Evaluation of error components in rainfall retrieval from collocated commercial microwave links

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The authors present yet another work on commercial microwave links (CMLs), widening the scope and understanding of such an interesting topic, which has gained momentum during the last two decades. The aim of this paper is to show the performance of collocated CMLs, i.e., CMLs sharing the same link-path, and receiving and transmitting antennas (operating at different frequencies though). Although past studies have dealt too with collocated CMLs, the approach that the authors present in this work is innovative as they expand, and mainly focus, on the performance of collocated CMLs against not collocated ones.

The manuscript needs some re-working as it is not perfectly written, something which at some point interferes with the narrative of the idea/message. Hence, I suggest its publication after some (quasi-) major changes.

MAJOR COMMENTS

- pag. 7, line 197: What the maximum 5-min intensity is computed for?. There seems to be no use of such estimates further down the analyses. Besides, further ahead in line 198, the median of the maximum 5-min intensities is not shown in Figure 3 (as the authors seem to suggest).
- pag. 8, lines 219 to 227: Enclose these two paragraphs into a section titled 'Radar data', for instance.
- pag. 8, line 231; and pag. 9, line 246: Equations (8) and (9) are very basic equations that can be removed, given that they are not essential in the analyses nor in the results presented in this manuscript.
- pag. 8, lines 232 to 241; and pag. 11-12, lines 333 to 341, pag. 24, Table 1: The authors propose 3 alternative methods to estimate baseline and WAA. Nevertheless, the description of such methods is not entirely clear. Furthermore, the authors do not offer a solid argument (neither do they present compelling results/figures) on how these alternatives would benefit potential future studies (which apparently is not the case, given what they conclude in pag. 12, lines 342 to 344). Overall, this unclarity and lack of results leads to confusion, and aimlessness with regard to alternatives in baseline and WWA estimates. What I suggest is that the authors either offer a more in-depth view of the alternatives they present, and the benefits in implementing them (with results included); or do not mention/present at all such alternatives, thus avoiding obscuring the simple/basic idea they center their work around. If the authors proceed with presenting these 3 alternatives, the enumeration (of the alternatives) should be 1 to 4, instead of 0 to 3 (as it presently is). It also worth mentioning in your description/analyses of Wet/Dry classification periods, works such as Song et al. [1], for instance.
- pag. 11, line 323: Instead of analyses for $10-\mathrm{min}$ aggregations, I'd prefer to see aggregations at $1-\mathrm{h}$. In practical applications 5 and $15-\mathrm{min}$ aggregations are near enough (to $10-\mathrm{min}$). Nevertheless, having hourly aggregates/estimates would allow comparisons with other rainfall products (e.g., satellite).
- pag. 19, Figure 2: This would be a more valuable plot if it were presented as a scatterplot of Frequency vs. Length (in the style of Figure 2, of your reference in line 420; or Figure 7, of your reference in line 428; or Figure 2, of your reference in line 443); which it is more common and "standard" in CML studies. If any color scale is to be applied, that could be site-code, for instance.
- pag. 20, Figure 5; and pag. 21, Figure 6B; and pag. 22, Figure 8B: Join these figures into one (i.e., one figure three panels).
- pag. 21, Figure 6A; and pag. 22, Figure 8A: Join these figures into one (i.e., one figure two panels).
- pag. 21, Figure 7; and pag. 22, Figure 9: Join these figures into one (i.e., one figure two panels).

MINOR COMMENTS

- pag. 1, line 10: Replace 'reference' by 'reference to'.

– pag. 1, line 13: Replace ‘2014 and 2016’ by ‘2014 - 2016’ (given that your study goes from 2014 through 2016, right?).

– pag. 1, line 13: Replace ‘in 1-min’ by ‘at 1-min’.

– pag. 1, lines 14, and 15: Replace ‘commercial microwave links’ by ‘CMLs’ (from line 1 the authors established the acronym, so why not use it here too?).

– pag. 1, line 27: Replace ‘studies’ by ‘studies have’.

– pag. 2, line 27: Replace ‘have not been, to the best of our knowledge, reported’ by ‘have not been reported, to the best of our knowledge’.

– pag. 3, line 64: Replace ‘or’ by ‘and’.

– pag. 3, line 68: Replace ‘the same frequencies and at’ by ‘equal and’.

– pag. 3, line 69: Replace ‘these’ by ‘such’.

– pag. 3, line 75: Remove ‘finally,’.

– pag. 3, line 77: Replace ‘utilizes’ by ‘uses’.

