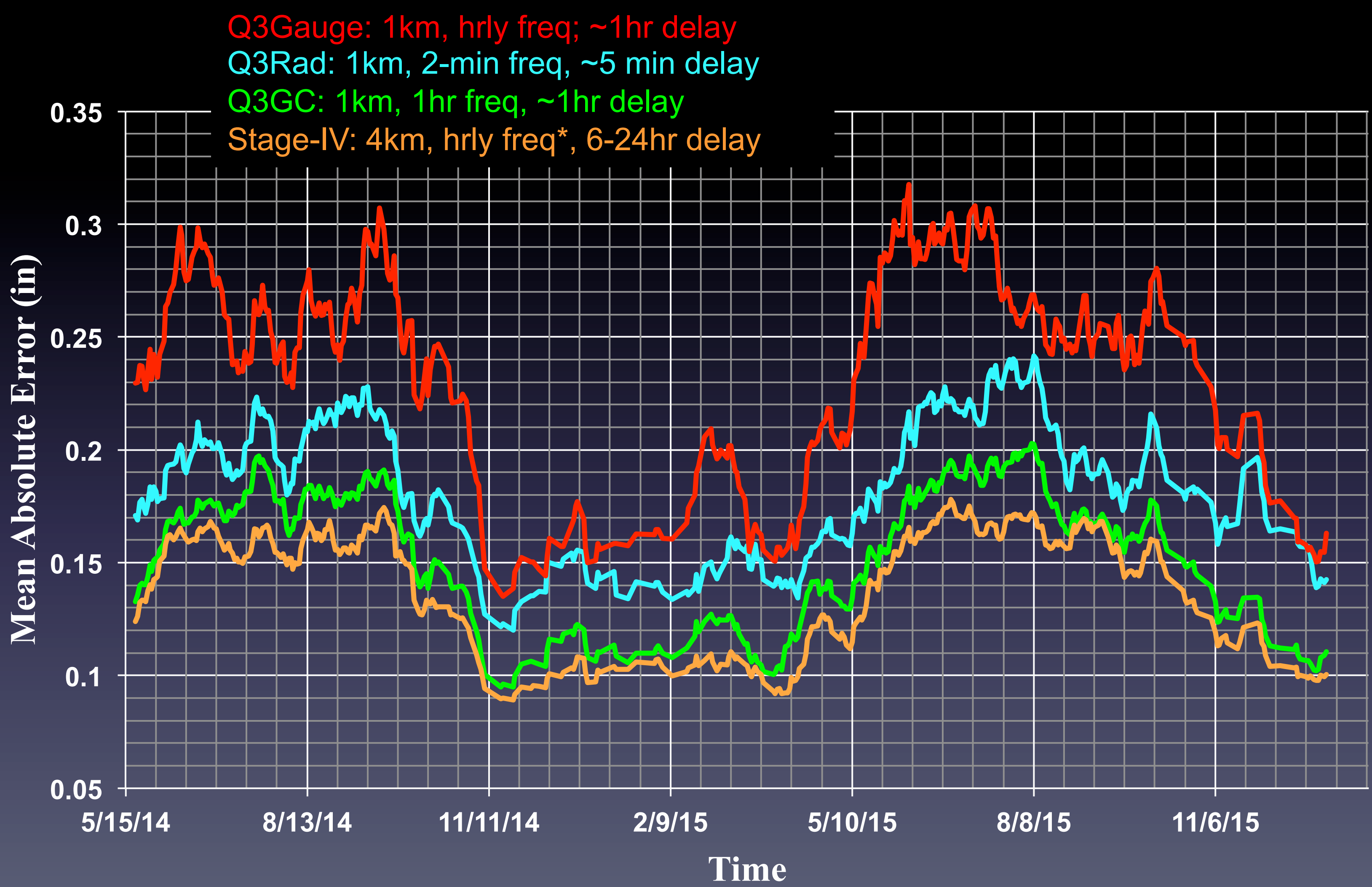
Performance: AZ 8/12/15



Performance: S. Plains 12/28/15



Performance: CONUS, 2014 – 15

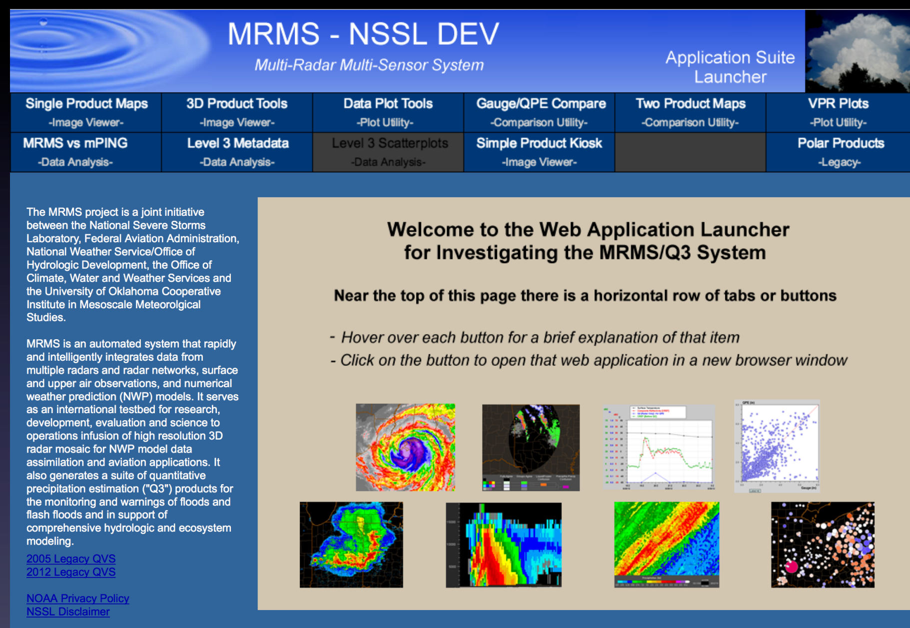


Comparison with 12Z CoCoRaHS gauges across the CONUS

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!



