2018 Analysis of Gridded Precipitation Estimation Techniques at the Lower Mississippi River Forecast Center

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1.0 Introduction

Creation of gridded rainfall estimates is an important component in the river forecast process at the National Weather Service (NWS) River Forecast Centers (RFCs) as they are one of the main inputs to the hydrologic models. A dedicated unit of hydrometeorological analysis and support (HAS) forecasters are tasked with the maintenance and training needs of this function of each office.

For most NWS RFCs, gridded rainfall estimates are produced each hour starting with a mosaic of raw NEXRAD-radar-derived rainfall estimates which are then bias-corrected using rain gauge reports. Forecasters may then manually edit the resulting gridded rainfall estimates incorporating daily rainfall totals, non-traditional rainfall reports, and forecaster experience in an attempt to provide the best possible estimate to hydrologic forecasters. Numerous radar-derived rainfall estimates are now available for this bias correction process, including the Multi-Radar Multi-Sensor (MRMS) system's Q3 and dual pol additions to individual NEXRAD sites.

Prior to fall 2013, the base radar field used for precipitation estimation at the LMRFC was a mosaicking of individual NEXRAD site rainfall estimates known as "Stage II." An evaluation of Q3 rainfall estimates provided by Chen et al. (2013) indicated that MRMS Q3 (then referred to as "Q2") was much closer to the final, quality controlled QPE product (referred to as "best estimate") than Stage II. Based upon this study, LMRFC switched the base radar field to Q3 in fall 2013. In 2016, LMRFC began using the Precip Scatterplot Utility program created by Ian Blaylock of Southeast River Forecast Center (SERFC)[1] as a tool to identify where daily rain gauges (independent gauges not used in the hourly rainfall analysis) differed from the daily gridded rainfall estimate (Figure 1). The program also provides simple error statistics for numerous daily gridded rainfall estimates (both raw radar and bias-corrected) including correlation coefficient (R), coefficient of determination (R^2), ratio, and bias. Over a 15 month period from January 2017 through March 2018, R^2 values were exported multiple times each day for the area covered by the LMRFC to help evaluate the continued usefulness of Q3 radar-only rainfall estimates as a base field.

[1] The Precip Scatterplot Utility developed at SERFC was based heavily on a similar gauge scatterplot program developed by Bob Corby at WGRFC

