

## ***Interactive comment on “Evaluation of GPM IMERG Early, Late, and Final rainfall estimates with WegenerNet gauge data in southeast Austria” by Sungmin O et al.***

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***We appreciate the comments and suggestions from Reviewer #1 which helped to improve the quality of this manuscript. We have addressed all issues indicated in the review report and provide a point-to-point response to the comments.***

### **Major issues:**

#1 Fig. 2 is very useful to characterize the uniformity of gauge rainfall measurement. Is that possible to expand the rain rate above the current  $\sim 0.16 \text{ mm}/30 - \text{min}$ ?

C1

***We limited the y-axis to emphasize where our interest lies, i.e., very low rain rates. An inset plot will be added in Fig.2 (attached) to show higher rain rates.***

#2 In Figs. 7 and 8, is it possible to add the analysis for PMW-based and IR-based rainfall estimates by using HQprecipitation and IRprecipitation data that come with the three datasets (E, L, and Final Runs) and quantify the contribution from the two (PMW and IR) measurements? The co-author, J. Tan, has done such work before. So far, the conclusion was only based on the work done by others.

***It is true that such data (HQ/IRprecipitation) can be used to analyze the contribution of each sensor to IMERG bias. However, given that we are more interested in comparing performance between three different IMERG runs, we approached the data in a slightly different way.***

***We examined how many HQprecipitation estimates were ingested into each IMERG run during the selected rain event, as indicated by vertical lines in Figures 7 and 8. For example, what we found in Fig.8 from HQprecipitation and IRprecipitation was that i) although IMERG Late uses more PMW estimates compared to IMERG Early, there is no difference in values of PMW- or IR-based estimates between IMERG Late and Early, and ii) IMERG Final shows a more significant difference (improvement) in its estimates after morphing or bias correction (i.e.,  $\text{precipitationCal}/\text{precipitationUncal}$ ), rather than in HQ/IRprecipitation.***

***Therefore, we analyzed data differences between IMERG runs from a view of applied algorithms. More explanation will be added on i) P.8, Line 32; “... all of which somehow overestimated the rain rates (no difference in data values between IMERG-E and IMERG-L once the data are collected from the same PMW sensor)...”, and ii) P.10 Line 24; “... and the upstream data sources (i.e., contribution of each PMW/IR sensor to biases in IMERG estimates) ...”.***

C2

#3 What can we do to correct the large positive biases in E and L Runs datasets since gauge data are not available at the time when the data are available?

***We appreciate the question. It seems to us that IMERG NRT errors will likely have to be dealt with at the algorithm-level (e.g. calculating accurate PMW or IR estimates), rather than at the user-level (e.g. applying bias correction) - unless the user has access to gauge data and can apply local corrections using data relevant to the NRT product. Therefore, at the moment, our results focus on i) providing accuracy information of IMERG NRT to data users, and ii) providing a benchmark point to see improvement in the next IMERG version.***

#4 The discussion part on some issues is missing. For example, are the results unique to Austria or can be applied to other places? It would be nice to discuss and compare your results with other studies that are already published.

***The reviewer asks a good question. It does seem that the results should be transferable to other WEGN-like regions, i.e., land areas with moderate elevations. However, any direct comparison with other studies is limited because, to the authors' knowledge, there has been no research which evaluates all IMERG three runs; the independence of WEGN gauges (e.g., gauge data are not part of any gauge-adjusted IMERG dataset) enables us to conduct the evaluation uniformly across the IMERG runs.***

***This point will be addressed in Conclusion, P.10 after Line 23; "... These results on the performance of IMERG runs could be representative of other regions under similar conditions (i.e., mid-latitude land areas). The study approach is, however, not easily applicable to different precipitation regimes. This is mainly due to the limited availability of independent ground reference data like WEGN. As a result, WEGN offers valuable information about the accuracy of***

C3

***IMERG estimates across its three different runs."***

#5 Major differences between v03 and v04 need to be discussed since v03 is obsolete. Morphing algorithm refinement, etc.

