Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-318-AC2, 2016

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Temporal and spatial changes of rainfall and streamflow in the Upper Tekeze–Atbara River Basin, Ethiopia" *by* Tesfay Gebretsadkan Gebremicael et al.

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Received and published: 8 November 2016

On behalf of myself and the co-author, I take the opportunity to thank the anonymous reviewer for her/his constructive comments, questions, and editions. We have responded to all questions and comments, as discussed below. We think the quality and readability of the paper have improved significantly.

General comments

Comment 1: The study presented historical trend analysis of rainfall and streamflow data in the Upper Tekeze-Atbara River Basin, Ethiopia. The statistical methods (Mann-Kendall and Pettitt tests) have been well applied in many other studies, hence the

methodology is not unique. However attributing hydrological changes, which were shown to be not statistically related to rainfall in the Tekeze-Atbara basin but rather to land and water resource management changes in the catchment will be of considerable use to managers and policy makers. This manuscript will therefore represent an important scientific knowledge addition to the region in question. I have provided annotated comments in the attached supplementary file, but my general comments are as follows: Greater emphasis could be placed on discussion of spatial variability of hydrological change, some of the sub-headings suggested this would be discussed but it never really materialised in the manuscript. I have suggested to amend fig 1 accordingly and thereby develop this discussion from there. Some of the charts to need to be reorganised to provide this spatio-temporal context to the data – see annotations.

Response: We agree with the reviewer that the spatial analyses is not discussed in-depth in the paper. Therefore, we have modified Fig 1 to include the sub-basins. Moreover, we have also included two maps (Fig. 3 for rainfall, and Fig. 5 for streamflow) to show the spatial variability across the basin. The two figures allow easy detection of trends in the basin. Charts (in Fig 2 to Fig. 3) are also modified following the given suggestions. Accordingly, the discussion part on the spatial variability of rainfall and streamflow has been improved in the manuscript (track version)

Comment 2: At some points in the manuscript there is some discussion on monthly data but this is not presented, only the aggregated seasonal/annual data. This data should be presented, perhaps as a supplementary file. I have pointed out also that other pre-statistical data is discussed at length but not given – again I think there is place for this at least as a supplementary file as the authors entrust the reader to believe some of the conclusions drawn from this pre-analysis.

Response: We have added summary results of the Mann-Kendall and Pettitt tests for monthly and seasonal rainfall as supplementary file in Table S1 and Table S2, respectively. While, results of monthly streamflow analyses from Pettitt test is given in Fig. S3. Additionally, we prepared supplementary files for TFPW of rainfall (Fig. S1) and

streamflow (Fig. S2). Then it is possible to check time series data before and after removal of serial correlation. In this file, samples of all time scales (monthly, seasonal and annul) are included. Therefore, discussions in the manuscript has been also improved accordingly.

Comment 3: Whilst conclusions are drawn on why hydrological changes have occurred in the basin as a result of land use/water management changes rather than being linked to rainfall, the authors point to subsequent work to unpack the causes (which will assumingly be published somewhere at a later date), one expects that grey literature/policy documents etc could be cited in this manuscript, if available, to substantiate the arguments in the interim – at editors discretion of course.

Response: The result of this study showed that streamflow variabilities are not caused by changes in rainfall. More likely attributed to land use management. However, as given in the paper, linking streamflow changes to landuse land cover changes requires a lot of analysis of satellite imageries during last four decades, which is beyond the scope of this paper. In fact, this will be our next exercise to quantify LULC changes and assess relation with stream flow changes. However, we attempted to support our argument by referring to some literature within the basin but at a smaller scale as well as from neighboring basin.

Detailed response on the specific issues

P1L24: delete"s" from alterations, avoid comma between seasonal, annual flows

Changed

P1L25-26: Rephrase sentence" a significant increasing/decreasing patterns"

Rephrased to show both significant increasing and decreasing trends

P2L16-17: change "reported that an increasing of trend of rainfall" to reported that a trend of increasing rainfall

Changed

P2L21: Analysed trend of hydro-climatic variables on what parameters?

Types of parameters used for analyses are now included in the sentences, which are streamflow and rainfall

P2L29: change "did not show statistically" to did not show a statistically, not clear what the annual flow statistics refer to - changes in mean annual runoff perhaps?

Corrected, modified into mean annual runoff

P3L3: change "trend" to trends and 50 and 60 years into 50 to 60

Corrected

P3L4: 30-40 what

Corrected to 30-40 years

P3L4-5: improve sentences into "Meanwhile, record lengths less than 25 years tended to show statistically significant increasing trends"'

Improved in the text to the above sentences.

