nhess-2020-1982: An analysis on temporal scaling behaviour of extreme rainfall of Germany based on radar precipitation QPE data (Pöschmann et al.)

Reply to the comments from Referee #3:

We are thankful for comments and suggestions from the anonymous referee #3 that helped us to improve our original draft. We have provided responses to all comments in blue and updated the manuscript accordingly. All line numbers given in our responses refer to the original version of the manuscript.

Comments:

General comments:

The contribution provides an interesting information about maximum rainfall and its scaling with duration for Germany. The methodology is quite clear and plausible. The manuscript is well written and concise. There are however some points which need clarification and improvement (see detailed comments).

Detailed comments:

1. Line 73: Compared to other Countries in Germany PMP is not used directly for design. A brief comment about this would be useful.

Response: Thank you for your comment! In order to avoid more text, we chose to simply remove the two last sentences from the introduction from the manuscript.

2. Line 92: A brief summarization for the pre-processing of the radar data would be very useful, so that the reader has not to consult other papers (see also comment 5).

Response: s. our text edits listed in Comment 5

3. Eq. (6): A closing bracket is missing before the equal sign. (answer together with next point)
4. Eq. (7): The second factor of the right side of the equation should read “tau to the power of b”.

Response: Following Reviewer#1 we have restructured the section and removed all equations.

We merged sections 2.2.1 and 2.2.2 into one paragraph 2.2. “Depth-Duration-Relationships” as follows:

“2.2 Depth-Duration relationships
Maximum rainfall values for each duration τ between 2001-2016 were calculated with rolling sums applied over moving windows using the R package RcppRoll (Ushey, 2018). Durations of up to 3 d were chosen for the analysis, with multiple steps for minutes and hours out of our interest for sub–hourly and sub–daily pattern. The records may include non-rainfall data and thus do not imply continuous precipitation for the period considered. Values were not aggregated spatially, since this usually reduces the maximum intensity values (Cristiano et al., 2018). First, the extreme values for each pixel and duration $M_{max}^{\tau,pixel}$ are calculated. Afterwards, the overall maxima for whole Germany for each τ (M_{max}^{τ}) is extracted from these calculated extreme values. Based on these results, the depth–duration relationships can be built for each pixel as well as for the whole of Germany.”

5. Line 140ff: The study is analysing maximum observed values from radar data. Considering the problem of clutter in radar data I am wondering that this seems not to influence the analysis very much, since these values “simulate” high precipitation intensities. Even if in radar pre-processing the clutter have been removed, there are usually still some of those left. Please, discuss this problem.

Response: After having worked with RADOLAN, there was some doubt concerning the quality of the RADKLIM product. We expected radar artefacts that would destroy our results, similar to what you mentioned. However,

we did not find any obvious problematic "high" precipitation intensities and were confirmed by Kreklow et al. (2019) who explained that remaining weaknesses of RADKLIM are a higher number of missing values as well as an overall negative bias, causing a rather "underestimation" of high intensity rainfall due to spatial averaging and rainfall-induced attenuation of the radar beam.

We agree that a little more text on the data quality would add to a better understanding and thus edited several passages in the document as follows:

Lines 81 – 84 were edited as follows:

"Since the quality enhancement of RADOLAN is ongoing without post-correcting previous data, the so–called radar climatology project of the DWD, RADolanKLIMatologie (RADKLIM,Winterrath et al., 2017) has consistently reanalysed the complete radar data archive set since 2001 for improved homogeneity despite the originally different processing algorithms. Compared to RADOLAN, RADKLIM has implemented additional algorithms leading to consistently fewer radar artefacts, improved representation of orography as well as efficient correction of range-dependent path-integrated attenuation at longer time scales (Kreklow et al., 2019). Whereas RADOLAN is not well suited for climatological applications with aggregated precipitation statistics, RADKLIM is a promising data set for these climatological applications. The RADKLIM data is available.."

Lines 91 – 94 were edited as follows:

"The YW product covers the area composed of 1100 x 900 pixels with the spatial resolution of 1 km (improved compared to former version of RADOLAN). Remaining weaknesses of RADKLIM (as outlined in Kreklow et al. (2019)) are the greater number of missing values (compared below) compared to RADOLAN as well as negative bias causing an underestimation of high intensity rainfall due to spatial averaging and rainfall-induced attenuation of the radar beam."

The following sentence was added at line 151 (centre):
"As mentioned in the data quality description, it is possible that these sub-hourly values do not represent the true extreme across Germany for 2001-2016 since radar-based measurements at fine timescale (e.g. xx minutes) are highly sensitive to the averaging effects."

Following sentence was added at the end of the conclusion:

"Also, the known issue of rainfall extreme underestimation by RADKLIM-YW and the potential impact on the results need further investigation."

6. Line 143: "(blue solid line)" I don't see a solid line in Fig. 4.

Response: We changed it to the characteristics shown in Figure 4: Triangles (filled/empty) and dots.

7. Figure 4: It would be interesting to see the maximum observed values from rain gauges for the same period as the radar data. This would in comparison with the longer period allow a discussion about sample size and record length (space vs time).

Response: Thank you for this suggestion! However, we chose to not add another uncertainty into the analysis. The gauge data used for Figure 4 is available as final product and we did not calculate it ourselves, and a time series with fine resolution of 5 minutes is not freely available, which would make the gauge data more comparable to our data. There exist data with 10 minutes resolution, but the quality of the data is not verified.

