

## ***Interactive comment on “Improving the precipitation accumulation analysis using radar-, gauge- and lightning measurements” by E. Gregow et al.***

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This paper describes an assessment of the quality of quantitative rainfall estimates using a combination radar, cloud-to-ground lightning, and rain gauge data. The effect of adding GC lightning data to radar data on rainfall accumulations is investigated, both before and after gauge adjustment. In these analyses, several methods of estimating relations between lightning activity and rain intensity are utilized. Furthermore, the effect of the length of the accumulation interval used for gauge adjustment is also studied. The paper is interesting, and its topic relevant. It is not entirely clear to me what the main goal of this paper is. I think that the paper could benefit from a clearer description of what its main goals are, how the analyses that are presented contribute

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to these goals, and coming back to these goals in the Discussions and Conclusions section. When reading the paper for the first time I was sometimes confused because new analyses are proposed in the Results section and some of the methods described in the Methods section were not entirely clear to me. Hence, the paper could benefit from some restructuring, where all methods that are used are presented clearly in the Methods section. I think that the paper needs major revisions in order for it to be suitable for publication. More specific remarks are given below.

### **Specific comments**

1. Section 1, Given the fact that there are not very many lightning strikes in Finland, how much would you expect that adding this information would influence the final rainfall estimates? I think that this should be thoroughly discussed in the introduction of the paper.
2. Section 3.3, It's not entirely clear how radar and lightning data are merged to come up with a final rainfall estimate. Did I understand correctly that the number of recorded GC lightning strikes within a LAPS pixel (3x3 km) and in a 5-minute interval are counted. These counts are then related to a vertical reflectivity profile, and subsequently the maximum of the radar reflectivity and the 'lightning reflectivity' are taken at a given height. The rainfall estimate is then based on the lowest data point. In practice, this means that the rainfall estimate is based on the maximum of the lowest-level radar reflectivity and the lowest-level 'lightning reflectivity'. If this is indeed the case, the description of the method to estimate rain rates could be simplified and clarified. If not, I recommend clarifying this section.
3. I.137-149, Given the fact that lightning only occurs in convective situations, it would make sense to me if a  $Z - R$  relation specifically derived for convective

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rain is used wherever lightning is observed. This would be a simple addition to the LDA that could improve results even further.

4. l.174-177, the rationale behind the regression part of the RandB method is that radar rainfall estimates often suffer from large-scale multiplicative biases, and that using regression on radar and gauge data can correct for this error. When adding lightning data to radar data, the errors are likely to be very different, and this could have a large effect on the final rainfall estimates. Something similar can be said for the Barnes-part of the RandB method, where the influence of a gauge correction is in general relatively large compared to the area affected by lightning. I therefore strongly suggest to add a discussion of this in the paper.
5. l.176-177, What does it mean that Rad\_LDA\_Accum is the reference?
6. Section 4, Why are the graphs where rainfall intensities are compared plotted on log-log scales? If the aim is to study the performance of quantitative precipitation estimation algorithms for high intensities (as is stated in the paper), it would make most sense to me if these graphs were plotted using linear axes.
7. l.187-188, what exactly is meant by “the averaged (i.e. 50%-percentile) Rad-Lig reflectivity profiles from the LDA-method.”? How were these profiles determined, and based on what data? I think this should be discussed in the Methods section.
8. l.192-200, I suggest to remove the  $R^2$  statistic, because it is simply the correlation coefficient squared (see Eqs (6) and (7)) and it hence doesn't add any information relative to CORR.
9. l.202-207, The panels of Fig. 4 with LDA added (i.e. panels b and d) do not really add any information, as they are extremely similar to panels a and c, respectively. I therefore suggest making a remark in the text about this, and removing either panels a and c, or panels b and d.

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10. l.208-212, I would strongly suggest using different gauges for the independent measurements to test whether using LDA improves rain estimates, because this is what I understand the main objective of this paper to be.
11. l.209-210, The use of a 25-day subset is introduced here. I suggest introducing this earlier in the paper (the Methods section). And if this subset is used, what is the added value of using the 4-day subset? I think the clarity of the paper would improve if either the 4-day or the 25-day subset is used.
12. l.225-238, It's unclear to me how the new profiles are exactly generated. I strongly suggest to include a good description of this in the Methods section (preferably in Section 3.2).
13. l.240-245, Why not test sub-hourly scales?

#### Minor remarks

1. l.16, replace “such as;” by “such as” (remove semicolon)
2. l.17, replace “economically” by “economically”
3. l.39, replace “leass” by “less”
4. l.41, what is meant by “a timely accurate manner”?
5. l.133, replace “resulting from;” by “resulting from” (remove semicolon)
6. l.133-134, consider including clutter as an important source of error
7. l.144-145, do you mean to say here that convective rain is important for flooding events? I so, I suggest changing “such situations” to “convective events”. The

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first time I read this sentence I interpreted “such situations” to be the drizzle that is mentioned in the previous sentence.

8. l.187, the 50<sup>th</sup> percentile is not the average, but the median, and it is either the 50<sup>th</sup> percentile or the 50% quantile. So I suggest replacing “averaged (i.e. 50%-percentile)” by “median (i.e. 50% quantile).”
9. l.192, I suggest calling STDEV “relative standard deviation” or “logarithmic standard deviation” to make clear that it is different from a regular standard deviation.

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