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A QPE ANALYSIS USING PORTABLE AUTOMATED RESEARCH MICROMETEOROLOGICAL STATIONS (PARMS) DEPLOYED AT THE TAR CREEK SUPERFUND SITE

Heather R. Campbell, Daniel R. Cheresnick and Jeffrey B. Basara
Oklahoma Climatological Survey
University of Oklahoma, Norman, OK

I. Introduction

Recently, portable automated research micrometeorological stations (PARMS) were designed and fabricated by staff at the Oklahoma Climatological Survey (OCS) to provide enhanced observations of atmospheric conditions at remote locations. During 2005 and 2006, four PARMS were deployed at the Tar Creek Superfund site near Picher, Oklahoma (Fig. 1) to provide enhanced environmental monitoring. Because the transport of hazardous toxins through the surface water system is such a critical aspect of research and remediation at the Tar Creek Superfund Site, multiple research objectives were identified using the PARMS. These objectives include: (a) quantifying precipitation variability at the Tar Creek watershed for initialization into hydrologic models, (b) comparing radar estimated precipitation and variability with in situ observations, and (c) quantifying the spatial variability of surface observations across the watershed.

During more than one year of nearly continuous observations, over 30 rainfall events were observed by the PARMS. For each of these events, the variability of precipitation across the watershed was quantified. Further, the in situ rainfall observations were compared with quantitative precipitation estimation (QPE) products created by the National Weather Service Arkansas-Red Basin River Forecast Center (NWS ABRFC). This study will present the results of the comparison between PARMS observations and various mosaic radar data products and will provide insight into the unique challenges of QPE at Tar Creek.

Figure 1. The location of the Tar Creek Superfund Site (Center for Children's Environmental Health and Disease Prevention).

2. Background

Tar Creek is located in the northeast corner of Oklahoma near the town of Picher. During the early 1900s to the late 1960s the area was part of the Tri-State Mining District. The extensive mining produced pollutants of zinc, lead, and cadmium that caused highly acidic water which flowed into streams and ponds on the surface and seeped into groundwater. Mine tailings were also piled into large chat mounds over much of the area. Not only have the 30,000 people living in the area felt the affects of the Superfund site, but Grand Lake approximately 15 miles away from Tar Creek has begun to see elevated levels of the primary pollutants of

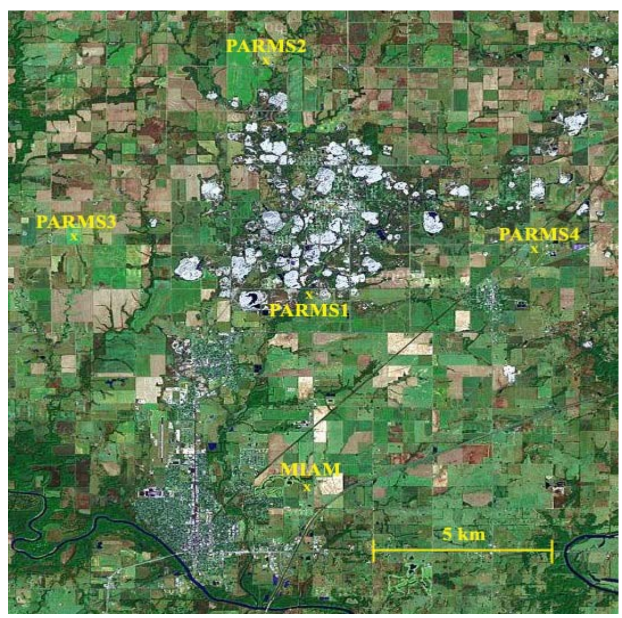

Figure 2. The location of each PARMS and the MIAM Mesonet site.

* *Corresponding author address*: Heather R. Campbell, Oklahoma Climatological Survey, 120 David L. Boren Blvd., Suite 2900, Norman, Oklahoma, 73072. E-mail: Heather.R.Campbell-1@ou.edu

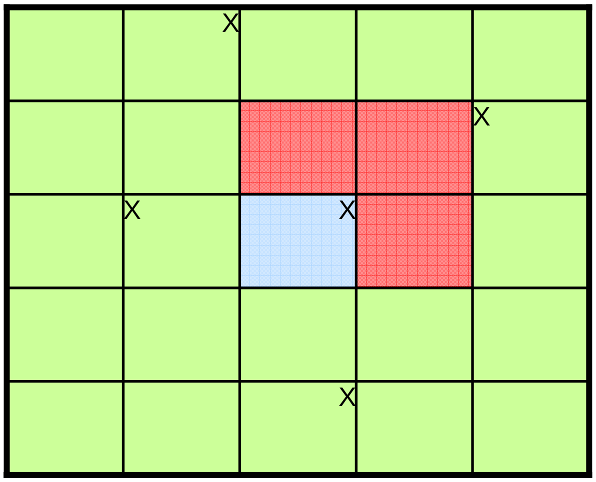

Figure 3. A visual depiction of three rainfall estimations taken from each set of radar data. In this figure, the location of PARMS and MIAM are represented by an 'X', with the single grid and 2x2 grid shown for PARMS1.

