Hydrol. Earth Syst. Sci. Discuss., 7, C5161–C5172, 2011
www.hydrol-earth-syst-sci-discuss.net/7/C5161/2011/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Multi-objective regionalisation for lake level simulation, the case of Lake Tana in the Upper Blue Nile, Ethiopia" *by* T. H. M. Rientjes et al.

T. H. M. Rientjes et al.

haile07634@itc.nl

Received and published: 28 February 2011

Anonymous Referee #3

General comments

This is an interesting study to retrieve regional hydrological results from an HBV model for Lake Tana basin. However, structure can be improved to focus only on regionalization study rather than extending the analysis to simulate Lake Tana water level. Sources of uncertainty increases as one move downstream in a hydrological system. Therefore, I think the paper would have been stronger, if limited to regionalization analysis alone. By removing lake simulation, the author may find enough space to strengthen the regionalization analysis, assess uncertainty involved, etc.

Reply : We thank the reviewer for the suggestion to remove the sections on the simulation of Lake Tana water levels that would result in a paper with a different scope. We note that the other two reviewers did not make similar suggestions and therefore after some consideration we decided to maintain the setup of the original manuscript. As such the sections on the water level simulation are maintained. To our opinion, this work presents a sound case study where outcomes of regionalization directly are used to (better) understand the water balance of a large and important water body. We note that Lake Tana is the source of the Upper Blue Nile with major interest from water managers in the Blue Nile area and Nile basin area at large. We acknowledge the suggestion to assess uncertainty of the approach but to our opinion is asked too much for this paper. A very different paper would then resolve that requires different techniques and analysis. We leave such analysis for further work but also refer to Wale et al., (2009) where a relatively simple analysis is presented.

However, lake water balance simulation can also be used to assess error of computed runoff. i.e., compare Qin from ungauged catchment by the regionalization with the backward computation of Qin-ungauged from lake water balance. However, it is critical to realize what sources of errors in such analysis are, and try to assess each one separately.

Reply: The procedure suggested also aims at estimating a closure term for the water balance. To our opinion, in essence we do the same except we do it through a forward modeling approach instead of the inverse approach suggested by the reviewer. In our work we assess the accuracy of the lake water balance by comparing simulated to observed lake levels.

Need to emphasize the physical meaning of the retrieved correlation results between HBV parameters and PCCs.

Reply: A similar comments has been made by reviewer 1 and descriptions have been added.

Needs to refer to literature using HBV model on the same catchment, but failed to retrieve regional results on daily time step, e.g., Uhlenbrook et al., 2010.

Reply: Works by Uhlenbrook et al., (2010) and others are now referred to in the discussion section.

Also refer to Lake Tana water balance studies, they were many.

Reply: To the knowledge of the authors only a limited number of novel studies on the water balance of Lake Tana are reported. Novel studies that address Lake Tana's water balance are reported by Setegn et al., 2005; Kebebe et al., 2006; SMEC, (2008), Chebud and Melesse, 2009; Wale et al., (2009). We note that earlier works often state that 93% of the Lake Tana inflow is from gauged areas although a clear reference to this number is absent in e.g. Kebebe et al., 2006 and Chebud and Melesse, 2009. We further note that many references in Uhlenbrook et al., (2010) on Lake Tana's water balance consider the same inflow figure. SMEC (2008), Setegn et al., 2005 and Wale (2009) indicate much lower inflows from gauged systmes. Therefore we hesitate to further address the previous works since outcomes of the studies cannot be regarded reliable by the unrealistic high inflow (i.e. 93%) from gauged systems.

Conclusion is too general. Try to make it specific with quantitative outputs. Don't concentrate only on evaluating results of Wale, 2009

Reply: the conclusion section has been revisited and modifications have been made following the suggestion by the reviewer.

Specific comments

The title does not reflect the content. It is rather confusing. The study is a hydrological study, to model inflow from ungauged catchment using HBV model, as well as regression analysis. The water balance result is only small part of the paper. Therefore, a

simpler title could be better, e.g., Regionalization of stream flow for the simulation of Lake Tana water balance, Upper Blue Nile, Ethiopia

Reply: As described above we disagree to the viewpoint of the reviewer to only focus on regionalization issues. We agree to the comment on the title and changed the title to 'Regionalisation for lake level simulation, The case of Lake Tana in the Upper Blue Nile, Ethiopia

P7342, L14; Would be good to show HBV model performance, and verification of transferability first, then results on lake level.

