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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Identification of the main attribute of river flow temporal variations in the Nile Basin" *by* C. Onyutha and P. Willems

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GENERAL This is potentially an interesting case study. However, I find the structure of the manuscript most unhelpful in trying to explain the scientific goals, the methodology used and interpretation of the result. In many places, the authors are assuming too much prior knowledge on behalf of the reader which makes it very difficult to follow the descriptions.

COMMENT No.1

In addition, several sections such as the methodology read more like an internal working paper, where steps are reported in the order the analysis were made without first clarifying why these steps are necessary or what they hoped to achieve. As such I think

the methodology needs a much better justification and introduction before leaping into detailed analysis. For example, why is it necessary to group the stations in section 3.1? This is only made clear much later, so it is difficult/impossible to assess if this is a reasonable thing to do when reading the description, which is very distracting(potentially irritating).

REPLY No.1

The authors are grateful to the reviewer for identifying the need to restructure the paper. The authors confirm that in the revised version of the manuscript, there will be improved justification and introduction for the methodology as suggested. For the systematic and logical flow of the text under the Methodology Section, some of the changes that will be made are as follows: âĂć The entire block of text in lines 1-13 on page 12180 from the paragraph explaining the rationale for grouping of catchments will be moved from Section 4.1 to 3.1. âĂć The paragraph in lines 24-28 of page 12182 and 1-4 on page 12183 will be moved from section 4.4 and inserted after the second sentence of Section 3.2 (in line 11 of page 12173). âĂć The sentences in lines 24-29 (of page 12186) and 1-16 (of page 12187) will be moved to replace the text in lines 7-23 on page 121690 of the Introduction Section. âĂć The residual trend results from the MK test will be inserted in line 19 (page 12186) of Section 4.6 in the Discussion Paper.

COMMENT No.2

In the same vein, I think the introduction is inadequate. It should clearly set-up the current state-of-the art knowledge, identify gaps in this knowledge, and define the objective of this study and how it might close this knowledge gaps. For example, in the literature review in the introduction, I would like to see a more detailed discussion and criticism of the findings of previous studies regarding the effects of land-use change on flow in the basin – especially given that the major finding of this study is that these factors are have a negligible influence on basin runoff characteristics.

REPLY No.2 The authors agree with the reviewer on the need to: 1) include the missing

gaps in the knowledge on flow variation attribution in the study area, and 2) show how the current state-of-the-art addressed the gaps. Clarifications on this comment will be made in the revised manuscript by replacing the second paragraph (Lines 7-23 on page 121690 of the Discussion Paper) using more considered text (for the details of the changes that will be made in the Introduction Section of the revised manuscript, see Section 1 (lines 1-81 on pages 1-3) of the attached supplementary file named "hessd-12-C1-2016-supplement.pdf").

COMMENT No.3

I cannot follow the description in Section 3.4. It jumps between references to previous studies by the authors and some very detailed statistical characteristics of a Brownian bridge, ending up with a description of a non-parametric scaling method. I find this very confusing, and perhaps a more considered explanation, including a schematic figure trying to convey the essence of the CRD methodology would be helpful?

It is disappointing to see that a study of trend and change does not try to embrace the issue of attribution. For example, Merz et al. (2012) have argued that trend studies without careful consideration of attribution does not add much to our scientific understanding of the hydrological systems. Perhaps the authors could also discuss the excellent paper by Harrigan et al (2014) on attribution and trend detection.

REPLY No.3

The authors are grateful to the reviewer for the constructive comments on the need for: i) improved clarity of the text in Section 3.4 of the Discussion Paper, and ii) the issue of attribution. For clarity, the blocks of text in lines 3-27 (on page 12176), 1-23 (on page 12177) and 1-2 (on page 12178) of the Discussion Paper will be replaced with a more considered explanation on the CRD. To address this comment, a new block of text will be inserted in the Methodology Section of the paper (for how these changes will appear in the revised manuscript, see Section 3.4 or lines 93-247 on pages 4-9 of the attached supplementary file named "hessd-12-C1-2016-supplement.pdf"). In this

supplementary file: i) the text on the CRD method is revised and graphical illustration included, ii) the issue of attribution in line with the remarks of Merz et al. (2012) was comprehensively handled, iii) the use of the Mann-Kendall test to detect trend in the model residuals was inserted, and iv) discussion on the paper by Harrigan et al (2014) was also incorporated.

