

Reply to the Comments from Referee #2 for AMT-2018-395

We would like to thank the referee for the review of our paper and the constructive comments provided. In the following, we have provided an item-by-item reply to the comments.

Major Comments:

- 1) The paper presents an evaluation of precipitation estimates by the DPR onboard the GPM Core Satellite by using a very dense gauge network located in Austria. The study can be of interest for the GPM DPR user community, because it aims at providing an independent validation of DPR precipitation estimates. Anyway many issues are present in the manuscript, that are worthwhile of further investigation. First of all the 22 selected case studies include many very light precipitation events, or no precipitation at all. The high number of correct negatives has a strong impact on the statistics and should be not included in the analysis. Moreover I do not see an evaluation of the rainfall variability in the DPR footprint, thanks to the very dense gauge network. Thus the usefulness of such a density seems to be not fully exploited. English can be improved. Many typos are present and terminology used is often quite approximative and needs to be checked. Moreover the statistical analysis is not well designed in my opinion. At the end my feeling is that the paper does not add enough relevant and new knowledge on the topic stated in the title. Thus I think the paper could be considered for publication in AMT, provided that a careful effort of major revision is undertaken.

You are right, the number of correct negatives influences the statistics, even though the amount of rain/no-rain events is balanced. In order not to provide misleading numbers, we will therefore exclude these biased indicators (PC and POFD). Instead, we will include the ETS, CSI and HSS to provide reasonable statistics. As the rainfall variability is not sufficiently addressed we will discuss the intra-footprint variability based on a scatter plot of $|WegenerNet - DPR|$ and $std(WegenerNet)$. The inter-footprint variability will be approached by $avg(|WegenerNet - DPR|)$ in one event and $std(WegenerNet)$ in one event. Terminology and English will be checked and improved.

Specific Comments:

- 1) Page 2 Line 18: If by “The microwave imagers” you mean the GMI, please reword “The microwave imagers augment the core satellite and enable a high temporal resolution for global precipitation maps.” to “The GMI completes the core satellite, enables a high temporal resolution for global precipitation maps and is used as a calibrator for the other radiometers in the constellation.” If you are referring to the other radiometers of the GPM constellation, please use the words “microwave radiometers”, not “microwave imagers”, because not all of the constellation instruments are imagers (e.g. MHS is a sounder).

Thank you for the correction and phrasing. We are happy to use your nice wording, that is exactly what we wanted to say.

- 2) Page 3 line 2: “only measurements at points in time” means “instantaneous precipitation rate”

Thank you for the clarification, which will be incorporated.

- 3) Page 3 lines 4-5: more and better with respect to?

It was meant to be with respect to the GPM-DPR measurements.

- 4) Page 4 line 12: what do you mean by “up to 0.1 mm”?

The bucket has a volume of 0.1 mm equivalent.

- 5) Page 4 lines 19-28: I do not agree with the authors about this paragraph. Why do they say that the WegenerNet is twice as good as the DPR? The availability of about 1 gauge per 2 km², while the DPR resolution is roughly 5x5 km², makes the difference in resolution much higher. Moreover they say “there is no other precision (quality) information for the GPM-DPR estimates”: what do they exactly mean? Finally: I do not think that the gridded gauge data are actually characterized by a higher resolution, with respect to the station data. I think that the inverse distance method used to regrid data cannot really “increase” the resolution from 2 km² to 200m x 200 m. Please explain better this issue.

Twice as good is referring to the minimum resolution in the amount of rain, not to the areal resolution, but you are right, this is a “non-scientific” phrasing. The sentence “there is no other precision (quality) information for the GPM-DPR estimates”, had the intention to state that the DPR products do not deliver a value to assess the quality of each estimate (e. g. the standard deviation). The interpolation does indeed not add new information, but allows to include rainfall information from gauges that are located outside of DPR footprints - but still within a radius of influence. This is one of the advantages of a dense network. We rephrase that paragraph for more clarity.

- 6) Page 5 lines 5-10. The concept is often right, but this paragraph should be written in a more precise way. The DPR swath includes 49 beams (or rays), not bins. TheKaPR includes 49 beams in total, but only 25 are overlapped to the KuPR ones, the other 24 are interlaced. The sentence “The KaPR on the other hand, has half of the swath size of KuPR with 120 km and 49 bins” seems to mean that KaPR has roughly twice the KuPR resolution. The sentence “KaPR shall provide better information on light rainfall and snow.” is not completely correct. This was the aim, in some sense, of the availability of Ka-band in the DPR, with respect to TRMM PR I mean. Anyway there is a relevant bibliography dealing with the problem of detecting light rainfall and especially snow by means of KaPR, because of its low sensitivity (e.g. Casella et al, that is the list of references, but is not cited in the manuscript).

