

# Responses to the comments of reviewer #1: An assessment of the accuracy of global rainfall estimates without ground-based observations

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Summary: This study proposes to use a Triple Collocation (TC) method to assess uncertainties associated with rainfall estimates using different products at the daily/1degree scale. The study addresses important issues that are relevant to the HESS readership. I recommend this manuscript for publication after minor revisions.

We thank the reviewer for appreciating the value of the paper and for her/his valuable comments.

## **Page 1:**

1. Title and throughout the text: I think there is some confusion regarding the difference between accuracy and precision (uncertainty vs. error, systematic vs. random). Accuracy refers to how close a measured value is to a standard value (i.e., the “true” value). Precision describes the statistical variability. Accuracy and precision are independent. It seems to me that the TC method provides a measure of precision (error variances and correlations), but no information regarding the accuracy, which would require a reference/benchmark. I urge the authors to clarify this difference in the text and revise the text where needed.

R: The reviewer makes a very good point here. If TC is to provide a true assessment of accuracy, it requires a perfectly-calibrated, bias-free scaling target which, of course, is not generally available in data-scarce regions. Instead, we utilize TC to provide an assessment of linear correlation against the “true” rainfall accumulation value. We agree that referring to this as “accuracy” is not correct. However, about the term “precision” can be still misleading since the term precision is used in describing the agreement of a set of results among themselves and is usually expressed in terms of the deviation of a set of results from the arithmetic mean of the set (e.g., standard deviation).

Therefore, to resolve this issue, we will use the word “performance” instead of “accuracy” and clarify early in the paper (at the end of the introduction section, pag.3, lines 23) that “performance” is defined in terms of correlation against “true” rainfall values:

Thanks to the ability of the Extended TC (McColl et al. 2014) to provide the correlation against the “unknown” truth, in this study the assessment of the products will be carried out in terms of correlation against “true” rainfall values. As a result, the word “performance” and “TC results” are here onward referred to this index (additional clarifications are provided in section 2.3).

Based on this strategy, the title will be changed in:

“An assessment of the performance of global rainfall estimates without ground-based observations”

Additional changes will be made in the revised manuscript at lines where the term is not appropriate:

- Abstract line 14. “Results convey the relatively high accuracy of the satellite rainfall estimates in Eastern North and South America, South Africa, Southern and Eastern Asia, Eastern Australia as well as Southern Europe and complementary performances...” That will be changed in

“Results convey the relatively high performance of the satellite rainfall estimates in Eastern North and South America, South Africa, Southern and Eastern Asia, Eastern Australia as well as Southern Europe and complementary performances...”

- Pag. 10 line 5 “Assessment of CPC accuracy”. The section will be titled “Assessment of the CPC product”
- Pag. 10 line 29. “... Triplet C leads to an overly-optimistic assessment of their accuracy.” will be changed to “Triplet C leads to an overly-optimistic assessment of their performance.”
- Pag. 10 line 32. “It is often important to understand which is the best available rainfall product provides the highest relative accuracy.” will be changed to “It is often important to understand which is the best available rainfall product provides the highest relative performance”.
- “particular TC configuration approach to assess the accuracy” will be changed to “particular TC configuration approach to assess the performance”.
- Pag. 14 line 10. “Results convey the relatively high accuracy of daily rainfall accumulations” will be changed to “Results convey the relatively high performance of daily rainfall accumulations”

2. Line 1: remove “value”.

We will remove it.

3. Line 4: remove “of this variable”

We will change the sentence in:

“Recent studies have suggested the use of Triple Collocation (TC) to characterize uncertainties associated with rainfall estimates by using three collocated rainfall products.”

4. Line 5: replace “among” with “with”

We will substitute it.

5. Line 18: is it really the best product? It is if precision is the chosen criterion, but it may not be the case if accuracy is considered to be more important.

Since we are not talking about the accuracy here the sentence is now adequate. See also the discussion to point 1.

## **Page 2:**

6. Line 35: replace “provides” with provide”

We will replace it.

### **Page 3:**

7. Lines 3 and 6: add “the” before “TC”

We will remove “method” at line 3 and added “the” at line 6.

8. Line 9: rephrase as “if each product is affected by mutually-independent errors”

We think the sentence is correct.

9. Line 20: deleted “analysis” and “the”

We will remove “analysis” term.

10. Lines 20-25: CMORPH and TMPA 3B42RT are not completely independent. Can the authors explain what is the implication with using these two products in the TC analysis?

Cross-correlated error in CMORPH and TMPA 3B42RT have large implications for the application of TC. In fact, these implications provide the central motivation for the paper (particularly our proposed use of a soil moisture-based rainfall accumulation product).

This is an important point for us to convey to the reader. To make sure that it is clear, we will add some clarifying details after line 25 about the possible consequences of applying TC to a triplet containing the two products to facilitate the understanding of this important point.

“Note that, given the number of common sensors shared by CMORPH and TMPA 3B42RT the application of TC to the triplet containing the two products will serve for demonstrating the impossibility to use both of them in the same triplet within the TC analysis. Therefore, additional independent source of rainfall accumulation information are needed.”

In addition, note that we have already highlighted this point in the original manuscript at lines 8-13 page 3.

“TC can theoretically provide error and correlations of three products (a triplet) without using ground based observations – provided that each of the three products is afflicted by mutually-independent errors. However, given that state-of-the-art satellite rainfall products use a highly-overlapping set of common sensors for the retrieval of rainfall (see section 2.1 for further details), there is an inherent difficulty in obtaining triplets with mutually-independent errors.”

11. Line 28: rephrase as “Section 2 presents datasets and methods;”

The sentence will be rephrased.

12. Line 31: rephrase as “Results and discussion are shown in Section 3 and the final remarks are presented in Section 4.”

The sentence will be rephrased.

#### **Page 4:**

13. Line 13: delete “a”

It will be deleted.

#### **Page 7**

14. Lines 2-4: this is a fair model only to model the error for the “hit cases” when both sensor and ground truth are larger than zero or for cumulative rain over a long enough period of time. Otherwise, the multiplicative error model would assign zero anytime the sensor measure a zero. Some explanation is given towards the end of the paragraph, but I believe that this should be discussed when multiplicative error models are introduced. The authors can also refer to Tian et al. 2013: Modeling errors in daily precipitation measurements: Additive or multiplicative?

In this section (2.2.1), we discuss thoroughly the multiplicative error assumption along with advantages and limitations when it is used within TC. As a results, we think this is a good place for debating the issue related to presence of zero values in the rainfall time series and the potential problems they can create when the log-transformation is applied.

We will add the reference of Tian et al. (2013).

#### **Page 8**

15. Line 6: shouldn't it be “utilizes”? What’s the subject of that verb?

$\rho_{t,x_i}$  refer the correlations of the products, with  $i=1,2,3$  so we used the plural.

#### **Page 9:**

16. Line 16: replace “serve to” with “are used to”

We will replace it.

#### **Page 10:**

17. Line 6: please replace “assessing” with “to assess”

We will replace it.

18. Line 32: please rephrase (2 verbs).

We will rephrase it.

#### **Page 11:**

19. Line 9: drop the comma.

We will drop it.

**Page 12:**

20. Lines 1-2: can the authors speculate on why this happens?

Some explanations are given at page 11 lines 30-35. In particular, the use of daily rainfall accumulations necessitates the removal of a lot of zero values for applying the log-transformation. This might shorten the dataset too much and decrease the robustness of the TC analysis.

21. Line 17: rephrase as “this corroborates what shown by....”

We will rephrase it.

**Page 13:**

22. Line 2: replace “paper” with “study”.

We will rephrase it.