Tar Creek

3. Methods

For the Tar Creek study, data was assimilated from three different sources for comparison. The first set used was a raw radar mosaic of rainfall which had no human adjustment. In this analysis, rainfall estimates from all radars for a given location were averaged. Each radar analysis computes the rainfall amounts in a grid of four by four kilometer squares across the ABRFC domain. The raw radar mosaic product, which was made available by the ABRFC for this project starting on 17 June 2006, was created daily at 1200 UTC for the preceding 24 hour period. The second data set was a human adjusted radar mosaic created by the ABRFC and was available during the entire study period beginning 14 August 2005. An analysis was created daily at 1200 UTC for the preceding 24-hour period. Additionally, 6-hour analyses were also created throughout the study period and were issued at 0000, 0600, 1200 and 1800 UTC The third set of data used for comparison was observations from the four PARMS and the Miami Mesonet site (MIAM), which were positioned to form transects across the Tar Creek Watershed (Fig. 2). To make the comparisons easier, this data was overlaid onto the existing ABRFC four by four kilometer grid.

4. Analysis

During every significant rainfall event (>6 mm) in a 24-hour period, three rainfall estimations from the ABRFC products were produced: a) at single grid spaces containing a PARMS or MIAM, b) a 2x2 grid average of those squares closest to the PARMS or MIAM location, and c) a 5x5 grid product over the entire watershed (Fig. 3). After each of the three estimations were completed, the calculations were compared with the observed measurements from the PARMS and MIAM. The data from 10 May 2006 (Table 1) is shown as an example.

The 6-hour analyses were performed beginning on 14 August 2005. The 6-hour adjusted radar mosaic rainfall estimates were compared with the observations by adding multiple analyses (Fig. 4). The differences between the observed PARMS and MIAM values and adjusted radar mosaic were also calculated.

The 24-hour rainfall analysis comprised of the raw radar mosaic, the adjusted radar mosaic, and the PARMS and MIAM measurements (Fig. 5). The differences between the raw mosaic and the observed measurements were calculated along with the differences between the adjusted mosaic and the observed measurements. Because the raw data became available 17 June 2006, there was only one trial case competed at this time, 11 July 2006, however more cases will be added as rainfall events occur in the future.

Date	PARMS1	PARMS1 2x2	PARMS2	PARMS2 2x2	PARMS3	PARMS3 2x2	PARMS4	PARMS4 2x2	MIAM	MIAM 2x2	5x5
5/10 06z	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.05	1.27	0.51
12z	10.67	10.41	6.35	4.06	9.40	6.35	8.89	10.67	14.22	13.46	9.91
18z	10.67	12.45	4.32	4.57	7.87	5.08	21.34	19.05	14.99	17.02	11.18
5/11 00z	0.76	0.76	1.52	1.78	0.76	1.02	0.51	0.76	0.51	0.76	0.76
TOTAL	22.10	23.62	12.19	10.41	18.03	12.45	30.73	30.48	32.77	32.51	22.35
Observed	6.35		8.89		9.65		N/A		14.22		

Table 1. Data from human adjusted radar mosaic rainfall 6 hour estimates (mm) from 10 May 2006 arranged in format used for comparison.

