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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Spatial and temporal variability of rainfall in the Nile Basin" *by* C. Onyutha and P. Willems

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MAJOR COMMENTS

No. (1)

Although the topic is very interesting and the paper is well written and structured, I believe that it does not present any novel idea with respect to previous authors' works in terms of methodology (Ntegeka and Willems, 2008; Nyeko-Ogiramoi et al., 2012; Moges et al., 2014, Onyutha and Willems, 2014a and 2014b), investigated variable and applications (Mbungu et al., 2012; Taye and Willems, 2011 and 2012; Nyeko-Ogiramoi et al., 2013), albeit with some variations (in previous studies applications were limited to specific catchments within the Nile river basin, whereas in the present study the whole

basin is considered). The authors should explain in details the innovating aspects of this study compared to previous publications.

REPLY

Because the robustness of the QPM for the hydrometeorological variables of the study area was already demonstrated by Mbungu et al. (2012), Moges et al. (2014), Nyeko-Ogiramoi et al. (2013), Onyutha and Willems (2014a, b), and Taye and Willems (2011, 2012), the authors clarify that the innovation of the paper lies rather in the improved hydro-meteorological variability insights for the entire Nile basin than the methodology.

The shortcomings of the previous publications that are addressed in this study are explained next.

Nyeko-Ogiramoi et al. (2013) focused on the variability and trends in the annual rainfall extremes. Also in the previous publications (Mbungu et al., 2012; Ogiramoi et al., 2013; Onyutha and Willems, 2014a, b; Taye and Willems, 2012), the variability analyses were confined mostly to sub-basins. Given that over 70% of the people within the Nile Basin depend on subsistence rain-fed agriculture for their livelihoods (International Water Management Institute IWMI 2014), variability in the seasonal and annual rainfall volumes as considered in this study is also important for the study area. Importantly, considering the entire River Nile Basin as done in this study, helps to understand the regional differences in the rainfall statistics. This, again, is vital for regional planning given that subsistence and rain-fed agriculture, together with high rainfall variability is one of the main causes of food insecurity and the most daunting challenge the entire Nile Basin faces (Melesse et al. (2011).

Attempts to investigate any possible linkages of the rainfall variability to ocean-atmosphere interactions as made in study were not considered in some of the previous studies e.g. Mbungu et al. (2012), and Onyutha and Willems (2014a, b).

As mentioned in lines 6-8 on page 11953 of the discussion paper, in the previous studies, investigation of the possible drivers of rainfall variability over the Lake Victoria Basin (Nyeko-Ogiramoi et al., 2013) and Blue Nile Basin (Moges et al., 2014; Taye and Willems, 2012) were only limited to four climate indices. In this study, to find the origin of the driving forces, also other series and/indices relevant in explaining the variability patterns of rainfall over the Nile Basin were used. These included a total of 10 (instead of only 4) climate indices, and the global monthly historical SLP (HadSLP2) data and SST (HadSST2) anomalies.

Furthermore, the variability analyses of the previous studies were based on observed short-term data picked over different time periods and from few meteorological stations. This affects the spatial coherence of results for the variability analyses as similarly shown for rainfall trends by Onyutha et al. (2015). Eventually in this study, for conclusiveness of drivers of rainfall variability on regional basis, 37 meteorological stations with series over the periods (not less than 35 years in length) in which each station had data records were considered.

No. (2)

With reference to the methodology, the QPM is based on a comparison between quantiles with similar return periods derived from the complete time series of length n and sub series of fixed length D. Return periods are computed as n/j or D/j, with j the rank of each value of the series sorted in descending order. For small sample series (i.e. n<100) the latter represents a biased estimator of return periods for all distributions, thus in principle it would not be recommended. The authors should demonstrate that the use of an unbiased estimator does not change the results significantly.

REPLY

The authors agree that the estimation of return periods T (years) from data of short record length can be characterized by bias. This bias becomes large when Ts being estimated (by extrapolation after fitting theoretical distribution in the frequency analysis) is far higher than the data record length. It is known that extrapolation of data measured

over relatively short record length introduces large uncertainties (Klemeš, 2000). This clearly indicates that caution must be exercised in using data of short record length for estimating very high T. This was verified using the flow-duration-frequency relationships for the river flows of the Lake Victoria Basin of the study area (Onyutha and Willems, 2013). According to Kangieser and Blackadar(1994), extrapolation of quantiles should be limited to Ts not far larger than three times the data record length.

