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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Using the nonlinear aquifer storage–discharge relationship to simulate the baseflow of glacier and snowmelt dominated basins in Northwest China" *by* R. Gan and Y. Luo

R. Gan and Y. Luo

luoyi.cas@hotmail.com

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Dear editors and reviewers,

Thank you for your valuable comments and kind suggestions. Accordingly, we have revised the manuscript. Following are the point to point replies to the comments and suggestions.

Anonymous Referee # 2

Comments: I noticed some points that seem somewhat unclear to me still. To me it seems, that the terms "runoff", "flow / streamflow" and "discharge" are not clearly

distinguished within the paper.

Response: We have revised the manuscript for coherence of these terms.

Comments: In order to compare the simulation results of the different baseflow routines, it might be helpful to mention the time periods used for calibration and validation of the model explicitly.

Response: We improved the description to the SWAT model setup and parameterization. Specifically, daily streamflow data at the KHS from 1961-1999 were used. In the simulation, data from 1 January 1961 to 31 December 1980 was used for model calibration and data from 1 January 1981 to 31 December 1999 for validation. Model calibration was conducted by comparing the SWAT simulation to the streamflow observation at the KHS on a daily basis (P5L18-22, section 2.3 in the revised manuscript).

Comments: p. 5538, ll. 5,6,10: You are using Qb and not Q as in the Wittenberg (1999) paper, which somehow implies that you refer to baseflow. Then, in line 14 you only use Q (consistent with Wittenberg (1999)) – is there a difference between Qb and Q in your paper?

Response: There is no difference between Qb and Q. We changed Q into Qb for coherence.

Comments: p. 5540, ll. 6-7: It might be clearer to add "for the non-linear approach" to "the constants in Eq. (2)." Also, I would recommend using "coefficients/parameters" rather than "constants".

Response: We prefer to "parameters". We rephrased this point as "the parameters in Eq. (2) for the non-linear approach have been optimized" (P5L9 in the revised manuscript).

Comments: p. 5540, ll. 7-9: To me, this sentence suggests that the simulation results in Luo et al. (2012) verify that the observation is correct, which does not seem logical.

Response: The expression of the sentence is not accurate. It was restated as "The simulated runoff is not well matched with the measured runoff during the high-flow period. This may be attributed to the snowmelt simulation (Arnold et al., 2000). Luo et al. (2012) thought that these differences might be due to the meteorological speculation in mountainous areas for SWAT model, which are derived from the records at the foot of the mountain using a single precipitation lapse rate."

Comments: p. 5540, l. 12: Adding "in Eq. (2)" would make the sentence clearer. In general, putting the sentence in ll. 13-14 before that in ll. 12-13 would be more logical.

Response: We rewrote this paragraph according to the comments. "The one-nonlinear approach in Eq. (2) overestimates the annual streamflow by 1.1%, and the two-linear reservoir approach overestimates it by 3.1%. Slight differences exist between the simulated and measured annual streamflow for the two-linear reservoir and one-nonlinear baseflow simulation approaches."

Comments: p. 5540, ll. 13-19: As NSE is usually very high in catchments with a strong annual cycle (see for example Schaefli and Gupta 2007) and overestimates high-flow periods it may not be the best performance criterion to compare different approaches of baseflow simulation in a catchment with strong seasonality. It might help to consider quality criteria more applicable to the evaluation of low flow, like NSE with logarithmic discharge values or the Volume Efficiency suggested by Criss and Winston (2008).

Response: We added the evaluation indices: NSE with logarithmic discharge values and the Volume Efficiency (VE) suggested by Criss and Winston (2008). The results were added to Table 2 in the manuscript and cited there (Table 1).

p. 5540, ll. 10-12: "Generally, the nonlinear relation performs much better than the linear relation" – This is not visible from Fig. 2, Normalization of the figures or adding of meaningful criteria might help here.

Response: The comment is highly appreciated. It was a pity that we pasted a wrong graph during preparing the manuscript. The correct graphs should be as Fig. 1.

Comments: pp. 5541-2, ll. 17 "which is sustained by outflow from groundwater" I wonder if this is the only case, or could it be also due to 1) water management in some way or 2) the methodology of discharge measurement?