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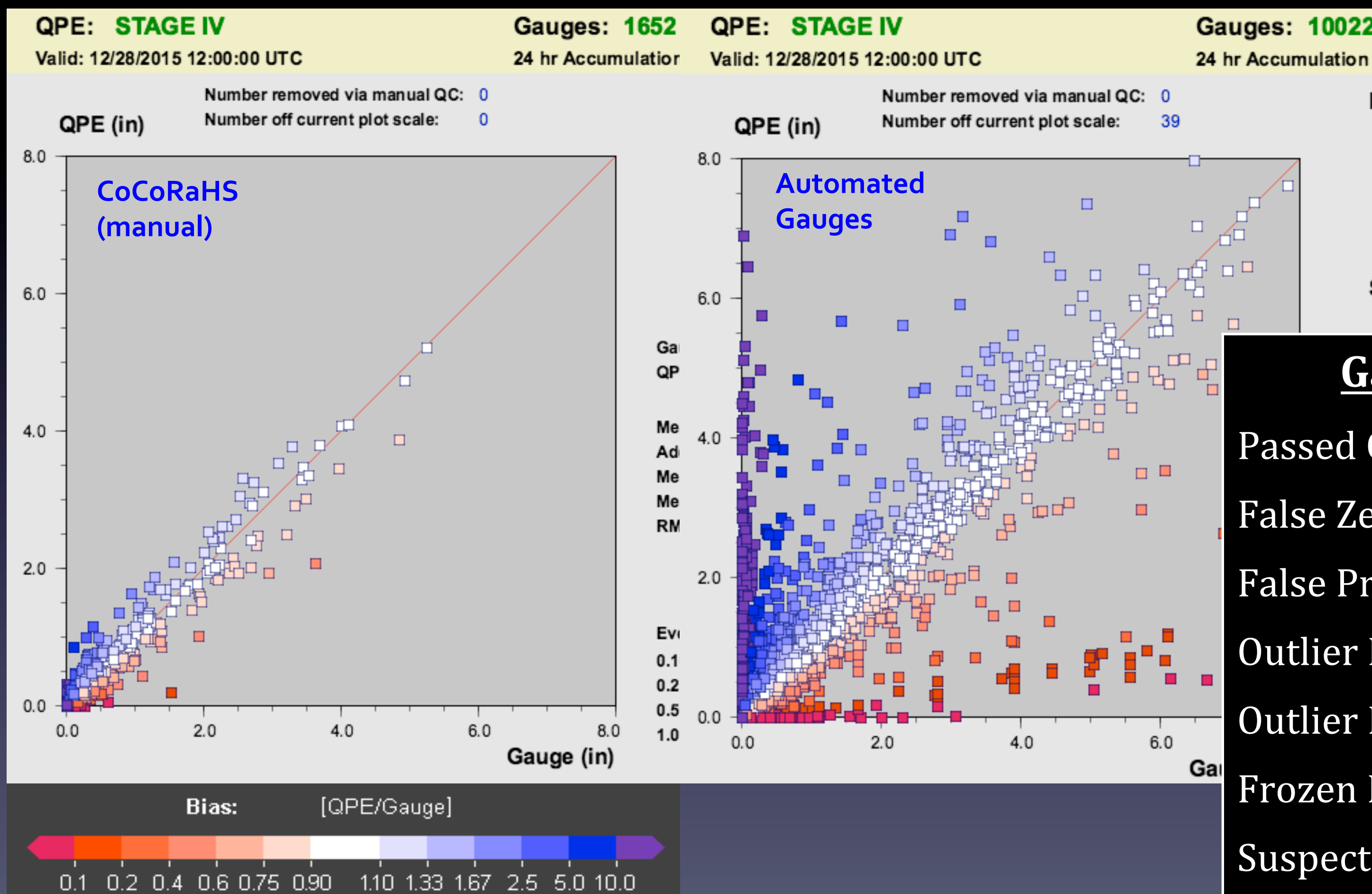
