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Discussions

Interactive comment on "Rainfall estimation from a German-wide commercial microwave link network: Optimized processing and validation for one year of data" *by* Maximilian Graf et al.

Anonymous Referee #1

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General assessment.

The paper underpins the potential of rainfall estimation employing commercial microwave links (CMLs) from cellular telecommunication networks by using a full-year of data over entire Germany. The size of the dataset in terms of its coverage and number of CMLs is unprecedented. The original 1-minute temporal resolution is very high compared to other studies, which typically have 15-minute sampling strategies. Good results are obtained against a high-quality gauge-adjusted radar rainfall dataset, except for non-liquid precipitation, which was to be expected. Different rain event detection and wet antenna attenuation correction algorithms are compared. The evaluation

of CML-based path-averaged rainfall rates or sums and CML rainfall maps is fairly extensive. The paper is well written and clearly contributes to the upscaling of CMLs for rainfall monitoring. I congratulate the authors on obtaining such a large dataset, and the work they have done to facilitate this (Chwala et al., 2016).

Despite this positive assessment, I do have a number of more serious comments:

1) A comparison of the quality of CML-based rainfall estimates with those from other studies is completely missing. Please have a look at e.g. de Vos et al. (2019), who provide an overview for studies based on Dutch CML data, having a similar climate as many regions in Germany (see Table A1). Naturally, a fair comparison is only possible in case of similar thresholds and metrics, which may complicate some comparisons. It seems that no threshold is applied in your work, i.e. also zero rainfall estimates are incorporated. Please state this explicitly in your manuscript. You may also consider to show metrics for other thresholds, e.g. > 1mm. The performance can be highly dependent on the chosen threshold. This could facilitate the comparison with other studies. I miss the (relative) bias in the mean in e.g Figure 6 and Table 2.

2) It would be interesting to see scatter density plots or metrics of daily path-averaged rainfall (e.g. as. Fig. 6). It would also be interesting to see scatter density plots or metrics of hourly and daily interpolated rainfall. This would also help to compare results with those from other studies.

Specific comments.

1. pp. 1., l. 14-16: This is quite a bold statement. Though results are definitely good, correlation is not perfect and especially the coefficient of variation is rather high (Table 2). Although, part of this can be explained by representativeness errors, I think the statement is a bit too strong.

2. pp.2, l. 14-18: Add some information on geostationary satellite products. These have typically a fairly high temporal resolution of 15 min, but provide rather indirect

and therefore less accurate rainfall estimates. In addition, you could state that satellite products often have a limited spatial resolution, e.g. 0.1 degrees for GPM IMERG.

3. pp. 3., l. 21-22: Mention that all these gauges report hourly rainfall and add their spatial density (at least for the German ones), e.g. number of gauges per square kilometer.

4. pp. 3: Some more details on the reference dataset could be mentioned. What kind of rain gauge adjustment was performed (bias, spatial and what name)? Were dual-pol based algorithms employed, e.g. for clutter removal, attenuation correction, Kdp-R or Zdr-Zh-R rainfall retrieval? Why did you choose this radar rainfall product (perhaps: this is the shortest duration for which the radar product has been adjusted with gauges; even better radar products exist using more gauge data, but we wanted to show the performance with respect to a (near) real-time radar product). Is the used RADOLAN product really available in real time or is there a slight latency?

5. pp. 4, l. 5: Is this Ericsson network sufficient to provide full coverage over Germany, or is this one of the CML types used in the network of this company?

6. pp. 4, l. 11: How do you select the sub-link when two are available? Are there any criteria involved?

7. pp. 4, l. 19-23: Is the availability of radar data 100%? Please mention the availability. Is this availability taken into account, e.g. when comparing the radar-based versus CML-based rainfall maps?

8. pp. 6, l. 11: The authors could also add a reference to the overview paper by Messer et al. (2015).

9. pp. 6, l. 14: “requires repeatedly testing with the complete data set”: Does this imply that part of the methodology has been optimized using the complete data set, i.e. that the evaluation is not entirely independent?

10. pp. 7: l. 8-11 & p.8, l. 1-2: Are these checks performed for each month? So that a

link may be discarded for one month, but be available for another month?

11. pp. 8, l. 23: Can you provide a reference for the 5 percent of the time it is raining? Here you assume that it is equally distributed over Germany.

12. pp. 8, l. 23-25: Could sources of error also constitute part of this 5 percent? So, assuming that 5 percent of the time it is indeed raining, this percentage would be too low if sources of error resulting in attenuation during dry periods have a similar magnitude.

13. pp. 8, l. 26-29 & pp. 9, l. 4-6: Can you provide somewhat more information on the optimization (e.g. which criteria)?

14. pp. 8, l. 33: Replace “for of” by “for”.

15. pp. 9, l. 19: And what determines the decrease after an event?

16. pp. 9, l. 25: Do all these Ericsson antennas have the same cover?

17. pp. 9, l. 24: Is this 2.3 dB for one or two antennas? Is this value reasonable compared to the literature? In the wet antenna experiment from Van Leth et al. (2018) a value of 3-5 dB for one antenna was found (although this was not real rainfall).

18. pp. 10, l. 5: Replace “the on” by “on”.

19. pp. 11, l. 18: Replace “also is” by “also”.

20. pp. 13, l. 8 & pp. 18, l. 1: I expect that especially melting snow and ice on the covers gives rise to attenuation.

21. pp. 13, l. 20: I suppose that the reference is used to select rain rates above 5 mm/h?

22. pp. 14 & 15: For clarity I suggest to add that these are path-averages (i.e. not based on maps).

23. pp. 14, l. 14: You could add that e.g. in the southwestern part of Germany this is

the case.

24. pp. 15, l. 7: You could add that an advantage of the applied interpolation method is its robustness and speed.

25. pp. 18.: You could recommend that studying the quality of rainfall maps for shorter durations, e.g. 1 minute, would be an interesting follow-up study, especially for urban water management.

26. Figures 8 & 9: The tick marks do often not match the transition from one color scale to another.

27. pp. 16, l. 14-15: I think that algorithms using neighbouring CMLs are much more promising than satellite-based ones provided that the density of the CML network is high enough.

28. pp. 17: You could add as a recommendation to compare methods from different research groups on the same dataset, e.g. concerning rain event detection and wet antenna attenuation correction.

29. pp. 17, Figure 9: You could consider adding a map showing the relative or absolute difference of CML-based rainfall with respect to RADOLAN.

30. pp. 17. Are there any plans of merging CML data with RADOLAN? That could be an interesting recommendation. And what do you expect in terms of improved performance and especially for which areas (cities, valleys, ...)?

References.

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