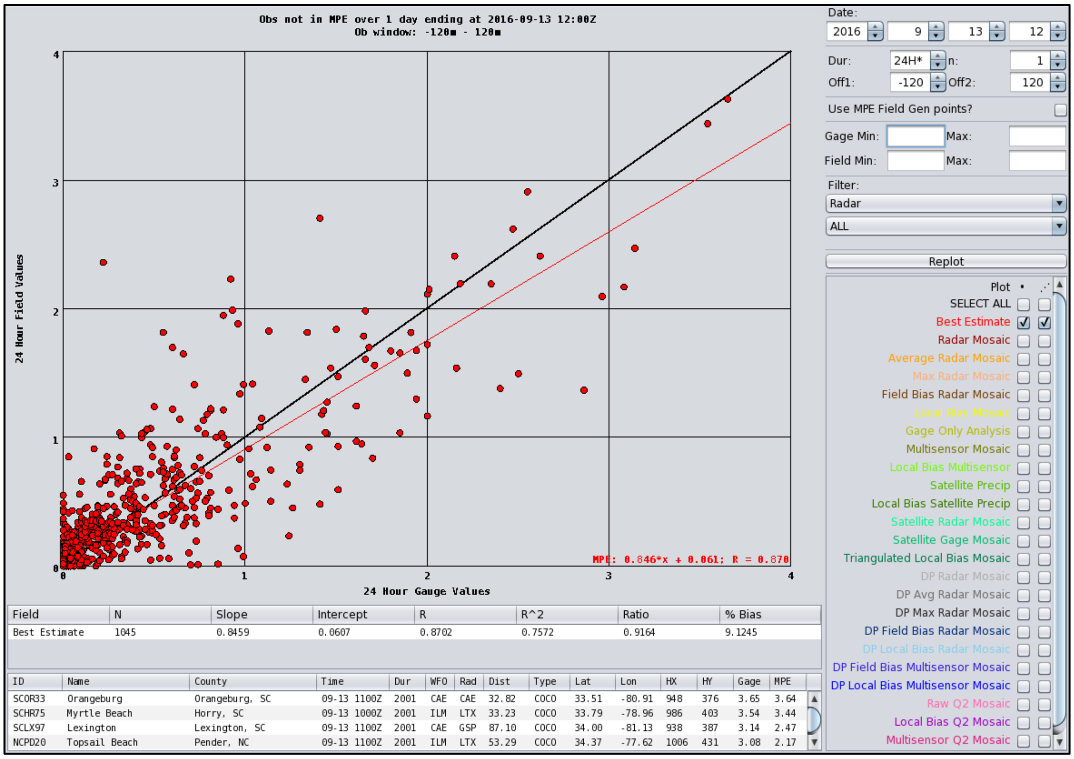

Figure 1. Illustration of the Precip Scatterplot Utility used by some NWS RFCs to evaluate gridded rainfall estimates against independent daily rain gauge observations.

1.1 Methodology

In the Precip Scatterplot Utility, daily rainfall reports (which would not have been available for the hourly gridded analysis) are considered an independent, “correct” answer against which hourly gridded rainfall estimates can be validated. The coefficient of determination (R^2) was exported for numerous estimates:

- radar-only legacy algorithm
- radar-only dual polarization algorithm
- radar field bias-corrected dual polarization algorithm
- local bias-corrected legacy algorithm
- raw radar-only Q3
- local bias-corrected Q3
- multi-sensor bias corrected Q3

R^2 values were exported each day after the 1200, 1300, 1400, 1500, 1600, 1700, and 1800 UTC hours starting in January of 2017. These values were then averaged by quarter (January-March, April-June, etc).

1.2 Results

1.2.1 Error Statistics by Rainfall Estimation Technique

First, statistics for each rainfall estimation technique were compared (Figure 2). Although statistics varied between quarters (time of year), relative R^2 values between rainfall estimation techniques generally followed similar trends. The highest-scoring product was often a tie between Local Bias Q2 and Multisensor Q2. The lowest scoring product was often Multisensor Mosaic or Local Bias Multisensor Mosaic. It should be noted, however, that the difference between the highest scoring rainfall estimation technique and the lowest scoring (averaged over 5 quarters) was rather small – 0.72 to 0.67.

