# Author response to reviewer's comments

On behalf of myself and the co-authors, I take the opportunity to thank the anonymous reviewers for his/her constructive comments, questions and editions. We have responded to all questions and comments, as discussed below. Most of the given comments and suggestions by the reviewers were relevant, and accordingly we have updated the manuscript significantly. We feel the quality and readability of the paper have been improved significantly.

## Reviewer #2

### General comment

The manuscript focuses on evaluating of different satellite rainfall products in the Tekeze-Atbara Basin, Ethiopia. It is interesting to see a validation study of satellite data in the hydrologically remote part of the world where there is limited data for understanding the climate and hydrology. However the structure of the paper is not easy and clear and the results are not clearly discussed. There are also many type errors. I see many spacing errors between words. On the abstract section alone I have seen more than 10 errors. I have indicated those errors as minor comments. Those errors are too many to list them in my review; I hope the authors will spend some time to correct those errors. With this and other concerns I have indicated below I cannot recommend to accept the paper for publication.

Response: The authors would like to thank the anonymous reviewer for his/her detailed review of our manuscript. All comments and suggestions were important to improve the quality of the paper. We have accepted almost all comments and incorporated in the main document. We agree with the reviewer that there were so many space errors throughout the document. Such space errors were created during uploading in the Pdf file, we apologies for such problems and we have now cross checked and corrected all spacing error. Response for each issue is also given as follows:

### Specific comments:

Abstract

1. The authors indicated that they have evaluated the performance of the products at various spatial and temporal scale. However, in the abstract Line 26 to 28, the spatial and temporal scale of the evaluation is not indicated.

Response: we agree with the reviewer that the spatial and temporal scale should be reflected in this sentences. The sentences in L26-28 indicates the mentioned products well performed than the remaining with ±25 of PBIAS and 0.5 of r in all spatial (point, sub-basin, basin) and temporal (daily, monthly and seasonal) scales. This explanation is also modified in the document to make it clear for readers.

2. The abstract should be rewritten to summarize the evaluation result at the multiple temporal and spatial scale. The authors indicated that they have done evaluated the 8 products at various temporal (daily, monthly, seasonal) and spatial (point, sub-basin,basin) scales. However, they did not indicated clearly which products worked at whatscale.

Response: We agree there was no clear indicationwhich products worked at what scale. We have now modified the abstract to show such details.

Introduction

3. Page 2: The statement from 23 to 28 needs a reference.

Response: We agree and references are now included to indicate the sources.

4. The authors indicated that tomography as a key factor influencing microclimates in the basin (Page 3 line 32 -33). However, Figure 2b which indicate the relationship betweenelevation and annual average rainfall doesn't capture the effect of topography. Thatrelationship between rainfall and topography as indicated in this figure is insignificant. What are the authors claming that the topography is a key factor?

Response: It is true that Fig.2b does not show a clear pattern of annual rainfall against the elevation of the station. In most regions, rainfall increases with elevation due to the orographic uplifts (Moreno et al., 2014;worqlul et al., 2014). Unlike to this pattern, the relationship between rainfall and topography is not uniform in the T-A Basin. Rainfall in the mountainous area is higher in some areas and lower in others. The total annual rainfall increases with elevation in the southern and southwestern parts of the basin, in contrast, it reduceswith elevation in most other parts of the basin. This is exactly what we observe in fig.2a and Fig, 2b that the annual rainfall increase with elevation increase in some stations and decrease with elevation increase in other stations. This non uniform pattern is attributed to the complex local topography, which alters proximity to the sources of moist airand seasonal movementsof the ITCZ, This has influenced the microclimate of the basin significantly (Kiros et al., 2016).

5. Figure 2b disproves the stament on page 4 line 18 and 19.

Response: We agree it disproves the general pattern that rainfall increases with an increase in elevation. See also the previous explanation (No.4). When the rain-bearing winds reach the basin, their direction is modified by the local topography forcing the release of moisture in the lower areas before they reach the top of mountains. This creates more intense and shorter duration convective rainfall events in the lowlands where warm and moist airflows encounter the mountain foothill (Van der Ent et al., 2010). This shows that topography in the basin plays an important role in moisture cycling either by blocking or capturing moving air masses.

6. The rainfall products were not described very well. As the authors indicated satellite

Response: We agree with the reviewer that including more detailed descriptions of each satellite product would help more to understand their performance. Although these products have been widely applied and documented in many literature, we have now significantly improved their descriptions following the reviewer's suggestion. We tried to include only the important once not to make it bulky for readers. More references where readers can get detailed information of each product are also included.