***The biggest difference in the new version would be the use of GPM intercalibrated data, rather than TRMM based intercalibrations. "IMERG V04 is the first version to use the GPM Core Observatory as a calibrator for the constellation satellite partners so it is expected to provide more consistent quality among the PMW/IR estimates." will be added at the end of Conclusion.***

**Minor:**

#1 Abstract: Please add the version number of the IMERG products to avoid confusion when new version is released in future. I assume it is Version 03.

***"In this study, IMERG version 3 Early, Late, and Final ..." will be in Abstract.***

#2 P2. Line 5. Would be nice to add a description about the differences between the 3 IMERG datasets (E, L, and F runs) from the algorithm point of view in case readers are not familiar with these datasets.

***We believe that "2.1 GPM IMERG satellite rainfall estimates (P3, Lines 20 to 30)" can provide information on the differences between IMERG runs including applied algorithms (e.g., morphing scheme, gauge correction). We will add "See Section 2.1" when 'IMERG runs' first comes out in the manuscript - Introduction***

C4

**P.2 Line 12.**

#3 Figure 1. What is the red dot in the map? Does it contain the two grids in red?

***It was referring to the location of WegenerNet network; Feldbach in Austria. We assume the red color made it confusing, so we have converted the mark in black (new figure is attached). Also the caption of Fig.01 will be; "... the Feldbach region (black square) ...".***

#4 Line 21. landslides => landslide?

***Thank you for the correction.***

#5 P4. Line 1. Why? Any comments on the no major change?

***First, as we mentioned, preliminary intercomparison between IMERG V03 and V04 did not identify any major changes in performance, so it is unlikely that our conclusions will change. Second, most of the changes in V04 (see V04 IMERG Final Run Release Notes; [https://pps.gsfc.nasa.gov/Documents/IMERG\\_FinalRun\\_V04\\_release\\_notes.pdf](https://pps.gsfc.nasa.gov/Documents/IMERG_FinalRun_V04_release_notes.pdf)) are applied to all three IMERG runs, so any improvements to the Final run should also involve a similar improvement to the Early and Late runs. Furthermore, it is likely that the algorithmic and data differences between the runs (e.g. use of backward morphing between Early and Late runs, the use of gauges in the Final runs) have a stronger influence than any of these changes.***

***This explanation will be added at the end of "2.1 GPM IMERG satellite rainfall***

C5

***estimates" (P.4)***

#6 Figure 2. What time period? It is not clear.

***The time period is same as the study period. "... (April to October in 2014-2015)..." will be added in the caption of Figure 2.***

#7 Table 1. Why don't have two seasons (warm and hot) for comparison?

***This table is intended to provide general information on data sets used in the study, rather than comparison results. In addition, some information (e.g., max value, number of rain data for each season) can be obtained from the Fig. 5 and Fig. 6. Therefore, we would prefer the table as it is for the readability of the manuscript.***

#8 P4. Line 27 the units are needed for 0.05

***'mm/30 – min<sup>-1</sup>' will be added.***

#9 P. 6. Lines 12-17. Would be nice to give some weather conditions for both warm and hot seasons such as average surface air temperatures.

***Thank you for the suggestion. "According to temperature measurements collected by WEGN, the average 2-m air temperature of the study period (2014-2015) was 12.2 °C in the warm season and 18.6 °C in the hot season" will be added at P.6 Lines 15.***

C6

#10 P. 8. Line 80. Any analysis on PMW observations? All datasets contain such parameters. I don't see any analysis here.

***The focus of this particular study was on the number of PMW observations used in each IMERG run during the events (e.g., P.8 Line 15, Lines 31-33). It is beyond our scope to examine the performance of the different PMW observations contributing to the IMERG estimates. Please also refer to the reply #2 in Main issue.***

#11 Line 12. Why the time offset begins from -20 min not -60 min?

