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Hydrology and Earth System Sciences Discussions

Interactive comment on "Joint statistical correction of clutters, spokes and beam height for a radar climatology in Southern Germany" *by* A. Wagner et al.

Anonymous Referee #2

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The paper contains an extensive analysis of radar reflectivity and rainfall data for southern Germany for the period 2000-2009. Corrections for clutter, spokes and beam height are applied to improve the quality of radar data. In general I believe the paper is well written. Most methodologies seem to be at least sufficient. Notwithstanding, I have remarks regarding the clearness of the paper as well as the order of the corrections or adjustments. A limitation of the paper is the limited number of reflectivity classes for the period 2000-2006. This hampers the usefulness of the proposed correction and adjustment methods and limits the suitability of the data set for climatological analyses (this should be clearly mentioned in the paper). On the other hand, this is a quite

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extensive study from which more can be learned about specific (sources of) errors in quantitative precipitation estimation using weather radar. I believe that this paper is suitable for publication if the remarks below are largely taken into account. A minimum demand is to clarify the text and to clearly describe the limitations of the paper.

p 4704, L8: change "was not achieved before" by "was often not achieved before". Probably longer archives have been stored for the United States.

p 4705, L 5: RMSE of what? Please describe the variable exactly.

p 4706, L 12-17: A statistical correction can also be combined with correcting single radar images. These two approaches do not automatically exclude each other. "The other way" is not to use statistical corrections. I would change this into, for instance: "Another way is to solely use statistical corrections".

p 4708: Is the temporal resolution of the data set 5 min or 15 min? If 5 min, then mention clearly that only the near-surface precipitation scan is used for the analyses. If 15 min, mention which elevations (angle of radiation) are used, and how/when the elevations are used. If 15 min, also discuss that this will give some errors with respect to rain gauge measurements, since only one observation per 15 min is available.

p 4708, L 4: "It is continuously available since 2004". Thus this implies that there are no missing images? Mention the data availability for both the DX- and PX-product.

p 4708: 8-bit depth means 256 classes. Please mention the resolution, e.g., 0.5 dBZ, and mention the range of the observations, e.g., 0.1 - 100 mm per hour. No threshold was applied to exclude hail (e.g., 60 dBZ) or noise (e.g., 7 dBZ)?

p 4709, L 1-5: First the assumption is mentioned, and subsequently it it stated that differences due to geographical characteristics have to be taken into account. It is probably meant that geographical characteristics are not specifically taken into account.

p 4709: The detection of corrupted pixels is not completely clear to me. It seems that first a visual selection is made, which would be quite laborious. Next, pixels which

HESSD

9, C1956–C1962, 2012

obviously differ from the distribution of uncorrupted pixels are manually separated by using histograms of frequencies of occurrence of radar reflectivities. This seems also to be quite laborious. Could it be explained how it is feasible to do these selections visually and manually? Finally, an additional separation is applied (automatically?). Please provide some more details regarding the method of detecting uncorrupted and corrupted pixels. Also mention how the classification between "city clutter", "mountain clutter", and "spokes" is carried out.

p 4709, L 21: Please clarify "the median of the frequency of occurrence of each radar reflectivity level for each altitude class". It is probably meant that all 5-min radar images are used to calculate the frequency of occurrence of level x for every radar pixel in a certain altitude class. For instance, the median is taken from the frequency of occurrence (calculated over all radar images) as found for each pixel in the altitude class. Or did you calculate it differently? Try to describe precisely how the median was calculated.

p 4710, L 8-12: Why calculate a mean bias correction factor on an annual basis? If such a factor would, e.g., be calculated on a daily basis, this would greatly improve the usefulness of this data set. I.e., the quality of daily rainfall depths would be increased, and these could be used for applications.

p 4710, L 15: Representativeness errors could be mentioned. A radar measures at different height and samples a larger volume compared to a rain gauge.

p 4710, L 19: I do not understand this sentence. Probably "proportion of the" should be added.

p 4711: A map with the locations of the uncorrupted and corrupted pixels would be interesting.

p 4711, L 21-22: This is not generally true. "In summer, convective rainfall occurs more frequently, which has a larger vertical extent and strong reflectivity cores aloft

HESSD

9, C1956–C1962, 2012

causing positive VPR gradients. For the United Kingdom, Hand (1996) shows idealized vertical reflectivity profiles for the cell stages of cumulonimbus clouds. For most stages reflectivities between the cloud base and the midcloud level are considerably larger than those below the cloud base." (Overeem, 2009).

p 4713, L 2-5: I don't understand this part. Could this be clarified?