P3LL6: This paragraph could benefit from a discussion on 'hydro-climatic zones' i.e. how does apparent hydrological change, if anthropogenically driven differ between humid and semi-arid regions?

Discussion on climatic zone included in the paragraph. The spatio-temporal runoff generation in semi-arid areas is strongly nonuniform as runoff generation controlling factors are different from that of a humid environment.

P3L10: Remained constant in what respect - rainfall depth (volumes) or intensity, or both?

Corrected into amount of rainfall

P3L10-13: suggest amend first part of sentence to: 'Despite the importance of stream-flow to assure sustainable water resource utilisation and food security.....'

Sentences improved.

P3L22: change river to River

Corrected

P3L23: change "near Ras Deshen" to near the Ras Deshen

Corrected

P3L29: Put "the" before elevation

Corrected

P3L30-32: change "himud" to humid and rangaing to ranges

Grammar corrected

P4L4: change "The river flow pattern follows that of rainfall in to "The river flow pattern typically follows that of rainfall"

Changed

P4L10: at what scale and for how long have these SWC activities been taking place?

Scale included in the text

P4L14-15: outlet of what?, avoid "s" after alters and re-write last part of sentence

Corrected to outlet of the basin, s avoided and last sentences has been improved in the text

P4L24: change "temporal and spatial" to spatio-temporal

Changed

P4L19-21: remove "s" from depends and efforts, delete scrutinizing of from the sentences

Changed

P4L26-27: change "varied" to varying, "remove despite that" and add whilst before gauging station

Corrected

P4L28: change "the" before 30 years to A 30 years

Changed

P5L6-7: what was the criteria for these rainfall datasets being deemed reliable?

Criteria are described in the next paragraph. The text of the manuscript has been updated accordingly

P5L10: add "an" before acceptable

Included

P5L16: apply full length names for CHIRPS and TRMM etc in the first paragraph of section 3.1.1. and use only the acronyms here

Changed

P5L17: why was 25km radius selected?

A 25 km radius area average of rainfall was taken considering the satellite data resolution and to avoid the effect of topography complex on the rainfall estimation. This sentence is also updated in the text.

P6L3: change "on the" to for the

Corrected

P6L17: Change “were these” to these were

Corrected

P6L16-17: explain why longer records are better, and why shorter period enhances spatial coverage - the point of this sentence is not clear.

Longer period is to increase identification of dominant trends while shorter period allows to include more representative stations even with less recording period. More explanation is included in the text.

P6L20: why is 20 years important?

To account spatial variability and obtaining reliable result from trend test tool. Also explained in the paper.

P6L28: “change explicitly point to” to which suggests

Corrected

P6L30: perhaps use better word than scanty - what do you mean, patchy and unverified?

Modified to “very limited”

P6L33: change “its” to for and “checked” to check

Corrected

P6L33-34: OK - but how did you use the other stations for flow verification - whilst you explain double mass and residual mass plots below, it’s not clear from your explanation what the other gauges are used for exactly - just needs some clarification.

Comparing between upstream and downstream stations can give preliminary evidence on the reliability of data. We compared each stations with nearby stations just to get first-hand information on the quality of data. Text has also been updated

P7L4: why was two years selected as criteria for omission? why two weeks avoided

More than two years data were excluded from the analysis in order to avoid unreliable time series data whilst below two years were included to enhance spatial coverage by including stations with some missing data. Similarly, more than two weeks of missing values during the rainy season were avoided as 80% of the annual rainfall is coming from this season. Clarification on this issue is also included to the text document.

P7L9: change “Man-kendall” to Mann-Kendall

Corrected

P8L16: For the reader, it will be worthwhile to see the difference before and after the TFPW analysis - as a supplementary file to accompany the manuscript.

Result on TFPW is now included as supplementary file. Comparison of rainfall (Fig. S1) and streamflow (Fig. S2) after and before TFPW from all time scales (monthly, seasonal and annul) are included.

P8L19: change “trend-free-prewhitened” change to TFPW, “the” added before Pettitt

Changed

P8L25: why was a user defined 5% chosen - any reason for this - does this literature commonly use this value?

It is commonly used in the literatures for hydro-climatic trend analyses. Text is improved with more explanations.

