Precipitation Estimation from the ARM Distributed Radar Network During the MC3E Campaign

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Overview

The ARM DOE-NASA Midlatitude Continental Convective Clouds Experiment (MC3E) was the first demonstration of the ARM Climate Research Facility scanning precipitation radar platforms. A goal for the MC3E field campaign at the Southern Great Plains (SGP) facility was to demonstrate the capabilities of ARM polarimetric radar systems for providing unique insights into deep convective storm evolution and microphysics. One practical application of interest for climate studies and the forcing of cloud resolving models is improved Quantitative Precipitation Estimates (QPE) from ARM radar systems positioned at SGP.

This study presents the results of ARM radar-based precipitation estimates during the two-month MC3E campaign. Emphasis is on the usefulness of polarimetric C-band radar observations from the C-band scanning ARM precipitation radar (C-SAPR) for rainfall estimation to distances within 100 km of the Oklahoma SGP facility. Collocated ARM/NASA rain gauge resources, precipitation profiling radars, and nearby surface Oklahoma Mesonet gauge records are consulted to evaluate potential ARM radar-based rainfall products and optimal methods. Rainfall products are also evaluated against the regional NEXRAD-standard observations.

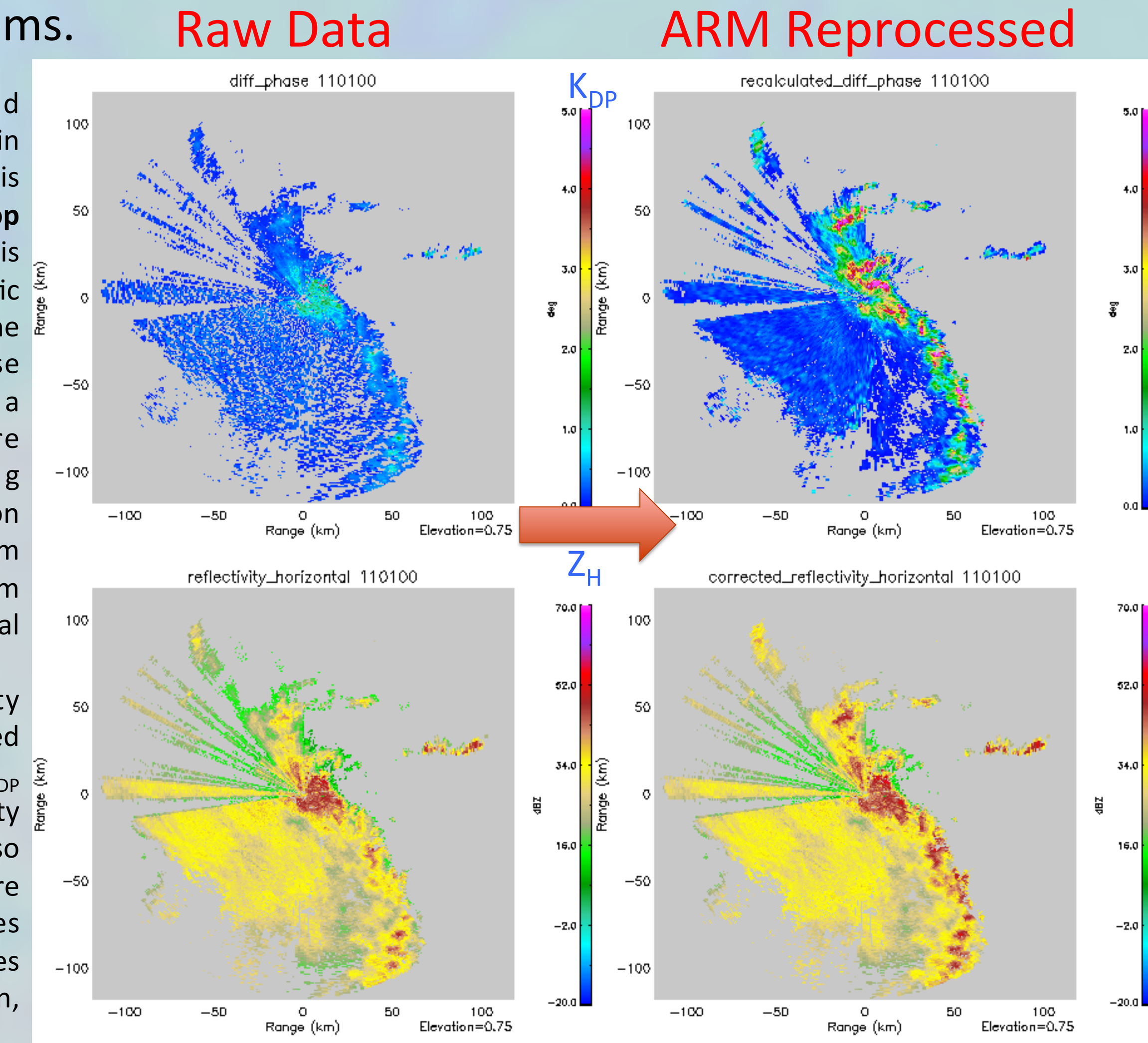
Radar Data Preprocessing and Rainfall Methods for the CSAPR System