p 4713: For other months the bright band is not that clear. Underestimation in January at long distance from the radar is apparent and probably mainly related to overshooting. The bright band classifies between the rainy and snowy region, but I believe that too much attention is paid to the bright band (also in the Summary). Please try to explain Figure 5 also by using other (sources of) error.

p 4713, L 15: Probably "from rain to snow" is meant.

p 4713, L 23-25: The comparison with the median of uncorrupted pixels of the closer environment is a bit vague. What is the definition of the closer environment?

p 4714, "City clutter": This paragraph could be clarified. If clutter is present you would expect positive values for "variation" in Figure 6. If the clutter has already been (partially) removed, this will result in negative values for "variation". It is mentioned that "This is likely due to clutter correction with less correct measurements". It is probably meant that the algorithm to remove clutter removes too much of the signal. In addition, I have a remark about the results for radar reflectivities of higher levels. Clutter will be less apparent because surrounding pixels also have larger values due to rainfall. This does not automatically imply that the clutter is not a problem anymore.

p 4714, L 8-9: This only holds for the left figure.

p 4714, L 11-13: The mode is clearly larger than 0. Is this conclusion justified?

p 4714, L 24-25: Usually, only part of the radar beam will be blocked. Therefore, most measurements in the spoke will still fall in class 1.

HESSD

9, C1956–C1962, 2012

p 4720: I would find it more logical to first remove clutter, than apply an altitude correction and, finally, apply a gauge adjustment. If I understand it correctly a different order is followed in this paper. First try to get the radar data as good as possible, without using additional data. I believe this is the usual approach.

p 4719, L 14-18: Are both ways subsequently used?

p 4729, L 22-24: annual rainfall amounts?

p 4722, L 11: "a certain variability in class 1". This box-plot is based on only 2 measurements. It would therefore be more appropriate to combine range class 0-20 km with range class 20-40 km.

p 4722, L 15-16: I find this quite remarkable, since the radar data have not been corrected. Is this an indication that the radar is well calibrated? Are there other explanations?

p 4722, L 20-21: This is certainly the case in winter, but in summer this decreasing rain rate by radar measurements with distance from the radar will probably often not be found.

p 4723, L 19-20: And also by representativeness errors (different sampling volume and measurement height).

p 4725, L 1-2: "additional pairs of value". The RMSE is larger for the calibration data set using the same gauges. Therefore, differences in RMSE cannot be explained by additional pairs of value.

p 4725: Two times a reference is made to Figure 1, but this can not be right.

p 4725, L 19: I don't understand this sentence. Is it meant that the radar data have been adjusted using rain gauge data (point measurements)?

p 4726, L 19: "homogeneity" instead of "homogeneity".

HESSD

9, C1956–C1962, 2012

p 4726, last paragraph: Why clutter or spoke corrections cannot be combined with a bright band or vertical profile of reflectivity correction? Moreover, a more sophisticated gauge adjustment, in which the adjustment factor field varies locally, could also be used to indirectly remove all kinds of (sources of) errors such as bright band and VPR-related errors. Of course this requires a sufficient number of rain gauges.

Table 1: It would be interesting to mention the corresponding rain intensities. In the text often level 1 data are analyzed. This is called "light rain", but according to Table 1 also contains dry periods. If this is the case it should be mentioned in the text that "light rain" also contains "no rain".

Table 3 refers to Figures 10 and 11, which contain, respectively, frequency of occurrence and annual precipitation. The RMSE will probably only refer to the annual precipitation. So, RMSE of what? Add this to the caption.

Table 4: RMSE of what? Figure 12 gives a percential difference, is the reference to this figure correct?

Figures: It would be clarifying to add "PX" or "DX" to the caption of the figures.

Figure 2: Could a distance scale be added to the figure?

Figure 6: I believe that "difference" is a more appropriate term than "variation" in the label of the horizontal axis. The name of the label of the vertical axis could also be replaced. "quantity" is a generic term.

Figures 10 - 11: You use "corrected" and "adjusted", but is not clear to which corrections or adjustments you refer to. "Corrected" can be used to specifically correct for radar errors. "Adjustment" refers to adjustment using other data sources, e.g., rain gauge data.

Figure 11: Print quality of figure should be improved. Is this a calibration?

Figure 13: Mention "calibration" and "validation".

HESSD

9, C1956–C1962, 2012

Figure 14: A map based on interpolated rain gauge data would be interesting.

Literature

Hand, W. H., 1996: An object-oriented technique for nowcasting heavy showers and thunderstorms. Meteorological Applications, 3, 31–41.

Overeem, Aart, Iwan Holleman, Adri Buishand, 2009: Derivation of a 10-Year Radar-Based Climatology of Rainfall. J. Appl. Meteor. Climatol., 48, 1448–1463.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 4703, 2012.