COMMENT No.4

Overall, the case study is probably interesting, but the reporting and structure of the paper is at present not sufficient to adequately judge the scientific quality of the contribution in my opinion. If the authors are prepared to make a concerted effort to improve the presentation, then I would recommend major revision, but anything less and I would have to recommend rejection.

REPLY No.4

Based on the need to restructure the paper as suggested by the reviewer, on top of the changes already mentioned in the Reply No.1, the following steps will also be taken: 1. New sentences on the model residual trends will be inserted in the Abstract. 2. The Introduction Section will be tremendously restructured as seen under the reply to the comment No.2. 3. The steps for grouping of the stations in Section 3.1 will be revised. 4. New sentences giving the rationale of the grouping in 3 above will also be inserted in Section 3.1. 5. The reasons for the analyses of the rainfall-flow co-variation on both regional and catchment-scale will be inserted in section 3.2. 6. Section 3.4 will be revised through logical description of the procedures in the analyses of simulation-based approach of flow variation attribution (see Section 3.4 or lines 93-247 on pages 4-9 of the attached supplementary file named "hessd-12-C1-2016-supplement.pdf"). 7. In Section 4.6, the text on the analyses of trends in the model residuals will be given (see lines lines 220-233 on page 9 of the attached supplementary file named "hessd-12-C1-2016-supplement.pdf");

TECHNICAL CORRECTIONS (TC):

TC No.1 :

Page 12168, line 25: remove ‘etc.’

Reply 1 :

In the revised manuscript, ", etc" will be removed.

TC No.2 :

Page 12168: ‘sufficient planning’ I wonder if sufficient is the right word? I think it suggests something like just crossing the lower threshold of acceptance. Maybe ‘careful planning’ would be more appropriate?

Reply 2 :

By replacing ’sufficient’ with ’careful’, the sentence under consideration will become To deal with these challenges, careful planning and management of the River Nile water resources is required.’

TC No.3 :

Page 12170, line 4: What is the meaning of ‘restively’ here?

Reply 3 :

For clarity, ’restively’ will deleted.

TCNo.4:

Page 12170, line 17: ‘These’ what? Maybe the impact of these factors result in lower runoff coefficients than might be expected from its vast drainage area. However, I am not sure catchment area is an altogether good predictor of runoff coefficients, if you mean runoff volume divided by rainfall volume – why should area have much control over this? For example, the SCS method does not include considerations of area when calculating excess rainfall.

Reply 4:

Indeed, ‘These’ was used in reference to the two factors including the negligible runoff from about 40% of the drainage (basin) area, and the loss of about 50% of the flow to evaporation in the Sudd region. For clarity, the sentence under consideration will be rephrased to "The impact of these factors result in lower runoff efficiency in the Nile Basin despite its vast drainage area of the Nile River."

The authors confirm that the runoff coefficient was inferred in terms of the ratio of the runoff volume to the rainfall volume. The catchment area influences the runoff coefficient by regulating the amount of the rainfall volume and thus the runoff efficiency (runoff volume per unit of area).Some of the factors which affect runoff volume include the soil type, vegetation, catchment slope, and catchment area. For a catchment with vast area under an arid and hyper-arid condition like the Nile Basin, so much of the rain water is lost to infiltration. Even within the portion of the Basin which is not in arid condition, the rain water is further lost by about 50% to evaporation especially in the Sudd region. Given that the time taken by the water to reach the catchment outlet when the area is large tends to be so long, the losses of the rain water by infiltration and evaporation make the runoff volume low despite the large amount of rainfall. Eventually, when the low runoff volume is divided by the large rainfall volume, a small runoff coefficient is obtained. In the same line, a smaller runoff efficiency would also be obtained. On the other hand, if the catchment with large area is less vegetated and characterized by steep slopes, high antecedent soil moisture (the case for non-arid conditions), large runoff volume can be generated thereby leading to high runoff coefficient.

