

Anonymous Referee #3 Received and published: 18 January 2018

Manuscript Review Comments to amt-2017-439 Title: X-BAND DUAL-POLARIZED RADAR QUANTITATIVE PRECIPITATION ESTIMATE ANALYSES IN THE MIDWESTERN UNITED STATES General Comments: This manuscript evaluates a large number of dual-polarization radar rainfall relations for an X-band radar deployed in central Missouri, USA. Rain gauge data collected during August 2015 to August 2017 are used for quantitative evaluation purposes. Overall, this topic well fits the scope of AMT. However, the manuscript is not well presented. Many fundamental issues in X-band QPE are missing. Following are some of my major concerns and minor comments. In addition, there are small typos here and there but since I am recommending a rather substantial revision, those issues can be left for a later time. The authors are encouraged to re-submit this manuscript after addressing the following issues.

Major Concerns: 1. Technically, I do not see anything novel in this work. Most of the sciences and principles have already been published in previous studies. Some of the analysis procedures are very similar to what has been used before. However, this manuscript reads like there are not many X-band studies in the literature, which is awkward. The introduction is very roughly written, without referring to proper previous studies. The uniqueness of this manuscript might be its study domain. Unfortunately, the authors fails to elaborate this point.

We thank the reviewer for this comment, and we have added proper, more recent literature.

References: Anagnostou, M. N., E. N. Anagnostou, and J. Vivekanandan, 2007: Comparison of raindrop size distribution estimates from X-band and S-band polarimetric observations. *IEEE Geosci. Remote Sens. Lett.*, 4, 601-605.

Chandrasekar, V., Y. Wang, and H. Chen, 2012: The CASA quantitative precipitation estimation system: a five year validation study, *Natural Hazards and Earth System Sciences*, 12, 2811-2820.

Chandrasekar, V., H. Chen, and B. Philips, 2018: Principles of high-resolution radar network for hazard mitigation and disaster management in an urban environment. *J. Meteor. Soc. Japan*, 96A, <https://doi.org/10.2151/jmsj.2018-015>.

Chen, H., Lim, S., Chandrasekar, V., and Jang, B.-J., 2017: Urban Hydrological Applications of Dual-Polarization X-Band Radar: Case Study in Korea, *Journal of Hydrologic Engineering*, 22, E5016001, 10.1061/(asce)he.1943-5584.0001421.

Cifelli, R., V. Chandrasekar, H. Chen, and L. E. Johnson, 2018: High resolution radar quantitative precipitation estimation in the San Francisco Bay Area: Rainfall monitoring for the urban environment. *J. Meteor. Soc. Japan*, 96A, <https://doi.org/10.2151/jmsj.2018-016>.

Kalogiros, J., M. N. Anagnostou, E. N. Anagnostou, M. Montopoli, E. Picciotti, and F. S. Marzano, 2014: Evaluation of a new Polarimetric Algorithm for Rain-Path Attenuation Correction of X-Band Radar Observations Against Disdrometer Data. *IEEE Geoscience and Remote Sensing Letters*, 52, 1369-1380.

Marzano, F. S., G. Botta, and M. Montopoli, 2010: Iterative Bayesian retrieval of hydrometeor content from X-band polarimetric weather radar. *IEEE Trans. Geosci. Remote Sens.*, 48, 3059-3074.

Matrosov, S. Y., D. E. Kingsmill, B. E. Martner, and F. M. Ralph, 2005: The utility of X-band polarimetric radar for quantitative estimates of rainfall parameters. *J. Hydrometeor.*, 6, 248-262.

Shakti, P. C., M. Maki, S. Shimizu, T. Maesaka, D.-S. Kim, D.-I. Lee, and H. Iida, 2013: Correction of Reflectivity in the Presence of Partial Beam Blockage over a Mountainous Region Using X-Band Dual Polarization Radar. *J. Hydrometeor.*, 14, 744-764.

Shi, Z., H. Chen, V. Chandrasekar, and J. He, 2018: Deployment and Performance of an X-Band Dual-Polarization Radar during the Southern China Monsoon Rainfall Experiment. *Atmosphere*, 9(1), 4, doi:10.3390/atmos9010004.

2. Details about X-band radar data quality control are NOT enough. In addition, Kdp estimation and attenuation correction are completely neglected. These are all key aspects for X-band QPE. After reading this manuscript, the readers are even sure if the X-band radar data quality is enough for quantitative applications.

We appreciate this comment. We address the fact the radar is uncalibrated, and little-to-no quality control methods have been conducted. Still, we present rather promising results, which could only be further improved by adding these methods in our future QPE methods (which will be presented with larger gauge networks).

