

Review of “An integrated water system model considering hydrological and biogeochemical processes at basin scale: model construction and application” by Y. Y. Zhang, Q. X. Shao, A. Z. Ye, and H. T. Xing

This paper aims at presenting a new integrated watershed model for hydrology and several water quality parameters for large complex regulated and polluted basins which is an important scientific field in the Anthropocene. Thus, the content of the paper fits into the scope of HESS. The functioning of the model is explained using flow charts of process interactions and an Annex with all the equations. After presenting the model, it is tested in a Chinese basin and the results are compared to a former study of the authors (Zhang et al., 2013).

Although I think that the model extension and application of this paper are generally worth publishing, I have great concern about the focus of the paper and the presentation quality. In my opinion, the authors do not present a new model, but a modification to the SWAT (Soil and Water Assessment Tool) model since 90% of the model equations were taken from SWAT. Their modifications are restricted to the infiltration and nitrogen modules. Additionally, the paper would have to be re-structured and some parts (such as the conclusions) re-written from scratch. Thus, in my opinion, the paper should not be published in the present form. I would like to encourage the authors to re-write the manuscript with the focus on the presentation of modifications to the SWAT model code and a model test in the Shaying River Catchment.

General comments

- The title of the paper should be changed accordingly if the paper is re-written with a new focus. The structure of the paper is rather unusual. I recommend to re-structure the manuscript according to the scientific standard of Introduction – Methods – Results & Discussion – Conclusions (see specific comments).
- The language of the paper should be double-checked, probably by a native speaker. Often, articles are missing and the wrong tense is used which prevents a fluent reading of the paper.
- The research gap identified in this work consists of the assumption that the modules in the SWAT model are over-simplified (p. 9224, l.6-7). However, there is no reference given supporting this statement. In the context of a research gap there should be a literature review providing the basis for this assumption.
- In the discussion, the authors should set their results in a broader view by comparing with other modelling studies in large complex basins around the world. The conclusions are rather an extension/repetition of the results and discussion section. All passages containing references are not conclusions of this work but of other studies. The conclusions should be re-written from scratch to become clear and concise.
- Since the major part of the model is taken from the SWAT model, it is not necessary to create flow charts and to provide all the equations in the ANNEX. A reference to the SWAT Theoretical Documentation (Neitsch et al., 2011) would be enough. Only provide these Figures for the new model code. If the authors want to stick to all the equations, they should include the sources/references for the equations.

Specific comments:

p.9221, l. 2: ‘...faced over...’ should be ‘...faced all over...’.

p.9221, l. 13: ‘...all stations...’ is wrong, use ‘...most stations...’ instead.

p.9221, l. 14: ‘...low flow events...’ From Table 5 can be seen that this statement is wrong, the model has a clear weakness at low flow events.

p.9221, l. 19-20: ‘...good agreement ... city scale.’ This part is not clear to me.

p.9221, l. 21-25: A more humble attitude would be appropriate here. The HE^XM model will not solve all the problems all over the world but may contribute to the solution.

p.9222, l. 8: change ‘...and other...’ to ‘...and the other...’

p.9222, l. 15: It should not be ‘Singh et al., 2002’ but ‘Singh and Woolhiser, 2002’

p.9222, l. 15-25: Please provide references for the statements in this section.

p.9223, l. 2-10: ‘Furthermore...macro-scale.’ This section should be removed since it has nothing to do with the specific contents of this paper.

p.9223, l. 11-13: ‘Since...ecology)’ Please support this statements with references.

p. 9224, l.6-7: ‘...the mechanism of each module in SWAT is over-simplified...’ I agree that some modules in SWAT might be over-simplified. However, in the context of this paper it would mean that also 90% of the modules in HE^XM are over-simplified since it uses the SWAT equations... Is that really what the authors wanted to say?

p. 9224, l.13: The reference Neitsch et al. (2000) is missing in the reference list.

p. 9225, l. 7-9: This is a very ambition aim. It is not a very “scientific attitude” to expect to have the gold-standard for a scientific question. The authors might expect that their model contributes to solving these questions in the case study and elsewhere.

p. 9225, l. 17-20. I agree that the SCS model can be questioned and other infiltration model might be superior. However, it should be noted that there is the option of using the Green and Ampt infiltration model in the SWAT model (Neitsch et al., 2005, 2011). Why did the authors not use this more sophisticated option instead of implementing a new conceptualization?

p. 9231, l. 17. and p. 9232, l. 10: The reference Neitsch et al. (2002) is missing in the reference list.

p.9233, l.7: Please explain ‘GDP’.

p.9233, l.20: What is ‘GB/T21010-2007’? I couldn’t find it in the reference list.

p.9234, l.2-p.9236, l.3: ‘As an example.../2]’ Please move this whole part to the new Methods section. Results start from chapter 3.3

p. 9235, l.7-8. Please elaborate more on LH-OAT and SCE-UA and provide the references. What are these methods doing?

