Review of paper submitted to HESS.

Discussion paper **hess-2014-345**

Title: Scoping a Field Experiment: Error Diagnostics of TRMM Precipitation Radar Estimates in Complex Terrain as a basis for IPHEx2014

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The paper is an excellent piece of scientific work and it is well written. A careful and detailed error characterization and analysis of the TRMM PR 2A25 product in complex terrain is carried out. It is a very interesting study on sub-grid scale effects in mountainous regions where there is a strong space-time variability of precipitation. The rainfall measurements from the high-density rain gauge network in the Southern Appalachian deployed in preparation for the IPHEX-2014 field experiment are used as ground-truth. In the paper several different aspects crucial to the evaluation of satellite-based precipitation product error structure are considered, and in my opinion the diagnostic analysis in time and space over complex topography presented in this paper could be used as reference for future work on validation of satellite based precipitation estimates, such as the precipitation products from the GPM Dual-frequency Precipitation Radar (DPR) of the Global Precipitation Measurement (GPM). I strongly recommend the manuscript for publication. However, there are a few minor issues that in my opinion need to be addressed by the authors prior to publication, such as further clarification on the methodology used to couple rain gauge rainfall data to the TRMM-PR pixel based product.

Minor revisions:

1) p. 11146, line 13-17: The matching between rain gauge and TRMM-PR (or other satellite derived estimates) in space and time introduces uncertainties not only linked to the sparse sampling, but also due to the different type of measurements made by ground-based instruments (such as rain gauges) and by spaceborne observations. It should always be taken into account that temporal range of the spaceborne MW sensor measurements is not really “instantaneous”, and it refers to the cloud volume where the rainfall originates. The relationship between the measurement and the surface precipitation is highly dependent on the type of cloud (spatial extension, homogeneity, microphysical structure, precipitation regime, etc.). The rain gauges, on the other hand, measure directly the precipitation near the surface, and the result is based on integration over time. I would suggest to add some more comments on this regard, specifying that the challenge in the validation of satellite-derived estimate is also the temporal matching between the different dataset, linked to the type of measurements available from the different instruments.

2) P. 11147 line 5-14: I would suggest to add a reference to the work by Porcù et al. (2014) where the error associated to temporal and spatial sampling of rain gauges in the validation of satellite-derived precipitation estimates is analyzed and evaluated. Some of their conclusions are relevant to the study presented here, such as the choice of the time interval for integration of rain gauges measurements to be compared to a pixel-scale precipitation measurement.
Please, clarify the meaning of the following sentence (line 8-9) : “the gauge rain rates are integrated and temporally averaged over a range of time-scales (10–60 min) centered at the time of overpass” Do you integrate in time over 10-60 minutes time and then average

in space (meaning that all rain gauge integrated precipitation values falling within each PR pixel are averaged to obtain a mean value to be associated to the PR estimate, as for example it seems to be the case for the results shown in Fig. 4)? Or else there is no averaging made within each PR pixel? What does “temporally averaged means”? Is it a total average over all temporally integrated rainfall values? It is not clear how the spatial association between each PR pixel and the rain gauges falling within that pixel is made. Please clarify the meaning of the following sentence (line 9-13): “When multiple gauges exist in same pixel, the PR measurements are paired separately with different raingauges, hereafter referred to as point-to-pixel comparisons, to increase the sample size and avoid ambiguity associated with the spatial representativeness of the gauges within the pixel.” Is this an alternative procedure to the one described above (line 8-9)? It is not clear if you choose randomly gauges within the PR pixels or if you select all rain gauges falling within one pixel. How does this point-to-pixel comparison relate to the averaging and integration mentioned above?

3) p. 1149 line 21-26: The underestimation can be attributed also to the fact that, to my understanding, no spatial averaging of 10 min integrated rainfall values from the rain gauges falling within each PR pixel is made (see point 2) in this review). If that is the case, please provide an explanation of why the spatial averaging is not applied, and possible implication on the results, especially for heavy rain rates.
Why are results in Fig. 4 shown for the 10 min integration interval? Please, provide an explanation (I believe it is because the error bias is minimum at 10 min, as stated in Section 3.1) and a short discussion of how the PDF differ for average rain gauge rates computed at 20 min, 30 min and 60 min.

4) Section 3.3. The discussion of Fig. 8 is quite complex, as the figure itself. I would suggest adding a short paragraph at the end of Section 3.3 summarizing the most relevant findings from the analysis of Fig. 8.

Tables:
Table 2: Section b) in the Table 2 should be titled “near-nadir cases” according to the caption.

Figures:
Please, enlarge all Figures, in particular Fig. 8, 9, 10 and 11.

Fig. 5b: Please, show to which class the third sector in the scatter plot (without label) correspond (according to the classification provided in Table 4).

Fig. 8: The figure is very complex, and it is very hard to read. This figure should be enlarged to at least half a page. I would suggest modifying the figure to make it more readable, and simplify the plots. Please, indicate “UND”, “OVR” and “FA” on top of each column, and “stratiform with BB”, “stratiform without BB”, and “convective” on the left of each row. The red marks and the blue boxes are hard to see. Enlargement could be enough to make them more readable. The two horizontal lines “whiskers” could be eliminated from they figure, as they are not essential to the discussion. You could keep the outliers (red marks) specifying that they represent points falling out of the +/- 1.5 IQR.

Fig. 9: It is not clear how the track of the TRMM PR overpass shown is related to the cross sections in Fig. 10, 11, and 12 (latitude here goes roughly from 34N to 36.3N, a

much larger interval than the one corresponding to the black lines in Fig. 9). My suggestion for Fig. 9 is that the TRMM PR overpass could be shown as two parallel lines delimiting the whole swath over the region shown. The line within the swath corresponding to the cross section for each event should also be shown in each image. The border of the region of study (the Pigeon River basin) could appear on the radar map as reference as well.

Fig. 10: Label c) is missing on last four panels. The black arrow and the colored asterisks are hard to read. Please, enlarge the figure. Each panel should be at least as large as in Fig. 12.

Fig. 11: The black arrow and the colored asterisks are hard to read. Please, enlarge the figure. Each panel should be at least as large as in Fig. 12.

Technical corrections:

Please, use either “rain gauges” or “raingauges” throughout the manuscript.

p. 11148 line 3: Please change “In V7 (see Table 2a), …” in “The results for all rain gauges (see Table 2a) for V7 show…”.

p. 11148 line 10-11: Please, specify “Overall, V7 exhibits slightly better detection skill *than V6*…”.

p. 11161 line 22: “Dual-Polarization Radar” should be “Dual-frequency Precipitation Radar “ (DPR)

Reference

Federico Porcù, Lisa Milani, Marco Petracca. (2014) On the uncertainties in validating satellite instantaneous rainfall estimates with raingauge operational network. *Atmospheric Research* **144**, 73-81.