– pag. 3, line 78: Replace ‘total loss’ by ‘total path loss’.

– pag. 3, line 79: Replace ‘rainy’ by ‘wet’.

– pag. 3, line 79: Replace ‘and accounting for’ by ‘plus the’.

– pag. 3, line 79: Replace ‘that is caused by water’ by ‘caused by the water’.

– pag. 3, line 80: Replace ‘forming on antenna’ by ‘accrued on the antenna’.

– pag. 3, line 80: Replace ‘rain and dew’ by ‘rain and/or dew’.

– pag. 3, line 80: Add your reference ‘Leth et al., 2018’ (which should actually be ‘van Leth et al., 2018’) after/before ‘Chwala and Kunstmann, 2019’ (please, note that is ‘Chwala’, and not ‘Chawla’). Double check all your references for such inconsistencies.

– pag. 3, line 80: ‘The specific raindrop attenuation...’. You have so far not defined what ‘specific attenuation’ is. Please, add accordingly something like: ‘, which is the total path loss divided by the link-path distance...’.

– pag. 3, line 81: Replace ‘estimation’ by ‘estimates’.

– pag. 3, line 91: Replace ‘0.3 resp. 1 dB’ by ‘0.3 and 1 dB, respectively’. Furthermore, the authors seem to use (quite often) ‘resp.’ as an acronym of ‘respectively’, something I have personally never seen before. Therefore, please change accordingly all the ‘resp.’ instances (e.g., lines 97, 186, 200).

– pag. 3, line 92: Please specify again what the ‘second case’ refers to.

– pag. 4, lines 98, and 100: Remove ‘losses due to’.

– pag. 4, line 99: Replace ‘losses causing’ by ‘caused by the’.

– pag. 4, line 100: Remove ‘wet antenna attenuation’ (The authors already established the acronym in pag. 3).

– pag. 4, lines 101, and 102: Remove this sentence. The authors already established what WAA is (

– pag. 3, line 80).

– pag. 4, line 103: Replace ‘separated’ by ‘regard to’.

– pag. 4, line 106: Remove ‘, thus,’.

– pag. 4, line 108: Replace ‘necessarily fulfilled’ by ‘entirely accurate’.

– pag. 4, line 109: Replace ‘, as well as temperature, can’ by ‘and temperature’.

– pag. 4, line 110: I'd suggest replacing 'raindrop path attenuation' by 'attenuation from raindrops'; in all possible instances, e.g., lines 131, and 134.

– pag. 4, line 111: Replace 'can' by 'do'.

– pag. 4, line 119: Replace 'WAA magnitude and pattern' by 'patterns of WAA magnitude'.

– pag. 4, line 121: Replace 'a power' by 'the power'.

– pag. 5, line 124: Replace 'on CML' by 'on the CML'.

– pag. 5, line 125: Use the DSD acronym first in pag. 2, line 36 (not here).

– pag. 5, line 125: Replace 'alpha and beta' by 'α and β'.

– pag. 5, line 128: Replace 'are lowest' by 'are the lowest'.

– pag. 5, line 130: Replace 'of total' by 'of the total'.

– pag. 5, line 131: Replace 'by CML' by 'by the CML'.

– pag. 5, line 132: Replace 'incorrectly estimated' by 'wrong estimates of'.

– pag. 5, line 133: Replace '$k - R$ relation non-linearity' by 'the non-linearity of the $k - R$ relation'.

– pag. 5, line 137: Replace 'The same collective of authors' by 'Fencl et al., 2020 also' (and remove this reference at the end of the sentence).

– pag. 5, line 139: Remove 'alone'.

– pag. 5, line 142: Remove 'can, however,'.

– pag. 5, line 143: Remove 'Losses on the antennas also include WAA caused by the formation of a water layer on the antenna radomes.' (too repetitive by now).

– pag. 5, line 147: Replace 'EM' by 'Eletromagnetic (EM)' (this acronym was not previously established).

– pag. 5, line 148: Replace ', however, they interact' by 'interacting'.

– pag. 5, line 148: Replace 'Discrepancies' by 'Therefore, discrepancies'.

– pag. 5, line 149: Remove 'thus'.

– pag. 5, line 150: Replace 'the same frequency' by 'equal'.

– pag. 5, lines 152 to 154: Remove the last sentence (it's repetitive of the above sentence, and adds confusion instead of clarity).

– pag. 6, line 156: Replace 'twelve' by '12'.

– pag. 6, line 160: Remove 'one pair of' (in both instances).