3. The authors included a huge number of rainfall relations in the evaluation without explaining why. Many of the relations are wrong (if applied at X-band). Why do you need so many R-Kdp relations? Why are you even implementing S-band R-Kdp relations? Which relation was derived using local raindrop size distribution data?

Thank you for this comment. We tested many different algorithm to test if they were robust to be transferred to ther X-band radars where disdrometic data is unavailable (such as for the current study). We implemented S-band algorithms such that the Z-containing algorithms proved do rather well in QPE, while the S-band KDP algorithms, indeed, showed very high QPE's. This study is just validating the large rainrates if S-band R(KDP) equations are used as opposed to X-band.

4. Page1,Line23: However, the literature as to their long-term performance is lacking. This is not true. Please rephrase the writing. Also refer to the references listed in Major Concern #1.

We appreciate this comment and have made the necessary changes.

5. Page 4, Lines 39-40: Most of the references are not current. A few widely used dual-pol rainfall algorithms are suggested here. References:

We thank the reviewer for this comment and have added the references accordingly.

Chen, H., V. Chandrasekar, and R. Bechini, 2017: An Improved Dual-Polarization Radar Rainfall Algorithm (DROPS2.0): Application in NASA IFloodS Field Campaign. *J. Hydrometeor.*, 18, 917-937.

Cifelli, R., V. Chandrasekar, S. Lim, P. C. Kennedy, Y. Wang, and S. A. Rutledge, 2011: A new dual-polarization radar rainfall algorithm: Application in Colorado precipitation events. *J. Atmos. Oceanic Technol.*, 28, 352-364.

Giangrande, S.E., and Ryzhkov, A.V., 2008: Estimation of rainfall based on the results of polarimetric echo classification. J. Appl. Meteorol. Climate, 47, 2445-2462.

Ryzhkov, A.V., T.J. Schuur, D.W. Burgess, P.L. Heinselman, S.E. Giangrande, and D.S. Zrnic, 2005: The Joint Polarization Experiment: Polarimetric Rainfall Measurements and Hydrometeor Classification. Bull. Amer. Meteor. Soc., 86, 809-824.

6. Page 2, Line 48-49: However, the cost ...are much larger.... Please use proper reference (i.e., McLaughlin et al. 2009).

The proper reference has been added. We thank the reviewer for this comment.

Reference: McLaughlin, D., D. Pepyne, B. Philips, and Coauthors, 2009: Short-Wavelength Technology and the Potential For Distributed Networks of Small Radar Systems. Bull. Amer. Meteor. Soc., 90, 1797-1817.

7. Page 4, Line 82: ...normalized standard error (NSE)... NSE has been expanded too many times all through this manuscript. Please pay attention to the usage of acronyms.

Thank you for this comment. We have fixed these along with the mean absolute error expansions.

8. Page 4, Line 84: ... relatively few articles on X-band... There are many X-band QPE studies. Please rephrase the writing. Again, the uniqueness of this study should be emphasized (particularly the local precipitation microphysics).

We appreciate this comment and have made the necessary change.

9. Page 4, Line 93: Over 100 different algorithms were implemented... This is very strange! Do you really need 100+ algorithms? The authors should pay more attention to the algorithms that can better reflect local rainfall microphysics. Most of the relations are taken from other papers that focused on different regions. Some of the algorithms used in this study were not even designed for X-band... A detailed investigation of local precipitation microphysics will be helpful.

Thank you for this comment. For future studies where quality control and calibration have become more concrete, research into adding more gauges for ground-truth as well as disdrometric data will be available and published.

10. Page5,Lines105-106: ...X-band radars will allow further indications as to whether they should be installed in regions devoid of optimal NWS WSR-88D coverage. The description on such aspect is weak. The authors may want to rephrase this sentence or refer to other studies.

We appreciate this comment, and have altered the text to

11. Page 7, Lines 162-163: R and Z ... should be independent of radar wavelength. This is true only when you are assuming Rayleigh scattering. Please clarify!

We greatly appreciate this comment and have addressed this issue accordingly.

12. Page 9, Line 210: $p < 0.10$ What is p? Probability?

We have indicated that p is, indeed, probability. Thank you for addressing this.

13. Page 23, Figure 2. Please include corresponding rainfall products derived from this radar.

Please accept our apologies, but Figure 2 corresponds to the gauge accumulated precipitation amount measured at each location. Additionally, no rainfall products / algorithms were derived specifically for this radar.