Accurate ARM radar products and the ability to quantify product uncertainty is strongly tied to our diligence with data quality and preprocessing. Successful applications of the ARM radars at SGP necessitate newer polarimetric radar methods. C/X-band observations are quickly undermined by calibration offsets and attenuation in deep convection. ARM methods should help reduce uncertainty in estimates rooted in physical process (DSD) variability and complement nearby radar systems.

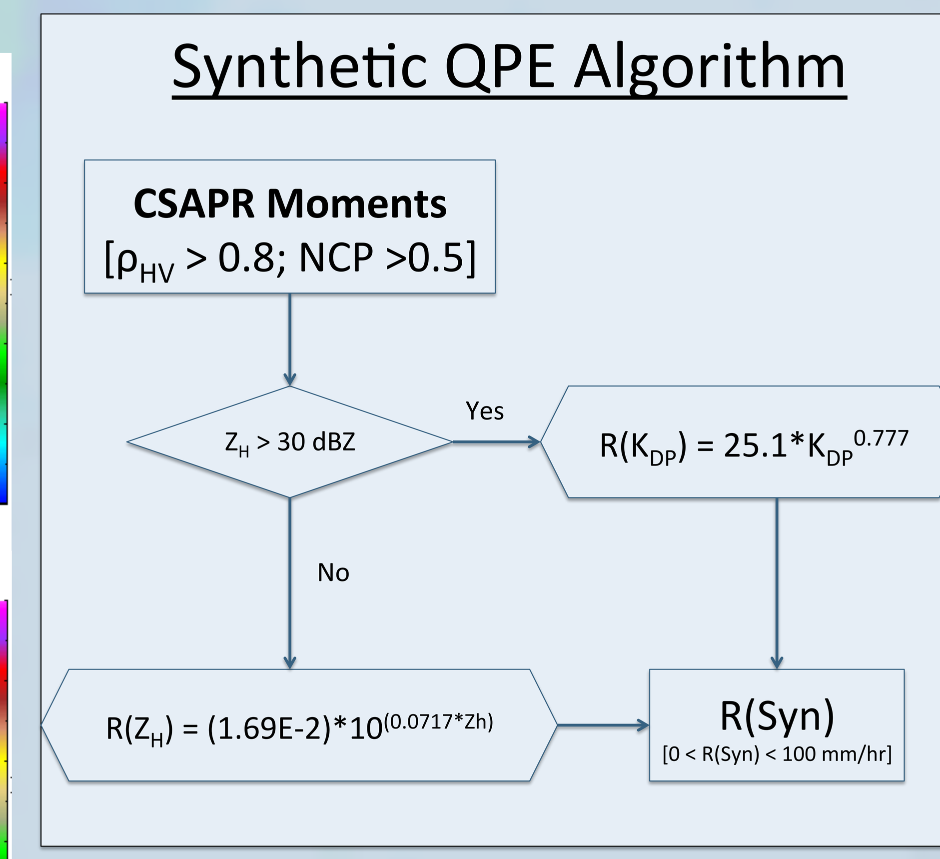
The ARM Value-Added Product, Corrected Moments in Antenna Coordinates (CMAC) is currently in evaluation. **(top right)** A 20 point Sobel filter is used in calculating the specific differential phase (K_{DP}) from the corrected differential phase (ϕ_{DP}). ϕ_{DP} was corrected using a linear algorithm to ensure monotonicity, removing deviations due to phase on backscatter and non-uniform beam filling using the algorithm described in Giangrande et al 2012.