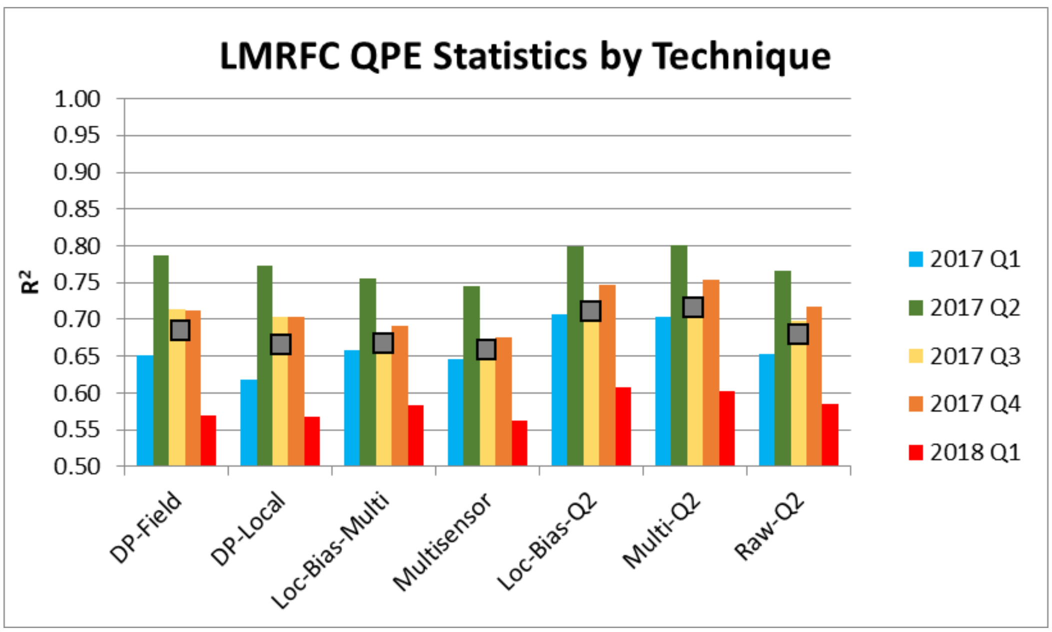

Figure 2. Coefficient of determination values for several different gridded rainfall estimation techniques averaged by quarter. Average of all five (5) quarters (Jan 2017 to Mar 2018) indicated by gray box.

Next, statistics were compiled specifically for radar-only legacy algorithm, raw radar-only Q3, local bias-corrected Q3, and best estimate (Figure 3). Comparison of these products helps to illustrate the progression of radar rainfall estimates as they work their way through the steps of the quality control process at LMRFC. The radar-only legacy algorithm is based upon a single radar-rainfall relationship applied to the entire radar coverage area, then resulting estimates are mosaicked together to cover the RFC domain. MRMS's raw radar-only Q3 mosaics radar reflectivity data first into a smooth field, then, based upon atmospheric conditions, applies a different radar-rainfall relationship to each area. Local bias-corrected Q3 is created after the raw Q3 grid is adjusted to better match observed rainfall amounts from rain gauges. Finally, manual adjustments and corrections are made to the rainfall estimate to produce the best estimate grid. This analysis shows a strong, increasing trend in R^2 values as the rainfall estimate progresses through each stage of the quality control process. The transition from radar-only legacy algorithm to raw radar-only Q3 showed the biggest gain.