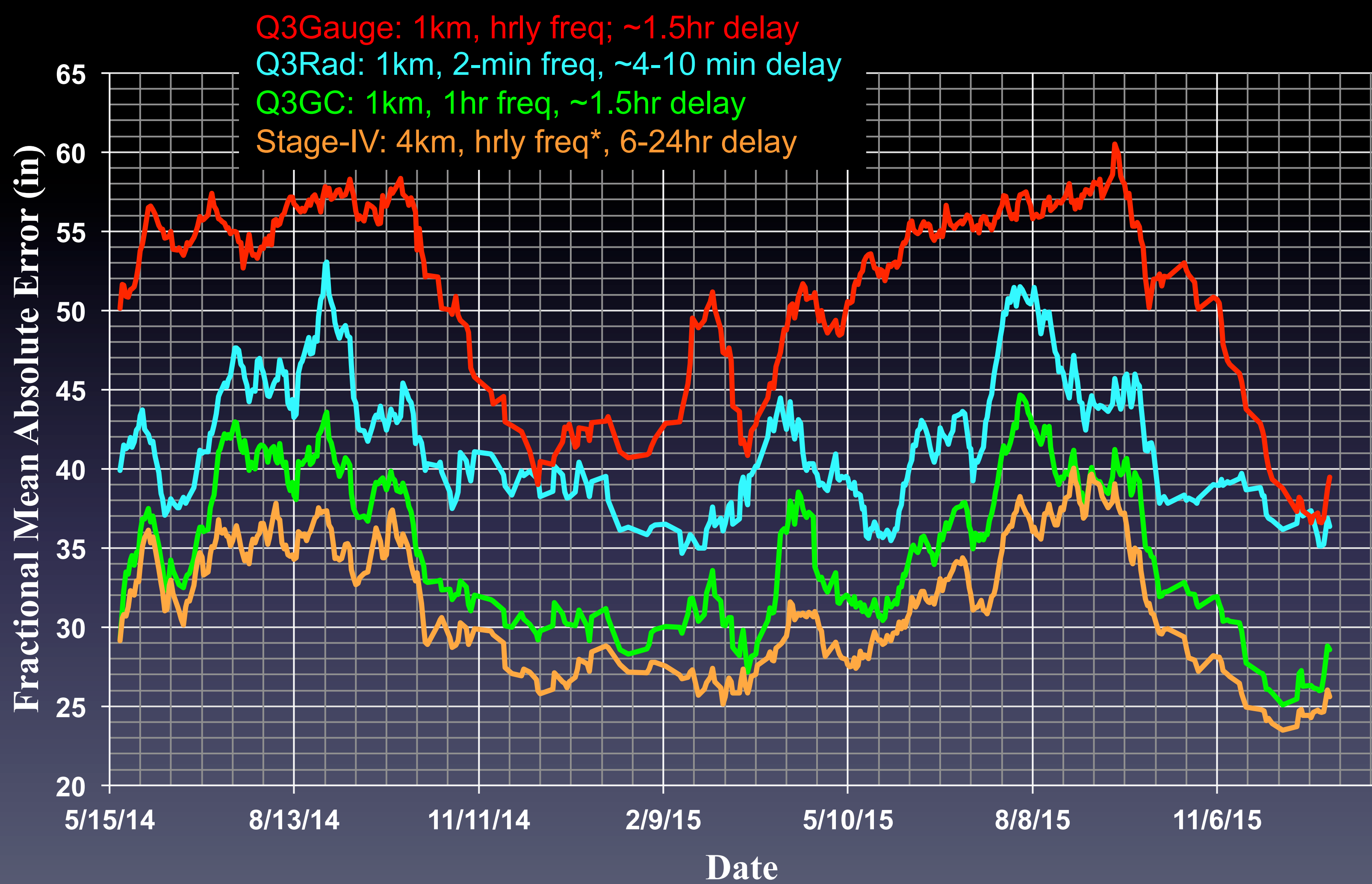
Gauge QC



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