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Interactive comment on "Commercial Microwave Links as a tool for operational rainfall monitoring in Northern Italy" *by* Giacomo Roversi et al.

Anonymous Referee #1

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Review of the paper "Commercial Microwave Links as a tool for operational rainfall monitoring in Northern Italy" submitted to AMTD by Roversi et al. in 2020.

This manuscript is the first one to analyze the performance of commercial microwave links (CMLs) with a large data set (350 CMLs) in Italy. The applied processing algorithm is based on an open-source state-of-the-art method (RAINLINK) which has only been modified slightly. The main contribution of the manuscript hence is the analysis and discussion of the unique CML data set for the target region. The authors also give some new insights into how CML rainfall estimates perform under certain circumstances. Since CML data is not easily available for analysis in most countries the current manuscript provides an important contribution to the scientific community working on rainfall estimation and is certainly interesting for readers of AMT.

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Discussion paper

The manuscript is well structured and the applied processing methods are sound. Writing should be improved, though. I also have two major general comments regarding the analysis of the results which will require a major revision of the manuscript. I also have some minor and specific comments.

Major general comments and suggested major changes:

1. The main limitation of this study is that it lacks comparability to other studies because the quantitative analysis of the skill of the produced CML rainfall maps is only carried out for a subset of the data, namely the data pairs where the reference and the CML rainfall is > 0.1 mm/h. None of the other studies that use the RAINLINK algorithm and similar CML data (15 minute min/max) use this approach (see Table A1 in de Los et al. 2019 DOI: 10.1175/JTECH-D-18-0197.1). This also limits the interpretability of the results in this manuscript since the effect of bad FAR and POD, which lead to overestimation (high FAR) and underestimation (low POD), cannot be studied in the resulting rainfall fields. I strongly suggest to carry out the analysis of the rainfall fields for different subsetting variations. The most commonly used ones for comparing rainfall maps seem to be: 1. No threshold 2. Reference > 0.1 mm. This does not mean that all the plots have to be done several times, but at least the main skill metrics should be provided for the different subsets.

2. Since a large part of the quantitative analysis is based on interpolated rainfall maps, I strongly suggest to show several examples of interpolated CML rainfall maps, e.g. of one or two specific events and e.g. accumulated over the whole period.

Minor general comments:

- Choice of POD and FAR: I assume (since it is not specified in the manuscript I looked at other papers that use RAINLINK) that POD is hits/(hits+misses) and FAR is false_alarm/(hits+false_alarm). If this is the case, POD is the true positive rate (TPR). Wouldn't it than be better to use the false positive rate (FPR), like it is used in the ROC curve, instead of FAR. FPR and TPR are both normalized by the reference conditions.

FAR instead is normalized by the predicted positive conditions. Can you elaborate on this choice?

- The writing needs improvement throughout the manuscript, in particular the introduction and conclusion. Hence, I stopped very early to note down technical corrections and suggestions for stylistic improvements when reading the manuscript.

Specific comments:

L28: It would be good to have another or additional reference for the claim that the "last generation polarimetric systems have only partially mitigated“ the radar QPE problems. The book by Ryzhkov and Zrnic, 2019 is certainly a very valuable textbook, but is is hard to find this conclusion in a 450 page reference. Access to it might also be limited.

L32: "...accuracy is still under evaluation (Tan et al., 2018)...“. This statement is a bit weak. In addition, there are many studies that evaluate the performance of IMERG, also on a broader level than Tan et al., 2018.

L34: I think "broad diffusion“ is the wrong term here. Something like "ubiquity“ would fit better.

L36: "Accurate algorithms were introduced to measure ... drop size distribution ... water content“. Since the sentence before talks about CMLs, the used references do not fit here, since they did not use, or only partly used, CML data. Dual-frequency and dual-polarization data, as used in the references, is mostly not (yet) available in operational CML networks.

L38: "...a spatially continuous rainfall path...“ It is not clear to me what that means. Please rephrase.

L50: This is a very long and confusing sentence.

Section 2.1: What is the power quantization of P_min and P_max? Please specify.

Fig1. and section 2.1.1: Are there pixels without a CML, i.e. LC = 0. This is not clear from the map and the text. Please clarify. If yes, what are the implications. E.g. if you would have to interpolate a rainfall field over two empty pixels in the west of Parma that would decrease the performance a lot compared to pixels that at least have one CML.

L170: It would be good to know what "set of consistency checks“ has been used. Is everything done as in Overeem et al 2016? Even if yes, a short summary (2-3 sentences) would be good so that the reader does not have to go through the explanation in the reference.

L174: What is "a comparable decrease“? Please be more specific.

L178: Also here, it would be good to get more info on the outlier filters. What exactly was done? And even more important. How much data was removed?

L186: Did you use specific a and b values from van Leth et al, 2018? If not, it is not clear why this is cited here. Please cite the source of the a and b values.