The horizontal reflectivity **(bottom right)** was corrected for liquid attenuation using K_{DP} and the intergral of reflectivity similar to Gu et al 2011. Also included in the CMAC files are corrected Doppler velocities and instantaneous rain rates calculated using attenuation, (neither shown here).

Raw Data | ARM Reprocessed



Synthetic QPE Algorithm



The synthetic rainfall method (**above**) is one of the methods used to determine radar rainfall. The algorithm used is dependent on the threshold of reflectivity, Z_H. Other methods include using the above equations of Z_H and K_{DP} independently, as well as using attenuation. Methods using differential reflectivity, Z_{DR}, were not employed as the CSAPR Z_{DR} has not been calibrated.

Citations

Attenuation Correction
Gu, J.-Y., A. Ryzhkov, P. Zhang, P. Neilley, M. Knight, B. Wolf, and D.-I. Lee, 2011: Polarimetric Attenuation Correction in Heavy Rain at C Band. *J. Appl. Meteor. Climatol.*, **50**, 39-58.

Linear Processing
Giangrande, S., R. McGraw and L. Lei, 2012: "An Application of Linear Programming to Polarimetric Radar Differential Phase Processing", Journal Atmospheric Oceanic Technology, Accept, Oct. 2012.

MC3E
Jensen, M. and coauthors, 2010; "Midlatitude Continental Convective Clouds Experiment (MC3E)", DOE ARM