It is important to note that in the QPM employed in this study, computation of anomalies is normally limited to the empirical Ts not greater than the data record length. The fact that the Ts from the time slice and those from the full series are first matched before the computation of the ultimate anomaly, it confirms that there are no extrapolations done in the estimation of the Ts. Because there are no extrapolations done for Ts, it can be importantly noted that the computed anomaly of each time slice does not significantly affect the variability results. The authors assure the reviewer that this clarification will be made in the revised manuscript.

MINOR COMMENTS

i)

Lines 7-8 p. 11959: “Correlations for groups A to C are obtained over the periods in which each station had data records i.e. 1935–1970 (36 years?), 1954–1992 (39 years?) and 1945–1985 respectively.” This is apparently in contrast with lines 20-22 at p. 11949: “To enhance the acceptability of the research findings, long-term rainfall series of length not less than 40 years and missing data points not more than 10% were used.” and Table 1. Please check.

REPLY

The authors agree with the comment of the reviewer. The shortest (longest) data record length as seen from Table 1 is 43 (96). The consideration of the periods in which each station had data records in the correlation analyses was for the conclusiveness of the driving forces of the rainfall variability. This was done because of the spatial coherence of the temporal variability results that could be obtained a regional basis when data from the different meteorological stations are of the same length and picked over the same time period for analysis.

To make this point clear in the revised manuscript, a new sentence will be inserted in line 22 of page 11949 after '………….data points not more than 10% were used' as follow.

However, to check on the spatial coherence of the variability results across the study area, the period of not less than 35 years over which each station had rainfall data was considered.

ii)

Lines 21-23 p. 11960. "Although for brevity, spatial maps for correlations between HadSLP2 or HadSST2 and annual rainfall are presented Figs. 5 and 6, for those with the rainfall in the main wet seasons of the different groups, see Figs. A1 and B1." Please rephrase.

REPLY The spatial maps for correlations between HadSLP2 or HadSST2 and annual rainfall are presented Figs. 5 and 6. For the correlations between HadSLP2 or HadSST2 and the rainfall in the main wet seasons of the different groups, the spatial maps are shown in Figs. A1 and B1.

iii)

References Jury (2010) is not in the text. Some references are not in alphabetical order (e.g Grist and Nicholson, 2001 is before Goovaerts, 2000 and Gleick and Adams, 2000). Please check.

REPLY

The authors verify that Jury (2010) was cited in line 7 of page 11960. In the list of

references, Jury (2010) was put in line 20 of page 11967 of the discussion paper. However, the authors confirm that it was by mistake that alphabetical order was not followed for the three references including Grist and Nicholson, 2001, Goovaerts, 2000 and Gleick and Adams, 2000. In the revised manuscript, these references will be alphabetically arranged such that they appear in the order: Gleick and Adams (2000), Goovaerts (2000) and Grist and Nicholson (2001).

Furthermore, the authors wish to notify that correction will be made to the reference in lines 15-16 of page 11969 in the discussion paper by changing the name of the co-author 'Gaddi-Ngirane, K' to 'Ngirane-Katashaya, G.' as below.

Nyeko-Ogiramoi, P., Willems, P., and Ngirane-Katashaya, G.: Trend and variability in observed hydrometeorological extremes in the Lake Victoria Basin, J. Hydrol., 489, 56–73, 2013.

iv)

Tables and Figures I suggest to homogenize captions of Tables 4 and 5, as well as captions of Figures 5 and 6.

REPLY

For clarity, the captions of Tables 4 and 5, as well as for Figures 5 and 6 will be changed. The captions will take the form as follow:

Table 4. Correlation between QPM results for annual rainfall and climate indices over the periods 1935–1970 (for group A), 1954–1992 (for group B) and 1945–1985 (for group C)

Table 5. Correlation between QPM results for annual rainfall and climate indices considering full series with lengths of data records shown in Table 1.