p.9236, l.7: ‘...112 distributed parameters for each sub-basin...’ Does this mean that the parameters have different values in each sub-basin, i.e. 112 parameters multiplied by 46 sub-basins? Please clarify!

p.9236, l.9: Please change ‘...LH-OAT is...’ to ‘...LH-OAT was...’

p.9236, l.10: Please change ‘...parameters are...’ to ‘...parameters were...’ The problem with the tense is appearing so often in this manuscript that I stop writing it down from here on.

p.9236, l.19-22: ‘Hydrological ... 2002).’ I can’t see how this sentence connects to the surrounding text. Please clarify or leave out.

p.9237, l.26-27: ‘All the dams and sluices are designed to control floods and supply water (Zhang et al., 2013). Is this a general statement or catchment specific? If it is the latter, please change the sentence to ‘All the dams and sluices in the Shaying River Catchment are....’

p.9237, l.28: Please change ‘...decrease...’ to ‘...decreased...’

p.9238, l.1-3: ‘The high...low flow.’ This is a (short) explanation of the method used to separate high and low flows. Please move this part to the ‘Methods’ section and expand it.

p.9239, l.3: '(Zhang et al., 2013)' This reference has been used quite often in this text. For the purpose of the specific statement in this sentence there are also other references (e.g. Gassmann et al., 2014)

p.9239, l.3-4: '...the unacceptable...hydrological processes.' This sentence is not clear to me, please revise.

p.9239, l.23-24: 'highly correlated...(r=0.506) and rice yield (r=0.799).' I don't think that r=0.5 is 'highly' correlated (considering that it is an R² of 0.25). Please provide significance levels of the regressions. Otherwise the r values have hardly any meaning, especially with a low number of points like this.

p.9239, l.28: Replace 'easy' by 'prone'.

p.9239, l.29: The reference Gao et al. (2008) is missing in the reference list.

p.9240, l.2: '... by statistics.' Which statistics? Please provide a reference.

p.9240, l.11: '...28.10 to 762164...' Please provide units. It is not necessary to give digits for such huge numbers.

p.9240, l.18: '...sub-basins results in the simulated errors...' I don't think that only the boundary mismatch is responsible for the errors. Thus, I advise to change the sentence to '...sub-basins may contribute to the simulation errors...'

p.9240, l.20: Please change '...investigations can further...' to '...investigations might further...'

p.9241, l.2: '...a new research direction...' I disagree. For example, the SWAT model is developed and applied for decades now.

p.9241, l.6ff: 'The results showed that: ...' Most of what is written in the list after this sentence is not a result/conclusion of this study!

p.9241, l.19-24: 'The proposed...complex basins.' It was not shown in this paper that the model is able to correctly simulate 'different forms of N/P/C' or 'leaf area index' or 'greenhouse gas emission'. Only the ability to simulate NH₄-N and discharge was shown. Please change.

p.9242, l.5: '...reference point...' This is an ambitious aim which has to be proven by many more studies using HE^XM for modelling different water quality and quantity parameters.

p.9242, l.15: '...with existing model results.' It would be more clear to write something like '...with prior SWAT model results.'

p.9242, l.17: '...and low flow events.' Prior in the manuscript the authors stated that the low flow simulation was bad and has to be improved further. Please change accordingly.

p.9243, l.2-4: Please avoid using references in the conclusions. What is meant by 'advanced mathematic analysis technologies'?

Equation A1: 'SW_{i+1}' should be 'SW_{i-1}'

Table 5: Explain 'Range'.

Figure 1: There is a typo in 'traspiration'

Figure 2: A typo in 'Runoff yeild model of surface water TVGM'

Figure 3b): What is 'Domancy'?

Figure 3b): Please arrange the text in a way that it doesn't overlay the boxes (e.g. Crop base temperature).

Figure 5: There is a typo in 'Water torage'.

Figure 7: Not much can be seen on this Figure because of the huge number of data points. Since Figure 8 already presents a (x,y)-style point diagram, Figure 7 might not be necessary at all, especially since the time series is not discussed any further.

Figure 10: Please provide the significance level of the regressions in this figure. This is especially necessary since the number of considered points in the regression is low.

Literature used in the review

Gassmann, M., Brito, D., Olsson, O., 2014. Estimation of phosphorus export from a Mediterranean agricultural catchment with scarce data. *Hydrol. Sci. J.* 59 (1), 221–233.

Neitsch, S., Arnold, J., Kiniry, J., Williams, J., 2005. SWAT2005 Theoretical Documentation. Texas Water Resources Institute, Temple, Texas.

Neitsch, S., Arnold, J., Kiniry, J., Williams, J.R., 2011. SWAT2009 Theoretical Documentation. Texas Water Resources Institute Technical Report No. 406.

Zhang, Y., Xia, J., Shao, Q., and Zhai, X.: Water quantity and quality simulation by improved SWAT in highly regulated Huai River Basin of China, *Stoch. Env. Res. Risk A*, 27, 11–27, 2013.