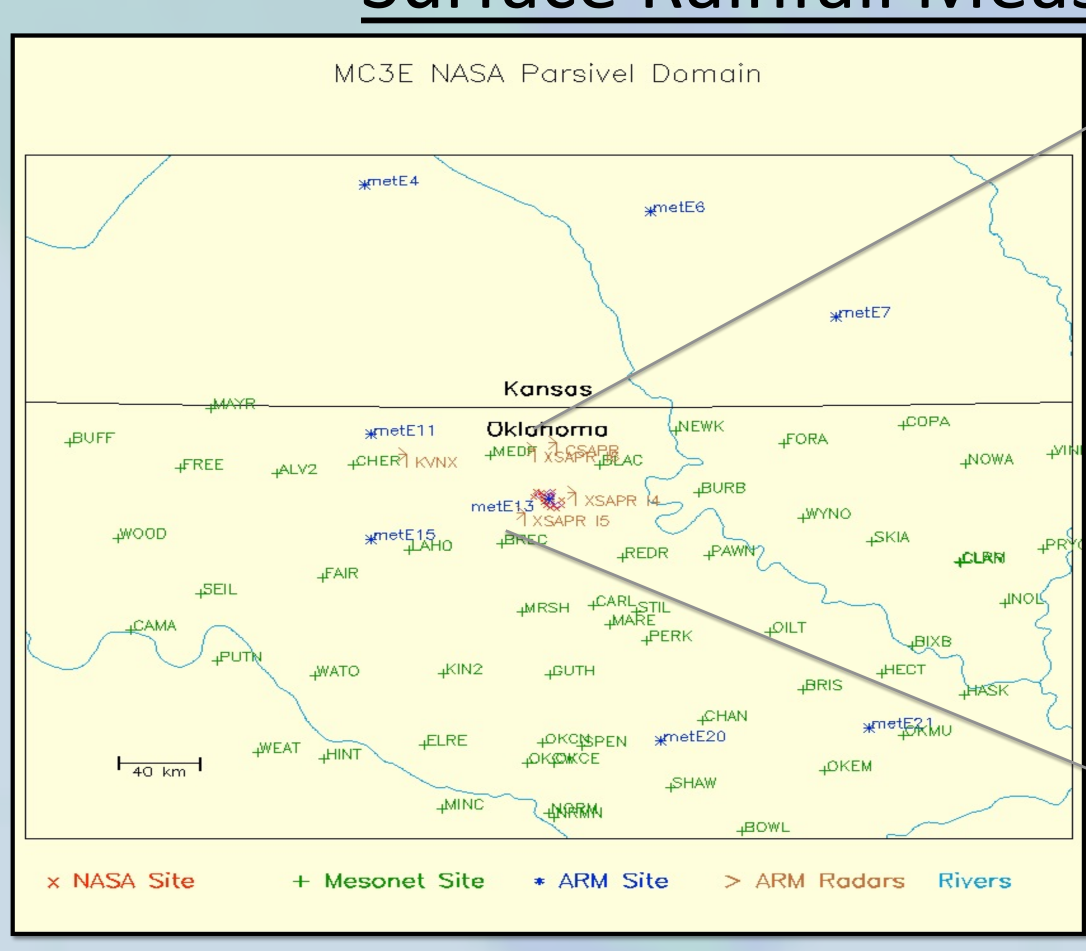
Mesonet
McPherson, R. A., C. Fiebrich, K. C. Crawford, R. L. Elliott, J. R. Kilby, D. L. Grimsley, J. E. Martinez, J. B. Basara, B. G. Illston, D. A. Morris, K. A. Kloesel, S. J. Stadler, A. D. Melvin, A.J. Sutherland, and H. Shrivastava, 2007: Statewide monitoring of the mesoscale environment: A technical update on the Oklahoma Mesonet. *J. Atmos. Oceanic Technol.*, **24**, 301–321.

Brock, F. V., K. C. Crawford, R. L. Elliott, G. W. Cuperus, S. J. Stadler, H. L. Johnson, and M. D. Eilts, 1995: The Oklahoma Mesonet: A technical overview. *J. Atmos. Oceanic Technol.*, **12**, 5-19.

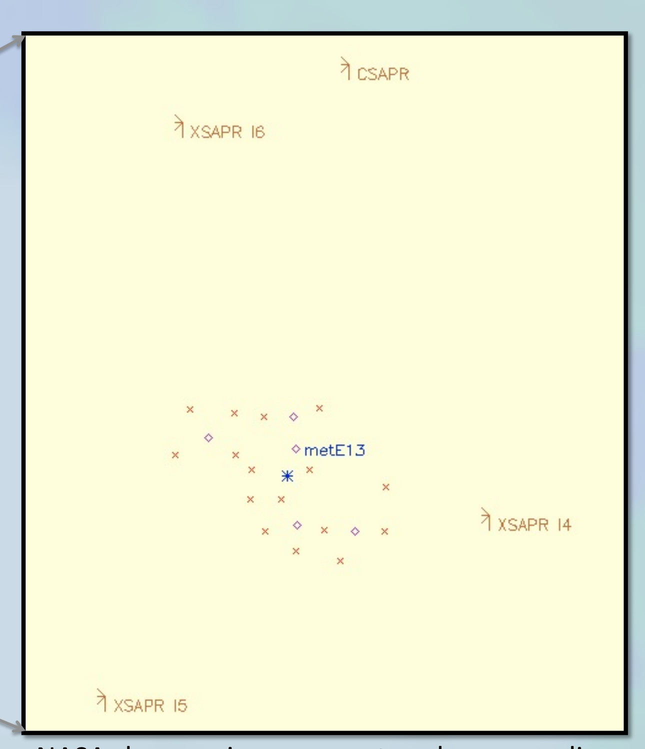
NEXRAD QPE
Giangrande, S. and A. Ryzhkov, 2008: Estimation fo Rainfall Based on the Results of the Polarimetric Echo Classification. *J. Appl. Met. And Clim.*, 47, 2445-2462

