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Discussions

# *Interactive comment on* "Rain erosivity map for Germany derived from contiguous radar rain data" *by* Franziska K. Fischer et al.

**Anonymous Referee #2**

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This review is for the article "Rain erosivity map for Germany derived from contiguous radar rain data" by Fischer et al. In this work the authors use 17 years of gauge-corrected radar data to produce values of erosivity at 1 km$^2$ resolution over Germany. The data were noisy so significant data treatment was applied to produce a "typical" erosivity map and an annual cycle of erosivity. The new values show greater erosivity than previously produced maps and the seasonal distribution shows an increase in winter erosivity. The main advantage of the new approach is the use of continuous data over the region.



## General comments

The article is very well written, the analyses are clearly described and figures are well chosen. The results will clearly be of use.

However, some of the choices made in data treatment require further justification. My primary concern is about the level of data treatment that has been applied, which is, as the authors state, "extraordinarily large". Because the amount of smoothing applied is indeed more than normal, it should be carefully justified.

The aim is to produce a map of "typical" erosivity over Germany, but the erosivity distributions in time are skewed and contain outliers (from rare, extreme events) that make finding one representative value per pixel a challenge. A related problem is possible sampling effects, meaning differences between the sampled and true distribution of values (the authors mention this with respect to measurements from gauge networks that may miss entire events). The authors have applied data transformation techniques to find typical values, smooth them in space, and smooth the evolution of the average erosion index over time.

I'd like to comment on each data transformation undertaken, first to produce the per-pixel values:

1. **Winsorizing:** For each pixel, the mean erosivity over 17 yearly values is taken using winsorizing. In this case the authors only replace the lowest and the highest value (with the second-lowest and second-highest respectively). How was the choice made to use winsorizing over, say, the sample median? The choice of the method used (e.g. sample median or winsorizing, and the amount of winsorizing used) should be justified – for example through the use of a density plot of erosivity values, in which the skewness will be clearly visible, to show that the final values produced are representative of "typical" values of erosivity.

2. **Bias-correction:** The authors state that the winsorized mean is biased for long-tailed variables. But, for skewed distributions the winsorized mean should be closer to a "typical value" of the population than the sample mean because of the removal of outlier values. So is it not the case that winsorizing produces a less biased estimate of a central tendancy than the sample mean, and the bias correction suggested by the authors undoes the benefit of the winsorizing by matching back to the (spatial) sample means which are themselves affected by outliers?

3. **Ordinary kriging:** Kriging is used to fill gaps not covered by the radar data (due to beam-blocking, for example), and block kriging is used to smooth the output field. Kriging requires at least roughly symmetrically distributed input data (ideally they would be normally distributed) so that mean values are representative. It should therefore be mentioned in the article whether the distribution of "typical" values after the winsorizing procedure is symmetric, and if not whether steps have been taken to correct for this (possible options are a log transformation and/or use of the Cressie variogram estimator). Block kriging is being used in a non-standard way, as a smoother, so that each $1 \times 1$ km$^2$ pixel is estimated as the mean of values across a $10 \times 10$ km$^2$ block. How was the block size of $10 \times 10$ km$^2$ chosen?

After the spatial processing, the annual cycle of erosivity is calculated. Afterwards, smoothing was applied to the daily timeseries of averages. Again commenting on each step:

1. **Daily erosion index:** The erosion index is calculated for each pixel and then averaged across space for each day of the year. It was not clear to me whether the pixel values used to make this average were treated in any way (kriged perhaps?) or were raw 1 km$^2$ values (I assume it was the raw values so that they



were daily). If the distribution of daily EI values (across space for each day) is heavily skewed, then the mean of their values may not be representative (the median or a winsorized mean, for example, may be better). Was any testing for this done?

2. **13-day centred median, 3-day skip mean, and 25-day centred hanning mean:** This choice of smoothing routines needs to be better justified. Why was this combination of window sizes (13, 3, and 25 day) and operators chosen, and how was it judged whether the smoothed values represented the true signal?

As a suggestion that may provide more information to the reader: the authors could consider displaying maps not only of winsorized mean of annual values, but also per-pixel median, 10th percentile, and 90th percentile, to show not only "typical" values but maps of extreme erosivity values as well, and to show the spread of values for each pixel.

**Specific comments**

1. Page 2, line 24–25: "Unstable and unreliable transfer functions result that differ pronouncedly" – I do not understand the sentence, could you please rephrase?

2. Page 2, line 30: Please include a general reference for the radar measurement principle. One such reference could be the book by Bringi and Chandrasekar (2001), *Polarimetric Doppler Weather Radar*, Cambridge Uni. Press.