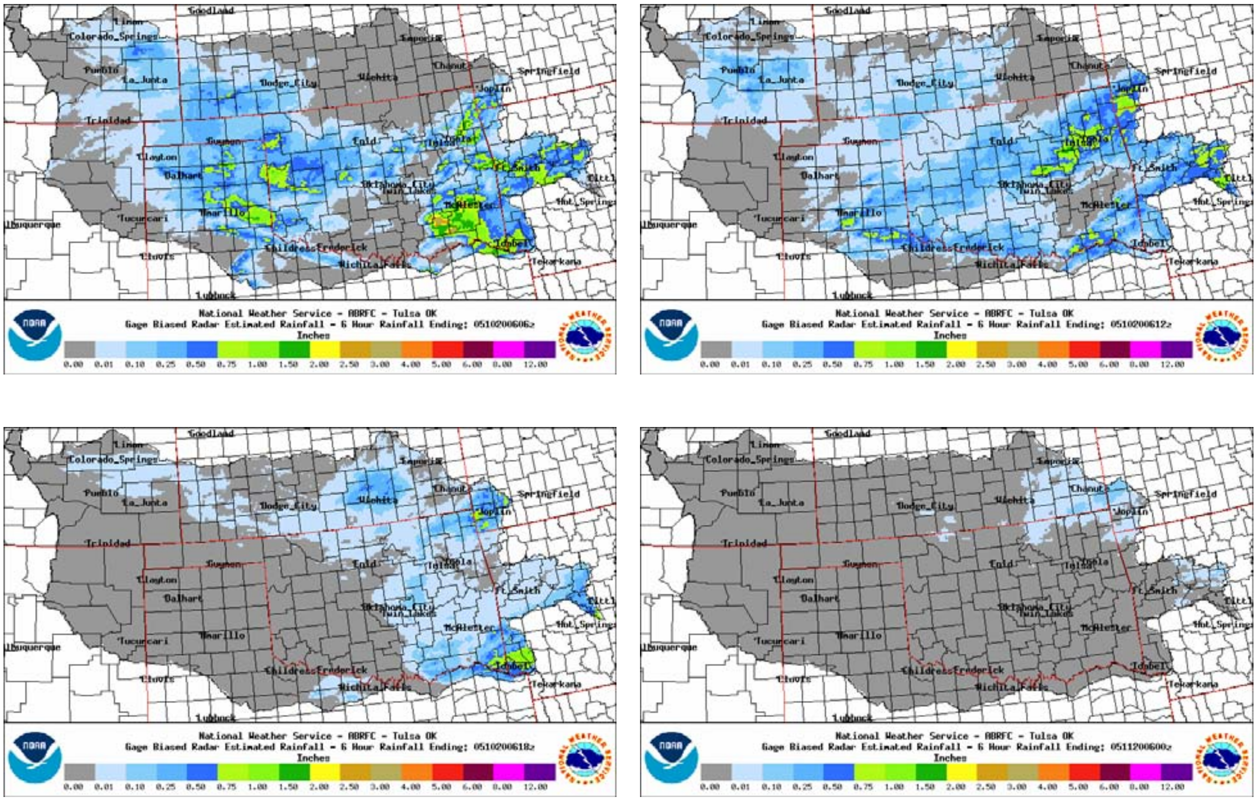

Figure 4. 6-hour products from 10 May 2006 (ABRFC).

4.1 Single Grid Data Set

a. 6-hour Analysis

This analysis found that the averages of the differences in rainfall amounts between observed PARMS and MIAM gauges minus the adjusted radar mosaic values were all within 1 mm of each other (Table 2). Every average was negative, showing the adjusted radar mosaic estimates were consistently greater than the PARMS measurements. The standard deviations were all within 2 mm of each other, but the ranges varied between 39.01 mm and 55.63 mm. The maximum positive difference between observed values and calculated values was 29.46 mm and the maximum negative difference was -36.07 mm. This is significant because the difference in the averages is small and consistent between sites, despite a large range of difference in individual cases.

b. 24-hour analysis

The results in Table 3 show that there is no significant bias between the number of positive differences and negative differences for this case. Neither the adjusted radar mosaic nor the raw radar mosaic were consistently overestimating or underestimating relative to the PARMS and MIAM measurements. The greatest underestimation was from the adjusted mosaic at PARMS 1 with 25.3 mm while the largest overestimation was made by the raw mosaic at 21.9 mm.

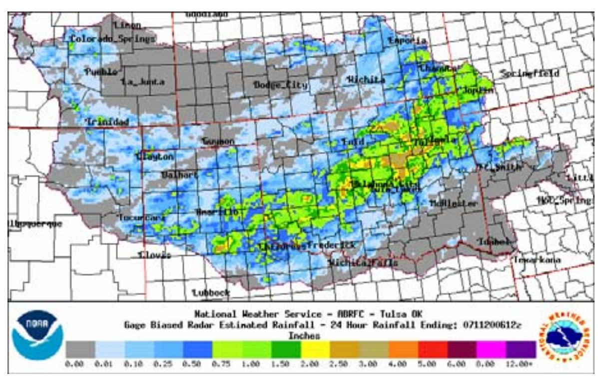

Figure 5. 24-hr human adjusted mosaic radar rainfall estimates for 10 July 2006.

1x1	P1	P2	P3	P4	MIAM
Average	-2.22	-2.18	-2.44	-1.45	-2.13
Standard Deviation	9.32	9.43	9.70	8.27	10.41
Maximum	29.46	17.42	23.11	15.75	18.54
Minimum	-15.80	-33.68	-32.51	-23.27	-36.07
Range	45.26	51.10	55.63	39.01	54.61

Table 2. Data calculated for the single grid (1x1) data set.

single grid point	Raw	Adj.	Observed	Raw Diff.	Adj. Diff.
PARMS1	40.3	33.6	58.9	18.6	25.3
PARMS2	33.8	30.9	19.8	-14.0	-11.1
PARMS3	26.4	34.1	17.5	-8.9	-16.5
PARMS4	71.2	48.6	49.3	-21.9	0.6
MIAM	29.6	17.3	32.5	2.9	15.2
2x2 Grids	Raw	Adj.	Observed	Raw Diff.	Adj. Diff.
PARMS1	54.0	41.8	58.9	5.0	17.1
PARMS2	23.4	21.0	19.8	-3.6	-1.2
PARMS3	27.4	33.5	17.5	-9.9	-16.0
PARMS4	67.1	42.7	49.3	-17.8	6.6
MIAM	37.6	20.1	32.5	-5.0	12.4
5x5 Grid	Raw	Adj.	Observed	Raw Diff.	Adj. Diff.
Watershed	29.6	31.6	35.6	6.0	4.0

Table 3. Analysis of raw radar mosaic and adjusted radar mosaic compared with observed values.

