Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2017-256-RC2, 2017
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Hydrology and Earth System Sciences
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# *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.

**Anonymous Referee #2**

Received and published: 1 July 2017

This study evaluates the GPM IMERG products using rain gauge data from a dense network in Austria. The three IMERG products (Early, Late, and Final) are compared with the areal average of rain gauge data over two IMERG grid cells of $0.1^\circ \times 0.1^\circ$. The authors perform statistical analyses to quantitatively and qualitatively define errors in the IMERG products and also visually inspect two example rainfall events for diagnosing some detailed performance of the IMERG estimates. They conclude that "the IMERG-Final estimates are in the best agreement with the WEGN data, particularly for the hot season."

I think that this is an interesting paper dealing with an early evaluation of the IMERG



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products, and the topic of GPM Ground Validation (GV) is suitable for Hydrology and Earth System Sciences. I also think that this study provides useful information and some insight for algorithm developers as well as hydrologic users. However, I have some major concerns and questions, and the manuscript needs to provide some more clear insight and discussions on the findings. I would recommend this manuscript for publication after some moderate revisions. My detailed comments are provided below:

Major comments:

1. Gauge representativeness I think that 40 and 39 for given 0.1° × 0.1° (roughly 10 × 10 km2) grid cells are definitely good numbers of gauges for estimating areal average rainfall at a typical temporal scale of satellite rainfall products (e.g., three-hourly or monthly). However, since this study evaluates 30-min products for which random variability is much higher, I think that the authors should justify that the gauge representativeness error is not significant at the space and time scales used in this study. The authors could provide the structure of spatial correlation and variance reduction for the study area as shown in Villarini and Krajewski (2007).

I also think that the use of 200 × 200 m2 gridded rainfall data at 5-min scale is not reasonable (but this does not significantly affect the results of this study because the gridded data are aggregated over 30-min and 10 × 10 km2 scales and then used). The 5-min gridded map contains so much variability (in terms of gauge representativeness) due to high space and time scales used as well as the tipping bucket rain gauge error itself with tip counts within 5-min (this will also decrease with longer time integration).

2. Gauge data independence Please clarify that the rain gauge data used in this study are from an independent network. The authors state that “the WEGN is not a member network of the GPCC network” (Page 4 Line 32). However, there is another statement (Page 7 Line 33 – Page 8 Line 2) that a better performance may be attributed to an Austrian national station that are associated with the GPCC product. These are confusing.





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3. Figure 5 (the second and third columns) I may miss something, but the WEGN PDFs and CDFs exist for the entire rain rate regions although they are presented for low (<1.2 mm) and high (>1.2mm) rain amounts each. For example, shouldn't the PDFs and CDFs start from 1.2 mm in the third column (high rain rate)? Why do the PDFs and CDFs exist for R<1.2 mm?

4. Time shift in Figures 7 and 8 It is hard to say that the observed patterns in Figures 7 and 8 show a time shift. I think that we can say there is a time shift only when the rainfall durations are the same between reference (WEGN) and IMERG products and starting times are different. It seems to me like that the observed patterns are just errors, probably by morphing and other reasons. In Figure 8, the shapes and peak times are all different and it is hard to find any consistent or systematic tendency.

Minor comments:

1. Page 3 Line 1. ". . .. has been suggested to guarantee a monthly error of under 10%". This cannot be directly applied to this study because of the temporal scale difference (monthly vs. 30-min). The gauge representativeness is a function of space and time scales used (Seo and Krajewski 2010).

Reference: Seo, B.-C., and W. F. Krajewski (2010), Scale dependence of radar-rainfall uncertainty: Initial evaluation of NEXRAD's new super-resolution data for hydrologic applications, Journal of Hydrometeorology, 11(5), 1191-1198.

2. Page 4 Line 24. Please explain "high native time resolution."

3. Page 4 Line 27. Please clarify the rainfall threshold used in this study. In the caption of Figure 2, there is a phrase "$\geq$ 0.1 mm at single station". How big is the tip resolution against the threshold?

4. Page 6 Line 33. Please clarify the difference between Figures 4 and 5. Is the threshold 0.05 mm applied to both Figures 4 and 5?

5. Page 7 Line 5. Isn't it 0.05 instead of 0.5?





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6. Page 7. Line 6. Please explain “the entire WEGN data.” Is it without applying the threshold?

7. Page 7 Line 31. It would be useful if the correlation coefficient values obtained from other evaluation studies are provided and compared with those of this study.

8. Page 9 Line 2-4. What (more PMW estimates or rain gauge correction) has more contribution to the improvement? I think that this is very important point in the satellite product evaluation.

9. Section 4.3. Please add some implication of the result found in Section 4.3 and discussions on how to use the products for hydrologic applications.

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