PY-ART
Collis, S., K.North, and S. E. Giangrande, 2012: Py-ART: THe Python ARM Radar Toolkit. *92nd AMS Ann. Meeting,* New Orleans, LA, American Meteorological Society.

Surface Rainfall Measurements



Instrumentation within 200 KM of the ARM CSAPR. Instrumentation within 100 KM of the radars were used in this study.



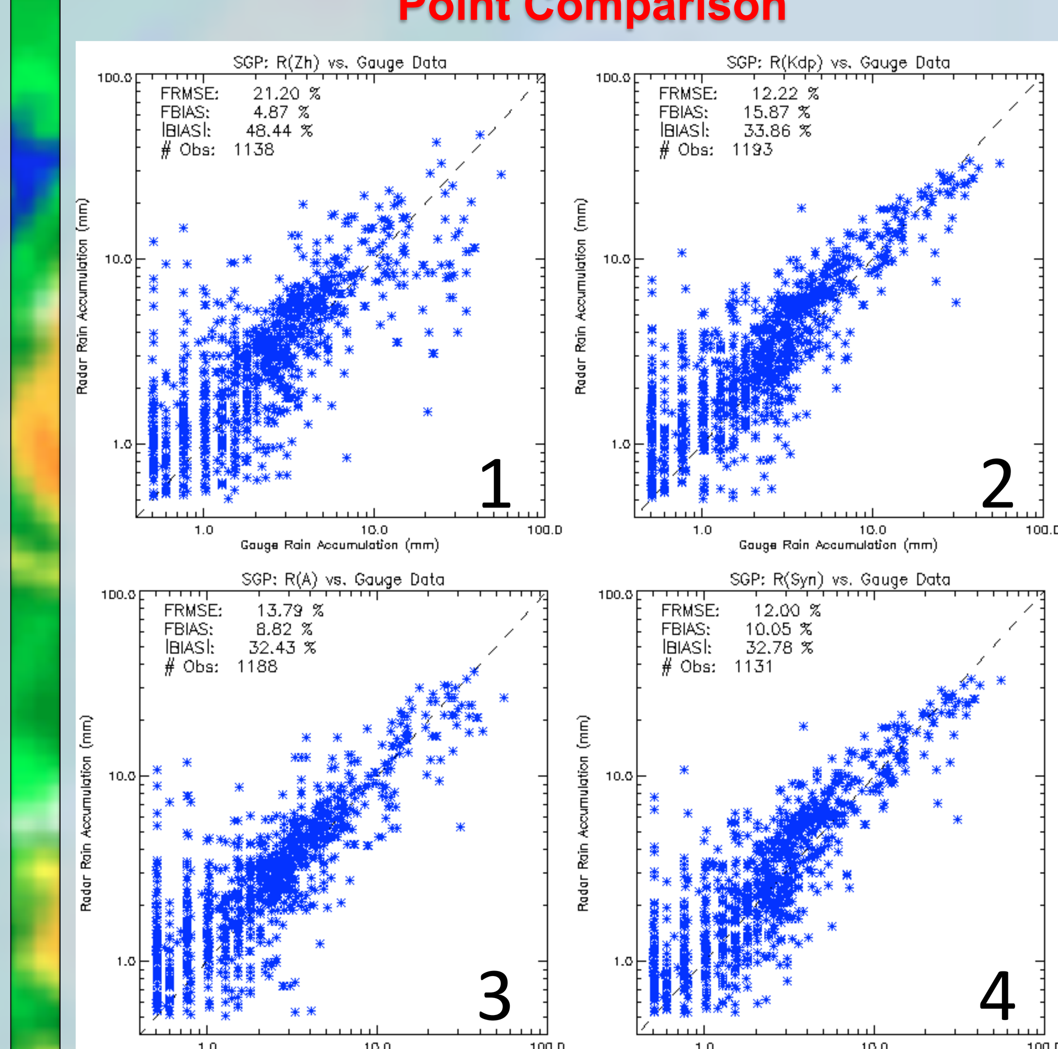
NASA dense rain gauge network surrounding the SGP Central Facility. **x**-Tipping Bucket Rain Gauge, ◆-2D Video Disdrometer. Each NASA tipping bucket location held 2 gauges for a total of 32 gauges.