Response: Thank you for your suggestion and such misleading phrase is now improved in the text.

Response: Thank you for your suggestion and it is now corrected in the text

Response: Thank you for your suggestion. The temporal resolution is now changed into 3 hourly and the name TRMM 3B42V7 is changed into TMPA-3B42 in the table.

Response: IDW was adopted in this study for its simple and robust technique which has been commonly applied for rainfall interpolation worldwide (e.g. Haile et al., 2010; Jiang et al., 2012; Hu et al., 2014; Worqlul et al., 2014). We agree that each techniques (e.g., IWD and Kriging) have their own advantage and disadvantage, however, the authors believe that applying kriging instead of IWD may not bring significant change on the result of this study. The gridded daily, monthly, and seasonal rainfall of 1km x 1km resolution were obtained from 34 gauge measurements. The manuscript is also improved accordingly.

Response: yes, we agree there are several widely applied statistical indices for performance evaluation of satellite rainfall. The first and most commonly applied group which includes Root Mean Square Error (RMSE), Percent of Bias (PBIAS), Absolut Mean Error), Mean Error (ME), and correlation coefficient (r) are used to evaluate the amount of rainfall against the ground measurement (e.g., Meng et al., 2013; Dinku et al., 2007; Derin and Yilmaz, 2014; Katsnaos et al., 2015; Jiang et al., 2012; Worqlul et al., 2014; Dembele et al., 2016; Asadullah et al., Guo et al., 2016; Feidas, 2010; Hu et al., 2014; Thiemig et al., 2013). The second group which are commonly used to detect the ability of the satellite products in describing rain/no rain event or rainfall occurrence in general includes probability of Detection (POD), Frequency of Hit (FOH), False Alarm Ratio (FAR), Critical Success Index (CSI) and Heidke Skill score (HSS) (Haile et al., 2010; Xu et al., 2017; Wang et al., 2017). In this study we focused to evaluate the amount of rainfall using the first group of statistical indices. We agree with the reviewer that these group of statistical indices are simple but they are the most commonly applied and well documented in the literature as shown above. More than 90% of the references listed in this manuscript which focused on satellite rainfall validation have used the same techniques of performance evaluation and the authors believes the used performance evaluation matrices are enough to evaluate the efficiency of these products.

We agree that both AME and RMSE are used to evaluate the average magnitude of the error but RMSE gives a relatively high weight to large errors comparing to MAE. This means the RMSE should be more useful when large errors are particularly undesirable. However, RMSE does not describe average error alone and has other implications that are more difficult to tease out and understand and the MAE is the winner in such cases. The MAE is suitable to describe uniformly distributed errors while the RMSE is more appropriate if the errors are normally distributed (Chai and Draxler, 2014). Moreover, the RMSE is not a good indicator of average performance and might be a misleading indicator of average error and thus the MAE would be a better metric for that purpose. Thus, evaluating of the satellite products using both indices is advantageous for the above reasons. More explanation is also added to the text document

Response: Thank you for your critical comment. We agree that such criteria are used to evaluate simulated streamflow and we have now modified the explanations in the main document to avoid the confusion. The lower in the values of PBIAS, RMSE, and MAE and higher in correlation coefficient, the better agreement between the satellite and ground measured rainfall.

Response: Thank you for your essential comment. We agree range of variability is more explanatory than an average value. Although the value of each station is provided as supplementary file (S2-S5) and in Fig.3, we have also included the range of these statistical indices in the discussion part. Standard deviation is also included in the discussion and in all tables. Their relation to the landscape is also discussed in section 4.1 of second paragraph (p11) and second paragraph in P13.

Response: we fully agree with the reviewer and we have made improvements accordingly. The value for each station is already provided as a supplementary file. However, following the reviewer's suggestion the range value of each measuring indices is also now included in the discussion part. Moreover, standard deviation of each statistical indices is also calculated and included in each Table (S2-S7) of the supplementary file. The average line indicated in both the PBIAS and r graphs helps to identify how far the value of each product from the average value of all products. This is also included in the manuscript.

Response: The value of RMSE and AME also shows lower value for these products which implies obtained errors by comparing the satellite rainfall against ground measurement is smaller for CHIRPS, RFEv2 and TRMM products compared to the remaining products. The manuscript is also modified accordingly.