TC No.5 :

Page 12172, top: Is it sensible to use monthly average flow as an indicator, when there is clear intra-annual variation based on wet/dry seasons?

Reply 5 :

If the reviewer referred to page 12171 instead of 12172, Indeed, the values in the last column of Table 1 are the long-term mean of the annual flow but not of monthly time scale as it mistakenly appears. The authors clarify that the use of the adverb 'monthly' was by mistake. Eventually, 'monthly' will be changed to 'annual' in the revised manuscript.

TC No.6:

Page 12171, in 6: What does '4 (6)' mean? Is it 4 or 6? Table 2 and 3: Please make sure to report station details in the same format. Table 3 should be formatted to look like Table 2, and why not merge the two tables into a single table containing information on all the rainfall data used in the study?

Reply 6 :

In line 6 of page 12171 in the Discussion Paper, '4 (6)' was referring to the number of locations from where rainfall data were obtained. For clarity in the revised manuscript, the sentence under consideration will be rephrased to 'Daily rainfall at 4 locations over Kagera, and monthly rainfall series from 6 stations in and around Atbara were obtained from the FRIEND/Nile project.'

As suggested by the reviewer, Tables 2 and 3 were merged as below and will appear as Table 2 in the revised manuscript; eventually, other tables will be re-numbered accordingly. To see how Tables 2 and 3 were merged, page 10 of the attached supplementary file named "hessd-12-C1-2016-supplement.pdf").

TC No.7:

Page 12172, line 16-on wards: Merge (i) and (ii) and say take each of the 18 stations in turn , and define the selected station as a master station (iii) for what aspect of the flow series is the correlation computed? (iv) this seems overly complicated, presumably you form a group of stations that are correlated positively with the master station? Is step (v) necessary? Seems like a repeat of (iv)?

Reply 7 :

In the grouping of the hydrological stations: âĂć Steps i) and ii) were merged, âĂć it was clarified that the correlation was computed for annual and seasonal discharges, âĂć Step (iv) was rephrased for clarity, âĂć Step (v) was deleted.

Eventually, the text on the grouping of stations was revised for correction in the revised manuscript as below.

The steps taken to group the discharge stations were as follows: i) take each of the 18 stations in turn, and define the selected station as a master station; ii) using annual or seasonal discharges, compute the correlation between the flow of the selected station and the series from the other stations; iii) form as a candidate group, stations which have their flows positively correlated with that of the master station; iv) check if the geographical locations of the stations in the group formed in Step (ii) are spatially coherent; remove the stations whose locations are incongruous and put them back into the pool; confirm the remaining members of the candidate group as homogeneous; v) repeat steps (ii) to (iv) till the pool is empty.

TC No.8 :

Section 3.3: Why three rainfall-runoff models? Why these three models?

Reply 8 :

In this study, because of the data limitation and quality problem for rainfall-runoff modeling in the Nile Basin, three rainfall-runoff models including NAM, HBV and NAM were applied so as to balance the uncertainty stemming from the influence of the model selection on the modeled results. These three models were adopted in this study because they have been recently used by Taye and Willems (2013) (for NAM and VHM), and Gebrehiwot et al. (2013) (HBV) in the investigation of the effect of land-use change on the flow regimes in the study area.

The above response can already be found incorporated in the reply to comment No.2

for correction in the revised manuscript.

TC No.9 :

Page 12175 line 26: Why suddenly introduce the extreme high/low flows? The previous analysis has focused on seasonal and annual flow, but this is much more detailed.

Reply 9 :

The impact of anthropogenic factors, climate variability and/or change on hydrology seem to increasingly alter the frequency and severity of risk-based water disasters such floods and droughts from their expected normal occurrences. For rainfall-runoff models to be applied for impact investigation, for instance due to climate variability and/or change on extreme flows, the ability of the models to capture the high and low flows are important for risk-based planning and management. On the other hand, considerations of seasonal and annual time scales in rainfall-runoff modelling tend to be limited to applications related to agricultural management.

The above clarification for the consideration of extreme high/low flows in the modelling will be inserted in line 2 of page 12175 in the Discussion Paper.