– pag. 6, line 161: Replace 'intercompared for' by 'compared among'.

– pag. 6, line 151: Replace 'frequency bands' by 'frequencies' (here and everywhere else in the manuscript; e.g., lines 169, 244, 247, 263, 264, 288, 289, 382, 385, 386, 515, 570).

– pag. 6, line 162: Replace 'sites' by 'the sites'.

– pag. 6, line 164: Remove the title 'Materials'.

– pag. 6, line 165: Enumerate 'CML' as 3.1.

– pag. 6, line 168: Replace 'To compare, such' by 'Such'.

– pag. 6, line 169: Replace 'urbanized' by 'urban'.

– pag. 6, line 170: Replace '682 m to 5836 m' by '~ 0.7 to $\sim 5.8\,\mathrm{km}$'.

– pag. 6, line 173: Replace 'having' by 'having a'.

- pag. 6, line 173: Replace 'are 0.3 m or 0.6 m in diameter' by 'have diameter of 30 or $60\,\mathrm{cm}$'.
- pag. 6, line 174: Replace 'polarizations, are' by 'polarization is'.
- pag. 6, line 176: Replace 'respectively' by ', respectively'.
- pag. 6, line 177: Enumerate 'Gauge-adjusted radar rainfall' as 3.2 (and re-enumerate the remaining titles accordingly).
- pag. 6, line 180: Replace 'permanent municipal RG' by 'municipal rain gauge' (as the authors do not use anywhere else the 'RG' acronym).
- pag. 6, line 182: Replace 'monthly and regularly dynamically calibrated' by 'and regularly calibrated on a monthly basis'.
- pag. 6, line 186: Replace 'spatial and temporal' by 'spatiotemporal'.
- pag. 6, line 186: Replace 'resp.' by 'every'.
- pag. 7, line 188: Replace 'uses a data set collected during the monitoring of the' by 'is for the monitoring'.
- pag. 7, line 188: Replace '2014 and' by '2014 through'.
- pag. 7, line 189: Replace 'In total' by 'In total,'.
- pag. 7, line 190: Replace 'one hour' by '$1\,\mathrm{h}$'.
- pag. 7, line 191: Replace '304 h and 15 min' by '$\sim 304\,\mathrm{h}$'.
- pag. 7, line 191: Remove 'and 15 min'.
- pag. 7, line 194: Replace 'First' by 'one'.
- pag. 7, line 195: Replace 'Second' by 'the other'.
- pag. 7, line 196: Replace 'ten' by '10'.
- pag. 7, line 197: Replace 'maximal' by 'maximum'.
- pag. 7, line 198: Replace 'median maximal' by 'average maximum'.
- pag. 7, line 199: Replace 'reached up to' by 'was'.
- pag. 7, line 199: Replace 'events up to' by 'events was'.
- pag. 7, line 199: Replace 'median' by 'average'.
- pag. 7, line 202: Remove 'temporal'.
- pag. 7, line 203: It is not clear how the authors perform 1-min aggregations 'using averaging'.
- pag. 7, line 210: Replace 'wet antenna attenuation model was' by 'WAA model is'.
- pag. 7, line 213: Replace 'maximum Aw' by 'maximum WAA' (why not use WAA instead of Aw in Equation (6)?).
- pag. 8, line 216: Replace 'product grid cells' by 'pixels'.
- pag. 8, line 225: Replace 'The data were resampled to 1 h timesteps' by 'Radar data was aggregated from 5-min to 1-h'.
- pag. 8, line 230: Remove 'of the' from 'mean of the rainfall'.
- pag. 8, line 243: Remove '(Figure 2)'.
- pag. 9, line 250: Replace ':' by ', i.e., '.
- pag. 9, line 252: Replace 'which one' by 'which at least one'.
- pag. 9, line 253: Remove the first sentence.