8. Lin 159: A quantile is one value, so it should read for instance "0.99999 is the forth greatest cell value" not the plural ". . . cells".

Response: This is true, we change it!

9. Figure 6: This figure does not make sense to me. It shows the locations of different quantile values. However, it would make more sense to show all values which exceed the probabilities and not only the one exact quantile.

Response: We are sorry that the interpretation of the Figure is unnecessarily difficult. The purpose of placing the Figure like this is related to Figure 5: We want to show that if not taking the maxima of

maxima, but certain quantiles of maxima (we chose to take numbers that correspond to 99.999%, 99.99 %, 99.9% and 99%, but obviously other values could have been chosen):

1) Seven locations (as in Figure 4) no longer hold all maxima, but the number of locations is increased and locations are also spread over all of Germany.

2) Interestingly, despite 1), the corresponding depth-duration relationships are straightening out (=getting smoother) and start to reflect rather natural rainfall conditions (e.g. dominance of Alpine region in Figure 6d) instead of seen before singular "extremes of extremes".

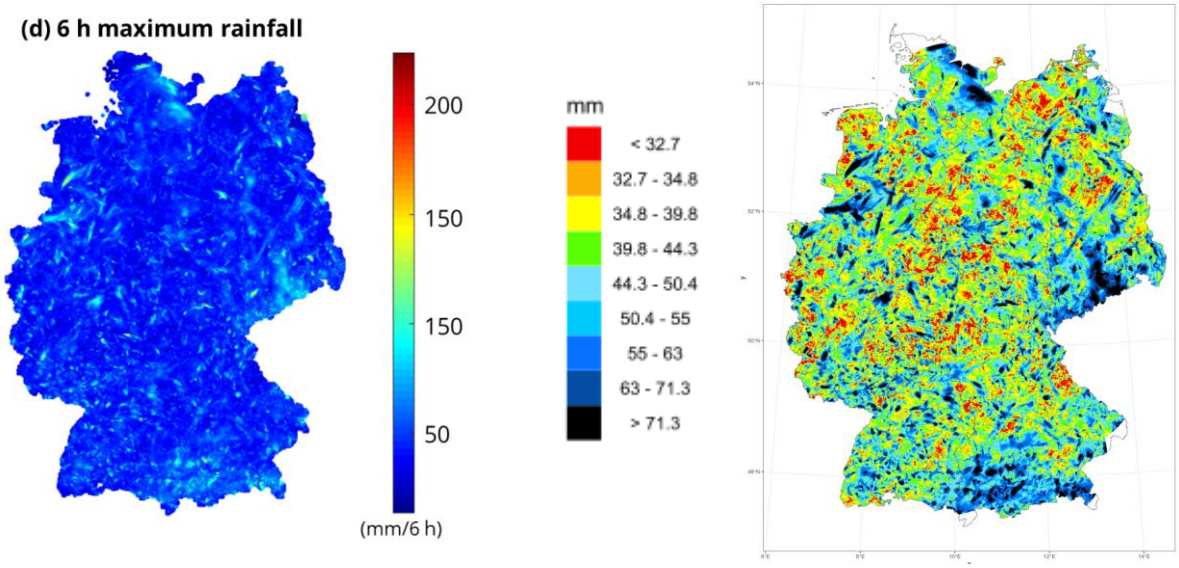
10. Line 164ff: "The lower the quantile, the sparser the location . . ." I don't understand this. From my point of view, I would say "The lower the quantile the more cells occur exceeding this quantile."

Response: Your answer is true, even though we want to focus on a different aspect. Find our text edition from line 164ff (including referee #1 and #2's comments):

"It shows that the number of locations increases the lower the quantile of maximum rainfall is. This suggests the reduction of the influence of one single rainfall event on the depth-duration relationship causing inflection in the curve. Additionally, from a certain degree of quantile (Fig. 6 d) the locations of maximum rainfall contributing to the development of the rainfall-duration relationship seem to happen mainly in the wider Alpine region in South Germany....."

11. Figure 7: I would suggest scaling the colours not simply from minimum to maximum (may be from 0.1 to 0.9 quantile and non-linear), so that we have more contrast and not only blue in the figures.

Response: If the referee would find it more suitable, we could change the colour scheme as given in the following example (colours represent quantiles):



12. Figure 8: What is the reason for selecting cities here? There might even be anthropogenic influence on rainfall in urban areas. Please discuss.

Response: Thank you for this comment! We chose these cities since they are distributed relatively well over Germany. We could have also selected random pixels, but preferred to choose known locations. The purpose of showing it is to reflect the variation in the depth-duration relationships. We believe that even anthropogenic influence will not change the message of the figure.

13. Figure 10: Please include description of the lines in caption or legend.

Response: We edited Figure 10's caption as follows:

"Dependency of maximum depth-duration relationship characteristic on underlying pixel sample size. The maximum rainfall values are derived from (a) 10, (b) 100, (c) 1000, and (d) 10000 random pixels from all considered pixels (n=392 128) within Germany. For each sample size, 30 ensembles are displayed and compared to the overall maximum curve from Fig. 4 and 5 (yellow top line in (a) – (d))."

Reference

J. Kreklow, B. Tetzlaff, G. Kuhnt, and B. Burkhard. A Rainfall Data Intercomparison Dataset of RADKLIM, RADOLAN, and Rain Gauge Data for Germany, Data, 4, 118, https://doi.org/10.3390/data4030118, 2019.