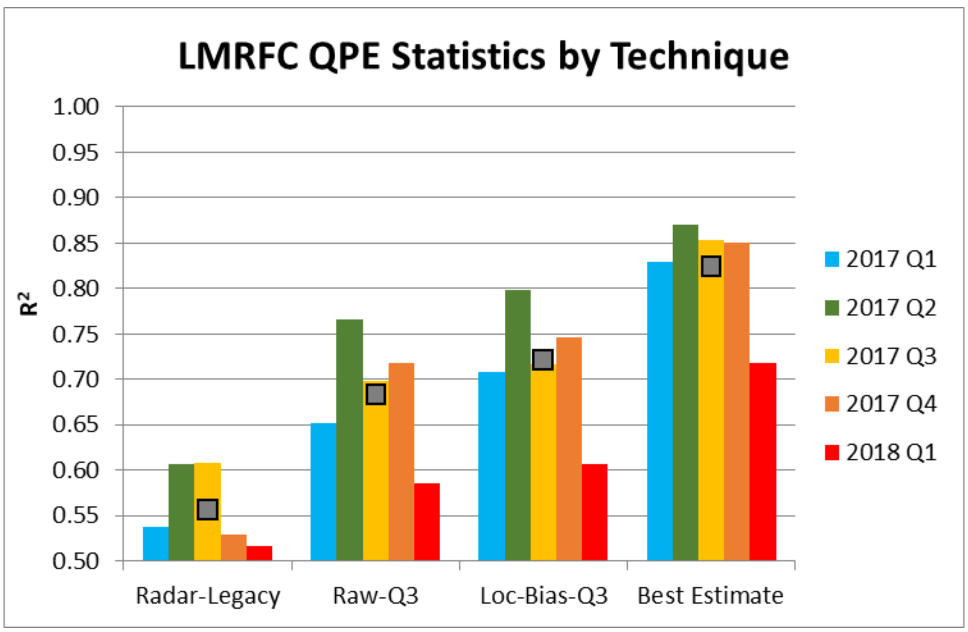

Figure 3. Coefficient of determination values for various steps in the MRMS Q3 rainfall estimation technique averaged by quarter. Average of all five (5) quarters (Jan 2017 to Mar 2018) indicated by gray box. Results for the radar-only legacy algorithm, which uses different mosaicking and Z-R techniques, and the best estimate, were included for comparison.

Finally, statistics were compiled specifically for the non-bias-corrected products (radar-only legacy algorithm, radar-only dual polarization algorithm, raw radar-only Q3) and the best estimate "final answer." Comparison of these products helps to illustrate which raw-radar "starting point" should be used as the base field. A base field that is closer to the "final answer" has the potential to make the rainfall quality control process more efficient and allow forecasters to focus more on higher-impact areas. This analysis shows that the raw radar-only Q3 technique is consistently closer to the best estimate rainfall product than either the radar-only legacy algorithm or the radar-only dual polarization algorithm.

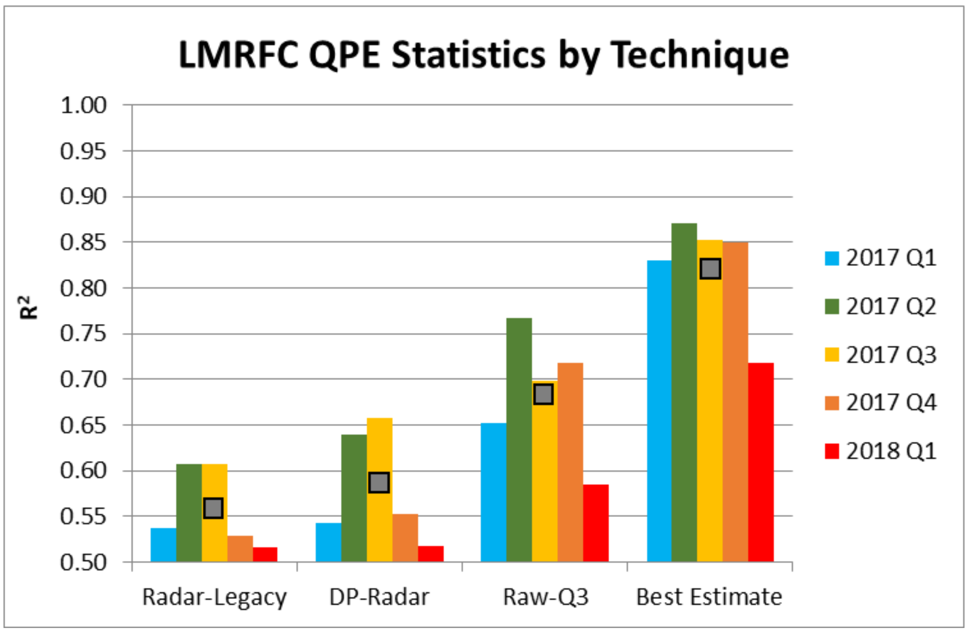

Figure 4. Coefficient of determination values for three (3) different radar-only ("starting point") rainfall estimation techniques compared to the best estimate. Average of all five (5) quarters (Jan 2017 to Mar 2018) indicated by gray box.

1.2.2 Error Statistics by Time of Day

We also compiled statistics specifically for the best estimate rainfall product but at various points throughout the day to illustrate how manual quality control by forecasts improves the final rainfall estimate. This analysis shows an increasing trend in R^2 values over time specifically due to manual adjustments and corrections by human forecasters.