3. Page 3, line 12: I see your point that the use of continuous radar data avoids missing large and rare events that could be missed completely by gauge networks. But you do a lot of processing to the radar data, including winsorizing and smoothing, which reduces the influence of rare extreme events on the summary

statistics. There are two separate problems here: sampling (gauges may miss an event) and then what value to use as a "typical" value for a skewed distribution. It is important that justifications for the data treatment show that the chosen "typical" measure is appropriate.

4. Page 3, line 31: Which $Z$-$R$ relationship is used?

5. Page 4, line 6: Is the figure of 1 gauge per 80 km$^2$ an average value?

6. Page 4, line 20: For clarity, it would be helpful to include the units of $I_{\mathrm{max30}}$ and $E_{\mathrm{kin}}$ when the variables are introduced here; this is especially important because $E_{\mathrm{kin}}$ [kJ m$^{-2}$] and $E_{\mathrm{kin},i}$ [kJ m$^{-2}$ mm$^{-1}$] have different units.

7. Page 4, line 24: You should reference Fischer et al 2018 (from your references list) here since your definitions, units, and descriptions are very similar to those used in your previous paper.

8. Page 4, line 29: "the $R_e$ sum" – do you mean "the sum of $R_e$"?

9. Page 5, lines 14–15: For a given pixel, if too many years were excluded then the sampling may become less representative. How often were pixels affected by this exclusion of years, and were there pixels for which many years were excluded?

10. Page 5, lines 16–22: "replaced by the maximum 1-h rain depth" - should this read rain intensity?

11. Page 5, lines 16–22: As I understand it, the scaling factors are being used to adjust the method of calculating erosivity to put a "virtual rain gauge" in each radar pixel, to account for the fact that radar measurements are areal and integrated over time and therefore smooth out rainfall intensity peaks. Since rain intensity depends on temporal resolution, and you require 30 minute maximum rain rates



which would be smoothed by the use of 1 hour radar data, I see why a temporal scaling factor could be used. But spatially, the areal measurements at 1 km$^2$ resolution can be assumed to be representative of each 1 km$^2$ pixel, and since you are producing erosivity values at the same resolution, I don't understand why a spatial scaling factor (or indeed the method scaling factor) is required. Please could you explain more here why the scaling factors are used and how they are applied (e.g. it is not clear which threshold is lowered to 5.8 mm h$^{-1}$).

12. Page 6, line 14: The use of some independent data to test the spatial representativity of the smoothed data is a good idea, but is this test data independent? It is also based on radar data. Has the test region data been compared to gauges or other ground truth data to ensure it is accurate?

13. Page 7, lines 1–2: "The cumulative distribution curve for the test region calculated from 5-min data will then be a fair estimate of the return periods anywhere in the research area" – I do not think this is proven. Even if the test region and the whole area agree at 1 hour resolution, extreme intensities are smoothed out at this lower resolution, so it does not necessarily follow that the 5 minute cumulative distributions are the same across all regions.

14. Page 7, lines 19–20: Please include a reference for these statements about radar accuracy (they are correct but require a citation).

15. Section 3.1: I suggest that to back up your observation that the regional pattern in erosivity is dominated by orography, you should include a topographic map showing ground elevation for comparison with the map in Figure 2.

16. Page 8, line 13: "Using the normal distribution" – but are the erosivity values normally distributed?

17. Page 8, line 32: Which variogram was the kriging conditioned by? I would expect

kriging to maintain the spatial stucture even in a block kriging case, so it is odd that the kriging changes the variogram.

18. Section 3.3: I suggest adding more lines to your Figure 4 to show all the lines you mention in the text.
19. Page 9, line 21: I'm surprised that you would expect less than the mean erosivity for an event with a return period of 2 years. Any comment there?
20. Page 9, line 27: "d" is presumably for days but should be spelled out.
21. Page 9, line 32: To see exactly what is going on here, did you compare the the distributions of erosivity values for each of these example days? I suspect that the median values would be more stable.
22. Page 10, line 20: I think Fig. 5 should be Fig. 6.
23. Page 11, line 18: No definition of C-factor calculations is given; please add one.
24. Page 12, line 22: Please define (R)USLE.
25. Figures 2, A1, and A2: Units for the plotted variable should be stated either in the key or caption.

**Technical corrections**

- Page 5, line 19: The word "occurred" can be removed.
- Page 7, line 12: By "in the smooth" do you mean "in the smoothing operation"?
- Figure 2: In the caption the average sizes of the local authority and community areas should be areas (km$^2$).



- Page 8, line 8: "very extreme" is redundant when "extreme" will do.
- Page 9, line 23: "extremer" should be replaced by "more extreme".

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