L199: What was the length of the CMLs below 10 GHz? Even at 30 km (the maximal length in your data set according to section 2) a CML with 5 GHz is very insensitive to rainfall (approx. 0.05 dB at 1 mm/h path-averaged rainfall) so that light to moderate rain might not cause a detectable signal. Can you make sure that this does not have negative effects on the rainfall fields for light and moderate rainfall events (in the range 1-10 mm/h)? Couldn't it be that CMLs with zero rain rate are introduced in the interpolation method, which would better be left out? How much CMLs would you loose if you do not include CMLs below 10 GHz and how much does the "spatial coverage“ decrease?

L209: My feeling as a non-native speaker is that "delineate“ is the wrong term here.

Section 3.3: It is not clear from which reference you took which skill indicator. In my opinion, it would be best to define the skill indicators here to avoid any misconceptions.

L214: Complicated sentence and unclear formulation. I guess you are trying to say that your CML and reference products have a lot of rain rate that are so low that they can be neglected in any application.

Fig. 2: It would be good to know the minimal distance from the individual CMLs to the reference rain gauge.

Fig. 3: This figure contains a lot of useful information. It is a bit unstructured, though. It could be cleaned up by aligning the x-axis of each column and by sharing the legend in row 1 and 2. In row 3 two columns for "back“ and "forward“ could be used. Reusing the colors from row 2 in row 3 for different variables is also not ideal. The x-axis tick labels are also different in row 3 from row 1 and 2, so that it is not clear if the depicted periods are exactly the same. Hence, in particular the alignment of the x-axis would help. If you redo the plot, which is what I would suggest, than you could also reconsider the order of the rows. I feel that starting with the raw data (now row 2) would make more sense since this follows the CML data processing workflow. The meaning of the pink horizontal band, explained in the text, should also be explained in the figure caption.

L262: Can the overestimation of the one CML be explained by the spatial distance between this CML, the other CMLs and the gauge? If not, what is your explanation?

L269: Does this CML show these differences between P_max and P_min during the whole period? If yes, are there other CMLs that show something similar? Do you have any explanation or mitigation strategy? Regarding an operational application of CMLs there should be a way to deal with this kind of signals.

L281: If I understand correctly this data set is not part of the data set for the main analysis of the paper, correct? Please clarify in the text.

Section 4.1.3: It would be important to know the height of the antennas and the estimated height of the melting layer or zero-degree level. Form the fact that the data is from the month of March is cannot be concluded that the CML measured mixed-phase or solid precipitation.

L288: "...âĂŽbright band‘ in the radar reflectivity maps and is thus easily detected“. If you have a dual-pol radar with a working hydrometeor classification, then yes, it can be detected. If not, than this is quite hard to do for smaller scale precipitation events and on short temporal durations. I suggest to add some more details to the explanation in the text.

L296: Is this underestimation due to missed event or to a general underestimation of the CML rain rates? And why didn't you try to adjust the wet antennae compensation to compensate this underestimation? Overeem et al. 2013 and 2016 calibrated the wet-antenna compensation for a specific subset of their data, so it might neither be optimal nor applicable to your data. Please explain.

L298: Since your study and the two other studies all use a different "Filter“ (see your Table 2) the results are not really comparable. In particular your choice of "Ref. AND Product > 0.1 mm h−1“ neglects the negative effects of false positives and false negatives. See my major comment above.

L318: "The accuracy in the estimates is reached at the expense of POD, ETS and BIAS: around 50% of the rainfall duration is lost in this are“. I understand that when FAR is lower (mentioned in the sentence before) and POD is lower there are less rain events, both correct and incorrect ones, in the resulting CML rainfall time series. That would explain that there is even more tendency to underestimate here. But, if I understood correctly, the bias is only calculated from values where both CML and reference are above 0.1 mm/h, so that false and missed CML rain events have no impact on the calculation of the bias. Can you elaborate on that?

L324: Remove the "For“ at the beginning of the sentence

L327: "...this suggests that LC is probably not the only variable at play there“. This is good to know, since that would have meant that regions with high CML density perform bad with the used algorithm. The CML data set of Overeem et al 2016 also has regions with a very dense network and regions with a coarser network. Hence, a strong dependence of the RAINLINK algorithm on LC should have already been noticed by them. Could it be that there is one CML in this area that shows "strange“ behavior, e.g.

strong fluctuations, that negatively affects the POD of the many surrounding CMLs by not letting RAINLINK do the detection of rain events?

L355: Since your reference data set ERG5 is an interpolated rain gauge product, it might miss small scale rain events compared to the radar. Assuming that clutter removal was done in a sufficiently good way, the radar should not have a high FAR in general. Couldn't the fact that ERG5 might miss some real rain events explain the high FAR of the radar product?

L362: "...making CML a more robust sensor.“ Robust in what sense? Please explain in more detail in the text.

L365: When speaking about the "operational context“ and the advantages of CMLs it should be discussed how the low POD, found in this study, affects the CML's potential for operational applications. This should be part of this paragraph.

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