Response: During the low-flow period, the runoff is mainly sustained by outflow from groundwater due to less precipitation and melting water (Rui, 2004; Chen et al., 2006).

Comments: pp. 5541-2, ll. 28-5. It might be useful to stress differences between the catchment used in your study and that used in the Partington et al. (2012) paper and maybe similarities to that used in the McCuen (2005) paper to be able to compare the results better.

Response: The comments are appreciated. We gave some more explanations about the catchment used in our study and that used in the Partington et al. (2012) paper and McCuen (2005) paper.

Comments: p. 5542, l. 7 – Not every reader will be familiar with this filter method. Could you please describe it in the methods part also?

Response: We added the description of the automated digital filter in the method section (P4-5, section 2.2 in the revised manuscript).

Comments: p. 5543, ll. 1-3 –"There is a good agreement in the baseflow patterns of the SWAT and filter methods" – I do not agree with this statement. The overall seasonality is met, but magnitude of the baseflow and also the rising limb and the recession phase differ a lot between the approaches.

Response: Agree. This statement is not accurate, and it was deleted.

Comments: p. 5546, ll. 8-10 – This sentence implies that the parameters are calibrated without consideration of the observed streamflow data. Probably you wanted to stress, that the parameters are calibrated independently from one another (and not independently from the observed streamflow, which they are in fact calibrated against).

Response: We did not express correctly. We intended to say that the parameters a and b can be optimized by fitting the recession curve with the Eq. (1) (Wittenberg, 1999) to the streamflow records during the low flow periods independent of the SWAT model.

$$Q_{bt} = Q_{b0}[1 + (1 - b)Q_{b0}^{1-b}t/ab]^{1/(b-1)}$$

where Qbt is the discharge rate at time t, and Qbo is the discharge rate at the beginning of interest. We rephrased this part.

Comments: p. 5554, Table 5: To me the correlation matrix is still somewhat unclear, especially it is not mentioned which statistical test is used.

Response: Table 5 was modified.

Comments: In general, the paragraphs under 3.2, 3.3 and 3.4 seem somewhat mixed, especially considering the description of observed streamflow.

Response: Agree. We reorganized these sections in the revised manuscript.

Comments: While the variation of coefficient b is explained in detail in 3.5 and 4, the explanation for coefficient a is still missing details in 3.5 and completely missing in the conclusion parts. In the conclusion, the coefficients a and b should be described.

Response: If the parameter b is 1, the storage-discharge relationship is linear, and the parameter b has been subject to many descriptions (Wittenberg, 1994, 1999; Chapman, 1999; Harman and Sivapalan, 2009; Aksoy et al., 2012). We want to emphasize the difference between our results and above studies, and the parameter b is explained in detail. We added the description for the parameter a

in the conclusion section.

Comments: The tables and figures shown support the contents of the paper. Still, I also would like to add some minor remarks considering the figures: In figure 3, you used a dashed line in the actual plot, but a solid line in the legend. Also, perception of the plot would be easier if you used one colour for each model approach exclusively. In that case, you could also put all three models in one plot and add one plot for only one low-flow period, where the differences between two-linear and one-nonlinear could be shown more in detail.

Response: Thanks. We improved the figures in the revision.

Comments: Proper credit is given to related work. But, some authors which are referred to in the bibliography are misspelt in the text: “Ferker” should be “Ferket” (p. 5536, l. 20, “Neistch” should be “Neitsch” (p. 5539, l. 2) “Morasi” should be “Moriasi” (p. 5539, l.16, p. 5541, l.15).

Response: They are typos. We made the changes in the revision, "Ferker" into "Ferket" (P2 L7, section1 in the revised manuscript); "Neistch" into "Neitsch" (P4L10, section 2.1 in the revised manuscript); "Morasi" into "Moriasi" (P5L24, section2.3 in the revised manuscript).

Comments: For one reference you mixed the first and last name of the author in the bibliography: “Paolo, V.” should be “Villani, P.” (p. 5547, l. 28); “Institute of Hydrology (1980)” is cited in the text (p. 5543, l. 13), but not mentioned in the bibliography.

Response: We changed "Paolo, V." into "Villani, P." (P13L2, in the references section), and added the “Institute of Hydrology (1980)” in the bibliography.