Reply: This work aims at testing a procedure where a regional model is developed that serves to estimate inflows from all ungauged systems. The procedure suggested by the reviewer aims at a regionalisation procedure as based on spatial proximity principles. We note that such procedure already has been applied by the first author in Wale et al., (2009) and yielded poor simulation results. Therefore we did not further assess issues of parameter transferability in this study but aimed at regionalization by use of an improved regional model. We note that assessing the limitations of respected regionalization procedures is a research topic of great interest but we feel that such comparison is out of scope for this paper. Presumably also a much larger number of gauged and ungauged systems then are required to establish under what specific catchment conditions parameter transferability fails.

P7342, L16; An average error of 85 mm/day over the lake, is approximately 250 million m^3/day (2800 m^3/s). Discuss implication of this error on outflow (_ average is 120 m^3/s) to verify sensitivity of various error sources. Please clarify if this extraction of results is not correct, and modify abstract accordingly. The results in the text of p 7362 is different, at least the interpretation.

Reply : We thank the reviewer for the suggestion to clarify the numbers and syntax. We clarify that the closure term is calculated per year and not per day. Obviously a closure term of 85 mm per day would result in a very large error as indicated by the *reviewer. Given the small error we ignore to further elaborate how such error could impact the Blue Nile river flows. Such assessments presumably also would require detailed records of Blue Nile flows and how water is used down-stream of Lake Tana.*

Keywords?

*Reply: For reasons not known to the authors during the Type sett process the list of Keywords was removed. Keywords initially added were**:** Multi-objective model calibration, regionalisation, Lake Tana, Water balance closure. The keywords have been added again.*

Include more literature discussion on lake water balance in the introduction, e.g. other than Lake Tana. What are pros and cons, key sources of errors, etc.

Reply: Following the suggestion we extended the description on the Lake Tana water balance studies. As stated above we hesitate to address (all) the sources of error and uncertainty. In the manuscript we introduce the uncertainty issue. The second comment aims at discussing uncertainties involved in water balance studies other than Lake Tana. Given the scope of this paper and given our previous comments on the scope of this work we hesitate to add such review. Again we feel like that such is outside the scope right now and leave that for further study.

Fig. 1: be consistent with naming of stations: ET station, Rain gauge station, etc.

Reply : This request is not clear since naming is consistently applied.

Fig.1.: too many colours, better make two colors only gauged and ungauged. e.g., Gumera gauged, Gumara ungauged, not clear?

Reply : We revisited Figure 1 and introduced less colors following the suggestion by the reviewer.

P. 7343, L14; this sentence is not clear or not complete.

Reply: We agree that the sentence requires improvement and have reformulated the

sentence.

P7344 L 11; why? this argument should be supported by results.

Reply : the sentence has been modified to clarify. Results are referred to in the previous sentence so there is no need to repeat the result.

P. 7345, L 21; Include a short description of Chara Chara weir, and whether it regulated outflow after 1998 onward.

Reply : A short description has been added and it is indicated whether the wear regulated outflow.

P7346 L 8; is the gauge upstream or downstream Chara Chara weir, does lake outflow it affected by regulation of the weir?

Reply : a comment on the operation and construction Chara Chara weir is added to the previous paragraph.

P. 7347, L 7; refer also to Uhlenbrook et al, 2010, used HBV model for the same catchment

Reply: Done.

P. 7347, L 17; snowmelt is not relevant in study area, so need to explain snow routine of HBV.

Reply: we agree to the comment and have removed the description on snow melt.

