Reviewer #1

The study addresses polarimetric radar estimation of extreme rainfall using specific differential phase KDP. The performance of different versions of the KDP-based estimators is compared and tested using rainfall gauge measurements. The authors consider various KDP processing techniques and possible impacts of the DSD variability and raindrop orientations uncertainty on the quality of the polarimetric rainfall estimation.

It is demonstrated that all tested methods optimized by a locally measured DSD in a particular heavy rain event tend to yield reasonably good estimates of rainfall with hourly totals below 100 mm but significantly underestimate heavier rain with rain rates approaching 200 mm/h. The authors speculate that such underestimation can be attributed to a more random orientations of raindrops than is commonly assumed in the derivation of the R(KDP) relation or to a big difference between the radar and gauge sampling volumes.

This reviewer believes that the authors may underestimate the impact of downdrafts which are often associated with a torrential rain. They downplay such an impact arguing that it is not detected by the disdrometer. The fact is that the vertical air motion is always negligible near the surface which does not exclude high downdraft speeds just a few hundred meters above the surface where the radar samples rainfall. Under such scenario, radar underestimation of rain is inevitable because of the conservation of a precipitation flux. The authors have a unique chance to check this hypothesis. Of course, direct measurements of the vertical air velocity are usually not available with the operational radars but one can examine indirect radar attributes of downburst such as strong wind divergence near the surface which can be assessed from the Doppler measurements or rapidly descending KDP or Z cores that are proven to be linked to the downbursts / microbursts.

We would like to thank the reviewer for very good suggestions which helped us to refine this work. In the revised manuscript, we have added a figure showing the time serials of Doppler velocity and the radial divergence over the Zhengzhou national climatological station. The results suggest sustained divergence from 16:00 to 17:00 over the site reporting the 201.9 mm report. Therefore, we agree that the existence of downdrafts should not be ruled out. But we did not see significant descending K_{DP} or Z in our observations, which may be explained by the limited sampling heights (0.083 km, 0.132 km, 0.182 and 0.237 km at 1.5°, 2.4°, 3.3° and 4.3°). Please see the details in the revised manuscript.

I have several other recommendations and concerns.

1. What is the purpose of comparing the data from the Luoyang and Zhengzhou radars? Only the latter radar data are used for a qualitative analysis. Once the maps of rain totals retrieved from the two radar are displayed in Fig. 2, the reasons for discrepancies

have to be discussed. Most likely, an apparent shift in the areas of heaviest rainfall is related to the differences in the altitudes of the radar sampling volume and strong vertical gradients of rain rates which are typical for warm rain process.

The reviewer is correct. In the revised manuscript, we have made more detailed discussions on this point.

Yin et al. (2022) have made simulations on this event, and they found that the storms were tilted eastward. The sampling volume of the Luoyang radar over Zhengzhou city is about 2 km, while the Zhengzhou radar observes near-surface precipitation. Therefore, the precipitation observed by the Luoyang radar is more eastward than the Zhengzhou radar. In addition, warm rain processes may also significantly augment rain rates within the height of 2 km (Yu et al., 2022). Given the effects discussed above, Zhengzhou radar will be used for QPE in this study.

2. Self-consistency factor and Clpf should be defined.

   Both are tunable coefficients in Py-ART codes to impose the weights on final solutions. We have added the following information into the algorithm introduction section.

   In Py-ART, the self-consistency factor is used to define the weight of the Z_e-K_{DP} relationship on the final solution, and the default value is $6*10^4$.

   The effect that the low pass filter has on the final solution depends on a user-defined parameter Clpf. By changing the value of Clpf the user can control the amount of smoothing applied by the algorithm.

3. Averaging window lengths (len) have to be expressed in km.

   Agree, we have amended the manuscript as suggested.

4. Keep in mind that the LP procedure always tend to overestimate KDP because it ignores negative radial slopes of ΦDP. Negative KDP is always coupled with overestimated positive KDP in the close proximity and both shouldn't be quantitatively used. This is a nature of the nonuniform beam filling impact on the KDP.

   The reviewer is correct. But this effect does not seem to be significant in this study. We have added the discussion about this point in the revised manuscript:

   It should be noted that the non-uniform radar beam filling was not considered in idealized known-truth tests (Reimel and Kumjian, 2021), but it can lead to local perturbation of K_{DP} (Ryzhkov and Zrnic, 1998). Because the LP and Maesaka et al. (2012) methods assume the monotonic increase of ΦDP, and therefore they are expected to yield higher K_{DP} than the LSF method if the negative radial slope of ΦDP occurs in the close proximity. This effect does not seem to be significant in this study for the following reasons. Firstly, the Zhengzhou radar is close to the gauge site (3.15 km), and therefore the radar sampling volume is much smaller than that at larger distances. Then, the gauge site was not located in the edges of rain cells (see K_{DP} composites at https://github.com/HaoranLiHelsinki/Figs_Zhengzhou). Finally, we have manually checked ΦDP observations, and did not see significant negative radial slope *of ΦDP. In addition, the smallest Clpf (least smoothing) yields smaller K_{DP} than the LSF method from 16:00 to 17:00 LST (Fig. 3a), suggesting the selection of K_{DP} estimation method is more important than the effect of non-uniform radar beam filling in this study.*

5. I don't see any difference between the three panels in Fig. 8, It is not clear what is displayed because the shading is not specified.

   We feel sorry that the explanation about the isolines was missing. We have amended the first sentence of the caption as,

   Satellite images from Google Maps overlapped by isolines indicating the rainfall accumulation [mm] during 14:00 ~ 17:00 LST.

English usage has to be substantially improved. Just a few examples follow

We thank the reviewer for correcting the grammar mistakes. We have made careful proofreading for the revised manuscript, please see the revised manuscript.

L 32. Should be "coefficient" instead of "ratio"

Corrected.

L 60. Remove "the" before "progress"

Corrected.

L 72. KDP is a radial derivative (not derivation)

This sentence has been amended as:

K_{DP} is one-half the range derivative of differential phase shift.

L 120. This "may be attributed"

Corrected.

L 133. "A linear interpolation"

Corrected.

L 153. "At 274°"

Corrected.

L 174. KDP is less dependent on DSDs than what?

This sentence has been amended as:

K_{DP} is less dependent on DSDs than other radar products.

L 196. "Earlier" instead of "early"

Corrected.

L 217. "Analyze" instead of "analysis"

Corrected.

L 222. Replace “decent”

“Decent” has been replaced by “detectable”.

L 278. “In-depth” instead of “depth-in”

Corrected.

L 298. Remove “at the”

Corrected.

L 304. Gridded

Corrected.

L 309. Replace “decent” with “significant” or “noticeable”

Corrected.