TC No.10:

Page 12176, line 23: what is a 'sub-trend analysis'?

Reply 10 :

Sub-trend analysis entails construction of the CRD plots to identify and assess the significance of the short-durational changes in the trend directions over unknown periods of the time series.

Description of sub-trend identification will be elaborated in the Section 3.4 of the revised manuscript as already shown in the reply to comment No.3.

TC No.11:

Table 4-5: Some of the correlations a very high (>0.9); was the connectivity between stations via the river network considered at any stage in the analysis? Also, I don't understand if the 100s of numbers dumped in Tables 4, 5, 6& 7 are the same as what is shown in Figure 2? But again, I am not sure I understand what is the significance of this result?

Reply 11:

The cross-correlations of the flows from each group are sometimes high because of the connectivity of the stations along the two river networks i.e. the White Nile (for group 1) and Blue Nile (for group 2). This clarification on the connectivity of the stations along the river network will be made in Section 4.1 of the revised manuscript.

By looking at, say, Figures 3 and 4 the close agreements between the flows at stations of each region or group might seem speculative. Eventually, to support the graphical visualization of the homogeneity of the flow variations in each group shown in Figure 3 a) and b), cross correlations were investigated and the results summarized in Tables 4 and 5, respectively. In the same line, to support the graphical results from Figure 5 a) and b) showing the close agreements between the rainfall over the two regions, cross-correlations between the stations were also summarized in Tables 6 and 7. The discussion on Figure 5 and Tables 6 (for group 1) and 7 (for group 2) can be found in lines 3-15 (on page 12182) of Section 4.3 in the Discussion Paper.

Figure 2 was to demonstrate the heterogeneity in the flow variation in the two groups 1 and 2. In other words, the flow any selected station in group 1 is not positively correlated to that of another station in group 2. This elaboration was already made in lines 5 to 9 on page 12179 of the Discussion Paper.

TC No.12:

Section 4.2: I think the discussion in this section is rather speculative and based solely on a visual inspection of the scaled flow series.

Reply 12 :

One statistical measure to understand variation in the series is the consideration of the metric coefficient of variation (Cv). The CV values for the various flow stations as shown in Table 3 were computed and will be included in the last column of Table 1 in the Discussion Paper (see page 11 of the attached supplementary file named "hessd-12-C1-2016-supplement.pdf").

The block of text below will be inserted at the beginning of Section 4.2 on page 12180.

One statistical measure to understand variation in the series is the consideration of the metric coefficient of variation (Cv). As already seen from Table 1, the Cv values of the annual flow were shown to vary in range from 0.15 (station 15) to 0.77 (station 6) thereby indicating a moderate variability on a year to year basis. However, to separate the periods over which the flows were above or below the long-term average, graphical plots of the series were made.

TC No.13:

Page 12182, line 20: 'two and three' what?

Reply 13 :

'two and three' was used to mean the number of groups formed by Onyutha and Willems (2015).For clarity, "into two and three" appearing in line 20 of page 12181 of the Discussion Paper will be deleted in the revised manuscript.

TC No.14 :

Page 12181, line 28: What is a 'variation pattern'? Reply 14 :'

variation pattern' was used to mean how flow vary with time. For clarity, "pattern" will be deleted from the same expressions throughout the paper e.g. in lines 4 (page 12168), 3 (page 12172), 12 (page 12173), 28 (page 12181), 20 (page 12182), 7 (page 12183), and 7 (page 12188).

TC No.15:

Page 12182, line 1-2: Is this not obvious, as most of the catchment is upstream of Egypt, and the rainfall in Egypt is very low?

Reply 15 :

The authors agree that most of the catchments in the Nile Basin are upstream of Egypt. For clarity, the sentence under consideration will be rephrased to become

"Furthermore, it is known that the influence of the rainfall over Egypt on the Nile flow is minimal because the largest area of the Nile Basin is upstream of Egypt."

REFERENCES CITED BOTH HERE AND IN THE SUPPLEMENTARY FILE "hessd-12-C1-2016-supplement.pdf"

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Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/12/C6746/2016/hessd-12-C6746-2016-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 12167, 2015.