2x2	P1	P2	P3	P4	MIAM
Average	-0.76	-2.09	-1.54	-1.59	-2.21
Standard Deviation	10.58	8.18	8.00	8.92	9.11
Maximum	33.32	15.14	18.54	18.54	18.03
Minimum	-17.27	-24.64	-24.38	-23.01	-34.29
Range	50.60	39.78	42.93	41.55	52.32

Table 4. Data calculated for the 2x2 data set.

4.2 2x2 Grid Data Set

a. 6-hour Analysis

A similar comparison was completed between the observed rainfall totals and the adjusted radar mosaic estimates for the 2x2 grid around the sites (Table 4). The averages are more varied, ranging from -0.76 mm at PARMS1 to -2.21 mm at MIAM. The standard deviation and ranges were similar to with the single grid data.

This again is significant that the overall averages are very similar, however the range of difference is large for individual cases.

b. 24-hour Analysis

The raw mosaic estimations were consistently larger than the PARMS and MIAM measurements. The largest difference between the observed values and the raw mosaic was 17.8 mm. Between the adjusted mosaic and observed measurements, there was no bias of overestimation or underestimation.

4.3 5x5 Grid Data Set

a. 6-hour Analysis

Another set of data used in the comparison was an average of all PARMS and MIAM rainfall observations minus the average value of a 5x5 grid of adjusted radar mosaic rainfall estimates (Table 5). The average difference was equal to -2.19 mm with a lower standard deviation and maximum and a higher minimum than the 2x2 and single grid analyses.

To assess the association between the observed and calculated values, the correlation and R-squared values were calculated. The correlation was 0.92, and R squared value was approximately 0.84 (Fig. 6). In limited tests, these values were higher than the other grids.

5x5	
Average	-2.19
Standard Deviation	5.71
Maximum	6.73
Minimum	-20.24
Range	26.97

Table 5. Data calculated for the 5x5 data set.

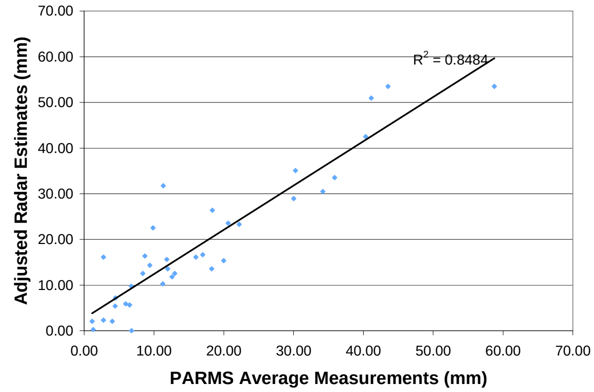

Figure 6. Comparison of radar rainfall estimates and the observed rainfall totals for the 5x5 grid.

b. 24-hour Analysis

From the data presented in Table 3, there was no consistent bias toward the raw mosaic radar data vs. the adjusted mosaic radar data. There is also no bias between the number of positive numbered differences vs. number of negative numbered differences. Across the averaged watershed, in both the raw mosaic radar data and the adjusted mosaic radar data the difference was positive.

5. Summary and Conclusions

Since the summer of 2005, four PARMS have been deployed around the Tar Creek watershed. Using the rainfall measurements from the PARMS and the MIAM mesonet, comparisons were made between these observed measurements and two types of radar data, the raw mosaic and the adjusted mosaic provided by the ABRFC. Three estimations were calculated using a four by four kilometer grid: a) at single grid spaces containing a PARMS or MIAM, b) a 2x2 grid average of those squares closest to the PARMS or MIAM location, and c) a 5x5 grid product over the entire watershed.

Comparisons were completed between the differences in the observed measurements by PARMS and MIAM and the adjusted radar mosaic. Even though no consistent bias existed in any of the statistics, the averages were mostly within 1 to 2 mm of each other.

For the 24-hour analysis, the preliminary results found that there appeared to be no consistent bias in either the adjusted difference or the raw difference. Neither analysis showed a stronger correlation to observed values, with both analysis closer at certain locations.

6. Acknowledgements

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7. References

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