

Interactive comment on “Improvement of the SWAT model for event-based flood forecasting on a sub-daily time scale” by Dan Yu et al.

Anonymous Referee #1

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Review of the manuscript "Improvement of the SWAT model for event-based flood forecasting on a sub-daily time scale by Yu et al.

In this manuscript, Yu et al. suggest an improvement for the SWAT model version 2005 in two ways. First, spatial heterogeneity is inserted into the unit hydrograph parametrisation by using the SWAT model parameter on the subbasin level instead on the catchment level. Second, a sub-daily event-based modelling is suggested for the modelling of flood events. I see some interesting ideas in this study. However, I think that the manuscript needs to be strongly improved to identify its major strength in a better way. Thus, I recommend major revision.

Major comments:

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The authors have to be more specific concerning the spatial resolution of the SWAT model. First, the SWAT model is a semi-distributed model consisting of subbasins and hydrological response units (HRU). Thus, please change from "distributed model" to "semi-distributed model".

Since the manuscript is focused on spatial heterogeneity, a clear description of the three levels in the SWAT model, namely catchment, subbasin and HRU level, is required.

Moreover, concerning the parameter heterogeneity and variability, it has to be clarified that some parameters (e.g. included in .bsn) are fixed for the whole catchment, others can be modified for each subbasins and a third group can be varied for each HRU. The authors should mention that the unit hydrograph is parameterized in the SWAT model version on the catchment level, which means that no spatial variation within a catchment is possible. In general, the SWAT model also allows a parameter variation on subbasin or HRU level. This has to be considered in the whole manuscript. In addition, the sentence in the abstract in L. 18 has to be more precise to avoid a misunderstanding.

The SWAT model version 2005 is a very old one. SWAT2009 and SWAT2012 are available since several years. Thus, please justify the use of SWAT2005. This is in particular relevant since the SWAT model was continuously improved and bugs were removed. Thus, the newer version are certainly better. Please give a statement on this.

The justification for the use of SWAT2005 (P.3, L. 13-15) cannot be accepted. Certainly it is possible to use SWAT-CUP for calibration, but it is certainly possible to use different calibration method for all SWAT version. There are lots of study using a different calibration approach for the SWAT model. Moreover a link between the use of SWAT2005 and the selected study catchment is not clear. Thus, please remove this part and provide a better explanation why SWAT2005 was selected instead of SWAT2009 or SWAT2012.

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It is not acceptable to use only four sub-basins for 30630 km² catchment and claim at the same time limitations in spatial heterogeneity. According to my experience at least more than 100 subbasins can be expected for this catchment size. In particular, since the manuscript is focused on spatial heterogeneity, it is surprising that the subbasin number is very low.

Moreover, the SWAT model only provides spatially located outputs for each subbasin. In contrast, the authors stated that there are 138 gauges available. Thus, why do you not define a separate subbasin for each gauge or at least for the majority of the gauges? This would be even more a good approach to consider spatial heterogeneity.

The evaluation of the model results with Nash-Sutcliffe efficiency coefficient (ENS) and coefficient of determination (R2) is redundant. Both indices are mathematically closely related. R2 did not provide any additional knowledge about process or parameter behaviour. Even though that I am aware that there are still publications using ENS and R2, it is not anymore state-of-the-art. At the same time, the use of three performance criteria is recommended. Thus, please select in addition to ENS and PBIAS, a contrasting performance criteria which provides additional information and replace R2.

I do not think that your approach really shows an example for flood forecasting. It is a sub-daily model studies, but I do not see that there is a forecasting. The model is calibrated and validated. Could you please provide more information on how your approach is related to flood forecasting? Or say that this approach might be also beneficial for flood forecasting, but this was not considered here or will be part of future projects?

I have one general major comment: The authors suggest to improve the SWAT model in two ways. At first, at the spatial level, the model parameter t_{adj} is moved from the catchment level to the subbasin level to allow an individual parameterization for each subbasin and thus to consider spatial heterogeneity. Secondly, at the temporal scale, a sub-daily modeling is suggested to improve the representation of flood peaks.

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Both aspects, spatial and temporal improvements, are not clearly enough separated. It would be interesting to know why one aspect improves the model more and in which part of the hydrograph. The study would benefit from a four-step comparison instead of a two-step comparison. To be more precise: I recommend to add two cases: (1) Sub-daily calculation with t_{adj} at catchment level (without t_{subadj}) and the opposite case (2) daily calculation with t_{adj} at subbasin level (with t_{subadj}).

The model modification of Jeong et al. (2010) to simulate on sub-daily resolution needs to be explained and not only mentioned (P.5, L.4). This is a core point of the manuscript. The readers need to understand this modification without reading the paper of Jeong et al. (2010).

You have mentioned that the SWAT is in its default version not adapted to sub-daily flood peak simulations. Keeping in mind that a large number of models is available: Why do you have selected the SWAT model and not a model which is focused on the hydrograph simulation. The major points of the SWAT model such as nutrient simulation, detailed land managements operation etc. are not relevant for your study.

The model results from SWAT2005 are used as input for SWAT-EVENT to simulate the flood peak. Is the model output of SWAT-EVENT then transferred back to SWAT2005? This point might be relevant since the first two flood events occurred with a time lag of 19 days (P.9, L. 11). Thus, I expect a difference in the model states at the end of the first flood between SWAT and SWAT-EVENT. In this context, I like to mention that SWAT-EVENT does not impact the amount of water available in the system, but the water redistribution.

P.5, L.16-29: This part needs to be reformulated to present the idea in a better way. In the current version, it is difficult to understand.

P. 7, L. 1-2: This is a major point of the manuscript and has to be emphasised. A new model parameter is introduced at the subbasin level to include spatial heterogeneity. This is really important that it becomes clear.

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P. 11, L. 18-19: This statement is not right. The SWAT model is not limited in representing low flows. It is more that there is a trade-off between high and low flow simulations at the same time. At it is true that it is difficult to represent high and low flows in a very good quality with the same model run. This is by the way an often occurring problem in hydrological modelling. The major point here is that the selection of the performance measures is at the same time a decision on the study focus. By selecting the Nash-Sutcliffe Efficiency high flows are more weighted than low flows. Thus, it would not be a surprise if the high flows are well represented while low flows perform poorly. This results could be different if using ENSlog or a different performance measure related to low flows. Please improve this statement.

The aspect of flood forecasting is strongly emphasised in the conclusion. I still do not see that the strength of the manuscript is related to flood forecasting. Please rework the conclusion accordingly.

Specific comments:

P.3, L.3: How do you "relate hydrologic response to specific catchment characteristics"? By parameter settings?

P.4, L. 18: The weather generator is only used in the case of missing climate data. Please improve this statement.

P. 5, L. 21: It was not mentioned before that the SWAT model includes HRUs. Please improve the description of the SWAT model.

P. 7, L. 9: Please denote the 26 parameters, maybe in the attachments.

P. 8, L.13: Please explain the three indices, at best with equations.

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