P8L33: add “the” before Indicators

Corrected

P9L2: 20 IHA parameters are not listed here - and only 8 referred to in Table 6. Perhaps add table describing all the parameters used.

Corrected to 8 parameters.

P9L21: what is meant by non-normal data?

It was to mean unreliable data, now changed to unreliable data

P9L24: Do you mean natural storage heterogeneity e.g. variable vadose zone properties - or man-made storage (dams etc)?

Man-made storage, text modified accordingly

P9L23: change “flow is very small” to discharges are very low

Changed accordingly

P9L23-24: not sure I follow your point here - why will low flows cause temporal dependency? - do you mean that hydrographs are relatively homogenous between gauges during low flow conditions?

It is to mean similarity of flows between consecutive days and to make it explicit the text is now rephrased.

P9L27: not much discussion in the manuscript on the spatial variability element and this needs to be developed further - one way of achieving this will be spatial plots of increasing/decreasing trends - see my comment on fig 1.

The discussion of spatial variability has been improved by including different maps showing the distribution of sub-basins and the main results with different icons, Fig. 3, Fig. 5. To make it more sound the caption is also changed into “rainfall variability over the basin”.

P10L6-7: repeated sentences “The result of rainfall analyses shows no trend”

Removed

P10L6-7: Grammar mistakes

Corrected

P10L9: refer to monthly data in this section, but none given in the tables - may be worth including in supplementary file to accompany paper.

Summary of monthly result is now included as supplementary file (Table S1)

P10L17-10: why not? it would be useful to see the statistical indices you refer to. Again - maybe to add in supplementary file.

Supplementary file included (Table S2)

P10L15-19: refer to monthly data in this section, but none given in the tables - may be worth including in supplementary file to accompany paper

Supplementary file for all monthly result is now included (Table S1 and Table S2)

P10L25: meaning what exactly - are you referring to the ITCZ?

ITCZ included in bracket

P10L27-30: did the authors referred to in this paragraph use trend detection methods or alternatively infer trends?

They have applied same methodology of trend analyses and text is also modified to reflect that.

P11L8: avoid repetitive sentences

Removed

P11L14: sorry - I may have missed previously was the flow data disaggregated to seasonal data sets?

Seasonal data sets were obtained by aggregating the monthly data of each season

P11L15: change decreasing to decrease

Changed

P11L29: change “ungagged” to ungauge d Corrected throughout the document

P12L14: change have to has

Corrected

P13L1: land degradation through what mechanism(s)?

Deforestation and over cultivation on the rugged topography, document also modified

P13L13: what is a water condition? do mean hydrological condition?

Changed to hydrological condition

P13L26: due to homogenisation of the low flow and peak flow hydro graph?

Modified

P14L10: is there any literature whether peer reviewed or grey literature that can be used to cite for land-use changes in the study region?

Discussions on land use change and its effect on hydrological processes are included from previous literature which was studied at watershed levels.

P14L27: as above - but it will be useful to infer on some causative mechanisms from any literature that is available, as quick reference - i.e you have spoken of water abstractions, but not land-use changes explicitly

Discussions on the effect of land use added from few existing studies at small watershed level. To make it sound this discussion has merged with the above (P12L10).

P20L7: remove “age” from Table 1 Removed

P22L6: change “annual flow” in Table 3 to annual average flow Corrected

P22L5: level the station names in Table 3 on fig 1. Included in the figure

P26.Fig.1: may be worth replotting map in grayscale, with rainfall and flow gauges

- added value may be to use icons that show increasing/decreasing or static trends. Include stations names and -sub-catchments referred to in manuscript. Map will need to be reproduced at greater dpi resolution. Lat/Long in Tables are given in Degrees Decimal this map should also be

All suggestions are included in the figure and the map is now significantly improved.

P27.Fig. 2: If having a combined plot then use the legend only once, consider plotting all four against one x-axis with four charts plotted one of top of each other with individual y-axis. The individual chart titles NSE, BIAS, RMAE, r, will be the y-axis label

We found this comment is also very important and now modified to have one x-axis and contains only one legend.

P28.Fig. 3: It would be useful to plot the data above each other - with all sharing the same x-axis - for context plot 1950-2020. That way if these gauges are labelled in fig 1, we can see the spatial variability.

Similarly, modified all charts under this fid to shared same x-axis for the context of 1950-2020

P29Fig. 4: again, these plots should have same x-axis scale 1970-2020 remove clutter by moving the labels ’annual’, ’rainy season’ etc to top of the chart column.

Improved to the recommended style.

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