- pag. 9, line 256: Please clarify what do you mean by 'the deviation' (deviation from what?).
- pag. 9, line 258: Remove the last sentence (of the paragraph).
- pag. 9, lines 261 to 262; and pag.12, line 346: Please, remove this "filling" text (no need for it).
- pag. 9, line 264: Remove 'are evaluated in this subsection'.
- pag. 9, line 265: Replace 'demonstrates' by 'shows'.
- pag. 9, line 265: Remove 'at two stages of processing: rain-induced attenuations are shown in the top panel, and rain rates in the bottom panel'.
- pag. 9, line 268: Remove ', which, on the other hand, is not evident from the scatterplots (Fig. 6)'.
- pag. 9, line 269: Replace 'represents all eight' by 'shows all 8'.
- pag. 9, line 272: Replace 'To conclude, this' by 'This'.
- pag. 9, line 273: Replace 'is low in total CML observation error' by 'in total CML observation error is low'.
- pag. 9, line 274: Replace 'Scatterplots' by 'Figure 6 shows scatterplots'.
- pag. 10, line 276: What is 'sensitivity'?; and how it's measured? (do you mean 'uncertainty', maybe?).
- pag. 10, line 283: Replace '(Fig. 7)' by 'in Figure 7'.
- pag. 11, line 310: Remove ', thus,'.
- pag. 11, line 315: When the authors say 'the WAA model used', to what WAA-model exactly you're referring to? (please see my "major" comment in regard to the models of WAA (and baseline) estimation).
- pag. 11, line 311: What do you mean by 'match'.
- pag. 11, line 332: Remove 'further,'.
- pag. 12, lines 358, and 359: It is not clear form this last sentence whether the antenna size does influence (or not) the performance the rainfall retrievals. Please clarify.
- pag. 13, line 376: Replace 'The presented' by 'This'.
- pag. 13, line 378: Replace 'The' by 'This'.
- pag. 13, line 385: Replace 'RMSE (differences) of the retrieved rainfall information' by 'differences in RMSE of rainfall retrievals'.
- pag. 13, line 386: Please update all instances of $\mathrm{mm\ h^{-1}}$ to $\mathrm{mm \cdot h^{-1}}$.
- pag. 13, line 388: Replace 'types,' by 'types (convective and stratiform),'.
- pag. 13, line 393: Remove this first sentence (please also see my "major" comment in regard to the models of WAA (and baseline) estimation).
- pag. 11, line 397: Remove ', first and foremost,'. This sentence needs rewording. There's no clarity in what the authors want to convey, especially it been in the "Conclusions".
- pag. 12, line 401: When the authors say 'perform consistently'; do they mean 'consistently good' or 'consistently bad'?.
- pag. 13, line 412: Replace 'Last but not least, we would like to' by 'We also'.
- References section: there are at least two references in which the DOI links do not work, i.e., pag. 15, line 461; pag. 16, line 469. Please check that all the DOIs of the cited references point to valid addresses.
- pag. 18, line 515: Replace 'and "b"' by 'whereas "b"'. I also suggest a change in the color scale. It's hard to distinguish those CMLs in yellow.

– pag. 19, Figure 3: I still don't see the need for a 5-min moving average. This means that in principle, the authors are averaging out potential larger 1-min intensities, for instance. So, what's the purpose of using a 5-min moving average, if in the end the authors are performing analyses at 1-min resolution (e.g. Figure 11).

– pag. 20, Figure 4: I think these two sub-figures/panels could be join into only one figure, by having a secondary Y-axis (on the right) representing either rainfall intensity or attenuation

– pag. 22, line 555: Replace 'line $y = x$' by '$1{:}1$ line'.

– pag. 25, line 568: Replace 'Metadata table of CMLs' by 'CML metadata'.

– pag. 25, line 569: Remove the first sentence.

– pag. 25, lines 569 to 572: This paragraph should not be presented as an independent paragraph but as the caption of Table A1.

– pag. 25, line 570: Replace 'The frequency' by 'The frequencies'.

– pag. 25, line 571: Replace 'of one link' by 'in one link path'.

– pag. 26, line 574: Add this line add at the end of the caption of Table A1.

– pag. 25, Table A1: Remove the current title of the table. Column $\alpha - \beta$ should be split into two columns (i.e., α, and β) (if that creates a wider table, then present it in landscape mode). Columns 'Antenna size node A (m)', and 'Antenna size node B (m)' are taking too much space, and not contributing too much to the table; you can avoid this just by stating (e.g., in the caption of the table) that all antenna sizes are $30\,\mathrm{cm}$, except for node B in site 1b (UKY 22046/SC15), and nodes B in sites 10a...etc.

– pags. 27 and 28, Table B1: I don't see the need of this table, especially given that the authors presented this data in Figure 3.

REFERENCES

[1] Song, K., Liu, X., Zou, M., Zhou, D., Wu, H., and Ji, F.: Experimental Study of Detecting Rainfall Using Microwave Links: Classification of Wet and Dry Periods, IEEE J. Sel. Topics Appl. Earth Observ. Remote Sens., 13, 5264–5271, https://doi.org/10.1109/JSTARS.2020.3021555, 2020.