Figure 5. Correlation between anomaly in annual Sea Level Pressure (SLP) and that in region-wide annual rainfall for group (a) A, (b) B, (c) C. In the legend, Gp denotes

group.

Figure 6. Correlation between annual Sea Surface Temperature (SST) and that in region-wide annual rainfall for group (a) A, (b) B, (c) C. In the legend, Gp denotes group.

v)

Figure 7. Charts 7.g and 7.h are not commented in the text. Furthermore, charts 7.d and 7.h are apparently referred to the same station (Helwain), but the corresponding time series are different. Please check!

REPLY

The authors admit that there were mistakes made on Figure 7 and they will be addressed as follow: âĂć In the caption, '( )' will be changed to '[ ]' âĂć Charts c) and f) will be deleted. This is because there are already two stations for group B presented in Figure 7. âĂć Label of chart d) will be changed to c) âĂć Label of chart e) will be changed to d) âĂć Label of chart g) will be changed to e) âĂć Label of chart h) will be changed to f) âĂć Label [D] of charts d) and h) will be changed to [C]. This is because there is no group D.

Eventually, the new Figure 7 of the revised manuscript will be as below (See Figure 1 of this reply).

» Caption of the revised figure

Figure 7. Annual SLP differences and rainfall at selected stations of the different groups A–C for a time slice of 5 years; the group labels are in [ ]. The label of a legend indicates the coordinates (degree longitude and latitude) from where the SLP differences were taken. The label in { } show the locations where the coordinates are found. Annual and seasonal time scales are shown in charts (a)–(c) and (d)–(f) respectively.

Furthermore, the authors confirm that the appearance of the same station (HELWAIN)

in two charts of Figure 7 is correct. The series are different because one is for the annual rainfall and the other the ONDJF season (see the last sentence of Figure 7 caption of the discussion paper).

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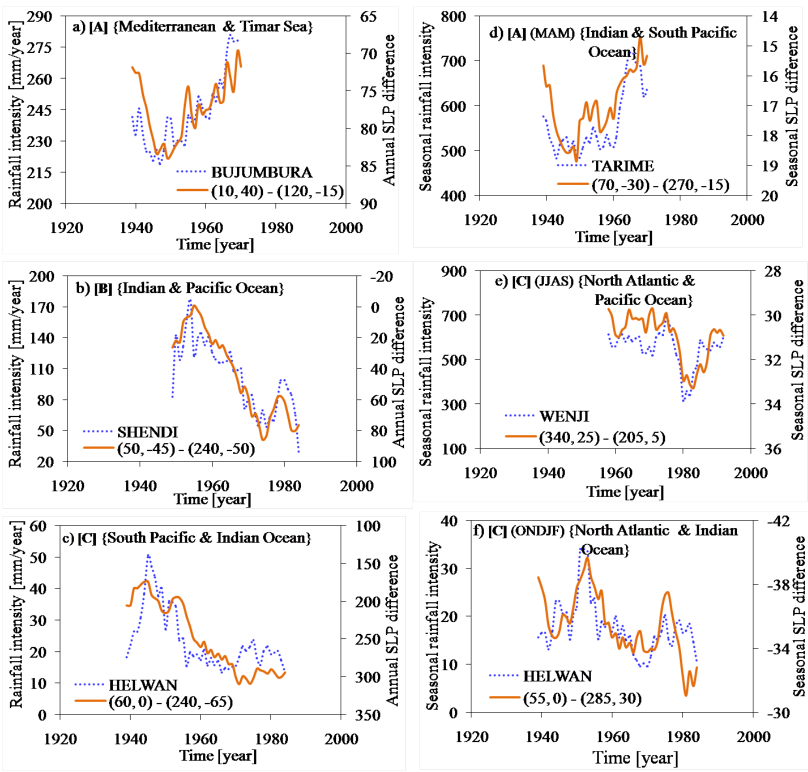

Fig. 1. Annual SLP differences and rainfall at selected stations of the different groups A– C for a time slice of 5 years; the group labels are in [ ]. The label of a legend indicates the coordinates ......