Responses to comments posted by Referee #2

We thank the second referee for reviewing our article and providing his fruitful feedbacks. In the following, we answer to all of the comments one by one. The Referee comments are in blue.

Comment 1: Page 2, line 24: It seems to me that the work of Vignal et al (1999) and (2000) only addresses the variability of Z from high altitude to the ground but not directly the variability of the Z-R relationship along the vertical.

Reply 1: We agree. To make things clearer, we will better explain the content of Vignal et al. (1999) and (2000) and will add another reference which more closely addresses the variability of the Z-R relationship to the ground: Peters, G., Münster, H., Clemens, M., and Wagner, A., (2005): Profiles of raindrop size distributions as retrieved by microrain radars. J. Appl. Meteor., 44, 1930–1949,https://doi.org/10.1175/JAM2316.1.

Comment 2: Page 12, line 11: the reflectivity factors of the MRR, due to the short wavelength used, can also sometimes be greatly attenuated, with consequences on the retrieved DSD.

Reply 2: Good point. It is true that one has to clarify this important possible influence on the results. We will include a short discussion of this potentially significant source of uncertainty in a revised version of the manuscript.

Comment 3: Page 12, line 11: why is the 3.5 moment used and not (the most commonly used) 3.67? Could you add a reference?

Reply 3: Thanks for indicating this point. Actually we calculated the rain rate by using the 3.67^{th} moment. In a first version however we used the 3.5^{th} moment of the drop size distribution for the rain rate by using the approximation for the fall velocity $v(D) \approx c \cdot D^{0.5}$, which we took from the script of a radar meteorology class. We missed correcting the text accordingly, but will do so in a revised version.

Comment 4: Page 17, Line 11: A 15.3% reduction in uncertainty when RR0 is conditioned bydBZ1500Rad seems quite low, doesn't it? This proves that radar reflectivity is one of the most important sources of information but that there is a high variability in the Z-R relationship that limits entropy reduction. This explanation is suggested later (experiment 3) but could perhaps already be mentioned here. I think we are also suffering here from the effects of PVR and perhaps even attenuation for high intensities.

Reply 4: We agree. It makes sense to mention the explanation - suggested later in experiment 3 - already in this section. Also, as suggested, we will in a revised version of the manuscript point out that while the radar reflectivity factor is one of the most important sources of information, there remains a high variability in the Z-R relationship that limits entropy reduction.

Comment 5: Page 24, Line 3-5: I understand that DKL=3.43 bits and 5.04 correspond to the application of the Z-R Marshall Palmer relationship and that DKL=2.69 and 4.30 correspond to the optimized Z-R relationship. But I don't understand what differentiates 3.43 from 2.69 (and 5.04 from 4.30): what are the differences in terms of condition applied?

Reply 5: It is correct that DKL = 3.43 and Cross Entropy (total uncertainty) = 5.04 bit result from the application of the (deterministic) Marshall-Palmer relationship (red line in Fig. 6), and DKL = 2.69 and Cross Entropy = 4.30 bit result from applying a deterministic Z-R relationship fitted to the available data (black line in Fig. 6). So the difference between 3.43 and 2.69 (and 5.04 and 4.30) comes from using a general Z-R relation (derived from the Z-R data pairs Marshall and Palmer had available) in the first and a fitted-to-the-available data Z-R relation in the second case. So while the Marshall-Palmer relation may be better overall (if used over a large variety of data), the custom-made Z-R relation quite expectedly works better when applied directly to the data it was built from. To us, it was rather surprising how good the Marshall-Palmer relation performed compared to the custom-made relation: It really seems to be a good default.

Comment 6: Page 26, Line 22: after "attributed to the ambiguous relationship between radar reflectivity and rain rate", I think that "due to the natural variability of Drop Size Distribution" may be added.

Reply 6: This is definitely correct. We will add this statement.

Comment 7: Section 3.6: Why kriging (often used method) was not considered for the rain-gauge approach?

Reply 7: We agree that it would be interesting to compare our results to established interpolation methods such as kriging. However, performance comparison of interpolation methods was not our main focus in this section. Rather, the goal was to show that our data-based approach easily allows joint use of several information sources without many additional assumptions, and secondly to demonstrate that information content is a function of distance between stations. In order to keep the study short, we suggest keeping this section as it is. As a side note: We are currently exploring the potential of data- and information based spatial interpolation in depth, comparing it to a range of established interpolation methods. We hope to submit a related manuscript by mid-2019.

Comment 8: The publication of Cecinate et al (2017) cited on page 2 does not appear in the list of references.

Reply 8: This is right. Thank you for detecting this missing reference. We will add it in a revised version of the manuscript.

Comment 9: Section 1.1, page 3, is a little "orphaned". It may not be necessary to distinguish this paragraph from the introduction. Its content could appear just before the announcement of the plan (between lines 10 and 11 on page 3).

Reply 9: Another Referee also commented on this section, to which we already replied (Reply 6 to referee #1). In a revised version of the manuscript we will give the block of text before 1.1 a number and subtitle title as well, such maintain the same level of text hierarchy throughout.

Comment 10: Table 1: I propose to replace "[min, max]" by"[center of the min bin, center of max bin]" or something like that.

Reply 10: We agree, that this would be a more robust value range and not so vulnerable to error prone outliers. On the other hand, we already cut down the outliers and fulfilled a thorough data quality analysis, so that we think, that the total value range is already quite robust and directly shows the total range of possible values.

Comment 11: Figures 4, 5, 6 and 7: I think that the texts of the legends should be enlarged.

Reply 11: We agree that the legends are relatively small. We will ask the HESS typesetting team whether they recommend larger legends for the final layout of the paper and will do so if recommended.

Comment 12: Figure 6: Wouldn’t the figure in a log-log frame be more readable and give less weight to very weak reflectivities?

Reply 12: We agree that a log-log display would put more emphasis on the higher reflectivities and rain rates, which are commonly of higher interest than the low ones. However, we would like to keep the figure in its current form as the non-transformed data better reveal the non-linear power-law shape of the Z-R relation as mentioned in the figure caption and in the text (page 23 lines 10 pp).

Comment 14: Table 3: I propose to replace "RR0" by "RR0Dis" to highlight that disdrometer is used (as for dBZ0Dis).

Reply 14: RR0 does not just contain rain rates measured by the disdrometers, but also by standard rain gauges at Useldange, Roodt and Reichlange (please see the paragraphs 'Distrometer data' and 'Rain gauge data' in section 2.3, and column 'description' in table 1). For this reason, we think the general term 'RR0' is more appropriate than 'RR0Dis'.

Yours sincerely,

Malte Neuper and Uwe Ehret