The ARM scanning radar dataset presents an unprecedented opportunity for the development of rainfall methods. The SGP facility is home to an array of radars, precipitation instrumentation, and radar profilers to maintain radar calibration and along with Oklahoma Mesonet stations constrain rainfall and drop size distribution (DSD) retrievals. For MC3E, a dense network of rain gauges were deployed by NASA.

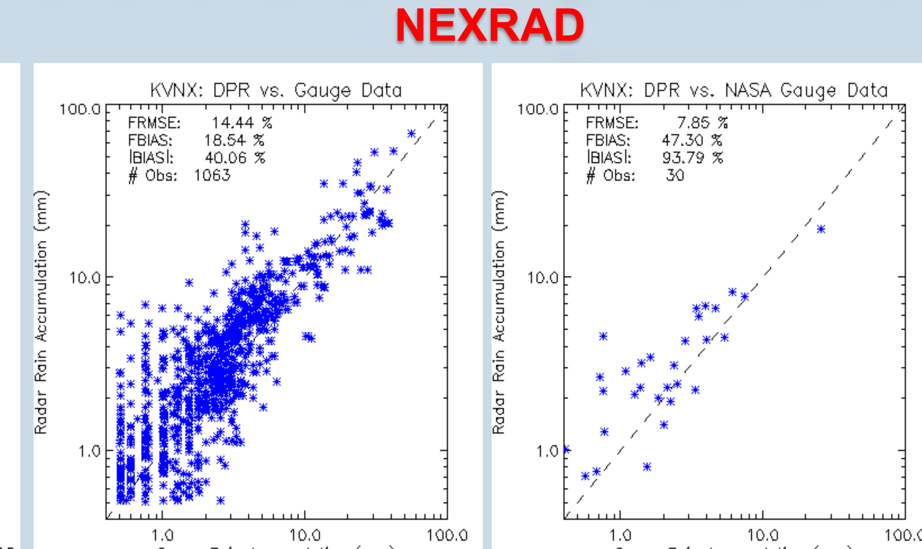
Rainfall Performance During the MC3E Campaign

During the MC3E campaign, the CSAPR system was in operation for approximately 50 hours during which standard hourly rainfall accumulation comparisons could be performed between CMAC evaluation products and nearby surface ARM platforms, the Oklahoma Mesonet and NASA MC3E tipping bucket rain gauges. Results from the local NEXRAD dual-Polarization QPE method are also presented.

Point Comparison



NEXRAD



Hourly Radar rain accumulations vs. gauges within 100 km of the respective radars are shown for KVNX (**above left**) and ARM CSAPR (**left**) for all cases when the CSAPR was operational during MC3E.

Areal rain accumulation averages over the NASA dense Tipping Bucket Rain Gauge network are shown for KVNX (**above right**) and the ARM CSAPR (**right**) for all cases when the CSAPR was operational during MC3E

Algorithms used for the ARM CSAPR are **1.)** Reflectivity, **2.)** Specific Differential Phase, **3.)** Attenuation, and **4.)** Synthetic

Note, the rain rates for both the radar and rain gauges were threshold at 0.5 mm in order to remove possible noise.

Areal Comparison