Review of the paper

Exploring the potential of utilizing high resolution X-band radar for urban rainfall estimation

By Wen-Yu Yang, Guang-Heng Ni, You-Cun Qi, Yang Hong, Ting Sun

No.: amt-2016-388

General comments

In this manuscpript, X-band radar observations are explored highlighting the strengths of high resolution rainfall estimations over urban area. A typical data processing for rain estimation that includes different corrections applied to X-band radar measurements are under analysis. The dataset used includes measurements from an X-band radar in single polarization installed in Beijing, a laser disdrometer (OTT Parsivel) and eight rain gauges installed in the area coverage by radar. The disdrometer measurements are used to obtain a relation for attenuation correction through reflectivity (calculated from DSDs) and two relations (R-Z) for rain estimation in convective and stratiform cases, while the rain gauges are used as reference for rain estimation. Several type of procedures for common error corrections are applied to one year of data, while one case study is selected to assess the wind drift correction.

This work is interesting, in fact, contributions to the potential of low-cost and small size radar, such as X-bands radar is an important task. However, this work lacks of novelty: most of the procedures used for common error corrections are derived from literature without improvements and validation. The main innovations of the work are related to the use of disdrometer measurements and the wind drift correction, although these procedures are not adequately described and the results are qualitative and not validated. Furthermore, possible interesting results, such as the calibration using the disdrometer and the wind drift correction are limited to one case study.

Major comments

- The use of disdrometer measurements for radar calibration in single polarization is an interesting approach since the DSDs measured are representative of the climatology of the region in which are collected. However, different points need to be clarified before applied this method: How the Mie calculation is performed? Which radar pixels are considered for the comparisons in Fig. 3? What is the error of the relationship shown in Fig.3? I suggest to investigate deeply the calibration results in particular, quantitative results, performances of the method and the extension at the entire dataset. These actions are indispensable before to decide if the calibration factor found is necessary or not to be applied.

- Certain issues (such as the instrumental error and the sampling error) have to be carefully considered when the disdrometer data have been used. Since in this work the disdrometer measurements are taken as reference, some considerations on instrumental limitations are needed. In relation to the attenuation correction: how is the performance of the relation between specific attenuation (k) and reflectivity shown in Fig.4? What indicate each point in the figure? Is the reflectivity at which time? How many radar volumes are plotted?

- The spectra of DSD collected by disdrometer have an error structure, being more or less sensitive to small drops or more precise for larger drops. Such errors impact applications, like the study of radar algorithms. Furthermore, some procedure of post processing for DSDs collected by disdrometer are necessary, for example to filter out spurious drops due to splashing or wind effect (Tokay et al, 2001). Furthermore, the R-Z relations obtained from the DSDs measurements need to be validate. In particular, the intrinsic validation (that can be obtained from the scatter plot between the Rain Rate (RR) derived from DSDs and the RR obtained from R-Z relation) and the comparison of rain with rain gauges.
- Besides the application of a fixed threshold (why 39 dBZ?) to divide stratiform/convective events a classification of rain regimes based on disdrometer measurements can be used (see Bringi et al 2003, Roberto et al 2016, Adirosi et al, 2015).

- In section *beam integration* the partial beam blocking is not correct, rather the elevation with optimal visibility is select without compensate the part of signal blocked. There are different approach to compensate the partial beam blocking effect for instance, that proposed by Bech et al 2003.

- The largest improvements found in the results shown in Tab. 3, are found for the beam integration procedure. This result appears obvious, if the radar beam is blocked the rain estimated by radar, compared to that measured by rain gauge will be underestimated. The correction that should be assessed is the rain estimated at the optimal visibility elevation before and after applied the partial beam blocking correction.

- In order to assess the improvements of Z-R relations from DSD measurements at least these validations are necessary: i) validate the performances of the Z-R relations in terms of intrinsic validation (as explained in previous comments) and ii) the performance of the Z-R relations applied to radar measurements comparing to the standard Z-R relations. In this

work the intrinsic validation is not implemented, while if the validation using radar measurements is applied or not is not clear (see lines 392-396 pag 20). I think that in this work is necessary a session dedicated to DSDs measured by Parsivel, that describes the Parsivel data processing and the validation of the relations derived (calibration, attenuation correction and R-Z relations).

Minor Points

Line 110 pag 7 Among the advanced methods that mitigate the error for rain estimation using X-band radar measurements, an approach that reduces the attenuation effect and calibration error is the combined algorithm between Kdp-R and Z-R (Vulpiani et Al. 2015).

Line 290 pag 15 What is "BW"?

Line 295 pag 15 Which is the origin of the threshold of 6.5 Kg m^{-2} to categorize stratiform and convective pixels?

Lines 298 pag 16 Please insert the reference for the standard Z-R relationships.

Lines 326 pag 17 Since in this work the fall velocity is available from disdrometer measurements, did you check if the fixed falling speed of 5 m/s is representative of your case study? I suggest to use the fall velocity measured by disdrometer, at least for the pixels around the Parsivel in order to obtain the error on the hypothesis of fixed speed velocity.

Lines 237 pag 17. Do you mean Eq.(9) instead of Eq.(12)?

Lines 328-332 pag 17 Is not clear if the tracking algorithm is applied in this work? Please rewrite this part.

Lines 358-362 pag 19 Which are the radar pixels considered to calculate the *ra* and *ra*? Instead of select the event based on *ra* and *rd* ratio, you should associate a confidence level to each rain gauge based on the radar visibility and on the distance.

Line 366 pag 19 What about RMSE?

References

Tokay, A., A. Kruger, and W. Krajewski, 2001: Comparison of drop size distribution measurements by impact and optical disdrometers. J. Appl. Meteor., 40, 2083–2097.

Bringi, V. N., Chandrasekar, V., Hubbert, J., Gorgucci, E., Randeu, W. L., Schoenhuber M.: 9 Raindrop size distribution in different climatic regimes from disdrometer and dual-polarized 10 radar analysis, J. Atmos Sci. 60**,** 354-365, 2003.

Roberto, N., Adirosi, E., Baldini, L., Casella, D., Dietrich, S., Gatlin, P., Panegrossi, G., Petracca, M., Sanò, P., and Tokay, A.: Multi-sensor analysis of convective activity in central Italy during the HyMeX SOP 1.1, Atmos. Meas. Tech., 9, 535-552, doi:10.5194/amt-9-535-2016, 2016.

Adirosi, E., Baldini, L., Roberto, N., & Russo, F. (2016). C/S algorithm based on properties of dual-polarization radar measurements derived from disdrometer data. In *International Conference of Numerical Analysis and Applied Mathematics 2015, ICNAAM 2015.* (Vol. 1738). [430002] American Institute of Physics Inc.. DOI: 10.1063/1.4952215

Vulpiani, G., Baldini, L., and Roberto, N.: Characterization of Mediterranean hail-bearing storms using an operational polarimetric X-band radar, Atmos. Meas. Tech., 8, 4681-4698, doi:10.5194/amt-8-4681-2015, 2015.

Bech, J.; Codina, B.; Lorente, J. and Bebbington, D. The sensitivity of single polarization weather radar beam blockage correction to variability in the vertical refractivity gradient. *J. Atmos. Oceanic Technol.*, **2003**, 20, 845–855, doi: 10.1175/1520-0426(2003)020<0845:TSOSPW>2.0.CO;2