24).

Response: The authors would like to thank the reviewer for his/her important and constructive comments. We fully agree with him/her that providing average value does not give the temporal and spatial variability. After the reviewer's comment, we have improved the manuscript by providing the range value of each indicators in the discussion part. Moreover, all station values of RMSE, AME, PBIAS and r as well as the average value and standard deviations are now provided as supplementary files (Table S2-S7) which is helpful for the readers who wants to see the result from each station and their relation with the location of the station.

Tables

19.  Table 2: On Figure 3a I can see a PBIAS value of negative but under Table 2 the authors indicated rage of PBIAS from 0 to infinity. How do you council that?

Response: We thank you for your very crucial comment and we have now corrected the range value in the table.

20.  Table 2: The authors should remember that R = 1 doesn't mean perfect, it is obvious we have to check the slope and interest of the fitted line. Eg. Y = 5x + 8 has Pearson correlation coefficient (r) of 1 but Y and X are not similar.

Response: We agree with the reviewer that it may not necessarily perfect for the given reason. We have now removed such explanations from the table to avoid the confusion.
21. Table 3 is duplicated on Table 4. Remove Table 3

Response: They are not the same, Table 3 is the summary of average (now modified to range value) accuracy indicators from pixel-to-point monthly comparison while Table 4 shows the summary of statistical indices from aerial averaged rainfall comparisons at basin level.

Figures

22.  Figure 1. Label the two figures. What does the dotted line over the DEM represent?

Response: Thank you for your help. The name of the study area was missed from the legend. We have now improved the figure to include the label. The two dotted line in the figure represents group of rainfall stations in highland (>2500 m.a.s,l) and lowlands (<2500 m.a.s.l) which was later used to compare the performance of satellite rainfall products in highland against lowlands. The figure caption is improved to explain this.

23.  Figure 2. Label the two figures and describe them independently.

Response: Figures are now labelled independently and description of each figure is given under the figure.

24. Figure 3. What does the average line representing?

Response: The average line indicated represents the average value of PBIAS and r of all products and is helpful to identify how far the value of each product from the average value of all products. Tis is also included in the manuscript

25. Figure 4 where are those representative station located in the watershed?

Response: Thank you for your important comment. Indicating these stations will help readers the effect of landscapes on the performance of the satellite rainfall.

General comments:

Abstract: the abstract full or problem

Response: We agree with the reviewer that there were so many space errors throughout the document. Space errors were created when the sources document was converted into Pdf file during uploading, we apologies for such problems and we have now cross checked and corrected all spacing error.
1. Line 21: space between rainfallproducts


Response: corrected

2. Line 26 space between thatCHIRPS, Line 26 space between TRMM,and, Line 26 space between wereable

Response: corrected in the file

2. Line 27 space between BIASand

Response:corrected

3. Line 28 space between >0.5over different

Response:corrected

4. Line 35 space between respectively.CMORPH

Response:corrected

5. Line 35 space between scale.Their

Response:corrected

6. Line 39 space between lowlandswhereas

Response:corrected

    7.   Line 40 space between athighland

Response:corrected

    8.   Line 41 space between thepixel-to-pointcomparison

Response:corrected

    9.   Line 42 space between showthat

Response:corrected

10. Line 42 space between scalesin

Response:corrected

11. Page 3 line 29 and 30 modify it as: with a significant elevation variation

Response:Sentences modified accordingly

12. Page 6 Line 17: sofar PM and IR are not defined. I see later in the paper they are defined.

Response:  They are now defined in the first sentences and aberrations are used in the remaining document

14.  Many many errors (dailyrainfall page 9 line 10, (r)of page 9 line 11, andTables page 9 line 14, double fullstops (page 9 line 17), MAE,which line 18,

Response: Thank you very much. Such errors were clearly seen in the Pdf file, uploaded in the HESSD website. We will take care of such problems during uploading of our manuscript.

15.  Page 9: wasfurther (line 24), investigatedat, that the, correlationfor, reducedat, Forexample

Response: Space problem is now corrected

16.  Page 10: madefor, correlationcoefficients, of the, season.CHIRPS,

Response: Space problem is now corrected

17.  Page 11: many

Response: All space problems corrected in the document

Response: All space problems corrected in the document

Response: We would like to thank you and all problems corrected in the document

Reference

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Response: Thank you for the sugestions we have used these references in our document.


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