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)

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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: \textit{inverse distance weight (IDW)}

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

- \(r\): distance.
- \(b\): exponent; values between 1 \(\sim\) 2.5.
- \(R_0\): radius of influence; values between 50 \(\sim\) 250km

• \(b\) and \(R_0\) are “\textit{optimized}” hourly through a cross-validation that minimizes the interpolation error of R-G differences:

\[
J = \sum_{n=1}^{N} \left( \varepsilon_n - \bar{\varepsilon}_n \right)^2 \\
\varepsilon_n = R_n - G_n
\]

\[
\bar{\varepsilon}_n = \frac{\sum_{k=1,N}^{w_{k\neq n}} w_k \varepsilon_k}{\sum_{k=1,N}^{k\neq n} w_k}
\]

- \(N\): 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

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
- R/G: 1.22
- CC: 0.82
- MAE: 0.45 in
- # Gauges: 515
- Gmean: 1.02 in

Q3GAUGE 24h QPE 12Z 6/4/14
- R/G: 0.53
- CC: 0.76
- MAE: 0.50 in

Q3GC 24h QPE 12Z 6/4/14
- R/G: 0.97
- CC: 0.90
- MAE: 0.24 in
Performance: AZ 8/12/15

Q3RAD 24h QPE 13Z 8/12/15
- R/G: 1.92
- CC: 0.76
- MAE: 0.41 in
- # Gauges: 192
- G mean: 0.4 in

Q3GAUGE 24h QPE 13Z 8/12/15
- R/G: 0.44
- CC: 0.35
- MAE: 0.26 in

Q3GC 24h QPE 13Z 8/12/15
- R/G: 1.12
- CC: 0.77
- MAE: 0.19 in
Performance: S. Plains 12/28/15

Q3RAD 24h QPE 13Z 12/28/15
R/G: 0.76  
CC: 0.86  
MAE: 0.68 in

Q3GAUGE 24h QPE 13Z 12/28/15
R/G: 0.74  
CC: 0.91  
MAE: 0.64 in

Q3GC 24h QPE 13Z 12/28/15
R/G: 0.88  
CC: 0.94  
MAE: 0.43 in
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!

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

- 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

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 EOSDIS Facility in collaboration with the National Institute of Meteorological Studies.

MRMS is an automated system that spatially and temporally integrates data from multiple radar and sensor networks, surface and upper air observations, and numerical weather prediction (NWP) models. It serves as an international testbed for research, development, evaluation, and scientific community outreach. The MRMS uses advanced visualizations and tools to provide easy access to the broad data and products from NWP models, radar data, and other observational data. It also produces a suite of quantitative precipitation estimates (QPE) products for the monitoring and warning of floods and flash floods and in support of comprehensive hydrologic and ecosystem modeling.

2005 Lessons Q1S
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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
Comparison with 12Z CoCoRaHS gauges across the CONUS
CONUS CoCoRAHS Gauge Statistics

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