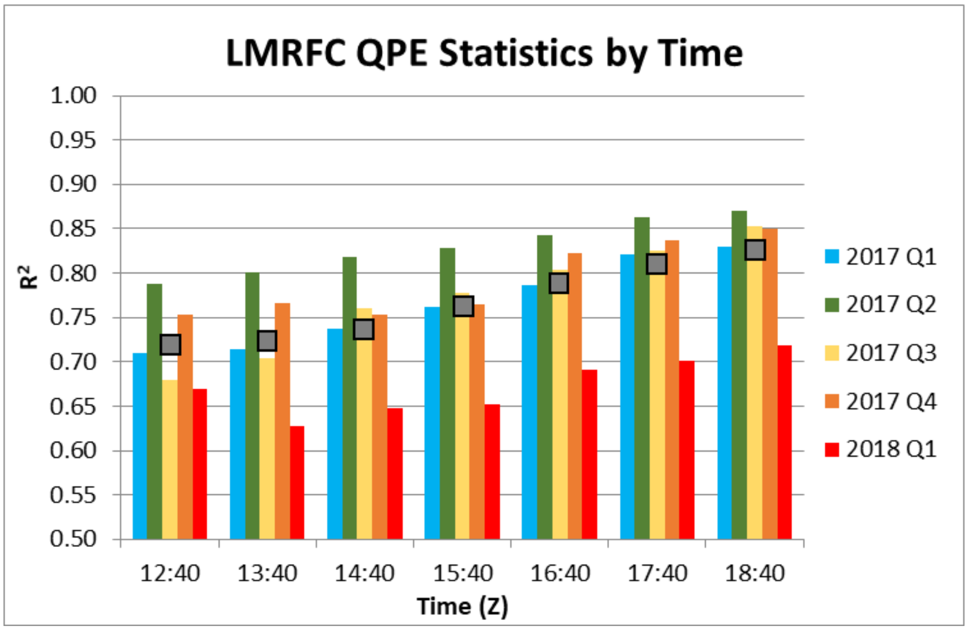

Figure 5. Coefficient of determination values for the best estimate gridded rainfall product at different times of the day, averaged by quarter. Average of all five (5) quarters (Jan 2017 to Mar 2018) indicated by gray box.

2.0 Discussion and Conclusions

Starting in January 2017, forecasters at the LMRFC began collecting statistics for the various rainfall estimation techniques available in the NWS. The coefficient of determination (R^2) between a rainfall estimation technique and independent daily rain gauge totals was averaged over 3-month periods and collected through March 2018. R^2 values of various techniques were compared, and R^2 values for the quality controlled best estimate rainfall product were compared at various times of day.

These statistics suggest that the rainfall estimation product that most closely matched the independent daily rainfall observations was local bias-corrected Q3, with multisensor Q3 a very close second. MRMS's raw-radar Q3 product (with no gauge bias correction) was much closer to the best estimate rainfall product than the other two raw radar rainall techniques examined. It was also shown that manual adjustments and corrections from forecasters at the LMRFC continued to improve the best estimate product throughout the day.

Our findings are similar to that of Chen (2013) in that local bias-corrected Q3 is a better base rainfall estimation source than the radar-only legacy algorithm because it starts the quality control process off much closer to the end result (best estimate). Our findings support the necessity of ground truth rainfall observations which greatly improve rainfall estimation and the necessity of human forecasters as part of the quality control process. Collection of multiple years of additional data could help illustrate improvements to the MRMS Q3 product over time as well as improvements to the best estimate rainfall product produced at the NWS RFCs.

3.0 References

Chen, S., Gourley, J., Hong, Y., Kirstetter, P., Zhang, J., Howard, K., . . . Qi, Y. (2013, January). Evaluation and Uncertainty Estimation of NOAA/NSSL Next-Generation Noational Mosaic Quantitative Precipitation Estimation Product (Q2) over the Continental United States. *J. Hydromet., 14*, 1308-1321. doi:10.1175/JHM-D-12-0150.1