***This is because the best agreement (lower RMSE) between data is found in a positive Offset region (i.e., above 0-min), so this time range is selected to 'zoom in' at where the minima occur.***

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2017-256>, 2017.

C7

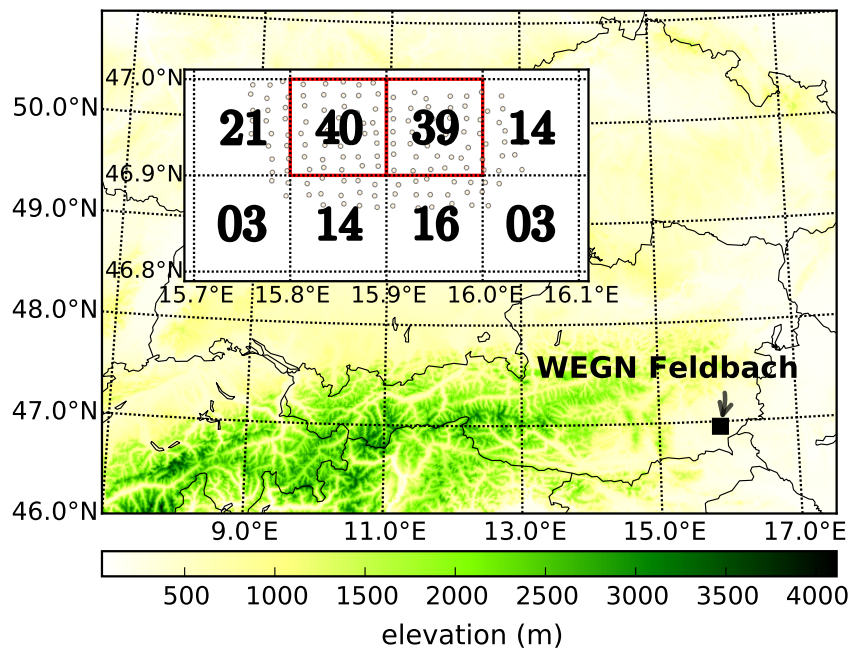


Fig. 1.

C8

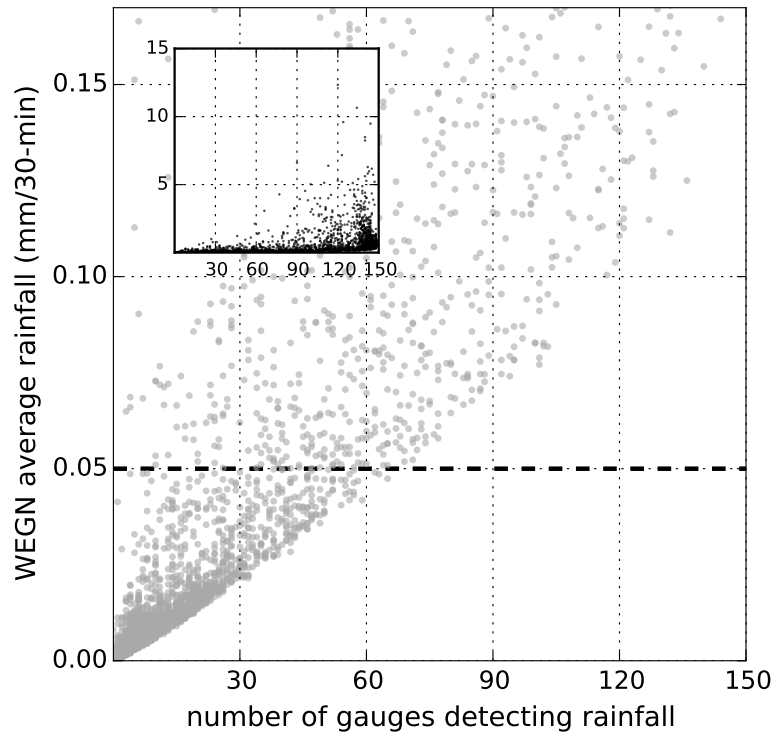


Fig. 2.