Comments: Overall, the language is fluent and precise. Not being a native speaker myself, I still would suggest some minor corrections regarding choice of words, grammar and punctuation:

p. 5537, l. 6: Replace “, Wittenberg” with “. Wittenberg”. p. 5537, l. 11: Replace “is

relevant to" with "is related to" or better "is dependent on". p. 5539, l. 5: Replace "is described in detailed" with "is described in detail". p. 5539, l. 11: "as the period used" is redundant to "the low-flow period (: : :) was selected" and can be eliminated. p. 5539, l. 16: Replace "and their ranking system" by "considering also the ranking system after Moriasi et al. (2007). p. 5540, l. 20: Replace "Streamflow" with "streamflow".

Response: Thanks. Some of the above errors are typos. We replaced ", Wittenberg" with ". Wittenberg" (P2L18); replaced "is relevant to" with "is dependent on" (P2L23); replaced "is described in detailed" with "is described in detail" (P5L7); deleted "as the period used" (P5L14); replaced "and their ranking system" by "considering also the ranking system by Moriasi et al. (2007)" (P5L24); replaced "Streamflow" with "streamflow" (P8L11).

p. 5541, l. 17: Replace "The observed streamflow eventually became nearly constant" with "During the summer months, streamflow is nearly constant".

Response: We rephrased this point as "During the low-flow period, the streamflow is mainly sustained by outflow from groundwater due to less precipitation and melting water, while surface runoff is larger than baseflow during the high-flow period, when rainfall and snow/glacier melting occur" (P9L12-15).

p. 5542, l. 7: Replace "and filter method" with "and "the automatic digital filter technique" (Nathan and McMahon 1990). p. 5542, l. 13: Replace "startes" with "starts". p. 5542, l. 26: Replace "The peak time" with "During the peak time" or "For the peak time".

Response: Agree. "and filter method" was replaced with "and the automatic digital filter technique (Nathan and McMahon, 1990) " (P10L16); "startes" was replaced with "starts" (P10L23); "The peak time" was replaced with "During the peak time" (P11L16).

p. 5543, l. 20: Instead of "index" the plural "indexes/indices" should be used. p. 5545, l.

5: Omit the comma. p. 5545, ll. 18-19: Replace "was" with "is" or restate the sentence. p. 5546, l. 12: Replace "constant" with "coefficient" – as you explain the range of the parameter, it cannot be considered a constant.

Response: We changed "index" into "indexes" (P12L19); omitted the comma (P14L11); replaced "was" with "is" (P15L13) and replaced "constant" with "parameter" (P16L17).

References:

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 5535, 2013.

Table 1 Efficiency measures for the Manas River basin using the different baseflow approaches

Model	Segment	NSE	NSE_{log}	PBIAS	VE
One-linear reservoir	calibration	0.68	-4.93	-4.0	0.59
	validation	0.62	-4.9	-3.5	0.56
	overall	0.65	-4.91	-3.7	0.57
Two-linear reservoir	calibration	0.76	0.88	-2.6	0.70
	validation	0.69	0.87	-3.6	0.67
	overall	0.72	0.88	-3.2	0.68
One-nonlinear reservoir	calibration	0.74	0.87	1.8	0.69
	validation	0.70	0.88	-3.2	0.67
	overall	0.72	0.87	-1.1	0.68

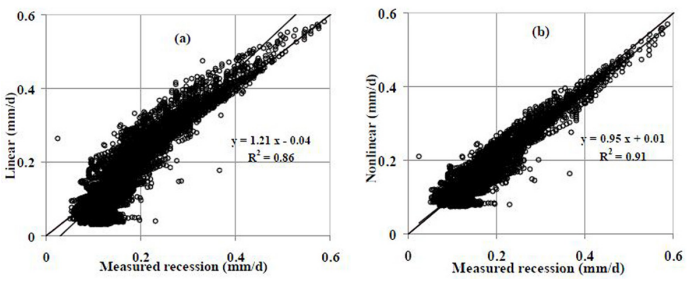

Fig. 1. Comparison of the fitted and measured recession data for 1961-1999 in the Manas River basin. (a) Using the linear aquifer storage-discharge relation; (b) using the nonlinear aquifer storage-discharge