P. 7351, L 10; you may also check NS for log Q to evaluate low flows.

Reply: We thank the reviewer for the comment but we used only generic performance indicators since we do not aim at evaluating specific properties such as high flows, low flows or the shape of rising or falling limp of a hydrograph as shown by the author in (De Vos and Rientjes, 2007). We note that by the low flow discharges the errors in low flows only are relatively small as compared to wet season flows. As such we do not aim *at estimating low flows as good as possible for instance in a multi-objective calibration approach and refer to De Vos and Rientjes, 2008 for such exercise.*

de Vos, N.J. and Rientjes, T.H.M. (2007). Multi - objective performance comparison of an artificial neural network and a conceptual rainfall - runoff model. In: Hydrological sciences journal = Journal des sciences hydrologiques : open acces, 52, (2007)3, pp. 397-413.

de Vos, N.J. and Rientjes, T.H.M. (2008). Multi-objective training of artificial neural networks for rainfall - runoff modeling. In: Water resources research, 44(2008), pp. W08434.

P. 7351, L 15; more realistic to use absolute values, or RMSE, Root Mean Square Error

Reply: We thank the reviewer for the comment. We purposely selected 2 generic performance indicators that should indicate on the overall shape of the hydrograph and on the water balance error (see also Madson, 2000). We agree to the reviewer that the RMSE produces absolute values that possibly may be more objective but RMSE also squares all deviations such as NS. Similar to the previous comment, in this work we do not aim at evaluating more specific properties of the hydrograph such as high flows, low flows or differently. We note that such assessments commonly are of high relevance in advanced model performance assessment studies. We further note that RMSE can be normalized (NRMSE) as well (see de Vos et al., 2010).

De Vos, N. J., T. H. M. Rientjes, and H. V. Gupta (2010), Diagnostic Evaluation of Conceptual Rainfall–Runoff Models Using Temporal Clustering. *Hydrol. Processes*., DOI: 10.1002/hyp.7698

P. 7354; unnecessary long discussion on statistics.

Reply: This comment causes a dilemma to the authors. Reviewer 1 demands a more extensive description while reviewer 3 prefers to have a much more condensed description. We have left the description unchanged..

P. 7355, L 22; it is not clear why retrieving albedo from MODIS for the water surface of Lake Tana to obtain a representative spatial pattern, while using climate data from one station for the Penman equation. Justify? Spatial variability of albedo could be least sensitive compared to other climate parameters of radiation, temperature, and humidity.

Reply: The remark why lake average values for albedo are used is simply to obtain more representative values for albedo as compared to when albedo is used for single locations. Albedo is estimated on a daily base to make up an annual cycle. Albedo ranged from 0.08 to 0.16 by the gradually changing solar zenith angle during the course of the year. We used data from Bahir Dar station since this is the only station close to Lake Tana and thus, presumably, best reflects on lake meteorological properties. A description has been added to the manuscript

P7369, Table 3; Koga and Gilgel Abay are not feeding directly into the lake, still large catchment before the lake , how flow was estimated?

Reply: In the Lake Tana basin area both catchments are drained by the Gilgel Abay river that drains directly into Lake Tana. Therefore we add the flows directly to the water balance of Lake Tana and ignore the flow and travel time of runoff water in the lower (ungauged) part of the Gilgel Abay catchment. The same procedure is applied for all gauged and ungauged catchments by lack of gauge data at the inflow points of Lake Tana (see figure 1). We note that runoff is estimated for all ungauged parts of the larger catchments that are gauged (e.g. Gilgel Abay, Ribb, etc).

P. 7357, L11; not clear, elaborate.

Reply: We thank the reviewer for the comment and have made the necessary modifications.

P. 7357, L 23; number of catchments is a key point in regionalization analysis, and deserve critical discussion, e.g., to evaluate how much uncertainty for using only 6 catchments

Reply : We thank the reviewer for this critical comment and have added a description on the issue how catchment variability may affect regionalization.

P. 7357, L 27; assuming comparable catchment characteristics because of proximity may not be true. e.g., Koga is very much different compared to the neighboring Gilgel Abay, because of extensive dambos in the former. This renders no transferability between the two catchments for daily time step, see Uhlenbrook et al, 2010.

Reply: We thank the reviewer for the remark and have removed the sentence.

P. 7379; Fig. 3, size is very small, please increase to allow the reader to distinguish observed and simulated. The plot may give much better information than NS, RVE alone.

Reply: We assume that the reviewer aims at figure 5. We acknowledge that the figure is somewhat compressed but increased the font size to improve readability.

