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Interactive comment on "Exploring the potential of utilizing high resolution X-band radar for urban rainfall estimation" *by* Wen-Yu Yang et al.

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Response to Reviewer 3

We deeply appreciate the reviewer for his/her very insightful and constructive comments.

We would note that we decided to change our topic to "Utilizing X-band radar monitoring fast-moving rainfall events" considering the nature of the revision. Such change is motivated by following reasons: 1) The urban hydrologic simulations are very sensitive to the spatiotemporal variability of rainfall (Schilling, 1991, Emmanuel,et al, 2012) and thus require rainfall inputs of high spatiotemporal resolution. Although X-band radars can provide rainfall products of high spatial resolution (Chen and Chandrasekar, 2015), they still lack the ability to provide products of high temporal resolution. 2) The radar-

rainfall accumulations generated from periodic sampling often poorly represent the actual rain fields due to the coarse temporal resolution of the radar rainfall product. This error will be amplified for fast moving storms and fine spatial resolution data (Seo and Krajewski, 2015). In the revised manuscript, we monitor the fast-moving rainfall events with downscaled X-band radar product using the extrapolation technique. First, we quantitatively evaluate the "common error" correction approach to assess the quality of the coarse temporal resolution product. Then, we investigate the impacts of advection correction on the radar QPE. We also examine impacts of the physical factors on the correction accuracy.

The connection between the previous and revised manuscripts are: 1. Same observations from the Beijing X-band radar system, including an X-band radar and a disdrometer; 2. Same QPE algorithm to retrieve rainfall from radar measurement.

However, due to the unexpected amount of work in the revision, we are unable to finish the revision in time even though one extension had been kindly granted by the editor. As such, we first address the specific concerns of the reviewer as best as we can; meanwhile we are working on the revision with more thorough analysis.

Below we detail how we addressed the specific concerns of the reviewer: Major comments: 1. The first doubt is about the shortness of the observations: some uncertainties, like anomalous propagation, are directly linked to climatological conditions of the site that can not be evaluated with one year observations. Response: We thank the reviewer for the suggestion. And we agree with the reviewer one year's observations cannot be used to evaluate the effects of anomalous propagation. As the theme of the revised manuscript is changed, this part will be removed.

2. The wind drift correction contains severe theoretical issues: it is arguable to apply advection-derived wind instead of wind profile below precipitation, obtained from observations or NWP. The corresponding strong assumption is that the convective system displacement corresponds at least to the wind in the atmosphere from the cloud base to

the ground! Response: We did make oversimplified assumption in the wind drift correction. In fact we intended to investigate the temporal sampling bias caused by advection rather than the wind drift effects (Thorndahl et al. 2017). It has been acknowledged that radar-rainfall accumulations generated by weather radars from periodic sampling often incorrectly represent actual rain fields. Coarse temporal resolution radar product suffers spatially discontinuous patterns that were caused by the intermittent radar scanning frequency. This error will be amplified for fast moving storms and fine spatial resolution data (Seo and Krajewski, 2015). Therefore, in the revised manuscript, we use an extrapolation techniques to downscale the radar product to very fine temporal resolution (1 min). The effect of temporal sampling error on the results will be further discussed for four fast moving events.

3. Moreover, the derivation of Z-R relationships discriminating stratiform and convective shows unclear key points: how is the 39 dBZ threshold chosen? How many data are respectively used for stratiform and convective non-linear fittings? Is the decimal precision of "a" coefficient in Z-R relationships (in this study 426.5 or 499.3) really meaningful? Which are data quality checks applied on distrometer? The two derived equations are quite similar (i.e. similar DSD for stratiform and convective rainfall), and it is quite surprising: how can the authors explain it? Response: We thank the reviewer for pointing out our mistake. Here, we apologize that we make a serious mistake which is citing wrong paper. In the previous manuscript, we used this simple threshold method due to its computational efficiency compared with the radar-based LWC method. In the revised manuscript, as we now focus on only four rainfall events, it is feasible to use the radar-based LWC method.

4. To reduce the bias in radar-gauges comparison, the authors consider 33 of 43 events. This choice need to be clarified: how are they chosen? Which are their characteristics? Response: In this work, 8 gauges are used to validate the radar QPE. Among the 43 events, there are 33 events during which at least three gauges have valid measurements. Therefore these 33 events are chosen to investigate the radar-gauge ratios

of the daily accumulated rainfall (Fig. 6). When comparing hourly accumulated rainfall, all the events in the study period are utilized.

5. Finally, the authors assert that anomalous propagation (AP) contributes a minimal improvement. The effect of AP on weather radar measurements should be evaluated more rigorously: - the authors consider only rainfall events, while AP has impact also during dry weather, carrying to false rainfall; - the overall effect depends on AP climatology of the considered site, that must evaluated on longer period (see Bech et al 2012, ; Fornasiero et al, 2006a, 2006b). Response: We thank the reviewer for the suggestion. As stated in Response 1, we have realized one year's observation cannot be used to evaluate the effects of anomalous propagation. Also, as the theme of the revised manuscript is changed, this part will be removed.

6. The exposition of the study is unclear and very hard to evaluate. The language is often poor with several spelling mistakes, even in physical units ("Ghz" or "kw" in Table 1). Response: We will thoroughly polish the language and correct all the technical issues.

References: Chen, H., Chandrasekar, V.: The quantitative precipitation estimation system for Dallas–Fort Worth (DFW) urban remote sensing network, J. Hydrol., 531, 259-271, 2015. Emmanuel, I., Andrieu, H., Leblois, E., Flahaut, B.: Temporal and spatial variability of rainfall at the urban hydrological scale, J. Hydrol., 430, 162–172, 2012. Fabry, F., Bellon, A., Duncan, M.R., Austin, G.L: High resolution rainfall measurements by radar for very small basins: the sampling problem reexamined, J. Hydrol., 161, 415–428, 1994. Qi, Y., Zhang, J., Zhang, P.: A real-time automated convective and stratiform precipitation segregation algorithm in native radar coordinates, Q. J. R. Meteorolog. Soc., 139, 2233-2240, 2013. Schilling, W.: Rainfall data for urban hydrology: what do we need, Atmos. Res., 27, 5–21, 1991. Seo, B., Krajewski, W.F.: Correcting temporal sampling error in radar-rainfall: Effect of advection parameters and rain storm characteristics on the correction accuracy. J. Hydrol., 531, 272–283, 2015. Thorndahl, S., Einfalt, T., Willems, P. et al.: Weather radar rainfall data in urban hydrology, Hydrol. Earth Syst. Sci., 21, 1359–1380, 2017

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/amt-2016-388/amt-2016-388-AC3-supplement.pdf

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