Thank you very much for this comment. We will rewrite that for more clarity. The use of “bins” stems from the GPM Data Utilization Handbook (third edition), where the beams are referred as “angle bins”. It was not meant to be mixed up with the range bins within one angle bin.

- 7) Page 5 line 14-15: DPR does not measure cumulated rainfall, but instantaneous one. So here you should write 0.2 mm/h and 0.5 mm/h.

Thank you for the remark, we will change it accordingly.

- 8) Page 9 lines 23-24: because the authors are aware that correct negatives take an effect on the results, why do they include them in the statistical analysis. I should suggest to avoid them and to use other scores (e.g. ETS, HSS) to evaluate the performances. In which way you carefully choose the events?

The "careful choice" means that we found a balanced environment of rain/no-rain events. Following your suggestion, we will cancel the PC and the POFD to avoid the usage of correct negatives and move to ETS and CSI as well as HSS. Consequently, the "careful" choice can be omitted as well.

- 9) Page 11 lines 6-12: This paragraph is not clear. I do not understand how you round to zero. The analysis of the subpixel-scale variability is cited, but non investigated in details throughout the manuscript.

One digit after the decimal point is considered, which means zero = 0.0 mm/h. The "rounded to zero" will be omitted, that was for the visual interpretation. As the rainfall variability is not sufficiently addressed we will discuss the intra-footprint variability based on a scatter plot of |WegenerNet-DPR| and std(WegenerNet).

- 10) Pages 12-14: all this part is not clear and in general should be rethought. Moreover the last analysis, with the constraint on GPM-DPR estimates and standard deviation, could be completely avoided. Section 4.2 The analysis of case studies is misleading. How can it happen that for some footprint stations do not measure precipitation and gridded data show a (relevant) amount of rainfall? It often happens and the authors should explain if the inverse distance used to regrid data is responsible for this strange behaviour. If so, I do not think that the gridded data have to be used, also because of the artificial higher resolution.

We delete the analysis with the constraint of the standard deviation. The interpolated gridded data can include rainfall information from gauges that are located outside of DPR footprints but still within a radius of influence.

- 11) Page 16 lines 1-6. Light rain are of convective nature? I cannot understand how you discriminate between convective and stratiform events.

We are sorry for the confusion. In fact it is vice versa than written in the paper.

- 12) Page 19 Lines 6-8: the analysis of the lag effect is correct in principle, but I do not understand the use of such a large time interval (+ 30 minutes).

The large lag time was not only to show a potential time lag referring to an error in the estimated surface bin but also to have a look at the patterns that might arise

(especially of interest in case of light rain). However, since this obviously causes confusion, we decided to restrict the lag-window to 15 minutes.

13) Page 20 Line 6: what does “although the grid changed obviously” mean?

We wanted to draw the attention to the fast moving core of the rainfall event, which is reflected in the correlation. The explanation for the correlation peak by the time of the measurement is the only valid one.

14) Page 21 Lines 12-14: I do not understand what are the authors’ plans as far as HS scan is concerned.

We will rephrase the last paragraph and cancel the HS-plans as it is off the track. We are sorry for the confusion.

References:

Many items present in the list of references (e.g. Casella et al., Petracca et al., Seto et al., Speirs et al., Szeberényi et al.) are actually not cited in the manuscript. Please check carefully. In the list of references please write the author names in the right way and put them in the right alphabetical order (e.g. Jackson is actually Skofronick-Jackson)

Thank you for the remarks. There was a misunderstanding concerning correct citations. We revise the manuscript for this deficiency.

Technical corrections:

There are many typos through the manuscript. Just some of them are listed below. The authors have to check very carefully all of them.

We checked the manuscript carefully and found quite some typos. Thank you for the kind remarks, we cleaned up the mess, deleted duplicates and performed the changes as suggested.

Figures

Figure 1: Place the label somewhere else.

Figure 3: Does min resolution Ka (that is 0.2 mm/h not mm) need to be shown?

Figure 4 caption: what is resp.? “The diagonal denotes the line where the satellite measures the same as the terrestrial network.” is obvious.

Figure 5 top panel is the same as Figure 3. Please avoid to show the same data twice.

Figure 6-9. The DPR data superimposed to the Wegener gridded ones in the bottom panel should be removed, because already shown in the top panel.

Thank you for all those remarks. The information that is shown twice was just for easy reading. If better, we remove it. The “resp” in the caption of Fig. 4 was meant to be

respective, which indeed needs to be written in full. We adapt the figures according to the remarks.