P. 7358, L 20; how HBV parameters compared to literature, e.g., Uhlenbrook et al., 2010, and why big differences. Diversify literature sources, not so frequent reference to Wale, 2009 alone

Reply: After comparing the model structure some differences are observed that may impact parameterization. Also the references for selecting prior ranges differ while for some parameters (e.g. ALFA) values are not shown in Uhlenbrook et al., 2010. Lastly, we present parameter values as average over 25 best performing parameter sets of 15 MCS runs (of 60,000 each) as compared to single best parameter sets in Uhlenbrook et al., 2010.

P.7359 L11; could be useful to test regional results on some of the gauged catchments and assess error involved

Reply: We applied this procedure for validating the regional model. A description has

been added to section 5.7.

P. 7360, L 2; Could be better to discuss the physical meaning of these correlations, rather than repeating numerical values gain here.

Reply: We have added small descriptions based on hydrologic reasoning and plausibility.

P. 7360, L 21; why albedo shows a big range for the water surface of Lake Tana? Any validation?

Reply: We think the reviewer refers to page. Albedo may range between 0.03 and 0.1 when zenith angles are small and between 0.1 and 1.0 when zenith angles are large. In this case Albedo ranged from 0.08 to 0.016 during the year as shown in the attached figure. To our opinion values are not unrealistic. A small description has been added to the manuscript.

P. 7360, L 2; on comparing observed, and computed lake level, how good is the match,

give quantitative analysis of errors, and why? Discuss

Reply : For the lake level simulation NS and RVE are calculated. Results are added to the manuscript and a short discussion is added. A description on uncertainties is already added to Wale et al., (2009) and therefore is not repeated. This is added to the manuscript..

P7363 L1; Such conclusion could be misleading, because the Q ungauged has never been verified! so uncertainty in the water balance could be due to various reasons -equifinality problem! so, the paper could be clearer if the lake balance is used to verify Q ungauged.

Reply: We agree to the observations by the reviewer and we have modified the paragraph.

P7375 Fig 1 ; river water level or discharge station or hydrological stations

Reply: From the MoW only discharge time series have been received.

P7379 Fig 5 ; the size is very small to see plots, makes 4 times bigger

Reply: The figure can be enlarged when printing the article.

P7380 Fig 6 ; show comparison of simulated vs. observed

Reply: For these variables there is no comparison possible since real world observations are not available.

P7381 Fig 7; why? Large deviation after 03

Reply : In the manuscript it is described that the Chara Chara weir is in operation from 2001 onwards. The deviation suggests that more water is released from Lake Tana as compared to free outflow conditions.

P7368 Table 2 : Koga and Gilgel Abay are not feeding directly into the lake, still large catchment before the lake , how estimated?

Reply: This is already addressed above and a description is added to the manuscript.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 7341, 2010.

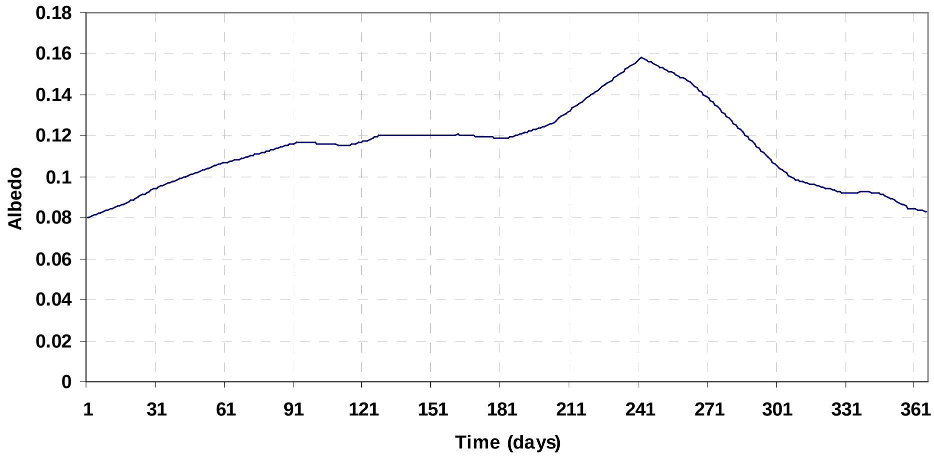

Fig. 1.